Table I Low-Emission Vehicle exhaust emission standards for passenger cars at 50,000 miles.

Vehicle Category	Grams/Mile by Pollutant			
	NMOG[a]	NO_x	CO	HCHO
Current	0.390	0.4	7.0	none
1993	0.250	0.4	3.4	0.015[b]
TLEV	0.125	0.4	3.4	0.015
LEV	0.075	0.2	3.4	0.015
ULEV	0.040	0.2	1.7	0.008
ZEV[c]	0.000	0.0	0.0	0.000

[a]NMHC for current and 1993 standards, NMOG with reactivity adjustment for others.
[b]Methanol-fueled vehicles only.
[c]Does not include power generation emissions.

The regulations require vehicle manufacturers to meet fleet average NMOG standards that begin at 0.250 grams/mile in 1994 and are progressively reduced to a level of 0.062 grams/mile in 2003. Any combination of TLEV, LEV, ULEV, ZEV and 1993 conventional vehicles can be used to meet the fleet average standards. A separate requirement for the production of small percentages of ZEV begins in 1998. It is entirely up to the vehicle manufacturers whether to build cars fueled with alternative fuels or not. The manufacturers also receive a reactivity credit for California's reformulated gasoline specifications, called Phase II gasoline, that goes into effect in 1994.

B. Reactivity Adjustment

The Low-Emission Vehicles and Clean Fuels regulations use reactivity adjustments to encourage the use of cleaner burning fuels without mandating any particular fuel. Reactivity credits appear to be the only way to assure fair and equitable treatment for both manufacturers of motor vehicles and for producers of all cleaner burning fuels. The exhausts of most alternatively-fueled vehicles are too different from conventional gasoline-fueled vehicles to assume that they have the same ozone-forming potential per unit of mass emissions.

The downside in all this is readily apparent: first, determining a universal reactivity scale is a matter of considerable complexity. Second, enforcing standards for a wide range of certified fuels and vehicle technologies may turn out to be an even more complex matter. Third, there have been virtually no studies of emission control system durability for newer technologies and the effect of catalyst aging on the reactivity of exhaust emissions.

The regulations use the MIR scale to define reactivity. The principal advantage of this scale is that it defines reactivity where hydrocarbon control has its greatest benefits, in the upwind areas where the highest emission densities are found. This is complementary to California's NO_x control program, which has its greatest benefit in the downwind, peak ozone areas. Even though all hydrocarbons eventually react, there is

little to be gained in designing a reactivity scale that is applicable only to areas where hydrocarbon control has little or no benefit. More advantages of the MIR scale over other approaches are the ease of RAF calculations, a single scale for use in the statewide regulations, and a framework to easily incorporate chemical mechanism updates.

III. Technical Issues

Several ARB and industry-sponsored reviews of the MIR approach over the past year, including the Reactivity Conference in Irvine, California in April 1991 and six meetings of the ad hoc Reactivity Advisory Panel, identified a number of key technical issues related to the development of the reactivity scale.

A. Criteria Used in Deriving Reactivity Scales

Perhaps the most important objective of the work done over the past year has been to establish a general set of principles and criteria for reactivity assessment that can be used not only for calculation of the present scale, but for those in the future. Changes in the criteria used to derive the reactivity scale would be much more likely to cause large changes in the RAFs than advances in the knowledge of atmospheric chemistry or airshed conditions.

1. "Equal Air Quality" Criteria

The principle behind the RAF concept is that equal impacts on air quality will result from reactivity-adjusted emissions that just meet the emissions standard. But what is meant by "equal air quality"? Unless all vehicles emit exactly the same types of hydrocarbons, it is not possible to derive a single RAF that yields equal air quality impacts in all places at all times. A RAF determined so that two vehicles have equal impacts on peak ozone will, in general, be different from a RAF derived so that the vehicles have equal impacts on integrated ozone. Therefore, specific criteria of what is meant by "equal air quality" have been established. Since the main reason for regulating ozone is to reduce impacts on human health, medical experts, not atmospheric chemists or modelers, have determined these criteria.

Two questions need to be addressed in relation to setting "equal air quality" criteria for the ozone reactivity scale. First, which of several criteria should be used to judge "equal air quality" for the purpose of calculating reactivity scales? Second, how should the areas of ozone decreases and increases that result when two fuel/vehicle combinations are compared in the airshed model evaluation of the reactivity scale be weighted? The ARB health effects staff has consulted with other experts on ozone health and welfare effects studies, including staff from the Environmental Protection Agency (EPA). The ARB staff's conclusion is that both peak exposures and cumulative exposures are important. Since the national and California ambient air quality standards for ozone are not expected to change from the current form of one-hour peak exposure, and because the California one-hour standard is protective of cumulative exposures, the reactivity scales will be derived based on ozone peaks. The airshed model evaluation will demonstrate a successful reactivity scale when two fuel/vehicle combinations result in equal one-hour basin peak concentrations and equal ozone geographic dosage (in units of ppm-hours for all hours in all surface grid cells over land with absolute ozone concentrations above 0.09 ppm).

2. "Pollution Scenario" Criteria

The second major issue is the set of criteria used to establish which models for airshed conditions, or "pollution scenarios", are used to calculate the reactivity scale. The MIR scale was developed using the criteria that: (1) accurate representation of the chemical mechanism and the chemical environment is more important to reactivity calculations than accurate representations of physical characteristics of the scenarios; (2) that approximate representation of a wide variety of airshed conditions was more important than accurate representation of any single scenario; and (3) that the scenarios employed be those in which hydrocarbon emissions have the largest effect on ozone.

An alternative to the first two of these criteria is the principle of using scenarios that are as physically realistic as possible, i.e., using grid models. However, no one has proposed developing a complete reactivity scale based on grid model calculations, since separate simulations would be required for each of the more than one hundred hydrocarbons. It is not impractical, however, to derive RAFs for given vehicles using this method, which requires only direct calculations of reactivities of whole exhaust mixtures. It is more difficult to do this for a comprehensive variety of airshed conditions, since grid models are set up for only a limited number of scenarios. In addition, because of biases and uncertainties in emissions inventories, one has no real assurance that a grid model is any more accurate in representing chemical effects than the physically much simpler Empirical Kinetics Modeling Approach (EKMA). In fact, just the opposite could be the case. Given the uncertainty in emissions and representation of other airshed conditions, the ARB staff judged that the criterion of using a wide variety of scenarios be adopted.

3. Maximum Reactivity Criterion

The most controversial of the criteria underlying the MIR approach is the principle of basing the scale on airshed conditions where hydrocarbons have the greatest effect on ozone, i.e., the "maximum reactivity" criterion. The use of this criterion has been criticized because it means that reactivity scales are calculated for conditions where NO_x levels are higher than those where peak ozone levels occur. Many believe that alternatives, such as basing the scale on conditions where peak ozone levels occur or on averages of airshed conditions regardless of sensitivity of ozone levels to hydrocarbon controls, are more appropriate. The principle behind use of the maximum reactivity criterion is that, in California, the hydrocarbon controls are being implemented in conjunction with NO_x controls. NO_x controls are being implemented to reduce ozone under conditions that are sensitive to NO_x, and hydrocarbon controls to reduce ozone under conditions sensitive to hydrocarbons. The ARB staff believes that the maximum reactivity criterion is the most appropriate in this context. Even though all hydrocarbons eventually react, there is little to be gained in designing a reactivity scale that is applicable only to areas where hydrocarbon control has little or no benefit. This aspect has been missing in previous critiques of the MIR approach.

In addition to the MIR scale, Carter developed the maximum ozone reactivity (MOIR) scale for maximum ozone conditions. If this alternative had provided a better fit to the airshed modeling results than the MIR scale, the ARB staff would have recommended its use for calculating the RAFs.

B. Uncertainty in Understanding of Atmospheric Chemistry

Computer model calculations can be used to estimate hydrocarbon reactivities. The reliability of these calculations depends on the accuracy of the chemical mechanism used in the model. Atkinson (1990) has recently reviewed and discussed the status (as of mid-1989) of the knowledge of the atmospheric chemistry of organic gases. While there are numerous areas of uncertainty, major uncertainties concern the reaction mechanisms of alkanes with five or more carbon atoms and aromatic hydrocarbons with the hydroxyl radical, and of alkenes with ozone. The MIR and MOIR scales were calculated using the chemical mechanism developed by Carter (1990), commonly called the SAPRC90 mechanism. The mechanism includes measured or estimated rate constants and other mechanistic parameters for the more than one hundred organic gases that comprise the bulk of vehicle emissions, allowing their reactivities to be calculated. Detailed mechanisms for approximately twenty species have been tested against environmental chamber data. Even in these cases, there are many uncertainties concerning details of the individual reactions and products, and in some cases (particularly for aromatic hydrocarbons) empirical mechanisms with adjustable parameters have to be used to "fit" the environmental chamber data. The mechanisms for the other organic gases are based on interpolations and extrapolations from the mechanisms for the twenty well-studied species, or on estimates that rely on laboratory data and theoretical considerations.

The uncertainties in the chemical mechanisms do not have much effect on reactivity determinations for fuels whose emissions are dominated by a few species, such as ethene, methanol, or formaldehyde, with well-tested mechanisms. The major uncertainty concerns the reactivity of the conventional gasoline against which alternative fuels will be compared. One important benefit of the interest in reactivity-based hydrocarbon controls is that it has served as a catalyst for increased support of kinetic, product, and mechanistic studies by government agencies and industry research groups.

1. Comparison of SAPRC90 with Other Chemical Mechanisms

It was noted at the Reactivity Conference that SAPRC90 contains a number of estimates that are, in effect, Carter's "personal opinion", and that others have made different estimates. Only Derwent and Jenkin (1991) have made a comparable attempt to estimate the atmospheric reactions of a comprehensive set of hydrocarbon for the purpose of reactivity calculations. Their reactivity scale has significant differences from both the MIR and MOIR scales calculated using SAPRC90, but it is not clear if this is attributable to differences in the mechanisms or to differences in the airshed scenarios. All other current mechanisms, such as Carbon Bond IV (CB4), LCC (a 1987 predecessor of SAPRC90) and RADM-II, are condensed mechanisms designed primarily to simulate reactions of complete atmospheric mixtures, rather than for calculations of reactivities of individual hydrocarbons. They can, in principle, be used to calculate reactivities for any hydrocarbon for which "lumping" rules have been derived. But only reactivity calculations for species which they can represent without "lumping" can have a potential claim to chemical accuracy comparable to those of detailed mechanisms such as Carter's or Derwent's.

The CB4 and LCC are the only mechanisms that have been compared with SAPRC90 using the same scenarios. The CB4 reactivity scales showed many similarities and a few differences with those derived using SAPRC90, with the greatest differences being for toluene and formaldehyde reactivities under MOIR conditions. As shown on Table II, the differences between these two mechanisms in calculations of the RAF range from 0 to 8% for MIR conditions and 3 to 12% for MOIR conditions. The differences between SAPRC90 and LCC are even smaller.

Table II Effect of different chemical mechanisms on RAFs.

Fuel[a]	Reactivity Adjustment Factors					
	MIR			MOIR		
	SAPRC90 (1990)	CB4 (1990)	LCC[b] (1987)	SAPRC90 (1990)	CB4 (1990)	LCC[b] (1987)
Base	1.00	1.00	1.00	1.00	1.00	1.00
M85	0.37	0.39	0.37	0.39	0.40	0.38
LPG	0.50	0.54	0.50	0.59	0.66	0.60
CNG	0.18	0.18	0.17	0.23	0.22	0.22
E85	0.63	0.64	0.62	0.77	0.82	0.70

[a]Composite speciation profiles from vehicles that met the TLEV standards (ARB 1991b):
Base - U.S. industry average gasoline
M85 - 85% methanol/15% U.S. industry average gasoline blend
LPG - Liquefied petroleum gas
CNG - Compressed natural gas
E85 - 85% ethanol/15% U.S. industry average gasoline blend (did not meet TLEV NMOG standard)
[b]Computed with surface photolysis rates. Others rates at 640 meters.

2. Peer Review of SAPRC90

The ARB staff considers SAPRC90 to be the most appropriate of the currently available mechanisms for calculating reactivity scales. Unlike Derwent's mechanism, it was tested as much as possible against environmental chamber data and, unlike CB4, LCC and RADM-II, it was specifically designed for calculating reactivities of individual organic gases. However, it was clear that the assumptions underlying SAPRC90 should undergo thorough peer review, and that a systematic estimate of effects of chemical uncertainties on its reactivity predictions be carried out. Dr. Michael Gery, a recognized expert in the field of atmospheric chemistry, was retained by ARB staff to review and critique SAPRC90. The review was done on two levels, theoretical and operational. The theoretical level review examined the principles and assumptions behind the mechanism. Gery focused on what was reasonable for Carter to have done, given the state of the science (i.e., considering the limitations in chemistry knowledge, environmental chamber data and the need for condensed mechanisms because of computer limitations). The operational level review was to assure that Carter had correctly translated his chemical mechanism into computer code.

In his peer review, Gery (1991) found that, while the mechanism was basically sound, there were several areas where updates would be desirable. Those characterized as "needed updates" included: (1) updates to the formaldehyde ultraviolet absorption cross sections; (2) updates to the rate constants involved in the peroxyacetyl nitrate (PAN) formation reactions; (3) re-examination of assumptions used in representing unknown portions of the aromatic mechanisms; (4) addition of several organic gases; and (5) fixes of several minor errors found in the program and data used to derive the mechanistic parameters for the alkanes.

The recommendations given lower priority included: (6) re-examination of assumptions used to derive nitrate yields from the alkanes; (7) use of measured OH radical rate constants for alkanes where available, rather than estimates; (8) re-examination of the method used to represent cycloalkenes; (9) re-examination of the method used to represent isoprene; (10) updates of several nitrate radical (NO_3) + alkene rate constants; and (11) update of products from the NO_3 + HO_2 reaction.

Gery had a number of other "significant concerns" regarding treatments of many areas of uncertainty in the mechanism where he might have made different assumptions, or where further work is clearly needed. However, he recognized that addressing these latter concerns is a longer term research need that cannot be addressed in this round of the RAF calculations, and recommended that the present effort be restricted to the priority items listed above.

3. Updates to SAPRC90

Carter concurs with most of Gery's recommendations, and will find his review of major utility when updating the mechanism in the coming years. Unfortunately, there was insufficient time to make all the modifications to the mechanism that Gery characterized as "needed updates" prior to the calculation of the RAFs. This is because major modifications of the mechanism which would significantly affect its predictions would require re-evaluation against the environmental chamber data used in the mechanism's development. In particular, it was found when the formaldehyde and PAN kinetics updates were incorporated, the mechanism exhibited a significant positive bias (on the order of 25%) in simulations of the chamber runs. This bias may be due to either the chemical mechanism or the representation of chamber conditions. An EPA-funded project, conducted by Professor Harvey Jeffries, with support from Carter, Gery and others, to review and evaluate the environmental chamber base was (and continues to be) well behind schedule, as was a component to develop a chemical mechanism evaluation protocol.

Based on the recommendations of Gery, Jeffries and other modeling experts on the ad hoc Reactivity Advisory Panel, it was decided that it would be more prudent to calculate the RAFs using a mechanism which has already been evaluated and documented in the refereed literature, rather than to make partial updates without time to adequately evaluate their effects. Therefore, the changes to the mechanism were restricted to only those affecting individual NMOG for which there is no significant evaluation data base. A major update to the SAPRC90 mechanism will not be completed before 1993 at the earliest, and will be used for the scheduled 1994 update to the reactivity scale. Concerns about the correctness of the mechanism are partially alleviated by the minor effect on the RAFs of previous major updates to the mechanism (see Table II).

It should be noted that there are a few cases where Carter disagreed with Gery's recommendations. Carter did not think it was advisable to make major changes to the representation of the uncertain portions of the aromatic mechanisms without incorporating new information concerning the effects of aromatic product yields on NO_x, and completely evaluating the consequences of these changes. There was insufficient time available to do this. In addition, Carter does not agree with Gery (and Jeffries) that the shape of the action spectrum used for the unknown products will necessarily introduce a bias into the simulations. These products probably include unsaturated carbonyl compounds, which may be similar in some respects to acrolein. Carter found that using the action spectrum for acrolein (with unit photodecomposition quantum yields) to represent those unknown products gives essentially the same results in simulating the environmental chamber data, including outdoor chamber runs, as the spectrum used in SAPRC90. Therefore, while the true action spectra for these products are unknown, Carter did not believe the representation in the present model needed to be updated before proceeding with the RAF calculations.

As noted above, Gery made a number of recommendations for updates for individual NMOG which could be implemented. Other updates not noted by Gery were also made. The errors in the alkane parameter calculation program were corrected, and the measured alkane + OH rate constants were used whenever available. Rate constants for the reactions of alkenes with NO_3, ozone, and $O(^3P)$ atoms were updated. (No significant updates were found to be needed for the alkene + OH reactions.) The representation of the ozone + cycloalkene reaction was corrected so the overall radical yield was assumed to be the same as for other internal alkenes. (The parameterization in the previous mechanism caused the fragmentation yield to be half as much as other alkenes, which is not what would be estimated.) Errors found by Gery concerning some of the higher alcohols were also corrected, although none of these are needed for the RAF calculations. A number of alkane and alkene species were added to the list of NMOG which could be separately represented. Therefore, although the common portions of the mechanism which affect reactivities of all NMOG were not significantly changed, there are a number of updates concerning reactions of individual NMOG.

4. Assessment of Effects of Chemical Uncertainties

The assessment of chemical uncertainties on a NMOG's reactivity can be aided by considering separately the uncertainties in a NMOG's "kinetic reactivity" and its "mechanistic reactivity". The kinetic reactivity of a NMOG is the fraction of emitted NMOG which undergoes reaction in the ozone episode; mechanistic reactivity is the amount of ozone formed when a given amount of the NMOG reacts. The kinetic reactivity is determined by rate constants for the NMOG's initial reactions in the atmosphere. The uncertainties in the kinetic reactivities are easy to quantify, since evaluations of kinetic data generally give uncertainty ranges for the measured values. Translating uncertainties in rate constants to uncertainties in kinetic reactivities is relatively straightforward, and can be done without having to explicitly recalculate all reactivities.

Determination of uncertainties in mechanistic reactivities is much more difficult, since it depends on a large number of parameters, environmental as well as mechanistic. Without carrying out a systematic evaluation of the effects of all these parameters (and making guesses as to their ranges of uncertainty), the only approach Carter could use was to make largely subjective estimates of likely uncertainty ranges. These are given in

Table III. These estimates are based in part on: (1) the estimated uncertainty ranges of parameters which are important in affecting mechanistic reactivity and the reactivities of "pure mechanism" species corresponding to these parameters (Carter and Atkinson, 1989); (2) sensitivity calculations on effects of alternative assumptions on mechanisms of the NMOG; (3) differences between mechanistic reactivities for CB4 and SAPRC90 for those species which CB4 represents explicitly; and (4) an arbitrarily assumed minimum uncertainty of 20% for all mechanistic reactivities of all NMOG. For some NMOG whose mechanistic reactivities are determined by combinations of mechanistic characteristics which have opposing effects on reactivity, such as the alkanes and the aromatic hydrocarbons under maximum ozone conditions, it is more meaningful to express uncertainties in terms of an absolute number of ozone per NMOG reacted, rather than a relative factor.

5. Updates to MIR Scale Every Three Years

Of course, assessing the uncertainties in SAPRC90 and comparing its predictions to other mechanisms will not solve the underlying problems causing these uncertainties. These can only be addressed by fundamental studies aimed at improving the knowledge of the atmospheric reactions of hydrocarbons, and environmental chamber experiments to test the models for these reactions. Research of this type is being sponsored by the Board and others, so the knowledge in these areas will continue to advance, and the mechanisms will improve accordingly. The ARB staff welcomes involvement by other interested parties in such research.

Because of the residual uncertainties in the chemical mechanisms, the reactivity scale will be subject to re-calculation at three-year intervals using the mechanism reflecting the current knowledge. It is expected that changes in the chemical mechanism alone will not greatly change the RAFs for vehicles whose emissions are dominated by a few species, such as ethene, methanol or formaldehyde, whose mechanisms are already well tested. However, industry must be prepared to anticipate and deal with the changes that may occur, since the Board intends to base all of its regulations on the best available kinetic and mechanistic data.

C. Representation of Airshed Conditions

1. EKMA Conditions

The EPA provided EKMA model inputs for the 1986 to 1988 ozone design values for thirty-nine cities across the United States (Baugues 1991). The initial NMHC and NO_x concentrations were based on the median of levels measured during all days exceeding 0.124 ppm or the top ten episodes if more than ten exceedances were measured during the NMHC sampling period. Ozone concentrations aloft were based on downwind measurements made just after the morning increase in the mixing height. Hourly emissions by county were obtained from the 1985 National Acid Precipitation Assessment Program inventory. These represent weekday emissions for the appropriate season of the year. Motor vehicle emissions were computed using MOBILE3.9 using seasonal activity levels, but annual-average temperature. Biogenic hydrocarbon emission estimates were also included. EPA is preparing an update with day-specific motor vehicle emissions (based on MOBILE4 with day-specific temperatures and county vehicle miles traveled), but the results were not available in time for the reactivity calculations.

07007

Table III Mechanistic reactivity uncertainty estimates for MIR and MOIR conditions.

Organic Gas Class	Mechanistic Reactivity Uncertainty (moles ozone/mole C)[a]	
	MIR	MOIR
CO	15%	20%
Alkanes		
C_1 to C_8	greater of 20% and 0.5/#C	greater of 20% and 0.2/#C
C_9 and above	0.5/#C[b]	0.25/#C[b]
cycloalkanes	0.6/#C[b]	0.3/#C[b]
Alkenes		
ethene	20%	20%
propene	25%	25%
C_4	30%	30%
C_5 and above	40%	50%
dialkenes	50%[c]	50%[c]
cycloalkenes	50%	50%
Alkynes	50%	50%
Aromatic Hydrocarbons	30%	0.35[d]
styrene	50%	0.2[d]
Oxygenates		
methanol	20%	20%
ethanol	20%	20%
formaldehyde	40%[e]	30%[e]
acetaldehyde	40%	30%
propionaldehyde	40%	30%
acetone	40%	30%
acrolein	50%[c]	50%[c]
methyl *t*-butyl ether	20%	30%
ethyl *t*-butyl ether	40%	30%

[a]Relative uncertainties unless otherwise indicated.
[b]Absolute uncertainty. #C is the number of carbons in the alkane.
[c]Uncertainty primarily due to inappropriateness of mechanism. More accurate mechanisms can be derived for 1,3-butadiene, isoprene and acrolein, but were not used in these calculations.
[d]Absolute uncertainty.
[e]High uncertainty primarily due to sensitivity to ambient NMOG speciation.

07008

Several changes were made to the EKMA scenarios. Professor James N. Pitts has noted that nitrous acid (HONO), an important radical initiator, is not normally included in EKMA and other photochemical models. A constant HONO to NO_x ratio of 0.02 was used to specify initial conditions, with a ratio of 0.001 for emissions. These ratios represent typical values found in urban areas. Initial and transported conditions for methane were set at the current global background estimate of 1.79 ppm. Zero NO_x was used aloft instead on EPA's value of 2 ppb. The SAPRC90 mechanism for biogenic emissions of isoprene and α-pinene was used with unknown biogenic hydrocarbons treated as α-pinene. Parameters to calculate photolysis rates at 640 meters, the approximate average mid-point of the mixed layer during daylight hours, were provided by Jeffries.

Dr. William Lonneman of EPA made extensive speciated NMHC measurements around the country in 1987 and 1988, including the 1987 Southern California Air Quality Study (SCAQS). The 1987-88 all-city average profile was found to be similar to the 1987 SCAQS profile. The all-city average was used since it is a more robust data base. Previous calculations by Carter (1991) used the EKMA-recommended default value of a two percent mass fraction for formaldehyde and a three percent mass fraction for acetaldehyde. These default values are not measurement-based. The current calculations used the SCAQS measurements of one percent for both formaldehyde and acetaldehyde. The SCAQS data base is the only one in an urban area with higher ($>C_3$) aldehyde measurements. The existence of higher aldehydes in ambient air has been confirmed by gas chromatography/mass spectrometer measurements in other parts of California. The SCAQS higher aldehyde measurements, reduced by a factor of two because of problems with the blank corrections, were used in all thirty-nine cities.

2. Sensitivity Tests of Reactivity Scales

Carter performed a series of sensitivity tests to investigate the effects of uncertainties in HONO levels, photolysis rates and ambient NMOG speciation on the MIR and MOIR scales. The results are shown in Table IVab. The largest effect on a RAF was a 5% decrease for E85 when photolysis rates were computed at the surface. The reactivities (relative to the ambient NMOG speciation profile) of many slower reacting organic gases also drop with the use of surface photolysis rates, while the relative reactivity of formaldehyde increases when HONO is set to zero, especially for MIR conditions.

Table IVa Effect of HONO, photolysis and ambient NMOG on RAFs.[a]

Fuel	Reactivity Adjustment Factors							
	MIR				MOIR			
	Base	HONO	hv	NMOG	Base	HONO	hv	NMOG
Base	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
M85	0.39	0.40	0.38	0.39	0.41	0.43	0.42	0.41
LPG	0.51	0.52	0.50	0.52	0.60	0.60	0.59	0.60
CNG	0.18	0.18	0.17	0.18	0.21	0.22	0.21	0.21
E85	0.63	0.62	0.60	0.64	0.70	0.70	0.67	0.71

Table IVb Effect of HONO, photolysis and ambient NMOG on relative reactivities of individual organic gases.[a]

Organic Gas	Reactivity Relative to Base Ambient NMOG Speciation Profile (mass basis)							
	MIR				MOIR			
	Base	HONO	hv	NMOG	Base	HONO	hv	NMOG
Carbon Monoxide	0.022	0.020	0.018	0.022	0.038	0.037	0.036	0.039
Methane	0.0058	0.0053	0.0049	0.0060	0.0085	0.0085	0.0081	0.0087
Propane	0.17	0.16	0.145	0.18	0.25	0.24	0.23	0.25
n-Butane	0.35	0.32	0.30	0.37	0.49	0.48	0.46	0.50
n-Octane	0.21	0.18	0.17	0.22	0.29	0.27	0.25	0.30
Branched C_8 Alkanes	0.39	0.35	0.33	0.40	0.48	0.46	0.44	0.50
Ethene	2.6	2.5	2.5	2.6	3.0	2.9	3.0	3.0
Propene	3.0	2.9	3.0	3.0	3.2	3.2	3.2	3.2
Isobutene	1.7	1.7	1.8	1.7	1.7	1.8	1.9	1.7
trans-2-Butene	3.0	3.1	3.1	2.9	3.1	3.2	3.2	3.1
Benzene	0.145	0.138	0.134	0.146	0.119	0.111	0.109	0.116
Toluene	0.88	0.87	0.88	0.88	0.53	0.50	0.52	0.53
m-Xylene	2.6	2.6	2.8	2.6	2.2	2.2	2.3	2.2
1,3,5-Trimethylbenzene	3.2	3.3	3.4	3.1	2.8	2.9	3.1	2.8
Methanol	0.21	0.20	0.19	0.22	0.26	0.26	0.25	0.27
Ethanol	0.44	0.40	0.38	0.45	0.51	0.49	0.46	0.52
Formaldehyde	2.2	2.7	2.4	2.1	2.0	2.3	2.2	1.9
Acetaldehyde	1.7	1.7	1.7	1.7	1.8	1.8	1.7	1.8

[a]Using "average conditions" scenario (Carter 1991).

Conditions for Sensitivity Tests

Base - Conditions of current reactivity calculations with HONO = 2% of initial NO_x and 0.1% of NO_x emissions; photolysis rates computed at 640 meters; EPA all-city NMOG with SCAQS measured aldehydes.

HONO - No initial or emitted HONO.

hv - Photolysis rates computed at surface.

NMOG - EPA all-city NMOG with EPA assumed aldehydes.

IV. Airshed Model Evaluations of the MIR Approach

A. Evaluation of Individual Reactivities

The MIR scale was calculated with an EKMA-like, chemically detailed, one-dimensional model that operates with one-day simulations and lacks physical detail. At issue is whether this is an adequate representation of actual ozone episodes, which tend to extend over several days in California, and whose severity is strongly dependent on meteorological conditions. Russell and coworkers (McNair et al. 1992) addressed this issue by computing incremental reactivities with a physically detailed, three-dimensional airshed model for a severe, three-day stagnation episode in Los Angeles when the daily ozone maximum was limited by the availability of NO_x. Because airshed models are, of necessity, formulated with condensed chemical mechanisms, incremental reactivities were derived for only eleven individual and "lumped" organic gases. As shown in Table V, despite large differences in the physical details and NO_x availability of the two modeling approaches, the agreement between the airshed modeling and the MIR scale is within 15% for most organic gases. Poorer agreement was found with the MOIR scale, with differences larger than 25% for most organic gases.

Table V Comparison of CMU airshed model results with Carter reactivity scales.

Organic Gas Class	Incremental Reactivity Relative to CO (mass basis)		
	Airshed Model	Carter Reactivity Scale	
	Exp>0.12 ppm	MIR	MOIR
CO	1	1	1
Alkanes			
C_4 and above	27	24[a]	21[a]
Alkenes			
ethene	120	135	83
C_3 and above	154	163[b]	90[b]
Aromatic Hydrocarbons			
toluene	57	51	12
xylenes and above	198	156[c]	67[c]
Oxygenates			
methanol	11	10	7
ethanol	17	25	19
formaldehyde	175	132	55
higher aldehydes	85	102[d]	57[d]
methyl ethyl ketone	23	22	14
methyl *t*-butyl ether	13	11	11

[a]Averaged reactivities of *n*-butane, branched C_5 alkanes and branched C_6 alkanes.
[b]Averaged reactivities of propene, C_4 alkenes and C_5 alkenes.
[c]Averaged reactivities of xylenes and trimethylbenzenes.
[d]Reactivity for acetaldehyde.

B. Evaluation of RAFs

There have been concerns expressed as to whether the MIR scale will lead to fuel-neutral RAFs. This issue can be addressed by implementing the regulation in an airshed model using the so-called "null test". That is, if an increased amount (based on the RAF) of less reactive organic emissions is substituted for conventional gasoline in the baseline emission inventory, then the ozone should remain unchanged.

1. Model Applications

Russell evaluated the RAFs with the results of his airshed model for the August 27 to 29, 1987 SCAQS episode. The modeling simulations were performed with two different emission inventories. The 2010 emission inventory with Tier I controls represents a low hydrocarbon to NO_x ratio. Because of concerns that the low hydrocarbon to NO_x ratios predicted by airshed models will bias the comparison in favor of the MIR scale, the 1987 emission inventory with motor vehicle hydrocarbon exhaust multiplied by two was also used. The August 30 to September 1, 1982 episode was also simulated with the 1987 and 2010 emission inventories to provide a different set of meteorological conditions. HONO emissions were not added to either episode because the model creates HONO with night-time reactions. Biogenic hydrocarbon emissions and chemistry were not included because of their negligible contribution to ozone concentrations in the South Coast Air Basin.

2. Motor Vehicle Profiles

Only profiles from vehicles that met the TLEV emission standards (ARB 1991b) were processed. Simulations were performed for vehicles fueled with the U.S. industry average gasoline, CNG, M85 and LPG. These four fuels lead to very different exhaust profiles, and provide a very stringent test of the reactivity scale. Data from testing programs conducted by ARB, the Auto/Oil Program and Chevron Research and Technology were averaged to create composite profiles.

The Auto/Oil Program protocol for processing the hydrocarbon emission profiles was followed. The main departure from previous work (Russell et al. 1991; Smylie et al. 1990; Dunker 1991) is that a more realistic distribution of mass emissions between cold start, running and hot start exhaust emissions was used (see Tables VIab). Temperature and speed corrections to the data were not available. Evaporative emission rates and speciation profiles were not changed from the baseline vehicle fleet. Carbon monoxide and NO_x emissions were unchanged from the base case. These assumptions are not realistic, but did allow a fair test of the way the reactivity scale is being applied in the ARB regulations.

The emission inventories for each fuel were adjusted by the proposed RAF (ARB 1991b). While the airshed model uses a different chemical mechanism than that used to calculate the MIR scale, Table VII shows that the LCC mechanism gives virtually the same RAFs, except for E85. The results do not depend on whether ambient or emission inventory speciation is used.

Table VIa Exhaust emissions distribution for test data for TLEVs.

Vehicle Type	Percent of Mass in Each Exhaust Mode					
	1987 Activity Data			2010 Activity Data		
	Cold	Run	Hot	Cold	Run	Hot
Base	72	22	6	71	24	5
M85	95	4	1	95	4	1
LPG	60	26	14	59	28	13
CNG	7	91	2	7	92	1

Table VIb Exhaust reactivity-weighted emissions distribution for test data for TLEVs.

Vehicle Type	Percent of Reactivity in Each Exhaust Mode					
	1987 Activity Data			2010 Activity Data		
	Cold	Run	Hot	Cold	Run	Hot
Base	78	17	5	77	19	4
M85	87	11	2	86	12	2
LPG	71	21	8	70	23	7
CNG	33	65	2	31	67	2

Table VII RAFs for reactivity scales based on SAPRC90 and LCC.

Fuel	Reactivity Adjustment Factors					
	MIR			MOIR		
	SAPRC90	LCC[a]	LCC w/EI[a]	SAPRC90	LCC[a]	LCC w/EI[a]
Base	1.00	1.00	1.00	1.00	1.00	1.00
M85	0.37	0.36	0.37	0.38	0.38	0.38
LPG	0.50	0.50	0.50	0.59	0.60	0.59
CNG	0.18	0.17	0.17	0.23	0.21	0.21
E85	0.63	0.60	0.58	0.77	0.69	0.67

[a]Computed with surface photolysis rates, airshed model uses higher values aloft. MEK + OH reaction not fixed.

3. Null Test Results

The air quality impacts were calculated relative to a case with no TLEV NMOG emissions. A null test result of 1.00 in Tables VIIIab indicates no bias. A result greater than one indicates a bias against the base gasoline, while a result less than one indicates a bias against the alternative fuel. The modeling protocol document established that the one-hour basin peak concentrations and ozone geographic dosage (in units of ppm-hours summed over all hours in all surface grid cells over land with absolute ozone concentrations above 0.09 ppm) should be within 25%. Later, it was decided that the 25% criterion was too loose, and that the dosage should be population-weighted. The null test results for the more typical 1987 episode, with some deviations (less than 10%) from equal ozone impacts, are very encouraging. The deviations in the peak ozone results are not important, since the ozone peaks are relatively insensitive to changes in NMOG emissions. The ozone peaks were predicted far downwind near the eastern boundary of the modeling domain (past Palm Springs, more than 100 miles from the major source areas). Distant downwind areas are relatively insensitive to hydrocarbon emission changes, so the null test results are the ratios of two very small numbers.

In early November, 1991, it was found that the LCC mechanism documentation incorrectly states one of the products of the methyl ethyl ketone (MEK) reaction with OH. The consequence of this mistake is that the reactivity of MEK will be overstated by about a factor of two and the reactivity of alkanes and MTBE will be overstated by a lesser amount. Only one of the cases (1982 episode, 2010 inventory) has been run with the MEK mechanism fixed, which generally resulted in a 5% improvement. Because of the good agreement between the MIR scale and the airshed modeling results for individual and lumped organic gases, these deviations from unity for the null test are more likely due to differences in spatial and temporal patterns of emissions between vehicle fleets, rather than a problem with the MIR approach. The fleet with the highest cold-start emissions (M85), which have longer to react in comparison to the conventional gasoline fleet, had the highest null test results, while the fleet with the lowest cold-start emissions (CNG), had the lowest null test results. Russell plans to investigate this issue further.

The approximately 10% bias in the population-weighted dosage results for the higher 1982 episode are of concern. The only formally adopted RAF to date, a value of 0.41 for M85 vehicles, includes a 10% increase based on the airshed modeling results. When more vehicle test data become available for the other alternative fuels, airshed modeling will be performed to determine a fuel-specific RAF correction.

V. References

Atkinson, R. (1990) Gas-phase tropospheric chemistry of organic compounds: A review. *Atmos. Environ.*, **24A**: 1.

~~Baugues, K. (1991) Personal communication. May 13.~~

California Air Resources Board (1990) Proposed Regulations for Low-Emission Vehicles and Clean Fuels--Staff Report and Technical Support Document. State of California, Air Resources Board, P.O. Box 2815, Sacramento, CA 95812, August 13.

California Air Resources Board (1991a) Proposed Regulations for Low-Emission Vehicles and Clean Fuels--Final Statement of Reasons. State of California, Air Resources Board, July.

California Air Resources Board (1991b) Proposed Reactivity Adjustment Factors for Transitional Low-Emission Vehicles--Staff Report and Technical Support Document. State of California Air Resources Board, Sacramento, CA, September 27.

Carter W. P. L. and R. Atkinson (1989) Computer modeling study of incremental hydrocarbon reactivity. *Environ. Sci. Technol.*, **23:** 864.

Carter, W. P. L. (1990) A detailed mechanism for the gas-phase atmospheric reactions of organic compounds. *Atmos. Environ.*, **24A:** 481.

Carter, W. P. L. (1991) Development of Ozone Reactivity Scales for Volatile Organic Compounds. Final Report prepared for United States Environmental Protection Agency, EPA 600/3-91/050, August.

Croes, B. E., J. R. Holmes and A. C. Lloyd (1992) ARB/SCAQMD conference on reactivity-based hydrocarbon controls: Scientific issues and potential regulatory applications. *J. Air Waste Manage. Assoc.*, in press.

Derwent, R. G. and M. E. Jenkin (1991) Hydrocarbons and the long-range transport of ozone and PAN across Europe. *Atmos. Environ.*, **25A:** 1661.

Dunker, A. M. (1991) Reactivity Calculations for the Auto/Oil Program. Presented at the conference Reactivity-Based Hydrocarbon Controls: Scientific Issues and Potential Regulatory Applications, Irvine, California, April 8-9.

Gery, M. W. (1991) Review of the SAPRC-90 Chemical Mechanism. Draft Final Report prepared for the California Air Resources Board, Contract No. A132-055, August 8.

McNair, L., A. Russell and M. T. Odman (1992) Airshed calculation of the sensitivity of pollutant formation to organic compound classes and oxygenates associated with alternative fuels. *J. Air Waste Manage. Assoc.*, **42:** 174.

Russell, A. G., L. A. McNair, M. T. Odman and N. Kumar (1991) Organic Compound Reactivities and the Use of Alternative Fuels. Draft Final Report to the California Air Resources Board, Agreement #A832-112, May.

Smylie, G. M., G. Z. Whitten, R. E. Morris, J. L. Fieber and K. O'Connor (1990) Technical Analysis of the ARB Staff Proposal for Hydrocarbon Reactivity Adjustment Factors for Clean Fuel/Low Emission Vehicle Regulations. Final Report SYSAPP-90/092 prepared for Western States Petroleum Association, 505 North Brand Blvd., Glendale, CA 91203, September 21.

Table VIIIa Null test results for CMU airshed model simulations of 1987 episode.

Ozone Statistic	Null Test Result					
	1987 Inventory[a,b]			2010 Inventory[b]		
	M85	LPG	CNG	M85	LPG	CNG
Basin peak[c]	1.24	1.36	1.18	0.91	1.36	1.73
Grid hours > 0.09 ppm	1.02	1.02	0.84	1.01	1.14	0.84
Grid hours > 0.12 ppm	1.05	1.07	0.89	1.01	1.12	0.92
ppm-hours > 0.09 ppm	1.04	1.05	0.90	1.00	1.15	0.91
ppm-hours > 0.12 ppm	1.05	1.09	0.93	1.00	1.16	0.97
10^6 Person-ppm-hours > 0.09 ppm	1.03	1.00	0.77	1.02	1.09	0.74
10^6 Person-ppm-hours > 0.12 ppm	1.05	1.03	0.79	1.01	1.14	0.83

Table VIIIb Null test results for CMU airshed model simulations of 1982 episode.

Ozone Statistic	Null Test Result					
	1987 Inventory[a,b]			2010 Inventory		
	M85	LPG	CNG	M85	LPG	CNG
Basin peak[c]	1.10	1.13	1.08	1.12	1.29	0.94
Grid hours > 0.09 ppm	1.23	1.21	1.18	1.14	1.09	0.94
Grid hours > 0.12 ppm	1.18	1.19	1.16	1.14	1.11	1.04
ppm-hours > 0.09 ppm	1.20	1.22	1.17	1.13	1.12	1.01
ppm-hours > 0.12 ppm	1.18	1.20	1.15	1.12	1.12	1.06
10^6 Person-ppm-hours > 0.09 ppm	1.05	1.02	0.89	1.10	1.05	0.86
10^6 Person-ppm-hours > 0.12 ppm	1.07	1.05	0.89	1.10	1.05	0.86

[a]With motor vehicle hydrocarbon exhaust multiplied by two.
[b]MEK + OH reaction not fixed, null test results likely to be smaller.
[c]Far downwind ozone peak near boundary (past Palm Springs). Peak relatively insensitive to hydrocarbon emission changes, so ratio of two small numbers.

Summary of Test Results
for CNG-Fueled Vehicles

Vehicle	Test #	Species Table #	Test Date	NMOG (mg/mi)	CH4 (g/mi)	CO (g/mi)	NOx (g/mi)
Ford	3C1	III-5e	10/22/91	55.81	1.298	1.16	0.392
Taurus	3C2	III-5e	10/23/91	43.44	1.185	1.03	0.386
(Impco)	3C3	III-5f	10/29/91	40.24	1.208	0.94	0.516
			Mean	46.49	1.230	1.04	0.431
Ford	4C1	III-5g	10/25/91	38.62	0.832	2.88	0.158
Taurus	4C2	III-5g	10/29/91	31.60	0.797	2.56	0.251
(S&S)	4C3	III-5h	10/30/91	40.78	0.797	2.25	0.289
	4C4	III-5h	10/31/91	51.83	0.825	2.35	0.328
			Mean	40.71	0.813	2.51	0.257
Chevrolet	1C6	III-5i	10/29/91	108.65	2.099	1.07	0.162
Astrovan	1C7	III-5i	10/30/91	95.75	2.067	0.87	0.197
	1C8	III-5j	10/31/91	129.36	2.082	0.66	0.255
			Mean	111.25	2.083	0.87	0.207

Table III-5j
Speciated FTP Results
Chevrolet Astrovan

Light-End Species	mg Ozone/ mg NMOG MIR	mg Ozone/ mg NMOG MOR	Test 1C8A, 10/31/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	Ozone (mg/mi) MOR
Ethane	0.25	0.17	88.73	22.18	15.08
Ethene	7.29	3.16	11.98	87.30	37.84
Propane	0.48	0.31	10.42	5.00	3.23
Ethyne	0.50	0.33	0.38	0.19	0.12
Methylpropane	1.21	0.73	0.91	1.11	0.67
Butane	1.02	0.66	1.85	1.88	1.22
Propene	9.40	3.77	2.62	24.65	9.88
Methylbutane	1.38	0.87	0.58	0.80	0.50
Pentane	1.04	0.68	0.47	0.49	0.32
1-Butene	8.91	3.51	0.66	5.91	2.33
2-Methylpropene	5.31	1.93	1.24	6.60	2.40
Light-End HC Subtotal			119.84	156.11	73.60

Mid-Range Species	mg Ozone/ mg NMOG MIR	mg Ozone/ mg NMOG MOR	Test 1C8A, 10/31/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	Ozone (mg/mi) MOR
1,3-butadiene	10.89	4.16	0.03	0.27	0.10
2-Methylpentane	1.53	0.90	0.17	0.26	0.15
n-Hexane	0.98	0.65	0.20	0.20	0.13
Benzene	0.42	0.14	0.54	0.23	0.08
2,2,4-Trimethylpentane + Alkene	2.59	1.11	0.27	0.70	0.30
Toluene + C8H18	2.73	0.63	0.34	0.92	0.21
2,2,5-Trimethylhexane	0.97	0.58	0.11	0.11	0.06
m & p-Xylenes	7.38	2.22	0.12	0.85	0.26
Mid-Range HC Subtotal			1.77	3.53	1.29

Oxygenates	mg Ozone/ mg NMOG MIR	mg Ozone/ mg NMOG MOR	Test 1C8A, 10/31/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	Ozone (mg/mi) MOR
Formaldehyde	7.15	2.08	6.09	43.55	12.67
Acetaldehyde	5.52	2.17	0.81	4.46	1.75
Acrolein	6.77	2.59	0.21	1.45	0.56
Acetone	0.56	0.20	0.48	0.27	0.10
Propionaldehyde	6.53	2.50	0.16	1.07	0.41
Oxygenates Subtotal			7.76	50.80	15.48

NMOG Summary		Test 1C8A, 10/31/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	Ozone (mg/mi) MOR
Light-End Species		119.84	156.11	73.60
Mid-Range Species		1.77	3.53	1.29
Oxygenates		7.76	50.80	15.48
Total		129.36	210.43	90.38
Ozone/NMOG			1.63	0.70

Table III-5i
Speciated FTP Results
Chevrolet Astrovan

Light-End Species	mg Ozone/ mg NMOG MIR	mg Ozone/ mg NMOG MOR	Test 1C6, 10/29/91 NMOG (mg/mi)	Test 1C6 Ozone (mg/mi) MIR	Test 1C6 Ozone (mg/mi) MOR	Test 1C7, 10/30/91 NMOG (mg/mi)	Test 1C7 Ozone (mg/mi) MIR	Test 1C7 Ozone (mg/mi) MOR
Ethane	0.25	0.17	74.90	18.73	12.73	55.06	13.77	9.36
Ethene	7.29	3.16	8.14	59.31	25.71	9.68	70.60	30.60
Propane	0.48	0.31	8.05	3.86	2.49	9.00	4.32	2.79
Ethyne	0.50	0.33	0.31	0.15	0.10	0.38	0.19	0.13
Methylpropane	1.21	0.73	0.96	1.17	0.70	0.72	0.87	0.52
Butane	1.02	0.66	1.73	1.76	1.14	0.89	0.91	0.59
Propene	9.40	3.77	2.07	19.42	7.79	2.66	24.98	10.02
Methylbutane	1.38	0.87	0.59	0.81	0.51	0.10	0.13	0.08
Pentane	1.04	0.68	0.33	0.34	0.23	0.25	0.26	0.17
1-Butene	8.91	3.51	0.12	1.10	0.43	0.17	1.55	0.61
2-Methylpropene	5.31	1.93	0.87	4.59	1.67	1.28	6.78	2.46
Light-End HC Subtotal			98.06	111.25	53.51	80.19	124.36	57.34

Mid-Range Species	mg Ozone/ mg NMOG MIR	mg Ozone/ mg NMOG MOR	Test 1C6, 10/29/91 NMOG (mg/mi)	Test 1C6 Ozone (mg/mi) MIR	Test 1C6 Ozone (mg/mi) MOR	Test 1C7, 10/30/91 NMOG (mg/mi)	Test 1C7 Ozone (mg/mi) MIR	Test 1C7 Ozone (mg/mi) MOR
1,3-butadiene	10.89	4.16	0.03	0.29	0.11	0.00	0.00	0.00
Cyclopentane	2.38	1.41	0.41	0.97	0.58	0.00	0.00	0.00
2-Methylpentane	1.53	0.90	0.16	0.24	0.14	0.00	0.00	0.00
n-Hexane	0.98	0.65	0.21	0.21	0.14	0.18	0.18	0.12
Benzene	0.42	0.14	0.53	0.22	0.07	0.56	0.24	0.08
~~3-Methylhexane~~	~~1.40~~	~~0.83~~	~~0.16~~	~~0.22~~	~~0.13~~	~~0.15~~	~~0.22~~	~~0.13~~
2,2,4-Trimethylpentane + Alkene	2.59	1.11	0.31	0.79	0.34	0.31	0.80	0.34
Toluene + C8H18	2.73	0.63	0.41	1.12	0.26	0.31	0.84	0.19
2,2,5-Trimethylhexane	0.97	0.58	0.00	0.00	0.00	0.14	0.14	0.08
m & p-Xylenes	7.38	2.22	0.15	1.14	0.34	0.00	0.00	0.00
1,2,4-Trimethylbenzene	8.83	2.67	0.49	4.30	1.30	0.00	0.00	0.00
Mid-Range HC Subtotal			2.85	9.51	3.41	1.65	2.41	0.94

Oxygenates	mg Ozone/ mg NMOG MIR	mg Ozone/ mg NMOG MOR	Test 1C6, 10/29/91 NMOG (mg/mi)	Test 1C6 Ozone (mg/mi) MIR	Test 1C6 Ozone (mg/mi) MOR	Test 1C7, 10/30/91 NMOG (mg/mi)	Test 1C7 Ozone (mg/mi) MIR	Test 1C7 Ozone (mg/mi) MOR
Formaldehyde	7.15	2.08	6.02	43.05	12.52	11.47	82.03	23.86
Acetaldehyde	5.52	2.17	0.92	5.10	2.01	1.42	7.86	3.09
Acrolein	6.77	2.59	0.22	1.50	0.58	0.29	1.96	0.75
Acetone	0.56	0.20	0.41	0.23	0.08	0.41	0.23	0.08
Propionaldehyde	6.53	2.50	0.17	1.09	0.42	0.31	2.00	0.77
Oxygenates Subtotal			7.75	50.98	15.60	13.91	94.09	28.55

NMOG Summary		Test 1C6, 10/29/91 NMOG (mg/mi)	Test 1C6 Ozone (mg/mi) MIR	Test 1C6 Ozone (mg/mi) MOR	Test 1C7, 10/30/91 NMOG (mg/mi)	Test 1C7 Ozone (mg/mi) MIR	Test 1C7 Ozone (mg/mi) MOR
Light-End Species		98.06	111.25	53.51	80.19	124.36	57.34
Mid-Range Species		2.85	9.51	3.41	1.65	2.41	0.94
Oxygenates		7.75	50.98	15.60	13.91	94.09	28.55
Total		108.65	171.73	72.53	95.75	220.85	86.83
Ozone/NMOG			1.58	0.67		2.31	0.91

Table III-5h
Speciated FTP Results
Ford Taurus (S+S), CNG

Light-End Species	mg Ozone/ mg NMOG MIR	mg Ozone/ mg NMOG MOR	Test 4C3, 10/30/91 NMOG (mg/mi)	Test 4C3 Ozone (mg/mi) MIR	Test 4C3 Ozone (mg/mi) MOR	Test 4C4, 10/31/91 NMOG (mg/mi)	Test 4C4 Ozone (mg/mi) MIR	Test 4C4 Ozone (mg/mi) MOR
Ethane	0.25	0.17	25.308	6.33	4.30	31.93	7.98	5.43
Ethene	7.29	3.16	5.508	40.15	17.41	7.293	53.17	23.05
Propane	0.48	0.31	2.9627	1.42	0.92	4.1141	1.97	1.28
Ethyne	0.50	0.33	1.1774	0.59	0.39	1.5296	0.76	0.50
Methylpropane	1.21	0.73	0.4001	0.48	0.29	0.5888	0.71	0.43
Butane	1.02	0.66	0.9041	0.92	0.60	0.7926	0.81	0.52
Propene	9.40	3.77	0.9665	9.09	3.64	0.7411	6.97	2.79
Methylbutane	1.38	0.87	0.2805	0.39	0.24	0.3567	0.49	0.31
Pentane	1.04	0.68	0.2094	0.22	0.14	0.2662	0.28	0.18
1-Butene	8.91	3.51	0.0451	0.40	0.16	0.1231	1.10	0.43
2-Methylpropene	5.31	1.93	0.0773	0.41	0.15	0.1316	0.70	0.25
Light-End HC Subtotal			37.84	60.40	28.24	47.87	74.94	35.18

Mid-Range Species	mg Ozone/ mg NMOG MIR	mg Ozone/ mg NMOG MOR	Test 4C3, 10/30/91 NMOG (mg/mi)	Test 4C3 Ozone (mg/mi) MIR	Test 4C3 Ozone (mg/mi) MOR	Test 4C4, 10/31/91 NMOG (mg/mi)	Test 4C4 Ozone (mg/mi) MIR	Test 4C4 Ozone (mg/mi) MOR
1,3-butadiene	10.89	4.16	0.0045	0.05	0.02	0	0.00	0.00
Benzene	0.42	0.14	0	0.00	0.00	0.1187	0.05	0.02
Toluene + C8H18	2.73	0.63	0	0.00	0.00	0.1227	0.33	0.08
Mid-Range HC Subtotal			0.00	0.05	0.02	0.24	0.38	0.09

Oxygenates	mg Ozone/ mg NMOG MIR	mg Ozone/ mg NMOG MOR	Test 4C3, 10/30/91 NMOG (mg/mi)	Test 4C3 Ozone (mg/mi) MIR	Test 4C3 Ozone (mg/mi) MOR	Test 4C4, 10/31/91 NMOG (mg/mi)	Test 4C4 Ozone (mg/mi) MIR	Test 4C4 Ozone (mg/mi) MOR
Formaldehyde	7.15	2.08	2.65	18.96	5.52	3.24	23.16	6.74
Acetaldehyde	5.52	2.17	0.28	1.54	0.61	0.33	1.85	0.73
Acetone	0.56	0.20	0.00	0.00	0.00	0.15	0.08	0.03
Oxygenates Subtotal			2.93	20.51	6.12	3.72	25.09	7.49

NMOG Summary		Test 4C3, 10/30/91 NMOG (mg/mi)	Test 4C3 Ozone (mg/mi) MIR	Test 4C3 Ozone (mg/mi) MOR	Test 4C4, 10/31/91 NMOG (mg/mi)	Test 4C4 Ozone (mg/mi) MIR	Test 4C4 Ozone (mg/mi) MOR
Light-End Species		37.84	60.40	28.24	47.87	74.94	35.18
Mid-Range Species		0.00	0.05	0.02	0.24	0.38	0.09
Oxygenates		2.93	20.51	6.12	3.72	25.09	7.49
Total		40.78	80.96	34.38	51.83	100.41	42.76
Ozone/NMOG			1.99	0.84		1.94	0.83

Table III-5g
Speciated FTP Results
Ford Taurus (S+S), CNG

Light-End Species	mg Ozone/ mg NMOG MIR	mg Ozone/ mg NMOG MOR	Test 4C1A, 10/25/91 NMOG (mg/mi)	Test 4C1A Ozone (mg/mi) MIR	Test 4C1A Ozone (mg/mi) MOR	Test 4C2A, 10/29/91 NMOG (mg/mi)	Test 4C2A Ozone (mg/mi) MIR	Test 4C2A Ozone (mg/mi) MOR
Ethane	0.25	0.17	26.36	6.59	4.48	15.50	3.87	2.63
Ethene	7.29	3.16	4.58	33.42	14.48	4.74	34.52	14.96
Propane	0.48	0.31	2.24	1.07	0.69	4.82	2.31	1.50
Ethyne	0.50	0.33	1.04	0.52	0.34	0.86	0.43	0.28
Methylpropane	1.21	0.73	0.44	0.53	0.32	0.47	0.57	0.34
Butane	1.02	0.66	0.53	0.54	0.35	0.48	0.49	0.31
Propene	9.40	3.77	0.47	4.42	1.77	0.47	4.41	1.77
Methylbutane	1.38	0.87	0.14	0.19	0.12	0.11	0.16	0.10
Pentane	1.04	0.68	0.19	0.19	0.13	0.35	0.36	0.24
1-Butene	8.91	3.51	0.04	0.39	0.15	0.01	0.05	0.02
2-Methylpropene	5.31	1.93	0.08	0.42	0.15	0.07	0.37	0.13
Light-End HC Subtotal			36.11	48.29	23.00	27.86	47.53	22.29

Mid-Range Species	mg Ozone/ mg NMOG MIR	mg Ozone/ mg NMOG MOR	Test 4C1A, 10/25/91 NMOG (mg/mi)	Test 4C1A Ozone (mg/mi) MIR	Test 4C1A Ozone (mg/mi) MOR	Test 4C2A, 10/29/91 NMOG (mg/mi)	Test 4C2A Ozone (mg/mi) MIR	Test 4C2A Ozone (mg/mi) MOR
1,3-butadiene	10.89	4.16	0.01	0.15	0.06	0.01	0.12	0.05
2-Methylpentane	1.53	0.90	0.37	0.57	0.34	0.00	0.00	0.00
3-Methylpentane	1.52	0.94	0.05	0.08	0.05	0.00	0.00	0.00
n-Hexane	0.98	0.65	0.05	0.05	0.03	0.00	0.00	0.00
Methylcyclopentane	2.82	1.55	0.20	0.56	0.31	0.00	0.00	0.00
Benzene	0.42	0.14	0.03	0.01	0.00	0.05	0.02	0.01
~~Toluene + C8H18~~	~~2.73~~	~~0.83~~	~~0.03~~	~~0.09~~	~~0.02~~	~~0.00~~	~~0.00~~	~~0.00~~
m & p-Xylenes	7.38	2.22	0.08	0.62	0.19	0.00	0.00	0.00
3-Ethyltoluene	7.20	2.16	0.05	0.33	0.10	0.00	0.00	0.00
1,2,4-Trimethylbenzene	8.83	2.67	0.05	0.48	0.15	0.00	0.00	0.00
Mid-Range HC Subtotal			0.94	2.95	1.24	0.06	0.14	0.05

Oxygenates	mg Ozone/ mg NMOG MIR	mg Ozone/ mg NMOG MOR	Test 4C1A, 10/25/91 NMOG (mg/mi)	Test 4C1A Ozone (mg/mi) MIR	Test 4C1A Ozone (mg/mi) MOR	Test 4C2A, 10/29/91 NMOG (mg/mi)	Test 4C2A Ozone (mg/mi) MIR	Test 4C2A Ozone (mg/mi) MOR
Formaldehyde	7.15	2.08	1.36	9.71	2.82	3.32	23.77	6.91
Acetaldehyde	5.52	2.17	0.17	0.94	0.37	0.28	1.53	0.60
Acetone	0.56	0.20	0.05	0.03	0.01	0.08	0.04	0.02
Oxygenates Subtotal			1.57	10.67	3.20	3.68	25.34	7.53

NMOG Summary		Test 4C1A, 10/25/91 NMOG (mg/mi)	Test 4C1A Ozone (mg/mi) MIR	Test 4C1A Ozone (mg/mi) MOR	Test 4C2A, 10/29/91 NMOG (mg/mi)	Test 4C2A Ozone (mg/mi) MIR	Test 4C2A Ozone (mg/mi) MOR
Light-End Species		36.11	48.29	23.00	27.86	47.53	22.29
Mid-Range Species		0.94	2.95	1.24	0.06	0.14	0.05
Oxygenates		1.57	10.67	3.20	3.68	25.34	7.53
Total		38.62	61.91	27.44	31.60	73.01	29.87
Ozone/NMOG			1.60	0.71		2.31	0.95

Table III-5f
Speciated FTP Results
Ford Taurus (IMPCO), CNG

Light-End Species	mg Ozone/ mg NMOG MIR	mg Ozone/ mg NMOG MOR	Test 3C3 , 10/29/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	Ozone (mg/mi) MOR	
Ethane	0.25	0.17	29.32	7.33	4.98	
Ethene	7.29	3.16	7.13	51.97	22.53	
Ethyne	0.50	0.33	0.27	0.13	0.09	
Methylpropane	1.21	0.73	0.32	0.39	0.23	
Butane	1.02	0.66	0.82	0.84	0.54	
Propene	9.40	3.77	0.25	2.34	0.94	
Methylbutane	1.38	0.87	0.14	0.19	0.12	
Pentane	1.04	0.68	0.14	0.14	0.09	
1-Butene	8.91	3.51	0.03	0.24	0.10	
2-Methylpropene	5.31	1.93	0.04	0.22	0.08	
Light-End HC Subtotal			38.45	63.80	29.70	

Mid-Range Species	mg Ozone/ mg NMOG MIR	mg Ozone/ mg NMOG MOR	Test 3C3 , 10/29/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	Ozone (mg/mi) MOR	
1,3-butadiene	10.89	4.16	0.01	0.14	0.05	
Mid-Range HC Subtotal			0.01	0.14	0.05	

Oxygenates	mg Ozone/ mg NMOG MIR	mg Ozone/ mg NMOG MOR	Test 3C3 , 10/29/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	Ozone (mg/mi) MOR	
Formaldehyde	7.15	2.08	1.48	10.57	3.07	
Acetaldehyde	5.52	2.17	0.18	0.97	0.38	
Acetone	0.56	0.20	0.13	0.07	0.03	
Oxygenates Subtotal			1.78	11.61	3.48	

NMOG Summary		Test 3C3 , 10/29/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	Ozone (mg/mi) MOR	
Light-End Species		38.45	63.80	29.70	
Mid-Range Species		0.01	0.14	0.05	
Oxygenates		1.78	11.61	3.48	
Total		40.24	75.55	33.24	
Ozone/NMOG			1.88	0.83	

Table III-5e
Speciated FTP Results
Ford Taurus (IMPCO), CNG

Light-End Species	mg Ozone/ mg NMOG MIR	mg Ozone/ mg NMOG MOR	Test 3C1A, 10/22/91 NMOG (mg/mi)	Test 3C1A Ozone (mg/mi) MIR	Test 3C1A Ozone (mg/mi) MOR	Test 3C2A, 10/23/91 NMOG (mg/mi)	Test 3C2A Ozone (mg/mi) MIR	Test 3C2A Ozone (mg/mi) MOR
Ethane	0.25	0.17	42.37	10.59	7.20	33.14	8.29	5.63
Ethene	7.29	3.16	1.24	9.01	3.91	1.20	8.73	3.79
Propane	0.48	0.31	5.91	2.84	1.83	4.78	2.29	1.48
Ethyne	0.50	0.33	0.25	0.12	0.08	0.19	0.09	0.06
Methylpropane	1.21	0.73	0.50	0.60	0.36	0.37	0.45	0.27
Butane	1.02	0.66	0.85	0.87	0.56	0.82	0.83	0.54
Propene	9.40	3.77	0.20	1.92	0.77	0.21	1.93	0.77
Methylbutane	1.38	0.87	0.15	0.21	0.13	0.28	0.38	0.24
Pentane	1.04	0.68	0.22	0.23	0.15	0.12	0.13	0.08
1-Butene	8.91	3.51	0.01	0.12	0.05	0.04	0.31	0.12
2-Methylpropene	5.31	1.93	0.02	0.11	0.04	0.01	0.07	0.02
Light-End HC Subtotal			51.73	26.63	15.09	41.15	23.51	13.02

Mid-Range Species	mg Ozone/ mg NMOG MIR	mg Ozone/ mg NMOG MOR	Test 3C1A, 10/22/91 NMOG (mg/mi)	Test 3C1A Ozone (mg/mi) MIR	Test 3C1A Ozone (mg/mi) MOR	Test 3C2A, 10/23/91 NMOG (mg/mi)	Test 3C2A Ozone (mg/mi) MIR	Test 3C2A Ozone (mg/mi) MOR
1,3-butadiene	10.89	4.16	0.00	0.05	0.02	0.01	0.10	0.04
2-Methylpentane	1.53	0.90	0.13	0.19	0.11	0.01	0.02	0.01
3-Methylpentane	1.52	0.94	0.05	0.08	0.05	0.00	0.00	0.00
n-Hexane	0.98	0.65	0.10	0.10	0.07	0.05	0.05	0.03
Methylcyclopentane	2.82	1.55	0.07	0.21	0.11	0.00	0.00	0.00
Benzene	0.42	0.14	0.09	0.04	0.01	0.02	0.01	0.00
2,2,4-Trimethylpentane + Alkene	2.59	1.11	0.21	0.55	0.24	0.00	0.00	0.00
Toluene + C8H18	2.73	0.63	0.50	1.36	0.31	0.15	0.42	0.10
m & p-Xylenes	7.38	2.22	0.15	1.12	0.34	0.10	0.76	0.23
Styrene	2.22	-0.30	0.05	0.12	-0.02	0.00	0.00	0.00
1,2,4-Trimethylbenzene	8.83	2.67	0.00	0.00	0.00	0.19	1.64	0.50
n-Undecane	0.42	0.28	0.64	0.27	0.18	0.06	0.02	0.02
Mid-Range HC Subtotal			2.01	4.09	1.43	0.59	3.02	0.92

Oxygenates	mg Ozone/ mg NMOG MIR	mg Ozone/ mg NMOG MOR	Test 3C1A, 10/22/91 NMOG (mg/mi)	Test 3C1A Ozone (mg/mi) MIR	Test 3C1A Ozone (mg/mi) MOR	Test 3C2A, 10/23/91 NMOG (mg/mi)	Test 3C2A Ozone (mg/mi) MIR	Test 3C2A Ozone (mg/mi) MOR
Formaldehyde	7.15	2.08	1.64	11.71	3.41	1.41	10.11	2.94
Acetaldehyde	5.52	2.17	0.35	1.91	0.75	0.29	1.60	0.63
Acetone	0.56	0.20	0.09	0.05	0.02	0.00	0.00	0.00
Oxygenates Subtotal			2.08	13.68	4.18	1.70	11.70	3.57

NMOG Summary		Test 3C1A, 10/22/91 NMOG (mg/mi)	Test 3C1A Ozone (mg/mi) MIR	Test 3C1A Ozone (mg/mi) MOR	Test 3C2A, 10/23/91 NMOG (mg/mi)	Test 3C2A Ozone (mg/mi) MIR	Test 3C2A Ozone (mg/mi) MOR
Light-End Species		51.73	26.63	15.09	41.15	23.51	13.02
Mid-Range Species		2.01	4.09	1.43	0.59	3.02	0.92
Oxygenates		2.08	13.68	4.18	1.70	11.70	3.57
Total		55.81	44.39	20.69	43.44	38.24	17.51
Ozone/NMOG			0.80	0.37		0.88	0.40

Final Statement of Reasons
Low-Emission Vehicles and Clean Fuels Rulemaking

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Attachment B: List of Commenters

State of California
AIR RESOURCES BOARD

Final Statement of Reasons for Rulemaking
Including Summary of Comments and Agency Responses

PUBLIC HEARING TO CONSIDER THE ADOPTION OF REGULATIONS REGARDING LOW-EMISSION VEHICLES AND CLEAN FUELS

Public Hearing Date: September 27-28, 1990
Agenda Item No: 90-14-1

I. GENERAL

On September 27 and 28, 1990, the Air Resources Board ("ARB" or "Board") conducted a public hearing to consider the adoption and amendment of regulations and incorporated documents (collectively referred to as "the regulations") to require the production of low-emission vehicles and the distribution and availability of clean fuels. As proposed, the regulations would establish a program for phasing in new low-emission passenger cars, light-duty trucks and medium-duty vehicles, and for assuring that clean fuels needed by these vehicles will be distributed and made available to motorists.

At the conclusion of the hearing, the Board adopted Resolution 90-58 approving the regulations proposed by the staff with various modifications. Many of the modifications were based on changes suggested by the staff at the hearing. The Board directed the Executive Officer to incorporate the approved modifications into the originally proposed regulatory text with such other conforming changes as were appropriate. In accordance with Government Code section 11346.8(c), the Resolution directed the Executive Officer to make the modified regulatory text available to the public for a supplemental written comment period of 15 days. He was then directed either to adopt the modified regulations with such additional changes as may be appropriate in light of the supplemental comments, or to present them to the Board for further consideration if he determined such an action was warranted by the comments.

The modified text of the regulations was made available on January 3, 1991 for a 15-day period for supplemental public comment. At the same time, additional documents and information were made available for public inspection pursuant to 1 C.C.R. section 45. The comment period was extended until January 31, 1991, for one incorporated document that was inadvertently omitted from the January 3, 1991, mailout. During these supplemental comment periods, the Board received several written comments. After considering the comments, the Executive Officer issued Executive Order G-604, amending 13 C.C.R. sections 1900, 1904, 1956.8, 1960.1, 1960.1.5, 1960.5, 1965, 2061, 2111, 2112, 2125, 2139, and the documents incorporated by reference therein; adopting the new "Non-Methane Organic Gas Test Procedures" and "California Test Procedures for Evaluating the Emission Impacts of Substitute Fuels or New Clean Fuels," documents incorporated by reference in the amended regulations; and adopting new Subchapter 8 of Chapter 3, Title 13, California Code of Regulations, sections 2300 through 2317.[1]

The Staff Report: Initial Statement of Reasons for Rulemaking ("Staff Report") for this rulemaking was available for public inspection on August 13, 1990. On the same date, the staff made available a Technical Support Document ("TSD"). The Staff Report and TSD included the texts of the regulations and amendments as initially proposed by the staff, along with extensive descriptions of the rationale for the proposal. The Staff Report and TSD are incorporated by reference herein. This Final Statement of Reasons updates the Staff Report by identifying and explaining the modifications made to the originally proposed texts. The Final Statement of Reasons also contains a summary of the comments the Board received on the proposed regulations during the formal rulemaking process and the ARB's responses to the comments.

The amended "California Exhaust Emission Standards and Test Procedures for 1988 and Subsequent Model Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles" (the "LDV/MDV Test Procedures") is incorporated by reference in 13 C.C.R. section 1960.1; the amended "California Exhaust Emission Standards and Test Procedures for 1985 and Subsequent Model Heavy-Duty Diesel Engines and Vehicles" (the "HDD Test Procedures") and "California Exhaust Emission Standards and Test Procedures for 1987 and Subsequent Model Otto-Cycle Heavy-Duty Engines and Vehicles" are incorporated by reference in 13 C.C.R. section 1956.8; the amended "California Motor Vehicle Emission Control Label Specifications" is incorporated by reference in 13 C.C.R. section 1965; the amended "Guidelines for Certification of 1983 and Subsequent Model-Year Federally Certified Light-Duty Motor Vehicles for Sale in California" is incorporated by reference in 13 C.C.R. section 1960.5; the newly adopted "California Non-Methane Organic Gas Test Procedures" are incorporated by reference in 13 C.C.R. section 1960.1, and the newly adopted "California Test Procedures for Evaluating the Emission Impacts of Substitute Fuels or New Clean Fuels" are incorporated by

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1. As adopted, the regulations included various nonsubstantial modifications to the texts made available on January 3, 1991, for supplemental public comment. These additional modifications are identified in Attachment A to this Final Statement of Reasons. Many of the nonsubstantial modifications to the low-emission vehicle regulations reflect corrections of the manner in which the preexisting regulatory text is set forth. This preexisting text includes amendments regarding medium-duty vehicles which have recently been reviewed by the Office of Administrative Law.

reference in 13 C.C.R. section 2317 and in the "California Exhaust Emission Standards and Test Procedures for 1988 and Subsequent Model Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles." Some of these incorporated documents in turn incorporate certification test procedures adopted by the U.S. Environmental Protection Agency ("EPA") and contained in Title 40, Code of Federal Regulations, Part 86.

The above-referenced sections of the California Code of Regulations identify the incorporated ARB documents by title and date. The ARB documents are readily available from the ARB upon request and were made available in the context of the subject rulemaking in the manner provided in Government Code section 11346.7(a). The Code of Federal Regulations is published by the Office of the Federal Register, National Archives and Records Administration, and is therefore reasonably available to the affected public from a commonly known source.

The various ARB documents are incorporated by reference because it would be impractical to print them in the California Code of Regulations. Existing ARB administrative practice has been to have test procedures incorporated by reference rather than printed in the California Code of Regulations. These procedures are highly technical and complex. They include "nuts and bolts" engineering protocols and have a very limited audience. Because the ARB has never printed test procedures in the California Code of Regulations, the affected public is accustomed to the incorporation format utilized herein. The ARB's test procedures as a whole are extensive and it would be both cumbersome and expensive to print these lengthy, technically complex procedures with a limited audience in the California Code of Regulations. Printing portions of the ARB's test procedures in the California Code of Regulations when the bulk of the test procedures are incorporated by reference would be unnecessarily confusing to the affected public.

The ARB documents incorporate portions of the Code of Federal Regulations because they are substantially based on the federal regulations. Manufacturers typically certify vehicles and engines to both the federal and state emissions standards and test procedures. Incorporation of the federal regulations by reference makes it easier for manufacturers to know when the two sets of requirements are identical and when they differ.

The Board has determined that this regulatory action will not result in a mandate to any local agency or school district the costs of which are reimbursable by the state pursuant to Part 7 (commencing with section 17500), Division 4, Title 2 of the Government Code.

The Board has further determined that no alternative considered by the agency would be more effective in carrying out the purpose for which the regulatory action was proposed or would be as effective and less burdensome to affected private persons than the action taken by the Board.

II. MODIFICATIONS TO THE REGULATIONS

A. Modifications Pertaining to the Low-Emission Vehicle Elements of the Regulations

Set forth below is a description of the modifications that were made to the originally proposed low-emission vehicle elements of the rulemaking, along with the rationale for the modifications. To place the description of the modifications in context, it is preceded by an overview of the low-emission vehicle provisions.

1. Overview of low-emission vehicle elements

a. Emission standards

The vehicle elements of the rulemaking establish substantially more stringent 50,000 and 100,000 mile emission standards for passenger cars and light-duty trucks, 50,000 and 120,000 mile emission standards for medium-duty vehicles, and emission standards for incomplete medium-duty vehicles and engines. Four progressively more stringent exhaust emission categories have been established: Transitional Low-Emission Vehicle ("TLEV"), Low-Emission Vehicle ("LEV"), Ultra Low-Emission Vehicle ("ULEV") and Zero-Emission Vehicle ("ZEV").

Exhaust emission standards for non-methane organic gases ("NMOG"), carbon monoxide, and oxides of nitrogen ("NOx") have been established for each category. (§ 1960.1(g)(1).) Two-tiered standards for NMOG in the TLEV, LEV, and ULEV categories have been established for fuel-flexible vehicles ("FFVs") which are capable of operating on both gasoline and a clean fuel. (§ 1960.1(g)(1) note (4).) In addition, as measurable amounts of formaldehyde are known to be emitted from gasoline and alternative fuel vehicles, and formaldehyde is a toxic air contaminant, separate emission standards for formaldehyde have been set for each category. (§ 1960.1(e)(3).) Also, consistent with previously adopted regulations, the rulemaking includes emission standards for particulate matter ("PM") and highway NOx. (§ 1960.1(g)(1).) The PM emission standards apply only to diesel vehicles and engines as other engine cycles have shown only minimal levels of PM emissions. The highway NOx emission standards have been established in order to limit NOx emissions from vehicles operating at speeds typical of highway driving.

b. Implementation

For passenger cars and light-duty trucks, a manufacturer may certify any combination of its vehicles to comply with the sales-weighted, light-duty fleet average requirements for emissions of NMOG established for model-years 1994 through 2003. (§ 1960.1(g)(2).) In addition to meeting the fleet average NMOG requirement, the manufacturer's sales fleet must contain a minimum percentage of ZEVs beginning in the 1998 model year for passenger cars and light-duty trucks under 3,750 lbs. loaded vehicle weight ("LVW"). (§

1960.1(g)(2) note (9).) Although there is no ZEV requirement for light-duty trucks over 3,750 lbs. LVW or for medium-duty vehicles, ZEVs in these vehicle classes can be used to satisfy the light-duty ZEV requirement.

For medium-duty vehicles, beginning with the 1998 model year manufacturers are required to produce specified percentages of medium-duty LEVs and ULEVs instead of meeting a fleet average NMOG requirement. (§ 1960.1(h)(2).) This approach was taken for medium-duty vehicles because only a limited number of engine families are certified within the same emission standard test weight category, and there is little opportunity for averaging. However, compliance flexibility is provided to medium-duty vehicle manufacturers through the use of trading ratios which allow sales of greater numbers of ULEVs than required or ZEVs to offset the specified percentage requirements. (§ 1960.1(h)(2) note (12).)

The regulations provide manufacturers with considerable flexibility in complying with these requirements. In addition to the categorized emission averaging program, the following features are included to ensure adequate flexibility:

* Intermediate in-use standards
* Credit banking
* Deficits banking
* Credit trading
* NMOG adjustments for hybrid electric vehicles

c. Reactivity adjustment

Because the new requirements may result in certification of low-emission vehicles which operate on fuels other than gasoline, and since emissions from vehicles which operate on these fuels may have different ozone-forming potential relative to gasoline, an adjustment factor for NMOG will be established for each fuel/emission category. The reactivity adjustment factors will effectively make NMOG emission comparisons between vehicles operating on gasoline and other fuels more equitable.

The procedure for calculating the reactivity adjustment factors involves the application of maximum incremental reactivity ("MIR") factors to speciated exhaust emission data. (LDV/MDV Test Procedures, Appendix VIII.) The MIR approach was chosen because it is a quick and easy method for estimating the reactivity of vehicle exhaust emissions while providing results comparable to more complex airshed models. A list of preliminary MIR factors is included in the regulations. These MIR factors were derived from smog chamber work conducted up until the summer of 1990 by Professor William Carter, as referenced in Chapter VII of the TSD. The Board plans to conduct an additional rulemaking hearing in the fall of 1991 to update the MIRs in the regulations as appropriate based on any new information and further scientific reviews. The regulations establish a methodology for the Executive Officer to set reactivity adjustment factors for the various vehicle/fuel combinations by applying the MIRs to emissions data generated from tests on motor vehicles meeting the different NMOG standards. At the rulemaking hearing planned for the fall of 1991, the Board intends to consider adopting the different reactivity adjustment factors for specific inclusion in the regulations.

d. Other certification requirements

Vehicle manufacturers who certify vehicles designed to operate on fuels other than gasoline or diesel are required to provide the ARB Executive Officer with projected sales and fuel economy estimates two years prior to certification. (LDV/MDV Test Procedures, § 4.a.2.) This information is needed to determine the number of clean fuel retail outlets needed, as described in section II.B.

An additional certification requirement for light-duty and medium-duty vehicles calls for emission testing at 50°F to demonstrate compliance with the emission standards at this lower temperature. An engineering evaluation of the effectiveness of the emission control system from 20 to 86°F is also required. (§ 1960.1(g)(1) note (8); § 1960.1(h)(2) note (13); LDV/MDV Test Procedures, § 11.1. & k.) Because ZEVs by definition have no emissions of any pollutant under any operating condition, ZEVs are exempt from the 50°F demonstration and other emission and durability test requirements.

Other features of the regulations which add to or modify previously adopted certification requirements are listed below. The rationale for these features is set forth in the Staff Report and/or the TSD.

* The engines of hybrid electric vehicles are to be tested under highest emission scenarios.
* Durability testing of hybrid electric vehicles shall be based on miles of engine operation to the extent possible.
* Emissions from fuel-fired heaters used in electric vehicles shall be measured for certification.
* Fuel-flexible and dual-fuel vehicles are to use the non-gasoline fuel for mileage accumulation.

The remainder of this section II.A. describes the modifications made to the originally proposed regulations.

2. Period for balancing emission deficits

To provide added flexibility during the initial years of the low-emission vehicle program, the period for balancing shortfalls in a manufacturer's fleet average NMOG emission value was revised. The original proposal would have required vehicle manufacturers to balance any deficits incurred in a given model year by the following model year. As modified, deficits incurred from 1994 to 1997 must be made up within three model years and prior to the end of the 1998 model year. Therefore, a manufacturer will be required to balance a 1994

NMOG deficit by 1997. Any deficits incurred in 1995, 1996, or 1997 will have to be balanced by the end of 1998. A one-year balancing period will apply for 1998 and subsequent model years. (§ 1960.1(g)(2) note (7).)

3. Hybrid electric vehicles

In the original NMOG fleet average calculation procedure, hybrid electric vehicles ("HEVs") certified to either conventional or low-emission vehicle standards received an adjustment in the NMOG value used to calculate the fleet average value based on the range of the battery. This provision was included to provide incentives for manufacturers to produce HEVs capable of operating large distances on battery power alone, and therefore have zero emissions during the duration of most driving trips. The adjustment for HEVs certified to conventional vehicle standards was deleted to encourage certification of cleaner HEVs. HEVs with engines certified to the TLEV, LEV, or ULEV standards will continue to receive NMOG adjustment based on the operating range of the battery. (§ 1960.1(g)(2) note (4)(a) & note (5)(a).)

4. NMOG definition

The originally proposed NMOG definition in the incorporated "California Exhaust Emission Standards and Test Procedures for 1988 and Subsequent Model Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles" (the "LDV/MDV Test Procedures") were updated to include the heavier organic gases found in diesel exhaust. For diesel vehicles, NMOG will include all non-oxygenated organic gases with 25 or fewer carbon atoms and all oxygenated organic gases with 5 or fewer carbon atoms. (LDV/MDV Test Procedures, § 2.z.)

5. Certification fuel

The specifications of gasoline used as a certification fuel were modified to give manufacturers the option of using gasoline with a 7.8 pounds per square inch (psi) Reid vapor pressure (RVP), a sulfur content of 0.03 weight percent, and other properties to certify 1992 and subsequent model-year vehicles. These specifications correspond to the specifications for commercial gasoline required for sale in California beginning in 1992 as a result of the "Phase 1 reformulated gasoline" rulemaking. Manufacturers have requested the use of this gasoline to facilitate meeting recently adopted evaporative emission regulations because of its lower RVP, compared to the current certification gasoline. Also, more representative emission results are obtained with the 7.8 RVP gasoline since its specifications are similar to commercially available gasoline. (LDV/MDV Test Procedures, § 9.a.1.)

The definition of conventional gasoline was clarified to refer to a certification gasoline whose specifications are substantially equivalent to gasoline available commercially in the 1989 calendar year. (LDV/MDV Test Procedures, § 2.Am.)

The specifications for diesel certification fuel for light-duty vehicles were revised to reflect the low-sulfur and low-aromatics specifications for motor vehicle diesel fuel required beginning on October 1, 1993 by 13 C.C.R. sections 2255 and 2256. (LDV/MDV Test Procedures § 9.a.6.(3); HDD Test Procedures § 86.1313-90 (b)(2).)

6. Assembly-line testing

In light of the resources needed to measure NMOG and formaldehyde emissions for assembly-line quality audit testing, manufacturers requested an alternative method to determine NMOG and formaldehyde emissions from vehicles certified to the low-emission vehicle standards. Accordingly, the LDV/MDV Test Procedures were modified to allow the use of NMOG to NMHC emission ratios and formaldehyde to NMHC emission ratios, established at certification, in NMHC emission measurements for assembly-line quality audit testing. (LDV/MDV Test Procedures § 11.m.)

7. Labeling requirements

The following changes were made to the requirements in the incorporated "California Motor Vehicle Emission Control Label Specifications" (the "Label Specifications") in response to comments.

a. Operating fuel statement

To conserve labeling space, the statement specifying the operating fuel(s) on which the vehicle or engine is certified will be required only for vehicles designed to be capable of operating on fuels other than gasoline. (Label Specifications § 3.(a)iii.)

b. OBD statement

Since some 1992 model-year labels have already been printed and it is highly unlikely that vehicles will have certified OBD II systems by the 1992 model year, the statement clarifying which OBD system the vehicle is utilizing will not be required until the 1993 model year. (Label Specifications § 3.(a)iv.)

c. VEC coding

Coding for the eighth character of the VEC bar code has been modified to be consistent with VEC coding currently in use. (Label Specifications § 3.(b).)

8. NMOG Test Procedures

Two parts of the "California Non-Methane Organic Gas Test Procedures", incorporated by reference in section 1960.1(g)(1) note (3) and section 1960.1(h)(2) note (3), were replaced with updated sections. One part--the "California Non-Methane Hydrocarbon Test Procedures"--was expanded to include the formulas for calculating nonmethane hydrocarbon (NMHC) emissions from all candidate fuels.

Another part--the interim SOP No. MLD103A, "Procedures for the Determination of Midrange Hydrocarbons in Automotive Exhaust by GC", was also updated to reflect the most up-to-date gas chromatograph procedures.

9. <u>Small volume manufacturers</u>

Vehicle manufacturers which have annual sales of less than or equal to 3,000 vehicles, known as small volume manufacturers, have been given special consideration in meeting the low-emission vehicle requirements in view of their limited resources. The small volume manufacturer criteria for the fleet average standards have been expanded to be based on a manufacturers' average annual production for the 1989 through 1991 model years. This change was included to alleviate the concerns of small volume manufacturers which would have to comply with the more stringent requirements of larger manufacturers for temporary increases in annual vehicle production over 3,000, and to provide sufficient leadtime if a small volume manufacturer became subject to larger manufacturer requirements. (§ 1960.1(g)(2) note (7).)

10. <u>Medium-duty vehicles</u>

The original proposal would have allowed certification of medium-duty vehicles to the standards specified in section 1960.1(h)(1), established in the Board's recent medium-duty vehicle rulemaking, through the 2000 model year. To provide the same flexibility allowed for light-duty vehicles, this provision was modified to allow certification of medium-duty vehicles to the standards specified in section 1960.1(h)(1) subsequent to 2000 provided that the medium-duty LEV and ULEV requirements are met. (§ 1960.1(h)(1).)

11. <u>Clarifications</u>

The following changes to the regulations were made to clarify various regulatory provisions in response to comments.

(a) The provisions specifying the procedure for the 50°F test requirement were expanded to more clearly and precisely identify the procedures to be followed. (LDV/MDV Test Procedures § 11.k.)

(b) The use of credits to comply with requirements for ZEVs was clarified. Credits earned by manufacturers through production of more ZEVs than required may be sold or banked internally to satisfy future ZEV requirements. These credits will be discounted similarly to credits earned through the sale of low-emission vehicles. If a manufacturer is unable to comply with the ZEV requirement in a given model year, the deficit may be made up by the end of the next model year. (§ 1960.1(g)(2) note 9.)

(c) As a result of recently adopted ARB regulations, in-use compliance testing of incomplete medium-duty vehicles and engines is limited to those vehicles and engines having fewer than 90,000 miles.

Language clarifying this provision for low-emission vehicles was added for consistency with the previously adopted regulations. (§ 1956.8(f) note F.) Similarly, clarifying language was added for light- and medium-duty vehicles; for these vehicles in-use compliance testing is limited to passenger cars and light-duty trucks with fewer than 75,000 miles and medium-duty vehicles with fewer than 90,000 miles, consistent with previously adopted regulations. (§ 1960.1(h)(2) note 14.)

In addition, several other nonsubstantial modifications were also made to clarify the regulatory language, correct references, or make the language consistent with other noted changes.

B. Modifications Pertaining to the Clean Fuel Elements of the Regulations

1. Summary

The overall objective of the clean fuel regulations is to assure that the fuels used to certify low-emission vehicles are readily available and used by motorists. As discussed on page 39 of the Staff Report, there are two categories of clean fuel vehicles that may be produced by vehicle manufacturers: "dedicated" vehicles designed to run only on a clean fuel, and dual-fueled or flexible-fueled vehicles (collectively "FFVs") designed to operate on either a clean fuel or gasoline but meeting a more stringent emission standard only with the clean fuel. Dedicated clean fuel vehicles generally cannot be expected to be produced in quantity unless the manufacturer is confident that the potential car buyer will be assured of finding the clean fuel reasonably available. In the case of FFVs, the full air quality benefits of the vehicles will be realized only to the extent the vehicles are actually fueled with the clean fuel.

As originally proposed, there were three primary components of the clean fuel regulations. First, all gasoline suppliers (refiners, blenders, and importers) would have to distribute specified minimum volumes of each clean fuel[2] for use in motor vehicles. The minimum volumes would be assigned by the Executive Officer quarterly based on criteria in the regulations. This has often been referred to as the

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2. The regulations contain three definitions connected to the meaning of "clean fuels." As defined, a "clean fuel" is any fuel used in a low-emission vehicle. A "clean alternative fuel" is any clean fuel other than the two fuels that have been commonly used in motor vehicles--gasoline and diesel fuel. The clean fuel requirements in the regulations apply to "designated clean fuels." This term is defined to include all clean alternative fuels other than electricity; CNG falls under the definition only after a determination by the California Public Utilities Commission that resellers will not be public utilities (and in the original proposal only for provisions other than the distribution requirement). The reason for these definitions is to assure that the "clean fuel" requirements only apply to fuels that might not otherwise be adequately available, while acknowledging that gasoline and diesel fuel might also be used in "clean" low-emission vehicles. To simplify syntax, the term "clean fuel" is used in this Final Statement of Reasons to describe what the regulations refer to as "designated clean fuels."

"distribution requirement." Second, owner/lessors[3] of retail gasoline outlets ("gasoline stations") would have to equip a specified number of their stations to dispense clean fuels; again, the particular number of clean fuel outlets would by assigned by the Executive Officer on the basis of criteria in the regulations. This is referred to as the "retail outlet requirement." Third, operators of stations equipped to dispense a clean fuel would have to actually offer the fuel for sale. This is referred to as the "retail availability requirement." In 1994-1996, the program applied only in the South Coast Air Quality Management District (the "South Coast") and only to major gasoline suppliers and operators of their stations. Starting in 1997, the program applied statewide to all gasoline suppliers and to all owner/lessors and operators of gasoline stations.

The distribution requirement was the central element of the original proposal. As long as a specified minimum volume of clean fuel must be introduced into commerce for use in motor vehicles, at least that volume of fuel can be expected to actually be used by motorists. The retail outlet and retail availability requirements were somewhat ancillary to the distribution requirement. For instance, one of the rationales for the retail outlet requirement was to assure gasoline suppliers that there would be retail outlets through which the clean fuel the suppliers were required to distribute could be sold.

After considering the public comments, the Board decided to delete the distribution requirement and to substantially expand other elements of the clean fuels proposal. The Board concluded that when the other components of the clean fuel regulations were strengthened, the distribution requirement may not be necessary to assure adequate availability and use of clean fuels.

The first aspect of the regulations expanded by the Board was the retail outlet requirement. The Board substantially increased the total number of retail outlets required to be equipped to dispense clean fuels, both by establishing minimum numbers of stations in the first several years of the program and by adjusting the formula for determining the number of stations. In the absence of a requirement that minimum volumes of clean fuel be distributed, the Board wanted to

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3. The term "owner/lessor" is defined in section 2300(a)(21) of the regulations. The definition uses terms defined in Business and Professions Code section 20999, part of the state law applicable to petroleum marketing franchises. Where the station is operated under a franchise from a refiner or distributor, then the refiner or distributor is the owner/lessor. Where it is operated by a refiner or distributor who owns, leases or controls the station, then the refiner or distributor is the owner/operator. In all other cases, the owner of the station is the owner/lessor.

make sure that there are enough service stations dispensing clean fuels to make it convenient for motorists to purchase these fuels.

Second, several new requirements were added to assure that at those service stations where clean fuels are offered for sale, the clean fuels are marketed in as an attractive manner as gasoline. For instance, compared to the gasoline dispensers at a station, the clean fuel dispensers will have to have substantially similar visibility, accessibility, signs, lighting, and canopy coverage, and clean fuel customers will have to have substantially similar access to restrooms as gasoline customers. The clean fuel dispensers will also have to be kept in good working order. These requirements are particularly important in order to maximize the extent to which drivers of FFVs purchase the clean fuel rather than gasoline.

Third, the adopted regulations contain provisions to help assure that supplies of clean fuels will be readily accessible to the operators of clean fuel outlets who are required to have the clean fuels available for sale. This is accomplished by imposing joint liability on the owner/lessor of a clean fuel outlet for the operator's failure to have clean fuel available under certain circumstances where the owner/lessor has failed to respond to a supply request.

In addition, the Board made numerous additional modifications to make the program work more effectively and efficiently. The significant modifications to the clean fuel regulations, including those summarized above, are described and explained in the rest of this section of the Final Statement of Reasons.

2. Deletion of requirement that gasoline suppliers distribute specified volumes of clean fuels

One of the key elements of the clean fuel regulations as originally proposed was a requirement that gasoline suppliers distribute specified minimum volumes of clean fuels, assigned quarterly to each gasoline supplier by the Executive Officer. The Board substantially expanded various other elements of the regulation and deleted the distribution requirement. In light of the expansion of the other program elements, the Board concluded that the distribution requirement may not be needed to assure adequate availability and use of clean fuels. Accordingly, former sections[4] 2301, 2302, and 2303(b) and (c) were eliminated.

In addition to deleting the specific volume distribution requirement, the Board eliminated all ancillary provisions that were

4. The term "former section" is used in this document to identify a section of the regulations as originally proposed.

no longer needed. These included provisions allowing compliance with the distribution requirement by the use of credits generated from the distribution of excess volumes of clean fuels or from the distribution of compressed natural gas ("CNG") or electricity for use in motor vehicles (former § 2310), and reporting and recordkeeping requirements for various entities regarding the distribution and transfer of clean fuels and credits (former §§ 2320, 2321, 2322, and 2323).

3. Changes to the required numbers of clean fuel outlets

The originally proposed regulations provided that the total number of retail outlets required for a given fuel in a particular quarter would be calculated from a formula set forth in the regulations. Under the formula, the number of required retail outlets for each clean fuel was proportional to the number of low-emission vehicles that would be certified on that fuel. Since the number of clean fuel vehicles was not known, the required number of outlets was indefinite.

With the deletion of the distribution requirement, it became necessary to have a regulatory mechanism to assure that there will be a sufficient number of stations selling the clean fuels previously covered by the distribution requirement for the fuels to be reasonably convenient to motorists. Therefore, the Board added a requirement for the early years of implementation (1994-1997) that a minimum number of stations be equipped to dispense liquid clean fuels. These are the fuels previously covered by the distribution requirement. The Board also modified the formula used to calculate the required number of clean fuel outlets so that a substantially greater number of outlets would be required for a given number of low-emission vehicles certified on a clean fuel.

At the same time, the Board sought to balance the need to have a convenient number of clean fuel outlets with the need to avoid requiring so many outlets that each one would have very little demand. Thus the Board maintained the requirement that clean fuel outlets will not be required for a given fuel until a minimum number of vehicles certified on the fuel are expected. The Board also made the increase in the required minimum number of clean fuel outlets in the third year dependent on substantial penetration of vehicles certified on the fuel.

a. Required numbers of outlets for liquid clean fuels in the South Coast in 1994 to 1996

The final regulations provide that total number of retail outlets required for each liquid clean fuel in the South Coast during each year from 1994 through 1996 will be either a specified minimum number or the number calculated by the formula, whichever is greater. In no case will outlets for a clean fuel be required until 20,000 vehicles are expected to be certified on the clean fuel. (§ 2304, replacing former § 2334; also modifications to the determination of total projected maximum volumes in § 2303.)

The minimum number of outlets for liquid clean fuels during 1994-1996 is 90 stations in the first year for which 20,000 vehicles are expected to be certified on the fuel, and 200 stations in the second such year. For 1996, the minimum number of liquid clean fuel outlets is 400, but only if the expected number of vehicles certified on the particular clean fuel is at least 200,000. As noted above, the required minimum number of stations will help limit the distance motorists will have to travel to obtain clean fuels. The particular values of the minima (90, 200, 400) were chosen in consideration of the need for access to clean fuel outlets balanced against the need to avoid requiring so many stations that each will have a very small clean fuel throughput.

Under the formula for determining the required number of clean fuel outlets in the original proposal, the projected statewide maximum demand volume for each clean fuel was multiplied by an adjustment factor ranging from 0.25 to 0.90 (and for 1994-1996 by a South Coast factor of 0.5). The adjusted volume was then reduced by the volume projected to be distributed by nonretail (fleet) outlets, and then divided by a specified reasonable throughput volume per station to reach the total required number of stations. In modifying the formula, the Board increased the fuel volume adjustment factor to 0.75 in the first two years and 0.90 in the third year. The effect is to multiply the number resulting from the calculation by 3.0 in the first year, by 1.5 in the second year, and by 1.8 in the third year relative to results under the originally proposed formula.

The modifications to the formula were connected to deletion of the distribution requirement. In the original proposal, the same fuel volume adjustment factors applied to calculating volumes for both the distribution requirement and retail outlet requirement. Relatively low values were chosen for the early years because of potential difficulties suppliers would have in distributing their assigned volumes of fuel. With deletion of the distribution requirement, the adjustment factors no longer need to be so conservative in the early years. The modified values were chosen to make the results of the calculation commensurate with the minima; i.e, to ensure that if the number of vehicles is great enough to support more than the minimum number of clean fuel outlets, more than the minimum will be required.

b. <u>Required numbers statewide of outlets for liquid clean fuels in 1997 and later years</u>

Under the original proposal, the statewide required number of liquid clean fuel outlets in 1997 and subsequent years was calculated from the same formula that applied during 1994-1996, without the South Coast adjustment factor. The adopted regulation provides that in 1997, the number of outlets statewide shall be the greater of (i) twice the number of outlets required in the South Coast in 1996, or (ii) the number of outlets calculated by the modified formula with the fuel volume adjustment factor increased to 0.90 (again without the South Coast adjustment factor). For 1998 and later, the required number of additional clean fuel outlets shall be calculated solely based on the modified formula. (§ 2304(a).)

The minimum required number of stations for 1997 will assure that the number of outlets will increase in that year relative to 1996 as the program becomes statewide for the first time. Also, it will encourage locating the new outlets in urban areas outside the South Coast at a geographic density similar to the density existing in 1996 in the South Coast. As is the case during the South Coast phase of the program, too low a density of clean fuel outlets in the rest of the state would harm the effort to encourage the maximum use of clean fuels in FFVs and to facilitate the introduction of dedicated clean fuel vehicles. The same factors supporting modification of the formula for 1994-1996 apply to the formula for 1997 and the subsequent years.

c. Required numbers of outlets for nonliquid clean fuels such as CNG

The changes to the formula for determining the required number of clean fuel outlets discussed above for liquid fuels apply as well to outlets of nonliquid fuels such as CNG. The minimum required numbers for liquid fuel outlets in the early years of the program were added primarily as a partial substitute for the deleted distribution requirement. Since the distribution requirement did not apply to CNG, the minimum required number provisions were not made applicable to CNG. (§ 2304(a).) This treatment was further justified by the substantially higher cost of CNG outlets and the likelihood that a higher percentage of CNG vehicles will be in fleets.

d. Required number of CNG outlets--adjusting for existing outlets

When CNG outlets become required (assuming CNG satisfies the criteria for a clean fuel and more than 20,000 CNG low-emission vehicles are projected), it is likely there will already be some existing CNG retail outlets owned by persons who are not owner/lessors of gasoline stations. If the number of required outlets is not adjusted on account of these preexisting retail outlets, the total number of retail CNG outlets would likely exceed the required number.[5] While that situation would not be undesirable in terms of public availability of CNG, it could represent an uneconomic over-building of capacity to dispense CNG. The economic concern stems from the high capital investment required to create an outlet for CNG. Accordingly, the Board modified the regulations so that the required number of CNG outlets is adjusted to account for preexisting retail CNG outlets if the criteria described below are met. (§ 2304(a)(5).)

First, the owner/lessor of the CNG outlet must not be the owner/lessor of any retail gasoline stations. If the owner/lessor did have such stations, no special provision would be necessary because the owner/lessor could simply count the station against his or her required number. Second, because the station will substitute for a required CNG outlet, it must meet the design criteria for required clean fuel outlets. Third, for an outlet in the South Coast, it must be installed by November 30, 1992. For other outlets, the necessary installation date is November 30, 1995 or earlier. These criteria are necessary so that only preexisting stations are covered and the Executive Officer has sufficient leadtime for determining the final required number of stations. Fourth, the outlet must be in operation at least 13 months prior to the beginning of the year for which it is counted, in order to provide some assurance it will in fact be in operation in the year it is used to reduce the required number of stations. Finally, a station meeting all of the above criteria could not be constructively allocated to a gasoline station owner in satisfaction of that owner's requirement for CNG outlets. Otherwise, the station could in effect be double-counted.

e. Minimum number of clean-fuel vehicles

In the original proposal, there would be no required number of retail outlets for a clean fuel assigned for any year in the 1994-1996 South Coast phase of the program if the expected number of low-emission vehicles certified on the fuel and operated in the South Coast at any time during the year would not exceed 10,000. (former § 2335(d).) The minimum number for triggering new outlets in the South Coast has been changed to the same criterion for triggering new outlets after 1996: 20,000 vehicles statewide. (§ 2304(a)(1).) Since about half of all low-emission vehicles are expected in the South Coast (based on the existing distribution of vehicles in the

5. The total number of CNG retail outlets would not exceed the required number if all the pre-existing outlets were constructively allocated by their owners to owner/lessors of gasoline stations. However, the payments exacted by the owners of the preexisting CNG outlets could be regarded as windfall profits. The Board concluded that it would be unfair to put owner/lessors of gasoline stations in a position of choosing between making such payments or over-building the CNG dispensing capacity with the accompanying reduced throughput per individual station.

state), this change should have a minimal effect but it will eliminate the problem of having to estimate precisely how many of the state's clean fuel vehicles will be in the South Coast. In addition, the basis for calculating the minimum number of statewide clean fuel vehicles has been revised to be identical to methods used for making other estimates of the numbers of clean fuel vehicles. (§§ 2304(a)(1), 2303(b).) This will simplify the determinations and enhance uniformity.

4. <u>Changes to the calculation of maximum clean fuel demand for purposes of determining required numbers of clean fuel outlets</u>

A key component of the formula for determining the required number of clean fuel outlets is the determination of projected maximum volumes of clean fuels, made by the Executive Officer pursuant to section 2303. For each year, the Executive Officer will determine what clean fuels are expected to be used as certification fuel, and estimate the number of low-emission vehicles certified on a particular clean fuel that will be on the road or newly produced during the year. An estimate is then made of the amount of clean fuel that those vehicles will use in the year, assuming in the case of FFVs that the vehicles will always be fueled with the clean fuel. Various modifications have been made to the approach in the original proposal.

a. <u>Estimating the number of vehicles</u>

The original proposal directed the Executive Officer to estimate the number of low-emission vehicles certified on each clean fuel and operated in the quarter. This has been revised to refer, for each year and each clean fuel, to the sum of (i) number of low-emission vehicles certified on the fuel and projected by manufacturers to be manufactured in the corresponding model year, and (ii) the number of low-emission vehicles certified on the fuel and registered with the Department of Motor Vehicles ("DMV") through September 30 of the year two years prior to the year for which the estimates are being made. The estimates described in the modified regulations more closely reflect the primary available sources of data--vehicle manufacturers' production estimates and DMV records. (§ 2303(b).)

b. <u>Calculating the projected maximum volumes of clean fuel vehicles</u>

The procedure for calculating the total fuel volume for low-emission vehicles certified on a particular fuel has been clarified in several respects to make the calculations more accurate. The regulation states expressly that the calculation is separate for each model year and each of three weight classes of vehicles. A separate calculation for dedicated low-emission vehicles has been eliminated because it was appropriate only for the distribution requirement. The units of volume have been clarified to be gallons of gasoline equivalent in energy to the amount of the clean fuel in question. (§ 2303(c).)

c. Making the calculations annually

In the original proposal, the maximum clean fuel demand was calculated quarterly. This was because the calculation was used as the basis of the minimum volumes of clean fuels assigned quarterly under the distribution requirement. Since the required numbers of retail clean fuel outlets are only revised on a yearly basis, the calculations of maximum clean fuel demand have been modified so they are also made on a yearly basis.

d. Clean fuel dispensed at private locations

In the originally proposed formula for determining the required number of clean fuel outlets, the total projected maximum clean fuel volume determined in accordance with section 2303 was reduced by the volume of clean fuel dispensed at nonretail (fleet) outlets. (§ 2304(a)(4).) This treatment was modified so that only the clean fuel volume dispensed at nonretail outlets to low-emission vehicles is subtracted. Much LPG and CNG that may be dispensed at fleet locations may be used by vehicles that are not low-emission vehicles. It would be undesirable to subtract such fuel from the amount of clean fuel that determines the number of clean fuel outlets available to the public, since the calculated projected maximum clean fuel volume includes only clean fuel used in low-emission vehicles.

5. Other changes to the retail outlet requirements

a. Clarification and refinement of the underlying retail outlet requirements

The basic retail outlet requirements established in sections 2301 and 2302 (former §§ 2330 and 2332) were modified and refined in several respects. The requirements originally applied for each calendar quarter. In any quarter that a person (in 1994-1996 only a major gasoline supplier) is the owner/lessor of an operating retail gasoline outlet, the person would have to equip the required minimum number of his or her outlets as clean fuel outlets for the entire quarter. As noted elsewhere, the assignment of the required minimum number of clean fuel outlets is made on a yearly basis under the adopted regulation. To avoid potential hardship, the terms in sections 2301 and 2302 were modified so that the retail outlet requirements only apply during periods that a person is the owner/lessor of an operating gasoline outlet (and in 1994-1996 are major gasoline suppliers).

For a given gasoline station owner/lessor, the required number of clean fuel outlets will not decrease over time (unless the total number of vehicles certified on the clean fuel drops below 20,000). Providing for such reductions would introduce major complications in reallocating the reduction to other owner/lessors. If a gasoline station owner/lessor should dispose of some gasoline stations, he or she could be left with fewer stations than the number of clean fuel outlets already required by the time of the sale. To avoid this problem, the original proposal has been changed so that the basic retail outlet requirements will in any case be satisfied with regard to a particular clean fuel if all of an owner/lessor's operating gasoline stations are equipped to dispense the clean fuel.

b. Changes to the schedule for notifying station owners of the required numbers of clean fuel outlets

As in the original proposal, the final regulations require the Executive Officer to inform each affected gasoline station owner/lessor of the person's required number of clean fuel outlets at least 12 months before the date on which the clean fuel dispensing equipment must be operational. However, the regulations have been modified to also require the Executive Officer to transmit a preliminary estimate of the eventual requirement at least 18 months before the operational deadline. (§§ 2304(d) and 2307(e); see also § 2303.) This is needed to provide the owner/lessor sufficient time to satisfy the new requirement to submit proposed locations of outlets to the Executive Officer, described in section II.B.6.b. below. If the owner/lessor does not know the required number until 12 months before the operational deadline, it would be logistically difficult to await the ARB's review of proposed locations before beginning installation. The basis for the preliminary estimates will be slightly different from the basis of the final projections, as the available sources of data will be less precise at the earlier date.

c. Required capacity of a qualifying CNG outlet

In the original proposal, a CNG outlet could qualify as a clean fuel outlet only if the dispensing device is capable of four hours of operation daily at an average fill rate of at least 600 standard cubic feet per minute (scfm). The intent was to assure that CNG vehicles could be filled as quickly as gasoline vehicles. However, the cost of meeting a specification of 600 scfm could be high, raising the cost of the system above $250,000 (compared to $50,000 for methanol dispensing capability). Also, such a specification could restrict other desirable design features. Therefore, the minimum fill-rate specification for CNG outlets was changed to a capability of four hours of high volume operation per day. This should satisfy the objectives of fast fills and flexibility. (§§ 2301(b), 2302(b).)

6. Requirements regarding the siting of clean fuel outlets

In the original proposal, it was assumed that the distribution requirement would create a strong incentive for gasoline station owner/lessors to locate clean fuel outlets in a way that would maximize the volumes of clean fuels sold to motorists. With the deletion of the distribution requirement, there could be a decreased likelihood that clean fuel outlets are sited in an efficient manner with an adequate geographic distribution. Therefore the Board added provisions imposing general standards for the siting of clean fuel outlets, and requiring individual owner/lessors to consult with staff of the ARB and the Energy Resources, Conservation and Development Commission (the "CEC") after all owner/lessors have submitted preliminary locations. (§ 2309(a).)

a. Criteria for choosing the locations of clean fuel outlets

Section 2309(a)(1) of the adopted regulations provides that in determining the locations of clean fuel outlets, a gasoline station owner/lessor shall provide a reasonable geographical dispersion of the outlets and place the outlets in locations that are convenient to drivers of low-emission vehicles that operate on the particular clean fuel. These requirements were added to help assure that drivers of clean fuel vehicles will have reasonable access to clean fuel outlets. It would be inappropriate, for instance, for a major gasoline supplier to site all of its outlets for a given clean fuel in the immediate vicinity of the clean fuel terminal.

The regulation also provides that any clean fuel outlet that was equipped to dispense a clean fuel as part of the CEC's methanol demonstration program will be deemed to satisfy the siting criteria. The methanol demonstration program is a voluntary effort to encourage the early installation of methanol outlets. Outlets are equipped pursuant to an agreement with the CEC. Since one of the factors the CEC considers is the adequacy of the location, there is little need to impose any additional requirements regarding the choice of these locations. It would be inappropriate and inefficient for the Board's regulations to prevent the use of methanol outlets originally equipped pursuant to the CEC's program.

b. Submittal of preliminary sites of clean fuel outlets locations and consultation regarding locations

Section 2309(a)(2) of the adopted regulations requires that gasoline station owner/lessors who have received preliminary estimates of their required minimum number of clean fuel outlets must submit proposed locations of outlets to the ARB, along with optional locations equal to at least 20 percent of the required number. The submittal will be due 15 months before the outlets have to be operational. Following submittal of the proposed locations, the owner/lessors must consult with the staff of the ARB and the CEC regarding optimal locations. Since proposed locations will be submitted by each gasoline station owner/lessor that will have to install clean fuel equipment, the agency staffs will have a much more complete picture than any individual entity of the overall matrix of potential locations. Thus the agency staffs will be able to provide useful input not otherwise available. The reference to CEC staff was included because of that staff's expertise developed through administration of the methanol demonstration program. Although consultation with the agencies' staff is required, the regulation does not authorize the staff to dictate locations to the gasoline station owner/lessors.

7. Requirements on how clean fuel outlets are equipped, maintained and operated

As discussed elsewhere, it is likely that a substantial proportion of the clean fuel low-emission vehicles will be FFVs (flexible-fueled), particularly in the early years. The operators of these vehicles will choose whether to purchase clean fuel or gasoline each time they fuel their vehicles. With the original proposal, it was expected that the distribution requirement would provide a powerful incentive for clean fuels to be marketed in a manner that was sufficiently attractive to induce drivers of FFVs to purchase clean fuels and therefore achieve the full emission benefits of the vehicle control technology. In the absence of the distribution requirement, the Board decided to add requirements to help assure that clean fuels are offered in a manner no less attractive than the gasoline being offered at the outlets, so that FFVs will not be discouraged from purchasing clean fuels. These requirements include provisions applicable both to the owner/lessor and to the operator of a clean fuel outlet. (§§ 2309(b), 2310(a).)

a. Requirements imposed on the owner/lessors of clean fuel outlets

Adopted section 2309(b) provides that the owner/lessor of a clean fuel outlet counted against the assigned minimum number of outlets must do all the following:

* put the clean fuel dispensers in a location substantially as accessible and as visible to a customer entering the station as are the gasoline dispensers (dispensers equipped to dispense clean fuels as part of the CEC's methanol demonstration program more than a year before the ARB's requirements apply will be deemed to satisfy this criterion for the reasons described in section II.B.6.a above);

* ensure that the clean fuel dispensers are substantially as well-marked and as clearly identified as the gasoline dispensers with regard to the type of fuel;

* maintain lighting which keeps the clean fuel dispenser area substantially as well-illuminated as the gasoline dispensing area when the outlet operates at night; and

* ensure that customers using the clean fuel dispensers have substantially the same access to services such as canopy coverage, air and water, vending, and restrooms as do customers using the gasoline pumps in the same service mode.

Each of these requirements is designed to help assure that the driver of an FFV entering the station will find the clean fuel facilities at least as attractive as the gasoline facilities.

In addition, certain gasoline station owner/lessors must provide a training program for attendants that teaches them to answer customers' questions about the clean fuels, or a functionally equivalent alternative. Such training or equivalent is necessary because neither the attendants nor the customers will be as familiar with the clean fuel as they are with gasoline. This requirement applies only to a gasoline station owner/lessor that is a distributor or refiner who authorizes operation of the station under franchise; such entities are most likely to have the appropriate resources to provide the training. Finally, the owner/lessor must maintain the clean fuel dispensers in good working order. Inoperable dispensers will not provide the requisite availability.

b. Requirements imposed on the operators of clean fuel outlets

Adopted section 2310(a)(3)-(7) contains new requirements that the operator of a clean fuel outlets counted against an assigned minimum number of outlets must do all the following whenever gasoline is offered at the station:

* keep the clean fuel pump area substantially as well-illuminated as the gasoline dispensing pumps;

* during the time the clean fuel is offered for sale, have present at least one attendant who has been trained in the training program discussed in the preceding subsection, or provide a functional equivalent;[6]

* keep the clean fuel pump area and pad substantially as clean as the gasoline pump area and pad;

* provide a clearly visible sign indicating that clean fuel(s) are being offered for sale;[7] and

* conspicuously post on the dispenser the price of clean fuel for the volume that provides the energy equivalent to a gallon of gasoline; for this purpose, the regulation specifies energy contents for several fuels that are most likely to become clean fuels.

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6. This requirement applies only if the gasoline station owner/lessor is required to provide the training program or equivalent since in other cases the program may not be available to the operator.

7. To avoid a situation where the operator is precluded by law from complying, the regulation states that the operator shall not be required to display a sign in a manner inconsistent with applicable local ordinances.

The first two operator requirements track requirements described in the previous subsection applicable to owner/lessors of clean fuel outlets. The requirement regarding cleanliness will help keep drivers of FFVs from being discouraged from purchasing clean fuels. The sign requirement will help assure that motorists know a clean fuel is available at the service station. The energy equivalent price requirement will enable motorists to more accurately compare the prices of various clean fuels and gasoline.

As in the original proposal (former §§ 2331 and 2333), adopted section 2310(a)(1) requires the operators of clean fuel outlets counted against an assigned minimum number of outlets to store a commercially reasonably quantity of the clean fuel and to offer it for sale to the public. Consistent with the new provisions designed to assure that the clean fuel is offered as attractively as the gasoline, the regulation has been clarified to provide that requirements on storing and offering the clean fuel apply during the periods that gasoline is for sale at the station. Finally, section 2310(a)(2) requires the operator to maintain the clean fuel dispensing equipment in good working order, so that the fuel will in fact be available.

8. Responsibilities of the owner/lessors of clean fuel outlets regarding supplying clean fuels

The regulations require that operators of clean fuel outlets counted against an assigned minimum number of outlets have the clean fuel available for sale. Under the original proposal, there was a strong likelihood that operators would have plentiful wholesale supplies of clean fuels because gasoline suppliers would be seeking to satisfy the distribution requirement. With the elimination of the distribution requirement, there could be a potential danger that operators of clean fuel outlets would have difficulty obtaining the necessary supplies of clean fuel. In most cases, the operators of gasoline stations are not directly involved in motor vehicle fuel and would have difficulty supplying clean fuel themselves. Therefore section 2309(c) contains new provisions designed to assure that the operators of clean fuel outlets will have reasonable access to adequate supplies of clean fuels.

The owner/lessor of the clean fuel outlet is the person or entity best suited to bear some responsibility for supplying clean fuels. As noted in footnote 3, whenever a refiner or distributor has an ownership or lease interest in the service station, the refiner or distributor is the "owner/lessor." Thus in most cases the owner/lessor of the station will have both some access to a supply network and a concrete connection with the station. This is most vividly the case in the critical early years when the program applies only in the South Coast, as only major gasoline suppliers will be station owner/lessors during that time. Consideration was given to imposing clean fuel supply obligations on all gasoline suppliers, but there was concern that it would be inappropriate to impose such requirements on upstream-only suppliers who have neither a distribution network to stations nor a concrete relationship with service stations.

The responsibility of the station owner/lessor to supply clean fuel to the station is implemented by making the owner/lessor jointly liable with the station operator in certain circumstances for a failure to have clean fuel at the station and available for sale. Under section 2309(c)(1), the potential joint liability is triggered by the station operator's request that the owner/lessor of the station provide for the delivery, within a specified time not less that 72 hours from the request, of specified commercially reasonable quantities of a clean fuel on commercially reasonable terms. The owner/lessor's joint liability for clean fuel not being available for retail sale at the station will start with the requested date of delivery unless the owner operator either (i) supplies the requested fuel within the specified timeframe and terms, or (ii) identifies a third party capable and willing to make such supplies.

The structure of the requirement will help assure the station operator that supplies of clean fuel will be available, while affording a good deal of flexibility to both the operator and the station owner/lessor. Most arrangements for supplying gasoline to service stations call for supplies in 72 hours or less. Therefore the 72 hour reference in the regulation would put the clean fuel on roughly the same footing as gasoline. It would be inappropriate to require the station owner/lessor to supply the clean fuel under terms or conditions that are not commercially reasonable.

The overall objective of the supply provisions is to make sure that clean fuels are in fact available, not to create substantial liabilities. Section 2309(c)(2) provides that each time the owner/lessor of a clean fuel outlet submits notification of final outlet locations, the owner/lessor must describe how he or she intends to comply with the supply requirements. This provision is designed to encourage timely planning for compliance, as well as to provide the Executive Officer with early information regarding potential supply problems. In order to assure that the description is adequately detailed and that the owner/lessor has engaged in appropriate planning, the regulation identifies several relevant areas of information that must be provided.

9. Relief from liability

To prevent undue hardships, two kinds of provisions have been added which allow relief from liability in extraordinary situations.

a. "Force majeure" provisions

Language was added providing that the supply requirements for owner/lessors of clean fuel stations (§ 2309(c)(1)) and the retail outlet requirements for operators of clean fuel stations (§ 2310(a)(1)) do not apply if the person demonstrates he or she is unable to comply because of a natural disaster, an act of war, a civil disorder, or the operation of law. In these narrowly defined circumstances, any liability would not be appropriate.

b. Relief for breakdowns of CNG equipment

Section 2311 of the adopted regulations relieves owner/lessors and operators of CNG outlets from violations resulting from breakdowns of CNG dispensing equipment in certain circumstances. Because CNG compressors are much more expensive than dispensers for liquid fuels, a CNG outlet will probably have only one compressor. Therefore it is appropriate to have a relief provision applicable only to CNG outlets. With respect to other fuels, station owner/lessors can be expected to have installed multiple dispensers or extra outlets as back-ups for disabled outlets.

Under the regulation, minor and major breakdowns of CNG dispensing equipment are treated differently. A minor breakdown is one that can be repaired in 72 hours or less. (§ 2300(a)(19).) In order to be relieved from liability, an owner/lessor with a minor breakdown must (i) report it within four hours of the time he or she learns or reasonably should learn of the breakdown, (ii) repair it as quickly as reasonably possible not exceeding 72 hours, (iii) report completion of the repair within twelve hours and describe future corrective actions to be taken, and (iv) demonstrate that the breakdown was caused by reasons beyond the owner/lessor's reasonable control. These provisions are patterned after breakdown rules of the local air pollution control districts (e.g. South Coast Air Quality Management District rule 430). They are designed to assure that relief is available only when the otherwise liable person has acted prudently, and the shutdown period is as brief as possible. In the case of a major breakdown, up to six months relief is available. Because of the longer downtime, the person seeking relief must submit a plan on how the repair will be made as soon as reasonably possible.

10. Recordkeeping and Reporting Requirements

The original proposal required gasoline suppliers, clean fuel suppliers, and persons who would generate credits by selling CNG or electricity to record and report many kinds of data on the volumes and dispositions of clean fuels. (former §§ 2320, 2321, 2322, and 2323.) The data would have been needed in enforcing the distribution requirement. With the deletion of the distribution requirement, the number of reporting parties and the scope of the required data have been greatly reduced. All of the original reporting requirements for fuel suppliers have been eliminated. Instead, adopted section 2314 simply requires that persons who first introduce clean fuels into commerce in California submit quarterly reports of the volume of clean fuel distributed by the person in the quarter, broken down between production and imports. Such data will allow the ARB to estimate how much clean fuel is being used by low-emission vehicles.

Requirements that gasoline station owner/lessors submit annual reports on the locations of their clean fuel outlets were moved but not substantively changed. (former § 2339; adopted § 2309(d).) The due-date of required annual reports by gasoline station owner/lessors of regarding the number and location of all gasoline stations was changed to track the dates the Executive Officer must assign preliminary numbers of clean fuel outlets. (former § 2340; adopted § 2312.)

The requirement for fleet operators to report the volume of clean fuel they expect to supply to their fleet vehicles in the following year was changed to clarify that the information shall be for fuel dispensed into low-emission vehicles. (former § 2341; adopted § 2313.) The amount of a clean fuel expected to be dispensed into low-emission vehicles at private dispensers will be subtracted from the volume that will determine the required number of public clean fuel outlets. In addition, the due-date for the reports were changed so that the data can be used for the Executive Officer's annual preliminary estimates.

11. <u>Determination of Violations</u>

The original provisions on determining violations of the distribution requirement were eliminated. Provisions were added on determining violations of the new requirements imposed on owner/lessors of clean fuel outlets regarding how the outlets are equipped and maintained. (§ 2315(b).) Because the requirements pertain to activities at individual service stations, the same approach was used as applies to violations by service station operators. The other provisions regarding violations by gasoline station owner/lessors and operators were refined to reflect other modifications to the regulations. (§ 2309(a),(c).)

12. <u>Substitute Clean Fuels</u>

Section 2317 (former § 2345) allows requirements pertaining to a particular clean fuel to be met with a substitute fuel that has been determined to have an equivalent emissions performance and that has been approved by the Board by regulation. The provisions on comparing toxic emissions of the two fuels were modified. Under the original proposal, mass emissions of each of four toxic compounds from the substitute fuel and the clean fuel would have been compared separately. The adopted regulation provides that the <u>sum</u> of the emissions of those compounds, each weighted by a specified value for its carcinogenic potency, is to be compared between the two fuels. The original criterion was unnecessarily stringent and could have led to the rejection of a substitute fuel that actually would cause lower overall risk than does a clean fuel. Conforming changes were made to the incorporated "California Test Procedures for Evaluating the Emission Impacts of Substitute Fuels or New Clean Fuels" (the "Substitute Fuel Test Procedure").

In addition, a modification was made to allow the clean fuel requirements to be met with a substitute fuel immediately upon the Board's approval of the substitute fuel, rather than at the beginning of the next quarter as stated in the original proposal. This will afford the regulated public additional flexibility. The regulatory language was also modified to make clear that if a person chooses to comply with a substitute fuel, all requirements regarding the clean fuel will apply to the substitute fuel.

Finally, the Substitute Fuel Test Procedure was clarified. It originally was drafted to reflect the assumption that the existing fuel against which a candidate new or substitute fuel should be tested would always be gasoline. However, gasoline would not be appropriate as the comparison fuel for testing in non-gasoline vehicles capable of using the candidate fuel. Since it has been the underlying intent that emissions from such vehicles be included in the evaluation of a candidate fuel, the Substitute Fuel Test Procedures were modified to specify that for vehicles not certified on gasoline, the comparison fuel will be the certification fuel.

13. <u>Definitions</u>

The Board made a number of modifications to the definitions in section 2300. Definitions of terms no longer used in the regulation were deleted. Several definitions were added or modified to enhance clarity. Three of the more substantive modifications are described below.

The definition of "designated clean fuel" (§ 2300(a)(5)) was modified to clarify that CNG will be included when the California Public Utilities Commission certifies that gasoline retailers may sell CNG without being regulated as a public utility. This better expresses the concept reflected in the original language regarding retailers being able to purchase CNG from a public utility and resell it for use as a fuel in motor vehicles. In addition, the provisions regarding when the PUC's certification triggers applicability to CNG were clarified. As modified, the retail outlet requirements would apply to retail outlets for CNG starting with the first year that commences 18 months after the PUC certification. This will allow for orderly planning for and review of CNG outlet locations.

The definition of "major gasoline supplier" was changed in response to public comments (see Comments 180 and 182 below).

The definition of "vehicle conversion" was modified to include only vehicles not originally certified to a low-emission standard. A vehicle conversion is a vehicle that has been converted into a low-emission vehicle using a designated clean fuel or CNG. The modification was made to prevent a vehicle originally certified as low-emission vehicle on gasoline or diesel from being double-counted as both a low-emission vehicle and a vehicle conversion, and to allow vehicles converted into CNG low-emission vehicles to be counted in determining the number of retail outlets to be required. The definition was also expanded to identify the criteria for determining whether a converted vehicle is capable of meeting low-emission vehicle standards.

III. SUMMARY OF PUBLIC COMMENTS AND AGENCY RESPONSES

The Board received numerous written and oral comments, both in connection with the September 27-28, 1990 Board hearing and during the subsequent 15-day public comment period. Attachment B contains a list of all persons who presented comments during the comment periods, including the date and form of each comment and the shorthand identification of the commenter as used in this Final Statement of Reasons.

Set forth below is a summary of each objection or recommendation made regarding the the specific regulatory actions proposed, together with an explanation of how the proposed action was changed to accommodate each objection or recommendation, or the reasons for making no change. The comments have been grouped by topic whenever possible. Comments not involving objections or recommendations specifically directed towards the proposal action or the procedures followed by the ARB regarding the rulemaking are not summarized below.[8]

A number of commenters generally supported adoption of the proposed regulations. These commenters included the Sierra Club, the American Lung Association, the North East States for Coordinated Air Use Management ("NESCAUM"), U. S. Congressmen Henry Waxman and Jerry Lewis, State Senators Hershel Rosenthal and Bill Leonard, State Assemblyman Lloyd Connelly, the Sacramento Board of Supervisors, eleven of California's Air Pollution Control Districts, the South Coast and Bay Area Air Quality Management Districts, and several individuals and private organizations.

Many of the commenters supporting the regulations emphasized that mobile sources are the major source of ozone precursor emissions in California. Several legislators, including Lloyd Connelly and Hershel Rosenthal, stated that timely adoption of the regulatory action is

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8. Both the proposed low-emission vehicle/clean fuels regulations, and proposed phase 1 reformulated gasoline regulations, were noticed for the same two day meeting of the Board. Some written comments covered both sets of regulations. Comments pertaining to the phase 1 reformulated gasoline regulations are not summarized here.

In preparing the modifications to the originally-proposed clean fuel regulations, the staff conducted an informal consultation meeting (workshop) on the draft regulatory text on December 12, 1990. The letter announcing the consultation meeting noted that comments made before or at the meeting would not be considered formal comments in the rulemaking, and that only comments received during the subsequent 15-day comment period would be part of the record of the rulemaking. The record accordingly does not include comments presented at the consultation meeting.

essential if California is to overcome its current serious air quality problems. Congressman Henry Waxman also emphasized the key role that adoption of the regulations would play in achieving national energy security. Several California Air Pollution Control Districts and Air Quality Management Districts adopted resolutions expressing their support for the regulations and stating that adoption of the regulations is essential to the achievement and maintenance of the state and federal ambient air quality standards. NESCAUM described the regulations as achieving an impressive balance between clean air objectives and the various economic, infrastructure and political ramifications associated with the introduction of new fuels and new vehicle emission control technologies. Comments in support of the proposed regulations are not summarized below.

A. Comments Pertaining Generally to Both the Low-Emission Vehicle and Clean Fuels Regulations

1. Comment: The ARB should sponsor economic incentive programs to stimulate market demand for low-emission vehicles and clean fuels. The economic incentives should include one or more of the following:

(a) The ARB should offer an incentive for a specific term to induce the first few retail outlets to begin offering new fuels without the full market risk. (WSPA)

(b) The ARB should consider a tax incentive program to make both the new vehicles and fuels more competitive. These include tax credits for both the consumer (vehicle sales and/or registration fees and gasoline taxes) and producer (business income tax, investment credits, etc.). The reason that the staff gave for not including such a program--that the ARB does not have the legal authority to implement such a program--is not sufficient. (EDF, LP Coalition, Arco)

(c) The ARB should work with the California legislature in drafting economic incentive legislation that would stimulate market demand for low-emission vehicles and clean fuels. If substantial subsidies or concessions are necessary to overcome customer reluctance to particular vehicles, fuels, or technology, the ARB should make appropriate revisions in its policies and seek more acceptable alternative approaches to seeking its goals. (Chrysler, EDF) Economic incentives are necessary because of our concerns about the willingness of the public to accept the vehicles and fuels that will be required, especially vehicles with electrically heated catalysts and their 20-40 second warm-up times. (Chrysler) Without cost incentives for alternative fuels to make them marketable, customers will not respond accordingly by fueling their cars with these new fuels. (AIAM)

Agency Response: The ARB does not have the statutory authority to establish a program that provides incentives through either a tax program or other mechanism to encourage the introduction of low-emission vehicles and clean fuels. Only the Legislature can do that. To the extent that incentive programs are found to be appropriate and beneficial, we are prepared to work with the Legislature in the development of such a program.

2. Comment: Based on recent studies, actual in-use emissions of CO and HC may be three times greater than estimated by ARB because of inadequate emission test procedures and/or underestimated deterioration rates. ARB should update its emission inventories and emission reduction strategies to reflect this, especially in consideration of this proposal. (EDF)

Agency Response: The ARB is currently examining the emissions inventory to identify sources which may affect its accuracy. The impact of off-cycle emissions is being investigated with the intention of establishing future control measures if its impact is significant. As part of this investigation, preliminary tests have been conducted by the ARB to assess the effects of acceleration on emissions under various driving conditions. The results have confirmed that emissions can be substantially higher during moderate to high accelerations than during the accelerations on the FTP cycle. The ARB believes that lower emission standards and improved control of off-cycle emissions should both be pursued.

3. Comment: There must be a better way to achieve the goal of improving our environment without placing unfair financial burdens on unwilling participants. We should worry more about the existing high polluters rather than future vehicles, which will emit even less pollutants than today's cars due to improved technology. More consumer education would also be helpful to encourage nonpolluting behavior and habits. (Hail, Honda)

Agency Response: The ARB and the local districts are engaged in a wide range of programs to reduce air pollution. These include an enhanced Smog Check program geared to reducing the emissions from high-emitting vehicles, and vehicle trip reduction programs. However, those programs are not projected individually or cumulatively to achieve the state ambient air quality standards for ozone in the South Coast. Health and Safety Code section 43018 requires the Board to endeavor to achieve the maximum degree of emission reduction possible from vehicular and other mobile sources in order to accomplish the attainment of the state standards at the earliest practical date, in order to comply with ambient air quality standards. The adopted regulations are necessary and appropriate under that mandate.

4. Comment: The ARB's proposed plan does not move quickly enough. Even if the program succeeds in meeting its proposed emissions reduction goals, it still will not be sufficient to bring the South Coast Air Basin into compliance with state or federal ambient air quality standards. We therefore urge the Board to incorporate wherever possible the most aggressive strategy possible. (EDF)

Agency Response: We have attempted to do so, consistent with the requirements of Health and Safety Code sections 43013 and 43018.

5. Comment: I oppose the proposed regulations because we need to go way beyond them to totally eliminate fossil fuel in transportation. We need a constitutional amendment or initiative or referendum requiring all nonprivate fleet vehicles to be converted to non-fossil-fuel propulsion within four years. All private vehicles should be converted to non-fossil-fuels in the subsequent four years. (Wachtel/Quail)

Agency Response: Under Health and Safety Code sections 43013 and 43018, the Board cannot adopt motor vehicle or fuels regulations without first finding they are technologically feasible. It is not technologically feasible at this time to mandate the total replacement of fossil fuels in transportation in the timeframe proposed by the commenter. However, the adopted provisions on ZEVs should help foster the introduction of vehicles operated on other than fossil fuels. The adopted regulations also represent a significant advancement in achieving the air quality goals in California, and establish the world's most stringent vehicle emissions standards. The Board does not have the authority in this rulemaking to require the complete substitution of non-fossil fuels in nonprivate fleets in the next four years.

6. Comment: Annual reviews of the implementation of the low-emission vehicle and clean fuels regulations are necessary. The reviews should include an assessment of the feasibility of meeting the low-emission vehicle standards, the status of development of ZEVs, the extent to which clean fuels are available, the emissions impact of different fuels, the real world air quality benefits, and consistency with other regulations. (GM)

Agency Response: In Resolution 90-58, the Board directed the Executive Officer to report by the spring of 1992, and thereafter at least biennially, on the status of implementation of the program, identifying any significant problems and proposing any appropriate regulatory modifications. The staff plans to review implementation of the regulations on an ongoing basis. In addition, the California Administrative Procedure Act gives the public the right to petition for modifications to any regulation.

7. Comment: The ARB must specify the degree of opportunity afforded the public to review the biennial reports and make comments. (WSPA)

Agency Response: In Resolution 90-58 the Board stated that the Executive Officer shall consult with the regulated public and other interested parties during the preparation of the biennial reports, and that the public shall be provided an opportunity to make oral and written comments to the Board in conjunction with the reports.

B. **Comments Pertaining to the Low-Emission Vehicle Regulations Made Before or at the Hearing**

1. General technological feasibility within the available leadtime

8. Comment: We believe that the standards and implementation schedule for the low-emission vehicle regulations are not technologically feasible within the available leadtime.

The previously-adopted 0.25 g/mi NMHC standard, 100,000 mile durability, OBD II requirements, revised MDV standards, revised evaporative emission standards, and other new requirements will all become effective in the 1993-1995 model-years. Additionally, more stringent federal emission standards are a near certainty in the same timeframe. With all this, we urge the Board to consider the resource implications for vehicle manufacturers of any further requirements. The number of technical experts and available financial resources are finite. Emission control expertise requires years to develop. Because of inadequate lead-time, rushed development of new technology could result in customer dissatisfaction and possibly tampering or in-use emissions exceedances. (Chrysler, Volvo, GM, Nissan, Ford, MVMA, EMA/MVMA, AIAM, Honda, VW)

Agency Response: Health and Safety Code section 43018(a) directs the Board to endeavor to achieve the maximum degree of emission reduction possible from vehicular and other mobile sources in order to accomplish the attainment of the state ambient air quality standards at the earliest practicable date. The need for major additional emission reductions is set forth in Chapter I of the Staff Report. The ARB is faced with a mandate to achieve dramatic reductions in motor vehicle emissions in a very short timeframe. At the same time, there must be careful consideration of feasibility before any emission control proposal is brought to the Board. We believe that the adopted regulations appropriately reflect both the need to achieve maximum emission reductions at the earliest practicable date, and the need for the standards to be technologically feasible and cost effective.

We have expended considerable effort in demonstrating that it is feasible and cost effective to meet the low-emission vehicle requirements. For example, many test vehicles have been equipped with advanced emission control technologies and, through extensive testing, have shown potential in meeting the stringent standards. The data demonstrating the technological feasibility of the low-emission vehicle program are set forth in Chapter II of the Staff Report and in Chapter II of the TSD. Data were also presented by staff at the hearing. (Transcript, Day 1, pp. 17-27 and accompanying slides.)

Significant emission control system advances may not be necessary to meet the earlier year fleet-average requirements. Since vehicles already meet a 0.4 g/mi NOx standard, compliance with the TLEV NOx standard should not be a concern. For hydrocarbon control, many 1990 and 1991 model-year vehicles have NMHC levels below the TLEV standard with emission levels as low as 0.067 g/mi. (See Chapter II.A. of the TSD.) This may allow a sufficient margin for in-use compliance with the TLEV NMOG standard of 0.125 g/mi. Technology such as heated fuel preparation systems which have been installed on California-certified vehicles may be used to secure an even larger margin for in-use compliance.

For the later years of the low-emission vehicle program, there is adequate leadtime to develop advanced emission control technology to meet the fleet-average requirements. ARB test vehicles utilizing electrically-heated catalyst ("EHC") systems have been successful in meeting the ULEV standards at approximately 4,000 miles. Although more durability testing is needed, this technology has shown considerable promise in meeting the LEV and ULEV standards. Other potential technical strategies to comply with the regulations have been identified in the TSD. Regarding the ZEV mandate, competitive electric vehicles such as General Motors' Impact have been developed and may satisfy the ZEV requirement for the 1998 model-year once issues regarding battery life are resolved.

In addition, the low-emission vehicle regulations are designed to provide flexibility in the means of compliance where needed. Examples include fleet average standards, separate in-use standards, and a credit banking/trading system. While there are some minimal requirements in 1994, the bulk of the requirements do not take effect until the 1997 model-year. Also, in the initial years, manufacturers have been given a longer period to balance any shortfalls in meeting the fleet average NMOG standards.

Finally, if the ARB's projections prove to be overly optimistic, amendments to the regulations can be considered as part of the Board's biennial review of the status of implementation and technological development.

9. Comment: The proposal will most likely fail because it is premised on two high-risk expectations--(a) the expectation that technology forcing standards will bring forth the innovations needed in the required timeframe, and (b) the expectation that the public will accept the added cost and inconvenience associated with the alternative fuel vehicles and EHCs needed to meet the standards. The staff is proposing standards that are not technologically feasible. The staff's expectations are overly optimistic and will place an intolerable burden on manufacturers. (Chrysler)

Agency Response: The ARB has historically set the pace for manufacturers to meet progressively more stringent vehicle emission standards. Without technology-forcing standards, it is doubtful that voluntary efforts would be expended to develop and employ the best available emission control technology. For example, catalytic converters and feedback fuel control were developed to meet stringent vehicle emission standards in the late-1970s and early-1980s. The success of this strategy indicates that ARB has been reasonable in gauging the stringency of proposed standards. The additional cost of EHC systems and specific alternative fuel technology is not significant considering the anticipated emission benefits. The inconvenience of fueling alternative-fueled vehicles is expected to be minimal since the requirements of the proposal ensure the availability of alternate fuels if manufacturers develop these vehicles. In any event, although we expect the regulations to be successfully implemented, the biennial reviews provide an opportunity for the Board to consider changes if needed. See also the response to the preceding comment.

10. Comment: The fleet-average requirements should be treated as targets until there is a consensus among responsible organizations such as the U.S. EPA and the National Academy of Science of the technological feasibility. (Fiat)

Agency Response: The technological feasibility of meeting the fleet-average requirements is discussed in detail in the response to the first Comment in this section; for the reasons stated there we believe that the fleet-average requirements can be met. However, we will be monitoring the progress of implementation and amendments to the regulations can be considered by the Board if necessary as part of the biennial review process.

11. Comment: We recommend that the Board adopt an alternative implementation schedule for the fleet average emission standards. It would only delay the 0.25 g/mi NMOG average requirement one year from the Staff proposal. It would also result in a fleet average which differs by only 0.009 g/mi from that proposed by staff in the year 2003. (AIAM, Honda)

Agency Response: AIAM characterizes their proposed schedule as only a delay of the 0.25 g/mi fleet average by one year and a 0.009 g/mi increase of the 2003 model-year fleet average. However, the suggested changes in the schedule attached to their comment letter increase the fleet average for each model year from 1995 through 2003 with an increase of as much as 97% for the 2000 model year. The proposed schedule is not acceptable since it would delay efforts to attain ambient air quality standards by significantly diminishing the emission reductions expected from the low-emission vehicle regulations. The cummulative effect of allowing ten model-years of vehicles over their useful lives to meet a significantly less stringent standard would be excessive. Further, any relaxation of the requirements is unnecessary since we believe the adopted regulations are technologically feasible for the reasons set forth in the response to the first comment in this Section.

12. Comment: We recommend the adoption of only the TLEV standard, beginning in 1996 rather than 1994, but at an initial rate of 20% rather than 10%. The proposed fleet average NMOG emission

standard concept (including banking and trading) should also be adopted. The future lower emission standards for LEVs and ULEVs and related phase-in schedules should be delayed. If the Board wishes to establish a plan for further emission reductions beyond the 1996 model year, that should be approved as a long-range plan rather than as a regulation. The plan should include a well-defined protocol for further regulatory requirements. (Ford)

Agency Response: The proposed delays are not necessary for the reasons stated in the response to the first comment in this Section.

13. Comment: Compliance with the proposed 1994 model-year requirements could necessitate the redesign of as much as 25% of 1994 model-year passenger vehicles, because the proposal is contradictory with the stringent HC and CO standards adopted by the Board in 1989. (MVMA, EMA)

The original schedule for the 1994 model year was 20% of 0.39 g/mi HC vehicles and 80% of the 0.25 g/mi HC vehicles. With the new schedule for the 1994 model year, 0.25 vehicles will need to be redesigned because the effect will be 22.5% production of TLEV assuming 0.39 HC remains at 20%. This cannot be done without jeopardizing quality and reliability of the new vehicles. In addition, the evaporative emissions rulemaking approved in August 1990 gives manufacturers one more year leadtime than this rulemaking. (GM)

Agency Response: The 0.25 g/mi NMHC standard approved by the ARB in June, 1989 requires 80% of a manufacturer's sales to be certified to 0.25 g/mi NMHC in the 1994 model year, with the remaining vehicles certified to the 0.39 g/mi NMHC standard. The regulations adopted in the current rulemaking establish fleet-average NMOG requirements beginning in the 1994 model year and allow a considerable amount of flexibility in the means of compliance. Since the fleet-average requirement in 1994 is 0.25 g/mi, manufacturers could certify 100% of their fleet to a 0.25 g/mi NMHC standard (resulting in a 20% redesign of 0.39 vehicles) or convert only 10% of the 0.39 g/mi NMHC vehicles to TLEVs. This should not pose a significant technical problem since currently certified vehicles have already been able to achieve emission levels well below the TLEV standards as described in the response to the first Comment in this Section.

The leadtimes provided in this rulemaking and the evaporative emissions rulemaking are based on the comparative steps required to comply with the respective requirements. We believe that adequate leadtime is provided in this rulemaking for the reasons set forth in the response to the first comment in this Section.

14. Comment: When the 0.25 g/mi NMHC standard was adopted in 1989, the phase-in schedule allowed enough time to experiment with new emission control technology. The new standards overlap the phase-in schedule and, thus, will not allow for this. The 0.25 g/mi NMHC

standard should be completely phased-in before the low-emission standards are implemented. (Chrysler, Honda, GM)

1991 model-year vehicles are already being produced, 1992 vehicles are undergoing certification, 1993 vehicles have already been designed, and 1994 vehicles are under final development. In spite of this schedule, the planned resource allocation would have to be interrupted to meet a standard for the 1994 model-year which is twice as stringent as expected for that model-year. (AIAM)

Agency Response: We believe that compliance with both the adopted regulations and the 0.25 g/mi NMHC standards is technologically feasible for the reasons stated in the response to the previous comment and the response to the first Comment in this Section.

15. Comment: The proposed regulations do not allow for stepwise progression in the development of more sophisticated emission control system hardware and in-use performance evaluation in the hands of the consumer. (VW, Honda, AIAM) Therefore, the standards cannot be considered technologically feasible. (VW, Nissan, MVMA/EMA, AIAM)

Agency Response: See the response to the first Comment in this section. We believe the implementation schedule is technologically feasible. Prototype technology to meet the standards already exists and there is sufficient leadtime for refinements and durability testing. The ARB's certification testing requirements to demonstrate emission system durability sufficiently assures adequate performance of these systems in-use.

16. Comment: In 1989 when the proposed 0.25 g/mi NMHC standard and 100,000 mile durability requirement were approved, the ARB recognized that the emission standards would require the most advanced technology available for the timeframe considered (1993-1995). Then why is ARB requiring even more stringent standards by the 1994 model year? (Chrysler, GM)

Agency Response: Since the 1989 rulemaking for 0.25 g/mi NMHC was adopted, new more promising emission control technologies have emerged. Advances in fuel preparation systems, electrically heated catalyst systems, and improvements in alternative fuel technology are a few developments that show promise for reducing emissions. These technological advancements, coupled with the emission reductions called for by the California Clean Air Act, prompted the ARB to establish more stringent control measures to significantly reduce mobile source emissions. Since the phase-in of cleaner vehicles begins slowly under the adopted regulations, only a limited number of low-emission vehicles would be required for the 1994 and 1995 model-years. Additionally, manufacturers will be allowed until the 1997 model-year to balance shortfalls in meeting fleet-average standards incurred in the 1994 model-year, and shortfalls incurred in the 1995 through 1997 model-years could be balanced by the 1998 model-year.

17. Comment: The new NMOG standards adopted by the Board in 1989 that apply starting with the 1993 model year still represent an engineering challenge. In addition to tighter standards, useful life was doubled to 100,000 miles. These new requirements inherently add 4-7 months to a certification program alone, not to mention long-term in-use testing and monitoring, and place an enormous burden on engineering, test and development personnel. (AIAM)

Agency Response: Manufacturers have already had notice of the 100,000 mile useful life requirements, and should be adjusting their development schedules to accommodate the additional durability testing needs. Diminished durability requirements should not be expected for future regulations. However, to alleviate the burden of in-use compliance with the low-emission standards, less stringent in-use standards are provided for the initial years of TLEV, LEV, and ULEV introduction, as discussed in Chapter I.B.3. of the TSD. See also the response to the first comment in this section.

18. Comment: Although the ARB has shown that some vehicles already meet TLEV emission levels at certification, manufacturers typically strive to certify vehicles at approximately 50% of the standard to compensate for test and production variability as well as emissions in-use. (Chrysler, AIAM) Further, this safety margin must be even larger for very low emission levels because the effects of test-to-test variability are greater. Fuel preparation systems, as envisioned by the ARB, will be inadequate to meet TLEV standards. (Chrysler)

Agency Response: Certification and other test data indicate emission levels of 0.067 g/mi to 0.090 g/mi NMHC for several 1991 model-year light-duty engine families. (See Chapter II.A. of the TSD.) These low emission levels were achieved using conventional technology such as heated oxygen sensors, multipoint fuel injection, air injection and three-way catalysts. Since these vehicles are already certified very near 50% of the TLEV standard, fuel preparation systems can be used to secure an even greater margin of safety for compliance. There is little concern over the effects of test-to-test variability at very low emission levels since the ARB has been testing vehicles at ULEV levels with no significant repeatability problems.

19. Comment: Close-coupled catalysts and secondary air injection using electric air pumps or heated fuel preparation systems require technology that is currently beyond mass production techniques. In addition, there are many issues to confirm such as durability, deterioration characteristics and evaluation of emission control systems. Furthermore, additional studies must be completed to determine the ability to reduce the production variation within the

emission system. As a result, it is uncertain when we can introduce TLEVs into the market. (Nissan)

Agency Response: Close-coupled catalysts have been successfully used in California-certified vehicles since at least the 1983 model-year. Heated fuel preparation systems are also being used in certified vehicles which must undergo the standard certification durability test requirements. Manufacturers have indicated plans to use electric air pumps with current vehicle technology for 1992 model-year certification. Since these technologies are developed, there is ample leadtime to design an emission control system utilizing any or all of these technologies to meet the TLEV standards. Regarding production variability, as the emission standards become progressively more stringent, the tolerance of production variation will also be more limited. Manufacturers will have to employ appropriate measures to address this issue utilizing the leadtime provided.

20. Comment: It may be easier to meet TLEV NMOG standards for FFVs but there is concern over the inherent problems with methanol such as component wear or the need for development of special engine oil and reduction of formaldehyde emissions at low temperatures. Confirmation of the emission deterioration and durability of FFVs is insufficient at this time. (Nissan)

Methanol powered FFVs continue to have problems with formaldehyde at high mileage, especially at formaldehyde levels in the 15 mg/mi range. Aldehydes are generated in large quantities during catalyst light-off, therefore hardware with rapid light-off (e.g., close-coupled or electrically heated catalysts) will be required for FFVs. Other technical issues also need resolution before FFVs will be ready for production, including the fuel sensor, engine oil, vapor management, hot fuel handling, cold start and materials specifications. (Ford)

Agency Response: The lower reactivity of methanol fuel does give FFVs an advantage over gasoline in meeting the NMOG standard. However, gasoline-powered vehicles have already demonstrated NMHC levels well below the TLEV standard as described in the response to the first Comment in this Section. Nevertheless, if manufacturers choose to develop FFVs for TLEV certification, there is adequate leadtime to resolve issues such as component wear. Also, special engine oils have been developed and are being used in experimental FFVs. Regarding formaldehyde emissions, low-mileage vehicles participating in ARB-sponsored test programs have been able to achieve formaldehyde levels as low as 0.5 mg/mi under normal Federal Test Procedure ("FTP") temperatures. This may allow a sufficient cushion to meet the 15 mg/mi formaldehyde standard.

21. Comment: According to staff, TLEV standards will not necessarily require significant modifications to current engine design and control technology. Yet, for the 0.25 g/mi HC standard, it

concedes that dual oxygen sensors and close-coupled catalysts may be required. To further reduce cold start HC and CO emissions, use of heated PTC elements and combined air and fuel injectors is suggested. These changes require redesign of the intake manifold, additional hardware, and development time. (AIAM)

Agency Response: The strategies cited in the TSD are only suggested approaches to meet the low-emission standards. The ARB is confident that manufacturers will be able to design and develop an emission control system capable of meeting the TLEV requirements in the suggested timeframe as discussed in the response to the first Comment in this Section. Still, if there are doubts in meeting the fleet-average requirements for the initial years of the proposal, section 1960.1(g)(2) note (7) allows deficits incurred in meeting the 1994 model-year fleet-average requirement to be balanced by the 1997 model-year and deficits incurred in the 1995, 1996, and 1997 model-years to be balanced by the 1998 model-year.

22. Comment: Achieving TLEV standards on heavier vehicles with large displacement engines may require EHC systems and achieving LEV standards may require EHC systems on FFVs, contrary to the ARB's projections. (Nissan)

Agency Response: See response to the first Comment in this section.

23. Comment: The Staff Report makes broad claims on the potential improved fuel economy and reduced engine wear by using improved fuel preparation systems but there is no technical data, besides a few laboratory tests. In reality, the leaning capability may be limited therein limiting the amount of cold HC and CO reduction as well as other benefits. (AIAM)

Agency Response: Although substantial data on fuel economy and reduced engine wear are not available, heated fuel preparation systems have been of great interest to manufacturers worldwide over the past several years because of emission reductions, lower cost of emission control, and better cold starting and cold start drivability. One manufacturer certified an engine family to the same NMHC standard for two different model-years with essentially the same emission control system except a heated fuel preparation system was used instead of a close coupled catalyst on the later model. The emission reduction potential (as much as 55% reduction of HC) and the low cost of this technology make it an attractive option. Many vehicles utilize a relatively larger amount of fuel (lower air-fuel ratio) at cold start to compensate for the problem of cold engine starting which typically results in higher cold start emissions and higher fuel consumption. Heated fuel preparation systems can be used to improve cold starting and cold drivability with improved emission control through improved atomization of the fuel. However, manufacturers are not limited to the development of heated fuel preparation systems. Other potential emission control options are cited in the TSD.

24. Comment: Concurrent introduction of LEVs and ULEVs in 1997 is optimistic and counters the natural evolution of new technology; these standards should be ramped up slowly to accommodate effective piloting of new technology. (Ford, AIAM) Twenty-five percent year-to-year increases and concurrent introductions are too aggressive. (Ford)

Agency Response: Manufacturers are not required to simultaneously introduce LEVs and ULEVs. The fleet-average requirements provide the flexibility to delay LEV and ULEV introduction to the 1999 and 2000 model-years, respectively. We believe that the adopted schedule is reasonable since prototype technology to meet these standards already exists and there is ample leadtime for refinements and durability testing. For example, ARB test vehicles utilizing EHC technology have demonstrated emission levels below the ULEV standard. However, should technology developments to meet the low-emission standards falter, modifications to the regulations can be considered by the Board as part of the biennial review.

25. Comment: Emission data for the feasibility of heated fuel preparation systems and EHC technology on large cars, light-duty trucks, and medium-duty vehicles are not offered that justify setting the proposed lower standards. (Ford)

Agency Response: The ARB has already installed and tested an EHC system on a relatively large vehicle (a 3.8L Buick LeSabre) with emission levels consistently below the ULEV standards. Also, a 3.0L vehicle equipped with a heated fuel preparation system achieved a 30-50% reduction in hydrocarbon emissions. These data were presented at the Board hearing (Transcript, Day 1 pp. 20-22 and accompanying slides.) Based on axle ratio, tire size, and other engine load considerations, previous testing has shown that larger passenger cars and light-duty trucks have equivalent difficulty in meeting the standards. As such, the applicability and performance of heated fuel preparation systems and EHC systems on light-duty trucks should be comparable to that of larger passenger cars. The low-emission standards have been set proportionately higher for medium-duty vehicles, and with this adjustment we expect the technology to work adequately on larger vehicles. The EHC may be placed further downstream on medium-duty vehicles to withstand increased temperatures in the exhaust resulting from higher load conditions experienced by larger vehicles.

26. Comment: Meeting LEV and ULEV standards through use of EHC systems is dubious since this technology has not been well developed for practical use: the prolonged warm-up time may promote tampering, power requirements will necessitate improved battery technology,

increased weight of the battery may harm fuel economy, and durability of the EHC system has not been proven. (Chrysler, GM, AIAM, Mercedes, Nissan, Ford, Toyota)

Agency Response: With current ARB testing of EHC technology, a 10-20 second heating time has been achieved depending on the exhaust system configuration. Reduced heating times are expected in the very near future through use of capacitors now being developed to provide electrical energy more quickly to the EHC than conventional batteries. For example, Isuzu has developed a new "ultra capacitor" which they claim provides about 40 times the starting power of a conventional battery, is lighter, less expensive, will last at least ten years and recharges in less than 30 seconds. Emitech has developed an electrically heated catalyst system which does not require preheating. Further, remote control capabilities exist which will allow the EHC to begin heating as the driver approaches the vehicle before starting (e.g. remote alarm systems now in widespread use allow unlocking the vehicle using a transmitter). For these reasons, staff does not expect heating time to be an insurmountable issue.

Although the EHC does have significant power requirements, ultra capacitors can provide the necessary power instantaneously. Also, high capacity batteries available today can provide sufficient power, though at a slightly slower rate than an ultra capacitor.

Durability characteristics of an EHC would be comparable to that of conventional catalysts since the metal substrates used are similar. Also, as a conventional catalyst ages, the amount of heat required to achieve an adequate level of effectiveness increases. This increase in "light-off" time results in higher emissions as the catalyst ages. However, the ARB is testing the EHC system with preheating to a high initial temperature to compensate for this aging effect; this could then yield lower deterioration than conventional catalysts. Durability of the EHC system is currently being evaluated through mileage accumulation of ARB test vehicles.

27. Comment: The ARB assumes that ULEV standards can be achieved through use of EHC technology in conjunction with improved fuel preparation systems on alternate-fueled vehicles as well as through use of electric vehicles. As stated before, the EHC system is not developed and Chrysler's only alternate fueled vehicles being researched, M85 vehicles, do not show promise in meeting very stringent NMOG standards. Furthermore, although Chrysler is considering production of the electric-powered TEVan, it will not be developed and ready for sale by the ULEV deadline. (Chrysler)

Agency Response: Since current demonstration programs of M85 vehicles indicate that there are no extensive development needs and sufficient leadtime has been provided to complete the development of EHC systems, ULEV standards may be achieved through use of the EHC system on M85 vehicles. Testing of a fuel-flexible Chevrolet Corsica equipped with an EHC system has shown emission results on M85 (prior to reactivity adjustment) as low as 0.018 g/mi NMOG.

Besides dedicated electric vehicles such as the TEVan, the ULEV standard may also be achieved by hybrid electric vehicles. This strategy is being pursued by General Motors which is committed to producing the Impact electric vehicle and possibly a hybrid electric vehicle, probably by the mid-1990s. Even though the suggested introduction schedule of ULEVs occurs in the 1997 model-year, manufacturers have the flexibility in the averaging program to delay production of ULEVs to the 2000 model-year should more leadtime be needed.

28. Comment: The ARB claims that the high temperature resistance of today's advanced catalysts will allow for equivalent in-use performance of EHCs. This is not a valid conclusion because of effects such as telescoping of the unbrazed metal substrate. (Ford, Toyota)

Agency Response: Although the issue of "telescoping" of the catalyst was a problem for initial EHC designs, a new design has been developed which offers a higher degree of protection from telescoping under high temperature conditions. This design utilizes stronger metal supports within the catalyst to prevent this problem. Several other mechanical designs have been developed which mitigate concerns about mechanical stability, e.g., the Emitech catalyst design. Regarding deterioration in catalyst activity, the ARB is testing an EHC system utilizing higher initial temperature preheating to compensate for aging effects typical of conventional catalysts with similar metal substrates. Durability of EHC systems on ARB test vehicles is currently being evaluated through mileage accumulation.

29. Comment: The feasibility of the 0.2 NOx standard is very questionable on a long term in-use basis. (Ford, GM) The ARB staff does not identify a technical approach to achieve 0.2 g/mi NOx. CNG vehicles have less capability than gasoline-powered vehicles to meet this level as experienced by Ortech International. (Ford)

Agency Response: In Chapter II.B.6. of the TSD, staff identified many certified engine families which have achieved NOx levels below 0.10 g/mi using conventional technology. Low NOx levels may be maintained in-use through the use of dual oxygen sensors and increased catalyst loading of Rhodium with improved washcoat durability. Some 1991 model-year certified passenger cars utilizing three-way catalysts, heated oxygen sensors, EGR, and electronic fuel injection have NOx certification levels at 0.03 g/mi. These technologies may be developed for use with CNG systems to meet the 0.2 g/mi NOx standard for LEVs, or other strategies may be explored since there is adequate leadtime for design and development before compliance with 0.2 g/mi NOx may be needed. However, manufacturers are not limited to the development of CNG vehicles to meet the ULEV standard.

30. Comment: The data on CNG vehicles indicate that NMOG levels range from 0.1 to 0.2 g/mi; hence there appears to be some question in achieving the NMOG standards. Also, system cost, weight and volume, engine modification, vehicle range, and vehicle safety compliance must be resolved. (Ford)

Agency Response: A number of CNG vehicles in the ARB's test fleet have consistently achieved NMOG levels below 0.1 g/mi (before reactivity adjustment). Although there may be a higher initial cost, this may be offset by the lower cost of the fuel and maintenance. The weight of the CNG tank and the volume it occupies may make CNG more suitable for larger vehicle applications. However, it is possible to redesign the tanks for passenger car applications to maintain reasonable cargo space. Further, the overall weight may be reduced by using lighter-weight tanks such as composite-reinforced aluminum tanks which are approximately 25% lighter than commonly used composite steel tanks. Ample leadtime and flexibility are offered so that engine modification issues can be resolved. We acknowledge that since the energy content per fuel gallon of CNG is less than gasoline, the operating range is effectively reduced. However, vehicles may be designed to carry more fuel or operate on both gasoline and CNG to increase the operating range. Also, safety compliance is not a major concern since CNG vehicles have been widely used for many years without significant safety-related mishaps.

31. Comment: Our engineering efforts could lead to a diesel vehicle meeting the 0.08 g/mi particulate standard, with hydrocarbon emissions potentially at the ULEV standard, significantly lower CO emissions, no evaporative emissions, and superior CO_2 emissions. The only difference between such engine technology and gasoline technology is the inability of the diesel engine to meet the 0.4 NOx emission limits. Therefore the staff should be directed to report back with a specific proposal for future light-duty diesel standards which would reduce the NOx standard to a technologically-feasible level, while achieving maximum hydrocarbon and particulate reductions.

In addition, the 0.04 g/mi particulate standard cannot be technologically justified and should be proposed with alternative diesel standards at a later date. (Mercedes)

Agency Response: Although the ARB recognizes some inherent benefits of diesel engines, the adopted regulations are designed to be fuel neutral. The same standards apply to all vehicle-fuel combinations, on a reactivity-adjusted basis. Therefore, it would be inappropriate for the ARB to make special allowances for vehicle/fuel systems incapable of meeting the standards when other potential technologies exist to meet the standards, as discussed in the response to the first comment in the Technological Feasibility section. Further, should manufacturers chose to develop diesel vehicles to meet the ULEV standard, there is adequate leadtime before the production of ULEVs may be needed.

32. Comment: Staff should work closely with manufacturers to review data on emerging technology so that California consumers will not be forced to accept technology which will not hold up in the field. (Mercedes)

Agency Response: The ARB staff has been working closely with vehicle manufacturers on these issues, and will continue to do so.

2. Zero-Emission Vehicles

33. Comment: As a result of slow battery technology developments, there is significant doubt about the likelihood of new advanced battery technology being available in the time mandated under the regulations. This would have a dramatic impact on the potential consumer acceptance of such technologies, as well as the staff's cost projections. (Mercedes). State-of-the-art electric vehicle technology has been demonstrated to provide limited driving range, poor performance and costly operation, which would lead to unfavorable consumer acceptance. (VW, Toyota). Concerns with electric vehicles include battery weight, volume, life, cost, and vehicle range limitations. (Ford) The ZEV mandate could be unproductive because they could irreparably harm the consumers' view of the new technology. (Ford, Nissan) The Board should drop the ZEV requirement and consider it a goal. (Mercedes, Ford, Chrysler, Volvo)

Agency Response: The efforts to develop battery technology in the past, although significant, have not been pursued with the intensity that the ZEV mandate ensures. General Motors, Chrysler and Ford have initiated a consortium for the advancement of battery technology with a possible budget of $190 million over the next three years. Current research efforts have been concentrated towards development of more commercially viable advanced batteries. Since the ZEV requirement does not apply until the 1998 model-year, there is sufficient time to develop better-performing batteries. Additionally, General Motors has indicated it plans to introduce its Impact electric vehicle by 1996, and this vehicle is competitive in performance to gasoline-powered vehicles, although battery life is less than desired. The increased cost of electric vehicles is expected to be minimal as GM, for one, is working hard to make electric vehicles competitive in the marketplace. If the ZEV mandate was dropped and left to be considered a goal, the efforts cited above and the technological advancements necessary to meet ARB's air quality goals would most likely be delayed.

34. Comment: The cost of operating electric vehicles on foreseeable battery technology in Europe has been $1/mile. These costs have not been factored into the staff analysis. (Mercedes)

Agency Response: The low cost of electricity in California is one of the factors expected to make electric vehicles appealing to the consumer. We estimate the operating cost of an electric vehicle in the 2000 model-year to be $0.024/mi compared to $0.057/mi for premium gasoline meeting current fuel specifications. The electric vehicle operating cost includes the cost of conversion losses in producing electricity at the power plant and the cost of installing an outlet to dispense electricity. This calculation is derived from data in Chapter IX of the TSD, assuming a 24.3 mi/gal vehicle efficiency. Other assumptions on electric vehicle efficiency are provided in Appendix B-1 of the TSD. Southern California Edison has been considering a special lower rate for off-peak hour charging which may reduce this cost even further.

35. Comment: Considering the current state of battery technology, the incremental additional cost of an electric vehicle will be $6,000 to $20,000, and not $1,300 as staff predicted. (Mercedes, Chrysler)

Agency Response: The ARB's cost estimates for electric vehicles are based on consultation with experts from Aerovironment, an engineering firm involved in the development of the GM Impact electric vehicle. These estimates take into account high production volumes and technological advancements expected by the year 2000. The higher incremental costs claimed by manufacturers would apply only to today's conditions where technology needs development and there is no volume production of electric vehicles. Lower priced, better performing batteries are expected to emerge from research programs such as the United States Advanced Battery Consortium. Electric vehicles of the future are also expected to operate more efficiently and, thus, be less demanding of the battery. As the ZEV production requirements increase, vehicular cost will decrease.

36. Comment: In order to encourage the use of electric vehicles, an alternate program, not intended to substitute electric for gasoline vehicles, is more sensible and could be established without mandatory sales and purchase requirements. Electric vehicles can be successfully introduced into the marketplace after a concerted research effort and public demonstration program in cooperation with government, universities, and industry is completed. (Toyota) The requirement to produce ZEVs should be eliminated. However, manufacturers should be given credit for production of electric vehicle technology. This would provide an incentive for the development of such vehicles. (Honda)

Agency Response: The primary objective of the adopted regulations is to achieve substantial emission reductions in an attempt to attain the state and federal ambient air quality standards. Therefore, the ARB has established stringent, yet technologically feasible, vehicle emission standards. Although the ARB is not requiring electric vehicles to satisfy the ZEV mandate, electric vehicle technology exists and, in fact, has been utilized for many years in selective applications. The 1998 model year implementation date for the ZEV requirements allows sufficient leadtime to refine this technology for widespread commercial use. It was necessary to establish the ZEV mandate in order to assure the development of vehicles with zero emissions in-use. Without the mandate, the emission benefits through large-scale use of ZEVs could not be achieved.

37. Comment: Since current technology electric vehicles cannot replace conventional vehicles and may only be used for limited purposes, the ZEV mandate will not contribute significantly to air quality improvements. Also, if fleet-average standards are imposed, the mandate is superfluous and unjustified. (Nissan)

Agency Response: Current technology electric vehicles, such as General Motors' Impact, are very competitive in performance with conventional vehicles. Although battery life is a concern, electric vehicles require less maintenance and the cost of recharging is much lower than fueling requirements of conventional vehicles. The energy capacity of current batteries is limited, but the average commute trip is well within the operating range of an electric vehicle on a single charge. With the lead-time provided, issues regarding battery life are expected to be resolved. Large-scale production will reduce the cost of an electric vehicle, and strategies to resolve infrastructure issues are being considered by a number of utilities. For these reasons, there is little concern of the commercial viability and public acceptance of electric vehicles.

The fleet-average requirement will ensure substantial emission reductions regardless of the vehicle emission category mix. However, we believe that the significant penetration of ZEVs is crucial to long-term attainment of the ambient standards in the South Coast, and there is no assurance that ZEVs will be developed without the limited, measured ZEV sales requirements in the regulations. Also, greater overall emission reductions are expected through use of ZEVs since, unlike conventional vehicles, ZEVs have no emission deterioration in-use.

38. Comment: We do not believe a specific mandate requiring certain percentages of production to be ZEVs is appropriate. This kind of regulation is a technology mandate and not an emission performance mandate since internal combustion engines cannot possibly have zero emissions under all conditions and no other technology exists to meet ZEV requirements. (GM) We are uncomfortable with mandated electric vehicle production. Your goal is low emissions, and mandating certain technologies to achieve that may not be the best way to get there. (Aerovironment)

Agency Response: Manufacturers are not limited to the development of electric vehicles or refinement of internal combustion systems to meet the ZEV requirement. Other technologies such as fuel cells may be developed to meet the ZEV mandate. As such, the ZEV mandate is not a technology mandate. Although these technologies require further development for commercial application, ZEV production requirements do not begin until the 1998 model-year, and ZEV credits may be bought to satisfy the mandate if a particular manufacturer needs additional leadtime.

39. Comment: Emissions which may occur at the point of electricity generation for ZEVs should be taken into account and the vehicle consequently reclassified as an LEV or ULEV as appropriate. (EDF) It is important to acknowledge that electric vehicles are not zero-emission vehicles. We cannot ignore the emissions from power plants. (CCA, VW)

Agency Response: All motor vehicle power sources have some emissions associated with their generation and/or distribution. For instance, there are refinery emissions associated with the production of gasoline. For the purposes of establishing standards for the various tiers of low-emission vehicles, we believe it is appropriate to look only at exhaust emissions of the vehicles. In doing so, we do not intend to suggest that there are no emissions associated with the generation of electric power for electric vehicles. However, when such emissions are taken into account, emissions per electric vehicle are still substantially less than the ULEV standards.

40. Comment: The emissions resulting from use of auxiliary heaters in electric vehicles are negligible, and these vehicles should therefore qualify as ZEVs. (SCE, Aerovironment, GM, Ford) This would create an incentive for the production of these vehicles. (SCE) An electric vehicle with a fuel-fired heater would not be used during high ozone periods when ambient temperatures are abnormally warm. (GM)

Agency Response: By definition, zero-emission vehicles produce no emissions of any criteria pollutant under all operational modes and conditions throughout the life of the vehicle. Therefore, if electric vehicles utilizing auxiliary heaters have negligible emissions at certification and can demonstrate that there is no increase in emissions resulting from deterioration of the heater, the Board could consider amending the regulations in the future to designate such vehicles as zero-emission vehicles. However, we need to develop more information regarding heaters for electric vehicles and their emissions before a modification to the regulations would be appropriate.

It is not certain that heaters would not be used under seasonal conditions which are likely to include high ozone days. As noted on page 27 of the Staff Report, in the South Coast Air Basin morning low temperatures drop to about 50°F. This is low enough for there to be a reasonable possibility that heaters may be used by some motorists.

41. Comment: The Federal Motor Vehicle Safety Standard 103 requires vehicles to have defrosting and defogging capabilities.

Could electric vehicles do this and would anyone in California buy a car without air conditioning? With all this, is there really such a thing as a ZEV? (AIAM, Volvo)

Agency Response: Electric vehicles may utilize power from the battery to operate air conditioning, heating, defrosting and defogging units without depleting the energy supply to a great extent. Current experimental high-efficiency heat exchanger units allow continuous operation of an electric heater or air conditioner while sacrificing as low as 10% of the vehicle range. Further refinement of these systems may reduce this power requirement even further. Since these systems derive power from the battery alone, the electric vehicle would still qualify as a ZEV.

42. Comment: For electric vehicles utilizing auxiliary combustion heaters, where is the test procedure outlined for these heaters and what standard would they have to meet? (AIAM)

Agency Response: Testing requirements for electric vehicles utilizing auxiliary combustion heaters have already been provided in the LDV/MDV Test Procedures, section 4.b.2. Manufacturers will be required to determine, based on the minutes per mile of the CVS test cycle, the emissions per mile resulting from use of the auxiliary heater. Based on the emissions from the heater, a statement of the standards to which the vehicle complies will be required at certification.

43. Comment: Based on current research of ZEVs and short-range HEVs, it may be counterproductive to promote ZEVs or HEVs with long electric-only ranges. Due to these uncertainties, the HEV and ZEV regulations should be proposed after more research is done in this area. (HEV)

Agency Response: The ZEV minimum production requirements were established to promote development of vehicles with zero emissions in-use. Should manufacturers select electric vehicle technology to meet the ZEV standards, the ZEV requirements will ensure the necessary battery development for production of competitive electric vehicles with adequate driving range. Since the ZEV production requirement occurs in the 1998 model-year, sufficient lead-time has been provided for developing battery technology. Depending on the degree of success in developing batteries with greater energy storage capability, the credits provided to hybrid electric vehicles for their minimum operating range when operating on batteries only can be modified. For now, the ARB wishes to maintain incentives for developing better batteries rather than prematurely providing hybrid vehicles with credits for a mediocre operating range before the on-board engine is activated.

44. Comment: HEVs that have an internal combustion engine as a backup source should be counted toward the ZEV mandate if the HEV is operated on its zero emission energy source most of the time. At the very least, they should be counted toward the ZEV mandate based on the percentage of battery versus engine operation. (GM) HEVs that can operate at least 40 miles on a battery charge should be designated as ZEVs. (SCE)

Agency Response: The adopted regulations reflect a conservative stance toward special provisions for HEVs because, unlike ZEVs, HEV emissions are expected to deteriorate in-use due to the existence of the auxiliary engine. Also, as batteries deteriorate in HEVs, use of the auxiliary engine would probably increase. Incentives to produce HEVs, such as allowing HEV credits to substitute for the ZEV mandate, will delay battery development for better performing ZEVs (and, therefore, HEVs). However, since HEV development is in the initial stages, the ARB staff plans to maintain communications with manufacturers to discuss how HEV and ZEV regulations might be modified as development of these vehicles progresses.

45. Comment: Electric vehicles should be SHED tested during their charge cycle to ensure that there are no noxious or toxic emissions. (Arco)

Agency Response: Since development efforts have been expended for a variety of battery technologies and electric vehicle systems, this may be a valid concern. The ARB staff will look into this issue and will recommend a regulatory approach if needed once the necessary data have been gathered. Regulatory action is not needed at this time because of the long leadtime before the ZEV minimum production requirements begin with the 1998 model year.

46. Comment: Intermediate volume manufacturer ZEV requirements begin in 2003 at 10%. We have a significant question as to the ability of medium-sized manufacturers to instantaneously develop a market representing 10% of their California sales during the first year of introduction of ZEVs. Therefore the requirement should be reduced to 2%, as is the case for large volume manufacturers. (Mercedes)

Manufacturers the size of Volvo cannot justify the development efforts for an electric vehicle over an annual production of approximately 400 vehicles. These vehicles will be high priced and difficult to market. Also, our current Volvo market cannot be served by electric vehicles because of limited range and utility. (Volvo)

Agency Response: A delay of five years for compliance with the ZEV mandate was provided to intermediate volume manufacturers (§ 1960.1(g)(2) note (9)d.) in light of their limited resources to develop and produce ZEVs. Since many of the significant concerns such as vehicle design uncertainties, battery development requirements (in the case of electric vehicles), marketing concerns, and vehicle production needs would be resolved by large volume manufacturers by the 2003 model-year, it is unnecessary for intermediate volume manufacturers to have a lower percentage requirement of ZEVs <u>and</u> five years additional lead-time. Manufacturers also have the option to buy ZEV credits if production requirements cannot be met in the proposed timeframe. However, if large volume manufacturers encounter difficulties in complying with the ZEV mandate, the Board can consider subsequent amendments to the regulations, including appropriate accommodations for intermediate volume manufacturers.

3. <u>Medium-Duty Vehicles</u>

47. <u>Comment</u>: The same technical concerns we have raised regarding low-emission vehicle technology for light-duty vehicles apply to MDVs with the added challenge of the rigorous duty cycles for which they must be designed. The task will be made even more difficult by the ARB's new requirements, starting with the 1995 model year, that the MDV category include 6,000-14,000 gross vehicle weight ("GVW") instead of 6,000-8,500 GVW. (Chrysler)

<u>Agency Response</u>: See generally the responses to the comments on technological feasibility of the standards for light-duty vehicles in III.B.1. Factors such as the stringency of MDV standards vs. light-duty vehicle standards, the operational characteristics and typical loading of MDVs, the technological feasibility of more stringent standards and chassis dynamometer testing for light-heavy-duty vehicles were taken into account when the revisions to the MDV standards and test procedures were approved by the Board in June 1990. Additionally, the revised MDV standards reflect the more rigorous duty cycle and expanded weight range of MDVs. The implementation schedule of the MDV regulations requires partial compliance with these standards by the 1995 model-year and 100% compliance at certification by the 1996 model-year.

Since the MDV low-emission requirements begin in the 1998 model-year and since light-duty vehicle low-emission technology will probably be well developed by that time, there is sufficient leadtime to apply this technology to low-emission MDV applications. Some of the proposed low-emission light-duty vehicle technology has already been tested with promising emission results as described in the response to the first comment in III.B.1. Also, to account for the more rigorous duty cycle of MDVs, the percent reduction in NMOG required for medium-duty ULEVs is less than that for light-duty ULEVs compared to the conventional standards (70% vs. 84%). As such, we believe that the low-emission MDV standards and implementation schedule are reasonable.

48. <u>Comment</u>: The MDV standards are based on a false assumption that recent advances in emission control technology for light-duty low-emission vehicles are easily transferable to MDVs. Light-duty

vehicles and MDVs differ in loading, operating cycles and often the operating fuels used. There currently are no data to demonstrate that devices such as catalytic converters used on light-duty vehicles are technologically feasible for all MDV applications. With respect to diesel-fueled medium-duty vehicles, industry has had limited development experience and even less production experience with after-treatment devices. Further development work is required before such devices can be considered commercially viable. It is premature for the Board to rely on experimental after-treatment devices applied to passenger cars to demonstrate technological feasibility of the LEV and ULEV standards for either gasoline- or diesel-fueled medium-duty vehicles. (MVMA/EMA)

The phase-in schedule proposed for MDVs is too ambitious. The percentage of LEV phase-in should start with less than 25%, and ULEVs should start their phase-in after LEVs have been introduced. (Ford)

Agency Response: Some effective light-duty vehicle emission control technology has already been successfully applied to certified MDV systems, e.g., feedback fuel control, exhaust gas recirculation, air injection, and three-way catalysts. Since some proposed technologies for meeting the light-duty low-emission standards are currently being tested and show promising emission results, the development effort needed to configure these systems for MDVs should not be excessive. For example, an electrically-heated catalyst can be placed further downstream to avoid higher exhaust temperatures associated with MDVs. Should manufacturers choose not to take this approach, development of bypass catalyst systems is an option. Heated fuel preparation systems such as the one used by Mercedes simply provide more efficient use of fuel through improved atomization and should not be affected by heavier load conditions. Manufacturers also have the option to develop alternate fuel systems such as natural gas. In this case, less advanced emission control technology may be needed since these fuels characteristically have cleaner hydrocarbon exhaust. CNG-powered test engines have already demonstrated emissions at or very near low-emission levels. Many fleet operators convert MDVs to operate on LPG and CNG since the additional carrying capacity of MDVs allows for on-board tanks, and the fuels are less expensive than gasoline. Other alternative fuel systems such as methanol may also be explored to meet the low-emission MDV standards.

49. Comment: The standards for MDVs approved in June, 1990 should be completely phased-in before new low-emission standards are implemented. (Chrysler)

Agency Response: Manufacturers are required to certify 100% of their MDVs to the standards approved in June, 1990 by the 1996 model year. The alternative in-use standards apply only through the 1997 model year and, thereafter, 100% compliance with the certification standards is required in-use. Since the MDV low-emission standards do not take effect until the 1998 model-year, the June, 1990 standards will be completely phased-in before the low-emission standards are implemented.

50. Comment: The MDV standards should be proposed in two to four years, after both the ARB and industry have had an opportunity to develop data necessary for the standards' meaningful adoption. (EMA/MVMA) If this is not acceptable, the Board should formally resolve to reassess the technological feasibility of the proposed standards biennially starting in 1992. (EMA/MVMA)

Agency Response: The technological feasibility of the low-emission standards for MDVs is discussed in the responses to the first two comments in this Section. Also, ample lead time has been provided since MDVs will have until the 1998 model-year to comply with the lower standards. The ARB is reluctant to delay implementation of these standards since it would probably mean a delay in the efforts to reduce emissions from MDVs. Because this is a long-range plan, the status of implementation of the regulations will be biennially assessed by the Board in accordance with the directive in Resolution 90-58, and any necessary changes may be considered during or as a result of such reviews.

51. Comment: The proposed standards for ULEVs are so low that the sulfur content of diesel fuel may still prohibit the manufacturers' ability to achieve the particulate emissions standard. The realities of the combustion process simply make it impossible to operate or design an engine which will run on certification fuel with a 0.05% sulfur content and meet the proposed standards in use. In addition, the use of lubricating oils contributes to particulate emissions irrespective of the fuel used. (EMA/MVMA) 30 to 60% of the proposed 0.05 g/bhp-hr particulate standard will be eaten up by fuel-produced sulfates and test measurement variability over which the manufacturers have little control. We see the ULEV particulate standard as technically unfeasible. Similarly, we do not believe that the combined NMHC+NOx standard of 2.5 g/bhp-hr is feasible. (Navistar)

Agency Response: Vehicle manufacturers are not limited to the development of diesel systems in order to meet the medium-duty ULEV standards. Based on current information, medium-duty ULEV levels may be more easily achieved by vehicles operating on cleaner fuels. The heavy-duty engine test results cited on page II.18 of the TSD show particulate levels of 0.01 to 0.06 g/bhp-hr from CNG engines and 0.02 to 0.08 g/bhp-hr from methanol engines. These data also show that CNG engines are capable of achieving NMHC+NOx levels as low as 1.37 g/bhp-hr. However, it may be possible for diesel vehicles to achieve ULEV emission levels through use of catalyzed particulate traps. In fact, of the numerous trap systems being investigated, a particulate level of 0.05 g/bhp-hr has been recently demonstrated using the Donaldson Dual Catalyzed Trap Oxidizer System on a DDC bus engine. Since ULEV standards will not become effective until the 1998 model-year, there is ample time to develop this technology or explore other options to meet ULEV requirements. Moreover, under the regulations no more than 15% of the 2003 and subsequent model-year MDVs must meet the ULEV standards. In any case, should the medium-duty requirements prove to be overly optimistic, the standards can be reconsidered subsequently, including when staff proposes further reductions of the heavy-duty standards in 1992.

52. Comment: The proposed primary MDV 50,000 mile emission standards are not technologically feasible for diesels. Without providing any air quality justification or a determination of feasibility, the staff has proposed reductions for diesel MDVs significantly more severe than those proposed for gasoline engines and vehicles. This reflects an arbitrary preference for gasoline over diesel. Given the current proposed primary standards, the option provided by the regulations to certify engines according to the federal test procedures is the only means by which diesel engine manufacturers can even attempt to meet the proposed standards. The recently adopted MDV standards for the 1995 model year only require diesel engines to meet 120,000 mile emission standards, not the 50,000 mile standards applicable to gasoline engines and vehicles. We recommend that the Board revise the low-emission vehicle proposal so that diesels certified to the primary standards need not meet the 50,000 mile LEV and ULEV standards but only the 120,000 mile standards. This would make the proposal comparable to the 1995 model-year MDV standards. (MVMA/EMA)

Agency Response: In the recently adopted MDV regulations, it was determined that, although diesels showed higher emissions than gasoline systems at 50,000 miles, lifetime diesel and gasoline emissions are approximately equal; therefore, diesels were required to meet only the 120,000 mile standards. However, because the deterioration characteristics of emission control systems likely to be used on diesels to meet the low-emission standards are more sophisticated than those used to meet less stringent emission standards, they are also subject to potentially greater deterioration (e.g., particulate traps and catalysts on heavy-duty engines will likely exhibit deterioration characteristics similar to the emission control systems of conventional fuel). Therefore, it is necessary to establish 50,000 mile as well as 120,000 mile standards. Also, adding a special provision for diesel MDVs to comply only with the 120,000 mile exhaust emission standards would be inconsistent with the concept of fuel neutrality recommended by the AB 234 Advisory Board on Air Quality and Fuels. Since the adopted regulations have been structured around this concept, it would be inappropriate to make special provisions for diesel vehicles.

It is not correct to say that we have proposed no air quality justification for the MDV standards. The air quality justification is the need to reduce emissions of ozone precursors and other pollutants because of the frequent exceedances of ambient air quality standards in the state, particularly in the South Coast. The technological feasibility of the MDV standards is discussed in the responses to the first two comments in this Section; the feasibility of the ULEV particulate standard is discussed in the response to the preceding comment.

53. Comment: As the proposal states, the AB 234 Advisory Board recommended that clean fuel technologies be introduced through state regulation. What the proposal does not state is that the Advisory Board also specifically recommended that heavy-duty vehicles be excluded from any clean fuel technology because of diesel engines' and diesel fuels' unique ability to meet the durability and fuel-economy needs of heavy-duty vehicles. The "heavy-duty" vehicles defined in the report included vehicles of 6,001 to 14,000 pounds GVW, the category which has been reclassified as "medium-duty" and included in this proposal. (MVMA/EMA)

Agency Response: The Advisory Board recommended that the ARB propose fuel-neutral regulations for the heavy-duty sector one year after proposing regulations for the light-duty sector. The one-year delay in proposing low-emission heavy-duty regulations would allow ARB enough time to incorporate results from ongoing demonstration programs. Although the revised MDV category (which had included vehicles in the 6,001-8,500 GVW range) includes a portion of vehicles previously considered heavy-duty (i.e., 8,501-14,000 GVW), we believe that the current technical status and potential capabilities of vehicles in the expanded weight range will allow the low-emission standards to be achieved within the proposed timeframe. The technological feasibility of low-emission MDVs has been detailed in the responses to the first two comments in this section. As such, the ARB's actions are consistent with the intent of the Advisory Board's recommendations.

54. Comment: Fleet averaging should be extended to MDVs. (GM)

Agency Response: The fleet averaging concept for MDVs may not benefit manufacturers compared to averaging for the light-duty category. Since there are relatively more engine families within a light-duty test weight class, manufacturers may choose to certify to the TLEV, LEV, and/or ULEV standard(s) and may vary production volumes to meet the fleet average. For MDVs, however, there are very few engine families within the same emission standard test weight category and, hence, there is little opportunity for averaging. However, the proposal does provide flexibility in the means of compliance by requiring phase-in based on percentages of LEVs and ULEVs to meet the lower standards regardless of which emission standard test weight class the vehicles may fall in. In other words, the phase-in percentages apply to the entire group of MDVs rather than each standards category based on weight class separately.

55. Comment: The small range for each weight classification of medium-duty trucks along with the prohibition of a fleet average

system can result in excessive complexity and may not be.containable from a calibration standpoint. A reduction in the number of classifications, and an averaging system, would significantly reduce workload and minimize the chances for a given vehicle to fall into multiple categories due to option content or engine choice. (Ford)

<u>Agency Response</u>: Separate emission standards have been established for each MDV test weight category to account for the varied vehicle loading characteristics of MDVs. If these categories were to be consolidated, the emission standards would be more difficult to achieve for a heavier MDV than a lighter MDV in the same test weight category. Tailoring emission standards for each category benefits manufacturers in that the stringency of the standards for all MDVs is generally comparable. The compliance scheme for MDVs provides flexibility in that only a specified percentage of LEVs and ULEVs is required regardless of the test weight category. The rationale for not allowing MDV fleet averaging is set forth in the response to the previous comment.

4. <u>Flexible-Fuel Vehicles</u>

56. <u>Comment</u>: Should FFVs be considered "clean-burning" vehicles even though they would be allowed to emit twice the quantity of ozone-forming emissions when they burn conventional gasoline rather than a "clean fuel" or should FFVs also meet more stringent emission standards when using gasoline? (Maddy, Johnson, Brown, Arco, WSPA) ~~We believe they should have to give the same ozone emissions on both~~ fuels. (WSPA) The proposed treatment of FFVs creates a clean air loophole. (Arco)

<u>Agency Response</u>: The reasons for the the two-tiered NMOG standards for FFVs are set forth on pages 21-22 of the Staff Report. FFVs are considered to be transitional vehicles. As such, requiring an FFV to meet the same NMOG standard when operating on both gasoline and an alternative fuel would force the vehicle manufacturer to optimize the emission control system for gasoline, and thus discourage the introduction of alternative fuel vehicles. The clean fuel elements of the proposal are designed to assure that sufficient clean fuels are available so that the maximum air quality benefits associated with the low-emission standards are achieved from vehicles capable of operating on a clean fuel.

57. <u>Comment</u>: The staff proposal for FFV certification is to require certification on conventional gasoline as well as M85, but at "one whole tier" higher on gasoline. This could cause a shortfall from possible or projected emission reductions. We recommend a two-phase solution. In Phase I (short term), the conventional gasoline certification standard for FFVs would be only one-half tier above the "clean fuel" standard for FFVs. The half-tier is based on our present belief that M85 exhaust is about 25% to 30% less reactive than conventional gasoline exhaust. This would result in reduced

emissions. It should not significantly raise the cost of an FFV, while it increases the likelihood that reformulated gasoline can have the same ozone effect in the FFV as M85. In a longer term Phase 2 requirement, FFVs should be certified on reformulated gasoline and M85 at the same emission standard. (Arco)

Agency Response: Manufacturers already face a burden in meeting the fleet average NMOG emission standard for 1994-1996. Manufacturers choosing to meet the TLEV standard by modifying gasoline-powered vehicles to FFVs may not have sufficient leadtime to develop the clean fuel system and refine the gasoline control system as well to meet a lower standard. Although the ARB has certified vehicles having emission levels below the TLEV standard, these are gasoline-dedicated vehicles having small engines which are optimized for gasoline operation rather than multiple fuels. Also, FFVs are expected to operate on the alternative fuel most of the time in light of the clean fuel elements of the adopted regulations. In order to achieve the emission reductions expected from the low-emission vehicle and clean fuel program, it is beneficial to encourage more development effort in optimizing the clean fuel system instead of the gasoline system. Since alternative fuel systems need less emission controls relative to gasoline, the commenter's proposal could burden FFVs with additional weight and increased cost from the use of more gasoline emission controls.

58. Comment: Under the proposal, whether dual-fueled vehicles will actually be low-emitting depends critically on consumer choice. Additional requirements, possibly aimed at vehicle manufacturers through the certification procedure, are needed to ensure that clean fuels are, in fact, consumed in sufficient quantities by owners of dual-fuel vehicles. (EDF, CCA)

Agency Response: Since FFVs allow consumers the choice to use gasoline or the clean fuel, measures which can be taken at certification to ensure consumption of the clean fuel are limited. However, this issue is addressed in the regulations by the provisions assuring adequate availability of clean fuels. Also, the Executive Officer will continue to evaluate the clean fuel elements to assure that sufficient quantities of clean fuels are distributed such that the maximum air quality benefit is achieved from low-emission vehicles capable of operating on a clean fuel.

59. Comment: We are opposed to the proposal that auto manufacturers be given full credit towards their low-emission vehicles production requirement for sales of FFVs. Clearly these vehicles will only be operated on the cleaner fuel part of the time. We propose that partial credit be awarded based on the vehicle's performance on both fuels. For example, a car that meets the ULEV standard on one fuel but only meets the TLEV standard on the other will be counted as one half ULEV and one-half TLEV. The fractional credit could be adjusted to reflect actual sales of each fuel. This will provide an

incentive to make FFVs as clean as possible and will more accurately reflect what the real air quality benefits are likely to be. (EDF)

Agency Response: Although this suggestion is intended to provide an equitable means of treating FFVs, it would be difficult to implement. There is no mechanism for manufacturers to determine, with certainty, the fuel being used and in what quantities. The uncertainties in this suggested process would make planning for new models all but impossible since such decisions are made three to four years prior to production. The suggested method of adjusting FFV credits based on fuel sales would imply that all FFVs consume the same percentage of clean fuel, regardless of the manufacturer, model-year, and vehicle design.

The commenter's hypothetical situation involves a car that meets the ULEV standard on a clean fuel and the TLEV standard on another (presumably gasoline). The adopted regulations do not permit certification of such a vehicle because when FFVs are run on gasoline they must meet an NMOG standard no more than one tier higher than the clean fuel certification standard (e.g., an FFV certified to the ULEV standard on clean fuel must meet the LEV standard on gasoline). The regulations therefore will result in less of a potential emissions difference depending on the fuel used than would the situation envisioned by the commenter.

5. Reactivity Adjustment

60. Comment: The validity of the maximum incremental reactivity ("MIR") method is questionable. It should be more fully evaluated and tested before it is incorporated into the regulations. (GM, WSPA, Arco) Prior to being considered for adoption the methodology should be given scientific peer review by the ARB's Modeling Advisory Committee ("MAC"), and workshopped both with industry in general and local regulatory agencies. (Texaco)

Agency Response: The rationale and basis for the MIR approach is set forth in Part C of the TSD. Of the many reactivity adjustment approaches considered, results from the MIR method were most comparable to those of airshed modeling which incorporates all known considerations of environmental conditions. However, the MIR method offers advantages over airshed modeling in that it is a much more simplified approach and the results can be obtained in a shorter period of time. Also, airshed modeling is limited to a particular episode being modeled. We believe that an adjustment for reactivity is an important and necessary component of the low-emission vehicle regulations, and that the MIR approach is sufficiently developed to be included in the regulations.

Prior to proposing the regulations we conducted multiple workshops on the MIR concept, and the public has had an opportunity to comment on it in this rulemaking. The MIR approach is continuing to undergo scientific peer review, and any appropriate modifications that are identified through further evaluation can be considered by the Board in a future hearing. We do not believe it would be appropriate for the MIR approach to be formally peer reviewed by the MAC. In establishing the MAC the ARB expected that it would provide technical advice and guidance to the staff in modeling related areas, but not be involved in ongoing regulatory issues expected to come before the ARB.

61. Comment: The ARB should split the rulemaking into two phases and resolve open technical questions so that reactivity factors, vehicle standards, and fuel standards can be finalized simultaneously. To develop adjustment factors by September 1991, the ARB will be testing a limited number of vehicles based on its projection of the technology likely to be used in each category. It is not clear how many vehicles will be available for testing, what the vehicle-to-vehicle variability in species will be, and whether technologies chosen by the ARB will represent the low-emission vehicles that may be certified. There is another complication because the final specifications for the fuels will not be set until September 1991. Hasty establishment of reactivity factors followed by subsequent revisions will discourage manufacturers from seriously considering alternative fuels. (GM)

Agency Response: We believe that a sufficient number of vehicles will be available, and that the vehicles chosen will utilize representative technology since they will be procured from the ARB's test fleet, from other agencies and from private industry. The industry is being kept informed of the status of reactivity factor development, and data and/or vehicles are being solicited to ensure representative factors. Should there be any doubt that the ARB is not utilizing vehicles having representative technology, manufacturers have sufficient opportunity to supply the ARB with their candidate low-emission vehicles for testing.

Fuel specifications to be considered by the Board in the fall of 1991 will be developed concurrently with the reactivity adjustment factors. The adjustment factors will reflect any changes to the fuel specifications since the data collected to develop these factors will be from low-emission vehicles operating on these fuels. The reactivity adjustment factors will result in manufacturers being assured of a minimum level of adjustment. If manufacturers can demonstrate that a higher level of adjustment is possible for a particular vehicle/fuel category, Section 8 of Appendix VIII to the LDV/MDV Test Procedures allows manufacturers to use an alternative provided this factor differs from the adopted factors by 25% and other criteria are met.

Establishing reactivity adjustment factors by the fall of 1991 should not discourage manufacturers from considering alternative fuels. For the reasons stated above, we believe that sufficient data will be available to allow the establishement of technically sound adjustment factors for alternaitve fuels within the planned timeframe.

62. Comment: It is impossible to determine feasibility of the standards for alternative-fuel vehicles since reactivity adjustment factors will not be available until September 1991. (AIAM, GM, Mercedes) In the absence of reactivity factors as engineers we are unable to comment on the air quality impacts of the proposed standards. (Mercedes)

If the reactivity adjustment factors are not available until September 1991, this is after the time requirement for manufacturers to notify the ARB of which alternative fuels will be used in 1994 model-year vehicles, and allows for only a year and a half until production. This is not an adequate time for design, development, certification and release of components. (Ford)

Agency Response: We believe reasoned decisions can be made in a timely fashion about potential reactivity adjustment factors, particularly for vehicles that may be certified to the TLEV and LEV standards in the 1994 model year. Appendix VIII of the LDV/MDV Test Procedures contains MIRs for NMOG constituents. While we plan to conduct a rulemaking in the fall of 1991 to modify these MIRs as appropriate, we expect that the modified MIRs will not significantly differ from those presently in the test procedures. Appendix VIII of the LDV/MDV Test Procedures also contains the methodology that will be used in applying the MIRs to vehicle emissions data in order to establish reactivity adjustment factors. Manufacturers can apply this methodology now to emissions test data from current or prototype alternative fuel vehicles, and predict likely reactivity adjustment factors.

63. Comment: We are uncomfortable with a regulatory approach that would adopt procedures and interim factors while key research to complete and validate them is still in progress. (WSPA, Mobil)

Agency Response: See the responses to the previous comments in this Section.

64. Comment: The MIR approach is not conservative; it may not provide an adequate margin of safety. Under the proposed approach, vehicle/fuel combinations with low emissions reactivity can emit more VOC. It is important that the reactivity credit not be overestimated, because an adverse air quality impact could result if reactivity effects did not fully compensate for increased VOC emissions. The proposed use of MIR factors may increase the risk of an adverse air quality impact because the MIR factors overestimate reactivity differences among VOC compared to alternative reactivity scales. (WSPA)

Agency Response: The differences in VOC reactivity for different reactivity scales are not significant and have been calculated to be less than 15% for most fuels tested. A Carnegie Mellon University study of ozone formation from M85 and CNG vehicles compared to gasoline vehicles based on airshed modeling indicates strong agreement with the MIR method. In light of the analysis in Part C of the TSD, we believe there is sufficient justification for the MIR approach for it to be included in the regulations at this time. We expect that further analysis will be done before a final determination of the reactivity adjustment factors in the fall of 1991. We are receiving input from the _ad hoc_ Reactivity Advisory Panel ("RAP"), with representatives from the California Energy Commission, South Coast Air Quality Management District, Auto/Oil Air Quality Improvement Program, Motor Vehicle Manufacturers Association, Western States Petroleum Association, California Natural Gas Vehicle Coalition, California Renewable Fuels Council and Western Liquid Gas Association. The RAP is scheduled to hold three public meetings, prior to the fall 1991 hearing, at which issues related to reactivity scales will be discussed.

65. _Comment_: There is a significant difference in the predicted reactivity of methanol exhaust using the CBM-IV and SAPRC chemical mechanism; this is due to a greater reactivity for formaldehyde predicted by CBM-IV. The MIR factors in the proposed ARB regulation are based on the SAPRC mechanism; these factors may underestimate the reactivity of formaldehyde and overestimate reactivity for toluene. (WSPA)

Agency Response: Although there is a difference in the estimated reactivity of formaldehyde and toluene between the SAPRC mechanism and the Carbon Bond-4 mechanism proposed by Systems Application International, the ARB considers these differences as uncertainties within the mechanisms. In the final calculation of reactivity, the uncertainties will be estimated and taken into account before reactivity adjustment factors are established.

66. _Comment_: An SAI analysis of the reactivity adjustment factor application method indicates that it could result in more ozone formation from vehicles receiving the reactivity adjustment credits than those from the base fuel. (WSPA)

Agency Response: The SAI analysis is based on emission results from vehicles which are not fully optimized for low emissions and therefore are not representative of vehicles meeting the TLEV standards. Also, there are inconsistencies in the results of the SAI analysis. SAI did not properly account for differences in the chemical mechanisms and differences in the weighting of the FTP results when interpreting the results.

67. _Comment_: The relative reactivity of aromatic compounds is a strong function of the VOC/NOx ratio. The MIR factors are based on low VOC/NOx ratios where the reactivity of aromatics is greatest. This scale may overestimate aromatic reactivity for typical atmospheric conditions in California. This potential overestimation

of aromatic reactivity also indicates the MIR approach is not conservative. Since photochemical modeling experts generally agree that the atmospheric chemistry of aromatics is not well understood at this time, we believe an approach that does not overestimate the reactivity of aromatics should be selected. (WSPA)

Agency Response: The rationale for selecting the MIR approach toward hydrocarbon control is described in Chapter VII of the TSD. The MIR approach is being used to reduce ozone under conditions sensitive to hydrocarbon control, i.e. at low hydrocarbon to NOx ratios. Thus, MIR serves as a complement to NOx control. Aromatics have a lower reactivity relative to other hydrocarbons at high hydrocarbon to NOx ratios, but hydrocarbon control is not very beneficial at these conditions. Additional assessments of the appropriateness of the MIR approach can be taken in the future in conjunction with the establishment of reactivity adjustment factors. However, there is currently sufficient justification of the MIR approach to make regulatory adoption appropriate at this time. This is particularly important because a comparison of the reactivities of the different hydrocabon species is necessary for reactivity adjustments to be incorporated in the low-emission vehicle NMOG standards.

68. Comment: A peer review analysis of the treatment of exceptional compounds in chemical mechanisms should be initiated. At a minimum, toluene, formaldehyde, and isoprene should be discussed as well as any other compounds that are either treated significantly differently in chemical mechanisms or represent a major component of gasoline or an alternative fuel. (WSPA)

Agency Response: The ARB has contracted with Dr. Michael Gery for a peer review of the Carter chemical mechanism used to develop the reactivity scale. Any changes to the reactivity scale as the result of the peer review of the chemical mechanism can be considered by the Board at a future hearing.

69. Comment: Some VOC compounds (in particular formaldehyde) are extremely sensitive to changes in the VOC base mixture. This is supported by observed changes in the MIR factors from the initial set derived by Dr. Carter to his latest set. In addition, the base mixture can be expected to change over time, especially if alternative fuels become significant fractions of the mobile emission inventory. An evaluation of VOC base mixtures from various experimental studies in different regions of the state should be developed to determine the sensitivity of VOC species, and particularly those that represent a significant portion of exhausts emissions from alternative fuels, to the base mixture. (WSPA)

Agency Response: The VOC base mixture used to determine the MIR factors was based on detailed measurements taken by the U.S. Environmental Protection Agency (EPA) at many cities around the country. This mixture is very similar to measurements taken in California during the Southern California Air Quality Study ("SCAQS").

70. Comment: Large changes in reactivity might delay ozone formation so that the setting sun adds to the reductions in ozone from reducing VOC and reactivity. However, more studies are needed to determine the fate of such effects on subsequent days (i.e., multi-day studies). (WSPA)

Agency Response: The Carnegie Mellon University ("CMU") airshed model was used to judge whether the MIR factors were effective over multi-day studies. The CMU study showed very good agreement with MIR scale over three day simulations.

71. Comment: An assumption is made in the development of MIR factors that multi-day effects are not important considerations. However, the results of the UAM simulations in the SAI study indicate that the impact on the peak ozone levels did increase over the three study days. Similarly, the ARB has identified transport source/receptor regions in the state that experience ozone episodes resulting from the movement of ozone and ozone precursors from one region of the state to another. Trajectory models, such as EKMA, simulate single-day episodes. UAM simulations for various parts of the state should therefore be conducted to isolate any potential effects from multi-day or transport episodes. (WSPA)

Agency Response: See the response to the preceding comment.

72. Comment: The effects of NOx control combined with VOC reductions in reactivity need further study since preliminary simulations suggest that benefits from the "setting sun" synergism would be lost with NOx controls. (WSPA)

Agency Response: There is no evidence of a "setting sun synergism lost with NOx control", and we have never received "preliminary simulations" suggesting otherwise.

73. Comment: It is recognized that California has a number of studies in progress to evaluate current driving cycles and the weighting of the phases of exhaust emission. The results of these studies should be considered in the proposed regulation. In addition, these studies should be compared with the FTP cycle and weighting scheme. (WSPA)

Agency Response: Since studies have not been completed, they cannot be considered in this rulemaking. However, when the results are available, they will be evaluated and any changes to the regulations can be considered in a future biennial review.

74. Comment: A number of recent fleet test programs have indicated that vehicles designed to meet future emission standards may exhibit different cold start/hot stabilized mass and reactivity ratios from current vehicles. This will be particularly true as the use of heated and close-coupled catalysts grows. This change in exhaust emission ratios could have an effect on the reactivity of various fuel types. The use of the Federal Test Procedure may not accurately account for these changes and therefore would diminish or exaggerate the environmental benefits derived from these technologies. (WSPA)

Agency Response: The ARB will be using future technology vehicles to develop reactivity adjustment factors. Therefore, we have accounted for the fact that future technology vehicles will have different reactivity characteristics than current technology vehicles. We will be evaluating the effects of reactivity with respect to the different test cycles when more test data are available.

75. Comment: Additional peer review is needed to discuss the ramifications of the use of an EKMA model for the development of these factors. Of particular concern should be the use of an average model tuned to maximize incremental reactivity (low VOC-to-NOx ratio) and its relevance to actual urban atmospheric conditions. (WSPA)

Agency Response: See the response to comment 67.

76. Comment: The 25% threshold requirement in proposing a new reactivity adjustment factor has been prematurely determined and may actually discourage technological improvements. The 25% threshold requirement should be eliminated and the need for such a requirement reassessed when more is known about low-emission technology. (Chrysler, Ford)

A threshold requirement somewhere on the order of 10% would be more reasonable. This is particularly important in the early years of the program because the ARB testing to define fuel-specific reactivity factors will probably be based largely on ARB modified vehicles rather than prototype vehicles obtained by manufacturers. (Arco)

The ARB proposes that, to avoid operational complexity, a manufacturer must have data indicating that the generic adjustment factor established by the staff is 25% too high before a request for a separate factor will be considered. No basis other than operational complexity is offered for the 25% cut-off. Because the generic adjustment factors will be developed on technology that may be substantially different than the technology used in production of low-emission vehicles, the benefit of the doubt should be given to the production vehicle data. Therefore, a statistical test such as that prescribed in Appendix C of the Staff Report should be considered. Also, we question why the automobile industry needs to petition for a change in this factor two years prior to when the change is applied. (GM)

Agency Response: The 25% threshold level specified in Section 8 of Appendix VIII of the LDV/MDV Test Procedures was established with the intent of discouraging manufacturers from proposing new reactivity adjustment factors that vary little from the adopted factors. The operational complexity resulting from manufacturers suggesting a myriad of slightly different factors for essentially the same technology would far outweigh any potential benefit. However, the ARB plans to monitor the continuing appropriateness of this criterion. As part of this process, the minimum percent difference among established reactivity adjustment factors within an emission category (i.e., TLEV, LEV, and ULEV) will be taken into account as well as the variability in grams ozone/gram NMOG for the same technology and fuel. Proposals to change the threshold requirement can be included in the biennial review process.

We believe that a two-year period prior to certification is necessary to enable the ARB to confirm the validity of a proposed adjustment factor, and to allow manufacturers sufficient time to make appropriate changes to their vehicle design/production schedule if the proposed factor is disapproved.

77. Comment: Staff should consider evaporative and running loss emissions in the reactivity calculations, and provide reactivity adjustment factors for incomplete vehicles tested on an engine dynamometer. (Ford)

Agency Response: With the new evaporative emission requirements approved by the Board in August 1990, emissions at normal operating conditions are expected to be virtually zero and the anticipated benefits of reactivity adjustment would be negligible.

At this time, regulations for low-emission heavy-duty vehicles are being developed for consideration by the Board in 1992 which would include reactivity adjustment for emissions from engine-dynamometer tested vehicles. Adjustment factors for engine dynamometer tested medium-duty vehicles would be developed as part of the 1992 rulemaking.

78. Comment: Deterioration factors at 50,000 and 100,000 miles should be reactivity adjusted. Assuming the same reactivity at 4,000 miles as at 50,000 and 100,000 miles is not technically sound. We concur with Sierra Research's suggestion that NMOG reactivity at 4,000 mile certification should be based on measured (i.e., speciated) NMHC and oxygenated compounds. (Arco)

Little data exists on the deterioration of emission control systems over the useful life of alternative fueled vehicles. At a minimum, a study should be initiated to evaluate the effects of these technology changes on the contribution of exhaust emission during all three driving phases. (WSPA)

Agency Response: At this time, the ARB does not have data which indicate there is a substantial change in hydrocarbon composition at high mileage to justify separate adjustment factors at 4,000, 50,000 and 100,000 miles. Additionally, because of the stringency of the standards and the 100,000 mile certification requirement, it is unlikely that deterioration will be significant. Accordingly, requiring speciated emission testing at 50,000 and 100,000 mile certification to determine reactivity of vehicular exhaust would not be justified at this time. However, we plan to continue studying the effects of deterioration on reactivity and should further exhaust emission analysis indicate a need for additional speciated emission testing, the Board can consider appropriate modifications to the regulations at a later date.

79. Comment: All ARB tests to determine reactivity adjustment factors should be designed to produce statistically significant results, not numbers based on trends. (Arco)

Agency Response: Low-emission vehicle data are being collected from the ARB's test fleet and more data are being solicited from industry to develop representative adjustment factors. The ARB has limited data at this time; however, more testing and analysis will be done before the follow-up hearing in the fall of 1991. The ARB intends to develop as many factors as available data allow before the hearing, and the development of any remaining factors will be delayed until more testing can be completed. It is better to identify reactivity adjustment factors which provide a minimum level of adjustment based on available data rather than delay implementation of the low-emission vehicle regulations. Industry will have the opportunity to comment on proposed factors prior to the follow-up hearing.

80. Comment: Industry should be allowed to comment on the reactivity adjustment factors before they are presented to the Board for adoption. (EMA/MVMA, WSPA)

Agency Response: Appendix VIII of the LDV/MDV Test Procedures provides that the reactivity adjustment factors are to be established by the Executive Officer based on the methodology specified in the Appendix. However, it has been and continues to be our intent that as many reactivity adjustment factors as possible will be developed by staff and presented to the Board at a rulemaking hearing in the fall of 1991 for specific inclusion in the regulations. At the same hearing the Board can consider modifications to the MIRs specified in the Test Procedures. Since this will be a formal rulemaking process, the public will have an adequate opportunity to comment. In addition, we plan to conduct a public workshop if possible before the rulemaking hearing is noticed. This item would follow the established rulemaking process; therefore, industry will have adequate opportunity to comment on the factors presented at the hearing. The ARB has requested industry assistance in obtaining the necessary vehicles to ensure all anticipated vehicle/fuel systems are tested and reactivity adjustment factors developed.

6. Credit System

81. Comment: The ARB should expand the scope of the credit market (e.g. credits trading between stationary and mobile sources, incentives to reduce VMT, buy-backs of existing vehicles, etc.). This would provide further emission reductions by allowing industry flexibility to choose from a number of reduction strategies. (EDF, CCA, SCE)

Agency Response: Such a system would be extremely difficult to enforce because it would be necessary to assure that the all of emission reductions for which credits are claimed are actually occurring.

If manufacturers are capable of accumulating large amounts of credit under such an expanded credit system, this would imply that the emission standards and control measures in other areas are not as stringent as available technology allows. The current proposal establishes technology forcing standards with sufficient measures of flexibility. Pursuing both technology-forcing mobile and stationary source emission standards separately yields greater emission reductions than allowing broad emission trading, and both are necessary in order to attain and maintain the ambient air quality standards.

82. Comment: Credits should be extended to individuals who have converted their vehicles to operate on gaseous fuels which may now qualify as LEVs or ULEVs. At a minimum, vehicles already operating on an approved alternative fuel should qualify as being part of percentage schedules of TLEVs, LEVs, and ULEVs. (LP Coalition)

Manufacturers should be allowed to meet the standards through retrofits of existing vehicles; such credits could be easily discounted. (EDF)

Agency Response: The suggestion that credits be given for preexisting conversions would not result in any emission reductions because the conversions have already occurred.

Currently approved alternate fuel conversion systems are limited to gaseous fuel. Extending credits to promote gaseous fuel conversions or allowing these conversions to satisfy the low-emission vehicle percentages may not help in meeting the air quality goals of the low-emission vehicle/clean fuels program. First, it is highly unlikely that any existing vehicle conversions can achieve the low emission levels, especially the NOx requirements. Even if this were possible, the full emission benefit of these systems is usually not realized due to improper installations in the field. In addition, in-use deterioration of gaseous fuel conversion systems has become a prominent concern based on in-use emission tests of these systems. Therefore, to ensure the desired emission reductions, the ARB currently favors originally certified low-emission vehicles which, unlike gaseous fuel conversion systems, must go through rigorous emission and deterioration tests. However, the ARB plans to revise the retrofit regulations to include in-use performance and warranty requirements which will substantially improve the durability of conversion systems and may allow retrofitted vehicles to be certified to the TLEV, LEV, or ULEV standards. Allocation of credits for these systems would be more appropriately discussed at a later biennial review when the retrofit regulations have been fully developed and approved.

83. Comment: The ARB should establish incentives for manufacturers to buy back older vehicles by providing emissions credits for such purchases that can be used towards the manufacturers' NMOG fleet-average emissions requirements. (AIAM, Honda, VW, EDF) Even though 1975-1980 model-year vehicles represent 25% of the total vehicle miles travelled, they contribute 53% of HC, 50% of NOx and 49% of CO. To gain some rapid benefits in emission reductions, older vehicles must be retired more quickly. (AIAM)

Agency Response: The ARB is currently evaluating the feasibility of a "buy back" program to remove older, higher-polluting vehicles from the vehicle population. However, emission reductions from such programs should not be traded for emission reductions from a low-emission vehicle program, when reductions from removal of older vehicles and the lowest possible new vehicle standards are both essential to attaining and maintaining the state ambient air quality standards as expeditiously as practicable.

84. Comment: The ARB should require vehicle manufacturers to develop a plan for maximizing the use of clean fuels in low-emission vehicles. Manufacturers who were able to demonstrate that such programs have been successful could be given more credits toward their LEV requirements. This would encourage vehicle manufacturers to become more active in promoting the use of clean fuels. (EDF)

Agency Response: We have attempted to structure the adopted regulations to be as "fuel-neutral" as possible. The overall objective is to assure the introduction of low-emission vehicles, and to have clean fuels available in the marketplace to the extent those fuels are needed for the vehicles. It would be inappropriate to dictate to manufacturers what fuels should power their vehicles, or to allow manufacturers to receive credits for the use of one fuel rather than another fuel in a vehicle meeting one of the LEV standards.

85. Comment: The Board should direct staff to work with industry in developing an expanded credit program which would include credits given to those vehicles which certify between standard levels. (EMA/MVMA)

Agency Response: The ARB does not believe that such a program would be appropriate because of the major administrative and technical obstacles identified in the response to comment 138.

86. Comment: We believe that the mechanics of the credit program are impractical. To make the credit system useful, we recommend that credits retain 100% of their value for at least four years after being earned. This would allow manufacturers to apply credits to a model-year for which the design plans have not yet been fully established. (GM)

Agency Response: The ARB realizes that it is necessary for manufacturers to schedule the development and marketing plans well in advance of actual vehicle production. Since manufacturers are aware of approximate production plans during the vehicle development stage, it is reasonable to assume that credit banking projections can also be done. As is the case with most credit systems, an adequate safety margin should be established to avoid any penalties resulting from miscalculation. Manufacturers can balance any credit miscalculations by trading and selling credits to other manufacturers. Another method of balancing credits is by varying vehicle production numbers. Considering the various means of flexibility offered to manufacturers for credit banking, the proposed method of discounting credits is reasonable. The rationale for the discounting provisions is set forth on page 26 of the Staff Report.

87. Comment: Credits from ZEVs should never be discounted because the purpose for discounting credits is to discourage early introduction of vehicles with inferior emissions durability and performance. This reasoning does not apply to ZEVs since, by definition, ZEVs have zero emissions under any and all conditions throughout their lives. (GM)

Agency Response: The proposal calls for credit discounting to discourage early introduction of vehicles with inferior emissions durability and performance and this also applies to ZEVs. Although by definition ZEVs have no emissions in-use, it is still possible to have ZEVs with poor performance and durability. Electric powered ZEVs introduced early may have lower driving range, poor acceleration, higher cost, inferior battery quality, etc. This may create consumer dissatisfaction with electric vehicles and may discourage future acceptance. Therefore, credits from ZEVs will be discounted according to the credit banking scheme.

88. Comment: If ZEVs are going to be required, the credit system absolutely must be extended to the required ZEV production percentages that start in 1998. Credits should be tradeable, and should accrue for ZEVs produced before 1998. (GM)

Agency Response: As noted in II.A.11., we have modified the regulations to make clear that ZEV credits may be used to satisfy future ZEV requirements, and may be traded.

89. Comment: A credit system for control of evaporative emissions should be established which includes a provision to allow interchange with exhaust emission credits. This would encourage early introduction of the much improved evaporative systems needed to meet the new evaporative test procedure, and would give manufacturers additional flexibility without a reduction in air quality benefits. (GM)

Agency Response: The suggested change may be beneficial in that it could encourage early introduction of vehicles meeting the more stringent evaporative emission requirements. However, it is the ARB's intent to promote the development of improved evaporative emission control systems as well as more sophisticated exhaust emission control systems. An emissions trading scheme would most probably lessen the development effort of either the exhaust or evaporative emission control system. Further, since the operating conditions under which evaporative and exhaust measurements are taken are very different, it would be difficult to establish an equitable trading scheme.

7. Cold Temperature Testing

90. Comment: We oppose the 50°F testing requirement. It should be abandoned due to the lack of data showing that vehicle emission levels on summer mornings in Los Angeles present a problem that justifies a unique testing requirement, or the standard levels being proposed. (Chrysler, Ford) This test requires vehicles to be soaked at 45-55°F for 12-36 hours which is more severe than vehicles experience in mornings at 50°F. If anything, an engineering evaluation indicating control algorithm continuity below 68°F should be adequate and is a better utilization of resources. (Chrysler) Standards should be established at a representative temperature, and we do not believe there is a need to establish new requirements for 50°F testing. (Nissan)

Agency Response: The rationale for the cold temperature testing requirements is set forth on pages 27-28 of the Staff Report. Morning low temperatures in the South Coast can drop to about 50°F during the summer months when ozone levels are highest. The 50°F test requirement is being established to ensure the effectiveness of emission control systems on these cooler summer mornings. It is necessary to require emission testing in this circumstance instead of an engineering evaluation in order to adequately guarantee proper performance of the emission control system. Soaking the vehicle at 45-55°F for 12-36 hours ensures stability of the emission control system, thus providing more reliable emission results at 50°F. Because ARB engineers cannot know all of the engineering details and implications of the myriad of emission control systems each year, an engineering evaluation of each manufacturer's computer systems is impractical. In view of this, vehicular emissions are more efficiently and accurately characterized by FTP testing. For temperatures below 50°F, the ARB may rely on the manufacturers' engineering analysis of the control system since these temperature levels are not as frequently observed during the smog season and the concern is therefore not as great.

91. Comment: 50°F testing will require costly cold emission test facilities. (Chrysler, Nissan, Ford)

Agency Response: Since emission test facilities typically have temperature control systems with a wide temperature control range, modifications to current facilities for 50°F testing may be unnecessary. For air conditioning systems currently in use which do not permit 50°F testing, an upgraded system will be needed. With the recent revisions to EPA regulations, manufacturers planning to certify federal vehicles may have to consider upgrading temperature control systems since they will have to comply with an even lower test temperature requirement of 20°F.

92. Comment: Manufacturers should first gain experience with achieving the proposed standards at current FTP temperatures, document the benefits for testing at non-FTP temperatures, and subsequently the ARB should consider adopting the non-FTP temperature requirements. (Nissan, AIAM, Honda) There is a requirement in the federal Clean Air Act bills to require a cold CO standard for which manufacturers would have to invest in environmental testing facilities. (Ford) The ARB should review whether the EPA cold temperature test requirements are sufficient to control of emissions at lower temperatures or whether additional requirements for California are necessary. (AIAM)

Agency Response: The implementation schedule in the adopted regulations allows sufficient lead-time for manufacturers to design vehicles which can meet the requirements of this proposal. Testing of advanced technology vehicles in the ARB's laboratory at 55°F has resulted in very moderate changes in emissions compared to the standard FTP temperature. Thus, compliance with the emission standards at 50°F should be achievable with only minor design considerations. Manufacturers typically design vehicles so emission levels are well below the FTP standards at low mileage to compensate for the effects of deterioration. Since the regulations specify that the 50°F test requirement is demonstrated on 4,000-mile data vehicles with no deterioration factors applied, there should be a sufficient margin for vehicles to easily pass the 50°F test. The ARB has a strong interest to confirm compliance with emission standards at 50°F since these temperature lows are observed in summer months when ozone levels are a concern. The ARB plans to follow industry's progress in meeting EPA's requirement for 20°F testing, and compliance with EPA's 20°F standard would constitute a partial demonstration that a discontinuity in emissions does not occur in the temperature range of 20 to 86°F as required in the Light Duty Test Procedures.

8. Certification Procedures and Testing Requirements

93. Comment: If the ARB adopts a phase-in schedule which eliminates the category requirements of the previous proposals for NMHC, does it intend to retain the category requirements for NOx and CO? The Board should consider and specify the consequences of using different regulatory approaches to control NMHC, NOx and CO. We urge that the NOx and CO as well as the NMHC requirements be based on a category weighted average.(NRDC)

Agency Response: Although an emissions averaging approach has been established only for NMOG emissions, this approach does not undermine CO and NOx reductions. The NMOG averaging approach was selected to provide manufacturers flexibility in complying with the standards while simultaneously achieving maximum hydrocarbon emission reductions. Since CO emissions generally track hydrocarbon reductions, the benefits of concurrently averaging CO emissions with NMOG emissions is limited. There are no benefits to a NOx averaging approach since the feasibility of significant NOx reductions is limited regardless of the fuel used. Although NOx and CO emissions are not averaged, the adopted regulations establish the most stringent NOx and CO standards considered technologically feasible in the proposed timeframe.

94. Comment: Vehicle production dates are more stable than vehicle certification dates. Therefore projected sales data, certification fuel data, and fuel economy data should be required two years prior to production rather than two years prior to the end of certification. (Chrysler)

Agency Response: Even though vehicle production dates may be more certain than vehicle certification dates, past certification records indicate reasonably accurate sales projection data. Requiring data two years prior to the end of certification will provide earlier information that can be used for making the necessary estimates under the clean fuels regulations. The number of retail clean fuel outlets needed to ensure adequate availability of clean fuels by the time clean fuel vehicles are produced is calculated from this data.

95. Comment: As one approach to complying with the stringent low-emission vehicle requirements for 100,000 miles, we are considering requiring catalyst replacement at 50,000 miles.

Accordingly, we request that the ARB include this in the list of allowable maintenance items. (Chrysler)

Agency Response: The ARB has decided against this provision because it is too difficult to assure that vehicle maintenance will take place reliably and in a timely manner. It would be difficult to determine if a catalyst had actually been replaced. Should this maintenance requirement not be fulfilled as intended, the emission standards would likely be exceeded. This suggestion is also counter to ARB's intent to promote the development of vehicles having longer durability of emission control systems and fewer maintenance requirements.

96. Comment: The staff suggestion that current emission test procedures are sufficient to allow for certification and compliance testing at the proposed lower standards raises serious questions. The staff's acknowledgment that it will allow manufacturers to use unspecified but alternate test procedures upon the Executive Officer's approval and since a joint effort will be undertaken to address future problems seems to verify our concerns. We believe it is inconsistent with the Board's statutory authority to establish standards which require more accurate and revised test procedures without having the accompanying test procedures available for public comment. (Mercedes)

Agency Response: The NMOG Test Procedures include a provision allowing manufacturers to use alternate test procedures upon the Executive Officer's approval. This feature was included because this is a long-range program and uncertainties may surface or improvements may be suggested as development efforts to meet the requirements progress. The ARB has been using the procedures currently specified in the regulations to measure NMOG with few difficulties. The only procedure of significant concern at this time is the sampling and analytical procedure for diesel exhaust speciation. The NMOG Test Procedures include interim guidelines for developing sampling and analysis procedures for diesel speciation. However, the ARB plans to coordinate with industry in developing procedures which would satisfy the requirements of the proposal and be reasonable to manufacturers.

97. Comment: The proposed gas chromatograph ("GC") analysis method is highly complex and delivers only a total test result. For effective R&D work, specific NMOG species need to be measured by a continuous analysis method. Such technology, however, is not yet developed for reliable application. (Mercedes)

Agency Response: Although a continuous analysis capability may facilitate research and development efforts by providing real-time emission results, this does not preclude the use of currently specified measurement methods of hydrocarbon exhaust analysis. If a manufacturer wishes to investigate speciated emission results from a specific operative mode (e.g., acceleration), appropriate dynamometer test cycles can be developed with subsequent speciation. In ARB testing of vehicles for the proposed reactivity-based standards, current measurement methods have proven to be adequate.

98. Comment: The techniques specified in the proposal to measure NMOG emissions for LEV and ULEV levels are not adequate. (Ford, Chrysler) New significantly advanced analytical techniques have been developed by the Auto/Oil Air Quality Improvement Research Program and should be shared with the ARB to enhance emission measurement capabilities of future test programs. (Ford)

Agency Response: The proposed NMOG measurement techniques are adequate since ARB has been reliably measuring NMOG emissions at LEV and ULEV levels in its own emission test facility. However, the ARB plans to follow the progress of the Auto/Oil Air Quality Improvement Research Program. Any valid suggestions for improvements of the test procedures will be evaluated by staff and may be presented to the Board for incorporation into the test procedures as part of ARB's biennial assessment of the adopted regulations.

99. Comment: The change to NMOG standards will necessitate measurement capabilities that we do not have at the present time. This raises serious leadtime issues. As a consequence, we request that the ARB continue to allow gasoline-fueled vehicles to be certified according to current measurement procedures during the initial years of the low-emission vehicle program. We also urge ARB staff to continue working closely with manufacturers in developing NMOG measurement procedures to minimize the burden on their emission laboratories. (Chrysler)

Agency Response: In order to measure NMOG, the only additional requirement to measuring NMHC is the measurement of aldehydes, ketones, and alcohols which is not expected to require significant resources. Measuring NMOG emissions from gasoline-powered vehicles will not require the additional measurement of alcohols, only aldehydes and ketones, which the ARB accomplishes through liquid chromatography. Since the ARB does not believe that this would be a significant burden, the test requirements for gasoline-powered vehicles are not being altered as suggested. The ARB will monitor the progress of manufacturers in complying with the adopted regulations, including the test procedures, and will recommend improvements as needed.

100. Comment: The proposed standards are so low that measurement variability may cause gaseous and particulate emissions to exceed the standards. This will make it difficult for manufacturers to set a design target that will assure the vehicles meet the standards during certification and in use. (EMA/MVMA)

Agency Response: The ARB has conducted a number of tests on electrically heated catalyst-equipped vehicles with emissions at LEV and ULEV levels. These tests show little variability in emission results. We therefore conclude that reproducibility should not be a problem. Although sampling and analytical procedures for diesel vehicles have been provided, the ARB will continue to consider suggestions from manufacturers to refine these techniques. EPA has reported PM levels at 0.05 g/bhp-hr for a DDC engine using a Donaldson Dual Catalyzed Trap Oxidizer System, which indicates reasonable measurement capability in this range is possible. The ARB is also following the progress of the Auto/Oil Air Quality Improvement Research Program for improvements to the test procedures.

101. Comment: We agree with the staff's proposal to retain Indolene Clear (with the RVP lowered to 7.8 psi) as the certification fuel for gasoline vehicles prior to the 1997 model-year. When the specifications for Phase 2 commercial gasoline are developed, specifications for the certification gasoline for 1997 and later model-year vehicles should be revised to be consistent with the commercial gasoline. (Chrysler)

Agency Response: Indolene Clear has been retained as the certification fuel for at least the 1992 through 1994 model years. For the same time period, manufacturers have been given the option of using a 7.8 RVP certification fuel as specified in the LDV/MDV Test Procedures, Section 9.a. Neither Indolene Clear nor the 7.8 RVP fuel will likely be retained as certification fuel through the 1997 model year because commercial gasoline specifications are expected to change in 1996 (Phase 2 gasoline), and we intend to specify a certification gasoline which closely aligns with Phase 2 gasoline. Phase 2 gasoline specifications are scheduled to be considered by the Board in the fall of 1991.

102. Comment: We think the criteria in paragraph 4 on page 47 of Appendix A of the May 1990 draft of the TSD for "other alcohol fuels" should be extended to all potential new clean fuels (e.g., exotic gasoline blends), specified by an OEM for vehicle certification. (Arco)

Agency Response: It is more appropriate to consider a modification to the test procedures for other clean fuels or exotic gasoline blends at a later biennial review when these fuels have been developed for commercial use. There is no reason at this time to establish test procedures for scenarios which are uncertain in the near future. However, the regulations do currently identify a test protocol for candidate substitute clean fuels. If a person petitions the ARB to adopt the specifications of a substitute fuel, or to adopt the specifications of a new clean fuel which can be used in vehicles certified on a conventional fuel, the emission impacts of the substitute fuel or the new clean fuel are to be be evaluated in accordance with the procedures set forth in the Substitute Fuels Test Procedures.

9. Cost

103. Comment: The staff's estimate of an additional $170 cost for gasoline-powered light-duty vehicles certified to LEV or ULEV standards is flawed. The staff inappropriately assumes use of certain technologies which have not been proven to meet the standards in-use, e.g., the electrically-heated catalyst. (GM, Chrysler) The estimated costs do not include numerous additional costs for supporting an EHC system, including additional hardware, maintenance, and development of the technologies. (GM)

Agency Response: Since the low-emission vehicle regulations involve long-range implementation, cost estimates have been projected for the most likely technologies to be used in meeting the standards. It is true that these estimates only reflect the cost of the hardware because it is impossible for the ARB to project research and development costs which can vary significantly from manufacturer to manufacturer. This information is also not readily accessible to the ARB. However, research and development expenses amortized over the number of years which a particular technology can be utilized will be minimal. Properly designed EHC systems should not require greater maintenance than current catalyst systems.

104. Comment: The ARB's cost estimates for low-emission vehicles are misleading because only the incremental cost of hardware beyond the 0.25 g/mi NMHC standard is considered. Meeting the 0.25 g/mi standard was estimated to cost approximately $200 - $350 more than current prices. Meeting TLEV standards would cost several hundred dollars in addition. A comprehensive cost analysis should include the cost of recall programs likely to occur. (Chrysler)

Agency Response: The additional cost of hardware to meet the 0.25 g/mi NMHC standard was estimated by the ARB to be $65 and not $200 - $350 as cited. In any case, the ARB has historically provided cost estimates which reflect additional cost above that of previous regulations. Meeting TLEV standards through use of improved fuel preparation systems has been estimated to cost $70 for hardware and not several hundred dollars as cited. Since this technology has been developed and is currently in use, cost is not expected to be a significant concern, especially in light of the lead-time provided. Also, alternative in-use standards have been provided to alleviate the burden of in-use compliance for the initial years of certification. This provision is expected to mitigate concerns of in-use recall.

10. Increasing the stringency of the proposed regulations

105. Comment: We believe that the ARB has a statutory obligation to specify vehicle emission standards at least to 2007 (but most probably to 2010) and to demonstrate how these will contribute to compliance with clean air mandates. (NRDC)

Agency Response: As adopted, the vehicle standards for 2003 continue to apply to subsequent model years. The regulations therefore do establish motor vehicle emission standards to 2007 and 2010. Similarly, the clean fuels elements of the regulations continue indefinitely. Health and Safety Code section 43018(a) directs the ARB to endeavor to achieve the maximum degree of emission reduction possible from vehicular and other mobile sources in order to accomplish the attainment of the state ambient air quality standards at the earliest practicable date. We believe the adopted regulations are consistent with this statute.

106. Comment: We strongly urge the Board to adopt the low-emission vehicle phase-in schedule as proposed by staff but to increase (preferably double) the percentage requirements for ULEVs and ZEVs starting at the latest by the 1995 model-year and provide no delays or exemptions for small and intermediate volume manufacturers. (NRDC, CCA)

Agency Response: We believe that the NMOG fleet average standards and the ZEV percentage requirements are technology-forcing yet technologically feasible in the specified timeframes. The commenters have not demonstrated that a more aggressive schedule would be technologically feasible as required by Health and Safety Code sections 43013 and 43018. We also believe it is necessary to provide allowances in the form of lead-time and/or less stringent standards for small and intermediate volume manufacturers which have limited resources, in order to assure the regulations are technologically feasible. In the biennial reviews, an assessment of progress in technology may show that the implementation schedule could be accelerated. In such a case, the Board could modify the regulatory schedules accordingly.

107. Comment: Any new strategy for reducing vehicular emissions must incorporate evaporative emissions. While we understand that the ARB is developing a separate program to bring evaporative emissions close to zero, we feel compelled to argue that the proposed clean fuels/low-emitting vehicles plan program consider all sources of emissions. (EDF)

Agency Response: Prior to the September 1990 hearing in this rulemaking, the Board approved new evaporative emission standards and test procedures that will greatly reduce evaporative emissions. Since new cars in California will already be subject to these requirements, there is no need for the requirements to be duplicated in this rulemaking.

108. Comment: Any new strategy for reducing vehicular emissions must address the expected decay of emissions control technologies. The recent "Tunnel Study" revealed that the real decay factor of emissions control equipment was greater than expected. The proposal

does not protect against such decay because it does not adequately lay out how the 100,000 mile compliance period will be enforced, nor what back-up steps or mitigation measures would be pursued in the event actual performance again falls below what is expected. The threat of recall, without a detailed implementation and enforcement program, does not appear sufficient to ensure in-use compliance. (EDF)

Agency Response: The ARB's in-use compliance and recall regulations are generally applicable to all California vehicles, including those certified under the low-emission vehicle regulations (subject to those instances where there are special in-use compliance provisions in this rulemaking). There is no need to overlay a duplicative in-use compliance or recall program. The ARB has administered its in-use compliance programs vigorously, and intends to continue to do so. Tunnel studies may indicate that in-use emissions are higher than anticipated; however, one cannot necessarily assume that this discrepancy is from decay of emission control equipment. Factors such as off-cycle emissions, ambient temperature, and model inputs greatly influence results of tunnel studies.

109. Comment: The regulations for low-emission vehicles should specifically include requirements for on-board diagnostic ("OBD") systems to assure manufacturer compliance with low-emission vehicle standards in-use and to assist motorists and repair mechanics with vehicle maintenance. (AAA)

Agency Response: New, more comprehensive OBD regulations, known as OBD II, have recently been adopted for 1994 and subsequent model light- and medium-duty vehicles having computerized feedback fuel control systems; it is expected that all low-emission vehicles (except possibly ZEVs) will need such systems to comply with the low-emission vehicles/clean fuels regulations. The OBD II regulations will require the on-board computer to monitor the performance of all emission control components and will alert the operator of a system malfunction. Since the malfunction criteria are based on remaining within the vicinity of applicable emission standards, proper in-use performance of low-emission vehicles will be assured since the malfunction criteria will track the emission standards as they become more stringent. The OBD systems also include fault codes for mechanics which identify the likely cause(s) of malfunction. As such, the new OBD regulations will promote better durability of emission-related components as well as aid in the control of in-use emissions through early detection of emission system failures.

110. Comment: We suggest that a lifetime performance standard be set for vehicles, to assure emissions performance beyond 100,000 miles. (EDF, CCA)

Agency Response: The Smog Check program already requires a biennial inspection of the emission control system and a tailpipe test to ensure proper performance of the emission control system. Other measures are being implemented to improve upon current in-use performance requirements. With the OBD II regulations, the vehicle operator will be alerted of any malfunction of the emission control system. Since the malfunction criteria of these systems is based on remaining within the vicinity of applicable emission standards, in-use performance can be maintained. The requirement to comply with emission standards in-use has only recently been doubled from 50,000 miles to 100,000 miles and success of this requirement will be monitored by ARB's In-Use Recall Program. ARB could examine more lengthy requirements in the future once the feasibility of doing so is more certain.

111. Comment: We urge you to regulate medium-duty, heavy-duty, and off-road vehicles as quickly as possible through technology-forcing emission standards. (CCA)

Agency Response: This rulemaking includes stringent low-emission vehicle standards for MDVs as well as for light-duty vehicles. It would be inappropriate to attempt to use one rulemaking to adopt all potentially beneficial new regulations for new motor vehicles. We are planning to bring proposed regulations on heavy-duty low-emission vehicles before the Board for consideration in September, 1992. The California Clean Air Act of 1988 directed the ARB to investigate control of emissions from a wide variety of previously unregulated mobile sources. We are developing proposed regulations for construction and farm equipment to be considered by the Board in October, 1991. Regulations for other off-highway vehicles may be presented to the Board in fall of 1992 with a concept hearing in fall of 1991. The ARB is also investigating methods of emission control for locomotives and marine vessels. Emission standards for small utility engines, such as those used in lawn mowers, were approved by the Board in 1990 and will become effective in 1994. Regulations for the control of emissions from off-road motorcycles are being considered and a concept hearing is scheduled for August, 1991.

112. Comment: We urge you to regulate benzene at this time, Benzene is simply too potent a carcinogen to allowed its continued release into the atmosphere. The ARB staff should adopt an emission standard for benzene since it is a carcinogen that is continually being introduced into the atmosphere. (CCA)

Agency Response: A benzene exhaust emission standard was considered by staff when these regulations were being developed. However, this requirement was not pursued since benzene-specific exhaust emission control technology is not currently available. In light of this and the fact that a reduction in benzene is achieved through the reduction of hydrocarbon emissions (with a reduction in NMHC, there is an approximately proportionate reduction in benzene), this requirement was eliminated. Alternate strategies of benzene control such as establishing benzene and aromatic specifications for gasoline may be considered when we develop our Phase 2 gasoline regulations.

11. Potential environmental issues associated with the low-emission vehicle regulations

113. Comment: There are environmental concerns associated with mandating battery technology through the ZEV requirements. At no point in the Staff Report do we see an analysis of the potential environmental impacts of battery recycling. The recycling of lead acid batteries and high energy batteries being developed for future use has significant environmental impacts. For instance, all available data demonstrate that the recycling of alcoline type batteries utilizing sophisticated equipment presently available still results in the emission of significant levels of highly carcinogenic materials to the air and water. Recycling units for high energy batteries (sodium-sulfur, sodium-nickel chloride) are not yet even developed. Accordingly, there is a significant question whether these even more potentially harmful products can be safely recycled. Our projections are that even if the California program results in only 200,000 batteries per year being recycled, this could result in the emission of approximately 24 tons of cadmium into the air and water of California. Clearly, this highly carcinogenic emission represents a significant environmental cost. (Mercedes)

Agency Response: The Board found in Resolution 90-58 that state and federal regulations characterize lead acid batteries as hazardous waste and regulate their disposal to protect public health and environment; it is thus expected that batteries used in electric vehicles will be integrated into the strong recycling mechanism currently in place for batteries now used in motor vehicles. The record contains information and analysis of recycling programs for lead acid batteries. (see particularly the September 26, 1990 letters from the Battery Council International and RSR Corporation.) In 1988 the California Legislature enacted mandatory battery recycling requirements, requiring all persons who sell batteries to take them back and ensure they are returned to secondary lead smelters for recycling. (Health and Safety Code §§ 25215 et seq.) Currently there is sufficient capacity to reclaim the batteries available for recycling in California, and new capacity is planned that could absorb any increase in the number of junk batteries. Secondary lead smelters, at which lead acid batteries are recycled, are subject to stringent environmental and occupational safety and health regulations. The air emission limitations imposed on smelters are health-based standards which must be achieved regardless of the volume of the batteries recycled.

Battery recyclers are also developing new recycling technologies. RSR is the principal United States developer of a new "electro-winning" technology for battery smelting that not only will increase recycling capacity but also will reduce overall emissions. New battery technologies are under development by motor vehicle manufacturers and others. In developing new battery technology, industry is keenly aware of the recycling issue, and development efforts are therefore addressing the need to eliminate or reduce toxic compounds from advanced batteries. We also expect that battery development will be accompanied by a concomitant development of appropriate recycling technologies. New technologies being developed for lead acid battery recycling may also be developed for other types of batteries. As new battery technologies are better identified and recycling issues become more defined, the Board can monitor and address any potential environmental impacts during its planned biennial review of the low-emission vehicles/clean fuels program.

The commenter has not provided data supporting its claims regarding cadmium emissions. Cadmium is not emitted in significant quantities during recycling of lead acid batteries. Cadmium emissions may be associated with recycling nickel-cadmium ("ni-cad") batteries. At present, we do not expect ni-cad batteries to be used to any great extent in motor vehicle applications.

114. Comment: How can the ARB mandate the production of electric vehicles before assessing their overall impact on the environment? Is it safe to assume all charging will occur at off-peak hours? What consideration has been given to the need to meet Federal crash safety standards? We have great concern about possible electrolyte spillage and managing the energy associated with the considerable mass of the batteries, in a collision. (AIAM) There exists with electric vehicles the potential for safety concerns with respect to electrolyte spillage and crashworthiness. (VW)

Agency Response: We believe we have assessed the impact of ZEVs on the environment. See Chapter IX of the TSD, the findings in the Resolution, the responses to the preceding comment, comment 39, and the comments in III.D.7.

On the subject of charging electric vehicles at off-peak hours, according to analysis done by the CEC (AB 234 Report: Cost and Availability of Low-Emission Motor Vehicles and Fuels Volume II: Appendix, August 1989), many commercial and industrial companies have special electricity rates during off-peak hours. Companies that have special rates will tend to be the ones where electric vehicle use makes the most economic sense. It is not likely that commercial and industrial companies choosing electric vehicles will charge during peak hours as such charging would be significantly more expensive than off-peak hours. In addition, off-peak rates apply to evening hours when the vehicles are not in use and since electric vehicles require six to eight hours to charge their batteries, most companies will charge the batteries at night. In any case, such companies have the option of recharging during off-peak hours so cost estimates accurately portray the possible costs associated with electric vehicles.

It is difficult to determine what electricity prices would be for a residential customer choosing to recharge an electric vehicle.

There is a possibility that utility companies would provide special rates for residential customers charging their vehicles during off-peak (evening) hours. If this occurs, it is likely that residential customers choosing electric vehicles would charge during evening hours since it would be less expensive and more convenient to recharge at night. Currently, all residential rates are the same regardless of the time of day. If this did not change, the cost of electricity to residential customers for electric vehicles would be approximately double that of the commercial and industrial rates estimated in the TSD.

On the subject of federal crash safety standards, we recognize that electric vehicles will have to meet the federal crash safety requirements. This is one reason we believe that safety concerns associated with electric vehicles will be no greater than those associated with gasoline-powered vehicles. There is little reason to expect unusual design problems in developing electric vehicles which meet federal crash safety standards.

12. Legal Issues

115. Comment: The proposed low-emission vehicle regulations are inconsistent with Health and Safety Code sections 43013 and 43018 because they are not technologically feasible. (Chrysler, EMA/MVMA).

A demonstration of technological feasibility must be made sufficiently in advance of the implementation date to allow manufacturers the leadtime required by law (EMA/MVMA). The proposed regulations clearly exceed any reasonable limit of a technology-forcing approach. The staff's projections of manufacturers' technological capabilities are highly qualified; the staff is relying on the manufacturers to invent the necessary technology. It is unreasonably optimistic for the staff to expect that many new developments of advance emission control technologies will develop in the next several years. (Chrysler)

Agency Response: There are no appellate court cases interpreting the requirements for a finding of technological feasibility under Health and Safety Code sections 43013, 43018 and 43101. However, useful guidance can be found in the federal cases construing the requirements of federal Clean Air Act section 202(a)(2) (42 U.S.C. § 7521(a)(2)) that EPA's motor vehicle standards:

> . . . shall take effect after such period as the Administrator finds necessary to permit the development and application of the requisite technology giving appropriate consideration to the cost of compliance in such period.

The leading federal cases are Natural Resources Defense Council [NRDC] v. EPA, 655 F.2d 318 (D.C. Cir. 1981) and International Harvester Co. v. Ruckelshaus, 478 F.2d 615 (D.C. Cir. 1973). NRDC makes clear that Congress intended EPA to project future advances in pollution control technology rather than be limited to the technology existing when the standards were set. (655 F.2d at 328.) The NRDC court noted that a longer leadtime "gives the EPA greater scope for confidence that theoretical solutions will be translated successfully into mechanical realizations." (655 F.2d at 329.) In addition, "The presence of substantial lead time for development before manufacturers will have to commit themselves to mass production of a chosen prototype gives the agency greater leeway to modify its standards if the actual future course of technology diverges from expectation." (Id.) The court concluded (655 F2d. at 331-2):

> We think that that the EPA will have demonstrated the reasonableness of its basis for prediction if it answers any theoretical objections to the [projected control technology], identifies the major steps necessary in refinement of the [technology], and offers plausible reasons for believing that each of those steps can be completed in the time available.

The bases for our projections of technological feasibility are set forth in the responses to the comments in section III.B.1.2., and 3., particularly the response to Comment 8. In light of the extensive leadtime and the numerous instances in which additional compliance flexibility is built into the regulations, we believe the adopted standards meet the NRDC test. See also the next comment and response.

116. Comment: The low-emission vehicle standards must be technologically feasible. The leading case law on the meaning of technological feasibility is Natural Resources Defense Council v. EPA, 655 F.2d 318 (D.C. Cir. 1981) and International Harvester Co. v. Ruckelshaus, 478 F.2d 615 (D.C. Cir. 1973). The NRDC case allows the presence of substantial leadtime to overcome technological uncertainties. However, this principle only applies when the mandated commencement of production is relatively distant, and the probable effect of a subsequent relaxation of the standard would be to mitigate the consequences of any excessive strictness in the initial rule. The ARB's proposal, and particularly the decoupled approach to vehicle and fuels rulemakings, needs to be modified in light of NRDC. First, the emissions credit system for model years 1994-1996 must be sufficiently flexible to allow meaningful alternatives to the TLEV programs in model year 1994. Second, there must be a review of the entire program no later than the early spring of 1992. (GM)

Agency Response: We have modified the regulations and biennial review plans in the areas sought by the commenter. As discussed in II.A.2., the period for balancing shortfalls in a manufacturer's fleet average NMOG emission value has been extended in the early years. Credit deficits incurred from 1994 may be made up within three model years and as long as they are also made up by the end of the 1988 model year. While the first biennial review was originally proposed for the fall of 1992, Resolution 90-58 directs the Executive Officer to make the first report by the spring of 1992.

117. Comment: The staff proposal fails to meet the California Clean Air Act requirement to be "cost-effective." Since many of the proposed actions are not technologically feasible, they cannot be effective, and since many of the costs are either questionable, or without reasonable foundation, the proposed actions cannot be considered "cost-effective." (Chrysler)

Agency Response: On the subject of technological feasibility, see the responses to the previous two comments and the responses in III.B. 1-3. On the subject of cost-effectiveness, see the response to comment 223.

118. Comment: Actions dictated by the staff proposal cannot be deemed "necessary" actions if they are not feasible. Actions that are "necessary" are those without which a condition cannot be fulfilled. Merely declaring an action to be "necessary," no matter how much a solution is needed for a problem, does not render it feasible. (Chrysler)

Agency Response: On the subject of technological feasibility, see the responses to the first two comments in this section and the responses in III.B. 1-3. On the air quality needs for the regulations and the resulting emission reductions, see the response to comments 223 and 227.

119. Comment: Government Code section 11346.5(a)(7) requires that the ARB determine that no alternative considered by the agency would be more effective or will be as effective and less burdensome to affected private persons than the proposed action. The California Clean Air Act requires the Board to adopt regulations that are "cost-effective." The proposed fleet averaging provisions allow averaging based only at an extremely limited number of certification and compliance levels. This restricts manufacturer flexibility to develop new technology, to optimize in-use emissions control performance, and to build durable control systems. We recommend that the Board use a "family-based" system of averaging that would allow manufacturers to select emissions compliance levels on an engine family basis, and to meet sales-weighted fleet average levels in the most efficient manner possible. This has already been used at the federal level. We have been advised that this approach is not acceptable to the ARB due to reasons of administrative convenience. We believe that the Board is required by the above-referenced Government Code section and by the California Clean Air Act to provide some description and quantification of exactly what the burdens on the staff would be, and an explanation of why those burdens outweigh the efficiencies that family-based averaging would provide to the public. (GM)

Agency Response: The reasons for not incorporating the commenter's suggestion of a family-based system of averaging are set forth in the response to Comment 138. For the reasons set forth in that response, we do not believe the suggested approach would be as effective as the adopted fleet averaging system. The fact that EPA has adopted a family-based averaging system as part of its heavy-duty engine NOx standard does not demonstrate it would be practical for the regulations adopted in this rulemaking. The low-emission vehicle regulations include a process for determining and applying potentially different reactivity adjustment factors for vehicle/fuel systems certified to the TLEV, LEV, and ULEV NMOG standards. This approach would not work if vehicles did not have to be subject to one of the specified low-emission vehicle standards. The federal heavy-duty NOx averaging program does not include adjustments for reactivity, and covers far fewer engine families than a light-duty vehicle program.

120. Comment: We previously proposed that the Board use "unified" vehicle emissions standards, which would combine exhaust and evaporative emissions into a single environmentally weighted gram-per-mile compliance standard for each applicable vehicle class. This would allow the use of the least costly combination of exhaust and evaporative control systems. In light of the statutes cited in the previous comment, the ARB's explanation of the reasons for rejecting this approach is inadequate. The staff's decision to defer a comprehensive "recipe" for gasoline reflects the statutory preference for minimizing costs without reducing benefits; the failure to propose a unified emission standard does not. The Board should not treat vehicular control strategies differently than in-use gasoline control strategies. (GM)

Agency Response: A "unified" exhaust and evaporative emissions standard is not appropriate or necessary. At an August 1990 hearing, the Board adopted new evaporative emissions requirements which will effectively require zero evaporative emissions during test conditions. It does not make sense to have a unified standard when one of the two proposed components will effectively have no tested emissions. (The commenter points out that potentially significant emissions may occur in real-life conditions that cannot reasonably be replicated in high-volume routine test procedures; as such it is not clear how such nontested emissions could be considered in a unified standard.) See also the response to Comment 140.

The commenter also does not acknowledge the structural difference between fuels standards and vehicle emission standards. We cannot set direct emission standards for fuels. Fuels standards typically establish specifications for the composition of fuel. Adequate data is necessary to identify the relationship between the specifications and the emissions from vehicles operating on the fuel; the need for additional data to demonstrate those relationships was the reason for delaying the Phase 2 gasoline regulations. Vehicle exhaust standards are direct emission standards, and we can now identify the emission impact of a given emission standard. Since a vehicle emission standard is a performance standard, vehicle manufacturers have the flexibility to meet the standard with the most cost-effective control technology of their choosing.

121. Comment: The limitation of carryback credits to a one-year timespan conflicts with the statutes cited in comment 119. There is no air quality reason why the Board should not allow broader use of "carryback" credits. (GM)

Agency Response: As discussed in II.A.2, the Board extended the period for balancing shortfalls in a manufacturer's fleet average NMOG emission value in the early years of the program. This was done to add flexibility. However, we do not believe there is any statutory requirement that manufacturers must be allowed to exceed the NMOG standard for several years before making up a violation. Such a system necessarily would allow greater emissions during the period before the deficit is made up; it would also pose major enforcement concerns because of the length of time that would have to pass before a violation of the emission standards could be established. Rather than providing for a permanent program allowing longterm deficits, we have allowed the use of marketable credits so that a manufacturer with a deficit can make it up by purchasing credits from another manufacturer as well as "carrying back" credits from the next year.

122. Comment: The provisions requiring that banked credits be discounted if not used in the next model year conflicts with the statutes cited in Comment 119. The justifications for credit discounting stated at page I-15 of the TSD and on page 8 of the Staff Report are unconvincing. (GM)

Agency Response: We believe there is a sound rationale for the credit discounting provisions. The commenter does not appear to challenge the likelihood that vehicles introduced early are likely to be inferior to later vehicles in durability and performance because of the shorter amount of time available for design and development and less stringent in-use requirements. Moreover, manufacturers will have an incentive to trade their unused credits to avoid discounting; credit market activity will therefore be enhanced by the discounting provisions.

123. Comment: In making the August 13, 1990 proposals the staff has apparently assumed that there will be little reactivity benefit from use of reformulated gasolines. At a September 20 meeting, for example, the staff indicated that Howell EEE gasoline was believed to be a good surrogate for an environmentally-based "reformulated" gasoline, and that exhaust products from Howell EEE had a reactivity-adjusted ozone impact that appeared to be similar to that of "conventional" gasoline. The data upon which the staff relied do not appear to be on the record. the data should be made available to the public. (cf. Portland Cement Ass'n v. Ruckelshaus, 486 F2d. 375, 392 (D.C. Cir 1973) (failure to make timely "full disclosure" of pilot test programs was "critical defect" disabling effective participation in decision-making process by regulated parties).) (GM)

Agency Response: The staff's proposals are not premised on an assumption that there will be little reactivity difference between conventional gasoline and reformulated gasoline. As stated in the response to Comment 101, after the Phase 2 reformulated gasoline specifications are established for commercial gasoline we intend to specify a certification gasoline which closely aligns with the Phase 2 specifications. Emissions associated with the use of this reformulated certification gasoline will be reactivity-adjusted from emissions associated with conventional gasoline (Appendix VIII, Light-Duty Test Procedures.) In promulgating this rulemaking the Board is not relying on any data comparing the reactivity of Howell EEE gasoline and conventional gasoline, so there is no need for such data to be in the record. The Portland Cement case involved data on which EPA was clearly relying in its rulemaking.

124. Comment: The provisions on the required submission of data for modification of the reactivity adjustment factor do not state what criteria the ARB staff should use in approving a modification; it only states what the petition must contain in order to be considered by the staff. This is inconsistent with requirements of clarity and objectivity. (GM)

Agency Response: The commenter is referring to section (8) of Appendix VIII of the Light-Duty Test Procedures. The intent of the proposed language was to establish criteria guiding the Executive Officer in determining whether to approve a request for unique adjustment factor. To remove any ambiguity, a nonsubstantial modification has been made to the adopted language to make clear that the Executive Officer is to approve a request for a unique adjustment factor if the manufacturer makes the requisite showing.

125. Comment: The Board should either allow the use of Phase 2 reformulated gasoline as a test fuel for new-technology vehicles by model-year 1994, or allow the use of a clean gasoline as an alternative fuel before MY 1997 without Board action at a public hearing. By one means or another, the affected industries must be given the flexibility to introduce clean gasolines and vehicles optimized for these vehicles before 1996. (GM)

Agency Response: Phase 2 gasoline will not be required as a commercial fuel before 1996. In order to assure that vehicle manufacturers have the benefit of the potential emissions improvements associated with Phase 2 gasoline starting in 1996, we expect that they will be allowed to certify 1995 model-year vehicles on Phase 2 gasoline. 1995 model-year vehicles would typically be available by the fall of 1994. However, we do not believe it is appropriate to allow 1994 model-year vehicles to be certified on a primary certification gasoline that is cleaner than the gasoline that will be commercially available for fueling the vehicles for their first two or three years. The result would be higher in-use emissions than the emissions of the certification vehicles. Since designation of a "new" clean fuel will trigger all of the requirements imposed on gasoline suppliers in the clean fuel elements of this rulemaking, we believe it is appropriate for the Board to be directly involved in the decision with an opportunity for public comment. There is no reason to conclude that the need for a new rulemaking will preclude introduction on a new clean fuel in less than 6 years (i.e. before 1997). In light of these factors, there is clearly no legal requirement that the Board make the changes requested.

126. Comment: Lack of clarity in a final rule is not acceptable. (see 1 C.C.R. § 16.) A regulated party is entitled to prior adequate note of what a regulation requires. The key sections of the proposed regulations that need attention in this regard include the procedures for initial calculation and modification of reactivity adjustment factors, the requirements for testing and compliance demonstration at non-FTP temperatures, the methods of verification of sales-weighted compliance with fleet average levels, and the rules relating to the use of credits. Manufacturers are entitled to testing criteria they can rely upon with certainty. (GM)

Agency Response: We believe that, as adopted, the referenced portions of the regulations are clear.

(a) Appendix VIII of the Light-Duty Test Procedures identify the MIRs and the methodology to be used by the Executive Officer in establishing reactivity adjustment factors. The Appendix provides clear guidance on how reactivity adjustment factors will be established. While we anticipate that the Board will conduct a subsequent rulemaking to update the MIRs based on new data and to establish reactivity adjustment factors in the regulation, the regulations as now adopted will apply until they are changed in a subsequent rulemaking.

(b) We have modified the provisions on the 50°F test requirement to make them clearer. (see II.A.11.(a) and the response to comment 148.)

(c) The fleet average requirement is structured similarly to the 0.4 g/mi NOx regulation (§ 1960.1.5 (a)(1)), which requires a multi-year phase-in based on the relative percentages of sales of vehicles meeting the 0.4 g/mi and 0.7 g/mi standards respectively. The 0.4 g/mi NOx regulation has been applied since 1989, and no significant problems in implementation have been encountered.

(d) The credit provisions are set forth in section 1960.1 (g)(2), notes (7), (8), and (9) and in section 1960.1 (h)(2), notes (11) and (12). They address all pertinent aspects of the credit program. The commenter has not identified any specific respect in which the regulations are claimed to be unclear. We believe that the regulations pertaining to the fleet average credits are clearly defined. We did identify an ambiguity in the ZEV credit requirements and have clarified the language subsequent to the original proposal. (see II.A.11.(b).)

127. Comment: In requiring compliance at the low levels mandated in the staff's proposal, it will be difficult to eliminate all potential sources of test-to-test variability. The ARB must hold itself to high standards of repeatability and objectivity, if only because the repeatability and objectivity of a rule affect the feasibility of passing it, and "feasibility" is required by [Health and Safety Code section 43013]. The best solution to the potential problems of variability and subjectivity in the proposed rule is for the Board to take final action now, and direct the staff to report back by the end of the calendar year on the repeatability and objectivity of the regulations as passed. (GM)

Agency Response: We believe that the test procedures provide adequate repeatability for the reasons set forth in the response to Comment 100. We will continue to monitor test results, and will propose amendments to further refine the test procedures if appropriate.

128. Comment: Three components of the staff's proposal need careful review by the Board under the "necessity" standard of [Health and Safety Code section 43013]. First, the ZEV production mandates are not necessary because achieving the fleet average standards are not dependent on the existence of a particular category of vehicles such as ZEVs. If ZEVs are in some sense "necessary," then it is unclear why the staff's proposal exempts "small volume" manufacturers and delays compliance for "intermediate volume" manufacturers. Second, the intermediate-range temperature testing and compliance requirements in the staff proposal lack any demonstration of air quality benefit or cost-effectiveness. Third, the lower NOx standards for LEVs and ULEVs in the proposal are not based on any showing of need. In addition to failing to meet the "necessity" criterion, this approach fails to consider the potentially adverse effect of additional NOx controls on air quality. If the ARB can meet its mandated reductions in NOx under the California Clean Air Act without the LEV and ULEV standards, this requirement should be deleted. (GM)

Agency Response: The rationale and need for the ZEV production requirements are set forth on page 5 of the Staff Report and in the response to Comment 37. The rationale for the provisions on small and intermediate volume manufacturers is set forth on p. I-14 of the TSD. A determination that the ZEV requirements are not practicable for small volume manufacturers does not obviate the need for the requirements as they apply to other manufacturers.

The rationale and need for the intermediate-range temperature testing and compliance requirements are set forth on page 27 of the Staff Report and in the responses to the comments in III.B.7 and Comment 106.

On the need for NOx reductions, see the responses to Comments 132 and 133. As discussed in the response to Comment 233, the ARB's responsibility to reduce vehicle NOx emissions is not limited to the percentage reductions specified in Health and Safety Code section 43018(b) if further reductions are necessary to achieve the ambient air quality standards.

13. Miscellaneous

129. Comment: Purchase of electric vehicles should be encouraged through government economic incentives instead of mandates such as the ZEV mandate. (GM, AIAM, Chrysler, Nissan)

Agency Response: The ARB does not have the statutory authority to establish a program providing economic incentives for the purchase of ZEVs. Even if we had such authority, there is a question whether incentives would prompt the motor vehicle manufacturers to produce ZEVs. The required limited percentages of ZEVs required by the regulations will ensure that energetic development activity takes place for this needed technology. The substantial emission reductions from the widescale implementation of ZEVs are needed for attainment of the state and federal ambient air quality standards for ozone. Any modifications to the ZEV program based on subsequent information on technological development can be considered by the Board in the future. In addition, the Legislature can be approached with proposals for economic incentive programs for ZEVs if appropriate and beneficial.

130. Comment: The current proposal should be consistent with SB 1905 (known as DRIVE +) currently being considered by the California Legislature which provides economic incentives for a manufacturer certifying an individual engine family to have its own set of emission standards. (GM)

Agency Response: SB 1905 passed the Legislature in 1990 but was vetoed by the Governor. We believe that the low-emission vehicle/clean fuel regulations adopted in this rulemaking establish a sound and comprehensive program for introducing low-emission vehicles into the state. If the Legislature decides to adopt an economic incentive program such as DRIVE + to encourage the introduction of low-emission vehicles, we believe that such a program can easily be made consistent with these regulations.

131. Comment: Based on data we have developed, it is quite possible that the most effective strategy for reducing real world emissions is not through further tightening of the already stringent FTP standards, but rather through control of so-called "off-cycle emissions"--emissions currently not quantified by the FTP cycle--nor accounted for in inventory estimates and air quality models. We

believe that reducing off-cycle emissions would be much more cost-effective than the staff proposal, we urge the ARB to evaluate strategies for reducing off-cycle emissions before hastily implementing tighter FTP standards. These new strategies should include ways to change traffic patterns. Only if the Board carefully evaluates the issue of non-FTP emissions will it be possible for the Board to determine whether it has reduced in-use emissions as effectively as possible, and at the lowest cost to consumers. (GM)

Agency Response: The ARB recognizes that control of off-cycle emissions is a significant issue, and it is being evaluated at this time. However, this does not preclude the need to further control vehicular emissions under ARB's currently established program. A significant air quality benefit is expected from implementation of the adopted regulations through reduction of ozone precursors. In fact, the exhaust emissions of total organic gases and oxides of nitrogen from light-duty vehicles are expected to be reduced by approximately 60% and 40%, respectively, in the South Coast Air Basin by 2010. Other emission reduction strategies, such as control of off-cycle emissions, may be implemented to augment these reductions; both may be needed to assure attainment of the ozone ambient standards in the South Coast.

132. Comment: In its analysis, the staff only considers tons per day reductions in NOx emissions, and not whether this will result in a decrease in ozone levels. A reduction in NOx does not imply a reduction in ozone which the ARB considers the primary factor in air quality; NOx can either increase or decrease ozone formation. The ARB should do more photochemical grid modeling analysis on the impact of the proposed NOx reductions. Recent studies indicate the possibility that further motor vehicle NOx reductions may be a costly mistake. (GM)

Agency Response: Although NOx can either increase or decrease ozone formation depending on the proportion of HC and NOx present in a certain area, extensive photochemical grid modeling shows that NOx control will effectively decrease ozone in the most severely impacted areas. Also, the consensus of the scientific community is that simultaneous hydrocarbon and NOx control is needed to reduce the highest atmospheric ozone levels in California.

133. Comment: Since it is very difficult to achieve simultaneous NOx and HC control, and since it is not clear whether reductions in NOx emissions increase or decrease ozone, the proposed tighter NOx standards may be contradictory to improved air quality. (GM)

Agency Response: The TSD cites strategies for both NOx and HC reductions. Reductions in NMOG can be achieved through use of improved fuel controls, intake manifold heating, electrically-heated catalysts, and clean fuel technology. Vehicles in the ARB's test fleet equipped with electrically-heated catalysts show appreciable reductions in NMOG and CO without a significant effect on NOx. NOx control measures may be used in conjunction with this technology such as increased loading of rhodium in the main catalyst with improvements in washcoat durability and the use of dual oxygen sensors to achieve and maintain low NOx levels.

134. Comment: Present estimates of in-use deterioration for low-emission vehicles assume that deterioration is reduced in the same proportion as the reduction in the NMOG standards. In order for deterioration to be affected, the present proposal would have to somehow address the rate at which vehicles in the "normal" emission mode migrate into the other "high" emitting modes in the EMFAC and CALIMFAC models as vehicles age. There is nothing in the proposal, however, that would address this. Due to the lack of experience with alternative fuel vehicles, it is likely that in-use levels could be higher than current EMFAC and CALIMFAC predictions. For these and other reasons, we believe that in-use deterioration of low-emission vehicles may be very similar to the deterioration the staff assumes for a 0.25 NMHC vehicle with OBD II controls and enhanced I/M. (GM)

Agency Response: In-use deterioration estimated by the CALIMFAC model is a function of both migration of "normal" emitting vehicles into the "high" emitting regimes and the numerical emission levels of the high regimes. Although the rate of migration into higher regimes may not be significantly impacted by this regulatory action, the lower emission levels of these regimes will effectively result in decreased deterioration. Additionally, a major cause of in-use deterioration is catalyst deactivation. This typically manifests itself in the form of increased temperature for proper operation which results in increased cold-start emissions. Vehicles equipped with EHCs (a likely ULEV strategy) can overcome this problem by placing the temperature set point above the minimum light-off temperature (the feasibility of EHC systems is discussed in detail in the response to Comment 26.

We do not believe its is necessary to specifically address the rate of deterioration of alternative fueled low-emission vehicles because the regulations require all 1995 and subsequent model-year vehicles to undergo the same durability test requirements at certification (100,000 mile durability). Thus all vehicles must be designed to meet the minimum durability requirement regardless of the emission control technology or operating fuel. Further, exceedances in-use will be checked through the ARB's in-use recall testing program. Additionally, OBD II systems will help assure proper in-use performance of low-emission vehicles.

135. Comment: The Federal Clean Air Act revisions may include a requirement for manufacturers to produce low-emission vehicles in California. The state and federal requirements should be harmonized so that they do not create dual requirements that will result in separate groups of vehicles for each program. To alleviate the development burden of manufacturers, a high priority must be placed on

harmonization of the introduction schedule and emission standards of federal and California regulations. (Nissan, GM, Ford)

Agency Response: The federal Clean Air Act Amendments of 1990 were enacted on November 14, 1990. They include a California Pilot Test Program for the development of clean fuels. (new § 249 of the federal Clean Air Act.) It is structured to rely on our low-emission vehicle standards as much as possible. We believe the programs are not inconsistent, and we will attempt in the future to assure the state and federal programs do not impose conflicting requirements. The California requirements call for more low-emission vehicles earlier than the federal program. The federal cold temperature testing requirement remains the only significant point of difference which may require an additional test not required by California. We plan to monitor this situation with EPA and resolve it if possible.

136. Comment: Methanol and CNG appear to be the most likely to enable medium-duty engine manufacturers to meet the ULEV standards. These fuels are also the most likely to raise fuel economy and fuel availability concerns. The energy content of methanol is only about one-half that of diesel fuel. In order to restore acceptable driving range, fuel tanks will have to be redesigned to hold larger amounts of fuel. CNG-fueled vehicles will have shorter range and a decrease in vehicle payload because of the heavier CNG tanks. For medium-duty vehicles to travel long distances, an infrastructure of fueling stations for alternate fuels will have to be established statewide and perhaps nationwide at a significant cost. The TSD underplays all of these issues. (EMA/MVMA)

Agency Response: Gasoline vehicles as well as methanol and CNG vehicles may be capable of meeting the medium-duty ULEV standards. If, however, manufacturers choose to develop CNG or methanol MDVs, the operational characteristics of these fuels should not be a significant limiting factor. It is true that the volumetric fuel consumption of methanol and CNG is greater than gasoline. However, redesign of fuel tanks for methanol has already taken place on FFVs, yielding vehicle range between refueling of more than 250 miles. Also, larger methanol tanks on experimental vehicles have not significantly impeded vehicle performance. Since most CNG-powered vehicles are trucks designed to carry larger loads, the concern of reduced payload resulting from the weight of gaseous-fueled tanks is minimal. It is also possible to use redesigned lighter-weight CNG tanks. GM has announced it plans to produce 1,000 CNG-dedicated medium-duty pick-up trucks with no reduction in the normal load carrying capacity and a driving range of over 200 miles. This will be accomplished by utilizing three light-weight tanks which add approximately 200 pounds to an equivalent gasoline-dedicated truck with a fully fueled tank.

Regarding an infrastructure of fueling stations, the clean fuel elements of this rulemaking require the establishment of an alternate fuel infrastructure throughout California should manufacturers decide to market alternative-fueled vehicles. The costs of the program are addressed in the responses in III.D.5. In order to travel interstate, there is an option to utilize dual-fueled or fuel-flexible vehicles. Unlike heavy-duty vehicles, however, medium-duty vehicles are not often used for interstate travel.

137. Comment: Although NMOG standards are based on average values, if we were to comply with the proposed limits, all four categories of vehicles: TLEV, LEV, ULEV and ZEV, must be developed simultaneously and introduced successfully into the market, as well as the 0.25 g/mi NMHC vehicles currently under development. This will create duplication of efforts and inefficiencies, and will exceed our development capacity to a significant degree. (Nissan)

Agency Response: Fleet average standards were proposed based on requests of vehicle manufacturers to provide added flexibility. It is a misconception that the proposal will require simultaneous development of TLEVs, LEVs, ULEVs, and ZEVs. Except for ZEVs, manufacturers can skip the development of some categories of vehicles so long as the fleet average requirement is met; even the ZEV production requirement can be offset through the use of credits. Each vehicle manufacturer has the flexibility to develop its own strategy in meeting the fleet average standards. It is unnecessary for manufacturers to expend resources inefficiently when there are so many provisions for flexibility in compliance such as fleet averaging, credit banking/trading, and a longer period in the early years to balance shortfalls in meeting the fleet average standards.

138. Comment: For light-duty vehicles, the emission standard classes (TLEV, LEV, ULEV, and ZEV) should be completely decategorized and only fleet-average standards established, thus allowing manufacturers to specify emission standards for each engine family. This would allow vehicles with significant NOx control to certify alongside vehicles with better HC/CO control as long as the fleet average is met. As a compromise, one or two other levels between 0.25 g/mi and 0.125 g/mi NMOG should be adopted for added flexibility. (GM)

Agency Response: Although decategorization of emission standard classes and fleet averaging would be advantageous to vehicle manufacturers, it would impose substantial technical and administrative burdens on the ARB. Since a reactivity adjustment factor will be developed for each emission standard category (TLEV, LEV, ULEV) and operating fuel(s) within that category, an alternate method of reactivity adjustment for vehicles certified to non-specified standards would have to be developed which may not be as straightforward (if at all possible). From an administrative implementation perspective, it would be very time-consuming to track certification standards per engine family unless certification records were made readily available to all affected programs including those outside of ARB. Considering the small increments of emissions between standards, adding several other categories would only serve to further complicate the proposal instead of providing added flexibility. The adopted regulations already contain numerous measures to provide flexibility, such as a credit banking system, separate in-use standards, and an initial three-year period to balance any shortfalls in meeting fleet-average NMOG standards.

139. Comment: The ARB should extend the separate phase-in of in-use standards to four years instead of two, and also provide for future review and extension if needed. (Chrysler)

Agency Response: Other recent ARB regulatory actions have provided a two-year phase-in of in-use standards, and our experience to date is that such a phase-in provides an adequate accommodation of the potential problems of in-use compliance. Any new information on the adequacy of the phase-in can be considered by the Board during its biennial reviews, and modifications can be adopted if appropriate.

140. Comment: The ARB may be relying too heavily on new tailpipe standards to achieve mobile source emission reductions. While we support the proposed tailpipe standards, we believe they should be more thoroughly integrated with other methods of reducing vehicular emissions. The ARB should take a whole-vehicle approach to regulation. If a manufacturer can meet a total vehicle reduction standard by drastically reducing evaporative emissions while keeping tailpipe emissions the same, there is no reason that should not be allowed. In effect we endorse the concept of putting a bubble over the automobile. (EDF)

Agency Response: The Board has approved substantially more stringent evaporative testing requirements and a new standard for running loss emissions (0.05 g/mi) for 1995 and subsequent model-year vehicles. The existing exhaust emission requirement combined with the evaporative and running loss emission requirements account for all emission sources from a vehicle. Thus, a combined standard is unnecessary. Separately regulating exhaust and evaporative emissions produces greater emissions reductions because it forces manufacturers to thoroughly control all emission sources from an automobile.

141. Comment: We are disappointed that the ARB has focused on the formulation of emission requirements for future vehicles while little has been done to address one of the the major sources of emissions, namely the older vehicle population. We recommend that the ARB consider the following programs, which would have an immediate positive influence on air quality: (a) retirement of older vehicles; (b) retrofit programs aimed at the replacement of catalytic converters on vehicles having in excess of 100,000 miles; (c) buy-back of older vehicles in return for emission credits; and (d) enhanced Smog Check programs with a more rigorous emission-related component inspection and the elimination of the price limit above which vehicle repairs may be waived. (VW) The ARB should take steps to reduce the emissions of in-use vehicles, including intensification of the I/M program,

improvements in the fuel quality, and accelerating fleet.turnover through market incentives. (Nissan)

Agency Response: Although the programs identified by the commenter bear serious consideration, because of the air quality needs of the state the suggested programs should be seen as supplementary to the adopted regulations rather than substitutes.

Some of the suggested programs would need new legislation to implement (e.g. eliminating the cost limit for repairs in the Smog Check program). The need for others (such as a catalytic converter retrofit program) should be evaluated in light of recent developments such as the enhancement of the Smog Check program, revised OBD monitoring requirements, longer useful life requirements, and the more rigorous in-use enforcement program. With regard to fuel quality, the ARB approved its Phase 1 reformulated gasoline regulations in September, 1990, and plans to conduct a hearing on the Phase 2 reformulated gasoline regulations in the fall of 1991. See also the response to Comment 83.

142. Comment: The Board should build into the rulemaking specific requirements for staff to review the status of technology development and report to the Board biennially on the feasibility of the low-emission vehicle standards. (AIAM, Chrysler, Mercedes, EMA/MVMA, VW, Honda, Navistar, Ford, Toyota)

We suggest that, as part of this rulemaking, the Board commit to a reevaluation and reauthorization of the standards rather than just a biennial review of progress. (MVMA) Implementation of the low-emission vehicle standards should be contingent upon a satisfactory demonstration of feasibility at the biennial review. (Nissan)

Agency Response: In Resolution 90-58, the Board directed the Executive Officer to report to the Board by the Spring of 1992, and thereafter at least biennially, on the status of the implementation of the low-emission vehicle/clean fuels program, identifying any significant problems and proposing any appropriate regulatory modifications. This provides sufficient assurance that technological development will be adequately monitored.

C. Comments Pertaining to the Low-Emission Vehicle Regulations Made During the 15-Day Comment Period

1. Period for Balancing Emission Deficits

143. Comment: There is an inconsistency between the proposed modified language on balancing emission deficits (§ 1960.1(g)(2) note 7(b)) and the contents of the document "Staff's Suggested Changes to the Proposed Low-Emission Vehicles and Clean Fuel Regulations" (the "Suggested Changes") distributed at the Board hearing and incorporated in the Board's action. We interpreted the Suggested Changes as meaning that all model years through and including 1998 have a three year period to balance emission deficits (e.g. a 1998 model year deficit could be balanced by the end of the 2001 model year), while model years after 1998 had a one-year period to balance deficits. However, the language in the proposed modified regulatory text seems to imply that all deficits generated during the 1994-1997 model years have to be balanced "prior to the end of the 1988 [should read 1998] model year." To eliminate the inconsistency, this latter clause should be eliminated from the modified text. (GM, MVMA)

Agency Response: The modified text reflects the staff's original intent and is appropriate (we have corrected the typographical error in the reference to 1998). We believe that the three-year balancing period should apply only for the initial years of the program and that all deficits arising from the 1994-1997 model years should be balanced by 1998. This allowance provides sufficient time to accommodate the uncertainties in the production and sales of new product lines. Any additional increases in the balancing period could lead to abuses by manufacturers and significantly delay the introduction of low-emission vehicles.

144. Comment: We are concerned that unanticipated and uncontrollable changes in sales could cause our fleet average NMOG level to be greater than the requirement and there would not be enough time to balance the deficit. Adding the following language would provide the ARB with additional flexibility to address these situations: "The Executive Officer may allow manufacturers additional time to balance emission deficits if the Executive Officer determines that the deficit occurred due to circumstances beyond the manufacturer's control." (GM)

Agency Response: The fleet average NMOG provisions are included to provide greater flexibility to vehicle manufacturers. The provisions on carrying over emission deficits, particularly with the modifications applicable to the 1994-1997 model years, increase the flexibility further. We believe that manufacturers should be able to work within this structure as long as they engage in prudent planning. In addition, the ARB can exercise its enforcement discretion in determining appropriate remedies based on individual circumstances where a deficit has been incurred and has not been made up on a timely basis. The suggested additional language is not necessary at this time.

145. Comment: We strongly disagree with the modification allowing a three year deficit carryover for the early years of the program. (§ 1960.1(g)(2) note 7(b).) This change vitiates the results of long discussions between CEC, SCAQMD, and the ARB to estimate reasonably achievable introduction rates of low-emission vehicles. It is not justified by the current state of readiness of manufacturers to supply TLEVs. At the very least, the magnitude of shortfalls should be increased by a factor of two for each year the deficit is not made up. (SMAQMD.)

Agency Response: The Board approved the three-year balancing period to provide vehicle manufacturers with additional leadtime during the first years of the program. The modification was based on information contained in oral and written comments regarding the need for additional flexibility. Escalating the shortfall by a factor of two would greatly diminish the flexibility provided by the carryover provisions.

2. Cold Temperature Testing

146. Comment: The temperature tolerances specified in section 11.k.i. of the LDV/MDV Test Procedures should be revised to delete the continuous ±5°F tolerance for the preconditioning, soak, and test temperatures. Instead, a requirement should be added providing that the temperature may not exceed 50 ±5°F for more than 3 consecutive minutes during each test phase. The soak temperature should be sampled every minute, instead of every 5 minutes. An average ±3°F over each test segment, instead of overall, should be required. (Ford)

Agency Response: Maintaining a ±5°F tolerance continuously would provide better temperature control than the suggested 3 consecutive minutes provision and be more suitable to a 50°F test. Revising the procedure at this time to require that the soak temperature be sampled every minute instead of every 5 minutes, and to require a ±3°F average over each test segment, would not result in significant benefits.

147. Comment: The temperature tolerances specified in section 11.k. of the LDV/MDV Test Procedures should be revised to be consistent with EPA's cold CO procedures: ±3°F at start of emission testing, ±5°F on an average basis during preconditioning, soak, and test phases, and ±10°F continuously during the three phases. Controlling temperature to 50°F is very difficult and stringent.

Since we believe that vehicle manufacturers will use the same test facility for both EPA's cold temperature CO and ARB's 50°F test, the test facility requirements should be identical for both cold CO and 50°F test regulations. (Toyota)

Agency Response: Smaller temperature tolerances are needed for 50° compared to 20° because of its proximity to normal FTP temperatures. Having larger tolerance limits would limit the accuracy in characterizing vehicular emissions at 50°F. However, if the temperature control equipment is calibrated for the tolerances specified in the LDV/MDV Test Procedures, manufacturers should be able to use the same test facility to meet EPA's requirements assuming the facility is capable of conducting an FTP test at 20°F.

148. Comment: A test sequence table should be provided in the regulations to clarify the 50°F test requirement. It should point out that there are no evaporative emission testing or diurnal tank heating requirements. (Honda)

Agency Response: In preparing the modified text for the 15-day comment period, the staff did not believe that a full test sequence table was necessary. However, nonsubstantial modifications clarifying the test sequence have been added to section 11.k. of the LDV/MDV Test Procedures. The modified language expressly states that vehicles subject to the 50°F test requirement will not have to undergo a diurnal heat build and hot soak enclosure test for the measurement of evaporative emissions.

3. Zero-Emission Vehicles

149. Comment: We do not agree with the ARB that NMOG emission credits from ZEVs should be discounted. The stated rationale for discounting was that early model year vehicles would deteriorate more than later model year vehicles. ZEVs, however, do not deteriorate. Therefore, discounting is inappropriate. (GM)

Agency Response: The credit discounting provisions in section 1960.1(g)(2) note 7.d. appropriately apply to ZEVs as well as other low-emission vehicles. Although ZEVs do not deteriorate in-use, ZEVs introduced early are likely to be less desirable than later ZEVs in performance and range. Encouraging poorer ZEV designs in the early years could result in public backlash, ultimately hampering the introduction of well-designed ZEVs.

150. Comment: We believe the small fuel-fired heaters likely to be used in future pure electric vehicles will have negligible emissions impacts compared to ultra-clean vehicles. If it is demonstrated that fuel-fired heaters have negligible emissions, the ARB should be open to revising the regulations at some future date to allow electric vehicles with fuel-fired heaters to qualify as ZEVs. (SCE)

Agency Response: If the data show that fuel-fired heaters do indeed have negligible emissions and that these emissions do not deteriorate significantly in-use, then we would be willing to consider amending the regulations to classify electric vehicles with such heaters as ZEVs.

151. *Comment*: We recommend that section 1960.1(g)(2) note 9.c., and the corresponding provision in the LDV/MDV Test Procedures, be revised to add the following: "Small volume manufacturers may earn and market credits for ZEVs they produce and sell." This would further clarify that small volume manufacturers can earn and market credits if they produce and sell ZEVs. (SCE)

Agency Response: The regulatory intent has been to allow small volume manufacturers to earn credits for ZEVs, and nothing in the 15-day modified language precluded such manufacturers from earning credits from ZEVs. However, to further clarify the regulations, the requested language has been added.

4. *Hybrid Electric Vehicles*

152. *Comment*: We believe the portions of the regulations concerning HEVs will need to be revised as additional information becomes known about these vehicles. (GM)

Agency Response: The staff has been following the progress of hybrid development and plans to work with manufacturers in assessing the need to modify the hybrid regulations. Any necessary regulatory changes may be recommended to the Board as part of the biennial review in 1992 or as otherwise appropriate.

153. *Comment*: In the interest of encouraging HEV development, the optional g/bhp-h standard (engine dynamometer test procedures) should be allowed for HEVs that are in the medium-duty vehicle class. (Renner)

Agency Response: The overall emission impact of hybrids is dependent on both the emission level of the engine (as measured by engine test procedures) and the extent that the engine is used during vehicle operation. Since chassis dynamometer testing better simulates the conditions under which hybrids are driven, it is not appropriate at this time to allow engines used in medium-duty HEVs to be tested under the optional engine dynamometer test procedures. However, this issue will be revisited at the biennial review in 1992.

5. *Fuel Issues*

154. *Comment*: In the specifications for Phase 1 certification gasoline in section 9.a. of the LDV/MDV Test Procedures, the

distillation ranges for the Initial Boiling Point and 10% Point should be narrowed to 80-100 and 125-140°F, respectively, from 75-100 and 120-140. Some of the points of the distillation range are wider than in the federal regulation (40 C.F.R. § 86.113-90). (Toyota)

Agency Response: Because there were no available data on the composition of 7.8 RVP fuel, the tolerances were expanded to ensure that most 7.8 RVP gasolines could be used. We believe that additional data should be obtained before the tolerances are narrowed. Any necessary regulatory changes may be recommended to the Board as part of the biennial review in 1992 or as otherwise appropriate. We also note that since the ARB's distillation ranges overlap with EPA's, nothing precludes a manufacturer from doing its certification testing with gasoline within both the ARB's and EPA's ranges.

155. Comment: The fuel used in in-use compliance testing should be the same as the fuel used to certify the vehicle. (Honda)

Agency Response: No modifications are necessary in this regard because current ARB regulations already provide that the same fuels are used for certification and in-use compliance testing. (13 C.C.R. § 2138.)

156. Comment: Deterioration factors generated from a durability vehicle operating on indolene should be allowed to be used for emission data or fuel economy data vehicles tested on 7.8 psi RVP Phase 1 certification gasoline. (Honda)

Agency Response: We believe that additional data should be obtained before the regulations are modified as requested by the commenter. Any appropriate regulatory changes can be recommended to the Board as part of the biennial review in 1992 or in other contexts.

6. NMHC Test Procedures.

157. Comment: The National Bureau of Standards, as referenced in the NMHC Test Procedures, has been renamed the National Institute of Standards and Technology. (Ford)

Agency Response: We have changed the reference as suggested.

158. Comment: In the NMHC Test Procedures, use of ±2% accuracy test analysis gases should be specified for calibration of the gas chromatograph instead of ±1%. This would be consistent with the accuracy requirements for HC (propane), CO, CO2 and NOx span gases specified in the Code of Federal Regulations (40 C.F.R. § 86.114-79(a)7c. [the commenter apparently was referring to 86.114-79(c)].) (Ford)

Agency Response: The use of ±1% accuracy span gases has been specified in the NMHC Test Procedures since their original adoption in 1978. Since this has not been a problem in the past, we do not believe a change is necessary at this time. However, this could be reconsidered as part of the biennial review process in 1992. We additionally note the a manufacturer could conduct one set of tests using ±1% accuracy span gases and satisfy both the ARB and EPA requirements, since such gases would not be inconsistent with EPA's ±2% accuracy criteria.

159. Comment: Procedures for measuring NMHC in exhaust from CNG vehicles are not included in the NMHC Test Procedures. Will they be revised again to include this information? (Ford)

Agency Response: Because of the high methane fraction, the current procedures could result in negative NMHC values at low emission levels. However, the procedures do include criteria to treat negative measured values of NMHC. ARB has developed an improved procedure to measure NMHC emissions from CNG vehicles which may be included as a future update to the NMHC measurement procedures. In the interim, manufacturers planning to certify CNG vehicles may utilize these improved procedures subject to the approval of the Executive Officer. (See NMHC Test Procedures V.A.)

7. Miscellaneous

160. Comment: The status of small volume manufacturer is based on the average sales between 1989 to 1991. (§ 1960.1(g)(2) note 6.) The regulation should contain provisions to either add or delete this status if a manufacturer's sales changes before 2000. This feature would avoid unfair advantages or disadvantages for all manufacturers. (Ford)

Agency Response: The modified language was included for the reasons stated in II.A.9. above. Further modifications which provide sufficient predictability while recognizing substantial subsequent changes in production volume can be considered during the biennial review in 1992.

161. Comment: The ARB should delay the adoption of the NMOG definition for diesel vehicles (LDV/MDV Test Procedures § 2.z.) and consideration of associated test procedures until a future rulemaking. If a revised definition must be included in this rulemaking, the ARB should review the propriety of the definition at the reactivity hearing and the biennial review. (EMA/MVMA)

Agency Response: The definition proposed for NMOG pertaining to diesel vehicles was developed based on ARB's assessment of the ozone impact of specific diesel constituents. The ARB will be working with manufacturers in following the progress of research in this area, and if the NMOG definition needs to be changed, a recommendation will be made to the Board at the biennial review in 1992. ARB is currently developing test procedures for diesel exhaust speciation. These procedures will also be considered at the biennial review.

162. Comment: Neither the 1995 medium-duty standards nor the proposed low-emission vehicle standards for MDVs make clear that vehicle manufacturers and their engine suppliers may decide among themselves who has the responsibility and who receives the corresponding "credit" for compliance with the ARB's phase-in requirements. We understand that MAC #87-07 will be revised to include a specific scenario for vehicles greater than 8500 lbs. GVW, under which manufacturers may allocate responsibility and corresponding credits among themselves as long as engines are not double-counted. We would support this. (EMA/MVMA)

Agency Response: This comment is not directed towards the modifications made available for 15-day comment, and the commenters do not request any revisions to the regulations. In any case, allocation of responsibility and corresponding credits among manufacturers is not precluded under the regulations as long as engines are not double-counted.

163. Comment: In the modified regulatory texts made available for 15-day comment, the following references to fleet average "standards" should be changed to fleet average "requirements" for consistency. (GM):

(a) Attachment II, page 18, footnote (8).b. (§ 1960.1(g)(2) note 8.).

(b) Attachment II, the title on page 8 of the LDV/MDV Test Procedures. (§ 3.h., title of table.)

(c) Attachment II, page 12 of the LDV/MDV Test Procedures, footnote (8).b. (§ 3.h. note 8(b).)

Agency Response: These nonsubstantial modifications have been made as suggested.

D. Comments Pertaining to the Clean Fuel Regulations Made Before or at the Hearing

1. The proposed clean fuel distribution requirements

164. Comment: We oppose adoption of the proposed clean fuel distribution requirements, which mandate that gasoline suppliers distribute assigned volumes of clean fuels. We have one or more of the following concerns regarding the distribution requirements. (Arco, CMA, Chamber, Hail, WSPA, EDF, Mobil, Chevron, Ultramar, Texaco, CIOMA, Sierra Club, AMI, Tosco).

Concerns with the distribution requirements in general

The distribution requirements are unreasonable and impractical since suppliers and retailers would be required to sell specific quantities of clean fuels while the owners of vehicles which could operate on either the clean fuel or gasoline are not required to buy clean fuel.

The distribution requirements would create a hidden subsidy for clean fuels. The cost of a clean fuel will have to be shared with gasoline in order to make more expensive clean fuels sufficiently affordable to enable gasoline suppliers to distribute their mandated volumes. This approach will encourage the development of alternative fuels that are not cost-effective. It is the equivalent of a regulatorily-imposed gasoline tax increase and subsidy for some clean fuels. The producers and feedstock suppliers of the least competitive clean fuels will be the recipients of the subsidies paid by others. The ARB has not provided an analysis showing that requiring the distribution of clean fuels is the most efficient way for the ARB to achieve its air quality goals.

The distribution requirements reflect poor economic policy. They do not satisfy the cost-effectiveness requirements of Health and Safety Code sections 43013 and 43018, adopted by the California Clean Air Act of 1988, because they allow vehicle manufacturers unilaterally to select fuels without consideration of the economics of producing those fuels. Fuel suppliers would be required to sell certain quantities of whatever clean fuels the vehicle manufacturers choose. There would be a diminished incentive to reduce costs to be more competitive because of the protection offered to the clean fuels through the distribution requirement. The distribution requirements are being proposed only because the mandated "clean fuels" are expected to be poor competitors in the marketplace. The cost in administration, compliance, and misallocation of resources from the distribution requirements could be enormous.

Requiring specific volumes of clean fuels to be distributed ignores the finding of the AB 234 Advisory Board that mandates to introduce alternative fuels are unnecessary and unreasonably intrusive into the marketplace.

Fuel diversification does not necessarily mean improved energy security. We may be simply trading a dependence on raw materials for a dependence on products.

The ARB lacks the legal authority to require the distribution of clean fuels.

<u>Concerns with specific provisions in the distribution requirements</u>

Allocation of the clean fuel volumes required to be distributed according to gasoline market share is unreasonable. It may result in shortages and overages in many parts of the state.

A marketable credit system would be very difficult to administer and enforce, and would provide great potential for fraud and abuse. The purchase of CNG credits would produce an additional profit for the natural gas companies and an additional cost of doing business for the refiner or importer.

The proposed recordkeeping provisions in the distribution requirements are overly burdensome.

The 1994-1996 distribution requirements should apply to all fuel suppliers, not just majors. To do otherwise is discriminatory and inequitable, and puts the major suppliers at a competitive disadvantage.

Independent refiners are important suppliers of gasoline who do not have sufficient capital resources to meet the distribution requirements during the 1994-1996 period.

The timeframe for implementing the distribution requirements may be too short for market adjustment because it is too early to predict what fuel or fuels are likely to be required as the low-emission fuel to meet the requirements.

<u>Agency Response</u>: As discussed in II.B above, the Board decided to delete the proposed distribution requirements.

2. <u>Alternative approaches for introducing clean fuels</u>

165. <u>Comment</u>: An economic incentive program, sunsetted after five years, would help alleviate the costly introduction of clean fuels into the marketplace. (WSPA)

<u>Agency Response</u>: Economic incentives do not alleviate cost, they simply shift cost. The AB234 Advisory Board evaluated the use of economic incentives such as lower registration and/or smog check fees, lower sales tax, lower permitting fees for station owners required to install clean fuel outlets, etc. and concluded that the best approach was to establish performance standards for fuels that were consistent

with achieving environmental goals. Economic incentives alone would not ensure that clean fuels would be distributed in sufficient quantities to adequately supply low-emitting vehicles.

In any case, as discussed in the response to the previous comment, the Board lacks the authority to incorporate an economic incentive program in the regulations at this time.

166. Comment: Should fuel producers be mandated to sell specific quantities of clean fuels when the owners of flexible-fueled vehicles (FFVs) are not required to buy clean fuels? Would mandated availability be a better approach? (Brown, Roberti, Maddy, Johnson)

Agency Response: As discussed in II.B.1. & 2., the Board decided to delete the distribution requirements which would have mandated the distribution of specific quantities of clean fuels, and has enhanced the retail outlet and availability requirements.

167. Comment: Should the marketplace and free market mechanisms and the existing cooperative program between the CEC and a number of oil companies to supply methanol fuel (M85) be allowed to work before the state moves directly to mandate sales of specific types and volume of fuel? (Brown, Maddy, Roberti, Johnson, Arco)

Agency Response: As stated in the response to the preceding comment and in II.B.1. & 2., the Board decided to delete the distribution requirements. Accordingly, the regulations will not mandate the sales of any specific volume of any fuel.

We do not believe that the marketplace and free market mechanisms alone will assure the adequate availability of clean fuels, particularly in the early years, as discussed in II.B. above. In the early years of the program, consumer demand for low-emission vehicles will depend heavily on the consumer's perceived availability of clean fuels. While this may be true to a lesser degree for consumers purchasing FFVs that could be fueled with either gasoline or a clean fuel, the maximum air quality benefits from low-emission vehicles will be achieved only when owners of FFVs use the clean fuel to the maximum extent feasible. Thus it is appropriate to assure that the clean fuels are marketed such that they are substantially as attractive to a motorist as gasoline. There has been no demonstration that the market system alone would assure this.

The adequacy of the CEC program to substitute for the clean fuels elements of the adopted regulations is discussed in the response to the next comment.

168. Comment: In the event FFVs operating on M85 are chosen by fleet operators in the South Coast to meet the 1993-96 transitional vehicle program, the ARB should consider the current CEC voluntary

program adequate to meet M85 fuel needs. This voluntary program will likely provide all of the outlets necessary to meet consumer demand particularly when you consider that a great portion, probably 50% or more of the fleet vehicles, will utilize their own facilities for refueling the vehicles. In our judgment, the voluntary program could easily be expanded as needed to meet projected market demands for M85 fuel. (Mobil)

We do not believe that requirements for alternative fuel availability are necessary. Based on our experience with the introduction of diesel fuel vehicles into light-duty service in the late 1970's and early 1980's, our industry has demonstrated its capability and willingness to make alternative fuels available without the need for government intervention. (Texaco)

Agency Response: Sole reliance on the voluntary CEC methanol demonstration program is not appropriate because with a voluntary program there would be no assurance that an adequate number of stations would be equipped to dispense M85. However, if M85 becomes a clean fuel included in the availability requirements, any stations equipped under the voluntary CEC program will qualify as clean fuel outlets. (see § 2309(b)(1).) If a sufficient number of M85 outlets are equipped under the CEC program, no further stations would be required by the clean fuel regulations.

The expansion of light duty diesel fuel vehicles in the 1970's and 1980's is not analgous. Diesel fuel was already a widespread motor vehicle fuel for heavy-duty vehicles, and was already being produced by most refiners.

169. Comment: As California is the third largest consumer of gasoline in the world and imports the majority of both its crude and refined product, we are extremely susceptible to external market forces. Is there a method which could be implemented to factor availability into the supply requirements of your regulations? (Roberti)

Agency Response: As noted in II.B.1. & 2., the Board decided to delete the distribution requirements and expand the availability requirements. Thus there is no remaining need to factor availability into supply provisions.

170. Comment: Instead of a mandatory "produce and distribute" requirement, we recommend an approach that would require every service station in a nonattainment area to have at least one "clean fuels" pump and the associated product always available for sale. Furthermore, the fuel marketer should be required to "be capable of producing and distributing" a minimum percentage of clean fuel for his sales mix, where the percentage is based on the total number of low-emission vehicles in the on-road fleet. A reformulated gasoline would be our clean fuel of choice, while other marketers may make different choices. (Arco)

Agency Response: As noted in II.B. 1. & 2., the Board has deleted the distribution requirements and has expanded the retail outlet requirements. However, we do not believe that several aspects of the commenter's suggested approach are appropriate.

First, the statewide program should not be limited to nonattainment areas. A uniform program would improve compliance with the regulatory requirements and would be much simpler to administer. Also, since vehicles currently travel in and out of nonattainment areas regularly, restricting the program to nonattainment areas could impede the progress of those areas in meeting attainment status.

Second, we do not believe it is necessary to require every station in a nonattainment area to install a pump dispensing designated clean fuel (as defined in section 2300(a)(5).) The demand for clean fuel will grow as auto manufacturers produce more low-emission vehicles to meet stricter fleet-wide emission standards. Requiring all gasoline stations in nonattainment areas to install clean fuel pumps before there is a sufficient number of low-emission vehicles on the road will result in unnecessary costs to service station owner/lessors and operators. The adopted regulations reduce the possibility of the clean fuel supply far exceeding demand by basing the number of clean fuel stations required throughout the state on the projected and existing clean fuel demand of low-emission vehicles. The regulations also reduce the chances of localized oversupply of clean fuels by requiring gasoline station owner/lessors to submit plans to the ARB identifying the proposed locations of their required number of clean fuel outlets.

We agree with the general concept suggested by the commenter of requiring fuel marketers to demonstrate clean fuel production and distribution capability. As discussed in II.B.8 above, the provisions in adopted section 2309(c) impose responsibilities on service station owner/lessors (who are often fuel distributors) in assuring adequate supplies of clean fuel to their stations.

The commenter states that a reformulated gasoline would be its fuel of choice. One of the conceptual underpinnings of the regulations is that clean fuels are fuels that used to meet the low-emission vehicle standards and that are not otherwise widely available. To the extent the ARB's Phase 2 reformulated gasoline regulations require that all gasoline in the state meets the reformulated gasoline standards, selling such a "reformulated gasoline" should certainly not satisfy "clean fuel" requirements. The regulations are structured so that if vehicle manufacturers certify low-emission vehicles on a new gasoline that is cleaner than Phase 2 reformulated gasoline, that new gasoline would be a clean fuel covered by the regulatory requirements. However, it would still not be appropriate to allow an owner/lessor of gasoline stations to completely satisfy its clean fuel requirements by selling only clean fuel, because there would not be adequate assurance that there would be sufficient availability of each clean fuel used in low-emission vehicles.

171. Comment: One foreseeable flaw in the clean fuels program is the Board's authority to dictate the number of retail outlets at which the fuels must be sold. As long as a fuel supplier is required to sell fuel, the decision regarding how many stations should be equipped would be best left to the supplier. It is unreasonable to expect an environmental regulatory agency to understand gasoline markets to the same degree that the fuel suppliers do. (EDF)

Agency Response: The commenter's position leaves the Board in a difficult dilemma. Under the original proposal, the distribution requirements would have mandated that suppliers distribute allocated amounts of clean fuels. As discussed generally in II.B.1., it was expected that the distribution requirements would result in a reduced need for ancillary retail outlet requirements. This was because gasoline suppliers would find the most efficient ways to satisfy the distribution requirements, and the distribution requirements would assure that adequate amounts of clean fuel enters the market. EDF and numerous oil companies opposed the distribution requirements, and the Board ultimately decided to delete that aspect of the proposal. However, without the driving force of the distribution requirements, it becomes necessary to include significantly more regulatory requirements in the retail outlet and availability parts to assure that the clean fuels necessary to achieve the maximum emission benefits of clean fuel vehicles are adequately available and attractive to motorists. Without a determination by the ARB of the necessary minimum number of clean fuel outlets, there is no assurance that the market will provide even a minimal number of outlets in the crucial early years of the program.

3. The proposed retail outlet requirements

a. Number of required outlets and allocation among owner/lessors

172. Comment: The use of a statewide market share to allocate among major gasoline suppliers the number of clean fuel outlets required in the SCAQMD during the first three years of the program is inappropriate and inequitable. The statewide market share is not evenly distributed throughout the state for each industry. The clean fuel outlet requirement should be based on South Coast Air Basin's retail market share. If this cannot be done, the requirement could be based on the share of the retail gasoline outlets for each major gasoline supplier in the South Coast Air Basin, provided that each the major gasoline supplier reports its number of retail gasoline outlets to the ARB annually. (Ultramar)

The allocation for retail outlets in the first three years of the program in the SCAQMD based on statewide market share will lead to foreseeable problems, since the geographic distribution of the retail outlets of major suppliers is probably not uniform; some suppliers will have a greater presence in some parts of the state than others. (EDF)

Agency Response: The total incremental number of outlets required to be installed by each major gasoline supplier from 1994 through 1996 will be allocated in accordance with the fraction of the statewide taxable gasoline sales by each major gasoline supplier to the total taxable gasoline sales by all major gasoline suppliers. (§ 2305(a).) We have elected to use statewide sales because these numbers are currently available through the Board of Equalization, while corresponding South Coast figures are not currently available. We do not believe that calculating South Coast sales data is feasible given the short time frame of the South Coast program (1994-1996), the low fuel volumes, and the administrative resources that would be required for the ARB to make such a determination. (Sales data from the South Coast Air Basin alone cannot be easily attributed to each major gasoline supplier since "fuel trading" occurs among major gasoline suppliers that own refineries in different geographic locations.) We also believe that basing the allocation of clean fuel outlets on market share data represents a fairer approach than basing the allocation on the number of retail gasoline outlets owned in the South Coast, since the number of retail gasoline outlets owned does not necessarily reflect the volume of business of a major gasoline supplier.

173. Comment: It is not clear how the staff selected the percentages, set forth in the discussion in the TSD at pp. III-9 to III-13, of the clean fuel that FFVs and dual-fuel vehicles will consume (the fuel volume adjustment factors). A relatively high fuel volume requirement would presumably increase the costs of delivery and/or production; a low-volume requirement could make sales of the low-emission vehicles more difficult, and would increase the frequency with which FFVs fuel with gasoline with the associated higher emissions.

There is no evidence that the TSD systematically considered those tradeoffs in developing the fuels availability policies. We do not understand why the TSD did not include a sensitivity analysis of its benefit estimates to assess the full relationship between the fuel availability policy and the benefits of the TLEV program. (GM)

Agency Response: The fuel volume adjustment factors are not as central to the adopted regulations because of the deletion of the distribution requirements and the addition of the minimum required numbers of liquid clean fuel outlets in the early years of the program.

The fuel volume adjustment factors in the final regulation (0.75 for the first two years a fuel is introduced and 0.90 for the third year and beyond, see § 2303(c)) were included in the calculation of maximum demand volume of each designated liquid clean fuel for the following reasons:

(a) Owners of flexible- and dual-fueled vehicles will have the option of fueling their vehicles with gasoline or clean fuel. The fuel volume adjustment factors account for consumer choice.

(b) There are some uncertainties associated with the data used in calculating the maximum demand volume. These uncertainties are greater during the first years a clean fuel is introduced. The fuel volume adjustment factor guards against the overestimation of clean fuel demand that could result from these uncertainties.

Originally, there were three fuel volume adjustment factor schedules (see TSD, Appendix B-2, Table B-2-3, Table B-2-4, and Table B-2-5). The two originally-proposed schedules for calculating volumes for FFV/DFVs reflected lower initial fuel volume adjustment factors and a more gradual annual increase in fuel volume adjustment factor value. As part of the modifications prepared in response to the Board's directions at the September 27-28 hearing, the originally proposed schedules were consolidated and modified to the final schedule in section 2303(c). The increases in the schedules will more adequately assure availability of clean fuel outlets. The third schedule in the original proposal listed fuel volume adjustment factors for dedicated vehicles. It mirrored the final schedule in all but the first two years, where the existing schedule had correspondingly lower fuel volume adjustment factor values. This change was made to reduce the administrative burden of tracking dedicated vehicles for the first two years only.

A sensitivity analysis was not done to compare the cost/benefit relationship of the TLEV program exclusively because TLEVs are part of a larger program of progressively more stringent emission standards that include low emission vehicles (LEVs), ultra low emission vehicles (ULEVs), and zero emission vehicles (ZEVs). Moreover, the fleet average standard is structured such that vehicle manufacturers may introduce vehicles at any one of those levels during 1994-96. In addition, an evolving infrastructure will develop as emission standards change, and new vehicles and fuels to run them are introduced. Therefore, it would be unfair to attribute all costs associated with an ongoing program such as vehicle introduction and alternative fuel facility installation to the first three years of the program.

174. Comment: The staff's proposal states that if less than 10,000 alternative fueled vehicles are projected for sale, no alternative fuel will be required to be available. Most customers will not be willing to take the risk of purchasing such a vehicle unless assured of the availability of clean fuel for that vehicle. Nor should manufacturers need to risk development and production of vehicles for which no fuel may be available. (GM)

Agency Response: The ARB considered the economic impact on vehicle manufacturers and fuel suppliers in establishing the clean fuels availability requirement in the regulation. As a result, it was determined that a minimum number of low emission vehicles would be necessary to support a clean fuel infrastructure. This de minimus level was initially set at 10,000 low-emission vehicles in the South Coast region for 1994 through 1996 and 20,000 for 1997 and beyond. The prime considerations in establishing the de minimus number were to avoid the need to develop a large infrastructure for a short-term fuel, and to allow the owners of clean fuel outlets a reasonable opportunity to adequately recover their costs, assuming a vehicle life of 10 years. (see the TSD, Appendix B-1.) For the reasons set forth in II.B.3.e. above, the final regulations were modified to identify a statewide de minimis level of 20,000 vehicles.

In most cases, the de minimis levels should not preclude manufacturers from developing and producing clean fuel vehicles. In the first place, we expect that most of the clean fuel vehicles, particularly in the early years, will be FFVs. Since these vehicles can operate on gasoline as well as the clean fuel, the widespread availability of clean fuel will not be a necessary prerequisite for consumers to purchase these vehicles. (Indeed, there may well be considerable sales of FFVs outside the South Coast in 1994-1996 even though the clean fuels program will not start in those areas until 1997.) In addition, we expect that there will be some methanol availability because of the CEC demonstration program. We expect sales of dedicated vehicles to be considerably less than FFVs during the early years. However, even if the de minimis levels are not immediately triggered there could be a market for dedicated vehicles among fleet operators who rely on centralized fueling and therefore can provide the alternative fuel for their vehicles.

175. Comment: The ARB should assure the availability of the fuels needed to operate low-emission vehicles in all areas where the vehicles will be sold. (Chrysler)

Agency Response: As discussed in II.B.1 and 2., the Board has enhanced the retail outlet and availability requirements to assure that clean fuels will be readily available to owners of low-emission vehicles. New provisions in the adopted regulations imposing requirements on the siting of clean fuel outlets to assure adequate geographic distribution are discussed in II.B.6. We have retained the feature under which the clean fuels requirements apply starting in 1994 in the South Coast and starting in 1997 for the rest of the state. Since the South Coast has the worst air qualtiy in the state, we believe it makes sense to start the program in that area. In Resolution 90-58 the Board specified a framework under which other areas may be able to opt-in to the 1994-1996 program if they make certain demonstrations. For the reasons set forth in the response to the previous comment, we do not believe that the phase-in program will be a significant deterrent to the introduction of clean fuel vehicles outside the South Coast in 1994-1996.

176. Comment: If sales of alternative fueled vehicles are projected to be greater than 10,000, the staff's proposal only requires a fraction of the amount of clean fuel that could be in demand. This is especially true in the early years of the program. As a result, it could be expected that dedicated alternative fueled vehicles would not have adequate fuel most of the time and that FFVs would be operated on gasoline some or most of the time. In this instance. the actual air quality benefits of FFVs are much less than would be expected. (GM)

Agency Response: We do not expect that the fuel volume adjustment factors will result in the reduction of potential air quality benefits.

With the absence of the distribution requirements from the adopted program, the fuel volume adjustment factors are pertinent only in the determination of the required number of gasoline stations that will be required to be equipped to dispense clean fuels. As noted in the response to the preceding comment, the originally-proposed fuel volume adjustment factor schedules have been modified to generally include higher values, thus increasing the potential number of clean fuel stations. In the case of liquid clean fuels, it is very likely that the total number of clean fuel outlets in the first four years of the program will be based on the minimum numbers set forth in section 2304(a)(2) and discussed in II.B.3.a. above.

It is also important to note that the throughput values used in the calculation of the number of stations are estimated minimum throughputs. They are not meant to represent design constraints on the maximum amount of fuel a clean fuel outlet can supply. If demand for clean fuel exceeds what the ARB has calculated, the ARB anticipates most clean fuel outlets to be able to accommodate throughputs much greater than the minimum defined in the calculation. The greatest inconvenience we anticipate the owner of a low-emission vehicle to encounter is that he may have to drive slightly farther to refuel.

b. Including CNG outlets in the retail outlet requirements

177. Comment: Should gasoline stations be mandated to sell compressed natural gas (CNG) or do space limitations and the estimated cost of $270,000 per station for tanks, compressor, etc. make that impractical and economically infeasible and represent a "taking" without compensation? (Brown, Maddy, Roberti, Johnson)

Agency Response: No CNG will be required to be made available in California unless there is a minimum number (20,000) of CNG low-emission vehicles projected for sale in the state. The retail clean fuel outlet requirements are triggered only after this number is reached. To the extent that more than the de minimis number of CNG low-emission vehicles are introduced, we do not believe it is appropriate to exempt CNG from the clean fuel requirements, because it is potentially a viable clean fuel.

It is unlikely that a large number of CNG outlets will be required under the regulations, at least in the early years of the program. First, the required minimum numbers of outlets required for liquid clean fuels in the first four years do not apply to CNG. Second, the amount of fuel projected to be dispensed at nonretail (fleet) facilities is excluded from the volume of fuel used to calculate the required number of CNG outlets. (§ 2304(a)(4).) Third, as discussed in II.B.3.d. above, the required number of CNG outlets is reduced to account for certain preexisting retail CNG outlets. (§ 2304(a)(5).) In addition, we do not anticipate that vehicle manufacturers will introduce a large number of CNG vehicles in the early years. Even if an optimistic 10 percent of the clean fueled vehicles sold during the first 3 years of the program (1994 through 1996) were CNG vehicles, this would result in a requirement of fewer than four CNG retail dispensing outlets for each major gasoline supplier.

Space limitations can be a problem at some retail gasoline outlets. This is why the regulations have been designed to allow suppliers to choose whatever locations they please for the installation of CNG dispensers. Major gasoline suppliers typically own hundreds of stations, and they will likely be able to find enough of them with sufficient space for the equipment. The regulations also allow for constructive allocation so that if for some reason a supplier cannot install a dispenser, someone else (a utility, for example) can install one on their behalf.

The economic feasibility of requiring owners of gasoline stations to install CNG outlets is adequately addressed by the regulations in the following two ways. First, the regulations are structured so that major gasoline suppliers (who are in a better financial position) share the greater burden in the installation cost, especially in the first three years of the program. Second, with an estimated 10 year vehicle life, suppliers should at least be able to recover their installation costs through the demand for the fuel, even if the number of CNG vehicles did not rise above 20,000. These two factors, combined with the expected small number of CNG retail outlets, means that sales revenues will be spread among a few suppliers who should be able to recover their costs quickly.

With respect to the claim that application of the regulation to CNG will result in an unconstitutional "taking" without compensation, see the responses to comments in III.C.7. below.

178. Comment: The regulations would require many service stations to sell CNG. Even if space is available for the large above-ground tanks and compressor equipment, and the fire marshal and local land use authorities consent, the cost for a service station owner will be prohibitive. The capital costs are very high and range from $250,000

to $300,000 for two dispensing nozzles. A requirement to install CNG outlets is considerably more burdensome than a requirement for other alternative fuels such as M85.

CNG is primarily a fleet fuel, and we do not believe it will be economically attractive to the general consumer. It is unlikely that a sufficient quantity of CNG would be sold to make a reasonable return on the required investment.

We do not agree that CNG will be less costly to the consumer than other clean fuels. We believe that CNG dispensed form retail gasoline outlets will be 6 cents per gasoline equivalent gallon more costly that conventional gasoline. Adding in the higher costs of CNG vehicle, the total cost to the consumer for CNG will be at least 31 cents gasoline equivalent gallons (geg) more than conventional gasoline. (Arco)

Agency Response: See the response to the preceding comment. We recognize that the cost of equipping a gasoline station to dispense CNG will be substantially higher than for a M85 outlet. That is one reason why the regulation requires a specific minimum number of clean fuel outlets only for liquid fuels in the first four years.

The commenter may well be correct that CNG will primarily be used for as a fleet fuel. However, the effect of this will be to reduce the number of stations gasoline suppliers will have to equip to dispense CNG, since the CNG dispensed to low-emission vehicles at nonretail (fleet) outlets will be excluded in the calculation of the required number of stations.

We do not agree with the commenter's assessment of the potential costs of CNG to consumers as a motor fuel. We believe that CNG will be economically attractive to consumers. The ARB has estimated the annual equivalent of the combined cost of using and fueling a CNG vehicle to be less than the combined cost of using and fueling a gasoline vehicle. The cost of CNG is estimated to be about $ 0.71 in 1993, while the cost of gasoline is estimated to be approximately $ 1.21. Details on how this estimate was determined are described in Chapter IX, Part D of the TSD. However, to the extent that the commenter is correct in its assessment of the economic attractiveness of CNG vehicles, the likely consequence would be that fuel CNG vehicles would be sold and few in any CNG outlets would be required.

179. Comment: Given that the natural gas industry acknowledges CNG's application to fleet situations, the natural gas industry should be willing to provide the refueling sites which will offer them further opportunities to sell their product.

If the natural gas suppliers, the advocates of inclusion of CNG as a clean fuel, think that CNG is going to be a viable fuel for general use, then they should be willing to bear the cost of providing the required refueling facilities along with the necessary property. (Arco)

Agency Response: In order to achieve the maximum emission reductions possible, it is necessary for clean fuels to be made available to those consumers who wish to purchase them. It makes sense to provide these fuels at traditional refueling sites--retail gasoline outlets--for the following three reasons:

(a) Vehicles that are currently fueled with gasoline generate more than half of the air pollution in the state. The owners of retail gasoline stations sell gasoline and should share the responsibility with vehicle manufacturers in reducing the amount of these vehicular emissions.

(b) Retail gasoline station owners have the existing retail market facilities to make clean fuels available and the expertise to market them successfully.

(c) Consumers that purchase flexible- or dual-fueled vehicles will have the choice of refueling their vehicles with gasoline or clean fuel. It is critical to the realization of potential emission reduction benefits that the clean fuel be as readily available as gasoline to these consumers.

c. Distinctions between major and other gasoline suppliers

180. Comment: The ARB should change the definition of a major gasoline supplier from a gasoline supplier with a minimum crude oil capacity of 50,000 barrels per stream day (bpsd) to one with 55,000 bpsd. Because it has been unable to develop an economically viable means to manufacture low sulfur diesel in compliance with the ARB's new specifications, Golden West has opted to exit the diesel fuel market and manufacture jet fuel instead. This will be achieved by retraying the refinery's crude column to permit separation of a jet fuel cut. In turn, the refinery's high sulfur diesel production will be reduced to the extent that it can be consumed as charge to other upgrading units. This will result in the expansion of Golden West's throughput capacity to 55,000 bpsd and, accordingly, result in Golden West's inadvertent inclusion in the definition of "major gasoline supplier." (Golden West, AIRA)

Agency Response: In response to this comment we have modified the definition of "major gasoline supplier" in section 2300(a)(18) as requested.

181. Comment: Small and independent refiners should be given additional time to comply with the regulations. This would allow them additional time to take advantage of technological change, resulting in the desired level of control for reduced cost. For small refineries, capital improvements cost more on a per barrel basis and there is less opportunity to take advantage of economies of scale.

Furthermore, independent refiners have more limited sources of capital relative to major oil companies because loans are generally not available for these non-economic investments. Therefore, the needed improvements have to be financed internally from savings and available cash flow. (Golden West)

Agency Response: Further modifications to the regulations to accommodate small and independent refiners are not necessary or appropriate. As noted elsewhere, the regulations have been modified by deleting distribution requirements and enhancing the retail outlet and availability requirements. Under the modified regulation, only those refiners that are the owner/lessors of retail gasoline stations are required to install clean fuel dispensing equipment (and to incur capital expense) to comply with the regulation. From 1994 through 1996, only major gasoline suppliers will be required to comply with the regulation. Beginning in 1997, small and independent refiners that own retail gasoline outlets may need to install clean fuel dispensing equipment. However, the number of clean fuel pumps they will need to install will depend on how many gasoline stations they own.

182. Comment: A gasoline supplier with 25 retail gasoline outlets and a 50,000 bpsd refinery cannot reasonably be considered a major gasoline supplier. In order to be an effective major gasoline supplier, a degree of integration or balance must exist between the ability to produce and market gasoline. Ideally, a major gasoline supplier should be defined on the basis of a minimum market share in the South Coast. If collecting the necessary data is an administrative burden, as a fallback method, we would suggest that ARB use a limit of 100 retail gasoline stations in the South Coast--about 2% of the total retail outlets in the South Coast--for the definition of major gasoline supplier. (Ultramar)

Agency Response: Section 2300(a)(1) has been modified to define a "major gasoline supplier" to be a refiner with a crude oil production capacity of greater than 55,000 barrels per stream day and owning 35 or more gasoline outlets. We do not believe that a refiner who has a refinery exceeding 55,000 bpsd capacity and is the owner/lessor of up to 99 retail gasoline stations in the South Coast is small enough to be excluded from the 1994-6 phase of the program.

183. Comment: We strongly oppose the proposal for TLEV fuel supply to be assigned to only the major producers in the South Coast Basin. We are a strong supporter of the free market and we believe if a fuel is required for a given area, then all persons who market in the designated area should be required to supply a fuel meeting the approved standards in a reasonable number of stations based on their market share. (Mobil)

Agency Response: It would not be appropriate to require all gasoline suppliers to provide clean fuels since many do not own the retail gasoline outlets that would be required to offer clean fuel for sale, and because the retail gasoline outlets that will be required to offer clean fuels can be served adequately by their owners--major gasoline suppliers. Furthermore, the ARB staff has determined that the major gasoline suppliers are financially in a better position than most smaller, independent gasoline suppliers and therefore better able to absorb the cost associated with making clean fuels available during the first phase of the program.

d. Miscellaneous

184. Comment: The planning for and installation of new retail dispensing facilities may take at least 12 to 24 months. This time factor does not appear to be accounted for in the ARB's proposals that will only provide 12 months advance notice of the number of retail outlets required to carry/dispense clean fuels. (WSPA)

Agency Response: As modified, the regulations now provide for notification of preliminary estimates of the required number of retail outlets 18 months before compliance is required. (§§ 2305(d), 2307(e)) This will allow sufficient additional leadtime.

In addition, affected owners of retail gasoline outlets have access to the method the Executive Officer will be using to determine the number of clean fuel outlets required. Further, the information used to determine the number of required clean fuel outlets will be available from vehicle manufacturerers and federal and state agencies. Each owner can use this information to estimate the number of retail clean fuel outlets that each will be required to install. Currently, it is possible for each major gasoline supplier to estimate the minimum number of clean fuel outlets it will be required to install for 1994, and possibly for 1995. For 1994, the minimum number could be estimated for each designated liquid clean fuel by multiplying the major gasoline suppliers marketshare by 90, the minimum number of stations for each designated liquid clean fuels. For 1995, each minimum number could be estimated by multiplying the major gasoline suppliers marketshare by 200. These estimates allow affected owners of retail gasoline outlets to prepare well in advance for the installation of their required outlets.

185. Comment: The Executive Officer in ARB's proposal has a high degree of control over various elements of the process and a high degree of discretion in decision-making. We would like to request that there be a mechanism for the public to see a well-documented rationale for the decisions made by the Executive Officer. For example, we would like to have access to the background information that the executive officer use in his/her determination of the clean fuel volumes and number of retail outlets mandated periodically by the Executive Officer. (WSPA)

Agency Response: The regulations have been modified to accommodate the commenter's concerns. Sections 2305(d)(1) and (2), and 2307(e)(1) and (2), now require that the Executive Officer's preliminary and final notifications of the required number of clean fuel outlets include a detailed analysis of how the numbers were derived.

186. Comment: We would like clarification of whether the retail outlets that have been and will be participants in the CEC's methanol demonstration program will be included in the ARB's program and will count towards individual company's mandated requirements. (WSPA)

Agency Response: There has never been anything in the proposed regulatory language that would preclude M85 outlets equipped under the CEC program from being used to comply with the ARB's clean fuels regulations. In any event, Section 2309(b)(1) of the adopted regulations clearly provides that any dispenser equipped by a major gasoline supplier prior to January 1, 1993 to dispense methanol or M85 as part of the CEC's methanol demonstration program will be deemed to satisfy the requirements pertaining to siting clean fuel outlets. Similarly, section 2309(b)(1) provides that such dispensers will also be deemed to satisfy the requirements pertaining to accessibility and visibility.

4. Substitute fuels

187. Comment: We need clarification of originally-proposed section 2345(a) which alludes to the fact the substitute fuel can be used to substitute for retail availability requirements as well as the supply volume distribution requirements. Since CNG is currently included only on the retail side requirements, we need clarification of which fuels ARB sees being substituted for in this provision. (WSPA)

Agency Response: Section 2317 of the adopted regulations contains the substitute fuels provisions. Section 2317(a) states that a substitute fuel may be used instead of a primary designated clean fuel to satisfy any requirements of the subchapter pertaining to a designated clean fuel. Thus a qualifying substitute fuel could substitute for any designated fuel, including CNG, for the purpose of satisfying any clean fuel requirement.

188. Comment: Section 2345(a)(1) of the proposed regulations states that emissions of NMOG, NOx, CO, benzene, 1,3 butadiene, formaldehyde, and acetaldehyde from the substitute fuel must be no greater than those from the primary designated clean fuel in order to qualify. Since the list includes both criteria pollutants and toxic pollutants on a mass basis we do not foresee an "ultra-clean" gasoline ever being able to qualify as a substitute fuel. We request a more

fair treatment of the pollutant criteria we have to meet that takes into account more than just a mass emissions comparison. (WSPA)

Agency Response: As discussed in II.B.12, the criteria for comparing toxic emissions from the candidate substitute fuel and the primary designated fuel have been changed so that a fuel may qualify as a substitute fuel provided that its use does not result in potential health risks from exposure to the four identified toxic compounds in the aggregate greater than the corresponding potential health risks resulting from the primary designated clean fuel. (§ 2317(a)(2).) Thus toxic pollutants will not be compared solely on a mass emissions basis.

189. Comment: We are concerned with a provision in originally proposed section 2345(2)(A)(c) (apparently the commenter intended to refer to § 2345(c)) which requires suppliers of substitute fuel to provide volumes of fuel equal to the total required quarterly volume for the primary designated clean fuel plus the average quarterly volume of all gasoline attributed by a supplier to vehicles which are capable of using the substitute fuel. We have problems with this requirement since: (a) the oil companies may only be able to produce the substitute fuel in relatively small volumes and would not be prepared to produce a significant portion of the whole pool as a substitute fuel, and (b) we do not believe it is good planning to have the oil companies expend considerable resources in preparing to produce Phase 2 gasoline as the predominant gasoline and then switch over to an ultra-clean gasoline as the predominant gasoline. (WSPA)

Agency Response: The provisions requiring the distribution of substitute clean fuel volumes have been deleted with the rest of the distribution provisions, and the language of concern to the commenter is therefore no longer in the regulation.

190. Comment: The definition of a substitute fuel puts a tremendous burden of environmental superiority on the candidate substitute fuel. The proponent would have to demonstrate that "use of the substitute fuel would not result in higher criteria pollutant emissions than when the primary clean fuel is used . . ." All clean fuels involve tradeoffs, which means that some emissions types will be higher while others are lower. It is not practical to limit the substitute fuels to this stringent criteria for acceptance. (WSPA)

Agency Response: Rigorous testing of the effects of a substitute fuel in vehicles designed to use the primary designated clean fuel or some other fuel is necessary to ensure that the air quality benefits of the low-emission vehicles/clean fuels program are achieved. When vehicles are certified, they must meet all of the emission standards (as adjusted for reactivity) regardless of the fuel used. Similarly, a fuel should not be qualified as a substitute fuel unless vehicles using the fuel will meet the same emissions standards that they meet on the primary designated clean fuel.

We believe that the methods that will be used to compare criteria pollutants and toxic emissions from vehicles using a candidate substitute fuel versus the primary designated fuel are the most practical available. Emissions of criteria pollutants will be compared on a mass basis. At this time, there is no practical means to determine if one particular criteria pollutant could be offset by another, therefore, comparison on a mass basis is the most practical. Toxic emissions will be compared on a potency weighted basis, as discussed II.B.12. This is a practical means of determining the effects of toxic emissions associated with the use of a substitute fuel versus the fuel it may replace.

191. Comment: Under the proposed regulations, to qualify a substitute fuel for ARB approval the fuel proponent would have to demonstrate that the use of the substitute fuel would not adversely affect the durability of the emissions control systems. It would be highly inappropriate for any party other than the vehicle manufacturer to certify vehicle/fuel systems, especially if the manufacturer will be held accountable for replacement of parts or components under warranty or recall for vehicle/fuel systems over which they have no control. (GM)

Agency Response: Section 2317 does not authorize the "certification" of vehicle/fuel systems by any person other than the vehicle manufacturer, and does not abrogate the warranty relationship between the vehicle manufacturer and purchaser. Section 2317(a) provides that any designation of a substitute fuel by the Board will be made by regulation. Accordingly, vehicle manufacturers will have an adequate opportunity in the rulemaking proceeding to comment on the effects of the candidate substitute fuel on the durability of the emission control system or other components of the manufacturer's vehicles, or on the manufacturer's warranty obligations.

192. Comment: The proposed substitute fuel provisions do not spell out a specific protocol for durability testing. Rather, it seems that a candidate fuel must not increase vehicle deterioration "based on a consensus approval of the affected auto manufacturers." We think the durability test protocol should be specifically defined in the regulation. (Arco)

Agency Response: Section 2317(a)(3)(C) provides that, whenever a proposed substitute fuel may be used to fuel motor vehicles other than low-emission vehicles certified on the primary designated clean fuel, the proponent must demonstrate that use of the substitute fuel in the other vehicles will not result in increased deterioration of the emission control system or void the warranties of the vehicles. A substitute fuel can only be designated pursuant to a new rulemaking. The durability criteria provide sufficient guidance for the Board to be able to evaluate the adequacy of a candidate substitute fuel in future rulemakings. If more complete criteria are developed, the

Board can always consider amending the regulation to incorporate the new criteria.

193. Comment: The requirement that evaporative NMOG emissions from vehicles using a substitute fuel not increase when compared to evaporative emissions from those vehicles using the primary designated clean fuel would limit the possibility of qualifying a "splash blended" ethanol blend as a clean fuel. This seems contrary to existing EPA and California RVP regulations allowing a RVP waiver for gasoline blends containing 10 percent alcohol. (Ultramar)

Agency Response: An alternative fuel will trigger the clean fuel requirements only if it is used in a low-emission vehicle which does not meet the same low-emission standard when running on conventional gasoline. A fuel should not be permitted to serve as a substitute for the primary designated clean fuel unless it achieves an equivalent emissions performance. The application of the RVP regulation to gasoline-ethanol blends is not relevant to whether a fuel should qualify as a substitute fuel.

194. Comment: Since the substitute fuel provisions have only very recently been incorporated into the staff's recommendations, and there is so much lack of clarity as to how the procedure will actually be implemented, we request that the Board defer adoption of the substitute fuel provisions until they have been workshopped by the ARB staff with affected industry groups. (Texaco)

Agency Response: The substitute fuel section and protocol was added to the clean fuel regulations to address concerns raised by the oil industry during the development of the regulations. The substitute fuel test protocol was part of the proposed regulations released on August 13, 1990 at the commencement of the 45-day comment period. Final section 2317 and the substitute fuel test protocol were revised and re-released for fifteen day comments in January 1991. We have considered the comments made during the initial and supplemental comment periods, and have modified the substitute fuel provisions and protocol as appropriate in light of these comments. We do not believe the substitute fuel provisions are unclear or unworkable.

The substitute fuel provisions offer an option that no one is required to use. If some oil companies believe the program is unworkable, the companies do not have to use the option. However, this is not a reason to eliminate it as an option for all oil companies.

195. Comment: We believe the ARB's intent is to insure statistical significance in the substitute clean fuels test protocol to demonstrate equivalence. The t-test method proposed is designed to prove there is a difference between two fuels, but not, conversely, that two fuels are equivalent. The statistical protocol should

specify that the tester do a certain minimum number of replicates and achieve a maximum ratio of standard deviation to the mean of the replicates. (Arco)

Agency Response: The adopted test procedure is adequate to serve its purpose under the clean fuel regulations, which is to compare two fuels and detect nonequivalency. The issues of the "t-test" and maximum allowable deviation among replicates are pertinent but not critical to the practicality of the test procedure. If experience in applying the procedure shows that changes would be useful, the ARB staff may propose changes in the future.

196. Comment: As we understand the substitute clean fuels test protocol, a substitute clean fuel must demonstrate equivalence or superiority in each and every technology class. To us, a more reasonable criterion would be an equivalency when the test data from each technology class are "weighted" by a vehicle population model like EMFAC7E to get a total fleet vehicle result that is equivalent or superior. (Arco)

Agency Response: A change to using a single comparison rather than multiple comparisons, as the commenter suggests, could be an improvement. However, it would not be necessary to the practicality of the adopted procedure, which is adequate for the purpose of the regulations. Amendments can be considered in the future if experience demonstrates they are appropriate.

5. Costs and cost-effectiveness

197. Comment: The cost of compliance with the regulations and the cost-effectiveness of the program have not been adequately considered. Methanol could cost as much as $.25-$.40 per gasoline equivalent gallon (geg) more than regular gasoline and the combined methanol and vehicle cost could be as much as $.33-$.44 per geg than conventional gasoline. The cost of CNG varies depending on the type of service, non-interruptable natural gas supply versus other, and the season, and would cost $.06 per geg more than conventional gasoline. LPG would cost the same amount as conventional gasoline; however, the LPG vehicle cost would be $900-$2000 higher than the gasoline vehicle cost resulting in a combined fuel/vehicle cost of $.18 per geg higher than conventional gasoline-fueled vehicles. Electric vehicles are more expensive to operate due to the cost associated with batteries that need to be replaced every 20,000 miles. The electricity used to power an electric vehicle would be $.08 per mile higher than gasoline. The California Council for Environmental and Economic Balance reported that the initial cost difference of an electric vehicle would equate to $.05 per mile when amortized over 100,000 miles of life. If applicable, this would bring the total cost of the Impact (an electric vehicle) to $.08 per mile over a gasoline vehicle, and the price of gasoline would have to increase by $2.00 per gallon before the total

purchase and operating costs of the Impact were less than a car fueled by conventional gasoline. (Arco)

Agency Response: Our estimates on costs of clean fuels and cost-effectiveness are set forth in Part D of the TSD, particularly on pages IX-8 and following. The staff has compiled its cost estimates from a variety of sources we believe are reliable.

The estimated cost for methanol is the cost quoted in the AB234 Advisory Panel's Executive Summary. It is based on what the majority of the panel believed the cost for methanol would be after hearing testimony from various fuel industry representatives as well as the CEC. The CEC used the study prepared by Bechtel, Inc., California Fuel Methanol Cost Study, to estimate the cost of building a methanol producing facility and transporting methanol to Los Angeles. This study was sponsored by a number of major oil companies, the Canadian Oxygenated Fuels Association, Electric Power Research Institute, SCAQMD, and the CEC. Additional costs for transportation to the retail service station were then added to obtain the ultimate price to the customer. The cost to install methanol dispensing equipment is based on actual cost incurred by retail service stations in the South Coast that are required to install methanol-compatible tanks as well as stations that have installed methanol dispensing equipment as part of the CEC's Methanol Program.

The estimated cost for CNG is the CEC's estimate based on information supplied from PG&E, a utility that currently distributes CNG for use in motor vehicles. The cost for natural gas delivered to an outlet designed to dispense CNG to motor vehicles is based on an equal allocation of cost associated with interruptable and non-interruptable service to current industrial customers and does not include the cost of an attendant at the dispenser. The cost of the dispensing equipment is estimated for a 250 standard cubic feet/minute, 3,600 psi, 2 nozzle dispenser capable of a 5 minute refueling time. These costs were corroborated by Southern California Edison, SoCal Gas, British Columbia Gas, San Diego Gas and Electric, and the ARB.

Estimated LPG fuel costs are the CEC's estimates based on the current cost of LPG. LPG price tracks the price of gasoline. According to the Western Liquid Gas Association, LPG is priced at 60 percent of the price of unleaded gasoline, so that the differential remains approximately constant. The costs in the TSD are based on the Delphi IV petroleum price forecast. LPG suppliers currently project LPG supplies available in California to continue in excess of California demand. Therefore, it is likely that the current retail availability of LPG would be adequate to supply the number of LPG vehicles likely to be produced. LPG vehicle costs are estimates by the Mobile Source Division ("MSD") of the ARB based on the current technology for LPG vehicles and the emission control technology associated with such vehicles. Additional costs above gasoline vehicles for LPG vehicles are ascribed to the revised fuel system and fuel storage components for OEM vehicles. In order to meet LEV and

ULEV standards for NOx, an LPG vehicle would also require electronic fuel injection. Based on information the ARB obtained from companies producing the equipment necessary to build low-emission LPG vehicles, the ARB estimated the total cost of producing these vehicles to be $600-$870.

The estimated cost of electricity is the off-peak cost projected for the years 1993 and 2000 based on data collected from PG&E, SCE, and SDG&E for the commercial and industrial sectors. MSD estimated the cost of electric vehicles assuming they were produced in large enough volumes to benefit from economies of scale. Under this assumption, the extra cost associated with electric vehicles when compared to gasoline vehicles is due to the battery which costs approximately $1350.

For all low-emission vehicles and clean fuels the additional costs are based on a comparison with the cost of a gasoline vehicle built to meet the emission standards applicable in 1994 and the estimated weighted average price of gasoline in 1994--not conventional vehicle and gasoline prices.

The emission reduction estimates used to determine cost-effectiveness were obtained from computer simulated models (EMFAC7E/BURDEN7C) we believe represent the emission benefits of the low-emission vehicles/clean fuels program. These estimates are based on the requirements of the low-emission vehicles/clean fuels regulations.

To obtain program cost and cost-effectiveness, we analyzed scenarios for different combinations of low-emission vehicles/clean fuels believed to be representative of what may occur and determined cost and cost-effectiveness based on these scenarios.

Finally, as discussed above, we believe that our cost estimates are reasonable and that we have adequately considered the cost-effectiveness of the regulations. The cost estimates asserted by the commenter were not documented in the material submitted, so we cannot determine the differences in our analyses. Even if the commenter's cost estimates are reasonable, perhaps as upper-bound estimates, the commenter has failed to show that the cost-effectiveness associated with their cost estimates is unreasonably high. Cost-effectiveness calculations were also not included in the material submitted. We believe our estimates of cost and cost-effectiveness to be the best possible and, due to the lack of documentation affirming the estimates set forth by the commenter, it is impossible to compare our estimates to its estimates and determine the discrepancies.

198. Comment: We estimate the cost to install M85 refueling equipment to be as high as $100,000 and the cost to install CNG refueling equipment to be $225,000-$396,000. Because of the low volume of fuel sold it may not be possible to amortize the capital

investment in a reasonable time period. This may be especially true for small businesses. (WSPA, Mobil, EMA/MVMA)

The capital cost per station to handle CNG will be about $270,000, which is an extremely large burden on the small business people who operate many of the stations in this country. (Arco)

Agency Response: In the TSD, the staff has estimated the cost of refueling equipment for M85 and CNG to be $50,000 and $250,000 respectively. The cost of installing M85 dispensing equipment is based on information obtained from several major gasoline suppliers and from the CEC. The CEC data--set forth in the AB 234 Report--is based on the actual cost associated with the storage and dispensing equipment installed as part of their Methanol Program. As such, we believe this data is both current and accurate. The cost of installing CNG dispensing equipment is based on information supplied by British Columbia Gas ("BCG"). BCG has overseen the installation of 30 CNG outlets in the Vancouver BC area.

The regulations impose the retail outlet requirements on the owner/lessors of gasoline stations, not the operators. In the first three years of the program, only major gasoline suppliers (big oil companies) will be subject to the requirements. In light of the way section 2306 identifies owner/lessors who will be required to install clean fuel outlets starting in 1997, we expect it will be several more years before an owner/lessor with only a few stations could have to install a methanol or CNG dispenser, and this would only happen if methanol or CNG substantially penetrates the low-emission vehicle market.

In the TSD's analysis of the cost of CNG outlets and the capacity to recover this cost, we made the following assumptions:

(a) compressor installation cost of $250,000;

(b) a capital recovery rate of 10 percent over 10 years for the compressor;

(c) retail CNG price includes the spot price, taxes, transport costs, and electricity cost for gas compression;

(d) each vehicle travels 10,000 miles per year;

(e) light-duty vehicles get 24.3 miles per energy equivalent gallon and medium-duty vehicles get 12.5 miles per energy equivalent gallon; and

(f) each vehicle has a 10 year lifetime.

Under these assumptions and the formula detailed in Appendix B-6 of the TSD, there should be sufficient throughput to enable the recovery of expenses.

Even in the most extreme case, where no CNG stations are installed by fleet owners and, consequently, retail service station owners would have to install the maximum number of stations required by the regulation, the number of CNG vehicles would support the number of stations required. We base this on cost estimates indicating that CNG will be less expensive than gasoline, an incentive for dual-fueled vehicles to choose CNG over gasoline, and the fact that the assumptions used to calculate fuel consumption are considered conservative--meaning fuel consumption will likely be higher than we estimated.

The same generally methodolgy was used to project cost recovery for methanol dispensers. In the case of methanol many larger owner/lessors are expected to already have the dispensing equipment installed due to voluntary entrance into the CEC's methanol program or the South Coast requirement to install methanol compatible tanks. Station owners who have installed refueling equipment as part of the CEC's methanol program will be able to count these stations towards the station requirement in the regulation. The majority of the cost associated with stations installed as part of the CEC methanol program is assumed by the CEC. Stations that have methanol compatible tanks can install dispensing equipment for as little as $2000. Thus, for owners of a large number of stations, the capital investment, if any, can be easily recovered in the ten-year period the staff assumed.

199. Comment: Health and Safety Code section 43018 requires a finding of cost-effectiveness as compared to other control strategies. ARB's analyses do not show methanol vehicles as cost-effective compare to gasoline vehicles even under their high gasoline price scenario. In addition, the California Council for Environmental and Economic Balance (CCEEB) in their Alternative Motor Vehicle Fuels to Improve Air Quality report found that strategies to substitute methanol for gasoline are not relatively cost-effective means of improving air quality, even in the South Coast Air Basin and even under a high oil price scenario. We continue to believe that there are much more cost-effective measures available than fuel sales mandates. (Chevron)

Agency Response: On the issue of the cost-effectiveness finding required by Health and Safety Code section 43018, see the response to Comment 223. To the extent that the commenter's primary concern is the fuel sales mandate component of the original proposal, we note that that component has been deleted from the final regulations.

We have considered the CCEEB report and we do not agree with the way it assesses the costs and cost-effectiveness of methanol-fueled vehicles. The staff's estimate of the additional cost associated with methanol vehicles is based on the current cost of making such vehicles in large enough quantities to benefit from economies of scale. To meet the low-emission vehicle standards, methanol vehicles will require one or more of the following: modifications to gasoline vehicles so that they are alcohol-compatible; an improved fuel system; a close coupled catalyst; an electrically heated catalyst; and/or an electric air pump. We tested methanol vehicles and determined that the above mentioned technologies can be used to meet low-emission vehicle standards. Information received from the manufacturers of this technology indicates that the associated cost will be $200-$370. (See TSD, Chapter IX.B.)

The cost of a reformulated or ultra-clean gasoline capable of meeting low-emission vehicle standards below the level of a TLEV has not been determined. However, it is possible that the cost associated with reformulating gasoline to the extent necessary to meet the lower standards would be equivalent to the cost of methanol. In this case, the only cost associated with using methanol rather than gasoline would be the cost of the vehicle. The same technologies necessary to meet low-emission vehicle standards on methanol would be necessary for gasoline vehicles with the exception that gasoline vehicles do not have to be alcohol compatible. Testing done by the ARB indicates that a methanol low emission vehicle will cost $100 more than a gasoline low emission vehicle.

We have determined cost-effectiveness for both vehicles certified on methanol and vehicles certified on gasoline. The cost-effectiveness associated with methanol vehicles is estimated by the the staff to be approximately $5 per pound, with the assumption that methanol is 5-10 cents more expensive than gasoline. The cost-effectiveness associated with gasoline low-emission vehicles is estimated by the staff to be $2 per pound. Both are cost-effective. However, it may not be possible to meet low-emission vehicles standards with gasoline unless it is further reformulated to cost as much or more than methanol. Therefore, we believe that it may be necessary to substitute methanol for gasoline to meet low-emission vehicle standards or reformulate gasoline to the extent that the relative cost-effectiveness are equal.

200. <u>Comment</u>: We are concerned that methanol delivered to oil companies for distribution into the established marketing system will be priced less competitively than gasoline regardless of the price at which it was delivered to the oil companies. (AMI)

<u>Agency Response</u>: We do not believe that this is a likely scenario. In the case where oil companies own clean fuel stations, it is in their best interest to sell methanol at a price which will be competitive with gasoline so that they can recover the capital investment of installing methanol dispensing equipment. If an oil company does not own stations but provides methanol to its customers, then that company would not benefit by installing the equipment necessary to store and deliver methanol and not using the equipment. In either case, it is unreasonable that an oil company would buy methanol at a good price and deliberately overprice it, thereby denying itself profit. Therefore, we do not believe that fuel suppliers will price methanol such that it cannot compete with gasoline if it was purchased at a competitive price. In any case, in Resolution 90-58 the Board directed staff to monitor on an ongoing

basis the clean fuel pricing practices of wholesalers and retailers in comparison to the pricing of gasoline. If unfair pricing occurs, we can seek to take remedial action.

201. Comment: Based on available data, it looks to us like there is a reasonably good chance that some M85 and CNG fueled vehicles may be able to meet the TLEV standards for both NOx and CO. It looks improbable to us, however, that they will be able to meet both the NOx and CO standards for either the LEV or ULEV classes. Reformulated gasoline, on the other hand, appears to have a much better chance of meeting LEV and ULEV NOx and CO standards. This leaves the fuel marketers exposed to the risk that we will have to put an M85 or CNG pump in each of our stations to fuel a type of vehicle that will have a very short lived presence in the market. We can envision a scenario in which many TLEVs are FFVs, but the subsequent LEVs and ULEVs are gasoline fueled. That would leave us unable to recover the capital expended to M85- or CNG-equip our stations.

Moreover, the direction of the proposed regulations and the explicit objective of the existing Air Quality Management Plan for the South Coast Air Basin is to move to "zero emission" or electric vehicles, which do not burn any fuel on board. The cost of initiating and then phasing out an an entire fuel production and distribution infrastructure for new clean fuels would be monumental and unnecessary. Reformulated gasoline, however, can take advantage of the existing fuel marketing and distribution network and can be made through modifications of existing refineries. (Arco)

Agency Response: We do not agree with the assertion that M85 and CNG vehicles will not meet LEV and ULEV standards. Page 29 of the Staff Report outlines possible fuel/vehicle systems that the staff foresees as appropriate for the various emission categories. It anticipates that M85 and CNG could be used in vehicles meeting even the ULEV standards. Page 31 of the Staff Report presents preliminary data on a 1990 model passenger car equipped with an electrically heated catalyst and fueled with M85. Testing has shown that this vehicle has hydrocarbon emissions below the ULEV standards.

The ARB is keenly aware of the potential problems associated with a clean fuel being short-lived and has included provisions in the regulation to mitigate the potential impacts of such a phenomenon on gasoline suppliers. The commenter's claim that a gasoline supplier could have to place a dispenser of a short-lived fuel at each of its stations is quite unrealistic. Under section 2304(a)(1), no clean fuel outlets are required until a minimum of 20,000 low-emission vehicles are projected for sale in California. Once the requirement for a particular clean fuel is in place, the number of required clean fuel outlets above the prescribed minimum will increase only if the number of registered vehicles using that fuel increases. (see § 2304(a).) With an approximate 10-year vehicle life, suppliers who have invested in the installation of the required number of clean fuel outlets should have sufficient time to recover their investment, even if no more vehicles using the fuel are built. Should the number of registered vehicles using a particular clean fuel ever fall below 20,000, then there will be no further requirement to offer that fuel.

The commenter's inference that the move toward zero emission vehicles increases the chance that certain fuels may have a "very short-lived presence" fails to consider the actual timetable for introducing these vehicles.

It is true that meeting the emission standards and regulatory requirements of the future will require a more extensive use of electric vehicles and that these vehicles are an integral part of an overall air-quality program to ensure that long-term air quality goals are met. However, it is highly unlikely that electricity will replace a large fraction of vehicle fuels, at least in the foreseeable future. The minimum production requirement for ZEVs will begin with the 1998 model year. We estimate that by 2003 about 3 percent of all the vehicles in California will be ZEVs, and the remaining vehicles will be gasoline, diesel, or alternatively fueled vehicles. Even with the more aggressive ZEV schedule proposed in the South Coast Air Quality Management Plan, only about 15 percent of the light-duty vehicle fleet in the year 2010 would be ZEVs.

The commenter's assertion that reformulated gasoline can take advantage of the existing fuel marketing and distribution network and can be made through modifications of existing refineries is not determinative. The clean fuel regulations are designed to let all fuels and emission technologies compete. Automobile manufacturers are free to choose the emission control technology/fuel combination they wish to use to meet the low-emission vehicle standards. The clean fuels regulations merely ensure that the fuel chosen by the automobile manufacturers is available to the public. If reformulated gasoline is obviously the preferable fuel, it is likely the market will respond by producing motor vehicles certified to the low-emission vehicle standards on reformulated gasoline. It can also be evaluated as a possible substitute fuel under section 2317.

202. <u>Comment</u>: We do not fully understand the need to introduce two new and probably different fuels in the marketplace during 1996 and 1997. In our judgment, such a program would not be cost-effective. We believe that once the tailpipe standards reach the very low levels of 0.075 gpm or lower, the impact of fuels on the tailpipe emissions is minimal. We believe the state in establishing the fuels standards for 1996 should take into consideration the 1997 requirements and develop fuel specifications for a single fuel to meet LEV and ULEV standards. (Mobil)

<u>Agency Response</u>: The regulations do not require the introduction of any specific number of clean fuels during 1996-7 or some other period. The fuels subject to the availability requirements will be determined by the fuels used in low-emission vehicles produced by vehicle manufacturers. To the extent a vehicle manufacturer produces

vehicles that meet the same low-emission vehicle standard on an alternative fuel and gasoline, those vehicles will not trigger any clean fuel requirements (see § 2303(d).) We plan to consider Phase 2 reformulated gasoline regulations in 1991, and we plan generally to have the same specifications for in-use and certification gasoline. However, it would be inappropriate for the Board to dictate to manufacturers any single fuel that would have to be used in vehicles meeting the LEV and ULEV standards.

203. Comment: By the time the new fuels are introduced in 1996 or 1997, fleet turnover of pre-1975 vehicles will provide substantial decreases in exhaust emissions to the point that a single reformulated gasoline will suffice. (Mobil)

Agency Response: Health and Safety Code section 43018(a) directs the ARB to endeavor to achieve the maximum degree of emission reduction possible from vehicular and other mobile sources in order to accomplish the attainment of the state ambient air quality standards at the earliest practicable date. Even with the adoption of these and other recent regulations, we have not yet been able to comfortably project attainment of the state ozone standard in the South Coast Air Basin, even past 2005. It is thus inappropriate to relax the standards because of the emissions benefits of fleet turnover. To the extent that vehicle manufacturers are able to achieve the low-emission vehicle standards using Phase 2 reformulated gasoline alone, nothing precludes them from doing so.

204. Comment: The costs of clean fuels should be expressed in dollars per British Thermal Units (BTUs) when a comparison is being made to gasoline. Comparing the costs associated with fuels on a gasoline gallon equivalent basis does not show the true cost of clean fuels. (CIOMA)

Agency Response: A gasoline equivalent gallon of a clean fuel is determined as the amount of that clean fuel with an energy (BTU) content equal to that of a gallon of gasoline. The costs of clean fuels are expressed in dollars per gasoline-equivalent-gallon. The comparison was made in this manner so that it would be clear to the reader that the cost of each fuel is based on an amount of clean fuel that would allow for the same travel distance as a gallon of gasoline.

205. Comment: Methanol and CNG appear to be the most likely to enable medium-duty engine manufacturers to meet the ULEV standards. These fuels are also the most likely to raise fuel economy and fuel availability concerns. The energy content of methanol is only about one-half that of diesel fuel. In order to restore acceptable driving range, fuel tanks will have to be redesigned to hold larger amounts of fuel. CNG-fueled vehicles will have shorter range and a decrease in vehicle payload because of the heavier CNG tanks. The TSD fails to consider important factors such as the cost of establishing

alternative fuel refueling facilities. For medium-duty vehicles to travel long distances, an infrastructure of fueling stations for alternate fuels will have to be established statewide and perhaps nationwide at extreme costs. The TSD underplays all of these issues. (EMA/MVMA)

Agency Response: It is true that the volumetric fuel consumption of methanol and CNG is greater than gasoline. However, redesign of fuel tanks for methanol has already taken place on FFVs, yielding vehicle range between refueling of more than 250 miles. Also, larger methanol tanks on experimental vehicles have not significantly impeded vehicle performance. Since most CNG-powered vehicles are trucks designed to carry larger loads, the concern of reduced payload resulting from the weight of gaseous-fueled tanks is minimal. It is also possible to use redesigned lighter-weight CNG tanks. GM has announced its plans to produce 1,000 CNG-dedicated medium-duty pick-up trucks with no reduction in the normal load carrying capacity and a driving range of over 200 miles. This will be accomplished by utilizing three light-weight tanks which add approximately 200 pounds to an equivalent gasoline-dedicated truck with a fully fueled tank.

The TSD does not ignore the costs of establishing alternative fuel refueling facilities; those costs are included in the cost analysis in Chapter X.B.

The ARB is not requiring, and need not require, clean fuel outlets to be installed outside the state of California. Flexible- or dual-fueled vehicles which also operate on gasoline or diesel fuel can be used for those MDVs that are expected to travel out of state. In addition, MDVs are used for interstate travel less frequently than heavy-duty vehicles.

206. Comment: Given the recent situation in the mideast, which is already causing increased fuel prices at the pump, is there a method which could be developed that would prevent fuel prices from reaching a point where they would not be affordable to lower income levels? (Roberti)

Agency Response: Situations such as the one that recently took place in the mideast are extremely unpredictable and can instantly affect world economics. The resulting fuel prices are difficult to control or predict.

The ARB does not have the legal authority to set fuel prices. In implementing the California Clean Air Act, we are seeking to attain the ambient air quality standards through adoption of the most cost-effective combination of control measures. We believe that the adopted regulations fall within that set of cost-effective measures. There is no doubt that the regulations will result in some increase in motor vehicle fuel prices. However, it is useful to recognize that the cost increase is much less than can occur from an oil shock or a substantial tax increase.

The ARB does not have the legal authority to institute special programs to mitigate the impacts of its programs on lower-income people. Such programs may well be appropriate. In accordance with Resolution 90-58, the staff plans to monitor the price of clean fuels in comparison to gasoline. If during implementation of the program we conclude that legislation to mitigate the impacts on lower income people is appropriate, we can bring that to the attention of the Legislature.

207. Comment: Should owners of existing gasoline-powered vehicles be forced to pay higher prices for gasoline in order to subsidize more expensive clean fuels for the newer vehicles mandated by the proposal? How much would gasoline prices have to rise in order to provide the subsidy for clean fuels? If clean fuels are to be subsidized, should the subsidy be out in the open and approved by the Legislature rather than being a hidden cross-subsidy not subject to review? (Brown, Maddy, Roberti, Johnson)

Agency Response: With the deletion of the distribution requirements, gasoline suppliers will no longer be mandated to sell specific quantities of clean fuels. Therefore, they will not be forced to subsidize more expensive clean fuels in an effort to sell mandated quantities of such fuels.

It is not certain that clean fuels would be more expensive than gasoline. According to the the analyses in the TSD, many clean fuels (including CNG, propane, and electricity) are less expensive than gasoline. Ethanol is currently much more expensive than gasoline, but is not expected to be used widely by vehicles designed to meet low-emission vehicle standards. Methanol is currently somewhat more expensive than gasoline. However, once methanol is used on a larger scale and as the price of gasoline and crude oil rise, methanol would be competitively priced with gasoline.

Gasoline prices are expected to rise without relation to the low-emission vehicles and clean fuels regulations. The reasons for this include the anticipated higher cost of crude oil, the new regulations adopted by the ARB pertaining to gasoline, and provisions contained in the federal Clean Air Act requiring a cleaner, reformulated gasoline. Because current gasoline does not reduce pollution to the extent possible, there is a hidden "air pollution subsidy" that is not reflected in its current retail price. If the adopted regulations reduce this subsidy, the price of gasoline will increase, and the relative difference in price between gasoline and clean fuel will decrease.

We have estimated the possible increase in gasoline price if the extra cost of methanol were spread over the gasoline pool. These estimates are based on the assumption that half of the low-emission vehicles are designed to use methanol and methanol costs 5-10 cents per gallon more than gasoline:

* in 1994, gasoline prices might increase by as much as two-hundredths of a cent per gallon;

* in 1998, gasoline prices might increase by a third of a cent per gallon; and

* in 2000, gasoline prices might increase by less than one penny per gallon.

Under this scenario, drivers of gasoline-powered vehicles that generate more than half of the air pollutants in the state might pay up to a penny per gallon extra (which translates into less than $5.00 per year for a typical driver) for a clean air program that will benefit us all.

To the extent that any increase in gasoline prices occurs as a result of the clean fuels program, we believe that this is simply part of the cost of the control program and not a hidden cross-subsidy. Such increases in gasoline prices are common within the industry. Recently, in an effort to clean up the gasoline used in older vehicles, at least one fuel supplier increased the price of gasoline used in newer vehicles to help pay for the necessary reformulation. Price fluctuations are common in the petroleum industry and we do not believe the Legislature need approve a possible slight increase in the price of gasoline to support clean fuels.

208. Comment: We believe that reformulated gasoline is the most cost-effective clean fuel in the context of satisfying the vehicle emissions standards proposed by the ARB staff. The distribution system is already in place and consumer acceptance will not be an issue. At an M85 equivalency level, it will result in a 30 percent reduction in NMOG compared to conventional gasoline, will probably have the same or slightly lower NOx emissions, and about 30 percent lower CO emissions. In addition, it can have an immediate and lasting effect in existing vehicles as well. The fuel/vehicle system life cycle costs, at the same air quality effect, are lower for reformulated gasoline than for conventional gasoline, CNG, methanol, electricity, or LPG. (Arco)

Agency Response: The commenter offers no description of its conception of reformulated gasoline, nor does it offer any information on the cost of producing it.

According to the staff's estimates, the cost per pound of emissions reduced would be less for buying and fueling CNG or LPG vehicles than for buying and fueling vehicles that use conventional gasoline. (See Table 17 in the Staff Report.) Unless a reformulated gasoline were significantly cheaper than conventional gasoline, or unless a reformulated gasoline would allow achieving low-emission standards with lesser controls on the vehicle--both doubtful propositions--it would appear that meeting the low-emission standards with a reformulated gasoline would not be more cost-effective than using CNG or LPG.

In particular cases, a reformulated gasoline may become useful in certifying vehicles to low-emission standards. Current data suggest that even conventional gasoline may allow some vehicles to certify as TLEVs or even as LEVs. If so, an improved (reformulated) gasoline might extend the range of models that would not need alternative fuels to achieve the standards. However, given the low value to which the fleet-average NMOG limit eventually descends, the unknown reactivity adjustments for fuels, and the lack of a description of a reformulated gasoline, it is impossible to determine how useful a reformulated gasoline would be in achieving the emission standards in new-car fleets in the future.

We plan to conduct our Phase 2 reformulated gasoline rulemaking in late 1991, which will involve a number of specifications for cleaner, reformulated gasoline. Such fuel will ultimately be identified as the certification gasoline as well, and may produce many of the emission benefits identified by the commenter. If an "ultra-clean" gasoline proves promising, it could be considered as either a new clean fuel for vehicle certification purposes or as a possible substitute fuel pursuant to section 2317.

209. <u>Comment</u>: The selection of a two-phased approach to the reformulated gasoline regulations also being considered by the ARB must have been based on one or both of the following assumptions: (a) the air-quality benefits of low-emission vehicles/clean fuels regulations are less likely to require modifications than any conceivable refinery-based program to control benzene or aromatics, or to mandate oxygen content; and/or (b) there are higher public, private or consumer costs associated with starting a new refinery regulatory control program for benzene, aromatics, olefins, or oxygenate content that later requires modification, than there would be for the low-emission vehicles/clean fuels regulations that will also later require modification. We would appreciate being advised whether we have accurately described the regulatory assumptions that supported the limitation of the reformulated gasoline strategy to "the near future" while the vehicle strategy was extended to the long term. (GM)

<u>Agency Response</u>: Neither of the assumptions identified by the commenter were used to determine the regulatory strategy for reformulated gasoline. The development of fuels specifications is dependent on adequate technical knowledge regarding the effect of the specifications on emissions. The staff concluded that much additional data would be forthcoming in the year following the September 1990 Board hearing from major projects such as the joint Auto/Oil study, it was prudent to defer Phase 2 until such data could be analyzed. Since the low-emission vehicle and clean fuel regulations are ultimately driven by the numerical vehicle emission standards, further delay for additional data on the emissions impacts of various fuel qualities was not necessary.

210. Comment: To replace the entire 505 million barrel per day demand for gasoline in the Los Angeles Basin with electricity for vehicles would require about 40,000 megawatts (MW). SCE's Los Angeles Basin peak capacity is 20,000 MW and their offpeak demand is about 6000 MW. This at least allows for the theoretical possibility that the 14,000 MW of offpeak slack could be used to recharge the batteries of about 35 percent of the Basin's vehicles before new generating capacity would be required. Whether or not new power generating facilities would actually have to be built will depend on a number of factors, such as the number of electric vehicles actually in use, the actual length of time the batteries can go between recharges, (and how "low" a commuter would let the battery get before he charged it), the time it takes to recharge a battery, growth in non-vehicular demand for electricity, etc. (Arco)

The recharging infrastructure for electric vehicles is a concern that must be addressed to assure customers recharging capabilities. (Ford)

Agency Response: The ARB does not expect zero-emission vehicles to make up 35 percent of the vehicle fleet in the LA Basin until after 2010. By this time, vehicles other than electric vehicles may be capable of meeting the zero-emission standard. For those vehicles that are electric, we expect battery technology to have advanced to the point where batteries are more efficient and less expensive.

The CEC has published a report on the capacity to produce electricity in the South Coast Air Basin. The Electricity Report, published biennially, includes scenarios for future use of electricity with the introduction of electric vehicles. The 1990 report indicates that with conservation techniques and programs planned for the future, the South Coast Air Basin will be able to meet the demand for electricity with the facilities now producing electricity and those already approved for construction in and around the Basin. If the demand in the South Coast Air Basin were to increase beyond the capacity of those facilities, electricity would most likely be obtained from sources outside the basin.

With the growing interest in electric vehicle development, the Los Angeles Department of Water and Power and Southern California Edison are coordinating closely with vehicle manufacturers and regulators to assure the satisfaction of infrastructure needs of electric vehicles, including charging specifications for electric component needs, public and private installations of charging packages, and possible building modifications at charging sites. We believe that infrastructure needs will be readily met within the timeframe of the introduction of electric vehicles.

6. Legal Issues

a. The ARB's legal authority to adopt the regulations

211. Comment: The ARB has no statutory authority to impose the supply and sales mandates. The legal analysis on pages 76-83 of the Staff Report is circular. Health and Safety Code section 43018 cannot be read as giving the ARB carte blanche to do anything it wants. Such a broad construction would violate the constitutional prohibitions against unlimited and unguided delegation of legislative power. WOGA v. Orange County APCD, 14 Cal. 3d 411 (1975) does not support the ARB's position; that case is not about expanding the ARB's powers but about the agency's exercise of powers it already possessed. (WSPA, Texaco)

The ARB does not have the statutory authority to promulgate the clean fuels regulations. (Ultramar) There are serious legal questions concerning the sales mandate, including the lack of statutory authority. (Chevron)

Are sales mandates within the ARB's existing statutory authority, or should mandates be considered by the Legislature, along with possible incentives, as recommended by the Advisory Board on Air Quality and Fuels? (Brown, Maddy, Roberti, Johnson)

Agency Response: As noted elsewhere, the Board decided not to adopt at this time the proposed provisions mandating the distribution of specified volumes of clean fuels. This is the area where the oil companies have most strenuously challenged the Board's statutory authority. Indeed, on p. 1 of its September 27, 1990 comments on the legal implications of the clean fuels proposal, WSPA states that it "continues to be committed to retail availability of fuels for low-emission vehicles commensurate with consumer demand."

The basis of Board counsel's conclusion that the ARB has the statutory authority to adopt the clean fuel regulations is set forth on pp. 76-83 of the Staff Report and in a July 31, 1990 memorandum attached as Appendix C of the Technical Support Document. We note that various commenters have submitted substantial legal analyses concurring with the conclusion that adequate statutory authority exists. (See September 14, 1990 joint letter from attorneys for PG&E, SDG&E and SoCal Gas, pp. 2-4; September 26, 1990 Supplemental Statutory Analysis submitted by GM, pp. 4-5.)

Additional authority for the clean fuels regulations, not discussed in the Staff Report and the Technical Support Document, was conferred by AB 4392 (Stats 1988 ch. 940). This bill added sections 39663 and 39667 to the Health and Safety Code and expands the Board's authority to limit emissions of toxic air contaminants by regulating motor vehicle fuels. Section 39663 requires the ARB by June 30, 1989, to conduct a hearing to review the potential nature, extent, and severity of public exposure to known and suspected toxic air contaminants emitted by vehicular sources in California, and to prepare a report on pertinent issues regarding vehicular toxic emissions. Section 39663(c) directs the Board by June 30, 1990 to hold a public hearing to consider a plan for reducing exposure to known and suspected toxic air contaminants emitted from motor vehicles. Section 39667 directs the Board, based on the determinations made pursuant to section 39663, to consider the adoption of regulations which will achieve the maximum possible reductions in exposure to toxic air contaminants from vehicles. The law expressly provides that the regulations "may include, but are not limited to, the modification, removal, or substitution of vehicular fuel, vehicular fuel components, or fuel additives. . . ."

At a June 21, 1990 public hearing, the Board approved the Motor Vehicle Toxics Control Plan for toxic emissions prepared in response to AB 4392. The plan identifies the low-emission vehicle and clean fuels proposal as a "key element" for vehicle toxic reductions. The Staff Report demonstrates that the reductions in hydrocarbon emissions which would result from the low-emission vehicle/clean fuel regulations are also expected to result in significant reductions in emissions of toxic pollutants. The clean fuels provisions are an integral and necessary part of the overall strategy to reduce vehicular emissions of hydrocarbons and toxics. The Board's counsel believes that the clean fuel distribution requirements fall within the kinds of control measures explicitly authorized by section 39667, particularly the authorization of regulations requiring the substitution and removal of vehicle fuels.

With respect to the 1975 WOGA case, that decision is not as narrow as WSPA suggests. The holding clearly takes a very broad view of the Board's powers. While the Board did have express authority to regulate the Reid vapor pressure and degree of unsaturation of gasoline (former Health and Safety Code §§ 39051.1, 39051.2, current §§ 43830, 43831), it did not have the express authority to regulate motor vehicle fuels in other respects. (See WOGA, supra, 14 Cal.3d at 414.) Nevertheless, the Supreme Court concluded that the ARB's authority to adopt motor vehicle emission standards includes a general authority to regulate the composition of motor vehicle fuel as it affects emissions. The court expressed an unwillingness to attribute to the Legislature an intention to deprive the Board of the only realistic means at its disposal to achieve the clean air goals identified in state law. (WOGA, supra, 14 Cal.3d at 420.)

Finally, interpreting the relevant statutes as conferring authority does not result in an unconstitutional delegation of legislative power. The test for an unconstitutional delegation of power was described in People v. Wright, 30 Cal.3d 705, 712-713 (1982) (fns. omitted):

> An unconstitutional delegation of legislative power occurs when the Legislature confers upon an administrative agency unrestricted authority to make fundamental policy decisions . . . . The doctrine prohibiting delegations of legislative power does not invalidate reasonable grants of power to an

> administrative agency, when suitable safeguards are established to guide the power's use and to protect against misuse. . . . The Legislature must make the fundamental policy determinations, but after declaring the legislative goals and establishing a yardstick guiding the administrator, it may authorize the administrator to adopt rules and regulations to promote the purposes of the legislation and to carry it into effect. . . . Moreover, standards for administrative application of a statute need not be expressly set forth; they may be implied by the statutory purpose. . . .

In Health and Safety Code section 43018, the Legislature has authorized the Board to adopt control measures regarding motor vehicles and motor vehicle fuels which are necessary to attain the state ambient quality standards at the earliest practical date, and which are technologically feasible and cost effective. Sections 43018 and 39667 clearly establish the legislative goals and provide a yardstick guiding the Board. The statutes are certainly adequate to remove the possibility of unlimited or unguided discretion.

212. Comment: In requiring the installation of a certain number of CNG outlets, the regulations will effectively make the oil industry a kind of public utility. See California Public Utilities Code sections 216, 221 and 222. In this case, a number of requirements which accord protections to public utilities and are administered by the Public Utilities Commission will come into play; there is no way these requirements can legally be applied to oil companies. While the ARB staff does seem to recognize there needs to be some authorization from the PUC to permit service stations to dispense CNG, the ARB has no jurisdiction to compel the PUC to take such action. (WSPA)

The proposed regulations violate the California Constitution because they attempt to transform service stations into public utility status. (Ultramar)

Agency Response: The regulations will not transform oil companies or service stations into public utilities. The retail availability and other requirements apply to "designated clean fuels." Section 2300(a)(5) defines designated clean fuel to include CNG only after the PUC certifies that a practical mechanism exits under which a gasoline retailer may, without being regulated as a public utility, sell CNG for use as a motor vehicle fuel. Therefore there will be no requirements pertaining to CNG unless and until satisfaction of those requirements will not result in the oil company or service station from becoming a public utility.

213. Comment: Even when a public utility is involved the courts have held that a state cannot require the utility to expand its services into other areas or with respect to services to which the utility's management has not dedicated the business. By requiring a

refiner, distributor or service station operator to enter a new line of business, the State potentially could convert motor fuel manufacturer and marketing into a public utility without bearing the burden of assuring the marketer has a reasonable rate of return. In this case compensation would be required. (WSPA)

Agency Response: The regulations do not convert oil companies into public utilities, for the reasons set forth in the response to the preceding comment.

The constitutional principles invoked in this comment appear to be Fifth amendment "takings" and substantive due process. The takings issues are discussed in the responses to Comments 216-218, as well as on pp. 79-81 of the Staff Report and pp. 11-13 of Appendix C to the Technical Support Document. Substantive due process is discussed on pages 81-82 and 13-14 of those documents.

Moreover, there is already precedent for governmental requirements that gasoline suppliers provide additional services to their customers. Business and Professions Code section 13651 provides that services stations must furnish water, compressed air, and a gauge for measuring air pressure. It also requires that certain new service stations provide public restrooms without charge.

214. Comment: The ARB does not have the authority to require independent businesses to construct new facilities at enormous costs. In the alternative, the ARB must offer proof that the costs are justifiable, must offer proof that independent businesses will recoup these expenditures, and must offer proof of the rate of return the independent businesses should anticipate from such expenditures. (Ultramar)

Agency Response: The commenter has provided no authority for these claims. We agree that the Board may not adopt regulations such as these without determining that they are cost-effective; such findings have been made (see the discussion in the response to Comment 223). We are not aware of any pertinent additional associated requirements other that the constitutional issues addressed elsewhere in this section.

215. Comment: The clean fuel regulations constitute an unlawful delegation of rulemaking authority. All of the detail is left to be fixed by the Executive Officer. Without knowing what fuels are to be embraced finally, how much, and at what stations, it is impossible to evaluate the regulations for consistency with the statutory criteria in Gov. Code section 11349.1. While Health and Safety Code section 39515 grants authority to the Board to delegate broad implementation powers to the Executive Officer, the Legislature intended rulemaking to be done by the Board. In addition, Executive Officer implementation of the regulations by determining what fuels must be carried, in what quantities and by how many sellers and stations

itself would constitute a rulemaking. Such implementation could therefore only be done after following all the procedural requirements for rulemaking, see Armistead v. State Personnel Board, 22 Cal.3d. 198 (1978). (WSPA, Ultramar)

Agency Response: The clean fuel regulations do not represent an unlawful delegation of rulemaking authority. They establish the parameters of the program in substantial detail. While in certain instances the Executive Officer is directed to make specific determinations in implementing the regulations, the regulations provide well defined standards and criteria for those determinations. The approach is analogous to a regulatory permit program, in which the Executive Officer would make specific permit determinations based on the criteria in the regulations.

The commenter is correct that the fuels to which the availability requirements apply will are not identified by name. However, the regulations provide very clear and unambiguous criteria which the Executive Officer will use to identify such fuels with very limited exercise of discretion (see §§ 2300(a)(5); 2303(a),(b); 2304(a)(1).) The Armistead case is inapposite. In that case the agency applied standards without adopting them in a noticed rulemaking. In administering the clean fuels regulations, the Executive Officer will apply standards which have been duly adopted as regulations.

WSPA's claim that the Legislature did not intend the Board to have the authority to delegate rulemaking to the Executive Officer is not relevant because no such delegation has been made. However, it should be noted that Health and Safety Code 39515 expressly authorizes the Board to delegate any of its duties to the Executive Officer. Based on that express and clear authority, the Executive Officer has in the past on numerous occasions adopted or amended regulations following a delegation from the Board.

216. Comment: The requirement to distribute all designated clean fuels, and the requirement to provide facilities for the sale of CNG, constitute a taking of property under Loretto v. Teleprompter Manhattan CATV Corp., 458 U.S. 419 (1982). Loretto establishes a per se taking rule in the case of a physical occupation of property. In the case of CNG retail facilities, the ARB would be requiring the expenditure by the oil company which is entirely for the benefit of someone else. While the oil company may technically own the facilities, they would as a practical matter be "occupied" by the gas company. In the case of retail outlets for fuels other than CNG, the retailer is still required to dedicate space for installation of equipment, without any certainty that he will not lose money; this is also a per se taking. (WSPA)

Agency Response: Loretto is not applicable, and there is no per se taking involved in the regulations.

Loretto involved a state law that prohibited landlords from interfering with the installation of cable television facilities upon the landlord's property or premises. (458 U.S. at 423.) Pursuant to this law, defendant cable company permanently maintained certain cable equipment on the plaintiff's apartment building. The cable equipment was owned by the cable company. It is abundantly clear that occupation of a portion of the plaintiff's building by the third party cable company's equipment was central to the court's holding. The court distinguished various cases affirming the broad power of the states "to regulate housing conditions in general and the landlord-tenant relationship in particular without paying compensation for all economic injuries that such regulation entails" (458 U.S. 440), stating:

> In none of these cases, however, did the government authorize the permanent occupation of the landlord's property by a third party. Consequently, our holding today in no way alters the analysis governing the State's power to require landlords to comply with building codes and provide utility connections, mailboxes, smoke detectors, fire extinguishers, and the like in the common area of a building. So long as these regulations do not require the landlord to suffer the physical occupation of a portion of his building by a third party, they will be analyzed by the multifactor inquiry generally applicable to nonpossessory governmental activity. See Penn Central Transportation Co. v. New York City, 438 U.S. 104, 57 L.Ed.2d 631, 98 S.Ct. 2646 (1978).[19]
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> 19. If sec. 828 required landlords to provide cable installation if a tenant so desires, the statute might present a different question from the question before us, since the landlord would own the installation. Ownership would give the landlord rights to the placement, manner, use, and possibly the disposition of the installation. The fact of ownership is, contrary to the dissent, not simply "incidental," post, at 450, . . . ; it would give the landlord (rather than a CATV company) full authority over the installation except only as government specifically limited that authority. The landlord would decide how to comply with applicable government regulations concerning CATV and therefore could minimize the physical, aesthetic, and other effects of the installation. Moreover, if the landlord wished to repair, demolish, or construct in the area of the building where the installation is located, he need not incur the burden of obtaining the CATV company's cooperation in moving the cable.
>
> In this case, by contrast, appellant suffered injury that might have been obviated if she had owned the cable and could exercise control over its installation. . . .
>
> (485 U.S. at 440-441 (emphasis in original).)

The court's discussion makes abundantly clear that the per se rule of Loretto is premised entirely on a physical occupation of property by the government or a third party, and the case has been so characterized by leading commentators. (see, e.g., Tribe, American Constitutional Law (2nd ed.) pp. 602-604.)

In contrast to Loretto, the clean fuels regulations do not involve a physical occupation of property by the government or a third party under authority of the government. To the extent an oil company has to install equipment to ensure compliance, the equipment will belong to the oil company rather than to the government or a third party under governmental authority. In this sense, there is no more an "occupation" of the oil company's property than there is when the company installs desulfurization equipment to comply with a regulation limiting the sulfur content of gasoline or diesel fuel. After extensive research, the Board's counsel has found no per se takings cases that did not involve an actual and real physical occupation.

217. Comment: The law in the takings area is complex and uncertain. As a general matter, however, the U.S. Supreme Court has shown it is increasingly willing to find that a taking has occurred. Agencies should demonstrate a close connection between the activity regulated and the problem the regulation seeks to address. One of the major deficiencies in the proposed clean fuels mandates is that there is nothing in the rulemaking record to establish that alternative fuels will, in the end, produce lower emissions or be any better from a health and safety standpoint than conventional or reformulated gasoline. A policy of retail availability, as advocated by WSPA, is more appropriate than mandated "supply" and "sale." (WSPA)

Agency Response: To the extent that the commenter is claiming that the proposed volume distribution requirements constitute a taking, we note that that portion of the proposed regulations was not adopted. Instead, the final regulations focus on retail availability as recommended.

The Board's counsel has carefully considered the law of unconstitutional "takings", including recent U.S. Supreme Court cases. Based on the analysis on pages 79-81 of the Staff Report and 11-13 of the TSD, we believe that the adopted regulations do not constitute a taking. The connection or "nexus" between the activities regulated and the problem addressed are described in these analyses.

218. Comment: The three-factor test in Penn Central Transportation Co. v. City of New York, 438 U.S. 104 (1978) is usually considered in "as applied" takings challenges. Even under the three factor test--the character of the governmental action, the degree to which the challenged regulation interferes with the claimant's reasonable investment-backed expectations, and the severity of the economic impact--a taking could be established here. (WSPA)

Agency Response: As noted in the Staff Report (p.81), the clean fuel regulations can only be evaluated on their face because we do not know the extent to which clean fuel vehicles will be sold and the availability of clean fuels will be required. The character of the governmental action of the proposed regulations is discussed on pages 79-80 of the Staff Report, and the severity of the economic impact is discussed on page 80. With reference to potential interference with the claimant's reasonable investment-backed expectations, the commenter's only discussion pertains to the distribution mandates which the Board decided not to adopt at this time. Normally, this prong involves an inquiry into whether the claimant parted with something of economic value in reliance on an expectation that the government would not act in a particular manner. (See Peterson, The Takings Clause: In Search of Underlying Principles, Part I--A Critique of Current Takings Clause Doctrine, 77 Cal.L.Rev. 1301, 1321 (1989).) The one circumstance where reasonable expectations are likely to be found to be disappointed is when the government has broken a promise. (Id.) The clean fuels regulations reflect one aspect of extensive and pervasive regulation of gasoline supply and retail operations. The state has certainly not made any representations or promises upon which an oil company could reasonable conclude that the regulations would not be adopted.

Application of the three-pronged Penn Central test is also discussed at length on pages 6-10 of the September 14, 1990 joint letter from attorneys for PG&E, SDG&E and SoCal Gas, with the conclusion that the proposed regulations do not constitute a taking. We find the analysis in this letter to be persuasive.

219. Comment: In effect, the proposed regulations require gasoline suppliers and owner/lessors of retail outlets to subsidize producers of alternative fuels even though such rules are not economically competitive. This is tantamount to taxation and is even more outrageous when one looks at the "credit" system for CNG in originally proposed regulations. Imposition of a private tax on a selected segment of one industry and a transfer of the revenue to other directly benefited private businesses violates the California Constitution. See Cal. Constitution, Art. XIII A, sec. 3; Gov. Code sec. 53722; City and County of San Francisco v. Farrell, 32 Cal.3d 47, 57 (1982). (WSPA)

Agency Response: The commenter's primary focus is the originally proposed credit program for the volume distribution requirements (proposed 13 C.C.R. § 2310); this program has been deleted from the final regulations. The cited constitutional and statutory provisions pertain to governmentally imposed taxes which require payments to the governmental agency. Farrell involved a city's payroll and gross receipts tax. The Board's counsel is aware of no authority for the novel proposition that a regulatory program not involving any fees or other payments to state or local governments imposes an prohibited "tax," and the commenter has cited none.

220. Comment: The sales and supply mandates are prohibited by the doctrine of unconstitutional conditions, which precludes an administrative agency from using the lawful authority to regulate one thing to impose a condition relating to something else, over which it has no authority. The regulations condition the right to sell gasoline on the requirement to supply and sell clean fuels. This is not remotely comparable to the mid-1970's EPA regulations conditioning the sale of leaded gasoline on making unleaded gasoline available. The classic unconstitutional conditions case is Nollan v. California Coastal Commission, 483 U.S. 825 (1987). Just as that case held that the Coastal Commission could not require use of the property owner's land without paying for it, the ARB cannot lawfully force service station owners to make available a portion of their property for the gas company to sell it without paying for it, nor can it essentially transfer money from the oil companies to other clean fuel suppliers. (WSPA)

Agency Response: The retail availability and other requirements in the adopted regulations do not impose unconstitutional conditions because the conditions on the sale of gasoline are rationally related to a legitimate state purpose and there is a nexus between the clean fuel requirements and the air pollution burdens created by the sale of gasoline.

In the Nollan case, the Coastal Commission granted a permit to build a residence on beachfront property, but conditioned the permit on having the owners grant an easement permitting the public to walk along the beach on their land. The Commission argued that there were legitimate police power purposes that would justify denying the permit, and that issuing the permit with conditions was therefore justified. The Court agreed this would be the case as long as the conditions furthered the same legitimate police power purposes that would justify a ban. However, if there is not a "nexus" between the condition being imposed and the burdens or problems created by the new building, then the condition would constitute a "taking" rather than a legitimate regulation of land use. (Nollan, supra, 483 U.S. at 836.) The court looked at each of the asserted justifications for restricting the building and determined there was no nexus between them and the condition that beach access be provided. For instance, although the new house was found to interfere with visual access to the beach, requiring lateral beach access did nothing to ameliorate the visual access. (Nollan, supra, 483 U.S. at 838.)

Unlike the situation in the Nollan case, there is a definite nexus between the activities being regulated--the sale of gasoline--and the governmental interests being furthered by the clean fuel requirements. This nexus is described on pages 80-81 of the Staff Report. (See also the September 14, 1990 joint letter from counsel to PG&E, SDG&E and SoCal Gas, pp. 10-17.)

The other instance in which the doctrine of unconstitutional conditions is invoked is the granting of a governmental benefit is conditioned on the waiver or violation of a constitutional right, although this application has recently been questioned. (See Tribe, American Constitutional Law (2nd ed.), p. 681, fn. 29.) As discussed in the responses to other comments, no constitutional rights are infringed by the conditions imposed by the regulations on the sale of gasoline.

221. Comment: The proposed clean fuels regulations violate the California Constitution in that they are not being legally promulgated. (Ultramar)

Agency Response: The commenter has not identified any specific basis for its claim that the regulations are not being legally promulgated, and we are not aware of any valid grounds for such an assertion.

222. Comment: The proposed clean fuels regulations violate the California Constitution in that they do not propose to regulate all entities equally. (Ultramar)

Agency Response: The commenter has not identified the instances in which entities are not treated equally under the regulations. In any case, the equal protection clause does not require that all entities be treated equally. Rather, classifications meet constitutional muster as long as they are reasonable in light of the purposes of the legislation or administrative rule (e.g. McLauglin v. Florida, 379 U.S. 184 (1964); classifications that are based on suspect classifications such as race or infringe on fundamental interests such as the right to travel are valid only if they are justified by a compelling state interest. (e.g. Korematsu v. United States, 323 U.S. (1944); Shapiro v. Thompson, 394 U.S. 618 (1968).) The regulations do contain some classifications, such as the 1994-1996 requirements for major gasoline suppliers only. None of the classifications are suspect or affect a fundamental interest, and all have a rational basis.

b. Other legal issues

223. Comment: Health and Safety Code section 43018 requires the Board to conduct a cost-effectiveness analysis to support this rulemaking. The requirement is analogous to federal requirements mandating the most cost-efficient alternative. The term "cost-effective" is a more stringent requirement than merely requiring a cost-benefit analysis, and fairly implies a legislative intent that the agency undertake a formal analysis to determine the most efficient means for attaining its goal, and not merely that the cost of the program is reasonable by some objective standard. However, the ARB proposal does not include a cost-effectiveness analysis of the mandates proposal, and there is no analysis in the Staff Report which would enable one to conclude that the mandates proposal is the most efficient way for the ARB to achieve its air quality goals. (WSPA).

Agency Response: As noted in II.B.1. & 2., the Board deleted the distribution requirements.

Health and Safety Code section 43018(a) directs the Board to endeavor to achieve the maximum degree of emission reduction possible from vehicular and other mobile sources in order to accomplish the attainment of the state standards at the earliest practicable date. Section 43018(c) provides that in carrying out section 43018, the Board shall adopt standards and regulations which will result in the most cost-effective combination of control measures, including but not limited to four specified areas of measures. We believe the regulations satisfy this criterion.

In Resolution 90-58, the Board made the following finding:

> The overall cost-effectiveness of the regulations approved herein in reducing the emissions of ozone precursors in 2010, assigning one-half of the program costs to reductions of criteria air pollutants and one-half to reductions of toxic air contaminants, could range from $0.02 per pound to $4.90 per pound; these cost-effectiveness values are within the range of other measures that may be reasonably necessary to attain the state ambient standards pursuant to Health and Safety Code section 43018.

The estimated cost-effectiveness values of the proposal expressed in dollars per pound of ozone precursors reduced were set forth on pages 70-72 of the Staff Report, and were discussed in more detail in Chapter IX.C. of the TSD. At the hearing, the staff presented updated estimates of the cost-effectiveness values, and compared them to the cost-effectiveness values of other control measures recently adopted by the ARB or local air pollution control districts. The estimated cost-effectiveness of the low emission vehicle/clean fuels program was well within the range of the other identified adopted control measures. (Transcript, Day 1, pp. 63-64). The federal ambient air quality standard for ozone, which is less stringent than the state standard, is exceeded far more days per year in the South Coast than in any other area of the country. Numerous ambitious new control measures will be necessary to meet the state and federal ambient standards throughout the state. These measures would typically become increasingly more costly, since the more cost-effectiveness measures tend to be adopted earlier. There is thus little doubt that the regulations adopted in this rulemaking will be part of the most cost-effective combination of control measures that lead to attainment of the state ambient standards.

224. Comment: The clean fuel regulations purport to apply the "per vehicle" penalty provision of Health and Safety Code section 43016 which provides for "a penalty not to exceed $500 per vehicle" for violation of ARB regulations "adopted pursuant to [Part 5]." This is inappropriate because the "per vehicle" penalty would apply when there has been no violation of any rule with respect to any vehicle.

The violation would arise when the station supplier or seller cannot dispose of his mandated quota of CNG or M-85 because no one will buy it. People v. Mobil Oil, 143 Cal.App.3d 261, 276 (1983) held that the "per vehicle" penalty must be "construed literally." A statute which imposes a substantial civil penalty is considered to be penal and courts have uniformly held that such statutes must be as narrowly construed as is reasonably possible. (Hale v. Morgan, 22 Cal.3d 388, 405 (1978).)

The imposition of a "per vehicle" penalty provision--which could result in fines of nearly half a million dollars per supplier per quarter--in a situation where there is no control over consumer demand defies the bounds of both law and reason. The proposed sales mandate will impose an "egregiously extortionate" penalty. It is particularly inappropriate to apply the equivalent of a criminal penalty to a situation where compliance is outside the control of the supplier or seller, and may well be impossible. Impossibility of performance is a well-established defense to failure to take a required action. (WSPA)

Agency Response: This comment is primarily directed towards section 2315 of the adopted regulations. This section identifies how the Health and Safety Code section 43016 "per vehicle" penalty will be applied to violations of sections 2301, 2302, and 2309(b). The rationale is described on pp III-13 and III-14 of the TSD. The clean fuel requirements are generally imposed as conditions on the sale of gasoline. Therefore, the "per vehicle" penalty will apply to specified numbers of vehicles improperly fueled with gasoline by a person who has not satisfied the conditions for such sale. It is therefore not correct to say that the penalty would apply when there has been no violation of any rule with respect to any vehicle.

A review of the statutory framework demonstrates that it is appropriate for the Health and Safety Code section 43016 "per vehicle" penalty to apply to the identified violations. The section 43016 penalty applies to any violation of regulations adopted pursuant to Health and Safety Code Division 26, Part 5 ("Vehicular Pollution Control") where Part 5 does not provide any other specific civil penalty or fine. It should be uncontroverted that the clean fuel regulations are adopted pursuant to part 5 and that there are no other civil penalties or fines provided for such violations in Part 5. There also can be little doubt that the Legislature intended 43016 to apply to violations involving controls on motor vehicle fuels rather than on vehicles per se. When section 43016 was enacted in 1976, Health and Safety Code sections 43830 and 43831 expressly directed the ARB to adopt regulations controlling the Reid vapor pressure and degree of unsaturation of gasoline, and the ARB had adopted regulations controlling both these two gasoline characteristics and the lead and sulfur content of gasoline (see 13 C.C.R. §§ 2250, 2251, 2252, 2253.) Given the existence of these statutes and regulations, it must be assumed that the Legislature meant to cover fuels regulations when it referred to violations of "any" regulation adopted pursuant to Part 5.

It is our understanding that the commenter's claims of impossibility of performance are limited to the potential difficulty in complying with the originally proposed clean fuels volume distribution requirements in the absence of consumer demand. As noted elsewhere, these provisions were not adopted by the Board. Since there are no longer any requirements that specific volumes of clean fuels be distributed, we believe the claim of impossibility is no longer an issue. In addition, the penalty provisions would not result in excessive penalties. Health and Safety Code section 43016 authorizes a penalty of up to $500 per vehicle; a court is not required to impose the maximum amount. In People v. Superior Court (Olson), 96 Cal.App.3d 181, 198 (1979), the court upheld Business and Professions Code sections 17200 and 17500 in the face of a claim that the statutes could result in extremely high liability; the court recognized that in actually imposing the monetary penalty the court "must manifestly act reasonably in light of all pertinent factors."

225. Comment: The proposed regulations have not been prepared in compliance with California Environmental Quality Act ("CEQA") guidelines. (Ultramar)

While the proposed clean fuels regulations appear to be exempt from the requirements of CEQA for preparing Environmental Impact Reports ("EIRs") and negative declarations, the CEQA Guidelines make clear that they remain subject to all other provisions of CEQA "such as the policy of avoiding significant adverse effects on the environment where feasible." 14 C.C.R. section 15250. The Guidelines also spell out what must be contained in the document used by an agency under its certified programs as a substitute for an EIR or negative declaration. At a minimum, the substitute document shall include a description of the proposed activity and one of the following: (1) alternatives to the activity and mitigation measures to avoid or reduce any significant or potentially significant effects of the environment, or (2) a statement that the agency's review of the project showed that the project would not have any significant or potentially significant effects on the environment and therefore no alternative or mitigation measures are proposed to avoid or reduce any significant effects on the environment. If a statement as described in (2) is prepared, it shall be supported by a checklist or other documentation to show the possible effects that the agency examined in reaching this conclusion. 14 C.C.R. section 15252.

Although the staff document states that the regulations would not result in any substantial, adverse environmental impact, the proposal does not include any documentation of effects examined by the agency in reaching its conclusion, as required by the CEQA Guidelines. Further, ARB regulations provide that where an action contemplated "may have a significant effect on the environment," a staff report is to be prepared in a manner consistent with the "environmental protection purposes of the state board's regulatory program and with the goals and policies of [CEQA]." 17 C.C.R. section 60005. The regulations also provide for the consideration of feasible mitigation measures and feasible alternatives, and of comments received which raise significant environmental issues. 17 C.C.R. sections 60006-60007.

In fact, there may well be significant environmental impacts resulting from implementation of the clean fuels regulations. For example, there is potential for increased pollution of the water table through the use of methanol or other alternative fuels, toxicity risks to both consumers and service station personnel in connection with methanol, and increased air pollution as a result of the distillation processes involved in the creation of ethanol, to name a few. None of these potential impacts was examined in detail in the staff proposal. In order to comply with CEQA, a thorough examination of these impacts and others must be undertaken prior to adoption of the clean fuels regulations. Numerous courts have invalidated state regulatory programs for failure to adequately evaluate environmental impacts. (WSPA)

Agency Response: We believe that the ARB has complied with CEQA in this rulemaking. Potential adverse environmental impacts were considered, and appropriate findings were made, in the Staff Report, the TSD, the Resolution, and/or the Response to Significant Environmental Issues.

In considering the effects in California of motor vehicle fuels that are alternatives to gasoline, the staff recognized that gasoline itself presents considerable hazards in its production, marketing and use. To the degree that clean fuels displace gasoline, potential undesirable effects of the clean fuels will replace--not augment--the hazards of gasoline. (TSD at p. IX-26) The above documents identified various potential adverse environmental impacts associated with the use of clean fuels. The Staff Report also expressed the staff's belief that the potential safety hazards and negative environmental impacts associated with clean fuels are no greater than the potential adverse impacts associated with the gasoline that would otherwise be used, while the benefits are significantly greater.

Pages IX-26 to IX-31 of the TSD identify various potential adverse environmental impacts that could result from the use of various clean fuels. These impacts are also expressly identified in the 18 CEQA findings on pages 10-12 of the Resolution. The findings in the Resolution further identify mitigation measures that the Board has taken--the January 22, 1990 adoption of formaldehyde exhaust emission standards which will reduce the adverse impact of formaldehyde emissions from methanol-powered vehicles, and requirements in the methanol vehicle regulations that vehicle manufacturers design methanol fuel tank fill pipe assemblies to discourage siphoning where feasible. The Board approved the low-emission vehicles/clean fuels regulations only after determining that there were no remaining feasible mitigation measures or alternatives available to the Board that would substantially reduce the potential adverse impacts of the proposed standards while at the same time providing the substantial overall public health benefit from the emissions reductions that will result from the rulemaking.

The ARB considered all of the potential adverse environmental impacts that have been identified by WSPA in this comment. The TSD states that methanol can contaminate surface water or ground water supplies, and can diffuse through ground water faster than gasoline does. (TSD p. IX-27.) The TSD also notes that in general aquatic life recovers faster from methanol spills than it does from oil spills (citing the AB 234 Report), and that methanol is detectable in water and can be cleaned up, although the best methods of clean-up are not clear. (Id.) The TSD noted that ingestion of small amounts of methanol can result in blindness or even death (as noted above, the Resolution found that accidental ingestion of methanol will be prevented or minimized as a result of the Board's requirements pertaining to anti-siphoning devices.) The TSD noted that the inhalation of methanol vapors may pose a health threat, but the threat appears less than that posed by gasoline vapors. (Id.) Finally, the Staff Report addressed issues pertaining to potential air pollutant emissions from the production of clean fuels. Such emissions would replace rather than add to emissions from gasoline production. Further, persons constructing new production facilities for clean fuels in California would be subject to new source review ("NSR") rules generally requiring the application of best available control technology and offsets of any emissions increases. Some air pollution control districts may afford special treatment of construction of facilities intended to implement air pollution control regulations; in such cases there would still be a net air quality benefit.

226. <u>Comment</u>: The proposed mandate that oil companies distribute specific quantities of clean fuels will force companies into a mine field of potential liability under the antitrust laws and the Petroleum Marketing Practices Act ("PMPA"). Concerns include prohibitions against illegal tie-ins in the Sherman Act, the Clayton Act and the state Cartwright Act; PMPA prohibitions against discriminatory treatment of dealers; Robinson-Patman Act prohibitions against improper price discrimination; and federal and state restrictions on allowances and below cost sales. (WSPA, Ultramar, Mobil)

<u>Agency Response</u>: All of the antitrust concerns expressed by WSPA pertain to the difficulties in complying with the originally proposed volume distribution requirements. As noted elsewhere, these requirements were not included in the regulations as adopted.

To the extent that antitrust concerns may remain regarding the retail availability requirements, these concerns are addressed on pages 82-83 of the Staff Report.

227. <u>Comment</u>: The proposed clean fuel mandates program does not meet the statutory criterion of "necessity" in Gov. Code section

11349.1. The dictionary defines "necessity" as "compulsory," "inescapable" and "logically unavoidable." Since there has been no showing of any consumer demand for any clean fuel, it is hard to imagine the necessity of a requirement to carry all clean fuels at an undetermined number of stations or sell a particular volume of these fuels. Moreover, there no demonstration that mandated supply and sale of alternative fuels is necessary to achieve the air quality benefits required by Health and Safety Code section 43018. (WSPA)

Agency Response: The "necessity" criterion is more appropriately defined in the context of 1 C.C.R. section 10 than by dictionary words such as "inescapable." In any case, the Board decided not to adopt any volume distribution mandates at this time, so no demonstration of the necessity for such an approach is necessary.

The Staff Report provides an ample demonstration of the necessity for adopted clean fuel regulations. The Board has established extremely stringent low-emission vehicle emission standards, and it is very likely that some or all vehicle manufacturers will decide it is necessary or advisable to use alternative fuel vehicles to meet the standards in at least some instances. Unless alternative fuels are adequately available to the motoring public, there will be no market for vehicles designed to run only on clean fuels, and FFVs will not achieve the full emissions reductions that would result from the use of clean alternative fuels. The clean fuel regulations will without doubt reduce ozone formation in the state. The Board is required by Health and Safety Code section 43018(a) to endeavor to achieve the maximum degree of emission reduction possible from mobile sources in order to attain the state standards for ozone and other pollutants at the earliest practicable date. Even with these regulations and other planned measures, statewide attainment of the state ozone standard cannot be projected. The regulations are therefore necessary.

228. Comment: The clean fuel regulations do not meet the "clarity" standard in Gov. Code section 11349.1 for several reasons.

(a) Provisions such as proposed sections 2338 [adopted § 2308] and 2345 [adopted § 2317] are nearly impossible to understand.

(b) There are critical details in the regulatory scheme which appear in the Staff Report but not the regulations. For example, the Staff Report states that the 10,000 vehicle trigger level is computed based on the number of vehicles in the SCAQMD, but the regulation imposes no geographical qualification on the number of vehicles.

(c) The regulations use certain terms to mean different things in different places. The terms "clean fuel," "clean alternative fuel," and "dedicated clean fuel" are often used interchangeably but the result is that in different contexts they have different meanings.

(d) There are critical areas which are not addressed in the regulations. Under section 2303, for example, assuming that a flexible fueled vehicle (FFV) can operate on both M85 and E85 as well as gasoline, there is no provision for who the total required volume of each fuel will be determined for a vehicle certified on more than one clean fuel. (WSPA)

Agency Response: We believe the clean fuel regulations are clear.

(a) The commenter has not identified any specific respect in which sections 2308 and 2317 are unclear. Where commenters have pointed out specific instances of unclear language, we have sought to modify the text to make it clearer.

(b) The one example the commenter has given of details in the staff report but not the regulatory text is the minimum vehicle trigger level. We agree that the originally proposed text was unclear in this area, and we have modified and clarified it accordingly. (see adopted § 2304(a)(1); former proposed §§ 2303(c)(3), 2335(d), 2337(e).)

(c) The regulation provides specific definitions of "clean alternative fuel" and "designated clean fuel" (see §§ 2300(a)(3), 2300(a)(5); there is no separate definition of "clean fuel" and the term "dedicated clean fuel" is not used in the regulations.) We have sought to use the terms advisedly, and we are not aware of any instance in which an incorrect term was used.

(d) The regulations do not address apportioning clean fuels in the case of an FFV certified on more than one fuel because the vehicle certification regulations do not provide for such certifications. We are not aware of any interest among vehicle manufactures to produce such vehicles.

229. Comment: The July 31, 1990 memorandum from ARB Senior Staff Counsel Thomas Jennings (Appendix C to the TSD) states that in considering the clean fuel regulations, the Board should consider other alternative vehicular control measures. That consideration must also include alternative fuel control measures and vehicle/fuel combinations. (GM)

Agency Response: Board counsel agrees. The reference to "vehicular" control measures was intended to include all measures that limit vehicular emissions, whether the measures apply to the vehicle or the vehicular fuel.

230. Comment: The above-referenced July 31, 1990 memorandum states that regulations adopted pursuant to Health and Safety Code section 43018 must be among the most cost-effective options that could

be expected to result in statewide attainment of the ambient standards. However, under the statute they must constitute as a whole <u>the</u> most cost-effective combination, including both vehicle and fuel controls. (GM)

Agency Response: The ozone problems are so intractable in the South Coast Air Basin that a feasible overall strategy to attain the state standards has not yet been identified. It is not necessary for the Board to identify the entire mix of necessary controls before adopting component measures which reasonably appear to be among the most cost-effective options necessary for attainment. In any case the Board has adopted both vehicle and vehicular fuel measures in this rulemaking.

231. Comment: Health and Safety Code section 43018(b) requires the Board not later than January 1, 1992 to take whatever actions are necessary to achieve, by the end of the year 2000, specified percentage reductions in actual emissions of pollutants from motor vehicles compared to 1987 emission levels. How will the prediction of compliance with this requirement be made? (GM)

Agency Response: The staff plans to present to the Board for possible adoption in 1991 a "tracking" regulation which will identify the process by which compliance with this and other emission reduction mandates in the California Clean Air Act will be measured. We are confident that by the end of 1991 we will have adopted regulations which will in fact result in the necessary emissions reductions to meet the year 2000 percentage mandates.

232. Comment: Health and Safety Code section 43018(a) requires the Board to achieve the maximum degree of emission reduction possible from vehicular sources in order to attain the state standards at the earliest practicable date. Must each rule adopted by the Board pursuant to section 43018 be shown to provide "the maximum degree of emission reduction possible . . . at the earliest practicable date," or is it adequate if a package of proposals, not all of which are adopted at once, meet the statutory criteria? (GM)

Agency Response: ARB legal counsel believes the latter characterization appropriately states our legal obligations. Section 43018(c) requires the ARB to adopt "the most cost-effective combination of control measures;" this mandate clearly requires the Board to broadly consider individual control measures in a broader context rather than in isolation. Moreover, an air pollution control program typically involves a myriad of measures each of which makes some contribution to overall emission reductions. It would be unrealistic to assume that the Board would be able to at one hearing to adopt all of the measures which over the years will be necessary for attainment of the ambient standards in the SCAQMD and elsewhere in the state.

233. Comment: Does Health and Safety Code section 43018(a) create an obligation for the Board to proceed more rapidly than the percent-reduction requirements expressed in section 43018(b)? (GM)

It is not clear that California needs lower vehicle NOx standards to meet the 15% NOx reduction requirement in section 43018(b). (GM)

Agency Response: We believe section 43018(a) does create an obligation for the Board to proceed more rapidly than the percent-reduction requirements expressed in section 43018(b), to the extent that greater reductions are possible and practicable. The two subsections both apply to the Board, and section 43018 mandates reductions of "at least" the stated percentages. If those percentages are not sufficient for attainment, we must continue to consider additional control measures. Lower NOx standards are therefore appropriate even if they are not needed to achieve the 15% NOx reduction.

In addition, NOx emissions reductions are also appropriate to reduce PM10 concentrations and acid deposition, and to improve visibility.

7. Potential environmental and safety issues associated with clean fuels

234. Comment: CNG has totally different properties than the fuels that retail outlets currently market, and may present safety and maintenance problems for service station operators and the motoring public. (WSPA, Ford, Arco)

The principal safety concerns of CNG center on the high pressure storage systems--both on board and at the refueling facilities. Specific issues relate to system crashworthiness and the need for automatic fuel cutoff switches, cylinder design specifications, "fool proofing" and "tamper proofing" (particularly for unattended night time situations) the refueling facilities, and vehicle venting requirements. The safety aspects of CNG retailing are much more onerous than for other liquid clean fuels. (Arco-79CL)58

Agency Response: There are currently about 230 CNG stations operating in Italy, about 30 CNG stations in Vancouver, Canada, and numerous CNG stations in New Zealand, as well as several CNG stations operating in Colorado and California. Experience with CNG has not shown it to be more dangerous than gasoline as a vehicular fuel. As discussed on page IX-29 of the TSD, CNG appears to pose fewer and less severe problems to the environment and public safety than do gasoline and methanol. Except for trace contaminants such as hydrogen sulfide, natural gas is not toxic, carcinogenic, or caustic. Relative to unleaded gasoline, natural gas needs slightly more energy to ignite and it requires a higher concentration in air to burn or detonate. Natural gas flames are cooler and therefore radiate less heat and it ignites spontaneously at a higher temperature than gasoline. With regard to the safety of CNG equipment, the location of storage tanks, compression equipment, dispensing equipment and relief valves must meet national fire code space requirements to help ensure safe operation. Methanol and gasoline retail outlets have corresponding code requirements that they must meet. In general, the safety problems associated with a CNG retail outlet are no more extensive than those of a gasoline retail outlet. (See also p. IX-26 of the TSD.)

235. Comment: The cost-benefit analysis presented in Chapter IX of the TSD gives short shrift to serious safety concerns which are raised by alternative fuel vehicles. These concerns must be resolved before alternative fuel vehicles are prematurely forced into the market by the proposed regulations. The basic flaw in the TSD is its apparent failure to recognize that medium-duty vehicles are designed for long distance transport and delivery and often require midday "hot engine" refueling. When the engine is "hot", refueling with methanol, CNG, or LPG is more dangerous than the relatively risk-free refueling for diesel. (EMA/MVMA)

Agency Response: We do not believe that the discussion in Chapter IX.E. of the TSD gives "short shrift" to safety issues pertaining to clean fuels. As stated in the TSD, clean fuels have not been shown to be more dangerous than other vehicular fuels.

CNG is less flammable and needs more energy to ignite than gasoline. Due to the high ignition temperature of natural gas, simple exposure to a hot surface (such as the exhaust manifold) is unlikely to lead to a fire.

While LPG can pose a significant fire or explosion hazard in vehicles, it is widely used as a vehicle fuel in the United States. The hazard of fire or explosion depends on two factors: a correct mixture of fuel and air, and a source of heat within the narrow band of ignition temperatures. Like CNG, LPG also requires more energy to ignite than gasoline. In addition, because the fueling system is completely pressurized, the LPG fuel cannot easily escape to ignite.

Under ambient conditions, methanol is flammable which is not a problem with gasoline or diesel. However, this hazard is minimized by adding a suitable percentage of gasoline which creates an atmosphere that is too rich to burn over a broader range of temperatures.

LPG and CNG vehicles have been widely used for many years, and there has been a very low incidence of mishaps related to fueling, even "hot engine" refueling. The dangers involved with methanol refueling should be no greater than those of gasoline overall. The ARB's methanol demonstration fleet has been operating successfully from its inception ten years ago with no safety-related refueling problems. For at least two years the Southern California Rapid Transit District has been testing approximately forty methanol and CNG buses with plans to greatly expand their program. Although these buses accumulate higher mileage and must be frequently refueled, no significant safety-related problems have occurred. While diesel fuel appears to involve less refueling risks than other fuels (including gasoline), sufficient experience exists with CNG, LPG and methanol to project a low incidence of refueling safety problems.

236. Comment: Safety concerns pose serious obstacles to consumer acceptance of LPG vehicles. Many areas have laws forbidding them from being parked in covered garages, or driven through tunnels in order to eliminate the potential for explosions. There are various studies showing the explosion risk has been exaggerated, but LPG usage will be restricted by the laws until they are revised. (Arco).

Agency Response: As the commenter indicates, the cited studies demonstrate that concerns regarding the explosion risks of LPG have been exaggerated. LPG is already used in widespread applications in the United States. If it becomes a potentially attractive alternative light- and medium-duty motor vehicle fuel, we expect that the restrictions the commenter refers to will be eliminated or modified.

237. Comment: The fire and safety issues for methanol are not insurmountable, but they will add equipment and training related costs to the product. Methanol is odorless and colorless in both the liquid and vapor states. It is tasteless and water soluble in the liquid state. This makes its presence difficult to detect, and accidental exposure or ingestion when present is more likely than a corresponding situation with gasoline. Predicting concentrations during exposure is difficult.

Methanol's toxicity is well known. What is not well understood are the health effects of chronic exposure to methanol and its combustion byproduct, formaldehyde. There needs to be considerable work done to define acceptable exposure levels. (Arco)

Agency Response: As part of the AB 234 process, the Advisory Board on Air Quality and Fuels extensively reviewed the potential environmental, health, and safety aspects of methanol as a motor vehicle fuel. The Advisory Board found that methanol does not offer any unusual or unaccepatalbe problems, at least when compared with gasoline and diesel fuel.

Because of customer unfamiliarity with methanol and the differing characteristics of the fuel, it would be useful for service station attendants to be trained to answer customers' questions about the fuel. As discussed in II.B.7.a., owner/lessors of retail clean fuel outlets who are also distributors or refiners will be required to provide a attendant training program (or the functional equivalent) covering the performance characteristics of the fuel, the type of vehicles capable of using the fuel, and appropriate safety and handling considerations. (§ 2309(b)(5).) Operators stations covered by the training requirements would have to assure that a trained attendant is on hand, or the functional equivalent is provided. (§ 2309(a)(5).) In addition, formaldehyde is regulated by the specific formaldehyde exhaust emission standards in section 1960.1(e)(3).

238. Comment: Greenhouse gas emissions of clean fuels must be considered in any proposal to promote their use. (EDF, CCA)

Provisions should be made to most strongly encourage the use of clean fuels which have the lowest greenhouse gas impact. The regulations should include measures such as giving more credits to vehicle manufacturers for LEVs with very low greenhouse gas emissions. The ARB's contention that shifting to clean fuels will have no adverse impact on greenhouse gas emissions is not necessarily correct. For example, if the use of either methanol or CNG derived from coal become widespread, the greenhouse gas emissions from vehicles could be nearly double that of vehicles operated on gasoline. (EDF)

Agency Response: The ARB has considered the effects of greenhouse gas emissions from clean fuel/low emission vehicles. Table IX-12 of the TSD provides estimates of the warming potential of various fuels relative to that of gasoline. Although the regulations do not directly address emissions of the greenhouse gases, the staff believes that the regulation could indirectly reduce the overall emissions of greenhouse gases through the production, transportation, and use of clean alternative fuels which generally emit less greenhouse gases than gasoline.

Economic factors and major environmental problems diminish the prospect of coal being used to produce natural gas or methanol. Natural gas is plentiful in North America and it is likely that additional pipeline capacity will be installed to transport it to California. The expense of producing natural gas from coal would outweigh the cost of additional pipeline capacity. Analysis done by Bechtel Corporation indicates that a large methanol production facility would most likely be built outside the United States near a large source of natural gas because such a location would be the most cost effective. Thus, it is unlikely that either natural gas or methanol will be produced from coal.

Although we expect that the overall impact of the regulations on greenhouse gas emissions will be positive, we do not believe it would be appropriate to provide credits for vehicles emitting fewer greenhouse gases. The object of this rulemaking is to fulfill the mandates of the California Clean Air Act of 1988 by seeking attainment of the state ambient air quality standards at the earliest practicable date.

239. Comment: Table IX-12 of the TSD compares the global warming contribution of alternate fuel emissions, but does not make a similar comparison to diesel fuel emissions. Such a comparison would show that diesels contribute less to global warming than do several of the

alternative fuels. In addition, some alternative-fueled engines, including those fueled by methanol, produce higher levels of formaldehyde and benzene emissions than do diesel engines. Methanol engines also produce high levels of evaporative emissions compared to the ultra low levels from diesels. (EMA/MVMA)

Agency Response: Table IX-12 in the TSD shows the potential global warming emissions from new alternative fuels relative to the dominant motor vehicle fuel--gasoline. Since diesel fuel is an existing, but not dominant, motor vehicle fuel it was not included in the table.

On the question of formaldehyde and benzene emissions, see the response to the following comment. The Board's new evaporative emission standards, approved in August 1990, will effectively require zero emissions during test conditions.

240. Comment: The ARB should consider emissions of various toxic air contaminants (TACs) from the various clean fuels. A recent article indicated that one reformulated gasoline being currently sold may produce a 34 percent increase in a suspected carcinogen. Though the reduction in benzene and other air contaminants may well be worth the tradeoffs, we must exercise great care in assuring that we do not solve one problem by creating another. (CCA)

Agency Response: The ARB is aware of the potential health risks that could result from exposure to TAC emissions from both clean fuels and clean fuel vehicles. One known (benzene) and three probable (formaldehyde, acetaldehyde, and 1-3 butadiene) human carcinogens have been associated with vehicle exhaust emissions. Benzene, the only one of the four compounds officially identified by the ARB as a TAC, is not found in most alcohol fuels, CNG, or LPG, but is found in limited amounts in the gasoline portion of alcohol/gasoline blends. The ARB is currently developing benzene standards that will be part of the Phase 2 gasoline regulation to be brought to the Board in late 1991. Formaldehyde is regulated by the specific formaldehyde exhaust emission standards in section 1960.1(e)(3). It merits its own standard due to its high reactivity. The last two toxic compounds, 1-3 butadiene and acetaldehyde, which are mainly products of combustion, currently do not have specific exhaust vehicle emission standards directed at controlling them. Clean fuels are not expected to emit higher quantities of 1-3 butadiene and acetaldehyde than gasoline. Also, since all these compounds are organic gases, the amount of TACs emitted from vehicles will be reduced as the NMOG (hydrocarbon) standards become more restrictive. Therefore the NMOG standards adopted in this rulemaking are expected to result in a significant overall reduction in the emissions of TACs from motor vehicles.

8. Miscellaneous

241. Comment: We continue to be concerned with the approvals and permitting processes and acquisition of offsets with some the the Air Quality Maintenance Districts in the state. Although not a direct responsibility of the ARB, we would like the ARB to actively support WSPA in current and future discussions with various AQMDs on this subject. (WSPA)

The permitting and CEQA review process is becoming ever more cumbersome, politically charged, and time consuming. We strongly recommend that the ARB work with the local districts to consider methods for expediting the permitting and CEQA process for clean fuel projects. (Tosco)

Agency Response: The ARB staff is certainly willing to work with the oil companies and local districts to help assure that industry is able to do the construction work necessary for compliance with these regulations, consistent with the districts' stationary source controls and CEQA requirements.

We believe that obtaining permits for clean fuel outlets should not pose a significant obstacle. Most facility construction or modification permits take between 3 to 9 months to process. Retail gasoline station owner/lessors that are required to install clean fuel outlets will be given a preliminary estimate of the number of clean fuel outlets that they will be required to install 18 months prior to the installation deadline as specified by the regulation. A final notification will be given 12 months prior to the installation deadline. See also the response to the next comment and to Comment 241.

The ability to acquire offsets for the modification or construction of facilities in most nonattainment areas should not pose a problem. For retail gasoline station owner/lessors that replace an existing gasoline pump with a clean fuel pump offsets may not be required. The emissions from these clean fuel outlets should be less than the emissions from the displaced gasoline outlets.

For those retail gasoline outlet owners that elect to install new clean fuel pumps without reducing their number of gasoline pumps, acquiring offsets may be necessary. However, many districts support the clean fuels program and view the emission reductions associated with the clean fuels regulation as an aid in their compliance with the California Clean Air Act. We believe they will make every effort to insure timely issuance of permits for installation of clean fuel outlets. The ARB will support discussions with the districts and industry regarding the impact the aquisition of offsets has on meeting the requirements of the regulation.

242. Comment: Acquiring offsets to allow the modification of facilities in nonattainment areas of the state appears to have been

somewhat alleviated if the current amended version of the SCAQMD's New Source Review regulation does not change. (It would allow us to install or modify equipment without offset requirements, provided BACT is utilized and there is no increase in maximum emission ratings.) Similar allowances will be needed to meet implementation requirements for other nonattainment areas of the state. (Mobil)

Agency Response: We are not convinced that all modifications of facilities will require obtaining offsets. To the extent that clean fuel facilities replace gasoline facilities, it is likely that no emission increase would result, and therefore, no offsets will be needed. This is particularly true for the emissions of certain toxic air contaminants, such as benzene, which is not found in several clean fuels but is found in gasoline. If emission levels from clean fuel facilities result in exceedances of applicable state and local emission levels, the owners of the facilities will be required to modify operations, e.g. reduce their total gasoline throughput per outlet, so that they will be in compliance. We believe the districts will support changes to existing regulations where necessary to assure that clean fuels can be sold.

243. Comment: The transition from one type of vehicle technology to another could pose significant infrastructure problems. For example, if the ultimate fuel of choice is electricity, this transition may be made more difficult if in the meantime large investments are made in infrastructure to support a fleet of methanol or CNG vehicles. Infrastructure issues should be explicitly examined and addressed in the ARB plan. (EDF)

Agency Response: The regulations are intended to be as fuel-neutral as possible, and we believe it would be inappropriate to mandate one clean fuel and make infrastructure plans accordingly. Although we expect there to be significant electric vehicle penetration in the long term, that development is far enough away that it does not justify lengthy delay in the rest of the program. We have sought to structure the regulations so that there is a substantial relationship between the number of vehicles needing a clean fuel and the availability of the clean fuel. We do not expect broad new infrastructures to be developed to support a new fuel unless that fuel is going to play a significant and economically viable role as an motor vehicle fuel.

244. Comment: The Resolution should be revised so that districts can opt into the clean fuels program before 1997 if it is necessary to attain the standards as expeditiously as practical in their areas, and it is included in the adopted plan. (CAPCOA)

Agency Response: The last paragraph of Resolution 90-58 contains the language requested by the commenter.

245. Comment: We are concerned with the staff's proposal to possibly amend the regulations and allow the extension of the 1994-96 SCAQMD program to other districts in the state. In our opinion, prior to amending the regulation, the ARB needs to follow the appropriate public regulatory process and allow comments from the potentially affected parties.

Additionally, we would have the same concerns with any new program as we have with the proposed SCAQMD program and we again suggest that any produce and distribute regulation to allocate clean fuels and number of retail gasoline outlets be done by regional market share (or by share of retail gasoline outlets.) (Ultramar)

Agency Response: We agree with the first point made by the commenter. Under the opt-in concept described in the last paragraph of the Resolution, any opt-in would be accomplished by an amendment to the regulations, with the requisite notice and comment.

On the second point, the regulation no longer contains "produce and distribute" provisions. The allocation of required outlets in any opt-in area can be considered during the opt-in rulemaking. See also the response to comment 182.

246. Comment: The modest amount of predictability included previously to phase in clean fuels (SCAQMD in 1994, statewide in 1997) has been lost in the latest staff proposal by allowing other APCD's to "opt in." Accelerated implementation will impose significantly greater implementation burdens on the gasoline industry that are not accounted for in the current proposal. The Board should first evaluate the actual air quality benefits of the proposal during its initial implementation in the South Coast. If the program is found to be effective, it could appropriately be expanded to other nonattainment areas. (WSPA)

Agency Response: Districts outside the South Coast cannot opt-in during the 1994-96 period without a new rulemaking hearing and an opportunity to comment. The commenter's concerns regarding "opt-in" can be considered at that time.

We believe it is reasonable to extend the clean fuels program statewide after 1996 because low-emission vehicles will be sold in increasing numbers throughout the state.

We will be following the implementation and progress of the clean fuels program closely. Any necessary modifications can be considered during the biennial reviews directed by the Board or through a petition.

247. Comment: It is not clear at all whether the mandated "clean" fuels program accounts for continued long-term use of diesel as a vehicular fuel. Hopefully, the Board does not intend to explicitly or

implicitly exclude diesel fuel from the slate of potential clean fuels. (WSPA)

Agency Response: Nothing in the clean fuels regulations prohibits the use of diesel fuel. The regulations do not require any expanded availability of either gasoline or diesel fuel because those fuels are already widely available to motorists. We note also that most motor vehicle diesel fuel is used in heavy-duty engines and vehicles, which are not affected by this rulemaking. Under the light-duty low-emission vehicle regulations, auto manufacturers may certify diesel vehicles to the applicable standards provided the fleet-average requirements are met. Similarly, under the medium-duty low-emission vehicle regulations, manufacturers may certify diesel vehicles to the conventional or low-emission standards as long as the specified percentage requirements of LEVs and ULEVs are met in the proposed timeframe. As such, diesel light-duty and medium-duty vehicles are not specifically excluded from the requirements of this proposal.

248. Comment: Gasoline has a 30 cents per gallon tax which includes a road tax. I don't believe all the fuels have that. As we mandate the shift from gasoline to these other fuels, there should be a shortfall in road taxes. We will need to be concerned with who's going to fund this difference, and shouldn't it be presented in a fairer way. (CIOMA)

Agency Response: The prices for methanol, ethanol, and LPG as motor fuels currently include road taxes. The road taxes for methanol and ethanol are slightly lower than gasoline taxes on an energy-equivalent basis. This slight difference occurs because of the energy content of these fuels and was not meant as a subsidy. Currently, ethanol is heavily subsidized by the federal government; however, in the future this subsidy may be eliminated. The prices for these fuels quoted in the low-emission vehicles/clean fuels technical support document include road taxes equivalent to gasoline. If these fuels are introduced as motor vehicle fuels to the public, they would not be exempt from taxes and would likely be taxed to the same extent as gasoline unless the legislature approves a tax exemption as an economic incentive to consumers to purchase clean fuels.

CNG and electricity do not currently include road taxes equivalent to those of gasoline. CNG does include a state road tax but not a federal road tax. PG&E, SoCal Gas, and SCE have stated that these fuels are taxed to the extent that gasoline is taxed but the taxes are not being used as road taxes. Once these fuels are being used as motor vehicle fuels, the taxes being collected for the fraction of these fuels being used in motor vehicles will most likely be allocated as road taxes unless the legislature approves a tax exemption as an economic incentive to consumers to purchase clean fuels.

In conclusion, to the extent new motor vehicle fuels not subject to road taxes are introduced, we would expect the legislature to take the appropriate steps to assure adequate revenues and tax fairness.

249. Comment: Your objective of "fuel neutrality" is seriously handicapped by the effect of the current federal system that biases the vehicle manufacturers towards methanol and CNG vehicles because of the CAFE (corporate average fuel economy) credit of up to $2500 per methanol or CNG vehicle. Knowing that your proposal will force the availability of the fuels they select, the auto manufacturers may select fuels based solely upon their own manufacturing economics and ignore the economics and practicalities of producing and distributing fuels. (Arco)

Agency Response: The ARB does not have control over incentives offered by the federal government. The clean fuels regulation itself does not contain a bias associated with CAFE credits. Alternative fuel advocates could argue that the existing statewide and nationwide gasoline infrastructure versus no infrastructure for alternative fuels presents a strong inherent bias in favor of reformulated gasoline. Also, we estimate that it costs an extra $100 to $200 per vehicle to make it methanol-compatible and $900 to $1000 per vehicle to equip it for CNG.

E. Comments Pertaining to the Clean Fuels Regulations Made During the 15-Day Comment Period

1. Number of required clean fuel outlets, and allocations among owner/lessors

250. Comment: We are concerned about provisions under which the required number of a gasoline supplier's outlets for a particular clean fuel will not decrease from year to year unless the number of vehicles needing the clean fuel falls below 20,000 (sections 2305(c) and 2307(d).) This requirement should be modified to allow for decreasing the number of required outlets if the number of vehicles needing the fuel decreases. Without such an adjustment, the station throughput could become very low and reduce the incentive and flexibility for dealers/operators to market effectively and promote clean fuels. (WSPA, Mobil)

The provisions generally not authorizing decreases in the required number of outlets for a particular clean fuel are far too restrictive. If the demand for a fuel decreases year after year because its initial popularity is not sustained, there ought to be a better mechanism to allow a decrease in the number of required outlets for a particular clean fuel. Otherwise, the fuel in question will either have to be higher priced than necessary, or other fuels will have to be higher priced than necessary in a cross subsidy fashion. (Arco)

Agency Response: If the number of clean fuel vehicles requiring a particular clean fuel falls below 20,000, the requirement to maintain clean fuel outlets for that clean fuel will end. (§ 2304(a)(1).) However, as long as there remain a substantial number of vehicles using a particular clean fuel, it is important to avoid the elimination of clean fuel outlets that have already been installed. The emission reduction from providing the vehicles with their clean fuel could be substantial and the people driving those vehicles will still need to have convenient access to the fuel.

Since the typical lifetime of a vehicle is 10 years (see TSD, Appendix B-1), the potential demand for a clean fuel would not fall sharply even if the rate of introduction of new cars for that fuel were to fall to zero. Therefore station owner/lessors could maintain sales of that clean fuel long enough to recover their capital investments in the dispensing equipment. There is also sufficient time before any significant decline in the number of clean fuel vehicles for the Board to evaluate the need to modify the regulations based on changed circumstances.

251. Comment: The provisions generally prohibiting decreases in the required number of outlets of a particular clean fuel should be modified to allow for a downward adjustment if the supplier's market share factor decreases significantly. Such an adjustment should be

allowed since any decrease would be offset by those suppliers with a market share increase. (WSPA, Mobil)

Agency Response: Market share only determines the allocation of required clean fuel outlets during the first three years of the program, when only major gasoline suppliers are subject to the requirements. The gasoline market shares of major gasoline suppliers have not varied dramatically over the past several years. There is no reason to expect their market shares to change significantly from 1994 to 1996.

Once a major gasoline supplier's market share factor has been established for 1994, the initial number of clean fuel outlets to be provided by that supplier will not change under the regulation, regardless of subsequent changes in market share. Only the additional numbers of stations allocated in 1995 and 1996 could be affected by changes in market share. (see §§ 2305(c) and 2307(d).) Thus the commenters' statement that any decrease in market share would be offset by those suppliers with a market share increase is not correct under the regulations as drafted. Modifying the regulations to allow reallocation of numbers of required outlets assigned in previous years would introduce additional complexity. In general it is preferable to avoid reallocations once the clean fuel outlets have already been installed.

The regulations do contain mechanisms under which a major gasoline supplier's total required number of stations can be affected by a decrease in market share. A major gasoline supplier's assigned number of additional clean fuel outlets in 1995 or 1996 will be affected by a decline in market share, and the company will never be required to provide a number of clean fuel outlets greater than the number of gasoline stations for which it is the owner/lessor. In addition, as noted in the response to the next comment, no retail outlet requirements will apply in 1994-1996 to a company that ceases to be a "major gasoline supplier."

252. Comment: If a supplier ceases to be a "major gasoline supplier" during the initial three year period, we do not believe it should be required to maintain the allocated number of outlets. (WSPA)

Agency Response: The regulations have the effect sought by the commenter. The 1994-1996 retail outlet requirement is contained in section 2301. This section provides in part that, "The requirements of this section shall apply at all times that a person is a major gasoline supplier." If a company ceases meet the definition of a "major gasoline supplier", the section 2301 requirements no longer apply.

253. Comment: Section 2305(c) reads extremely awkwardly. We believe that it basically requires that the required minimum number of

stations under these regulations will never decrease compared to the prior year. (CEC)

<u>Agency Response</u>: One of the effects of section 2305(c) is that the number of outlets required for a particular clean fuel will not decrease compared to a prior year (unless the number of low-emission vehicles using that fuel falls below 20,000 vehicles, in which case no outlets will be required for that fuel). We believe the language is clear. The previous three comments regarding the limitations on decreasing the required number of outlets indicate the commenters' clear understanding of the effect of the subsection.

254. <u>Comment</u>: We are concerned that the number of clean fuel outlets potentially required in 1997 will be 800 regardless of vehicle population or fuel demand. While we understand the doubling of the 1996 level is an attempt to address the statewide application, this requirement could be excessive and result in very low station throughputs of a clean fuel. The selection of the commitment level of "two times the number of outlets required in the SCAQMD in 1996" appears to be arbitrary and does not include cost-effectiveness considerations. We also question whether this is representative of the Board's directive to ARB staff at the September public hearing. (WSPA, Mobil)

<u>Agency Response</u>: The fact that the number of clean fuel stations increases by a factor of two between 1996 and 1997 (§ 2304(a)) reflects the probable doubling of the number of low-emission vehicles covered by the clean-fuel program when it expands from the South Coast to statewide in 1997. Since roughly half of all vehicle sales in the state occur in the South Coast, the populations of low-emission vehicles in and out of the South Coast should be about equal. Therefore, the number of clean fuel outlets that will be appropriate statewide in 1997 should be at least twice the number applicable for the South Coast in 1996 (which will be based on fewer vehicles than will exist in 1997). The rationale for this approach is also discussed in II.B.3.b. above.

Considerable attention was given to cost-effectiveness for both the South Coast and statewide phases of the clean fuel program. The cost effectiveness analysis found in Appendix B-2 of the TSD assumed there would be 770 outlets established in 1997, which is similar in number to the minimum of 800 outlets required by the regulation for the year 1997. If, once the program starts, data show that a factor of two for calculating the number of outlets required statewide does not reflect the increase in potential demand for clean fuel, the regulations can be modified to specify a more appropriate value.

The provisions on the number of clean fuel outlets in 1997 are consistent with the Board's direction at the public hearing. In Resolution 90-58, the Board directed the Executive Officer to significantly expand the number of retail outlets required to be equipped to dispense clean fuels.

255. Comment: We support the modification in section 2301(a) stating that the requirements will be satisfied for a given clean fuel if all of a major gasoline suppliers South Coast outlets are equipped to dispense a clean fuel. We would suggest a very slight modification recognizing that clean fuel installations may not be allowed in every potential site because of local ordinances or conflicting environmental requirements. (Ultramar)

Agency Response: Such an additional provision is not necessary or appropriate. It is very unlikely that a major gasoline supplier will have to equip all of its outlets to dispense a clean fuel during 1994-1996. In the event this occurs, we have not seen any restrictions that would completely preclude the installation of a clean fuel outlet.

256. Comment: The number of retail clean fuel outlets should be twice the number that was originally envisioned in the early stages of the regulation. We recommend that you increase the number for the South Coast in 1994 to 180, in 1995 to 400, and in 1996 to 800. This is necessary to account for equipment being out of service due to breakdown and because many early low-emission vehicles will be dual or flexible fuel capable technology. (SMAQMD)

Agency Response: The rationale for the minimum required number of clean fuel outlets is set forth in II.B.3.a. above. The minimum numbers were selected in consideration of the need for access to clean fuel outlets balanced against the need to avoid requiring so many stations that each will have a very small throughput. The requirements that clean fuel dispensers be kept in good operating order (§§ 2309(b)(6) and 2310(a)(2)) should minimize the number of outlets out of service due to breakdown.

257. Comment: No consideration is given in section 2304(b) to the large number of existing liquified petroleum gas (LPG) outlets already in operation. Consequently the required number of outlets would far exceed the actual need for such facilities. Allowance is given only to CNG facilities already in existence before 1994. Why aren't LPG facilities given the same credit? (WLGA)

Agency Response: The rationale for the section 2304(a)(5) provisions on adjusting the CNG outlet requirement to reflect existing stations is discussed in II.B.3.d. The cost of installing CNG outlets is considerably higher than LPG outlets. Unlike LPG, CNG had been excluded from the originally proposed distribution requirements. In any case, existing LPG outlets are not precluded from the constructive allocation program established in section 2308. Moreover, a gasoline station previously equipped to dispense LPG can be used to satisfy the retail outlet requirement.

258. Comment: The fuel volume adjustment factor, used in the calculation of the required number of clean fuel outlets, should be based on actual sales data beginning in 1996. (Chevron)

Agency Response: The fuel volume adjustment factor used in section 2303(c) accounts for the fact that many clean fuel vehicles are likely to be FFVs. It is unreasonable to assume all FFV drivers will always refuel on clean fuel. At the same time, in order to have clean fuels readily available, there needs to be an adequate number of clean fuel outlets. It is more reasonable to base the fuel volume adjustment factor on potential maximum use of clean fuels rather than on actual sales. In the latter case, oil companies could discourage sales with higher prices and reduce the number of clean fuel outlets they would have to install.

259. Comment: A fuel volume adjustment factor of 0.90 is appropriate through all years of the program for dedicated vehicles, instead of 0.75 in the first two years as is proposed in the 15-day comment package. Dedicated vehicles had an adjustment factor of 0.90 in the original proposal. Changes that could result in fewer clean fuel stations are inappropriate in light of the Board's clear directive to increase fuel availability. (CNGVC)

Agency Response: The fuel volume adjustment factor is used in the calculation that determines the projected maximum potential demand for each clean fuel (§ 2303(c)) and ultimately determines the number of retail clean fuel outlets required by the regulation. The number of retail clean fuel outlets will not decrease due to the change in the fuel volume adjustment factor from 0.90 to 0.75 for dedicated vehicles, unless there are more dedicated vehicles than FFVs. We believe it is unlikely that in the first two years of the program there would be more dedicated vehicles than FFVs, particularly since passenger cars will likely be driven to areas outside the SCAQMD where outlets may not be located. Flexible- or dual-fuel capability is required to allow a greater range of refueling possibilities. Moreover, if most vehicles are dedicated vehicles, then clean fuels would have captured a market niche and we would expect the demand for these fuels to be met by industry as a result of basic market forces.

For these reasons, the ARB staff does not feel it is necessary to have a separate fuel adjustment factor for dedicated vehicles for the first two years of the program.

260. Comment: The South Coast adjustment factor should not be set at 0.5 in the regulations, but instead should be set by the Executive Officer based on actual data on the fraction of LEVs registered in the South Coast. (CNGVC)

Agency Response: It is reasonable to use a South Coast adjustment factor of 0.5 since historical Caltrans data show that the South Coast counties of Los Angeles, Orange, Riverside, and San

Bernardino account for approximately 50 percent of the automobiles sold in the state and for approximately 50 percent of the population. The adjustment factor is only relevant for the first three years of the program, and LEV registration data would not be available in time for appropriate planning. However, we plan to track the effectiveness of the program, and the South Coast adjustment factor can be revised if necessary in a subsequent rulemaking.

261. Comment: Using gasoline market share as the basis for allocating the required clean fuel outlets in 1994-1996 is inappropriate. Clean fuel outlets should be allocated based on the number of branded gasoline stations operated by a company. Using a branded retail outlet share factor should provide better geographic dispersion and it would more equitably distribute the incremental costs of the clean fuels amongst the owner/lessors of retail clean fuel outlets. A market share factor requires major oil companies with highly efficient, low cost, high-throughput stations to equip a disproportionately high share of their outlets to dispense clean fuels. (Arco)

Agency Response: The cost of equipping clean fuel outlets will be recouped through the sale of fuel. Thus a fuel supplier's volumetric market share would determine the ease with which costs can be recovered. A fuel supplier with a large market share is also associated with a proportional share of the emissions from the use of gasoline. Therefore, it is reasonable to base the number of gasoline stations required on the market share of each fuel supplier.

2. Treatment of CNG

262. Comment: We are concerned with the provisions that establish minimum numbers of required stations only for fuels other than CNG (§§ 2304(a)(2)(B), (a)(2)(C) and (a)(4)). We could support a rule that provided greater initial numbers of liquid fuel refueling stations than CNG refueling stations, if the rule ensured that the initial numbers of public CNG stations would at least be adequate to fully meet anticipated needs. However, the proposed regulations would seriously underestimate such needs.

The proposed regulations require the Executive Officer to subtract 100 percent of the normal-emission CNG demand, 100 percent of the bi-fuel certified CNG demand, and 100 percent of the centrally-fueled fleet vehicle demand, and then only attempt to satisfy 75 percent to 90 percent of the remaining demand. Then, the number of stations needed to meet the remaining demand is based upon the assumption of a natural gas throughput of 400,00 therms per station per year. However, there is no requirement that the stations actually be capable of such a throughput. Nor is there any provision that the actual number of stations be adjusted in subsequent years if the throughput turns out to be erroneous. Finally, the stations actually provided are allowed to be "out-of-service" for as long as six months at a time. (PG&E)

Agency Response: We believe that the mechanisms for determining the required number of CNG outlets are appropriate.

The ultimate rationale for the clean fuel requirements is to assure that clean fuels are available where their use is necessary to attain the full air quality benefits from low-emission vehicles. Vehicles that are not LEVs are not counted in the program for this reason.

Under section 2303(d), FFVs that are certified to the same low-emission standards on CNG and gasoline are not included in the clean fuel program. This is because the use of CNG in these vehicles is not necessary to achieve the air quality benefits of meeting the LEV standards.

The reasons for fuel volume adjustment factors are described in the response to Comment 259.

It is incorrect to say that existing private CNG refueling capacity is subtracted. The volume of CNG projected to be supplied to low-emission vehicles at their central outlets will be subtracted out when determining the number of stations allocated (see § 2304(a)(4) and §§ 2304(a)(5)(B)&(C)). This provision is designed to prevent a potential over-supply of CNG outlets if, as expected during the initial years of the program, most CNG low emission vehicles are centrally fueled fleet vehicles. Also see the response to Comment 267.

The commenter is correct in stating that the 400,000 therm/yr CNG throughput value in the section 2304(a)(4) formula is not a design requirement that facilities must meet. It is an energy-equivalent throughput value comparable to existing gasoline retail outlets that will be used in calculating the number of CNG stations required. It represents the minimum yearly throughput for which the cost of CNG equipment installation can reasonably be recovered over a ten year period. To come up with an appropriate design criteria for CNG outlets, the ARB staff worked with British Columbia Gas and other natural gas utilities. Under sections 2301(b) and 2302(b), the minimum fill rate for gaseous fuels is a minimum of 4 hours of high volume operation per day. We expect that gaseous fuel dispensing equipment will be designed such that a dual-fueled low emission vehicle may be filled as quickly with the gaseous fuel as with gasoline. If during implementation of the program it appears that such fill rates are not being achieved, the regulations can be modified as appropriate in a subsequent rulemaking.

The reasons for the provisions on relief from enforcement for breakdowns of CNG dispensing equipment are discussed at II.B.9.b. and in the response to Comment 280.

The general thrust of the comment is that demand for CNG will exceed the number of stations equipped under the program to dispense CNG. We believe this is very unlikely. Because of basic market dynamics, we expect that additional CNG outlets will be installed to the extent that demand for such outlets increases.

263. Comment: The provision requiring that liquid fuels always be available within 72 hours of a request from a service station operator (§ 2309(c)(1)) should also apply to CNG. (CNGVC, PG&E)

Agency Response: In the original proposal, fuel suppliers were mandated to distribute only liquid fuels--not CNG. The new responsibility for owner/lessors to assure the supply of clean fuels partially replaced the distribution requirements (See II.B.8. above). Thus it is reasonable that the new responsibilities apply to only the liquid fuels and not to CNG.

In addition, the distribution system for CNG is not like the distribution system for gasoline and other liquid fuels. Supply pipelines for natural gas are primarily controlled by utility companies; traditional motor vehicle fuel suppliers do not have control over its delivery. The distribution constraints that exist for gasoline and likewise for other liquid fuels do not exist for natural gas. Distribution of natural gas is more like the distribution of water in that a customer simply turns on a tap; no delivery trucks are necessary as in the case of gasoline and other liquid fuels. Therefore a requirement upon fuel suppliers to ensure that CNG be available within 72 hours would not be appropriate.

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264. Comment: The throughput used to calculate the number of required number of CNG retail outlets should be revised upwards to 500,000 therms per year in 1994-96, and to 750,000 therms per year for 1997 and later. A higher throughput would allow a lower margin on natural gas price and improve its economic viability. (Chevron)

Agency Response: The fuel throughput used to calculate the required number of outlets for natural gas was originally assumed to be 360,000 gasoline equivalent gallons per year as originally specified in the regulation. This is equivalent to the 400,000 therms per year specified in the adopted regulations (§ 2304(a)(4)), which corresponds to an installation investment of approximately $250,000. We calculate that an outlet that sells a minimum of 400,000 therms per year should recover its initial investment ($250,000) over a ten-year period of operation with a reasonable margin. This is the estimated cost as outlined in Chapter IX.B of the TSD. It is consistent with data supplied to the ARB by Pacific Gas and Electric Co., British Columbia Gas, and Southern California Gas and Electric Co., and it reflects a price margin and capital recovery rate comparable to those assumed for other clean fuel installations. We anticipate that CNG will become an economically viable vehicle fuel when widely available, which is also reflected in the estimates that show that the retail price of CNG will be much less than the retail price of gasoline.

265. Comment: The requirement in sections 2301(b) and 2302(b) that CNG outlets be designed for a minimum of four hours of high volume operation should be revised to two hours so as to reduce the cost and the amount of property needed for dispensing equipment. Based on our experience marketing CNG in New Zealand, a typical facility there had a capacity of around 750,000 therms per year, cost abut $250,000 and requires an area for the CNG ancillary facilities of at least 500 ft^2. The area requirement is dominated by the storage facilities needed to meet the peak fueling requirements. (Chevron)

Agency Response: A CNG outlet designed for high-volume operation during four hours per day would cost about $250,000. The outlet would be capable of a yearly throughput of 400,000 therms per year. Based on information supplied by gas utilities and equipment supply companies we estimate that approximately 400 square feet of space, including the service island, would be needed for all the dispensing equipment.

Equipment as described above would provide vehicle fill rates similar to fill rates for gasoline vehicles. This is an important consideration in gaining the consumer's acceptance of natural gas. Additionally, a four- hour high-volume operation would be desirable to accommodate all potential refueling during the rush hour periods of the morning and evening.

We do not believe that the cost associated with meeting the specifications will be unreasonable for a major oil company. It is unlikely that the regulations would result in requirements for large numbers of new natural gas dispensers, at least in the early years. Further, it is anticipated that major gasoline suppliers would be able to fully recover their costs in ten years or less.

The regulations are designed so that when small companies will be required to install CNG dispensing equipment, market pressures should already be prompting the same action, without a regulatory requirement.

With regard to space considerations, the regulations allow companies to choose the locations for the installation of outlets. Gasoline suppliers will be able to locate their relatively few required CNG outlets among any of the gasoline stations they own. This should provide enough flexibility to find the space for the equipment.

266. Comment: We are concerned that the 18 months specified in section 2300(a)(5) not be additive to the 18 months specified in section 2303, making the minimum length of time from PUC certification to requirement for installation of CNG stations subject to the regulations 36 months. (CNGVC)

Agency Response: Section 2300(a)(5) states, "the requirements of section 2301 and 2302 shall be applicable to retail outlets for CNG starting with the first year that commences at least 18 months after such certification" by the PUC. This language is clear. The 18 months stated in 2300(a)(5) simply allows for the same notification period allowed other clean fuels. Once the PUC has certified CNG (and the minimum vehicle number is reached), the Executive Officer will give retail station owners 18-month advance notification of the preliminary number of CNG outlets that will be required, and 12-month advance notification of the final number of CNG outlets that will be required. (§§ 2305(d) and 2307(e).) Once a gasoline station owner/lessor has been given the preliminary notification, that owner will have 18 months to install CNG dispensing equipment just as in the case of dispensing equipment for other clean fuels. In no case will the minimum length of time from PUC certification to requiring the installation of CNG stations be 36 months.

267. Comment: The proposal to subtract 100 percent of nonretail fleet fuel use from the fuel demand equation in section 2304(a)(4) could result in a serious underestimate of CNG vehicle fuel demand unless every effort is made to account for and include retail CNG used by existing and incremental LEV and non-LEV CNG vehicles. (CNGVC)

Agency Response: Every effort will be made to accurately estimate the number of retail outlets necessary to maximize the availability of CNG for use in low-emission vehicles. Section 2313 requires fleet operators to report information regarding the low-emission vehicle fuel demand and the refueling habits of the low-emission vehicles (home-base refueling versus off-base refueling). This information as well as DMV registration data and Caltrans travel data will be used to estimate the number of CNG outlets that will be required for low-emission vehicles.

It would be inappropriate to include CNG used in vehicles that do not meet low-emission vehicle standards in the calculation of the number of CNG outlets that are required. The low-emission vehicles/clean fuels regulations are designed to help assure that the full air quality benefits from clean fuel LEVs are achieved. It is not our intent to require more CNG stations than would meet the demand of CNG low-emission vehicles. It is conceivable that CNG vehicles that do not meet low-emission vehicle standards would refuel at a station installed to meet the requirements of the clean fuels regulation. However, this would not reduce the amount of CNG available at that station due to the method by which CNG is distributed (pipeline versus truck delivery).

268. Comment: A provision should be added that requires fleet owners to notify the executive officer a year before a fleet plans to sell its CNG-fueled vehicles, so that adequate retail outlets can be planned for the increased number of CNG vehicles in service for the nonfleet population. (Ford)

Agency Response: Section 2313 will require fleet operators to submit to the ARB, fifteen months in advance, the expected number of low-emission fleet vehicles to be operated during each year starting with 1994. Additionally, the ARB will obtain registration data through the Department of Motor Vehicles that would give accurate information on number of fleet vehicles registered by each owner. These two mechanisms will provide sufficient information for the Executive Officer to make the necessary estimates of clean fuel volumes.

3. Requirements on locating, equipping, and maintaining clean fuel outlets

269. Comment: We believe that competitive practices will provide a superior approach to clean fuels marketing versus compliance with the myriad of detailed requirements in section 2309(b). These requirements will reduce marketing flexibility and could be potentially confusing to the motorist. We are particularly concerned about the requirement that facilities similar to gasoline be available to clean fuel customers. We should have the flexibility to optimize facilities based on site considerations, demographics, etc. (Mobil)

Agency Response: The rationale for the requirements on how clean fuel outlets are equipped and maintained is described in II.B.7. above. The underlying function of the requirements is to assure that the clean fuel is marketed at a given station in a manner that provides substantially the same convenience that is associated with the gasoline at the station. This is because a substantial portion of low-emission vehicles will be FFVs, and the drivers will therefore choose each time they purchase fuel whether to buy the clean fuel or gasoline. In the absence of a distribution requirement, we are concerned that competitive practices alone would not assure that clean fuels are marketed in a sufficiently attractive manner to maximize the emission benefits from low-emission vehicles.

The regulatory requirements on equipping and maintaining clean fuel outlets provide a good deal of flexibility. Rather than establish concrete design requirements, the standards are solely relative to the manner in which gasoline is being marketed at the station. Similarly, the provisions on location provide enough flexibility that oil companies will not be straight-jacketed in selecting locations.

The commenter has not identified a specific instance in which the requirements would result in motorists being confused. In fact, several of the requirements are specifically geared towards providing adequate information to motorists to minimize confusion. (e.g. § 2309(b)(2) (clear identification of dispensers); § 2309(b)(5) (attendant training program).)

270. Comment: We oppose the requirement in section 2309(b)(4) that for each clean fuel outlet, the access to canopy coverage must be substantially the same for the clean fuels as for gasoline. This requirement will reduce the number of locations an owner can consider as potential clean fuel outlets, largely because of local use permit and zoning restrictions. Since the majority of locations in the South Coast have small lot sizes, erecting remote dispensing sites with canopies may be impossible at an otherwise excellent site. Decisions on providing canopy coverage when expanding an existing station must be made on a site-by-site basis in light of a wide range of factors. (WSPA, Chevron, Mobil)

Agency Response: The regulation requires substantially similar accommodations for clean fuel and gasoline dispensers at clean fuel outlets. This is especially important for drivers of flexible-fueled vehicles for whom better accessibility for gasoline than for the clean fuel could prompt a choice of gasoline, resulting in a reduced air quality benefit from low-emission vehicles. The presence or absence of a canopy can be particularly important in inclement or very hot weather.

When installing clean fuel dispensers at existing gasoline stations, the owner/lessor of the stations must insure that local ordinances are observed. Section 2309(b)(4) authorizes a waiver of the equivalent canopy requirement when the owner/lessor demonstrates that providing a canopy for the clean fuel dispenser is prohibited by local ordinance. This removes any danger that the regulation could require the owner/lessor to do something that local laws do not permit. However, before granting a waiver the executive officer would that require all feasible options be exhausted. Possible options could include conversion of a gasoline pump into a clean fuel dispenser on an island that is covered, or installing a clean fuel dispenser in place of a leaded gasoline pump, which will have to be phased out under the ARB's and EPA's reformulated gasoline regulations (the ARB's Phase 1 reformulated gasoline regulations, approved on September 28, 1990, will prohibit the use of lead in gasoline starting January 1, 1992; the 1991 amendments to the federal Clean Air Act will prohibit lead in gasoline nationwide starting January 1, 1996 and in the South Coast starting January 1, 1995 (42 U.S.C. §§ 7545(n) and 7545(k), as amended by §§ 219 and 220 of the Clean Air Act Amendments of 1990).)

271. Comment: A controlled card-lock facility that dispenses clean fuels should be credited against the allocated number of clean fuel outlets required under the regulations. Fleet operators are often serviced by card-lock facilities, and the use of clean fuel vehicles by fleet operators is encouraged. (Chevron, Ultramar)

Agency Response: The regulations do not preclude using a card-lock station dispensing clean fuel to be counted as a clean fuel retail outlet, as long as the clean fuel is offered to the general public and the other requirements on locating, equipping and maintaining the outlet are satisfied.

272. Comment: In locating clean fuel outlets and in meeting requirements as to accessibility, lighting and other services, any dispenser for clean fuel equipped prior to January 1, 1993 as part of the CEC methanol demonstration project will be deemed to satisfy the requirements in section 2309(a)(1) and (b)(1). There are numerous LPG outlets that have for years satisfactorily meet the needs of motorists. Why are they not deemed to meet the requirements? As drafted, the regulations appear to extend the methanol bias of the CEC program and to reduce the objectivity of the ARB's regulations. (WLGA)

Agency Response: The rationale for the references to the CEC methanol demonstration program is explained in II.B.6.a. above. For stations in the CEC program, the station and dispenser locations have already been approved by the CEC staff. It is therefore unnecessary to impose additional requirements for these stations. On the other hand, there will not have been any prior agency review of the locations or configurations of LPG outlets. The LPG outlets introduced to date have generally been installed to provide not motor vehicle fuel but auxiliary fuel for vehicles such as campers and recreational vehicles. While these sites are not precluded from being counted towards required LPG sites, it is not appropriate to exempt them from review for adequacy as motor vehicle fueling sites. Some or most LPG motor vehicles are expected to be dual-fueled, and the drivers of such dual-fuel vehicles may choose to refuel with gasoline if accessibility, lighting, and other services at a given station are inferior for LPG compared to gasoline.

4. Submittal of proposed compliance plans

273. Comment: Section 2309(d)(1) requires each major supplier to report only very basic information. At the September 28 Board hearing, we understood that the gasoline supplier will be required to submit marketing plans to move clean fuels. Although the CEC has agreements with five major oil companies, they have done minimal, if any, marketing of methanol. (CEC)

Agency Response: The adopted regulations appropriately reflect the Board's direction in Resolution 90-58 and provide adequate assurances that clean fuels will be marketed effectively. As discussed in II.B.7 above, the requirements in sections 2309(b) and 2310 should assure that drivers of FFVs entering a clean fuel outlet will find the clean fuel facilities at least as attractive and convenient as the gasoline facilities. Section 2309(c) should assure that operators of clean fuel stations have adequate supplies of clean fuels.

Apart from the regulatory requirements, the Board in Resolution 90-58 directed the Executive Officer to monitor on an ongoing basis the pricing practices of wholesalers and retailers of motor vehicle fuel to determine how clean fuels are being priced in comparison to gasoline. If the monitoring program indicates that gasoline suppliers and others are not taking adequate action to assure that sufficient quantities of clean fuels are actually being distributed to motorists and used in low-emission vehicles, the Board can conduct a future rulemaking to modify the regulations as appropriate.

274. Comment: We recommend that the requirements in section 2309(c)(1) that gasoline station owner/lessors submit specific compliance plans on how they plan to supply or arrange for the supply of clean fuels be deleted. Such plans are not necessary because under section 2309(c)(1) the owner/lessor will be jointly liable with the operator for violations resulting from a failure to supply the operator with clean fuels. Further, we do not understand why it is necessary to provide the ARB with projections of the future which we may not even know, or to provide confidential information (e.g. prices) that might be beneficial to our competitors. (Chevron)

Agency Response: As discussed in II.B.8. above, section 2309(c)(2) is necessary to help assure that gasoline station owner/lessors engage in adequate planning for compliance with the supply requirements. Since the owner/lessor is submitting a currently proposed plan, he or she clearly will not be required to submit information that is not known at the time. Moreover, as discussed in the response to the next comment, the California Public Records Act and ARB regulations provide an adequate mechanism for protecting trade secret information from disclosure to competitors. (Government Code § 6254.7(e); 17 C.C.R. § 91022)

275. Comment: There are aspects of the section 2309(c)(2) requirements that appear to be outside the authority of the ARB, e.g. the requirements to disclose plans and contracts, designate where storage may be, and identify capacity for delivery including identities of parties, etc. This is proprietary information. Do provisions of other regulations provide for confidentiality? (WLGA)

Agency Response: The ARB has the authority to adopt these requirements, and other regulations and statutes provide an adequate mechanism to treat trade secrets confidentially.

Health and Safety Code sections 43013 and 43018 provide the basic authority for the clean fuel regulations; this authority is discussed at length on pages 77-78 of the Staff Report and pages 2-11 of Appendix C of the TSD. We have concluded that those sections authorize the ARB to adopt regulations necessary to assure that drivers of clean fuel low-emission will have the clean fuels reasonably available. Section 2309(c)(2) is one of requirements that we believe are necessary to achieve such availability.

The ARB has adequate procedures for protecting the confidentiality of trade secrets. Reports submitted pursuant to section 2309(c)(2) will be subject to the ARB's regulations on disclosure of records, 17 C.C.R. sections 91020-91022. These regulations in turn implement the California Public Records Act, Government Code sections 6250 et seq. Government Code section 6254.7 authorizes agencies to treat trade secrets (other than trade secrets which constitute emission data) confidentially.

5. Relief from enforcement

276. Comment: The "force majeure" provisions in sections 2309(c)(1) and 2310(a)(1) which insulate owner/lessors and operators in specified circumstances from liability for a failure to have clean fuel available at a station are far too restrictive. They regulatory provisions should be replaced with language which, among other things, protects an owner/lessor or operator from liability whenever a failure to comply with the availability requirements is caused by any occurrence beyond the control of the owner/lessor or operator. (WSPA, Chevron, Arco)

Agency Response: The rationale for the force majeure provisions is explained in II.b.9. above. These provisions were inserted because oil companies were concerned they could be held liable even where they could not comply because of an earthquake, fire, or other disaster. Sections 2309(c)(1) and 2310(a)(1) have been carefully drafted so that relief is available only when the failure to comply is due to a natural disaster, act of war, civil disorder, or the operation of law. In this respect it is not dissimilar from Civil Code section 1511, which relieves a party to a contract from the obligation to perform in very narrow circumstances where performance is impossible.

The language proposed by the commenters is too broad. We are not aware of any environmental regulations which provide, without even a prior hearing, blanket immunity whenever a violation is caused by reasons "beyond the control" of the violator. In order to assure the success of the program, it is important that gasoline station owner/lessors and operators be prepared for nonextraordinary contingencies. In anticipation of such events, some owners may find it prudent to install clean fuel outlets in excess of the required numbers.

277. Comment: While we support the general intent of the section 2309 provisions on site locations and marketing practices, there may be factors beyond our control which prevent us with complying with the requirements as written. For example, local governmental restrictions and the unavailability of contractors and equipment may make it difficult to equip clean fuel outlets in the 12 to 15 month time-frame provided in the regulation. Consequently we advocate the inclusion of provisions which hold owner/lessors harmless for noncompliance

situations due to factors beyond their control, provided.they can demonstrate a good faith effort to comply. (Arco)

Agency Response: There should be sufficient lead time to install clean fuel outlets. Plans for new outlets can begin as soon as it appears that 20,000 clean fuel vehicles are scheduled for production. In the early years of the program, major gasoline suppliers will have a good idea of the number and types of clean fuel vehicles to be produced by virtue of their involvement in the Auto/Oil Air Quality Improvement Research Program. Using their own market share data, each major gasoline supplier should be able to estimate the minimum number of clean fuel outlets required in advance of the ARB's preliminary (18 month) estimate. We also expect that many or most of any required methanol facilities in the first year will already have been installed pursuant to the CEC methanol demonstration program.

During the development of the regulations, ARB staff looked into the issue of labor and equipment available for installing 1000 clean fuel outlets per year. Staff found that through EPA's underground tank program, there is an experienced workforce available to meet the requirements of the regulations in the time-frame specified. A shortage of clean fuel equipment is unlikely since most items are currently available in sufficient numbers. Many underground tanks used for gasoline are already compatible with methanol, making it unnecessary to replace the tank. In this case, replacing all methanol-incompatible hoses and seals, and purging the dispenser of gasoline is all that is needed. (see Transcript, Day 1, pp. 67,68, and 195)

278. Comment: The retail outlet requirements and the requirements in section 2309 may be impossible for oil companies to comply with due to the requirements of the SCAQMD's Rule 1401. and other similar existing or proposed district toxics rules, which deal with New Source Review of Carcinogenic Air contaminants. The requirements of Rule 1401 may make it impossible for gasoline station owner/lessors to obtain the necessary permits to install new clean fuel outlets or to modify existing gasoline stations to incorporate clean fuel capability. Therefore we recommend that a provision be added to the regulations excusing gasoline station owner/lessors from compliance if they cannot obtain the necessary permits under SCAQMD Rule 1401 or similar regulation. (WSPA, Chevron)

Agency Response: We do not believe the provisions of SCAQMD Rule 1401 will make it impossible for gasoline stations to obtain the necessary permits to install clean fuel outlets. We are also not aware of any other districts with a proposed or existing regulation that place restrictions on gasoline-dispensing facilities similar to Rule 1401. We believe it unnecessary to add a provision to the regulation excusing gasoline station owner/lessors from compliance with the clean fuels regulation if they cannot obtain the necessary permits since we believe compliance is possible and the regulations are a legitimate use of local prerogative.

SCAQMD Rule 1401 (New Source Review of Carcinogenic Air Contaminants) requires any new or modified source to demonstrate that the maximum individual cancer risk is no greater than ten in one million (1×10^{-6}) at any receptor location. The commenter raises concern that it will not be possible to install clean fuel dispensing equipment at gasoline stations because of the requirements of Rule 1401.

We believe two scenarios are likely for gasoline stations installing clean-fuel-dispensing equipment: (1) replacing existing leaded gasoline service with a clean fuel, or (2) adding new clean fuel service while maintaining all existing services.

Under scenario 1, where existing leaded gasoline service is replaced by a clean fuel, it appears that the gasoline station would not be subject to Rule 1401. A provision in Rule 1401 exempts any modification "that causes a reduction or no increase in the estimated cancer cases or individual cancer risk at any receptor location." Since the primary source of potential cancer risk at a gasoline station is due to benzene emissions from gasoline, and since all clean fuels are very low in benzene, replacing a leaded gasoline service with a clean fuel service would likely result in a reduction in potential individual cancer risk. Thus, we do not believe the source would be subject to review under Rule 1401.

Under scenario 2, where a new clean fuel service is added while all existing services are maintained, a source may or may not have to comply with 1401 depending on the type of clean fuel offered. For CNG, LPG, pure methanol and pure ethanol we would not anticipate a increase in individual cancer risk. For methanol/gasoline or ethanol/gasoline blends, an increase in potential cancer risk may occur if one assumes that existing gasoline sales remain at the same level. An increase in cancer risk could occur from the increased benzene emissions associated with the portion of the clean fuel that is gasoline. In this situation, the source would have to comply with 1401. Whether the maximum individual risk would exceed ten in a million depends on many factors including: the volume of fuel sold, the type of fuels sold and the distance to the nearest receptor. However, if the risk does exceed this level, the source could identify measures, such as throughput restrictions, that would allow a permit to be issued.

In conclusion, Rule 1401 will have in many cases no impact on the installation of clean fuel facilities. In some cases where service for clean fuels containing gasoline are installed and all existing gasoline service is maintained, some additional measures may be required. In no case should it be impossible to comply with both the clean fuels regulations and SCAQMD's Rule 1401.

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279. Comment: The reporting requirements in section 2311 related to the maintenance and repair of CNG dispensing equipment that has broken down--particularly the requirements to submit repair plans, a

description of corrective measures, and a demonstration of correct preventive maintenance and operational procedures--are overly burdensome. We are not aware of such complete reporting requirements anywhere else in our business. (Chevron)

Agency Response: As noted in II.B.9.b above, the reporting requirements are patterned after local air pollution control district breakdown rules such as South Coast Air Quality Control District rule 430. Rule 430(e) requires submittal of a description of the corrective measures undertaken and/or to be undertaken to avoid a breakdown in the future information on future corrective actions even though that rule provides relief only for a maximum of 24 hours. Since section 2311 provides relief for up to six months, it is important that the Executive Officer be able to monitor the situation carefully and that the owner/lessor or operator evaluate any reasonable actions that might avoid a repeat of the problem. In the initial years of the program when the CNG outlets will be few, the loss of an outlet could significantly reduce the availability of natural gas and discourage the growth of its use. Thus it is important to ensure that CNG is maintained properly and repaired promptly.

280. Comment: The CNG breakdown provisions in section 2311, which may allow CNG to be unavailable at a clean fuel outlet for up to six months, should apply equally to both liquid and gaseous fuels. (CNGVC, PG&E, Mobil)

Agency Response: It is appropriate for section 2311 to apply to CNG facilities only. It is more difficult to replace equipment associated with CNG dispensers because much of this equipment cannot be purchased "off-the-shelf" as can the equipment for liquid fuel dispensers. CNG equipment is also significantly more costly than the dispensing equipment for other clean fuels. Thus it is reasonable to allow for extra time to repair or replace CNG equipment.

The same is not true for liquid clean fuel dispensing equipment. Because dispensing equipment for liquid clean fuels is approximately one-fifth the cost of CNG dispensing equipment and can be purchased readily, it is reasonable to assume that an owner of such equipment could obtain replacement parts with relative ease. Thus an owner/lessor could ensure (without incurring much expense) against noncompliance by installing enough dispensers so that if one were to break down the owner/lessor would still have the required number of liquid clean fuel outlets.

6. Substitute Fuels

281. Comment: In dealing with the demonstration regarding toxic emissions, the Substitute Fuel Test Procedure should use the Department of Health Services's ("DHS's") lower value of the range of potency for benzene rather than the upper value that is proposed. The

upper value is based on animal data, which in no way reflects a quantitative estimate of human risk from benzene at low levels of exposure. Using the DHS's lower value of potency factor, which is based on human data, would be consistent with EPA's approach to risk assessment and with the other toxic risk weighting factors which appear to all be based on human data. (Chevron, WSPA)

Agency Response: In estimating risks from toxic air contaminants such as benzene, the ARB has consistently used estimates of potency recommended by DHS and approved by the ARB's Scientific Review Panel ("SRP"). For a compound such as benzene, for which the DHS has provided lower and upper bounds for the probable potency without identifying a best or most probable value, the ARB has routinely used the upper bound value to compare the effect of emissions of that compound with emissions of other toxic pollutants. This policy is consistent with Health and Safety Code section 39662(d), which directs the Board to use "criteria which are protective of public health".

The commenters stated that the upper bound value for the potency of benzene should not be used, because it is based on animal data which does not reflect human risk at low levels, and instead that the lower value of the range be used. In the case of benzene, good data on cancer are available from both human and animal studies. For the majority of chemicals, sufficient data for the estimation of carcinogenic potency exist from animal studies only. Even when there are sufficient human evidence that something causes cancer, estimation of the dose received by humans is difficult. In several cases where data exists for both, animal and human carcinogenicity agree quite well. In any case, it is ARB policy, reflecting Health and Safety Code sections 39650 et seq., that neither the staff nor the Board should make and implement judgments concerning established potency values for toxic air contaminents. The ARB will continue to follow the formal recommendations of the DHS and SRP, which are expert in determining carcinogenic potency.

282. Comment: It is well known that current analytical techniques for 1,3-butadiene are unreliable. Since 1,3 butadiene has the highest toxic risk weighting factor, it is important that the implementation of any toxic risk weighting factor be deferred until a revised 1,3 butadiene exhaust emission analytical procedure is available and accepted by the scientific community. (WSPA)

Agency Response: 1,3-butadiene is recognized as one of the toxic compounds of significance in motor vehicle exhaust. For instance, it is one of the compounds expressly identified in the list of toxic air contaminants in the reformulated gasoline provisions of the 1990 amendments to the federal Clean Air Act (§ 220 of the Clean Air Act amendments of 1990). It would therefore be inappropriate to delete 1,3-butadiene from consideration in the comparison of toxic risks from a designated clean fuel and a proposed substitute fuel. We believe that the existing test method for 1,3-butadiene is adequate, particularly because the same method is used in evaluating the two fuels. If improved methods are developed, the Board can consider amending the test procedures to reflect the improvements.

283. Comment: New section 3(d)(ii) of the Substitute Fuel Test Procedure seems to require tests on 15 vehicles--three from each of the ULEV, LEV, and TLEV categories and six from the conventional (non-LEV) category. We believe that some of these categories may represent similar technologies and should be lumped together (such as TLEV TWC/FI and conventional TWC/FI). (WSPA)

Agency Response: It is true that 15 vehicles would be required if all of the four categories exist and contain vehicles capable of using the substitute or new clean fuel. However, 15 vehicles would actually be a very small sample of the potentially millions of vehicles that the sample would be intended to represent. Any diminution of the number of test vehicles would harm the ability to make confident inferences about the entire fleet.

The categorization of test vehicles has been made by certification categories because of the great differences between them in emission rates. Although vehicles in two categories might have superficially or broadly similar technologies, the great differences in effectiveness of emission control (by the approximate factor of 10 between conventional vehicles and ULEVs) could lead to differences in response when the ordinary certification fuel is replaced with the test fuel. Therefore, coalescing the categories would not be wise.

284. Comment: The Substitute Fuel Test Procedure should allow substituting vehicles in one class for another class if vehicles in the latter class are not available. (WSPA)

Agency Response: The procedure is not intended to require testing in a class that does not contain vehicles capable of using the test fuel. For classes wherein the test fuel is usable, it is doubtful that a sample of vehicles would be unobtainable. For the reasons explained in the preceding response, it is important that each emission class be tested.

285. Comment: We recommend that section 4 of the Substitute Fuel Test Procedures be modified to allow a change in the testing sequence from A, B, A, B to A, B, B, A where A is the primary designated clean or other certification fuel, and B is the substitute or new clean fuel. This will significantly decrease the testing time required. The alternative procedure was followed in the Auto/Oil program and presumably has been endorsed by EPA. (WSPA)

Agency Response: The staff does not believe there is any technical advantage offered by modifying the testing sequence as suggested.

286. Comment: We generally approve of the "aggregate toxic risk" approach that taken in section 7 of the Substitute Fuel Test Procedure. However, we remain concerned over the listed toxic risk weighting factors since they come from many different sources using different assumptions and there is currently no mechanism in the procedure for updating the factors as new information becomes available. (WSPA)

Agency Response: The factors come from only two sources. The factor for benzene was approved by the Board on the recommendations of DHS and the SRP when the Board identified benzene as a toxic air contaminant (TAC) in accordance with Health and Safety Code sections 39660-39662. The other three compounds have not yet been considered by the Board for identification as TACs. It is not critical that all four factors have the same derivation because the test procedure does not compare emissions or risks among the four compounds. Rather, the comparison is between emissions from using one fuel and emissions from using another. The important consistency is thus between the procedures used for each of the fuels (which are identical) rather than consistency among compounds.

If any of the compounds other than benzene become identified as TACs, we plan to propose an amendment to substitute the factors developed by DHS and the SRP during the identification process. The mechanism for updating the factors is the rulemaking process.

287. Comment: In the Substitute Fuel Test Procedure, requiring a demonstration of equal or lower emissions from a test fuel in each of five emission categories (exhaust NMOG, evaporative NMOG, CO, NOx, and toxic emissions) is unduly restrictive. We would prefer a procedure in which one or more categories may increase provided that reductions in other categories more than offset that increase. Parties unable to show equal or lower NOx should still be allowed the option of choosing that the amount by which NMOG and CO are reduced exceeded the amount by which NOx increased by more than enough to ensure a net reduction in ozone precursor emissions. (PG&E)

Agency Response: Attempting to demonstrate an emissions benefit in the aggregate would create very difficult issues of weighing the benefits of reducing one pollutant compared to others. This is made more difficult by the fact that the weights of different pollutants are not comparable on a one-to-one basis (e.g. NOx vs. CO) and the ozone-forming relationship of NMOG and NOx may differ in different areas of the state. Moreover, in addition to being a precursor to ozone, NOx emissions also contribute to PM10 concentrations, acid deposition, and reduced visibility.

288. Comment: The potency-weighted emissions for substitute fuels should be evaluated on the basis of all emissions, including evaporative, refueling, and running losses. (SMAQMD)

Agency Response: In the TSD (pp. IX-3 to IX-4, and Appendix A3), ARB staff estimated potency-weighted emission benefits for toxic air contaminants associated with the use of clean fuels. There are no specific toxic air contaminant standards for evaporative, refueling, and running loss emissions from which to determine the potency-weighted emission benefits.

Benzene is the only known toxic air contaminant present in any appreciable concentration in evaporative, refueling, and running loss emissions. It is appropriate to assume that these types of benzene emissions from clean fuel vehicles will not increase as compared to current or future gasoline vehicles. Reformulated gasoline will have to meet the benzene limit required pursuant to section 219 of the Federal Clean Air Act amendments of 1990 (or perhaps an even more stringent limit if the ARB adopts a benzene limit for gasoline in the coming year). The known clean fuels do not have evaporative, refueling, or running loss benzene emissions greater than that of gasoline. Further, because of new standards being proposed by ARB, we expect that evaporative and running loss emissions from low-emission vehicles will be very low.

We believe that evaporative, refueling, and running loss toxic emissions will not increase, and will almost certainly decrease, due to the implementation of new gasoline specifications and the low-emission vehicles/clean fuels program and that it is not appropriate or necessary to evaluate these types of emissions.

289. Comment: We did not receive the proposed modifications to the substitute fuel test protocol until January 15. The 15-day review should therefore be extended for this item. (Chevron)

Agency Response: We regret that the text of the Substitute Fuel Test Procedures was inadvertently omitted from the 15-day comment package distributed January 3, 1991. Accordingly, the modifications to the test procedure were distributed on January 16, and the comment period on the test procedures was extended another 15 days until January 31.

7. Future reevaluation and follow-up

290. Comment: We are disappointed that prior section 2310, which allowed retailers to earn, bank, and or trade credits in complying with the requirements of fuel availability, was deleted due to antitrust concerns. We recommend that the staff reevaluate this section for future reconsideration. (CEC)

Agency Response: The credit provisions in the original regulation would have allowed a fuel supplier to earn credits for distributing a particular fuel in excess of the fuel volume required. These credits could then be banked or traded to another fuel supplier. Since the regulations no longer requires gasoline suppliers to distribute a specific volume of fuel, but instead require clean fuel outlets to be installed and fuel to be available at these outlets, the credit provisions are no longer relevant to the regulatory requirements. However, we have retained section 2308 which allows companies installing more than the required number of outlets to "constructively allocate"--or transfer the credit for--these outlets to another company to meet the latter's retail outlet requirements.

291. Comment: Since the Board requires availability but not sales mandates, steps should be taken to ensure that clean fuels compete fairly with conventional fuels. We suggest that the Board establish an evaluation system to determine if clean fuels carry any unfair margins. (CEC)

Agency Response: As directed in Resolution 90-58, the staff intends to develop a program to monitor the pricing practices of wholesalers and retailers of motor vehicle fuels to determine how clean fuels are being priced in comparison to gasoline. We plan to involve CEC in this program. It is not necessary to have a regulatory directive to implement the monitoring program.

292. Comment: The clean fuel demand calculation of LEVs requiring a particular fuel should, upon adoption of LEV standards for heavy-duty vehicles, include an adjustment for heavy-duty vehicle fuel demand. Heavy-duty vehicle fleet operators who operate LEVs should also submit annual reports so that the fuel demand from these LEVs is known and can be included in the calculation of clean fuel demand. (CNGVC)

Agency Response: There are currently no low-emission vehicle standards for heavy-duty vehicles. Once such standards are adopted, the ARB will evaluate the need to modify the clean fuels regulation to accommodate the use of clean fuels in heavy-duty vehicles. Low-emission vehicle standards for heavy-duty vehicles are not expected to be adopted until late 1992.

293. Comment: There is an anomaly in the Resolution 90-58 language stating that an opt-in would simply adopt all the language applying to the SCAQMD which now includes a specific number of stations. Under this interpretation, it appears that Sacramento could opt-in for a station requirement equal to the South Coast; i.e. 90 in 1994, 200 in 1995, and 400 in 1996. This seems unlikely, but needs to be clarified. (SMAQMD)

Agency Response: The last paragraph of Resolution 90-58 states that where a district plan prepared pursuant to Health and Safety Code sections 40910-40926 demonstrates that expansion of the 1994-1996 clean fuels regulations to the district is reasonably necessary for timely attainment of the state ambient air quality standards within the district and other criteria are satisfied, it is the Board's intent to amend the clean fuels regulations as appropriate to make the 1994-1996 elements applicable within the district. This language clearly does not commit the Board to applying the South Coast minimum station numbers to Sacramento. In any case, since an opt-in can only be implemented by a subsequent rulemaking, the commenter can raise any relevant concerns in the context of that rulemaking.

294. Comment: In opt-in areas, stations should not be allocated on a percentage of the population basis, but rather on the number of LEVs operating in an area, plus any LEVs in any fleet mandated programs, plus the number of LEVs projected and verified in the district's Air Quality Attainment Plan. (SMAQMD)

Agency Response: Station allocation for opt-in areas would be determined in the subsequent rulemaking necessary to implement the clean fuels regulations in the opt-in areas. See also the response to the preceding comment.

8. Miscellaneous

295. Comment: The proposed rules allow only major gasoline retailers to obtain "station availability credits." The availability of lower emitting fuels would be enhanced, at no cost to any party, if other operators of refueling stations meeting the ARB's "public refueling station" criteria could also obtain station availability credits. If CNG is not granted the same minimum number of stations as liquid clean fuels, then we strongly suggest that "constructive allocation" be reconsidered at the earliest possible opportunity. (PG&E)

Agency Response: It appears the commenter is referring to the constructive allocation provisions of section 2308. Section 2308(a) clearly allows "any owner/lessor of a retail gasoline outlet, and any person who is the owner/lessor of a retail clean fuel outlet which is not a retail outlet" to constructively allocate a retail clean fuel outlet. It therefore covers more than just major gasoline suppliers. Retail clean fuel outlets may only be constructively allocated to a person who is subject to a requirement to have a minimum number of clean fuel outlets because the whole purpose of the constructive allocation program is to provide an alternative means of satisfying the availability requirements.

296. Comment: The number of vehicles specified in section 2304(a)(1) for triggering the requirement to install clean fuel stations should be reduced from 20,000 vehicles to 5000 vehicles. We expect that by the time that 5000 FFVs begin operation in 1992, we should have nearly 70 methanol fueling stations established. However, we expect that FFV drivers will refuel with M85 no more than 75 percent of the time because of the lack of conveniently placed fueling stations. (CEC)

Agency Response: We believe that the 20,000 vehicle *de minimis* level is an economically reasonable and practical limit. The 20,000 vehicle trigger was selected because the projected fuel demand of that number of vehicles represents a monthly throughput level per outlet that should allow a favorable rate of return on the investment in clean fuel storage and dispensing equipment. Assuming that 20,000 vehicles operate exclusively on a clean fuel, an average yearly fuel consumption of 400 gallons per vehicle per year, and a 0.9 fuel volume adjustment factor, the total fuel consumption would be about 7.2 million gasoline equivalent gallons per year.

If the clean fuel were M85, the 7.2 million gasoline equivalent gallons would be equal to approximately 12.9 million gallons of M85. Once the *de minimis* level is exceeded, a minimum of 90 stations must be equipped to dispense M85. The average monthly throughput (assuming 90 stations and 12.9 million gallons of M85) would be approximately 12,000 gallons per M85 outlet. Since many retail gasoline outlet$ currently offering leaded gasoline have monthly throughputs of leaded gasoline in the 10,000 to 15,000 gallons per month range, we believe an M85 throughput of 12,000 gallons per month is economically reasonable.

If the *de minimis* level was reduced to 5,000 vehicles, the average monthly throughput per outlet would be approximately 3,000 gallons per month (assuming the vehicle used M85 100 percent of the time). We are concerned that this low throughput may result in dealers posting higher margins on the M85 than gasoline and therefore adversely affecting the price of M85 and reducing consumer acceptance.

297. Comment: The definition of major gasoline supplier in section 2300(a)(18) has been modified to increase the minimum number of stations owned or leased from 25 to 35. This would have addressed our initial concerns had section 2309(a)(2) not have been added. This latter subsection requires each gasoline station owner/lessor to submit proposed locations of 120 percent of the number of clean fuel outlets preliminarily assigned. This could result in a requirement that a major gasoline marketer submit more proposed sites than the total number of stations of which it is the owner/lessor. As a result, the station cut-off in the definition of major gasoline supplier should be changed from 35 to 40. (Ultramar)

Agency Response: No modification is necessary because major gasoline suppliers are not required to submit more locations than the total number of stations they own or lease. Section 2301(a) provides that the basic retail outlet requirements will in any case be deemed satisfied if all of a major gasoline supplier's South Coast outlets are equipped to dispense the fuel. Accordingly, major gasoline suppliers will not be required to submit the locations of more stations than they have.

298. Comment: We oppose the proposed modification of the definition of "major gasoline supplier" in section 2300(a)(18) to increase the minimum crude oil capacity from 50,000 barrels per stream day ("bpsd") to 55,000 bpsd. (Ultramar)

Agency Response: The modification is being made in response to the comments of Golden West (See Comment 180). Golden West has historically been treated as a small refiner with a crude oil capacity of less than 50,000 bpsd. The company's comments indicated that refinery modifications being made to comply with the Board's recent regulations on diesel fuel (13 C.C.R. §§ 2255 and 2256) will result in an increase in throughput to slightly more than 50,000 bpsd. We do not believe this response to new regulatory requirements should have to result in a substantial change in the characterization of the refiner.

299. Comment: Some provision should be made for updating the energy contents specified in section 2310 for gasoline and other fuels, since the characteristics of fuels may change. (SMAQMD)

Agency Response: Whenever changes to the stated energy contents are appropriate, the Board can schedule a rulemaking hearing to consider revisions to section 2310.

MODIFICATIONS TO THE REGULATIONS
MADE AFTER THE 15-DAY AVAILABILITY PERIOD

Modifications to the Low-Emission Vehicles Regulations

Affected Sections, Title 13, California Code of Regulations

§ 1960.1(e)(1).

In the text introducing the table, on line 1, "(i)" has been changed to "(A)". On line 3, "(ii)" has been changed to "(B)". On line 5, "(iii)" has been changed to "(C)", and on line 7, "(iv)" has been changed to "(D)". These changes were made to conform with existing regulations.

In the text introducing the table, on line 2, a comma was added after "light-duty trucks" to conform with existing regulations.

In the title of the table, "THROUGH 1994" was italicized and "~~AND SUBSEQUENT~~" was added to conform with the amendments made to the regulations by the medium-duty vehicle rulemaking ("MDV amendments").

In the column headings of the table, column 2, "[~~*Equivalent Inertia*~~]" was added, and "Loaded Vehicle" was italicized to conform with the MDV amendments.

On line 3 of the table, "Diesel-Cycle" has been changed to "Diesel" to conform with existing regulations. The same change has been made on line 7 of the table.

On lines 3, 7, 10, and 12 of the table, "*(8)*" has been added to conform with the MDV amendments.

In note (2), on line 3, the period after "flexible-fueled vehicles" has been replaced with a comma.

In note (4), on line 10, "Section" has been changed to "section". On line 15, "Sections 2112 and 2113" has been changed to "subchapter 2.5". Also, on line 16, "commencing with section 2111" has been added after "California Code of Regulations". These changes were made to conform with existing regulations.

In note (6), on line 3, "Section" has been changed to "section" to conform with existing regulations.

In note (7), on line 2, a hyphen has been added to "model year". Also, on line 1, "Section" has been changed to "section" to conform with existing regulations.

§ 1960.1(e)(2).

In the heading of the table, column 2, "(3)" was italicized to conform with the MDV amendments. Also, the underline under the column headings has been deleted.

In note (2), on line 8, "Section" has been changed to "section". On line 14, "Sections 2112 and 2113" has been changed to "subchapter 2.5". Also, on line 15, "commencing with section 2111" has been added after "California Code of Regulations". These changes were made to conform with existing regulations.

In note (3), on line 2, "Section" has been changed to "section".

§ 1960.1(e)(3).

In the text introducing the table, on line 1, the word "formaldehyde" has been deleted. The same change has been made to the title of the table.

In note (3), on line 1, the "s" has been deleted from "vehicles". The same change has been made on lines 2 and 3.

In note (5)a., on lines 3 and 4, the hyphen in "model-year" has been deleted. The same change has been made in note (5)b., on lines 3 and 5.

§ 1960.1(f)(1).

In the title of the table, a hyphen has been added to "MODEL YEAR".

In note (4), on line 10, "Section" has been changed to "section". On line 15, "Sections 2112 and 2113" has been changed to "subchapter 2.5". Also, on line 16, "commencing with section 2111" has been added after "California Code of Regulations". These changes were made to conform with existing regulations.

In note (5), on line 1, "Diesel-cycle" has been changed to "Diesel". Also, in note (9), on line 1, "diesel-cycle" has been changed to "diesel". These changes were made to conform with existing regulations.

In note (7), on lines 2 and 5, the hyphen in "model-year" has been deleted. Also, on lines 4 and 7, "Section" has been changed to "section".

§ 1960.1(f)(2).

In the title of the table, a hyphen has been added to "MODEL YEAR".

In note (3), on line 5, "[~~*and medium-duty vehicles*~~]" has been added after "light-duty truck" to conform with the MDV amendments.

In note (4), on line 2, the hyphen in "model-year" has been deleted.

§ 1960.1(g)(1).

In note (2), on line 1, the "s" has been deleted from "vehicles". The same change has been made on lines 2 and 3.

In note (3)a., on lines 3 and 11, "Section" has been changed to "section". On lines 4 and 11, a comma has been added after "Title 13". Also, on line 10, the hyphen in "Model-Year" has been deleted.

In note (4)a., on line 1, a comma has been added after "LEVs".

In note (6), on lines 6, 7, 8, and 9, the hyphen in "model-year" has been deleted.

In note (7), on line 1, the word "must" has been changed to "shall".

§ 1960.1(g)(2).

In note (4), on lines 5 and 7, "Section" has been changed to "section".

In note (5), on lines 4 and 5, "Section" has been changed to "section".

In note (6), on lines 3, 5, and 7, the hyphen in "model-year" has been deleted. The same change has been made to note (6)b., line 1, and note (6)c., line 1.

In note (6)a., on line 1 "year 2000" has been changed to "model year 2000".

In note (7), on line 1, the hyphen in "model-years" has been deleted; the same change has been made to note (7)a., line 2, note (7)b., lines 1, 2, 3, 8, and 9, note (7)c., lines 1 and 2, note (7)d., lines 3, 5, and 7. Also, on line 3, the comma after "year" has been deleted; the same change has been made on line 3 of note (7)a.

In note (7), on line 3, "corresponding year" has been changed to "corresponding model year".

In note (7)b., on line 3, "1988" has been changed to "1998".

In note (8), on line 2, "and" has been changed to "or". On line 3, "and/or" has been changed to "or". Also, on line 2, "Section" has been changed to "section".

In note (8), on line 3, the hyphen in "model-years" has been deleted. The same change has been made to note (8)a., line 4, note (8)b., line 4, and note (8)c., lines 1 and 2.

In note (8)b., on line 2, "standards" has been changed to "requirements".

In note (9), on line 4, "in the 1998 through 2000 model-years" has been changed to "in each model year from 1998 to 2000". Also, on lines 4 and 5, the hyphen in "model-year" has been deleted; the same change has been made to note (9)b., lines 2 and 3, and note (9)d., line 3.

In note (9)a., "to the Executive Officer" has been added after "by submitting".

In note (9)b., on line 3, the comma after "model year" has been deleted.

In note (9)c., on line 2, the sentence "However, small volume manufacturers may earn and market credits for ZEVs they produce and sell." has been added.

In note (9)d., on line 1, "Section" has been changed to "section".

§ 1960.1(h)(1).

In the title of the table, a hyphen has been added to "MODEL YEAR". Also, the underline under the column headings of the table has been deleted.

In line 8 of the table, "[~~0.15~~]" has been added after "0.12", and on line 10 of the table, "[~~0.18~~] has been added after "0.12". These changes were made to conform with the MDV amendments.

In note (2), on lines 4 and 9, "Section" has been changed to "section".

In note (3), on line 1, the hyphen in "model-year" has been deleted.

§ 1960.1(h)(2).

In note (8), on lines 3 and 8, "Section" has been changed to "section".

In note (9), on lines 6 and 7, the hyphen in "model-year" has been deleted.

In note (10)a., on lines 2, 3, 4, 6, 7, and 8, the hyphen in "model-year" has been deleted. The same change has been made to note (10)b., on lines 2, 4, 5, and 6.

In note (10)b., on line 2, the phrase "in the 1998 through 2000 model-years" has been changed to "in each model year from 1998 through 2000".

In note (12), the hyphen in "model-years" has been deleted. The same change has been made to note (12)b., line 2, note (12)c., lines 1 and 2, note (12)d., lines 3, 5, and 7.

In note (13), on line 2, the abbreviations "CO" and "NOx" have been written out as "carbon monoxide" and "oxides of nitrogen".

§ 1960.1(i).

In the text introducing the table, on line 4, "Subchapter" has been changed to "subchapter".

In the column headings of the table, "(2)" has been changed to "*(2[~~1~~])*" to conform with the MDV amendments. Also, the underline under the column headings has been deleted.

In note (5), on line 3, "~~Subparagraph~~" has been deleted, and "<u>Subpart</u>" has been changed to "Subpart". These changes were made to conform with existing regulations.

In note (6), on line 1, "Section" has been changed to "section" to conform with existing regulations, and on line 2, "[*~~California Administrative Code~~*] has been added to conform with the MDV amendments.

In note (7), on line 1, "Section" has been changed to "section" to conform with existing regulations, and on line 2, "[*~~California Administrative Code~~*] has been added to conform with the MDV amendments.

In note (8), on line 1, "Section" has been changed to "section" to conform with existing regulations, and on line 2, "[*~~California Administrative Code~~*] has been added to conform with the MDV amendments.

In note (10), on line 1, "Diesel-powered" has been changed to "Diesel" to conform with existing regulations.

§ 1960.1(k).

On line 10, "[*~~December 20, 1989 and January 22, 1990~~*] *~~December 26, 1990~~*" has been added to conform with the MDV amendments.

§ 1960.1(o).

On lines 4 and 5, the hyphen in "model-year" has been deleted.

§ 1960.1 NOTE.

In the reference note, section 39667 has been added to conform with existing regulations.

§ 1956.8(a)(1).

In the text introducing the table, on line 1, "(i)" has been changed to "(A)". On line 4, "(ii)" has been changed to "(B)". On line 6, "(iii)" has been changed to "(C)". These changes were made to conform with existing regulations. Also, on line 3, the comma after "engines" was deleted to conform with the MDV amendments.

In the heading of the table, a hyphen has been added to "nonmethane". The same change has been made to note A, line 1.

In note B, on line 2, a hyphen has been added to "model year".

In note E on line 7, "0.01 grams per brake horsepower-hour particulates" has been changed to "a 0.10 grams per brake horsepower-hour standard for particulates".

§ 1956.8(b).

In line 6, "[*May 15, 1990, effective July 15, 1990*] *December 26, 1990*" has been added to conform with the MDV amendments.

§ 1956.8(c)(1).

In the text introducing the table, on line 1, "(i)" has been changed to "(A)". On line 5, "(ii)" has been changed to "(B)". These changes were made to conform with existing regulations. On line 3, the comma after "engines" has been deleted to conform with the MDV amendments. Also, on line 8, "[*Exhaust Emission Standards (grams per brakehorsepower-hour) Total Optional Hydrocarbons Nonmethane Carbon Oxides of*]" has been added, and the title of the table has been italicized to conform with the MDV amendments.

In the heading of the table, a hyphen has been added to "Nonmethane". The same change has been made to note A, line 1.

In lines 5 and 6 of the table, the superscripts "D" and "E" have been italicized to conform with the MDV amendments.

In note E, on lines 6 and 8, a hyphen has been added to "model year". Also, in line 6, the comma after "provided" has been deleted.

§ 1956.8(2).

In line 2, "cycles" has been changed to "cycle" to conform with the MDV amendments.

§ 1956.8(d).

In line 6, "[*May 15, 1990, effective July 15, 1990*] *December 26, 1990*" has been added and "[*January 22, 1990*] has been deleted to conform with the MDV amendments.

§ 1956.8(e).

Subsection (e) has been added to conform with existing regulations.

§ 1956.8(f).

Subsection (f) has been added to conform with existing regulations.

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§ 1956.8(g).

The subsection designation has been changed from "(e)" to "(g)" to conform with existing regulations.

In note A, on lines 6 and 10, "Section" has been changed to "section".

In note D, on line 1, the hyphen in "model-year" has been deleted.

§ 1956.8(h).

The subsection designation has been changed from "(f)" to "(h)" to conform with existing regulations.

In the text introducing the table, on lines 2 and 4, the comma after "incomplete medium-duty low-emission vehicles" has been removed. Also, on line 3, a comma has been added after "ultra-low-emission vehicles".

In the heading of the table, the hyphen in "Model-Year" has been deleted.

In note A, on lines 6 and 10, "Section" has been changed to "section".

In note E, on line 3, "Section" has been changed to "section".

§ 1900.

In subsection (b)(9), on lines 1, 3 and 6, a hyphen has been added to "model year".

§ 1904.

In lines 1 and 3, "Section" has been changed to "section".

§ 1960.1.5.

In the title, on line 2, "less" has been changed to "Less" to conform with existing regulations. Also, on line 3, ")" (end parenthesis) has been added after EIW.

In subsection (a)(1)(C), on line 1, a hyphen has been added to "model year".

§ 1960.5.

In the title, on line 1, a hyphen has been added to "Model Year".

In subsection (c), on lines 2 and 4, a hyphen has been added to model year".

§ 2061.

On lines 1 and 12, a hyphen has been added to "model year".

On line 4, "Section" has been changed to "section".

On line 15, the sentence "For vehicles certified to NMOG standards ... shall imply NMOG standards." has been underlined.

§ 2111.

In subsection (a)(1), on lines 5 and 6, "Section" has been changed to "section".

07226

§ 2112.

In subsection (l)(4), on lines 1 and 2, a hyphen has been added to "model year". The same change has been made to subsection (l)(5), lines 1 and 4, subsection (l)(6), lines 1 and 3, and subsection (l)(7), lines 1 and 2.

In subsection (l)(7), on line 10, "Section" has been changed to "section" to conform with existing regulations.

In subsection (l)(9), on line 1, a hyphen has been added to "model year".

In subsection (l)(10), on lines 5, 9, 11, and 16, "Section" has been changed to "section" to conform with existing regulations. On line 10, "[~~t~~]I" has been added to conform with the MDV amendments. Also, on lines 11 and 13, "Section" has been changed to "section".

§ 2125.

In subsection (b)(6), on lines 6 and 15, "Section" has been changed to "section".

In subsection (b)(12), on line 3, "Section" has been changed to "section".

§ 2139.

In subsection (c)(2), on lines 2 and 29, "Section" has been changed to "section".

<u>Incorporated Documents</u>

"California Exhaust Emission Standards and Test Procedures for 1988 and Subsequent Model Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles"

Section 2. Definitions

In item h., "pre-1995 model year", "and any 1995 and subsequent model year heavy-duty vehicle", and "having a manufacturer's gross vehicle rating of 14,000 pounds or less" have been italicized to conform with the MDV amendments.

In item q., "For those light-duty ... 100,000 mile emission standards", "the useful life shall be", "For 1995 and subsequent medium-duty vehicles", and "certified to ... whichever first occurs" have been italicized, and "[~~*of either, ... or if*~~]" and "[~~*any of*~~]" have been added to conform with the MDV amendments.

In item y., "Incomplete vehicle means ... with the definition of incomplete vehicle." has been italicized to conform with the MDV amendments.

In item Aa., on line 2, "stored separately on-board the vehicle" has been added.

In item Ao., on line 3, the hyphen in "model-year" has been deleted.

Section 3. Standards

In subsection b., note (4), on line 14, "Sections 2112 and 2113" has been changed to "Subchapter 2.5" and "commencing with Section 2111" has been added after "Title 13, California Code of Regulations" to conform with existing regulations.

In subsection c., in the table headings, in column 2, "(3)" has been italicized to conform with the MDV amendments. Also, in note (2), on line 12, "Sections 2112 and 2113" has been changed to "Subchapter 2.5" and on line 13, "commencing with Section 2111" has been added after "Title 13, California Code of Regulations" to conform with existing regulations.

In subsection d., on line 1, "formaldehyde" has been deleted from the introductory paragraph. The same change has been made to line 1 of the title of the table. In note 3, on lines 1, 2, and 3, the "s" has been deleted from "vehicles". Also, throughout note (4), the hyphen in "model-year" has been deleted where the term is used as a noun.

In subsection e., in the title of the table, a hyphen has been added to "MODEL YEAR". In note (4), on line 14, "Section 2112 and 2113" has been changed to "Subchapter 2.5", and "commencing with Section 2111" has been added after "Title 13, California Code of Regulations" to conform with existing regulations. Also, in note (9), on line 2, a hyphen has been added to "model year".

In subsection f., in the title of the table, a hyphen has been added to "MODEL YEAR".

In subsection g., in note (2), on lines 1, 2, and 3, the "s" has been deleted from "vehicles". Throughout note (6), the hyphen in "model-year" has been deleted where the term is used as a noun. Also, in note (7), on line 1, "must" has been changed to "shall", and on line 4, a comma has been added after "LEVs".

In subsection h., in note (6)a., on line 1, "year 2000" has been changed to "model year 2000". In note (7), on line 3, "corresponding year" has been changed to "corresponding model year", and the comma after "year" has been deleted. In note (7)b., on line 3, "1988" has been changed to "1998". In note (8), on line 2, "and" has been changed to "or" and "and/or" has been changed to "or". In note (8)b., on line 2, "standard" has been changed to "requirement". In note (9), on line 3, "in the 1998 through 2000 model-years" has been changed to "each model-year from 1998 through 2000". In note (9)a., on line 1, "to the Executive Officer" has been added after "submitting". The same change has been made on line 4 of note (9)b. In note (9)c., on line 2, the sentence "However, small volume manufacturers may earn and market credits for ZEVs they produce and sell." has been added. Also, throughout subsection g., the hyphen in "model-year" has been deleted where the term is used as a noun.

In subsection i., in the title of the table, a hyphen has been added to "MODEL YEAR". In note (2), on line 6, a comma has been added after "specify", and on 7, a comma has been added after "procedure" to conform with the MDV amendments. Also, in note (7), on line 10, a hyphen has been added to "model year".

In subsection j., in note (10)b., on line 2, "in the 1998 through 2000 model-years" has been changed to "in each model-year from 1998 through 2000". In note (13), on line 2, the abbreviations "CO" and "NOx" have been written out as "carbon monoxide' and "oxides of nitrogen", and on line 3, quotation marks has been placed around "California Exhaust Emission Standards ... Amended:_______ ". Also, throughout subsection j., the hyphen in "model-year" has been deleted where the term is used as a noun.

Section 4. Initial Requirements

In subsection c.4., on line 3, "*and 1995 through 1997 model-year medium-duty ~~trucks~~ vehicles*" has been added after "light-duty trucks". On line 8, "*(1995 for medium-duty ~~trucks~~ vehicles)*" has been added after "1993 model year". On line 9, "*(1998 for medium-duty ~~trucks~~ vehicles)*" has been added after "For 1997". On line 12, "*(1995 for medium-duty ~~trucks~~ vehicles)*" has been added after "For 1993". The italicized text has been added to conform with the MDV amendments.

Section 6. Demonstrating Compliance

In subsection a.1., on line 5, "and" has been deleted, and a comma has been added after "light-duty trucks". On line 6, "and 1995 model-year vehicles ... standards" has been added. On line 10, "(except those ... standards)" has been added. These changes were made to conform with the MDV amendments.

In subsection a.3.(A)(4), on lines 2, 5, 10, 16, 20, and 31, "[*~~100,000 mile~~*]" has been added before "the full useful life". On lines 2, 6, 10, 14, 16, 20, and 32, "the full useful life" has been italicized. On line 14, "[*~~the primary 100,000 mile~~*]" has been added before "the full useful life". On line 21, "[*~~75,000 miles~~*]" has been added after "At a minimum," and "75% of the full useful life" has been italicized. These changes were made to conform with the MDV amendments.

In subsection a.5., on lines 5 and 6, "[*~~100,000 mile~~*]" has been added after "to". On line 5, "the full useful life" has been italicized. On line 7, "beyond "50,000 miles" has been italicized. These changes were made to conform with the MDV amendments.

In subsection b.5.(B), on lines 7, 28, 38, and 40, "[*~~100,000 miles~~*]" has been added before "full useful life". On lines 8, 29, and 41, "full useful life" has been italicized. On line 39, "beyond 50,000 miles" has been italicized. These changes were made to conform with the MDV amendments.

Section 9. Test Requirements

In subsection a.1.(i), on line 3, "as an option to the specifications referred to in subparagraph (a)" has been added.

In subsection a.5.(2), "~~following~~", "~~Administrator~~", and "The grade of petroleum fuel ... shall be used." have been added to conform with existing federal regulations. "Except as noted below", "Executive Officer", and "For 1995 ... 86.113-90(b)(2)" have been double-underlined.

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In subsection a.6., "~~Administrator~~" and "The grade of petroleum fuel ... shall be used." have been added to conform with existing federal regulations. "Except as noted below", "Executive Officer", and "For 1995 ... service accumulation." have been double-underlined.

In subsection c., on line 2, "subsequently described" has been added after "procedures" to conform with existing federal regulations. On line 6, "For purposes of ... shall apply" has been double-underlined.

Section 11. Additional Requirements

In subsection k., on line 8, the sentence "The vehicles shall not be subject to a diurnal heat build prior to the cold start exhaust test or evaporative emission testing." has been added. On line 12, "must" has been changed to "shall". In item i, line 7, "soak temperature" has been changed to "soak period", and on line 10, "to employing a data acquisition system" has been added after "alternative".

In subsection l., on line 1, "For each TLEV, LEV, and ULEV engine family" has been changed to "For each engine family certified to TLEV, LEV, or ULEV standards". Also, on line 7, the sentence "For diesel vehicles, compliance with the applicable particulate standard shall also be demonstrated." has been changed to "For diesel vehicles, the engineering evaluation shall also include particulate emissions."

Appendix VIII.

In step (1)c., on line 4, "or mg/mile" has been added after "units of g/mile".

In step (1)d., on line 5, "12" has been changed to "twelve".

In step (2), on line 3, "given in step (9)" has been added after "maximum incremental reactivity".

In step (8), on line 1, "A vehicle manufacturer may request ... provided that:" has been changed to "The Executive Officer shall assign ... provided that:".

"California Exhaust Emission Standards and Test Procedures for 1987 and Subsequent Model Heavy-Duty Otto-Cycle Engines and Vehicles"

In 86.087-35 Labeling., on line 3, "[~~*January 22, 1990*~~] ~~*December 26, 1990*~~" has been added to conform with the MDV amendments.

In 86.1513-84 Fuel specifications., on line 1, "November 16, 1983" has been italicized to conform with the MDV amendments.

"California Exhaust Emission Standards and Test Procedures for 1985 and Subsequent Model Heavy-Duty Diesel Engines and Vehicles"

In 86.085-35, "~~*December 26, 1990*~~" has been added to conform with the MDV amendments.

"California Non-Methane Organic Gas Test Procedures"

In California Non-Methane Hydrocarbon Test Procedures, Section III. Sampling Procedures, on line 3, "National Bureau of Standards

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(NBS)" has been changed to "National Institute of Standards and Technology (NIST)". In Section IV. Instrument Calibration, on line 2, "NBS" has been changed to "NIST". Also, in Section V. Sample Analysis, in the second definition for $NMHC_e$, "r_{MeOH}" has been changed to "r_{CH_3OH}", and in the third definition for $NMHC_e$, "r_{EtOH}" has been changed to "$r_{C_2H_5OH}$".

"California Motor Vehicle Emission Control Label Specifications"

In Section 3. Label Content and Location, subsection (a), item iii, line 1, "1993 and subsequent model-year" has been added in front of "vehicles and engines".

In Section 3. Label Content and Location, subsection (a), item v, on the last line of the subsection, "revised SAE J1930, July 1990" has been changed to "SAE J1930, JUN 1988".

"Guidelines for Certification of 1983 and Subsequent Model-Year Federally Certified Light-Duty Motor Vehicle for Sale in California"

In Section V. Offsetting Procedure, subsection C, the subscripts i of the equation on line 5 have been moved to "Calsales" and "Calcert". Also, on line 15, the "$" has been changed to "=".

In Section V. Offsetting Procedure, subsection D, the entries in the table entitled "Calmean (g/mi)" have been underlined. Also the subscripts j of the equation following the table have been moved to "Fedsales" and "Fedcert".

In Section V. Offsetting Procedure, subsection G, the entries in the table have been underlined.

In Section V. Offsetting Procedure, subsection K, on line 7, the reference to section "V.I." has been changed to "V.J."

Modifications to the Clean Fuels Regulations.

Affected Sections, Title 13, California Code of Regulations

§ 2300.

At the beginning of the first line of text, "(a)" has been added. At 2300(31), a hyphen has been added between "low" and "emission".

§ 2303(c).

On line 2, "then" has been deleted.

In the first indented formula, the word "Where" introduces four paragraphs. The phrase "of text" has been added at the end of the second paragraph. A comma has been added after "is" in the fourth paragraph.

On the second line following the first indented formula, the comma after "class)" has been deleted. On line 7 of that paragraph, "factor, and for 1994 through 1996 only by a" has been changed to "factor and, for 1994 through 1996 only, by a".

The comma after "factor" has been moved to after "and". Also, a comma has been added after "only".

§ 2304(a)(2)(B).

In the heading, the comma has been deleted after "1995." The same change has been made in § 2305(a)(1), line 1; in § 2305(d)(2), line 2; and in § 2309(d)(1), line 2.

§ 2304(a)(3).

On line 1, "of" has been added.

§ 2305(d)(2).

On line 2, "The" has been changed to "the".

§ 2306.

In the indented formula, the word "Where" introduces two paragraphs. On line 7 of the first paragraph, "2340" has been changed to "2312", and "**[Revise]**" has been deleted.

§ 2307(a).

On line 1, a comma has been added after "year".

§ 2307(c)

After the heading, the text is started as a new paragraph.

In the denominator of the indented formula, "Owners/Lessors" has been changed to "Owner/Lessors." The same change has been made in line 2 of the second paragraph following "Where:".

§ 2307(d).

On line 8, "if" has been changed to "of".
On line 11, "that" has been changed to "then".
On line 14, "EO" has been changed to "executive officer".

§ 2307(e).

In heading, "Estimated and Final Determinations" has been changed to lower case.

On line 2, "each owner/lessor" has been changed to "each affected owner/lessor".

§ 2307(e)(1).

On line 6, "summary" has been changed to "detailed analysis".

§ 2307(e)(2).

On line 2, "The" has been changed to "the".

§ 2307(e)(2).

On line 5, "summary" has been changed to "detailed analysis".

§ 2308(g)(2).

On line 5, the extra "the" has been deleted.

§ 2308(h)(1).

On line 2, "owner/operator" has been changed to "owner/lessor".

§ 2308(h)(2).

On line 3, the extra "the" has been deleted.

§ 2309(a)(2).

On line 7, "location" has been changed to "locations".

§ 2309(b).

In heading, the words after "Requirements" have been made lower case.

§ 2309(b)(1).

On line 2, "reasonably as accessibility and visibility" has been changed to "substantially as accessible and visible".

§ 2309(b)(4).

On line 3, a comma has been inserted after ")".

§ 2309(b)(5).

On line 1, "franchisor" has been changed to "refiner".

§ 2309(c).

In the heading, the words after "Requirements" have been made lower case.

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§ 2309(c)(1).

On line 9, "outlet." has been changed to "outlet,".
On line 11, "[A]" has been changed to "[i]".
On line 14, "[B]" has been changed to "[ii]".
On line 16, "However, an owner/lessors..." now starts a new paragraph.
On line 17, "[A]" and "[B]" has been changed to "[i]" and "[ii]".

§ 2309(d)(1).

On line 5, "owner/operator" has been changed to "owner/lessor".
On line 6, "to" has been deleted.

§ 2309(d)(B).

On line 3, the extra "the" has been deleted.

§ 2310(a)(3).

On line 1, "substantial" has been changed to "substantially".

§ 2311(a)(1).

On line 3, "reasonably knows" has been changed to "reasonably should know".

§ 2311(b)(1).

On line 3, a comma has been added after "time".
On line 2, "reasonably knows" has been changed to "reasonably should know".

§ 2311.

Authority and Reference note has been added at the end of the section.

§ 2314(2).

On line 2, "and" has been added after "person".

§ 2316.

At the end of the table, "Net (low) heating values" has been deleted, and on line 2 of the text "the values" has been changed to "the lower heating values".
In the table, "FUEL" has been changed to "Fuel".

Attachment B

LIST OF COMMENTERS

<u>Commenters with Specific Concerns</u>

Code	Commenter and Date
AAA	Michael R. Appleby Automobile Club of Southern California Written Testimony: 9/12/90
Aerovironment	Alex Brooks Aerovironment Oral Testimony: 9/27/90
AIAM	Gregory J. Dana Association of International Automobile Manufacturers, Inc. Written Testimony: 9/18/90, 9/27/90 Oral Testimony: 9/27/90
AIRA	Craig Moyer American Independent Refiners Association Oral Testimony: 9/27/91
AMI	R. Lewis American Methanol Institute Oral Testimony: 9/28/90
Arco	G.H. Babikian ARCO Products Company Written Testimony: 9/14/90, 9/27/90, Oral Testimony: 9/27/90
	D. J. Townsend ARCO Products Company Written Testimony: 9/26/90, 9/28/90 1/18/91
Brown	Assemblyman Willie L. Brown, Jr. California Legislature, Assembly Written Testimony: 8/31/90
CAPCOA	Richard Sommerville California Air Pollution Control Officers Association Oral Testimony: 9/28/90

Code	Commenter and Date
CCA	Jan Chatten-Brown Coalition for Clean Air Oral Testimony: 9/27/90
CEC	Dan Fong California Energy Commission Written Testimony: 1/7/91
Chamber	Kirk West California Chamber of Commerce Written Testimony: 9/18/90
CNGVC	Leo B. Thomason, II California Natural Gas Vehicle Coalition Written Testimony: 1/17/91
Chevron	Dixon Smith Chevron USA Oral Testimony: 9/27/90 Written Testimony: 1/17/91, 1/29/91
	W.J. Price Chevron USA Inc. Written Testimony: 9/26/90
Chrysler	G.E. Allardyce Chrysler Motors Corporation Written Testimony: 9/21/90, 9/27/90 Oral Testimony: 9/27/90
CIOMA	Frank Greinke California Independent Oil Markerters Association Oral Testimony: 9/28/90
	Leigh Ross Written Testimony: 9/28/90
CMA	William Campbell California Manufacturers Association Written Testimony: 9/18/90
EDF	Diane Fisher Michael Cameron Environmental Defense Fund Written Testimony: 9/27/90

Code	Commenter and Date
Golden West	John E. Elgin, David Dragt Golden West Refining Company Written Testimony: 9/25/90, 9/27/90 Oral Testimony: 9/28/90
EMA/MVMA	Susan G. Feingold, Jed R. Mandel The Engine Manufacturers Association & The Motor Vehicle Manufacturers Association Written Testimony: 9/27/90 Oral Testimony: 9/27/90
Fiat	Alberto Negro Fiat Auto USA, Inc. Written Testimony: 9/19/90
Ford	Donald R. Buist Ford Motor Company Written Testimony: 9/25/90, 1/18/91
GM	Samuel A. Leonard General Motors Corporation Written Testimony: 9/6/90, 9/21/90, 9/26/90, 1/17/91 Oral Testimony: 9/27/90
Hail	Christopher S. Hail Private Citizen Written Testimony: 9/19/90
HEVP	Donald A. Dunn, Ph.D. John S. Reuyl, Ph.D. Hybrid Electric Vehicle Project Written Testimony: 9/24/90
Honda	Brian Gill Honda Motor Company, Ltd. Written Testimony: 9/27/90, 1/18/91 Oral Testimony: 9/27/90
Johnson	Assemblyman Ross Johnson California Legislature, Assembly Written Testimony: 8/30/90
LP Coalition	Robert E. Myers LP Gas Clean Fuels Coalition Written Testimony: 9/27/90

Code	Commenter and Date
Maddy	Senator Kenneth L. Maddy California State Senate Written Testimony: 8/30/90
Mercedes	Mercedes-Benz of North America, Inc. Written Testimony: 9/27/90 Oral Testimony: 9/27/90
Mobil	A. E. McCluskey Mobil Oil Corporation Written Testimony: 9/26/90, 1/18/91
MVMA	Dr. Fred W. Bowditch Motor Vehicle Manufacturers Assoc. Written Testimony: 9/27/90, 1/18/91, 1/17/91 Oral Testimony: 9/27/90
Navistar	Charles Hudson Navistar International Transportation Corporation Written Testimony: 9/27/90 Oral Testimony: 9/27/90
Nissan	J. Schutz Nissan Motors Written Testimony: 9/25/90, 9/27/90 Oral Testimony: 9/27/90
NRDC	Mary Nichols Veronica Kun Natural Resources Defense Council Written Testimony: 9/23/90
PG&E	John F. McKenzie Pacific Gas and Electric Company Written Testimony: 1/18/91, 1/31/91
Roberti	Senator David Roberti California State Senate Written Testimony: 9/12/90
Renner	Roy A. Renner Mechanical Engineer Written Testimony: 1/17/91

Code	Commenter and Date
SCE	Michael M. Hertel Southern California Edison Written Testimony: 9/27/90, 1/18/91 Oral Testimony: 9/27/90
Sierra Club	John White Sierra Club California Oral Testimony: 9/28/90
SMAQMD	Norm Covell County of Sacramento Environmental Management Dept. Written Testimony: 1/18/91
Texaco	Chuck Walz Texaco Written Testimony: 9/27/90 Oral Testimony: 9/27/90
Tosco	Tosco Refining Company Written Testimony: 9/26/90 Oral Testimony: 9/27/90
Toyota	Jonathan Haines Toyota Technical Center, USA, Inc. Written Testimony: 9/27/90, 1/18/91 Oral Testimony: 9/27/90
Ultramar	Steven O. Epperson Ultramar Inc. Written Testimony: 9/25/90, 1/17/91 Oral Testimony: 9/28/90
VW	Wolfgang Groth Volkswagen of America Written Testimony: 9/27/90 Oral Testimony: 9/27/90
Volvo	William Shapiro Volvo Cars of North America Written Testimony: 9/24/90
Wachtel/Quail	David Wachtel (aka BEloved Quail) Private Citizen Written Testimony: 9/28/90 Oral Testimony: 9/28/90

Code	Commenter and Date
WLGA	M. Steven Moore Western Liquid Gas Association and the National LP-Gas Clean Fuels Coalition Written Testimony: 1/16/91
WSPA	Douglas F. Henderson, Roger Beach, Donna Black, Richard P. O'Toole, Quart Graves, Alan Hirata Western States Petroleum Association Written Testimony: 9/19/90, 9/27/90, 1/17/91, 1/30/91 Oral Testimony: 9/27/90

Commenters in Support of Regulation

Congressman Henry A. Waxman
Congress of U.S.A.
Written Testimony: 9/7/90

Norman L. Bryan
PG&E/Ca. Natural Gas Vehicle Coaltion
Written Testimony: 9/11/90
Oral Testimony: 9/27/90

Roxanne L. Keith
Amador APCD
Written Testimony: 9/14/90

Robert L. Reynolds
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Written Testimony: 9/14/90

Mark Boese
Stanislaus APCD
Written Testimony: 9/17/90

William J. Roddy
Kern County APCD
Written Testimony: 9/17/90

James R. Dougherty
Ventura APCD
Written Testimony: 9/18/90

Ken Lacy
Private Citizen
Written Testimony: 9/19/90

Greg Vlasek
Southern Ca. Gas Company
Written Testimony: 9/19/90

Mike Graves
Monterey Bay UAPCD
Written Testimony: 9/19/90

Milton Feldstein
Bay Area AQMD
Written Testimony: 9/19/90

George Bleth
Fresno APCD
Written Testimony: 9/20/90

Peter McCuen
Contractor/Builder
Oral Testimony: 9/27/90

S. David Freeman
General Manager, SMUD
Oral Testimony: 9/27/90

Jim Lents
South Coast AQMD
Written Testimony: 9/27/90
Oral Testimony: 9/27/90

R.W. Jones
River City Petroleum
Written Testimony: 9/28/90

Senator Bill Leonard
California State Senate
Written Testimony: 9/19/90

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Electric Auto Assoc. & Electric
Vehicle Assoc.
Written Testimony: 9/20/90

Michael J. Bradley
NESCAUM
Written Testimony: 9/21/90

George M. Dewberry
Micro-Crystal Corp.
Written Testimony: 9/21/90

Michael W. Tolmasoff
Northern Sonoma County APCD
Written Testimony: 9/24/90

Arthur McCauley
Norwalk
Written Testimony: 9/24/90

James M. Ryerson
County of Santa Barbara APCD
Written Testimony: 9/25/90

Dwight R. Stenbakken
League of California Cities
Written Testimony: 9/26/90

Donald D. Doyle
S.F. Chamber of Commerce
Written Testimony: 9/26/90

Victor Magistrale
American Lung Association
Written Testimony: 9/27/90

Charles R. Imbrecht
California Energy Commission
Written Testimony: 9/27/90
Oral Testimony: 9/27/90

California Natural Gas Utilities
Written Testimony: 9/27/90

Rich Sommerville
California Air Pollution Control Officers Association
Oral Testimony: 9/27/90

Fredrick Duda
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Written Testimony: 9/27/90
Oral Testimony: 9/27/90

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City of Los Angeles
Written Testimony: 9/27/90

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Electric Power Research Institute
Written Testimony: 9/27/90

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L.A. County Transportation Commission
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Written Testimony: 9/27/90
Oral Testimony: 9/28/90

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Written Testimony: 9/27/90
Oral Testimony: 9/27/90

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The Cleaner Air Partnership of Sacto.
Written Testimony: 9/27/90

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U.S. EPA Region IX
Written Testimony: 9/27/90
Oral Testimony: 9/27/90

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W.R. Grace & Company
Written Testimony: 9/27/90
Oral Testimony: 9/27/90

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Written Testimony: 9/24/90

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Oral Testimony: 9/28/90

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Oral Testimony: 9/27/90

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Written Testimony: 9/26/90

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Battery Council International
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Written Testimony: 9/26/90

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California Air Resources Board

Proposed Regulations for Low-Emission Vehicles and Clean Fuels

Staff Report

Release Date: August 13, 1990

State of California
Air Resources Board

Initial Statement of Proposed Rulemaking for Low-Emission Vehicles and Clean Fuels

Release Date: August 13, 1990

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APPENDICES

INTRODUCTORY SUMMARY

This report presents proposed regulations for low-emission vehicles and clean fuels. Descriptions of the key provisions of the proposed requirements are contained in this report, and the full texts of the proposed regulations are included as appendices. A more detailed discussion of the data and analyses upon which the proposed regulations are based is provided in a separate technical support document, which is available upon request. This report begins with a summary followed by chapters describing the need for the proposal, provisions of the proposed vehicle and fuel regulations, potential impacts, and the California Air Resources Board's legal authority to adopt the proposed regulations.

Motor vehicles contribute more than 60 percent of the ozone precursor emissions generated in the state. Because motor vehicles and their fuels are major contributors to the air pollution problem in California, further control of mobile source emissions is needed to achieve healthful air quality.

To further reduce motor vehicle emissions in California, the staff of the Air Resources Board (ARB) has developed a proposal designed to maximize emission reductions by establishing new, stringent vehicle exhaust emission standards. Compliance with these standards can be achieved with the use of advanced vehicle emission control technology, cleaner-burning fuels, or a combination of the two. For the first time, a vehicle and its fuel would be treated as a system which would have to meet exhaust emission standards. This integrated approach, based on the performance of the vehicle/fuel system, provides flexibility and encourages the vehicle and fuel industries to work together to develop the least polluting and most cost-effective vehicle and fuel technologies.

The proposed regulations would require the phased introduction of low-emission vehicles and the clean fuels needed by those vehicles. A low-emission vehicle is a vehicle that has been certified by the ARB to meet one of four sets of exhaust emission standards. In order of increasing stringency, these emission standards are for: Transitional Low-Emission Vehicles (or TLEVs), Low-Emission Vehicles (or LEVs), Ultra-Low-Emission Vehicles (or ULEVs), and Zero-Emission Vehicles (or ZEVs). In this report, the term "low-emission vehicle(s)" is used to refer to all four types of low-emission vehicles, and not just those meeting the standards for LEVs. A clean fuel is any fuel used in an engine-family which is certified to any of the low-emission vehicle standards.

A. REPORT SUMMARY

1. What is the Air Resources Board staff proposing?

The staff proposal to reduce motor vehicle emissions consists of two programs: one for existing vehicles and another for new vehicles.

The program to reduce emissions from the existing fleet would require gasoline to meet a new set of specifications beginning in 1992 (Phase 1 gasoline) and more stringent specifications in 1996 (Phase 2 gasoline). Phase 1 gasoline specifications, discussed in a separate report entitled Proposed Regulations for New Gasoline Specifications, are intended to reduce emissions in the existing vehicle fleet without requiring major process changes by refiners. By September 1991, the staff will propose comprehensive specifications for Phase 2 gasoline to maximize reductions in toxic pollutants and in the mass and reactivity (ozone-forming potential) of non-toxic pollutant emissions from gasoline-fueled vehicles. The primary purpose of the specifications will be to reduce emissions from pre-1993 and off-road vehicles. However, the availability of this fuel may also facilitate vehicle manufacturers' compliance with the new vehicle emission standards proposed.

The program for new vehicles, described in this report, addresses the need to reduce emissions to levels that are lower than those achievable with existing emission control technology and conventional gasoline. The proposed program would implement aggressive new vehicle emission standards that take account of the potential for the emissions to form ozone. The standards could be met with very advanced conventional emission control technology, or by combining more advanced vehicle emission control technology with the use of fuels that ourn cleaner than conventional gasoline. In this case, compliance with the standards would be assessed based on the performance of the vehicle plus its fuel, functioning as a system. The proposed regulations would require the introduction of both the low-emission vehicles certified to meet the standards and any clean fuels needed by those vehicles.

2. <u>Why does the ARB need to take action?</u>

The ARB needs to take action to further reduce emissions from motor vehicles to improve air quality, fulfill statutory requirements, and support the efforts of other government agencies.

More than three-fourths of California's residents live in areas that do not meet at least one state or federal ambient air quality standard. Many areas of the state, including the South Coast, Bay Area, Central Valley, and Central Coast, are non-attainment areas for the state ozone standard. Mobile sources are the largest contributors of precursors that react in the atmosphere to form ozone. These ozone precursors include hydrocarbons (or organic gases) and oxides of nitrogen (NOx). Atmospheric ozone and other pollutants emitted directly by vehicles, including carbon monoxide (CO) and particulate matter (PM), are associated with respiratory irritation and illness. Motor vehicles also emit a substantial portion of both known and potential toxic air contaminants. Vehicle-related toxics include benzene, a known human carcinogen, as well as potential carcinogens such as 1,3-butadiene, formaldehyde, acetaldehyde, and diesel particulate.

The California Clean Air Act (California Health and Safety Code, Sections 39612 and 43018), requires the ARB to reduce emissions from mobile and stationary sources to the maximum degree possible, at the earliest practical date, in order to comply with state ambient air quality standards. The California Clean Air Act directs the ARB to adopt and implement more stringent vehicle emission standards and specifications for new fuels as a means to reduce emissions. State law also requires the control of toxic air contaminants from all sources and accelerated control for vehicular toxics.

The ARB's Long-Range Motor Vehicle Plan is comprised of an extensive list of mobile source pollution control measures. Since its adoption in 1987, many of the measures have been implemented, while others are presently being developed or are under evaluation. These measures are aimed at reducing excess emissions from vehicles currently in-use, establishing more stringent exhaust and evaporative emission standards, and/or promoting the use of cleaner fuels. The ARB's Long-Range Motor Vehicle Plan was developed to provide a regulatory agenda for reducing vehicle-related emissions to the lowest feasible levels.

The South Coast Air Quality Management District's (South Coast AQMD) effort to comply with ambient air quality standards, as documented in the District's <u>1989 Air Quality Management Plan</u>, relies on the ARB to achieve substantial emission reductions by implementing more stringent emission standards and cleaner fuels for vehicles. The South Coast AQMD's plan also notes that additional controls beyond those outlined in the ARB's Long-Range Motor Vehicle Plan will be required to attain National Ambient Air Quality Standards.

3. <u>How would adoption of the proposal benefit air quality?</u>

Implementation of the proposed regulations would benefit air quality by reducing vehicle emissions throughout the state. The staff estimates that by 2010, the regulations would:

- reduce vehicular emissions of non-methane organic gases (NMOG) by 28 percent and NOx by 18 percent;
- reduce vehicular emissions of CO by 8 percent and PM by about 2 percent;
- reduce vehicular toxics (benzene, 1,3-butadiene, formaldehyde, acetaldehyde, and diesel particulate) associated with reactive organic gases and the associated potential cancer burden by about 20 to 40 potential cancer cases per year statewide by 2010; and
- possibly reduce emissions of compounds identified as greenhouse gases that may contribute to global warming.

4. <u>What would the proposal require of motor vehicle manufacturers?</u>

Beginning in the mid-1990's, vehicle manufacturers would be required to produce vehicles that meet TLEV, LEV, ULEV, or ZEV exhaust emission standards. The emission standards for these vehicle categories differ in stringency, ranging from a 50 percent reduction in hydrocarbon emissions for TLEVs (compared to conventional gasoline-fueled vehicles sold in the same time period) to allowing no emissions of any pollutants for ZEVs.

For passenger cars and light-duty trucks, vehicle manufacturers would be required to comply with fleet average emission standards beginning in 1994. To meet a fleet average standard, manufacturers may choose to produce any combination of TLEVs, LEVs, ULEVs, or ZEVs such that the emissions from that combination of vehicles do not exceed the fleet average standard for the model-year. Beginning in 1998, the production of a limited number of ZEVs would also be required.

For medium-duty trucks, vehicle manufacturers would have to produce LEVs and ULEVs beginning in 1998. Although fixed percentages for LEV and ULEV implementation are proposed, trading provisions would allow manufacturers to produce any combination of LEVs, ULEVs, and ZEVs to meet the emission reduction goals.

5. <u>Does the staff proposal accommodate the use of alternate fuels?</u>

Although the proposal does not favor the use of any particular fuel, it does recognize that the use of alternate (clean) fuels may reduce ozone compared to conventional fuels. Clean-fueled and gasoline-fueled vehicles may emit similar amounts of hydrocarbons, but the capability of those hydrocarbons to form ozone in the atmosphere can vary greatly. To evaluate the air quality impacts of vehicles powered by different fuels, it is appropriate to compare the ozone impact rather than just the mass of the hydrocarbon emissions. The ozone impact is dependent on both the mass and the capability of the emissions to form ozone (or ozone reactivity).

The staff proposal would equalize the ozone impact of vehicles that operate on different fuels through the establishment of reactivity adjustment factors. For the first time in any regulation, the hydrocarbon emissions from vehicles powered by fuels cleaner than conventional gasoline would be numerically adjusted according to their ozone-forming potential. Thus, if the emissions from a vehicle powered by an alternate fuel have a lower ozone-forming potential than emissions from a gasoline-fueled vehicle, the alternate fueled vehicle would be allowed to emit a higher mass of hydrocarbons. An equal level of stringency is achieved since the emissions from both vehicles would lead to the same amount of ozone formation.

6. <u>Why is the staff proposing a requirement for zero-emission vehicles (ZEVs)?</u>

With respect to their emission benefits, ZEVs offer considerable advantages over conventional vehicles that utilize combustion engines. When a conventional vehicle ages, emissions increase due to deterioration of its engine and emission control system even if the vehicle is properly maintained. For a poorly maintained vehicle, the emissions increase is greater. At high mileage, emissions from poorly maintained vehicles can be several times higher than at low mileage. A requirement for ZEVs would ensure that vehicle manufacturers begin work on developing the cleanest possible technologies. At present, only battery-powered electric vehicles are candidates to be ZEVs, although it is conceivable that other technology (e.g. fuel cells) could be developed in the future.

With ZEVs, increasing emissions with vehicle age are not a concern because ZEVs, by definition, maintain zero emissions throughout their lifetimes. In severe non-attainment areas, such as within the boundaries of the South Coast Air Quality Management District ("South Coast region"), use of a substantial number of ZEVs will be necessary to attain healthful air quality in compliance with state and federal standards.

Vehicle manufacturers may be reluctant to develop commercially viable ZEVs without a regulatory requirement because of the resources required.

7. What would the proposal require of gasoline suppliers?

As previously mentioned, Phase 1 gasoline specifications would be required beginning in 1992. Phase 2 gasoline specifications, to be presented to the Board in September 1991, would take effect in 1996. (See the report previously referenced for details.)

Under the clean fuels proposal, gasoline suppliers (including refiners, blenders, and importers) would be required to distribute a minimum assigned volume of each clean fuel, excluding compressed natural gas (CNG) and electricity, needed by low-emission vehicles. The requirement to distribute a particular clean fuel would only apply when the number of vehicles in the fleet that were certified on that fuel reaches or exceeds a certain de minimus level. Once the distribution requirement is triggered for a clean fuel, the Executive Officer of the ARB would determine the minimum assigned volume of that fuel to be distributed by each supplier, based on the number of low-emission vehicles expected to be in use that require the clean fuel in order to meet low-emission standards.

The responsibility for providing clean fuels would be placed on gasoline suppliers because they have fuel distribution facilities and networks in place. Also, because the gasoline suppliers are the ones who now distribute, and will continue to distribute, conventional gasoline (which contributes substantially to statewide emissions), it is appropriate for them to take responsibility for the introduction of clean fuels. The gasoline distributed and sold by those suppliers who would be subject to the proposed regulations contributes to the very serious air pollution problems that exist in California. The clean fuel requirements would be expressly imposed as conditions on the permissable distribution of gasoline, and the clean fuel program would help mitigate the air pollution burdens created by the sale of gasoline.

Gasoline suppliers would not be required to distribute CNG or electricity, which are both potential clean fuels, because (1) they are already produced and widely distributed by utilities, (2) the gasoline suppliers' distribution systems are not equipped to handle them, and (3) they are offered by only one supplier (a utility) in each geographical area, which creates a monopolistic situation in terms of price and supply. Although CNG would not be included in the distribution requirement, retail gasoline station owners would have to make CNG available at some of their stations if vehicle manufacturers choose to produce CNG-powered vehicles in order to meet low-emission vehicle emission standards.

8. <u>How much clean fuel will gasoline suppliers be responsible for distributing?</u>

The staff proposal includes a method by which the Executive Officer of the ARB would determine the total required volume of each clean fuel to be distributed. This method would require the staff to first estimate the maximum demand for each clean fuel required to be distributed, based on the number of low-emission vehicles expected to need the fuel. The staff would then adjust this maximum demand downward by applying a fuel volume adjustment factor to account for the uncertainty in consumer demand for the fuel. The fuel volume adjustment factor would increase over time, from 0.25 initially to 0.90 in later years.

A fuel volume adjustment factor of 0.25 applied to a particular clean fuel would result in distribution of 25 percent of the estimated maximum demand for that clean fuel. Thus, all of the low-emission vehicles certified on that fuel could operate on the clean fuel one-fourth of the time. The rest of the time those vehicles would use higher polluting gasoline. The staff believes that most vehicles that use cleaner fuels to meet the proposed standards will also be able to burn gasoline, and gasoline use will result in higher emissions.

A gasoline supplier would also be allowed to distribute a substitute fuel in place of a clean fuel, provided that there would be no increase in vehicle emissions and no deterioration in the vehicles' emission control systems.

9. <u>What would the staff proposal require of retail gasoline station owners and operators?</u>

The staff proposal would require owners (and lessors) of retail gasoline stations to install dispensing equipment and storage tanks for clean fuels. Each <u>owner</u> would have to equip a certain number of stations to dispense each clean fuel that is subject to a distribution requirement, plus CNG. The ARB would determine the number of clean fuel retail outlets that each station owner would have to provide each year. In the initial years of the program, only a small number of stations would be required to be clean fuel outlets. The regulation is structured so that owners of one or two stations would not have to install equipment until the demand for a given clean fuel is high. Each <u>operator</u> of a station that is equipped as a clean fuel outlet would have to make the clean fuel(s) available for sale to the public.

The staff proposal would require station owners to install equipment to distribute CNG if CNG-powered vehicles are sold, contingent upon approval of this provision by the Public Utilities Commission (PUC). This provision is needed to ensure that there are sufficient CNG retail outlets to make the purchase of CNG convenient. Since electric vehicles are best recharged where they are garaged, and recharging can take many hours, station owners would not have to provide metered outlets for recharging.

10. **When would the proposed requirements for low-emission vehicles and clean fuels take effect?**

The proposed emission standards for light-duty vehicles would be effective beginning with the 1994 model-year. Medium-duty vehicles would follow, beginning with the 1998 model-year. The proposed requirements for clean fuels distribution and retail availability would take effect in the South Coast region in 1994 and statewide in 1997.

11. **Does the staff proposal offer flexibility to vehicle manufacturers and gasoline suppliers in meeting the requirements?**

Yes. The staff proposal provides flexibility through the creation of credit systems. Light-duty vehicle manufacturers could earn credits by achieving a sales-weighted emission level lower than the fleet average emission standard. Medium-duty vehicle manufacturers could earn credits by introducing low-emission vehicles in excess of the required fleet implementation percentages. Gasoline suppliers could earn credits by distributing clean fuel in excess of their required volumes. Credits could also be earned and marketed by utilities for supplying CNG or electricity to certain types of vehicles.

Vehicle manufacturers and gasoline suppliers could use credits they have earned or purchased from other companies to meet their own requirements under the staff proposal. Both vehicle and fuel credits would be discounted over time to avoid overaccumulation and to maintain active intercompany credit markets.

12. **How does the staff proposal address the recommendations of the California Advisory Board on Air Quality and Fuels (AB 234 Advisory Board) for the introduction of clean fuels?**

The AB 234 Advisory Board recommended that the ARB use emission-based performance standards and a fuel pool averaging program to introduce clean fuels in California. The objective of a fuel pool averaging program is to allow a variety of fuels to compete in the marketplace based on their emission characteristics. The staff proposal would establish emission-based performance standards for low-emission vehicle/clean fuel systems. The proposal would also satisfy the objective of the fuel pool averaging approach by allowing any fuel to qualify as a clean fuel, if it can be used to certify an engine-family to one of the low-emission standards. The provision for credit marketing also increases flexibility to industry.

13. **Why does the staff proposal address only exhaust emissions?**

The staff proposal would establish emission standards which would limit the exhaust emissions from new vehicles. Although other emissions resulting from the operation and storage of vehicles (running loss and evaporative emissions) can contribute considerably to total vehicle emissions, they can be more effectively addressed in other rulemakings.

Currently, a separate rulemaking is being developed for consideration by the ARB in August 1990 to control evaporative and running loss emissions which would take effect for 1995 model-year vehicles. Vehicle evaporative emission control systems that comply would be so tightly controlled that under normal operating conditions, evaporative and running loss emissions would be near zero, regardless of the fuel used. Furthermore, the evaporative and running loss emissions for all fuels are less reactive than exhaust emissions. Thus, including provisions to control these emissions in the low-emission vehicles/clean fuels regulations would only add complexity and provide little in terms of an air quality benefit.

14. **What would the proposal cost?**

The added cost associated with producing light-duty low-emission vehicles would vary according to the stringency of the emission standard achieved and the type of fuel used. If light-duty vehicles powered by gasoline are made to certify to TLEV standards, the added cost would be $70 per vehicle, for equipping the vehicle with an improved fuel preparation system. Estimated incremental costs for light-duty TLEVs powered by other types of fuels would range from $200 to $1000 per vehicle, depending on the type of fuel. For gasoline-powered light-duty vehicles certified to LEV or ULEV standards, the added cost would be $170 per vehicle, for installing an electrically heated catalyst. Estimated incremental costs for light-duty LEVs or ULEVs powered by other types of fuel would range from $270 to $1200 per vehicle, depending on fuel type. Vehicles qualifying as ZEVs would probably be powered by electricity and would cost about $1,350 more per vehicle. The added costs for medium-duty low-emission vehicles would generally be comparable or slightly higher than the costs for light-duty vehicles.

The capital cost to a retail gasoline station owner to equip a station as a clean fuel retail outlet, for a fuel other than CNG, would be about $40,000 to $75,000. This range includes the installation cost of new pumps, dispensers, and storage tanks. This cost would be reduced to almost zero if a station owner instead converted existing leaded gasoline pumps to clean fuel pumps. The cost for CNG dispensing equipment would be about $250,000.

The California Energy Commission (CEC) and the AB 234 Advisory Board estimated comparative prices of clean fuels in the year 2000. The projected retail price for conventional gasoline would be $1.35 to

$1.45. The approximate projected retail prices for other fuels on an energy-equivalent basis are: $0.59 for electricity, $0.84 for CNG, $0.98 for LPG, $1.44 to $1.49 for methanol, and $2.33 for ethanol.

Vehicle manufacturers, fuel producers, and retail stations could choose to pass all of their added costs along to the consumer. If they did, the combined added costs to purchase and operate a light- or medium-duty low-emission vehicle might range from a cost savings to an additional cost of almost $100 per year, relative to the cost for a conventional gasoline-fueled vehicle. The exception is ethanol, which would result in an additional annual cost of about $400.

15. Would the proposal impact any small businesses?

The staff does not believe that the proposal would have significant, adverse economic effects on small businesses. It is unlikely that any vehicle manufacturer is a small business and refiners are specifically excluded from being considered small businesses. Some independently owned and operated retail stations may be small businesses. Typically, the owner of this type of small business would own just one or two stations.

The proposed regulation would allow owners of one or two stations additional time before they would have to install clean fuel dispensing equipment. These owners would not be required to provide clean fuel retail outlets until the later years of the program when the clean fuel volume is large. By that time, competitive market pressure could necessitate installing clean fuel capability regardless of any requirement to do so. The staff anticipates that small businesses would recover their costs to provide clean fuel through higher product prices to the consumer. The only requirement of retail station operators (distinct from the owners of the stations) would be to make a clean fuel available if the owner has equipped the station to sell the fuel. In the view of the staff, the need to offer a clean fuel would not impose a significant hardship.

16. What effect would the staff proposal have?

If implemented as recommended in this report, the low-emission vehicles and clean fuels regulations would:

- encourage the vehicle and fuel industries to work together to develop the most cost-effective low-emission vehicle and clean fuel systems;

- provide flexibility in the industries' means of compliance through specific provisions in the regulations such as fleet emission averaging, substitute fuels, and vehicle/fuel credits; and

- improve air quality by significantly reducing statewide emissions of ozone precursors, toxics, and, possibly, greenhouse gases from vehicles.

17. <u>About this report.</u>

The staff prepared this report in consultation with the California Energy Commission and the South Coast AQMD. During the development of the proposed regulations and the technical support document, the staff held five public consultation meetings and numerous additional meetings with industry and government representatives.

B. RECOMMENDATION

The staff recommends that the Air Resources Board adopt the proposed low-emission vehicles and clean fuels regulations included as Appendices A and B and all modified standards and test procedures shown in Appendix C to this report or included in appendices to the technical support document to this report. The staff also recommends that it report back to the Board biennially on the implementation of this program. The staff intends to continue to work closely with both the vehicle and fuel industries in implementing these regulations and in identifying any appropriate changes to the regulations that may be needed in the future.

I.

BASIS FOR ACTION

Motor vehicles and their fuels are major contributors to the air pollution problem in California today. Motor vehicle emissions are the primary source of compounds which react in the atmosphere to form ozone or smog. Vehicle emissions also contain toxic air contaminants which increase the potential risk of cancer to residents of the state and "greenhouse" gases which contribute to global warming.

Past regulatory actions to reduce motor vehicle emissions have improved air quality in some areas of California and slowed the deterioration in others. However, further reductions in vehicle emissions are needed to offset the continuing increase in vehicle use. To attain healthful air quality throughout the state, the Air Resources Board (ARB or Board) must implement an aggressive program to dramatically reduce motor vehicle emissions.

While the ultimate objective is to improve air quality, the ARB has a responsibility to fulfill statutory obligations and to support the policy goals of other government agencies. The proposed low-emission vehicles/clean fuels program would accomplish all of these objectives.

A. NEED TO IMPROVE AIR QUALITY

As the population of California grows, more and more people are exposed to polluted air not only in the historic areas of urban activity, but also in areas that have been characterized by rural activities in the past. Because much of the air pollution in California is related to emissions from motor vehicles, control of motor vehicle emissions has played a major role in the ARB's program to reduce emissions to meet air quality goals. Motor vehicle emissions need to be reduced further to ensure progress in attaining and maintaining the state and federal air quality standards. Without these reductions, the air quality standards in many urban areas will not be met.

1. Criteria Pollutants

Criteria pollutants are those pollutants for which ambient air quality standards have been established, either by the U.S. Environmental Protection Agency (EPA) or the ARB. These pollutants may be present in the atmosphere in the form in which they are emitted from a source, such as carbon monoxide, or they may, like ozone, be formed in the atmosphere from precursor substances (in the case of ozone, from HC and NOx) that are directly emitted from a source.

The ambient air quality standards are exceeded in varying degree by pollutant and by location throughout California, but a high percentage of Californians live in air basins that experience exceedences of one or more of the criteria pollutant standards.

Motor vehicles contribute significantly to ambient concentrations of almost all criteria pollutants. Motor vehicles are the major source of CO emissions and the precursors to atmospheric ozone (HC and NOx). NOx emissions also contribute to the atmospheric burden of nitrogen dioxide (NO2), inhalable particulate matter (PM10), and visibility reducing particles. Sulfur dioxide emitted from motor vehicles is a precursor to atmospheric sulfate, PM10, and visibility reducing particles. Motor vehicles, especially diesel motor vehicles, also emit PM10 directly into the atmosphere. Vehicle exhaust, evaporative, and fuel quality standards that the ARB has adopted to date have been effective in reducing the contribution of motor vehicles to degraded air quality. However, additional emission reductions are needed to ensure additional progress toward the attainment of the state and federal air quality standards.

2. Toxic Air Contaminants

A wide variety of toxic air contaminants and potentially toxic air contaminants are emitted by motor vehicles. Toxic air contaminants are substances identified by the ARB under AB 1807 that may contribute to an increase in mortality or serious illness, or may pose a potential hazard to human health. When a vehicle is being operated, toxic pollutants like benzene, acetaldehyde, formaldehyde, 1,3-butadiene, and diesel particulate are present in the exhaust. In addition, toxic air contaminants are present in gasoline vapors that evaporate during refueling, and vehicle operation and storage (evaporative emissions). Continuous exposure to toxic air contaminants at levels currently being measured from vehicles could produce 13,000 to 23,000 potential cancer cases in the state over a 70-year period.

Regulations aimed at reducing vehicular hydrocarbon emissions also reduce emissions of the most significant toxic pollutants. Therefore, large reductions in toxic pollutant emissions will be realized from the implementation of a 0.25 gram-per-mile (g/mi) non-methane hydrocarbon standard for passenger cars beginning in 1993. However, for benzene, while emissions from all sources are estimated to decrease 45 percent by 2010, motor vehicles and their fuels will still be responsible for about three-fourths of the remaining emissions. The staff is planning to propose, in September 1991, a regulation for benzene in gasoline, as a part of the Phase 2 gasoline specifications.

3. Greenhouse Gases

Motor vehicles emit carbon dioxide (CO_2) and methane, which have been identified as potent greenhouse gases which may be causing global climatic changes. While the potential to form greenhouse gases varies for different fuels, the use of cleaner-burning fuels is not likely to increase emissions from present levels, and could possibly lower them.

B. NEED TO COMPLY WITH STATUTORY REQUIREMENTS AND OBLIGATIONS TO OTHER GOVERNMENT AGENCIES

State and federal clean air legislation requires the ARB to demonstrate progress toward attaining compliance with ambient air quality standards. Because motor vehicles are a major source of ozone precursors and toxic air contaminants, the ARB must take action in developing emission control strategies for motor vehicles and motor vehicle fuels. The actions of the ARB would serve as the basis for local and regional government agencies to develop control plans appropriate for their needs.

1. California Clean Air Act

The California Health and Safety Code, Section 43108, requires the ARB to reduce emissions from vehicles and other mobile sources to the maximum degree possible, as soon as possible. These emission reductions are required in order to attain compliance with state ambient air quality standards. To achieve these reductions, the ARB is explicitly given the authority to adopt and implement more stringent motor vehicle in-use performance standards and to develop new motor vehicle fuel specifications.

2. California Statutes Concerning Emissions of Toxic Air Contaminants

In 1983, the Legislature established the state's program for identifying and controlling toxic air contaminants by adopting AB 1807. In 1988, the Legislature adopted AB 4392 to accelerate the control of toxic air contaminants from vehicle exhaust. The regulations proposed in this report further the AB 1807 program of risk management for toxic air contaminants and would expedite reductions in vehicular emissions of toxic air contaminants as envisioned by AB 4392.

3. ARB Long-Range Motor Vehicle Plan

In 1987, the ARB adopted its Long-Range Motor Vehicle Plan to facilitate attaining the National Ambient Air Quality Standards for ozone and CO in California. In the plan, an extensive list of motor vehicle control measures is outlined, which serves as the framework for achieving reductions in criteria pollutant and toxic air contaminant emissions from mobile sources. Over the years, a large number of the measures have been adopted, while others are currently under development or are being evaluated. The list of control measures are aimed at: (1) reducing emissions from in-use vehicles that are operating in excess of their certification standards; (2) establishing more stringent exhaust and evaporative emission standards; and (3) facilitating the use of alternate fuels. By establishing very stringent, technology-forcing standards that consider the lower ozone-forming potentials of cleaner-burning alternate fuels, the proposed rulemaking would address two of these objectives (nos. 2 and 3) for both light- and medium-duty vehicles.

4. California Advisory Board on Air Quality and Fuels

By adopting AB 234 in 1987, the Legislature created the California Advisory Board on Air Quality and Fuels (AB 234 Advisory Board) which conducted an in-depth study to evaluate the necessity and feasibility of using mandates and incentives to initiate the use of cleaner-burning fuels in California. Members of the AB 234 Advisory Board included representatives of fuel and energy producers, automobile manufacturers, state and local governmental agencies, and the general public.

In its Report to the California Legislature in October 1989, the AB 234 Advisory Board concluded that the use of cleaner-burning fuels would provide improvements in air quality beyond what is achievable from conventionally fueled vehicles using the most advanced emission controls. In reaching this conclusion, the AB 234 Advisory Board took into consideration the future improvements likely from expected vehicle control technologies, based on the Advisory Board's understanding of emerging technologies in 1989. The AB 234 Advisory Board recommended that the ARB catalyze the introduction of cleaner-burning fuels by setting emission-based performance standards for fuels and by implementing a "fuel pool averaging" program. The objective of the fuel pool averaging recommendation is to create a "level playing field" and to allow a variety of fuels to compete in the marketplace, based on emissions performance. The Advisory Board recommended that the ARB consider adopting its recommendations for light-duty vehicles by September 1990.

5. Needs of the South Coast AQMD

The 1989 Air Quality Management Plan (AQMP) of the South Coast Air Quality Management District (South Coast AQMD) relies upon the implementation of low-emission vehicles and cleaner-burning fuels for complying with the federal ambient air quality standard for ozone. To achieve the reductions in mobile source emissions set forth in the District's AQMP, the ARB must adopt more stringent vehicle emission standards and phase-in cleaner-burning fuels. By developing rules to require that these vehicles and fuels be used in the South Coast region, the ARB would ensure that reductions in mobile source emissions are realized at the earliest possible date.

For the first time, reactivity adjusted emission standards are proposed. Reactivity adjustment is necessary to properly recognize the inherently lower ozone-forming potential of emissions from vehicles powered by fuels cleaner than conventional gasoline. Alternate fueled vehicles may emit similar amounts of hydrocarbons as gasoline-fueled vehicles, but the capacity of the emissions to form ozone can differ significantly. To allow all fuels to be evaluated on the same air quality basis, the so-called "level playing field", it is necessary to establish hydrocarbon standards in terms of ozone-forming potential rather than actual mass of emissions.

A. EMISSION STANDARDS

Emissions of ozone precursors and toxic air contaminants result from the interaction of the vehicle and its fuel. Whereas previous regulations have established standards for vehicles and fuels separately, this proposal considers the two components as parts of a single system--a vehicle/fuel system. Although the technological feasibility of the emission standards being proposed is based on the performance of very advanced vehicles operating on gasoline, to accommodate the diversity of technologies that may be developed to meet the proposed standards, emission standards need to be set in a way that will be equally stringent for all vehicle/fuel systems. Of the pollutants currently regulated, the greatest differences between vehicle/fuel systems occur in emissions of hydrocarbons. Both the mass and ozone-forming potential of hydrocarbon emissions can differ significantly among the various vehicle/fuel systems, and both need to be considered in order to equalize their effects on an air quality basis.

1. Non-Methane Organic Gas Standards

To control emissions of all reactive hydrocarbons, the staff is proposing, for the first time, that non-methane organic gas (NMOG) standards be adopted. Measurement of NMOG would include emissions of traditionally measured hydrocarbons as well as hydrocarbons that contain oxygen (oxygenated hydrocarbons). Alcohols, aldehydes, ketones, and ethers are examples of oxygenated hydrocarbons.

Previously, oxygenated hydrocarbons were not measured because they comprised only a small amount of the total mass of emissions from gasoline-fueled vehicles. However, because oxygenated hydrocarbons are being added to gasoline to boost octane and improve other fuel properties, emissions of oxygenated hydrocarbons will likely increase in future years. Furthermore, if the use of alcohol fuels gains wide acceptance, even greater emissions of oxygenated hydrocarbons could result. Because some of the oxygenated compounds are highly reactive in the atmosphere (e.g., aldehydes), it is important to measure these compounds to fully evaluate the ozone-forming potential of hydrocarbon emissions from candidate vehicle/fuel systems.

II.

LOW-EMISSION VEHICLE ELEMENTS OF THE PROPOSAL

The low-emission vehicle program would help achieve mandated emission reductions by requiring the production of vehicles whose emissions are dramatically lower than current gasoline-fueled vehicles. The proposal is designed to achieve the greatest possible emission reductions in the most efficient manner by spurring the development of advanced vehicle technology and allowing the use of cleaner-burning fuels. The thrust of the program lies in the establishment of environmentally-based performance standards and the flexibility provided to manufacturers to meet them.

Under the proposed regulation, four new categories of vehicles, subject to emission standards much more stringent than current standards, would be introduced over the next decade: transitional low-emission vehicles (TLEVs), low-emission vehicles (LEVs), ultra-low-emission vehicles (ULEVs), and zero-emission vehicles (ZEVs). These categories of vehicles differ in the amount of pollutants allowed to be emitted, ranging from 50 percent lower hydrocarbon emissions for TLEVs (compared to conventional vehicles) to no emissions of any pollutant for ZEVs.

Vehicle manufacturers would be allowed to produce any mix of alternate or conventional fueled TLEVs, LEVs, ULEVs, and ZEVs to meet the emission reduction goals with one exception: to foster the development of the cleanest vehicle technologies, mandatory production of a small number of ZEVs would be required beginning in 1998. This requirement for ZEVs is an important step toward the ultimate goal of achieving a vehicle fleet largely composed of vehicles which have emissions that approach zero.

2. Reactivity Adjustment Procedure

To equalize the air quality impact of all vehicle/fuel systems, standards limiting the amount of ozone formed by NMOG emissions would be established. The ozone reactivity of emissions from vehicles powered by gasoline would be used as the basis for determining whether emissions produced by vehicles powered by other fuels are more or less ozone-reactive. To determine the reactivity of baseline gasoline vehicles, testing would be conducted on vehicles operating on gasoline representative of gasoline currently being used nationwide.

For all viable vehicle/alternate fuel systems that have lower ozone-forming potentials than comparable gasoline systems, reactivity adjustment factors would be developed. These reactivity adjustment factors would be used to calculate the gasoline-equivalent NMOG emissions from a vehicle/alternate fuel system. Thus, if the emissions from a vehicle powered by an alternate fuel are less ozone reactive than emissions from a gasoline-fueled vehicle, the alternate fueled vehicle would be allowed to emit a higher mass of NMOG. For example, if a reactivity adjustment factor of 0.5 is found to be appropriate for a particular alternate fueled TLEV (TLEVs are subject to a 0.125 g/mi NMOG standard), the vehicle would be allowed to emit 0.25 g/mi NMOG (0.125/ 0.5 = 0.25 g/mi NMOG). An equal level of stringency is achieved since the emissions from both vehicle/fuel systems would lead to the same amount of ozone formation.

To determine the ozone-forming potential of NMOG emissions, the staff recommends the use of Maximum Incremental Reactivity (MIR) procedures, a scientifically accepted method which has been found to be a reliable predictor of changes in ambient ozone concentrations under environmental conditions that occur in the state. Over the past few years, Dr. William Carter of the Statewide Air Pollution Research Center at the University of California at Riverside has conducted laboratory and modeling studies to develop the MIR procedure. The work of Dr. Carter is presently being supported by the ARB and the U.S. Environmental Protection Agency (EPA).

Although regional photochemical grid modeling procedures are considered to be a conceptually more sophisticated and comprehensive means of evaluating the impact on ozone of changes in the reactivity of vehicle emissions than MIR, the complexity and uncertainties of such modeling renders it unsuitable for this rulemaking. The MIR procedure would offer a comparable level of accuracy while being considerably simpler and more cost-effective to use. Preliminary comparisons of the reactivity adjustment factors calculated by Dr. Carter and Prof. Armistead Russell, a recognized expert in the field of regional modeling from Carnegie Mellon University, have shown that the results determined by the two procedures are closely aligned.

Because further testing would be needed to determine the reactivity adjustment factors, only the method for deriving the factors and the preliminary MIRs determined by Dr. Carter are being considered for adoption at the present time. More reliable MIRs are currently being developed and would be presented to the Board in September 1991. The actual adjustment factor for each viable vehicle/clean fuel system would be presented to the Board at future hearings, after the necessary testing has been completed. The staff expects to be able to develop some of these adjustment factors as early as September 1991.

3. Certification Standards

Beginning in the mid-1990's, vehicle manufacturers would be required to certify portions of their sales fleet to TLEV, LEV, ULEV, or ZEV standards. These emission standards are much more stringent than standards recently adopted by the ARB. For example, gasoline-fueled passenger cars certified to TLEV standards would emit 50 percent less NMOG than would 1993 model-year conventional gasoline vehicles. The LEV standards for passenger cars represent a 70 percent reduction in gasoline-equivalent NMOG and a 50 percent reduction in NOx from 1993 standards. Similarly, ULEV standards would lower gasoline-equivalent NMOG, carbon monoxide (CO), and oxides of nitrogen (NOx) by 85, 50, and 50 percent, respectively, from 1993 levels. In addition, all TLEVs, LEVs, and ULEVs would be required to meet standards for formaldehyde, a suspected toxic air contaminant and highly reactive ozone precursor emitted by motor vehicles. Vehicles which certify as ZEVs must demonstrate emissions of no pollutants. A summary of the proposed NMOG, CO, and NOx standards for passenger cars is provided in Table 1. The standards for light-duty trucks and medium-duty vehicles are of similar stringency, although there is no TLEV category for medium-duty vehicles.

Table 1. 50,000 Mile Certification Standards (g/mi) for Passenger Cars Operating on Gasoline

CATEGORY	NMOG*	CO	NOx
Adopted for 1993	0.25	3.4	0.4
TLEV	0.125	3.4	0.4
LEV	0.075	3.4	0.2
ULEV	0.040	1.7	0.2

* NMOG emissions would be reactivity adjusted for cleaner-burning fuels.

4. <u>In-Use Compliance</u>

Because manufacturers may initially have difficulty meeting these low emission levels in-use, the staff is allowing intermediate in-use standards which are up to 30 percent less stringent than the corresponding certification standards for TLEVs, LEVs, and ULEVs. These in-use standards would be applicable for only two model-years after the expected introduction date of each vehicle emission category. Compliance with full useful life standards (i.e., 100,000 miles for light-duty vehicles and 120,000 miles for medium-duty vehicles) would be suspended for the initial two years as well.

In the early years of implementation, intermediate in-use standards would provide additional time to verify the in-use durability of vehicle emission control systems. It is envisioned that engineering resources would first be devoted to the design and development of the technologies which would enable vehicles to meet the proposed certification standards, and additional time would be needed to fine tune designs to assure that the vehicles meet all the standards in customer service.

5. <u>Standards for Flexible- and Dual-Fueled Vehicles</u>

Flexible-fueled and dual-fueled vehicles are capable of operating on both gasoline and an alternate fuel. Special consideration needs to be given to these vehicles because the stringency of the NMOG standard on gasoline or the alternate fuel ultimately determines the fuel for which vehicle operation is optimized. Because NMOG exhaust emissions from alternate fueled vehicles are likely to exhibit a lower ozone-forming potential than NMOG emissions from gasoline-fueled vehicles, alternate fueled vehicles may require less extensive emission control systems to meet a reactivity adjusted NMOG standard. Therefore, requiring a flexible- or dual-fueled vehicle to meet the same NMOG standard when operating on both gasoline and an alternate fuel would force the manufacturer to optimize the vehicle emission control system for gasoline and could lessen the value of introducing alternate fueled vehicles.

Thus, the staff is proposing a two-tiered NMOG standard for vehicles capable of operating on both gasoline and an alternate fuel as shown in Table 2 for passenger cars. For a significant air quality benefit to be realized from these vehicles, use of the alternate fuel must be encouraged to the maximum extent possible. In this regard, production and distribution requirements for alternate fuels would help ensure that adequate quantities of fuel would be available and that vehicle owners would use the alternate fuel much of the time.

Table 2. NMOG Standards (g/mi) for Flexible- and Dual-Fueled Passenger Cars When Operating on an Alternate Fuel and Gasoline at 50,000 Miles

CATEGORY	ALTERNATE FUEL*	GASOLINE
TLEV	0.125	0.25
LEV	0.075	0.125
ULEV	0.040	0.075

* Before reactivity adjustment.

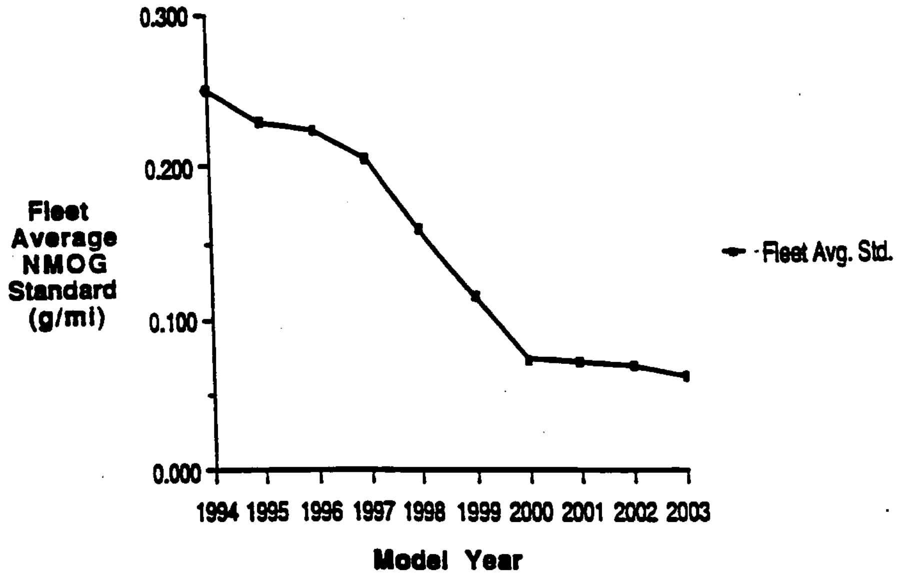
B. IMPLEMENTATION SCHEDULES

1. Light-Duty Vehicles

For passenger cars and light-duty trucks, a categorized emissions averaging program is proposed. Beginning in the 1994 model-year, vehicle manufacturers would be required to meet progressively more stringent fleet average standards for NMOG. Because averaging would be based on the NMOG emission standard that the vehicles are certified to (rather than the actual emission level that they exhibit in certification testing), categorized emissions averaging would provide flexibility to light-duty vehicle manufacturers in determining their phase-in schedule while maintaining the same air quality benefits as a fixed implementation schedule. Although only the NMOG emission standard would be averaged, all vehicles must meet standards for other pollutants applicable to the vehicle emission category.

The fleet average NMOG standards for passenger cars and small light trucks (less than 3750 lbs. loaded vehicle weight) are shown in Figure 1. Similar fleet average standards are also proposed for larger light trucks (greater than 3750 lbs. loaded vehicle weight). Small volume manufacturers which sell fewer than 3000 vehicles in California would be given a delay in having to comply with the fleet average standards until the year 2000.

Figure 1. Fleet Average NMOG Standards for Passenger Cars and Light-Duty Trucks <3750 lbs



Manufacturers may meet the fleet average standards by certifying vehicles to any combination of TLEV, LEV, ULEV, ZEV, or conventional vehicle standards, as long as their sales-weighted NMOG emissions (and NMHC for conventional vehicles) do not exceed the fleet average standard. For example, to meet a fleet average standard of 0.125 g/mi NMOG for passenger cars, one manufacturer's sales fleet may be composed of 100 percent TLEVs (which are certified to a 0.125 g/mi standard); another's may be 50 percent conventional vehicles certified to a 0.25 g/mi NMHC standard and 50 percent ZEVs.

For passenger cars and light-duty trucks less than 3750 lbs. loaded vehicle weight, the fleet average standards were determined by multiplying the implementation rates that the staff believes are sensible to achieve for conventional vehicles, TLEVs, LEVs, ULEVs, and ZEVs for each model-year by the applicable 50,000 mile certification standard (Table 3). For example, in the year 2003, the staff believes vehicle manufacturers are capable of producing, as a percentage of new sales, 75 percent LEVs, 15 percent ULEVs, and 10 percent ZEVs. To calculate the fleet average standard of 0.062 g/mi NMOG for 2003, the staff multiplied the LEV NMOG standard by 75 percent, the ULEV NMOG standard by 15 percent, and the ZEV NMOG standard by 10 percent: $(0.075 \times 0.75) + (0.040 \times 0.15) + (0.00 \times 0.10) = 0.062$. The fleet average standards for light-duty trucks greater than 3750 lbs. loaded vehicle weight were calculated in a similar manner, although ZEVs were not included since there are no ZEV requirements in this vehicle class.

Table 3. Implementation Rates for Conventional Vehicles, TLEVs, LEVs, ULEVs, and ZEVs Used to Calculate Fleet Average Standards for Passenger Cars

MODEL YEAR	0.39	0.25	TLEV 0.125	LEV 0.075	ULEV 0.040	ZEV* 0.00	FLEET AVG. STANDARD
1994	10%	80%	10%				0.250
1995		85	15				0.231
1996		80	20				0.225
1997		73		25%	2%		0.202
1998		48		48	2	2%	0.157
1999		23		73	2	2	0.113
2000				96	2	2	0.073
2001				90	5	5	0.070
2002				85	10	5	0.068
2003				75	15	10	0.062

* The percentage requirements for ZEVs are mandatory.

Beginning in 1998, certain percentages of each major manufacturer's sales would be required to be ZEVs. This proposed requirement reflects the staff's assessment that major manufacturers will be able to produce commercially viable electric vehicles. In 1998, ZEVs would comprise 2 percent of the passenger cars and light trucks (less than 3750 lbs. loaded vehicle weight) certified and sold by each major manufacturer to meet the fleet average standard. The percentage requirement for ZEVs would be raised in successive years, reaching 10 percent in 2003.

The proposal would not require small volume manufacturers producing fewer than 3,000 vehicles per year for sale in California to produce ZEVs. Intermediate volume manufacturers that sell more than 3,000 but fewer than 35,000 vehicles per year would not be required to produce ZEVs until 2003. To be classified as intermediate volume, a manufacturer's average sales of light- and medium-duty vehicles from 1989 to 1993 must be less than 35,000 vehicles per year. Manufacturers have commented that the costs of producing an electric vehicle could not be recovered until a volume of at least 3000 units was achieved. Thus, setting the intermediate volume manufacturer sales limit at 35,000 units assures that the 3000 unit volume is achieved in 2003 when the ZEV requirement reaches 10% of a manufacturer's total sales volume. Further, there is also a clear division in the production volumes between intermediate and large volume manufacturers at 35,000 units. Mandatory requirements for ZEVs affirm the ARB's commitment to reducing vehicular emissions to the greatest extent possible, at the earliest practical date.

a. Categorization of Hybrid Electric Vehicles

Hybrid electric vehicles are battery-powered vehicles that use a small combustion engine for additional range. When operating exclusively on the battery, these vehicles have no emissions. When the engine is used, however, the emissions can be significant. The conditions under which the engine is used are dependent on the way the vehicles are designed to operate.

To determine the emission levels of a hybrid electric vehicle for certification, the staff recommends emission testing of the vehicle with the engine operating at worst case conditions over the standard test cycle. This approach would ensure that the vehicle would not exceed the emission standard under any operating condition. However, to properly recognize the ability of some hybrid electric vehicles to operate exclusively on the battery much of the time (and therefore have no emissions), the NMOG emission standard for hybrid electric vehicles with minimum battery range would be adjusted for calculating the fleet average standard. Details of this procedure can be found in the technical support document.

2. Medium-Duty Vehicles and Engines

Due to low production volumes and limited model availability, categorized emission averaging is not feasible for medium-duty vehicles or engines used in medium-duty vehicles. Many medium-duty vehicle manufacturers certify and sell only a few different models in each vehicle weight class. Therefore, an emission averaging program would not be the most effective approach.

Instead, the staff is proposing implementation percentages that would apply to the total number of medium-duty vehicles or engines as a single class sold by each manufacturer (Table 4). In 1998, LEVs would be introduced as 25 percent of new vehicles and engines, and their numbers would be increased in 25 percent increments thereafter, reaching a maximum of 95 percent in the 2001 model-year. Also in 1998, ULEVs would be required at 2 percent of new medium-duty vehicle and engine sales. The ULEV implementation rate would remain at 2 percent until 2000 and would increase beginning in 2001.

To provide flexibility in meeting the proposed requirements, a system of trading ratios based on achieving equivalent emission reductions was developed. Through the use of trading ratios, a manufacturer could choose to meet its requirement for LEVs by producing more ULEVs than required or by producing ZEVs. Similarly, requirements for ULEVs could be met by producing more LEVs than required or by producing ZEVs.

Table 4. Implementation Schedule for Medium-Duty Vehicles

MODEL YEAR	LEV	ULEV
1998	25%	2%
1999	50%	2%
2000	75%	2%
2001	95%	5%
2002	90%	10%
2003	85%	15%

3. Credits

To provide incentives for introducing TLEVs, LEVs, ULEVs, and ZEVs earlier or in greater quantities than required, a system for earning marketable credits would be established. A credit system would also allow manufacturers to account for poor vehicle sales or overly optimistic sales projections in any given year by utilizing credits which had been banked internally or acquired from another manufacturer.

Light-duty vehicle manufacturers may earn credits by having a ~~sales-weighted emission average lower than the fleet average standard~~ (Figure 1). Medium-duty vehicle manufacturers may earn credits by selling a greater number of LEVs or ULEVs than indicated in the implementation schedule (Table 4) or by producing ZEVs. Credits could be earned by producing more ZEVs than needed to meet the requirements for LEVs and/or ULEVs (see Technical Support Document for details on medium-duty vehicle trading ratios).

To prevent excessive accumulation and/or misuse, credits would be discounted if not used in the next model-year. Vehicles introduced early may be inferior to later vehicles in durability and performance because of the shorter amount of time available for design and development and less stringent in-use requirements. Therefore, credits earned in any given model-year would be discounted to 50 percent of their original value if not used by the end of the next model-year and to 25 percent of their original value if not used by the end of the following model-year. The credits would have no value if not used by the end of the fourth model-year after being earned. Light-duty vehicle credits would be discounted beginning in the 1994 model-year; discounting of medium-duty vehicle credits would begin in the 1998 model-year.

C. VEHICLE CERTIFICATION PROCEDURE

Reactivity adjustment factors for all available vehicle/fuel systems would be established by September 1991. Vehicle manufacturers may then certify alternate fueled TLEVs, LEVs, and ULEVs beginning in the 1993 model-year (which begins in the 1992 calendar year), after the reactivity adjustment factors have been established. Because conventional gasoline-fueled TLEVs, LEVs, and ULEVs would be required to meet the standards without adjustment for reactivity, these vehicles may be certified beginning in the 1992 model-year. ZEVs may also be certified beginning in the 1992 model-year.

Manufacturers which intend to certify alternate fueled vehicles in 1993 and subsequent model-years must provide the ARB Executive Officer with projected sales data and fuel economy estimates for these vehicles two years before the end of the certification process. This information is needed to estimate the amount of alternate fuel that would need to be produced and distributed by the fuel industry.

For certification, vehicle manufacturers would submit the emission levels of each engine family to the ARB Executive Officer for approval, according to current procedures. For alternate fueled vehicles, manufacturers would submit the actual NMOG emission levels and the values of the emission levels multiplied by the applicable reactivity adjustment factor. If a manufacturer can demonstrate that the reactivity adjustment factor for its vehicle/fuel system is at least 25 percent lower than the adjustment factor determined by the ARB, the manufacturer could submit a request to the ARB Executive Officer for a more appropriate adjustment factor. This provision is intended to provide an incentive for the development of less reactive fuels and vehicle technologies, while minimizing the operational complexity of having many slightly different adjustment factors for the same basic vehicle/fuel system design.

The regulations would also accommodate certification of vehicles on any new fuels that might become viable in the future. Adjustment factors would be established by the Executive Officer of the ARB for any new vehicle/fuel system demonstrated to be commercially feasible, according to specified procedures.

Furthermore, manufacturers would also be required to submit an engineering evaluation of the effectiveness of their emission control systems with variances in temperature, from 20 to 86 degrees F. Present test procedures only measure emissions generated from vehicles operating at 68 to 86 degrees F. In the South Coast Air Basin, morning low temperatures can drop to about 50 degrees F during the summer, when ambient ozone levels are highest. Thus, unexpected increases in emissions could result if vehicle emission control systems were not optimized for operation below 68 degrees F. Similarly, the lower temperature evaluation would minimize CO emissions from vehicles in the winter months, when exceedances of the ambient CO standards are most likely to occur. In addition to the engineering evaluation, vehicle manufacturers would be required to submit emission data from a small number of vehicles demonstrating that their vehicle designs could comply with the applicable standards at 50 degrees F.

To identify vehicles and engines certified to the proposed standards, vehicle emission control labeling requirements have been modified. Furthermore, the offsetting procedure for federal vehicles under AB 965 has been revised to be consistent with the requirements of the proposed regulations while maintaining the same model unavailability previously determined by the Board.

D. TECHNICAL JUSTIFICATION

The proposed TLEV, LEV, ULEV, and ZEV standards reflect the capabilities of vehicle technologies and alternate fuels, and the need to limit emissions of toxic air contaminants. The vehicle/fuel systems projected to be able to comply with each category of standards are summarized in Table 5.

1. Transitional Low-Emission Vehicles (TLEVs)

To produce light-duty vehicles meeting TLEV standards, moderate improvements to engine designs and control technology would be needed. Vehicles meeting the 0.25 g/mi NMHC and 3.4 g/mi CO standards will utilize close-coupled catalysts and advanced fuel injection systems. For these gasoline-fueled vehicles to achieve TLEV levels, it is expected that manufacturers would first modify vehicles with small or medium displacement engines that are already near the TLEV emission levels in certification testing. To maintain TLEV emission levels for the vehicle's useful life, however, additional emission margin would be needed. Therefore, cold start emissions could be lowered further through the use of heated fuel preparation systems. These devices atomize any liquid fuel, effectively transforming the liquid fuel into a gaseous fuel which lowers cold start emissions by achieving more complete combustion. Emission tests have shown that hydrocarbon emissions during cold start could be reduced by up to 40 percent through the use of heated fuel preparation systems. Vehicle NMOG emissions would be lowered because the amount of excess unburned fuel would be substantially reduced.

Manufacturers could also choose to produce TLEVs powered by alternate fuels, which have lower ozone reactivities than gasoline. Less complex emission control systems would be needed for vehicles designed to operate on cleaner-burning fuels due to the lower reactivity of their exhaust emissions.

Methanol, ethanol, and liquified petroleum gas (LPG) are fuels composed primarily of a single, chemically simple, liquid compound. Because of the relative simplicity of these liquid fuels, the ozone-forming potency of their emissions is largely due to one or a few NMOG

Table 5. Projected Low-Emission Vehicle Technologies

50,000 Mile Stds. NMOG	CO	NOx	PROJECTED FUEL/VEHICLE SYSTEMS*
TRANSITIONAL LOW-EMISSION VEHICLES			Gasoline -- Small/Medium Displacement Engines -- Heated Fuel Preparation System -- Close-Coupled Catalyst Alcohol -- Improved Close-Coupled Catalyst CNG -- Underfloor Catalyst LPG -- Close-Coupled Catalyst
0.125	3.4	0.4	
LOW-EMISSION VEHICLES			Gasoline -- Electrically Heated Catalyst -- Phase 2 Gasoline Alcohol -- Heated Fuel Preparation System -- Close-Coupled Catalyst CNG -- Electronic Fuel Injection -- Close-Coupled Catalyst LPG -- Electronic Fuel Injection -- Close-Coupled Catalyst
0.075	3.4	0.2	
ULTRA-LOW-EMISSION VEHICLES			Gasoline -- Heated Fuel Preparation System -- Electrically Heated Catalyst -- Phase 2 Gasoline Alcohol -- Heated Fuel Preparation System -- Electrically Heated Catalyst CNG -- Electronic Fuel Injection -- Close-Coupled Catalyst LPG -- Electronic Fuel Injection -- Electrically Heated Catalyst Elect. -- Range-Extended Hybrid Vehicles -- Battery-Powered Vehicles with Auxillary Combustion Heaters
0.040	1.7	0.2	
ZERO-EMISSION VEHICLES			Elect. -- Battery-Powered Vehicles

* Improved NOx control also needed for all LEVs and ULEVs.

compounds. Thus, for these fuels, close-coupled catalysts would likely provide effective emission control since the reactive NMOG emissions are greatly reduced, compared to gasoline. For vehicles powered by compressed natural gas (CNG), as much as 90 percent of total hydrocarbon emissions is methane, a hydrocarbon that is very unreactive in forming ozone. In addition, CNG is a gaseous fuel which burns very completely and efficiently in present engine systems. Consequently, an underfloor catalyst system would be adequate for CNG-powered vehicles to meet TLEV emission standards. It should be noted that because diesel-fueled vehicles would have considerable difficulty in meeting the TLEV standards for NOx, they will likely be unavailable in the light-duty vehicle category by the mid-1990s.

2. Low-Emission Vehicles (LEVs)

Cold start emissions typically comprise 70 to 85 percent of total emissions measured during certification testing of vehicles at the TLEV emission level. To meet the requirements for LEVs, cold start emissions will need to be lowered beyond the levels achieved for TLEVs. For light-duty gasoline-fueled vehicles, electrically heated catalysts could be used to attain the needed reduction in NMOG emissions. The use of cleaner gasoline (i.e., Phase 2 gasoline) could be used to provide additional margin of compliance in meeting the LEV standards.

Because catalyst efficiency in reducing exhaust emissions is strongly dependent on operating temperature, pre-heating the catalyst enables emissions to be further reduced during the cold start period. This can be achieved by supplying energy from the vehicle's battery to pre-heat the catalyst to an efficient operating temperature before the engine is started. Preliminary data from recent emission tests performed on vehicles equipped with electrically heated catalysts are provided in Table 6. For comparison, the standards recently adopted for 1993 model-year vehicles are also provided in the table.

For controlling NOx emissions, improvements in catalyst washcoat durability, increased catalyst loading and revised distribution of precious metals within the catalyst substrate, and wider use of dual oxygen sensors would enable the proposed standard to be achieved and maintained for the useful life of the vehicle. Since 1986, when the current NOx emission standards were adopted for light-duty vehicles, average NOx emission levels from certification vehicles have decreased steadily. For the 1990 model-year, two vehicle manufacturers have even reported 0.00 g/mi NOx emissions for their certification vehicles. At present, 40 to 44 percent of 1990 passenger cars and small light trucks have demonstrated NOx certification levels of 0.2 g/mi or below at 50,000 miles, which is the level of NOx allowed to be emitted by light-duty LEVs and ULEVs. Although in-use NOx levels could be higher and the proposed standards require 100,000 mile compliance, the certification results give a strong indication that with modest design improvements, the LEV and ULEV NOx requirements could be achieved in-use.

Table 6. Preliminary Data (g/mi) from Vehicles Equipped with Electrically Heated Catalysts at Low Mileage

FUEL	VEHICLE	NMOG	CO	NOx	Formaldehyde
1993 Standards		0.25	3.4	0.4	0.015
Gasoline	'87 Golf	0.03	0.57	0.69	n/m
Gasoline	'86 Camry	0.03	0.35	0.22	n/m
Gasoline	'90 Celica	0.03	0.13	0.17	n/m
Gasoline	'90 LeSabre	0.03	0.21	0.19	n/m
M85	'90 Corsica	0.02	0.40	0.17	0.0036

n/m = not measured

Because some of the technologies likely to be employed at the LEV level do not include an electrically heated catalyst, the CO standard was maintained at the TLEV level. This is because there is less certainty concerning the feasibility of further lowering and maintaining CO emissions from alternate fueled vehicles with close-coupled catalysts when calibrating to a lower NOx standard over 100,000 miles.

Similar to TLEVs, using fuels with lower ozone reactivities than gasoline could enable manufacturers to meet LEV standards with less sophisticated emission control systems. While heated fuel preparation systems would be needed for vehicles powered by methanol and ethanol, the extent of cold start emission reductions needed to meet LEV standards may not require an electrically heated catalyst. For LPG-fueled vehicles, fuel injection systems would be needed to meet the NMOG and NOx standards for LEVs. For CNG-powered vehicles, fuel injection systems would be needed to meet the LEV standard for NOx.

At present, emission control systems on medium-duty vehicles are not as advanced as those found on light-duty vehicles. Thus, the staff believes that modifications needed to achieve LEV standards for light-duty vehicles could also be used to meet the medium-duty vehicle standards. The proposed standards for medium-duty LEVs take into account the larger size and increased engine loads of medium-duty vehicles and have not been reduced by the same percentage as the light-duty vehicle standards. The need to maintain low emission levels when carrying heavy loads will require proportionally larger catalyst systems.

3. Ultra-Low-Emission Vehicles (ULEVs)

The standards for ULEVs in both the light- and medium-duty sectors are based on the capabilities of vehicles powered by gasoline and equipped with an electrically heated catalyst. Gasoline-fueled vehicles which meet LEV standards should be able to comply with ULEV standards by improving the design and durability of electrically heated catalysts. By utilizing a cleaner-burning gasoline, such as Phase 2 gasoline, the necessary in-use compliance margin beyond the levels shown in Table 6 could be obtained to meet the NMOG standard. The use of heated fuel preparation systems could also provide additional compliance margin and/or could reduce onboard electrical requirements and allow downsizing of the electrically heated catalyst.

LEVs powered by alternate fuels such as methanol, ethanol, and LPG would likely need to be equipped with an electrically heated catalyst as well, and the alcohol-fueled vehicles would need to include improved fuel preparation systems. By comparison, CNG-powered vehicles could require only a very effective close-coupled catalyst. The ULEV standards could also be achieved by hybrid electric vehicles and by battery-powered electric vehicles that have auxiliary combustion heaters.

4. Zero-Emission Vehicles (ZEVs)

ZEVs are defined as vehicles that have no exhaust or evaporative emissions of any regulated pollutant. At present, only battery-powered electric vehicles without combustion heaters are expected to be able to qualify as ZEVs, although solar and fuel cell vehicles may be developed to meet the ZEV criteria in the future.

E. ISSUES OF CONTROVERSY

In discussions with the staff, representatives from the affected industries have expressed concern about several aspects of the low-emission vehicles proposal. In the following section, the main issues of controversy are identified and discussed.

1. Technological Feasibility of Standards

The emission standards for TLEVs, LEVs, and ULEVs are based on the staff's evaluation and projections of the capabilities of advanced emission control technology alone or in conjunction with the use of cleaner-burning fuels. The requirement for ZEVs is based on the projected viability of electric vehicles after receiving input from vehicle manufacturers and electric vehicle design engineers. It is widely acknowledged that further research and development will be needed before vehicles capable of meeting the emission standards in-use are ready for commercial production. Accordingly, the staff has provided an adequate lead-time for manufacturers to perform the necessary design work.

Significant technological advances are not expected to be needed for vehicles to comply with TLEV standards. Conventional and alternate fueled vehicles designed to meet a 0.25 g/mi NMHC standard should be able to meet TLEV standards with moderate improvements in fuel preparation (pre-heating) and more precise air and fuel control. Consequently, vehicle manufacturers should not have difficulty meeting TLEV standards, given sufficient lead-time (see Issue 2.)

For LEVs and ULEVs, electrically heated catalysts are projected to be utilized. The ARB's test vehicles equipped with electrically heated catalysts have demonstrated emission levels below the proposed ULEV standards (Table 6). The staff recognizes that these test results were obtained with low-mileage catalysts, and no in-use data are available yet. (The ARB has begun a program to assess the durability of electrically heated catalysts.) However, there is little reason to expect that the deterioration rates of fully developed electrically heated catalysts would be very different from present catalysts. Electrically heated catalysts do not operate at temperatures any higher than current catalysts, and metal substrate catalysts are already being used on production vehicles. The staff allowed for normal deterioration by proposing standards for 100,000 miles that are slightly less stringent than for 50,000 mile standards.

Based on their preliminary test programs, a number of vehicle manufacturers have cited potential problems with the use of electrically heated catalysts. Among these are the long pre-heat time (about 15 seconds) before the engine can be started, additional power requirements, and reliability concerns associated with transferring large amounts of current. However, these problems are capable of being resolved in the next several years as additional effort is being devoted to heated catalyst programs. The staff has already seen evidence that shorter pre-heat times are possible and that more powerful, yet lighter batteries and capacitors will be available for vehicle use.

Although the staff has identified the electrically heated catalyst as a promising technology, vehicle manufacturers are not constrained to using heated catalysts to meet the requirements of the program. The staff expects that many new developments of advanced emission control technologies and cleaner-burning fuels will materialize in the next several years. For example, CNG-powered vehicles should be able to meet the ULEV standard for NMOG with conventional close-coupled catalyst systems. For CNG-powered vehicles to meet the NOx requirement, however, would require an improved fuel control system. Such systems are currently being developed.

2. Schedule for Transitional Low-Emission Vehicles

The implementation rates for TLEVs shown in Table 3, 10 percent in 1994, 15 percent in 1995, and 20 percent in 1996, are based on the staff's assessment of the number of engine families which currently have emission performance that, with relatively minor engine and emission control optimization, could qualify as TLEVs. In addition, manufacturers could produce vehicles capable of operating on alternate fuels. The lower reactivity of exhaust emissions from alternate fueled vehicles could allow compliance with the TLEV standards. If the use of alternate fuels is the predominant method chosen for compliance, the proposed implementation rate for TLEVs is sufficient to support the development of an alternate fuel infrastructure, according to the assessment of the California Energy Commission (CEC). An established infrastructure is needed to ensure that sufficient quantities of the alternate fuel are available at reasonable prices for low-emission vehicles to use in the long-term.

It is uncertain at this time whether the majority of low-emission vehicles would be powered by alternate fuels. Under the proposed regulations, vehicle manufacturers would be allowed to utilize any fuel as long as the vehicle/fuel system meets the applicable emission standard. To produce TLEVs, manufacturers may choose to use either alternate or conventional fuels. However, an incentive to produce flexible- and dual-fueled vehicles is provided through federal Corporate Average Fuel Economy (CAFE) regulations. Manufacturers which produce flexible- or dual-fueled vehicles could earn CAFE credits, estimated to be worth several hundred to several thousand dollars per vehicle. Thus, the staff expects some alternate fueled TLEVs will be produced.

Regardless of whether conventional or alternate fuels were used, utilizing a larger percentage of TLEVs than proposed for determining the fleet average standards in the first few years of the program would greatly strain manufacturers' resources. In view of the many competing requirements from other regulations promulgated by the ARB, Congress, and EPA, fleet average standards based on substantial percentages for TLEVs in 1994 through 1996 may force manufacturers to devote their resources to complying with short-term TLEV requirements, perhaps at the expense of longer term research and development programs for LEVs and ULEVs.

A less aggressive TLEV implementation rate of 10 perent per year in 1994 through 1996 is an alternative to the 10, 15, and 20 percent TLEV implementation rate proposed by the staff. A lower implementation rate could be preferable if manufacturers choose not to produce many alternate fueled TLEVs or LEVs. In this situation, the development of a large alternate fuel infrastructure may not be justified. The slower implementation rate would allow manufacturers to shift limited resoures to the development of durable LEVs and ULEVs.

The staff has been unable to quantify the extent to which alternate fuels will be used to comply with the TLEV and LEV emission standards. The Board may wish to consider which TLEV implementation rate is preferred based on information received in response to this proposal.

3. Measurement Accuracy at Low-Emission Levels

Current test procedures and sampling techniques were designed for measuring emissions from vehicles which emit on the order of 0.1 g/mi hydrocarbons or higher. At the low-emission levels being proposed, particularly for ULEVs, vehicle manufacturers are concerned that emission measurements may not be reliable enough to accurately measure emissions for determining compliance with ULEV standards.

In performing optimization of air injection systems on the vehicles equipped with electrically heated catalysts at Southwest Research Institute, the staff has not encountered any significant problems with measuring low levels of emissions (0.04 g/mi hydrocarbons) or unusual test to test variability. While improvements to current measurement techniques are desirable, they are not essential for determining compliance with the standards proposed.

After talking with representatives from the Motor Vehicle Manufacturers Association (MVMA), the staff believes that better test and sampling procedures could be developed in the next few years. The ARB staff will work closely with the MVMA and other members of industry to develop reliable and accurate procedures. For example, techniques used to measure very low concentrations of atmospheric pollutants may be applicable to measuring low levels of exhaust emissions. The staff will provide some flexibility to manufacturers in the proposed test procedures for utilizing improved techniques and may propose improvements to the procedures when the staff returns to the Board to provide the biennial report concerning this rulemaking.

In the interim, several measures could be taken to improve the reliability of emission data at low levels. These measures include averaging of statistically valid numbers of repeat tests, minimizing background interference, and calibrating measurement instrumentation for better accuracy at low emission levels.

4. Availability of Reactivity Adjustment Factors

The TLEV, LEV, and ULEV standards were established based on emission data from gasoline-fueled vehicles utilizing very advanced emission control systems. Therefore, vehicle manufacturers could continue to produce gasoline-fueled vehicles to meet the requirements of the program. For conventional gasoline-fueled vehicles, the proposed emission standards would be met without adjustment for reactivity. If manufacturers chose to produce alternate fueled vehicles, however, reactivity adjustment factors would be needed to limit the ozone-forming potential of the hydrocarbon emissions.

In order to develop reliable reactivity adjustment factors for vehicle/alternate fuel systems, two types of testing must be performed. First, representative emission data is needed for vehicles powered by base gasoline and by viable alternate fuels. Second, the ozone-forming potential of individual hydrocarbons must be quantified in a scientifically acceptable manner. As these tasks will take several months to complete, the staff expects to present reactivity adjustment factors to the Board at a hearing in September 1991.

Manufacturers have commented that because the reactivity adjustment factors would not be available for a year, they could not design and develop alternate fueled low-emission vehicles until they knew what the allowable hydrocarbon emissions were. If the factors were adopted in September 1991, only a year and a half would remain before 1994 model-year vehicles were introduced. (The 1994 model-year typically begins in the middle of the 1993 calendar year.)

Because of the accelerated nature of this rulemaking, and the extensive testing required, only the procedure for determining the reactivity adjustment factors, not the actual factors themselves, can be presented at the September 1990 hearing. Although this can pose some difficulties with timing, timing problems should not impede the progress of manufacturers in developing vehicles to comply with the low-emission vehicle regulations.

At the September 1990 hearing, Dr. Carter's preliminary analysis of the ozone-forming potential of various hydrocarbons will be presented to the Board for adoption. Although Dr. Carter will refine these values over the next several months, the final set of ozone-forming potential values considered by the Board in 1991 will not be expected to change significantly. Consequently, vehicle manufacturers could evaluate the ozone-forming potential of the exhaust emissions from their developmental alternate fueled vehicles by conducting their own testing and applying the preliminary values for ozone-forming potential.

If a manufacturer's test results were significantly different from the reactivity adjustment factor that the staff ultimately adopts for that particular vehicle/fuel system, the regulations would allow the manufacturer to apply for a more appropriate adjustment factor.

5. Reactivity Adjustment of Carbon Monoxide and Evaporative Emissions

A number of individuals have suggested that in order to fully evaluate the air quality impacts of different vehicle/fuel systems, CO and evaporative emissions should be included in the reactivity adjustment procedure. As a compound, CO has a small but quantifiable ozone-forming potential. Because the mass of allowable CO emissions greatly exceeds the mass of allowable hydrocarbon emissions for low-emission vehicles, the ozone-forming potential of total CO emissions theoretically could be as significant as the total ozone-forming potential of NMOG emissions. Evaporative emissions could also have a significant ozone impact.

Vehicles powered by gaseous fuels such as CNG could benefit from the inclusion of CO and evaporative emissions. Current CNG-powered vehicles have very low CO emissions, and their evaporative emissions, if any, are composed mostly of methane, a very unreactive hydrocarbon.

However, as a result of the proposed low-emission standards and the evaporative test procedure changes that are being considered in a separate rulemaking, the disparity in the levels of CO and evaporative emissions for future vehicle/fuel systems should decrease dramatically. Most vehicle/fuel systems that comply with low-emission NMOG standards should also have CO emissions below the applicable standards. (Proportionally more latitude is provided for CO emissions than for NMOG due to a possible fuel system calibration bias in the rich direction in order to meet the LEV and ULEV NOx standard.) Also, vehicle/fuel systems that comply with the new evaporative test procedures should have nearly zero evaporative emissions under most driving and temperature conditions.

Therefore, although CO and evaporative emissions could in theory be major contributors to the total ozone-forming potential of different vehicle/fuel systems, in practice, the air quality impact should be very small. To quantify the reactivity of CO and evaporative emissions would add further complexity to an already complex proposal, while the actual benefits are questionable. However, if CO and evaporative emissions prove to have a significant effect on total ozone-forming potential, the staff would consider making appropriate revisions to the current proposal.

6. Early Introduction Credits for Ultra-Low-Emission and Zero-Emission Vehicles

Under the proposed regulations, credits could be earned by any manufacturer which certifies and sells a low-emission vehicle earlier or in greater quantities than required. These credits would be calculated based on the NMOG emission standard applicable to the vehicle. Thus, any TLEV, LEV, ULEV, or ZEV produced in excess of the proposed requirements would earn credits based on its allowable emission level.

To provide additional incentives for the early production of ULEVs and ZEVs, Southern California Edison recommends that the credits for ULEVs and ZEVs be substantially increased for vehicles produced before the beginning of the program. Edison believes that higher credits could accelerate current electric vehicle development programs.

However, because the production of ZEVs would be required beginning in 1998, major vehicle manufacturers would have strong incentives to begin developing commercially viable electric vehicles at the earliest possible date. In discussing the prospects of electric vehicles with design experts, their consensus was that commercially successful electric vehicles must be designed from the ground up, incorporating advanced aerodynamic improvements, low friction drivelines, and lightweight body designs (requiring innovations in materials and assembly techniques). Further, to reduce the initial cost of electric vehicles, advances in alternating current-based controller systems would be essential. Improved battery characteristics would also be needed to enhance vehicle range and battery life. These kinds of improvements will require the resources of major manufacturers, and more than a few years to accomplish.

The early introduction of heavy, inefficient, limited range, and excessively costly electric vehicles would do little to further electric vehicle technology. Conceivably, poorly designed electric vehicles could greatly damage public perception of this technology and hinder marketability when they are introduced by major vehicle manufacturers in the 1998 time frame. Finally, the staff has not been approached by any major manufacturer requesting higher credits for the early introduction of electric vehicles, which leads the staff to conclude that the level of credits being provided is adequate, and/or the likely introduction date of reasonable quantities of commercial electric vehicles would not occur before 1998. Therefore, the staff does not recommend providing any additional credits to promote the early introduction of electric vehicles.

III.

CLEAN FUELS ELEMENTS OF THE PROPOSAL

The clean fuels elements of the staff proposal would ensure that the fuels used to certify low-emission vehicles are also readily available for routine consumer operation of those vehicles. Both the low-emission vehicle and clean fuels elements of the staff's proposal must be adopted for the full air quality benefits to be realized. This chapter describes and explains the purpose of each of the proposed clean fuels requirements. The chapter also includes a discussion of the regulatory alternatives the staff evaluated.

The proposed regulations would allow vehicle manufacturers to choose the kinds of fuel on which to certify low-emission vehicles to the proposed standards. The use of clean fuels for certification may give vehicle manufacturers more flexibility in meeting the proposed emission standards and assist them in meeting the more stringent standards. To the extent that vehicle manufacturers choose clean fuels as a means of complying with the proposed standards, low emission levels will be achieved in customer use only if clean fuels are available and used by consumers to operate their vehicles.

Assurance that clean fuels would be made available to the customer is needed for two reasons. First, vehicle manufacturers might want or need to make some low-emission vehicles operable only on a particular clean fuel; that is, the vehicle would be "dedicated" to a specific clean fuel. Manufacturers must be confident that the potential car buyer will be assured of finding that fuel reasonably available. Second, the staff anticipates that most low-emission vehicles certified on a clean fuel will also be capable of using gasoline. These vehicles are referred to as dual-fueled or flexible-fueled vehicles (FFVs). If the clean fuel were not available at retail, these vehicles could still be operated on gasoline, but with greater associated emissions. For example, a low-emission FFV certified to transitional-low-emission vehicle (TLEV) standards and operated on gasoline instead of clean fuel would likely have emissions comparable to a vehicle meeting the current emission standards.

In order to achieve the air quality benefits associated with low-emission vehicle standards, any vehicles certified on clean fuels would have to actually operate on clean fuel in customer use. Clean fuels must be readily available and competitively priced to encourage customer use. To achieve this goal, the proposed clean fuels regulation requires gasoline suppliers (refiners, blenders, and importers) to distribute clean fuels in the volumes needed by the low-emission vehicles that are introduced into the fleet. The staff believes that this requirement will ensure the availability and use of the clean fuels needed by low-emission vehicles.

Other elements of the proposed regulation provide the means to implement the distribution requirement and give gasoline suppliers flexibility in the way they could comply. The other key elements of the proposed clean fuels regulation are:

-- use of credits as an alternative to direct distribution of the clean fuels;

-- a retail outlet requirement to ensure that infrastructure for clean fuel retail distribution is built;

-- a retail availability requirement to ensure clean fuel is available in sufficient quantities at retail outlets;

-- recordkeeping and reporting requirements to assist enforcement;

-- calculation and allocation of clean fuel volumes and number of clean fuel retail outlets required;

-- a provision to allow substitutes for clean fuels;

-- development of specifications for clean fuels (1991 rulemaking); and

-- provisions for identifying the violations that would occur when a gasoline supplier or service station owner fails to comply with the regulation.

All of the clean fuel requirements would take effect within the boundaries of the South Coast Air Quality Management District ("South Coast region") in 1994, in advance of statewide implementation in 1997. Since the South Coast region has the worst air pollution problem in the state, the staff believes it is reasonable and necessary to implement the clean fuels program in that region prior to statewide implementation. However, the staff proposes that the Board's resolution adopting the regulations express an intent to amend them to allow other districts in the state to also participate in this advance program. To initiate this process, the district would have to show a need for mobile source emission reductions prior to 1997 in the district's plan for attainment of state air quality standards required by the California Clean Air Act. If the Board amends the regulations to extend the advance program to other districts, the clean fuel distribution, retail outlet, and availability requirements would be made effective in those districts prior to 1997 also.

A. CLEAN FUEL DISTRIBUTION

This element would require all gasoline suppliers that distribute gasoline in a calendar quarter to also distribute minimum assigned volumes of each clean fuel over the calendar quarter. Clean fuel would be considered "distributed" when it has been released by the gasoline supplier into the marketing chain that moves the fuel to retail stations. To satisfy this requirement for a particular clean fuel, a gasoline supplier could either produce the fuel directly or acquire it from another source that has produced or imported it.

1. Fuels Covered by the Requirement

The following fuels are recognized as potential non-gasoline certification fuels for low-emission vehicles:

- methanol*
- ethanol*
- liquified petroleum gas (LPG)
- compressed natural gas (CNG)
- electricity

All of these fuels, except CNG and electricity, would be subject to the clean fuel distribution requirement if they are used by vehicle manufacturers to certify a low-emission vehicle. However, the distribution and other requirements for clean fuels would not be triggered for a particular clean fuel until the projected number of vehicles in the fleet that were certified on that fuel reaches a de minimus level. The clean fuel requirements for a particular fuel would remain in effect only as long as the projected number of vehicles certified on that fuel remains at or above the de minimus level.

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* Methanol and ethanol may be in either the pure, neat form (M100, for example, which is 100 percent methanol), or in mixtures with gasoline. M85, which is 85 percent methanol and 15 percent gasoline, is a common mixture. An analogous situation exists for ethanol.

The distribution requirement would also apply to any new fuel (such as a reformulated gasoline different from the expected Phase 2 gasoline) which the ARB specifies as a permissible certification fuel by regulation. The distribution and other clean fuels requirements would be triggered for a new fuel once the number of vehicles in the fleet certified on the new clean fuel reached the de minimus levels.

Although CNG and electricity have good potential as certification fuels for low-emission vehicles, the staff believes that it would be inappropriate to include them in the distribution requirement for three reasons: (1) these fuels are already produced and widely distributed by utilities, (2) the gasoline suppliers' distribution systems are not equipped to handle these non-liquid fuels, and (3) these fuels are offered by only one supplier (a utility) in each geographical area, which creates a monopolistic situation in terms of price and supply. Although CNG would not be included in the distribution requirement, retail gasoline station owners would have to make CNG available at some of their stations to provide fuel for CNG vehicles, if needed.

2. Specific Requirements

Under the proposed distribution requirements, the Executive Officer of the ARB would set a minimum assigned volume of each clean fuel to be distributed by gasoline suppliers each quarter. The total required volume to be distributed by all suppliers would be a percentage of the maximum possible demand volume for each clean fuel. The percentage of the maximum demand volume to be distributed would increase over time as clean fuels represent an increasingly greater share of the total fuel market. A detailed discussion of the methods in the proposed regulation for calculation and allocation of clean fuel volumes is provided later in the chapter.

The minimum assigned volume for a particular supplier would be the minimum amount of that clean fuel to be distributed during the given calendar quarter. The determination of the minimum assigned volumes for a quarter would be made no later than three months before the start of that quarter. However, the approximate volumes would be known well in advance as part of the process for determining the number of retail outlets to be equipped to sell the clean fuels.

As an alternative to the distribution requirement, the staff considered a requirement for minimum volumes of clean fuels to be sold by individual gasoline retailers. Many retailers are small businesses, owning one or two stations. It could be very difficult for these small retailers to obtain clean fuels if the suppliers are not obligated to make certain volumes available. Also, the demand for clean fuel from one retail location to another could vary considerably. Accordingly, it would be impractical to attempt to set station-by-station requirements.

3. Schedule for Requirements

From January 1, 1994 to December 31, 1996, the distribution requirement would apply only to major gasoline suppliers that market gasoline at retail stations in the South Coast region. The clean fuel volume to be distributed would be a portion of the amount of clean fuel that could be used in that region from 1994 to 1996 by vehicles that use that clean fuel to certify to any of the low-emission standards. Beginning the program in the South Coast region is intended to help meet commitments made in the South Coast Air Quality Management Plan.

A major gasoline supplier would be defined as any company that has a refining capacity in California greater than 50,000 barrels of crude oil per day and that owns (or leases) more than 25 retail gasoline stations in the district. The seven major suppliers in the South Coast region together supply more than three-fourths of all gasoline in California. These major suppliers have both the direct control over retail outlets and the resources needed to implement clean fuels efficiently and economically, as compared to other suppliers with no retail outlets and much smaller shares of the gasoline market.

After January 1, 1997, the distribution requirement would be extended to accommodate the clean fuel needs of low-emission vehicles throughout the state. All gasoline suppliers in the state would be required to distribute the necessary volumes of each fuel.

4. Use of Credits to Meet the Distribution Requirement

A gasoline supplier could satisfy its distribution requirement for a particular clean fuel in any of the following ways:

- -- produce (or import) and distribute the fuel;
- -- purchase the fuel from another supplier and distribute it;
- -- purchase credits from another supplier;
- -- purchase credits from others that sell electricity or CNG to vehicles; or
- -- any combination of the above.

The staff recommends the adoption of this provision so that gasoline suppliers will have some flexibility in meeting their volume distribution requirements. Economies of scale may make it more efficient for only some gasoline suppliers to make or buy a clean fuel and distribute it. For other suppliers, it may be more economical to buy credits than to do the actual distribution directly. This ability to buy credits could also provide emergency relief for a gasoline supplier that might be temporarily unable to distribute its own clean fuel.

The provisions for the use of credits as an alternative to direct distribution are intended to reduce the difficulty and cost of compliance with the distribution requirement. However, industry has asserted that use of credits could also increase the likelihood of fraud. Recordkeeping requirements and careful vigilance on the part of the ARB would help prevent fraudulent credit claims. The staff believes that the flexibility provided by the credit provisions outweighs the potential enforcement problems.

a. CNG and electricity credits

Under the staff proposal, a gasoline supplier could satisfy part of its distribution requirement for any clean fuel with CNG or electricity credits purchased from a utility. The utility could earn these transferable credits by delivering CNG or electricity directly to vehicles. For electricity, credits would be given only for the electricity demanded by ZEVs produced in excess of the required levels. This provision would give flexibility to the gasoline suppliers in their means of compliance.

These credits for the sale of CNG and electricity would be allowed to offset, or displace, an equivalent amount of the clean fuel that a gasoline supplier would be required to distribute. To prevent credits for CNG and electricity, which do not have distribution requirements, from displacing a significant amount of the clean fuels that do have distribution requirements, the staff proposes that the use of these credits be capped at 10 percent of a gasoline supplier's total quarterly clean fuel volume requirement. Without such caps, large volumes of the other clean fuels could be displaced and unavailable for consumer purchase and use. Owners of flexible-fueled vehicles could be limited to gasoline and owners of dedicated clean fuel vehicles could have difficulty finding the necessary clean fuels.

b. Banking of credits

In addition to using purchased credits, a gasoline supplier could draw on internally banked credits that it had earned in previous quarters for clean fuel sales in excess of the required minimum volumes. This provision could help a supplier through a period when its normal supply of a clean fuel might be reduced.

The staff recognizes, however, that allowing the banking of credits for internal use might have the effect of discouraging inter-company credit trading because companies might prefer to keep the credits for their own use. The staff believes that the inter-company credit trading provisions are important and recommends that the ability to bank credits internally be capped. The staff proposes that the allowable size of the bank be limited to 20 percent of a company's total quarterly volume requirement, and that the banked credits be gradually reduced in worth over a period of two years.

B. CLEAN FUEL RETAIL OUTLETS

This provision would require owners (and lessors) of operating retail gasoline stations to install dispensing equipment and storage tanks for clean fuels. For each clean fuel with a distribution requirement, and for CNG, station owners would have to provide the capability to sell that fuel in a certain number of retail gasoline stations. This requirement would take effect in 1994 for gasoline stations in the South Coast region that are owned (or leased) by major oil companies. Gasoline stations owned by other companies and individuals, in all areas of the state, would be phased into the clean fuel retail outlet program beginning in 1997. The proposed method for determining how many stations would have to be equipped to dispense clean fuel in a given year is described later in this chapter.

The staff believes that this clean fuel retail outlet provision is needed (1) to ensure that clean fuels are available to the consumer at convenient retail outlets and (2) to assure gasoline suppliers that there will be retail outlets through which the clean fuels they are required to distribute could be sold. Some refiners and importers subject to the distribution requirement do not own stations or retail businesses. If they had to rely upon the retailers who buy their fuels to voluntarily install dispensers for each clean fuel, they could be at a disadvantage relative to the major gasoline suppliers that have direct control over retail outlets. The Executive Officer of the ARB would determine the total number of clean fuel outlets, or number of stations required to be equipped to dispense the fuel, and the allocation of this number among the station owners.

The proposed regulation would require the allocation of clean fuel retail outlets required of each gasoline station owner, according to the total number of stations owned. The staff believes this is preferable to requiring clean fuel retail outlets at gasoline stations with gasoline throughput volumes above a defined threshold because the proposed approach provides much more flexibility to station owners. Under the staff proposal, station owners can choose which of their stations to equip as clean fuel outlets. Allowing station owners this choice would benefit the clean fuel consumer because owners would be expected to site their clean fuel outlets at the locations where they believe the greatest demand would exist.

CNG is a commodity regulated by the Public Utilities Commission (PUC). Inclusion of CNG in the retail outlet requirement is contingent on the PUC's certification that gasoline retailers may legally purchase CNG and resell it as a motor vehicle fuel. The staff is proposing that some retail gasoline stations be required to install compressor equipment so that CNG can be distributed to vehicles at the station. The staff recommends this approach to ensure that there are retail outlets that market CNG in sufficient numbers such that buying the fuel is convenient for owners of CNG vehicles. The regulation would not require that retail gasoline station owners be responsible for equipment to charge electric cars, however, because recharging is a slow process which is best done where electric vehicles are garaged.

C. CLEAN FUEL RETAIL AVAILABILITY

The proposed regulation would require the operator of any retail gasoline station equipped to sell a clean fuel to actually offer that fuel for sale. The staff believes that this requirement is needed to ensure that clean fuels are continually available to low-emission vehicle owners at the retail outlets equipped to dispense the fuels.

D. RECORDKEEPING AND REPORTING

Since the ARB would not be able to directly monitor the distribution of clean fuels, enforcement of the proposed regulation would have to be done through examination of appropriate records. Accordingly, the proposed regulation would require both gasoline suppliers and companies providing clean fuels or credits to keep records. The proposed requirements include the maintenance and reporting of detailed data on the origin and movement of all clean fuels distributed to comply with the regulation.

E. CALCULATION AND ALLOCATION OF CLEAN FUEL VOLUMES AND NUMBER OF RETAIL OUTLETS REQUIRED

To implement the proposed clean fuel regulations, the Executive Officer of the ARB would first have to identify the specific clean fuels that would be required to be distributed each quarter and made available at retail outlets each year. The distribution and other requirements for clean fuels would not be triggered for a particular clean fuel until the projected number of vehicles in the fleet that were certified on that fuel reaches a de minimus level. The clean fuel requirements for a particular fuel would remain in effect only as long as the projected number of vehicles certified on that fuel remains at or above the de minimus level.

In the South Coast region, for 1994 through 1996, the de minimus level would be a total of 10,000 vehicles in the fleet in that region certified on that clean fuel. The statewide de minimus level, for 1997 and on, would be 20,000 vehicles in the statewide fleet certified on the clean fuel. For example, if Clean Fuel X is used to certify low-emission vehicles and 5,000 of those vehicles are projected to be sold in the South Coast region in 1996, there would be no requirement to distribute (or provide retail outlets for) Clean Fuel X that year. If an additional 16,000 vehicles certified on Clean Fuel X are projected to enter the statewide fleet (in the South Coast and other areas) in 1997 for a total statewide fleet of 21,000 vehicles, the distribute (and retail outlet) requirement for Clean Fuel X would be triggered.

Once the clean fuels subject to the requirements have been identified, the proposed clean fuel regulation directs the Executive Officer of the ARB to determine the minimum assigned volume of each clean fuel to be distributed by each gasoline supplier and the number of retail outlets at which clean fuels must be provided by each retail station owner and lessor. Under the proposal, the Executive Officer must determine:

- the estimated maximum demand volume for each clean fuel that could be used by low-emission vehicles in the South Coast region from 1994 through 1996, and statewide for 1997 on, for each calendar quarter;

- the total required volume of each clean fuel to be distributed in the South Coast region for 1994 through 1996 and statewide for 1997 on, for each calendar quarter;

- the allocation of that required volume among gasoline suppliers;

- the total number of retail outlets needed to dispense each each clean fuel in the South Coast region for 1994 through 1996, and statewide for 1997 on; and

- the allocation of the required number of retail outlets among gasoline service station owners and lessors.

The methods the staff proposes to use to determine these numbers and implement the regulations are described below and in more detail in the technical support document.

1. <u>Determination of the Maximum Demand Volume for Each Clean Fuel</u>

The staff would determine the statewide maximum demand volume for each clean fuel on a quarterly basis. The staff would estimate the demand according to the volume of fuel needed by registered vehicles certified on the clean fuel and the volume expected to be needed by new vehicles entering the fleet over the next quarter. The staff would calculate the volume of each clean fuel expected to be needed by these new vehicles based on vehicle registration data and manufacturers' projections of the number of low-emission vehicles, operated on that fuel, that they intend to produce and offer for sale in California. For example, estimates of the statewide maximum demand volume for a clean fuel in the first quarter of 1997 would account for the fuel needs of (1) new low-emission vehicles certified on the fuel and expected to enter the fleet in that quarter and (2) all low-emission vehicles using that fuel that entered the fleet in 1994 through 1996 in the South Coast region and elsewhere in the state. The vehicle elements of the proposed regulations contain a mechanism for the reporting of these projections.

2. Determination of the Total Required Volume of Each Clean Fuel to be Distributed

The staff believes it is appropriate to adjust the maximum demand volume for a clean fuel in order to determine the total required volume of the fuel that gasoline suppliers would have to distribute. This adjustment would account for uncertainties that may affect consumer demand for a clean fuel and prevent oversupply of the fuel. The actual demand may be affected by uncertainties in the projected vehicle sales and the convenience of retail locations, especially in the earliest years of the program.

At the start of implementation of the proposed low-emission vehicles/clean fuels program, the total required volume for each clean fuel should be only a fraction of the maximum demand volume. As the uncertainty in the number of vehicles decreases, and as clean fuels become more established over time, the fraction applied to the demand volume should increase. The staff calls this fraction the fuel volume adjustment factor.

The staff believes that the fuel volume adjustment factor represents a reasonable approximation of the likelihood of uncertainty in the actual clean fuel demand over time. If some low-emission vehicles are dedicated to a clean fuel, it is appropriate to assign a higher adjustment factor to the fuel demand for that portion of the fleet because the fuel demand is more certain. These fuel volume adjustment factors, for flexible-fuel and dedicated-clean-fuel vehicles, would be applied to the maximum demand volume to determine the statewide total required volume of each clean fuel to be distributed. Table 7 shows the proposed fuel volume adjustment factor values for clean fuels introduced in 1994.

Table 7: Proposed Fuel Volume Adjustment Factors for Calculating the Total Required Volume to be Distributed

	Adjustment Factor	
Year(s)	Flexible-Fuel Vehicles	Dedicated-Fuel Vehicles
1994	0.25	0.90
1995-1997	0.50	0.90
1998-1999	0.75	0.90
2000+	0.90	0.90

It may not be reasonable to require a new clean fuel, introduced several years into the program, to be distributed in the first year after introduction in volumes corresponding to 75 or 90 percent of the maximum demand for flexible-fuel vehicles. To address this issue, the staff is proposing the use of an alternative fuel volume adjustment factor for fuels introduced after 1994. To calculate the total required volume for clean fuels introduced after 1994, the staff would use the appropriate fuel volume adjustment factor shown above, or the alternative fuel volume adjustment factor shown in Table 8 below, whichever is lower.

Table 8: Alternative Fuel Volume Adjustment Factor Schedule

Year of New Fuel Introduction	Adjustment Factor: Flexible-Fuel Vehicles	Adjustment Factor: Dedicated-Fuel Vehicles
1	0.25	0.90
2	0.50	0.90
3	0.75	0.90
4+	0.90	0.90

The staff proposes to retain the flexibility to adjust these factors in certain circumstances. The Executive Officer could modify the fuel volume adjustment factors by ± 0.10 to account for unforeseen uncertainties that affect fuel demand.

In addition to applying a fuel volume adjustment factor to the statewide maximum demand volume to calculate the total required volume of a clean fuel, the statewide maximum demand would also be adjusted in 1994 through 1996 to account for the demand in the South Coast region only. The staff is proposing a South Coast region adjustment factor (SC-factor) of 0.5.

3. Allocation of Total Required Clean Fuel Volumes

The total amount of a particular clean fuel required for the South Coast region only, for 1994 through 1996, would be allocated among all major oil companies that own (or lease) 25 or more retail gasoline stations in the region. The staff would allocate the total required volumes based on each company's recent share of the statewide gasoline market as determined from taxable sales. The volumes of clean fuel in the statewide program, for 1997 on, would be allocated among all gasoline suppliers, regardless of retail station ownership, according to their statewide market share.

4. Determination of Clean Fuel Retail Outlets

To accommodate the total required volume of each clean fuel to be distributed in the statewide program (1997 and later), and in the South Coast region only for 1994 through 1996, the staff would calculate a reasonable number of stations that need to be equipped to dispense the fuel.

The staff would calculate the number of required retail outlets for each clean fuel based on the volume needed after accounting for the fuel volumes supplied by non-retail stations (fleet outlets). To determine how many outlets would be required to supply the remaining volume, the staff would use a reasonable clean fuel throughput volume per station of 25,000 gallons per month for 1994 through 1997 and 50,000 gallons per month for 1998 on.

Based on the proposed fleet average emission standards for light-duty vehicles and the proposed fleet penetration percentages for medium-duty vehicles, the staff has estimated the approximate volume of all clean fuels and number of retail outlets needed over the first 12 years of the program. These estimates are shown in Table 9. In 1994 through 1996, the fuel volumes and retail outlets shown in Table 9 would apply only to major gasoline suppliers in the South Coast region.

The estimates in Table 9 assume: a South Coast region factor of 0.5 for 1994 through 1996, fuel volume adjustment factors as listed in Table 7, clean fuel throughput volumes of 25,000 gallons per month through 1997 and 50,000 gallons per month thereafter, and that 50 percent of the low-emission vehicles are flexible-fuel vehicles that use clean fuel part of the time and 50 percent are dedicated gasoline vehicles. If more than half of the low-emission vehicles are flexible-fuel vehicles that use clean fuel at least part of the time, the clean fuel volumes and number of retail outlets needed would be higher--as much as double the numbers shown in Table 9.

Table 9: Estimated Total Clean Fuel Volumes and Number of Retail Outlets Needed*

Year	Clean Fuel Volume in Gasoline-Equivalent Gallons (millions)	Number of Clean Fuel Retail Outlets
1994	10	30
1995	40	130
1996	60	200
1997	230	770
1998	600	1,000
1999	1,000	1,700
2000	1,700	2,800
2002	2,800	4,700
2005	4,000	6,700

* Assuming half of the low-emission vehicles are flexible-fuel vehicles using clean fuel part of the time and half are dedicated gasoline vehicles.

5. Allocation of Clean Fuel Retail Outlets

The ARB would allocate the requirement to provide clean fuel retail outlets to gasoline station owners/lessors in the South Coast region in 1994 through 1996 differently from the way that the retail outlet requirement would be allocated to gasoline station owners/lessors statewide from 1997 and on.

a. Which gasoline station owners/lessors in the South Coast region would have to provide clean fuel retail outlets in 1994 through 1996?

The major oil companies (defined as any refiner with greater than 50,000 barrels per day crude oil capacity and at least 25 retail stations in the South Coast region) would be responsible for providing all of the clean fuel retail outlets needed in that region for 1994 through 1996.

b. For the major oil companies in the South Coast region that would have to provide clean fuel outlets in the region in 1994 through 1996, how many outlets would each company have to provide in a given year?

Each major oil company would have to provide clean fuel retail outlets at a minimum number of its gasoline stations in the South Coast region. The minimum number of stations for each company for each clean fuel would be the total of the annual incremental number of new clean fuel outlets required for the year and the number of outlets required in prior years. The annual incremental number of new clean fuel outlets would be the result of multiplying the company's market share factor (the company's recent share of statewide taxable gasoline sales among the major oil companies) by the total annual incremental number of outlets needed statewide for the clean fuel.

c. Which gasoline station owners/lessors in the state would have to equip their stations to dispense clean fuel from 1997 on?

To identify the affected gasoline station owners and lessors who would have to equip their stations to dispense clean fuel statewide in a given year, the ARB would define the minimum ownership level (MOL) for that year. All individuals or companies that own or lease a number of gasoline stations equal to or greater than the MOL for the year would be responsible for providing the new clean fuel outlets needed statewide for that year.

To calculate the MOL for a given year, the ARB would first determine the number of non-clean-fuel stations statewide (stations not yet equipped to dispense at least one clean fuel). The number of non-clean-fuel stations would equal the total number of gasoline stations in the state minus the number of clean fuel outlets previously required. The ARB would calculate the MOL for a given year as follows:

$$\text{Minimum Ownership Level (MOL)} = \frac{\text{Number of Non-Clean-Fuel Stations Statewide}}{\text{Total Annual Incremental Number of New Clean Fuel Outlets for All Clean Fuels}}$$

Using the clean fuel volume and retail outlet estimates presented in Table 9 and assuming the same fuel volume adjustment factors, clean fuel throughput volumes, and vehicle types, the MOL for 1998 would be 62 stations, the MOL for 2000 would be 9 stations, and the MOL for 2005 would be 4 stations. The actual MOLs would depend on the number of low-emission vehicles certified on clean fuels, rather than conventional gasoline, each year. Once the ARB identified the station owners/lessors who are affected (owners/lessors who are at or above the MOL) for a particular year, the ARB would have to determine the minimum designated number of retail gasoline stations that each affected owner/lessor would have to equip as clean fuel outlets for that year.

d. For the affected gasoline station owners/lessors in a given year, how many gasoline stations would each owner/lessor have to equip as retail outlets for each clean fuel in that year?

To calculate the number of retail clean fuel outlets each affected station owner/lessor would have to provide for each clean fuel in a given year, the ARB would first determine the clean fuel fraction for that year. The clean fuel fraction would be calculated as follows:

$$\text{Clean Fuel Fraction (for Each Clean Fuel)} = \frac{\text{Total Annual Incremental Number of New Retail Outlets Needed Statewide for that Clean Fuel}}{\text{Number of Non-Clean-Fuel Stations Owned by All Affected Owners/Lessors}}$$

Each affected owner/lessor would have to equip the same fraction of stations to dispense each clean fuel. The ARB would calculate the minimum designated number of gasoline stations each affected station owner/lessor would have to equip to dispense each clean fuel by multiplying the owner/lessor's number of non-clean fuel stations by the clean fuel fraction and rounding the result to the nearest integer using conventional rounding.

For example, if the total annual incremental number of new retail clean fuel outlets needed statewide for Clean Fuel X is 100, the number of non-clean-fuel stations owned/leased by all affected owners/lessors is 3,000, and the number of non-clean-fuel stations owned by Owner A is 50, then the station clean fuel fraction would be 0.033 (or 3.3 percent). The number of new retail outlets Owner A would have to provide for Clean Fuel X would be 1.65, rounded to 2 outlets.

F. SUBSTITUTES FOR CLEAN FUELS

The proposed regulations would allow a gasoline supplier to meet the distribution requirement for a clean fuel by supplying a substitute fuel which is determined to be equally effective and is approved by the ARB by regulation. When evaluating a candidate substitute clean fuel, the ARB would consider the emissions of vehicles capable of using the fuel, the fuel's effect on the durability of the emission control systems of those vehicles, and the cost-effectiveness of producing commercial volumes of the fuel. These elements are discussed in more detail in the following section on specifications for clean fuels.

G. DEVELOPMENT OF SPECIFICATIONS FOR CLEAN FUELS

The ARB has established specifications for the fuels used by manufacturers to certify vehicles (certification fuels) and the comparable version of the fuel that is used by consumers (commercial fuels). As part of the overall process to implement the low-emission vehicles/clean fuels program, specifications would need to be adopted to control the quality of clean fuels, for both the certification fuels and commercial fuels. In adopting specifications for clean fuels, the ARB would consider all information presented by fuel producers and sellers, vehicle manufacturers, consumers, the EPA, and any other interested parties.

1. Existing Candidate Clean Fuels

The staff plans to propose, for consideration by the ARB in September 1991, amendments to certification fuel specifications and new commercial fuel specifications for methanol, ethanol, LPG, CNG, and any other existing candidate clean fuel. The new specifications could be in addition to, or more restrictive than, any existing specifications. In developing the new specifications, the staff would consider the effects on emissions, any safety considerations, and the feasibility and cost of producing the fuel. The new specifications for both commercial and certification clean fuels would be effective beginning early in 1992. The proposed distribution and retail requirements for these fuels would not take effect until 1994 in the South Coast region and 1997 statewide.

2. New Candidate Clean Fuels

The staff believes that research will continue in an effort to develop better fuels. If such research results in the development of a new clean fuel, the staff would provide a procedure under which a proponent of a new fuel could petition the ARB to amend its regulations to establish certification and commercial specifications for the fuel. Prior to adopting such specifications, the ARB would consider any comments received and the cost-effectiveness of producing commercial quantities of the new fuel. If a proposed new clean fuel is capable of being used in motor vehicles other than those certified on the new fuel, the fuel proponent would also have to demonstrate that use of the new fuel;

- would not adversely affect the durability of the emission control systems; and

- would not result in increased emissions of criteria pollutants or toxic pollutants (benzene, 1,3-butadiene, formaldehyde, and acetaldehyde).

3. Substitute Clean Fuels

A gasoline supplier or other party could petition the ARB to adopt specifications for a substitute fuel that could be distributed in place of a particular primary clean fuel (the clean fuel that the substitute fuel would replace). To qualify a substitute fuel for ARB approval, the fuel proponent would have to demonstrate that use of the substitute fuel:

- would not result in higher criteria pollutant emissions than when the primary clean fuel is used in low-emission vehicles certified on the primary clean fuel;

- would not result in higher emission of toxics (benzene, 1,3-butadiene, formaldehyde, and acetaldehyde) than when the primary clean fuel is used in low-emission vehicles certified on the primary clean fuel;

- would not adversely affect the durability of the emission control systems in low-emission vehicles certified on the primary clean fuel or in any other vehicles capable of using the substitute fuel; and

- would not result in increased emissions of criteria pollutants or toxic pollutants (benzene, 1,3-butadiene, formaldehyde, and acetaldehyde) when compared to the use of gasoline in any other vehicles capable of using the new fuel.

The staff proposal includes test protocols for these demonstrations. The protocols, found in Appendix C, are designed to very conservative estimate for gasoline-powered vehicles. This approach will help assure that an appropriate "per vehicle" penalty attaches to violations of the distribution requirements. The regulations also provide that where a gasoline supplier relies on credits for compliance, whenever the credits were improperly generated, withdrawn or transferred, they cannot be counted towards compliance. The gasoline supplier directly responsible for compliance should be obligated to assure the validity of any credits used. At the same time, the supplier may have a cause of action against a person who improperly transferred credits to the supplier.

Whenever the owner/lessor of a gasoline retail outlet fails to have equipped the requisite stations to dispense clean fuels, the owner/lessor will be deemed to have sold gasoline in violation of the regulations. For each day of violation, sales of gasoline at the outlet to the first ten vehicles would be considered illegal. This would provide the availability of an appropriate and measured penalty. As with the case of credits, improper "constructive allocation" of clean fuel outlets would not satisfy the owner/lessor's obligations. The same treatment as described earlier in this paragraph would apply to operators of retail outlet who fail to make clean fuels available to the public in violation of the regulations. In this case, sales to the first five cars fueled with gasoline on each day would be deemed to be in violation.

I. ALTERNATIVE REGULATORY APPROACHES

The staff evaluated five alternative regulatory approaches to implementing a low-emitting vehicle and clean fuel program: 1) providing economic incentives alone; 2) mandating a specific vehicle technology and fuel; 3) requiring the production of low-emission vehicles, but not clean fuels; 4) establishing a numerical emission value for the fuel pool that all gasoline suppliers would have to meet; and 5) implementing the proposed program, but limit the clean fuels requirements to nonattainment areas of the state.

1. Provide Economic Incentives

Economic incentives could be established to encourage the production and sale of low-emitting vehicles and clean fuels. Lower vehicle registration and/or smog check fees could be established for low-emission vehicles. Lower sales taxes could be levied on clean fuels. Tax credits and lower permitting fees could also be granted to those service station owners that install clean fuel dispensing equipment.

The AB 234 Advisory Board evaluated the use of economic incentives as one of the many options for introducing clean fuels, and concluded that the best approach was to establish performance standards for fuels that were consistent with achieving environmental goals. Economic incentives alone would not ensure that clean fuels require clear demonstration of equivalent emissions on the substitute fuel, and will require testing of a wide variety of vehicles.

If the substitute fuel would not be usable in any other vehicles except those certified on the primary clean fuel, then the total required volume of the substitute fuel would just have to equal the total required volume of the primary clean fuel.

If the substitute fuel would be usable in vehicles other than those certified on the primary clean fuel (e.g., reformulated gasoline), the required distribution volume for the substitute fuel would have to be greater than the distribution volume for the primary fuel. To ensure that the desired number of low-emission vehicles certified on the primary fuel would receive the substitute fuel, the total required volume of the substitute fuel would have to equal the total required volume for the primary clean fuel plus the average quarterly volume of all gasoline distributed by a supplier to vehicles which are capable of using the substitute fuel, multiplied by the fuel volume adjustment factor (0.25 to 0.90) for the quarter. For example, if the total required volume of a primary clean fuel is 50 units, and 1000 units of substitute fuel could potentially be used in vehicles other than those certified on the primary clean fuel, and if the fuel volume adjustment factor is 0.5, then the total required volume of the substitute fuel would be 50 units, plus 1000 units times 0.5, or 550 units.

The average quarterly volume of gasoline would be based on taxable distributions of motor vehicle fuel for the last four quarters for which data are available, as reported to the State Board of Equalization pursuant to Revenue and Taxation Code section 7301 et. seq.

H. DETERMINATION OF VIOLATIONS

The regulations include provisions for identifying the violations that occur when a gasoline supplier or retail outlet owner/lessor fails to comply with the regulatory requirements. The only applicable penalty under the Health and Safety Code is the section 43016 civil penalty of up to $500 per vehicle for violations of vehicle and fuel regulations for there are no other specified penalties. Therefore it is necessary to identify how this "per vehicle" penalty applies to noncompliance.

Whenever a gasoline supplier distributes gasoline in a quarter where it fails to distribute its minimum assigned volume of a clean fuel, the supplier would be deemed to have sold gasoline in violation of the regulations. The volume unlawfully sold would be the same volume on an energy equivalent basis as the shortfall of clean fuel. A separate motor vehicle would be deemed to have been fueled with each 20 gallons of unlawfully sold gasoline, unless the gasoline supplier demonstrates that fewer vehicles were fueled. Based on the experience of the ARB's Compliance Division, 20 gallons per vehicle fueling is a would be distributed in sufficient quantities to adequately supply low-emitting vehicles. Although these types of incentives could be useful in combination with the staff proposal, the staff cannot incorporate them into the proposal because the ARB does not have the authority to provide economic incentives.

2. Mandate a Vehicle Technology and Particular Fuel

With this approach, the ARB would choose a vehicle emission control technology that must be used and the particular fuel which must be distributed by the fuel suppliers. While this approach would make the proposal easier to implement and enforce, and would make the results more predictable, it could stifle the development of better vehicle/fuel systems in the future. Rather than having the ARB decide on the most appropriate technologies and fuels, the staff believes it would be more productive to give industry the flexibility to determine the best combination to meet the emission reduction goals.

3. Require the Production of Low-Emission Vehicles, But Not Clean Fuel Availability

This approach would relieve gasoline suppliers of having to meet a clean fuel distribution requirement, and service stations of having to meet clean fuel retail outlet and availability requirements. The clean fuel would be distributed and made available only as the market dictated.

The staff is not convinced that market forces would provide sufficient incentive for the timely introduction of clean fuels. To meet the emission reduction goals defined in the proposed regulation, the clean fuels required by low-emission vehicles must be made available at a sufficient number of retail stations to be convenient, and be priced competitively with gasoline. Clean fuel market forces, alone, may not respond quickly enough to the demand created by the low-emission vehicles introduced in accordance with the proposed regulations. If vehicles do not use the clean fuels, emission reductions will not be realized.

4. Establish a Numerical Emission Value for the Fuel Pool That All Gasoline Suppliers Would Have to Meet

The ARB could introduce clean fuels by establishing a numerical emission value for the fuel pool that all gasoline suppliers would have to meet. In such a system, each fuel would be assigned an emission value representing the relative emission potential for that fuel with respect to some baseline fuel, such as gasoline. To meet the required pool emission value, sales of fuels with high emission potential would have to be offset with sales of (or purchasing of credits for) clean fuels with low emission potential.

The staff believes that this approach has many positive elements and should be considered further after the program becomes more established. However, the main drawback with this approach is the difficulty and complexity in establishing emission values for each fuel. The emission value would depend on the fuel characteristics and the emissions of each type of vehicle (TLEV, LEV, ULEV, ZEV) using this fuel. To develop a non-arbitrary method for assigning emission values to each fuel, the staff would need considerable data on the emission characteristics of both the new vehicles and fuels. Data on the emission characteristics of each fuel and on the number of low-emission vehicles would not be available in the beginning of the program.

5. <u>Implement the Proposed Program, but Limit the Clean Fuels Requirements to Nonattainment Areas Only</u>

An alternative to implementing the clean fuels distribution, retail outlet, and retail availability requirements statewide in 1997 would be to limit the clean fuel portion of the program to serious and severe ozone nonattainment areas only. Under this approach, any area not attaining the state ozone standard by January 1, 1994, or any area identified as serious or severe ozone nonattainment areas in their first update to the 1990 attainment plans required by the California Clean Air Act, would automatically enter the program in 1997. However, if a district submitted a plan that demonstrated that the clean fuel portion of the program is not needed to attain the state ozone standard as expeditiously as practical and that the program is not needed to maintain the standards after attainment, then ARB could allow the district to not participate in the program. The staff is still evaluating this alternative.

IV.

IMPACTS OF THE PROPOSAL

If the staff proposal is adopted by the Board, implementation would result in air quality benefits, costs, and environmental impacts. This chapter presents the staff's estimates of emission reductions and costs, followed by a discussion of the possible effects on small businesses and potential impacts on public safety and the environment.

A. EMISSION REDUCTIONS

Implementation of the proposed regulations would reduce emissions of criteria and toxic pollutants from on-road motor vehicles, and might also reduce emissions of greenhouse gases.

1. Criteria Pollutant Emissions

To evaluate the impact of the proposal on emissions in future years, the staff compared the projected baseline emissions without the proposal to the estimated emissions with the proposal. The baseline emissions include the reductions attributable to the 0.25 gram per mile (g/mi) non-methane hydrocarbon (NMHC) standard, the 0.4 g/mi nitrogen oxide (NOx) standard, and the 3.4 g/mi carbon monoxide (CO) standard for light-duty vehicles previously adopted by the ARB, as well as the medium-duty vehicle regulations adopted by the Board in June 1990.

Table 10 shows the estimated reductions in non-methane organic gases (NMOG), NOx, CO, and particulate matter (PM) emitted from light- and medium-duty vehicles that would result from implementation of the proposed regulations. Statewide emissions from on-road mobile sources would be reduced by about 29 tons per day of NMOG and 36 tons per day of NOx in 2000. By 2010, NMOG emissions would be reduced by 185 tons per day and NOx emissions by 248 tons per day. These reductions in 2010 represent 28 percent of on-road vehicular NMOG emissions and 18 percent of on-road vehicular NOx.

Table 10. Potential Emission Reductions
(tons/day)

Year	Non-Methane Organic Gases (NMOG)	Nitrogen Oxides (NOx)	Carbon Monoxide (CO)	Particulate Matter (PM)
		Statewide		
2000	29	36	14	0.4
2010	185	248	317	1.4
		South Coast Region Only		
2000	11	14	5	0.1
2010	71	99	118	0.4

2. Toxic Pollutant Emissions

The reductions in organic compounds that would have to be achieved to comply with the proposed NMOG emission standard would also result in a decrease in toxic air contaminants. The staff estimates that the reduction in organic toxic compounds (benzene, 1,3-butadiene, formaldehyde, acetaldehyde, and diesel particulate) due to implementation of this program would result in an annual reduction of about 20 to 40 potential cancer cases statewide by the year 2010*.

* As noted in Chapter I, vehicular toxic emissions (both on-road and off-road) are estimated to account for approximately 13,000 to 23,000 potential 70-year cancer cases (or about 190 to 330 cases per year), based on ambient measurements made in the late 1980s. By 2010, those toxic emissions are expected to decrease (due to fleet turnover and existing ARB regulations for motor vehicles) to a level equivalent to approximately 110 to 200 potential cancer cases per year. The staff estimates that this proposal would reduce on-road vehicular NMOG emissions by 28 percent in 2010, which is 19 percent of total vehicular (on-road and off-road) emissions. It can therefore be assumed that, if the fuel used to meet the standard is gasoline, at least 19 percent of the potential cancer cases associated with vehicular emissions in 2010 would be avoided, which is about 20 to 40 cases per year.

These benefits are based on the assumption that the fuel used is gasoline. The staff believes that the benefits would be at least as high, and possibly higher, if alternative non-gasoline clean fuels were used.

Emissions of benzene, the toxic pollutant with the highest potential carcinogenic risk among exhaust pollutants, would be reduced in about the same proportion as NMOG if low-emission vehicles are gasoline vehicles. If other fuels are used, the reduction of benzene would be even greater. For 1,3-butadiene (1,3-BD), the dependence of emissions upon NMOG emissions or the kind of fuel is not well known. However, the close-coupled or heated catalysts that the staff anticipates for low-emission vehicles should significantly reduce emissions of 1,3-BD because virtually all the 1,3-BD measured in exhaust is in the cold-start emissions that these catalysts are designed to control.

Emissions of formaldehyde and acetaldehyde would decrease along with NMOG emissions from gasoline-fueled vehicles, but would increase as fractions of NMOG if methanol or ethanol were the clean fuels. However, even if the mass emissions of these pollutants should increase somewhat relative to a vehicle certified at 0.25 gram/mile of NMOG, the increase in risk from these pollutants is likely to be much smaller than the decrease in risk from the benzene and the 1,3-butadiene.

3. Greenhouse Gas Emissions

Motor vehicle exhaust emissions are a significant source of greenhouse gases (such as carbon dioxide and methane). The use of different fuels can result in different levels of greenhouse gas emissions. There would likely be no adverse effect from a shift to cleaner fuels, and there may be a benefit. The staff's analysis, summarized in Table 11, concludes that emissions of greenhouse gases from natural gas, methanol (when made from natural gas), and ethanol may be lower in comparison with conventional gasoline.

Table 11. Relative Global-Warming Emissions Due to Alternative Fuels

Fuel	Relative Global-Warming Emissions*
Gasoline	1.0
Methanol from Natural Gas	0.9
Ethanol	0.8
Compressed Natural Gas	0.8
Methanol from Coal	>1.0

* Carbon dioxide, methane, and nitrous oxide from typical production and distribution processes and from vehicles.

Sources: Report to the Legislature--Executive Summary. California Advisory Board on Air Quality and Fuels, October 1989.

Comparing the Impacts of Different Transportation Fuels on the Greenhouse Effect, California Energy Commission, April 1989.

B. COSTS

Implementation of the proposed regulations would impact the vehicle and fuel industries, as well as consumers. This section contains the staff's estimates of:

1) the added costs of producing low-emission vehicles (compared to conventional vehicles);

2) the costs to produce, distribute, and provide retail outlets for clean fuels;

3) the expected annual cost to consumers;

4) the cost of the overall program; and

5) the cost-effectiveness of the proposal.

Unless otherwise noted, all of the costs shown are in 1990 dollars. All fuel costs are expressed in terms of the fuel needed to provide an amount of energy equivalent to the energy in one gallon of gasoline (gasoline-equivalent gallon). The costs also account for the differences in reactivity of the clean fuels. In calculating the emission reductions used to determine the cost-effectiveness of the proposal, the staff assumed that the mass emissions would equal the appropriate low-emission vehicle certification standard although the actual tailpipe emissions may exceed the standard due to a reactivity credit. The technical support document to this report contains the detailed assumptions and calculations used to develop the cost estimates presented in this chapter.

1. Cost of Low-Emission Vehicles

There are added costs associated with making low-emission vehicles, relative to the costs of making conventional vehicles. For gasoline-powered vehicles, these costs include costs for improved fuel preparation systems ($70) for transitional low-emission vehicles (TLEVs) and electrically heated catalysts ($170) for low-emission vehicles (LEVs) and ultra-low-emission vehicles (ULEVs). Additional costs associated with producing alternate fueled vehicles at the TLEV emission level are estimated to be $200 for methanol and ethanol (for the fuel composition sensor and alcohol-compatible components), $600 for LPG (for fuel control components and fuel storage system), and $1000 for CNG (for fuel control components and high pressure fuel storage system).

At the LEV emission level, methanol- and ethanol-fueled vehicles would need improved fuel preparation systems ($70), while LPG- and CNG-powered vehicles would need electronic fuel injection systems primarily for adequate control of NOx ($100 for LPG, $200 for CNG). Electrically heated catalysts ($170) would be needed for methanol-, ethanol-, and LPG-fueled vehicles to meet the ULEV emission levels. The incremental cost estimates of zero-emission vehicles (ZEVs) are based on advanced designs likely to be available in the 2000 timeframe.

The staff consulted with electric vehicle experts on the projected cost differential of a commercial, moderate volume electric vehicle compared to a conventional vehicle. They estimated that by 2000, electric vehicles would be comparable in cost to conventional vehicles except for the additional cost of batteries. Most often cited reasons for achieving cost parity were reduced costs of the electronics in the power controllers and achieving higher volume production levels for many of the other power train and body components unique to electric vehicles. In year 2000, advanced production batteries were estimated to cost an additional $1,350 for light-duty vehicles (the use of more exotic batteries such as sodium sulfur would cost more, but without significant improvement, they are less likely to be competitive with other more conventional batteries being developed).

A summary of the added costs of making light-duty, low-emission vehicles is shown in Table 12. Relative to conventional gasoline vehicles, the incremental purchase costs for light-duty low-emission vehicles could range from $70 more for TLEVs fueled with gasoline (i.e., heated fuel preparation system) to $1,350 more for electric ZEVs (i.e., higher battery costs). Methanol-powered light-duty vehicles, that are flexible-fueled vehicles (FFVs), would cost from $200 extra for TLEVs to $370 extra for ULEVs. The costs for medium-duty vehicles are similar or slightly higher.

Table 12. Estimated Added Costs of Light-Duty, Low-Emission Vehicles

	Added Costs ($)			
	Low-Emission Vehicle Category			
Fuel	TLEV	LEV	ULEV	ZEV
Gasoline	70	170	170	n/a
Methanol or Ethanol	200	270	370	n/a
LPG	600	700	870	n/a
CNG	1000	1200	1200	n/a
Electricity	n/a	n/a	n/a	1350

n/a: Not applicable.

The costs shown in Table 12 are retail price equivalent costs, or the costs to buyers of low-emission vehicles. Further details of the components required by each vehicle/fuel system are contained in the technical support document. These costs include the cost of making the components, as well as the price markups normally taken by vehicle manufacturers.

To produce vehicles capable of meeting the low-emission standards, vehicle manufacturers would have to perform additional research and development work. Vehicle manufacturers could also purchase credits or technology from other manufacturers or form consortiums.

2. Cost for Clean Fuels

There are costs associated with providing the clean fuels needed by low-emission vehicles. Gasoline suppliers would incur costs to produce or acquire clean fuels and distribute them. Gasoline station owners would incur costs to equip some of their stations as clean fuel retail outlets.

Table 13 shows the prices, including any applicable taxes, for potential clean fuels estimated for the year 2000 by the California Energy Commission (CEC). All of the prices shown are for one gasoline-equivalent gallon. These prices include the costs to produce, distribute, and equip retail outlets for the clean fuels.

The price shown for gasoline ($1.35 to $1.45) reflects a weighted average of the projected price of regular and premium gasoline for the year 2000, including an estimated range of the cost for future improvements. The cost for gasoline is based on a price of $1.30 per gallon, plus $0.05 to $0.15 per gallon for future improvements (not including the June 1990 proposition calling for increased gasoline taxes). The potential future improvements for gasoline include the staff's Phase 2 program, to be presented to the ARB in September 1991, and changes to gasoline that may be required by the federal Clean Air Act.

The cost for methanol reflects the estimate of the AB 234 Advisory Board for methanol produced in large, state-of-the-art plants. Until the demand for methanol increases to a level justifying new plants, the methanol cost might be higher than shown in the table. The price for electricity includes an off-peak power rate adjustment and reflects an adjustment by the staff to account for the greater energy efficiency of a non-combustion engine. The energy efficiencies of some of the other alternative-fueled vehicles may also be somewhat different from that of gasoline-powered vehicles, but there are not enough data to quantify the effects.

Table 13. Estimated Prices of Potential Clean Fuels for a Gasoline-Equivalent Gallon in 2000

Gasoline	$1.35 to $1.45*
Ethanol	$2.33
Methanol	$1.44 to $1.49
LPG	$0.98
CNG	$0.84
Electricity	$0.59

* Projected cost of gasoline with future improvements, such as the Phase 2 specifications.

Owners of electric vehicles would probably choose to equip their homes for recharging. A dedicated outlet would have to be installed, and possibly a separate meter. Because the one-time cost of these installations should be small (and would be borne by either the vehicle owner or the electric utility) they were not included in the analysis.

Once the volume of a clean fuel required to be distributed became large enough to require the construction of new production plants, fuel suppliers might want to construct and operate such plants to ensure their supplies and to minimize their costs of acquiring the fuel. For example, an economically-sized new methanol plant would cost from $800 to $900 million dollars to build. Although a few large oil companies might be able to finance such a plant independently, fuel suppliers might instead choose to form a consortium to build such a plant. If a small refiner or importer could not be a part of such an arrangement, the cost for that refiner or importer to acquire methanol to distribute might be higher than for companies that produced their own supplies. However, the continuing planning, design, and construction of new methanol plants worldwide suggests that an adequate supply of methanol will be available to fuel suppliers at reasonable prices.

The fuel costs shown in Table 13 include allowances for recovering the costs of installing clean fuel dispensing equipment at gasoline stations. The estimated costs to provide these clean fuel retail outlets are shown in Table 14. These costs would apply if a station owner chose to install new tanks and dispensers for a clean fuel. Some station owners with leaded gasoline pumps or methanol-compatible tanks may convert their equipment to dispense liquid clean fuels at a lower cost than the estimates shown in Table 14 for installing new equipment.

Since the South Coast AQMD adopted Rule 1170 in May 1988, stations in that district have been required to make at least one new fuel tank at each station methanol-compatible. Many major gasoline suppliers have also chosen to install new methanol-compatible tanks. Since the clean fuel price estimates that are shown in Table 13 and used for calculating consumer and program costs assume that gasoline station owners would have to install new equipment, the fuel portion of these costs may be less than the staff has estimated.

Table 14. Capital Costs to Equip a Gasoline Station as a Clean Fuel Retail Outlet

Fuel	Installed Cost
Methanol or Ethanol	$50,000 to $70,000
LPG	$40,000 to $75,000
CNG	$250,000*
Gasoline	$50,000 to $70,000

* At 30,000 gasoline-equivalent gallon size.

Stations owned by major oil companies and large independent stations should be able to finance this new equipment without experiencing a significant economic impact. Small independent stations might have more difficulty financing new equipment if they were required to install it. However, the proposal allows owners of a small number of stations more time before they would have to provide clean fuel retail outlets.

3. Cost to Consumers

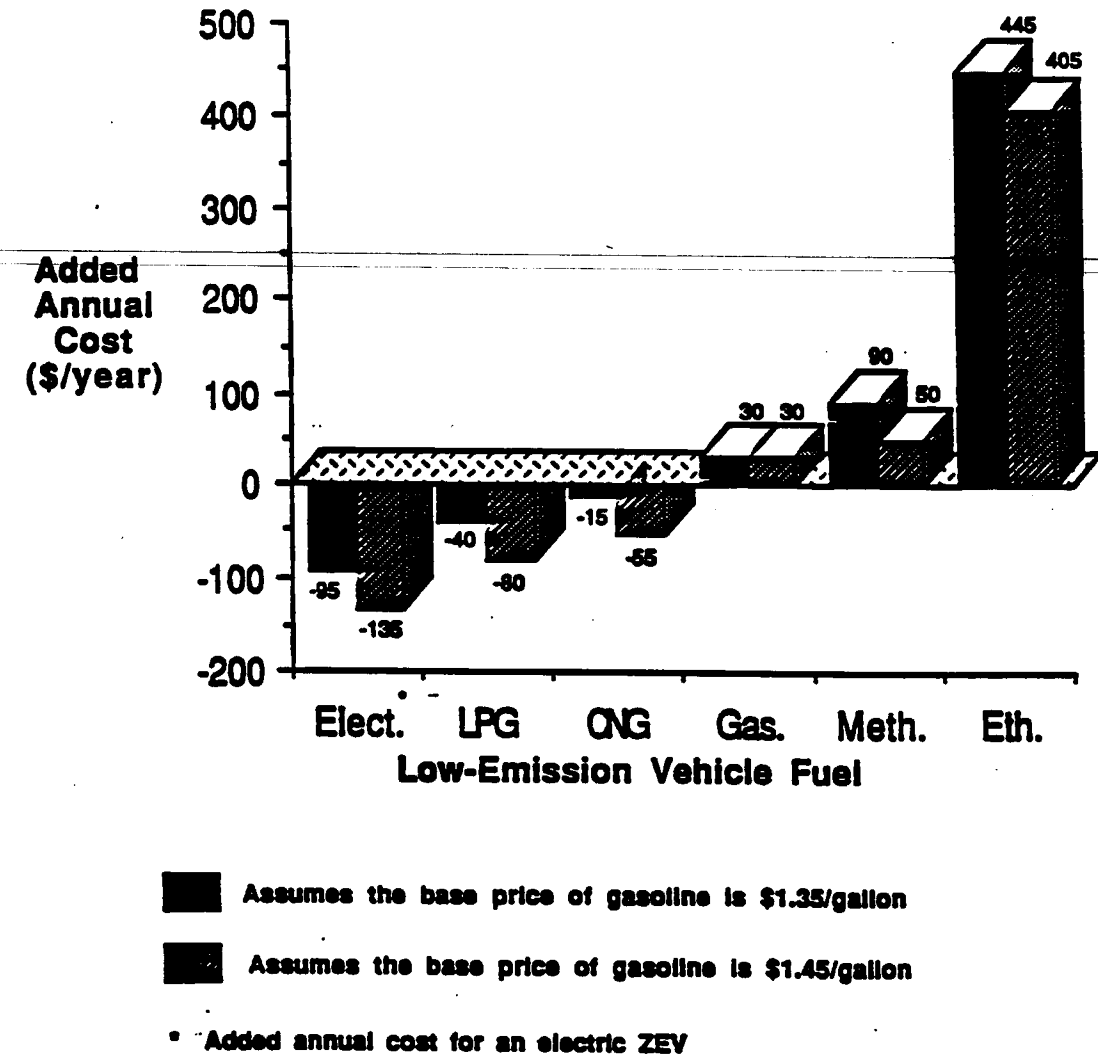
Vehicle manufacturers, clean fuel producers, gasoline suppliers, retail gasoline station owners, and station operators are likely to pass their costs to comply with the proposed regulations through to consumers. The staff evaluated the potential annual cost to consumers as a result of this proposal, including costs (or cost savings) for purchasing and fueling a low-emission vehicle. The staff assumed that the cost to consumers to maintain, insure, register, and smog-check most low-emission vehicles would be comparable to the cost for conventional gasoline-fueled vehicles. The maintenance cost for low-emission vehicles powered by gaseous clean fuels may be lower than the cost for conventional vehicles. The annual cost would vary depending on the low-emission standard (TLEV, LEV, ULEV, ZEV) that the vehicle is certified to and the type of clean fuel it needs.

Light-Duty Vehicles. The added costs (relative to the costs for conventional vehicles) of producing and fueling low-emission vehicles certified to LEV standards are shown in Figure 2. Costs run from a net savings for most categories of vehicles using LPG or CNG to over $400 per year for vehicles fueled with ethanol. The annual added costs for vehicles certified to TLEV or ULEV standards would be similar to those shown for LEVs. Costs for TLEVs could be $10 to $25 per year less than for LEVs, and costs for ULEVs could be zero to $25 per year more than for LEVs. Factors that may influence the relative cost of clean-fueled low-emission vehicles compared to conventional vehicles include changes in crude oil prices and the cost of reformulating conventional gasoline. An increase in oil prices would increase the price of gasoline and LPG to a greater degree than methanol, ethanol, and CNG. Increases in the cost of reformulating conventional gasoline, above the $0.05 to $0.15 assumed in the staff's costs, would also reduce the relative cost of the non-gasoline clean fuels.

The staff anticipates that all ZEVs will be powered by electricity. Owning and operating an electric ZEV would result in an estimated cost savings of about $90 to $130 per year, when the initial purchase price of the vehicle and the fuel cost savings are considered. Other factors affecting the lifetime cost of an electric ZEV include: the probable need to replace the battery once during a 10-year period, low or no maintenance costs, and no need for smog checks. Considering the uncertainties of the technology in 2000, the overall effects of these factors cannot be accurately predicted. It is likely, however, that the extra cost of the battery replacement will be offset by the reduced maintenance and avoided smog check costs.

Medium-Duty Vehicles. The added costs for medium-duty vehicles would be slightly higher than for light-duty vehicles because of a difference in fuel economy and use patterns between these two types of vehicles.

Figure 2. Added Annual Cost to Consumers to Own and Operate a Light-Duty, Low-Emission Vehicle (LEV) Relative to a Conventional Vehicle



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4. Overall Program Costs

The proposed regulations provide flexibility to vehicle manufacturers and fuel suppliers by allowing them to choose vehicle technologies and clean fuels to meet the requirements. Thus, the staff cannot predict the vehicle/fuel combinations that would be produced as a result of the program. To estimate the overall cost of the proposed low-emission vehicles and clean fuels program, the staff evaluated scenarios with different combinations of vehicles and fuels. The five scenarios and their corresponding estimated annual cost in the years 2000 and 2010 are shown in Table 15.

Table 15. Estimated Annual Program Cost in 2000 and 2010 for Five Low-Emission Vehicle/Clean Fuel Scenarios*

Low-Emission Vehicle/ Clean Fuel Combination	Annual Program Cost (million $) Year 2000 Gasoline @ $1.35/$1.45	Year 2010 Gasoline @ $1.35/$1.45
Scenario A TLEVs, LEVs, ULEVs use gasoline ZEVs use electricity	150 / 150	450 / 350
Scenario B TLEVs, LEVs, ULEVs use methanol ZEVs use electricity	590 / 300	2,100 / 950
Scenario C TLEVs use gasoline LEVs use methanol ULEVs use CNG ZEVs use electricity	510 / 250	1,600 / 470
Scenario D TLEVs use gasoline 80% of LEVs use methanol 20% of LEVs use ethanol 50% of ULEVs use CNG 50% of ULEVs use LPG ZEVs use electricity	910 / 660	3,100 / 2,000
Scenario E TLEVs, LEVs use gasoline ULEVs use CNG ZEVs use electricity	140 / 130	240 / 10

* These scenarios were selected for evaluation purposes and are not projections of the vehicle/fuel combinations that might occur. The scenarios assume all vehicles use the fuel they are certified on all the time.

5. Cost-Effectiveness of the Proposal

The cost-effectiveness of the proposal can be represented by the cost per pound of pollutants reduced from the vehicle fleet as a result of implementing the program, and the cost per potential cancer case avoided by the reduction of toxic air contaminants.

Because these regulations would reduce both ozone precursors and toxic pollutants, it is reasonable to divide the total program costs between the two. The staff has, therefore, allocated half of the program costs to criteria pollutant reductions and half of the costs to the estimated 20-40 potential cancer cases avoided per year as a result of toxic pollutant reductions. Using this approach, the cost per potential cancer case avoided is estimated to range from about $5 million to $50 million for most scenarios, (and up to $78 million per case for the most costly scenario). These values are within the range of cost-effectiveness values for other air toxic control measures already adopted by the ARB.

Table 16 presents the combined costs for the vehicles and the fuels (assuming the base price of gasoline is $1.35 per gallon) divided by the calculated per-vehicle emission reductions. The reductions in ozone precursors (NMOG and NOx) were computed by comparing the currently adopted standards with the low-emission standards, at 50,000 miles. The cost per pound of ozone precursors reduced ranges from a net savings for all kinds of LPG and CNG vehicles (plus their fuels) to $79 per pound for ethanol-powered TLEVs. The cost-effectiveness for methanol (M85) ranges from $5 to $16 per pound, depending on the emission standard and the cost of methanol. Electric vehicles would result in a cost savings.

Table 16. Cost-Effectiveness of Light-Duty, Low-Emission Vehicles and Clean Fuels if Gasoline is $1.35/Gallon*

	Cost Per Pound of Ozone Precursors Reduced ($) Low-Emission Standard			
Fuel	TLEV	LEV	ULEV	ZEV
Gasoline	2	2	2	n/a
Methanol (M85)	12-16	5-6	5-7	n/a
Ethanol	79	27	26	n/a
LPG	(-10)	(-2)	(-1)	n/a
CNG	(-9)	(-1)	(-1)	n/a
Electricity	n/a	n/a	n/a	(-3)

n/a: The fuel is not likely to be used for a vehicle certifying to the standard.

* These values were calculated assuming that one-half of the overall program cost is allocated to criteria pollutant reductions and one-half is allocated to the benefits of toxic air contaminant reductions.

Table 17 shows analogous numbers when the base price of gasoline is higher, at $1.45 per gallon. Accordingly, the costs per pound of emissions reduced are lower for the non-gasoline fuel types.

Table 17. Cost-Effectiveness of Light-Duty, Low-Emission Vehicles and Clean Fuels if Gasoline is $1.45/Gallon*

Fuel	Cost Per Pound of Ozone Precursors Reduced ($) Low-Emission Standard			
	TLEV	LEV	ULEV	ZEV
Gasoline	2	2	2	n/a
Methanol (M85)	5-9	2-4	3-4	n/a
Ethanol	72	25	23	n/a
LPG	(-17)	(-5)	(-3)	n/a
CNG	(-16)	(-3)	(-3)	n/a
Electricity	n/a	n/a	n/a	(-5)

n/a: The fuel is not likely to be used for a vehicle certifying to the standard.

* These values were calculated assuming that one-half of the overall program cost is allocated to criteria pollutant reductions and one-half is allocated to the benefits of toxic air contaminant reductions.

Table 18 shows the cost-effectiveness of the proposal for light-duty vehicles in 2010, for each of the same five scenarios shown in Table 15, applying half of the overall program cost to criteria pollutant reductions and half to toxic risk reductions. The cost per pound of ozone precursors reduced in Table 18 considers the reductions in NOx and NMOG emissions that correspond to the proposed emission standards. The cost-effectiveness numbers in Table 18 are based on the estimated cost-effectiveness of each potential low-emission vehicle and fuel combination (Table 16 and Table 17), along with assumed percentages of fleet penetration by fuel type for each scenario.

Table 18. Estimated Cost-Effectiveness of the Proposal for Year 2010 for Five Scenarios*

Low-Emission Vehicle/ Clean Fuel Combination	Cost Per Pound Of Ozone Precursors Reduced: Gasoline @ $1.35	Cost Per Pound Of Ozone Precursors Reduced: Gasoline @ $1.45	Cost per Potential Cancer Case Reduced: Gasoline @ $1.35	Cost per Potential Cancer Case Reduced: Gasoline @ $1.45
	($)		(million $)	
Scenario A TLEVs, LEVs, ULEVs use gasoline ZEVs use electricity	.70	.55	6 to 11	4 to 9
Scenario B TLEVs, LEVs, ULEVs use methanol ZEVs use electricity	3.30	1.50	26 to 53	12 to 24
Scenario C TLEVs use gasoline LEVs use methanol ULEVs use CNG ZEVs use electricity	2.50	.75	21 to 40	6 to 12
Scenario D TLEVs use gasoline 80% of LEVs use methanol 20% of LEVs use ethanol 50% of ULEVs use CNG 50% of ULEVs use LPG ZEVs use electricity	4.90	3.20	39 to 78	25 to 50
Scenario E TLEVs, LEVs use gasoline ULEVs use CNG ZEVs use electricity	.40	.02	3 to 6	.08 to .15

* These scenarios were selected for evaluation purposes and are not projections of the vehicle/fuel combinations that might occur. The scenarios assume all vehicles use the fuel they are certified on, all the time. It is assumed that the low-emission vehicle percentages in 2003 continue on through 2010. The values are based on the application of half of the overall program cost to criteria pollutant reductions and half to toxic pollutant reductions.

C. SMALL BUSINESS IMPACTS

Small businesses are defined by Government Code Section 11342 et seq. The Code requires the ARB to discuss how complying with a proposed regulation could adversely affect small businesses. The staff does not believe that adoption of the proposal would result in significant, adverse impacts on small businesses.

It unlikely that any vehicle manufacturer is a small business per criteria set forth in the code. The code also explicitly excludes refiners from the definition of a small business. Some independently owned and operated gasoline service stations may be small businesses. Typically, this type of small business could own only 1 or 2 stations in order to meet the small business requirement of combined retail sales of less than $2 million per year. This annual sales figure corresponds to gasoline sales of about 160,000 gallons per month, if gasoline is the only retail product or service offered at the station(s). The average net sales at retail gasoline service stations in the U.S. were about $1.3 million per station in 1989.

The proposed clean fuel regulation would allow these small businesses that own just a few gasoline stations additional time to comply with the clean fuel retail outlet requirement. The owners would not be required to equip any of their stations to dispense clean fuel until the total clean fuel volume approaches 50 percent of the statewide motor fuel volume. By this time, small businesses would have to install clean fuel capability to remain competitive in the fuel market, regardless of a requirement to do so.

The staff expects that any small businesses affected by the proposed regulations would be able to pass any compliance expenses through to the consumer in the form of higher product costs. In addition, small businesses affected by air pollution control regulations can apply for long-term, low interest loans for $10,000-$500,000 from the State Department of Commerce - Office of Small Business (OSB) and the California Pollution Control Financing Authority. Owners of gasoline stations that are small businesses could apply for these loans to ease the initial cost of installing clean fuel dispensing equipment.

The only requirement of retail station operators (distinct from the owners of the stations) would be to make a clean fuel available if the owner has equipped the station to sell the fuel. In the view of the staff, the need to offer a clean fuel would not impose a significant hardship.

D. POTENTIAL ENVIRONMENTAL IMPACTS

The staff believes that implementation of the proposed regulations would not result in substantial, adverse environmental impacts. The staff has not identified any adverse environmental or safety impacts due to low-emission vehicles that do not already exist with conventional vehicles. However, there may be potential environmental impacts associated with the clean fuels needed by those vehicles. The staff believes that the potential safety hazards and negative environmental impacts associated with clean fuels are no greater than the potential adverse impacts associated with the gasoline that would otherwise be used.

1. Environmental Impacts

Implementation of the proposal would have a substantial overall positive impact on the environment by reducing vehicle emissions. Although the proposal could result in increased production and use of clean fuels, the staff does not believe that it would result in any increase in overall fuel demand. The production, distribution, and marketing of clean fuels cause emissions of air pollutants. However, the emissions from clean fuels production and use would replace the emissions that would have been associated with a comparable amount of gasoline.

Should gasoline suppliers choose to construct new production facilities for clean fuels in California, they would need to obtain permits from the appropriate local air district to construct and operate a clean fuel production facility in the state. Existing new source review (NSR) rules would require the supplier to apply best available control technology (BACT) and offset the projected emission increases with equal or greater emission reductions at the same facility or another location. However, some districts have shown a willingness to consider exempting sources that make equipment modifications or process changes solely to implement an air pollution control regulation that will result in an overall air quality benefit. For example, South Coast AQMD Rule 1304 allows an increase in nonattainment air contaminants from equipment modifications or process changes if offsets are not available and if the increase resulted from complying with a district, state, or federal air pollution control regulation.

Gasoline service station owners would also have to obtain permits from the appropriate local agencies to install clean fuel dispensing equipment. A station would not generally have to obtain new permits if an existing gasoline pump was used instead to dispense a liquid clean fuel. A station required to obtain a permit to install new dispensing equipment might also be subject to the air district's NSR rules. The permit process and schedule for clean fuel dispensing equipment should be no different than the process and schedule for gasoline dispensing equipment.

2. <u>Global Warming and Ozone Depletion Impacts</u>

The production and use of low-emission vehicles and clean fuels are not expected to increase emissions of greenhouse gases that may contribute to global warming or pollutants that may contribute to stratospheric ozone depletion. Use of clean fuels may actually decrease emissions of greenhouse gases.

3. <u>Public Safety Impacts</u>

The various potential clean fuels identifiable today all carry risks of fire, explosion, poisoning, and water pollution. Some may be worse than gasoline in one or two of these regards but better in the others. The risks all appear to be manageable; and no fuel appears on the whole to be worse than gasoline in terms of safety.

V.

MAJOR LEGAL ISSUES

A. AUTHORITY FOR LOW-EMISSION VEHICLE ELEMENTS

The central mechanism of the low-emission vehicle elements of the proposal is the establishment of stringent exhaust emission standards for passenger cars, light-duty trucks and medium-duty vehicles. The state laws on vehicular pollution control clearly contemplate that the adoption by the ARB of exhaust emission standards for new vehicles is to be a central means for controlling emissions from motor vehicles (Health and Safety Code (HSC) sections 43013, 43018, 43101.) The ARB is authorized to adopt exhaust emission standards which it finds to be necessary, cost-effective, and technologically feasible (Id.) The extensive discussion on these factors in this report and its technical support document provides a basis for the required findings.

The lengthy leadtime for full implementation of the low-emission vehicle standards is pertinent to the technological feasibility of the proposal. The discussion in Chapter II indicates that the technologies which would enable compliance with the standards have been identified, the staff has evaluated the necessary steps for further refinement and development, and the staff has reasonably concluded that development can be completed in the time available. This is sufficient for a demonstration of technological feasibility. (cf. NRDC v. EPA, 655 F2d 318, 329-332 (CA DC, 1981).)

One manufacturer has asserted that the proposal contains "mandatory production percentages" and therefore may be inconsistent with the Board's authority under state and federal law. While the proposal provides that limited percentages of a manufacturer's production must meet the ZEV standards starting in the 1998 model year, this is conceptually no different from previous instances where the ARB has phased-in more stringent standards by establishing minimum percentages for some years. The technological feasibility of the ZEV standards is discussed in Chapter II.

The same manufacturer asserts that the "mandatory production percentages" would place an unconstitutional burden on interstate commerce, and would constitute an unconstitutional taking of property. There is no support for the interstate commerce clause claim. A relatively small percentage of motor vehicles sold in California are produced in the state, and the proposal in no way treats the two categories differently, either explicitly or in effect. The takings issue is discussed below in the context of the clean fuel element of the proposal. There is little doubt that the imposition of stringent air pollution emission standards is generally authorized under the police powers and does not constitute a taking of property.

B. AUTHORITY FOR CLEAN FUEL ELEMENTS

1. Statutory Authority

It is the opinion of the Board's counsel that the California Clean Air Act (CCAA) authorizes the Board, on appropriate findings of necessity, cost-effectiveness and technological feasibility, to adopt the clean fuels regulations proposed by staff.

The key statute is Health and Safety Code section 43018, enacted by the CCAA. Section 43018(a) and (b) spell out the goals and objectives the ARB must pursue in its motor vehicle regulatory program. Section 43018(a) directs the Board to endeavor to achieve the maximum degree of reductions possible from vehicles, in order to attain the state ambient standards by the earliest practicable date. Section 43018(b) directs the Board to achieve specified percentage reductions in emissions of reactive organic gases and NOx from motor vehicles by December 31, 2000, as well as maximum feasible reductions in particulates, carbon monoxide, and toxic air contaminants from vehicular sources. To do so, the Board is directed to take "whatever actions are necessary, cost effective, and technologically feasible." (emphasis added)

Section 43018(c) spells out the means by which the Board is to achieve the required goals and objectives. It directs the Board to adopt "standards and regulations which will result in the most cost-effective combination of control measures on all classes of motor vehicles and motor vehicle fuel . . . ." (emphasis added) The Legislature then lists in section 43018(c)(1)-(4) four broad types of control measures the Board must consider--reductions in exhaust and evaporative emissions, reductions in in-use emissions through improvements in emissions system durability and performance, requiring state fleet purchases of low-emission vehicles, and specification of vehicle fuel composition. However, the statute expressly provides that the Board's control measures are not to be limited to those specifically identified. The Board is authorized to adopt other sorts of control measures to reduce emissions from motor vehicles if they are necessary to achieve the goals and objectives.

Before enactment of the CCAA, the California Supreme Court had held that the Board's authority to establish vehicle emission standards included the authority to reduce vehicular emissions by regulating fuel composition. (Western Oil and Gas Ass'n [WOGA] v. Orange County APCD, 14 Cal.3d 411 (1975).) In enacting the CCAA, the Legislature stated its intent to clarify and expand the Board's authority with respect to the control of motor vehicle fuels. (HSC section 43000.5(e).) Since the Board already had the authority to regulate fuel composition, the Legislature must have intended section 43018 to grant additional authority to adopt control measures pertaining to fuels apart from just regulating fuel specifications. In addition, the court's reasoning in the 1975 WOGA case is illuminating. One reason the court gave for its holding was that the court was unwilling to attribute to the Legislature an intention to deprive the Board of the only realistic means it had to achieve the clean air goals established by state law (WOGA, 14 Cal.3d at 420). Similarly, it is unlikely that in the CCAA the Legislature intended to mandate the ambitious vehicle emission reduction goals in section 43018 without giving the Board the authority to adopt the range of control measures necessary to achieve those goals. As discussed elsewhere in this report, a program assuring the availability and distribution of clean fuels is necessary to attain the state ozone standard statewide.

The clean fuel availability provisions apply only to major gasoline suppliers in the first three years. Some commenters have suggested that this approach is prohibited by the recent Superior Court decision in Exxon v. CARB (Super. Ct., Sacramento County, No. 3362842). The court held that the CCAA provisions authorizing the Board's regulation limiting the aromatics content of diesel fuel (13 CCR sec. 2256) do not permit the Board to take into account the economic impact of its standards by adopting different limits for different segments of industry. As a Superior Court ruling, the case has no precedential effect. Moreover, the Board's counsel believes that the Board can differentiate among segments of industry on the basis of economic impacts. Section 43101 requires the Board to consider the impacts of its motor vehicle emission standards on the economy of the state; in light of the WOGA case this requirement applied to fuels regulations as well. The CCAA made sections 43013 and 43018 expressly applicable to both vehicles and fuels. It would be incongruous indeed for sections 43013 and 43018 to prohibit consideration of the economic impacts of fuel and vehicular regulations while section 43101 mandates such considerations for vehicular standards.

2. Constitutional Authority

a. The "Takings" Clause of the Fifth Amendment

WSPA and various oil companies have claimed that the provisions in the staff proposal requiring gasoline suppliers to distribute specified quantities of clean fuels violate the "takings clause" of the fifth amendment to the U.S. Constitution, which provides that "private property [shall not] be taken for public use without just compensation." The Board's legal counsel have considered these assertions and have concluded that on its face the proposal would not constitute an unconstitutional taking.

The threshold question is whether there is any property involved that could legitimately be claimed to be taken by the state or ARB. WSPA has asserted that the staff proposal in effect requires that a portion of each service station, bulk plant and perhaps each refinery be dedicated to the manufacture and distribution of alternative clean fuels, and that a regulation which requires dedication of private property for a public use constitutes a "taking." WSPA analogizes to Loretto v. Teleprompter Manhattan CATV Corp., 458 U.S. 419 (1982), which held that an ordinance requiring landlords to allow the installation of cable TV hook-up equipment constituted a "per se" taking of property because it sanctioned a "permanent physical occupation" of the landlord's property by the third party cable TV company. Loretto is clearly distinguishable because the proposed regulations in no way mandate the "occupation" of a refiner's or service station owner's property by the state or a third party. The business premises will continue to belong entirely to the refiner or station owner or lessor.

The staff proposal is much more closely analogous to other air pollution control regulations, promulgated under the state's basic police powers, which may necessitate the construction or installation of substantial equipment incident to meeting mandated emission reductions. A regulation prohibiting the sale of gasoline which exceeds specified sulfur or lead content limits may necessitate the installation of expensive new desulfurization or reforming equipment if the refiner is to continue to produce and distribute gasoline. Similarly, a gasoline vapor recovery regulation will necessitate the installation of vapor recovery systems if a service station is to continue operating. In neither of these cases is the necessary equipment--or the business as a whole--considered to be "occupied," "invaded," or "owned" by the state or a third party even though the sole reason for the equipment is the public purpose of reducing air pollution. While regulations of business activities such as these may raise issues of substantive due process (discussed below) in extreme situations, it is generally recognized that they do not constitute "takings of property" by the state.

Even if the proposed regulations were deemed to involve property interests that could be claimed subject to the "takings clause", the staff does not believe the regulations on their face impose a "taking." One of the key factors in a takings analysis is the "character of the governmental action." (Penn Central Transportation Co. v. New York, 438 U.S. 104 (1978).) This factor typically involves the question whether the government has "physically invaded" the claimant's property; as noted above, the proposed regulations do not present such an invasion. At times the U.S. Supreme Court has viewed the character of the governmental action in terms of the government's justification of the action--whether the regulation "substantially advance[s] legitimate state interests." (See Keystone Bituminous Coal Ass'n v. DeBenedictis, 480 U.S. 470, 485 (1987), quoting Agins v. Tiburon, 447 U.S. 255, 260 (1980).)

The staff believes that there are important ways in which the clean fuel provisions substantially advance legitimate governmental and public interests. Most broadly, the clean fuel program is designed to serve the public interest by contributing to the reduction of emissions of air pollutants from motor vehicles. As noted elsewhere in this report, the people of California face a very serious air pollution problem, and the clean fuel program is an integral part of the ARB's efforts to address the problem.

Moreover, the clean fuel requirements are expressly imposed as conditions upon the permissible distribution of gasoline, and the clean fuel program will help mitigate the air pollution burdens created by the sale of gasoline. Therefore there is a definite nexus between the activities regulated and the governmental interests being furthered.

First, the gasoline distributed and sold by those subject to the proposed regulations contributes to the very serious air pollution problems that exist in California. The alternative clean fuels that will be distributed under the program are expected to result in less pollution than gasoline. In particular, a majority of the alternative fuel vehicles will likely be designed to also run on gasoline so that they can be used in areas where only gasoline is available. Under the proposed regulations, such a vehicle would not be counted as a clean fuel vehicle unless it is certified to a more stringent standard while operating on the alternative fuel than while operating on gasoline. Therefore such vehicles will clearly pollute less when fueled with the alternative fuel compared to being operated when only gasoline is available. In this connection, the regulatory program is similar to the regulations adopted by EPA in the mid-1970's requiring any person operating a gasoline outlet with sales of more than 200,000 gallons per year to offer at least one grade of 87 octane unleaded gasoline. (40 CFR sec. 80.22(b).)

Second, oil companies have cumulatively contributed to the development of a motor vehicle fuel distribution network in which gasoline and diesel fuel are the only liquid fuels widely and conveniently available to the motoring public. This situation presents a strong deterrent to the effective introduction of alternative fuel vehicles. Requiring the distribution of appropriate volumes of clean alternative fuels for use in motor vehicles directly mitigates the present problem of a motor fuel distribution system focused almost exclusively on gasoline and diesel fuel. Finally, the gasoline production and distribution operations of refiners and service station operators emit substantial amounts of ozone-precursors and other air pollutants. The emissions reductions attributable to the clean fuel program will help mitigate these emissions.

Another key factor in a takings analysis is the economic impact of the government action. The U.S. Supreme court has stated that the nature of this inquiry depends on whether a regulation constitutes a taking "on its face" or "as applied" to a specific fact situation. Where a government action is challenged "on its face", it does not constitute a taking unless it denies an owner economically viable use of his or her property. (Keystone, supra, 480 U.S. at 494-495.) At this point the clean fuel regulations can only be analyzed on their face, as the staff does not know the extent to which clean fuel vehicles will be sold and the distribution of the clean fuels will be required, and what the economic impacts on refiners and station owners will be.

In evaluating the necessary effects of the proposed regulations on the economically viable use of the property of gasoline producers and service station owners, it is appropriate to look in the context of a reasonable unit of their business operations, rather than only the specific and limited operations of distributing the clean fuels. (see Keystone, supra, 480 U.S. at 499.) The staff believes that the refiners and others will be able to absorb the costs of the clean fuel program in their broader operations for distributing gasoline and diesel fuels. The staff is satisfied that gasoline producers and service station owners will continue to be able to operate on an adequately profitable basis.

b. "Substantive" Due Process

Police power regulations affecting economic interests generally satisfy the constitutional requirements of "substantive" due process as long as they are rationally related to a legitimate governmental interest. (American Bank & Trust Co. v. Community Hospital, 36 Cal.3d 359 (1984).) If such a regulation infringes upon a constitutionally protected personal liberty or fundamental right, it must be narrowly drawn and must further a sufficiently substantial government interest. (Griffin Development Co. v. City of Oxnard, 39 Cal.3d 256, 265 (1985).)

The "rational relationship" test is a less stringent variant of the "takings" test of whether a regulation substantially advances a legitimate state interest. The staff discusses above the ways in which the clean fuel regulations will substantially advance a legitimate state interest. These same factors demonstrate the rational relationship necessary to satisfy substantive due process.

Finally, the regulations do not trigger the more stringent substantive due process requirements which must be met where a constitutionally protected personal liberty or fundamental right is infringed. Selling gasoline is not a constitutionally protected activity. The California courts have held that constitutionally protected personal liberties and fundamental rights are not involved where a city prohibits the demolition or conversion of an apartment building to other uses unless no low or moderate income persons occupy or could afford units in the building, removal will not adversely affect housing supply, and the owner cannot make a reasonable return on his property (Nash v. City of Santa Monica, 37 Cal.3d 97 (1984)); where a city imposes stringent standards on conversions of apartment buildings to condominiums (Griffin Development, supra); and where a city prohibits the conversion of a residential hotel to another use unless one-to-one replacement of the hotel units is provided. (Terminal Plaza Corp. v. San Francisco, 177 Cal.App. 3d 892 (1986).) In light of these cases, the staff is not aware of any personal liberties or fundamental rights that would be infringed by the proposed regulations.

C. ANTITRUST CONCERNS

WSPA and various oil companies have vigorously expressed the view that federal and state antitrust laws severely restrict their ability to comply both with the clean fuel distribution provisions and with the clean fuel outlet requirements. The Board's counsel has evaluated these claims. The counsel has concluded that although compliance with the proposed requirements presents a challenge within the context of antitrust restrictions, the oil companies will have sufficient tools and flexibility to meet the clean fuel requirements.

The oil industry is concerned that refiners will be unable to establish adequate markets for distribution of their allocated amounts of clean fuel because under the federal Sherman Act and the state Cartwright Act they cannot control the price their independent dealers charge for the fuel. In addition, they are precluded in many circumstances by the Sherman and Clayton Acts from tying sales of clean fuels to sales of gasoline. However, the staff does not believe that such trade practices or restraints are necessary to achieve compliance. Particularly in light of the early year adjustment factors, the staff believes that gasoline suppliers will not have to distribute more clean fuel than the market will accept. Since a reasonable market should exist, gasoline suppliers should be able to distribute fuel as successfully as they distribute other products for which a strong distribution incentive exists. A prime example is unleaded premium, which has penetrated the market in substantially increasing volumes despite a substantially higher price than unleaded regular.

The industry has also expressed deep concerns about their ability to equip the requisite number of stations to dispense clean fuel, since in most cases the stations are not company-operated. Several refiners have stated that the federal Petroleum Marketing Practices Act (PMPA) in effect precludes non-uniform treatment of dealers. Board counsel has analyzed the PMPA and cases interpreting it. Oil companies wishing to equip a station to dispense a clean fuel may well need to revise the lease agreement to authorize such a change. In some instances a station operator might oppose such lease terms. The PMPA prohibits oil companies from terminating or failing to renew their lease and franchise agreements except on the basis if one of the specific grounds set forth in the PMPA. Under 15 USC section 2802(b)(3)(a), an oil company may refuse to renew a lease where the dealer and oil company fail to agree on lease changes, as long as the changes are the result of determinations made by the oil company in good faith and in the normal course of business, and the oil company is not using the changes as a pretext to avoid renewal. (See, e.g., Valentine v. Mobil Oil Corp., 814 F.Supp. 33 (USDC, D. Ariz. 1984).)

Where an oil company is required by state regulations to equip a minimum number of stations to dispense clean fuel, an approach in which the company selects stations based on reasonable, objective criteria without a discriminatory motive would appear to be consistent with the PMPA. Indeed, there are numerous instances in which oil companies have been permitted to convert full service stations with repair facilities to high volume "pumper stations" in the face of dealer opposition where good faith and non-discriminatory intent were shown. (e.g. Valentine, supra.) It is evident that such conversions could occur without the oil company simultaneously converting all stations.

Although a good deal of oil company flexibility does appear to exist, the staff is sensitive to the antitrust concerns raised. To the extent restraints are identified which could substantially preclude reasonable compliance, one possibility is the development of a more specific regulatory framework so that actions of the regulatory public may be justified under the "state action" doctrine first enunciated in Parker v. Brown, 317 U.S. 341 (1943).

LOW-EMISSION VEHICLES/CLEAN FUELS PROPOSAL
TITLE 13, CALIFORNIA CODE OF REGULATIONS, SECTIONS AFFECTED
(NOTE: Vehicle Sections Only)

Section 1900	- Definitions
Section 1904	- Applicability to Vehicles Powered by Fuels Other Than Gasoline or Diesel
Section 1960.1.5	- Optional NOx Standards for 1983 and Later Model Passenger Cars, and Light-Duty Trucks and Medium-Duty Vehicles less than 4000 lbs Equivalent Inertia Weight (EIW or 3751 lbs. Loaded Vehicle Weight (LVW)
Section 1960.5	- Certification of 1983 and Subsequent Model Year Federally Certified Light-Duty Motor Vehicles for Sale in California
Section 1965	- Emission Control Labels - 1979 and Subsequent Model Year Motor Vehicles
Section 2061	- Assembly-Line Test Procedures - 1983 and Subsequent Model Years
Section 2111	- Applicability
Section 2112	- Definitions
Section 2125	- Ordered Recall Plan
Section 2139	- Testing
Section 1960.1	- Exhaust Emission Standards and Test Procedures - 1981 and Subsequent Model Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles
Section 1956.8	- Exhaust Emission Standards and Test Procedures - 1985 and Subsequent Model Heavy-Duty Engines and Vehicles

NOTE: Amendments to Title 13, California Code of Regulations, proposed in this rulemaking are shown in <u>underline</u> to indicate additions to the text and ~~strikeout~~ to indicate deletions.

On June 14, 1990, the Board approved amendments to various sections in the California Code of Regulations to establish new regulations for medium-duty vehicles. These amendments have not yet been formally approved by the Office of Administrative Law. The amendments made by the medium-duty rulemaking are identified here by *italics*, with deletions shown in [*~~italicized strikeouts in brackets~~*]. The amendments pertaining to the June 14, 1990 medium-duty rulemaking are not a part of the present proposal made available at this time; however, some of the amendments in this proposal modify or otherwise affect the language from the medium-duty rulemaking. Deletions to the June 14, 1990 medium-duty rulemaking, proposed in this rulemaking, are shown in *~~italicized strikeouts~~*.

LOW-EMISSION VEHICLES/CLEAN FUELS PROPOSAL
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Section 1956.8	- Exhaust Emission Standards and Test Procedures - 1985 and Subsequent Model Heavy-Duty Engines and Vehicles

NOTE: Amendments to Title 13, California Code of Regulations, proposed in this rulemaking are shown in underline to indicate additions to the text and ~~strikeout~~ to indicate deletions.

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SECTION 1960.1.5, TITLE 13, CCR[2]

Amend Section 1960.1.5, Title 13, California Code of Regulations, as follows:

1960.1.5. Optional NOx Standards for 1983 and Later Model Passenger Cars, and Light-Duty Trucks and Medium-Duty Vehicles less than 4000 lbs. Equivalent Inertia Weight (EIW or 3751 lbs. Loaded Vehicle Weight (LVW).

(a)(1) Notwithstanding any other provision of this chapter, a vehicle manufacturer may certify 1983 and later model vehicles to optional NOx standards <u>except for vehicles certifying to TLEV, LEV, or ULEV standards</u> as follows:

(A) Passenger cars - 0.7 gm/mile - 1983 through 1988 model years.

LDT, MDV 0-3999 pounds EIW - 1.0 gm/mile - 1983 through 1987 model years.

LDT, MDV 0-3750 lbs. LVW - 1.0 g/mile - 1988 model year.

(B) For the 1989 model year, each manufacturer may certify no more than 50 percent of its projected California model-year sales of passenger cars, light-duty trucks (0-3750 lbs. LVW), and medium-duty vehicles (0-3750 lbs. LVW) to the optional NOx standard as follows:

Passenger cars - 0.7 gm/mi

LDT, MDV 0-3750 lbs. LVW - 1.0 gm/mi

(C) 1989 through 1993 model year passenger cars weighing more than 5250 lbs. LVW may be certified to the 0.7 gm/mile NOx standard.

(D) For the 1990 through 1993 model years, a vehicle manufacturer may certify passenger cars, light-duty trucks (0-3750 lbs. LVW), and medium-duty vehicles (0-3750 lbs. LVW) to the optional 0.7 gm/mi NOx standard subject to the following limitations:

For each model year, the total number of passenger cars (0-5250 lbs. LVW) each manufacturer may certify at 0.7 gm/mi NOx shall be limited to a maximum of 10 percent of the total previous California model-year sales of these vehicles.

For each model year, the total number of light-duty trucks (0-3750 lbs. LVW) and medium-duty vehicles (0-3750 lbs. LVW) each manufacturer may certify at 0.7 gm/mi NOx shall be limited to a maximum of 15 percent of the combined total previous California model-year sales of these vehicles.

For manufacturers certifying for the first time in California, "previous California model-year sales" shall mean projected California model-year sales.

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2. Subsections (b), (c), and (d) of Section 1960.1.5, Title 13, CCR, are not affected by this rulemaking.

SECTION 1960.1.5, TITLE 13, CCR[2]

Amend Section 1960.1.5, Title 13, California Code of Regulations, as follows:

1960.1.5. Optional NOx Standards for 1983 and Later Model Passenger Cars, and Light-Duty Trucks and Medium-Duty Vehicles less than 4000 lbs. Equivalent Inertia Weight (EIW or 3751 lbs. Loaded Vehicle Weight (LVW).

(a)(1) Notwithstanding any other provision of this chapter, a vehicle manufacturer may certify 1983 and later model vehicles to optional NOx standards except for vehicles certifying to TLEV, LEV, or ULEV standards as follows:

(A) Passenger cars - 0.7 gm/mile - 1983 through 1988 model years.
LDT, MDV 0-3999 pounds EIW - 1.0 gm/mile - 1983 through 1987 model years.
LDT, MDV 0-3750 lbs. LVW - 1.0 g/mile - 1988 model year.

(B) For the 1989 model year, each manufacturer may certify no more than 50 percent of its projected California model-year sales of passenger cars, light-duty trucks (0-3750 lbs. LVW), and medium-duty vehicles (0-3750 lbs. LVW) to the optional NOx standard as follows:

Passenger cars - 0.7 gm/mi
LDT, MDV 0-3750 lbs. LVW - 1.0 gm/mi

(C) 1989 through 1993 model year passenger cars weighing more than 5250 lbs. LVW may be certified to the 0.7 gm/mile NOx standard.

(D) For the 1990 through 1993 model years, a vehicle manufacturer may certify passenger cars, light-duty trucks (0-3750 lbs. LVW), and medium-duty vehicles (0-3750 lbs. LVW) to the optional 0.7 gm/mi NOx standard subject to the following limitations:

For each model year, the total number of passenger cars (0-5250 lbs. LVW) each manufacturer may certify at 0.7 gm/mi NOx shall be limited to a maximum of 10 percent of the total previous California model-year sales of these vehicles.

For each model year, the total number of light-duty trucks (0-3750 lbs. LVW) and medium-duty vehicles (0-3750 lbs. LVW) each manufacturer may certify at 0.7 gm/mi NOx shall be limited to a maximum of 15 percent of the combined total previous California model-year sales of these vehicles.

For manufacturers certifying for the first time in California, "previous California model-year sales" shall mean projected California model-year sales.

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2. Subsections (b), (c), and (d) of Section 1960.1.5, Title 13, CCR, are not affected by this rulemaking.

for Sale in California", adopted July 20, 1982, as last amended ~~December 20, 1989~~ ______________, which is incorporated herein by reference.

NOTE: Authority cited: Sections 39601, 43100 and 43102, Health and Safety Code. Reference: Section 43102, Health and Safety Code.

SECTION 1965, TITLE 13, CCR

Amend Section 1965, Title 13, California Code of Regulations, as follows:

1965. Emission Control Labels - 1979 and Subsequent Model Year Motor Vehicles.

In addition to all other requirements, emission control labels required by California certifiction procedures shall conform to the "California Motor Vehicle Emission Control Label Specifications", adopted March 1, 1978, as last amended ~~January 22, 1990~~ ___________.

NOTE: Authority cited: Sections 39600 and 39601, Health and Safety Code. Reference: Sections 39002, 39003, 43000, 43013, 43100, 43101, 43102, 43103, 43104, and 43107, Health and Safety Code.

SECTION 2061, TITLE 13, CCR

Amend Section 2061, Title 13, California Code of Regulations, as follows:

2061. Assembly-Line Test Procedures - 1983 and Subsequent Model Years.

New 1983 and subsequent model year passenger cars, light-duty trucks, and medium-duty vehicles, *excluding* <u>zero-emission vehicles and</u> *medium-duty vehicles certified according to the optional standards and test procedures of Section 1956.8, Title 13, California Code of Regulations,* subject to certification and manufactured for sale in California shall be tested in accordance with the "California Assembly-Line Test Procedures for 1983 and Subsequent Model Year Passenger Cars, Light-Duty Trucks and Medium-Duty Vehicles," adopted November 24, 1981, as last amended August 21, 1984, which is incorporated herein by reference, including federally certified light-duty motor vehicles, except as provided in "Guidelines for Certification of 1983 and Subsequent Model Year Federally Certified Light-Duty Motor Vehicles for Sale in California", adopted July 20, 1982, as last amended ~~December 20, 1989~~ ______________, which is incorporated herein by reference. For vehicles certified to NMOG standards, any reference to NMHC standards in "California Assembly-Line Test Procedures for 1983 and Subsequent Model Year Passenger Cars, Light-Duty Trucks and Medium-Duty Vehicles" shall imply NMOG standards.

for Sale in California", adopted July 20, 1982, as last amended ~~December 20, 1989~~ _______________ , which is incorporated herein by reference.

NOTE: Authority cited: Sections 39601, 43100 and 43102, Health and Safety Code. Reference: Section 43102, Health and Safety Code.

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Amend Section 1965, Title 13, California Code of Regulations, as follows:

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In addition to all other requirements, emission control labels required by California certifiction procedures shall conform to the "California Motor Vehicle Emission Control Label Specifications", adopted March 1, 1978, as last amended ~~January 22, 1990~~ ____________.

NOTE: Authority cited: Sections 39600 and 39601, Health and Safety Code. Reference: Sections 39002, 39003, 43000, 43013, 43100, 43101, 43102, 43103, 43104, and 43107, Health and Safety Code.

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Amend Section 2061, Title 13, California Code of Regulations, as follows:

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(5) For 1982 through 1987 model year gasoline heavy-duty vehicles (except medium-duty vehicles) certified using the steady-state emission standards and test procedures, and 1982 through 1987 model year gasoline heavy-duty motor vehicle engines certified using the steady-state emission standards and test procedures, a period of use of five years or 50,000 miles, whichever first occurs.

(6) For 1987 and subsequent model year gasoline heavy-duty vehicles (except medium-duty vehicles) certified to the transient emission standards and test procedures, and 1987 and subsequent model year gasoline heavy-duty motor vehicle engines certified using the transient emission standards and test procedures, a period of use of eight years or 110,000 miles, whichever first occurs.

(7) For 1985 and subsequent model year diesel heavy-duty vehicles (except medium-duty vehicles), and 1985 and subsequent model year motor vehicle engines used in such vehicles, a period of use of eight years or 110,00 miles, whichever firt occurs, for diesel light, heavy-duty vehicles; eight years or 185,000 miles, whichever first occurs, for diesel medium, heay-duty vehicles; and eight years or 290,000 miles, whichever first occurs, for diesel heavy, heavy-duty vehicles; or any alternative useful life period approved by the Executive Officer. (The classes of diesel light, medium, and heavy, heavy-duty vehicles are defined in 40 CFR Section 86.085-2, as amended November 16,1983.)

(8) For light-duty and medium-duty vehicles certified under the Optional 100,000 Mile Certification Procedure, and motor vehicle engines used in such vehicles, a period of use of ten years of 100,000 miles, whichever first occurs.

(9) For 1995 and subsequent model-year medium-duty vehicles, and motor vehicle engines used in such vehicles and <u>1992 and subsequent model-year medium-duty low-emission and ultra-low-emission vehicles, and motor vehicle engines used in such vehicles</u>*, a period of use of eleven years or 120,000 miles, whichever occurs first.*

[~~(9)~~] (10) For all other light-duty and medium-duty vehicles, and motor vehicle engines used in such vehicles, a period of use of five years or 50,000 miles, whichever first occurs. For those passenger cars, light-duty trucks and medium-duty vehicles certified pursuant to Section 1960.1.5, Title 13, California Code of Regulations, the useful life shall be seven years or 75,000 miles, whichever first occurs; however, the manufacturer's reporting and recall responsibility beyond 5 years or 50,000 miles shall be limited, as provided in Section 1960.1.5. For those passenger cars and light-duty trucks certified pursuant to Title 13, California Code of Regulations, Section 1960.1(f) <u>and Section 1960.1(g)</u>, the useful life shall be ten years or 100,000 miles, whichever first occurs; however<u>, for those vehicles certified under Section 1960.1(f),</u> the manufacturer's warranty failure and defects reporting and recall responsibility shall be subject to the conditions and standards specified in Section 1960.1(f).

NOTE: Authority cited: Sections 39600, 39601 *,43013, 43018, 43101, 43104*, and 43105, Health and Safety Code. Reference: Sections *39002, 39003*, 43000, 43009.5, *43013*, 43018, *43100*, 43101,

(5) For 1982 through 1987 model year gasoline heavy-duty vehicles (except medium-duty vehicles) certified using the steady-state emission standards and test procedures, and 1982 through 1987 model year gasoline heavy-duty motor vehicle engines certified using the steady-state emission standards and test procedures, a period of use of five years or 50,000 miles, whichever first occurs.

(6) For 1987 and subsequent model year gasoline heavy-duty vehicles (except medium-duty vehicles) certified to the transient emission standards and test procedures, and 1987 and subsequent model year gasoline heavy-duty motor vehicle engines certified using the transient emission standards and test procedures, a period of use of eight years or 110,000 miles, whichever first occurs.

(7) For 1985 and subsequent model year diesel heavy-duty vehicles (except medium-duty vehicles), and 1985 and subsequent model year motor vehicle engines used in such vehicles, a period of use of eight years or 110,00 miles, whichever firt occurs, for diesel light, heavy-duty vehicles; eight years or 185,000 miles, whichever first occurs, for diesel medium, heay-duty vehicles; and eight years or 290,000 miles, whichever first occurs, for diesel heavy, heavy-duty vehicles; or any alternative useful life period approved by the Executive Officer. (The classes of diesel light, medium, and heavy, heavy-duty vehicles are defined in 40 CFR Section 86.085-2, as amended November 16,1983.)

(8) For light-duty and medium-duty vehicles certified under the Optional 100,000 Mile Certification Procedure, and motor vehicle engines used in such vehicles, a period of use of ten years of 100,000 miles, whichever first occurs.

(9) For 1995 and subsequent model-year medium-duty vehicles, and motor vehicle engines used in such vehicles and 1992 and subsequent model-year medium-duty low-emission and ultra-low-emission vehicles, and motor vehicle engines used in such vehicles, *a period of use of eleven years or 120,000 miles, whichever occurs first.*

[~~(9)~~] *(10)* For all other light-duty and medium-duty vehicles, and motor vehicle engines used in such vehicles, a period of use of five years or 50,000 miles, whichever first occurs. For those passenger cars, light-duty trucks and medium-duty vehicles certified pursuant to Section 1960.1.5, Title 13, California Code of Regulations, the useful life shall be seven years or 75,000 miles, whichever first occurs; however, the manufacturer's reporting and recall responsibility beyond 5 years or 50,000 miles shall be limited, as provided in Section 1960.1.5. For those passenger cars and light-duty trucks certified pursuant to Title 13, California Code of Regulations, Section 1960.1(f) and Section 1960.1(g), the useful life shall be ten years or 100,000 miles, whichever first occurs; however, for those vehicles certified under Section 1960.1(f), the manufacturer's warranty failure and defects reporting and recall responsibility shall be subject to the conditions and standards specified in Section 1960.1(f).

NOTE: Authority cited: Sections 39600, 39601 *,43013, 43018, 43101, 43104*, and 43105, Health and Safety Code. Reference: Sections *39002, 39003*, 43000, 43009.5, *43013*, 43018, *43100*, 43101,

(C) An estimate of the average emission level per pollutant for a class or category of vehicles or engines after repair as corrected by the required capture rate. The estimated average emission level shall comply with the applicable emission standards. If the average emissions levels achieved by applying the average emission reduction per vehicle or engine after repair and the estimated capture rate, do not achieve compliance with the emissions standards, a manufacturer shall propose other measures to achieve average emissions compliance.

NOTE: Authority cited: Sections 39600, 39601 and 43105, Health and Safety Code. Reference: Sections 43000, 43009.5, 43018, 43101, 43104, 43105, 43106, 43107, and 43204-43205.5, Health and Safety Code.

SECTION 2139, TITLE 13, CCR[7]

Amend Section 2139, Title 13, California Code of Regulations, as follows:

2139. Testing.

(c)(2) Medium-duty vehicles may be tested according to the chassis test procedures specified in Section ~~*1960.1(j)*~~ 1960.1(k)*, if a manufacturer develops correlation factors which establish the relationship between engine and chassis testing for each engine family and includes these correlation factors as part of the manufacturer's application for certification. The correlation factors shall be applied to the measured in-use chassis exhaust emission data to determine the in-use engine exhaust emission levels. All correlation factors included in a manufacturer's application must be submitted to and approved by the Executive Officer in advance of their use by a manufacturer. The Executive Officer shall approve a submitted correlation factor if it accurately corresponds to other established empirical and theoretical correlation factors and to emission test data available to the Executive Officer.*

A manufacturer may choose, in the application for certification, to use the results from the chassis in-use testing as a screening test. If an engine family does not demonstrate compliance with any of the applicable in-use engine standards, as determined from the chassis test data and the applied correlation factors, the manufacturer shall be subject to the requirements and costs of in-use compliance engine testing, as specified in Section 2139(c)(1).

NOTE: Authority cited: Sections 39600, 39601,*43013, 43018, 43101, 43104*, and 43105, Health and Safety Code. Reference: Sections *39002, 39003*, 43000, 43009.5, *43013*, 43018, *43100*, 43101, *43101.5, 43102, 43103*, 43104, 43105, 43106, 43107, 43204-43205.5, Health and Safety Code.

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7. Subsections *(a)*, *(b)*, *(c)(1)*, *(c)(3)*, *(d)*, *(e)*, and *(f)* of Section 2139, Title 13, CCR, are not affected by this rulemaking.

(C) An estimate of the average emission level per pollutant for a class or category of vehicles or engines after repair as corrected by the required capture rate. The estimated average emission level shall comply with the applicable emission standards. If the average emissions levels achieved by applying the average emission reduction per vehicle or engine after repair and the estimated capture rate, do not achieve compliance with the emissions standards, a manufacturer shall propose other measures to achieve average emissions compliance.

NOTE: Authority cited: Sections 39600, 39601 and 43105, Health and Safety Code. Reference: Sections 43000, 43009.5, 43018, 43101, 43104, 43105, 43106, 43107, and 43204-43205.5, Health and Safety Code.

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A manufacturer may choose, in the application for certification, to use the results from the chassis in-use testing as a screening test. If an engine family does not demonstrate compliance with any of the applicable in-use engine standards, as determined from the chassis test data and the applied correlation factors, the manufacturer shall be subject to the requirements and costs of in-use compliance engine testing, as specified in Section 2139(c)(1).

NOTE: Authority cited: Sections 39600, 39601,*43013, 43018, 43101, 43104*, and 43105, Health and Safety Code. Reference: Sections *39002, 39003*, 43000, 43009.5, *43013*, 43018, *43100*, 43101, *43101.5, 43102, 43103*, 43104, 43105, 43106, 43107, 43204-43205.5, Health and Safety Code.

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7. Subsections *(a)*, *(b)*, *(c)(1)*, *(c)(3)*, *(d)*, *(e)*, and *(f)* of Section 2139, Title 13, CCR, are not affected by this rulemaking.

(a)(1) The exhaust emissions (i) from new 1985 and subsequent model heavy-duty diesel engines (except methanol-fueled engines) and heavy-duty natural-gas-fueled and liquified-petroleum-gas-fueled engines derived from diesel-cycle engines, (ii) from new 1991 and subsequent model heavy-duty methanol-fueled diesel transit bus engines, and (iii) from all new 1993 and subsequent model heavy-duty methanol-fueled, diesel engines, except in all cases engines used in medium-duty vehicles, shall not exceed:

Exhaust Emission Standards
(grams per brake horsepower-hour)

Model Year	Total Hydrocarbons or OMHCE[A]	Optional Nonmethane Hydrocarbons[A]	Carbon Monoxide	Oxides of Nitrogen	Particulates
1985-1986	1.3		15.5	5.1	---
1987[B]	1.3		15.5	5.1	---
1988-1989	1.3		15.5	6.0	0.60
1990	1.3	1.2	15.5	6.0	0.60
1991-1993[C]	1.3	1.2	15.5	5.0	0.10
1991-1993[D]	1.3	1.2	15.5	5.0	0.25 [E]
1994 and subsequent	1.3	1.2	15.5	5.0	0.10 [E]

[A] The total or optional nonmethane hydrocarbon standards apply to petroleum-fueled, natural-gas-fueled and liquified-petroleum-gas-fueled engines. The Organic Material Hydrocarbon Equivalent, or OMHCE, standards apply to methanol-fueled engines.

[B] As an option a manufacturer may elect to certify to the 1988 model year emission standards one year early, for the 1987 model year.

[C] These standards apply to urban bus engines only.

[D] For engines other than urban bus engines. For methanol-fueled engines, these standards shall be applicable beginning with the 1993 model year.

[E] Emissions averaging may be used to meet this standard. Averaging is restricted to within each useful life subclass and is applicable only through the 1995 model year. Emissions from engines used in urban buses shall not be included in the averaging program. However, emissions from methanol-fueled, natural-gas-fueled and liquified petroleum-gas-fueled urban bus engines certified to 0.10 grams per brake horsepower-hour particulates may be included in the averaging program for petroleum-fueled engines other than urban bus engines.

(a)(1) The exhaust emissions (i) from new 1985 and subsequent model heavy-duty diesel engines (except methanol-fueled engines) and heavy-duty natural-gas-fueled and liquified-petroleum-gas-fueled engines derived from diesel-cycle engines, (ii) from new 1991 and subsequent model heavy-duty methanol-fueled diesel transit bus engines, and (iii) from all new 1993 and subsequent model heavy-duty methanol-fueled, diesel engines, except in all cases engines used in medium-duty vehicles, shall not exceed:

Exhaust Emission Standards
(grams per brake horsepower-hour)

Model Year	Total Hydrocarbons or OMHCE[A]	Optional Nonmethane Hydrocarbons[A]	Carbon Monoxide	Oxides of Nitrogen	Particulates
1985-1986	1.3		15.5	5.1	---
1987[B]	1.3		15.5	5.1	---
1988-1989	1.3		15.5	6.0	0.60
1990	1.3	1.2	15.5	6.0	0.60
1991-1993[C]	1.3	1.2	15.5	5.0	0.10
1991-1993[D]	1.3	1.2	15.5	5.0	0.25 [E]
1994 and subsequent	1.3	1.2	15.5	5.0	0.10 [E]

[A] The total or optional nonmethane hydrocarbon standards apply to petroleum-fueled, natural-gas-fueled and liquified-petroleum-gas-fueled engines. The Organic Material Hydrocarbon Equivalent, or OMHCE, standards apply to methanol-fueled engines.

[B] As an option a manufacturer may elect to certify to the 1988 model year emission standards one year early, for the 1987 model year.

[C] These standards apply to urban bus engines only.

[D] For engines other than urban bus engines. For methanol-fueled engines, these standards shall be applicable beginning with the 1993 model year.

[E] Emissions averaging may be used to meet this standard. Averaging is restricted to within each useful life subclass and is applicable only through the 1995 model year. Emissions from engines used in urban buses shall not be included in the averaging program. However, emissions from methanol-fueled, natural-gas-fueled and liquified petroleum-gas-fueled urban bus engines certified to 0.10 grams per brake horsepower-hour particulates may be included in the averaging program for petroleum-fueled engines other than urban bus engines.

Exhaust Emission Standards
(grams per brake horsepower-hour)

Model Year	Total Hydrocarbons or OMHCE[A]	Optional Nonmethane Hydrocarbons	Carbon Monoxide[B]	Oxides of Nitrogen
1987[C]	1.1 [D] 1.9 [E]		14.4 [D] 37.1 [E]	10.6 10.6
1988-1989	1.1 [D] 1.9 [E]		14.4 [D] 37.1 [E]	6.0 6.0
1990	1.1 [D] 1.9 [E]	0.9 [D] 1.7 [E]	14.4 [D] 37.1 [E]	6.0 6.0
1991 [~~and~~] [~~Subsequent~~] *through 1994*	1.1 [D] 1.9 [E]	0.9 [D] 1.7 [E]	14.4 [D] 37.1 [E]	5.0 5.0
1995 and Subsequent 5.0	*1.9* [E]	*1.7* [E]	*37.1* [E]	

[A] The total and optional nonmethane hydrocarbon standards apply to gasoline-fueled, natural-gas-fueled and liquified-petroleum-gas-fueled engines. The Organic Material Hydrocarbon Equivalent, or OMHCE, standards apply to methanol-fueled engines.

[B] Carbon Monoxide emissions from engines utilizing exhaust aftertreatment technology shall also not exceed 0.5 percent of the exhaust gas flow at curb idle.

[C] Manufacturers with existing heavy-duty otto-cycle engines certified to the California 1986 steady-state emission standards and test procedures may as an option certify those engines, for the 1987 model year only, in accordance with the standards and test procedures for 1986 heavy-duty otto-cycle engines established in Section 1956.7.

[D] These standards are applicable to otto-cycle engines intended for use in all heavy-duty vehicles.

[E] Applicable to heavy-duty otto-cycle engines intended for use only in vehicles with a gross vehicle weight rating greater than 14,000 pounds. Also, as an option, a manufacturer may certify one or more *1988 through 1994 model* otto-cycle heavy-duty engine configurations intended for use in all heavy-duty vehicles to these emission standards, provided, that the total model year sales of such configuration(s) being certified to these emission standards represent no more than 5 percent of total model year sales of all otto-cycle heavy-duty engines intended for use in vehicles with a Gross Vehicle Weight Rating of up to 14,000 pounds by the manufacturer.

Exhaust Emission Standards
(grams per brake horsepower-hour)

Model Year	Total Hydrocarbons or OMHCE[A]	Optional Nonmethane Hydrocarbons	Carbon Monoxide[B]	Oxides of Nitrogen
1987[C]	1.1 D 1.9 E		14.4 D 37.1 E	10.6 10.6
1988-1989	1.1 D 1.9 E		14.4 D 37.1 E	6.0 6.0
1990	1.1 D 1.9 E	0.9 D 1.7 E	14.4 D 37.1 E	6.0 6.0
1991 [~~*and*~~] [~~*Subsequent*~~] *through 1994*	1.1 D 1.9 E	0.9 D 1.7 E	14.4 D 37.1 E	5.0 5.0
1995 and Subsequent 5.0	*1.9* *E*	*1.7* *E*	*37.1* *E*	

A The total and optional nonmethane hydrocarbon standards apply to gasoline-fueled, natural-gas-fueled and liquified-petroleum-gas-fueled engines. The Organic Material Hydrocarbon Equivalent, or OMHCE, standards apply to methanol-fueled engines.

B Carbon Monoxide emissions from engines utilizing exhaust aftertreatment technology shall also not exceed 0.5 percent of the exhaust gas flow at curb idle.

C Manufacturers with existing heavy-duty otto-cycle engines certified to the California 1986 steady-state emission standards and test procedures may as an option certify those engines, for the 1987 model year only, in accordance with the standards and test procedures for 1986 heavy-duty otto-cycle engines established in Section 1956.7.

D These standards are applicable to otto-cycle engines intended for use in all heavy-duty vehicles.

E Applicable to heavy-duty otto-cycle engines intended for use only in vehicles with a gross vehicle weight rating greater than 14,000 pounds. Also, as an option, a manufacturer may certify one or more *1988 through 1994 model* otto-cycle heavy-duty engine configurations intended for use in all heavy-duty vehicles to these emission standards, provided, that the total model year sales of such configuration(s) being certified to these emission standards represent no more than 5 percent of total model year sales of all otto-cycle heavy-duty engines intended for use in vehicles with a Gross Vehicle Weight Rating of up to 14,000 pounds by the manufacturer.

Exhaust Emission Standards [A]
(grams per brake horsepower-hour)

Model Year	*Carbon Monoxide*	*Non-methane Hydrocarbon and Oxides of Nitrogen* [B]	*Particulates* [C]
1995 [D] *and Subsequent*	*14.4*	*3.9*	*0.10*

[A] *This set of standards is optional. Manufacturers of engines used in incomplete medium-duty vehicles or diesel engines used in medium-duty vehicles from 8501-14,000 pounds, gross vehicle weight may choose to comply with these standards as an alternative to the primary emission standards and test procedures specified in Section 1960.1, Title 13, California Code of Regulations. Manufacturers that choose to comply with these optional heavy-duty standards and test procedures shall specify, in the application for certification, an in-use compliance test procedure, as provided in Section 2139(c), Title 13, California Code of Regulations.*

[B] *This standard is the sum of the individual non-methane hydrocarbon emissions and oxides of nitrogen emissions. For methanol-fueled engines, non-methane hydrocarbons shall mean organic material hydrocarbon equivalent.*

[C] *This standard shall only apply to diesel engines and vehicles.*

[D] *In the 1995 model-year only, manufacturers may certify up to 50 percent of their medium-duty engines or vehicles to the applicable 1994 model-year standards and test procedures. For the 1995 through 1997 models, alternative in-use compliance is available for medium-duty manufacturers. A manufacturer may use alternative in-use compliance for up to 100 percent of its fleet in the 1995 and 1996 model years and up to 50 percent of its fleet in the 1997 model year. The percentages shall be determined from the manufacturers' projected California sales of medium-duty vehicles. For engines certified to the standards and test procedures of this subsection, "alternative in-use compliance" shall consist of an allowance of 25 percent over the HC + NOx standard.*

(f) The exhaust emission levels from new 1992 and subsequent model-year engines used in incomplete medium-duty low-emission vehicles, and ultra-low-emission vehicles and for diesel engines used in medium-duty low-emission vehicles, and ultra-low-emission vehicles shall not exceed:

Exhaustive Emission Standards [A]
(grams per brake horsepower-hour)

Model Year	*Carbon Monoxide*	*Non-methane Hydrocarbon and Oxides of Nitrogen* [B]	*Particulates* [C]
1995 [D] *and Subsequent*	*14.4*	*3.9*	*0.10*

[A] *This set of standards is optional. Manufacturers of engines used in incomplete medium-duty vehicles or diesel engines used in medium-duty vehicles from 8501-14,000 pounds, gross vehicle weight may choose to comply with these standards as an alternative to the primary emission standards and test procedures specified in Section 1960.1, Title 13, California Code of Regulations. Manufacturers that choose to comply with these optional heavy-duty standards and test procedures shall specify, in the application for certification, an in-use compliance test procedure, as provided in Section 2139(c), Title 13, California Code of Regulations.*

[B] *This standard is the sum of the individual non-methane hydrocarbon emissions and oxides of nitrogen emissions. For methanol-fueled engines, non-methane hydrocarbons shall mean organic material hydrocarbon equivalent.*

[C] *This standard shall only apply to diesel engines and vehicles.*

[D] *In the 1995 model-year only, manufacturers may certify up to 50 percent of their medium-duty engines or vehicles to the applicable 1994 model-year standards and test procedures. For the 1995 through 1997 models, alternative in-use compliance is available for medium-duty manufacturers. A manufacturer may use alternative in-use compliance for up to 100 percent of its fleet in the 1995 and 1996 model years and up to 50 percent of its fleet in the 1997 model year. The percentages shall be determined from the manufacturers' projected California sales of medium-duty vehicles. For engines certified to the standards and test procedures of this subsection, "alternative in-use compliance" shall consist of an allowance of 25 percent over the HC + NOx standard.*

<u>(f) The exhaust emission levels from new 1992 and subsequent model-year engines used in incomplete medium-duty low-emission vehicles, and ultra-low-emission vehicles and for diesel engines used in medium-duty low-emission vehicles, and ultra-low-emission vehicles shall not exceed:</u>

PROPOSED

Amend Title 13, California Code of Regulations, Section 1960.1 to read as follows[1]:

1960.1. **Exhaust Emission Standards and Test Procedures - 1981 and Subsequent Model Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles.**

(a), (b), (c) and (d) [No change]

(e)(1) The exhaust emissions from (i) new 1989 through 1992 model passenger cars and light-duty trucks except those produced by a small volume manufacturer, (ii) new 1991 through 1994 model passenger cars and light-duty trucks produced by a small volume manufacturer, (iii) new 1989 *through 1994* [*~~and subsequent~~*] model medium-duty vehicles, except those produced by a small volume manufacturer, and (iv) new 1991 *through 1994* [*~~and subsequent~~*] model medium-duty vehicles produced by a small volume manufacturer, shall not exceed:

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1. Amendments to Section 1960.1, Title 13, California Code of Regulations, proposed in this rulemaking are shown in underline and ~~strikeout~~ to indicate additions and deletions, respectively. On June 14, 1990, the Board approved amendments to Section 1960.1 to establish new regulations for medium-duty vehicles. These amendments have not yet been formally approved by the Office of Administrative Law. The amendments made by the medium-duty rulemaking are identified here by *italics*, with deletions shown in [*~~italicized strikeouts in brackets~~*]. The amendments pertaining to the June 14, 1990 medium-duty vehicle rulemaking are not a part of the present proposal made available at this time; however, some of the amendments in this proposal modify or otherwise affect language from the medium-duty rulemaking. Deletions to the June 14, 1990 medium-duty rulemaking, proposed in this rulemaking are shown in *~~italicized strikeouts~~*.

PROPOSED

Amend Title 13, California Code of Regulations, Section 1960.1 to read as follows[1]:

1960.1. **Exhaust Emission Standards and Test Procedures - 1981 and Subsequent Model Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles.**

(a), (b), (c) and (d) [No change]

(e)(1) The exhaust emissions from (i) new 1989 through 1992 model passenger cars and light-duty trucks except those produced by a small volume manufacturer, (ii) new 1991 through 1994 model passenger cars and light-duty trucks produced by a small volume manufacturer, (iii) new 1989 *through 1994* [*~~and subsequent~~*] model medium-duty vehicles, except those produced by a small volume manufacturer, and (iv) new 1991 *through 1994* [*~~and subsequent~~*] model medium-duty vehicles produced by a small volume manufacturer, shall not exceed:

---

1. Amendments to Section 1960.1, Title 13, California Code of Regulations, proposed in this rulemaking are shown in underline and ~~strikeout~~ to indicate additions and deletions, respectively. On June 14, 1990, the Board approved amendments to Section 1960.1 to establish new regulations for medium-duty vehicles. These amendments have not yet been formally approved by the Office of Administrative Law. The amendments made by the medium-duty rulemaking are identified here by *italics*, with deletions shown in [*~~italicized strikeouts in brackets~~*]. The amendments pertaining to the June 14, 1990 medium-duty vehicle rulemaking are not a part of the present proposal made available at this time; however, some of the amendments in this proposal modify or otherwise affect language from the medium-duty rulemaking. Deletions to the June 14, 1990 medium-duty rulemaking, proposed in this rulemaking are shown in *~~italicized strikeouts~~*.

Sections 2112 and 2113, Title 13, California Code of Regulations, to require remedial action by the vehicle manufacturer. Such remedial action shall be limited to owner notification and repair or replacement of the defective component. As used in this section, the term "defect" shall not include failures which are the result of abuse, neglect, or improper maintenance. This provision is applicable for the 1989 through 1992 model years only. For small volume manufacturers, this provision is applicable for the 1991 through 1994 model years only.

(5) Diesel-cycle passenger cars, light-duty trucks, and medium-duty vehicles certifying to these standards are subject to a particulate exhaust emission standard of 0.08 gm/mi for the 1989 and subsequent model years. The particulate compliance shall be determined on a 50,000 mile durability vehicle basis.

(6) This set of standards is optional. A manufacturer may choose to certify to these standards pursuant to the conditions set forth in Section 1960.1.5.

(7) Pursuant to Section 1960.1.5(a)(1)(B), the optional standard for 1989 model year light-duty trucks and medium-duty vehicles only is 1.0 gm/mi NOx.

(8) The optional 100,000 mile certification standards and provisions are not applicable to methanol vehicles.

(e)(2) The exhaust emissions from new 1993 and subsequent model methanol-fueled vehicles, including fuel-flexible vehicles, shall meet all the requirements in (e)(1), (f)(1) and (f)(2) with the following modifications and additions:

Sections 2112 and 2113, Title 13, California Code of Regulations, to require remedial action by the vehicle manufacturer. Such remedial action shall be limited to owner notification and repair or replacement of the defective component. As used in this section, the term "defect" shall not include failures which are the result of abuse, neglect, or improper maintenance. This provision is applicable for the 1989 through 1992 model years only. For small volume manufacturers, this provision is applicable for the 1991 through 1994 model years only.

(5) Diesel-cycle passenger cars, light-duty trucks, and medium-duty vehicles certifying to these standards are subject to a particulate exhaust emission standard of 0.08 gm/mi for the 1989 and subsequent model years. The particulate compliance shall be determined on a 50,000 mile durability vehicle basis.

(6) This set of standards is optional. A manufacturer may choose to certify to these standards pursuant to the conditions set forth in Section 1960.1.5.

(7) Pursuant to Section 1960.1.5(a)(1)(B), the optional standard for 1989 model year light-duty trucks and medium-duty vehicles only is 1.0 gm/mi NOx.

(8) The optional 100,000 mile certification standards and provisions are not applicable to methanol vehicles.

(e)(2) The exhaust emissions from new 1993 and subsequent model methanol-fueled vehicles, including fuel-flexible vehicles, shall meet all the requirements in (e)(1), (f)(1) and (f)(2) with the following modifications and additions:

(e)(3) The exhaust emissions of formaldehyde from 1992 and subsequent model-year transitional low-emission vehicles, low-emission vehicles, and ultra-low-emission vehicles, including fuel-flexible and dual-fuel vehicles, shall meet all the requirements of (g)(1) and (h)(2) with the following additions:

FORMALDEHYDE EXHAUST EMISSION STANDARDS
FOR TRANSITIONAL LOW-EMISSION VEHICLES, LOW-EMISSION VEHICLES,
AND ULTRA-LOW-EMISSION VEHICLES IN THE
LIGHT-DUTY AND MEDIUM-DUTY VEHICLE WEIGHT CLASSES (5)(6)
["milligrams per mile" (or "mg/mi")]

Vehicle Type (1)	Vehicle Weight (lbs.)(2)	Durability Vehicle Basis (mi)	Vehicle Emission Category(3)	Formaldehyde (mg/mi)(4)(5)
PC and LDT	All 0-3750	50,000	TLEV	15 (23)
			LEV	15 (15)
			ULEV	8 (12)
		100,000	TLEV	18
			LEV	18
			ULEV	11
LDT	3751-5750	50,000	TLEV	18 (27)
			LEV	18 (18)
			ULEV	9 (14)
		100,000	TLEV	23
			LEV	23
			ULEV	13
MDV	0-3750	50,000	LEV	15 (15)
			ULEV	8 (12)
		120,000	LEV	22
			ULEV	12
MDV	3751-5750	50,000	LEV	18 (18)
			ULEV	9 (14)
		120,000	LEV	27
			ULEV	13
MDV	5751-8500	50,000	LEV	22 (22)
			ULEV	11 (17)
		120,000	LEV	32
			ULEV	16
MDV	8501-10,000	50,000	LEV	28 (28)
			ULEV	14 (21)
		120,000	LEV	40
			ULEV	21
MDV	10,001-14,000	50,000	LEV	36 (36)
			ULEV	18 (27)
		120,000	LEV	52
			ULEV	26

(e)(3) The exhaust emissions of formaldehyde from 1992 and subsequent model-year transitional low-emission vehicles, low-emission vehicles, and ultra-low-emission vehicles, including fuel-flexible and dual-fuel vehicles, shall meet all the requirements of (g)(1) and (h)(2) with the following additions:

FORMALDEHYDE EXHAUST EMISSION STANDARDS
FOR TRANSITIONAL LOW-EMISSION VEHICLES, LOW-EMISSION VEHICLES, AND ULTRA-LOW-EMISSION VEHICLES IN THE
LIGHT-DUTY AND MEDIUM-DUTY VEHICLE WEIGHT CLASSES (5)(6)
["milligrams per mile" (or "mg/mi")]

Vehicle Type (1)	Vehicle Weight (lbs.)(2)	Durability Vehicle Basis (mi)	Vehicle Emission Category(3)	Formaldehyde (mg/mi)(4)(5)
PC and LDT	All 0-3750	50,000	TLEV	15 (23)
			LEV	15 (15)
			ULEV	8 (12)
		100,000	TLEV	18
			LEV	18
			ULEV	11
LDT	3751-5750	50,000	TLEV	18 (27)
			LEV	18 (18)
			ULEV	9 (14)
		100,000	TLEV	23
			LEV	23
			ULEV	13
MDV	0-3750	50,000	LEV	15 (15)
			ULEV	8 (12)
		120,000	LEV	22
			ULEV	12
MDV	3751-5750	50,000	LEV	18 (18)
			ULEV	9 (14)
		120,000	LEV	27
			ULEV	13
MDV	5751-8500	50,000	LEV	22 (22)
			ULEV	11 (17)
		120,000	LEV	32
			ULEV	16
MDV	8501-10,000	50,000	LEV	28 (28)
			ULEV	14 (21)
		120,000	LEV	40
			ULEV	21
MDV	10,001-14,000	50,000	LEV	36 (36)
			ULEV	18 (27)
		120,000	LEV	52
			ULEV	26

(f)(1) The exhaust emissions from new 1993 and 1994 model passenger cars and light-duty trucks, except those produced by a small volume manufacturer, shall not exceed:

1993 AND 1994 MODEL YEAR *PASSENGER CAR AND LIGHT-DUTY TRUCK* EXHAUST EMISSIONS STANDARDS (5)(8)(9)
(grams per mile)

Vehicle Type(1)	Loaded Vehicle Weight (lbs.)	Durability Vehicle Basis (mi)	Non-Methane Hydrocarbons (2)(7)	Carbon Monoxide (7)	Oxides of Nitrogen (1)(3)(4)
PC	All	50,000	0.39 (0.25)	7.0 (3.4)	0.4
PC(6)	All	50,000	0.39 (0.25)	7.0 (3.4)	0.7
PC	All	100,000	(0.31)	(4.2)	n/a
Diesel PC (Option 2)	All	100,000	0.46 (0.31)	8.3 (4.2)	1.0
LDT	0-3750	50,000	0.39 (0.25)	9.0 (3.4)	0.4
LDT (6)	0-3750	50,000	0.39 (0.25)	9.0 (3.4)	0.7
LDT	0-3750	100,000	(0.31)	(4.2)	n/a
Diesel LDT (Option 2)	0-3750	100,000	0.46 (0.31)	10.6 (4.2)	1.0
LDT	3751-5750	50,000	0.50 (0.32)	9.0 (4.4)	1.0
LDT	3751-5750	100,000	(0.40)	(5.5)	n/a
Diesel LDT (Option 1)	3751-5750	100,000	0.50 (0.40)	9.0 (5.5)	1.5

(1) "PC" means passenger cars.
"LDT" means light-duty trucks.
"n/a" means not applicable.

(2) For methanol-fueled vehicles certifying to these standards, including flexible-fueled vehicles, "Non-Methane Hydrocarbons" shall mean "Organic Material Hydrocarbon Equivalent" (or "OMHCE").

(3) The maximum projected emissions of oxides of nitrogen measured on the federal Highway Fuel Economy Test (HWFET; 40 CFR Part 600 Subpart B) shall be not greater than 1.33 times the applicable passenger car standards and 2.00 times the applicable light-duty truck and medium-duty vehicle standards shown in the table. Both the projected emissions and the HWFET standard shall be rounded in accordance with ASTM E29-67 to the nearest 0.1 gm/mi before being compared.

(4) The standard for in-use compliance for passenger cars and light-duty trucks certifying to the 0.4 g/mi NOx standard shall be 0.55 g/mi NOx for 50,000 miles. If the in-use compliance level is above 0.4 g/mi NOx but does not exceed 0.55 g/mi NOx, and based on a review of information derived from a statistically valid and representative sample of vehicles, the Executive Officer determines that a substantial percentage of any class or category of such vehicles exhibits, prior to 50,000 miles or 5 years,

(f)(1) The exhaust emissions from new 1993 and 1994 model passenger cars and light-duty trucks, except those produced by a small volume manufacturer, shall not exceed:

1993 AND 1994 MODEL YEAR *PASSENGER CAR AND LIGHT-DUTY TRUCK* EXHAUST EMISSIONS STANDARDS (5)(8)(9)
(grams per mile)

Vehicle Type(1)	Loaded Vehicle Weight (lbs.)	Durability Vehicle Basis (mi)	Non-Methane Hydrocarbons (2)(7)	Carbon Monoxide (7)	Oxides of Nitrogen (1)(3)(4)
PC	All	50,000	0.39 (0.25)	7.0 (3.4)	0.4
PC(6)	All	50,000	0.39 (0.25)	7.0 (3.4)	0.7
PC	All	100,000	(0.31)	(4.2)	n/a
Diesel PC (Option 2)	All	100,000	0.46 (0.31)	8.3 (4.2)	1.0
LDT	0-3750	50,000	0.39 (0.25)	9.0 (3.4)	0.4
LDT (6)	0-3750	50,000	0.39 (0.25)	9.0 (3.4)	0.7
LDT	0-3750	100,000	(0.31)	(4.2)	n/a
Diesel LDT (Option 2)	0-3750	100,000	0.46 (0.31)	10.6 (4.2)	1.0
LDT	3751-5750	50,000	0.50 (0.32)	9.0 (4.4)	1.0
LDT	3751-5750	100,000	(0.40)	(5.5)	n/a
Diesel LDT (Option 1)	3751-5750	100,000	0.50 (0.40)	9.0 (5.5)	1.5

(1) "PC" means passenger cars.
"LDT" means light-duty trucks.
"n/a" means not applicable.

(2) For methanol-fueled vehicles certifying to these standards, including flexible-fueled vehicles, "Non-Methane Hydrocarbons" shall mean "Organic Material Hydrocarbon Equivalent" (or "OMHCE").

(3) The maximum projected emissions of oxides of nitrogen measured on the federal Highway Fuel Economy Test (HWFET; 40 CFR Part 600 Subpart B) shall be not greater than 1.33 times the applicable passenger car standards and 2.00 times the applicable light-duty truck and medium-duty vehicle standards shown in the table. Both the projected emissions and the HWFET standard shall be rounded in accordance with ASTM E29-67 to the nearest 0.1 gm/mi before being compared.

(4) The standard for in-use compliance for passenger cars and light-duty trucks certifying to the 0.4 g/mi NOx standard shall be 0.55 g/mi NOx for 50,000 miles. If the in-use compliance level is above 0.4 g/mi NOx but does not exceed 0.55 g/mi NOx, and based on a review of information derived from a statistically valid and representative sample of vehicles, the Executive Officer determines that a substantial percentage of any class or category of such vehicles exhibits, prior to 50,000 miles or 5 years,

(f)(2) The exhaust emissions from new 1995 and subsequent model passenger cars and light-duty trucks shall not exceed:

1995 AND SUBSEQUENT MODEL YEAR *PASSENGER CAR AND LIGHT-DUTY TRUCK* EXHAUST EMISSIONS STANDARDS (5)(6)(8)
(grams per mile)

Vehicle Type(1)	Loaded Vehicle Weight (lbs.)	Durability Vehicle Basis (mi)	Non-Methane Hydrocarbons (2)(7)	Carbon Monoxide (7)	Oxides of Nitrogen (1)(3)
PC	All	50,000	0.25	3.4	0.4(4)
PC	All	100,000	0.31	4.2	n/a
Diesel PC (Option 2)	All	100,000	0.31	4.2	1.0
LDT	0-3750	50,000	0.25	3.4	0.4(4)
LDT	0-3750	100,000	0.31	4.2	n/a
Diesel LDT (Option 2)	0-3750	100,000	0.31	4.2	1.0
LDT	3751-5750	50,000	0.32	4.4	*0.7*[~~1.0~~]
LDT	3751-5750	100,000	0.40	5.5	n/a
Diesel LDT (Option 1)	3751-5750	100,000	0.40	5.5	1.5

(1) "PC" means passenger cars.
"LDT" means light-duty trucks.
"n/a" means not applicable.

(2) For methanol-fueled vehicles certifying to these standards, including flexible-fueled vehicles, "Non-Methane Hydrocarbons" shall mean "Organic Material Hydrocarbon Equivalent" (or "OMHCE").

(3) The maximum projected emissions of oxides of nitrogen measured on the federal Highway Fuel Economy Test (HWFET; 40 CFR Part 600 Subpart B) shall be not greater than 1.33 times the applicable passenger car standards and 2.00 times the applicable light-duty truck standards shown in the table. Both the projected emissions and the HWFET standard shall be rounded in accordance with ASTM E29-67 to the nearest 0.1 gm/mi before being compared.

(4) Small volume manufacturers may choose to certify to an optional 0.7 g/mi NOx standard for the 1995 model-year only, pursuant to the conditions set forth in Sections 1960.1 (f)(1) and 1960.1.5.

(5) Diesel passenger cars and light-duty trucks certifying to these standards are subject to a particulate exhaust emission standard of 0.08 g/mi, determined on a 50,000 mile durability vehicle basis.

(6) For all vehicles, except those certifying to optional diesel standards, in-use compliance with the exhaust emission standards shall be limited to vehicles with less than 75,000 miles.

(f)(2) The exhaust emissions from new 1995 and subsequent model passenger cars and light-duty trucks shall not exceed:

1995 AND SUBSEQUENT MODEL YEAR *PASSENGER CAR AND LIGHT-DUTY TRUCK* EXHAUST EMISSIONS STANDARDS (5)(6)(8)
(grams per mile)

Vehicle Type(1)	Loaded Vehicle Weight (lbs.)	Durability Vehicle Basis (mi)	Non-Methane Hydrocarbons (2)(7)	Carbon Monoxide (7)	Oxides of Nitrogen (1)(3)
PC	All	50,000	0.25	3.4	0.4(4)
PC	All	100,000	0.31	4.2	n/a
Diesel PC (Option 2)	All	100,000	0.31	4.2	1.0
LDT	0-3750	50,000	0.25	3.4	0.4(4)
LDT	0-3750	100,000	0.31	4.2	n/a
Diesel LDT (Option 2)	0-3750	100,000	0.31	4.2	1.0
LDT	3751-5750	50,000	0.32	4.4	*0.7*[~~1.0~~]
LDT	3751-5750	100,000	0.40	5.5	n/a
Diesel LDT (Option 1)	3751-5750	100,000	0.40	5.5	1.5

(1) "PC" means passenger cars.
"LDT" means light-duty trucks.
"n/a" means not applicable.

(2) For methanol-fueled vehicles certifying to these standards, including flexible-fueled vehicles, "Non-Methane Hydrocarbons" shall mean "Organic Material Hydrocarbon Equivalent" (or "OMHCE").

(3) The maximum projected emissions of oxides of nitrogen measured on the federal Highway Fuel Economy Test (HWFET; 40 CFR Part 600 Subpart B) shall be not greater than 1.33 times the applicable passenger car standards and 2.00 times the applicable light-duty truck standards shown in the table. Both the projected emissions and the HWFET standard shall be rounded in accordance with ASTM E29-67 to the nearest 0.1 gm/mi before being compared.

(4) Small volume manufacturers may choose to certify to an optional 0.7 g/mi NOx standard for the 1995 model-year only, pursuant to the conditions set forth in Sections 1960.1 (f)(1) and 1960.1.5.

(5) Diesel passenger cars and light-duty trucks certifying to these standards are subject to a particulate exhaust emission standard of 0.08 g/mi, determined on a 50,000 mile durability vehicle basis.

(6) For all vehicles, except those certifying to optional diesel standards, in-use compliance with the exhaust emission standards shall be limited to vehicles with less than 75,000 miles.

(g)(1) The exhaust emissions from new 1992 and subsequent model-year light-duty transitional low-emission vehicles, low-emission vehicles, and ultra-low-emission vehicles shall not exceed:

EXHAUST EMISSION STANDARDS
FOR TRANSITIONAL LOW-EMISSION VEHICLES, LOW-EMISSION VEHICLES
AND ULTRA-LOW-EMISSION VEHICLES IN PASSENGER CARS
AND LIGHT-DUTY TRUCK VEHICLE CLASSES (6)(7)(8)
[grams per mile (or "g/mi")]

Vehicle Type (1)	Loaded Vehicle Weight (lbs.)	Durability Vehicle Basis (mi)	Vehicle Emission Category (2)	Non-Methane Organic Gases (3)(4)	Carbon Monoxide	Oxides of Nitrogen (5)
PC and LDT	All 0-3750	50,000	TLEV	0.125 (0.188)	3.4 (3.4)	0.4 (0.4)
			LEV	0.075 (0.100)	3.4 (3.4)	0.2 (0.3)
			ULEV	0.040 (0.058)	1.7 (2.6)	0.2 (0.3)
		100,000	TLEV	0.156	4.2	0.6
			LEV	0.090	4.2	0.3
			ULEV	0.055	2.1	0.3
LDT	3751-5750	50,000	TLEV	0.160 (0.238)	4.4 (4.4)	0.7 (0.7)
			LEV	0.100 (0.128)	4.4 (4.4)	0.4 (0.5)
			ULEV	0.050 (0.075)	2.2 (3.3)	0.4 (0.5)
		100,000	TLEV	0.200	5.5	0.9
			LEV	0.130	5.5	0.5
			ULEV	0.070	2.8	0.5

(1) "PC" means passenger cars.
"LDT" means light-duty trucks.

(2) "TLEV" means transitional low-emission vehicles.
"LEV" means low-emission vehicles.
"ULEV" means ultra-low-emission vehicles.

(3) "Non-Methane Organic Gases" (or "NMOG") shall mean the total mass of oxygenated and non-oxygenated hydrocarbon emissions. To demonstrate compliance with a NMOG standard, NMOG emissions shall be measured in accordance with the "California Non-Methane Organic Gas Test Procedures." For TLEVs, LEVs, and ULEVs designed to operate exclusively on any fuel other than conventional gasoline, manufacturers shall multiply the measured NMOG mass emissions at 50,000 and 100,000 miles by the reactivity adjustment factor established for the particular vehicle emission category and fuel combination in the application for certification. The Executive Officer shall determine the reactivity adjustment factor according to the procedure described in Appendix VIII of the "California Exhaust Emission Standards and Test Procedures for 1998 and Subsequent

(g)(1) The exhaust emissions from new 1992 and subsequent model-year light-duty transitional low-emission vehicles, low-emission vehicles, and ultra-low-emission vehicles shall not exceed:

EXHAUST EMISSION STANDARDS
FOR TRANSITIONAL LOW-EMISSION VEHICLES, LOW-EMISSION VEHICLES
AND ULTRA-LOW-EMISSION VEHICLES IN PASSENGER CARS
AND LIGHT-DUTY TRUCK VEHICLE CLASSES (6)(7)(8)
[grams per mile (or "g/mi")]

Vehicle Type (1)	Loaded Vehicle Weight (lbs.)	Durability Vehicle Basis (mi)	Vehicle Emission Category (2)	Non-Methane Organic Gases (3)(4)	Carbon Monoxide	Oxides of Nitrogen (5)
PC and LDT	All 0-3750	50,000	TLEV	0.125 (0.188)	3.4 (3.4)	0.4 (0.4)
			LEV	0.075 (0.100)	3.4 (3.4)	0.2 (0.3)
			ULEV	0.040 (0.058)	1.7 (2.6)	0.2 (0.3)
		100,000	TLEV	0.156	4.2	0.6
			LEV	0.090	4.2	0.3
			ULEV	0.055	2.1	0.3
LDT	3751-5750	50,000	TLEV	0.160 (0.238)	4.4 (4.4)	0.7 (0.7)
			LEV	0.100 (0.128)	4.4 (4.4)	0.4 (0.5)
			ULEV	0.050 (0.075)	2.2 (3.3)	0.4 (0.5)
		100,000	TLEV	0.200	5.5	0.9
			LEV	0.130	5.5	0.5
			ULEV	0.070	2.8	0.5

(1) "PC" means passenger cars.
"LDT" means light-duty trucks.

(2) "TLEV" means transitional low-emission vehicles.
"LEV" means low-emission vehicles.
"ULEV" means ultra-low-emission vehicles.

(3) "Non-Methane Organic Gases" (or "NMOG") shall mean the total mass of oxygenated and non-oxygenated hydrocarbon emissions. To demonstrate compliance with a NMOG standard, NMOG emissions shall be measured in accordance with the "California Non-Methane Organic Gas Test Procedures." For TLEVs, LEVs, and ULEVs designed to operate exclusively on any fuel other than conventional gasoline, manufacturers shall multiply the measured NMOG mass emissions at 50,000 and 100,000 miles by the reactivity adjustment factor established for the particular vehicle emission category and fuel combination in the application for certification. The Executive Officer shall determine the reactivity adjustment factor according to the procedure described in Appendix VIII of the "California Exhaust Emission Standards and Test Procedures for 1998 and Subsequent

operating on any available fuel other than conventional gasoline, intermediate compliance standards shall apply to TLEVs through the 1995 model-year, and LEVs and ULEVs through the 1998 model-year. Compliance with standards beyond 50,000 miles shall be waived through the 1995 model-year for TLEVs, and through the 1998 model-year for LEVs and ULEVs.

a. For TLEVs, LEVs, and ULEVs designed to operate on any fuel other than conventional gasoline, including fuel-flexible and dual-fuel vehicles when operating on any fuel other than conventional gasoline, measured NMOG emissions shall be multiplied by the reactivity adjustment factor to determine compliance with intermediate compliance standards for NMOG.

b. For fuel-flexible and dual-fuel PCs and LDTs from 0-3750 lbs. LVW, intermediate compliance standards for NMOG emissions at 50,000 miles, when the vehicle is operated on conventional gasoline, shall be 0.32 g/mi, 0.188 g/mi, and 0.100 g/mi for TLEVs, LEVs, and ULEVs, respectively.

c. For fuel-flexible and dual-fuel PCs and LDTs from 3751-5750 lbs. LVW, intermediate compliance standards for NMOG emissions at 50,000 miles, when the vehicle is operated on conventional gasoline, shall be 0.41 g/mi, 0.238 g/mi, and 0.128 g/mi for TLEVs, LEVs, and ULEVs, respectively.

(7) Manufacturers of diesel vehicles must also certify to particulate standards at 100,000 miles. For all PCs and LDTs from 0-5750 lbs LVW, the particulate standard is 0.08 g/mi, 0.08 g/mi, and 0.04 g/mi for TLEVs, LEVs and ULEVs, respectively.

(8) Manufacturers shall demonstrate compliance with the above standards for NMOG, CO, and NOx at 50 degrees F according to the procedure specified in "California Exhaust Emission Standards and Test Procedures for 1988 and Subsequent Model Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles" as adopted May 20, 1987 and last amended ________. For diesel vehicles, compliance with the particulate standard shall also be demonstrated.

operating on any available fuel other than conventional gasoline, intermediate compliance standards shall apply to TLEVs through the 1995 model-year, and LEVs and ULEVs through the 1998 model-year. Compliance with standards beyond 50,000 miles shall be waived through the 1995 model-year for TLEVs, and through the 1998 model-year for LEVs and ULEVs.

a. For TLEVs, LEVs, and ULEVs designed to operate on any fuel other than conventional gasoline, including fuel-flexible and dual-fuel vehicles when operating on any fuel other than conventional gasoline, measured NMOG emissions shall be multiplied by the reactivity adjustment factor to determine compliance with intermediate compliance standards for NMOG.

b. For fuel-flexible and dual-fuel PCs and LDTs from 0-3750 lbs. LVW, intermediate compliance standards for NMOG emissions at 50,000 miles, when the vehicle is operated on conventional gasoline, shall be 0.32 g/mi, 0.188 g/mi, and 0.100 g/mi for TLEVs, LEVs, and ULEVs, respectively.

c. For fuel-flexible and dual-fuel PCs and LDTs from 3751-5750 lbs. LVW, intermediate compliance standards for NMOG emissions at 50,000 miles, when the vehicle is operated on conventional gasoline, shall be 0.41 g/mi, 0.238 g/mi, and 0.128 g/mi for TLEVs, LEVs, and ULEVs, respectively.

(7) Manufacturers of diesel vehicles must also certify to particulate standards at 100,000 miles. For all PCs and LDTs from 0-5750 lbs LVW, the particulate standard is 0.08 g/mi, 0.08 g/mi, and 0.04 g/mi for TLEVs, LEVs and ULEVs, respectively.

(8) Manufacturers shall demonstrate compliance with the above standards for NMOG, CO, and NOx at 50 degrees F according to the procedure specified in "California Exhaust Emission Standards and Test Procedures for 1988 and Subsequent Model Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles" as adopted May 20, 1987 and last amended _________. For diesel vehicles, compliance with the particulate standard shall also be demonstrated.

"Type B HEV" shall mean an HEV which achieves a range of 40 - 59 miles as defined by the "Federal Highway Fuel Economy Test Procedure" (HWFET: 40 CFR 600 Subpart B) without the use of the engine. Use of vehicle accessories cannot lower the battery-only range below 40 miles.

"Type C HEV" shall mean an HEV which achieves a range of 0 - 39 miles as defined by the "Federal Highway Fuel Economy Test Procedure" (HWFET: 40 CFR 600 Subpart B) without the use of the engine, an HEV which enables the vehicle operators to control the engine time and modes of operation either directly or indirectly, an HEV which can be operated solely through the use of the engine, and all other HEVs excluding "Type A" and "Type B" HEVs.

(4) Each manufacturer's fleet average NMOG value for the total number of PCs and LDTs from 0-3750 lbs. "Loaded Vehicle Weight" (or "LVW") sold in California shall be calculated in units of g/mi NMOG as: {[(No. of Vehicles Certified to the Exhaust Emission Standards in Section 1960.1 (e)(1) excluding HEVs and Sold x (0.39)] + [(No. of Vehicles Certified to the Exhaust Emission Standards in Section 1960.1 (f)(2) excluding HEVs and Sold x (0.25)] + [(No. of Transitional Low-Emission Vehicles (or "TLEVs") excluding HEVs and Sold) x (0.125)] + [(No. of Low-Emission Vehicles (or "LEVs") excluding HEVs and Sold) x (0.075)] + [(No. of Ultra-Low-Emission Vehicles (or "ULEVs") excluding HEVs and Sold) x (0.040)] + (HEV contribution factor)}/(Total No. of Vehicles Sold, Including Zero-Emission Vehicles and HEVs):

a. "HEV contribution factor" shall mean the NMOG emission contribution of HEVs to the fleet average NMOG. The HEV contribution factor shall be calculated in units of g/mi as follows.

HEV contribution factor = {{[No. of "Type A HEVs" Sold which certify to the Exhaust Emission Standards in Section (e)(1)] x (0.320) + [No. of "Type B HEVs" Sold which certify to the Exhaust Emission Standards in Section (e)(1)] x (0.355) + [No. of "Type C HEVs" Sold which certify to the Exhaust Emission Standards in Section (e)(1)] x (0.39)} + {[No. of "Type A HEVs" Sold which certify to the Exhaust Emission Standards in Section (f)(2)] x (0.187) + [No. of "Type B HEVs" Sold which certify to the Exhaust Emission Standards in Section (f)(2)] x (0.219) + [No. of "Type C HEVs" Sold which certify to the Exhaust Emission Standards in Section (f)(2)] x (0.25)} + {[No. of "Type A HEV" TLEVs Sold] x (0.100) + [No. of "Type B HEV" TLEVs Sold] x (0.113) + [No. of "Type C HEV" TLEVs Sold] x (0.125)} + {[No. of "Type A HEV" LEVs Sold] x (0.057) + [No. of "Type B HEV" LEVs Sold] x (0.066) + [No. of "Type C HEV" LEVs Sold] x (0.075)} + {[No. of "Type A HEV" ULEVs Sold] x (0.020) + [No. of "Type B HEV" ULEVs Sold] x (0.030) + [No. of "Type C HEV" ULEVs Sold] x (0.040)}}

b. "Zero-Emission Vehicles" (or "ZEVs") classified as medium-duty vehicles by weight may be designated as light-duty vehicles for the purpose of calculating fleet average NMOG values.

"Type B HEV" shall mean an HEV which achieves a range of 40 - 59 miles as defined by the "Federal Highway Fuel Economy Test Procedure" (HWFET: 40 CFR 600 Subpart B) without the use of the engine. Use of vehicle accessories cannot lower the battery-only range below 40 miles.

"Type C HEV" shall mean an HEV which achieves a range of 0 - 39 miles as defined by the "Federal Highway Fuel Economy Test Procedure" (HWFET: 40 CFR 600 Subpart B) without the use of the engine, an HEV which enables the vehicle operators to control the engine time and modes of operation either directly or indirectly, an HEV which can be operated solely through the use of the engine, and all other HEVs excluding "Type A" and "Type B" HEVs.

(4) Each manufacturer's fleet average NMOG value for the total number of PCs and LDTs from 0-3750 lbs. "Loaded Vehicle Weight" (or "LVW") sold in California shall be calculated in units of g/mi NMOG as: {[(No. of Vehicles Certified to the Exhaust Emission Standards in Section 1960.1 (e)(1) excluding HEVs and Sold x (0.39)] + [(No. of Vehicles Certified to the Exhaust Emission Standards in Section 1960.1 (f)(2) excluding HEVs and Sold x (0.25)] + [(No. of Transitional Low-Emission Vehicles (or "TLEVs") excluding HEVs and Sold) x (0.125)] + [(No. of Low-Emission Vehicles (or "LEVs") excluding HEVs and Sold) x (0.075)] + [(No. of Ultra-Low-Emission Vehicles (or "ULEVs") excluding HEVs and Sold) x (0.040)] + (HEV contribution factor)}/(Total No. of Vehicles Sold, Including Zero-Emission Vehicles and HEVs);

a. "HEV contribution factor" shall mean the NMOG emission contribution of HEVs to the fleet average NMOG. The HEV contribution factor shall be calculated in units of g/mi as follows.

HEV contribution factor = {{[No. of "Type A HEVs" Sold which certify to the Exhaust Emission Standards in Section (e)(1)] x (0.320) + [No. of "Type B HEVs" Sold which certify to the Exhaust Emission Standards in Section (e)(1)] x (0.355) + [No. of "Type C HEVs" Sold which certify to the Exhaust Emission Standards in Section (e)(1)] x (0.39)} + {[No. of "Type A HEVs" Sold which certify to the Exhaust Emission Standards in Section (f)(2)] x (0.187) + [No. of "Type B HEVs" Sold which certify to the Exhaust Emission Standards in Section (f)(2)] x (0.219) + [No. of "Type C HEVs" Sold which certify to the Exhaust Emission Standards in Section (f)(2)] x (0.25)} + {[No. of "Type A HEV" TLEVs Sold] x (0.100) + [No. of "Type B HEV" TLEVs Sold] x (0.113) + [No. of "Type C HEV" TLEVs Sold] x (0.125)} + {[No. of "Type A HEV" LEVs Sold] x (0.057) + [No. of "Type B HEV" LEVs Sold] x (0.066) + [No. of "Type C HEV" LEVs Sold] x (0.075)} + {[No. of "Type A HEV" ULEVs Sold] x (0.020) + [No. of "Type B HEV" ULEVs Sold] x (0.030) + [No. of "Type C HEV" ULEVs Sold] x (0.040)}}

b. "Zero-Emission Vehicles" (or "ZEVs") classified as medium-duty vehicles by weight may be designated as light-duty vehicles for the purpose of calculating fleet average NMOG values.

for the corresponding year, shall receive credits in units of g/mi NMOG determined as: {[(Fleet Average NMOG Standard) - (Manufacturer's Fleet Average NMOG Value)] x (Total No. of Vehicles Sold, Including ZEVs and HEVs)}.

a. Manufacturers with fleet average NMOG values greater than the fleet average standard for the corresponding model-year, shall receive debits in units of g/mi NMOG equal to the amount of negative credits determined by the aforementioned equation.

b. Manufacturers shall equalize emission debits within one model-year by earning g/mi NMOG emission credits in an amount equal to their previous model-year's total of g/mi NMOG debits, or by submitting a commensurate amount of g/mi NMOG credits to the Executive Officer that were earned previously or acquired from another manufacturer.

c. The g/mi NMOG emission credits earned in any given model-year shall retain full value through the subsequent model-year.

d. The g/mi NMOG value of any credits not used to equalize the previous model-year's debit, shall be discounted by 50% at the beginning of the second model-year after being earned, discounted to 25% of its original value if not used by the beginning of the third model-year after being earned, and will have no value if not used by the beginning of the fourth model-year after being earned.

e. The g/mi NMOG emission credits earned by a manufacturer may be applied toward the fleet average standard for passenger cars and light-duty trucks from 0-3750 lbs. LVW, or the fleet average standard for light-duty trucks from 3751-5750 lbs. LVW, at the manufacturer's discretion.

(10) Manufacturers that sell vehicles certified to the exhaust emission standards in Sections 1960.1 (f)(2) and 1960.1 (g)(1) and/or ZEVs, in the 1992 and 1993 model-years, shall receive emission credits for the sale of these vehicles as determined by the equations in footnotes (4) or (6), depending upon Vehicle Weight Class, and (9).

a. For PCs and LDTs from 0-3750 lbs. LVW, the fleet average NMOG standard for calculating a manufacturer's emission credits shall be 0.390 and 0.334 g/mi NMOG for vehicles certified for the 1992 and 1993 model-years, respectively.

b. For LDTs from 3751-5750 lbs. LVW, the fleet average NMOG standards for calculating a manufacturer's emission credits shall be 0.500 and 0.428 g/mi NMOG for vehicles certified for the 1992 and 1993 model-years, respectively.

c. Emission credits earned prior to the 1994 model-year shall be considered as earned in the 1994 model-year and discounted in accordance with the schedule specified in footnote (9).

for the corresponding year, shall receive credits in units of g/mi NMOG determined as: {[(Fleet Average NMOG Standard) - (Manufacturer's Fleet Average NMOG Value)] x (Total No. of Vehicles Sold, Including ZEVs and HEVs)}.

a. Manufacturers with fleet average NMOG values greater than the fleet average standard for the corresponding model-year, shall receive debits in units of g/mi NMOG equal to the amount of negative credits determined by the aforementioned equation.

b. Manufacturers shall equalize emission debits within one model-year by earning g/mi NMOG emission credits in an amount equal to their previous model-year's total of g/mi NMOG debits, or by submitting a commensurate amount of g/mi NMOG credits to the Executive Officer that were earned previously or acquired from another manufacturer.

c. The g/mi NMOG emission credits earned in any given model-year shall retain full value through the subsequent model-year.

d. The g/mi NMOG value of any credits not used to equalize the previous model-year's debit, shall be discounted by 50% at the beginning of the second model-year after being earned, discounted to 25% of its original value if not used by the beginning of the third model-year after being earned, and will have no value if not used by the beginning of the fourth model-year after being earned.

e. The g/mi NMOG emission credits earned by a manufacturer may be applied toward the fleet average standard for passenger cars and light-duty trucks from 0-3750 lbs. LVW, or the fleet average standard for light-duty trucks from 3751-5750 lbs. LVW, at the manufacturer's discretion.

(10) Manufacturers that sell vehicles certified to the exhaust emission standards in Sections 1960.1 (f)(2) and 1960.1 (g)(1) and/or ZEVs, in the 1992 and 1993 model-years, shall receive emission credits for the sale of these vehicles as determined by the equations in footnotes (4) or (6), depending upon Vehicle Weight Class, and (9).

a. For PCs and LDTs from 0-3750 lbs. LVW, the fleet average NMOG standard for calculating a manufacturer's emission credits shall be 0.390 and 0.334 g/mi NMOG for vehicles certified for the 1992 and 1993 model-years, respectively.

b. For LDTs from 3751-5750 lbs. LVW, the fleet average NMOG standards for calculating a manufacturer's emission credits shall be 0.500 and 0.428 g/mi NMOG for vehicles certified for the 1992 and 1993 model-years, respectively.

c. Emission credits earned prior to the 1994 model-year shall be considered as earned in the 1994 model-year and discounted in accordance with the schedule specified in footnote (9).

(5) *The maximum projected emissions of oxides of nitrogen measured on the federal Highway Fuel Economy Test (HWFET; 40 CFR Part 600 Subpart B) shall be not greater than 2.00 times the applicable medium-duty vehicle standards shown in the table. Both the projected emissions and the HWFET standard shall be rounded in accordance with ASTM E29-67 to the nearest 0.1 g/mi before being compared.*

(6) *Particulate standards are only applicable for diesel vehicles and shall be determined on a 120,000 mile basis.*

(7) *In-use compliance testing shall be limited to vehicles with less than 90,000 miles. For the 1995 through 1997 models, alternative in-use compliance is available for medium-duty vehicle manufacturers. A manufacturer may use alternative in-use compliance for up to 100 percent of its fleet in the 1995 and 1996 model years and up to 50 percent of its fleet in the 1997 model year. The percentages shall be determined from the manufacturers' projected California sales of medium-duty vehicles. For vehicles certified to the standards and test procedures of this subsection, "alternative in-use compliance" shall consist of an in-use allowance of 25 percent over the applicable 50,000 mile emission standards and a waiver of the emission standards beyond 50,000 miles.*

(8) *All medium-duty vehicles, except those incomplete and diesel vehicles certifying to heavy-duty engine test procedures, are subject to 50,000 mile and 120,000 mile non-methane hydrocarbon, carbon monoxide, and oxides of nitrogen standards.*

(5) The maximum projected emissions of oxides of nitrogen measured on the federal Highway Fuel Economy Test (HWFET; 40 CFR Part 600 Subpart B) shall be not greater than 2.00 times the applicable medium-duty vehicle standards shown in the table. Both the projected emissions and the HWFET standard shall be rounded in accordance with ASTM E29-67 to the nearest 0.1 g/mi before being compared.

(6) Particulate standards are only applicable for diesel vehicles and shall be determined on a 120,000 mile basis.

(7) In-use compliance testing shall be limited to vehicles with less than 90,000 miles. For the 1995 through 1997 models, alternative in-use compliance is available for medium-duty vehicle manufacturers. A manufacturer may use alternative in-use compliance for up to 100 percent of its fleet in the 1995 and 1996 model years and up to 50 percent of its fleet in the 1997 model year. The percentages shall be determined from the manufacturers' projected California sales of medium-duty vehicles. For vehicles certified to the standards and test procedures of this subsection, "alternative in-use compliance" shall consist of an in-use allowance of 25 percent over the applicable 50,000 mile emission standards and a waiver of the emission standards beyond 50,000 miles.

(8) All medium-duty vehicles, except those incomplete and diesel vehicles certifying to heavy-duty engine test procedures, are subject to 50,000 mile and 120,000 mile non-methane hydrocarbon, carbon monoxide, and oxides of nitrogen standards.

NMOG emissions at 50,000 and 120,000 miles by the reactivity adjustment factor appropriate to the vehicle emission category and fuel combination in the application for certification. The reactivity adjustment factor shall be determined by the Executive Officer according to the procedure described in Appendix VIII of the "California Exhaust Emission Standards and Test Procedures for 1988 and Subsequent Model Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles" as adopted May 20, 1987 and last amended ________.

(4) Fuel-flexible and dual-fuel medium-duty vehicles (or "MDVs") from 0-14,000 lbs. TW shall be certified to exhaust mass emission standards for NMOG established for the operation of the vehicle on any fuel other than conventional gasoline, and conventional gasoline.

a. For LEVs and ULEVs, manufacturers shall multiply measured NMOG emissions at 50,000 and 120,000 miles by the appropriate reactivity adjustment factor in the application for certification.

b. For MDVs from 0-3750 lbs. TW, the applicable exhaust mass emission standard for NMOG when certifying the vehicle for operation on conventional gasoline shall be:

(i) For LEVs, 0.25 g/mi and 0.36 g/mi for 50,000 and 120,000 miles, respectively.

(ii) For ULEVs, 0.125 g/mi and 0.190 g/mi for 50,000 and 120,000 miles, respectively.

c. For MDVs from 3751-5750 lbs. TW, the applicable exhaust mass emission standard for NMOG when certifying the vehicle for operation on conventional gasoline shall be:

(i) For LEVs, 0.32 g/mi and 0.46 g/mi for 50,000 and 120,000 miles, respectively.

(ii) For ULEVs, 0.160 g/mi and 0.230 g/mi for 50,000 and 120,000 miles, respectively.

d. For MDVs from 5751-8500 lbs. TW, the applicable exhaust mass emission standard for NMOG when certifying the vehicle for operation on conventional gasoline shall be:

(i) For LEVs, 0.39 g/mi and 0.56 g/mi for 50,000 and 120,000 miles, respectively.

(ii) For ULEVs, 0.195 g/mi and 0.280 g/mi for 50,000 and 120,000 miles, respectively.

e. For MDVs from 8501-10,000 lbs. TW, the applicable exhaust mass emission standard for NMOG when certifying the vehicle for operation on conventional gasoline shall be:

(i) For LEVs, 0.46 g/mi and 0.66 g/mi for 50,000 and 120,000 miles, respectively.

(ii) For ULEVs, 0.230 g/mi and 0.330 g/mi for 50,000 and 120,000 miles, respectively.

f. For MDVs from 10,001-14,000 lbs. TW, the applicable exhaust mass emission standard for NMOG when certifying the vehicle for operation on conventional gasoline shall be:

(i) For LEVs, 0.60 g/mi and 0.86 g/mi for 50,000 and 120,000 miles, respectively.

NMOG emissions at 50,000 and 120,000 miles by the reactivity adjustment factor appropriate to the vehicle emission category and fuel combination in the application for certification. The reactivity adjustment factor shall be determined by the Executive Officer according to the procedure described in Appendix VIII of the "California Exhaust Emission Standards and Test Procedures for 1988 and Subsequent Model Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles" as adopted May 20, 1987 and last amended ________.

(4) Fuel-flexible and dual-fuel medium-duty vehicles (or "MDVs") from 0-14,000 lbs. TW shall be certified to exhaust mass emission standards for NMOG established for the operation of the vehicle on any fuel other than conventional gasoline, and conventional gasoline.

a. For LEVs and ULEVs, manufacturers shall multiply measured NMOG emissions at 50,000 and 120,000 miles by the appropriate reactivity adjustment factor in the application for certification.

b. For MDVs from 0-3750 lbs. TW, the applicable exhaust mass emission standard for NMOG when certifying the vehicle for operation on conventional gasoline shall be:

(i) For LEVs, 0.25 g/mi and 0.36 g/mi for 50,000 and 120,000 miles, respectively.

(ii) For ULEVs, 0.125 g/mi and 0.190 g/mi for 50,000 and 120,000 miles, respectively.

c. For MDVs from 3751-5750 lbs. TW, the applicable exhaust mass emission standard for NMOG when certifying the vehicle for operation on conventional gasoline shall be:

(i) For LEVs, 0.32 g/mi and 0.46 g/mi for 50,000 and 120,000 miles, respectively.

(ii) For ULEVs, 0.160 g/mi and 0.230 g/mi for 50,000 and 120,000 miles, respectively.

d. For MDVs from 5751-8500 lbs. TW, the applicable exhaust mass emission standard for NMOG when certifying the vehicle for operation on conventional gasoline shall be:

(i) For LEVs, 0.39 g/mi and 0.56 g/mi for 50,000 and 120,000 miles, respectively.

(ii) For ULEVs, 0.195 g/mi and 0.280 g/mi for 50,000 and 120,000 miles, respectively.

e. For MDVs from 8501-10,000 lbs. TW, the applicable exhaust mass emission standard for NMOG when certifying the vehicle for operation on conventional gasoline shall be:

(i) For LEVs, 0.46 g/mi and 0.66 g/mi for 50,000 and 120,000 miles, respectively.

(ii) For ULEVs, 0.230 g/mi and 0.330 g/mi for 50,000 and 120,000 miles, respectively.

f. For MDVs from 10,001-14,000 lbs. TW, the applicable exhaust mass emission standard for NMOG when certifying the vehicle for operation on conventional gasoline shall be:

(i) For LEVs, 0.60 g/mi and 0.86 g/mi for 50,000 and 120,000 miles, respectively.

gasoline, shall be 0.58 g/mi and 0.345 g/mi for LEVs and ULEVs, respectively.

f. For fuel-flexible and dual-fuel MDVs from 10,001-14,000 lbs. TW, intermediate compliance standards for NMOG emissions at 50,000 miles, when the vehicle is operated on conventional gasoline, shall be 0.75 g/mi and 0.450 g/mi for LEVs and ULEVs, respectively.

(10) Each manufacturer's MDV fleet shall be defined as the total number of MDVs from 0-14,000 lbs. TW certified and sold in California.

a. Manufacturers of MDVs shall certify an equivalent of 25% of their MDV fleet to LEV standards in the 1998 model-year, a minimum of 50% of their MDV fleet to LEV standards in the 1999 model-year, a minimum of 75% of their MDV fleet to LEV standards in the 2000 model-year, a minimum of 95% of their MDV fleet to LEV standards in the 2001 model-year, a minimum of 90% of their MDV fleet to LEV standards in the 2002 model-year, and a minimum of 85% of their MDV fleet to LEV standards in the 2003 and subsequent model-years.

b. Manufacturers of MDVs shall certify an equivalent of 2% of their MDV fleet to ULEV standards in the 1998 through 2000 model-years, a minimum of 5% of their MDV fleet to ULEV standards in the 2001 model-year, a minimum of 10% of their MDV fleet to ULEV standards in the 2002 model-year, and a minimum of 15% of their MDV fleet to ULEV standards in the 2003 and subsequent model-years.

(11) For the purpose of calculating "Vehicle Equivalent Credits" (or "VECs"), the contribution of hybrid electric vehicles (or "HEVs") will be calculated based on the range of the HEV without the use of the engine. For the purpose of calculating the contribution of HEVs to the VECs, the following definitions shall apply:

"Type A HEV" shall mean an HEV which achieves a minimum range of 60 miles over the Dynamometer Driving Cycle as defined by the "Federal Highway Fuel Economy Test Procedure" (HWFET; 40 CFR Part 600 Subpart B) without the use of the engine. Use of vehicle accessories cannot lower the battery-only range below 60 miles. This also includes vehicles which have no tailpipe emissions, but use fuel fired heaters.

"Type B HEV" shall mean an HEV which achieves a range of 40 - 59 miles over the Dynamometer Driving Cycle as defined by the "Federal Highway Fuel Economy Test Procedure" (HWFET; 40 CFR Part 600 Subpart B) without the use of the engine. Use of vehicle accessories cannot lower the battery-only range below 40 miles.

"Type C HEV" shall mean an HEV which achieves a range of 0 - 39 miles over the Dynamometer Driving Cycle as defined by the "Federal Highway Fuel Economy Test Procedure" (HWFET; 40 CFR Part 600 Subpart B) without the use of the engine, an HEV which enables the vehicle operators to control the engine time and modes of operation either directly or indirectly, an HEV which can be operated solely through the use of the engine, and all other HEVs excluding "Type A" and "Type B" HEVs.

(12) In 1992 and subsequent model-years, manufacturers that sell MDVs in excess of the minimum requirements for LEVs and/or ULEVs, shall receive VECs calculated as: {[(No. of LEVs Sold excluding HEVs) + (No. of "Type C HEV" LEVs Sold)] + [(No. of "Type B HEV" LEVs Sold) x (1.1)] + [(No of "Type A HEVs" LEVs Sold) x (1.2)] - (Minimum No. of LEVs Required to be Sold)} + {[(No. of ULEVs Sold excluding HEVs) x (1.4)] + [(No. of "Type C HEV" ULEVs Sold) x (1.4)] + [(No. of "Type B HEV" ULEVs Sold) x (1.5)] + [(No. of "Type A HEV" ULEVs Sold) x (1.7)] - (Minimum No. of ULEVs Required to be Sold)} + [(No. of ZEVs Sold as MDVs) x (2.0)].

a. Manufacturers that fail to sell the minimum quantity of MDVs certified to LEV and/or ULEV exhaust emission standards, shall receive "Vehicle-Equivalent Debits" (or "VEDs") equal to the amount of negative VECs determined by the aforementioned equation.

b. Manufacturers shall equalize emission debits within one model-year by earning VECs in an amount equal to their previous model-year's total of VEDs, or by submitting a commensurate amount of VECs to the Executive Officer that were earned previously or acquired from another manufacturer.

c. The VECs earned in any given model-year shall retain full value through the subsequent model-year.

d. The value of any VECs not used to equalize the previous model-year's debit, shall be discounted by 50% at the beginning of second model-year after being earned, discounted to 25% of its original value if not used by the beginning of the third model-year after being earned, and will have no value if not used by the beginning of the fourth model-year after being earned.

e. Only ZEVs certified as MDVs can be included in the calculation of VECs.

(13) Manufacturers shall demonstrate compliance with the above standards for NMOG, CO, and NOx at 50 degrees F according to the procedure specified in "California Exhaust Emission Standards and Test Procedures for 1988 and Subsequent Model Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles" as adopted May 20, 1987 and last amended ________. For diesel vehicles, compliance with the particulate standard shall also be demonstrated.

(i)(h)[(g)] The exhaust emissions from new 1981 and subsequent model passenger cars, light-duty trucks, and medium-duty vehicles certified to special standards authorized by Sections 1960.2, 1960.3, and 1960.4, Subchapter 1, Chapter 3, Title 13, California Code of Regulations, shall not exceed (1):

SPECIAL EXHAUST (10)
EMISSION STANDARDS
(grams per mile)

Year	Vehicle Type(2)	Equivalent Inertia Weight (lbs.)(3)	Durability Vehicle Basis (mi)	Non-Methane Hydro-carbons (4)	Carbon Monoxide	Oxides of Nitrogen (5)
1981	PC(6)	All	50,000	0.39(0.41)	7.0	1.5
	LDT,MDV(7)	0-3999	50,000	0.39(0.41)	9.0	1.5
1982(8)	PC	All	50,000	0.39(0.41)	7.0	1.0
1983(8)	PC	All	50,000	0.39(0.41)	7.0	0.7(9)
	LDT,MDV	0-3999	50,000	0.39(0.41)	9.0	1.0
1984(8)	PC	All	50,000	0.39(0.41)	7.0	0.7
	LDT,MDV	0-3999	50,000	0.39(0.41)	9.0	0.7(9)
1985(8)	LDT,MDV	0-3999	50,000	0.39(0.41)	9.0	0.7

(1) Subsection (i)(h)[(g)] shall remain in effect until December 31, 1990, and as of that date is repealed unless a later regulation deletes or extends that date. Notwithstanding the repeal or expiration of this regulation on December 31, 1990, the provisions of the regulation as they existed prior to such repeal or expiration shall continue to be operative and effective for those events occurring prior to the repeal or expiration.

(2) "PC" means passenger cars.
"LDT" means light-duty trucks.
"MDV" means medium-duty vehicles.

(3) Equivalent inertia weights are determined under subparagraph 40 CFR 86.129-79(a).

(4) Hydrocarbon standards in parentheses apply to total hydrocarbons.

(5) The maximum projected emissions of oxides of nitrogen measured on the federal Highway Fuel Economy Test (HWFET; 40 CFR Part 600, ~~Subparagraph~~ Subpart B) shall be no greater than 1.33 times the applicable passenger car standards and 2.0 times the applicable light-duty truck and medium-duty vehicle standards shown in the table. Both the projected emissions and the HWFET standard shall be rounded to the nearest 0.1 gm/mi before being compared.

(6) For vehicles certified to special standards authorized by Section 1960.2, Article 2, Subchapter 1, Chapter 3, Title 13, California Code of Regulations.

(7) For vehicles certified to special standards authorized by Section 1960.3, Article 2, Subchapter 1, Chapter 3, Title 13, California Code of Regulations.

(8) For vehicles certified to special standards authorized by Section 1960.4, Article 2, Subchapter 1, Chapter 3, Title 13, California Code of Regulations. Special standards revert to "1983 and subsequent" standards for 1985 and subsequent passenger cars and 1986 and subsequent LDTs and MDVs.

(9) The Executive Officer may grant limited relief from the 1983 passenger car and 1984 LDT and MDV special NOx standard to a manufacturer who exceeds the standard because of unforeseen technical problems.

(10) Diesel-powered passenger cars, light-duty trucks, and medium-duty vehicles are subject to the following particulate exhaust emission standards: 0.4 gm/mi for the 1985 model year, 0.2 gm/mi for the 1986 through 1988 model years, and 0.08 gm/mi for the 1989 and subsequent model years. The particulate compliance shall be determined on a 50,000 mile durability vehicle basis.

(j)~~(i)~~[~~(h)~~] [No Change]

(k)~~(j)~~[~~(i)~~] The test procedures for determining compliance with
these standards are set forth in "California Exhaust Emission Standards and Test Procedures for 1981 through 1987 Model Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles", adopted by the State Board on November 23, 1976, as last amended May 20, 1987, and in "California Exhaust Emission Standards and Test Procedures for 1988 and Subsequent Model Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles", adopted by the state board on May 20, 1987, as last amended ________________.

(l)~~(k)~~[~~(j)~~] [No Change]

(m)~~(l)~~[~~(k)~~] [No Change]

(n)~~(m)~~[~~(l)~~] [No Change]

(o) For the purposes of this section, an "intermediate volume manufacturer" is any vehicle manufacturer with California sales between 3,001 and 35,000 new light- and medium-duty vehicles per model-year based on the average number of vehicles sold by the manufacturer each model-year from 1989 to 1993; however, for manufacturers certifying for the first time in California, model-year sales shall be based on projected California sales.

NOTE: Authority cited: Sections 39600, 39601, 43013, *43018*, 43101 and 43104, Health and Safety Code. Reference: Sections 39002, 39003, 43000, 43013, *43018*, 43100, 43101, 43101.5, 43102, *43103*, 43104, 43106 and 43204, Health and Safety Code.

APPENDIX B

PROPOSED REGULATIONS FOR CLEAN FUELS

Proposed Regulatory Language for Clean Fuels Program

Adopt a new Subchapter 8 of Chapter 3, Title 13, California Code of Regulations, to read as follows:

[Note: The entire text of Subchapter 8 set forth below is new language proposed to be added to the California Code of Regulations.]

Subchapter 8. Clean Fuels Program.

Section 2300. **Definitions.**

The following definitions apply to Subchapter 8.

(1) "Affiliate" means any person who owns or controls, is owned or controlled by, or is under common ownership and control with, another person.

(2) "Clean alternative fuel" means any fuel used as the certification fuel in a low-emission vehicle, other than conventional gasoline or diesel fuel as specified in 40 CFR Section 86.113-90 (with any modifications contained in the ARB's "California Exhaust Emission Standards and Test procedures for 1988 and Subsequent Model Passenger Cars, Light-Duty Trucks and Medium-Duty Vehicles" as incorporated by reference in Title 13, California Code of Regulations, Section 1965.8).

(3) "Dedicated vehicle" means any motor vehicle that is engineered and designed to be operated solely on a particular designated clean fuel.

(4) "Designated clean fuel" means any clean alternative fuel other than electricity or compressed natural gas; provided that for purposes of sections 2330 to 2336 only, compressed natural gas may also be a designated clean fuel within this definition starting one year after the California Public Utilities Commission certifies to the state board that a practical mechanism exists under which a gasoline retailer may purchase compressed natural gas from a public utility and resell it for use as a fuel in motor vehicles.

(5) "Distribute" means to physically transfer from a production or importation facility and irrevocably release into commerce for use as a motor vehicle fuel in California; provided that electricity or compressed natural gas shall not be deemed distributed until it is physically transferred to a motor vehicle in California from a metered outlet or metered compressor clearly dedicated only for fueling motor vehicles, or from another specified dispensing system where the executive officer has determined that the other dispensing system and any associated measurement methods provide adequate assurances that the electricity or compressed natural gas is being used for motor vehicle fueling.

(6) "Dual-fuel" vehicle means any motor vehicle that is engineered and designed to be capable of operating on gasoline, and on liquified petroleum gas, compressed natural gas or liquified natural gas.

(7) "Executive officer" means the executive officer of the Air Resources Board, or his or her designee.

(8) "Fleet operator" means the operator of fifteen or more motor vehicles under common ownership or operation.

(9) "Flexible-fuel vehicle" means any alcohol-fueled motor vehicle that is engineered and designed to be operated using any gasoline-alcohol mixture or blend.

(10) "Franchise," "franchisor," "franchisee," "refiner," and "distributor" have the same meaning as defined in Section 20999 of the Business and Professions Code.

(11) "Gasoline supplier" means any person, including affiliates of such person, who produces gasoline for use in California or imports gasoline into California.

(12) "Import" means to bring motor vehicle fuel into California for the first time for use in motor vehicles in California.

(13) "Independent supplier of designated clean fuel" means a person who distributes designated clean fuel that the person has produced or imported, and who is not a gasoline supplier or the affiliate of a gasoline supplier.

(14) "Low-emission vehicle" means any vehicle certified to the transitional low-emission vehicle, low-emission vehicle, ultra-low-emission vehicle, or zero-emission vehicle standards established in Title 13, California Code of Regulations, Section 1956.8.

(15) "Major gasoline supplier" means a gasoline supplier who owns or operates a refinery in California with a crude oil capacity of 50,000 barrels per stream day or more, and who is also an owner/lessor of 25 or more retail gasoline outlets in the SCAQMD.

(16) "Non-retail facility" means any establishment at which one or more motor vehicle fuel is supplied or offered for supply to motor vehicles, but is not supplied or offered to the general public.

(17) "Owner/lessor" means:

(A) In the case of a retail gasoline outlet which is owned, leased, or controlled by a franchisor, and which the franchisee is authorized or permitted, under the franchise, to employ in connection with the sale of gasoline, the franchisor.

(B) In the case of a retail gasoline outlet which is owned, leased or controlled by a refiner or a distributor, and is operated by the refiner or distributor or his agent, the refiner or distributor.

(C) In the case of all other retail gasoline outlets, the owner of the retail gasoline outlet.

(18) "Primary designated clean fuel" means a designated clean fuel for which a substitute fuel has been proposed or designated pursuant to section 2345.

(19) "Produce" means, in the case of any liquid motor vehicle fuel, to convert in California liquid compounds which do not constitute the fuel into the fuel.

(20) "Quarter" means the three month calendar quarters January-March, April-June, July-September, and October-December.

(21) "Retail clean fuel outlet" means an establishment at which a designated clean fuel is sold or offered for sale to the general public for use in motor vehicles.

(22) "Retail gasoline outlet" means any establishment at which gasoline is sold or offered for sale to the general public for use in motor vehicles.

(23) "SCAQMD" means the South Coast Air Quality Management District.

(24) "Vehicle conversion" means a modification of a gasoline or diesel fueled vehicle to a vehicle using a designated clean fuel and capable of meeting low-emission vehicle exhaust emissions standards.

NOTE: Authority cited: Sections 39600, 39601, 43013, 43018, and 43101, Health and Safety Code; and Western Oil and Gas Ass'n. v. Orange County Air Pollution Control District, 14 Cal. 3d 411, 121 Cal. Rptr. 249 (1975). Reference: Sections 39000, 39001, 39002, 39003, 39500, 39515, 39516, 43000, 43013, 43018, and 43101, Health and Safety Code; and Western Oil and Gas Ass'n. v. Orange County Air Pollution Control District, 14 Cal. 3d 411, 121 Cal. Rptr. 249 (1975).

Section 2301. **Distribution of Designated Clean Fuels by Gasoline Suppliers Starting January 1, 1994.**

(a) Starting January 1, 1994, until December 31, 1996, any major gasoline supplier who distributes gasoline in the SCAQMD in a quarter shall also distribute in the SCAQMD in the quarter its minimum assigned volume, as determined in accordance with section 2303, of each designated clean fuel.

(b) Starting January 1, 1997, any gasoline supplier who distributes gasoline in a quarter shall also distribute in the quarter its minimum assigned volume, as determined in accordance with section 2303, of each designated clean fuel.

NOTE: Authority cited: Sections 39600, 39601, 43013, 43018, and 43101, Health and Safety Code; and Western Oil and Gas Ass'n. v. Orange County Air Pollution Control District, 14 Cal. 3d 411, 121 Cal. Rptr. 249 (1975). Reference: Sections 39000, 39001, 39002, 39003, 39500, 39515, 39516, 43000, 43013, 43018, and 43101, Health and Safety Code; and Western Oil and Gas Ass'n. v. Orange County Air Pollution Control District, 14 Cal. 3d 411, 121 Cal. Rptr. 249 (1975).

Section 2302. **Calculation of Volume of Designated Clean Fuel Distributed by a Gasoline Supplier in a Calendar Quarter.**

(a) For the purposes of this Subchapter 8, the volume of each designated clean fuel distributed by a gasoline supplier in a quarter shall consist of [i] all of the designated clean fuel distributed by the gasoline supplier in the quarter that was produced by the gasoline supplier, or that was acquired by the gasoline supplier under the conditions set forth in subsection 2302(b), [ii] after excluding any designated clean fuel produced by the gasoline supplier which was subsequently acquired under the conditions set forth in subsection 2302(b) by another gasoline supplier in the quarter.

(b) The volume of designated clean fuel distributed in a quarter by a gasoline supplier shall include designated clean fuel acquired from another person only if the person from whom the fuel is acquired produced or imported the fuel and has agreed in writing prior to acquisition that s/he is not the distributor of the fuel for purposes of this Subchapter 8, and does not claim to have distributed the fuel in its reports required under section 2320.

NOTE: Authority cited: Sections 39600, 39601, 43013, 43018, and 43101, Health and Safety Code; and Western Oil and Gas Ass'n. v. Orange County Air Pollution Control District, 14 Cal. 3d 411, 121 Cal. Rptr. 249 (1975). Reference: Sections 39000, 39001, 39002, 39003, 39500, 39515, 39516, 43000, 43013, 43018, and 43101, Health and Safety Code; and Western Oil and Gas Ass'n. v. Orange County Air Pollution Control District, 14 Cal. 3d 411, 121 Cal. Rptr. 249 (1975).

Section 2303. **Determination of Minimum Assigned Volumes of Designated Clean Fuels.**

(a) **Determination of total required volume of designated clean fuel.**

For each quarter starting with the first quarter of 1994, the executive officer shall determine the total required volume of each designated clean fuel, at least three months before the start of the quarter, as follows:

(1) The executive officer shall determine what designated clean fuels are expected to be used as the certification fuel in low-emission vehicles that will be operated in California in the quarter. This determination shall be based on registration records of the Department of Motor Vehicles and reports of projected sales data submitted by motor vehicle manufacturers to the executive officer pursuant to the California Exhaust Emission Standards and Test Procedures for 1988 and Subsequent Model Passenger Cars, Light-Duty Trucks and Medium-Duty Vehicles.

(2) For each designated clean fuel identified pursuant to section 2303(a)(1), the executive officer shall estimate the number of low-emission vehicles, certified on the fuel, that will be operated in California in the quarter. This number shall be the sum of (i) the number of low-emission vehicles, certified on the fuel, projected to be operating on the last day of the previous quarter, and (ii) one-half of the number of low-emission vehicles, certified on the fuel, that are projected to be introduced and operating during the quarter. The estimates shall be based on all reasonably available relevant

information, including registration records of the Department of Motor Vehicles and reports of projected and actual production and sales data submitted by motor vehicle manufacturers to the executive officer pursuant to the "California Exhaust Emission Standards and Test Procedures for 1988 and Subsequent Model Passenger Cars, Light-Duty Trucks and Medium-Duty Vehicles" as incorporated by reference in Title 13, California Code of Regulations, section 1965.8, and the California Assembly-Line Test Procedures for 1983 and Subsequent Model Year Passenger Cars, Light-Duty Trucks and Medium-Duty Vehicles" as incorporated by reference in Title 13, California Code of Regulations, section 2061.

(3) For each designated clean fuel identified pursuant to section 2303(a)(1), the executive officer shall then estimate the total required volume (TRV) of the designated clean fuel for the quarter, assuming all low-emission vehicles designed to operate on the designated clean fuel will be operated exclusively on that fuel. The total required volume for each designated clean fuel shall be the sum of the maximum demand volumes (MXDV) calculated by model year, vehicle class (passenger car, light-duty truck, or medium duty truck) and vehicle type (flexible and dual fueled, or dedicated).

The following equation will be used to calculate total demand volume:

$$TRV = \sum_{\text{model year } (x)}^{\text{model year } (y)} MXDV \text{ (vehicle class i, vehicle type ii)}$$

Where: *TRV* is the total required volume for a particular clean fuel.

MXDV is the maximum demand volume for a particular clean fuel for vehicle class i and vehicle type ii.

Vehicle class i is one of three possible class of vehicles--passenger cars (PC), light-duty trucks (LDT) or medium-duty vehicles (MDV).

Vehicle type ii is one of two possible types of vehicles-- flexible and dual fueled (FFV/DFV) or dedicated vehicles (Ded).

Maximum demand volume for a designated clean fuel (for a given model year, vehicle class, and vehicle type), shall equal the number of vehicles in a particular vehicle class and type certified on a particular fuel, multiplied by the average vehicle miles travelled per vehicle by those vehicles, divided by the average fuel economy of those vehicles. This value shall then be multiplied by a fuel volume adjustment factors and sc-factor (for 1994 through 1996 only).

The following equation will be used to calculate maximum demand volumes:

$$\text{MXDV}_{(\text{vehicle class i, vehicle type ii})} = \frac{(\text{number of vehicles certified on fuel}) \times (\text{AMT per vehicle})}{(\text{average fuel economy})} \times (\text{fuel volume adjustment factor}) \ (\text{sc-factor})$$

Where: *MXDV* is the maximum demand volume for a particular clean fuel for vehicle class i and vehicle type ii.

Vehicle class i is one of three possible class of vehicles--passenger cars (PC), light-duty trucks (LDT) or medium-duty vehicles (MDV).

Vehicle type ii is one of two possible types of vehicles-- flexible and dual fueled (FFV/DFV) or dedicated vehicles (Ded).

Schedule B: Fuel Volume Adjustment Factor (f-factor)
FFV/DFV

	Adjustment Factor
1st year introduced	0.25
2nd year introduced	0.50
3rd year introduced	0.75
4th year introduced	0.90

The fuel volume adjustment factor for dedicated vehicles shall be 0.90 for all years.

SC-factor is the fraction of new vehicles expected to be sold in the SCAQMD. The value of the SCAQMD factor shall be 0.50 and shall be multiplied by the maximum designated clean fuel demand estimates for 1994, 1995 and 1996 only.

(b) **Determination of each gasoline supplier's market share factor.**

(1) For each of the years 1994, 1995, and 1996, the executive officer shall determine, for the last four quarters for which data are available, by November 1 of the previous year, the total volume of gasoline distributed by each major gasoline supplier for use in motor vehicles in California, and the total volume of gasoline distributed by all major gasoline suppliers for use in motor vehicles in California. The determinations shall be based on taxable distributions of gasoline as reported to the State Board of Equalization pursuant to Revenue and Taxation Code sections 7301 et seq. The executive officer shall calculate the market share factor of each major gasoline supplier for the year as the ratio of the volume of gasoline sold by each major gasoline supplier for use in motor vehicles in California as determined in accordance with this subsection, to the total volume of gasoline sold by all major gasoline

suppliers for use in motor vehicles in California as determined in accordance with this subsection.

(2) For each year starting with 1997, the executive officer shall determine, for the last four quarters for which data are available, by November 1 of the previous year, the volume of gasoline distributed by each gasoline supplier for use in motor vehicles in California, and the total volume of gasoline sold by all gasoline suppliers for use in motor vehicles in California. The determinations shall be based on taxable distributions of gasoline as reported to the State Board of Equalization pursuant to Revenue and Taxation Code sections 7301 et seq. The executive officer shall calculate the market share factor of each gasoline supplier for the year as the ratio of the volume of gasoline sold by each gasoline supplier for use in motor vehicles in California as determined in accordance with this subsection, to the total volume of gasoline sold by all gasoline suppliers for use in motor vehicles in California as determined in accordance with this subsection.

(3) Whenever a person acquires a gasoline production facility or gasoline importation facility from a gasoline supplier and uses it to produce or import gasoline, the volume of gasoline which was distributed by the transferring gasoline supplier and was attributable to the transferred gasoline production facility or gasoline importation facility shall be deemed, for the purposes of this subsection 2303(b), to have been distributed by the acquiring person.

(4) If a person is a gasoline supplier in a calendar year starting with 1997 where s/he was not a gasoline supplier in one or

more of the four quarters identified in subsection 2303(b)(2), the executive officer shall determine the person's market share factor for that year on a quarterly basis. At least 100 days before the start of each quarter in the year, the executive officer shall determine the total volume of gasoline distributed by the person for use in motor vehicles in California, and by all gasoline suppliers, in the most recent quarter for which data are available. The determinations shall be based on taxable distributions of gasoline as reported to the State Board of Equalization pursuant to Revenue and Taxation Code sections 7301 et seq. The executive officer shall calculate the market share factor of the person for the quarter as the ratio of the volume of gasoline sold by the person for use in motor vehicles in California as determined in accordance with this subsection, to the total volume of gasoline sold by all gasoline suppliers for use in motor vehicles in California as determined in accordance with this subsection.

(c) **Allocation of the total required volume of each designated clean fuel.**

(1) At least three months before the beginning of each quarter starting January 1, 1994 and ending December 31, 1996, the executive officer shall notify each major gasoline supplier in writing of the major gasoline supplier's minimum assigned volume of each designated clean fuel for that quarter. The minimum assigned volume shall be determined by multiplying the total demand volume of each designated clean fuel for the quarter (as determined pursuant to subsection 2303(a)(3)) by the major gasoline supplier's market share factor (as determined in accordance with subsection 2303(b)(1)).

(2) At least three months before the beginning of each calendar quarter starting January 1, 1997, the executive officer shall notify each gasoline supplier in writing of the gasoline supplier's minimum assigned volume of each designated clean fuel for that quarter. The minimum assigned volume shall be determined by multiplying the total demand volume of each designated clean fuel for the quarter (as determined pursuant to subsection 2303(a)(3)) by the supplier's market share factor (as determined in accordance with subsection 2303(b)(2)).

(3) Subsections 2303(c)(1) and (2) notwithstanding, no gasoline supplier shall be assigned any minimum assigned volume for a designated clean fuel for any calendar year for which the Executive Officer estimates, on the basis of the information identified in subsection 2303(a)(2), that the total number of vehicles certified on the fuel and operated in the state at any time in the year will not exceed 10,000 (for calendar years 1994 through 1996), or 20,000 (for calendar years starting with 1997).

NOTE: Authority cited: Sections 39600, 39601, 43013, 43018, and 43101, Health and Safety Code; and Western Oil and Gas Ass'n. v. Orange County Air Pollution Control District, 14 Cal. 3d 411, 121 Cal. Rptr. 249 (1975). Reference: Sections 39000, 39001, 39002, 39003, 39500, 39515, 39516, 43000, 43013, 43018, and 43101, Health and Safety Code; and Western Oil and Gas Ass'n. v. Orange County Air Pollution Control District, 14 Cal. 3d 411, 121 Cal. Rptr. 249 (1975).

2304. Characterization of Dual-Fuel or Flexible-Fuel Vehicles.

Any dual-fuel or flexible-fuel vehicle which is certified to meet, while operated on gasoline or diesel fuel, low-emission vehicle standards at least as stringent as the most stringent low-emission vehicle standards to which the vehicle is certified while operated on a fuel other than gasoline shall not be included in the determination of minimum assigned volumes of designated clean fuels under section 2303, and shall not be included in the determination of the number of retail gasoline outlets required to have a designated clean fuel available pursuant to sections 2331 and 2332.

NOTE: Authority cited: Sections 39600, 39601, 43013, 43018, and 43101, Health and Safety Code; and Western Oil and Gas Ass'n. v. Orange County Air Pollution Control District, 14 Cal. 3d 411, 121 Cal. Rptr. 249 (1975). Reference: Sections 39000, 39001, 39002, 39003, 39500, 39515, 39516, 43000, 43013, 43018, and 43101, Health and Safety Code; and Western Oil and Gas Ass'n. v. Orange County Air Pollution Control District, 14 Cal. 3d 411, 121 Cal. Rptr. 249 (1975).

Section 2310. **Trading and Banking of Designated Clean Fuel Credits.**

(a) **General.**

Gasoline suppliers may use designated clean fuel credits acquired or withdrawn in accordance with this section to demonstrate compliance with section 2301 in whole or in part. Credits generated from the distribution of a particular designated clean fuel may only be used to demonstrate compliance with requirements pertaining to that fuel. Credits for liquid designated clean fuels shall be quantified in units of gallons.

(b) **Generation of credits by gasoline suppliers.**

A gasoline supplier may generate designated clean fuel credits in a quarter in the amount by which the volume of a designated clean fuel distributed by the gasoline supplier in the quarter exceeds the gasoline supplier's minimum assigned volume of the designated clean fuel for the quarter.

(c) **Generation of credits by independent suppliers of designated clean fuel.**

An independent supplier of designated clean fuel may generate designated clean fuel credits in a quarter in the amount of the volume of each designated clean fuel that the supplier distributes in the calendar quarter, provided that the supplier may only generate credits for designated clean fuel that the supplier has produced or imported, and must exclude any designated clean fuel acquired by a gasoline supplier pursuant to section 2302(b).

(d) **Banking of credits.**

A gasoline supplier or independent supplier of designated clean fuel may bank designated clean fuel credits generated in a calendar quarter. However, at the end of any quarter after accounting for any withdrawals in the quarter, a gasoline supplier shall forfeit any banked credits for a designated clean fuel that exceed 20 percent of the gasoline supplier's minimum assigned volume of the designated clean fuel for that quarter.

(e) **Withdrawals of banked credits.**

A banked credit may be withdrawn in any of the eight calendar quarters following the quarter in which the credit was generated. Credits not withdrawn within that period shall be forfeited. A banked credit must be used in the quarter in which it is withdrawn. The value of credits generated more than two quarters before they are withdrawn shall be discounted in accordance with the following table:

Time Period Between Generation and Use	Value Remaining
3 or 4 quarters	75%
5 or 6 quarters	50%
7 or 8 quarters	25%

A gasoline supplier may not generate credits for a fuel in the same quarter that the supplier uses or trades previously banked credits for that fuel.

(f) **Use of Credits.**

A gasoline supplier may use in a quarter credits generated in that quarter by another gasoline supplier or by an independent supplier of designated clean fuel, or banked credits which have been withdrawn by the gasoline supplier, another gasoline supplier, or an independent supplier of designated clean fuel. A gasoline supplier may not use in a quarter credits acquired from another person after the final day of the quarter, or withdrawn from the gasoline supplier's bank after the final day of the quarter.

NOTE: Authority cited: Sections 39600, 39601, 43013, 43018, and 43101, Health and Safety Code; and Western Oil and Gas Ass'n. v. Orange County Air Pollution Control District, 14 Cal. 3d 411, 121 Cal. Rptr. 249 (1975). Reference: Sections 39000, 39001, 39002, 39003, 39500, 39515, 39516, 43000, 43013, 43018, and 43101, Health and Safety Code; and Western Oil and Gas Ass'n. v. Orange County Air Pollution Control District, 14 Cal. 3d 411, 121 Cal. Rptr. 249 (1975).

Section 2311. **Credits from Distribution of Compressed Natural Gas or Electricity.**

(a) **General.**

Gasoline suppliers may use compressed natural gas or electricity credits generated or acquired in accordance with this section to demonstrate compliance with Sections 2301 or 2302, in addition to using designated clean fuel credits pursuant to Section 2310. Credits generated from the distribution of compressed natural gas or electricity may be used to demonstrate compliance with requirements pertaining to any designated clean fuel.

(b) **Generation of compressed natural gas or electricity credits.**

Beginning in 1994, any person may generate compressed natural gas credits in a quarter based on the amount of compressed natural gas that the person distributes to motor vehicles in the calendar quarter. Any person who distributes electricity to motor vehicles may generate electricity credits for the amount of electricity actually provided to electric vehicles operating in the state. The credit shall only be given for the amount of electricity provided to electric vehicles that are produced in excess of the required number of zero-emission vehicles identified in California Exhaust Emission Standards and Test Procedures for 1988 and Subsequent Model Passenger cars, Light-Duty Trucks, and Medium-Duty Vehicles. Only vehicles with a model-year age of ten or less shall be eligible for generated credits.

(c) **Determination of compressed natural gas or electricity credits.**

Compressed natural gas credits shall be quantified in standard cubic feet. Electricity credits shall be determined on an annual basis by multiplying the electricity supplied to electric vehicles by an E-factor. The E-factor shall be determined annually by the executive officer and announced on March 1 of each year. Starting January 1, 1994, until December 31, 1997, the E-factor shall equal

1.0. For each subsequent year, the executive officer shall determine the E-factor by dividing the cumulative number of electric vehicles that have been sold in excess of the number of zero-emission vehicles required to be sold by the cumulative number of all electric vehicles that have been sold. Compressed natural gas and electricity credits shall be converted to credits for designated clean fuel on an energy-equivalent basis in accordance with the following conversion factors:

FUEL	CNG therms per gallon	ELECTRICITY kw-hrs per gallon
LPG	0.92	59.3
Methanol (M100)	0.57	36.6
M85	0.65	42.1
Ethanol (E100)	0.76	49.0
E85	0.82	53.0

(d) **Banking of compressed natural gas or electricity credits.** Beginning in 1994, any person who distributes compressed natural gas or electricity to motor vehicles may bank compressed natural gas or electricity credits generated.

(e) **Withdrawals of banked credits.** Prior to January 1, 1998, banked credits for compressed natural gas and electricity will not be discounted and can be withdrawn in any quarter. Beginning January 1, 1998, a banked compressed natural gas or electricity credit will be subject to the credit discounting provisions of section 2310(e).

(f) **Use of compressed natural gas or electricity credits.**

A gasoline supplier may use in a quarter compressed natural gas or electricity credits generated in that quarter by the gasoline supplier or by another person. However, in any quarter the total amount of combined compressed natural gas and electricity credits used by a gasoline supplier may not exceed 10 percent of the gasoline supplier's minimum assigned volume for all designated clean fuels for the quarter. A gasoline supplier may not use in a quarter compressed natural gas or electricity credits acquired from another person after the final day of the quarter.

NOTE: Authority cited: Sections 39600, 39601, 43013, 43018, and 43101, Health and Safety Code; and Western Oil and Gas Ass'n. v. Orange County Air Pollution Control District, 14 Cal. 3d 411, 121 Cal. Rptr. 249 (1975). Reference: Sections 39000, 39001, 39002, 39003, 39500, 39515, 39516, 43000, 43013, 43018, and 43101, Health and Safety Code; and Western Oil and Gas Ass'n. v. Orange County Air Pollution Control District, 14 Cal. 3d 411, 121 Cal. Rptr. 249 (1975).

Section 2320. **Reporting Requirements for Gasoline Suppliers.**

(a) For each quarter commencing with the first quarter of 1994, each gasoline supplier who has received a minimum assigned volume for the quarter shall within 30 days after the end of the quarter submit to the executive officer a report containing the information set forth below. The information shall be separately reported for each designated clean fuel for which the gasoline supplier has received a minimum assigned volume for the quarter. If the gasoline supplier complies with any requirement by the use of a substitute fuel designated in accordance with Section 2345, information for the substitute fuel shall be separately reported. The report shall be executed in California under penalty of perjury.

(1) The volume of designated clean fuel distributed by the gasoline supplier in the quarter as determined in accordance with section 2302.

(2) The volume of designated clean fuel identified in (a)(1) that was produced by the gasoline supplier.

(3) The volume of designated clean fuel identified in (a)(1) that was imported by the gasoline supplier.

(4) The volume of designated clean fuel identified in (a)(1) that was acquired by the gasoline supplier from another person, the volume acquired from each such person, and the name and address of each such person.

(5) The volume of designated clean fuel supplied to another gasoline supplier entitled to count it pursuant to section 2302, the volume supplied to each such person, and the name and address of each such person.

(6) The amount of designated clean fuel credits generated by the gasoline supplier in the quarter.

(7) The amount of designated clean fuel credits identified under (a)(6) which were banked by the gasoline supplier.

(8) The amount of designated clean fuel credits transferred to other gasoline suppliers in the quarter, the quarter in which such credits were generated, and for each supplier to whom the credits were traded, the name and address of the supplier, the amount of credits transferred.

(9) The amount of designated clean fuel credits acquired from other gasoline suppliers in the quarter, and for each gasoline supplier from whom credits were acquired, the name and address of the supplier, and the amount of credits acquired.

(10) The amount of designated clean fuel credits acquired from independent suppliers of designated clean fuels in the quarter, and for each such supplier from whom credits were acquired, the name and address of the supplier, and the amount of credits acquired.

(11) The amount of compressed natural gas or electricity credits acquired from generators of such credits in the quarter, and for each such person from whom such credits were acquired, the name and address of the person, and the amount of credits acquired.

(12) The amount of designated clean fuel credits that the gasoline supplier withdrew from its bank in the quarter, and the quarter(s) that all such withdrawn credits had been banked.

NOTE: Authority cited: Sections 39600, 39601, 43013, 43018, and 43101, Health and Safety Code; and Western Oil and Gas Ass'n. v. Orange County Air Pollution Control District, 14 Cal. 3d 411, 121 Cal. Rptr. 249 (1975). Reference: Sections 39000, 39001, 39002, 39003, 39500, 39515, 39516, 43000, 43013, 43018, and 43101, Health and Safety Code; and Western Oil and Gas Ass'n. v. Orange County Air Pollution Control District, 14 Cal. 3d 411, 121 Cal. Rptr. 249 (1975).

Section 2321. **Reporting Requirements for Independent Suppliers of Designated Clean Fuel and Persons Who Generate Compressed Natural Gas or Electricity Credits.**

(a) For each quarter commencing with the first quarter of 1994, each independent supplier of designated clean fuel who in the quarter has transferred designated clean fuel or designated clean fuel credits to a gasoline supplier, or who claims to have generated clean fuel credits through the distribution of designated clean fuel, shall within 30 days after the end of the quarter submit to the executive officer a report containing the information set forth below. The information shall be separately reported for each designated clean fuel. The report shall be executed in California under penalty of perjury.

(1) The volume of designated clean fuel produced or imported by the independent supplier which was supplied in the quarter to gasoline suppliers entitled to count it pursuant to section 2302, the volume supplied to each such gasoline supplier, and the name and address of each such gasoline supplier.

(2) The volume of designated clean fuel produced or imported by the independent supplier which was supplied in the quarter to gasoline suppliers not entitled to count it pursuant to section 2302, the volume supplied to each such gasoline supplier, and the name and address of each such gasoline supplier.

(3) The volume of designated clean fuel produced or imported by the independent supplier which was distributed by the independent supplier in the quarter, and the amount of designated clean fuel credits generated by the independent supplier in the quarter from such distribution.

(4) The amount of designated clean fuel credits that were transferred to a gasoline supplier in the quarter, the quarter in which such credits were generated, and for each supplier to whom the credits were traded, the name and address of the supplier, the amount of credits transferred.

(5) The amount of designated clean fuel credits identified under (a)(3) which were banked by the gasoline supplier.

(b) For each quarter commencing with the first quarter of 1994, each person who has transferred compressed natural gas or electricity credits in the quarter shall within 30 days after the end of the quarter submit to the executive officer a report containing the information set forth below. The information shall be separately reported for compressed natural gas and electricity. The report shall be executed in California under penalty of perjury.

(1) The amount of compressed natural gas and electricity, produced or imported by the person, which was distributed by the person in the quarter, and the amount of compressed natural gas and electricity credits generated by the person in the quarter from such distribution.

(2) The name and address of each gasoline supplier to whom the person transferred compressed natural gas or electricity credits, and the amount of credits transferred to the supplier.

NOTE: Authority cited: Sections 39600, 39601, 43013, 43018, and 43101, Health and Safety Code; and Western Oil and Gas Ass'n. v. Orange County Air Pollution Control District, 14 Cal. 3d 411, 121 Cal. Rptr. 249 (1975). Reference: Sections 39000, 39001, 39002, 39003, 39500, 39515, 39516, 43000, 43013, 43018, and 43101, Health and Safety Code; and Western Oil and Gas Ass'n. v. Orange County Air Pollution Control District, 14 Cal. 3d 411, 121 Cal. Rptr. 249 (1975).

Section 2322. **Recordkeeping Requirements for Gasoline Suppliers Starting January 1, 1994.**

(a) Starting January 1, 1994, each gasoline supplier shall establish, maintain and retain adequately organized records containing the following information:

(1) For each discrete quantity of a designated clean fuel claimed to be distributed by the gasoline supplier in compliance with section 2301 or 2302, including designated clean fuel which generates credits for the gasoline supplier and substitute fuels designated pursuant to section 2345:

(A) The volume, the quarter in which it was distributed (or if distributed in more than one quarter, the volume distributed in each quarter in which it was distributed), and a means of identifying the discrete quantity.

(B) The volume produced or imported by the gasoline supplier, and data adequately documenting that it was produced or imported by the supplier.

(C) The volume acquired from another person, the identity of that person, the date on which it was acquired, and the invoice and/or bill of lading representing the acquisition, and a copy of the written agreement described in section 2303(b).

(D) The name and address of the recipient, the immediate destination of the fuel, a copy of the invoice and/or bill of lading, and data adequately demonstrating that the fuel is offered for use as a motor vehicle fuel.

(E) The amount of credits, if any, which were generated from the distribution of the fuel, the date of generation, and the date of withdrawal.

(2) For each discrete quantity of designated clean fuel transferred to another gasoline supplier pursuant to section 2302(b),

(A) The volume and date transferred, the name and address of the person to whom the fuel was transferred, and a copy of the invoice and/or bill of lading.

(B) A copy of the written agreement described in Section 2302(b).

(3) For each instance in which the gasoline supplier transferred designated clean fuel credits,

(A) The quarter in which the credits were generated, and the basis by which the credits were calculated.

(B) Records adequately memorializing the transfer, including the type of fuel for which the credit applied, the date of transfer, the name and address of the transferee, and the amount of credits transferred.

(4) For each instance in which the gasoline suppliers acquired credits from another person, records adequately memorializing the acquisition, including the type of fuel for which the credit applied, the date of acquisition, the name and address of the person from whom the credits were acquired, and the amount of credits acquired.

(b) The gasoline supplier shall retain all records required to be maintained under this section for a period of 4 years from the end to the quarter to which they pertain. During the period of required retention, the gasoline supplier shall make any of the records available to the executive officer upon request.

NOTE: Authority cited: Sections 39600, 39601, 43013, 43018, and 43101, Health and Safety Code; and Western Oil and Gas Ass'n. v. Orange County Air Pollution Control District, 14 Cal. 3d 411, 121 Cal. Rptr. 249 (1975). Reference: Sections 39000, 39001, 39002, 39003, 39500, 39515, 39516, 43000, 43013, 43018, and 43101, Health and Safety Code; and Western Oil and Gas Ass'n. v. Orange County Air Pollution Control District, 14 Cal. 3d 411, 121 Cal. Rptr. 249 (1975).

Section 2323. **Recordkeeping Requirements for Independent Suppliers of Designated Clean Fuel and Generators of Compressed Natural Gas or Electricity Credits.**

(a) Starting January 1, 1994, each independent supplier of designated clean fuel who at any time has generated or withdrawn designated clean fuel credits shall establish, maintain and retain adequately organized records containing the following information:

(1) For each discrete quantity of a designated clean fuel produced or imported by the independent supplier and claimed to be distributed by the independent supplier:

(A) The volume, and the quarter in which it was distributed (or if distributed in more than one quarter, the volume distributed in each quarter in which it was distributed).

(B) The volume produced or imported by the independent supplier, and data adequately documenting that it was produced or imported by the independent supplier.

(C) The name and address of the recipient, the immediate destination of the fuel, a copy of the invoice and/or bill of lading, and data adequately demonstrating that the fuel is offered for use as a motor vehicle fuel.

(D) The amount of credits, if any, which were generated from the distribution of the fuel, the date of generation, and the date of withdrawal.

(2) For each discrete volume of designated clean fuel transferred to a gasoline supplier pursuant to section 2302(b),

(A) The volume and date transferred, the name and address of the person to whom the fuel was transferred, and a copy of the invoice and/or bill of lading.

(B) A copy of the written agreement described in Section 2302(b).

(3) For each instance in which the independent supplier transferred designated clean fuel credits,

(A) The quarter in which the credits were generated, and the basis by which the credits were calculated.

(B) Records adequately memorializing the transfer, including the type of fuel for which the credit applied, the date of transfer, the name and address of the transferee, and the amount of credits transferred.

(b) Starting January 1, 1994, each person who has transferred compressed natural gas or electricity credits shall establish, maintain and retain adequately organized records containing the following information:

(1) For each discrete quantity of compressed natural gas and electricity produced or imported by the person and claimed to be distributed by the person:

(A) The amount distributed and the quarter in which it was distributed.

(B) Data adequately documenting that the compressed natural gas and electricity was produced or imported by the person.

(C) Data adequately demonstrating that compressed natural gas and electricity was used as a motor vehicle fuel.

(D) The amount of credits, if any, which were generated from the distribution of the fuel, the date of generation, and the date of withdrawal.

(3) For each instance in which the person transferred designated clean fuel credits,

(A) The quarter in which the credits were generated, and the basis by which the credits were calculated.

(B) Records adequately memorializing the transfer, including the type of fuel for which the credit applied, the date of transfer, the name and address of the transferee, and the amount of credits transferred.

(c) A person shall retain all records required to be maintained under this section for a period of 4 years from the end to the quarter to which they pertain. During the period of required retention, the person shall make any of the records available to the executive officer upon request.

NOTE: Authority cited: Sections 39600, 39601, 43013, 43018, and 43101, Health and Safety Code; and Western Oil and Gas Ass'n. v. Orange County Air Pollution Control District, 14 Cal. 3d 411, 121 Cal. Rptr. 249 (1975). Reference: Sections 39000, 39001, 39002, 39003, 39500, 39515, 39516, 43000, 43013, 43018, and 43101, Health and Safety Code; and Western Oil and Gas Ass'n. v. Orange County Air Pollution Control District, 14 Cal. 3d 411, 121 Cal. Rptr. 249 (1975).

Section 2330. **Equipping Retail Gasoline Outlets in the SCAQMD to Dispense Designated Clean Fuels in 1994 Through 1996.**

Between January 1, 1994 and December 31, 1996, any major gasoline supplier who in a quarter is the owner/lessor of an operating retail gasoline outlet in the SCAQMD shall, for each designated clean fuel, equip during all of the quarter at least the required minimum number, as determined in accordance with section 2335, of the retail gasoline outlets in the SCAQMD of which it is the owner/lessor so that the outlet is capable of dispensing the fuel into motor vehicles. In the case of any designated clean fuel which is in gaseous form, the dispensing equipment shall be designed for a minimum of four hours of high volume operation with an average fill rate of at least 600 standard cubic feet per minute. For all retail gasoline outlets that are claimed by the owner/lessor to be equipped in order to satisfy the requirements of this subsection, the owner/lessor shall notify the operator in writing that the outlet is so equipped.

NOTE: Authority cited: Sections 39600, 39601, 43013, 43018, and 43101, Health and Safety Code; and Western Oil and Gas Ass'n. v. Orange County Air Pollution Control District, 14 Cal. 3d 411, 121 Cal. Rptr. 249 (1975). Reference: Sections 39000, 39001, 39002, 39003, 39500, 39515, 39516, 43000, 43013, 43018, and 43101, Health and Safety Code; and Western Oil and Gas Ass'n. v. Orange County Air Pollution Control District, 14 Cal. 3d 411, 121 Cal. Rptr. 249 (1975).

Section 2331. **Availability of Designated Clean Fuels in 1994 Through 1996 at Retail Gasoline Outlets in the SCAQMD Equipped to Dispense the Fuel.**

From January 1, 1994 through December 31, 1996, whenever an operator of a retail gasoline outlet in the SCAQMD equipped to dispense a designated clean fuel into motor vehicles in order to comply with section 2330 offers gasoline for sale at the outlet, the operator shall store a commercially reasonable quantity of the designated clean fuel at the retail gasoline outlet and offer the designated clean fuel for sale to the public.

NOTE: Authority cited: Sections 39600, 39601, 43013, 43018, and 43101, Health and Safety Code; and Western Oil and Gas Ass'n. v. Orange County Air Pollution Control District, 14 Cal. 3d 411, 121 Cal. Rptr. 249 (1975). Reference: Sections 39000, 39001, 39002, 39003, 39500, 39515, 39516, 43000, 43013, 43018, and 43101, Health and Safety Code; and Western Oil and Gas Ass'n. v. Orange County Air Pollution Control District, 14 Cal. 3d 411, 121 Cal. Rptr. 249 (1975).

Section 2332. **Equipping Retail Gasoline Outlets to Dispense Designated Clean Fuels Starting in 1997.**

(a) Starting January 1, 1997, any person who is the owner/lessor of a retail gasoline outlet operating in a quarter shall, for each designated clean fuel, equip during all of the quarter at least the minimum designated number, as determined in accordance with section 2337, of his or her retail gasoline outlets so that the outlet is capable of dispensing the fuel into motor vehicles. In the case of any designated clean fuel which is in gaseous form, the dispensing equipment shall be designed for a minimum of four hours of high volume operation with an average fill rate of at least 600 standard cubic feet per minute. For all retail gasoline outlets that are claimed by the owner/lessor to be equipped in order to satisfy the requirements of this subsection, the owner/lessor shall notify the operator in writing that the outlet is so equipped.

NOTE: Authority cited: Sections 39600, 39601, 43013, 43018, and 43101, Health and Safety Code; and Western Oil and Gas Ass'n. v. Orange County Air Pollution Control District, 14 Cal. 3d 411, 121 Cal. Rptr. 249 (1975). Reference: Sections 39000, 39001, 39002, 39003, 39500, 39515, 39516, 43000, 43013, 43018, and 43101, Health and Safety Code; and Western Oil and Gas Ass'n. v. Orange County Air Pollution Control District, 14 Cal. 3d 411, 121 Cal. Rptr. 249 (1975).

Section 2333. Availability of Designated Clean Fuels Starting in 1997 at Retail Gasoline Outlets Equipped to Dispense the Fuel.

(a) Starting January 1, 1997, whenever an operator of a retail gasoline outlet equipped to dispense a designated clean fuel in order to comply with section 2332 offers gasoline for sale at the outlet, the operator shall also store a commercially reasonable quantity of the designated clean fuel at the retail gasoline outlet and offer the designated clean fuel for sale to the public.

NOTE: Authority cited: Sections 39600, 39601, 43013, 43018, and 43101, Health and Safety Code; and Western Oil and Gas Ass'n. v. Orange County Air Pollution Control District, 14 Cal. 3d 411, 121 Cal. Rptr. 249 (1975). Reference: Sections 39000, 39001, 39002, 39003, 39500, 39515, 39516, 43000, 43013, 43018, and 43101, Health and Safety Code; and Western Oil and Gas Ass'n. v. Orange County Air Pollution Control District, 14 Cal. 3d 411, 121 Cal. Rptr. 249 (1975).

Section 2334. **Determination of Total Incremental Number of Retail Gasoline Outlets Required to Be Equipped to Dispense Each Designated Clean Fuel For Each Year Starting in 1994.**

(a) For each year starting with 1994, the executive officer shall determine for each designated clean fuel the required total number of retail gasoline outlets capable of dispensing the fuel to motor vehicles in the year, at least twelve months before the start of the year, calculated as follows:

$$\text{Required Retail Outlets} = \frac{\text{Total Required Clean Fuel Volume} - \text{Clean Fuel Volume at Non-Retail Stations} + \text{Total Clean Fuel Volume From Vehicle Conversions}}{\text{Clean Fuel Throughput Volume per Station}}$$

Where: *Total Required Clean Fuel Volume* shall be determined in accordance with the procedures set forth in section 2303(a), provided that all references to "quarter" shall be changed to "calendar year."

Clean Fuel Volume at Non-Retail Stations means the total volume of the designated clean fuel estimated to be dispensed into motor vehicles at non-retail stations during the year. This figure shall be determined by the executive officer based on the reports filed pursuant to section 241 and on any other relevant reasonably available information. For 1994, 1995 and 1996, the volume shall be based on stations in the SCAQMD only.

Clean Fuel Volume from Vehicle Conversions means the total amount of the designated clean fuel for each vehicle class from conversions. This figure shall be determined by the executive officer based on information provided by California Department of Motor Vehicles. For 1994, 1995 and 1996, the volume shall be based on stations in the SCAQMD only.

Clean Fuel Throughput Volume Per Station for liquid fuel is calculated as 300,000 gallons per year for each designated clean fuel for the years 1994-1997, and as 600,000 gallons per year for each designated clean fuel starting in 1998. For gaseous fuel, the clean fuel throughput per station is calculated as 42.5 million standard cubic feet per year (360,000 gallon per year).

(b) For each year starting with 1994, the executive officer shall determine the total annual incremental number of retail gasoline outlets required to be equipped during the year to dispense each designated clean fuel by subtracting the total annual incremental number of retail stations determined in accordance with this subsection for the previous year, from the number determined pursuant to section 2334(a).

NOTE: Authority cited: Sections 39600, 39601, 43013, 43018, and 43101, Health and Safety Code; and Western Oil and Gas Ass'n. v. Orange County Air Pollution Control District, 14 Cal. 3d 411, 121 Cal. Rptr. 249 (1975). Reference: Sections 39000, 39001, 39002, 39003, 39500, 39515, 39516, 43000, 43013, 43018, and 43101, Health and Safety Code; and Western Oil and Gas Ass'n. v. Orange County Air Pollution Control District, 14 Cal. 3d 411, 121 Cal. Rptr. 249 (1975).

Section 2335. Allocation of Incremental Number of Each Major Gasoline Supplier's Retail Gasoline Outlets in the SCAQMD Required to Be Equipped to Dispense A Designated Clean Fuel in 1994 Through 1996.

(a) Allocation of incremental number of outlets.

For each of the years 1994, 1995 and 1996, the executive officer shall determine twelve months in advance the annual incremental number of new each major gasoline supplier's retail gasoline outlets in the SCAQMD required to be equipped to dispense each designated clean fuel. This number shall be calculated, for each designated clean fuel, by multiplying the total annual incremental number of new retail gasoline outlets needed (determined in accordance with section 2334(b)) by the most recent market share factor for the major gasoline supplier determined in accordance with section 2303(b).

(b) Determination of total required minimum number of outlets. For each of the years 1994, 1995 and 1996, each major gasoline supplier's required minimum number of retail gasoline outlets equipped to dispense each designated clean fuel in the SCAQMD shall consist of the incremental number of outlets for the year determined in accordance with section 2334(b), added to the number of outlets determined in accordance with section 2332(b) for the major gasoline supplier for all previous years.

(c) The executive officer shall make the determinations set forth in this section for each year twelve months in advance, by January 1. The executive officer shall promptly notify all major gasoline suppliers of the minimum designated number of retail gasoline outlets for each quarter.

(d) Subsections 2335(a) and (b) notwithstanding, no major gasoline supplier shall be assigned any required minimum number of retail gasoline outlets pursuant to this section for a designated clean fuel for any calendar year for which the executive officer estimates, on the basis of the information identified in subsection 2303(a)(2), that the total number of vehicles certified on the fuel and operated in the SCAQMD at any time in the year will not exceed 10,000.

NOTE: Authority cited: Sections 39600, 39601, 43013, 43018, and 43101, Health and Safety Code; and Western Oil and Gas Ass'n. v. Orange County Air Pollution Control District, 14 Cal. 3d 411, 121 Cal. Rptr. 249 (1975). Reference: Sections 39000, 39001, 39002, 39003, 39500, 39515, 39516, 43000, 43013, 43018, and 43101, Health and Safety Code; and Western Oil and Gas Ass'n. v. Orange County Air Pollution Control District, 14 Cal. 3d 411, 121 Cal. Rptr. 249 (1975).

Section 2336. **Identification of Affected Owner/Lessors Required to Equip Retail Gasoline Outlets to Dispense a Designated Clean Fuel Each Year Starting in 1997.**

For each year, beginning in 1997, the executive officer shall identify the affected retail gasoline outlet owner/lessors required to equip retail gasoline outlets to dispense each designated clean fuel. An affected station owner is any person who owns or leases a number of retail gasoline outlets equal to or greater than the minimum ownership level (MOL) for the year, calculated as follows:

$$\text{Minimum Ownership Level (MOL)} = \frac{\text{Number of Non-Clean Fuel Outlets Statewide}}{\text{Total Annual Incremental Number of Retail Gasoline Outlets for All Clean Fuels}}$$

Where: *Number of Non-Clean Fuel Outlets Statewide* is calculated by subtracting the sum of the required retail outlets calculated in section 2334(a) for all clean fuels from the total number of retail gasoline outlets statewide estimated by the executive officer based on the reports submitted pursuant to section 2340 and other reasonably available relevant information.

Total Annual Incremental Number of Retail Gasoline Outlets for All Clean Fuels is the sum of the total annual incremental number of retail gasoline outlets calculated for the year for each clean fuel in accordance with section 2334(b).

The executive officer shall round the result of the calculation for minimum ownership level to the nearest integer.

NOTE: Authority cited: Sections 39600, 39601, 43013, 43018, and 43101, Health and Safety Code; and Western Oil and Gas Ass'n. v. Orange County Air Pollution Control District, 14 Cal. 3d 411, 121 Cal. Rptr. 249 (1975). Reference: Sections 39000, 39001, 39002, 39003, 39500, 39515, 39516, 43000, 43013, 43018, and 43101, Health and Safety Code; and Western Oil and Gas Ass'n. v. Orange County Air Pollution Control District, 14 Cal. 3d 411, 121 Cal. Rptr. 249 (1975).

Section 2337. **Allocation of Incremental Number Gasoline Retail Outlets of Each Affected Owner/Lessor Required to be Equipped to Dispense a Designated Clean Fuel Starting in 1997.**

(a) **Allocation of incremental number of outlets.**

For each year, beginning in 1997, the executive officer shall determine twelve months in advance the minimum designated number of retail gasoline outlets that each affected retail gasoline outlet owner/lessor is required to equip to dispense each designated clean fuel. The executive officer shall calculate the minimum designated number of retail gasoline outlets for each affected owner/lessor by multiplying the owner/lessor's number of non-clean fuel retail gasoline outlets (determined in accordance with section 2337(b)) by the clean fuel fraction (determined in accordance with section 2337(c)), rounded to the nearest integer using conventional rounding.

(b) **Determination of an owner/lessor's number of non-clean fuel retail gasoline outlets.**

The executive officer shall determine an owner/lessor's number of non-clean fuel retail gasoline outlets by subtracting the sum of the minimum designated number of retail gasoline outlets that the owner/lessor was required to equip to dispense all designated clean fuels in all prior years of the program (based on reports submitted pursuant to section 2340) from the owner/lessor's total number of retail gasoline outlets (based on reports submitted pursuant to section 2340).

(c) **Determination of clean fuel fraction.** For each designated clean fuel, the executive officer shall calculate the clean fuel fraction for each designated clean fuel as follows:

$$\text{Clean Fuel Fraction} = \frac{\text{Total Annual Incremental Number of Retail Gasoline Outlets}}{\text{Number of Non-Clean Fuel Outlets Owned by All Affected Owners/Lessors}}$$

Where: *Total Annual Incremental Number of Retail Gasoline Outlets* is the total annual incremental number of retail gasoline outlets calculated for the year for the clean fuel in accordance with section 2334(b).

Number of Non-Clean Fuel Outlets Owned by All Affected Owners/Lessors is calculated by subtracting the sum of the required retail outlets calculated in section 2334(a) for all clean fuels from the sum of the number of retail gasoline outlets owned or leased by all of the affected owners and lessors estimated by the executive officer based on the reports submitted pursuant to section 2340 and other reasonably available relevant information.

(d) The executive officer shall make the determinations and estimates set forth in this section for a calendar year, and shall identify the minimum designated number of of retail gasoline outlets that each owner/lessor is required to equip to dispense each designated clean fuel each year, one year in advance, by January 1.

The executive officer shall promptly notify all owner/lessors in writing of the minimum designated number.

(e) Section 2336 and subsections 2337(a) through (d) notwithstanding, no owner/lessor shall be assigned any required minimum number of retail gasoline outlets pursuant to this section for a designated clean fuel for any calendar year for which the executive officer estimates, on the basis of the information identified in subsection 2303(a)(2), that the total number of vehicles certified on the fuel and operated in the state at any time in the year will not exceed 20,000.

NOTE: Authority cited: Sections 39600, 39601, 43013, 43018, and 43101, Health and Safety Code; and Western Oil and Gas Ass'n. v. Orange County Air Pollution Control District, 14 Cal. 3d 411, 121 Cal. Rptr. 249 (1975). Reference: Sections 39000, 39001, 39002, 39003, 39500, 39515, 39516, 43000, 43013, 43018, and 43101, Health and Safety Code; and Western Oil and Gas Ass'n. v. Orange County Air Pollution Control District, 14 Cal. 3d 411, 121 Cal. Rptr. 249 (1975).

Section 2338. **Constructive Allocation of Facilities Equipped to Dispense Designated Clean Fuel to Motor Vehicles.**

(a) Any owner/lessor of a retail gasoline outlet, and any person who owns or is the lessor of a retail clean fuel outlet which is not a retail gasoline outlet, may constructively allocate one or more retail clean fuel outlets to a major gasoline supplier, or to an owner/lessor, for purposes of demonstrating compliance with the requirements in sections 2330 or 2332, as long as the requirements of this section are met.

(b) Any agreement to constructively allocate a retail clean fuel outlet pursuant to this section shall be in writing. The constructive the constructive allocation agreement. The report shall be executed in California under penalty of perjury and shall contain the following information.

(1) The name, address and telephone number of the person making making the constructive allocation.

(2) The street address of each retail clean fuel outlet constructively allocated, the type of designated clean fuel dispensed at the outlet, the business interest in the outlet of the person making the constructive allocation, and the brand, trade, or other name under which the the business at the outlet is conducted.

(3) For each constructively allocated retail clean fuel outlet, the name and address of the major gasoline supplier or owner/lessor to whom the outlet was constructively allocated, and the starting and ending dates of the constructive allocation.

(4) The name of the operator of the retail clean fuel outlet.

(h) Any major gasoline supplier or owner/lessor who receives a constructive allocation of a retail clean fuel outlet shall submit a report to the executive officer by January 10 of each year covered by the constructive allocation agreement. The report shall be executed in California under penalty of perjury and shall contain the following information.

(1) The name, address and telephone number of the major gasoline supplier or owner/operator.

(2) The street address of each retail clean fuel outlet constructively allocated, the type of designated clean fuel dispensed

allocation shall be in calendar year increments, and shall not cover less than one calendar year. The agreement shall be executed before the start of the first year of constructive allocation covered by the agreement.

(c) A retail clean fuel outlet may not be constructively allocated unless it meets any applicable dispensing capacity requirements set forth in sections 2330, 2332 and 2334.

(d) If the retail clean fuel outlet being constructively allocated is not a retail gasoline outlet, the person making the constructive allocation shall obtain prior approval from the executive officer. The executive officer shall approve the constructive allocation if s/he determines that the facility is is adequately accessible for fueling of motor vehicles by the general public with the designated clean fuel.

(e) Any person who constructively allocates a designated clean fuel dispensing facility to an owner/operator or major gasoline supplier shall be obligated to assure that the facility remains equipped to dispense the fuel to motor vehicles operated by the public during the period covered by the constructive allocation agreement.

(f) The owner/lessor of any clean fuel retail outlet which is constructively allocated shall notify the operator in writing that it is claimed to be equipped in order to satisfy the requirements of section 2330, or 2332, as applicable.

(g) Any person who constructively allocates a retail clean fuel outlet to a major gasoline supplier or owner/lessor shall submit a report to the executive officer by January 10 of each year covered by at the outlet, and the brand, trade, or other name under which the the business at the outlet is conducted.

(3) For each constructively allocated retail clean fuel outlet, the name and address of the person constructively allocating the outlet, and the starting and ending dates of the constructive allocation.

(4) A copy of the executed constructive allocation agreement.

NOTE: Authority cited: Sections 39600, 39601, 43013, 43018, and 43101, Health and Safety Code; and Western Oil and Gas Ass'n. v. Orange County Air Pollution Control District, 14 Cal. 3d 411, 121 Cal. Rptr. 249 (1975). Reference: Sections 39000, 39001, 39002, 39003, 39500, 39515, 39516, 43000, 43013, 43018, and 43101, Health and Safety Code; and Western Oil and Gas Ass'n. v. Orange County Air Pollution Control District, 14 Cal. 3d 411, 121 Cal. Rptr. 249 (1975).

Section 2339. **Reports by Major Gasoline Suppliers and Owner/Lessors of Retail Gasoline Outlets Regarding Compliance with Sections 2330 and 2332.**

(a) Each major gasoline supplier shall for each of the calendar years 1994, 1995, and 1996 submit to the executive officer by January 10 of the year a report containing the information set forth below regarding compliance with section 2330, provided in the calendar year the supplier is the owner/lessor of an operating retail gasoline outlet in the SCAQMD. For each calendar year starting with 1997, each owner/operator who is required to equip one or more retail gasoline outlets to dispense a designated clean fuel shall submit to the executive officer by January 10 of the year a report containing the information set forth below regarding compliance with section 2332.

The information shall be categorized by each designated clean fuel. The reports shall be executed in California under penalty of perjury.

(1) The street address of each of the major gasoline supplier's or owner/lessor's retail gasoline outlets claimed to be equipped to dispense a designated clean fuel to satisfy the requirements of section 2330 or 2332.

(2) For each such outlet, the type of designated clean fuel dispensed at the outlet, the brand, trade, or other name under which the the business at the outlet is conducted, and the name of the operator of the outlet.

NOTE: Authority cited: Sections 39600, 39601, 43013, 43018, and 43101, Health and Safety Code; and Western Oil and Gas Ass'n. v. Orange County Air Pollution Control District, 14 Cal. 3d 411, 121 Cal. Rptr. 249 (1975). Reference: Sections 39000, 39001, 39002, 39003, 39500, 39515, 39516, 43000, 43013, 43018, and 43101, Health and Safety Code; and Western Oil and Gas Ass'n. v. Orange County Air Pollution Control District, 14 Cal. 3d 411, 121 Cal. Rptr. 249 (1975).

Section 2340. **Reports by Owner/Lessors of Retail Gasoline Outlets.**

(a) By July 1, 1992, and by July 1 of every year thereafter, each owner/lessor of a retail gasoline outlet shall report to the executive officer the total number of retail gasoline outlets in the state of which the person is the owner/lessor, the street address of the retail gasoline outlet, and the owner/lessor's business interest in the outlet.

NOTE: Authority cited: Sections 39600, 39601, 43013, 43018, and 43101, Health and Safety Code; and Western Oil and Gas Ass'n. v. Orange County Air Pollution Control District, 14 Cal. 3d 411, 121 Cal. Rptr. 249 (1975). Reference: Sections 39000, 39001, 39002, 39003, 39500, 39515, 39516, 43000, 43013, 43018, and 43101, Health and Safety Code; and Western Oil and Gas Ass'n. v. Orange County Air Pollution Control District, 14 Cal. 3d 411, 121 Cal. Rptr. 249 (1975).

Section 2341. **Reports by Fleet Operators.**

(a) Every fleet operator shall, for any year starting with 1994 in which the fleet operator reasonably expects to operate fleet vehicles certified on a designated clean fuel, supply the following information to the executive officer, at least thirteen months before the start of the year:

(1) The expected number of low-emission vehicles in the fleet to be operated in the year that will be certified on a designated clean fuel, categorized by designated clean fuel and by vehicle type (TLEV, LEV, ULEV, and ZEV).

(2) The total volume of each designated clean fuel expected to be used by the vehicles in the year.

(3) The total volume of designated clean fuel expected to be supplied to fleet vehicles during the year from the fleet operator's own dispensing facilities.

NOTE: Authority cited: Sections 39600, 39601, 43013, 43018, and 43101, Health and Safety Code; and Western Oil and Gas Ass'n. v. Orange County Air Pollution Control District, 14 Cal. 3d 411, 121 Cal. Rptr. 249 (1975). Reference: Sections 39000, 39001, 39002, 39003, 39500, 39515, 39516, 43000, 43013, 43018, and 43101, Health and Safety Code; and Western Oil and Gas Ass'n. v. Orange County Air Pollution Control District, 14 Cal. 3d 411, 121 Cal. Rptr. 249 (1975).

Section 2342. **Determination of Violations**

(a) **Violations of section 2301.**

In any quarter in which a gasoline supplier who distributes gasoline fails to distribute its minimum assigned volume of a designated clean fuel in violation of section 2301, the gasoline supplier shall be deemed to have sold or supplied gasoline in violation of these regulations. The volume of gasoline unlawfully sold or supplied by the gasoline supplier shall be the volume of gasoline first consecutively sold by the gasoline supplier in the quarter up to the volume, calculated on an energy equivalent basis, of each designated clean fuel that the gasoline supplier failed to distribute in the quarter as required. A separate motor vehicle shall be deemed to have been fueled with each twenty gallons of the unlawfully sold or supplied gasoline, unless the gasoline supplier demonstrates that a lesser number of motor vehicles were so fueled. If a gasoline supplier claims to comply with the requirements of section 2301 wholly or partially on the basis of acquired or withdrawn credits, such claimed credits shall not satisfy the gasoline supplier's obligations to the extent the credits were generated, withdrawn, or transferred in noncompliance with these regulations.

(b) Violations of sections 2330 and 2332.

At any time that an owner/lessor fails to have equipped the number of retail gasoline outlets required by sections 2330 or 2332 to be equipped to dispense a designated clean fuel, the owner/lessor shall be deemed to have sold or supplied gasoline to motor vehicles in violation of these regulations. For each day that the owner/lessor violates section 2330 or 2332, the first ten motor vehicles fueled at one of the owner/lessor's retail gasoline outlets shall be deemed to have been unlawfully fueled for each retail gasoline outlet not equipped as required. If an owner/lessor claims to comply with the requirements of sections 2330 or 2331 on the basis of designated clean fuel dispensing facilities constructively allocated pursuant to section 2338, such facilities shall not satisfy the owner/lessor's obligations if the requirements in section 2338 for constructive allocation are not met.

(c) **Violations of sections 2331 and 2333.**

At any time that the operator of a retail gasoline outlet offers gasoline for sale at the retail gasoline outlet in violation of sections 2331 or 2333, the operator shall be deemed to have sold or supplied gasoline to motor vehicles in violation of these regulations. For each day that the owner/lessor violates sections 2331 or 2333, the first five motor vehicles fueled with gasoline at each such retail gasoline outlet shall be deemed to have been unlawfully fueled.

NOTE: Authority cited: Sections 39600, 39601, 43013, 43018, and 43101, Health and Safety Code; and Western Oil and Gas Ass'n. v. Orange County Air Pollution Control District, 14 Cal. 3d 411, 121 Cal. Rptr. 249 (1975). Reference: Sections 39000, 39001, 39002, 39003, 39500, 39515, 39516, 43000, 43013, 43016, 43018, and 43101, Health and Safety Code; and Western Oil and Gas Ass'n. v. Orange County Air Pollution Control District, 14 Cal. 3d 411, 121 Cal. Rptr. 249 (1975).

Section 2342. **Determinations of Energy Equivalency of Fuels.**

Whenever a regulation in this subchapter provides for the comparison of fuels on an energy equivalent basis, the following conversion factors shall be used.

VOLUMETRIC ENERGY CONVERSION FACTORS

FUEL	ENERGY CONTENT (BTUs per gallon)	GASOLINE-BASED CONVERSION FACTORS
Gasoline	116,500	1.00
LPG	91,500	0.79
Methanol(M100)	56,500	0.48
M85	65,000	0.56
Ethanol (E110)	75,700	0.65
E85	81,800	0.70
CNG	1.17 therms	--
Electricity	75.5 kW-hrs	--

NOTE: Authority cited: Sections 39600, 39601, 43013, 43018, and 43101, Health and Safety Code; and Western Oil and Gas Ass'n. v. Orange County Air Pollution Control District, 14 Cal. 3d 411, 121 Cal. Rptr. 249 (1975). Reference: Sections 39000, 39001, 39002, 39003, 39500, 39515, 39516, 43000, 43013, 43018, and 43101, Health and Safety Code; and Western Oil and Gas Ass'n. v. Orange County Air Pollution Control District, 14 Cal. 3d 411, 121 Cal. Rptr. 249 (1975).

Section 2345. **Satisfaction of Designated Clean Fuel Requirements with A Substitute Fuel.**

(a) Any person may petition the state board to designate by regulation a substitute fuel which may be used instead of a primary designated clean fuel to satisfy the distribution requirements for that fuel in sections 2301, and the retail availability requirements for that fuel in sections 2330 and 2332. The state board shall designate such a substitute fuel if it is satisfied that the petitioner has demonstrated all of the following:

(1) That use of the fuel in low-emission vehicles certified on the primary designated clean fuel will result in emissions of NMOG (on a reactivity-adjusted basis), NOx, CO, benzene, 1,3-butadiene, formaldehyde, and acetadehyde no greater than the corresponding emissions from such vehicles fueled with the primary designated clean fuel, as determined pursuant to the procedures set forth in the "California Test Procedure for Evaluating the Emission Impacts of Substitute Fuels or New Clean Fuels", as adopted [insert date], which is incorporated herein by reference.

(2) That if the proposed substitute fuel may be used to fuel any motor vehicles other than low-emission vehicles certified on the primary designated clean fuel:

(A) Use of the substitute fuel in such other motor vehicles would not increase emissions of NMOG (on a reactivity-adjusted basis), NOx, CO, benzene, 1,3-butadiene, formaldehyde, and acetadehyde as determined pursuant to the procedures set forth in the "California Test Procedure for Evaluating the Emission Impacts of Substitute Fuels or New Clean Fuels", as adopted **[insert date]**, which is incorporated herein by reference.

(B) Use of the substitute fuel in such other motor vehicles would not result in increased deterioration of the emission control system on the vehicle and would not void the warranties of any such vehicles.

(b) Whenever the state board designates a substitute fuel pursuant to this section, the state board shall also establish by regulation required specifications for the substitute fuel.

(c) Commencing with the start of the next quarter after the effective date of a regulatory action of the state board designating a substitute fuel pursuant to this section, any person may satisfy his or her obligations under sections 2301, 2330, or 2332 pertaining to a primary designated clean fuel, in whole or in part, by substituting the substitute fuel in place of the primary designated clean fuel. However, if the substitute fuel would be usable in vehicles other than those certified on the primary designated clean fuel, the required distribution volume for the substitute fuel shall be greater than the distribution volume for the primary fuel. The required volume of the substitute fuel for a gasoline supplier for a quarter shall equal the total required volume for the primary designated clean fuel plus the average quarterly volume of all gasoline distributed by a supplier to vehicles which are capable of using the substitute fuel multiplied by the fuel volume adjustment factor set forth in section 2303 (a)(3) (0.25 to 0.90) for the quarter. The average quarterly volume of gasoline shall be based on taxable distributions of motor vehicle fuel for the last four quarters for which data are available, as reported to the State Board of Equalization pursuant to Revenue and Taxation Code section 7301 et. seq.

NOTE: Authority cited: Sections 39600, 39601, 43013, 43018, and 43101, Health and Safety Code; and Western Oil and Gas Ass'n. v. Orange County Air Pollution Control District, 14 Cal. 3d 411, 121 Cal. Rptr. 249 (1975). Reference: Sections 39000, 39001, 39002, 39003, 39500, 39515, 39516, 43000, 43013, 43018, and 43101, Health and Safety Code; and Western Oil and Gas Ass'n. v. Orange County Air Pollution Control District, 14 Cal. 3d 411, 121 Cal. Rptr. 249 (1975).

APPENDIX C

CALIFORNIA TEST PROCEDURES FOR EVALUATING THE EMISSION IMPACTS OF SUBSTITUTE FUELS OR NEW CLEAN FUELS

This appendix contains the California test procedures for evaluating the emission impacts of substitute fuels or new clean fuels.

The staff proposal also includes amendments to and adoption of the documents set forth below, which are incorporated by reference in the proposed regulations. All of these documents, with the proposed amendments clearly indicated, are attached to the technical support document, which is available from the:

Air Resources Board
Public Information Office
1102 Q Street
P.O. Box 2815
Sacramento, CA 95812
(916) 322-2990

1. California Exhaust Emission Standards and Test Procedures for 1988 and Subsequent Model Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles.

2. Guidelines for Certification of 1983 and Subsequent Model-Year Federally Certified Light-Duty Motor Vehicles for Sale in California

3. California Exhaust Emission Standards and Test procedures for 1985 and Subsequent Model Heavy-Duty Diesel Engines and Vehicles

4. California Exhaust Emission Standards and Test Procedures for 1987 and Subsequent Model Heavy-Duty Otto-Cycle Engines and Vehicles

5. California Motor Vehicle Emission Control Label Specifications

6. California Non-Methane Organic Gas Test Procedures

PROPOSED
State of California
AIR RESOURCES BOARD

CALIFORNIA TEST PROCEDURES FOR EVALUATING THE EMISSION IMPACTS OF SUBSTITUTE FUELS OR NEW CLEAN FUELS

Adopted:________________

State of California
AIR RESOURCES BOARD

California Test Procedures For Evaluating The Emission Impacts Of Substitute Fuels Or New Clean Fuels

1. Purpose.

Whenever any person petitions the Air Resources Board to adopt the specifications of a substitute fuel, or to adopt the specifications of a new clean fuel which can be used in vehicles certified on a conventional fuel, the emission impacts of the substitute fuel or the new clean fuel shall be evaluated according to the procedures contained herein.

2. Applicability.

The Air Resources Board shall determine whether use of a substitute fuel or new clean fuel in vehicles capable of using the substitute or new clean fuel will result in an increase in exhaust emissions of non-methane organic gases (NMOG) on a reactivity-adjusted basis, carbon monoxide (CO), oxides of nitrogen (NOx), toxic air contaminants, and evaporative NMOG emissions.

For the purposes of this document, 'toxic air contaminants' shall refer to exhaust emissions of benzene, 1,3-butadiene, formaldehyde, acetaldehyde and diesel particulate.

Substitute fuels must be demonstrated to cause no increases in any of the emissions identified above in:

a) low-emission vehicles that have been certified on the primary designated clean fuel (the fuel that the substitute fuel is replacing), compared to operation on that primary designated clean fuel;

b) low-emission vehicles that have been certified on a different fuel (but are capable of operating on the substitute fuel), compared to operation on gasoline; and

c) conventional vehicles in the fleet that were certified on gasoline (but are capable of operating on the substitute fuel), compared to operation on gasoline.

New clean fuels will be used as certification fuels for new low-emission vehicles. New clean fuels must also be demonstrated to cause no increases in any of the emissions identified above in:

a) low-emission vehicles that have been certified on a different fuel (but are capable of operating on the new fuel), compared to operation on gasoline; and

b) conventional vehicles in the fleet that were certified on gasoline (but are capable of operating on the new fuel), compared to operation on gasoline.

3. Selection of Vehicles.

For purposes of evaluating the emission impacts of a substitute fuel, representative vehicles shall be selected from vehicles certified on the primary designated clean fuel which the substitute fuel is to replace, and vehicles certified on gasoline but capable of using the substitute fuel.

For purposes of evaluating the emission impacts of a new clean fuel, representative vehicles shall be selected from existing vehicles certified on gasoline but capable of using the new fuel.

(A) To be eligible for selection, representative vehicles shall have accumulated between 4,000 and 50,000 miles, and must demonstrate compliance with applicable emission standards.

(B) Any scheduled maintenance shall be permitted to ensure that the test vehicles meet manufacturer performance specifications.

(C) Prior to emission testing, the vehicles shall be preconditioned to remove any residual fuel from the vehicle fuel system and evaporative canister.

(D) The representative test pool for each vehicle emission category shall be comprised, at a minimum, of the number of vehicles needed to determine statistically significant differences in emissions at a level of $p < 0.10$ using paired t-tests.

i. <u>Substitute fuel versus primary designated clean fuel (in vehicles certified on the primary designated fuel)</u>

a. The composition of the representative test fleet shall include vehicles from the vehicle emission categories listed below, equipped with the designated catalyst technology and fuel metering system:

Vehicle Emission Category	Catalyst Technology/Fuel Metering System
Transitional Low-Emission Vehicles	Three Way Catalyst/Fuel-Injected
Low-Emission Vehicles	Uniform Mix of Technologies
Ultra-Low-Emission Vehicles	Uniform Mix of Technologies

b. Prior approval must be granted by the Board's Executive Officer for use of vehicles exceeding mileage accumulations of 50,000 miles.

c. The test vehicles from each vehicle emission category must be certified for use on the primary designated clean fuel.

d. The representative test pools of transitional low-emission vehicles, low-emission vehicles and ultra-low-emission vehicles shall consist, at a minimum, of three different vehicles per vehicle emission category.

ii. Substitute fuel or new clean fuel versus gasoline (in low-emission and conventional vehicles)

a. The composition of the representative test fleet shall include vehicles from the vehicle emission categories listed below, equipped with the designated catalyst technology and fuel metering system:

Vehicle Emission Category	Catalyst Technology/Fuel Metering System
Conventional Vehicles	Non-Catalyst/Carbureted Oxidation Catalyst/Carbureted Three Way Catalyst/Carbureted Three Way Catalyst/Fuel-Injected
Transitional Low-Emission Vehicles	Three Way Catalyst/Fuel-Injected
Low-Emission Vehicles	Uniform Mix of Technologies
Ultra-Low-Emission Vehicles	Uniform Mix of Technologies

b. Prior approval must be granted by the Board's Executive officer for use of vehicles exceeding mileage accumulations of 50,000 miles.

c. The representative test pool of conventional vehicles shall consist of 50% Three Way Catalyst/Fuel-Injected vehicles, and a uniform mix of vehicles from the other three combined technology groups listed in the above table.

d. The representative test pools of transitional low-emission vehicles, low-emission vehicles and ultra-low-emission vehicles shall consist, at a minimum, of three different vehicles per vehicle emission category.

4. Emission Testing of Vehicles.

The air quality impact of a substitute fuel or new clean fuel shall be based on results from standardized emission tests conducted on a representative fleet of vehicles. Each of the test vehicles selected would be subjected to two sets of 'consecutive' Federal Test Procedure emission tests (Title 40, Code of Federal Regulations, Part 86).

(a) For purposes of evaluating the emission impacts of a substitute fuel in a low-emission vehicle certified on the primary designated fuel, consecutive tests shall consist of measuring the exhaust emissions of NMOG, CO, NOx, each of the toxic air contaminants, and evaporative NMOG emissions produced by vehicles when operated on the primary designated clean fuel followed by an emission test of the vehicles when fueled with the substitute fuel.

(b) For purposes of evaluating the emission impacts of a substitute fuel in low-emission vehicles that have been certified on a different fuel (and are capable of operating on the gasoline) and conventional vehicles certified on gasoline, consecutive tests shall consist of measuring the exhaust emissions of NMOG, CO, NOx, each of the toxic air contaminants, and evaporative NMOG emissions produced by vehicles when operated on gasoline followed by an emission test of the vehicles when fueled with the substitute fuel.

(c) For purposes of evaluating the emissions impacts of a new clean fuel, consecutive tests shall consist of measuring the exhaust emissions of NMOG, CO, NOx each of the, toxic air contaminants, and evaporative NMOG emissions produced by vehicles when operated on gasoline followed by an emission test of the vehicles when fueled with the new clean fuel.

(d) During one set of consecutive tests, a speciated NMOG profile shall be measured for determining the ozone-forming reactivity of the vehicle's exhaust emissions of NMOG produced when a vehicle is operated on its primary designated clean fuel or gasoline and when the vehicle is operated on a substitute fuel or new clean fuel.

(e) Speciated NMOG emissions shall be identified and quantified using the procedures outlined in the <u>California Non-Methane Organic Gas Test Procedures</u> (referenced in the California Exhaust Emission Standards and Test Procedures for 1988 and Subsequent Model Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles).

(f) Alternate test procedures yielding equivalent results may be used, if approved in advance by the Executive Officer.

5. Evaluating the Air Quality Impact of NMOG Exhaust Emissions.

The following procedure shall be used to evaluate the air quality impacts of NMOG exhaust emissions from vehicles operating on a substitute fuel compared to those of vehicles operating on the primary designated clean fuel and to those of vehicles operating on gasoline, or emissions from vehicles operating on a new clean fuel compared to those of vehicles operating on conventional fuel.

(a) The 'g ozone per mile' produced by any test vehicle shall be determined by the procedure described in Appendix VIII of the 'California Exhaust Emission Standards and Test Procedures for 1988 and Subsequent Model Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles.'

(b) For each vehicle, values for 'g ozone per mile' shall, at a minimum, be equal to the average of two 'g ozone per mile' values recorded and calculated for the vehicle in duplicate tests.

(c) For each vehicle emission category, individual vehicle average 'g ozone per mile' values shall be used to compare the air quality impact of the substitute fuel to the air quality impact of the primary designated clean fuel (for those vehicles certified on it) or gasoline (for other vehicles), or to compare the air quality impact of a new clean fuel to the air quality impact of a conventional fuel.

(d) Statistically significant differences attributable to the use of the substitute fuel or new clean fuel shall be determined using paired t-tests.

(e) Unless the 'g ozone per mile' value for any vehicle emission category when operated on the substitute fuel is demonstrated to be equal to or lower than that category when operated on a primary designated clean fuel (for those vehicles certified on it) or gasoline (for other vehicles), or the 'g ozone per mile' value for any vehicle emission category when operated on a new clean fuel is demonstrated to be equal or lower than that category when operated on gasoline, use of the substitute fuel or new clean fuel shall be considered to result in an increase in exhaust emissions of NMOG on a reactivity-adjusted basis.

6. Evaluating the Impact of Carbon Monoxide, Oxides of Nitrogen and Toxic Air Contaminant Exhaust Emissions.

The following procedure shall be used to evaluate the air quality impact of CO, NOx and toxic air contaminant emissions from vehicles operating on a substitute fuel compared to those of the primary designated clean fuel or gasoline, or emissions from vehicles operating on a new clean fuel compared to those of gasoline.

(a) The 'g/mile' exhaust emissions of CO, NOx and each of the toxic air contaminants produced by any test vehicle shall be measured according to the 'California Exhaust Emission Standards and Test Procedures for 1988 and Subsequent Model Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles.'

(b) For each vehicle, values for 'g/mile' exhaust emissions of CO, NOx and each of the toxic air contaminants shall, at a minimum, be equal to the average of two 'g/mile' values recorded for the vehicle in duplicate tests.

(c) For each vehicle emission category, individual vehicle average 'g/mile' values shall be used to compare the emissions from the substitute fuel and the emissions from the primary designated clean fuel (for those vehicles certified on it) or gasoline (for other vehicles), or to compare the emissions from a new clean fuel to the emissions from gasoline.

(d) Statistically significant differences attributable to the use of the substitute fuel or new clean fuel shall be determined using paired t-tests.

(e) Unless the 'g/mile' value for any vehicle emission category when operated on the substitute fuel is demonstrated to be equal to or lower than that category when operated on the primary designated clean fuel (for those vehicles certified on it) or gasoline (for other vehicles), or the 'g/mile' value for any vehicle emission category when operated on a new clean fuel is demonstrated to be equal to or lower than that category when operated on gasoline, use of the substitute fuel or new clean fuel shall be considered to result in increased exhaust emissions of CO, NOx and/or toxic air contaminants on a 'g/mile' basis.

7. Evaluating the Impact on Evaporative Non-Methane Organic Gas Emissions

The following procedure shall be used to evaluate the air quality impact of evaporative NMOG emissions from vehicles operating on a substitute fuel compared to that of the primary designated clean fuel or gasoline, or vehicles operating on a new clean fuel compared to that of gasoline.

(a) The 'g/test' evaporative emissions of NMOG produced by any test vehicle shall be measured according to the 'California Exhaust Emission Standards and Test Procedures for 1988 and Subsequent Model Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles.'

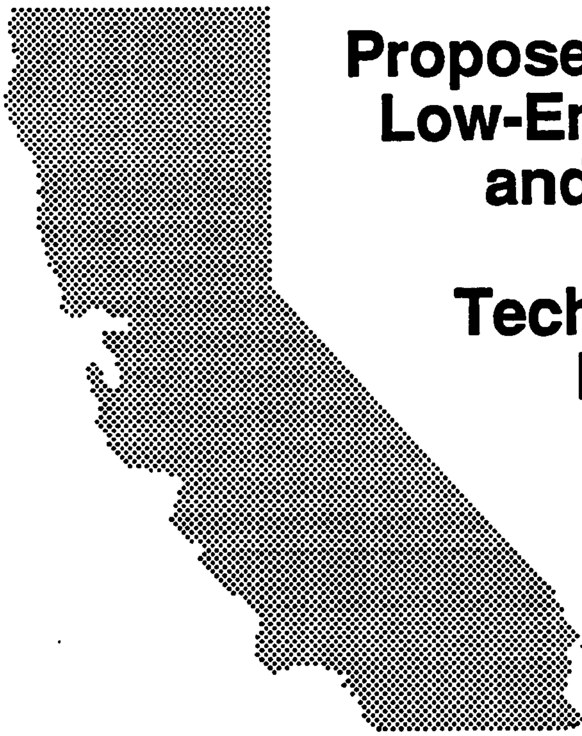
(b) For each vehicle, values for 'g/test' evaporative emissions of NMOG shall, at a minimum, be equal to the average of two 'g/test' values recorded for the vehicle in duplicate tests.

(c) For each vehicle emission category, individual vehicle average 'g/test' values shall be used to compare the emissions from the substitute fuel to the primary designated clean fuel (for those vehicles certified in it) or gasoline (for other vehicles), or the emissions from a new clean fuel to gasoline.

(d) Statistically significant differences attributable to the use of the substitute fuel or new clean fuel shall be determined using paired t-tests.

(e) Unless the 'g/test' value for any vehicle emission category when operated on the substitute fuel is demonstrated to be equal to or lower than that category when operated on the primary designated clean fuel (for those vehicles certified on it) or gasoline (for other vehicles), or the 'g/test' value for any vehicle emission category when operated on a new clean fuel is demonstrated to be equal to or lower than that category when operated on gasoline, use of the substitute fuel or new clean fuel shall be considered to result in increased evaporative emissions of NMOG on a 'g/test' basis.

California Air Resources Board



Proposed Regulations for Low-Emission Vehicles and Clean Fuels

Technical Support Document

Release Date: August 13, 1990

State of California
Air Resources Board

base gasoline would constitute the reactivity adjustment factor for the particular vehicle/clean fuel system. Actual NMOG mass emission levels for alternate fueled vehicles would be multiplied by the reactivity adjustment factor to determine compliance with the NMOG standard for the corresponding emission control category.

The incremental reactivity factor for each NMOG found in vehicle exhaust emission profiles would be determined by the procedures described in Part C of this document. A preliminary set of the ozone-forming potentials of individual NMOG components is provided in Appendix A-1. Vehicle manufacturers could use this set of incremental reactivity factors to evaluate the reactivity of exhaust emissions from developmental vehicles. Although the ARB is currently sponsoring studies to determine more accurate incremental reactivity factors for selected compounds, the factors are not expected to change significantly.

Because methane and CO could possibly have a large effect on the total ozone-forming potential of a vehicle/fuel system at the proposed low-emission levels, Sierra Research has suggested that emissions of these compounds be included in the reactivity adjustment procedure. While this suggestion has technical merit, the real impact of including methane and CO emissions is still unclear at the present time. However, if it became clear that methane and CO would have a significant ozone impact based on actual emission data from low-emission vehicles, the staff would consider appropriate revisions to the current proposal.

4. Procedure for Obtaining New Reactivity Adjustment Factors

By September 1991, reactivity adjustment factors for TLEVs, LEVs, and ULEVs powered by Phase 2 gasoline, methanol, ethanol, and CNG would be established. These adjustment factors would depend on the staff's projections of the technology likely to be used for each vehicle category and the actual vehicles available for testing. The reactivity adjustment factors could then be used by any vehicle manufacturer to certify low-emission vehicles of the applicable emission control category and weight class utilizing the specified fuel.

If the emission profile for a specific vehicle/fuel system is significantly different from the one used by the staff to establish the reactivity adjustment factor, the regulations would allow a manufacturer to request a more appropriate adjustment factor. Requests would only be considered if the manufacturer can demonstrate that the appropriate reactivity adjustment factor is 25% different from the one established by the staff. The 25% criteria was chosen to ensure that new adjustment factors are issued only for vehicle/fuel systems whose emission profiles are significantly different from the ones used by the staff. Operational complexity prohibits the ARB from allowing slightly different adjustment factors for vehicle/fuel systems that are identical in most respects.

To demonstrate a 25% difference in the reactivity adjustment factor, vehicle manufacturers would submit representative exhaust emission profiles to the Executive Officer of the ARB two years prior to submittal of the application for certification. The ozone-forming potential would be calculated from the profiles and compared to the data set used by the ARB to establish the original adjustment factor. A new adjustment factor could be issued if a statistically valid difference of 25% is found.

The regulations would also allow vehicle manufacturers to apply for reactivity adjustment factors for vehicle/fuel systems that have not been assigned an adjustment factor. Vehicle manufacturers that wish to certify other vehicle emission categories or weight classes on established certification fuels would also submit representative exhaust emission profiles to the Executive Officer two years before the certification application. The emission profiles should be determined using approved sampling procedures and be derived from a statistically valid number of different vehicles. To certify low-emission vehicles on fuels for which specifications have not been established, vehicle manufacturers would petition the Board to request the development of an appropriate adjustment factor.

D. IMPLEMENTATION PROGRAM

Under the proposed regulations, production schedules for light- and medium-duty vehicles have been structured through the model-year 2003 and beyond. In the next several years, the ability of vehicle manufacturers to comply with the implementation rates and the emission reductions needed to attain compliance with air quality standards would be re-evaluated, and the schedules would be revised to be more or less aggressive as necessary.

1. Light-Duty Vehicles

For light-duty vehicles, the staff is proposing a categorized emissions averaging program with a system of earning marketable credits. Beginning in the 1994 model-year and continuing through 2003, manufacturers that certify vehicles for sale in California would be required to meet the fleet average NMOG standards listed in Table I-5. Separate fleet average NMOG standards would apply to all passenger cars and light-duty trucks under 3751 lbs. Loaded Vehicle Weight (LVW) and to light-duty trucks between 3751 and 5750 lbs. LVW.

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Table I-5. Fleet Average NMOG Emission Standards (g/mi) for Light-Duty Vehicles

(Based on 50,000 Mile Certification Levels)

Model Year	PC & LDT < 3750 lbs*	LDT > 3751 lbs
1992**	0.390	0.500
1993**	0.334	0.428
1994	0.250	0.320
1995	0.231	0.295
1996	0.225	0.287
1997	0.202	0.260
1998	0.157	0.205
1999	0.113	0.150
2000	0.073	0.099
2001	0.070	0.098
2002	0.068	0.095
2003+	0.062	0.093

* Mandatory production of 2% ZEVs in model-years 1998-2000, 5% in 2001-2002, and 10% in 2003 and subsequent would also be required.

** Compliance with fleet average standard would be required beginning in the 1994 model-year. Credits may be earned for attaining a fleet average standard lower than the values listed in the 1992 and 1993 model-years.

Manufacturers would meet the fleet average standards for passenger cars and light-duty trucks under 3751 lbs. LVW by certifying their vehicles to NMHC or OMHCE levels of 0.25 g/mi for conventional vehicles, and NMOG levels of 0.125 g/mi for TLEVs, 0.075 g/mi for LEVs, and/or 0.040 g/mi for ULEVs. (For diesel vehicles certified only to 100,000 mile standards, the corresponding 50,000 mile NMHC standard would be used for averaging.) Vehicles meeting a 0.39 g/mi NMHC standard could be certified through the 1994 model-year only. The situation would be analogous for light-duty trucks from 3751 to 5750 lbs. LVW.

Manufacturers could certify vehicles to any combination of conventional and low-emission vehicle categories if they could ensure that their California sales volume-weighted NMOG average does not exceed the fleet average standard. The manufacturer's sales volume-weighted NMOG average would be determined by summing, for each category, the number of vehicles sold in California (based on previous model-year sales) multiplied by the applicable NMOG standard (NMHC or OMHCE for conventional vehicles), and dividing by the total number of vehicles sold (including ZEVs). (The NMOG standard could be adjusted for hybrid electric vehicles, as discussed in section E.5. of this

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chapter.) The appropriate CO, NOx, HCHO, and PM emission standards would apply to each of the different vehicle emission categories, but would not be considered in the averaging process.

Small volume manufacturers that sell fewer than 3000 vehicles in California per year would be given a delay in having to comply with fleet average standards. Beginning in model-year 2000, small volume manufacturers which sell passenger cars and light-duty trucks under 3751 lbs. LVW would have to meet a fleet average standard of 0.075 g/mi NMOG. For light-duty trucks greater than 3750 lbs. LVW, a fleet average standard of 0.100 g/mi NMOG would be applicable for small volume manufacturers in the model-year 2000.

a. Requirement for Zero-Emission Vehicles

To foster the development of the cleanest possible vehicle technologies, mandatory production of ZEVs would be required. Beginning in 1998, certain percentages of each major vehicle manufacturer's sales fleet of passenger cars and light-duty trucks less than 3751 lbs. LVW would be required to be ZEVs. ZEVs would comprise at least 2% of a manufacturer's sales in model-years 1998 through the year 2000, 5% in 2001 and 2002, and 10% in 2003 and subsequent model-years.

Manufacturers have commented that the costs of producing an electric vehicle could not be recovered until a volume of at least 3000 units was achieved. In response to these comments, the staff recommends that small volume manufacturers (which produce fewer than 3000 vehicles per year for sale in California) not be required to produce ZEVs and that the category of intermediate volume manufacturers be established. Intermediate volume manufacturers would be defined0as having average sales of light- and medium-duty vehicles from 1989 to 1993 of less than 35,000 units per year and would not be required to comply with the ZEV requirement for major vehicle manufacturers until the year 2003. Setting the sales limit for intermediate volume manufacturers at 35,000 units assures that the 3000 unit volume would be achieved in 2003 when the ZEV requirement would reach 10% of a manufacturer's total sales volume. Furthermore, there is a clear division in the production volumes of intermediate and large volume manufacturers at 35,000 units per year.

b. Credits

Manufacturers which attain sales volume-weighted averages below the fleet average standard would earn credits equal to the difference between the fleet average standard and their volume-weighted average multiplied by the total number of vehicles sold (including ZEVs). These credits would have units of g/mi NMOG and could be banked internally or traded/sold to other manufacturers. Credits earned for the sale of passenger cars and light-duty trucks less than 3751 lbs. LVW could be used to offset requirements for light-duty trucks greater than 3750 lbs. LVW, or vice versa, at the manufacturer's option.

To discourage manufacturers from accumulating credits as a means to delay certifying LEVs and/or ULEVs at the earliest possible date, credits would be discounted if not used in the next model-year. Vehicles introduced early are likely to be inferior to later vehicles in durability and performance because of the shorter amount of time available for design and development and less stringent in-use requirements. Therefore, the g/mi NMOG emission credits earned in any given model-year would retain their full value through the subsequent model-year, but the credits would be discounted to 50% of their original value if not used by the beginning of the second model-year, and to 25% of their original value if not used by the beginning of the third model-year. The credits would have no value if not used by the beginning of the fourth model-year after being earned. Credits earned prior to the 1994 model-year would retain their full value through the 1995 model-year, and would be discounted to 50% of their value at the beginning of the 1996 model-year, and to 25% of their value at the beginning of the 1997 model-year. The credits would have no value after the end of the 1997 model-year.

Manufacturers which fail to achieve the fleet average standard in any given model-year would be required to make up the shortfall in the next model-year by lowering their sales volume-weighted average to an appropriate level or utilizing acquired credits. Failure to do so would result in the assessment of a non-compliance penalty. The California Health and Safety Code, Section 43211, gives the ARB the authority to levy a maximum civil penalty of $5000 per vehicle against any manufacturer which sells a new motor vehicle that fails to meet the applicable emission standards. To determine the number of non-complying vehicles under an emission averaging program, the g/mi NMOG shortfall would be multiplied by the manufacturer's sales volume and divided by the fleet average emission standard for that year.

c. <u>Calculation of Fleet Average Standards</u>

The fleet average standards were determined by multiplying the staff's suggested implementation rates for conventional vehicles, TLEVs, LEVs, ULEVs, and ZEVs for each model-year by the applicable 50,000 mile certification standard for NMOG. The implementation schedule used by the staff is shown in Table I-6.

2. Medium-Duty Vehicles

Because standards for medium-duty vehicles differ for each of the five different test weight classes, an emission averaging approach for medium-duty vehicles is not feasible. Emission averaging could only be implemented for each individual test weight class, and the relatively limited number of engine families actually produced in each

Table I-6. Implementation Schedule Used to Calculate Fleet Average Standards for Light-Duty Vehicles ≤ 3750 lbs. LVW

(Schedule for Light-Duty Vehicles ≥ 3751 lbs. LVW Given in Parentheses.)

	0.39 (0.50)	0.25 (0.32)	TLEV	LEV	ULEV	ZEV
1994	10%(10)	80%(80)	10%(10)	--	--	--
1995	--	85 (85)	15 (15)	--	--	--
1996	--	80 (80)	20 (20)	--	--	--
1997	--	73 (73)	--	25%(25)	2%(2)	--
1998	--	48 (48)	--	48 (50)	2 (2)	2%(0)
1999	--	23 (23)	--	73 (75)	2 (2)	2 (0)
2000	--	--	--	96 (98)	2 (2)	2 (0)
2001	--	--	--	90 (95)	5 (5)	5 (0)
2002	--	--	--	85 (90)	10 (10)	5 (0)
2003	--	--	--	75 (85)	15 (15)	10 (0)

test weight class would make emissions averaging impractical for many manufacturers. Therefore, the staff has proposed an implementation schedule that would treat all medium-duty vehicles or engines of any test weight certified by each manufacturer as a single group. This schedule, together with allowances for trading between different vehicle categories, would provide the same degree of flexibility to medium-duty vehicle manufacturers as emission averaging would to light-duty vehicle manufacturers.

The schedule for low-emission medium-duty vehicles, provided in Table I-7, would begin in the 1998 model-year with a 25% requirement for LEVs and a 2% requirement for ULEVs. The requirement for LEVs would increase by 25% increments for the next two years and reach a maximum of 95% in model-year 2001. The ULEV implementation rate would reach 5% in 2001 and increase by 5% increments thereafter, reaching 15% in 2003 and subsequent model-years.

Production of medium-duty ZEVs would not be required through the 2003 model-year. However, any ZEVs sold which are classified as medium-duty vehicles could be used to offset requirements for medium-duty LEVs and/oz ULEVs or to fulfill light-duty ZEV production requirements.

a. Trading Ratios and Credits

To provide additional flexibility, a trading system would be established for medium-duty vehicle manufacturers in which marketable credits could be earned. For 1998 and subsequent model-years, the following equation would be calculated by each manufacturer based on the number of LEVs, ULEVs, and ZEVs certified in that model-year and

Table I-7. Implementation Schedule for Medium-Duty Vehicles and Engines

(Percentage of All Medium-Duty Vehicles and Engines Certified for Sale in California Per Manufacturer*)

Model Year	LEV	ULEV
1998	25%	2%
1999	50	2
2000	75	2
2001	95	5
2002	90	10
2003+	85	15

* Manufacturers which sell LEVs, ULEVs, and ZEVs prior to 1998 would be eligible to earn credits. Credits may be earned beginning in the 1992 model-year; discounting would begin in the 1998 model-year.

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the number of LEVs and ULEVs required based on the implementation schedule:

(No. of LEVs certified - No. of LEVs required) + 1.4 (No. of ULEVs certified - No. of ULEVs required) + 2.0 (No. of ZEVs certified) = X

(The coefficients could be adjusted for hybrid electric vehicles, as discussed in section E.5 of this chapter.) If X equals 0.0, the LEV and ULEV requirements have been met. If X is a negative number, the manufacturer has failed to meet its requirements and would have to make up the deficit by the end of the next model-year. Otherwise, a maximum civil penalty of $5000 would be assessed for each deficit vehicle. If X is a positive number, the manufacturer will receive marketable credits of the value X. The number of vehicles required to be sold will be based on previous model-year sales data or projections.

The coefficients 1.7 and 2.0 of the equation above were determined by equating the NMOG emission standards for the LEVs, ULEVs, and ZEVs involved in the trading, and for the conventional vehicles that would replace each LEV or ULEV not sold as a result of trading. Similar to the categorized averaging provision for light-duty vehicles, trading ratios for medium-duty vehicles are based on achieving emission reductions equivalent to the implementation schedule that the staff feels is sensible to achieve.

The credit system for medium-duty vehicles is also structured similarly to that for light-duty vehicles, although units for medium-duty credits would be in numbers of LEVs. Credits earned by medium-duty manufacturers would be discounted similarly to credits earned by light-duty vehicle manufacturers. Any medium-duty credits earned before 1998 would be considered as earned in 1998. Thus, the credits would retain their full value through the 1999 model-year, and be discounted to 50% at the beginning of 2000 and to 25% at the beginning of 2001. The credits would have no value after the end of the 2001 model-year.

E. VEHICLE CERTIFICATION PROTOCOL

For vehicle/fuel systems that do not require reactivity adjustment factors--conventional gasoline-fueled vehicles and ZEVs, certification could begin in the 1992 model-year for the purpose of accumulating credits. For vehicle/fuel systems that do need reactivity adjustment factors, certification could begin as early as the 1993 model-year. Beginning in the 1994 model-year for light-duty vehicles and 1998 for medium-duty vehicles, compliance with the low-emission vehicle requirements would be enforced.

1. 50 Degree F Test

Manufacturers which intend to certify low-emission vehicles would also be subject to a new requirement. To ensure that there is no discontinuity in the effectiveness of emission control systems at temperatures below those specified in the Federal Test Procedure, a minimum of three emission data or developmental vehicles per year would need to be tested at 50 degrees F. The vehicle must be able to comply with the certification standards (without applying deterioration factors) for NMOG (multiplied by the reactivity adjustment factor, if appropriate), CO, NOx, HCHO, (and PM for diesels) after cold soaking at 45 to 55 degrees F for at least 12 hours. In addition, for each engine family, an engineering evaluation of the performance of the emission control system with variances in temperature from 20 to 86 degrees F would be required to be submitted for certification.

2. Certification of Gasoline-Fueled Low-Emission Vehicles

Manufacturers could certify gasoline-fueled vehicles according to current procedures. Measurements of mass emission levels for NMOG, CO, NOx, and HCHO would be required. To determine the NMOG emission levels, manufacturers could measure NMHC emissions using current instrumentation (a flame ionization detector and a methane analyzer). Aldehydes, ketones, (and alcohols if present in the certification fuel) would be measured using impingers. (Any ethers present would be measured with the NMHC emissions.) The detailed procedures for measuring NMOG emissions are provided in "California Non-Methane Organic Gas Test Procedures." The sum of the NMHC, aldehydes, ketones, and alcohol emissions would constitute the NMOG mass emission level, and would be the value submitted in the certification application. Speciation of NMOG emissions would not be required for certification.

In recognition of manufacturers' concerns with the accuracy of NMOG emission measurements at low levels, some flexibility would be provided with regard to the specified test procedures. Other techniques could be utilized by vehicle manufacturers to obtain more accurate measurements, subject to the approval of the ARB Executive Officer. The staff would also continue to work closely with the automotive industry to develop more accurate and less labor-intensive procedures.

For certifying gasoline-fueled vehicles before the 1997 model-year, the certification fuel would remain Indolene Clear, although the RVP would be lowered to 7.8 psi. The change in RVP for Indolene Clear is needed to reflect the lower RVP of the commercial gasoline that would be sold in that time frame (i.e., Phase 1 gasoline). When the specifications for Phase 2 gasoline are developed, specifications for the certification gasoline would be revised to be consistent with the commercial gasoline. Thus, a new fuel would be utilized for certifying 1997 model-year vehicles. The specifications for this new certification fuel would be established at a Board hearing in September, 1991.

3. Certification of Alternate Fueled Low-Emission Vehicles

Manufacturers which plan to certify alternate fueled vehicles must notify the ARB Executive Officer of the certification fuel and provide projected sales and fuel economy data two years prior to production. This data is needed to estimate the amount of fuel that would be needed for the vehicles to use in customer service.

To certify alternate fueled vehicles, emissions of NMOG (multiplied by the reactivity adjustment factor), CO, NOx, HCHO (and PM for diesel vehicles) would be submitted to the Executive Officer for approval. The mass emission levels for CO, NOx, HCHO, and PM would be measured using the same procedures for gasoline-fueled vehicles. Measurements of NMOG emissions, however, would depend on the fuel used. Utilizing the flame ionization detector and methane analyzer procedure specified for gasoline-fueled vehicles would not yield accurate NMHC results for vehicles powered by alcohol fuels or CNG.

For alcohol-fueled vehicles, analysis of NMOG exhaust emissions would be conducted according to EPA procedures, as outlined in the California test procedures. For CNG-powered vehicles, the speciation techniques specified in the test procedures (Standard Operating Procedures No. MLD 102 and 103A) could be used to obtain accurate NMHC measurements. However, the staff would work with the natural gas vehicle industry to develop less labor-intensive methods for measuring NMHC emissions from CNG-powered vehicles.

a. Certification of Flexible- and Dual-Fueled Vehicles

For flexible- and dual-fueled vehicles, exhaust emission data from vehicle operation on the conventional fuel would also be required. The NMOG emission standards listed in Table I-2 must be met with the vehicle operating solely on the alternate fuel (with reactivity adjustment) and solely on the conventional fuel; in addition the standards for CO, NOx, HCHO, (and PM if diesel-derived) must be met. Furthermore, separate 50 degree F test results would be required from vehicle operation on the alternate and the conventional fuel.

In response to concerns raised by manufacturers, the staff has revised previously adopted regulations concerning mileage accumulation for flexible-fueled vehicles. Previously, mileage accumulation was to be conducted by alternating between the alternate and conventional fuel. However, that provision has been revised to allow mileage accumulation to be conducted using only the alternate fuel. Mileage accumulation for dual-fueled vehicles would also be conducted on the alternate fuel.

4. Certification of Zero-Emission Vehicles

A ZEV is a vehicle that produces no emissions of any criteria pollutant under any possible operational mode or condition throughout its useful life, as determined by the Executive Officer of the ARB. Vehicles equipped with auxiliary combustion devices would not meet the ZEV criteria, as the emissions from these devices could be significant. For example, a fuel fired heater manufactured by Espar has been estimated to emit 0.007 g/mi total hydrocarbons, 0.035 g/mi CO, and 0.005 g/mi NOx under steady-state conditions (Renner, 1989). At present, only battery-powered electric vehicles that do not use fuel fired heaters are expected to be able to qualify as ZEVs.

The only ARB requirement for certifying ZEVs would be the submittal of an application for certification to the Executive Officer. Because ZEVs by definition would maintain zero emissions for their full useful lives, emission or durability testing would not be required.

Due to the increased weight of their batteries, it is possible for a ZEV to be classified as a medium-duty vehicle by weight even though its usage is more typical of a light-duty vehicle. To meet the proposed requirement for light-duty ZEVs, vehicle manufacturers would allowed to certify a medium-duty ZEV (by weight) as a light-duty vehicle.

5. **Certification of Hybrid Electric Vehicles**

To certify hybrid electric vehicles, emissions of NMOG, CO, NOx, HCHO, (and PM for hybrid electric vehicles which use a diesel engine) would be submitted to the Executive Officer. These emissions would be determined under conditions simulating worst case vehicle operation with its auxiliary engine, as specified in the test procedures.

For the purpose of calculating the light-duty NMOG fleet average, the NMOG standards at which hybrid electric vehicles certify would be adjusted based on the range at which the vehicles operate solely through the use of the battery. For a vehicle which could operate for a minimum of 60 miles without the use of the engine, the adjusted NMOG value would be equal to the NMOG standard at which the vehicle certifies minus one-half the difference between that standard and the NMOG standard which is one level more stringent. For a vehicle which could operate from 40-59 miles without the use of the engine, the adjustment would be one-fourth the difference between the standards. For example, if the vehicle could operate for a more than 60 miles by battery power alone and if the engine met ULEV emission standards under the specified operating conditions, an NMOG value of 0.02 g/mi would be used for calculating the manufacturer's fleet average. It should be noted that these adjusted NMOG levels are not separate emission standards, i.e., hybrid electric vehicles could not be certified to meet these emission levels. Range would be determined by using the "Federal Highway Fuel Economy Test Procedure."

For the medium-duty vehicles, the contribution of hybrid electric vehicles would"be adjusted based on the same minimum battery-only ranges proposed for light-duty hybrid electric vehicles. The trading ratios used to determine compliance with requirements for medium-duty vehicles would be adjusted for hybrid electric vehicles.

6. **Labeling Requirements**

The "California Motor Vehicle Emission Control Label Specifications" would be modified to include identification of vehicles and engines operating on any fuel and certifying as TLEVs, LEVs, ULEVs, or ZEVs. New character coding for the Vehicle Emission Configuration (VEC) label would be specified to include identification of on-board diagnostics requirements in a bar-code format.

7. **Offsetting Procedures for Federal Vehicles**

Offsetting procedures for federal vehicles would be extended to allow credit accumulation from California certified passenger cars and light-duty trucks operating on any fuel. To accommodate certification to the different emission categories established by these regulations, new Calmean values have been calculated for each model-year from 1994 to 2003, based on the implementation schedule used to derive the fleet average standards (Table I-6). Withdrawal limits for each model-year have also been calculated for each pollutant. However, model unavailability has not been altered from the values previously adopted by the Board. The data and calculation methods used to obtain the new Calmean values and withdrawal limits are provided in Appendix A-2.

II.

TECHNICAL JUSTIFICATION

This chapter describes the basis for the TLEV, LEV, and ULEV standards and presents the staff's assessment on how vehicle manufacturers could comply with the standards.

A. TRANSITIONAL LOW-EMISSION VEHICLES

Compliance with the TLEV standards should not necessarily require significant modifications to current engine designs and control technologies. A number of 1990 model-year vehicles have attained the TLEV levels in certification testing. However, it is uncertain whether these levels would be maintained in-use. In addition, data from demonstration programs have shown the ability of alternate fueled vehicles to meet the emission levels at low mileage. Conventional gasoline and alternate fueled vehicles which provide strong indications that the TLEV standards are achievable in the near future are listed in Table II-1 and Table II-2.

1. Non-Methane Organic Gases and Carbon Monoxide

A large number of the gasoline vehicles developed to meet the 0.25 g/mi NMHC standard will be equipped with dual oxygen sensors and a close-coupled catalyst. For these vehicles, hydrocarbon emissions need to be lowered significantly in order to meet the TLEV standard for NMOG. The staff envisions that manufacturers would focus on lowering cold start emissions through the use of improved fuel preparation systems to achieve the necessary reduction in NMOG emissions. Functionally, the reduction of cold start hydrocarbon and

Table II-1. 1990 Model-Year Vehicles that Met TLEV Standards in Certification Testing at 50,000 Miles

Mfr.	Engine Family			NMHC	CO	NOx
MERBZ	LMB5.0V6FA12	V-8	PC	0.11	1.30	0.10
DAHSU	LDH1.3V5HHC5	I-4	PC	0.10	0.58	0.11
MAZDA	LTK1.8V5FCE1	I-4	PC	0.12	1.90	0.11
TOYTA	LTY2.2V5FCC3	I-4	PC	0.12	1.80	0.13
MAZDA	LTK1.8V5FCD0	I-4	PC	0.12	1.90	0.13
TOYTA	LTY1.6V5FCEX	I-4	PC	0.09	0.64	0.15
GMC	L2G3.8W8XEB7	V-6	PC	0.11	1.60	0.15
NISSN	LNS3.0V5FGC6	V-6	PC	0.11	0.81	0.16
JEEP	LAM2.5V5LAC7	I-4	PC	0.09	1.20	0.20
TOYTA	LTY1.6V5FBE8	I-4	PC	0.12	0.80	0.21
GMC	L2G2.3W8XEB2	I-4	PC	0.11	2.40	0.27
NISSN	LNS1.6V5FAC3	I-4	PC	0.12	1.70	0.27
NISSN	LNS1.6V5FCC7	I-4	PC	0.12	2.90	0.28
TOYTA	LTY2.0V5FBD1	I-4	PC	0.11	0.69	0.31
FORD	LFM3.0V5FDC6	V-6	PC	0.11	2.50	0.34
GMC	L3G3.1X5XAT5	V-6	T1	0.11	1.90	0.06
TOYTA	LTY2.4T5FCC5	I-4	T1	0.11	1.60	0.18
TOYTA	LTY3.0T5FBB8	V-6	T1	0.11	0.60	0.26
GMC	L3G3.1X5XAT5	V-6	T2	0.15	2.10	0.07
TOYTA	LTY2.4T5FCD6	I-4	T2	0.16	1.40	0.17
TOYTA	LTY4.0T5FBB5	I-6	T2	0.15	1.70	0.24
NISSN	LNS2.4T5FCC4	I-4	T2	0.15	3.80	0.30
TOYTA	LTY3.0T5FBE0	V-6	T2	0.14	3.40	0.32
FORD	LFM3.0T5FEDX	V-6	T2	0.14	2.90	0.35

Table II-2. Data from Advanced Current Technology Alternate Fueled Vehicles

Fuel Vehicle	Miles	NMOG (MeOH)	CO	NOx	HCHO
M85 '89 Toyota Corolla	4,335	0.45 (0.41)	2.40	0.43	0.016
M85 '90 Plymouth Voyager	2,081	0.41 (0.37)	1.86	0.20	0.009
M85 '85 Toyota Camry*	low	0.31 (0.22)	1.09	0.27	0.010
M85 '89 Chev. Corsica*	low	0.19 (0.14)	1.07	0.12	0.007
LPG '88 Chev 1500 PickUp	14,000	0.19 (0.00)	1.40	0.27	---

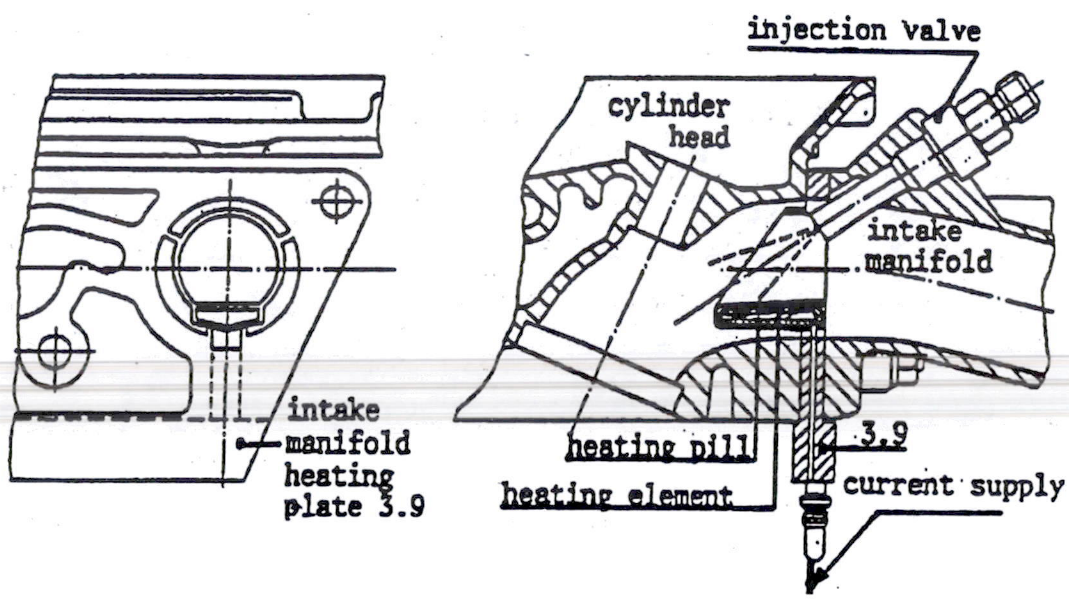
* Retrofitted with close-coupled formaldehyde catalyst.

CO emissions by improved fuel preparation systems is achieved through better fuel atomization. Presently, electrically heated PTC (positive temperature coefficient) ceramic elements and combined air and fuel injectors are two promising technologies being developed for use in light- and medium-duty vehicles.

In recent testing, electrically heated PTC ceramic elements were mounted adjacent to the fuel injector nozzle in the intake manifold of a test vehicle (Figure 2). Improved fuel atomization was achieved by spraying the fuel onto the heated surfaces, thus reducing condensation of fuel on the manifold walls at low coolant temperatures. By reducing the condensation, the engine could be operated close to stoichiometric during the warm-up phase. This caused a significant reduction of hydrocarbon and CO emissions until the light-off temperature of the underfloor catalyst was reached.

The power requirements for heating the elements was estimated to be 75 watts per cylinder; the elements began heating within 0.6 seconds, and temperatures greater than 100 degrees Celsius were attained within five seconds after starting the engine. Hydrocarbon emissions were reduced from 0.40 g/mi to 0.18 g/mi (i.e., lowered by 55%) for the test vehicle, which was a four cylinder, 2.3 liter engine utilizing port fuel injection. Similar reductions in hydrocarbon emissions have been reported for a throttle body injected test vehicle with a 3.0 liter, six cylinder engine (30 to 50%), and for a four cylinder, throttle body injected test vehicle with a 2.2 liter engine (22 to 44%).

Figure 2. Schematic of a Prototype Improved Fuel Preparation System



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Aside from lowering emissions of hydrocarbons and CO, improved fuel preparation systems would also provide benefits in terms of better fuel economy and reduced engine wear. Utilizing leaner air/fuel mixtures for vehicle starting results in lower fuel usage, and thus better fuel economy. The use of leaner air/fuel mixtures would also decrease the amount of unburned fuel in the combustion chamber during a cold start. Excess unburned fuel washes away the lubricating oil from the engine cylinder walls during cold start when cylinder bore wear is highest. Thus, the enhancement of combustion efficiency by improved atomization of liquid fuels could increase engine durability in a manner similar to that realized in engines powered by gaseous fuels.

The use of cleaner burning fuels is an alternative means by which manufacturers could choose to develop vehicles meeting low exhaust emission standards. The reactivity benefit associated with the use of cleaner burning fuels could allow alternate fueled vehicles to meet TLEV standards with emission control systems less advanced than for gasoline-fueled TLEVs. For example, in recent tests, the exhaust emissions from a flexible-fueled Plymouth Voyager operating on methanol were found to be significantly less reactive than when operating on base (i.e., U.S. average) gasoline (Table II-3). Although the reactivity of methanol-fueled vehicles should be compared to the reactivity of base gasoline-fueled vehicles that meet the applicable emission standards, the Plymouth Voyager test results provide a strong indication of the ability of methanol-fueled vehicles to achieve low-reactivity exhaust emissions.

Table II-3. Preliminary Analysis of the Reactivity of Exhaust Emissions (g/mi) from a 1990 Flexible-Fueled Plymouth Voyager

(Averaged from Duplicate Tests; Vehicle at 2000 Miles)

Fuel	NMOG	Ozone/mi	Ozone/g NMOG	CO	NOx	HCHO
Methanol*	0.416	0.314	0.754	1.954	0.229	0.010
Base Gasoline	0.181	0.521	2.888	3.512	0.184	0.005

* 85% chemical grade methanol, 15% base gasoline

Of the 0.42 g/mi of NMOG emitted by the Plymouth Voyager shown in Table II-3, unburned methanol comprised 88% of the total exhaust NMOG. Almost all of the methanol was emitted during the first few minutes of the test cycle, when the vehicle was cold started. The use of improved fuel preparation systems would be particularly useful for improving cold starting characteristics and could greatly lower the total mass of NMOG emissions from methanol- and ethanol-fueled vehicles.

2. Oxides of Nitrogen

The 50,000 mile NOx standards for TLEVs are unchanged from the standards that would apply to conventional gasoline-fueled vehicles. TLEVs would also be required to meet standards for NOx at 100,000 miles. By establishing 50,000 and 100,000 mile certification standards for all vehicle/fuel systems, diesel-fueled vehicles would no longer have the option of certifying to only 100,000 mile standards. Consequently, it would be very difficult for diesel-fueled vehicles to meet the TLEV standards for NOx.

B. LOW-EMISSION VEHICLES

To obtain further exhaust emission reductions from vehicles designed to meet the TLEV standards, it is clear that even better control of cold start emissions would be needed. Emission tests have been performed on two of the most technologically advanced vehicles currently available. (The vehicles will be used in the ARB program for establishing reactivity adjustment factors for TLEVs). These tests revealed that cold start emissions comprised 70 to 85% of total average-weighted Federal Test Procedure (FTP) emissions (Table II-4). A number of approaches are being pursued by vehicle manufacturers to further control emissions, with special emphasis on reducing emissions during the cold start period.

1. Electrically Heated Catalysts

Perhaps the most promising emission control technology being developed to substantially reduce cold start emissions is the electrically heated catalyst. Prior to cold starting a vehicle, these catalysts are resistively heated to operating temperature in about 15 seconds, using energy from the vehicle battery. In the most recent tests, electrical heating was continued for an additional 20 seconds after engine start to maintain the catalyst at operating temperature until the vehicle's exhaust temperature stabilized.

Table II-4. Percentage Of Hydrocarbon Emissions By Bag

Toyota Celica	NMHC (g/mi)	% Of Weighted Total
Cold Start BAG 1 :	0.395	85
BAG 2 :	0.016	8
BAG 3 :	0.023	7
Weighted Total :	0.099	

Buick LeSabre	NMHC (g/mi)	% Of Weighted Total
Cold Start BAG 1 :	0.454	72
BAG 2 :	0.042	16
BAG 3 :	0.058	12
Weighted Total :	0.135	

In testing at EPA on a 1987 Volkswagen Golf and at Southwest Research Institute on a 1986 Toyota Camry, average-weighted FTP emissions of NMHC as low as 0.03 g/mi were achieved when electrically heated catalysts were installed in place of the vehicles' original catalysts (see Table II-5). Auxiliary air from an off-board source was also injected. The catalysts used in these tests were supplied by Camet, an affiliate of W.R. Grace & Company. The front section of the catalyst was resistively heated, while the rear section of the catalyst was not. More recent versions of the Camet catalyst consist of a relatively small stand-alone heated metallic catalyst substrate placed in series with the existing catalyst system. This compact unit provides considerable design flexibility.

Work is also underway to reduce catalyst warm-up time to ten seconds or less. Shorter catalyst warm-up times may be realized in the near-term through the use of a compact, quick discharge battery being developed by Isuzu Motors Ltd. The new battery is reported to have 40 times greater starting power and 20 times greater energy output than a conventional lead/acid battery, be rechargeable in less than 30 seconds, and have an unlimited lifetime. The battery, which can be designed to any shape, will also be lighter, smaller, and less expensive to produce than conventional batteries.

Table II-5. Electrically Heated Catalyst Test Data (g/mi)

(Federal Test Procedure; Run at 72-74 degrees F on Indolene)

Vehicle/Catalyst	NMHC	CO	NOx
1987 VOLKSWAGEN GOLF			
Stock Catalyst	0.08	1.63	0.20
Camet*(Unheated, No Air)	0.063	1.06	0.72****
Camet (Heated, With Air)**	0.029	0.57	0.69****
1986 TOYOTA CAMRY			
Stock Catalyst	0.21	2.83	0.45
Camet (Unheated, No Air)	0.12	1.13	0.22
Camet (Heated, With Air)***	0.03	0.35	0.22

* Electrically heated catalyst developed by Camet.

** Catalyst heated 20 seconds prior to, and 20 seconds following cold start. Also heated 10 seconds prior to, and 15 seconds following hot start. Air injection flow rate was 2 cubic feet per minute (CFM).

*** Catalyst heated 15 seconds prior to, and 30 seconds following cold start. Also heated 5 seconds prior to, and 10 seconds following hot start. Air injection flow rate was 8 CFM.

**** The higher NOx from the Camet catalyst may be due to differing Rd:Pt ratios in the Camet and stock catalysts.

The ARB has selected two advanced 1990 vehicles to be equipped with the latest Camet catalysts. Because tests conducted to date have been with essentially new catalysts, it is important to obtain durability data under actual in-use conditions. As the earlier tests were conducted with an off-board air source, the ARB test cars are equipped with on-board electric air pumps. These pumps will only be used during the first two to three minutes of warm-up and would be deactivated before the additional air could adversely affect NOx levels. The vehicles are also fitted with an 875 cold cranking amp battery to ensure an adequate supply of electrical energy. ('Cold cranking amps' are the number of amps the battery can deliver over a 60 second period at 0 degrees F.) Camet will also provide its latest controller for regulating catalyst heating.

One of the test vehicles is a 1990 Toyota Celica with a 2.2 liter engine equipped with a close-coupled exhaust manifold catalyst and an underfloor catalyst. A Camet catalyst has been placed between the two factory installed catalysts to shield it from the higher exhaust temperatures encountered by the first catalyst.

Toyota has achieved a high durability level for their manifold close-coupled catalysts. Mileage accumulation tests by ARB on two 1988 Toyota Camrys have demonstrated that low emission levels of NMHC, CO, and NOx can be maintained for more than 30,000 miles in-use (Table II-6).

The 1990 Celica, which will also be tested with an electrically heated catalyst, uses a second catalyst located under the front floorpan and a dual oxygen sensor system, neither of which is contained on the 1988 Camry. The dual oxygen sensors maintain proper fuel control as mileage accumulates, thus maintaining a high catalyst conversion efficiency and lower overall emissions than the 1988 model.

The other vehicle under evaluation is a 1990 Buick LeSabre with a 3.8 liter V-6 engine, one of General Motors' (GM) most advanced engines. This model has exhibited very low emissions in certification and would be representative of vehicles equipped with larger engines. The vehicle uses only one large underfloor catalyst, located about two feet behind the rear bank exhaust manifold (the engine is in a

Table II-6. 1988 Toyota Camry Mileage Accumulation Study (g/mi)

Vehicle	Mileage	NMHC	CO	NOx
14	58	0.126	0.85	0.190
	1,776	0.135	1.10	0.130
	5,657	0.155	1.36	0.092
	10,486	0.187	1.81	0.130
	18,940	0.174	1.48	0.190
	31,376	0.192	2.44	0.180
	36,138	0.150	1.88	0.222
15	86	0.137	0.79	0.212
	6,127	0.167	1.56	0.111
	9,252	0.169	1.63	0.101
	15,156	0.249	2.22	0.110
	20,173	0.205	2.24	0.138
	25,190	0.192	1.76	0.134
	30,166	0.299	3.09	0.164
	39,349	0.360	2.48	0.309
	40,020*	0.171	2.77	0.284

* Tested after replacement of cold start timing switch

transverse position). A Camet catalyst has been placed just ahead of the main catalyst and will be directly exposed to the engine exhaust, but at a cooler downstream position compared to a close-coupled arrangement.

This project should demonstrate the emission capabilities of the latest Camet catalysts and will provide some indication of the durability of these systems. Given the very high temperature resistance of today's advanced catalysts, there is reason to expect that the Camet catalyst will perform at the same effectiveness in-use. The two vehicles will also be used to establish base gasoline reactivity adjustment factors for TLEVs (when configured without the electrically heated catalyst) and for ULEVs (with the electrically heated catalyst in place). Preliminary data from the project are shown in Table II-7.

Table II-7. Preliminary Data (g/mi) from the ARB's Test Vehicles Equipped with Electrically Heated Catalysts

(Federal Test Procedure; Vehicles Operated on Howell EEE)

Vehicle	NMOG	CO	NOx
1990 Toyota Celica*	0.03	0.13	0.17
1990 Buick LeSabre**	0.03	0.21	0.19

* Catalyst heated about 30 seconds prior to and 50 seconds following cold start. On-board air injection for 140 seconds during Bag 1 at 5.9 CFM. Heating time prior to cold start has been reduced to 20 seconds in more recent tests.

** Catalyst heated about 30 seconds prior to and 0 seconds following cold start. Off-board air injection for 75 seconds during Bag 1 and 30 seconds during Bag 3 at 10.7 CFM.

It is also possible that the electrically heated catalyst will become an oxidation-only design, since its primary function does not necessarily include NOx reduction during the period just after engine start-up (when NOx emissions are very low). Generally, oxidation-only catalysts can withstand higher temperatures more successfully than three-way catalysts containing rhodium. Electrically heating the catalyst also offers the possibility of relocating the catalyst further downstream of the engine relative to today's close-coupled arrangements, thus providing further reduction in catalyst deterioration due to high temperatures (although electrical heating requirements would be higher).

It is also possible to use PTC substrates in electrically heated catalysts. The use of PTC substrates would eliminate the need for a controller, since temperature and power output are regulated by the properties of the PTC ceramic itself. Furthermore, the use of traditional washcoat technology for ceramic substrates could be utilized. Thus, using PTC substrates could significantly reduce the costs of electrically heated catalyst systems. Some manufacturers are exploring this concept.

Based on the results of the electrically heated catalyst tests conducted thus far, it appears that when using conventional gasoline and today's engine control systems, a 0.075 g/mi NMOG exhaust emission level should be attainable by the 1997 model-year. Although the initial test vehicles achieved a lower hydrocarbon level than this, the staff has allowed for some catalyst deterioration and considered some of the uncertainty associated with the new technology when setting the LEV standard for NMOG.

2. Other Catalyst Systems

The staff has also learned that some manufacturers are experimenting with placing individual (conventional three-way and/or oxidation-only) catalysts directly adjacent to each exhaust port of the engine. This type of catalyst configuration could permit some engines to meet LEV emission levels without the use of an electrically heated catalyst. Given that these small catalysts would be exposed to high exhaust temperatures almost continuously, rapid deterioration of catalytic conversion efficiency may result.

The use of more conventional close-coupled catalyst arrangements (i.e., approximately 12 inches downstream of the exhaust port) could prove successful in achieving the LEV standard when alternate fuels are utilized. For example, close-coupled catalysts which reduce HCHO emissions to levels of about 7 mg/mi may become available for use on methanol-fueled vehicles (see Chevrolet Corsica data in Table II-2). If adequate 50,000 and 100,000 mile durability can be demonstrated for these catalysts, the reactivity of exhaust emissions from methanol-fueled vehicles could be lowered significantly. If this occurs, a relatively high reactivity adjustment factor could be assigned to this vehicle/fuel combination, thereby facilitating the attainment of LEV exhaust emission standards. Similarly, the low reactivity of natural gas could assist CNG-powered vehicles in meeting the LEV emission standards. Other alternate fuels such as ethanol or LPG may also benefit from the use of close-coupled catalyst technology.

3. Improved Fuel Preparation Systems

The use of electrically heated PTC ceramic elements or combined air and fuel injectors coupled with an electrically heated catalyst or another advanced catalyst system could provide additional possibilities for meeting the LEV standards. By combining improved fuel preparation with advanced catalyst designs, an optimized emission control system could reduce overall system cost, and when an electrically heated catalyst is used, warm-up time prior to engine starting and on-board electrical requirements.

4. Improved Fuel Control

Recent articles in the automotive press suggest that vehicle manufacturers are graduating from 8 to 16 bit engine control computers to further refine their fuel control system strategies and to comply with second generation on-board diagnostics requirements recently adopted in California. In order for vehicles to achieve low-emission levels over the FTP cycle, it is important to maintain very low emissions during the second bag. Precise fuel control is critical toward achieving low second bag emission levels.

5. Medium-Duty Vehicles

Most of the previous information also applies to medium-duty vehicles and engines; however, some discussion of the unique differences in the design of heavier vehicles is warranted. Because medium-duty vehicles are generally designed to carry heavy loads, exhaust temperatures can be significantly higher than for passenger cars and light-duty trucks. This requires that catalysts be placed further downstream from the engine in order to minimize deterioration. Improvements in catalyst durability, however, would allow them to be moved closer to the engine than in the past. Vehicles in this class are also beginning to utilize three-way catalyst systems with feedback fuel control for lower emissions. As a result, in June 1990, the ARB adopted new standards for medium-duty vehicles which would take effect beginning in the 1995 model-year.

The LEV standards for NMOG were determined by projecting the emission reductions that medium-duty vehicles would achieve from electrically heated catalysts and improved fuel preparation, compared to vehicles that would be certified beginning in the 1995 model-year. The use of electrically heated catalysts for medium-duty vehicles, however, would likely be less effective in reducing NMOG than for passenger cars and light-duty trucks. This is because in order to meet the 1995 model-year standards, it is estimated that about half of the medium-duty vehicles may utilize bypass catalyst systems which are expected to be quite effective at reducing cold start emissions and providing low deterioration rates. Thus, the expected benefit of electrically heated catalysts would be moderated compared to passenger cars which will not be using bypass catalyst systems.

In addition, because of the higher load factor of these vehicles and larger fuel tanks which contribute to greater canister vapor loading, fuel control is more difficult than for passenger vehicles. Therefore, the proposed NMOG standards for medium-duty LEVs represent less of a percentage reduction from the hydrocarbon standards applicable to conventional medium-duty vehicles than for light-duty LEVs.

6. Oxides of Nitrogen Requirements

The proposed standard for NOx from light-duty LEVs is 50% lower than the level for TLEVs; however, the NOx emission standard for medium-duty LEVs would remain at the same stringent level recently adopted for 1995 and subsequent conventional vehicles. Reduction of the NOx standard for light-duty vehicles is being proposed as a result of increasingly lower NOx emissions displayed in the certification fleet for the 1990 model-year. Since the adoption of the 0.4 g/mi NOx standard in 1986, fleet average engine family emissions for passenger cars and light-duty trucks have decreased for vehicles under 3751 lbs. and between 3751 and 5750 lbs. LVW (Table II-8). The 50,000 mile certification test data for 1990 model-year passenger cars lists eight engine families that exhibited emission levels less 0.10 g/mi (Table II-9), and two manufacturers have reported NOx emissions of 0.00 g/mi for their certification data vehicles. Presently, 40 to 44% of passenger car and light-duty truck engine families under 3750 lbs. LVW have demonstrated certification emission levels of 0.20 g/mi NOx or lower. For light-duty trucks from 3751 to 5750 lbs. LVW, 44% have demonstrated certification levels of 0.35 g/mi NOx or lower, the emission level proposed for LEVs in this vehicle weight class.

Table II-8. Fleet Average Engine Family Emissions of NOx (g/mi) for Passenger Cars and Light-Duty Trucks

(50,000 Mile Certification Test Data)

Model Year	0-3750 lbs. LVW	3751-5750 lbs. LVW
1986	0.42	0.66
1987	0.41	0.66
1988	0.36	0.60
1989	0.32	0.53
1990	0.26	0.58

Table II-9. 1990 Model-Year Passenger Car Engine Families Exhibiting NOx Emission Levels (g/mi) Less Than 0.10 g/mi.

(50,000 Mile Certification Test Data)

Manufacturer	Engine Family	NMHC	CO	NOx
GMC	L1G2.5V5XGG7	0.21	2.10	0.06
ISUZU	LSZ1.6V5FHA4	0.37	3.10	0.06
ISUZU	LSZ1.6V5FHC6	0.19	1.30	0.02
MERBZ	LMB5.6V6FA15	0.36	2.20	0.00
NUMMI	LNT1.5V5FCC5	0.15	1.08	0.08
VW	LVW1.8V5FWC6	0.21	2.00	0.00
VW	LVW1.8V6FAF3	0.23	2.00	0.08
VW	LVW2.0V6FAL4	0.17	1.90	0.09

Relative to in-use vehicle performance, further improvements in washcoat durability, increased catalyst loading of rhodium, and wider use of dual oxygen sensors will lead to the development of vehicles that will maintain low NOx levels to 100,000 miles in future years. In recent ARB testing of a Mazda and a Volkswagen engine family (certified to a 0.7 g/mi NOx standard), average in-use NOx levels of 0.21 and 0.25 g/mi were observed, respectively, at 30,000 to 50,000 miles (Table II-10).

Table II-10. In-Use Recall Test Results for 1987 Mazda and Volkswagen Engine Families Demonstrating Low NOx Emissions (g/mi)

MAZDA Engine Family JTK2.2V5FCH (Test Period: 7/7/90 to 7/20/90)		VOLKSWAGEN Engine Family HVW1.8V6FAC5 (Test Period: 2/16/90 to 3/1/90)	
Mileage	NOx	Mileage	NOx
34,098	0.222	34,162	0.528
46,666	0.193	33,703	0.254
41,999	0.156	34,949	0.116
30,520	0.246	31,807	0.093
31,727	0.154	44,276	0.367
30,616	0.163	30,678	0.336
39,703	0.282	40,772	0.299
32,433	0.160	32,522	0.255
34,841	0.140	34,443	0.156
33,910	0.416	31,878	0.127

7. Carbon Monoxide Requirements

The CO standards for light- and medium-duty LEVs are unchanged from the standards that would apply to conventional 1993 light-duty vehicles and 1995 medium-duty vehicles, which is consistent with the capabilities of the technologies likely to be employed to meet LEV standards. The use of alternate fuels could lead to a reactivity benefit for NMOG without reducing CO emissions. The use of CNG, for example, would result in less reactive NMOG emissions, but in order to achieve the NOx levels for LEVs, fuel control may need to be biased slightly rich in order to provide the catalyst with enough feedgas to allow the reduction reactions to occur. For light-duty LEVs, maintaining the same CO standard as for TLEVs would also facilitate achieving the lower NOx standard in-use.

8. Requirements for Incomplete Vehicles and Diesel Engines

Incomplete vehicles and diesel engines used in medium-duty vehicles above 8,500 lbs. GVW would be permitted the option of certifying to the Federal Engine Transient Test Procedure. This is consistent with the test procedure options recently adopted for medium-duty vehicles beginning in the 1995 model-year. In general, the chassis test procedure required for certifying the bulk of medium-duty vehicles is similar in stringency to the engine dynamometer test procedure, although the chassis test tends to stress cold start performance while the engine test emphasizes loaded engine operation.

For Otto-cycle engines certified under this option, emission control system design is expected to include the same elements as vehicles tested according to the chassis test, with the exception that the catalyst may be located at a somewhat greater distance from the engine. Achieving the 3.5 g/bhp-hr combined NMHC + NOx standard for incomplete LEVs could be accomplished partly through reductions expected in NMHC (OMHCE for methanol) from use of an electrically heated catalyst. Further, modest NOx control might be needed beyond that required to meet the 3.9 g/bhp-hr combined NMHC + NOx standard proposed for incompletes beginning in the 1995 model-year. This could be achieved through refinements in fuel control and catalyst systems or through implementation of electronically-controlled exhaust gas recirculation (EGR) systems. The CO and HCHO standards would not be altered from the already stringent standards proposed for incompletes beginning in the 1995 model-year.

For diesel-fueled engines, achieving the proposed 3.5 g/bhp-hr NMHC + NOx standard appears feasible with use of an indirect injection (IDI) combustion system coupled with either flow through catalysts or catalyzed particulate trap systems. For example, GM has certified a 6.2 liter heavy-duty diesel engine and Navistar a 7.3 liter engine, both utilizing IDI, to NOx levels significantly lower than comparable direct injection (DI) diesel engines (Table II-11). (The 1990 engines shown in the Table II-11 were chosen for comparison based on market share, comparable engine size, low emissions, and technology used.)

NOx emissions can be further controlled through the use of electronically-controlled EGR.

Based on information from a recent study (Sierra Research, 1988), adding electronically-controlled EGR to a light-heavy-duty diesel engine (now classified as a medium-duty engine as a result of proposed changes to medium-duty regulations) should reduce NOx emissions by 25-30%. With reduced NOx emissions, some increase in PM emissions may occur, but incorporation of a flow through catalyst or particulate trap system should enable manufacturers to offset any slight increase.

Table II-11. Certification Levels (g/bhp-hr) of Representative 1990 Medium-Duty Diesel Engines

Engine	THC	CO	NOx	PM	Emission Technology Used
GM 6.2L	0.4	1.7	3.6	0.45	IDI, Engine Modifications
Navistar 7.3L	0.6	-	4.4	0.24	IDI, Engine Modifications
Cummins 5.9L	0.4	-	5.2	0.43	DI, Turbocharger, Smoke Puff Limiter
Isuzu 5.8L	0.6	1.6	5.1	0.50	DI, Turbocharger

C. Ultra-Low-Emission Vehicles

1. Light-Duty Vehicles

It is expected that improvements to the design and durability of electrically heated catalysts and improved fuel preparation systems would enable gasoline-fueled vehicles to meet the ULEV standards. By utilizing a cleaner-burning gasoline, such as Phase 2 gasoline, the needed compliance margin could be obtained to meet the standards in-use. The use of heated fuel preparation systems could also provide additional compliance margin and/or could reduce onboard electrical requirements and allow downsizing of the electrically heated catalyst.

The use of electrically heated catalysts, improved fuel preparation systems, and/or improved fuel control could also allow vehicles powered by alternate fuels such as methanol, CNG, LPG, ethanol, and others to achieve the proposed NMOG emission standard for ULEVs. Preliminary data from the staff's formaldehyde catalyst test program have demonstrated the ability of a Chevrolet Corsica flexible-fueled vehicle to meet the ULEV standards at low mileage (Table II-12). Given that the ARB's test vehicles have been able to achieve 0.03 g/mi NMOG using gasoline and methanol with no adjustment factor (albeit with new electrically heated catalysts), a 0.040 g/mi NMOG standard was judged to be technically feasible when the long lead time for widescale implementation of ULEVs is considered.

There has been some speculation by the natural gas industry that CNG-fueled vehicles using close-coupled catalysts could be able to attain the ULEV standard for NMOG if mass emission levels are adjusted for the low reactivity of the exhaust emissions from CNG-powered vehicles.

Table II-12. Preliminary FTP Data (g/mi) from a 1989 Flexible-Fueled Chevrolet Corsica with an Electrically Heated Catalyst.

Fuel	Catalyst	NMOG	CO	NOx	HCHO	MeOH
M85	Stock Catalyst	0.301	1.75	0.25	0.0205	0.21
M85	Camet (Heat, No Air)	0.102	1.51	0.13	0.0048	0.07
M85	Camet (Heat, Air*)	0.021	0.40	0.17	0.0036	0.01

* Air injection for first 100 seconds of Bags 1 and 3

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2. Medium-Duty Vehicles

Medium-duty ULEV emission standards were determined based on expected benefits of LEV technology with the use of cleaner-burning fuels. For example, CNG could be especially useful as a fuel for medium-duty vehicles which can accommodate the large on-board fuel cylinders more easily than light-duty vehicles. Moreover, the price of CNG is competitive with current fuels. CNG-powered vehicles could also receive a large reactivity adjustment factor for NMOG, and when coupled with effective catalysts, would likely meet ULEV emission standards. While other fuels could also be used to attain the ULEV standards, unless they have reactivity adjustment factors similar to CNG, more advanced vehicle emission controls would need to be employed.

NOx emission standards for medium-duty ULEVs are one-half the level being proposed for 1995 model-year conventional medium-duty vehicles and for LEVs. Refinements in fuel control and catalyst technology which have led to lower NOx levels for light-duty vehicles could be applied to medium-duty vehicles to achieve these levels. For example, dual oxygen sensors for more stable fuel metering as mileage accumulates, improved catalysts and catalyst loading, and electronically-controlled EGR in medium-duty vehicles (if the latter has not been previously incorporated) would lead to further NOx reductions. For applications not utilizing a bypass catalyst system, the use of an electrically heated catalyst would also result in decreased NOx levels in-use because the main catalyst could be moved further downstream for improved durability. NOx reductions could also be obtained, particularly from these high load factor engines, by using a fuel which has a lower flame temperature, such as methanol.

3. Electric and Hybrid Electric Vehicles

The ULEV standards could also be achieved by electric vehicles. Battery-powered electric vehicles which do not use auxiliary combustion heaters would also qualify as ZEVs and would be exempt from emission testing for certification. Two types of battery-powered medium-duty electric vehicles are scheduled to be available in the very near future. In September 1990, Vehma International will begin limited production (60 - 75 units) of one-ton GM vans (i.e., G-Vans). The G-Vans will use lead-acid batteries, providing them with a 60 mile range and a 55 mph top speed. Production of the G-Van will continue through 1992 on a "build-to-order" basis. In addition, production of the battery-only Chrysler TEVan is scheduled to begin in 1994. The TEVan will use a nickel-iron battery, which allows a 100 mile range and a 70 mph top speed.

Another class of vehicles, hybrid electric vehicles, would also be strong candidates as ULEVs since they employ a small, low pollution, constant speed engine to generate electrical energy to increase the range of a battery-powered vehicle. These engines could utilize alternate fuels and electrically heated catalysts energized by the vehicle's on-board battery. In 1991 and 1992, two hybrid electric vehicles will go into production. These vehicles, developed by Unique Mobility and Clean Air Transport will combine lead-acid battery technology with power generated from small engines to extend the range of the vehicles. Unique Mobility has plans to produce 7,750 minivans through 1995 which will have a 100+ mile range and a top speed of 70 mph. After 1995, Unique Mobility plans to relinquish vehicle production to an original equipment manufacturer (probably Ford). Clean Air Transport plans to produce 43,625 four-passenger cars and/or one quarter ton microvans within the same time frame. The Clean Air Transport vehicles are expected to have a 150 mile range and a 70 mph top speed.

4. Requirements for Incomplete Vehicles and Diesel Engines

Emission requirements for this category reflect further reductions in NMHC (or OMHCE for methanol) + NOx, CO, PM, and HCHO. These reductions are being proposed under the assumption that alternate fuels would be used increasingly in this time frame and that traps and NOx control for diesel engines would continue to improve.

For Otto-cycle engines, examination of available heavy-duty engine test data for CNG and methanol engines indicates that the proposed medium-duty ULEV standards for incompletes are feasible, especially with expected improvements within the long implementation lead time for this category. Available data for heavy-duty CNG and methanol engines are shown in Table II-13. Although these data are for heavy-duty engines, medium-duty engines should demonstrate similar characteristics. Other fuels such as ethanol and LPG could also fare well, but data for evaluating their potential are currently unavailable.

Table II-13. Emission Data (g/bhp-hr) From Heavy-Duty CNG and Methanol Engines (Based on EPA Test Cycle)

CNG

Engine	NMHC	CO	NOx	PM	HCHO
Chevy Spark Ign.*	0.82	31.9	6.6	0.01	0.032
Chevy Spark Ign.* (w/3-way cat.)	0.17	6.60	1.2	0.01	0.001
Cummins L10 (w/cat.)+	0.90	4.00	4.5	0.06	N/A

+ projected

METHANOL (M100)

Engine	OMHCE	CO	NOx	PM	HCHO
DDC 6V92TA*	1.54	6.30	1.5	0.07	0.24
DDC 6V92TA (w/cat)*	1.22	5.00	1.6	N/A	0.10
DDC 6V92TA**	1.2	3.0	3.3	0.08	0.08
DDC 6V92TA (w/cat.)**	0.2	0.3	3.3	0.02	0.04

* SAE paper #881656, "Methanol vs. Natural Gas Vehicles: A Comparison of Resource Supply, Performance, Emissions, Fuel Storage, Safety, Costs, and Transitions"

** DDC latest test results, 7/90

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The use of CNG would be particularly effective in reducing NMHC emissions, although the ability of more efficient lean burn CNG engines to achieve low NOx emissions is uncertain. An NMHC + NOx standard would be well suited to the performance characteristics of CNG engines. Emissions of CO, PM, and HCHO emissions from CNG engines tend to be very low and would likely be below the proposed standards.

In a similar manner, the ability of optimized methanol engines to achieve low NOx emissions could offset their relatively higher OMHCE emissions, enabling compliance with the proposed 2.5 g/bhp-hr OMHCE + NOx standard. The use of catalysts on methanol engines would also facilitate meeting the OMHCE + NOx standard, and enable compliance with the proposed CO and PM standards. Formaldehyde control would require more effort.

For diesel engines, further reductions in NMHC and PM are expected with additional development and optimization of catalyzed particulate trap systems. In tests on the Donaldson catalyzed trap with an electrical regeneration system, reductions in PM and NMHC of 80 to 90% have been achieved for two-stroke engines, although at relatively low mileage. In addition, further NOx control would be needed to help achieve the 2.5 g/bhp-hr HC + NOx standard. The ULEV standards for medium-duty vehicles would be reconsidered when the staff proposes further reductions in the heavy-duty standards in 1991.

INTRODUCTION

Part B (Chapters III to V) describes in detail the proposed regulation concerning clean fuels and the program for implementing the regulation. The purpose of the proposed regulation is to ensure that the fuels used to certify low-emission vehicles are also readily available for routine consumer operation of those vehicles. The proposed regulation is appended to the staff report (under separate cover). An analysis of legal issues associated with the proposed regulation is presented in Appendix C.

The topics addressed in Part B include:

- The proposed requirement for gasoline suppliers to distribute the clean fuels needed by low-emission vehicles
- The proposed requirement for owners of retail gasoline stations to provide clean-fuel dispensing equipment
- The proposed requirement for operations of stations to make clean fuels available if their stations are equipped to dispense them
- How the ARB would implement these requirements
- Why the particular requirements for clean fuels are needed and superior to possible alternatives
- How specifications for clean fuels and gasoline would be set
- Permitting issues

III.

PROPOSED CLEAN-FUEL REGULATION

This chapter explains the purpose of the proposed regulation concerning clean fuels and describes the requirements in the regulation. Also, the chapter discusses the staff's reasons recommending the regulation in its particular form rather than alternatives that we have considered.

The proposed clean-fuel regulation is designed to ensure that clean fuels would be available at retail and that they would be used in the appropriate low-emission vehicles. The proposed regulation would allow vehicle manufacturers to choose the kind of fuel on which to certify low-emission vehicles to the proposed standards. The use of clean fuels for certification may give vehicle manufacturers more flexibility in meeting the proposed emission standards and assist them in meeting the most stringent sets of standards (for ULEVs and ZEVs). The low emission levels will be achieved in customer use only if clean fuels are available to and used by consumers to operate their vehicles.

Assurance that clean fuels would be made available to the vehicle owners is needed for two reasons. First, vehicle manufacturers might want or need to make some low-emission vehicles operable only on a particular clean fuel; that is, the vehicle would be "dedicated" to a specific clean fuel. Manufacturers must be confident that the potential car buyer will be assured of finding that fuel reasonably available. Second, the staff anticipates that during the early years of the program, many low-emission vehicles certified on a clean fuel will also be capable of using gasoline. [Such vehicles are referred to as "dual-fuel" vehicles (DFV) or "flexible-fuel" vehicles (FFVs)]. If the clean fuel was not available at retail, these vehicles could still be operated on gasoline, but with greater associated emissions.

The central element of the proposed regulation is the clean-fuel distribution requirement. Gasoline suppliers (refiners, blenders, and importers) would be required to distribute clean fuels into the retail market in volumes proportional to the numbers of low-emission vehicles in the fleet. The volumes to be distributed by any gasoline supplier would be set by the ARB Executive Officer through procedures explained later in this chapter.

The proposed clean-fuels regulation contains other elements that would provide the means to implement the distribution requirement and give gasoline suppliers flexibility in the way they could comply. The other key elements of the proposed regulation are:

-- an allowance for using credits from another company's distribution of a clean fuel as an alternative to a gasoline supplier's own distribution of that fuel;

-- a requirement for a certain number of gasoline stations to be equipped to dispense clean fuels, to ensure that there would be facilities where drivers could fuel their low-emission vehicles and through which gasoline suppliers could move their required volumes;

-- a requirement that operators of stations make clean fuels available at retail if their stations are equipped to dispense them;

-- recordkeeping and reporting requirements to assist enforcement;

-- the procedures for calculating and allocating clean fuel volumes to be distributed and the number of clean fuel retail outlets required;

-- enforcement provision; and

-- a provision to allow equally effective substitutes for clean fuels.

A. CLEAN-FUEL DISTRIBUTION REQUIREMENT

This element would require all gasoline suppliers that distribute gasoline in a calander quarter to distribute a minimum volume of each clean fuel during each calendar quarter. Clean fuel would be considered "distributed" when it had been released by the gasoline supplier into the marketing chain that moves the fuel to retail stations. To satisfy this requirement for a particular clean fuel, a gasoline supplier could distribute fuel produced or imported by that supplier or acquired from another source; or the supplier could obtain credits generated by another party's distribution of the same fuel or generated by a public utility's sales of CNG or electricity.

1. Fuels Subject to the Requirement

The following fuels are recognized as potential non-gasoline certification fuels for low-emission vehicles:

- methanol*
- ethanol*
- liquified petroleum gas (LPG)
- compressed natural gas (CNG)
- electricity

All of these fuels, except CNG and electricity, would be subject to the clean fuel distribution requirement if they are used by vehicle manufacturers to certify a low-emission vehicle. However, the distribution and other requirements for clean fuels would not be triggered for a particular clean fuel until the projected number of vehicles in the fleet that were certified on that fuel reaches a de minimus level. The clean fuel requirements for a particular fuel would remain in effect only as long as the projected number of vehicles certified on that fuel remains at or above the de minimus level.

The distribution requirement would also apply to any new fuel (such as a reformulated gasoline different from the expected Phase 2 gasoline) which the ARB specifies as a permissible certification fuel by regulation. The distribution and other clean fuels requirements would be triggered for a new fuel once the number of vehicles in the fleet certified on the new clean fuel reached the de minimus levels.

Although CNG and electricity have good potential as certification fuels for low-emission vehicles, the staff believes that it would be inappropriate to include them in the distribution requirement for three reasons: (1) these fuels are already produced and widely distributed by utilities, (2) the gasoline suppliers' distribution systems are not equipped to handle these non-liquid fuels, and (3) these fuels are offered by only one supplier (a utility) in each geographical area, which creates a monopolistic situation in terms of price and supply. Although CNG would not be included in the distribution requirement, retail gasoline station owners would have to make CNG available at some of their stations to provide fuel for CNG vehicles, if needed.

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* Methanol and ethanol may be in either the pure, neat form (M100, for example, which is 100 percent methanol), or in mixtures with gasoline. M85, which is 85 percent methanol and 15 percent gasoline, is a common mixture. An analogous situation exists for ethanol.

2. Specific Provisions

Under the proposed distribution requirement, the Executive Officer of the ARB would set minimum volumes of each clean fuel to be distributed. The total volume of a particular clean fuel to be distributed by gasoline suppliers collectively would be a fraction of the total fuel demand of low-emission vehicles certified on that fuel. The fraction would increase on a schedule set by the regulation. That total required volume would be allocated among gasoline suppliers, the amount assigned to a particular supplier being the minimum amount that must be distributed during the calendar quarter.

The final determination of the total required volumes for a quarter would be made no later than three months before the start of that quarter. However, the approximate volumes would be known a year in advance as part of determining the the corresponding numbers of retail outlets to be equipped to sell the clean fuels.

The methods that the staff proposes for setting the total required volumes of clean fuels and allocating them among the gasoline suppliers are described in section E. of this chapter.

3. Schedule for Requirements

All of the clean-fuel requirements would take effect within the boundaries of the South Coast Air Quality Management District ("South Coast region") in 1994, and statewide in 1997. Since the South Coast region has the worst air pollution problem in the state, the staff believes it is reasonable and necessary to implement the clean fuels program in that district prior to statewide implementation. However, other districts in the state could also participate in this advance program by showing a need for mobile source emission reductions prior to 1997 in the district's plan for attainment of state air quality standards required by the California Clean Air Act. If the ARB approved extension of the advance program to other districts, the clean fuel distribution, retail outlet and availability requirements would be effective in those districts prior to 1997 also.

The staff recommends beginning the clean fuels program earlier in the South Coast region than in the rest of the state to accommodate the schedule for reductions in vehicular emissions in the South Coast Air Quality Management Plan. The delay in implementing the requirements in areas outside the South Coast region would not affect the ultimate full implementation of the program in those areas. In 1997, the schedule for distributing clean fuels would be uniform statewide and would reflect the fuel demand of all low-emission vehicles sold since 1994.

4. Use of Credits to Meet the Distribution Requirement

A gasoline supplier could satisfy any part of its distribution requirement for a particular clean fuel by purchasing credits from another company. The credits would accrue from the same clean fuel distributed by another fuel supplier or from CNG or electricity distributed by a utility company and used in vehicles. Once a gasoline supplier had satisfied its distribution requirement for a particular clean fuel, further distribution of that fuel during the quarter would generate credit that the supplier could apply against its own distribution requirement in a future quarter or sell to another gasoline supplier.

The staff recommends the credit provisions to give gasoline suppliers flexibility in meeting their distribution requirements. Economies of scale may make it more efficient for only some gasoline suppliers to make or buy a clean fuel and distribute it. For other suppliers, it may be more economical to buy credits than to do the actual distribution directly. This ability to buy credits could also provide emergency relief for a gasoline supplier that might be temporarily unable to distribute its own clean fuel.

The provisions for the use of credits as an alternative to direct distribution are intended to reduce the difficulty and cost of compliance with the distribution requirement. However, industry has asserted that use of credits could also increase the likelihood of fraud. Recordkeeping requirements and careful vigilance on the part of the ARB would help prevent fraudulent credit claims. The staff believes that the flexibility provided by the credit provisions outweighs the potential enforcement problems.

a. <u>Credits for the sale of CNG and electricity</u>

Under the staff's proposal, a gasoline supplier could satisfy part of its distribution requirement for any clean fuel with CNG or electricity credits purchased from a utility. The utility could earn these transferable credits by delivering CNG or electricity directly to vehicles. For electricity, credits would be given only for the electricity demanded by ZEVs produced in excess of the required numbers. (See Appendix B-7.)

These credits for the sale of CNG and electricity would displace an equivalent amount of a clean fuel that a gasoline supplier otherwise would have to distribute. To prevent CNG and electricity credits from displacing a significant amount of other clean fuel, the staff proposes that use of these credits be capped in any quarter at ten percent of a gasoline supplier's total clean-fuel distribution requirement (over all fuels).

b. <u>Credit banking</u>

In addition to using purchased credits, a gasoline supplier could draw on banked credits that it had earned in previous quarters for its own clean-fuel sales in excess of the required minimum volumes. This provision could help a supplier through a period when its normal supply of a clean fuel might be reduced.

Although credit banking could be very useful to the gasoline suppliers, it could act to discourage inter-company credit trading because companies might prefer to keep the credits for their own use. Since the staff believes that the credit trading may be important, the staff recommends that the amount of banked credit be limited to 20 percent of a company's total clean-fuel distribution requirement for the quarter and that the worth of the credits be gradually discounted over two years from the date of deposit.

Utility companies would be allowed to bank credits for their sales of CNG and electricity. There would be no cap on the amount of credit banked and no discounting of credits that were generated before January 1, 1998. However, credits generated after that date would be discounted the same as for the gasoline suppliers.

B. CLEAN-FUEL RETAIL OUTLET REQUIREMENT

This provision would require owners (and lessors) of retail gasoline stations to install dispensing equipment and storage tanks for clean fuels. For each clean fuel with a distribution requirement and for CNG, owners and lessors would have to provide the capability to sell that fuel in a certain number of retail gasoline stations. The Executive Officer of the ARB would determine the total additional number of stations required each quarter to dispense the fuel and the allocation of this increment among the station owners. The procedures for this are discussed in section E. of this chapter. This requirement would take effect in 1994 for gasoline stations in the South Coast region (and in any other districts participating in the advance program) that are owned (or leased) by major oil companies. It would take effect statewide in 1997 for all station owners.

The staff believes that this clean fuel retail outlet provision is needed to ensure that clean fuels are available to the consumer at convenient retail outlets and to assure gasoline suppliers that there will be retail outlets through which the clean fuels they are required to distribute could be sold. Some refiners and importers subject to the distribution requirement do not own stations or retail businesses. If they had to rely upon the retailers who buy their fuels to voluntarily install dispensers for each clean fuel, they could be at a disadvantage relative to the major gasoline suppliers, who have direct control over some retail outlets and at least some degree of control at many other outlets.

The staff proposes that some retail gasoline stations be required to install CNG dispensing equipment to ensure that there would be enough CNG stations to be convenient for owners of CNG vehicles. However, including CNG in the retail outlet requirement is contingent on the approval of the Public Utilities Commission (PUC) because the marketing of CNG is regulated by the PUC. Gasoline stations would be required to install CNG equipment only to the degree that other entities (e.g., utilities and private fueling stations) do not provide enough CNG outlets.

The regulation would not require retail gasoline station owners to install equipment to charge electric cars. Since recharging will be done easily where electric vehicles are garaged, commercial recharging facilites should not be needed.

C. CLEAN-FUEL RETAIL AVAILABILITY REQUIREMENT

The proposed regulation would require the operator of any retail gasoline station equipped to sell a clean fuel to actually offer that fuel for sale. The staff believes that this requirement is needed to ensure that clean fuels are continually available to low-emission vehicle owners and that gasoline suppliers would have wholesale customers for the clean fuels that they must distribute.

D. RECORDKEEPING AND REPORTING

Since the ARB would not be able to directly monitor the distribution of clean fuels, enforcement of the proposed regulation would have to be done through examination of appropriate records. Accordingly, the proposed regulation would require both gasoline suppliers and companies providing clean fuels or credits to keep records. The proposed requirements include the maintenance and reporting of detailed data on the origin and movement of all clean fuels distributed to comply with the regulation.

All owners of retail gasoline stations would have to inform the ARB of the number and location of their stations.

E. CALCULATION AND ALLOCATION OF REQUIRED CLEAN FUEL VOLUMES AND THE NUMBER OF RETAIL OUTLETS

The proposed clean fuels regulation directs the Executive Officer of the ARB to determine the volume of clean fuels to be distributed by each gasoline supplier and the number of retail outlets at which clean fuels must be provided by each retail station owner. Under the proposal, the Executive Officer must determine:

-- the fuel demand ("maximum demand volumes" in the regulation) of low-emission vehicles certified on each clean fuel, for each quarter in the South Coast region in 1994 through 1996 and statewide in 1997 and later;

-- the total volume of each clean fuel to be distributed ("total required volume" in the regulation, a fraction of maximum demand volume) for each quarter;

-- the allocations of those total required volumes among gasoline suppliers;

-- the total incremental number of retail outlets needed to dispense each clean fuel in the South Coast region in 1994 through 1996 and statewide in 1997 and later; and

-- the allocation of the required incremental number of retail outlets among gasoline service station owners.

This section describes in general how these numbers would be calculated. More detail is in Appendix B-2.

1. Estimating the Maximum Demand Volume for Each Clean Fuel

The maximum demand volume for a particular clean fuel in a particular quarter would be the amount of fuel needed by all low-emission vehicles certified on that clean fuel. The number of such vehicles would be the number registered with the Department of Motor Vehicles (DMV) plus an estimate of the number of new vehicles (not yet registered) entering the fleet by the quarter in question. The number of new low-emission vehicles for the clean fuel would be estimated from the trend in vehicle registration data and from manufacturers' plans for sales. The proposed regulation requiring low-emission vehicles requires auto manufacturers to report these plans to ARB.

The statewide maximum demand volume for a fuel would be multiplied by 0.50 for each year from 1994 through 1996 because the distribution requirement would apply only in the South Coast region.

2. Determining the Total Required Volume for Each Clean Fuel

The maximum demand volume for a clean fuel would be multiplied by a factor less than 1.0 to arrive at the total volume of that fuel to be distributed. This adjustment would account for any uncertainty in the consumers' demand for a clean fuel and any potential over-estimation of the actual fuel demand by the vehicles certified on that clean fuel. For the demand volume of dedicated-fuel vehicles, the adjustment factor would be 0.90 at all times. For the demand volume of flexible-fuel and dual-fuel vehicles, the adjustment factor would be low when a clean fuel would first be required, and it would grow with time. Table III-1 shows the proposed fuel volume adjustment factor factors for flexible fuel or dual fuel vehicles and dedicated vehicles introduced in 1994.

Table III-1. Proposed Adjustment Factors for Clean-Fuel Distribution Volumes

Year	FFV/DFV	Dedicated
1994	0.25	0.90
1995 to 1997	0.50	0.90
1998 to 1999	0.75	0.90
2000+	0.90	0.90

It may not be reasonable to require a new clean fuel, introduced several years into the program, to be distributed in the first year after introduction in volumes corresponding to 75 or 90 percent of the maximum demand by FFVs and DFVs. For such fuels, the staff proposes an alternative set of adjustment factors. To calculate the required distribution volume for clean fuels introduced after 1994, the staff would use either the appropriate factor shown above or the alternative factor shown in Table III-2, whichever would be lower. The factor for fuel for dedicated vehicles would remain at 0.90.

Table III-2. Alternative Adjustment Factors for New FFV or DFV Fuels

Years since introduction of a fuel	Factor
1	0.25
2	0.50
3	0.75
4+	0.90

The proposed regulation would allow the Executive Officer to modify these factors somewhat in certain circumstances. The Executive Officer could modify the adjustment factors by ± 0.10 to account for uncertain factors that could affect fuel demand. For example, if the South Coast AQMD adopts a proposed rule requiring FFV/DFV fleet vehicles to use clean fuels 80 percent of the time, higher adjustment factors than those above could be appropriate.

3. Allocating the Total Required Volumes

The total amount of a particular clean fuel required for the South Coast region in 1994 through 1996 would be allocated among all major refiners in the state that own 25 or more retail gasoline stations in the District. The required volume of a clean fuel in the statewide program (1997 and later) would be allocated among all gasoline suppliers. The Executive Officer would allocate the required volumes in proportion to each company's recent share of the gasoline market as determined from taxable fuel distributions during the four most recent quarters under the California Motor Vehicle Fuel License Tax Law. In 1994 through 1996, a major refiner's market share would be its volume of taxable gasoline distributed statewide divided by the sum of that number over all major refiners. In 1997 and later, a gasoline supplier's share would be its statewide volume of taxable gasoline divided by total taxable gasoline in the state.

4. Determining the Increment in the Number of Clean Fuel Retail Outlets

For each year of the program, the staff would calculate the desired number of clean-fuel outlets as follows. A preliminary estimate* of the required volume would be calculated for each clean fuel for the average number of low-emission vehicles expected on the road during the year. (The required volume would be just the volume needed at retail, after accounting for clean fuel expected to be supplied at private fueling stations.) This volume would be expressed as the increment over the preceding year's required volume. The incremental volume divided by 300,000 gallons per year (25,000 gallons per month) for 1994 through 1997, or by 600,000 gallons per year (50,000 gallons per month) for later years, would yield the number of retail outlets needed for a liquid clean fuel in that year. For CNG, the divisor would be 360,000 gallons per year.

From the proposed fleet-average emission standards for light-duty vehicles and the proposed schedule for required sales of low-emission vehicles in the medium-duty class, the staff has estimated the combined volume of all clean fuels and the corresponding cumulative numbers of retail outlets for two hypothetical examples of clean-fuel demand. These estimates are shown in Table III-3. Additional information on how these estimates were derived are presented in Appendix B-6. In 1994 through 1996, the fuel volumes and retail outlets would apply only to major gasoline suppliers in the South Coast region. If other districts also would participate in this advance program, the numbers for those years would exceed the estimates in the table. The distribution of the total number of outlets among the various clean fuels would depend upon the number of vehicles for each fuel. The total number of retail outlets would not necessarily be the number of gasoline stations equipped to sell clean fuel because any station could be equipped to be the retail outlet for more than one clean fuel.

The difference between successive years in the desired number of retail outlets for a particular fuel would be the number of outlets to be added for that fuel for the next year.

5. Allocating the Required New Clean-Fuel Retail Outlets

In 1994 through 1996, the responsibility to equip each year's incremental number of new retail outlets for a particular fuel would be allocated among the major suppliers by gasoline market share (in the same way as the required clean-fuel volumes would be allocated).

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* The volumes would be only estimates of the required distribution volumes because the calculations here must be done well before the required volumes would actually be set.

In 1997 and later, the responsibility for the new retail outlets would be allocated among all stations owners/lessors who own or leases more than a certain number of stations. (Appendix B-4 presents information on gasoline marketing and distribution in California.) That criterion number of stations owned or leased ("minimum ownership level" in the regulation) would be equal to the total number of gasoline stations not yet required to offer any clean fuel divided by the total number of new clean-fuel outlets (over all fuels) needed for the year. The value obtained for the minimum ownership level would depend upon the number of low-emission vehicles expected to be introduced into the fleet in the year in question. However, it would generally decrease (bring smaller owners into the program) year-by year. Table III-4 shows the approximate sequence of the minimum ownership level year-by-year for two hypothetical situations. It should be noted, that the minimum ownership level rises in 1998 because the throughput volume variable per retail outlet increases from 300,000 gallons per year to 600,000 gallons per year. This decreases the number of retail outlets needed by one-half and increases the minimum ownership level.

Table III-3. Estimated Total Required Clean Fuel Volumes and Corresponding Numbers of Retail Outlets

	Required Clean Fuel (million gallons)[a]		Number of Clean-Fuel Retail Outlets[b]	
	A	B	A	B
1994 (SCAQMD)	18	9	58	24
1995 "	80	40	267	134
1996 "	125	63	417	209
1997 (state)	460	230	1,530	765
1998 "	1,150	575	1,930	965
1999 "	1,880	940	3,130	1,570
2000 "	3,370	1,650	5,610	2,810
2002 "	5,470	2,740	9,120	4,560
2005 "	7,880	3,940	13,100	6,550

[a] gasoline-equivalent; calculated for the example schedule of vehicle introduction in Table I-6 and as if A: all low-emission vehicles certify on clean fuel or B: half of all low-emission vehicles certify on clean fuel and half certify on gasoline.

[b] for scenarios A and B as defined above; calculated as if no clean fuel would be provided by private fleet stations; increments to the number of stations are equal to the increments in required fuel divided by 300,000 gal/year from 1994 through 1997 and by 600,000 gal/year later.

Table III-4. Approximate Minimum Ownership Levels

	Owners or lessors of this number or a greater number of stations fuel must provide new clean-fuel outlets	
	Case A	Case B
1997	11	23
1998	29	62
1999	10	20
2000	4	9
2002	2	6
2005	1	4

Case A: All low-emission vehicles certify on clean fuels.

Case B: Half of all low-emission vehicles certify on clean fuels.

The proposed retail outlet allocation procedure would delay the entry of small owners into the requirement until the total number of required stations is large. This is necessary because when few stations would be needed, the minimum number of stations a small owner could equip (one) would be an unfairly large fraction of his or her total stations. For example, if an owner of only two stations was required to equip one station for a clean fuel, that owner would equip half of his or her stations. According to preliminary data, one-fourth of all stations may be owned by persons having only one or two stations.

Among the station owners or lessors required to contribute new clean-fuel outlets, each would equip the same fraction of as-yet unequipped stations for a particular fuel. That fraction would equal the total number of new outlets needed for that fuel divided by the total (over all affected owners) number of stations not yet equipped for any clean fuel. For example, if in a particular year (1) the minimum ownership level were 35 stations owned and (2) among owners of 35 or more as-yet unequipped stations (affected owners), there were a total of 3,000 such stations and (3) 300 new outlets were needed for fuel A and 150 new outlets were needed for fuel B, each of the affected owners would have to equip 10% (.1 = 300/3,000) of his or her stations as new outlets for fuel A and 5% for fuel B. The sum of all new outlets over all affected owners would be approximately 300 for fuel A and approximately 150 for fuel B. (The sums would not exactly equal the required number because each owner's required number of outlets would have to be rounded to the nearest integer value.)

In either period (pre- or post-1997), a station owner or lessor would not necessarily have to newly equip a number of stations equal to his or her allocation of the incremental outlets. If an owner or lessor had already equipped a number of outlets equal to the combined increments required over prior years, plus the newly assigned increment, then the retail outlet requirement would be satisfied. Also, the regulation would allow an owner to receive credit for another owner's equipping a station in excess of the latter's assigned number. As a result, the scheme for calculating and allocating incremental numbers of clean-fuel outlets would lead to a desired total number of outlets for each fuel as a function of the demand for that fuel, rather than a set number of new outlets in each year.

F. DETERMINATION OF VIOLATIONS

The regulations include provisions for identifying the violations that occur when a gasoline supplier or retail outlet owner/lessor fails to comply with the regulatory requirements. The only applicable penalty under the Health and Safety Code is the section 43016 civil penalty of up to $500 per vehicle for violations of vehicle and fuel regulations for there are no other specified penalties. Therefore it is necessary to identify how this "per vehicle" penalty applies to noncompliance.

Whenever a gasoline supplier distributes gasoline in a quarter where it fails to distribute its minimum assigned volume of a designated fuel, the supplier would be deemed to have sold gasoline in violation of the regulations. The volume unlawfully sold would be the same volume on an energy equivalent basis as the shortfall of designated clean fuel. A separate motor vehicle would be deemed to have been fueled with each 20 gallons of unlawfully sold gasoline, unless the gasoline supplier demonstrates that fewer vehicles were fueled. Based on the experience of the ARB's Compliance Division, 20 gallons per vehicle fueling is a very conservative estimate for gasoline-powered vehicles. This approach will help assure that an appropriate "per vehicle" penalty attaches to violations of the distribution requirements. The regulations also provide that where a gasoline supplier relies on credits for compliance, whenever the credits were improperly generated, withdrawn or transferred, they cannot be counted towards compliance. The gasoline supplier directly responsible for compliance should be obligated to assure the validity of any credits used. At the same time, the supplier may have a cause of action against a person who improperly transferred credits to the supplier.

Whenever the owner/lessor of a gasoline retail outlet fails to have equipped the requisite stations to dispense clean fuels, the owner/lessor will be deemed to have sold gasoline in violation of the regulations. For each day of violation, sales of gasoline at the outlet to the first ten vehicles would be considered illegal. This would provide the availability of an appropriate and measured penalty. As with the case of credits, improper "constructive allocation" of clean fuel outlets would not satisfy the owner/lessor's obligations. The same treatment as described earlier in this paragraph would apply to operators of retail outlet who fail to make clean fuels available to the public in violation of the regulations. In this case, sales to the first five cars fueled with gasoline on each day would be deemed to be in violation.

G. SUBSTITUTES FOR CLEAN FUELS

The proposed regulations would allow a gasoline supplier to meet the distribution requirement for a clean fuel by supplying a substitute fuel approved by the ARB. The substitute fuel would have to allow the low-emission vehicles certified on the orginal clean fuel to emit at the same rates. When evaluating a candidate substitute clean fuel, the ARB would consider the emissions of all types of vehicles capable of using the fuel and the fuel's effect on the durability of the vehicular emission control systems. The provisions for substitute clean fuels are discussed more in Chapter V.

H. ALTERNATIVE REGULATORY APPROACHES

The staff evaluated alternative regulatory approaches for the various major elements of the clean-fuel regulation. These alternatives are discussed below.

1. Provide Economic Incentives

Economic incentives could be established to encourage the production and sale of low-emitting vehicles and clean fuels. Lower vehicle registration and/or smog check fees could be established for low-emission vehicles. Lower sales taxes could be levied on clean fuels. Tax credits and lower permitting fees could also be granted to those service station owners who install clean fuel dispensing equipment.

The AB 234 Advisory Board evaluated the use of economic incentives as one of the many options for introducing clean fuels, and concluded that the best approach was to establish performance standards for fuels that were consistent with achieving environmental goals. Economic incentives alone would not ensure that clean fuels would be distributed in sufficient quantities to adequately supply low-emitting vehicles. Although these types of incentives could be useful in combination with the staff proposal, the staff cannot incorporate them into the proposal because the ARB does not have the authority to provide economic incentives.

2. Mandate a Vehicle Technology and Particular Fuel

With this approach, the ARB would choose a vehicle emission control technology that must be used and the particular fuel which must be distributed by the fuel suppliers. While this approach would make the proposal easier to implement and enforce, and would make the results more predictable, it could stifle the development of better vehicle/fuel systems in the future. Rather than having the ARB decide on the most appropriate technologies and fuels, the staff believes it would be more productive to give industry the flexibility to determine the best combination to meet the emission reduction goals.

3. Require the Production of Low-Emission Vehicles, But Not Clean Fuel Availability

This approach would relieve gasoline suppliers of having to meet a clean fuel distribution requirement, and service stations of having to meet clean fuel retail outlet and availability requirements. The clean fuel would be distributed and made available only as the market dictated.

The staff is not convinced that market forces would provide sufficient incentive for the timely introduction of clean fuels. To meet the emission reduction goals defined in the proposed regulation, the clean fuels required by low-emission vehicles must be made available at a sufficient number of retail stations to be convenient, and be priced competitively with gasoline. Clean fuel market forces, alone, may not respond quickly enough to the demand created by the low-emission vehicles introduced in accordance with the proposed regulations. If vehicles do not use the clean fuels, emission reductions will not be realized.

4. Establish a Numerical Emission Value for the Fuel Pool That All Gasoline Suppliers Would Have to Meet

The ARB could introduce clean fuels by establishing a numerical emission value for the fuel pool that all gasoline suppliers would have to meet. In such a system, each fuel would be assigned an emission value representing the relative emission potential for that fuel with respect to some baseline fuel, such as gasoline. To meet the required pool emission value, sales of fuels with high emission potential would have to be offset with sales of (or purchasing of credits for) clean fuels with low emission potential.

The staff believes that this approach has many positive elements and should be considered further after the program becomes more established. However, the main drawback with this approach is the difficulty and complexity in establishing emission values for each fuel. The emission value would depend on the fuel characteristics and the emissions of each type of vehicle (TLEV, LEV, ULEV, ZEV) using this fuel. To develop a non-arbitrary method for assigning emission values to each fuel, the staff would need considerable data on the emission characteristics of both the new vehicles and fuels. Data on the emission characteristics of each fuel and on the number of low-emission vehicles would not be available in the beginning of the program.

IV.

SPECIFICATIONS FOR VEHICULAR FUELS

This chapter discusses how specifications for each fuel expected to be sold to the public (commercial fuel) and the specifications for the corresponding fuel used to certify new vehicles (certification fuel) will be developed. The only difference between a commercial fuel and its corresponding certification fuel would be the allowable variability of the specified properties of the fuel, which may be more narrowly restricted in the certification fuel than in the commercial fuel. Once specifications for each commercial fuel have been adopted by the Board, all fuel of that type sold for vehicular use in California must meet them. Once specifications for a corresponding certification fuel have been adopted by the Board, all vehicles designed to use that type of fuel would have to certify on fuel meeting those specifications.

There are five categories of fuel that need to be addressed: Phase 1 gasoline, Phase 2 gasoline, existing clean fuels, new clean fuels, and fuels used as substitutes for clean fuels already in use. For all categories except the last, both commercial and certification specifications would be determined. The ARB might also specify the composition of test fleets representative of the vehicles that would use new clean or substitute fuels. These fleets would be used to make certain demonstrations required for approval of the fuels.

A. INTERIM SPECIFICATIONS FOR PHASE 1 GASOLINE (1992-1995)

The ARB staff is proposing interim specifications for commercial gasoline to be presented to the Board in September 1990. These interim specifications would be more restrictive than the specifications that already exist for commercial gasoline. New specifications being proposed for Phase 1 gasoline are:

- 7.8 psi Reid vapor pressure (RVP) maximum
- detergent content requirement
- elimination of lead

The new specifications would take effect in January 1992 and remain in force until specifications for Phase 2 gasoline, which will be more restrictive, take effect. The proposed regulations and their justifications are available in other documents.

A new certification fuel, "Phase 1 Indolene," is being proposed for use as the certification fuel for all gasoline-capable low-emission vehicles prior to model-year 1996. ARB staff believes that Phase 1 Indolene better represents gasoline currently being sold for vehicular use in California than does the current certification gasoline, Indolene Clear. The specifications for Phase 1 Indolene will be modeled after the U.S. average gasoline being used in the joint Auto/Oil industry project as described in Part A, Chapter I, Section D.

B. PHASE 2 GASOLINE (1996 AND LATER)

The ARB staff proposes to develop new specifications for all gasoline sold for vehicular use in California. The staff would propose the new specifications for Phase 2 gasoline for adoption by the Board in September 1991. Beginning January 1, 1996, all gasoline sold for use in California would be required to meet the new Phase 2 specifications.

In developing specifications, the ARB will consider the reduction in ozone-forming potential of the emissions from the fuel and the reduction in toxic emissions from the fuel as compared to Phase 1 gasoline. The ARB will also evaluate the feasibility and cost of producing Phase 2 gasoline. All information presented by fuel producers and sellers, vehicle manufacturers, consumers, the U.S. Environmental Protection Agency (EPA), and any other interested parties will be considered. Although all gasoline sold in California would be required to meet the commercial specifications for Phase 2 gasoline set by the ARB, these specifications will allow the producers some flexibility. Alternative formulas, if approved by the Executive Officer (EO), many be allowed in certain cases.

The staff will also propose for Board adoption by September 1991 a new certification gasoline, representative of commercial Phase 2 gasoline, to be specified as the certification fuel for all gasoline-capable vehicles. Beginning with the 1997 model-year, the certification gasoline would be used to certify all gasoline-capable vehicles, including flexible-fuel and dual-fuel vehicles.

C. SPECIFICATIONS FOR CLEAN FUELS

1. Clean Fuels to Be Introduced in 1994

In September, 1991, the staff would propose for the Board's consideration amendments to existing specifications for methanol, ethanol, LPG, and CNG as certification fuels and new specifications for those fuels as new commercial fuels. the staff would also propose specifications for any other identifiable candidates for clean fuel. The new specifications could be in addition to, or more restrictive than, any existing specifications. In developing the new specifications, the staff would consider the effects on emissions, any safety considerations, and the feasibility and cost of producing the fuel. The new specifications for both commercial and certification clean fuels would be effective beginning early in 1992.

2. New Candidate Clean Fuels

Continued research may result in better fuels. If there is developed a new clean fuel apparently preferable to existing clean fuels, the ARB would conduct a public hearing to consider approving the new fuel as a certification and commercial clean fuel. The ARB would consider any comments received and the cost-effectiveness of producing commercial quantities of the new fuel.

If a new fuel could be used in existing vehicles, the ARB would approve it as a clean fuel only if the petitioner showed that use of the new clean fuel:

- -- would not increase emissions of criteria pollutants and of toxic pollutants (benzene, 1,3-butadiene, formaldehyde, and acetaldehyde) would not increase and
- -- would not adversely affect the durability of the emission control systems would not be harmed.

The ARB has established protocols by which the petitioner would make the demonstrations. These are discussed in Appendix B-3.

3. <u>Substitute Clean Fuels</u>

A gasoline supplier or other party could petition the ARB to adopt specifications for a substitute fuel that could be distributed in place of a particular primary clean fuel (the clean fuel that the substitute fuel would replace). To qualify a substitute fuel for ARB approval, the fuel proponent would have to demonstrate that use of the substitute fuel:

- would not result in higher criteria pollutant emissions than when the primary clean fuel is used in low-emission vehicles certified on the primary clean fuel;

- would not result in higher emission of toxics (benzene, 1,3-butadiene, formaldehyde, and acetaldehyde) than when the primary clean fuel is used in low-emission vehicles certified on the primary clean fuel;

- would not adversely affect the durability of the emission control systems in low-emission vehicles certified on the primary clean fuel or in any other vehicles capable of using the substitute fuel; and

- would not result in increased emissions of criteria pollutants or toxic pollutants (benzene, 1,3-butadiene, formaldehyde, and acetaldehyde) when compared to the use of gasoline in any other vehicles capable of using the new fuel.

The staff proposal includes test protocols for these demonstrations. The protocols are designed to require clear demonstration of equivalent emissions on the substitute fuel, and will require testing of a wide variety of vehicles. These protocols are found in Appendix A-3.

If the substitute fuel would not be usable in any other vehicles except those certified on the primary clean fuel, then the total required volume of the substitute fuel would just have to equal the total required volume of the primary clean fuel.

If the substitute fuel would be usable in vehicles other than those certified on the primary clean fuel (e.g., reformulated gasoline), the required distribution volume for the substitute fuel would have to be greater than the distribution volume for the primary fuel. To ensure that the desired number of low-emission vehicles certified on the primary fuel would receive the substitute fuel, the total required volume of the substitute fuel would have to equal the total required volume for the primary clean fuel plus the average quarterly volume of all gasoline distributed by a supplier to vehicles which are capable of using the substitute fuel, multiplied by the fuel volume adjustment factor (0.25 to 0.90) for the quarter. For example, if the total required volume of a primary designated clean fuel is 50 units, and 1000 units of substitute fuel could potentially be used in other vehicles capable of using the substitute fuel, and if the fuel volume adjustment factor is 0.5, then the total required volume of the substitute fuel would be 50 units, plus 1000 units times 0.5, or 550 units.

The average quarterly volume of gasoline would be based on taxable distributions of motor vehicle fuel for the last four quarters for which data are available, as reported to the State Board of Equalization pursuant to Revenue and Taxation Code section 7301 et. seq.

V.

PERMITTING ISSUES

To comply with the proposed regulations, some gasoline suppliers may have to construct new equipment for distributing clean fuels, such as methanol storage tanks, or desire to make process changes allowing the production of a special gasoline as a substitute clean fuel. Before construction of new equipment, a gasoline supplier would need to obtain construction permits from the appropriate air quality management district or air pollution control district. Gasoline suppliers have expressed concern about the ability to receive permits to construct and operate facilities that would emit criteria pollutants or toxic air contaminants. Also, some service station owners are concerned about obtaining on time the permits needed to install and operate equipment in response to the retail availability requirement.

Sections A and B of this chapter discuss the permits that gasoline suppliers would need to obtain from air pollution agencies for equipment needed to distribute clean fuels. Section C describes the permits needed by service stations for dispensing clean fuel.

A. PERMITS FOR CRITERIA POLLUTANT EMISSIONS

Air pollution control districts maintain new source review (NSR) rules to prevent significant increases in air pollution from new or modified emission sources (e.g., refineries, fuel storage tanks, or fuel shipping terminals). If the new emissions from the current project would cause the cumulative increase in emissions at the source to exceed a certain limit, NSR requires best available control technology (BACT) on all new or modified equipment. If the cumulative emission increase exceeds another (in most cases, higher) limit, the entire accumulation must be offset by emission reductions either accomplished elsewhere at the source or at a nearby source, purchased from another source, or withdrawn from a "bank" of reductions. However, not all districts offer all of these options in offsetting emissions. Generally, emissions must be offset at a ratio greater than one-to-one. That is, the emission reduction must exceed the emission increase.

Some of the districts allow previous emission reductions as credits in the calculation of accumulated new emissions for the offset requirement; however, most districts will not allow this credit in determining whether or not BACT is required.

The need for offsets is a concern of gasoline suppliers who would have to distribute clean fuels. Obtaining permits for major equipment modifications may be more difficult in the future as districts' NSR rules become more stringent. However, in the two largest districts where refiners operate, there appear to be mechanisms by which the offset requirement is manageable.

As an alternative to the requirements just described, the Bay Area Air Quality Management District (BAAQMD) uses an "emission cap" to regulate modifications for several refineries. The cap allows a source to increase emissions from one piece or group of equipment, provided that other emissions within the source are reduced by an amount equal to 1.10 times the increase. This allows certain refiners to modify their plants without obtaining changes to their permits or offsetting "back to zero". The "cap" provision does not apply to the BACT requirement.

The NSR regulation of the South Coast AQMD has been of particular concern to industry. However, that District recently adopted a provision in Rule 1304 exempting a source from the offset requirement if the new emissions are incidental to complying with air pollution control requirements adopted by other agencies, such as the ARB, and if the source's level of activity (e.g., gasoline production) does not increase.

B. PERMITS FOR EMISSIONS OF TOXIC POLLUTANTS

Under current BAAQMD and SCAQMD rules, these districts generally will not grant permits for new or modified equipment, even if constructed with BACT, if the equipment would emit toxic pollutants and the incremental risk to the maximally exposed individual would exceed ten in a million. If the incremental risk would be between one and ten in a million, the permit unit must be constructed with BACT for toxic pollutants. If the risk would be less than one in a million, no controls are required.

The SCAQMD would grant a permit if the increase in risk greater than ten per million would be offset by a simultaneous larger decrease in risk from another source in the same facility. The pollutant providing the decrease in risk could be from any carcinogenic air contaminant as identified in the district rules. The SCAQMD would grant a permit if the applicant installs Toxics Best Available Control Technology (T-BACT) and can demonstrate that the cumulative impact for the new or modified equipment and all other permit units located within a radius of 100 meters will not result in a maximum individual cancer risk greater than 100 per million. This risk must be reduced to 10 per million no later than five years after permit renewal. The staff cannot analyze at this time how districts' toxics permit regulations would affect efforts to comply with the proposed clean-fuel regulations.

C. PERMITS FOR CLEAN-FUEL RETAIL OUTLETS

Service station owners required to install clean fuel dispensing equipment would have to obtain permits from several agencies. These permits would be similar to those required for the installation of gasoline dispensing equipment. The number and the types of permits, and the agencies that implement them, vary from county to county. In general, the installation plans for underground storage tanks would first have to be approved by the local department of public works, and the dispensers would require approval by the air pollution control agency. Building, construction, and fire permits would also be needed from cities or counties. If the clean fuel is classified as a hazardous material, an emergency response plan would have to be developed in accordance with the state Health and Safety Code.

There are already hundreds of methanol-compatible storage tanks permitted and installed at retail stations throughout the state. Most are currently dispensing gasoline. No new permits would be required if the gasoline dispensed were replaced with methanol. However, the appropriate emergency response plan may have to be amended, depending on the clean fuel.

In the SCAQMD and BAAQMD, existing NSR rules for the criteria pollutant emissions and proposed NSR rules for toxic air pollutants would also apply to retail outlets. If a retail station increases emissions by increasing throughput, e.g., offering an additional fuel, it may have to obtain a new permit or request a modification to an existing permit.

PART C: DETERMINATION OF REACTIVITY

INTRODUCTION

The staff of the Air Resources Board (ARB) proposes to use the "maximum incremental reactivity" of each hydrocarbon to develop hydrocarbon reactivity adjustment factors for low-emission vehicle/clean fuel regulations in California. All vehicle/fuel combinations will have to meet the same emission standards for oxides of nitrogen (NOx), formaldehyde, evaporative hydrocarbons and carbon monoxide.

Conditions of maximum incremental reactivity occur well within the range of hydrocarbon to NOx ratios observed in California. The linearity assumption implicit in incremental reactivity appears valid up to a 30% change in basin-wide hydrocarbon emissions. The reactivities correlate well with ozone dose in a wide variety of city-specific box model scenarios, including those with hydrocarbon to NOx ratios far higher than maximum reactivity conditions.

In May 1990, Dr. William Carter of the Statewide Air Pollution Research Center at the University of California at Riverside determined an interim set of maximum incremental reactivities for individual hydrocarbons, based on environmental conditions representing a wide variety of ozone episodes throughout the United States. During the same time frame, Professor Armistead Russell of Carnegie Mellon University calculated incremental reactivities for a limited number of hydrocarbons with his airshed model for comparison. Other groups will compare these incremental reactivities with values derived from other chemical mechanisms and models. Dr. Carter's interim reactivities, presented in Appendix A-1, are proposed for adoption in the regulation for calculating reactivity adjustment factors until the final reactivities are available in 1991.

By the end of 1990, Dr. Carter will recalculate the maximum incremental reactivities using environmental conditions representative of ozone episodes in California, and estimate an uncertainty bound on each reactivity due to gaps in the current understanding of atmospheric chemistry. Therefore, fuel suppliers and vehicle manufacturers will better understand the risks of tailoring fuels and control technologies to remove specific hydrocarbons.

From now until the end of 1991, the staff will develop reactivity adjustment factors with hydrocarbon speciation profiles from vehicle/fuel emission tests. Professor Russell will use the reactivity-adjusted vehicle emission standards to predict if the regulations will have the intended effect of equal ozone impacts for any vehicle/fuel combination. These calculations will be repeated when the Southern California Air Quality Study (SCAQS) modeling work is complete.

The ARB will continue to sponsor laboratory studies to reduce uncertainties in incremental reactivities, particularly for aromatic compounds, and to review research sponsored by other organizations. The staff plans to update the reactivities for individual hydrocarbons every three years.

In the following sections, background information on the need for reactivity adjustments and a brief discussion of the fundamentals of ozone formation are provided. Next, the available measures of reactivity that can be used to compare emissions from alternate fueled vehicles are evaluated, and the reasons for selecting the maximum incremental reactivity approach are discussed. In the final section, protocols to develop reactivities for individual hydrocarbons and to calculate the hydrocarbon reactivity adjustment factors are given.

Traditionally, an emission standard sets limits on the amounts of non-methane hydrocarbons, carbon monoxide and NOx permitted from automobiles during standardized emission tests. Non-methane hydrocarbon emissions are composed of many different hydrocarbons and other organic gases. (The terms hydrocarbon and organic gas will be used interchangeably throughout the document.) Some of these hydrocarbons can lead to much higher ozone levels than others. So long as all automobiles with similar control technologies burn similar fuels, the mix of emitted hydrocarbons is roughly the same, and there is no need to consider the mixture in setting standards. However, the mix of emitted hydrocarbons can be very different when automobiles burn different fuels or use different control technologies.

While current emission standards apply to non-methane hydrocarbons measured by standard techniques, other organic gases emitted by automobiles also play important roles in the ozone problem. Methanol and acetaldehyde are examples of non-regulated organic gases that must be considered in order to evaluate ozone impacts due to the use of different fuels.

VI.

OZONE FORMATION

The fundamentals of ozone formation in the troposphere have been described elsewhere (Finlayson-Pitts and Pitts, 1986; Atkinson, 1990), and only the key points are summarized here.

A. OXIDES OF NITROGEN VERSUS HYDROCARBON CONTROL

Oxides of nitrogen are required for ozone formation. If NOx were not emitted, ozone formation would not occur. Hydrocarbons greatly enhance the build-up of ozone from NOx. If hydrocarbons were absent, ozone concentrations would remain acceptably low. Oxides of nitrogen have a shorter lifetime in the atmosphere than hydrocarbons, and their natural emissions are negligible. Therefore, man-made emissions of NOx ultimately limit how much ozone will be formed. Controlling NOx increases the rate of initial ozone formation, and may cause higher ozone near the source, where ozone concentrations are well below their peak values.

Controlling hydrocarbons slows the rate at which ozone builds up. The benefits of controlling hydrocarbons are greatest near the source, and less for the peak ozone concentrations downwind. Any comprehensive ozone control strategy needs to reduce the emissions of both NOx and hydrocarbons.

B. REACTIVITY

The most basic definition of reactivity is the tendency of an organic gas to contribute to the build-up of ozone in atmospheres containing NOx. Carter and Atkinson (1987) have approximated reactivity as the product of two components, the fraction of the hydrocarbon that reacts over the course of a day (kinetic reactivity) and the amount of ozone formed by the fraction reacted (mechanistic reactivity).

For most hydrocarbons, reaction with hydroxyl radicals is the only significant route towards ozone formation. Therefore, their kinetic reactivity can be calculated from the hydroxyl radical rate constant and radical levels. The hydroxyl radical rate constant has been measured (Atkinson, 1989) or can be estimated (Atkinson, 1987) for most hydrocarbons. Reactions of alkenes with ozone, and photolysis of aldehydes and ketones are alternate routes toward ozone formation. These rates of reaction are also known (Atkinson, 1990).

In contrast to the kinetic reactivities, the mechanistic reactivities are uncertain for most hydrocarbons (Atkinson, 1990). Suitable laboratory data are available for testing the mechanisms of only a limited number of hydrocarbons, and the mechanisms for most other compounds are based on estimates and extrapolations (see Table VI-1). The mechanistic reactivities for higher molecular weight hydrocarbons are particularly uncertain.

An additional complication is that laboratory (Carter and Atkinson, 1987) and modeling studies (Dodge, 1984; Carter and Atkinson, 1989) show that mechanistic reactivity is a complicated function of environmental conditions, particularly NOx levels. Some hydrocarbons that are normally considered to be highly reactive, such as aromatics, can even slightly suppress ozone build-up under low NOx conditions.

C. HYDROCARBON AND OXIDES OF NITROGEN DATA IN CALIFORNIA

The ratio of hydrocarbons to NOx serves as a useful measure of the relative availability of NOx. Table VI-2 summarizes 6:00 to 9:00 a.m. PDT average hydrocarbon to NOx ratios measured during the summer of 1989 in California. The ratio is quite variable from site to site and from day to day at the same site. The ratio also varies across an air basin (Lonneman and Seila, 1989).

Observed hydrocarbon speciation data are very similar at the sites listed in Table VI-2. The speciation is consistent with motor vehicle exhaust and any inconsistencies can be attributed to stationary sources (Poore et al., 1990). There are very few measurement programs for formaldehyde, the single most important contributor to reactivity, but primary emissions of formaldehyde appear to correlate well with early morning carbon monoxide and NOx concentrations (Lawson et al., 1990; Fujita et al., 1990).

Table VI-1. Status of Ability to Model Mechanistic Reactivities*

Mechanisms for these compounds are estimated from basic kinetic and mechanistic knowledge:

- methane
- ethane
- propane
- ethanol

Experimentally-tested mechanisms exist for the following, although there are some uncertainties:

- n-butane
- ethene
- propene
- formaldehyde
- acetaldehyde
- propionaldehyde
- methanol
- acetone
- methylethyl ketone

Experimentally-tested mechanisms are available for the following, but there are major uncertainties:

- several C_{5+} alkanes
- several C_{4+} alkenes
- 1,3,5-trimethylbenzene
- toluene
- xylenes
- 2,3-dimethylnapthalene
- benzene
- napthalene

Mechanisms for all other organic gases are approximated by those of chemically similar compounds.

*Carter (1990a)

Table VI-2. Summary of California Hydrocarbon to NOx Ratios*

Site	Mean	Median	Range
Bakersfield-Chester	10.5	8.9	5.2 to 23.3
Los Angeles-N. Main	6.6	6.0	3.0 to 12.0
Sacramento-Citrus Heights	12.2	10.4	4.1 to 31.1
San Diego-Island	8.3	6.6	1.7 to 21.2
Redding-Continental	17.5	16.7	7.0 to 44.1
Chico-Manzanita	11.2	9.9	4.2 to 23.3
San Luis Obispo	24.3	15.9	5.9 to 260
All Sites	12.9	9.3	1.7 to 260

* 6:00 to 9:00 a.m. PDT average, every third day on PM10 schedule, June to September 1989.

VII.

MEASURES OF REACTIVITY

Atmospheric scientists have proposed six measures of reactivity. In this section, the advantages and disadvantages of each measure are discussed, the rationale for selecting the maximum incremental reactivity approach is provided, and all evaluations of the method to date are summarized.

A. REVIEW OF MEASURES OF REACTIVITY

The measures are ordered by increasing complexity of the calculation and data requirements.

1. Total Mass (Exempting Some Compounds)

Current hydrocarbon control strategies in California regulate the total mass of emissions. Methane and chlorofluorocarbons are exempt from control because of their extremely low reactivities. This approach does not depend on environmental conditions or uncertainties in the knowledge of atmospheric chemistry. It is also relatively easy to enforce because it does not need speciated hydrocarbon measurements.

The total mass approach ignores large differences in reactivity between hydrocarbons, and can be an inefficient means of hydrocarbon control. Traditionally, oxygenated compounds such as formaldehyde and acetaldehyde have been ignored by the emission standards because of the specialized measurement techniques required. In extreme cases, this approach to hydrocarbon control could lead to ozone increases if it allows increases in reactivity despite reductions in the mass of emissions.

2. Hydroxyl Radical Rate Constant

A simple approach for considering reactivity is to use the relative rate of reaction with the hydroxyl radical (Darnall et al., 1976). This approach depends on the fact that most hydrocarbons react only with the hydroxyl radical. It is not a strict measure of reactivity as defined earlier, but its lack of dependence on environmental conditions allows the derivation of a single reactivity scale.

The hydroxyl radical rate constant approach is deficient in several respects. It can underestimate or overestimate reactivity by ignoring other loss processes of hydrocarbons, as well as all of the subsequent reactions that contribute to ozone formation. It also overestimates the relative reactivity of rapidly reacting hydrocarbons. A hydrocarbon that reacts in 30 minutes could have a similar reactivity as one that reacts in 300 minutes, because they both completely react during the course of a day. But the hydroxyl radical rate constant approach will always indicate that one hydrocarbon is ten times more reactive than the other.

These various deficiencies offset one another for mixtures of many hydrocarbons, but errors can be quite large for single compounds.

3. Relative Reactivity

In order to approximate the effects of large changes in emissions on ozone, a simplified linear modeling technique, relative reactivity, was developed. This technique assumes the change in peak one-hour ozone concentrations is proportional to the change in emission levels of broad hydrocarbon groupings. It has been used to derive the reactivities of methanol and formaldehyde relative to other hydrocarbons (Gold and Moulis, 1988; Chang et al., 1989), and has been extended to ethane, propane, ethanol and acetaldehyde (Chang and Rudy, 1990). Dunker (1990) used a similar measure for reactivity comparisons of methanol-fueled vehicles.

The disadvantages of relative reactivity are that it is dependent on environmental conditions, and the technique quickly becomes cumbersome as the number of hydrocarbon species is increased.

4. Incremental Reactivity

A measure that corresponds closely to the basic definition of reactivity is "incremental reactivity," the change in ozone caused by the addition of a small increment of hydrocarbons to a polluted environment, divided by the amount of hydrocarbons added (Carter and Atkinson, 1987; 1989). Incremental reactivity can be determined experimentally (Carter and Atkinson, 1987) or with model calculations (Dodge, 1984; Carter and Atkinson, 1989), but is very dependent on environmental conditions. It is even possible to calculate with an airshed model (Russell, 1990). Calculations by Carter (1990c), Chang and Rudy (1990) and Dunker (1980) indicate that the linearity assumption implicit in incremental reactivity appears valid up to a 30% change in basin-wide hydrocarbon emissions.

The disadvantage of incremental reactivity is that the environmental conditions must be set to derive a single reactivity scale.

5. Maximum Incremental Reactivity

A single incremental reactivity can be derived for each hydrocarbon by using the maximum incremental reactivity for a range of environmental conditions (Carter, 1989ab). This measure reflects the maximum potential for ozone formation of the hydrocarbon. This is an appropriate definition to use for regulatory purposes, since conditions where hydrocarbon reactivities tend to be the highest are by definition those where hydrocarbon control is the most effective control strategy for reducing ozone. In general, maximum incremental reactivities are found at a hydrocarbon to NOx ratio of six to eight, with some dependence on other environmental conditions.

In contrast to previous work (Carter, 1989b), Carter (1990d) has developed a scale that represents maximum reactivity only with respect to NOx availability, and represents average reactivity for other environmental conditions. These reactivities correlate well with ozone dose in a wide variety of city-specific box model scenarios, including those with hydrocarbon to NOx ratios far higher than maximum reactivity conditions.

The disadvantage of the maximum incremental reactivity approach is the uncertainty in the mechanistic reactivities. However, Carter (1990e) is working on an approach to determine maximum mechanistic reactivities with laboratory studies.

6. Airshed Modeling

An airshed model incorporates all known considerations of environmental conditions, and will also give the full ozone impact of a large change in emissions. Such models use condensed photochemical mechanisms, but current research (Carter and Atkinson, 1988) suggests that these mechanisms can give ozone predictions which are very close to those of more detailed mechanisms.

The major disadvantage of airshed models is that the relative amounts of hydrocarbons and NOx predicted by the models do not always agree with air quality measurements. Until this discrepancy is resolved, it is better to use measured environmental conditions as a reference point. Another disadvantage is that, strictly speaking, the results are only applicable to the particular episode being modeled.

Also, use of airshed models is not practical for assessing a large number of control strategy options.

B. RECOMMENDED MEASURE OF REACTIVITY

The staff recommends the use of the maximum incremental reactivity approach to develop hydrocarbon reactivity adjustment factors. While this approach has significant uncertainties for many hydrocarbons, it provides a systematic and scientifically justifiable basis for incorporating present knowledge of atmospheric chemistry in the derivation of reactivity adjustment factors for regulatory purposes. The approach estimates hydrocarbon reactivity for environmental conditions which yield the greatest ozone reductions. Conditions of maximum incremental reactivity occur well within the range of hydrocarbon to NOx ratios observed in California. Maximum incremental reactivity is a generalized scale which avoids the issue of which area is being modeled when using airshed models and the applicability of the results to other areas.

C. EVALUATION OF MAXIMUM INCREMENTAL REACTIVITY

Carter (1989b) has compared maximum incremental reactivities with the hydroxyl radical rate constant approach for alternate fuels where some exhaust speciation data are available (ARB, 1989). Despite errors in the hydroxyl radical rate constant approach, there is quite good agreement for alternate fuels other than methanol. Chang and Rudy (1990) found good agreement between maximum incremental reactivities and relative reactivities.

Dunker (1990) and Schleyer (1990) have compared reactivities derived using both the Lurmann, Carter, Coyner (LCC) and Carbon Bond 4 (CB4) condensed photochemical mechanisms. Dunker found large differences at high hydrocarbon to NOx ratios, where reactivity is less important. Schleyer observed differences in the reactivity of formaldehyde. This issue requires additional investigation.

Russell (1990) updated his airshed model with the LCC mechanism, and is in the process of calculating incremental reactivities for lumped hydrocarbon classes. Preliminary comparisons of these results to maximum incremental reactivities show good agreement for alkanes, ethene, other alkenes, toluene, formaldehyde, other aldehydes and methanol. There are large discrepancies for non-toluene aromatics that warrant additional investigation.

VIII.

PROTOCOLS

The reactivities of individual hydrocarbons are used with speciated exhaust profiles for the alternate fueled vehicles and base gasoline to develop the hydrocarbon reactivity adjustment factors. In this section, several ARB-sponsored projects for developing reactivities for individual hydrocarbons are described, and a protocol for developing the reactivity adjustment factors is proposed.

A. PROTOCOL FOR DEVELOPING REACTIVITIES FOR INDIVIDUAL HYDROCARBONS

1. Peer Review

The reactivity method was presented to the Modeling Advisory Committee (MAC) at its public meeting on May 31, 1990 at Sacramento Airport. The MAC provides scientific guidance to the ARB, and is chaired by Professor John Seinfeld of the California Institute of Technology. The ARB is also receiving input from an ad-hoc reactivity advisory panel, with representatives from the California Energy Commission, Assembly Bill 234 Advisory Board, South Coast Air Quality Management District, Auto/Oil Air Quality Improvement Program, Motor Vehicle Manufacturers Association, Western States Petroleum Association, California Natural Gas Vehicle Coalition, California Renewable Fuels Council, and Western Liquid Gas Association.

2. Interim Maximum Incremental Reactivities

By the end of May, Dr. Carter will publish a set of interim maximum incremental reactivities for individual hydrocarbons based on environmental conditions representing a wide variety of ozone episodes throughout the United States (Carter, 1990d) and using the latest version of his photochemical mechanism (Carter, 1990b). These reactivities will be contained in the regulation for use in calculating reactivity adjustment factors.

3. Further Studies Of Maximum Incremental Reactivities

By the end of 1990, Dr. Carter will recalculate the maximum incremental reactivities using environmental conditions representative of ozone episodes in California. This study will use observed data from ozone episodes captured during SCAQS' and ARB's 1989 and 1990 hydrocarbon measurement programs, as well as trajectories from all airshed simulations available for California. One area of investigation will be the reactivity effect of nitrous acid and methyl nitrite emissions, and the ratio of nitrogen dioxide to nitric oxide in the exhaust. The staff anticipates a recommendation will be made to measure these compounds during vehicle tests. If these studies indicate changes are necessary to the interim maximum incremental reactivities contained in the regulation, or that the maximum incremental reactivity method itself should be modified, the staff will recommend changes to the regulation.

Dr. Carter will also investigate the effect of uncertainties in rate constants and mechanisms on the maximum incremental reactivities. He will estimate an uncertainty bound on the maximum incremental reactivity for each hydrocarbon. With this information, the ARB and other organizations can focus research efforts on important hydrocarbons with large uncertainties, and fuel suppliers and vehicle manufacturers will better understand the risks of tailoring fuels and control technologies to remove specific hydrocarbons. The staff anticipates that this will be particularly important for aromatic compounds.

4. Compare Maximum Incremental Reactivities With Airshed Model

Professor Russell will compare the maximum incremental reactivities with the results of his airshed model for the August 30 - September 1, 1982 episode. This was a severe stagnation episode where the ozone peaks were NOx-limited (Milford et al., 1989). The modeling simulations will address concerns as to whether the slight negative reactivity aromatic compounds exhibit under NOx-limited conditions warrants a different basis for a reactivity scale. Both peak ozone and exposure statistics will be used in the comparison. This will be done for mixtures of many hydrocarbons and for single compounds. The comparison will be completed by the end of May. Other groups will compare the incremental reactivities with those derived from other chemical mechanisms and models.

The staff will develop hydrocarbon reactivity adjustment factors by the end of 1991, with speciation profiles from vehicle/fuel emission tests. Professor Russell will use the reactivity-adjusted vehicle emission standards to predict if the regulations will have the intended effect of equal ozone impacts for any vehicle/fuel combination. This calculation will be repeated when the SCAQS modeling work is complete.

5. Update Reactivities Every Three Years

The ARB will continue to sponsor laboratory studies to reduce uncertainties in current understanding of atmospheric chemistry, particularly for aromatic compounds, and to review research sponsored by other organizations. The staff plans to update the reactivities for individual hydrocarbons every three years. One research topic that deserves attention is whether low reactivity hydrocarbons contribute significantly to ozone formation at far downwind NOx sources. This transport issue needs to be addressed with detailed regional models.

B. PROTOCOL FOR CALCULATING REACTIVITY ADJUSTMENT FACTORS

1. Calculation Procedure

Step 1 - Calculate total reactivity of exhaust per mile.

Multiply the exhaust emission rates (in grams per mile) of each non-methane organic gas (including aldehydes, ethers, ketones and alcohols) by the corresponding reactivity (on a per gram basis). The sum of the products is the total reactivity of the exhaust per mile.

Step 2 - Calculate total reactivity of exhaust per gram of non-methane organic gases.

Divide the total reactivity of the exhaust (per mile) by the total emission rate (in grams per mile) of the non-methane organic gases (including aldehydes, ethers, ketones and alcohols).

Step 3 - Calculate reactivity adjustment factor.

Divide the total reactivity of the exhaust (per gram) by the corresponding measure for base gasoline. This is the reactivity adjustment factor.

2. Oxides Of Nitrogen Emission Standards

In many areas of the state, maximal ozone concentrations are determined largely by the availability of NOx. In these areas, hydrocarbon reactivities are a less critical factor in determining the total amount of ozone formed during an episode. Accordingly, emission standards for NOx will be established independently of emission standards for hydrocarbons.

3. Carbon Monoxide And Evaporative Emissions

Carbon monoxide and evaporative emissions contribute to ozone formation, but will not be considered with the other hydrocarbons when reactivity adjustment factors are calculated. Emission standards for carbon monoxide and evaporative emissions will be established independently of emission standards for exhaust hydrocarbons.

4. Refining And Marketing Emissions

The reactivity adjustment factors will not include changes in refining or marketing emissions. These stationary sources must meet emission standards established by local air pollution control agencies.

IX.

EMISSION REDUCTIONS, COSTS, AND OTHER EFFECTS OF THE PROPOSED REGULATION

This chapter discusses the costs, emission reductions, economic effects, and environmental effects of the proposed program for low-emission vehicles and clean fuels. The methods of estimation, the staff's assumptions, and important parameters for calculations are explained here. More detailed information on these subjects are provided in Appendices A-3 and B-1.

A. EMISSION REDUCTIONS

1. Criteria Pollutants

To estimate the emission reductions that the proposed regulations would provide, the staff has adjusted the output of its standard vehicular emission models for criteria pollutants (EMFAC7E/BURDEN7C). The estimates reflect all low-emission vehicles emitting at their low-emission rates (i.e., as if flexible- and dual-fueled vehicles use only clean fuels). This assumption might overestimate the reduction of non-methane organic gases (NMOG) in the first years of the program, but it is appropriate for later years.

The staff estimated an emission benefit from the proposed regulation using the following calculation procedure. First, emission factors were generated for transitional low-emission vehicles (TLEVs), low-emission vehicles (LEVs), and ultra-low-emission vehicles (ULEVs). These emission factors were combined (by model-year) with the nominal implementation rates in the phase-in schedule (Table I-6) used to calculate the fleet average standards. Fleet-weighted emission factors were then calculated for the years 2000 and 2010 by applying the appropriate travel fraction to each model-year. Finally, the fleet-weighted emission factors were applied to inventory results (i.e., EMFAC7E/BURDEN7C) to generate emission reductions (expressed in tons per day) for the South Coast Air Basin and the entire state. Additional details concerning the calculation procedure are provided in Appendix A-3.

Table IX-1 shows the estimated reductions of emissions of NMOG, oxides of nitrogen (NOx), and carbon monoxide (CO) that would be provided by the regulations. In year 2000, reductions of 29 tons/day in emissions of NMOG and and 36 tons per day for NOx represent four and three percent decreases, respectively, in statewide on-road emissions without the regulations. By year 2010, the reductions of 185 and 248 tons/day increase to 28 and 18 percent, respectively, of the baseline on-road NMOG and NOx emissions for that year.

The reductions in Table IX-1 reflect the differences between the proposed and the currently adopted in-use emission standards, all of which are expressed in terms of emissions from gasoline-fueled vehicles. If other fuels are used, the numerical values of the mass reductions would differ from those shown. However, the effect of the reductions on ambient ozone would not change, because the NMOG standards for other fuels would be set to yield an equivalent ozone effect.

Table IX-1. Emission Reductions Provided by Low-Emission Vehicles and Clean Fuels (tons per day)

	Lt.-Duty Vehicles			Med.-Duty Vehicles			Total		
Year	NMOG[a]	NOx	CO	NMOG[a]	NOx	CO	NMOG[a]	NOx	CO
				South Coast					
2000	10.3	14.0	5.1	0.9	0	0.3	11.2	14.0	5.4
2010	62.7	95.2	110	8.5	3.5	8.3	71.2	98.7	119
				Entire State					
2000	26.4	36.1	13.7	2.5	0	0.7	28.9	36.1	14.4
2010	162	238	293	23.2	10.1	24.3	185	248	318

[a] at reactivity equivalent to gasoline exhaust

2. Toxic Pollutants

Since almost all the potential carcinogenic risk from gasoline exhaust is due to organic compounds (ARB, 1990), it is reasonable to assume that if all low-emission vehicles used gasoline, the risk provided by low-emission vehicles would be reduced in the same degree as would NMOG emissions. In that case, the risk corresponding to toxic emissions from on-road vehicles would be reduced by 28 percent in 2010. An estimate of the reduction of potential cancer incidence can be made as follows:

In a recent report (ARB, 1990), there is an estimate of the lifetime (70-year) potential cancer incidence corresponding to vehicular emissions in or near 1988: 12,800 to 22,900 cases. The ARB's inventory of reactive organic gases (ROG) from vehicles in 1988 is 1,400 tons/day (tpd) for on-road vehicles plus 140 tpd for off-road vehicles and trains, totalling 1,540 tpd in the state. The estimated inventory for 2010 is 720 tpd for on-road vehicles plus 235 tpd for off-road vehicles and trains, totalling 955 tpd. Without the low-emission vehicle program, the potential cancer incidence corresponding to vehicular emissions in 2010 would be about:

955 / 1,540 x [12,800 to 22,900] = 7,840 to 14,000 cases

over 70 years. The vehicular inventory would be reduced by the low-emission vehicle program by:

185 tpd (Table IX-1) / 955 tpd = 19%

The estimate of cases reduced (if all low-emission vehicles were gasoline vehicles) is:

0.19 x [7,840 to 14,000] = 1,500 to 2,700 cases over 70 years

or 21 to 38 cases per year.

The effect of using fuels other than gasoline to meet the low-emission vehicle standards can be discussed only qualitatively. For benzene, which is a known toxic air contaminant and the most important toxic pollutant in exhaust, emissions would be even lower with other fuels than with gasoline. For the next most important pollutant, 1,3-butadiene, the dependence of emissions upon NMOG emissions or the kind of fuel is not well known. However, the close-coupled or electrically heated catalysts that the staff expects on low-emission vehicles should greatly diminish emissions of 1,3-butadiene regardless of fuel. This conclusion applies because virtually all the 1,3-butadiene measured in exhaust is in the cold start emissions that the catalysts are designed to control.

The other two significant toxic pollutants found in exhaust are formaldehyde and acetaldehyde. If methanol or ethanol were used, emissions of aldehydes would increase as fractions of total NMOG in low-emission vehicle exhaust. However, because of the magnitude and potency of benzene and 1,3-butadiene emissions, the increase in risk from aldehydes when alcohols were used instead of gasoline, should be minor compared to the decreases in risk from benzene and 1,3-butadiene.

B. COSTS

1. Producing Low-Emission Vehicles

a. Projected Vehicle Technologies

The cost calculations presented in this section are derived from the staff's assessments of the technologies that could be employed to meet the proposed standards. The following assumptions were made to determine the costs for light- and medium-duty vehicles and engines.

Close-Coupled Catalysts

No additional costs were ascribed to applying this technology. It is expected that most of the light-duty vehicle fleet will be outfitted with close-coupled catalysts to meet the 0.25 g/mi non-methane hydrocarbon regulation.

Electrically Heated Catalysts

The principal components required would be the relatively compact electrically heated catalyst, larger or quicker discharging battery, controller to regulate catalyst heating (unless a Positive Temperature Coefficient ceramic substrate catalyst is used), and additional wiring and electrical components. For TLEVs, electrically heated catalysts would probably not be needed unless a manufacturer decides to market a vehicle with a large engine (which is unlikely). Should one be necessary for TLEVs, a relatively small unit could be used, with an estimated cost of $125. For LEVs and ULEVs, a more powerful, larger electrically heated catalyst would be required, which the staff estimates would cost $150 for light-duty vehicles. For medium-duty vehicles, a larger catalyst and a more powerful battery would be needed to achieve the same level of emission control, at a cost of $200.

Improved Fuel Preparation Systems

For both light- and medium-duty vehicles, devices used to lower cold start emissions through improved fuel preparation include electrically heated substrate-based systems which would cost $70 per light- or medium-duty vehicle. This would cover the cost of the heating elements mounted in the intake manifold. Alternatively, combined air and fuel injector systems could also be developed at a comparable cost.

Electric Air Pumps

Given the very low LEV and ULEV emission levels being proposed, the staff estimates that manufacturers will utilize electric air pumps for operation only during the first few minutes after cold start to improve catalyst NMOG conversion efficiency. The staff estimated the cost of electric air pumps to be $20.

Bypassable Start Catalysts

The total cost of a bypass catalyst ($112), early fuel evaporator valve ($7), and vacuum control valve ($3) was determined to be $122 for medium-duty vehicles to meet the 1995 standards. It is expected that these types of catalysts would not be used on light-duty vehicles. However, projections indicate that only 50% of medium-duty vehicles would utilize a bypass catalyst, yielding a net cost of $60 (i.e., $122/2 rounded to the nearest $10 increment). This cost is referenced only because it is needed to calculate the differential cost of adding an electrically heated catalyst to medium-duty vehicles.

Electronically-Controlled Exhaust Gas Recirculation (EGR)

It is expected that electronic EGR will cost $30 to control NOx emissions from medium-duty vehicles.

Diesel Catalysts and Traps

It is estimated that an oxidation catalyst system will cost $500, and a catalyzed particulate trap system will cost $1500.

b. Incremental Costs per Vehicle

Transitional Low-Emission Vehicles (TLEVs)

Requirements for TLEVs would be met by gasoline-powered vehicles with smaller displacement engines, equipped with dual oxygen sensors, an improved fuel preparation system, and a close-coupled catalyst. Slight modifications to existing emission control systems may also be required, but no incremental costs other than the improved fuel preparation system have been ascribed to TLEVs. The cost for the improved fuel preparation system would be $70 per vehicle. The cost of equipping vehicles with dual oxygen sensors has previously been ascribed to the implementation of regulations for the 0.25 g/mi non-methane hydrocarbon standard and on-board diagnostics (for monitoring catalyst efficiency).

Methanol- or ethanol-fueled vehicles would need to be modified to make the vehicles alcohol-compatible. Presently, it is estimated that flexible-fueled vehicles would cost an additional $200 per vehicle to produce (relative to gasoline-dedicated vehicles), but alcohol-dedicated vehicles would cost slightly less. Equipping vehicles for operation on either liquified petroleum gas (LPG) or compressed natural gas (CNG) would require modifications to the vehicle fuel control system and fuel storage tank(s). Present estimates for original equipment manufacturer (OEM) dual-fueled vehicles are $600 per vehicle for LPG, and $1000 per vehicle for CNG; however, the costs for producing fuel-dedicated vehicles would be slightly less. The net additional cost ascribed to developing a TLEV would be $70 per vehicle, at a minimum.

Low-Emission Vehicles (LEVs)

For the light-duty sector, gasoline-powered vehicles would be expected to meet the standards through the use of an electrically heated catalyst ($150) and electric air pump ($20). The net additional costs for developing a light-duty LEV would be, at a minimum, $170 per vehicle.

Methanol or ethanol flexible-fueled vehicles equipped with an improved fuel preparation system ($70) and a close-coupled catalyst would also be expected to be cost-competitive with the aforementioned gasoline-powered vehicles, if the cost of changes needed to make the vehicles alcohol-compatible is $100 or less (i.e., for a fuel composition sensor and corrosion resistant fuel tanks and associated components).

For dual-fueled vehicles powered by LPG or CNG, an improved fuel preparation system would not be needed; however, the costs ascribed for a revised fuel system and fuel storage components would be $600 and $1000 per vehicle, respectively. These vehicles would also require electronic fuel injection for NOx control, which would cost an additional $100 for LPG-fueled and $200 for CNG-fueled vehicles.

For the medium-duty sector, vehicles would need to be equipped with the same emission control technologies used to achieve LEV standards for light-duty vehicles. Gasoline-powered vehicles would be equipped with an electrically heated catalyst ($200), electric air pump ($20), and electronic EGR ($30). In these vehicles, however, the bypassable start catalyst ($60) installed to meet the 1995 emission standards would be replaced by the electrically heated unit; thus the net additional cost would be $190 per vehicle, at a minimum.

The cost (per vehicle) for producing a flexible-fueled medium-duty LEV to operate on an alcohol fuel would be $300 for alcohol-compatible components plus $70 for an improved fuel preparation system. For an LPG dual-fueled vehicle, the cost would be $800 for a revised fuel system and fuel storage tank plus $100 for electronic fuel injection. For a CNG dual-fueled vehicle, a revised fuel system and fuel storage components ($1500), and electronic gaseous fuel injection ($200) would be needed to meet LEV standards.

Ultra-Low-Emission Vehicles (ULEVs)

To meet ULEV standards, light-duty vehicles would be expected to be powered by a cleaner-burning fuel and utilize an electrically

PROPOSED REGULATIONS FOR LOW-EMISSION VEHICLES AND CLEAN FUELS

--TECHNICAL SUPPORT DOCUMENT --

Mobile Source Division,
Research Division,
Stationary Source Division,
and Technical Support Division

State of California
Air Resources Board

August 13, 1990

Proposed Regulations for Low-Emission Vehicles and Clean Fuels

-- Technical Support Document --

Date of Board Meeting: September 27, 1990

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COMMENT LETTERS All written comments on the low-emission vehicle/ clean fuel proposal received from May 29,1990 through August 1, 1990 are contained in a separate volume of this report.

INTRODUCTION

This report presents technical information in support of the Air Resources Board (ARB) staff's proposed regulation on low-emission vehicles and clean fuels. The report consists of:

-- Part A, concerning the ARB staff's proposed regulation for low-emission vehicles;

-- Part B, concerning the staff's proposed regulation for clean fuels;

-- Part C, concerning the staff's proposed protocol for determining reactivity adjustment factors for exhaust emissions from low-emission vehicles powered by different fuels.

-- Part D, concerning the costs and effects of the proposed program

-- several appendices providing greater detail on the above subjects.

The proposed regulations are appended to another document, Proposed Regulation for Low-Emission Vehicles and Clean Fuels -- Staff Report, August 13, 1990.

The regulations on low-emission vehicles would augment measures in the ARB's Post-1987 Motor Vehicle Plan. The regulations are needed in the effort to implement the South Coast Air Quality Management District's Air Quality Management Plan. The reductions of organic gas emissions that would result from adopting the proposed emission standards would include reductions in emissions of identified and potential toxic air contaminants. Accordingly, the regulations would be consistent with the ARB's program of risk management for toxic air contaminants under AB 1807 and would expedite reductions in vehicular emissions of toxic air contaminants as prescribed in AB 4392.

The proposed regulations concerning availability and distribution of clean fuels respond to, and are consistent with, the recommendations of the California Advisory Board on Air Quality and Fuels (created by AB 234) in its Report to the Legislature.

I.

THE PROPOSED PROGRAM

This chapter focuses on the requirements of the low-emission vehicles portion of the regulation. A detailed description of the proposed emission standards, implementation schedule, procedure for determining reactivity adjustment factors, and protocol for certifying vehicles is provided, along with the basis for the requirements.

A. NON-METHANE ORGANIC GAS STANDARDS

1. Inadequacy of Current Standards for Quantifying Reactivity

In California, hydrocarbon emissions from motor vehicles are traditionally represented in terms of non-methane hydrocarbons (NMHC). Because gasoline and diesel have been the primary transportation fuels, quantifying emissions in this manner has been adequate since oxygenated hydrocarbons comprise only a small portion of total hydrocarbon emissions from gasoline- and diesel-fueled vehicles. Although exhaust emissions from conventionally fueled vehicles are known to contain measurable quantities of aldehydes, the great majority of the hydrocarbons are non-oxygenated. Therefore, measuring the mass of NMHC alone (i.e., not including oxygenated hydrocarbons) was an acceptable representation of the mass of hydrocarbons emitted by gasoline-fueled vehicles.

Exhaust emissions from alcohol-fueled vehicles, however, contain significant amounts of oxygenated compounds. As some of these oxygenated compounds can be highly reactive in forming ozone (e.g., formaldehyde), controlling just the mass of NMHC emissions would not ensure that the ozone impact of emissions from alcohol-fueled vehicles did not exceed that of gasoline-fueled vehicles.

In the absence of more rigorous methods for quantifying reactivity, the U.S. Environmental Protection Agency (EPA) developed emission standards for methanol-fueled vehicles based on the Organic Material Hydrocarbon Equivalent (OMHCE) procedure. The OMHCE approach is based on the assumption that the ozone reactivity of a vehicle's exhaust depends largely on the amount of carbon present and effectively limits the amount of carbon emitted by methanol-fueled vehicles to that of gasoline-fueled vehicles.

The OMHCE approach is useful in comparing the mass of emissions from methanol- and gasoline-fueled vehicles because it allows emission standards for methanol-fueled vehicles, expressed in terms of OMHCE, to be numerically equal to emission standards for gasoline-fueled vehicles, expressed as NMHC. Although the EPA had intended that the ozone-forming potential of OMHCE emissions from methanol-fueled vehicles be no greater than the NMHC emissions from gasoline-fueled vehicles, the OMHCE approach does not fully address the relative reactivity of these emissions.

2. Basis for Non-Methane Organic Gas Standards

To provide a better comparison of the reactivities of exhaust emissions from all candidate vehicle/fuel systems, the staff would consider the individual reactivities of all measurable hydrocarbon species in an exhaust sample, both oxygenated and non-oxygenated. Since the reactivity of exhaust constituents would be calculated for each vehicle/fuel system, it would no longer be appropriate to establish emission standards based on NMHC or OMHCE. A NMHC standard is inadequate in that it does not include aldehydes, alcohols, or other oxygenates which may contribute significantly to the overall reactivity of the exhaust emissions. An OMHCE standard is inappropriate because the full (i.e., unadjusted) weight of formaldehyde and methanol should be included in the reactivity calculation that the staff is proposing to adopt, along with the full weight of other oxygenates.

Therefore, the hydrocarbon standards for all vehicle/fuel systems in this proposal are for non-methane organic gases (NMOG), which consist of the full, unadjusted mass of all measurable non-oxygenated hydrocarbons (except methane) containing 12 or fewer carbon atoms, and all ketones, aldehydes, alcohols, and ethers containing 5 or fewer carbon atoms. The only exception proposed is for incomplete medium-duty vehicles and diesel engines, primarily for testing simplicity. (The term diesel engine/vehicle is used to refer to an engine/vehicle that has the design characteristics of a diesel-fueled engine/vehicle operating on any fuel.)

Manufacturers would thus be required to include measurements of aldehydes and ketones when certifying chassis-tested vehicles powered by any fuel. Measurement of alcohols and ethers would be required when certifying vehicles on fuels containing those compounds.

B. VEHICLE EXHAUST EMISSION STANDARDS

The emission standards for all vehicle/fuel systems that are being considered for adoption are summarized in Tables I-1, I-2, and I-3. For fuels other than conventional gasoline (including diesel), the NMOG exhaust emission standards for each of the chassis-tested low-emission vehicle categories would be adjusted according to the ozone-forming reactivity of the oxygenated and non-oxygenated hydrocarbons found in the exhaust, in proportion to the incremental reactivity factors determined by Dr. William Carter of the Statewide Air Pollution Research Center in Riverside, California. The NMHC + NOx emission standards for engine dynamometer-tested vehicle/fuel systems shown in Table I-1 would not be reactivity adjusted under the proposed regulations. However, a reactivity adjustment procedure would be developed for incomplete vehicles and diesel engines for a future regulation.

1. Certification Standards

Table I-1 provides a listing of the certification standards applicable to light-duty "Transitional Low-Emission Vehicles" (TLEVs), Low-Emission Vehicles" (LEVs), and "Ultra-Low-Emission Vehicles" (ULEVs) at 50,000 and 100,000 miles, and to medium-duty LEVs and ULEVs at 50,000 and 120,000 miles. LEV and ULEV standards in g/bhp-hr for incomplete medium-duty vehicles and diesel engines used in medium-duty vehicles over 8500 lbs. gross vehicle weight (GVW) are also listed in Table I-1.

2. Standards for Flexible- and Dual-Fueled Vehicles

Flexible- and dual-fueled vehicles capable of operating on both gasoline and an alternate fuel deserve special consideration in that the stringency of the NMOG standard for operation on either fuel could determine the fuel for which the vehicle is optimized. Because the use of an alternate fuel would result in lower emissions of reactive hydrocarbons than the use of conventional fuels (gasoline or diesel), alternate fueled vehicles may require less extensive emission control hardware to meet the same NMOG standard. Requiring a flexible- or dual-fueled vehicle to meet the same NMOG exhaust emission standard on both the conventional and the alternate fuel would likely force the manufacturer to optimize the vehicle emission control system for the conventional fuel and could delay the introduction of these vehicles.

Therefore, the staff is proposing a two-tiered NMOG standard for vehicles capable of operating on both conventional and alternate fuels, as shown in Table I-2. Flexible- and dual-fueled vehicles would also be required to meet the same CO, NOx, formaldehyde (HCHO),

Table I-1. Exhaust Emission Standards (g/mi) at 50,000 Miles

(The NMOG standards will be adjusted for reactivity; standards for formaldehyde (HCHO) apply to all vehicles; standards for particulate matter (PM) apply only to diesel vehicles and engines; 100,000 mile standards for light-duty vehicles and 120,000 mile standards for medium-duty vehicles are given in parentheses.)

Passenger Cars and Light Trucks ≤ 3750 lbs. Loaded Vehicle Weight

Cat.	NMOG	CO	NOx	PM	HCHO
TLEV	0.125 (0.156)	3.4 (4.2)	0.4 (0.6)	(0.08)	0.015 (0.018)
LEV	0.075 (0.090)	3.4 (4.2)	0.2 (0.3)	(0.08)	0.015 (0.018)
ULEV	0.040 (0.055)	1.7 (2.1)	0.2 (0.3)	(0.04)	0.008 (0.011)

Light Trucks 3751 ≤ Loaded Vehicle Weight ≤ 5750 lbs.

Cat.	NMOG	CO	NOx	PM	HCHO
TLEV	0.160 (0.200)	4.4 (5.5)	0.7 (0.9)	(0.08)	0.018 (0.023)
LEV	0.100 (0.130)	4.4 (5.5)	0.4 (0.5)	(0.08)	0.018 (0.023)
ULEV	0.050 (0.070)	2.2 (2.8)	0.4 (0.5)	(0.04)	0.009 (0.013)

Medium-Duty Vehicles ≤ 3750 lbs. Test Weight

Cat.	NMOG	CO	NOx	PM	HCHO
LEV	0.125 (0.180)	3.4 (5.0)	0.4 (0.6)	(0.08)	0.015 (0.022)
ULEV	0.075 (0.107)	1.7 (2.5)	0.2 (0.3)	(0.04)	0.008 (0.012)

Medium-Duty Vehicles 3751 ≤ Test Weight ≤ 5750 lbs.

Cat.	NMOG	CO	NOx	PM	HCHO
LEV	0.160 (0.230)	4.4 (6.4)	0.7 (1.0)	(0.10)	0.018 (0.027)
ULEV	0.100 (0.143)	2.2 (3.2)	0.4 (0.5)	(0.05)	0.009 (0.013)

Medium-Duty Vehicles 5751 ≤ Test Weight ≤ 8500 lbs.

Cat.	NMOG	CO	NOx	PM	HCHO
LEV	0.195 (0.280)	5.0 (7.3)	1.1 (1.5)	(0.12)	0.022 (0.032)
ULEV	0.117 (0.167)	2.5 (3.7)	0.6 (0.8)	(0.06)	0.011 (0.016)

Medium-Duty Vehicles 8501 ≤ Test Weight ≤ 10,000 lbs.

Cat.	NMOG	CO	NOx	PM	HCHO
LEV	0.230 (0.330)	5.5 (8.1)	1.3 (1.8)	(0.12)	0.028 (0.040)
ULEV	0.138 (0.197)	2.8 (4.1)	0.7 (0.9)	(0.06)	0.014 (0.021)

Medium-Duty Vehicles 10,001 ≤ Test Weight ≤ 14,000 lbs.

Cat.	NMOG	CO	NOx	PM	HCHO
LEV	0.300 (0.430)	7.0 (10.3)	2.0 (2.8)	(0.12)	0.036 (0.052)
ULEV	0.180 (0.257)	3.5 (5.2)	1.0 (1.4)	(0.06)	0.018 (0.026)

Incomplete Medium-Duty Vehicles and Diesel Engines* (g/bhp-hr)

Cat.	NMHC + NOx	CO	PM	HCHO
LEV	3.5	14.4	0.10	0.050
ULEV	2.5	7.2	0.05	0.025

* Includes engines derived from diesel-fueled engines powered by fuels other than diesel

Table I-2. NMOG Standards (g/mi) for Flexible- and Dual-Fueled Vehicles at 50,000 Miles When Operating on Alternate and Conventional Fuels.*

(100,000 mile standards for light-duty vehicles and 120,000 mile standards for medium-duty vehicles given in parentheses.)

Vehicle Class	Category	Alter. Fuel**	Conv. Fuel***
Passenger Car	TLEV	0.125 (0.156)	0.25 (0.31)
Passenger Car	LEV	0.075 (0.090)	0.125 (0.156)
Passenger Car	ULEV	0.040 (0.055)	0.075 (0.090)
LDT ≤ 3750 lbs LVW	TLEV	0.125 (0.156)	0.25 (0.31)
LDT ≤ 3750 lbs LVW	LEV	0.075 (0.090)	0.125 (0.156)
LDT ≤ 3750 lbs LVW	ULEV	0.040 (0.055)	0.075 (0.090)
LDT 3751≤LVW≤5750 lbs	TLEV	0.160 (0.200)	0.32 (0.40)
LDT 3751≤LVW≤5750 lbs	LEV	0.100 (0.130)	0.160 (0.200)
LDT 3751≤LVW≤5750 lbs	ULEV	0.050 (0.070)	0.100 (0.130)
MDV≤3750 lbs TW	LEV	0.125 (0.180)	0.25 (0.36)
MDV≤3750 lbs TW	ULEV	0.075 (0.107)	0.125 (0.190)
MDV 3751≤TW≤5750 lbs	LEV	0.160 (0.230)	0.32 (0.46)
MDV 3751≤TW≤5750 lbs	ULEV	0.100 (0.143)	0.160 (0.230)
MDV 5751≤TW≤8500 lbs	LEV	0.195 (0.280)	0.39 (0.56)
MDV 5751≤TW≤8500 lbs	ULEV	0.117 (0.167)	0.195 (0.280)
MDV 8501≤TW≤10,000 lbs	LEV	0.230 (0.330)	0.46 (0.66)
MDV 8501≤TW≤10,000 lbs	ULEV	0.138 (0.197)	0.230 (0.330)
MDV 10,001≤TW≤14,000 lbs	LEV	0.300 (0.430)	0.60 (0.86)
MDV 10,001≤TW≤14,000 lbs	ULEV	0.180 (0.257)	0.300 (0.430)

* Flexible- and dual-fueled vehicles would also be required to meet the CO, NOx, HCHO, and if appropriate, PM standards applicable to their vehicle class and emission category.

** Before reactivity adjustment.

*** Would be reactivity adjusted for diesel fuel.

and particulate matter (PM) standards applicable to their vehicle emission category and weight class, when operating on either the conventional or the alternate fuel.

3. In-Use Compliance Standards

Because manufacturers may initially have difficulty meeting the proposed standards in-use, the staff is allowing intermediate in-use compliance standards that would be implemented according to the schedule shown in Table I-3. Compliance with the 100,000 or 120,000 mile standards in-use would also be suspended until 50,000 mile certification standards are effective in-use. The intermediate in-use compliance standards being proposed for each vehicle emission category are half-way between the certification standards of the category and the next less stringent category, and should ease the burden of compliance on manufacturers during the early years of implementation.

C. DETERMINATION OF REACTIVITY ADJUSTMENT FACTORS

To equalize the air quality impact of different vehicle/fuel systems, reactivity adjustment factors that limit the ozone-forming potential of NMOG emissions would be developed. Over the next several months, testing would be conducted to obtain representative emission profiles for base gasoline and viable alternate fuels, and to better quantify the ozone-forming potential of individual NMOG compounds.

1. Exhaust Profiles for Base Gasoline

To determine the exhaust emission profiles for vehicles operating on base gasoline, the staff would test vehicles operating on the gasoline blend being used in the Auto/Oil Air Quality Improvement Research Project. The specifications for this fuel, "U.S. average gasoline," are shown in Table I-4.

By utilizing the U.S. average gasoline rather than the current certification fuel "Indolene," emission profiles could be derived from vehicles operating on gasoline representative of currently available commercial gasoline. Recent data provided by ARCO suggest that the hydrocarbon emissions from vehicles tested with Indolene are collectively less reactive than from vehicles operating on gasolines sold in California (Figure 1). To provide a meaningful comparison of the reactivity of alternate fuels, the base fuel should be representative of the gasoline that is actually being used. In this regard, the U.S. average gasoline is a good choice because its specifications are similar to those of gasoline typically sold in California.

Table I-3. In-Use Compliance Standards (g/mi) at 50,000 Miles Applicable through the Indicated Model-Year for All TLEVs, LEVs, and ULEVs, including Flexible- and Dual-Fueled Vehicles When Operating on Clean Fuel*.

(NMOG standards in parentheses apply only to flexible- and dual-fueled vehicles when operating on gasoline.)

Model Year	Vehicle Class	Category	NMOG**	CO	NOx	HCHO
1995	Passenger Car	TLEV	0.188 (0.32)	3.4	0.4	0.023
1998	Passenger Car	LEV	0.100 (0.188)	3.4	0.3	0.015
1998	Passenger Car	ULEV	0.058 (0.100)	2.6	0.3	0.012
1995	LDT≤3750 lbs LVW	TLEV	0.188 (0.32)	3.4	0.4	0.023
1998	LDT≤3750 lbs LVW	LEV	0.100 (0.188)	3.4	0.3	0.015
1998	LDT≤3750 lbs LVW	ULEV	0.058 (0.100)	2.6	0.3	0.012
1995	LDT 3751-5750	TLEV	0.238 (0.41)	4.4	0.7	0.027
1998	LDT 3751-5750	LEV	0.128 (0.238)	4.4	0.5	0.018
1998	LDT 3751-5750	ULEV	0.075 (0.128)	3.3	0.5	0.014
1999	MDV≤3750 lbs TW	LEV	0.188 (0.32)	3.4	0.4	0.015
1999	MDV≤3750 lbs TW	ULEV	0.100 (0.188)	2.6	0.3	0.012
1999	MDV 3751-5750	LEV	0.238 (0.41)	4.4	0.7	0.018
1999	MDV 3751-5750	ULEV	0.128 (0.238)	3.3	0.5	0.014
1999	MDV 5751-8500	LEV	0.293 (0.49)	5.0	1.1	0.022
1999	MDV 5751-8500	ULEV	0.156 (0.293)	3.8	0.8	0.017
1999	MDV 8501-10,000	LEV	0.345 (0.58)	5.5	1.3	0.028
1999	MDV 8501-10,000	ULEV	0.184 (0.345)	4.2	1.0	0.021
1999	MDV 10,001-14,000	LEV	0.450 (0.75)	7.0	2.0	0.036
1999	MDV 10,001-14,000	ULEV	0.240 (0.450)	5.3	1.5	0.027

* Diesel vehicles must also meet particulate standards applicable to their vehicle category and weight class.

** Before reactivity adjustment

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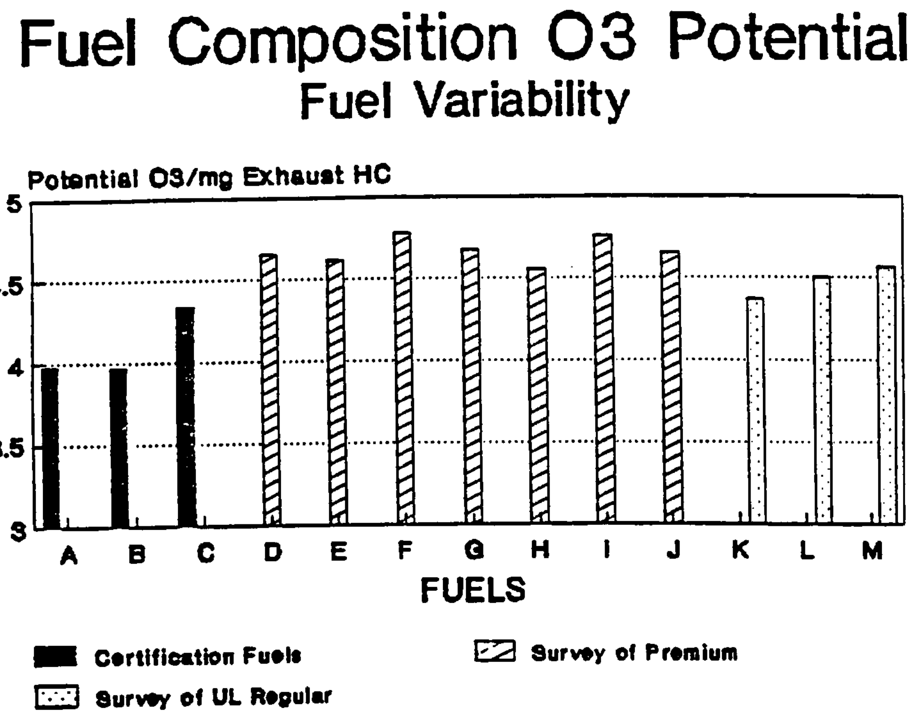
Table I-4. Specifications of Base Gasoline Used As Basis for Reactivity Adjustment

API Gravity	57.8
Sulfur, ppm	317
Color	Purple
Benzene, vol. %	1.35
Reid Vapor Pressure	8.7
Driveability	1195
Antiknock Index	87.3
<u>Distillation, D-86 °F</u>	
IBP	92
10%	126
50%	219
90%	327
EP	414
<u>Hydrocarbon Type, Vol. % FIA</u>	
Aromatics	30.9
Olefins	8.2
Saturates	60.9

Note: Laboratory analysis conducted by Phillips 66 Company, Borger, Texas

Figure 1. Preliminary ARCO Data

DRAFT



Pot O3=2.96 + (0.031)FC7A +(0.056)FC8+A

Note: Incremental reactivity values from Carter, W.P.L., Draft Report to W.L.G.A., July 11, 1989.

Each of the different technologies likely to be employed for gasoline-fueled TLEVs, LEVs, and ULEVs would be tested on the base gasoline, subject to the availability of vehicles that meet the standards. The staff would test a statistically valid number of vehicles which have accumulated at least 4000 miles and meet the standards for each emission category. Samples of the NMOG exhaust emissions would be speciated according to the procedures specified in "California Non-Methane Organic Gas Test Procedures."

To determine the emission profiles for base gasoline-fueled vehicles, the staff would test late-model passenger cars that meet all the applicable emission standards. For TLEVs, advanced current technology vehicles would be tested, including a 1990 model-year Buick LeSabre and a 1990 Ford Tempo. For LEVs, the staff would test vehicles able to meet the LEV standards, including a 1990 Toyota Celica. For ULEVs, the Buick LeSabre and Toyota Celica mentioned previously, retrofitted with electrically heated catalysts, would be tested.

2. Exhaust Profiles for Alternate Fuels and Phase 2 Gasoline

The profiles for the vehicles powered by the various candidate alternate fuels and Phase 2 gasoline (the formulation of gasoline that would be sold in California beginning in 1996) would be determined in a manner similar to the procedure for vehicles operating on base gasoline. By the end of 1991, emission profiles would be established for light-duty vehicles powered by Phase 2 gasoline, methanol (M85--an 85% methanol, 15% base gasoline blend), ethanol (E85--an 85% ethanol, 15% base gasoline blend with Reid Vapor Pressure (RVP) adjustment), and compressed natural gas (CNG). Emission profiles for other fuels and other vehicle classes would be established when vehicles operating on the fuels have been demonstrated to be commercially viable, and when vehicles that meet the appropriate standards are available for testing.

3. Procedure for Calculating Reactivity Adjustment Factors

Once representative exhaust emission profiles have been established, the ozone-forming potential of the NMOG exhaust emissions would be determined. The ozone-forming potential would be calculated as:

{[(g/mile of Exhaust NMOG No. 1) x (Incremental Reactivity Factor for Exhaust NMOG No. 1)] + [(g/mile of Exhaust NMOG No. 2) x (Incremental Reactivity Factor for Exhaust NMOG No. 2)] + ... [(g/mile of Exhaust NMOG No. ***) x (Incremental Reactivity Factor for Exhaust NMOG No. ***)]} / (Total g/mile of NMOG Emissions).

This equation would be used to calculate the ozone-forming potential of candidate vehicle/alternate fuel and base gasoline systems. The ratio of the ozone-forming potentials of clean fuel to heated catalyst ($150), electric air pump ($20), and improved fuel preparation system ($70). For vehicles utilizing improved fuel preparation systems, the cost would be offset by the savings associated with downsizing the overall catalyst system (afforded by the emission benefits of preheating the fuel). Therefore, the net additional cost for a gasoline-powered vehicle would be $170, at a minimum.

In addition to the previously described emission control technologies ($170), alcohol flexible-fueled vehicles would also need fuel system and other alcohol-related modifications ($200), whereas LPG dual-fueled vehicles would require electronic fuel injection ($100), and a revised fuel system and fuel storage tank ($600).

Light-duty dual-fueled vehicles powered by CNG would not likely utilize the aforementioned emission control technologies. They would only need electronic fuel injection ($200) for adequate NOx control, and a revised gaseous fuel system and high pressure storage tanks ($1000).

Medium-duty vehicles would be comparably equipped to light-duty ULEVs in order to meet the proposed standards. Vehicles would be powered by a cleaner-burning fuel and equipped with an electrically heated catalyst ($200), electric air pump ($20), improved fuel preparation system ($70), and electronic EGR ($30). For gasoline-fueled vehicles, the bypassable start catalyst ($60) needed to meet 1995 emission standards would be replaced by an electrically heated unit to meet ULEV standards. After deducting the cost of the bypassable start catalyst, the net additional cost for a gasoline-fueled vehicle would be $190, at a minimum. As for light-duty vehicles, the cost of the improved fuel preparation system would be offset by the savings associated with downsizing the catalyst system.

In addition to the previously described emission control technologies ($190), medium-duty alcohol flexible-fueled vehicles would need fuel system and alcohol-related revisions ($300), and LPG dual-fueled vehicles would require electronic fuel injection ($100), and a revised fuel system and fuel storage tank ($800).

Medium-duty dual-fueled vehicles powered by CNG would probably not be equipped with the aforementioned emission control technologies. They would only need electronic fuel injection ($200), and a revised fuel system and high pressure storage tanks ($1500).

<u>Zero-Emission Vehicles (ZEVs)</u>

The staff consulted with electric vehicle experts on the projected cost differential of a commercial, moderate volume electric vehicle compared to a conventional vehicle. They estimated that by year 2000, electric vehicles would be comparable in cost to conventional vehicles except for the additional cost of batteries. In year 2000, advanced production batteries were estimated to cost an additional $1,350 for light-duty vehicles and $2700 for medium-duty vehicles (to accomodate the larger size and load capacities).

Table IX-2. Summary of Added Costs of Making Low-Emission Vehicles ($)

	TLEV	LEV	ULEV	ZEV
Light-Duty				
gasoline	70	170	170	n/a
M85 or ethanol	200	270	370	n/a
LPG	600	700	870	n/a
CNG	1000	1200	1200	n/a
electricity	n/a	n/a	n/a	1350
Medium-Duty				
gasoline	n/a	190	190	n/a
M85 or ethanol	n/a	370	490	n/a
LPG	n/a	900	1090	n/a
CNG	n/a	1700	1700	n/a
electricity	n/a	n/a	n/a	2700

n/a: The combination of fuel and vehicle is not expected.

2. Producing Clean Fuels

There have been several studies estimating the retail prices of potential clean fuels. Table IX-3 shows estimates of the retail prices of M85, ethanol, LPG, electricity, and CNG made by the Environmental Protection Agency (EPA), the California Energy Commission (CEC), and the AB 234 Advisory Board. These estimates include the cost of production, transportation and distribution, retail dispensing equipment, federal and state taxes where applicable, and financial parameters such as equity financing, depreciation, retail margins, and return on investment. All the studies assumed the continuation of low oil prices.

Special considerations were needed for particular fuels. In the case of CNG, the prices include the cost of the electricity required for compression. In the case of electricity, the prices include the cost of conversion losses in producing electricity at the power plant and the cost of installing an outlet to dispense electricity. The price estimate for M85 calculated by the EPA assumed a five percent greater engine energy efficiency in M85 vehicles than in gasoline vehicles, lowering the cost expressed per gasoline gallon by five percent. The price estimates by the CEC do not credit alternatively fueled vehicles with extra energy efficiency. Details of the various studies are in Appendix B-1.

The numbers in the table reflect price margins typical of what fuel producers, transporters, and retailers obtain in the fuel business. The difference between the price in Table IX-3 for a clean fuel and the price of gasoline is a measure of the cost of providing the clean fuel. (The actual clean fuel prices under the requirements would be determined by market forces. The staff cannot predict actual fuel prices under the proposed regulation, but such predictions are not needed to estimate the costs of providing clean fuels.)

Table IX-3. Estimated Prices of Fuels without the Proposed Regulation (dollars per gallon[a])

reference:	EPA (1981)	CEC (1989)	CEC (1989)	AB 234 (1989)
year:	1990	1993	2000	1990
Methanol (M85)	1.14 to 1.24	1.44	1.36 to 1.63 (b)	.05 to .10 more than premium gasoline
Ethanol[c]		2.47	2.33	considerably more expensive than methanol
LPG		.88	.98	cheaper than gasoline
Electricity[d]		.71	.59	"
CNG		.71	.84	"
Premium gasoline[e]	1.23	1.21	1.39	---

[a] price of energy equivalent to a gallon of gasoline; 1988 dollars
[b] The range reflects different locations for new production plants.
[c] excluding the current exemption from federal tax
[d] Although electricity is more expensive than gasoline per unit of energy delivered to the vehicle, it is cheaper per unit of mechanical energy produced by the motor. CEC's price estimates, which do not reflect the greater fuel economy, have been adjusted by ARB staff to reflect this effect.
[e] meeting current specifications

As shown in the table, in the initial years alcohol fuels are apt to be more costly to produce than is today's gasoline, while CNG, LPG, and electricity would be cheaper. However, if the ARB adopts new standards for gasoline (Phase 1 in 1990 and Phase 2 in 1991) or if Congress adopts major new standards, gasoline may become more expensive than shown in the table. This would reduce the difference in cost between alcohols and gasoline. Also, if the estimates were based on an assumption of high oil prices, the prices of the alternative fuels would likely be less relative to the price of gasoline than shown in the table.

The price of M85 in Table IX-3 is based on producing methanol in new, large plants enjoying economy of scale. Methanol from existing sources might be more expensive. The creation of new, economically efficient methanol plant would tend to lower the cost of methanol. However, the capacity of a new large plant (10,000 metric tons per day) corresponds to an amount of M85 equal to about 6 percent of the gasoline demand in California. Therefore, the M85 supplied in the early years of a produce-and-distribute requirement could be more expensive than the table indicates until the demand reached a level triggering new production capacity. Thereafter, the prices for M85 in Table IX-3 should apply.

3. Producing Reformulated Gasoline

According to a survey of U.S. refiners done by API, gasoline formulated to meet requirements being considered by Congress (Daschle/ Richardson amendment) would cost about 10 to 15 cents per gallon more than current gasoline. This cost applies to a 2.7 percent minimum oxygen content, a 25 percent maximum aromatic limit, a 1.0 percent maximum benzene content, adjustments to gasoline to provide a 15 percent volatile organic content (VOC) reduction, a 3.1 percent oxygen content in non-attainment areas, transportation and service station modifications for ethanol blends, and fuel economy loss. The API concluded that the 10 to 15 cent increase may be a low estimate and may not reflect the costs for some of the smaller refiners not included in their survey.

A preliminary study done by the EPA estimated the cost of Daschle/Richardson gasoline to be less than 5 cents per gallon. This cost applies to a 2.7 percent minimum oxygen content (MTBE), a cost savings from the octane value of MTBE, a 25 percent maximum aromatic limit, a 1 percent maximum benzene limit, and a 0.3 to 0.8 RVP reduction from the current 9.0 RVP.

The Department of Energy (DOE) in a White House memo estimated the cost of reformulated gasoline to be 9.8 cents per gallon. This cost applies to a 2.7 percent minimum oxygen content (MTBE), aromatic content control, and a benzene content of 0.8 to 0.9 percent.

To obtain a range for the possible cost of Phase 2 gasoline, the staff considered these studies as well as our own analyses of the costs of benzene and RVP reductions in gasoline. The staff concluded that the range 5 to 15 cents per gallon of gasoline is reasonable for the purpose of this report. However, the actual cost of any eventual reformulation of gasoline could be different.

4. Combined Cost of Using Low-Emission Vehicles and Clean Fuels

The staff has estimated the annual equivalent of the combined costs of making and fueling the individual types of low-emission vehicles discussed in Section B.1. These are shown in Tables IX-4a and 4b. The added vehicle costs in Table IX-2 have been amortized over a ten-year useful life at ten percent discount rate. The annual cost of fuel was calculated for 10,000 miles (411 gallons of gasoline) per year in light-duty vehicles (LDVs) and 12,000 miles (960 gallons) per year in medium-duty vehicles (MDVs).

In Tables IX-4a and IX-4b, the unit costs of clean fuels, other than M85, are based on the estimates of prices in Table IX-3 by the Energy Commission (CEC) for 2000. As noted above, CEC assumed a continuation of low oil prices. If oil prices rise, alternative fuels may become cheaper in relation to the price of gasoline.

For M85, we have used the AB 234 Advisory Board's estimate of 5 to 10 cents more per gallon than premium gasoline ($1.39 per gallon in 2000), or $1.44 to $1.49 per gallon. For conventional gasoline, we use $1.30 in the year 2000. This equals CEC's price estimates for unleaded regular, $1.25 per gallon, and premium unleaded, $1.39 per gallon, weighted as 60 percent and 40 percent, respectively, of all gasoline. To the $1.30, we have added 5 to 15 cents per gallon to reflect future reformulations, as discussed in the preceding section. The result is two gasoline prices for comparison with the clean fuel prices in Table IX-3, $1.35 per gallon and $1.45 per gallon.

The combined annual cost of a type of vehicle is:

added cost of vehicle x annual capital recovery factor (0.163)

+ added cost of fuel per gallon (gasoline equivalent) x gallons used in a year

With Phase 2 gasoline at $1.35 per gallon (5 cents per gallon more expensive than conventional gasoline) as the basis for clean fuel cost, the added cost of making and fueling low-emission vehicles (in Table IX-4a) runs from net savings for most vehicles using LPG, CNG, or electricity to over $1000 per year for ethanol-powered medium-duty vehicles. M85-powered light-duty vehicles cost $28 to $118 per year. The costs differ between LDVs and MDVs because of their different vehicle costs and fuel economies. The annual costs if Phase 2 gasoline costs $1.45 per gallon (Table IX-4b) are somewhat less.

These costs do not necessarily reflect the consumer's costs (prices) because all of the extra costs of vehicles and clean fuels might not be passed to the consumer.

The staff cannot estimate the actual overall cost of the low-emission vehicle fleet nor the cost of providing it with fuel because we do not know which fuels automakers would choose as certification fuels nor how many vehicles they would make to the various standards in response to the proposed low-emission vehicle regulation. However, we can estimate the overall cost of each model year's fleet of new low-emission vehicles for specific possible combinations of clean fuels with emission standards and a possible composition of the year's fleet by vehicle types (TLEV, LEV, ULEV). For the latter, we assume that vehicle manufacturers would follow the particular (one of many possible) schedule of vehicle types shown in Table I-6. Table IX-5 poses five possible assignments of fuels to the TLEVs, LEVs, and ULEVs (as well as electricity for ZEVs). The costs for each model year are the annual costs per vehicle in Tables IX-4a and IX-4b weighted by the fractions of vehicles in Table I-6 and applied to about two million new LDVs and 200,000 new MDVs in each year. The calculations are shown in more detail in Appendix B-1.

The staff can also estimate the program cost for a particular calendar year for each scenario by summing the costs of each model year (Table IX-5) on the road in the calendar year. To do this we have assumed that all vehicles are on the road for ten years; i.e., in 2010 only vehicles from model years 2001 to 2010 will be on the road. These estimates are shown in Table IX-6.

Table IX-4a. **Total Added Cost of Making and Fueling a Low-Emission Vehicle ($; relative to conventional vehicle)**

Fuel cost basis: gasoline @ $1.35/gallon[a]

		Added cost of vehicle	Added fuel cost/year	Total[b] annual cost
		Light-Duty		
Gasoline	TLEV	70	n/a	11
	LEV, ULEV	170	n/a	28
M85	TLEV	200	37 to 58	70 to 90
	LEV	270	"	81 to 102
	ULEV	370	"	97 to 118
Ethanol	TLEV	200	403	436
	LEV	270	"	447
	ULEV	370	"	464
LPG	TLEV	600	-152	-54
	LEV	700	"	-38
	ULEV	870	"	-10
CNG	TLEV	1000	-210	-47
	LEV, ULEV	1200	"	-14
Electr.	ZEV	1350	-313	-93
		Medium-Duty		
Gasoline	LEV, ULEV	190	n/a	31
M85	LEV	370	86 to 134	147 to 195
	ULEV	490	"	166 to 214
ethanol	LEV	370	941	1001
	ULEV	490	"	1021
LPG	LEV	900	-355	-209
	ULEV	1090	"	-176
CNG	LEV, ULEV	1700	-490	-213
Elect.	ZEV	2700	-730	-290

[a] the price of Phase 2 gasoline as $.05/gallon more than the pool-averaged price of conventional gasoline in 2000

[b] amortized vehicle cost plus fuel cost

Table IX-4b. Total Added Cost of Making and Fueling a Low-Emission Vehicle ($; relative to a conventional vehicle)

Fuel cost basis: gasoline @ $1.45/gallon[a]

		Added cost of vehicle	Added fuel cost/year	Total[b] annual cost
		Light-Duty		
Gasoline	TLEV	70	n/a	11
	LEV, ULEV	170	n/a	28
M85	TLEV	200	-4 to 17	28 to 49
	LEV	270	"	40 to 60
	ULEV	370	"	56 to 77
ethanol	TLEV	200	362	395
	LEV	270	"	406
	ULEV	370	"	422
LPG	TLEV	600	-193	-96
	LEV	700	"	-79
	ULEV	870	"	-52
CNG	TLEV	1000	-251	-88
	LEV, ULEV	1200	"	-55
Electr.	ZEV	1350	"	-134
		Medium-Duty		
Gasoline	LEV, ULEV	190	n/a	31
M85	LEV	370	-10 to 38	51 to 99
	ULEV	490	"	70 to 118
ethanol	LEV	370	845	905
	ULEV	490	"	925
LPG	LEV	900	-451	-305
	ULEV	1090	"	-272
CNG	LEV, ULEV	1700	-586	-309
Elect.	ZEV	2700	-826	-386

[a] the price of Phase 2 gasoline as $.15/gallon more than the pool-averaged price of conventional gasoline in 2000

[b] amortized vehicle cost plus fuel cost

Table IX-5. Costs of the Proposed Program by Model Year[a] for Hypothetical Mixes of Clean Fuels (million $ / year)

Scenario	Model year	Cost of model-year fleet per year of its life	
		gasoline @ $1.35	gasoline @ $1.45
A.			
TLEVs, LEVs, ULEVs use gasoline	1995	3.3	3.3
ZEVs use electricity	1997	15	15
	2000	60	59
	2003	41	32
B.			
LEVs, ULEVs use methanol	1995	21- 27	8- 15
ZEVs use electricity	1997	44- 56	22- 33
	2000	190-250	89-140
	2003	180-230	66-120
C.			
TLEVs use gasoline	1995	3.3	3.3
LEVs use methanol	1997	40- 50	18- 28
ULEVs use CNG	2000	190-240	82-130
ZEVs use electricity	2003	130-170	18- 59
D.			
TLEVs use gasoline	1995	3.3	3.3
80% of LEVs use methanol	1997	77- 85	56- 62
20% of LEVs use ethanol	2000	370-410	260-300
50% of ULEVs use CNG	2003	280-310	170-200
50% of ULEVs use LPG			
ZEVs use electricity			
E.			
TLEVs, LEVs use gasoline	1995	3.3	3.3
ULEVs use CNG	1997	13	12
ZEVs use electricity	2000	58	54
	2003	19	no cost

[a] The numbers apply to the fleet of low-emission vehicles added to the road fleet in the indicated model year. The fleet composition in Table I-6 is assumed. All vehicles are assumed to use clean fuel, if applicable.

Table IX-6. Estimated Program Cost in 2000 and 2010[a] for Hypothetical Mixes of Clean Fuels (million $ in the year)

calendar year:	2000		2010	
gasoline price:	$1.35	$1.45	$1.35	$1.45
<u>Scenario A</u> TLEVs, LEVs, ULEVs use gasoline ZEVs use electricity	150	150	450	350
<u>Scenario B</u> TLEVs, LEVs, ULEVs use methanol ZEVs use electricity	590	300	2,100	950
<u>Scenario C</u> TLEVs use gasoline LEVs use methanol ULEVs use CNG ZEVs use electricity	510	250	1,600	470
<u>Scenario D</u> TLEVs use gasoline 80% of LEVs use methanol 20% of LEVs use ethanol 50% of ULEVs use CNG 50% of ULEVs use LPG ZEVs use electricity	910	660	3,100	2,000
<u>Scenario E</u> TLEVs, LEVs use gasoline ULEVs use CNG ZEVs use electricity	140	130	240	10

[a] The numbers are the costs of owning and operating the entire fleet of low-emission vehicles (all model years) existing in the indicated year.

5. Equipping Service Stations

One new liquid fuel could be supplied at some service stations merely by eliminating leaded gasoline as a product and cleansing the storage tank of lead and installing new methanol compatable dispensers. (However, not all retail companies sell leaded gasoline.) This would be possible for M85 if the storage system has already been made methanol-compatible, which has occurred in many stations. Leaded gasoline is likely to begin to disappear from retail stations whether or not the clean fuel regulation is adopted. Therefore, most stations should have room for a delivery system for a clean fuel, and many could use an existing system for that purpose.

To add a second liquid clean fuel, natural gas, or LPG, most stations would have to install new facilities. (In the case of LPG, the number of stations already offering LPG may be large enough to satisfy a retail availability requirement for an extended period. Also, LPG facilities can be rented from LPG suppliers, thereby avoiding a capital expense.) Table IX-7 shows the approximate capital costs, the annual cost of the capital amortized over ten years at ten percent interest, and amortization cost per gallon if the throughput is equivalent to 25,000 gallons of gasoline per month (as the proposed regulation would provide in 1994 to 1997) for liquid fuels or 30,000 gasoline gallons for CNG.

Table IX-7. Capital Costs of Installing Capability to Offer Clean Fuel

	Installed Cost (thousands)	Equivalent Cost[a] per year (thousands)	Equivalent Cost[a] per gallon[b]
M85 or ethanol	\$50 to 70	\$8.2 to 11	\$.027 to .038
LPG	\$40 to 75	\$6.5 to 12	\$.022 to .041
CNG	250[c]	\$40	\$.11
Gasoline	\$50 to 70	\$8.2 to 11	\$.027 to .038

[a] amortization over ten years at ten percent discount rate;

[b] @ 25,000 gallons (gasoline-equivalent) per month, except 30,000 gallons for CNG

[c] Larger systems are available but would not be consistent with the throughput assumed for this table.

6. Other Possible Costs

There could be an "opportunity" cost of using an existing gasoline delivery system for a clean fuel rather than for another product. This cost would be any difference in net revenues at the affected pumps. Net revenue equals volume sold times margin (retail price minus wholesale price). On a gasoline basis, the amount of fuel sold would not be affected by the clean fuel program. It is possible that dealer's margins would be different under the regulation than without, but there is no reason to predict or estimate such a change.

C. COST-EFFECTIVENESS OF THE PROGRAM

The cost-effectiveness of the proposal can be represented as the cost per pound of ozone-precursor emissions reduced by the regulations and as the cost per potential cancer case avoided through the reduction of toxic emissions.

The staff has computed the cost-effectiveness of reducing emissions of ozone precursors with low-emission vehicles and their clean fuels as one-half of the program's cost in a year divided by the reduction of emissions in that year. Likewise, half of costs has been used to estimate the cost-effectiveness of the program for reducing risk from toxic pollutants.

1. Criteria Pollutants

The cost-effectiveness of any kind of low-emission vehicle is one-half the annual cost from Table IX-4a or IX-4b divided by the annual emission reduction provided by that vehicle. The annual emission reduction is based on the difference in 50,000-mile standards between the low-emission vehicle and a conventional gasoline vehicle meeting the standards adopted for 1993 to 1995. For light-duty vehicles:

$$\text{NMOG \& NOx reduced (lb/yr)} = (.25 \text{ gm HC/mi.} - e_{NMOG} + .4 \text{ gm NOx/mi.} - e_{NOX}) \times 10{,}000 \text{ mi./yr.} / 454 \text{ gm./lb.}$$

For medium-duty vehicles:

$$\text{NMOG \& NOx reduced (lb/yr)} = (.39 \text{ gm HC/mi.} - e_{NMOG} + 1.1 \text{ gm NOx/mi.} - e_{NOX}) \times 12{,}000 \text{ mi./yr.} / 454 \text{ gm./lb.}$$

where "e" is the emission standard for the particular kind of low-emission vehicle. For medium-duty vehicles, the staff used the weight class $5751 \leq$ test weight ≤ 8500 (existing HC standard = .39 gm/mile) as representative.

Table IX-8a shows the results when Phase 2 gasoline is assumed to cost $1.35 per gallon. (The values of $/pound have been rounded to the nearest 0.10.) For NMOG plus NOx, the cost per pound reduced ranges from a net saving for most kinds of LPG, CNG, and electric vehicles (plus their fuel) to $97 per pound of reduced emission for ethanol-powered MDVs. For LDVs using M85, costs range from $4.90 to $16 per pound, depending on the emission standard and the assumed cost of methanol.

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Table IX-8b shows analogous numbers when Phase 2 gasoline is assumed to cost $1.45 per gallon. Costs per pound are somewhat lower than in Table IX-8a.

Table IX-8a. Cost-Effectiveness of Low-Emission Vehicles/Clean Fuels ($/pound of NMOG plus NOx reduced)[a]

fuel cost basis: gasoline @$1.35/gallon[b]

	TLEV	LEV	ULEV	ZEV
		light-duty		
Gasoline	2.10[c]	1.70	1.50	n/a
M85	12.60 to 16.40	4.90 to 6.20	5.40 to 6.20	n/a
Ethanol	79.00	27.10	25.70	n/a
LPG	-9.90	-2.30	-.60	n/a
CNG	-8.50	-.90	-.80	n/a
Electricity	n/a	n/a	n/a	-3.20
		medium-duty		
Gasoline	---	3.00	.70	n/a
M85	---	14.20 to 18.90	3.80 to 4.90	n/a
Ethanol	---	97.10	23.50	n/a
LPG	---	-20.20	-4.00	n/a
CNG	---	-20.60	-4.90	n/a
Electricity	---	n/a	n/a	-3.70

[a] these values were calculated assuming that one-half of the overall program cost is allocated to criteria pollutant reductions and one-half is allocated to the benefits of toxic air contaminant reductions.

[b] represents Phase 2 gasoline as $0.05/gallon more expensive than the pool-average gasoline in 2000

[c] Values of cost of vehicle and fuel divided by emission reduction have been rounded to the nearest 0.10 $/lb; the number of digits shown does not indicate the number of significant digits in the calculation.

"n/a" indicates that the type of fuel is not expected as a certification fuel for the type of low-emission vehicle.

Table IX-8b. Cost-Effectiveness of Low-Emission Vehicles/Clean Fuels ($/pound of NMOG plus NOx reduced)[a]

fuel cost basis: gasoline @$1.45/gallon[b]

	TLEV	LEV	ULEV	ZEV
light-duty				
Gasoline	2.10[c]	1.70	1.50	n/a
M85	5.20 to 8.90	2.40 to 3.70	3.10 to 4.30	n/a
Ethanol	71.50	24.60	23.40	n/a
LPG	-17.40	-4.80	-2.90	n/a
CNG	-16.00	-3.40	-3.10	n/a
Electricity	n/a	n/a	n/a	-4.70
medium-duty				
Gasoline	---	3.00	.70	n/a
M85	---	4.90 to 9.60	1.60 to 2.70	n/a
Ethanol	---	87.50	21.03	n/a
LPG	---	-29.60	-6.30	n/a
CNG	---	-29.90	-7.40	n/a
Electricity	---	n/a	n/a	-4.90

[a] these values were calculated assuming that one-half of the overall program cost is allocated to criteria pollutant reductions and one-half is allocated to the benefits of toxic air contaminant reductions.

[b] represents Phase 2 gasoline as $0.15/gallon more expensive than the pool-average gasoline in 2000

[c] Values of cost of vehicle and fuel divided by emission reduction have been rounded to the nearest 0.10 $/lb; the number of digits shown does not indicate the number of significant digits in the calculation.

As is the case with costs, the staff cannot state the cost-effectiveness of the proposed program due to the uncertainty in the number of vehicles of each emission category that manufacturers would choose to produce and the types of fuels on which they would operate. However, we can estimate the cost-effectiveness for a model year's fleet for the same hypothetical scenarios discussed above. Table IX-9 shows such costs per pound of NMOG + NOx reduced. As above, for all scenarios, we assumed that vehicle manufacturers would follow the example schedule of low-emission vehicles in Table I-6 and that all vehicles use the fuel on which they were certified. For light-duty vehicles:

$$\text{Cost effectiveness} = \frac{0.5 \times \text{SUM [\% i in MY fleet * cost of i]}}{\text{SUM [(\% i * NOx reduced) + .25 - NMOG std.]}}$$

where i = TLEV, LEV, ULEV, and ZEV; % i is from Table I-6 (MY means "model-year"); the cost is from Table IX-4; the NOx reduction is 0.4 g/mi less the proposed standard for the vehicle; and the NMOG standard is the fleet-average standard for the model-year. Values have been rounded to the nearest 0.10 $ per pound reduced.

Table IX-9. Cost-Effectiveness of Low-Emission LDVs in a Model Year's Fleet (Hypothetical Mixes of Clean Fuels)[a]

Scenario	Model Year	$/lb. of NMOG + NOx, for model-year fleet: gasoline @ $1.35	gasoline @ $1.45
TLEVs, LEVs, ULEVs use gasoline	1995	1.90[b]	1.90
ZEVs use electricity	1997	1.70	1.70
	2000	1.50	1.50
	2005	0.90	0.70
TLEVs, LEVs, ULEVs use methanol	1995	11.30 -15.00	4.70 - 8.00
LEVs use electricity	1997	4.90 - 6.20	2.40 - 3.70
	2000	4.60 - 5.90	2.20 - 3.90
	2005	3.70 - 4.70	1.40 - 2.40
TLEVs use gasoline	1995	1.50	1.10
LEVs use methanol	1997	4.70 - 5.90	2.10 - 3.30
ULEVs use CNG	2000	4.50 - 5.07	2.00 - 3.20
ZEVs use electricity	2005	5.20 - 3.60	.00 - 1.30
TLEVs use gasoline	1995	1.50	1.10
10% LEVs use methanol	1997	8.90 - 9.90	6.40 - 7.40
20% LEVs use ethanol	2000	8.70 - 9.70	6.30 - 7.20
50% ULEVs use CNG	2005	5.80 - 6.50	3.50 - 4.20
50% ULEVs use LPG			
ZEVs use electricity			
TLEVs and LEVs use gasoline	1995	1.50	1.10
ULEVs use CNG	1997	1.60	1.50
ZEVs use electricity	2000	1.50	1.40
	2005	0.50	no cost

[a] These values are based on the application of half of the overall cost to criteria pollutant reductions and half to toxic pollution reductions.

[b] Values of $/lb have been rounded to the nearest 0.10.

The cost-effectiveness of the program in calendar years 2000 and 2010 is shown in Table IX-10. The numbers are the costs in Table IX-6 divided by the combined (LDVs plus MDVs) emissions of NMOG and NOx in Table IX-1.

Table IX-10. Program Cost-Effectiveness in 2000 and 2010 for Entire Low-Emission Vehicle Fleet (Hypothetical)*
($ / lb of NMOG + NOx)

calendar year:	2000		2010	
gasoline price:	$1.35	$1.45	$1.35	$1.45
Scenario A TLEVs, LEVs, ULEVs use gasoline ZEVs use electricity	1.60	1.60	0.70	0.55
Scenario B TLEVs, LEVs, ULEVs use methanol ZEVs use electricity	6.20	3.20	3.30	1.50
Scenario C TLEVs use gasoline LEVs use methanol ULEVs use CNG ZEVs use electricity	5.40	2.60	2.50	0.75
Scenario D TLEVs use gasoline 80% of LEVs use methanol 20% of LEVs use ethanol 50% of ULEVs use CNG 50% of ULEVs use LPG ZEVs use electricity	9.60	7.00	4.90	3.20
Scenario E TLEVs, LEVs use gasoline ULEVs use CNG ZEVs use electricity	1.50	1.40	0.40	0.02

* These values are based on the application of half of the overall program cost to criteria pollutant reductions and half to toxic pollutant reductions.

2. Toxic Pollutants

Half the estimated costs in 2010 for scenario A, which has the entire low-emission fleet (except ZEVs) using gasoline, divided by the estimate of cases avoided per year (lifetime cases / 70) gives:

$[175 to 225] million / [21 to 38] cases = $[4.6 to 11] million per case

Since some of the cost scenarios are more expensive than the gasoline-only scenario, the actual cost per potential cancer case avoided could exceed these values. However, to the degree that low-emission vehicles do not use gasoline, the number of potential cases avoided probably would be greater than the 21 to 38 per year value.

D. ECONOMIC EFFECTS

1. Capital Costs for Gasoline Suppliers

Gasoline suppliers could avoid capital expenses by buying clean fuels from other companies. As discussed above, they would be likely to do that in the early years of a distribution requirement. Later, as new sources of some clean fuels would be needed, the gasoline suppliers might want to produce their own clean fuels. The fuels for which gasoline suppliers might consider investments are probably the liquid fuels: M85, ethanol, LPG, and any alternative gasoline. Information on the cost of a new production plant is available only for methanol. Appendix B-1 summarizes this information and presents an analysis of the ability of the refining industry to finance such plants.

2. Capital Cost for Retail Station Owners

Some station owners could add a liquid clean fuel without a significant capital expense by discontinuing the sale of leaded gasoline. If the clean fuel were methanol, this could be done only if the existing storage tank are methanol-compatible and a methanol-compatible dispenser is installed. Some stations already have methanol-compatible storage tanks and could be selected as the stations to offer methanol if a station owner must have a fraction of its stations capable of handling methanol.

If new equipment must be installed, the cost for a liquid fuel would be $40,000 to $75,000 per station affected. The staff has analyzed the ability of service station owners to finance this expense. The analysis is in Appendix B-1. In summary, the financial strength of the industry as a whole appears to have improved in the past few years as smaller stations have closed and the remaining operations have become bigger. Thus, for the major oil companies that own most of the "branded" stations, financing equipment for new liquid fuels should not be a problem. The large independently owned retail businesses also should be able to finance the project. (Only a fraction of each owner's stations would have to be equipped.) Since small retail operations have been closing under competitive pressures, some small stations might not be able to finance new equipment if required to install it. However, the proposed regulation would not require small retail businesses (one or two stations) to install new equipment until the amount of clean fuel needed would be large, and some stations could provide a new fuel without new equipment by dropping the leaded gasoline and installing a new methanol-compatible dispenser.

Equipment to vend natural gas at retail is estimated to cost $250,000 to $400,000 per station, depending on its capacity. Small retailers might not be able to afford to offer natural gas. However, under the draft regulation, offering natural gas in small stations or stations owned by small businesses would not likely be necessary; the amount of natural gas required to be sold is not likely to require more stations than large retailers would provide.

3. Effects on Small Businesses

Section 11342 et seq. of the Government Code (see Appendix B-8) defines small businesses and requires the ARB to identify small businesses that might be directly and adversely affected by the proposed regulations. It also requires the ARB to describe any alternatives that have been considered to lessen the adverse effects.

The proposed new emission standards could increase costs for automakers. However, to be a small business as defined by the code, an automaker would have to be independently owned, employ fewer than 250 persons, and receive less than $9.5 million annually in wholesale receipts. It is doubtful that any automakers meet both criteria.

The proposed regulation requiring the distribution of clean fuels could increase costs for small refining companies. However, the code explicitly excludes all refiners from the definition of a small business.

The code's definition of a small business, as applied to the owner of a gasoline retail business (the station operator as distinct from the owner of the facility), makes a gasoline retailer a small business if it receives less than two million dollars per year at retail. This criterion applies to all products and services at all locations that are part of the business. If gasoline is the only product or service sold, the criterion translates to about 130,000 gallons per month (combined for all locations of the business). Since there are many individually-operated stations, many stations pumping fewer than 130,000 gallons per month, and some stations whose sales are largely gasoline, it is likely that some retailers are small businesses.

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However, the only requirement that the clean fuel regulation would place upon small retailers is the requirement to offer a clean fuel for sale _if_ the _owner_ of the station has equipped the station for that fuel. Since the regulation would not restrict the amount or price at which the retailer would sell the clean fuel, the requirement to offer the fuel for sale appears unlikely to adversely affect the retailer (unless the retailer is also the owner of the station, which case is included in the following discussion).

The proposed clean fuel regulation would create costs for the owners of retail gasoline stations, who could have to install new storage tanks and dispensers for clean fuel. This kind of expense could be experienced by any station owner at some point in the program. However, although the code does not explicitly exclude station owners (landlords) from the definition of small business, it does not give any criterion for identifying a station owner who is a small business. Therefore, the staff cannot estimate which owners or what fraction of owners are small businesses.

Regardless of which station owners may be small businesses, they would have less severe requirements under the proposed regulation than would owners of many stations (e.g., major oil companies). In any year, only owners with more than a certain number of stations would have to install equipment for clean fuel. The fewer stations owned, the longer an owner would be unaffected by the requirement.

Further relief for station owners that are small businesses could be provided by totally exempting them (if they can be described) from the requirement to equip stations for clean fuels. However, that could exempt a large fraction of all stations. Then, to ensure that a reasonable number of stations would carry clean fuels, the burden on larger retail owners might have to be increased. In the absence of evidence that it would be economically necessary to shift the burden from the small businesses, the staff rejects this alternative.

E. POTENTIAL EFFECTS OF CLEAN FUELS ON ENVIRONMENT AND SAFETY

This section discusses effects on the environment and on occupational or personal safety associated with the production and use of methanol, ethanol, alternative gasoline, LPG, CNG, and electricity. More data are available on the effects of methanol and M85 than on the others.

In considering the effects in California of the fuels that are alternatives to gasoline, it should be kept in mind that gasoline presents considerable hazards in its production, marketing, and use. To the degree that clean fuels displace gasoline, any undesirable effects of the clean fuels will at worst replace--not augment--the hazards of gasoline. Of particular note is that most of the emissions from producing clean fuels might occur mostly outside of California, whereas virtually all emissions from refining gasoline occur in California.

The proposed regulation would require the use of clean fuels in low-emission vehicles. This requirement would enable the use of vehicle/fuel systems that meet the proposed low emission standards. The resulting reduction in emissions have been shown in Table IX-1.

1. Methanol

Methanol may allow automakers to achieve low-emission standards more easily than gasoline. Modelling of ozone formation applied to emission data indicate that the reactivity (ozone-forming potential) of the emissions from methanol vehicles is lower than that of gasoline. In a flexible-fuel vehicle (FFV), the difference in emissions between methanol operation and gasoline operation would be limited by the standards imposed upon the FFV for certifying on gasoline.

Vehicular emissions of carbon dioxide (CO2) are lower from methanol than from gasoline. Methanol vehicles thus contribute less to "greenhouse" gas emissions than do gasoline vehicles. Using methanol also produces lower emissions of other pollutants thought to effect human health--such as peroxyacetyl nitrate (PAN) and photochemically generated particulate matter--and emissions of benzene, a toxic air contaminant. (AB 234, 1989)

Methanol has several potential drawbacks:

-- Emissions of formaldehyde may be greater from low-emission vehicles using methanol rather than gasoline. However, the degree of this problem is mitigated by the standard for formaldehyde as part of the draft low-emission vehicle standards.

-- The ingestion of small amounts of methanol can result in blindness or even death. The danger of poisoning could be alleviated with anti-siphon devices on vehicles.

-- Methanol can contaminate surface water or ground water supplies. It can diffuse through ground water faster than gasoline does. In general, aquatic life recovers faster from methanol spills than it does for oil spills (AB 234, 1989). Methanol is detectable in water and can be cleaned up, though the best methods of clean-up are not clear.

-- The inhalation of methanol vapors may pose a health threat. However, this appears to be less of a health threat than that posed by gasoline vapors. Methanol has not been identified as a carcinogen or a reproductive toxin.

-- Methanol burns with an invisible flame, making fire detection difficult. This problem is overcome by adding a luminosity additive. For example, M85 initially has a visible flame, although the visibility diminishes in time. A compensating feature of methanol is its lower flame temperature.

-- The manufacture of methanol from coal can produce more CO_2 than that emitted from the manufacture of gasoline. However, most methanol for vehicle fuel is expected to be made from natural gas. This mode of production produces less CO_2 than does gasoline production, and it could reduce the flaring of natural gas from foreign oil fields. Improving the efficiency of methanol production would reduce CO_2 emissions.

2. Ethanol

The potential emission benefits of ethanol as a vehicular fuel are not well characterized. As with methanol, any benefits from using ethanol would be manifested as ease in meeting the low-emission vehicle standards.

Ethanol is produced by distilling fermented vegetable matter. The choices of distillation technique and crops and the energy efficiency of farming affect the net CO_2 emissions from producing and using ethanol as a vehicular fuel. However, the production of ethanol causes, on a net basis, less greenhouse gas emissions than does the manufacture of gasoline. This is due, in part, to the CO_2 consumed by the plants grown to provide feedstock.

In general, ethanol is less toxic than methanol and does not appear to pose significant environmental and safty risks, especially when compared to gasoline and diesel fuel.

3. Reformulated Gasolines

Specific differences between conventional gasoline and Phase 2 or other future gasolines are not known. Therefore, the environmental and safety aspects of making or using new gasolines cannot be addressed now. In general, there is no reason to expect them to be significantly different than those of gasoline. Any increase in emissions from refining new gasolines should be small compared to the reductions in exhaust emissions that such gasoline would be designed to provide as a certification fuel.

4. Liquified Petroleum Gas (LPG)

Overall, it appears LPG would provide automakers with emission benefits (ease of meeting low-emission vehicle standards) comparable to those of methanol. Also, compared to methanol in low-emission vehicles, LPG would cause lower emissions of aldehydes. (Aldehydes are eye irritants and possible human carcinogens). LPG appears to pose fewer and less severe problems to the environment and public safety than do gasoline and methanol. It is non-toxic, insoluble in water, and odorized for leak detection.

LPG for vehicles would be produced from gas fields that will be operating regardless of demand for the LPG. Thus, major new sources of emissions should not occur. The total CO_2 emissions from using LPG may be slightly less than those from using gasoline. However, this matter has not been well studied.

LPG can pose a significant fire or explosion hazard in both its transport and its use in vehicles. However, it is already widely used as a vehicle fuel in the Unites States, without apparent problems.

5. Compressed Natural Gas (CNG)

CNG also appears to offer benefits to automakers in meeting the low-emission standards. CNG can produce lower reactivity-adjusted hydrocarbon emissions than do liquid fuels such a M85 and LPG. In addition, using CNG may cause substantially less CO_2 than does gasoline, both in its production and use. The magnitude of the effect depends upon the uncertain relationship between the effect of lower CO_2 emissions and higher methane (another greenhouse gas) emissions.

CNG appears to pose fewer and less severe problems to the environment and public safety than do gasoline and methanol. It is non-toxic, insoluble in water, and odorized for leak detection. It is distributed by pipeline, avoiding the danger of release in bulk during traffic accidents.

CNG, as a pressurized flammable gas, carries the potential for accidents during vehicle refueling and explosions during severe auto accidents. However, natural gas is less flammable than gasoline. Experience with CNG has not shown it to be more dangerous than gasoline as a vehicular fuel.

6. Electricity

Virtually no emissions are produced from electrically fueled vehicles.

The manufacture of electricity rather than gasoline to fuel low-emission vehicles could reduce emissions of greenhouse gases and of criteria pollutants if the electricity were produced by hydroelectric, solar, wind, or nuclear plants. If the electricity were produced by natural gas- or oil-fired power plants, emissions from those plants would increase. The net of reduced emissions at refineries and increases at natural gas-fired power plants has not been examined. An analysis might not be useful without knowledge of how much of the extra electricity would be from natural gas- or oil-fired plants.

The improper handling of spent batteries from electric vehicles could lead to contamination of water by hazardous metals. This problem would lessen as battery lifetimes increase.

7. Summary of Greenhouse Gas Emission Effects

Currently, emissions from the production, distribution, storage, and use of gasoline contribute significantly to emissions of greenhouse gases. Carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) are the greenhouse gases of most concern. The draft regulation does not address emissions of these gases directly. However, it is possible that by requiring the use of clean fuels, the regulation could indirectly change the overall emissions of greenhouse gases from the production, transport, and use of vehicular fuels.

Table IX-11 provides estimates of the warming potential of various fuels relative to that of gasoline. The warming potential is the total emissions from all phases of supplying and using a fuel, with emissions of all gases expressed as the amount of CO_2 equivalent in global warming effect.

There are several unresolved issues regarding emissions of the greenhouse gases:

-- Emissions resulting from the flaring of natural gas during the production of gasoline are still uncertain. The amount of gas vented directly to the atmosphere as CH_4 is not known precisely.

-- In the future, improvements in fuel economy may reduce the emission of greenhouse gases associated with any given fuel.

-- Various modeling studies of global warming show widely different warming effects for each greenhouse gas.

-- There is much uncertainty about the lifetimes of the greenhouse gas molecules in the atmosphere; so the assumption that emission rates translate directly to changes in atmospheric concentration may not be accurate.

-- Compounds other than CO_2, N_2O, and CH_4 may contribute to the greenhouse effect.

8. Ozone Depletion

The staff does not expect any effect on emissions of ozone-depleting gases by the use of clean fuels.

Table IX-12. Relative Global-Warming Emissions Due to Alternative Fuels

Fuel	Relative Global-Warming Emissions*
Gasoline	1.0
Methanol from Natural Gas	0.9
Ethanol	0.8
Compressed Natural Gas	0.8
Methanol from Coal	>1.0

* Carbon dioxide, methane, and nitrous oxide from typical production and distribution processes and from vehicles

Sources: Report to the Legislature--Executive Summary, California Advisory Board on Air Quality and Fuels, October 1989.

Comparing the Impacts of Different Transportation Fuels on the Greenhouse Effect, California Energy Commission, april 1989.

APPENDIX A-1: PRELIMINARY MAXIMUM INCREMENTAL REACTIVITIES

NMOG CONSTITUENT	MAXIMUM INCREMENTAL REACTIVITY ($g\ O_3/g$ NMOG)
Alkanes	
Methane	0.0102
Ethane	0.147
Propane	0.33
n-Butane	0.64
n-Pentane	0.64
n-Hexane	0.61
n-Heptane	0.48
n-Octane	0.41
n-Nonane	0.29
n-Decane	0.25
n-Undecane	0.21
n-Dodecane	0.19
n-Tridecane	0.17
n-Tetradecane	0.16
n-Pentadecane	0.144
Isobutane	0.85
Lumped C4-C5 Alkanes	0.78
Branched C5 Alkanes	0.88
Iso-Pentane	0.88
Neopentane	0.19
2-Methylpentane	0.91
3-Methylpentane	0.95
Branched C6 Alkanes	0.91
2,3-Dimethyl Butane	0.74
2,2-Dimethyl Butane	0.41
Lumped C6+ Alkanes	0.70
2,4-Dimethyl Pentane	1.07
3-Methyl Hexane	0.85
4-Methyl Hexane	0.85
Branched C7 Alkanes	0.85
2,3-Dimethyl Pentane	0.96
Iso-Octane	0.70
4-Methyl Heptane	0.72
Branched C8 Alkanes	0.72
Branched C9 Alkanes	0.68
4-Ethyl Heptane	0.68
Branched C10 Alkanes	0.60
4-Propyl Heptane	0.60
Branched C11 Alkanes	0.72
Branched C12 Alkanes	0.75
Branched C13 Alkanes	0.57
Branched C14 Alkanes	0.44
Branched C15 Alkanes	0.41

Alkanes (cont'd)

Cyclopentane	1.6
Methylcyclopentane	1.7
C6 Cycloalkanes	0.84
Cyclohexane	0.84
C7 Cycloalkanes	1.17
Methylcyclohexane	1.17
Ethylcyclohexane	1.36
C8 Cycloalkanes	1.36
C9 Cycloalkanes	1.6
C10 Cycloalkanes	1.31
C11 Cycloalkanes	1.23
C12 Cycloalkanes	1.20
C13 Cycloalkanes	0.94
C14 Cycloalkanes	0.88
C15 Cycloalkanes	0.85

Alkenes

Ethene	5.3
Propene	6.6
1-Butene	6.1
1-Pentene	4.2
1-Hexene	3.0
C6 Terminal Alkenes	3.0
C7 Terminal Alkenes	2.4
C8 Terminal Alkenes	1.9
C9 Terminal Alkenes	1.6
C10 Terminal Alkenes	1.32
C11 Terminal Alkenes	1.15
C12 Terminal Alkenes	1.03
C13 Terminal Alkenes	0.93
C14 Terminal Alkenes	0.86
C15 Terminal Alkenes	0.80
Isobutene	4.2
2-Methyl-1-Butene	3.7
3-Methyl-1-Butene	4.2
trans-2-Butene	7.3
cis-2-Butene	7.3
2-Methyl-2-Butene	5.0
C5 Internal Alkenes	6.2
2,3-Dimethyl-2-Butene	3.7

Alkenes (cont'd)

C6 Internal Alkenes	5.3
C7 Internal Alkenes	4.4
C8 Internal Alkenes	3.6
C9 Internal Alkenes	3.2
C10 Internal Alkenes	2.8
C11 Internal Alkenes	2.5
C12 Internal Alkenes	2.3
C13 Internal Alkenes	2.1
C14 Internal Alkenes	1.9
C15 Internal Alkenes	1.8
1,3-Butadiene	7.7
Isoprene	6.5
Cyclopentene	4.0
Cyclohexene	3.3
a-Pinene	1.9
b-Pinene	1.9

Aromatic Hydrocarbons

Benzene	0.28
Toluene	1.9
Ethyl Benzene	1.8
n-Propyl Benzene	1.44
Isopropyl Benzene	1.5
n-Butyl Benzene	1.29
C10 Monoalkyl Benzenes	1.28
C11 Monoalkyl Benzenes	1.16
C12 Monoalkyl Benzenes	1.06
m-Xylene	6.0
o-Xylene	5.2
p-Xylene	5.2
C9 Dialkyl Benzenes	5.3
C10 Dialkyl Benzenes	4.8
C11 Dialkyl Benzenes	4.3
C12 Dialkyl Benzenes	3.9
1,3,5-Trimethyl Benzene	7.5
1,2,3-Trimethyl Benzene	7.4
1,2,4-Trimethyl Benzene	7.4
C10 Trialkyl Benzenes	6.7
C11 Trialkyl Benzenes	6.1
C12 Trialkyl Benzenes	5.6
Tetralin	0.73
Naphthalene	0.87
Methyl Naphthalene	2.4
2,3-Dimethyl Naphthalene	3.7

Alkynes

Acetylene	0.37

Alcohols

Methanol	0.40
Ethanol	0.79
n-Propyl Alcohol	1.33
Isopropyl Alcohol	0.37
Isobutyl Alcohol	0.72
n-Butyl Alcohol	1.6
t-Butyl Alcohol	0.29
Ethylene Glycol	1.13
Propylene Glycol	0.92

Aldehydes

Formaldehyde	6.2
Acetaldehyde	3.8
Propionaldehyde	4.6

Ketones

Acetone	0.39
C4 Ketones	0.76

Aromatic Oxygenates

Benzaldehyde	-0.54
Phenol	0.79
Cresols	1.6

Ethers

Methyl t-Butyl Ether	0.47
Ethyl t-Butyl Ether	1.33

APPENDIX A-2: DATA USED TO CALCULATE WITHDRAWAL LIMITS AND CALMEAN FOR OFFSETTING FEDERAL VEHICLES

DATA USED TO CALCULATE WITHDRAWAL LIMITS AND CALMEAN
FOR PASSENGER CARS

	HC		NOx	
Model Year	Cal Std *	Fed Std	Cal Std *	Fed Std
1994	0.250	0.410	0.400	1.0
1995	0.231	0.410	0.400	1.0
1996	0.225	0.410	0.400	1.0
1997	0.202	0.410	0.346	1.0
1998	0.157	0.410	0.292	1.0
1999	0.113	0.410	0.242	1.0
2000	0.073	0.410	0.196	1.0
2001	0.070	0.410	0.190	1.0
2002	0.068	0.410	0.190	1.0
2003	0.062	0.410	0.180	1.0

1. Max % Withdrawal = [percent unavailable] $\dfrac{\text{Fed avg emission} - \text{Cal Mean}}{[\text{Cal Std} - \text{Cal Mean}]}$

2. percent unavailable for passenger cars is 2.5%

3. Fed Avg Emission = .8 x Fed Std

4. Cal Mean = .8 x Cal Std

5. Cal Std is the fleet average based on the proposed implementation schedule.
e.g. for 2003, the Cal NOx Std is calculated as follows:

$$\text{Cal Std} = \{.75\}\underbrace{(.20)}_{\text{LEV Std}} + \{.15\}\underbrace{(.20)}_{\text{ULEV Std}} + \{.10\}\underbrace{(0.0)}_{\text{ZEV Std}}$$

Where {} indicates proposed fractions to meet fleet average NMOG standards. The proposed standards and implementation schedule used in these calculations can be found in the Technical Support Document.

DATA USED TO CALCULATE WITHDRAWAL LIMITS AND CALMEAN FOR LIGHT-DUTY TRUCKS

Model Year	HC Cal Std *		HC Fed Std		CO Cal Std *		CO Fed Std		NOx Cal Std *		NOx Fed Std	
	T1	T2	T1	T2	T1	T2	T1	T2	T1	T2	T1	T2
1994	.250	.320	.41	.80	3.40	4.86	3.4	10	.400	.970	1.2	1.7
1995	.231	.295	.41	.80	3.40	4.40	3.4	10	.400	.955	1.2	1.7
1996	.225	.287	.41	.80	3.40	4.40	3.4	10	.400	.940	1.2	1.7
1997	.202	.260	.41	.80	3.37	4.36	3.4	10	.346	.838	1.2	1.7
1998	.157	.205	.41	.80	3.30	4.36	3.4	10	.292	.688	1.2	1.7
1999	.113	.150	.41	.80	3.30	4.36	3.4	10	.242	.538	1.2	1.7
2000	.073	.099	.41	.80	3.30	4.36	3.4	10	.196	.400	1.2	1.7
2001	.070	.098	.41	.80	3.15	4.29	3.4	10	.190	.400	1.2	1.7
2002	.068	.095	.41	.80	3.06	4.18	3.4	10	.190	.400	1.2	1.7
2003	.062	.093	.41	.80	2.81	4.07	3.4	10	.180	.400	1.2	1.7

1. $$\text{Max \% withdrawal} = \frac{P1 \times (F1 - C1) \; + \; P2 \times (F2 - C2)}{Q1 \times (R1 - C1) \; + \; Q2 \times (R2 - C2)}$$

T_1 = 0-3751 LDT
P1 = # unavailable T_1
Q1 = # available T_1
C1 = Cal Mean for T_1
R1 = Cal Std for T_1
F1 = Fed avg emission for T_1

T_2 = 3751-5750 LDT
P2 = # unavailable T_2
Q2 = # available T_2
C2 = Cal Mean for T_2
R2 = Cal Std for T_2
F2 = Fed avg emission for T_2

2. Based upon 1988 model-year California production:

	Total #	Unavailable	Available
T_1	350,000	10,500	339,500
T_2	208,000	31,200	145,000

3. Fed Avg Emission = .8 x Fed Std

4. Cal Mean = .8 x Cal Std

5. Cal Std is the fleet average based on the proposed implementation schedule.
e.g. for 2003, the T_2 Cal NOx Std is calculated as follows:

Cal Std = {.85}(.40) + {.15}(.40)
LEV Std ULEV Std

Where {} indicates proposed fractions to meet fleet average NMOG standards. The proposed standards and implementation schedule used in these calculations can be found in the Technical Support Document.

APPENDIX A-3: CALCULATION OF EMISSION INVENTORY

To determine the emission benefit from the proposed regulation, the following methodology was employed. First, emission factors were generated for TLEVs, LEVs, and ULEVs. These emission factors were combined (by model-year) with the baseline factors based on the implementation schedule outlined in Table A3-1. Fleet-weighted emission factors (baseline and including the effect of the proposal) were then calculated for the years 2000 and 2010 by applying the appropriate travel fraction to each model-year. Finally, the fleet-weighted emission factors were applied to inventory results (EMFAC7E/BURDEN7C) to generate tons per day (tpd) reductions for the South Coast Air Basin (SCAB) and the entire state. In the following pages, a complete description of the methodology used for the analysis is provided. Detailed summaries of the motor vehicle inventory and copies of the spreadsheets used to generate the emission benefits of the proposal may be obtained by contacting Steve Albu, Chief of the Engineering Studies Branch, at the following address and telephone number:

Air Resources Board
9528 Telstar Ave.
El Monte, California 91731
Telephone: (818) 575-7010

Table A3-1. Production Schedule for Light-Duty TLEVs, LEVs, ULEVs, and ZEVs Used in the Calculation of Emission Benefits

Model Year	TLEV Production	LEV Production	ULEV Production	ZEV Production
1994	10%	--	--	--
1995	10	--	1%	--
1996	10	--	1	--
1997	10	25%	1	--
1998	10	48	1	2%
1999	10	73	1	2
2000	--	96	2	2
2001	--	90	5	5
2002	--	85	10	5
2003+	--	75	15	10

B. PASSENGER CARS

1. Emission Factors for TLEVs, LEVs, and ULEVs

Under the staff's categorized emissions averaging approach, manufacturers may chose to sell any combination of TLEVs, LEVs, ULEVs, and ZEVs to meet NMOG fleet average standards for a given model-year. The fleet average standards for NMOG were calculated based on the schedule that the staff felt was reasonable to achieve. For calculating the emission inventories, the schedule shown in Table A3-1 was used. Although the implementation schedule was subsequently revised for TLEVs and ULEVs (see Table I-6 in Part A of this report), utilizing the new schedule for calculating the emission reductions was found to result in differences of only 1%. Therefore, the staff did not revise its calculations.

To develop the emission factors, the baseline emission factors for the 1995 and subsequent model years used in the EMFAC7E model (zero-mile level, ZM, and deterioration rate, DR) were adjusted by the ratio of the proposed standard (e.g., 0.075 g/mi NMOG for LEVs) to the existing standard (0.25 g/mi NMHC). A sample emission factor calculation for total organic gas (TOG) emissions is shown below for LEVs.

$$ZM_{LEV} = 0.184 * (0.075/0.25) = 0.055 \text{ g/mi}$$

$$DR_{LEV} = 0.030 * (0.075/0.25) = 0.009 \text{ (g/mi)/10,000 mi}$$

Table A3-2 contains the results of this analysis for TOG, CO, and NOx for TLEVs, LEVs, and ULEVs.

Table A3-2. Estimated In-Use Passenger Car Exhaust Emission Factors for TLEVs, LEVs, and ULEVs

	TOG		CO		NOx	
Vehicle	ZM*	DR*	ZM	DR	ZM	DR
Baseline	0.184	0.030	1.26	0.35	0.305	0.037
TLEV	0.092	0.015	1.26	0.35	0.305	0.037
LEV	0.055	0.009	1.26	0.35	0.153	0.019
ULEV	0.029	0.005	0.63	0.18	0.153	0.019

* Units: ZM [=] g/mi
DR [=] (g/mi)/10,000 mi

2. Fleet-Weighted Emission Factors

Fleet-weighted emission factors were then generated for the baseline case (0.25 g/mi NMHC standard) and including the effect of the proposed regulation. The baseline TOG fleet-weighted emission factor for the year 2000 was calculated as shown in Figure A3-1. The model-year specific emission rates were calculated by applying the estimated odometer reading to the existing emission factor (DR and ZM); these were then weighted according to the estimated travel fraction for each model-year (column labeled "VMT SPLIT" in the figure). As seen in the figure, the year 2000 fleet-weighted TOG emission factor for PCs is 0.571 g/mi.

To include the effect of the regulation, the emission factors contained in Table A3-2 were combined with the baseline emission factors in a single spreadsheet. Each category of vehicle (0.25 NMHC, TLEV, LEV, ULEV, and ZEV) was weighted by model-year according to the implementation schedule outlined in Table A3-1. Each model-year emission factor was also weighted according to its estimated travel fraction for that year. For example, Figure A3-2 is a spreadsheet used to develop the fleet-weighted TOG emission factor for the year 2000 (including the effects of the regulation). The results of this analysis for TOG, CO, and NOx for the years 2000 and 2010 are summarized in Table A3-3.

Table A3-3. Passenger Car Fleet-Weighted Exhaust Emission Factors for Baseline and Low-Emission Vehicle Scenarios (g/mi)

Scenario	Year 2000 TOG	Year 2000 CO	Year 2000 NOx	Year 2010 TOG	Year 2010 CO	Year 2010 NOx
Baseline	0.571	6.79	0.677	0.403	3.90	0.562
Low-Emission Veh.	0.525	6.77	0.635	0.169	3.52	0.321

3. Tonnage Estimates

Next, baseline emission estimates for passenger cars (PCs) in the SCAB and the state were multiplied by the ratio of the low-emission vehicles to baseline fleet-weighted emission factors calculated above. This calculation provides the resulting emissions (in tons per day) with the regulation in place. A sample calculation is shown below for NOx in the SCAB for the year 2000.

$$NOx_{2000} = 161 \text{ tpd} * [(0.635 \text{ g/mi})/(0.677 \text{ g/mi})]$$

Figure A3-1

Spreadsheet Used to Develop Baseline Fleet-Weighted Emission Factor

TOG
2000 COMPOSITE EMISSION FACTORS--CAT PC

YEAR	VMT SPLIT	AVE ODO	ZM	DR	EF	WTD EF
2000	.06533	4919	.184	.030	.199	.013
1999	.09871	16198	.184	.030	.233	.023
1998	.10047	28439	.184	.030	.269	.027
1997	.09692	40019	.184	.030	.304	.029
1996	.08982	50973	.184	.030	.337	.030
1995	.07928	61355	.184	.030	.368	.029
1994	.07175	71137	.208	.034	.450	.032
1993	.06503	80408	.267	.044	.621	.040
1992	.05895	89178	.314	.050	.760	.045
1991	.05220	97474	.314	.050	.801	.042
1990	.04710	105322	.314	.050	.841	.040
1989	.04020	112745	.310	.052	.896	.036
1988	.03192	119766	.308	.054	.955	.030
1987	.02429	126409	.310	.054	.993	.024
1986	.02085	132692	.315	.054	1.032	.022
1985	.01550	138635	.320	.055	1.082	.017
1984	.01129	144257	.325	.059	1.176	.013
1983	.00797	149575	.319	.095	1.740	.014
1982	.00504	154605	.326	.105	1.949	.010
1981	.00351	159363	.328	.092	1.794	.006
1980	.00299	163934	.342	.165	3.047	.009
1979	.00264	168496	.369	.162	3.099	.008
1978	.00283	173058	.394	.155	3.076	.009
1977	.00275	177620	.424	.147	3.035	.008
1976	.00266	182182	.322	.273	5.296	.014
			FLEET-WEIGHTED EMISSION FACTOR:			.571

Figure A3-2

Spreadsheet Used to Develop Fleet-Weighted Emission Factor Including The Effects of the Clean Fuels Regulation

TOC
2000 COMPOSITE EMISSION FACTORS—CAT PC

			CERTIFIED TO .25/.39 HC				TLEV				LEV				ULEV				ZEV		MODEL YEAR EF	WEIGHTED EMISSION FACTOR
YEAR	VMT SPLIT	AVE ODO	WT	ZM	DR	EF	WT	ZM	DR	EF	WT	ZM	DR	EF	WT	ZM	DR	EF	WT	EF		
2000	.06533	4919	.00	.184	.030	.199	.00	.092	.015	.099	.96	.055	.009	.059	.02	.029	.005	.031	.02	.0	.058	.004
1999	.09871	16198	.14	.184	.030	.233	.10	.092	.015	.116	.73	.055	.009	.070	.01	.029	.005	.037	.02	.0	.095	.009
1998	.10047	28439	.39	.184	.030	.269	.10	.092	.015	.135	.48	.055	.009	.081	.01	.029	.005	.043	.02	.0	.158	.016
1997	.09692	40019	.64	.184	.030	.304	.10	.092	.015	.152	.25	.055	.009	.091	.01	.029	.005	.049	.00	.0	.233	.023
1996	.08982	50973	.89	.184	.030	.337	.10	.092	.015	.168	.00	.055	.009	.101	.01	.029	.005	.054	.00	.0	.317	.028
1995	.07928	61355	.89	.184	.030	.368	.10	.092	.015	.184	.00	.055	.009	.110	.01	.029	.005	.060	.00	.0	.347	.027
1994	.07175	71137	.90	.208	.034	.450	.10	.092	.015	.199	.00	.055	.009	.119	.00	.029	.005	.065	.00	.0	.425	.030
1993	.06503	80408	1.00	.267	.044	.621	.00	.092	.015	.213	.00	.055	.009	.127	.00	.029	.005	.069	.00	.0	.621	.040
1992	.05895	89178	1.00	.314	.050	.760	.00	.092	.015	.226	.00	.055	.009	.135	.00	.029	.005	.074	.00	.0	.760	.045
1991	.05220	97474	1.00	.314	.050	.801	.00	.092	.015	.238	.00	.055	.009	.143	.00	.029	.005	.078	.00	.0	.801	.042
1990	.04710	105322	1.00	.314	.050	.841	.00	.092	.015	.250	.00	.055	.009	.150	.00	.029	.005	.082	.00	.0	.841	.040
1989	.04020	112745	1.00	.310	.052	.896	.00	.092	.015	.261	.00	.055	.009	.156	.00	.029	.005	.085	.00	.0	.896	.036
1988	.03192	119766	1.00	.308	.054	.955	.00	.092	.015	.272	.00	.055	.009	.163	.00	.029	.005	.089	.00	.0	.955	.030
1987	.02429	126409	1.00	.310	.054	.993	.00	.092	.015	.282	.00	.055	.009	.169	.00	.029	.005	.092	.00	.0	.993	.024
1986	.02085	132692	1.00	.315	.054	1.032	.00	.092	.015	.291	.00	.055	.009	.174	.00	.029	.005	.095	.00	.0	1.032	.022
1985	.01550	138635	1.00	.320	.055	1.082	.00	.092	.015	.300	.00	.055	.009	.180	.00	.029	.005	.098	.00	.0	1.082	.017
1984	.01129	144257	1.00	.325	.059	1.176	.00	.092	.015	.308	.00	.055	.009	.185	.00	.029	.005	.101	.00	.0	1.176	.013
1983	.00797	149575	1.00	.319	.095	1.740	.00	.092	.015	.316	.00	.055	.009	.190	.00	.029	.005	.104	.00	.0	1.740	.014
1982	.00504	154605	1.00	.328	.105	1.949	.00	.092	.015	.324	.00	.055	.009	.194	.00	.029	.005	.106	.00	.0	1.949	.010
1981	.00351	159363	1.00	.328	.092	1.794	.00	.092	.015	.331	.00	.055	.009	.198	.00	.029	.005	.109	.00	.0	1.794	.006
1980	.00299	163834	1.00	.342	.165	3.047	.00	.092	.015	.338	.00	.055	.009	.203	.00	.029	.005	.111	.00	.0	3.047	.009
1979	.00264	168496	1.00	.369	.162	3.079	.00	.092	.015	.345	.00	.055	.009	.207	.00	.029	.005	.113	.00	.0	3.079	.008
1978	.00283	173058	1.00	.394	.155	3.076	.00	.092	.015	.352	.00	.055	.009	.211	.00	.029	.005	.116	.00	.0	3.076	.009
1977	.00275	177620	1.00	.424	.147	3.035	.00	.092	.015	.358	.00	.055	.009	.215	.00	.029	.005	.118	.00	.0	3.035	.008
1976	.00266	182182	1.00	.322	.273	5.296	.00	.092	.015	.365	.00	.055	.009	.219	.00	.029	.005	.120	.00	.0	5.296	.014

FLEET-WEIGHTED EMISSION FACTOR: .525

07570

NOx_{2000} = 151 tpd

(Note that 161 tpd represents NOx emissions only from catalyst-equipped PCs. In the year 2000 there will be a small contribution of 3 tpd from non-catalyst and diesel PCs. However, the ratio is only applied to the catalyst PC category since this is the only category affected by the proposal.

Baseline estimates and the results of this analysis for NMOG, CO, and NOx in the years 2000 and 2010 are summarized in Tables A3-4 and A3-5 for the SCAB and the state, respectively. As can be seen, the passenger car inventory for the SCAB in the year 2010 would be reduced by 33, 10, and 42 percent for NMOG, CO, and NOx, respectively, with similar reductions on a statewide basis.

Table A3-4. Passenger Car Emission Reductions from the Low-Emission Vehicle Proposal in the South Coast Air Basin (tpd)*

	Year 2000			Year 2010		
Scenario	NMOG	CO	NOx	NMOG	CO	NOx
Baseline	156	1267	164	138	818	154
Low-Emission Veh.	148	1263	154	92	738	89

* These values include emissions from noncatalyst and diesel vehicles which are not affected by this proposal. The NMOG numbers include evaporative emissions which are also not affected by this proposal.

Table A3-5. Passenger Car Emission Reductions from the Low-Emission Vehicle Proposal on a Statewide Basis (tpd)

	Year 2000			Year 2010		
Scenario	NMOG	CO	NOx	NMOG	CO	NOx
Baseline	392	3287	406	352	2142	372
Low-Emission Veh.	373	3278	381	237	1939	216

* These values include emissions from noncatalyst and diesel vehicles which are not affected by this proposal. The NMOG numbers include evaporative emissions which are also not affected by this proposal.

C. LIGHT-DUTY TRUCKS

The methodology outlined above was also used to generate the benefit for LDTs. Although implementation rates for the introduction of these vehicles were assumed to be the same as for PCs, the standards for the heavier LDTs are slightly different. For LDTs under 3750 lbs. loaded vehicle weight (LVW), the standards are the same as for the corresponding PCs; however, the standards for LDTs from 3751 to 5750 lbs. LVW have been modified as discussed elsewhere in this document.

Emission factors for the LDTs were estimated by assuming a sales split of 70 percent/30 percent for LDTs under 3750 lbs. and between 3751 and 5750 lbs., respectively. The results of this analysis are shown in Table A3-6. Fleet-weighted emission factors were then generated as outlined above. The results of these calculations are given in Table A3-7. Finally, these factors were applied to inventory results to obtain tonnage estimates for this vehicle category for the SCAB and the state in the years 2000 and 2010. These results are presented in Table A3-8 for the SCAB and Table A3-9 for the state.

Table A3-6. Estimated In-Use Light-Duty Truck Exhaust Emission Factors for TLEVs, LEVs, and ULEVs

Vehicle	TOG		CO		NOx	
	ZM*	DR*	ZM	DR	ZM	DR
Baseline	0.212	0.035	1.68	0.41	0.473	0.054
TLEV	0.105	0.017	1.68	0.41	0.473	0.054
LEV	0.065	0.011	1.68	0.41	0.251	0.029
ULEV	0.034	0.006	0.84	0.21	0.251	0.029

* Units: ZM [=] g/mi
DR [=] (g/mi)/10,000 mi

Table A3-7. Light-Duty Truck Fleet-Weighted Exhaust Emission Factors for Baseline and Low-Emission Vehicle Scenarios (g/mi)

Scenario	Year 2000 TOG	Year 2000 CO	Year 2000 NOx	Year 2010 TOG	Year 2010 CO	Year 2010 NOx
Baseline	0.658	8.12	0.905	0.486	5.02	0.878
Low-Emission Veh.	0.603	8.09	0.843	0.190	4.49	0.497

Table A3-8. Light-Duty Truck Emission Reductions from the Low-Emission Vehicles Proposal in the South Coast Air Basin (tpd)*

Scenario	Year 2000 NMOG*	Year 2000 CO	Year 2000 NOx	Year 2010 NMOG*	Year 2010 CO	Year 2010 NOx
Baseline	45.1	382	58.9	43.3	289	69.3
Low-Emission Veh.	42.6	381	54.9	26.5	259	39.5

* These values include emissions from noncatalyst and diesel vehicles which are not affected by this proposal. The NMOG numbers include evaporative emissions which are also not affected by this proposal.

Table A3-9. Light-Duty Truck Emission Reductions from the Low-Emission Vehicle Proposal on a Statewide Basis (tpd)*

Scenario	Year 2000 NMOG	Year 2000 CO	Year 2000 NOx	Year 2010 NMOG	Year 2010 CO	Year 2010 NOx
Baseline	127	1152	167	121	858	190
Low-Emission Veh.	120	1148	156	74	768	108

* These values include emissions from noncatalyst and diesel vehicles which are not affected by this proposal. The NMOG numbers include evaporative emissions which are also not affected by this proposal.

D. MEDIUM-DUTY VEHICLES (6001 to 8500 lbs. GVW)

The medium-duty class of vehicles has been segregated into those vehicles from 6001 to 8500 lbs. gross vehicle weight (GVW) and those from 8501 to 14,000 lbs. GVW. This breakdown was necessary because the inventory model, EMFAC7E, considers vehicles from 6001 to 8500 lbs. GVW as medium-duty vehicles (MDV), and those over 8500 lbs. GVW as heavy-duty vehicles (HDV). This creates some inconsistencies because the emission standards are based on "test weight." In the analysis that follows, every attempt has been made to keep the test weight categories in the proper GVW range.

The breakdown of MDVs in the 6001 to 8500 lbs. GVW range were assumed to be 50 percent in the 3751 to 5750 lbs. test weight category and 50 percent in the 5751 to 8500 test weight category. Thus, "effective" certification standards were generated for the MDVs as a whole by applying these percentages to the standards outlined in Part A. The results are given in Table A3-10. Also shown in Table A3-10 are the effective standards from the MDV Proposal adopted by the Board in June, 1990. These are represented by the '95 Conventional category.

Table A3-10. "Effective" Certification Standards for Medium-Duty Vehicles (6001 to 8500 lbs. GVW, g/mi at 50,000 Miles)

Vehicle	NMOG	CO	NOx
Current	0.55	9.0	1.25
'95 Conv.	0.36	4.7	0.9
LEV	0.18	4.7	0.9
ULEV	0.11	2.4	0.5

The in-use emission factors for the MDVs were then estimated by adjusting the LDT emission factors by the ratio of the appropriate standards. For example, the 1995 and subsequent TOG in-use emission factor for LDTs is 0.212 + 0.035M. This value is based on an effective certification standard of 0.27 g/mi. Thus, the MDV LEV emission factor for TOG would be:

$$ZM_{LEV} = 0.212 * (0.18/0.27) = 0.141 \text{ g/mi}$$

$$DR_{LEV} = 0.035 * (0.18/0.27) = 0.023 \text{ (g/mi)/10,000 mi}$$

The results of this analysis for TOG, CO, and NOx are given in Table A3-11. (LDT emission factors were used as the basis of calculation because these numbers are developed with more surveillance data than the MDV baseline emission factors. Thus, it was felt that the LDT emission factors were more appropriate for this use).

Table A3-11. Estimated In-Use Medium-Duty Truck (6001 to 8500 lbs. GVW) Exhaust Emission Factors for Conventional Vehicles Beginning in 1995, LEVs, and ULEVs

	TOG		CO		NOx	
Vehicle	ZM*	DR*	ZM	DR	ZM	DR
Baseline	0.318	0.051	3.71	0.67	0.784	0.078
'95 Conv.	0.283	0.047	2.13	0.52	0.734	0.084
LEV	0.141	0.023	2.13	0.52	0.734	0.084
ULEV	0.086	0.014	1.09	0.27	0.408	0.047

* Units: ZM [=] g/mi
DR [=] (g/mi)/10,000 mi

Fleet-weighted emission factors were then generated using the implementation schedule outlined in Table A3-12, and the results are summarized in Table A3-13. Finally, tonnage estimates for this vehicle category were calculated and are shown in Table A3-14 and A3-15 for the SCAB and the state, respectively.

Table A3-12. Production Schedule for Medium-Duty LEVs and ULEVs

Model Year	LEV Production	ULEV Production
1998	25%	2%
1999	50	2
2000	75	2
2001	95	5
2002	90	10
2003	85	15

Table A3-13. **Medium-Duty Truck (6001 to 8500 lbs. GVW) Fleet-Weighted Exhaust Emission Factors for Baseline, MDV Proposal, and Low-Emission Vehicle Scenarios (g/mi)**

Scenario	Year 2000 NMOG	Year 2000 CO	Year 2000 NOx	Year 2010 NMOG	Year 2010 CO	Year 2010 NOx
Baseline	0.743	9.36	1.32	0.676	8.45	1.32
MDV Proposal	0.712	8.02	1.30	0.619	6.03	1.31
Low-Emission Veh.	0.676	8.01	1.30	0.355	5.74	1.25

Table A3-14. **Medium-Duty Truck (6001 to 8500 lbs. GVW) Emission Reductions from the MDV and Low-Emission Vehicle Proposals in the South Coast Air Basin (tpd)***

Scenario	Year 2000 NMOG	Year 2000 CO	Year 2000 NOx	Year 2010 NMOG	Year 2010 CO	Year 2010 NOx
Baseline	19.2	146	30.4	19.4	152	35.1
MDV Proposal	18.6	126	30.0	18.1	108	34.8
Low-Emission Veh.	18.0	126	30.0	12.3	103	33.2

* These values include emissions from noncatalyst vehicles which are not affected by this proposal. The NMOG numbers include evaporative emissions which are also not affected by this proposal.

Table A3-15. **Medium-Duty Truck (6001 to 8500 lbs. GVW) Emission Reductions from the MDV and Low-Emission Vehicle Proposals on a Statewide Basis (tpd).***

Scenario	Year 2000 NMOG	Year 2000 CO	Year 2000 NOx	Year 2010 NMOG	Year 2010 CO	Year 2010 NOx
Baseline	50.8	426	82.4	51.0	442	91.6
MDV Proposal	49.3	368	81.2	47.7	315	90.9
Low-Emission Veh.	47.5	367	81.2	32.4	300	86.7

* These values include emissions from noncatalyst vehicles which are not affected by this proposal. The NMOG numbers include evaporative emissions which are also not affected by this proposal.

E. MEDIUM-DUTY VEHICLES (8501 to 14,000 lbs. GVW)

As alluded to above, the medium-duty category of vehicles has recently been redefined to include vehicles up to 14,000 lbs. Thus, in determining the emissions benefit of the Low-Emission Vehicles/Clean Fuels Regulation, a portion of this vehicle class had to be included in the heavy-duty truck (HDT) category, and it was necessary to derive HDT emission factors both with and without the effects of the proposed regulation.

Emission factors for heavy-duty vehicles are generally expressed in terms of grams per brake-horsepower-hour (g/BHP-hr). Since emission factors models require emissions input as g/mi, conversion factors have been developed to represent the g/BHP-hr values as g/mi. The conversion factors are a strong function of GVW and historically have been based on the following weight classifications:

Classification	GVW (lbs.)
Light Heavy-Duty (LHD)	8501 to 14,000
Medium Heavy-Duty (MHD)	14,001 to 33,000
Heavy Heavy-Duty (HHD)	> 33,000

The conversion factors for each classification are weighted by sales and VMT and then applied to the appropriate g/BHP-hr emission factors to obtain g/mi emission factors for gasoline- and diesel-fueled heavy-duty vehicles.

In the analysis that follows, g/mi emission factors were individually calculated for each weight classification. The LHD class was then modified to reflect the proposed emission standards, and a composite value was obtained by weighting the g/mi emission factors by sales and VMT. Once the composite values were estimated, the procedure outlined above was used to obtain emission benefits for the years 2000 and 2010.

1. Gasoline-Fueled MDVs (8500 to 14,000 lbs. GVW)

The development of heavy-duty emission factors has been discussed in detail in <u>Update of Heavy-Duty Truck Emission Factors</u> (ARB, December 1989). Using the conversion and emission factors presented in that document, the weight-specific emission factors (ZM and DR, g/mi basis) were calculated as shown in Table A3-16 for gasoline-fueled vehicles. The heavy-duty (greater than 8500 lbs. GVW) gasoline-fueled vehicles are primarily in the LHD classification with a small number of MHDs and no HHDs. On a sales-weighted basis, the LHD vehicles account for 91 percent of the VMT, while MHD vehicles account for 9 percent of the VMT. Thus, emission factors (ZM and DR) were weighted by these percentages in determining a baseline composite emission factor for the heavy-duty gasoline-fueled vehicles. The result of this calculation is also shown in Table A3-16.

Table A3-16. **Baseline Heavy-Duty Gasoline Emission Factors**

Vehicle	TOG ZM*	TOG DR*	CO ZM	CO DR	NOx ZM	NOx DR
LHD	.885	.08	11.92	.53	3.6	.09
MHD	1.39	.126	18.72	.82	5.66	.142
WTD GAS	.930	.084	12.53	.56	3.79	.095

* Units: ZM [=] g/mi
DR [=] (g/mi)/10,000 mi

Once the baseline composite heavy-duty emission factors were determined, the LHD class-specific emission factors were modified to reflect the change in certification standards. As outlined in Part A, vehicles in the 8501 to 10,000 lbs. GVW range will have different standards than the 10,001 to 14,000 lbs. GVW range. Through workshops and in meetings with manufacturers it was found that the 8501 to 10,000 lbs. GVW range accounts for approximately 90 percent of the gasoline LHD category with the remaining sales (10 percent) in the 10,001 to 14,000 range. Thus, "effective" standards were estimated for the LHD class as a whole by applying these percentages to the '95 Conv., LEV, and ULEV standards. The results of this calculation are given in Table A3-17.

Table A3-17. **"Effective" Certification Standards for LHD Gasoline Vehicles (g/mi at 50,000 Miles)**

Vehicle	NMOG	CO	NOx
Current*	0.82	13.1	4.55
'95 Conv.	0.47	5.7	1.4
LEV	0.24	5.7	1.4
ULEV	0.14	2.9	0.7

* Current standards (g/mi) were estimated by applying a conversion factor of 0.91 to the existing g/BHP-hr standards.

Using the effective standards generated above, the current light-duty truck emission factors were modified to represent in-use emission factors for the LHD category. (Light-duty truck emission factors were used as the basis for calculation because they have been developed from test data generated on a chassis dynamometer. The existing LHD emission factors have been developed from engine dynamometer testing with a conversion factor applied to give g/mi emission estimates). As discussed above for light-duty vehicles, the baseline emission factors were multiplied by the ratio of the appropriate standards to obtain estimates of emission rates with the standard in effect. For example, the in-use baseline TOG emission factor for LDTs is 0.212 + 0.035M. The effective LDT NMHC standard is 0.27 g/mi, and the effective LHD LEV standard is 0.24 g/mi. Thus, the in-use LEV TOG emission factor would be:

$$ZM = 0.212 * (0.24/0.27) = 0.188 \text{ g/mi}$$

$$DR = 0.035 * (0.24/0.27) = 0.031 \text{ (g/mi)/10,000 mi}$$

This calculation was performed for all vehicle categories ('95 Conv., LEV, and ULEV), and the results are given in Table A3-18.

Table A3-18. In-Use Emission Factors for LHD Gasoline Vehicles by Vehicle Category

	TOG		CO		NOx	
Vehicle	ZM*	DR*	ZM	DR	ZM	DR
Current	0.885	0.080	11.92	0.53	3.60	0.090
'95 Conv.	0.369	0.061	2.58	0.63	1.14	0.13
LEV	0.188	0.031	2.58	0.63	1.14	0.13
ULEV	0.110	0.018	1.31	0.32	0.56	0.064

* Units: ZM [=] g/mi
DR [=] (g/mi)/10,000 mi

Composite heavy-duty gasoline emission factors for the various vehicle categories were then calculated by combining the LHD factors shown in Table A3-18 with the baseline MHD emission factors shown in Table A3-16. As with the baseline composite numbers, these were weighted 91 percent LHD and 9 percent MHD. The results of this analysis are given in Table A3-19. Finally, fleet-weighted emission factors were generated for the years 2000 and 2010. A similar methodology was used as described above for light-duty vehicles and detailed in Figures 1 and 2. The results of the analysis are summarized in Table A3-20. The fleet-weighted emission factors were then applied to inventory results to obtain tonnage estimates for this vehicle class. These are summarized in Tables A3-21 and A3-22 for the SCAB and the state, respectively.

Table A3-19. In-Use Emission Factors for Heavy-Duty Gasoline Vehicles by Vehicle Category*

	TOG		CO		NOx	
Vehicle	ZM**	DR**	ZM	DR	ZM	DR
Baseline	0.930	0.080	11.92	0.53	3.60	0.090
'95 Conv.	0.461	0.067	4.03	0.65	1.55	0.131
LEV	0.297	0.040	4.03	0.65	1.55	0.131
ULEV	0.225	0.028	2.88	0.37	1.02	0.071

* Because of rounding differences and the application of I/M credits to the baseline numbers shown here, these baseline emission factors are slightly lower than the published EMFAC7E gasoline heavy-duty emission factors. Thus, all emission factors have been adjusted upward to maintain consistency with the EMFAC7E model.

** Units: ZM [=] g/mi
DR [=] (g/mi)/10,000 mi

Table A3-20. Heavy-Duty Gasoline Vehicle Fleet-Weighted Emission Factors for Baseline, MDV Proposal, and Low-Emission Vehicle Scenarios (g/mi)

	Year 2000			Year 2010		
Scenario	TOG	CO	NOx	TOG	CO	NOx
Baseline	1.73	17.69	4.66	1.82	18.28	4.75
'95 Conv.	1.28	12.26	3.30	1.20	10.26	2.80
Clean Fuels	1.25	12.24	3.30	0.85	9.92	2.69

Table A3-21. **Heavy-Duty Gasoline Vehicle Emission Reductions from the Low-Emission Vehicle and MDV Proposals in the South Coast Air Basin (tpd)***

Scenario	Year 2000 NMOG	CO	NOx	Year 2010 NMOG	CO	NOx
Baseline	14.6	200	57.7	14.5	156	67.4
MDV Proposal	12.9	169	44.7	11.4	96	43.0
Low-Emission Veh.	12.8	169	44.7	9.7	93	41.6

* These values include emissions from noncatalyst vehicles which are not affected by this proposal. The NMOG numbers include evaporative emissions which are also not affected by this proposal.

Table A3-22. **Heavy-Duty Gasoline Vehicle Emission Reductions from the Low-Emission Vehicle and MDV Proposals on a Statewide Basis (tpd)**

Scenario	Year 2000 NMOG	CO	NOx	Year 2010 NMOG	CO	NOx
Baseline	36.7	527	161	37.6	525	195
'95 Conv.	32.5	445	125	29.8	362	124
Low-Emission Veh.	32.2	445	125	25.4	355	120

* These values include emissions from noncatalyst vehicles which are not affected by this proposal. The NMOG numbers include evaporative emissions which are also not affected by this proposal.

2. Diesel-Fueled MDVs (8500 to 14,000 lbs. GVW)

As with the gasoline-fueled vehicles in this weight range, it was necessary to modify the existing heavy-duty diesel emission factors to estimate a benefit for the proposed regulation. For diesel-fueled vehicles, a smaller percentage are in the LHD category. On a sales-weighted VMT basis, LHDs account for 19.4 percent of heavy-duty diesel vehicles, MHDs account for 19.9 percent, and HHDs account for 60.7 percent. Again using data presented in Update of Heavy-Duty Truck Emission Factors, separate g/mi emission factors were developed for the three weight classes. These are shown in Table A3-23 along with the composite value. Also included in the composite emission factors is an assumed tampering offset.

Table A3-23. Baseline Heavy-Duty Diesel Emission Factors (Including an Offset for Tampering).

	TOG		CO		NOx		PM	
Vehicle	ZM*	DR*	ZM	DR	ZM	DR	ZM	DR
LHD	1.47	0.018	7.11	0.06	5.97	0.030	0.137	0.017
MHD	2.16	0.028	10.53	0.09	8.84	0.045	0.203	0.025
HHD	2.52	0.031	12.31	0.11	10.34	0.053	0.237	0.029
WTD	2.24	0.028	10.93	0.10	9.18	0.047	0.211	0.026
TMPR	20.8%		0		12.0%		85.3%	
WTD	2.71	0.028	10.93	0.10	10.28	0.047	0.390	0.026

* Units: ZM [=] g/mi
DR [=] (g/mi)/10,000 mi

"Effective" standards were then estimated for the LHD category as a whole. Unlike the gasoline-fueled vehicles in this weight range, there were no data available to determine the appropriate split between the 8500 to 10,000 lbs. GVW range and the 10,000 to 14,000 lbs. GVW range. Therefore staff assumed a 50/50 split between these categories. This seemed more reasonable than the 90/10 split used for gasoline-fueled vehicles because diesel-fueled vehicles are typically used in the higher weight classes. Using the 50/50 split, effective standards were generated and are given in Table A3-24.

Table A3-24. "Effective" Certification Standards for LHD Diesel Vehicles (g/mi)*

Vehicle	NMOG	CO	NOx	PM
Current**	1.82	23.6	7.6	0.152
'95 Conv.	0.53	6.3	1.65	0.165
LEV	0.27	6.3	1.65	0.135
ULEV	0.16	3.15	0.85	0.07

* NMOG, CO, and NOx are 50,000-mile standards; PM is a 120,000-mile standard.
** Current standards (g/mi) were estimated by applying a conversion factor of 1.52 to the existing 100,000-mile g/BHP-hr standards.

The LHD diesel emission factors were then modified to reflect the effects of the proposed regulation. The assumed emission rates for TOG and NOx were based on the emission rates of gasoline-fueled vehicles by applying the ratio of the appropriate standards. Using gasoline data to represent emissions from diesel-fueled vehicles is not generally a very sound approach. However, to achieve the emission levels outlined in this proposal it would be necessary for manufacturers to add components such as trap/oxidizers and EGR systems. The result of this would be lower initial emission levels but higher deterioration rates. Since data do not exist to adequately represent in-use performance of these components applied to diesel engines, staff felt that using data from gasoline-fueled vehicles (which have higher deterioration rates) would be the most reasonable approach for TOG and NOx emission factors.

The CO emission rates from diesel-fueled vehicles are inherently low, and the current in-use levels are roughly the same as the LEV standard. Thus, no change was made to the CO emission factors for LEVs. For ULEVs the CO standard is halved; thus, the ZM level has been halved to represent this change. Finally, current PM emission factors were developed with the assumption that traps would be necessary. Thus, the current PM emission factors were simply adjusted based on the ratio of the appropriate standards. Table A3-25 summarizes the results of this analysis for the LHD weight class.

Table A3-25. In-Use Emission Factors for LHD Diesel Vehicles by Vehicle Category

	TOG		CO		NOx		PM	
Vehicle	ZM*	DR*	ZM	DR	ZM	DR	ZM	DR
Current	1.47	0.018	7.11	0.06	5.97	0.03	0.137	0.017
'95 Conv.	0.42	0.070	7.11	0.06	1.35	0.15	0.137	0.017
LEV	0.21	0.035	7.11	0.06	1.35	0.15	0.122	0.015
ULEV	0.13	0.021	3.5	0.06	0.7	0.08	0.064	0.01

* Units: ZM [=] g/mi
DR [=] (g/mi)/10,000 mi

These LHD emission factors were combined with the MHD and HHD categories using the same percentages as those used for the baseline numbers. The composite heavy-duty diesel emission factors are listed in Table A3-26. Finally, fleet-weighted emission factors were generated for the years 2000 and 2010 using the methodology outlined above for light-duty vehicles. The results of this analysis are shown in Table A3-27. These numbers were applied to inventory results to obtain tonnage estimates for this vehicle class which are summarized in Tables A3-28 and A3-29 for the SCAB and the state, respectively.

Table A3-26. In-Use Emission Factors for Heavy-Duty Diesel Vehicles by Vehicle Category

	TOG		CO		NOx		PM	
Vehicle	ZM*	DR*	ZM	DR	ZM	DR	ZM	DR
Baseline	2.71	0.028	10.93	0.10	10.28	0.47	0.39	0.026
'95 Conv.	2.46	0.038	10.93	0.10	9.28	0.070	0.39	0.026
LEV	2.41	0.031	10.93	0.10	9.28	0.070	0.38	0.025
ULEV	2.39	0.028	10.23	0.10	9.13	0.057	0.36	0.024

* Units: ZM [=] g/mi
DR [=] (g/mi)/10,000 mi

Table A3-27. Heavy-Duty Diesel Vehicle Fleet-Weighted Emission Factors for Baseline, MDV Proposal, and Low-Emission Vehicle Scenarios (g/mi)

	Year 2000				Year 2010			
Scenario	TOG	CO	NOx	PM	TOG	CO	NOx	PM
Baseline	3.31	13.44	12.23	1.46	3.22	13.18	11.63	1.05
'95 Conv.	3.22	13.44	11.82	1.46	3.12	13.18	11.14	1.05
Clean Fuels	3.20	13.44	11.82	1.45	2.99	13.10	11.10	1.02

Table A3-28. **Heavy-Duty Diesel Vehicle Emission Reductions from the Low-Emission Vehicle and MDV Proposals in the South Coast Air Basin (tpd)**

Scenario	Year 2000 NMOG	Year 2000 CO	Year 2000 NOx	Year 2000 PM	Year 2010 NMOG	Year 2010 CO	Year 2010 NOx	Year 2010 PM
Baseline	20.2	84.6	123	14.1	23.3	98.7	139	12.1
MDV Proposal	19.6	84.6	119	14.1	22.6	98.7	133	12.1
Low-Emission Veh.	19.5	84.6	119	14.0	21.7	98.1	133	11.7

Table A3-29. **Heavy-Duty Diesel Vehicle Emission Reductions from the Low-Emission Vehicle and MDV Proposals on a Statewide Basis (tpd)**

Scenario	Year 2000 NMOG	Year 2000 CO	Year 2000 NOx	Year 2000 PM	Year 2010 NMOG	Year 2010 CO	Year 2010 NOx	Year 2010 PM
Baseline	71.2	306	495	53.9	85.4	371	582	48.2
MDV Proposal	69.2	306	478	53.9	82.8	371	558	48.2
Low-Emission Veh.	68.8	306	478	53.5	79.3	369	556	46.8

APPENDIX B-1

COSTS AND ECONOMIC EFFECTS OF THE PROPOSED CLEAN-FUEL REGULATION

CONTENT

I. COST STUDIES OF VARIOUS LEV FUELS

There have been a number of studies done to estimate the retail price of potential clean fuels such as M85, ethanol, LPG, electricity, and CNG. These estimates include such factors as the cost of production, transportation, and distribution, federal and state taxes, and financial variables such as equity financing, depreciation, and return on investment. Detailed descriptions follow for each of the studies cited in the Technical Support Document.

A. COST AND AVAILABILITY REPORT - (California Energy Commission (CEC), 1989)

Premium Gasoline:

Price: $1.21/gal in 1993; $1.39/gal in 2000

Methanol M-85:

Price:* private vehicle: $1.44/gal in 1993
$1.36-$1.63**/gal in 2000.

Assumptions:

- In-state transport, wholesaling, and distribution costs are based on gasoline distribution cost with additional costs for methanol assumed to be $.10/gal;
- Retail margin is assumed to be $.01/gal more than premium due to additional handling and fueling requirements for methanol;
- CEC assumed certain financial variables after consulting with methanol producers, consultants, oil companies, and public agencies:
  - -- 100% equity financing for new methanol plants
  - -- Plant will operate for 20 years with straight-line depreciation.
  - -- An after tax return on investment, or capital recovery rate of 15%.

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* All "gallons" in all studies refer to the amount of fuel with energy equivalent to a gallon of gasoline. All costs in all studies are in 1988 dollars.

** The range in price is due to the different costs of building methanol plants at various locations.

Parameters:

- 1993 methanol based on existing capacity;
- 2000 price of methanol based on building new production facilities at remote natural gas sites and shipping the methanol to a California port;
- Used the landed price in California of neat methanol determined by the California Fuel Methanol Cost (CFMC) (Bechtel, Inc., 1988) study; the high and low price were discarded and a range was determined based on the remaining locations;
- Included federal and state excise taxes in the price;
- Used Jensen Assoc. feedstock natural gas prices.

Caveats:

- The estimated price does not account for any greater fuel economy of methanol as compared to gasoline when used in LEV's. The CEC estimates that in 1993 the fuel economy for methanol would be 5 percent greater than for gasoline and by year 2000 the fuel economy would be 10 percent greater than for gasoline. If taken into account, this would reduce the cost of methanol as compared to gasoline on a cents/mile basis.
- The CEC believes feedstock natural gas prices may be lower than the prices quoted by Jensen Assoc., thus decreasing the price of methanol to the consumer.
- The CEC predicted efficiency increases in vehicular fuel use due to technological improvements; however these improvements were not accounted for in price estimates for either gasoline or methanol.
- Dealer margin factors in the initial market introduction of alcohol fuels are complex, speculative and in need of more analysis.

Ethanol:

Price*,** : in 1993 - $1.43-$2.39/gal for a large Fleet of vehicles; in 2000 - $2.24/gal for a large fleet of vehicles and $2.33/gal for private vehicle owner.

Assumptions:

- The federal tax credit which is now in effect was not assumed to be in effect in the year 2000.

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* See footnote, p. 2.
** Range is due to the price with and without federal fuel tax credit

Parameters:

- Included in the price are distribution and handling costs, federal and state excise taxes, and dealer margin.

- Used the average of estimates from the United States Department of Agriculture (USDA) and a Congressional advisory panel for the capital cost, operating cost, and feedstock cost of producing ethanol.

Caveats:

- The estimated price does not account for the greater fuel economy of ethanol as compared to gasoline when used in LEV's. The CEC estimates that in 1993 the fuel economy for ethanol would be 5 percent greater than for gasoline and by the year 2000 the fuel economy would be 10 percent greater than for gasoline. If taken into account, this would reduce the cost of ethanol as compared to gasoline on a cents per mile basis.

- The CEC predicted technological improvements in efficiency of vehicular fuel use; however, these improvements were not accounted for in price estimates above for either gasoline or ethanol.

- The USDA concluded that technological improvements in the production of ethanol could reduce the production costs by 9 cents per gallon; however this reduction was not included in their cost estimates.

- Dealer margin factors in the initial market introduction of alcohol fuels are complex, speculative, and in need of more analysis.

Natural Gas:

Price:* $.71/gal in 1993, $.84/gal in 2000 for an individual car owner.

Assumptions:

- For the study years of 1993 and 2000, the cost of installing a gas compressor in the home was assumed to be approximately $1800.00 including plumbing; for a fleet compressor the cost is assumed to be a range from $42,900-$750,000 including plumbing and dependent upon the size of the compressor.

- Maintenance for a gas compressor stored in the home is assumed to be negligible, although some studies indicate otherwise.

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* See footnote, p. 2.

- Because CNG is not currently used by the general public and fleet operators negotiate with the utilities for a special wholesale price, there is no protocol to determine the price of CNG as a transportation fuel to the general public. The CEC assumed that a retail price would be based on the spot price, taxes, transport costs, and electricity costs for gas compression.

Caveats:

- There is currently no specific pricing schedule for CNG used in transportation applications.

- Efficiency in vehicular fuel use of CNG is assumed to be the same as gasoline-fueled vehicles. Therefore the cost on a cents per mile basis would remain the same as stated above.

LPG:

Price*: $.88/gal in 1993; $.98/gal in 2000

Assumptions:

- Distribution and handling costs are assumed to be $.10/gal;

Parameters:

- Used Western Liquid Gas Association's analysis stating that the wholesale cost of LPG is approximately 60% of the cost of unleaded gasoline;

- Added federal and state excise taxes, sales tax, and dealer margin to the wholesale cost.

Caveats:

- The current structure of supply may not adequately serve transportation uses for LPG. Adding such a capability would increase the price by about 20% ($.04-$.07/gal) of the cost estimate above.

- The price quoted does not reflect the greater fuel economy of LPG as compared to gasoline. The CEC estimates that the fuel economy from LPG is 5 percent greater than the fuel economy for gasoline. If taken into account, this would reduce the cost of LPG as compared to gasoline on a cents per mile basis.

- Proposed regulatory actions to reduce benzene and RVP in gasoline by the ARB are expected to increase the amount of LPG available.

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* See footnote, p.2.

Electricity:

Price:* $1.56 in 1993; $1.31 in 2000

Assumptions:

- Electric vehicles are assumed to re-fuel during off-peak hours.
- Typical installation of a refueling outlet was assumed to cost $300.00.

Parameters:

- At present, over-capacity drives up the unit price. The unit price will decrease as demand increases to meet capacity.
- Used residential off-peak electricity prices from three major utilities to determine retail price. These prices included the cost of conversion losses in producing electricity and delivery to site, and a profit return to the utility company.
- No sales or excise taxes were included in the price quoted.

Caveat:

- The price quoted by the CEC does not account for the significantly greater fuel economy achieved through the use of a non-combustion engine in an electric vehicle. To determine the reduction in fuel cost due to engine efficiency, the ARB obtained fuel economy estimates for various types of gasoline vehicles and divided them by the fuel economies for equivalent types of electric vehicles. These estimates were obtained from three separate sources and the corresponding reduction ratios ranged from 0.28 when electric vehicles were using a nickle-iron battery to 0.56 when electric vehicles were using a lead-acid battery. The ARB chose the reduction ratio based on CEC's estimates of fuel economies for delivery vans where the electric vehicle was built with a lead-acid battery: the gasoline delivery van achieved 17.0 miles per gallon and the electric delivery van acheived 37.6 miles per gallon which equates to a 0.452 reduction ratio. This ratio was chosen because it was an approximate midpoint within the range of ratios observed. The price of electricity given by the CEC was then multiplied by 0.452 to approximate cost benefit due to the fuel efficiency of an electric vehicle.

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* See footnote, p.2.

B. METHANOL COST STUDY - (Environmental Protection Agency (EPA), 1989)

Premium Gasoline:	$1.23 in September 1989
M85	
Price:*	$1.14 - $1.24 in September 1989; once the demand for methanol increases, the price will drop below the price of gasoline

Assumptions:

- M85 is assumed to have one-half the energy per gallon of gasoline.
- M85 is assumed to have a 5 percent greater energy efficiency or fuel economy than does gasoline.
- Capital investment for new plants assumed to include:
  - An annual capital recovery rate of 16.2%. This rate is based on a 5 percent return on investment for gasoline refineries in the years 1977-1985 with a 5 percent increase to account for the possibility that these years may have been atypical and the assumption that a methanol plant entails more risk than a gasoline refinery.
  - Assumed a 15 year plant life.

Parameters:

- Included 1989 production and transport costs in the price quoted;
- Used Jensen Assoc. cost estimates for natural gas feedstock;
- Used the low-cost sites in the CFMC study to estimate the required investment for a 10,000 metric tons per day methanol plant capacity using conventional technology.
- Included distribution from port to retail pump, federal and state taxes, and service station mark-up in the price quoted.

Caveats:

- Economies of scale will reduce the future price of methanol;
- EPA believes that the price of methanol will be even lower than projected here due to new emerging technology.

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* See footnote, p.2.

- Estimates of annual capital recovery rate can vary widely and have a major impact on the cost of methanol.
- The most sensitive and controversial factor influencing the price of methanol is the price at which natural gas is available as a feedstock.
- The EPA concluded that cost estimates for a methanol plant would be reduced by about 13 percent if emerging technologies were implemented.

C. THE COST OF ALTERNATIVE FUELS - (Chevron U.S.A., Corp., 1989)

Chevron published a study on the economic timing and feasibility of alternative transportation fuels. The published paper had this to say regarding alternative fuels:

- CNG, LPG and electricity are not desirable because each requires expensive retrofits of existing vehicles or the purchase of specially-equipped new vehicles.
- Methanol still requires more study and will not be able to take advantage of economies of scale. Rigid and inappropriate incentives or mandates could divert capital away from more pressing needs of society.

They concluded that further evolutionary improvements with existing fuels and engine technology are preferable to any of the alternative fuels being considered at present.

D. CALIFORNIA FUEL METHANOL COST STUDY - (Bechtel, Inc., 1988)

This study was sponsored by a broad cross section of affected interests and was prepared by Bechtel, Inc. It analyzed the on- and off-site costs of building a large-scale methanol producing plant.

Assumptions:

- A substantial methanol fuel market was assumed to exist, and very large methanol production facilities can be built to serve this market.
- The methanol fuel market was assumed to be concentrated in LA.
- A factored cost estimating technique was used to determine all costs. This method allows the estimates to be scope-, site-, and time-specific.

- It was assumed that each plant would be built using conventional technology.

- It was assumed that the total natural gas required (feedstock and supplemental fuel) would be the same for each site, approximately 110 billion cubic feet per year.

- All plant sites were assumed to use a methane-rich (over 95 percent) natural gas with a 1,030 Btu per standard cubic-foot (higher-heating value).

Parameters:

- A plant capacity of 10,000 metric tons per day (MTD);

- 99.5 volume percent methanol production;

- Product shipment specifications (i.e. tankers, wharves, and pipelines) were determined for each site depending upon the site location;

- Project design and construction period was determined for each site.

- Investment costs included:

  -- Direct field costs such as major equipment, bulk materials, and direct labor (i.e. labor involved in the installation of equipment and materials);

  -- Indirect field costs (i.e. unallocated labor, temporary facilities, etc.);

  -- Other field costs (i.e. sales taxes, ocean freight, import duties, etc.);

  -- Engineering and home office costs incurred by the contractor or licensor(s) for engineering, procurement, and fees;

  -- Owner costs (i.e. environmental review, land and right-of-way acquisitions, etc.);

  -- A contingency to cover unforeseen expenses.

- Operating costs included:

  -- utility costs;

  -- operating and labor supplies;

  -- maintenance materials and supplies;

  -- taxes, insurance, and corporate overhead.

- Transportation costs included investment and operating costs for marine and/or pipeline transport associated with each site.

Using conventional technology, the study came up with these costs for a 10,000 MTD methanol plant for these six sites:

	Investment (million $)	Operating Cost (million $/yr.)	Cost of Tranport to L.A. (cents/gal)
Port Arthur, Texas	883	64	9
Point Lisas, Trinidad	985	68	5
Jubail, Saudi Arabia	1,088	82	5
Dampier, Australia	1,537	105	4
Edmonton, Western Canada	925	62	8
Prudhoe Bay, Alaska	1,498	110	52

II. COST OF A LARGE NEW METHANOL PLANT

A. INTRODUCTION

This section provides a cost analysis of the capital expenditures for building a 10,000 metric tons per day (MTD) methanol plant, which is probably the minimum desirable size for economic efficiency. 10,000 MTD of methanol is equivalent to about 80,000 barrels of methanol or 94,000 barrels of M85 per day (about six percent of the state's demand for motor fuel). The capital cost data are from the California Fuel Methanol Cost Study. A net cash flow analysis is used to derive the annual after-tax net cash outflow as the cost of the project to the business.

B. COST ANALYSIS OF METHANOL PLANT

The net cash flow analysis of the capital and operating costs of building and operating a methanol plant resulted in the costs listed in Table 8-1. The methodology to calculate net cash flow accounts for all annual outflow and inflow of cash from and to a company because of a proposed project. Examples of cash flow are expenditures for equipment (outflow of cash), operating and maintenance costs (outflow), and tax benefits (inflow). The method then calculates net cash flow from all necessary expenditures and annualizes them over the life of the project (for additional information see Price Waterhouse research contract report number A0-136-32). The methodology involves the steps below.

Depreciation for California Income Tax: The California corporate income tax codes allow deduction of depreciation using 10-year life and double declining balance method for petroleum refining related depreciable properties as defined by the federal government. The California tax codes allow five-year depreciation life for equipment certified as pollution control equipment. For simplicity, we assume that the company will use ten-year life for depreciation purposes rather than the special provision. The special pollution equipment depreciation provision has a tedious way to certify that the installed equipment is strictly for pollution control and does not enhance the company's efficiency.

Reduction of Cost to the Industry Because of Income Tax Liability Reduction: Depreciation and operating and maintenance costs (O&M) are deductible. The expenditures for the control equipment result in lower taxable income and therefore lower taxes. We call the difference in taxes before and after the project tax benefits or reduction in project cost.

Depreciation Calculation for Federal Taxes: For federal taxes, the control equipment and any structures can be depreciated according to an accelerated schedule, similar to that for California. The depreciation method allowed by the IRS codes is an accelerated declining balance at 200 percent of the straight-line rate at ten-year life.

Reduction of Cost to the Industry Because of Income Tax Liability Reduction: Depreciation and operating and maintenance costs (O&M) are deductible also from federal tax liability resulting in less cash outflow for the firm.

Net Cash Flow: the final step (Table B-2-1) accounts for the cash which leaves the company (cash outflows) because of expenses and investments, and the cash which returns to the company (cash inflow) because of the tax benefits. The net of the annual inflows and outflows for a fifteen-year project life are discounted at 9 percent after-tax discount rate to the initial year to derive present value of the net cash flows. Then, the present value is annualized to derive a levelized estimate of annual cash ouflows which would have to come from the company's profits in absence of any costs pass-through to its customers.

Revenue Requirement: Revenue requirements is the amount the company needs to increase its revenues to cover the costs of the investment and the investment itself. The annualized net cash flow represents an after-tax cost to the industry. To raise enough revenues to counter the after-tax cost and pay the taxes on new revenues, we adjust the after-tax cost to a total revenue requirement. This is done by adding to the after-tax cost the combined state and federal taxes at 40.4 percent. Table B-1-1 shows the results for the four options offered in the California Fuel Methanol Cost Study (Bechtel, Inc., 1988).

Table B-1-1. Annualized Costs and Revenue Requirements of Methanol Plants

	Conventional Technology	Combined Reforming	Catalytic Partial Oxidat.	Fluidized Bed
Capital Outlay (million $)	883	773	766	823
Operating & Maintenance (million $/year)	64	65	64	69
Annualized Cost (million $/year)	85	79	78	84
Revenue Requirement (milion $/year)	142	132	131	141

C. FINANCING

This section discusses the financing of the capital required to build the methanol plant estimated at $883 million, the highest capital cost case. Many factors affect ability to raise capital. A discussion of the factors follow.

Recent History

Crude oil prices declined rapidly in the second half of the 1980s. The refined product prices, however did not decline as fast as crude oil prices. This resulted in improved profit margins for the refiners.

The demand for the refined products has continued to increase. The refiners have responded by more efficient use of current equipment and, in some case, have added new equipment to increase capacity. Gasoline demand continues to increase and is forecasted to increase further. The supply and demand for gasoline are in balance as of early 1990. The demand for gasoline has changed to higher quality environmentally better types. Thus the refinery investments has been directed towards switching capacity from regular low quality to premium higher quality gasoline.

The total 1989 U.S. crude input capacity increase by 140 thousand barrels per day (b/cd), from 15,418.7 to 15,558.9 thousand b/cd, or a 0.9 percent increase. The total capacity stood at about 18,000 b/cd in 1981. The demand for petroleum products, including gasoline and other products, have been increasing at around 1.5 percent per year.

Gasoline sales for highway use in California increased by 2.5 percent in 1988, and a little more than 2 percent in 1989. The 1989 sales were possible by increased refinery efficiency and despite idling of a 18.8

thousand b/cd refinery in Newhall. The gasoline demand is forecasted to grow throughout the 1990s.

The recent history indicates that in the near future the refining capacity will have to expand. The oil companies would need to raise capital to finance the expansion. Most likely, the gasoline prices would rise somewhat because of capacity constraints before new capacity is added. The price rise could improve profit margins to facilitate the new financing.

Recent Capital Expenditures

Table B-1-2 shows the total 1988 world-wide capital expenditures by the top 15 U.S. oil companies. The sixth column of the table shows the percentage increase in the 1988 capital spending, if the company had to increase it by $900 million, the cost of a 10,000 MTD methanol plant. The $900 million capital investment seems a significant amount for any of the top 15 oil companies. However, not all of the required capital would be spent in one year; rather, it would be spread over several years.

Table B-1-2. Financial Information on Top 15 U.S. Oil Companies (million dollars in 1988)

Oil Company	Total Assets	Total Revenues	Net Income	Stock Equity	Capital Spending	% Increase in Spending[a]
EXXON[b]	74,293	88,563	5,260	31,767	7,508	12.0
MOBIL[b]	38,820	54,361	2,087	15,686	3,915	23.0
CHEVRON[b]	33,968	28,857	1,768	14,788	2,459	36.6
AMOCO	29,919	23,919	2,063	13,342	3,697	24.3
SHELL OIL[b]	27,169	21,399	1,239	15,381	3,318	27.1
TEXACO[b]	26,337	35,138	1,304	8,105	2,435	37.0
BP AMERICA	22,452	16,661	2,129	-	2,496	36.1
ARCO[b]	21,514	18,868	1,583	6,247	3,038	29.6
OCCIDENTAL	20,747	19,417	302	6,224	1,193	75.4
PHILLIPS	11,968	11,490	650	2,113	797	112.9
USX	11,450	9,949	116	4,347	981	91.7
CONOCO	9,736	12,806	391	-	2,069	43.5
UNOCAL[b]	9,508	10,085	480	2,161	1,193	75.4
ENRON	8,695	5,756	109	1,637	294	306.1
COASTAL[b]	7,865	8,233	157	1,272	197	456.9

[a] to fund a $900 million, 10,000 MT/day methanol plant

[b] operates a refinery in California

The 1988 capital funds spent in the U.S. by all refiners on refining operations amounted to $2.9 billion. It increased to $3.2 in 1989, and in 1990 up to a planned $4.0 billion dollars. The three year total is $10.1 billion. If the $900 million would have been required in the three-year period, the refiners would have had to increase their capital expenditure by roughly 10 percent. This is significant by itself. But the methanol plant would have replaced the demand for gasoline and thus, the investment for the methanol plant would have been a part of the $10.1 billion capital funds which the industry spent or will spend from 1988 through 1990.

The U.S. capital market (sources of financing) is very large. A $900 million package of financing is not beyond the capabilities of the financial institutions and the oil market participants. The main question is whether the proposed project would command enough profit rate at a reasonable risk to justify financing the project instead of alternative projects. Oil companies have financed a peak 1981 capital spending of $25.2 billion dollars when the refined products and overall oil market commanded a healthy profit.

Conclusions

We believe that the petroleum refining industry has been able to raise significant sums of capital for expansion and improvements. The supply and demand conditions of refined products market dictate additional refinery expansions in the near future. Because investment in the methanol plant contributes to the needed expansion, we believe financing a $900 million project is not beyond the industry's capability. Thus, it is plausible to conclude that the petroleum refining industry is capable of financing the methanol plant. However, because the financing depends on project profitablity, and because a single refiner may not be able to establish a market share large enough for the economically efficient minimum plant size of about 80,000 barrels per day, financing might not be forthcoming if a single refiner had to do it alone.

III. ECONOMIC EFFECTS ON GASOLINE RETAILERS

A. INTRODUCTION AND CONCLUSION

This chapter analyzes the ability of service stations in California to raise the estimated $50,000 of capital needed (California Energy Commission estimate) to finance installation of storage tanks and pumps required to distribute methanol in the service stations. Financial and other data for the stations indicate that the industry has shrunk in number of stations, but it seems to have strengthened its financial position in the last few years. More specifically, in the case of the oil companies distributing the methanol in the stations which they either own or lease to operators, raising the $50,000 capital requirement should pose no significant problem. The overall financial data for the industry including the oil company-owned, leased, or independent operators, presented later in this analysis, also confirm the conclusion that the gasoline service stations' financial strengths seem sufficient to finance the capital needed for the distribution equipment.

B. BACKGROUND

The gasoline service station industry in California has been declining in number of stations, but gaining in number of nozzles, indicating more efficient use of the station because of increasing volume of gasoline pumped. For example, in the Los Angeles metropolitan area, the number of service stations has declined from about 8,000 in 1974 to about 4,700 in 1988, a drop of 41 percent. In 1989 alone, the number of service stations dropped by 137 stations (2.9 percent) from the previous year, while the number of nozzles increased from about 61,000 to 66,000 (8.2 percent). The number of cars serviced by these station has steadily increased. The number stood at 9.0 million vehicles in 1988 and 9.2 million in 1989 for the Los Angeles area.

C. FINANCIAL DATA AND ANALYSIS

The surviving gasoline service stations seem to have become financially stronger during the 1984 to 1989 period. The reasons are increasing volumes of gasoline sales per station leading to more efficient use of property and equipment, and declining cost of gasoline brought about by lower crude oil prices which were not entirely passed on to consumers. Table B-1-3 presents financial data from a sample of gasoline service stations (standard industrial classification 5541, about 200 to 330 stations depending on the data year) in the nation. The California market is large enough to closely resemble and influence the national financial data. We assume that the national data is representative of the California market.

The financial data tends to confirm that the service stations are more efficient than a few years back. The data in the table shows that gross profit rate (sales less cost of goods sold) increased from 16.2 cents per dollar of sales in the nine-month period ending in March 1984 to 20.5 in the same period ending in 1989. Operating expenses also increased from 14.8 to 17.9 cents. However, the increase in operating expenses was not sufficient to erode operating profits per dollar of sales. The operating profits doubled from 1984 to 1989, from 1.3 to 2.3 cents per dollar of sales. Other expenses which include interest, general and administrative expenses also increased but not enough to hurt profits before taxes. These changes led to profits before taxes per dollar of sales to increase from 1.2 in 1984 to 2.1 in 1989, a 75 percent increase. The only expenses not accounted for up to this point are state and federal taxes. The state income tax rates were unchanged throughout the 1984 to 1989 period. The federal income tax rates were reduced in 1986. Because the income tax rates could not have affected negatively the profits before taxes, the bottom-line after-tax profits should have improved from 1984 to 1989 also. Thus the industry income data indicate the gasoline service stations, those remaining in the market have strengthen their financial position.

The balance sheet data (assets, liabilities and net worth) for the gasoline service station industry also indicate improvements in financial

Table B-1-3. Financial Data on Gasoline Service Stations (percents)

	6/30/83 to 3/31/84	6/30/84 to 3/31/85	6/30/85 to 3/31/86	6/30/86 to 3/31/87	6/30/87 to 3/31/88	6/30/88 to 3/31/89
Income						
Net Sales	100.0	100.0	100.0	100.0	100.0	100.0
Gross Profit	16.2	16.7	17.7	21.0	20.5	20.5
Operating Expens.	14.8	15.1	16.1	18.3	18.4	17.9
Operating Profit	1.3	1.7	1.6	2.6	2.2	2.6
Other Expenses	0.1	0.1	0.2	0.3	0.2	0.4
Profit Before Tax	1.2	1.5	1.4	2.3	2.0	2.1
Assets						
Cash & Receivab.	24.6	25.3	23.7	24.8	22.5	22.0
Inventory	21.0	18.7	21.9	20.5	19.2	19.0
Others	2.3	2.0	2.1	2.3	2.8	2.1
Total Current	47.9	46.0	47.7	47.6	44.5	43.1
Fixed	39.9	42.6	41.2	43.0	44.7	46.2
Others	12.2	11.4	11.1	9.4	10.8	10.7
Total Assets	100.0	100.0	100.0	100.0	100.0	100.0
Liabilities						
Short Term	45.3	43.8	41.6	39.0	34.9	35.6
Long Term	25.2	25.8	26.2	25.1	25.4	28.3
Total Liab.	70.5	69.6	67.8	64.1	60.3	63.9
Net Worth	29.5	30.4	32.2	35.9	39.7	36.1
Total Net Worth And Libilities	100.0	100.0	100.0	100.0	100.0	100.0
Ratios						
Current	1.1	1.0	1.1	1.2	1.2	1.2
Cash Flow/LT Debt	1.9	2.4	2.6	3.4	2.6	2.7
Debt/Net Worth	2.7	2.9	2.6	2.0	1.7	2.0

position of the industry. One indication is that less of the total assets are kept in the current assets (cash, receivables, inventory, and others). Lower current assets, in general, means less assets are left idle, sign of improvements on operations. Another reason is that of every dollar of total assets a larger portion was committed to equipment (fixed assets which have a life longer than one year) in 1989 than in 1984. The increase in the number of pumps and nozzles per station, expenditures on renovation, and possible larger land area are the likely reasons for increase in the relative position of the fixed assets to the rest of the assets.

The liabilities have shifted from short term to long term. This fits the pattern of shifts to fixed assets which are usually financed with long-term debt, at least in part. Net worth (owners' equity) has also increased its share. Out of every dollar of assets 29.5 cents were financed by owners' equity in 1984. By 1989, it stood at 36.1 cents. This increase in share of owners' equity indicates that gasoline stations either made enough profits to reinvest a significant portion of it back in the stations, successfully raised capital, or both in the 1984 to 1989 period.

The financial ratios also support the conclusion that the gasoline service station industry has gained financial strength. The current ratio (current assets divided by current liabilities), a measure of liquidity and ability to meet short-term debt, changed very little. At about 1.2 it indicates the industry has ample short-term assets to cover its short-term debt.

Cash flow needed to cover long-term debt (depreciation and profits divided by long-term debt) improved from 1.9 in 1984 to 2.7 in 1989, a 40 percent increase, after peaking at 3.4 in 1987. The leverage ratio (liabilities divided by net worth), a measure of business investment risk and ability to absorb more debt, improved by about 25 percent from 2.7 to 2.0. The lower leverage ratio, higher cash flow coverage of long-term debt point out to improved credit worthiness and lower risk for creditors of the gasoline service stations. This leads us to believe that the stations have sufficient strength to raise $50,000 of capital for methanol distribution equipment.

IV. COST-EFFECTIVENESS OF VEHICLE/FUEL COMBINATIONS

The cost-effectiveness of a particular low-emission vehicle using a particular fuel has been determined by dividing the amortized cost of the vehicle plus the the cost of the fuel by the reduction in emissions provided by the vehicle. This number was then mutiplied by one-half. We attributed one-half of the cost to the reductions in NMOG and NOx and the other half to the reductions in toxic emissions. The staff used this calculation for determining the cost-effectiveness:

$$\frac{(\text{amortized lifetime cost of the vehicle})^{*} + (\text{lifetime cost of fuel})^{*}}{(\text{emission reductions, lb/mi}) \times (\text{lifetime miles traveled})}$$

Assumptions:

1. A capital recovery rate of 0.163 (discount rate 10 % over 10 years) was used.

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* added cost relative to a gasoline non-LEV

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2. Light-duty vehicles get 24.3 miles per equivalent of a gasoline gallon (on all fuels) and travel an average of 100,000 miles in a lifetime (4,115 lifetime gallons).

3. Medium-duty vehicles get 12.5 miles per gasoline gallon and travel an average of 120,000 miles in a lifetime (9,600 lifetime gallons).

4. The cost of all fuels other than M85 were taken from the California Energy Commissions (CEC) estimates of cost. The cost of M85 was taken from the estimate given by the AB234 advisory board, 5-10 cents per gallon more expensive than premium gasoline which amounts to a price of 1.44 to 1.49 in the year 2000. For electricity, CEC's cost was multiplied by 0.452 to account for greater efficiency of the electric engine than the internal combustion engine. This ratio was taken from the CEC's estimates of the increased efficiency for a delivery van run on gasoline versus a delivery van run on electricity.

5. The reductions in emissions of NMOG and NOx are 0.25 gm NMOG/mile + 0.4 gm NOx/mile less the proposed low-emission vehicle standards at 50,000 miles (e.g., 0.075 gm NMOG/mile + 0.2 gm NOx/mile, for LEVs). Reductions in emissions of toxic pollutants are proportional to the reduction in NMOG.

V. PROGRAM COSTS AND COST-EFFECTIVENESS

The overall program cost and cost-effectiveness can be estimated for specific scenarios of numbers and mixes of low-emission vehicles sold in response to the proposed regulations. For this analysis, the staff has used five scenarios selected for evaluation purposes only. They are not projections of the vehicle/fuel combinations that might occur. The scenarios are:

A. All LEVs use gasoline, ZEVs use electricity;

B. All LEVs use methanol, ZEVs use electricity;

C. TLEVs use gasoline, LEVs use methanol, ULEVs use CNG, ZEVs use electricity;

D. TLEVs use gasoline, 80% LEVs use methanol, 20% LEVs use ethanol, 50% ULEVs use CNG, 50% ULEVs use LPG, ZEVs use electricity;

E. TLEVs and LEVs use gasoline, ULEVs use CNG, ZEVs use electricity.

These assumptions were made:

1. Vehicle manufacturers follow the example implementation schedule of LEV types by year in Table I-6 of Part A of this document.

2. Costs for individual types of vehicle/fuel combinations are those shown in Tables IX-4a and 4b of Part D.

3. All the vehicles use the fuel on which they were certified all of the time.

4. All vehicles will be on the road for ten years and drive 10,000 miles per year.

5. All vehicles, including those meeting the 0.25 NMHC standard currently required of new vehicles, continue to meet their certification standards for the ten years that they are on the road.

6. In model years 1994 to 1999, 2.0 million new light-duty vehicles and 198,000 new medium-duty vehicles will be sold; in 2000 to 2010, 2.18 million new light-duty vehicles and 216,000 new medium-duty vehicles will be sold.

A. PROGRAM COSTS

To calculate the program cost for a model year, the staff multiplied the fraction of vehicles to be sold of a particular type (from Table I-6) by the total number of new vehicles to be sold in that model year and then multipied this number by the annual cost of that particular vehicle (from Table XI-4). This product, summed over all vehicle types, yields the program cost for the model year. For example, for the model year 2000, if Phase-2 gasoline costs $1.35 per gallon, for Scenario C, the following equations would apply:

$$\text{low} = \overset{\#\text{ LDVs}}{2.18 \times 10^6}\,[\overset{\text{LEVs}}{.96(\$81)} + \overset{\text{ULEVs}}{.02(-\$14)} + \overset{\text{ZEVs}}{.02(-\$93)}] + \overset{\#\text{ MDVs}}{.216 \times 10^6}\,[\overset{\text{LEVs}}{.75(\$147)} + \underset{\text{ULEVs}}{.02(-\$212)}]$$

$$= \$187 \text{ million}$$

$$\text{high} = 2.18 \times 10^6[.96(\$102) + .02(-\$14) + .02(-\$93)] + .216 \times 10^6\,[.75(\$195) + .02(-\$212)]$$

$$= \$239 \text{ million}$$

where "low" is the cost when methanol is five cents more expensive than gasoline and "high" is the cost when methanol is 10 cents more expensive than gasoline. These numbers apply to only the model-year fleet of vehicles.

To estimate the cost of all vehicles in a calendar year, the staff added the model-year costs for the ten model years assumed on the road in that year. For example, to calculate the cost in 2000 if Phase-2 gasoline costs $1.35 and for the average of the high and low costs for methanol in Scenario C, the program costs for model years 1994 through 2000 are added.

Rounded to two significant figures, the cost of all vehicles and fuel in 2000 for scenario C would be approximately 510 million dollars.

Model Year	Program Cost (million $)	
1994	2.2	
1995	3.3	
1996	4.4	
1997	45	
1998	91	
1999	145	
2000	214	(avg. of 187 & 239)

total= approximately 510 when rounded to two significant figures

B. PROGRAM COST-EFFECTIVENESS

To estimate the cost-effectiveness of the program for light-duty vehicles in a model year, the staff divided one-half of the program cost for that year's new light-duty low-emission vehicles by the reductions in NMOG and NOx emissions in that fleet. We weighted the NOx and NMOG reductions of each type of light-duty vehicle in the same way as costs (per Table I-6). For example, for model year 2000, for light-duty LEVs, if Phase 2 gasoline costs \$1.35, for Scenario C, at the low estimate for the cost of methanol:

$$\text{Cost Effectiveness} = \frac{.96(\$81) + .02(-\$14) + .02(-\$93)}{2 \times [\underbrace{.98(.2)}_{\text{NOx, LEV+ULEV}} + \underbrace{.02(.4)}_{\text{NOx, ZEV}} + \underbrace{(.25-.073)}_{\text{NMOG}}] \times \underbrace{10{,}000/454}_{\text{mile/yr}}}$$

$$= \$4.50 \text{ / lb. of NMOG plus NOx}$$

To estimate the cost-effectiveness of the proposal for a model year for light- and medium-duty vehicles combined, the staff divided one-half of the program cost for that model year, as determined in A of this section, by the reductions in NMOG and NOx emissions in the year's fleet of new vehicles. For medium-duty vehicles, the standards for the weight class with 5751 ≤ test weight ≤ 8500 were used as representative. For example, to calculate cost-effectiveness in model year 2000, if Phase-2 gasoline costs \$1.35, for Scenario C, for the average of the low and high methanol costs:

$$\text{Cost Effect.} = \frac{(\$187 + \$239)/2}{2 \times 10{,}000/454 \times \{[\underbrace{.98(.2) + .02(.4)}_{\text{NOx, LDV}} + \underbrace{(.25 - .075)}_{\text{NMOG, LDV}}] \times \underbrace{2.18}_{\text{\# LDVs}} + [\underbrace{.02(.5)}_{\text{NOx, MDV}} + \underbrace{.75(.195) + .02(.273)}_{\text{NMOG, MDV}}] \times \underbrace{.216}_{\text{\# MDVs}}\}}$$

$$= \$5.55 \text{ / lb. of NMOG plus NOx}$$

To estimate the cost-effectiveness of the entire low-emission fleet in calendar years 2000 and 2010, the staff divided one-half of the program cost in the years 2000 and 2010 for a particular scenario (as determined in A of this section) by the sum of fleet NMOG and NOx reductions for the year (values in Table XI-1 in Part D of this document multiplied by 2000 lb/ton and by 365 days/yr). For example, to calculate cost-effectiveness in year 2000 if Phase-2 gasoline costs $1.35, for Scenario C, for the average of the low and high costs for methanol:

$$\text{Cost Effectiveness} = \frac{\$510 \text{ million}}{2 \times (29 + 36)\text{lb.} \times 2000 \times 365}$$

$$= \$5.37 \text{ / lb of NMOG plus NOx}$$

VI. FINANCIAL DATA ON REFINING COMPANIES (1989)

Independent Refiners* That Make Gasoline

	Parent Company	Debt/Assets	% Return on: equity	assets	sales
Fletcher Oil & Refining	Hondo Oil & Gas Co.	.80	.09	.02	.02
Golden West Ref'ing	Thrifty Oil Co.	nd	nd	nd	nd
Kern Oil & Ref'ing	(same)	nd	nd	nd	nd
Pacific Refining	Coastal & Sino-chem of China	nd	nd	nd	nd
Paramount Petro-	(bankrupt)	1.3	nd	nd	nd
Powerine Oil Co.	Powerine Oil Holiday Co.	nd	nd	nd	nd
Tosco Corporation	(same)	.66	.12	.039	.022
Ultramar, Inc.	(same)	.39	.049	.030	.052
mean:		.79	.058	.024	.025

* capacity less than 50,000 barrels of crude oil per day or fewer than 25 retail stations in the South Coast Air Basin

Major Refiners

	Parent Company	Debt/Assets	% Return on: equity	assets	sales
Atlantic Richfield	ARCO Corporation	.71	.30	.088	.12
Chevron USA	(same)	.59	.018*	.007*	.008*
Exxon	Exxon Corp.	.64	.12	.042	.036
Mobil Oil Corp.	Mobil Corp. -	.58	.11	.046	.032
Shell Oil Co.	(same)	.42	.088	.051	.064
Texaco Refining	Texaco, Inc	.64	.26	.094	.068
UNOCAL Corporation	(same)	.75	.11	.028	.023
mean:		.62	.14	.051	.050
mean w/o Chevron:		.62	.16	.058	.057

* abnormally low because of accounting anomally in 1989

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APPENDIX B-2

PROCEDURES FOR CALCULATING REQUIRED FUEL VOLUMES AND REQUIRED NUMBER OF RETAIL OUTLETS

I. DETERMINATION AND ALLOCATION OF THE CLEAN-FUEL VOLUME REQUIREMENT AND RETAIL-OUTLET REQUIREMENT

This section describes the method proposed by the staff of the ARB for determining periodically:

- o the total volume of each clean fuel required to be distributed by gasoline suppliers collectively,
- o the allocation among gasoline refiners, blenders, and importers of the responsibility for distributing that required volume,
- o the total number of clean fuel retail outlets required to dispense each clean fuel, and
- o the allocation of responsibility for establishing clean fuel retail outlets among gasoline retail station owners

A. DETERMINING THE TOTAL REQUIRED DISTRIBUTION VOLUME FOR EACH CLEAN FUEL FOR EACH CALENDAR QUARTER

From January 1, 1994 through December 31, 1996, the proposed clean-fuel regulation would require specific volumes of clean fuels to be distributed for low-emission vehicles* located in the South Coast Air Quality Management Region (South Coast region). For January 1, 1997, and later, the draft regulation would require clean-fuel volumes to be distributed for low-emission vehicles located throughout the entire state.

Beginning with the first quarter of 1994, the ARB staff would determine the volume of each clean fuel to be distributed in the South Coast region as a portion of the fuel requirements of both low-emission vehicles identified by the Department of Motor Vehicles (DMV) vehicle registration reports and additional low-emission vehicles that are predicted to be sold by the end of the quarter. Major gasoline suppliers (defined as any refiner with greater than 50,000 barrels per stream day crude capacity and at least 25 retail gasoline outlets in the South Coast region) would be notified of their required volumes 90 days prior to the first day of each quarter. For each calendar quarter in the year 1997 and later, requirements would be set in a similar manner for all gasoline suppliers in the entire state.

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* low-emission vehicles = transitional low emission vehicles (TLEVs), low-emission vehicles (LEVs), ultra-low emission vehicles (ULEVs), and zero emission vehicles (ZEVs)

Gasoline suppliers will not be required to distribute a clean fuel if the total number of vehicles certified on the fuel is not projected to exceed 10,000 (for 1994 through 1996), or 20,000 (for 1997 and later).

The following equation will be used to calculate the total required volume--termed the "total required volume" in the proposed regulation (TRV)--for a particular clean fuel for any calendar quarter.

$$TRV = \sum_{\text{model year 1994}}^{\text{model year } y} \text{Maximum Demand Volume (MXDV)}_{(\text{vehicle class, vehicle type})}$$

where:

- **model year y** represents the latest model year of low-emission vehicle that will exist on the road during the calendar quarter of concern.

- **MXDV** is the maximum demand volume of the particular clean fuel by a particular model year of low-emission vehicle. The **MXDV** would be calculated separately for each vehicle class (passenger car (PC), light-duty truck (LDT), and medium duty vehicle (MDV) and vehicle type (FFV/DFV and dedicated vehicle). Since there are three different classes and two different types of low-emission vehicles, there would be a maximum of six possible MXDV calculations per model year of low-emission vehicle. (It is assumed that MXDV is not a function of the emission standard for an LEV.)

The basic equation that defines the **MXDV** of a particular clean fuel (for a vehicle class in a model year) is:

$$\mathbf{MXDV} = \frac{(\text{Number of LEVs}) * (\text{Avg miles travelled (AMT)})}{\text{Fuel economy of LEVs (MPG)}} * (\text{Adjustment factors})$$

where:

- **Number of LEVs** is the predicted number of low-emission vehicles (in the vehicle class and model year) certified on that clean fuel on the road at the end of the quarter.

- **AMT** and **MPG** are the average miles travelled per quarter and the average fuel economy of low-emission vehicles in the vehicle class.

- **Adjustment factors** are the fuel-volume adjustment factor (F-factor) and the SC-factor. The F-factor reduces the total demand volume to account for uncertainties in fuel demand and the market's inability to perfectly allocate all of the clean fuel to be distributed. The SC-factor represents the number of low-emission vehicles in the South Coast region as a fraction of all low-emission vehicles in the state.

A more detailed discussion of these variables and parameters follows.

Number of Low Emission Vehicles (Number of LEVs) represents the end-of-quarter population of low-emission vehicles of a given model year, vehicle class, and vehicle type that require the same clean fuel. The three main sources of information that would be used to estimate low-emission vehicle populations include DMV registration data, automobile manufacturers' certification sales estimates, and automobile manufacturers' two-year advanced production estimates. Figure 1 is a timeline illustrating when the DMV and manufacturers sales and production projections would become available relative to the beginning of each quarter from 1994 through 1997.

During the initial quarter of the regulation, the total required volume would be based on manufacturers' estimates of future low-emission vehicle sales and advanced production estimates. After several quarters, these estimates would be augmented by registration data for low-emission vehicles. The ARB would announce the clean fuel volume required to be distributed in a quarter by each gasoline supplier three months before the quarter begins. However, the vehicle registration data generally will only provide data up to three months before this announcement date. Therefore, for each quarter there would be three separate estimations that when summed equal **Number of LEVs**:

1) number of low-emission vehicles registered from DMV data up to six months prior to the beginning of the quarter

2) number of low-emission vehicles predicted to be introduced and operating during the six months prior to the quarter

3) one-half the number of low-emission vehicles that are predicted to be introduced during the quarter. (The average operating number of new vehicles over the days of the quarter is about equal to half of the number of new vehicles over the entire quarter.)

Average miles travelled per vehicle per quarter (AMT) represents the estimated miles travelled by a typical LEV during a quarter, based on the age and vehicle class of the low-emission vehicle (See Table B-2-1). **AMT** is assumed to be constant among clean fuel vehicles of the same age and class. ARB's EMFAC emission inventory model will be used to generate **AMT** data.

Table B-2-1. Example quarterly mileage accrual rates

Vehicle Age (years)	PC	LDT	MDV
1	3205	4349	4571
2	3026	4033	4191
3	2857	3740	3842
4	2697	3469	3469
5	2547	3217	3231
6	2405	2984	2963
7	2271	2767	2717
8	2144	2567	2492
9	2024	2380	2286
10	1911	2208	2097
11	1805	2047	1924
12	1704	1899	1765
13	1609	1761	1620
14	1519	1633	1482
15	1434	1515	1364

PC = passenger car
LDT = light duty truck
MDV = medium duty vehicle

Average Fuel Economy (MPG) represents the estimated average fuel economy in miles per gallon (mpg) of low-emission vehicles of the same vehicle class and model year that require the same clean fuel. An overall fuel economy estimate is made for all such vehicles. No delineation is made for different models or types (FFV/DFV or Dedicated) of low-emission vehicles within the same vehicle class. The **MPG** estimate for an LEV is generated by taking CalTrans estimates of **MPG** for a gasoline vehicle of the same model year and vehicle class and multiplying it by the appropriate gasoline based volumetric energy conversion factor listed in Table B-2-2. (For liquid clean fuels this factor is defined as the ratio of the volumetric energy content of the clean fuel to the the volumetric energy content of gasoline. For CNG, the conversion factor is the energy content of gasoline, since CNG is measured in units of energy.)

The proposed regulation would require auto manufacturers to provide **MPG** estimates fopur months prior to each quarter and in conjunction with their two-year advanced production estimates. It is possible that these estimates could not only be categorized by vehicle class but also by engine family. This would allow for a more accurate calculation of clean fuel volume if low-emission vehicles used engines predominantly from one engine family. On the negative side, it would result in a more complex and data-intensive calculation. The staff is currently researching the merits of this approach.

Table B-2-2. Energy Conversion Factors

To convert miles per gasoline gallon (MPGg) to miles per gallon of:	multiply MPGg by:	To convert MPGg to miles per:	multiply MPGg by:
LPG	0.79	therm (10^5 BTU) of CNG	.854
methanol (M100)	0.48		
M85	0.56		
ethanol (E100)	0.65	Kw-hr of electricity	0.065[a]
E85	0.70		

[a] This value applies if an electric motor is 2.2 times as efficient as a combustion engine in converting fuel energy to mechanical energy. It may require adjustment to reflect actual motor efficiencies of production vehicles

Adjustment Factors

Fuel-volume adjustment factor (F-factor) is the annual adjustment factor that accounts for uncertainties in clean fuel demand. The main reason for using an F-factor in the calculation of clean fuel volumes is to prevent an over-estimation of fuel demand.

Important uncertainties that an F-factor accounts for include:

1) uncertainty in the rate of low-emission vehicle sales;

2) uncertainty associated with the data used in calculating the total demand volumes; and

3) uncertainty in the market's ability to allocate clean fuels perfectly. (Retail outlets, particularly in the initial years, may not be located conveniently enough for all low-emission vehicle owners.)

Three different F-factor schedules are proposed to account for these uncertainties and are identified as Tables B-2-3 through -5.

Table B-2-3 shows the F-factor schedule to be used in the calculation of the volumes of fuel used by FFVs/DFVs if the clean fuel in question is first introduced in 1994. The F-factor is smallest in the early years, when the amount of each clean fuel required is based mainly on manufacturers sales projections and not DMV registration data. If a clean fuel used by FFV/DFVs is first introduced in a subsequent year, an alternative schedule of preliminary F-factors may be applicable. This schedule is shown by Table B-2-4. Depending on the year the clean fuel is introduced, an F-factor value from Table B-2-4 may be greater than the corresponding value from Table B-2-3. If this situation occurs, the value from Table B-2-3 (the smaller value) takes precedence. For example, if clean fuel A is introduced in 1995, its 1997 F-factor would be 0.75 according to the alternative schedule. However, since Table B-2-3 lists 0.50 as the F-factor for 1997, 0.50 would be the F-factor used in determining the required volume of clean fuel A.

Table B-2-3. F-factors for calculating volumes of clean fuels for FFV/DDVs, for fuels introduced in 1994

Year	F-factor
1994	.25
1995	.50
1996	.50
1997	.50
1998	.75
1999	.75
2000+	.90

Table B-2-4. Alternative F-factors for calculating volumes of clean fuels for FFV/DFVs, for fuels introduced after 1994

1st year introduced	.25
2nd year introduced	.50
3rd year introduced	.75
4th year introduced	.90

Table B-2-5 shows the F-factor schedule used in the calculation of volumes of clean fuels used in dedicated vehicles. The F-factor values shown in Table B-2-5 are higher then the corresponding values listed in Table B-2-3.

Table B-2-5. F-factors for calculating volumes of clean fuels for dedicated vehicles

Year	F-factor
1994	.90
1995	.90
1996	.90
1997	.90
1998	.90
1999	.90
2000+	.90

The Executive Officer would have the option of adjusting the F-factors +/- 0.10 from the values listed in Tables B-2-3 through -5 to account for uncertainties in the fuel demand. Possible reasons for adjusting the F-factor include:

- o FFV/DFV owners could purchase more or less clean fuel than originally assumed.

- o Future air pollution control district rules could require FFV/DFV fleets to use clean fuel a certain percent of the time. This may differ from the staff's original assumptions.

SC-factor (South Coast factor) adjusts statewide clean fuel demand to the South Coast region clean fuel demand for the years 1994 to 1996. The value of the SC factor is 0.50. This number corresponds with the ratio of automobiles sold in the South Coast counties of Los Angeles, Orange, Riverside, and San Bernardino to the automobiles sold throughout the state. Additional data suggesting that a factor of 0.50 is appropriate is population data which shows that 46 percent of the population of California lives in the four counties listed above.

B. ALLOCATING THE DISTRIBUTION OF THE TOTAL DEMAND VOLUME OF EACH CLEAN FUEL

During 1994 through 1996, the proposed regulation would require major gasoline suppliers to distribute clean fuel in the South Coast region, only. A major gasoline supplier is defined as any refiner with crude oil capacity greater than 50,000 barrels per stream day and at least 25 retail gasoline stations in the South Coast region. The collective requirement among the major suppliers would be the total required volume calculated as in the preceding section. For the following years (1997 and later), the total required clean fuel volume would be distributed by all gasoline suppliers. This volume would be distributed throughout the state.

1. <u>Allocating clean-fuel volumes among major gasoline suppliers (1994-1996)</u>

For each of the years 1994, 1995, and 1996, the total required volume of each clean fuel would be divided among all major gasoline suppliers in proportion to their statewide gasoline market share. The market share would be the volume of gasoline distributed by a major gasoline supplier divided by the total volume of gasoline distributed by all major gasoline suppliers, calculated using State Board of Equalization taxable distribution gasoline figures. This market share would be computed yearly from the last four quarters (last quarter of prior year and first three quarters of current year) for which data were available. This market share would be multiplied by the total required volume of each clean fuel for each quarter to determine the volume of each clean fuel that a major gasoline supplier would be demand to distribute. The total required volumes of each clean fuel would be announced 90 days before the beginning of the corresponding calendar quarter.

Table B-2-6 lists preliminary estimates for the total required volumes of all clean fuels for distribution for the years 1994 through 1996. They are taken from Appendix B-5 and have been computed as if all low-emission vehicles would be certifed on fuels with distribution requirements. The market shares are based on taxable sales in 1989. The values in Table B-2-6 are not meant to be projections.

2. <u>Allocating clean-fuel volumes among all gasoline suppliers (1997 and later)</u>

The total required volume of each clean fuel would be divided among <u>all</u> gasoline suppliers on the basis of their statewide market shares. The method of determining the volume of each clean fuel would be similar to the method described in B.1, but it would apply to all gasoline supplier and the resulting clean fuel volumes would be distributed throughout, the state, not just the South Coast region. Each gasoline suppliers market share would be determined by dividing the total volume of gasoline distributed by each gasoline supplier by the total volume of gasoline distributed by all gasoline suppliers. As with the first three years of the regulation, the source of this information would be the State Board of Equalization taxable distribution gasoline figures. This market share factor would be multiplied by the total required volume of each clean fuel for each quarter to determine the volume of each clean fuel each gasoline supplier would be required to distribute. The total required volumes would be announced 90 days before the beginning of the corresponding calendar quarter.

Table B-2-6. Example Allocation of Clean-Fuel Volumes Among Major Gasoline Suppliers (1994-1996)

Major Supplier	Market Share[a]	Total Required Clean-Fuel Volume[b] 1994	1995	1996
A	.23	4,025,000	18,400,000	28,750,000
B	.19	3,325,000	15,200,000	23,750,000
C	.07	1,225,000	5,600,000	8,750,000
D	.10	1,750,000	8,000,000	12,500,000
E	.19	3,325,000	15,200,000	23,750,000
F	.08	1,400,000	6,400,000	10,000,000
G	.15	2,625,000	12,000,000	18,750,000

[a] based on State Board of Equalization "Annual Report", 1988-1989.

[b] market share fraction times total clean-fuel volume estimate from Appendix B-5, Table B-5-11.

If a new gasoline supplier enters the market place and was not a gasoline supplier for at least one quarter of the four quarters used to determine the market shares of existing gasoline suppliers, the market share of that gasoline supplier would be determined on quarterly basis. The total required volumes of each clean fuel would be announced 90 days before the start of each quarter.

If a person acquires a gasoline producing or importing facility from a gasoline supplier, any gasoline distributed prior to the transfer of ownership would be attributed to the person acquiring the facility. At the time of aquisition, the new owner would immediately assume the past owner's market share.

C. DETERMINING THE NUMBER OF RETAIL OUTLETS

This section describes the equation and associated variables that staff would use to define the number of retail outlets demand each year under the proposed regulation. The equation that defines the total number of clean fuel retail outlets for a particular year of the regulation is:

$$\text{Total \# of clean-fuel outlets} = \frac{\text{Annual clean-fuel volume} - \text{Clean fuel volume supplied at non-retail stations} + \text{Annual clean-fuel volume for vehicle conversions}}{\text{Clean-fuel throughput per station}}$$

Annual Clean Fuel Volume is an estimate of what will be the sum of total required volumes of a clean fuel for the year's four quarters. The equation for calculating clean fuel volumes has been defined and discussed in the previous section. However, two variables-- "**Number** of LEVs" (based on manufacturers projections given 2 years in advance of the certification of the model) and "**AMT**"--are calculated on an annual rather than quarterly basis. The annual clean fuel volume would be set once a year for one year in advance. It would be applicable in the South Coast from 1994 through 1996, and it would be applicable statewide in 1997 and later.

Clean Fuel Volume Supplied by Non-Retail Fleet Stations is the volume of a required clean fuel predicted to be dispensed during the year by non-retail stations (e.g., fleet outlets). This volume is estimated once a year, 13 months in advance, from data supplied by fleet operators. The clean-fuel volume dispensed by non-retail stations would be calculated for the South Coast, only, from 1994 through 1996 and for the entire state in 1997 and later.

Clean Fuel Volume from Conversions is the total amount of clean fuel required by gasoline or diesel vehicles that have been converted into clean-fuel vehicles. The total number of converted vehicles would be determined from DMV registration data. The clean-fuel volume required by these vehicles would be calculated using the same method described in A.1, for low emission vehicles. This clean-fuel estimate would be determined once a year, one year in advance. This requirement would be applicable for the South Coast from 1994 through 1996 and throughout the state in 1997 and later.

Throughput Per Station for liquid clean fuels is will be set at 300,000 gallons per year for each clean fuel for the years 1994 to 1997. For 1998 and later, it will be set at 600,000 gallons per year. The throughput per station for CNG will be set at the equivalent of 360,000 gallons of gasoline per year for the years 1994 and later. These numbers are based on information gained from gasoline retail station owners concerning the minimum economic throughput of a typical gasoline station.

D. ALLOCATION OF THE NUMBER OF CLEAN FUEL OUTLETS

1. South Coast Region (1994 through 1996)

The proposed regulation would require each major gasoline supplier in the South Coast region to provide clean fuel at a fraction of its stations in the South Coast region, beginning in 1994. Twelve months prior to the beginning of a year, the staff would determine the required number of clean-fuel outlets for that year. This number would be determined by subtracting the total number of clean fuel outlets that had been required for the preceding year from the new total number required for the year in question. An increment of stations would be required for each clean fuel. The gasoline market share (described above for allocating clean fuels) of each supplier would be multiplied by the number of clean fuel outlets required for that year for a particular clean fuel to yield the number of retail outlets a major gasoline supplier will be required to equip.

$$\frac{\text{Total taxable gasoline sales volume for a specific major supplier}}{\text{Total taxable gasoline sales volume for all major gasoline suppliers}} * \text{\# of clean fuel stations required for a particular clean fuel}$$

2. Statewide--1997 and Later

Beginning in 1997, the retail outlet requirement will be statewide. The ARB would allocate the required number of new outlets among all station owners as described below.

To determine which gasoline service station owners would have to provide new clean fuel outlets in any particular year, we define a minimum ownership level in equation (2-1). The minimum ownership level is equal to the total number of stations in the state less the number of clean-fuel outlets required to date divided by the total number of new clean fuel outlets (for all clean fuels) needed for a particular year.

$$MOL = (TSU)/(TCFS) \qquad (2\text{-}1)$$

Where: MOL = minimum ownership level (number of stations)

TSU = the total number of retail gasoline stations statewide less the sum of the required clean fuel outlets for all clean fuels to date (Note: Since a retail gasoline station could be an outlet for two or more fuels, the number gasoline retail stations equipped might not equal the number of retail outlets required.

TCFS = the sum of the incremental numbers of retail outlets for all clean fuels, calculated per Section C.

Equation (2-2) would determine the fraction of stations each owner, who owns at least as many stations as the minimum ownership level, would have to newly equip to dispense a particular clean fuel.

$$(SF)_k = (CFS)_k/(UES) \qquad (2\text{-}2)$$

Where: $(SF)_k$ = the fraction of stations each owner has to equip to dispense fuel k

$(CFS)_k$ = the incremental number of clean fuel outlets required for fuel k

(UES) = the sum of stations within the group that own at least as many stations as the minimum ownership level minus the sum of all incremental clean-fuel outlets (over all clean fuels) required of the same group in previous years

The incremental number of outlets each owner has to equip to dispense each clean fuel is calculated using equation (2-3).

$$(CFS)_{i,k} = (UES)_i * (SF)_k \qquad (2\text{-}3)$$

Where: $(CFS)_{i,k}$ = incremental clean fuel outlets owner i has to install to dispense fuel k for the upcoming year.

$(UES)_i$ = the number of stations of owner i minus the total clean fuel outlets (all fuels) required of owner i in all previous years

$(SF)_k$ = station fraction for fuel k {from equation (2-2)}

Each owner affected would equip the same fraction of stations, $(SF)_k$, based on the number of stations needed for a particular clean fuel. For example if the number of outlets required to distribute fuel A is 100 and the sum of the unequipped stations (total stations - required clean fuel outlets to date) for those owners with at least as many stations as the minimum ownership level for that year is 3,000, then the fraction would be 3.3 percent (100/3,000). Each owner would have to equip 3.3 percent of his stations to dispense fuel A, rounded to the nearest integer using conventional rounding. The sum of the clean fuel outlets in the group would equal 100, except for a small deviation caused by rounding.

The actual number of stations an owner has to newly equip to dispense a particular clean fuel would be the above result less outlets already provided voluntarily. Therefore, in any given year a station owner may not have to install additional clean fuel outlets, if s/he has already equipped enough stations to meet hers/his incremental allocation. The actual incremental number of clean fuel outlets an owner has to install is given by equation (2-4).

$$\text{Actual Incremental Number of Outlets for Fuel k required of Owner i} = (CFS)_{i,k} - [AE_k - SCFS_{i,k}] \quad (2\text{-}4)$$

Where: AE_k = number of clean fuel outlets actually equipped to dispense fuel k

$SCFS_{i,k}$ = sum of the outlets required of owner i, equipped to dispense fuel k, in all previous years

This procedure would be repeated for each clean fuel to calculate the allocation for each owner in the group responsible for providing the clean fuel outlets for a particular year. Using this procedure, the ARB would make the allocation of clean fuel outlets required for each fuel a year before the year of compliance.

If a station owner installs more than one outlet for a particular clean fuel at the same location, the owner would only receive credit for one clean fuel outlet. An owner could, however, install multiple clean fuel outlets at the same location as long as no two are equipped to dispense the same clean fuel. For example, if an owner installs an M-85 and a CNG outlet at the same location both would be credited towards meeting his requirement for each fuel.

Sample Calculations

Table B-2-7 presents an example of possible clean-fuel volumes and the associated number of outlets for 1997 through 2005. In 1997 we have used a throughput of 25,000 gallons per month, and 50,000 gallons per month from 1988 on. Also, we have assumed that half of the low-emission vehicles are clean-fuel vehicles and half are dedicated gasoline vehicles.

Table B-2-7. Possible Total Clean Fuel Volumes and Numbers of Retail Outlets Needed

Year	Clean-Fuel Volume (million gal.) *	Number of Clean-Fuel Outlets
1997	230	770
1998	600	1,000
1999	1,000	1,700
2000	1,700	2,800
2002	2,800	4,700
2005	4,000	6,700

* calculated as if half of the low-emission vehicles are clean fuel vehicles and half are dedicated gasoline vehicles, using appropriate F-factors for each year.

Table B-2-8 shows possible minimum ownership levels for 1997 through 2005. The clean-fuel volumes used to estimate the minimum ownership levels are those presented in Table B-2-7. Actual values will depend on the number of LEVs actually certified on clean fuels each year.

Table B-2-8. Possible Retail Outlet Minimum Ownership Levels*

Year	MO Levels for Clean-Fuel Outlet Requirement (number of stations owned)
1997	23
1998	62
1999	20
2000	9
2002	6
2005	4

* calculated as if half of the low-emission vehicles are clean fuel vehicles and half are dedicated gasoline vehicles, using appropriate F-factors for each year.

APPENDIX B-3

TEST PROCEDURES FOR EVALUATING THE EMISSION IMPACTS OF SUBSTITUTE FUELS OR NEW CLEAN FUELS

State of California
AIR RESOURCES BOARD

California Test Procedures
For Evaluating The Emission Impacts Of
Substitute Fuels Or New Clean Fuels

1. Purpose.

Whenever any person petitions the Air Resources Board to adopt the specifications of a substitute fuel, or to adopt the specifications of a new clean fuel which can be used in vehicles certified on a conventional fuel, the emission impacts of the substitute fuel or the new clean fuel shall be evaluated according to the procedures contained herein.

2. Applicability.

The Air Resources Board shall determine whether use of a substitute fuel or new clean fuel in vehicles capable of using the substitute or new clean fuel will result in an increase in exhaust emissions of non-methane organic gases (NMOG) on a reactivity-adjusted basis, carbon monoxide (CO), oxides of nitrogen (NOx), toxic air contaminants, and evaporative NMOG emissions.

For the purposes of this document, 'toxic air contaminants' shall refer to exhaust emissions of benzene, 1,3-butadiene, formaldehyde, acetaldehyde and diesel particulate.

Substitute fuels must be demonstrated to cause no increases in any of the emissions identified above in:

a) low-emission vehicles that have been certified on the primary designated clean fuel (the fuel that the substitute fuel is replacing), compared to operation on that primary designated clean fuel;

b) low-emission vehicles that have been certified on a different fuel (but are capable of operating on the substitute fuel), compared to operation on gasoline; and

c) conventional vehicles in the fleet that were certified on gasoline (but are capable of operating on the substitute fuel), compared to operation on gasoline.

New clean fuels will be used as certification fuels for new low-emission vehicles. New clean fuels must also be demonstrated to cause no increases in any of the emissions identified above in:

a) low-emission vehicles that have been certified on a different fuel (but are capable of operating on the new fuel), compared to operation on gasoline; and

b) conventional vehicles in the fleet that were certified on gascline (but are capable of operating on the new fuel), compared to operation on gasoline.

3. Selection of Vehicles.

For purposes of evaluating the emission impacts of a substitute fuel, representative vehicles shall be selected from vehicles certified on the primary designated clean fuel which the substitute fuel is to replace, and vehicles certified on gasoline but capable of using the substitute fuel.

For purposes of evaluating the emission impacts of a new clean fuel, representative vehicles shall be selected from existing vehicles certified on gasoline but capable of using the new fuel.

(A) To be eligible for selection, representative vehicles shall have accumulated between 4,000 and 50,000 miles, and must demonstrate compliance with applicable emission standards.

(B) Any scheduled maintenance shall be permitted to ensure that the test vehicles meet manufacturer performance specifications.

(C) Prior to emission testing, the vehicles shall be preconditioned to remove any residual fuel from the vehicle fuel system and evaporative canister.

(D) The representative test pool for each vehicle emission category shall be comprised, at a minimum, of the number of vehicles needed to determine statistically significant differences in emissions at a level of $p < 0.10$ using paired t-tests.

i. Substitute fuel versus primary designated clean fuel (in vehicles certified on the primary designated fuel)

a. The composition of the representative test fleet shall include vehicles from the vehicle emission categories listed below, equipped with the designated catalyst technology and fuel metering system:

Vehicle Emission Category	Catalyst Technology/Fuel Metering System
Transitional Low-Emission Vehicles	Three Way Catalyst/Fuel-Injected
Low-Emission Vehicles	Uniform Mix of Technologies
Ultra-Low-Emission Vehicles	Uniform Mix of Technologies

b. Prior approval must be granted by the Board's Executive Officer for use of vehicles exceeding mileage accumulations of 50,000 miles.

c. The test vehicles from each vehicle emission category must be certified for use on the primary designated clean fuel.

d. The representative test pools of transitional low-emission vehicles, low-emission vehicles and ultra-low-emission vehicles shall consist, at a minimum, of three different vehicles per vehicle emission category.

ii. Substitute fuel or new clean fuel versus gasoline (in low-emission and conventional vehicles)

a. The composition of the representative test fleet shall include vehicles from the vehicle emission categories listed below, equipped with the designated catalyst technology and fuel metering system:

Vehicle Emission Category	Catalyst Technology/Fuel Metering System
Conventional Vehicles	Non-Catalyst/Carbureted Oxidation Catalyst/Carbureted Three Way Catalyst/Carbureted Three Way Catalyst/Fuel-Injected
Transitional Low-Emission Vehicles	Three Way Catalyst/Fuel-Injected
Low-Emission Vehicles	Uniform Mix of Technologies
Ultra-Low-Emission Vehicles	Uniform Mix of Technologies

b. Prior approval must be granted by the Board's Executive officer for use of vehicles exceeding mileage accumulations of 50,000 miles.

c. The representative test pool of conventional vehicles shall consist of 50% Three Way Catalyst/Fuel-Injected vehicles, and a uniform mix of vehicles from the other three combined technology groups listed in the above table.

d. The representative test pools of transitional low-emission vehicles, low-emission vehicles and ultra-low-emission vehicles shall consist, at a minimum, of three different vehicles per vehicle emission category.

4. Emission Testing of Vehicles.

The air quality impact of a substitute fuel or new clean fuel shall be based on results from standardized emission tests conducted on a representative fleet of vehicles. Each of the test vehicles selected would be subjected to two sets of 'consecutive' Federal Test Procedure emission tests (Title 40, Code of Federal Regulations, Part 86).

(a) For purposes of evaluating the emission impacts of a substitute fuel in a low-emission vehicle certified on the primary designated fuel, consecutive tests shall consist of measuring the exhaust emissions of NMOG, CO, NOx, each of the toxic air contaminants, and evaporative NMOG emissions produced by vehicles when operated on the primary designated clean fuel followed by an emission test of the vehicles when fueled with the substitute fuel.

(b) For purposes of evaluating the emission impacts of a substitute fuel in low-emission vehicles that have been certified on a different fuel (and are capable of operating on the gasoline) and conventional vehicles certified on gasoline, consecutive tests shall consist of measuring the exhaust emissions of NMOG, CO, NOx, each of the toxic air contaminants, and evaporative NMOG emissions produced by vehicles when operated on gasoline followed by an emission test of the vehicles when fueled with the substitute fuel.

(c) For purposes of evaluating the emissions impacts of a new clean fuel, consecutive tests shall consist of measuring the exhaust emissions of NMOG, CO, NOx each of the, toxic air contaminants, and evaporative NMOG emissions produced by vehicles when operated on gasoline followed by an emission test of the vehicles when fueled with the new clean fuel.

(d) During one set of consecutive tests, a speciated NMOG profile shall be measured for determining the ozone-forming reactivity of the vehicle's exhaust emissions of NMOG produced when a vehicle is operated on its primary designated clean fuel or gasoline and when the vehicle is operated on a substitute fuel or new clean fuel.

(e) Speciated NMOG emissions shall be identified and quantified using the procedures outlined in the California Non-Methane Organic Gas Test Procedures (referenced in the California Exhaust Emission Standards and Test Procedures for 1988 and Subsequent Model Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles).

(f) Alternate test procedures yielding equivalent results may be used, if approved in advance by the Executive Officer.

5. Evaluating the Air Quality Impact of NMOG Exhaust Emissions.

The following procedure shall be used to evaluate the air quality impacts of NMOG exhaust emissions from vehicles operating on a substitute fuel compared to those of vehicles operating on the primary designated clean fuel and to those of vehicles operating on gasoline, or emissions from vehicles operating on a new clean fuel compared to those of vehicles operating on conventional fuel.

(a) The 'g ozone per mile' produced by any test vehicle shall be determined by the procedure described in Appendix VIII of the 'California Exhaust Emission Standards and Test Procedures for 1988 and Subsequent Model Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles.'

(b) For each vehicle, values for 'g ozone per mile' shall, at a minimum, be equal to the average of two 'g ozone per mile' values recorded and calculated for the vehicle in duplicate tests.

(c) For each vehicle emission category, individual vehicle average 'g ozone per mile' values shall be used to compare the air quality impact of the substitute fuel to the air quality impact of the primary designated clean fuel (for those vehicles certified on it) or gasoline (for other vehicles), or to compare the air quality impact of a new clean fuel to the air quality impact of a conventional fuel.

(d) Statistically significant differences attributable to the use of the substitute fuel or new clean fuel shall be determined using paired t-tests.

(e) Unless the 'g ozone per mile' value for any vehicle emission category when operated on the substitute fuel is demonstrated to be equal to or lower than that category when operated on a primary designated clean fuel (for those vehicles certified on it) or gasoline (for other vehicles), or the 'g ozone per mile' value for any vehicle emission category when operated on a new clean fuel is demonstrated to be equal or lower than that category when operated on gasoline, use of the substitute fuel or new clean fuel shall be considered to result in an increase in exhaust emissions of NMOG on a reactivity-adjusted basis.

6. Evaluating the Impact of Carbon Monoxide, Oxides of Nitrogen and Toxic Air Contaminant Exhaust Emissions.

The following procedure shall be used to evaluate the air quality impact of CO, NOx and toxic air contaminant emissions from vehicles operating on a substitute fuel compared to those of the primary designated clean fuel or gasoline, or emissions from vehicles operating on a new clean fuel compared to those of gasoline.

(a) The 'g/mile' exhaust emissions of CO, NOx and each of the toxic air contaminants produced by any test vehicle shall be measured according to the 'California Exhaust Emission Standards and Test Procedures for 1988 and Subsequent Model Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles.'

(b) For each vehicle, values for 'g/mile' exhaust emissions of CO, NOx and each of the toxic air contaminants shall, at a minimum, be equal to the average of two 'g/mile' values recorded for the vehicle in duplicate tests.

(c) For each vehicle emission category, individual vehicle average 'g/mile' values shall be used to compare the emissions from the substitute fuel and the emissions from the primary designated clean fuel (for those vehicles certified on it) or gasoline (for other vehicles), or to compare the emissions from a new clean fuel to the emissions from gasoline.

(d) Statistically significant differences attributable to the use of the substitute fuel or new clean fuel shall be determined using paired t-tests.

(e) Unless the 'g/mile' value for any vehicle emission category when operated on the substitute fuel is demonstrated to be equal to or lower than that category when operated on the primary designated clean fuel (for those vehicles certified on it) or gasoline (for other vehicles), or the 'g/mile' value for any vehicle emission category when operated on a new clean fuel is demonstrated to be equal to or lower than that category when operated on gasoline, use of the substitute fuel or new clean fuel shall be considered to result in increased exhaust emissions of CO, NOx and/or toxic air contaminants on a 'g/mile' basis.

7. Evaluating the Impact on Evaporative Non-Methane Organic Gas Emissions

The following procedure shall be used to evaluate the air quality impact of evaporative NMOG emissions from vehicles operating on a substitute fuel compared to that of the primary designated clean fuel or gasoline, or vehicles operating on a new clean fuel compared to that of gasoline.

(a) The 'g/test' evaporative emissions of NMOG produced by any test vehicle shall be measured according to the 'California Exhaust Emission Standards and Test Procedures for 1988 and Subsequent Model Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles.'

(b) For each vehicle, values for 'g/test' evaporative emissions of NMOG shall, at a minimum, be equal to the average of two 'g/test' values recorded for the vehicle in duplicate tests.

(c) For each vehicle emission category, individual vehicle average 'g/test' values shall be used to compare the emissions from the substitute fuel to the primary designated clean fuel (for those vehicles certified in it) or gasoline (for other vehicles), or the emissions from a new clean fuel to gasoline.

(d) Statistically significant differences attributable to the use of the substitute fuel or new clean fuel shall be determined using paired t-tests.

(e) Unless the 'g/test' value for any vehicle emission category when operated on the substitute fuel is demonstrated to be equal to or lower than that category when operated on the primary designated clean fuel (for those vehicles certified on it) or gasoline (for other vehicles), or the 'g/test' value for any vehicle emission category when operated on a new clean fuel is demonstrated to be equal to or lower than that category when operated on gasoline, use of the substitute fuel or new clean fuel shall be considered to result in increased evaporative emissions of NMOG on a 'g/test' basis.

APPENDIX B-4

GASOLINE MARKETING IN CALIFORNIA

This appendix presents a brief description of the gasoline marketing system in California. It also presents an estimate of the distribution of gasoline retail stations in the state by size of station ownership.

A. GASOLINE MARKETING SYSTEM

1. Gasoline Suppliers

Figure 1 illustrates the gasoline distribution system from refinery to the consumer. Gasoline is distributed from the refineries to the distribution terminal by barges, tankers (ships), pipeline or a combination of these. From these terminals, gasoline is transported to retail outlets in tanker trucks owned by refiners or by independent companies referred to as jobbers (wholesale distributors). Delivery to the retail outlet by trucks owned or operated by refiners is referred to as direct supply. Independent companies that transport gasoline to retail outlets are referred to as branded jobbers or unbranded jobbers.

A branded jobber is a wholesale distributor who sells under the refiner's brand name and operates between the refiner and the retail outlets. Branded jobbers often have a contract with the refiner that may include provisions such as the number of gallons the jobber must purchase and a minimum volume the refiner must make available. Branded jobbers purchase gasoline at a lower price than the dealer's delivered price, in part because the refiner does not incur the transportation costs. Unbranded jobbers usually have contracts with more than one refiner and may also purchase gasoline without contracts at the current market price.

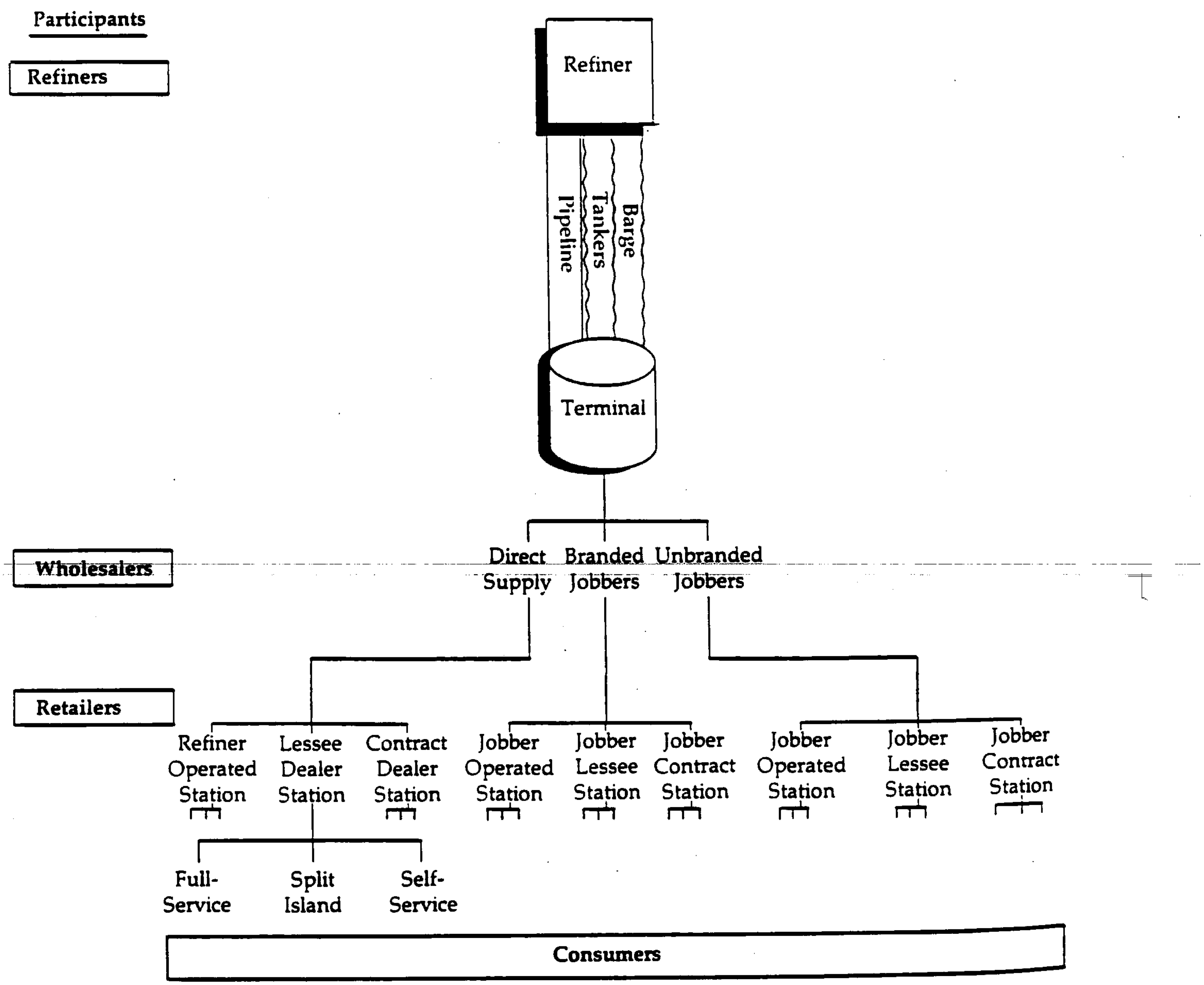
2. Gasoline Retail Service Stations

Gasoline marketing at the retail level consists of three main groups: those directly supplied by the refiner, those supplied by a branded jobber, and those supplied by an unbranded jobber. Retail service stations operate under a variety of contract and ownership arrangements, including company-(refiner or jobber) owned-and-operated stations, lessee dealer stations, and contract or open dealer stations.

Company-Owned and Operated

Company-operated stations generally include stations operated by an employee or agent of the company. (These companies can be owned by refiners, banded jobbers, or unbranded jobbers.) The company sets the retail price of the gasoline and services offered at the retail outlet. The station operators sell only gasoline supplied by the company. Company-operated stations are usually located on land owned or leased by the company.

Figure 1. Gasoline Marketing System



Source: Nordhaus, William D., R. Robert Russell, and Frederick D. Sturdivant, Turmoil and Competition in the Gasoline Marketing Industry, Management Analysis Center, Inc. 1983.

Lessee Dealer

The lessee dealer station is the most common arrangement in gasoline retailing. It is estimated that over half of the gasoline stations are of the lessee dealer type. In this arrangement, the refiner or jobber owns (or controls by a lease) the land, buildings and equipment and leases them to the dealer-operator. The dealer usually buys fuels from the leasing company, but lessee dealers have also been permitted to buy fuel from other sources as long as certain conditions are met. The lessee dealers operate their stations independently and set the retail prices of gasoline and other services, retaining all profits from the operation. The dealer pays the owner/lessor monthly rent on the facility and for the gasoline supplied. The contracts often contain incentives for the dealers to increase gasoline sales.

Contract or Open Dealer

Dealers who own stations or lease them from a third party other than their gasoline supplier are referred to as contract dealers or open dealers. Open dealers also set their own prices and choose their gasoline supplier. If a contract dealer chooses to display the brand name of a refiner or jobber, however, the owner of the brand will usually specify certain conditions of operation that the dealer has to meet. The contract dealer can tailor the operation to the particular combination of prices, hours, and services that maximizes profit at that station without specific regard for the effect of the dealer's decision on the network of branded stations.

B. DISTRIBUTION OF RETAIL GASOLINE STATIONS BY SIZE OF OWNERSHIP

There are about 13,000 retail gasoline stations statewide. Currently, there is not a complete inventory showing the number of stations owned by all owners of stations. From various sources, the staff estimates that forty percent of stations are controlled (owned or leased) by major oil companies. The other 60 percent are owned by independent companies (jobbers) or individual operators. An estimated 20 percent of the total stations (3,000) are owned by people who own only one or two stations, and over 30 percent of the stations are owned by people with five or fewer stations. Another 20 percent of the stations are owned by companies with over 20 stations.

Table 1 shows the estimated distribution of service stations according to number owned per owner. The numbers presented in Table 1 are preliminary estimates intended only to illustrate the range of ownership among the size categories. Under the proposed program, service station owners would report to ARB the number of stations they own, thus providing an accurate distribution among owners.

Table 1. Estimated Ownership Distribution

Ownership Category	Percent of All Stations
Major oil companies	40
Other owners:	
# stations owned	
<5	34
5 - 10	3
11 - 20	3
21 - 50	6
51 - 100	6
>100	8

APPENDIX B-6

PRELIMINARY ESTIMATION OF CLEAN FUEL
VOLUMES AND NUMBER OF RETAIL OUTLETS

INTRODUCTION

The purpose of this section is to describe the method used by the ARB staff to determine preliminary estimates of the clean fuel volumes, shown in Tables B-6-1 through B-6-12 (and in Table III-3 in the TSD and Table 9 in the Staff Report), that might be required by the proposed regulation.

The clean fuel volume estimate addresses both light-duty vehicle (LDV) (passenger cars and light-duty trucks) and medium-duty vehicle (MDV) requirements. It was assumed that the phase-in of LDVs and MDVs requiring clean fuel would follow the schedule described in Tables I-6 and I-7 in the Technical Support Document (TSD). (It was assumed that all LDVs would be phased-in according to the schedule for light-duty vehicles that have a loaded vehicle weight (LVW) of less than or equal to 3750 lbs, since light-duty vehicles that have LVWs of 3751 or greater typically make up only 5% of the total LDV population)

Preliminary estimates of the number of clean fuel retail outlets required each year of the regulation were deduced from these clean fuel volume estimates.

A. DETERMINING THE CLEAN FUEL VOLUME IN GASOLINE EQUIVALENT UNITS

The equation used to determine the annual volume of clean fuel demanded by LDV or MDV low-emission vehicles[1] is:

Annual clean fuel volume (CFV) = Clean fuel fraction (CFF) x Annual LDV or MDV gasoline volume (GV)

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1 low-emission vehicles = transitional low-emission vehicles (TLEVs), low-emission vehicles (LEVs), ultra-low-emission vehicles (ULEVs), and zero-emission vehicles (ZEVs).

The CFV represents the total volume of clean fuel required to exactly meet the needs of the low-emission vehicles (excluding ZEVs which are assumed to be fueled with electricity) if low-emission vehicles were phased-in in accordance with Tables I-6 and I-7. The CFV was calculated separately for LDVs and MDVs. The CFV does not represent the volume of clean fuel required to be distributed by gasoline suppliers. The volume to be distributed by gasoline suppliers is equal to the CFV multiplied by the adjustment factors discussed in Section B.

Subsections 1 and 2 discuss how the variables CFF and GV were determined.

1. Determining the Clean Fuel Fraction (CFF)

The CFF represents the fraction of the volume of gasoline used by on-road vehicles that would be displaced by clean fuels. It was calculated separately for LDVs and MDVs.

$$CFF = \frac{\dfrac{\%\ \text{low-emission vehicle vmt}}{\text{low-emission vehicle mpg}}}{\dfrac{\%\ \text{low-emission vehicle vmt}}{\text{low-emission vehicle mpg}} + \dfrac{\%\ \text{Other vmt}}{\text{Other mpg}}} \qquad (2)$$

Below the derivation of the variables in the equation to calculate the CFF are discussed.

a. Percent vehicle miles travelled (vmt) estimates

The fraction of the total annual vmt made up by low-emission vehicles (% LEV vmt) and non-low-emission vehicles (% other vmt) was determined using annual vehicle travel fraction estimations provided by ARB's EMFAC7C emissions inventory model. Separate travel fraction values were calculated for LDVs and MDVs. This information, coupled with the phase-in schedules provided by Table I-6 and Table I-7 allows for the calculation of the percentage of vmt that would be attributed to TLEVs, LEVs and ULEVs. It must be noted that the actual percentage of vmt made up by low-emission vehicles could vary from these projections since the proposed regulation allows auto manufacturers to meet emission averages rather than these phase-in schedules.

The fraction of total VMT made up by LDVs or MDVs is referred to as the travel fraction. Travel fraction values for the LDV fleet for the years 1994 through 2005 were taken from EMFAC7C's LDA1.CAT table. In using these values, the following assumptions were made:

- o The consumption of gasoline by the non-catalyst on-road fleet is insignificant during the period of 1994-2005. From EMFAC7C it is estimated that non-catalyst vehicles will make up approximately 2% of the gasoline LDV on-road fleet in 1994 and less than 1% by the year 2000.

- o The percent vmt from LDVs as a whole does not vary significantly from the percent vmt of light-duty automobiles. This is due to both the similar annual vmt distributions of the LDT (light-duty truck) and PC (passenger car) fleets and the relatively large population of PCs (approximately 80% of all LDVs).

The following is an example of how the travel fraction attributed to LDV LEVs was determined.

In the calendar year 1999, LDV LEVs (model years 1997 through 2000) would contribute, as shown below, approximately 16.8% of the total vmt of all LEVs (% LEV vmt = 16.8).

MODEL YEAR	PHASE IN LDV LEV PERCENTAGE		TRAVEL FRACTION OF ALL VEHICLES (from EMFAC7C LDA.CAT)		TRAVEL FRACTION OF LEVs
1997	.25	x	.10502	=	.02626
1998	.48	x	.10456	=	.05019
1999	.73	x	.09391	=	.06855
2000	.96	x	.02353	=	.02259

					.16759

The travel fraction for MDV LEV fleet were derived from the travel fractions listed in EMFAC7Cs MDT.CAT and HDT.CAT tables. MDT.CAT lists travel fractions for MDTs that have a gross vehicle weight (GVW) of less than 8500 lbs. HDT.CAT lists travel fractions for MDTs that have a GVW greater than 8500 lbs, as well as the travel fractions associated with HDTs.

In using these values, the following assumptions were made:

- o On a sales weighted basis, 91% of the percent vmt listed in HDT.CAT is attributed to medium duty vehicles.

- o Also on a sales weighted basis, 63% of MDV vmt is attributed to MDVs with a GVW less than 8500 lbs, and 37% of MDV vmt is associated with MDVs with a GVW greater than 8501 lbs.

The determination of MDV travel fractions from the EMFAC7C MDT.CAT and HDT.CAT tables is similar to the method described previously for determining percent vmt for LDVs from LDA.CAT. Once the MDT and HDT values are determined, they must be multiplied by the appropriate percentages and combined to reflect an overall MDV percent vmt. The equations used in calculating MDV percent vmt are shown below:

For MDV GVW < 8500 lbs :

% vmt=(MDT.CAT % vmt)(fraction of MDT veh that are cat)(.63)

For MDV GVW >8501 lbs. :

% vmt=(HDT.CAT % vmt)(fraction of HDT veh that are cat) (.91)(.37)

The overall MDV % vmt for a given year is equal to the summation of the % vmts calculated above.

b. Fuel economy (mpg) estimates

The average fuel economy of low-emission vehicles (LEV mpg) was assumed to be equal to the average fuel economy of a new gasoline vehicle of the same classification. Using annual overall LDV fleetwide average fuel economy numbers derived from CalTrans fuel economy estimates for autos and TWC (truck weight class) 1 (0-6000 lbs GVW), and factoring out the component of that overall average that is made up by LEVs, the non-LEV mpg for LEVs (other mpg) was determined. The MDV mpg estimates were similarly derived from CalTrans data for Truck Weight Class (TWC) 2 (6001-10000 lbs GVW). TWC 2 does not account for vehicles with GVWs of 10001-14000 lbs, however, these vehicles are estimated to comprise less than 1% of the entire on road fleet and less than 10% of the MDV fleet.

2. Determining the average annual gasoline volume (GV) for LDVs and MDVs

The annual gasoline volume required (GV) represents the number of gallons of gasoline that would be required to fuel the entire fleet of on-road LDVs (or MDVs) if no clean fuel vehicles were introduced. The LDV GV values were provided by CalTrans; the MDV GV values were derived from CalTrans estimates for TWC 2 and TWC 3-7. The amount of gasoline attributed to TWC 3 (10,000-14000 lbs) was assumed to be 10% of the value estimated for the TWC 3-7 grouping. These volumes, when multiplied by the CFF (see equation 2 above), represent the required annual gasoline equivalent clean fuel volumes (CFV) for LDVs and MDVs.

Tables 1 through 5 provide a summary of the values used in the calculation of the annual gasoline equivalent clean fuel volume (CFV).

B. DETERMINING THE ANNUAL GASOLINE EQUIVALENT CLEAN FUEL VOLUMES GASOLINE SUPPLIERS WOULD BE REQUIRED TO DISTRIBUTE AND THE NUMBER OF RETAIL OUTLETS REQUIRED TO OFFER CLEAN FUEL

The CFV discussed in Section A. represents the estimated amount of clean fuel needed to exactly meet the demands of the LEVs. To account for the uncertainty in the rate of sale of LEVs, and the uncertainty in the market's ability to allocate clean fuels perfectly, the CFV was multiplied by two factors -- a fuel volume adjustment factor (F-factor) and the South Coast region adjustment factor (SC-factor) (for the years 1994 through 1996 only). The resulting adjusted gasoline equivalent clean fuel volume would be required to be distributed by gasoline suppliers. The main reason for using these factors in the calculation of clean fuel volumes is to prevent the oversupply of clean fuel and prevent an excess number of clean fuel dispensing facilities from being required.

The number of retail outlets required each year was determined by dividing the annual clean fuel volume required to be distributed by a monthly clean fuel throughput variable.

Tables B-6-6 through 10 list the F-factors and SC-factors used in calculating clean fuel volumes; the calculated annual gasoline equivalent clean fuel volumes that would be required to be distributed by gasoline suppliers, and the number of retail outlets that would be required to install dispensing equipment for the calculated volume of clean fuel using throughput variables of 15000 gal/month, 20000 gal/month, 25,000 gal/month, 30,000 gal/month, and 50,000 gal/month. The proposed regulation specifies for liquid clean fuel retail outlets a 25,000 gal/month throughput for the years 1994 through 1997 and 50,000 gal/month throughput for the years 1998 and later. For gaseous clean fuel retail outlets, the throughput specified in the proposed regulation is 30,000 gal/month for the years 1994 and later.

Table B-6-11 provides an overall summary of LDV and MDT clean fuel volume and retail outlet requirements. Table B-6-12 provides an overall summary of LDV and MDT clean fuel volume and retail outlet requirements but assumes that half of the LDV and MDT will be gasoline vehicles.

TABLE B-6-1:
LDV TLEV Annual Clean Fuel Volume (CFV) Summary

Year	%TLEV (vmt)	%Other (vmt)	TLEV (mpg)	Other (mpg)	CFF	LDV gasoline volume (GV) (gals x E9)	Clean Fuel gasoline volume (CFV) (gals x E9)
1994	1.3	98.7	23.4	22.2	0.013	11.0	0.14
1995	3.0	97.0	23.4	22.4	0.028	11.0	0.31
1996	4.5	95.5	23.4	22.7	0.044	11.0	0.48
1997	4.7	95.3	23.4	22.8	0.046	11.0	0.50
1998	4.5	95.5	23.4	23.0	0.045	11.0	0.49
1999	4.2	95.8	23.4	23.0	0.041	11.1	0.45
2000	3.7	96.3	23.4	23.2	0.037	11.2	0.41
2002	2.8	97.2	23.4	23.3	0.028	11.3	0.32
2005	1.7	98.3	23.4	23.3	0.017	11.5	0.19

TABLE B-6-2:
LDV LEV Annual Clean Fuel Volume (CFV) Summary

Year	% LEV (vmt)	%Other (vmt)	LEV (mpg)	Other (mpg)	CFF	LDV gasoline volume (GV) (gals x E9)	Clean Fuel gasoline volume (CFV) (gals x E9)
1994	0	100	--	--	--	--	0.00
1995	0	100	--	--	--	--	0.00
1996	0	100	--	--	--	--	0.00
1997	3.5	96.5	23.4	22.8	0.034	11.0	0.38
1998	8.9	91.1	23.4	23.0	0.087	11.0	0.96
1999	16.8	83.2	23.4	22.9	0.165	11.1	1.83
2000	26.3	73.7	23.4	23.1	0.261	11.2	2.92
2002	42.9	57.1	23.4	23.2	0.427	11.3	4.83
2005	58.0	42.0	23.4	23.2	0.578	11.5	6.64

TABLE B-6-3:
LDV ULEV Annual Clean Fuel Volume (CFV) Summary

Year	%TLEV (vmt)	%Other (vmt)	TLEV (mpg)	Other (mpg)	CFF	LDV gasoline volume (GV) (gals x E9)	Clean Fuel gasoline volume (CFV) (gals x E9)
1994	0.00	100.0	23.4	22.2	0.000	11.0	0.00
1995	0.12	99.9	23.4	22.4	0.001	11.0	0.01
1996	0.22	99.8	23.4	22.7	0.002	11.0	0.02
1997	0.33	99.7	23.4	22.8	0.003	11.0	0.04
1998	0.43	99.6	23.4	23.0	0.004	11.0	0.05
1999	0.54	99.5	23.4	23.0	0.005	11.1	0.06
2000	0.79	99.2	23.4	23.2	0.008	11.2	0.09
2002	2.4	97.6	23.4	23.3	0.024	11.3	0.27
2005	6.8	93.2	23.4	23.3	0.068	11.5	0.78

TABLE B-6-4:
MDV LEV Annual Clean Fuel Volume (CFV) Summary

Year	%LEV (vmt)	%Other (vmt)	LEV (mpg)	Other (mpg)	CFF	MDV gasoline vol. (GV) (gals x E9)	Clean Fuel gasoline vol. (CFV) (gals x E9)
1994	0.00	100.0	--	--	--	--	0.00
1995	0.00	100.0	--	--	--	--	0.00
1996	0.00	100.0	--	--	--	--	0.00
1997	0.00	100.0	--	--	--	--	0.00
1998	2.4	97.6	12.5	12.3	0.024	1.8	0.04
1999	8.5	91.5	12.5	12.3	0.084	1.8	0.15
2000	17.3	82.7	12.5	12.4	0.172	1.8	0.31
2002	37.9	62.1	12.5	12.4	0.377	1.8	0.68
2005	55.3	44.7	12.5	12.4	0.552	1.9	1.05

TABLE B-6-5:
MDV ULEV Annual Clean Fuel Volume (CFV) Summary

Year	%ULEV (vmt)	%Other (vmt)	ULEV (mpg)	Other (mpg)	CFF	MDV gasoline volume (GV) (gals x E9)	Clean Fuel gasoline volume (CFV) (gals x E9)
1994	0.00	100.0	--	--	--	--	0.00
1995	0.00	100.0	--	--	--	--	0.00
1996	0.00	100.0	--	--	--	--	0.00
1997	0.00	100.0	--	--	--	--	0.00
1998	0.19	99.82	12.5	12.3	0.002	1.8	0.00
1999	0.48	99.52	12.5	12.3	0.005	1.8	0.01
2000	0.72	99.28	12.5	12.4	0.007	1.8	0.01
2002	2.3	97.7	12.5	12.4	0.022	1.8	0.04
2005	7.1	92.9	12.5	12.5	0.071	1.9	0.13

TABLE B-6-6:
LDV TLEV Clean Fuel Volumes to be Distributed / Retail Stations

Year	F-factor	SC-factor	Clean fuel volume distributed (gal/yr.)	Number of Retail Outlets at 15,000 gal/mo throughput	Number of Retail Outlets at 20,000 gal/mo throughput	Number of Retail Outlets at 25,000 gal/mo throughput	Number of Retail Outlets at 30,000 gal/mo throughput	Number of Retail Outlets at 50,000 gal/mo throughput
1994	0.25	0.50	17,000,000	97	73	58	49	29
1995	0.50	0.50	77,500,000	431	323	258	215	129
1996	0.50	0.50	120,000,000	667	500	400	333	200
1997	0.50	--	250,000,000	1,389	1,042	833	694	417
1998	0.75	--	367,500,000	2,042	1,531	1,225	1,021	613
1999	0.75	--	337,500,000	1,875	1,406	1,125	938	563
2000	0.90	--	369,000,000	2,050	1,538	1,230	1,025	615
2002	0.90	--	288,000,000	1,600	1,200	960	800	480
2005	0.90	--	171,000,000	950	713	570	475	285

TABLE B-6-7:
LDV LEV Clean Fuel Volumes to be Distributed / Retail Stations

Year	F-factor	SC-factor	Clean fuel volume distributed (gal/yr.)	Number of Retail Outlets at 15,000 gal/mo throughput	Number of Retail Outlets at 20,000 gal/mo throughput	Number of Retail Outlets at 25,000 gal/mo throughput	Number of Retail Outlets at 30,000 gal/mo throughput	Number of Retail Outlets at 50,000 gal/mo throughput
1994	0.25	0.50	0	0	0	0	0	0
1995	0.50	0.50	0	0	0	0	0	0
1996	0.50	0.50	0	0	0	0	0	0
1997	0.50	--	190,000,000	1,056	792	633	528	317
1998	0.75	--	720,000,000	4,000	3,000	2,400	2,000	1,200
1999	0.75	--	1,372,500,000	7,625	5,719	4,575	3,813	2,288
2000	0.90	--	2,628,000,000	14,600	10,950	8,760	7,300	4,380
2002	0.90	--	4,347,000,000	24,150	18,113	14,490	12,075	7,245
2005	0.90	--	4,347,000,000	33,200	24,900	19,920	16,600	9,960

TABLE B-6-8:
LDV ULEV Clean Fuel Volumes to be Distributed / Retail Stations

Year	F-factor	SC-factor	Clean fuel volume distributed (gal/yr.)	Number of Retail Outlets at 15,000 gal/mo throughput	Number of Retail Outlets at 20,000 gal/mo throughput	Number of Retail Outlets at 25,000 gal/mo throughput	Number of Retail Outlets at 30,000 gal/mo throughput	Number of Retail Outlets at 50,000 gal/mo throughput
1994	0.25	0.50	0	0	0	0	0	0
1995	0.50	0.50	2,500,000	14	10	8	7	4
1996	0.50	0.50	5,000,000	28	21	17	14	8
1997	0.50	--	20,000,000	111	83	67	56	33
1998	0.75	--	37,500,000	208	156	125	104	63
1999	0.75	--	45,000,000	250	188	150	125	75
2000	0.90	--	81,000,000	450	338	270	225	135
2002	0.90	--	243,000,000	1,350	1,013	810	675	405
2005	0.90	--	702,000,000	3,900	2,925	2,340	1,950	1,170

TABLE B-6-9:
MDV LEV Clean Fuel Volumes to be Distributed / Retail Stations

Year	F-factor	SC-factor	Clean fuel volume distributed (gal/yr.)	Number of Retail Outlets at 15,000 gal/mo throughput	Number of Retail Outlets at 20,000 gal/mo throughput	Number of Retail Outlets at 25,000 gal/mo throughput	Number of Retail Outlets at 30,000 gal/mo throughput	Number of Retail Outlets at 50,000 gal/mo throughput
1994	0.25	0.50	0	0	0	0	0	0
1995	0.50	0.50	0	0	0	0	0	0
1996	0.50	0.50	0	0	0	0	0	0
1997	0.50	--	0	0	0	0	0	0
1998	0.75	--	30,000,000	167	125	100	83	50
1999	0.75	--	112,500,000	625	469	375	313	188
2000	0.90	--	279,000,000	1,550	1,163	930	775	465
2002	0.90	--	612,000,000	3,400	2,550	2,040	1,700	1,020
2005	0.90	--	945,000,000	5,250	3,938	3,150	2,625	1,575

TABLE B-6-10:
MDV ULEV Clean Fuel Volumes to be Distributed / Retail Stations

Year	F-factor	SC-factor	Clean fuel volume distributed (gal/yr.)	Number of Retail Outlets at 15,000 gal/mo throughput	Number of Retail Outlets at 20,000 gal/mo throughput	Number of Retail Outlets at 25,000 gal/mo throughput	Number of Retail Outlets at 30,000 gal/mo throughput	Number of Retail Outlets at 50,000 gal/mo throughput
1994	0.25	0.50	0	0	0	0	0	0
1995	0.50	0.50	0	0	0	0	0	0
1996	0.50	0.50	0	0	0	0	0	0
1997	0.50	--	0	0	0	0	0	0
1998	0.75	--	0	0	0	0	0	0
1999	0.75	--	7,500,000	42	31	25	21	13
2000	0.90	--	9,000,000	50	38	30	25	15
2002	0.90	--	36,000,000	200	150	120	100	60
2005	0.90	--	117,000,000	650	488	390	325	195

TABLE B-6-11:
Overall LDV and MDV CFVs / Clean Fuel Volumes to be Distributed
and Retail Stations (If all low-emission vehicles are clean-fuel vehicles)

Year	Overall CFV (galxE9)	F-factor	SC-factor	Overall Clean fuel Volume (galxE9)	Number of Retail Outlets at 15,000 gal/mo throughput	Number of Retail Outlets at 20,000 gal/mo throughput	Number of Retail Outlets at 25,000 gal/mo throughput	Number of Ratail Outlets at 30,000 gal/mo throughput	Number of Retail Outlets at 50,000 gal/mo throughput
1994	0.14	0.25	0.50	0.017	97	73	58	49	29
1995	0.32	0.50	0.50	0.080	444	333	267	222	133
1996	0.50	0.50	0.50	0.125	694	521	417	347	208
1997	0.92	0.50	--	0.460	2,556	1,917	1,533	1,278	767
1998	1.50	0.75	--	1.155	6,417	4,813	3,850	3,208	1.925
1999	2.5	0.75	--	1.875	10,417	7,813	6,250	5,208	3,125
2000	3.7	0.75	--	3.366	18,700	14,025	11,220	9,350	5,610
2002	6.1	0.90	--	5.472	30,400	22,800	18,240	15,200	9,120
2005	8.8	0.90	--	7.884	43,800	32,850	26,280	21,900	13,140

TABLE B-6-12:
Overall LDV and MDV CFVs / Clean Fuel Volumes to be Distributed
and Retail Stations (Assuming half of all low-emission vehicles use gasoline and half use clean fuel)

Year	Overall CFV (galxE9)	F-factor	SC-factor	Overall Clean fuel Volume (galxE9)	Number of Retail Outlets at 15,000 gal/mo throughput	Number of Retail Outlets at 20,000 gal/mo throughput	Number of Retail Outlets at 25,000 gal/mo throughput	Number of Ratail Outlets at 30,000 gal/mo throughput	Number of Retail Outlets at 50,000 gal/mo throughput
1994	0.07	0.25	0.50	.009	49	36	29	24	15
1995	0.16	0.50	0.50	.040	222	167	133	111	67
1996	0.25	0.50	0.50	.063	347	260	208	174	104
1997	0.46	0.50	--	.230	1,278	958	767	639	383
1998	0.8	0.75	--	.578	3,208	2,406	1,925	1,604	963
1999	1.3	0.75	--	.938	5,208	3,906	3,125	2,604	1,563
2000	1.9	0.90	--	1.683	9,350	7,013	5,610	4,675	2,805
2002	3.1	0.90	--	2.763	15,350	11,513	9,210	7,675	4,605
2005	4.4	0.90	--	3.942	21,900	16,425	13,140	10,950	6,570

APPENDIX B-7

CREDITS FROM THE SALE OF ELECTRICITY TO VEHICLES

Beginning in 1994, the proposed regulation allows electric utilities to generate credit for electricity provided to electric vehicles. Credit would be accrued only for electricity provided to electric vehicles sold in excess of the required number of zero-emission vehicles. Credit would be determined on an annual basis by multiplying a utility's total metered amount of electricity supplied to electric vehicles in a year by a calculated adjustment factor for that year, called the E-factor.

The E-factor is defined as the cumulative sum of the excess number of electric vehicles sold each year for the past ten years divided by the cumulative sum of the total number of zero-emission vehicles sold each year for the past ten years[1]. The E-factor would be multiplied by the amount of electricity supplied to electric vehicles in the previous calendar year. The E-factor would equal 1.0 until December 31, 1998; then, beginning in 1999, the E-factor would be determined by the Executive Officer and announced on March 1 of each year.

The following example, using hypothetical information, illustrates how the E-factor for the year 2000 and a utility's credit would be determined.

Example: The E-factor can be expressed as follows:

$$E_{f-2000} = \sum_{i=1991}^{2000} xEV_i \Big/ \sum_{i=1991}^{2000} tZEV_i$$

$$xEV_i = tZEV_i - rZEV_i$$

Where E_{f-2000} = the E-factor for the calendar year 2000;

xEV_i = the number of electric vehicle sold in excess of the required number of zero-emission vehicles;

$tZEV_i$ = the total number of electric vehicle sold in any year from 1991 to 2000; and

$rZEV_i$ = the required number of zero-emission vehicles sold in any year.

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1. Ten years are used because it is assumed that a vehicle's useful life is ten years.

The following hypothetical data will be used to illustrate how to calculate an E-factor for the year 2000.

Table B-7-1. Example Calculation of E-Factor

Year	$tZEV_i$	$rZEV_i$	xEV_i
1991	no credit allowed		
1992	"		
1993	"		
1994	100	0	100
1995	200	0	200
1996	200	0	200
1997	200	0	200
1998	1,000	900	100
1999	1,000	900	100
2000	1,000	900	100
	-----	-----	-----
total	3,700	2,700	1,000

$$E_{f-2000} = 1{,}000/3{,}700 = 0.27$$

The amount of credit a utility would receive is the total amount ~~of electricity provided to electric vehicles during the prior year~~ times the E-factor, as shown by the following equation:

$$EC_{2000} = E_{f-2000} \times \text{kw-hr}_{2000}$$

Where EC_{2000} = the credit earned for electricity supplied to electric vehicles in the year 2000, and

kw-hr_{2000} = the amount of metered electricity supplied by a utility in the year 2000.

If in 2000, a utility provided 100,000 kw-hr of electricity to electric vehicles, the credit that the utility would be earn would be the 100,000 kw-hr times 0.27, or 27,000 kw-hrs. This credit would be converted into the equivalent volume of a clean fuel that has a distribution requirement. (See Appendix B-2 for conversion factors.)

APPENDIX B-8

DEFINITION OF A SMALL BUSINESS

The definition of "small business" is specified in the Government Code Section 11342 (e). This section of the code is reproduced here.

"Small business means

(1) A business activity, unless excluded in paragraph (2) below, that is all of the following:

(a) Independently owned and operated.

(b) Not dominant in its field of operation.

(c) Not exceeding the following annual gross receipts in the categories of:
(i) Agriculture, one million dollars ($1,000,000).
(ii) General construction, nine million five hundred thousand dollars ($9,500,000).
(iii) Special trade construction, five million dollars ($5,000,000).
(iv) Retail trade, two million dollars ($2,000,000).
(v) Wholesale trade, nine million five hundred thousand dollars ($9,500,000).
(vi) Services, two million dollars ($2,000,000).
(vii) Transportation and warehousing, one million five hundred thousand dollars ($1,500,000).

(d) A manufacturing enterprise not exceeding 250 employees.

(e) A health care facility not exceeding 150 beds or one million five hundred thousand dollars ($1,500,000) in annual gross receipts.

(f) Generating and transmitting electric power not exceeding 4.5 million kilowatt hours annually.

(2) The following professional and business activities shall not be considered a small business for purposes of this regulation:

(a) Financial institutions including banks, trusts, savings and loan associations, thrift institutions, consumer and industrial finance companies, credit unions, mortgage and investment bankers, and stock and bond brokers.

(b) Insurance companies, both stock and mutual.

(c) Mineral, oil, and gas brokers; subdividers and developers.

(d) Landscape architects, architects, and building designers.

(e) Entities organized as nonprofit institutions.

(f) Entertainment activities and productions including motion pictures, stage performances, television and radio stations, and production companies.

(g) All utilities, water companies, and power transmission companies, except electrical power generating transmission companies providing less than 4.5 million kilowatt hours annually.

(h) All petroleum and natural gas producers, refiners and pipelines."

State of California
Air Resources Board

M E M O R A N D U M

RECEIVED
AUG 3 1990
Stationary Source Division
Air Resources Board

To: Peter Venturini, Chief
Stationary Source Division

Through: Michael P. Kenny
General Counsel

From: W. Thomas Jennings
Senior Staff Counsel

Date: July 31, 1990

Re: Authority of Air Resources Board to Adopt Requirements for the Distribution and Retail Availability of Clean Motor Vehicle Fuels

The staff of the Air Resources Board (ARB or Board) has prepared a regulatory proposal which would establish stringent, long-term tiered exhaust emission standards for low-emission motor vehicles. It is expected that, in order to meet these stringent standards, vehicle manufacturers will design some of the vehicles to operate on clean alternative fuels. An integral part of the proposal is that, to the extent vehicles are certified to meet the applicable emission standards only when operated on alternative fuels, gasoline suppliers will be required to distribute appropriate quantities of the fuels to be used in the vehicles. In addition, owners or lessors of service stations will be required to equip a specified percentage of stations to dispense clean fuels used to certify vehicles, and station operators will have to have the fuel available at the stations. Certain *de minimis* trigger levels for the number of clean fuel vehicles operated would have to be reached before the clean fuel requirements become applicable. The regulatory proposal is described in detail in the public hearing notice dated July 31, 1990.

This memorandum addresses the authority of the Board to adopt the clean fuel portions of the proposal.

SUMMARY

The California Clean Air Act of 1988 (CCAA) among other things enacted Health and Safety Code section 43018. It is our opinion that section 43018 authorizes the Board, upon appropriate findings, to adopt clean fuel regulations of the sort proposed by the staff. The CCAA expanded the Board's previous authority to regulate and control the sale of motor vehicle fuels. Section 43018 does not limit the Board's regulatory options to "specifications" of fuels. Rather, it authorizes the Board to adopt whatever control measures pertaining to fuels it finds are technologically feasible, cost-effective, and necessary to attain the state ambient air quality standards at the earliest practicable date and to meet the emissions reductions mandated in the statute. Therefore, the Board has the statutory authority to adopt the proposal as long as it makes the requisite statutory findings.

The staff proposal would not constitute on its face an unconstitutional taking of property under the fifth amendment to the U.S. Constitution. There does not appear to be any "property" that would be "taken" by the proposal. In any case, the clean fuel proposal would substantially advance legitimate state interests, and there is an identifiable nexus between the activities regulated and the governmental interests being furthered. In addition, the proposal cannot be shown on its face to deny gasoline suppliers or service station owners or operators the economically viable use of their property, because the extent to which the clean fuel requirements will be triggered by new alternative clean fuel vehicles is not yet known.

The proposal also would not violate "substantive" due process under the fifth amendment. The proposed regulations are rationally related to a legitimate state interest. The proposal does not trigger the more stringent substantive due process requirements which apply when a regulation infringes on a constitutionally protected personal liberty or fundamental right.

ANALYSIS

I. STATUTORY AUTHORITY

A. Background--The ARB's authority to regulate motor vehicle fuels before enactment of the California Clean Air Act of 1988.

Prior to enactment of the CCAA in 1988, the ARB was only expressly authorized to regulate motor vehicle fuels in two areas--limiting the Reid vapor pressure (RVP) of gasoline (Health and Safety Code section 43830[1]) and limiting the degree of unsaturation of gasoline (measured by bromine number) in the South Coast Air Basin (section 43831). However, the California Supreme Court had determined in Western Oil and Gas Ass'n [WOGA] v. Orange County APCD, 14 Cal.3d 411 (1975), that the Board had additional authority to regulate motor vehicle fuel stemming from its authority to establish motor vehicle emission standards. In 1975, former section 39052.6 provided that the Board could adopt and implement motor vehicle emission standards for the control of air contaminants, other than standards specified by the Legislature, where the Board found its standards to be

1. All section references are to the Health and Safety Code unless otherwise indicated.

necessary and technologically feasible to carry out the purposes of the state air pollution laws. The WOGA court held that section 39052.6 authorized the ARB to control emissions of lead from motor vehicles not just by setting vehicle emission standards which require the use of a mechanical device on the vehicle, but also by regulating the fuel composition and limiting the lead content of gasoline. (id., 14 Cal.3d at 419-420.) Noting the ambitious air quality goals imposed by the Legislature on the ARB and the unavailability of mechanical devices for reducing lead emissions, the court stated:

> If we were to hold that the ARB has no power to regulate fuel content, we would be attributing to the Legislature an intention to deprive the agency of the only realistic means at its disposal to achieve the purposes of the act. (id. at 420)

In 1975, section 39052.6 was recodified as sections 43013 and 43101. (Stats 1975 ch 957, sec. 12.) Section 43013 permitted, and section 43101 mandated, the Board to adopt and implement motor vehicle emission standards that it found necessary and technologically feasible to carry out the purposes of the state clean air laws. Pursuant to these sections and the WOGA case, the Board adopted limits on the lead content of gasoline (13 CCR sections 2253, 2253.2), the sulfur content of unleaded gasoline (13 CCR section 2252(a)-(c)), and the sulfur content of diesel fuel (13 CCR section 2252(d) ff).

In addition, in 1988 the Legislature enacted sections 39663 and 39667, which require the Board to consider additional motor vehicle fuels regulations to control the emissions of toxic air contaminants. (Stats. 1988 ch. 940) Section 39663 directs the Board to prepare a report addressing specific aspects of exposure to known and suspected toxic air contaminants emitted by vehicular sources in California, and by June 30, 1990 to consider a plan for reducing exposure to such air contaminants. Section 39677 directs the Board to consider, in light of its determinations pursuant to section 39663, revisions to its regulations specifying the content of motor vehicle fuel, and its vehicular emission standards, in order to achieve the maximum possible reduction in public exposure to toxic air contaminants. Section 39667 continues,

> Those regulations may include, but are not limited to, the modification, removal, or substitution of vehicle fuel, vehicle fuel components, or fuel additives, or the required installation of vehicular control measures on new motor vehicles.

B. The California Clean Air Act of 1988.

The California Clean Air Act of 1988 is ambitious and far-reaching legislation enacted in recognition of the fact that most urban areas of the state had not attained federal ambient air quality standards by the federal deadline of August 31, 1988. (Stats. 1988, ch. 1568, uncodified section 1(b)(4).) The CCAA directed the development and implementation of

California's own program to attain the ambient air quality standards at the earliest practicable date. (id., uncodified section 1(b).)

While much of the CCAA involves establishment of a process for developing and implementing air pollution control district plans for attaining the ambient standards, it also contains important provisions directing the ARB to reduce emissions from motor vehicles. In the motor vehicle area, the CCAA added a new findings and declaration section (sec. 43000.5), amended section 43013, and enacted a central new section 43018.[2]

In new section 43000.5(d), the Legislature finds and declares that, "the state board should take immediate action to implement both short- and long-range programs of across-the-board reductions in vehicular emissions which can be relied upon by the districts in the preparation of their attainment plans or plan revisions...." In section 43000.5,(e), the Legislature declares that,

> [I]n order to attain the state and federal standards as expeditiously as possible, it is necessary for the authority of the state board to be clarified and expanded with respect to the control of motor vehicles and motor vehicle fuels.

The CCAA amended section 43013 by adding additional subsections specifically authorizing standards and regulations for identified types of motor vehicles and equipment, and making the following additions to the first paragraph:

> 43013. (a) The state board may adopt and implement motor vehicle emissions standards, in-use performance standards, and motor vehicle fuel specifications for the control of air contaminants and sources of air pollution which the state board has found to be necessary, cost-effective, and technologically feasible to carry out the purposes of this division.

Finally, the CCAA enacted new section 43018. Subsections (a)-(c) are set forth below. Subsection (d) establishes a specific timetable for the Board to conduct workshops and rulemaking hearings for specific regulations regarding motor vehicles and motor vehicle fuels. The full text of section 43018 is attached.

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2. The only other CCAA amendment to Division 26, Part 5 ("Vehicular Air Pollution Control") was the enactment of section 43019 regarding expanded fees for the certification of motor vehicles and engines.

43018. (a) The state board shall endeavor to achieve the maximum degree of emission reduction possible from vehicular and other mobile sources in order to accomplish the attainment of the state standards at the earliest practicable date.

(b) Not later than January 1, 1992, the state board shall take whatever actions are necessary, cost-effective, and technologically feasible in order to achieve, not later than December 31, 2000, a reduction in the actual emissions of reactive organic gases [ROG] of at least 55 percent, [and] a reduction in emissions of oxides of nitrogen [NOx] of at least 15 percent from motor vehicles. These reductions in emissions shall be calculated with respect to the 1987 baseline year. The state board also shall take action to achieve the maximum feasible reductions in particulates, carbon monoxide, and toxic air contaminants from vehicular sources.

(c) In carrying out this section, the state board shall adopt standards and regulations which will result in the most cost-effective combination of control measures on all classes of motor vehicles and motor vehicle fuel, including, but not limited to, all of the following:

(1) Reductions in motor vehicle exhaust and evaporative emissions.
(2) Reductions in emissions from in-use emissions from motor vehicles through improvements in emission system durability and performance.
(3) Requiring the purchase of low-emission vehicles by state fleet operators.
(4) Specification of vehicular fuel composition.

C. Effect of the California Clean Air Act of 1988

It is our opinion that section 43018 authorizes the Board, upon appropriate findings, to adopt clean fuel regulations of the sort prepared by the staff. The CCAA expanded the Board's previous authority to regulate and control the sale of motor vehicle fuels. Section 43018 does not limit the Board's regulatory options to "specifications" of fuels. Rather, section 43018 authorizes the Board to adopt whatever control measures pertaining to fuels it finds are technologically feasible, cost-effective, and necessary to attain the state ambient air quality standards at the earliest practicable date and to meet the emissions reductions specified in section 43018(b).

Section 43018(a) and (b) spell out the goals and objectives the ARB must pursue in its motor vehicle regulatory program. Section 43018(a) directs the Board to endeavor to achieve the maximum degree of reductions possible from vehicles, in order to attain the state ambient standards by the earliest practicable date. Section 43018(b) directs the Board to achieve the specified percentage reductions in emissions of reactive organic gases and oxides of nitrogen from motor vehicles by December 31, 2000, as well as maximum feasible reductions in particulates, carbon monoxide, and toxic air contaminants from vehicular sources. To do so, the Board is directed to take "whatever actions are necessary, cost effective, and technologically feasible." (emphasis added)

Section 43018(c) spells out the means by which the Board is to achieve the required goals and objectives. While sections (c) and (d) mandate consideration of numerous potential controls, the Board is given wide authority to enact whatever vehicle and fuels controls are necessary to attain the ambient standards and mandated emissions reductions. Section 43018(c) directs the Board to adopt "standards and regulations which will result in the most cost-effective combination of control measures on all classes of motor vehicles and motor vehicle fuel . . . ." (emphasis added) The Legislature then lists in section 43018(c)(1)-(4) four broad types of control measures the Board must consider, but the sorts of control measures the Board is authorized to adopt are expressly not limited to those specifically identified.

It is evident that section 43018 provides the ARB with broad regulatory motor vehicle and fuel authority not otherwise granted in the Health and Safety Code, including authority beyond the grants in section 43013. First, one of the nonexclusive control measures specifically identified in section 43018(c) is "requiring the purchase of low-emission vehicles by state fleet operators." (Section 43018(c)(3).) Such a requirement does not fall within the authority granted by section 43013 to adopt "motor vehicle emission standards, in-use performance standards, and motor vehicle fuel specifications." Neither is the authority to require state fleet operators to purchase low-emission vehicles granted to the ARB in the low-emission fleet provisions in sections 43800-43805[3], 40447.5, 40920(a)(3), and 41011. Since the Legislature has listed among the specific control measures to be considered by the ARB a measure nowhere else authorized, it is clear that section 43018 grants the Board expanded authority to adopt regulatory control measures regarding motor vehicle fuels.

Second, the categories of control measures identified in section 43018(c)(1), (2) and (4) essentially correlate to the three categories authorized by section 43013. "Reductions in motor vehicle exhaust and evaporative emissions" in section 43018(c)(1) correlates to "motor vehicle

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3. Section 43802 requires the ARB annually to submit a listing of certified low-emission vehicles to the Department of General Services. Section 43804 provides that if a low-emission vehicle meets the performance, cost, service, and maintenance requirements of the Department of General Services, and if funds are appropriated, the Department shall purchase as many low-emission vehicles as it determines are reasonable and available to meet state needs.

emission standards," "reductions in emissions from in-use emissions from motor vehicles through improvements in emission system durability and performance" in section 43018(c)(2) correlates to "in-use performance standards," and "specification of vehicular fuel composition" in section 43018(c)(4) correlates to "motor vehicle fuel specifications." However, although these three categories are effectively coterminous with the categories authorized in section 43013, section 43018(c) expressly provides that the control measures the Board may adopt <u>are not limited to these categories.</u> Therefore, the Board's authority under section 43018 is necessarily broader than its authority under section 43013.

Third, a broader reading of the authority to control motor vehicle fuels granted by section 43018 is consistent with section 43000.5(d). As discussed above, the 1975 <u>WOGA</u> case had already recognized the Board's authority to regulate the specifications of motor vehicle fuel, stemming from the predecessor statute to sections 43013 and 43101. This preexisting authority was codified by the CCAA amendments to section 43013 which expressly authorized the Board to adopt "motor vehicle fuel specifications." However, in section 43000.5(d) the Legislature declared the necessity that the Board's authority with respect to motor vehicle fuels be "clarified and <u>expanded</u>." That <u>expanded</u> authority to control motor vehicle fuels must be found in section 43018.

Fourth, an analysis of the various versions of section 43018(c) as the CCAA moved through the Assembly and Senate strongly suggests that the Legislature intended a broad grant of authority. The California Clean Air Act was was considered by the legislature as Assembly Bill 2595 (Sher). When the bill was initially introduced March 3, 1987, there were no specific motor vehicle provisions. Language for a new section 43018 was first introduced in a set of May 14, 1987 amendments in the Assembly Natural Resources Committee. At that time the section consisted of a subsection (a), which directed the Board to take whatever actions are necessary to achieve specified ROG and NOx reductions by year 2000, and a subsection (b), which read as follows:

> (b) In carrying out this section, the state board shall adopt standards and requirements which result in the most cost-effective combination of control measures, including but not limited to, reductions in new motor vehicle emissions, <u>requiring use of clean burning fuels</u>, and improvements of in-use vehicle emissions from all classes of motor vehicles sold within the state. (emphasis added)

On April 14, 1988, section 43018 was amended in the Senate Government Organization committee. A new subsection (a) was relatively similar to the version finally enacted, as was subsection (b). The amended version of section 43018(c) read as follows:

> (c) In carrying out this section, the state board shall adopt standards and regulations which will result in the most cost-effective combination of control measures on all classes of motor vehicles and motor vehicle

fuel, including but not limited to, all of the following:

(1) Reductions in motor vehicle exhaust and evaporative emissions.

(2) Reductions in emissions from in-use emissions from motor vehicles through improvements in vehicle certification procedures and emission system durability and performance.

(3) Requiring the manufacture of vehicles capable of utilizing cleaner-burning fuels.

(4) Requiring the purchase of clean fuel vehicles by state fleet operators.

(5) Specification of vehicular fuel composition.

The April 14, 1988 amendments also added for the first time a schedule of workshops and rulemaking hearings the Board was to follow in considering specifically identified control measures. Subsequent amendments to section 43018(c) on May 18, 1988 and June 28, 1988 resulted in the finally enacted text.

The intermediate versions quoted above of what ultimately became section 43018(c) followed the same structure as the enacted text. The Board was mandated to meet certain air quality goals, and then was broadly directed to carry out the mandates by adopting a cost-effective combination of control measures. The Legislature further itemized specific categories of control measures which the broader range of measures were to include but not be limited by. The Legislature did not meaningfully change in the various versions the description of the broader range of control measures the Board was authorized to adopt. It therefore follows that each of the specifically itemized categories listed in the intermediate versions of the bill fell within the broader range of control measures the Legislature intended to authorize for Board action. These more specific categories included "requiring the use of clean burning fuels" (May 14, 1987 version) and "requiring the manufacturer of vehicles capable of utilizing cleaner-burning fuels." (April 14, 1988 version.) The ARB would not have the authority to adopt such approaches, particularly a mandate for the use of clean fuels, unless section 43018 is interpreted as granting broad regulatory authority.[4]

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4. The Legislature's ultimate decision to delete the specific references to clean fuels did not demonstrate an intent to limit the Board's authority to act in this area. The listing of specific control measures in section 43018(c), particularly in the versions that referred to control measures "including, but not limited to, all of the following," imposed an affirmative requirement that the Board consider or adopt the specific measures. The legislature also established in section 43018(d) a specific

(Footnote continues on next page)

Fifth, legislative analyses of the CCAA prepared during the enactment process indicate a legislative recognition that the widespread introduction of clean fuels could well be necessary to meet the air quality goals the CCAA imposes on the ARB. In a June 15, 1987 report on the bill as amended May 14, 1987, the Legislative Analyst took note of the original language for section 43018 and stated:

> Reduced Motor Vehicle Emissions. The bill requires the Air Resources Board (ARB) to take necessary actions by January 1, 1992 to reduce motor vehicle emissions by the year 2000 to certain levels. According to the ARB, methanol fuel powered vehicles would be required to meet the emission reductions mandated by the bill.

Similarly, In a June 5, 1987 analysis of the May 14, 1987 version of the bill, transmitted to bill author Assemblyman Sher from the Department of Finance, the Department stated:

> The bill would also require that the ARB develop a plan by January 1, 1992 to reduce pollutants from mobile sources by a specified amount by the year 2000. The ARB indicates that this is an indirect mandate to shift to alternative fuels such as methanol because it is the only way this mandate could be met. The issue is more adequately addressed in AB 234 (Leonard), and the ARB indicates it may be appropriate to delete it from this bill.

While the specific reference to control measures "requiring use of clean burning fuels" in the May 14, 1987 version of the bill was deleted, the basic mandate for the ARB to meet specified emissions reductions by year

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(Footnote continued from previous page)

schedule for workshops and rulemaking hearings on identified measures including, in the April 14, 1988 version, the required manufacture of vehicles capable of utilizing cleaner burning fuels. Elimination of the references to these clean fuel control measures simply eliminated the mandate that those specific approaches be considered or adopted; in no way did it remove the discretionary authority of the Board to adopt clean fuel control measures if deemed necessary to attain and maintain the ambient standards.

2000 was not.[5] In fact, the mandates on the ARB were strengthened by the new requirement in section 43018(a) that the ARB endeavor to achieve the maximum emissions reductions possible from vehicular sources in order to attain the state ambient standards at the earliest practicable date. The bill analyses quoted above indicate that the legislature was aware that the goals mandated on the ARB by section 43018 might only be achievable through the introduction of clean fuels such as methanol. The decision to retain the mandates in light of such information strongly indicates that the Legislature intended to authorize the Board to adopt control measures related to clean fuels if necessary to meet the mandated goals.

Finally, in this regard the Supreme Court's analysis in the WOGA case demonstrates that a broader reading of the Board's motor vehicle fuel authority under section 43018 is appropriate. As discussed above, the court expressed an unwillingness to attribute to the Legislature an intention to deprive the Board of the only realistic means at its disposal to achieve the clean air goals identified in state law. (WOGA, supra, 14 Cal.3d at 420.) This was a primary reason the court unanimously interpreted the Board's authority to adopt motor vehicle emission standards to include the authority to regulate the composition of motor vehicle fuel. Similarly, in the CCAA the Legislature has mandated in section 43018(a) and (b) ambitious goals for maximum possible reductions of emissions from motor vehicles, as well as specific percentage reductions. To the extent these goals may only be achieved through the introduction of clean fuels and clean fuel vehicles, section 43108 should not be read narrowly to deprive the Board of the means to achieve the mandated goals.

D. Appropriate findings to support adoption of the clean fuels regulations.

As indicated above, it is our opinion that the Board has the statutory authority to adopt the clean fuels regulations described above upon the making of appropriate findings. First, a finding is required that the regulations are necessary to achieve the goals set forth in section 43018(a) or (b). It would be appropriate for the Board to explore other alternative vehicular control measures, and to determine whether the state and federal ambient air quality standards could be expected to be achieved throughout the state without the clean fuels components of the proposed regulations. In this respect, reference to the Air Quality Management Plan for the South Coast Air Quality Management District would be appropriate. A determination that the state ambient standard could not reasonably be attained in the south coast air basin without the clean fuel requirements would help support a conclusion that they are within the range of control measures authorized by section 43018.

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5. The only revisions to the specifically mandated reductions were the change in ROG emission reductions from 50% to 55%, and the change in NOx emissions reductions from 25% to 15%.

In addition, the Board must determine that the requirements are technologically feasible, and are among the most cost-effective control measures that could be expected to result in statewide attainment of the ambient ozone standards.

II. CONSTITUTIONAL AUTHORITY

A. The "Takings" Clause of the Fifth Amendment.

The Western States Petroleum Association (WSPA) and various oil companies have claimed that the provisions in the staff proposal requiring gasoline suppliers to distribute specified quantities of clean fuels violate the "takings clause" of the fifth amendment to the U.S. Constitution, which provides that "private property [shall not] be taken for public use without just compensation." We have considered these assertions and have concluded that on its face the proposal would not constitute an unconstitutional taking.

The threshold question is whether there is any property involved that could legitimately be claimed to be taken by the state or ARB. WSPA has asserted that the staff proposal in effect requires that a portion of each service station, bulk plant and perhaps each refinery be dedicated to the manufacture and distribution of alternative clean fuels, and that a regulation which requires dedication of private property for a public use constitutes a "taking." WSPA analogizes to Loretto v. Teleprompter Manhattan CATV Corp., 458 U.S. 419 (1982), which held that an ordinance requiring landlords to allow the installation of cable TV hook-up equipment constituted a "per se" taking of property because it sanctioned a "permanent physical occupation" of the landlord's property by the third party cable TV company. Loretto is clearly distinguishable because the proposed regulations in no way mandate the "occupation" of a refiner's or service station owner's property by the state or a third party. The business premises will continue to belong entirely to the refiner or station owner or lessor.

The staff proposal is much more closely analogous to other air pollution control regulations, promulgated under the state's basic police powers, which may necessitate the construction or installation of substantial equipment incident to meeting mandated emission reductions. A regulation prohibiting the sale of gasoline which exceeds specified sulfur or lead content limits may necessitate the installation of expensive new desulfurization or reforming equipment if the refiner is to continue to produce and distribute gasoline. Similarly, a gasoline vapor recovery regulation will necessitate the installation of vapor recovery systems if a service station is to continue operating. In neither of these cases is the necessary equipment--or the business as a whole--considered to be "occupied," "invaded," or "owned" by the state or a third party even though the sole reason for the equipment is the public purpose of reducing air pollution. While regulations of business activities such as these may raise issues of substantive due process (discussed below) in extreme situations, it is generally recognized that they do not constitute "takings of property" by the state.

Even if the proposed regulations were deemed to involve property interests that could be claimed subject to the "takings clause", we do not believe the regulations on their face impose a "taking." One of the key factors in a takings analysis is the "character of the governmental action." (Penn Central Transportation Co. v. New York, 438 U.S. 104 (1978).) This factor typically involves the question whether the government has "physically invaded" the claimant's property; as noted above, the proposed regulations do not present such an invasion. At times the U.S. Supreme Court has viewed the character of the governmental action in terms of the government's justification of the action--whether the regulation "substantially advance[s] legitimate state interests." (See Keystone Bituminous Coal Ass'n v. DeBenedictis, 480 U.S. 470, 485 (1987), quoting Agins v. Tiburon, 447 U.S. 255, 260 (1980).)

We believe that there are important ways in which the clean fuel provisions substantially advance legitimate governmental and public interests. Most broadly, the clean fuel program is designed to serve the public interest by contributing to the reduction of emissions of air pollutants from motor vehicles. The people of California face a very serious air pollution problem, and the clean fuel program is proposed as an integral part of the ARB's efforts to address the problem.

Moreover, the clean fuel requirements are expressly imposed as conditions upon the permissible distribution of gasoline, and the clean fuel program will help mitigate the air pollution burdens created by the sale of gasoline. Therefore there is a definite nexus between the activities regulated and the governmental interests being furthered.

First, the gasoline distributed and sold by those subject to the proposed regulations contributes to the very serious air pollution problems that exist in California. The alternative clean fuels that will be distributed under the program are expected to result in less pollution than gasoline. In particular, a majority of the alternative fuel vehicles will likely be designed to also run on gasoline so that they can be used in areas where only gasoline is available. Under the proposed regulations, such a vehicle would not be counted as a clean fuel vehicle unless it is certified to a more stringent standard while operating on the alternative fuel than while operating on gasoline. Therefore, such vehicles will clearly pollute less when fueled with the alternative fuel than they will if operated when only gasoline is available. In this connection, the regulatory program is similar to the regulations adopted by EPA in the mid-1970's requiring any person operating a gasoline outlet with sales of more than 200,000 gallons per year to offer at least one grade of 87 octane unleaded gasoline. (40 CFR sec. 80.22(b).)

Second, oil companies have cumulatively contributed to the development of a motor vehicle fuel distribution network in which gasoline and diesel fuel are the only liquid fuels widely and conveniently available to the motoring public. This situation presents a strong deterrent to the effective introduction of alternative fuel vehicles. Requiring the distribution of appropriate volumes of clean alternative fuels for use in motor vehicles directly mitigates the present problem of a motor fuel distribution system focused almost exclusively on gasoline and diesel fuel.

Finally, the gasoline production and distribution operations of refiners and service station operators emit substantial amounts of ozone-precursors and other air pollutants. The emissions reductions attributable to the clean fuel program will help mitigate these emissions.

Another key factor in a takings analysis is the economic impact of the government action. The U.S. Supreme court has stated that the nature of this inquiry depends on whether a regulation constitutes a taking "on its face" or "as applied" to a specific fact situation. Where a government action is challenged "on its face", it does not constitute a taking unless it denies an owner economically viable use of his or her property. (Keystone, supra, 480 U.S. at 494-495.) At this point the clean fuel regulations can only be analyzed on their face, as we do not know the extent to which clean fuel vehicles will be sold and the distribution of the clean fuels will be required, and what the economic impacts on refiners and station owners will be.

In evaluating the necessary effects of the proposed regulations on the economically viable use of the property of gasoline producers and service station owners, it is appropriate to look in the context of a reasonable unit of their business operations, rather than only the specific and limited operations of distributing the clean fuels. (see Keystone, supra, 480 U.S. at 499.) We believe that the refiners and others will be able to absorb the costs of the clean fuel program in their broader operations for distributing gasoline and diesel fuels. We are satisfied that gasoline producers and service station owners will continue to be able to operate on an adequately profitable basis.

B. "Substantive" Due Process

Police power regulations affecting economic interests generally satisfy the constitutional requirements of "substantive" due process as long as they are rationally related to a legitimate governmental interest. (American Bank & Trust Co. v. Community Hospital, 36 Cal.3d 359 (1984).) If such a regulation infringes upon a constitutionally protected personal liberty or fundamental right, it must be narrowly drawn and must further a sufficiently substantial government interest. (Griffin Development Co. v. City of Oxnard, 39 Cal.3d 256, 265 (1985).)

The "rational relationship" test is a less stringent variant of the "takings" test of whether a regulation substantially advances a legitimate state interest. We discuss above the ways in which the clean fuel regulations will substantially advance a legitimate state interest. These same factors demonstrate the rational relationship necessary to satisfy substantive due process.

Finally, the regulations do not trigger the more stringent substantive due process requirements which must be met where a constitutionally protected personal liberty or fundamental right is infringed. Selling gasoline is not a constitutionally protected activity. The California courts have held that constitutionally protected personal liberties and fundamental rights are not involved where a city prohibits the demolition or conversion of an apartment building to other uses unless no low or moderate income persons occupy or could afford units in the building, removal will not adversely affect housing supply, and the owner cannot make a reasonable return on his property (Nash v. City of Santa Monica, 37 Cal.3d 97 (1984)); where a city imposes stringent standards on conversions of apartment buildings to condominiums (Griffin Development, supra); and where a city prohibits the conversion of a residential hotel to another use unless one-to-one replacement of the hotel units is provided. (Terminal Plaza Corp. v. San Francisco, 177 Cal.App. 3d 892 (1986).) In light of these cases, we are not aware of any personal liberties or fundamental rights that would be infringed by the proposed regulations.

REFERENCES

Air Resources Board (ARB) (1989) Definition of a low-emission motor vehicle in compliance with the mandates of Health and Safety Code Section 39037.05 (Assembly Bill 234, Leonard, 1987). Final report by Mobile Source Division, California Air Resources Board, El Monte, CA.

Atkinson, R. (1987) A structure-activity relationship for the estimation of rate constants for the gas-phase reactions of OH radicals with organic compounds. **Int. J. Chem. Kinet., 19,** 799-828.

Atkinson, R. (1989) Kinetics and mechanisms of the gas-phase reactions of the hydroxyl radical with organic compounds. **J. Phys. Chem. Ref. Data, Monograph No. 1.**

Atkinson, R. (1990) Gas-phase tropospheric chemistry of organic compounds: A review. **Atmos. Environ., 24A,** 1-41.

Bechtel, Inc., California Fuel Methanol Cost Study, prepared for Chevron USA, Inc. et al., December 1988.

California Energy Commission, Energy Technology Development Division, AB 234 Report Cost and Availability of Low-Emission Motor Vehicles and Fuels Volume I, II, August 1989.

Carter W. P. L. and R. Atkinson (1987) An experimental study of incremental hydrocarbon reactivity. **Environ. Sci. Technol., 21,** 670-679.

Carter W. P. L. and R. Atkinson (1988) Development and implementation of an up-to-date photochemical mechanism for use in airshed modeling. Final report to California Air Resources Board, Contract No. A5-122-32. Sacramento, CA.

Carter W. P. L. and R. Atkinson (1989) A computer modeling study of incremental hydrocarbon reactivity. **Environ. Sci. Technol., 23,** 864-880.

Carter W. P. L. (1989a) Estimates of photochemical reactivities of solvent species used in architectural coatings. Paper 89-73.3 of the Air & Waste Management Association 82nd Annual Meeting, June 25-30, 1989, Anaheim, CA.

Carter W. P. L. (1989b) Ozone reactivity analysis of emissions from motor vehicles. Draft report for the Western Liquid Gas Association, July 11, 1989.

Carter W. P. L. (1990a) Personal communication.

Carter W. P. L. (1990b) Response to comments and questions presented at February 21, 1990 workshop on ARB staff proposal for hydrocarbon reactivity adjustment factors for Low-Emission Vehicle/Clean Fuel regulations. Prepared for California Air Resources Board Reactivity Advisory Panel Meeting, April 6, 1990, Berkeley, CA.

Carter W. P. L. (1990c) Comment on use of maximum incremental reactivities in regulatory applications, and summary of results of recent related research. Prepared for California Air Resources Board Reactivity Advisory Panel Meeting, April 6, 1990, Berkeley, CA.

Carter W. P. L. (1990d) Environmental chamber studies of atmospheric reactivities of components of vehicle emissions. Pre-proposal to the Coordinating Research Council, April 9, 1990.

Chang, T. Y., S. J. Rudy, G. Kuntasal and R. A. Gorse, Jr. (1989) Impact of methanol vehicles on ozone air quality. **Atmos. Environ., 23, 1629-1644.**

Chang, T. Y. and S. J. Rudy (1990) Ozone-forming potential of organic emissions from alternative-fueled vehicles. **Atmos. Environ.,** submitted.

Chevron Corporation, Economic Timing for Alternative Transportation Fuels, Prepared for Presentation at 1989 Summer Meeting Symposium **on Alternative Transportation Fuels, Summer 1989.**

Darnall, K. R., A. C. Lloyd, A. M. Winer, J. N. Pitts, Jr. (1976) Reactivity scale for atmospheric organic gases based on reaction with hydroxyl radical. **Environ. Sci. Technol., 10,** 692-696.

Dodge, M. (1984) Combined effects of organic reactivity and NMHC/NOx ratio on photochemical oxidant formation -- A modeling study. **Atmos. Environ., 18, 1657-1665.**

Dunker, A. M. (1980) The response of an atmospheric reaction-transport model to changes in input functions. **Atmos. Environ. 14,** 671-679.

Dunker, A. M. (1990) The relative reactivity of emissions from methanol-fueled and gasoline-fueled vehicles in forming ozone. **Environ. Sci. Technol.,** in press.

Environmental Protection Agency, Office of Mobile Sources; Analysis of the Economic and Environmental Effects of Methanol as an Automotive Fuel, September 1989.

Finlayson-Pitts, B. J. and J. N. Pitts, Jr. (1986) Atmospheric Chemistry: Fundamentals and Experimental Techniques, Wiley, New York.

Fujita, E. M., B. E. Croes, A. M. Winer and H. W. Biermann (1990) Formaldehyde emissions in the South Coast Air Basin derived from ambient measurements. Presented at the Air & Waste Management Association Specialty Conference on Tropospheric Ozone and the Environment, March 19-22, 1990, Los Angeles, CA.

Gold, M. D. and C. E. Moulis (1988) Effects of emission standards on methanol vehicles - Related ozone, formaldehyde, and methanol exposure. Paper 88-41.4 of the Air Pollution Control Association 81st Annual Meeting, June 19-24, 1988, Dallas, TX.

Johnson, G. M. and S. M. Quigley (1989) A universal monitor for photochemical smog. Paper 89-29.8 of the Air & Waste Management Association 82nd Annual Meeting, June 25-30, 1989, Anaheim, CA.

Lawson, D. R., H. W. Biermann, E. C. Tuazon, A. M. Winer, G. I. Mackay, H. I. Schiff, G. L. Kok, P. K. Dasgupta and K. Fung (1990) Formaldehyde measurement methods evaluation and ambient concentrations during the Carbonaceous Species Methods Comparison Study. **Aerosol Sci. Technol., 12,** 64-76.

Lonneman, W. A. and R. L. Seila (1989) Speciated hydrocarbon and NOx comparisons at SCAQS source and receptor sites. Paper 89-152.5 of the Air & Waste Management Association 82nd Annual Meeting, June 25-30, 1989, Anaheim, CA.

Milford, J. B., A. G. Russell and G. J. McRae (1989) A new approach to photochemical pollution control: Implications of spatial patterns in pollutant responses to reductions in nitrogen oxides and reactive organic gas emissions. **Environ. Sci. Technol., 23,** 1290-1301.

Poore, M., G. Sweigert and N. Lapurga (1990) Speciated hydrocarbon results from seven locations in California: Comparison between locations with emphasis on sources. Presented at the Air & Waste Management Association Specialty Conference on Tropospheric Ozone and the Environment, March 19-22, 1990, Los Angeles, CA.

Russell, A. (1990) Air quality modeling of alternative fuel use in Los Angeles, CA: Sensitivity of pollutant formation to individual pollutant compounds. Submitted paper for the Air & Waste Management Association 83rd Annual Meeting, June 24-29, 1990, Pittsburgh, PA.

Schleyer, C. H. (1990) Photochemical reactivity of gasoline and methanol vehicle emissions. Presented at California Air Resources Board Reactivity Advisory Panel meeting, April 6, 1990, Berkeley, CA.

Sierra Research (1988) A study of motor vehicle emissions.

APPENDIX E-1: LIGHT- AND MEDIUM-DUTY VEHICLE TEST PROCEDURES

PROPOSED

State of California
AIR RESOURCES BOARD

CALIFORNIA EXHAUST EMISSION STANDARDS AND TEST PROCEDURES FOR 1988 AND SUBSEQUENT MODEL PASSENGER CARS, LIGHT-DUTY TRUCKS, AND MEDIUM-DUTY VEHICLES

Adopted: May 20, 1987
Amended: December 20, 1989
Amended: January 22, 1990
Amended: ____________

NOTE: Amendments to the standards and test procedures proposed in this rulemaking are shown in underline to indicate additions to the text and ~~strikeout~~ to indicate deletions.

This document incorporates by reference various sections of the Code of Federal Regulations, some with modifications. In numerous instances, this document states that incorporated federal regulations are to be varied in some way. Where the directions introducing the variation (e.g. "amend paragraph 86.085-1 to read ...") are not entirely underlined the variation is displayed in an underline and ~~strikeout~~ form showing changes from the referenced federal regulation as previously incorporated in the California test procedures. Where the directions introducing the variation are entirely underlined, the federal language which will be modified is underlined and the modifications are displayed in double underline and ~~strikeout~~ to indicate proposed additions to or deletions from the federal language.

On June 14, 1990, the Board approved amendments to various sections in the Code of Federal Regulations to establish new regulations for medium-duty vehicles. These amendments have not yet been formally approved by the Office of Administrative Law. The amendments made by the medium-duty rulemaking are identified here by *italics*, with deletions shown in [*~~italicized strikeouts in brackets~~*]. The amendments pertaining to the June 14, 1990 medium-duty rulemaking are not a part of the present proposal made available at this time; however, some of the amendments in this proposal modify or otherwise affect the language from the medium-duty rulemaking. Deletions to the June 14, 1990 medium-duty rulemaking, proposed in this rulemaking, are shown in *~~italicized strikeouts~~*.

The numbering convention employed in this document, in order or priority, is: 1.a.1.i.A. Any references within specific sections in the Code of Federal Regulations are denoted in order of priority as: (a)(1)(i)(A) - the same numbering system employed in the Code of Federal Regulations.

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Appendices

CALIFORNIA EXHAUST EMISSION STANDARDS AND TEST PROCEDURES FOR 1988 AND SUBSEQUENT MODEL PASSENGER CARS, LIGHT-DUTY TRUCKS AND MEDIUM-DUTY VEHICLES

The provisions of Subparts A and B, Part 86, Title 40, Code of Federal Regulations as set forth in Appendix I, to the extent they pertain to Passenger Cars, Light-Duty Trucks and Medium-Duty Vehicles, are hereby adopted as the California Exhaust Emission Standards and Test Procedures for 1988 and Subsequent Model Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles, with the following exceptions and additions.

1. Applicability

   a. These test procedures are applicable to 1988 and subsequent model gasoline, gaseous, diesel, and, beginning in 1993, methanol passenger cars, light-duty trucks, and medium-duty vehicles~~, except motorcycles~~. Procedures specific to transitional low-emission, low-emission, and ultra-low-emission vehicles are applicable to 1992 and subsequent model-year gasoline and diesel, and to 1993 and subsequent model-year alternate fuel passenger cars, light-duty trucks, and medium-duty vehicles. Procedures specific to zero-emission vehicles are applicable to 1992 and subsequent model-year passenger cars, light-duty trucks and medium-duty vehicles. References to "light-duty trucks" in 40 CFR 86 shall apply both to "light-duty trucks" and "medium-duty vehicles" in these procedures.

   b. Any reference to vehicle sales throughout the United States shall mean vehicle sales in California.

   c. Regulations concerning EPA hearings, EPA inspections, specific language on the Certificate of Conformity, evaporative emissions high-altitude vehicles and testing, particulate and oxides of nitrogen averaging and engine family standards applicable in such averaging, alternative useful life, selective enforcement audit and heavy-duty engines and vehicles shall not be applicable to these procedures, except where specifically noted.

   d. Any reference to gasoline-powered vehicles shall also apply to vehicles powered by gaseous fuels.

   e. Regulations both herein and in Title 40, CFR Part 86, Subpart A and B, concerning otto-cycle and diesel-cycle vehicles shall be applicable to methanol vehicles, except where specifically noted otherwise.

   f. Regulations concerning methanol vehicles shall also be applicable to fuel-flexible vehicles, except where specifically noted otherwise.

   g. For engines used in medium-duty vehicles which are not distinctly diesel engines nor derived from such, the Executive Officer shall determine whether the engines shall be subject to diesel or otto-cycle engine regulations.

2. Definitions

a. "Administrator" means the Executive Officer of the Air Resources Board (ARB).

b. "Certificate of Conformity" means Executive Order certifying vehicles for sale in California.

c. "Certification" means certification as defined in Section 39018 of the Health and Safety Code.

d. "Passenger car" means any motor vehicle designed primarily for transportation of persons and having a design capacity of 12 persons or less.

e. "Heavy-duty engine" means an engine which is used to propel a heavy-duty vehicle.

f. "Heavy-duty vehicle" means any motor vehicle having a manufacturer's gross vehicle weight rating greater than 6000 pounds, except passenger cars.

g. "Light-duty truck" means any motor vehicle, rated at 6000 pounds gross vehicle weight or less, which is designed primarily for purposes of transportation of property or is a derivative of such a vehicle, or is available with special features enabling off-street or off-highway operation and use.

h. ~~"Medium-duty vehicle" means any pre-1995 model year heavy-duty~~ vehicle having a manufacturer's gross vehicle weight rating of 8500 pounds or less and any 1995 and subsequent model year heavy-duty vehicle or any 1992 and subsequent model-year low-emission, ultra-low-emission, or zero-emission vehicle having a manufacturer's gross vehicle rating of 14,000 pounds or less.

i. "Gaseous fuels" means liquefied petroleum gas, compressed natural gas, or liquefied natural gas fuels for use in motor vehicles.

j. "Trap oxidizer system" means an emission control system which consists of a trap to collect particulate matter and a mechanism to oxidize the accumulated particulate.

k. "Regeneration" means the process of oxidizing accumulated particulate matter. It may occur continually or periodically.

l. "Periodically regenerating trap oxidizer system" means a trap oxidizer system that utilizes, during normal driving conditions for cleaning the trap, an automated regeneration mode which can be easily detected.

m. "Continually regenerating trap oxidizer system" means a trap oxidizer system that does not utilize an automated regeneration mode during normal driving conditions for cleaning the trap.

n. "Non-regeneration emission test" means a complete emission test which does not include a regeneration.

o. "Regeneration emission test" means a complete emission test which includes a regeneration.

p. "Regeneration interval" means the interval from the start of a regeneration to the start of the next regeneration.

q. "Useful Life" means a period of use denoted by the emission standards to which a given vehicle is certifying. For those light-duty and medium-duty vehicles certified to optional 100,000 mile standards and those 1993 and subsequent vehicles certified to 100,000 mile emission standards, and those transitional low-emission, low-emission, and ultra-low-emission vehicles certified to 100,000 mile emission standards, the useful life shall be 10 years or 100,000 miles, whichever first occurs. For 1995 and subsequent medium-duty vehicles and medium-duty low-emission and ultra-low emission vehicles certified to 120,000 mile emission standards, the useful life shall be 11 years or 120,000 miles, whichever first occurs. For light-duty and medium-duty vehicles, certified only to 50,000 miles, the useful life shall be 5 years or 50,000 miles, whichever first occurs.

r. "Methanol" means any fuel for motor vehicles and motor vehicle engines that is composed of either commercially available or chemically pure methanol (CH_3OH) and gasoline as specified in section 9.a. (Fuel Specifications) of these procedures. The required fuel blend is based on the types of methanol-fueled vehicle being certified and the particular aspect of the certification procedure being conducted.

s. "Methanol vehicle" means any motor vehicle that is engineered and designed to be operated using methanol as a fuel.

t. "Fuel-Flexible Vehicle (FFV)" means any methanol-fueled motor vehicle that is engineered and designed to be operated using any gasoline-methanol fuel mixture or blend.

u. "Dedicated Methanol Vehicle" means any methanol-fueled motor vehicle that is engineered and designed to be operated solely on methanol.

v. "Diesel-cycle" means powered by an engine where the primary means of controlling power output is by limiting of the amount of fuel that is injected into the combustion chambers of the engine.

w. "Otto-cycle" means powered by an engine where the primary means of controlling power output is by limiting the amount of air and fuel which can enter the combustion chambers of the engine. Gasoline-fueled engines are otto-cycle engines.

x. "Organic Material Hydrocarbon Equivalent" (or "OMHCE") means the sum of the carbon mass contributions of non-oxygenated hydrocarbons, methanol and formaldehyde as contained in a gas sample, expressed as gasoline-fueled vehicle hydrocarbons. In the case of exhaust emissions, the hydrogen-to-carbon ratio of the equivalent hydrocarbon is 1.85:1. In the case of diurnal and hot-soak emissions, the hydrogen-to-carbon ratios of the equivalent hydrocarbons are 2.33:1 and 2.2:1, respectively.

y. "Incomplete vehicle" means any vehicle which does not have the primary load carrying device or container attached. In situations where individual marketing relationships makes the status of the vehicle questionable, the Executive Officer shall determine whether a specific model complies with the definition of incomplete vehicle.

z. "Non-methane organic gas" (or "NMOG") means the sum of non-oxygenated and oxygenated hydrocarbons contained in a gas sample, including, at a minimum, all oxygenated organic gases containing five or fewer carbon atoms (i.e., aldehydes, ketones, alcohols, ethers, etc.), and all known alkanes, alkenes, alkynes, and aromatics containing 12 or fewer carbon atoms. To demonstrate compliance with a NMOG standard, NMOG emissions shall be measured in accordance with the "California Non-Methane Organic Gas Test Procedures".

Aa. "Dual-fuel vehicle" means any motor vehicle that is engineered and designed to be capable of operating on a petroleum fuel and on another fuel.

Ab. "Transitional low-emission vehicle" or "TLEV" means any vehicle certified to transitional low-emission standards.

Ac. "Low-emission vehicle" or "LEV" means any vehicle certified to low-emission standards.

Ad. "Ultra-low-emission vehicle" or "ULEV" means any vehicle certified to ultra-low emission standards.

Ae. "Zero-emission vehicle" or "ZEV" means any vehicle which produces zero emissions of any criteria pollutants under any and all possible operational modes and conditions.

Af. "Electric vehicle" means any vehicle which operates solely by use of a battery or battery pack. This definition also includes vehicles which are powered mainly through the use of an electric battery or battery pack, but which use a flywheel that stores energy produced by the electric motor or through regenerative braking to assist in vehicle operation.

Ag. "Series hybrid electric vehicle" means any vehicle which allows power to be delivered to the driven wheels solely by a battery powered electric motor, but which also incorporates the use of a combustion engine to provide power to the battery.

Ah. "Parallel hybrid electric vehicle" means any vehicle which allows power to be delivered to the driven wheels by either a combustion engine and/or by a battery powered electric motor.

Ai. "Battery assisted combustion engine vehicle" means any vehicle which allows power to be delivered to the driven wheels solely by a combustion engine, but which uses a battery pack to store energy which may be derived through remote charging, regenerative braking, and/or a flywheel energy storage system or other means which will be used by an electric motor to assist in vehicle operation.

Aj. "Hybrid electric vehicle" means any vehicle which is included in the definition of a "series hybrid electric vehicle", a "parallel hybrid electric vehicle", or a "battery assisted combustion engine vehicle".

Ak. "Diesel Engine" means any engine powered with diesel fuel, gaseous fuel, or methanol for which diesel engine speed/torque characteristics and vehicle applications are retained.

Al. "Fuel fired heater" means a fuel burning device which creates heat for the purpose of warming the passenger compartment of a vehicle but does not contribute to the propulsion of the vehicle.

Am. "Conventional gasoline" means any certification gasoline.

An. "Reactivity adjustment factor" means a fraction applied to the mass of NMOG emissions from a vehicle powered by a fuel other than conventional gasoline for the purpose of determining a gasoline-equivalent NMOG emission level. The reactivity adjustment factor is defined as the ozone-forming potential of the exhaust from a vehicle powered by a fuel other than conventional gasoline divided by the ozone-forming potential of conventional gasoline vehicle exhaust.

Ao. "Intermediate volume manufacturer" is any vehicle manufacturer with California sales between 3,001 and 35,000 new light- and medium-duty vehicles per model-year based on the average number of vehicles sold by the manufacturer each year from 1989 to 1993; however, for manufacturers certifying for the first time in California, model-year sales shall be based on projected California sales.

3. Standards

The following standards represent the maximum projected exhaust emissions for the useful life of the vehicle.

a. The exhaust emissions from new 1988 model passenger cars, light-duty trucks, and medium-duty vehicles shall not exceed:

1988 EXHAUST EMISSIONS STANDARDS(5)(6)
(grams per mile)

Vehicle Type(1)	Loaded Vehicle Weight (lbs.)	Durability Vehicle Basis (mi)	Non-Methane Hydro-carbons(2)	Carbon Monoxide	Oxides of Nitrogen (3)
PC	All	50,000	0.39 (0.41)	7.0	0.4
PC(4)	All	50,000	0.39 (0.41)	7.0	0.7
PC (Option 1)	All	100,000	0.39 (0.41)	7.0	1.0
PC (Option 2)	All	100,000	0.46	8.3	1.0
LDT,MDV	0-3750	50,000	0.39 (0.41)	9.0	0.4
LDT,MDV (4)	0-3750	50,000	0.39 (0.41)	9.0	1.0
LDT,MDV (Option 1)	0-3750	100,000	0.39 (0.41)	9.0	1.0
LDT,MDV (Option 2)	0-3750	100,000	0.46	10.6	1.0
LDT,MDV	3751-5750	50,000	0.50 (0.50)	9.0	1.0
LDT,MDV (Option 1)	3751-5750	100,000	0.50 (0.50)	9.0	1.5
MDV	5751 & larger	50,000	0.60 (0.60)	9.0	1.5
MDV (Option 1)	5751 & larger	100,000	0.60 (0.60)	9.0	2.0

(1) "PC" means passenger cars.
"LDT" means light-duty trucks.
"MDV" means medium-duty vehicles.

(2) Hydrocarbon standards in parentheses apply to total hydrocarbons. In order to demonstrate compliance with a non-methane hydrocarbon emission standard, hydrocarbon emissions shall be measured in accordance with the "California Non-Methane Hydrocarbon Test Procedures."

(3) The maximum projected emissions of oxides of nitrogen measured on the federal Highway Fuel Economy Test (HWFET; 40 CFR Part 600 Subpart B) shall be not greater than 1.33 times the applicable passenger car standards and 2.00 times the applicable light-duty trucks and medium-duty vehicle standards shown in the table. Both the projected emissions and the HWFET standard shall be rounded in accordance with ASTM E29-67 to the nearest 0.1 gm/mi before being compared.

(4) This set of standards for 1988 and later model vehicles is optional. A manufacturer may choose to certify to these optional standards pursuant to the conditions set forth in Section 1960.1.5 of Title 13, California Code of Regulations.

(5) Diesel passenger cars, light-duty trucks, and medium-duty vehicles, except those fueled with methanol, are subject to the following particulate exhaust emission standards: 0.2 g/mi for the 1988 model years. The particulate compliance shall be determined on a 50,000 mile durability vehicle basis.

(6) For gaseous-fueled vehicles the calculation procedures provided in Appendix V shall be used for determining emissions and fuel economy.

b. The exhaust emissions from (i) new 1989 through 1992 model passenger cars and light-duty trucks, except those produced by a small volume manufacturer, (ii) new 1991 through 1994 model passenger cars and light-duty trucks produced by a small volume manufacturer, (iii) new 1989 *through 1994* [~~and subsequent~~] model medium-duty vehicles, except those produced by a small volume manufacturer, and (iv) new 1991 *through 1994* [~~and subsequent~~] model medium-duty vehicles produced by a small volume manufacturer, shall not exceed:

1989 *THROUGH 1994* [~~AND SUBSEQUENT~~] MODEL YEAR EXHAUST EMISSIONS STANDARDS(5)(6)
(grams per mile)

Vehicle Type(1)	Loaded Vehicle Weight (lbs.)	Durability Vehicle Basis (mi)	Non-Methane Hydro-carbons(2)	Carbon Monoxide	Oxides of Nitrogen (3)(4)
PC	All	50,000	0.39 (0.41)	7.0	0.4
PC(7)	All	50,000	0.39 (0.41)	7.0	0.7
Diesel PC (Option 2)	All	100,000(9)	0.46	8.3	1.0
LDT,MDV	0-3750	50,000	0.39 (0.41)	9.0	0.4
LDT,MDV (7)	0-3750	50,000	0.39 (0.41)	9.0	0.7(8)
Diesel LDT, MDV (Option 2)	0-3750	100,000(9)	0.46	10.6	1.0
LDT,MDV	3751-5750	50,000	0.50 (0.50)	9.0	1.0
LDT,MDV (Option 1)	3751-5750	100,000(9)	0.50 (0.50)	9.0	1.5
MDV	5751 & larger	50,000	0.60 (0.60)	9.0	1.5
MDV (Option 1)	5751 & larger	100,000(9)	0.60 (0.60)	9.0	2.0

(1) "PC" means passenger cars.
"LDT" means light-duty trucks.
"MDV" means medium-duty vehicles.

(2) Hydrocarbon standards in parentheses apply to total hydrocarbons. In order to demonstrate compliance with a non-methane hydrocarbon emission standard, hydrocarbon emissions shall be measured in accordance with the "California Non-Methane Hydrocarbon Test Procedures". For 1993 <u>through 1994</u> ~~and subsequent~~ model methanol-fueled vehicles <u>certifying to these standards</u>, including flexible-fueled vehicles, "Non-Methane Hydrocarbons" shall mean "Organic ~~Matter~~ <u>Material</u> Hydrocarbon Equivalent" (or "OMHCE").

(3) The maximum projected emissions of oxides of nitrogen measured on the ~~federal Highway Fuel Economy Test (HWFET; 40 CFR Part 600 Subpart B) shall be not greater than 1.33 times the applicable passenger car~~ standards and 2.00 times the applicable light-duty trucks and medium-duty vehicle standards shown in the table. Both the projected emissions and the HWFET standard shall be rounded in accordance with ASTM E29-67 to the nearest 0.1 g/mi before being compared.

(4) The standard for in-use compliance for passenger cars, light-duty trucks and medium-duty vehicles certifying to the 0.4 g/mi NOx standard shall be 0.55 g/mi NOx for 50,000 miles. If the in-use compliance level is above 0.4 g/mi NOx but does not exceed 0.55 g/mi NOx, and based on a review of information derived from a statistically valid and representative sample of vehicles, the Executive Officer determines that a substantial percentage of any class or category of such vehicles exhibits, prior to 50,000 miles or 5 years, whichever occurs first, an identifiable, systematic defect in a component listed in Section 1960.1.5(c)(2), Title 13, California Code of Regulations, which causes a significant increase in emissions above those exhibited by vehicles free of such defects and of the same class or category and having the same period of use and mileage, then the Executive Officer may invoke the enforcement authority under Sections 2112 and 2113, Title 13, California Code of Regulations, to require remedial action by the vehicle manufacturer. Such remedial action shall be limited to owner notification and repair or replacement of the defective component. As used in this section, the term "defect" shall not include failures which are the result of abuse, neglect, or improper maintenance. This provision is applicable for the 1989 through 1992 model years only. For small volume manufacturers, this provision is applicable for the 1991 through 1994 model years only.

(5) Diesel passenger cars, light-duty trucks, and medium-duty vehicles certifying to these standards are subject to a particulate exhaust emission standard of 0.08 g/mi for the 1989 and subsequent model years. The particulate compliance shall be determined on a 50,000 mile durability vehicle basis.

(6) For gaseous-fueled vehicles certifying to these standards, the calculation procedures provided in Appendix V shall be used for ~~determining emissions and fuel economy.~~

(7) This set of standards is optional. A manufacturer may choose to certify to these standards pursuant to the conditions set forth in Section 1960.1.5 of Title 13, California Code of Regulations.

(8) Pursuant to Section 1960.1.5(a)(1)(B), Title 13, California Code of Regulations the optional standard for 1989 model year light-duty trucks and medium-duty vehicles only is 1.0 g/mi NOx.

(9) The optional 100,000 mile certification standards and provisions are not applicable to methanol vehicles.

c. The exhaust emissions from new 1993 and subsequent model dedicated methanol vehicles and fuel-flexible vehicles shall meet all the requirements in b., d., e. and e. f with the following modifications and additions:

1993 AND SUBSEQUENT METHANOL-SPECIFIC EXHAUST EMISSION STANDARDS

Vehicle Type	Loaded Vehicle Weight (lbs.)(3)	Durability Vehicle Basis (mi)	Formaldehyde (mg/mi) Certification	In-Use Compliance (2)
PC	All	50,000	15	23 (1993-1995) 15 (1996 and later
LDT,MDV	0-3750	50,000	15	23 (1993-1995) 15 (1996 and later
LDT,MDV	3751-5750	50,000	18	27 (1993-1995) 18 (1996 and later
MDV	5751-*8500* [& larger]	50,000	22	33 (1993-1995) 22 (1996 and later
MDV	*8501-10,000*	*50,000*	*28*	*36 (1995)* *28 (1996 and later*
MDV	*10,001-14,000*	*50,000*	*36*	*45 (1995)* *36 (1996 and later*

(1) "PC" means passenger cars.
"LDT" means light-duty trucks.
"MDV" means medium-duty vehicles.

(2) If the formaldehyde in-use compliance level is above the respective certification level but does not exceed the in-use compliance level, and based on a review of information derived from a statistically valid and representative sample of vehicles, the Executive Officer determines that a substantial percentage of any class or category of such vehicle exhibits, prior to 50,000 miles or 5 years, whichever occurs first, an identifiable, systematic defeat defect in a component listed in Section 1960.1.5(c)(2), Title 13 California Code of Regulations, which causes a significant increase in emissions above those exhibited by vehicles free of such defects and of the same class or category and having the same period of use and mileage, the Executive Officer may invoke the enforcement authority under Section 2112 and 2113, Title 13, California Code of Regulations, to require remedial action by the vehicle manufacturer. Such remedial action shall be limited to owner notification and repair or replacement of the defect component. As used in this section, the term "defect" shall not include failures which are the result of abuse, neglect, or improper maintenance.

(3) For 1995 and subsequent model year medium-duty vehicles certifying to the standards and test procedures specified in Section 1960.1 (h)(1)(g), Title 13, California Code of Regulations, "Loaded Vehicle Weight" shall mean "Test Weight", which is the average of the vehicle's curb weight and gross vehicle weight.

d. The exhaust emission levels of formaldehyde from 1992 and subsequent model-year transitional low-emission vehicles, low-emission vehicles, and ultra-low-emission vehicles, including fuel-flexible and dual-fuel vehicles, shall meet all the requirements of g and j with the following additions:

FORMALDEHYDE EXHAUST EMISSION STANDARDS
FOR TRANSITIONAL LOW-EMISSION VEHICLES, LOW-EMISSION VEHICLES,
AND ULTRA-LOW-EMISSION VEHICLES IN THE
LIGHT-DUTY AND MEDIUM-DUTY VEHICLE WEIGHT CLASSES (5)
["milligrams per mile" (or "mg/mi")]

Vehicle Type (1)	Vehicle Weight (lbs.)(2)	Durability Vehicle Basis (mi)	Vehicle Emission Category(3)	Formaldehyde (mg/mi)(4)
PC and LDT	All 0-3750	50,000	TLEV	15 (23)
			LEV	15 (15)
			ULEV	8 (12)
		100,000	TLEV	18
			LEV	18
			ULEV	11
LDT	3751-5750	50,000	TLEV	18 (27)
			LEV	18 (18)
			ULEV	9 (14)
		100,000	TLEV	23
			LEV	23
			ULEV	13
MDV	0-3750	50,000	LEV	15 (15)
			ULEV	8 (12)
		120,000	LEV	22
			ULEV	12
MDV	3751-5750	50,000	LEV	18 (18)
			ULEV	9 (14)
		120,000	LEV	27
			ULEV	13
MDV	5751-8500	50,000	LEV	22 (22)
			ULEV	11 (17)
		120,000	LEV	32
			ULEV	16
MDV	8501-10,000	50,000	LEV	28 (28)
			ULEV	14 (21)
		120,000	LEV	40
			ULEV	21
MDV	10,001-14,000	50,000	LEV	36 (36)
			ULEV	18 (27)
		120,000	LEV	52
			ULEV	26

(1) "PC" means passenger cars.
"LDT" means light-duty trucks.
"MDV" means medium-duty vehicles.

(2) For light-duty or medium-duty vehicles, Vehicle Weight shall mean "Loaded Vehicle Weight" (or "LVW") or "Test Weight" (or "TW"), respectively.

(3) "TLEV" means transitional low-emission vehicles.
"LEV" means low-emission vehicles.
"ULEV" means ultra-low-emission vehicles.

(4) The standards in parentheses are intermediate compliance standards for 50,000 miles.

a. For PCs and LDTs from 0-5750 lbs. LVW, including fuel-flexible and dual-fuel vehicles, intermediate compliance standards shall apply to TLEVs through the 1995 model-year, and LEVs and ULEVs through the 1998 model-year. Compliance with standards beyond 50,000 miles shall be waived through the 1995 model-year for TLEVs and through the 1998 model-year for LEVs and ULEVs.

b. For MDVs from 0-14,000 lbs. TW, including fuel-flexible and dual-fuel vehicles, intermediate compliance standards shall apply to LEVs and ULEVs through the 1999 model-year. Compliance with standards beyond 50,000 miles shall be waived through the 1999 model-year for LEVs and ULEVs.

(5) Manufacturers shall demonstrate compliance with the above standards for formaldehyde at 50 degrees F, according to the procedure specified in the California Exhaust Emission Standards and Test Procedures for 1988 and Subsequent Model Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles, Adopted: May 20, 1987, Amended: December 20, 1989, Amended: January 22, 1990, Amended: ________.

d. e. The exhaust emissions from new 1993 and 1994 model passenger cars and light-duty trucks, except those produced by a small volume manufacturer, shall not exceed:

1993 AND 1994 MODEL YEAR *PASSENGER CAR AND LIGHT-DUTY TRUCK* EXHAUST EMISSIONS STANDARDS (5)(6)(10)
(grams per mile)

Vehicle Type(1)	Loaded Vehicle Weight (lbs.)	Durability Vehicle Basis (mi)	Non-Methane Hydrocarbons (2)(8)(9)	Carbon Monoxide (8)(9)	Oxides of Nitrogen (1)(3)(4)
PC	All	50,000	0.39 (0.25)	7.0 (3.4)	0.4
PC(7)	All	50,000	0.39 (0.25)	7.0 (3.4)	0.7
PC	All	100,000	(0.31)	(4.2)	n/a
Diesel PC (Option 2)	All	100,000	0.46 (0.31)	8.3 (4.2)	1.0
LDT	0-3750	50,000	0.39 (0.25)	9.0 (3.4)	0.4
LDT (7)	0-3750	50,000	0.39 (0.25)	9.0 (3.4)	0.7
LDT	0-3750	100,000	(0.31)	(4.2)	n/a
Diesel LDT (Option 2)	0-3750	100,000	0.46 (0.31)	10.6 (4.2)	1.0
LDT	3751-5750	50,000	0.50 (0.32)	9.0 (4.4)	1.0
LDT	3751-5750	100,000	(0.40)	(5.5)	n/a
Diesel LDT (Option 1)	3751-5750	100,000	0.50 (0.40)	9.0 (5.5)	1.5

(1) "PC" means passenger cars.
"LDT" means light-duty trucks.
"n/a" means not applicable.

(2) In order to demonstrate compliance with a non-methane hydrocarbon emission standard, hydrocarbon emissions shall be measured in accordance with the "California Non-Methane Hydrocarbon Test Procedures." For methanol-fueled vehicles certifying to these standards, including flexible-fueled vehicles, "Non-Methane Hydrocarbons" shall mean "Organic Material Hydrocarbon Equivalent" (or "OMHCE").

(3) The maximum projected emissions of oxides of nitrogen measured on the federal Highway Fuel Economy Test (HWFET; 40 CFR Part 600 Subpart B) shall be not greater than 1.33 times the applicable passenger car standards and 2.00 times the applicable light-duty truck and medium-duty vehicle standards shown in the table. Both the projected emissions and the HWFET standard shall be rounded in accordance with ASTM E29-67 to the nearest 0.1 gm/mi before being compared.

(4) The standard for in-use compliance for passenger cars and light-duty trucks certifying to the 0.4 g/mi NOx standard shall be 0.55 g/mi NOx for 50,000 miles. If the in-use compliance level is above 0.4 g/mi NOx but does not exceed 0.55 g/mi NOx, and based on a review of information derived from a statistically valid and representative sample of vehicles, the Executive Officer determines that a substantial percentage of any class or category of such vehicles exhibits, prior to 50,000 miles or 5 years, whichever occurs first, an identifiable, systematic defect in a component listed in Section 1960.1.5(c)(2), Title 13 California Code of Regulations, which causes a significant increase in emissions above those exhibited by vehicles free of such defects and of

the same class or category and having the same period of use and mileage, then the Executive Officer may invoke the enforcement authority under Sections 2112 and 2113, Title 13, California Code of Regulations, to require remedial action by the vehicle manufacturer. Such remedial action shall be limited to owner notification and repair or replacement of the defective component. As used in this section, the term "defect" shall not include failures which are the result of abuse, neglect, or improper maintenance. This provision is applicable for the 1993 model year only.

(5) Diesel passenger cars and light-duty trucks certifying to these standards are subject to a particulate exhaust emission standard of 0.08 g/mi, determined on a 50,000 mile durability vehicle basis.

(6) For gaseous-fueled vehicles certifying to these standards, the calculation procedures provided in Appendix V shall be used for determining emissions and fuel economy.

(7) This set of standards is optional. A manufacturer may choose to certify to these standards pursuant to the conditions set forth in Section 1960.1.5 of Title 13, California Code of Regulations.

(8) The emission standards in parenthesis are phase-in standards. For the 1993 model year, each manufacturer must certify a minimum of 40% of their vehicles to the phase-in standards or to the more stringent standards in Section g of these test procedures. For the 1994 model year, each manufacturer must certify a minimum of 80% of their vehicles to the phase-in standards or to the more stringent standards in Section g of these test procedures. The percentages shall be applied to the manufacturers' total projected sales of California-certified passenger cars and light-duty trucks for the model year.

(9) The following conditions shall apply to the in-use compliance standards of 1993 and 1994 model year passenger cars and light-duty trucks only.

(a) The in-use compliance standards for those passenger cars and light-duty trucks certifying to the 0.25 g/mi non-methane hydrocarbon and 3.4 g/mi carbon monoxide standards shall be 0.32 g/mi non-methane hydrocarbon and 5.2 g/mi carbon monoxide for 50,000 miles.

(b) The in-use compliance standards for those light-duty trucks certifying to the 0.32 g/mi non-methane hydrocarbon and 4.4 g/mi carbon monoxide standards shall be 0.41 g/mi non-methane hydrocarbon and 6.7 g/mi carbon monoxide for 50,000 miles.

(c) In-use compliance standards shall be waived beyond 50,000 miles.

(10) All passenger cars and light-duty trucks, except those diesel vehicles certifying to optional 100,000 mile standards, are subject to non-methane hydrocarbon, carbon monoxide, and oxides of nitrogen standards determined on a 50,000 mile durability basis and non-methane hydrocarbon and carbon monoxide standards determined on a 100,000 mile basis.

e.f. The exhaust emissions from new 1995 and subsequent model passenger cars and light-duty trucks shall not exceed:

1995 AND SUBSEQUENT MODEL YEAR *PASSENGER CAR AND LIGHT-DUTY TRUCK* EXHAUST EMISSIONS STANDARDS (5)(6)(8)(9)
(grams per mile)

Vehicle Type(1)	Loaded Vehicle Weight (lbs.)	Durability Vehicle Basis (mi)	Non-Methane Hydrocarbons (2)(7)	Carbon Monoxide (7)	Oxides of Nitrogen (1)(3)
PC	All	50,000	0.25	3.4	0.4(4)
PC	All	100,000	0.31	4.2	n/a
Diesel PC (Option 2)	All	100,000	0.31	4.2	1.0
LDT	0-3750	50,000	0.25	3.4	0.4(4)
LDT	0-3750	100,000	0.31	4.2	n/a
Diesel LDT (Option 2)	0-3750	100,000	0.31	4.2	1.0
LDT	3751-5750	50,000	0.32	4.4	*0.7*[~~1.0~~]
LDT	3751-5750	100,000	0.40	5.5	n/a
Diesel LDT (Option 1)	3751-5750	100,000	0.40	5.5	1.5

(1) "PC" means passenger cars.
"LDT" means light-duty trucks.
"n/a" means not applicable.

(2) In order to demonstrate compliance with a non-methane hydrocarbon emission standard, hydrocarbon emissions shall be measured in accordance with the "California Non-Methane Hydrocarbon Test Procedures." For methanol-fueled vehicles certifying to these standards, including flexible-fueled vehicles, "Non-Methane Hydrocarbons" shall mean "Organic Material Hydrocarbon Equivalent" (or "OMHCE").

(3) The maximum projected emissions of oxides of nitrogen measured on the federal Highway Fuel Economy Test (HWFET; 40 CFR Part 600 Subpart B) shall be not greater than 1.33 times the applicable passenger car standards and 2.00 times the applicable light-duty truck standards shown in the table. Both the projected emissions and the HWFET standard shall be rounded in accordance with ASTM E29-67 to the nearest 0.1 gm/mi before being compared.

(4) Small volume manufacturers may choose to certify to an optional 0.7 g/mi NOx standard for the 1995 model year only, pursuant to the conditions set forth in Title 13, California Code of Regulations, Sections 1960.1 (f)(1) and 1960.1.5.

(5) Diesel passenger cars and light-duty trucks certifying to these standards are subject to a particulate exhaust emission standard of 0.08 g/mi, determined on a 50,000 mile durability vehicle basis.

(6) For gaseous-fueled vehicles certifying to these standards, the calculation procedures provided in Appendix V shall be used for determining emissions and fuel economy.

(7) For all vehicles, except those certifying to optional diesel standards, in-use compliance with the exhaust emission standards shall be limited to vehicles with less than 75,000 miles.

(8) For the 1995 and 1996 model years, all manufacturers, except those certifying to optional diesel standards, are permitted alternative in-use compliance. Alternative in-use compliance is permitted for 60% of a manufacturer's vehicles in the 1995 model year and 20% of a manufacturer's vehicles in the 1996 model year. For the 1995 and 1996 model years, small volume manufacturers only are permitted alternative in-use compliance for 100% of the fleet. The percentages shall be applied to the manufacturers' total projected sales of California-certified passenger cars and light-duty trucks for the model year. "Alternative in-use compliance" shall consist of the following:

a. For all passenger cars and those light-duty trucks from 0-3750 lbs., loaded vehicle weight, except those diesel vehicles certifying to optional 100,000 mile standards, in-use compliance standards shall be 0.32 g/mi non-methane hydrocarbon and 5.2 g/mi carbon monoxide for 50,000 miles.

b. For light-duty trucks from 3751-5750 lbs., loaded vehicle weight, except those diesel light-duty trucks certifying to optional 100,000 mile standards, in-use compliance standards shall be 0.41 g/mi non-methane hydrocarbon and 6.7 g/mi carbon monoxide for 50,000 miles.

c. In-use compliance standards shall be waived beyond 50,000 miles.

(9) All passenger cars and light-duty trucks, except those diesel vehicles certifying to optional standards, are subject to non-methane hydrocarbon, carbon monoxide, and oxides of nitrogen standards determined on a 50,000 mile durability basis and non-methane hydrocarbon and carbon monoxide standards determined on a 100,000 mile durability basis.

g. The exhaust emissions from new 1992 and subsequent model-year transitional low-emission vehicles, low-emission vehicles, and ultra-low-emission vehicles shall not exceed:

EXHAUST MASS EMISSION STANDARDS
FOR TRANSITIONAL LOW-EMISSION VEHICLES, LOW-EMISSION VEHICLES,
AND ULTRA-LOW-EMISSION VEHICLES IN PASSENGER CAR
AND LIGHT-DUTY TRUCK VEHICLE CLASSES (6)(7)(8)
["grams per mile" (or "g/mi")]

Vehicle Type (1)	Loaded Vehicle Weight (lbs.)	Durability Vehicle Basis (mi)	Vehicle Emission Category (2)	Non-Methane Organic Gases (3)(4)	Carbon Monoxide	Oxides of Nitrogen (5)
PC and LDT	All 0-3750	50,000	TLEV	0.125 (0.188)	3.4 (3.4)	0.4 (0.4)
			LEV	0.075 (0.100)	3.4 (3.4)	0.2 (0.3)
			ULEV	0.040 (0.058)	1.7 (2.6)	0.2 (0.3)
		100,000	TLEV	0.156	4.2	0.6
			LEV	0.090	4.2	0.3
			ULEV	0.055	2.1	0.3
LDT	3751-5750	50,000	TLEV	0.160 (0.238)	4.4 (4.4)	0.7 (0.7)
			LEV	0.100 (0.128)	4.4 (4.4)	0.4 (0.5)
			ULEV	0.050 (0.075)	2.2 (3.3)	0.4 (0.5)
		100,000	TLEV	0.200	5.5	0.9
			LEV	0.130	5.5	0.5
			ULEV	0.070	2.8	0.5

(1) "PC" means passenger cars.
"LDT" means light-duty trucks.

(2) "TLEV" means transitional low-emission vehicles.
"LEV" means low-emission vehicles.
"ULEV" means ultra-low-emission vehicles.

(3) "Non-Methane Organic Gases" (or "NMOG") shall mean the total mass of oxygenated and non-oxygenated hydrocarbon emissions. To demonstrate compliance with a NMOG standard, NMOG emissions shall be measured in accordance with the "California Non-Methane Organic Gas Test Procedures." For TLEVs, LEVs, and ULEVs designed to operate on any fuel other than conventional gasoline, manufacturers shall multiply the measured NMOG mass emission level at 50,000 and 100,000 miles by the reactivity adjustment factor established for the particular vehicle emission category and fuel combination in the application for certification. The Executive Officer shall determine the reactivity adjustment factor according to the procedure described in Appendix VIII of these procedures.

a. Each manufacturer shall certify PCs or LDTs to meet the exhaust mass emission standards for TLEVs, LEVs, ULEVs, or to the exhaust emission standards of Sections b, e, or f of these test procedures.

or as Zero-Emission Vehicles such that the manufacturer's fleet average NMOG values for California-certified PCs and LDTs from 0-3750 lbs. "Loaded Vehicle Weight" (or "LVW"), and LDTs from 3751-5750 lbs. LVW sold in California are less than or equal to the value for the corresponding Model-Year, Vehicle Type, and LVW Class in Section h.

(4) Fuel-flexible and dual-fuel PCs and LDTs from 0-5750 lbs. LVW shall be certified to exhaust mass emission standards for NMOG established for the operation of the vehicle on any available fuel other than conventional gasoline, and conventional gasoline.

a. For TLEVs, LEVs and ULEVs, when certifying for operation on a fuel other than conventional gasoline, manufacturers shall multiply the measured NMOG emission levels by the applicable reactivity adjustment factor in the application for certification at 50,000 and 100,000 miles.

b. For PCs and LDTs from 0-3750 lbs. LVW, the applicable exhaust mass emission standard for NMOG when certifying the vehicle for operation on conventional gasoline shall be:

(i) For TLEVs, 0.25 g/mi and 0.31 g/mi for 50,000 and 100,000 miles, respectively.

(ii) For LEVs, 0.125 g/mi and 0.156 g/mi for 50,000 and 100,000 miles, respectively.

(iii) For ULEVs, 0.075 g/mi and 0.090 g/mi for 50,000 and 100,000 miles, respectively.

c. For LDTs from 3751-5750 lbs. LVW, the applicable exhaust mass emission standard for NMOG when certifying the vehicle for operation on conventional gasoline shall be:

(i) For TLEVs, 0.32 g/mi and 0.40 g/mi for 50,000 and 100,000 miles, respectively.

(ii) For LEVs, 0.160 g/mi and 0.200 g/mi for 50,000 and 100,000 miles, respectively.

(iii) For ULEVs, 0.100 g/mi and 0.130 g/mi for 50,000 and 100,000 miles, respectively.

(5) The maximum projected emissions of "Oxides of Nitrogen" (or "NOx") measured on the federal Highway Fuel Economy Test (HWFET; 40 CFR 600 Subpart B) shall not be greater than 1.33 times the applicable light-duty vehicle standards shown in the table. Both the projected emissions and the HWFET standard shall be rounded in accordance with ASTM E29-67 to the nearest 0.1 g/mi before being compared.

(6) The standards in parentheses are intermediate compliance standards for 50,000 miles. For PCs and LDTs from 0-5750 lbs. LVW, including fuel-flexible and dual-fuel vehicles when operating on any available fuel other than conventional gasoline, intermediate compliance standards shall apply to TLEVs through the 1995 model-year and to LEVs and ULEVs through the 1998 model-year. Compliance with standards beyond 50,000 miles shall be waived through the 1995 model-year for TLEVs, and through the 1998 model-year for LEVs and ULEVs.

a. For TLEVs, LEVs, and ULEVs designed to operate on any fuel other than conventional gasoline, including fuel-flexible and dual-fuel vehicles when operating on any fuel other than conventional gasoline, measured NMOG emission levels shall be multiplied by the reactivity adjustment factor to determine compliance with intermediate compliance standards for NMOG.

b. For fuel-flexible and dual-fuel PCs and LDTs from 0-3750 lbs. LVW, intermediate compliance standards for NMOG emissions at 50,000 miles, when the vehicle is operated on conventional gasoline, shall be 0.32, 0.188 and 0.100 for TLEVs, LEVs and ULEVs, respectively.

c. For fuel-flexible and dual-fuel PCs and LDTs from 3751-5750 lbs. LVW, intermediate compliance standards for NMOG emissions at 50,000 miles, when the vehicle is operated on conventional gasoline, shall be 0.41, 0.238 and 0.128 for TLEVs, LEVs and ULEVs, respectively.

(7) Manufacturers of diesel vehicles must also certify to particulate standards at 100,000 miles. For all PCs and LDTs from 0-5750 lbs. the particulate standard is 0.08 g/mi, 0.08 g/mi, and 0.04 g/mi for TLEVs, LEVs and ULEVs, respectively.

(8) Manufacturers shall demonstrate compliance with the above standards for NMOG, carbon monoxide and NOx at 50 degrees F, according to the procedure specified in the California Exhaust Emission Standards and Test Procedures for 1988 and Subsequent Model Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles, Adopted: May 20, 1987, Amended: December 20, 1989, Amended: January 22, 1990, Amended: ______. For diesel vehicles, compliance with the particulate standard shall also be demonstrated.

h. The fleet average non-methane organic gas exhaust mass emission values from a manufacturer's sales of passenger cars and light-duty trucks shall not exceed:

FLEET AVERAGE NON-METHANE ORGANIC GAS EXHAUST MASS EMISSION STANDARDS FOR LIGHT-DUTY VEHICLE WEIGHT CLASSES (7)(8)(9)(10)
["grams per mile" (or "g/mi")]

Vehicle Type (1)	Loaded Vehicle Weight (lbs.)	Durability Vehicle Basis (mi)(7)	Model Year	Fleet Average Non-Methane Organic Gases (2)(3)(4)(5)(6)
PC and LDT	All 0-3750	50,000	1994	0.250
			1995	0.231
			1996	0.225
			1997	0.202
			1998	0.157
			1999	0.113
			2000	0.073
			2001	0.070
			2002	0.068
			2003 and subsequent	0.062
LDT	3751-5750	50,000	1994	0.320
			1995	0.295
			1996	0.287
			1997	0.260
			1998	0.205
			1999	0.150
			2000	0.099
			2001	0.098
			2002	0.095
			2003 and subsequent	0.093

(1) "PC" means passenger cars.
"LDT" means light-duty trucks.

(2) "Non-Methane Organic Gases" (or "NMOG") shall mean the total mass of oxygenated and non-oxygenated hydrocarbon emissions.

(3) For the purpose of calculating fleet average NMOG values, a manufacturer may adjust the certification levels of hybrid electric vehicles (or "HEVs") based on the range of the HEV without the use of the engine. For the purpose of calculating the adjusted NMOG emission levels, the following definitions shall apply.

"Type A HEV" shall mean an HEV which achieves a minimum range of 60 miles as determined by the "Federal Highway Fuel Economy Test Procedure" (HWFET: 40 CFR Part 600 Subpart B) without the use of an auxiliary engine. Use of vehicle accessories cannot lower the range below 60 miles. This also includes vehicles which have no tailpipe emissions, but use fuel fired heaters.

"Type B HEV" shall mean an HEV which achieves a range of 40 - 59 miles as determined by the "Federal Highway Fuel Economy Test Procedure" (HWFET: 40 CFR Part 600 Subpart B) without the use of an auxiliary engine. Use of vehicle accessories cannot lower the range below 40 miles.

"Type C HEV" shall mean an HEV which achieves a range of 0 - 39 miles as determined by the "Federal Highway Fuel Economy Test Procedure" (HWFET; 40 CFR Part 600 Subpart B) without the use of an auxiliary engine, an HEV which allows the operators of the vehicle to control the engine time and modes of operation either directly or indirectly, an HEV which can be operated solely through the use of the engine, and all other HEVs excluding "Type A" and "Type B" HEVs.

(4) Each manufacturer's fleet average NMOG value for the total number of PCs and LDTs from 0-3750 lbs. "Loaded Vehicle Weight" (or "LVW") sold in California shall be calculated in units of g/mi NMOG as: {[(No. of Vehicles Certified to the Exhaust Emission Standards in Section b of these test procedures and Sold excluding HEVs x (0.39)] + [(No. of Vehicles Certified to the Exhaust Emission Standards in Section f of these test procedures and Sold excluding HEVs x (0.25)] + [(No. of Transitional Low-Emission Vehicles (or "TLEVs") Sold excluding HEVs) x (0.125)] + [(No. of Low-Emission Vehicles (or "LEVs") Sold excluding HEVs) x (0.075)] + [(No. of Ultra-Low-Emission Vehicles (or "ULEVs") Sold excluding HEVs) x (0.040)] + (HEV contribution factor)}/[Total No. of Vehicles Sold, Including Zero-Emission Vehicles ("ZEVs") and HEVs].

a. "HEV contribution factor" shall mean the NMOG emission contribution of HEVs to a manufacturer fleet average NMOG value. The HEV contribution factor shall be calculated in units of g/mi as follows:

HEV contribution factor = {[No. of "Type A HEVs" Sold which certify to the Exhaust Emission Standards in Section b of these test procedures] x (0.320) + [No. of "Type B HEVs" Sold which certify to the Exhaust Emission Standards in Section b of these test procedures] x (0.355) + [No. of "Type C HEVs" Sold which certify to the Exhaust Emission Standards in Section b of these test procedures] x (0.39)} + {[No. of "Type A HEVs" Sold which certify to the Exhaust Emission Standards in Section f of these test procedures] x (0.187) + [No. of "Type B HEVs" Sold which certify to the Exhaust Emission Standards in Section f of these test procedures] x (0.219) + [No. of "Type C HEVs" Sold which certify to the Exhaust Emission Standards in Section f of these test procedures] x (0.25)} + {[No. of "Type A HEV" TLEVs Sold] x (0.100) + [No. of "Type B HEV" TLEVs Sold] x (0.113) + [No. of "Type C HEV" TLEVs Sold] x (0.125)} + {[No. of "Type A HEV" LEVs Sold] x (0.057) + [No. of "Type B HEV" LEVs Sold] x (0.066) + [No. of "Type C HEV" LEVs Sold] x (0.075)} + {[No. of "Type A HEV" ULEVs Sold] x (0.020) + [No. of "Type B HEV" ULEVs Sold] x (0.030) + [No. of "Type C HEV" ULEVs Sold] x (0.040)}

b. ZEVs included in the above calculation may not be included in the calculation of vehicle emission credits for medium-duty vehicles in footnote 12 of Section j of these test procedures.

(5) While meeting the fleet average standards, each manufacturer's sales fleet shall be composed of at least 2% ZEVs in the model-years 1998 through 2000, 5% ZEVs in the 2001 and 2002 model-years, and 10% ZEVs in the 2003 and subsequent model-years.

a. "Zero-Emission Vehicles" (or "ZEVs") classified as medium-duty vehicles by weight may be designated as light-duty vehicles for the purpose of calculating fleet average NMOG values.

(6) Manufacturers that certify LDTs from 3751-5750 lbs. LVW, shall calculate a fleet average NMOG value in units of g/mi NMOG as: {[(No. of Vehicles Certified to the Exhaust Emission Standards in Section b of these test procedures and Sold excluding HEVs x (0.50)] + [(No. of Vehicles Certified to the Exhaust Emission Standards in Section f of these test procedures and Sold excluding HEVs x (0.32)] + [(No. of TLEVs Sold excluding HEVs) x (0.160)] + [(No. of LEVs Sold excluding HEVs) x (0.100)] + [(No. of ULEVs Sold excluding HEVs) x (0.050)] + (HEV contribution factor)}/(Total No. of Vehicles Sold, Including ZEVs and HEVs).

a. "HEV contribution factor" shall mean the NMOG emission contribution of HEVs to a manufacturer's fleet average NMOG value. The HEV contribution factor shall be calculated in units of g/mi as follows:
HEV contribution factor = {[No. of "Type A HEVs" Sold which certify to the Exhaust Emission Standards in Section b of these test procedures] x (0.410) + [No. of "Type B HEVs" Sold which certify to the Exhaust Emission Standards in Section b of these test procedures] x (0.455) + [No. of "Type C HEVs" Sold which certify to the Exhaust Emission Standards in Section b of these test procedures] x (0.50)} + {[No. of "Type A HEVs" Sold which certify to the Exhaust Emission Standards in Section f of these test procedures] x (0.240) + [No. of "Type B HEVs" Sold which certify to the Exhaust Emission Standards in Section f of these test procedures] x (0.280) + [No. of "Type C HEVs" Sold which certify to the Exhaust Emission Standards in Section f of these test procedures] x (0.32)} + {[No. of "Type A HEV" TLEVs Sold] x (0.130) + [No. of "Type B HEV" TLEVs Sold] x (0.145) + [No. of "Type C HEV" TLEVs Sold] x (0.160)} + {[No. of "Type A HEV" LEVs Sold] x (0.075) + [No. of "Type B HEV" LEVs Sold] x (0.087) + [No. of "Type C HEV" LEVs Sold] x (0.100)} + {[No. of "Type A HEV" ULEVs Sold] x (0.025) + [No. of "Type B HEV" ULEVs Sold] x (0.037) + [No. of "Type C HEV" ULEVs Sold] x (0.050)}

b. ZEVs included in the above calculation or in the calculation of footnote 4 may not be included in the calculation of vehicle emission credits for medium-duty vehicles in footnote 12 of Section j of these test procedures.

(7) In 2000 and subsequent model-years, small volume manufacturers shall comply with fleet average NMOG standards.

a. Prior to the year 2000, compliance with the specified fleet average NMOG standards shall be waived.

b. In 2000 and subsequent model-years, small volume manufacturers shall not exceed a fleet average NMOG standard of 0.075 g/mi for PCs and LDTs from 0-3750 lbs. LVW for 50,000 miles.

c. In 2000 and subsequent model-years, small volume manufacturers shall not exceed a fleet average NMOG standard of 0.100 g/mi for LDTs from 3751-5750 lbs. LVW for 50,000 miles.

d. Small volume manufacturers shall not be required to produce ZEVs.

(8) Intermediate volume manufacturers shall not be required to meet the ZEV requirement until the 2003 model-year.

(9) In 1994 and subsequent model-years, manufacturers that achieve fleet average NMOG values lower than the fleet average standard for the corresponding year, shall receive credits in units of g/mi NMOG determined as: {[(Fleet Average NMOG Standard) - (Manufacturer's Fleet Average NMOG Value)] x (Total No. of Vehicles Sold, Including ZEVs and HEVs)}.

a. Manufacturers with fleet average NMOG values greater than the fleet average standard for the corresponding model-year, shall receive debits in units of g/mi NMOG equal to the amount of negative credits determined by the aforementioned equation.

b. Manufacturers shall equalize emission debits within one model-year by earning g/mi NMOG emission credits in an amount equal to their previous model-year's total of g/mi NMOG debits, or by submitting a commensurate amount of g/mi NMOG credits to the Executive Officer that were earned previously or acquired from another manufacturer.

c. The g/mi NMOG emission credits earned in any given model-year shall retain full value through the subsequent model-year.

d. The g/mi NMOG value of any credits not used to equalize the previous model-year's debit, shall be discounted by 50% at the beginning of second model-year after being earned, discounted to 25% of its original value if not used by the beginning of the third model-year after being earned, and will have no value if not used by the beginning of the fourth model-year after being earned.

e. The g/mi NMOG emission credits earned by a manufacturer may be applied toward the fleet average standard for passenger cars and light-duty trucks from 0-3750 lbs. LVW, or to the fleet average standard for light-duty trucks from 3751-5750 lbs. LVW, at the manufacturer's discretion.

(10) Manufacturers that sell vehicles complying with the exhaust emission standards in Section f and g and/or ZEVs in the 1992 and 1993 model-years, shall receive emission credits for the sale of Section f and g of these test procedures certified vehicles as determined by the equations in footnotes (4), (6), and/or (9), depending upon Vehicle Weight Class.

a. For PCs and LDTs from 0-3750 lbs. LVW, the fleet average NMOG standard for calculating a manufacturer's emission credits shall be 0.390 and 0.334 g/mi NMOG for vehicles certified in the 1992 and 1993 model-years, respectively.

b. For LDTs from 3751-5750 lbs. LVW, the fleet average NMOG standards for calculating a manufacturer's emission credits shall be 0.500 and 0.428 g/mi NMOG for vehicles certified in the 1992 and 1993 model-years, respectively.

c. Emission credits earned prior to the 1994 model-year shall be considered as earned in the 1994 model-year and discounted in accordance with the schedule specified in footnote (9).

[f.] i. The exhaust emissions from new 1995 through 2000 and subsequent model medium-duty vehicles shall not exceed:

1995 THROUGH 2000 AND SUBSEQUENT MODEL YEAR
MEDIUM-DUTY VEHICLE EXHAUST EMISSIONS STANDARDS (1)(2)(3)(7)(8)
(grams per mile)

Test Weight(lbs.)	Durability Vehicle Basis(mi)	Non-Methane Hydrocarbons(4)	Carbon Monoxide	Oxides of Nitrogen(5)	Particulates (6)
0-3,750	50,000	0.25	3.4	0.4	n/a
0-3,750	120,000	0.36	5.0	0.55	0.08
3,751-5,750	50,000	0.32	4.4	0.7	n/a
3,751-5,750	120,000	0.46	6.4	0.98	0.10
5,751-8,500	50,000	0.39	5.0	1.1	n/a
5,751-8,500	120,000	0.56	7.3	1.53	0.12
8,501-10,000	50,000	0.46	5.5	1.3	n/a
8,501-10,000	120,000	0.66	8.1	1.81	0.15
10,001-14,000	50,000	0.60	7.0	2.0	n/a
10,001-14,000	120,000	0.86	10.3	2.77	0.18

(1) "n/a" means not applicable.
"Test Weight" shall mean the average of the vehicle's curb weight and gross vehicle weight.

(2) Manufacturers have the option of certifying engines used in incomplete and diesel medium-duty vehicles from 8501-14,000 pounds gross vehicle weight to the heavy-duty engine standards and test procedures set forth in Section 1956.8(e), Title 13, California Code of Regulations. Manufacturers certifying incomplete or diesel medium-duty vehicles to the heavy-duty engine standards and test procedures shall specify in the application for certification, an in-use compliance test procedure as provided in Sections 2139(c), Title 13, California Code of Regulations.

(3) For the 1995 model year only, manufacturers of medium-duty vehicles may certify a maximum of 50 percent of their vehicles to the applicable 1994 model year standards and test procedures. The percentage shall be based upon each manufacturer's projected sales of California-certified medium-duty vehicles.

(4) For methanol-fueled vehicles certifying to these standards, including flexible-fueled vehicles, "Non-Methane Hydrocarbons" shall mean "Organic Material Hydrocarbon Equivalent" (or "OMHCE").

(5) The maximum projected emissions of oxides of nitrogen measured on the federal Highway Fuel Economy Test (HWFET; 40 CFR Part 600 Subpart B) shall be not greater than 2.00 times the applicable medium-duty vehicle standards shown in the table. Both the projected emissions and the HWFET standard shall be rounded in accordance with ASTM E29-67 to the nearest 0.1 gm/mi before being compared.

(6) Particulate standards are only applicable for diesel vehicles and shall be determined on a 120,000 mile basis.

(7) *In-use compliance testing shall be limited to vehicles with less than 90,000 miles. For the 1995 through 1997 model years, alternative in-use compliance is available for medium-duty vehicle manufacturers. A manufacturer may use alternative in-use compliance for up to 100 percent of its fleet in the 1995 and 1996 model years and up to 50 percent of its fleet in the 1997 model year. The percentages shall be determined only from the manufacturer's projected California sales of medium-duty vehicles. For vehicles certified to the standards and test procedures of this subsection, "alternative in-use compliance" shall consist of an in-use allowance of 25 percent over the applicable 50,000 mile emission standards and a waiver of the emission standards beyond 50,000 miles.*

(8) *All medium-duty vehicles, except those incomplete and diesel vehicles certifying to heavy-duty engine test procedures, are subject to 50,000 mile and 120,000 mile non-methane hydrocarbon, carbon monoxide, and oxides of nitrogen standards.*

j. The exhaust emission levels from new 1992 and subsequent model-year medium-duty low-emission vehicles and ultra-low-emission vehicles shall not exceed:

EXHAUST EMISSION STANDARDS FOR LOW-EMISSION VEHICLES AND ULTRA-LOW-EMISSION VEHICLES IN THE MEDIUM-DUTY VEHICLE WEIGHT CLASS (8)(9)(10)(11)(12)
[grams per mile (or "g/mi")]

Test Weight (lbs.) (1)	Durability Vehicle Basis (mi)	Vehicle Emission Category (2)	Non-Methane Organic Gases (3)(4)	Carbon Monoxide	Oxides of Nitrogen (5)	Particulates (6)(7)
0-3750	50,000	LEV	0.125 (0.188)	3.4 (3.4)	0.4 (0.4)	n/a
		ULEV	0.075 (0.100)	1.7 (2.6)	0.2 (0.3)	n/a
	120,000	LEV	0.180	5.0	0.6	0.08
		ULEV	0.107	2.5	0.3	0.04
3751-5750	50,000	LEV	0.160 (0.238)	4.4 (4.4)	0.7 (0.7)	n/a
		ULEV	0.100 (0.128)	2.2 (3.3)	0.4 (0.5)	n/a
	120,000	LEV	0.230	6.4	1.0	0.10
		ULEV	0.143	3.2	0.5	0.05
5751-8500	50,000	LEV	0.195 (0.293)	5.0 (5.0)	1.1 (1.1)	n/a
		ULEV	0.117 (0.156)	2.5 (3.8)	0.6 (0.8)	n/a
	120,000	LEV	0.280	7.3	1.5	0.12
		ULEV	0.167	3.7	0.8	0.06
8501-10000	50,000	LEV	0.230 (0.345)	5.5 (5.5)	1.3 (1.3)	n/a
		ULEV	0.138 (0.184)	2.8 (4.2)	0.7 (1.0)	n/a
	120,000	LEV	0.330	8.1	1.8	0.12
		ULEV	0.197	4.1	0.9	0.06
10,001-14000	50,000	LEV	0.300 (0.450)	7.0 (7.0)	2.0 (2.0)	n/a
		ULEV	0.180 (0.240)	3.5 (5.3)	1.0 (1.5)	n/a
	120,000	LEV	0.430	10.3	2.8	0.12
		ULEV	0.257	5.2	1.4	0.06

(1) "Test Weight" (or "TW") shall mean the average of the vehicle's curb weight and gross vehicle weight.

(2) "LEV" means low-emission vehicle.
"ULEV" means ultra-low-emission vehicle.

(3) "Non-Methane Organic Gases" (or "NMOG") shall mean the total mass of oxygenated and non-oxygenated hydrocarbon emissions. To determine compliance with a NMOG standard, NMOG emissions shall be measured in accordance with "California Non-Methane Organic Gas Test Procedures."

a. For LEVs and ULEVs designed to operate exclusively on any available fuel other than conventional gasoline, including fuel-flexible or dual-fuel vehicles, manufacturers shall multiply measured NMOG emission levels at 50,000 and 120,000 miles by the reactivity adjustment factor appropriate to the vehicle emission category and fuel combination in the application for certification. The reactivity adjustment factor shall be determined by the Executive Officer according to the procedure described in Appendix VIII.

(4) Fuel-flexible and dual-fuel "Medium-Duty Vehicles" (or "MDVs") from 0-14,000 lbs. TW shall be certified to exhaust mass emission standards for NMOG established for the operation of the vehicle on any fuel other than conventional gasoline, and conventional gasoline.

a. For LEVs and ULEVs, manufacturers shall multiply measured NMOG emission levels at 50,000 and 120,000 miles by the appropriate reactivity adjustment factor in the application for certification.

b. For MDVs from 0-3750 lbs. TW, the applicable exhaust mass emission standard for NMOG when certifying the vehicle for operation on conventional gasoline shall be:

(i) For LEVs, 0.25 g/mi and 0.36 g/mi for 50,000 and 120,000 miles, respectively.

(ii) For ULEVs, 0.125 g/mi and 0.190 g/mi for 50,000 and 120,000 miles, respectively.

c. For MDVs from 3751-5750 lbs. TW, the applicable exhaust mass emission standard for NMOG when certifying the vehicle for operation on conventional gasoline shall be:

(i) For LEVs, 0.32 g/mi and 0.46 g/mi for 50,000 and 120,000 miles, respectively.

(ii) For ULEVs, 0.160 g/mi and 0.230 g/mi for 50,000 and 120,000 miles, respectively.

d. For MDVs from 5751-8500 lbs. TW, the applicable exhaust mass emission standard for NMOG when certifying the vehicle for operation on conventional gasoline shall be:

(i) For LEVs, 0.39 g/mi and 0.56 g/mi for 50,000 and 120,000 miles, respectively.

(ii) For ULEVs, 0.195 g/mi and 0.280 g/mi for 50,000 and 120,000 miles, respectively.

e. For MDVs from 8501-10,000 lbs. TW, the applicable exhaust mass emission standard for NMOG when certifying the vehicle for operation on conventional gasoline shall be:

(i) For LEVs, 0.46 g/mi and 0.66 g/mi for 50,000 and 120,000 miles, respectively.

(ii) For ULEVs, 0.230 g/mi and 0.330 g/mi for 50,000 and 120,000 miles, respectively.

f. For MDVs from 10,001-14,000 lbs. TW, the applicable exhaust mass emission standard for NMOG when certifying the vehicle for operation on conventional gasoline shall be:

(i) For LEVs, 0.60 g/mi and 0.86 g/mi for 50,000 and 120,000 miles, respectively.

(ii) For ULEVs, 0.300 g/mi and 0.430 g/mi for 50,000 and 120,000 miles, respectively.

(5) The maximum projected emissions of "Oxides of Nitrogen" (or "NOx") measured on the federal Highway Fuel Economy Test (HWFET; 40 CFR Part 600 Subpart B) shall not be greater than 2.00 times the applicable MDV standards shown in the table. Both the projected emissions and the HWFET standard shall be rounded in accordance with ASTM E29-67 to the nearest 0.1 g/mi before being compared.

(6) Particulate standards are only applicable for diesel vehicles and shall be determined on a 120,000 mile basis.

(7) "n/a" means not applicable.

(8) Manufacturers have the option of certifying engines used in incomplete and diesel MDVs to the heavy-duty engine standards and test procedures

set forth in Section 1956.8(f), Title 13, California Code of Regulations. Manufacturers certifying incomplete or diesel MDVs to the heavy-duty engine standards and test procedures shall specify in the application for certification an in-use compliance procedure as provided in Section 2139(c), Title 13, California Code of Regulations.

(9) The standards in parenthesis are intermediate compliance standards for 50,000 miles. For MDVs from 0-14,000 lbs. TW, including fuel-flexible and dual-fuel vehicles when operating on any available fuel other than conventional gasoline, intermediate compliance standards shall apply to LEVs and ULEVs through the 1999 model-year. Compliance with standards beyond 50,000 miles shall be waived through the 1999 model-year for LEVs and ULEVs.

a. For LEVs and ULEVs designed to operate on any available fuel other than conventional gasoline, including fuel-flexible and dual-fuel vehicles when operating on any available fuel other than conventional gasoline, measured NMOG emissions shall be multiplied by the appropriate reactivity adjustment factor.

b. For fuel-flexible and dual-fuel MDVs from 0-3750 lbs. TW, intermediate compliance standards for NMOG emissions at 50,000 miles, when the vehicle is operated on conventional gasoline, shall be 0.32 and 0.188 for LEVs and ULEVs, respectively.

c. For fuel-flexible and dual-fuel MDVs from 3751-5750 lbs. TW, intermediate compliance standards for NMOG emissions at 50,000 miles, when the vehicle is operated on conventional gasoline, shall be 0.41 and 0.238 for LEVs and ULEVs, respectively.

d. For fuel-flexible and dual-fuel MDVs from 5751-8500 lbs. TW, intermediate compliance standards for NMOG emissions at 50,000 miles, when the vehicle is operated on conventional gasoline, shall be 0.49 and 0.293 for LEVs and ULEVs, respectively.

e. For fuel-flexible and dual-fuel MDVs from 8501-10,000 lbs. TW, intermediate compliance standards for NMOG emissions at 50,000 miles, when the vehicle is operated on conventional gasoline, shall be 0.58 and 0.345 for LEVs and ULEVs, respectively.

f. For fuel-flexible and dual-fuel MDVs from 10,001-14,000 lbs. TW, intermediate compliance standards for NMOG emissions at 50,000 miles, when the vehicle is operated on conventional gasoline, shall be 0.75 and 0.450 for LEVs and ULEVs, respectively.

(10) Each manufacturer's MDV fleet shall be defined as the total number of California certified MDVs from 0-14,000 lbs. TW sold in California.

a. Manufacturers of MDVs shall certify an equivalent of 25% of their MDV sales to LEV standards in the 1998 model-year, a minimum of 50% of their MDV sales to LEV standards in the 1999 model-year, a minimum of 75% of their MDV sales to LEV standards in the 2000 model-year, a minimum of 95% of their MDV sales to LEV standards in the 2001 model-year, a minimum of 90% of their MDV sales to LEV standards in the 2002 model-year, and a minimum of 85% of their MDV sales to LEV standards in the 2003 and subsequent model-years.

b. Manufacturers of MDVs shall certify an equivalent of 2% of their MDV sales to ULEV standards in the 1998 to 2000 model-years, a minimum of 5% of their MDV sales to ULEV standards in the 2001 model-year, a minimum of 10% of their MDV sales to ULEV standards in the 2002 model-year, and a minimum of 15% of their MDV sales to ULEV standards in the 2003 and subsequent model-years.

c. The percentages shall be applied to the manufacturers' total projected sales of California-certified medium-duty vehicles.

(11) For the purpose of calculating " Vehicle Equivalent Credits" (or "VECs"), the contribution of hybrid electric vehicles (or "HEVs") will be calculated based on the range of the HEV without the use of the engine. For the purpose of calculating the contribution of HEVs to the VECs, the following definitions shall apply.

"Type A HEV" shall mean a hybrid electric vehicle (or "HEV") which achieves a minimum range of 60 miles as determined by the "Federal Highway Fuel Economy Test Procedure" (HWFET; 40 CFR Part 600 Subpart B) without the use of the engine. Use of vehicle accessories cannot result in a battery-only range drop below 60 miles. This also includes vehicles which have no tailpipe emissions, but use fuel fired heaters.

"Type B HEV" shall mean an HEV which achieves a range of 40 - 59 miles as determined by the "Federal Highway Fuel Economy Test Procedure" (HWFET; 40 CFR Part 600 Subpart B) without the use of the engine. Use of vehicle accessories cannot result in a battery-only range drop below 40 miles.

"Type C HEV" shall mean an HEV which achieves a range of 0 - 39 miles as determined by the "Federal Highway Fuel Economy Test Procedure" (HWFET; 40 CFR Part 600 Subpart B) without the use of an auxiliary engine, an HEV which allows the operator of the vehicle to control the engine time and modes of operation either directly or indirectly, an HEV which can be operated solely through the use of the engine, and all other HEVs excluding "Type A" and "Type B" HEVs.

(12) In 1992 and subsequent model-years, manufacturers that sell MDVs in excess of the minimum requirements for LEVs and/or ULEVs, shall receive "Vehicle-Equivalent Credits" (or "VECs") calculated as: {[(No. of LEVs Sold excluding HEVs) + (No. of "Type C HEV" LEVs Sold)] + [(No. of "Type A HEV" LEVs Sold) x (1.2)] + [(No of "Type B HEVs" LEVs Sold) x (1.1)] - (Minimum No. of LEVs Required to be Sold)} + {(1.4) x [(No. of ULEVs Sold excluding HEVs) + (No. of "Type C HEV" ULEVs Sold)] + [(1.7) x (No. of "Type A HEV" ULEVs Sold)] + [(1.5) x (No. of "Type B HEV" ULEVs Sold)] - (Minimum No. of ULEVs Required to be Sold)} + [(2.0) x (No. of ZEVs Sold as MDVs)].

a. Manufacturers that fail to sell the minimum quantity of MDVs certified to LEV and/or ULEV exhaust emission standards, shall receive "Vehicle-Equivalent Debits" (or "VEDs") equal to the amount of negative VECs determined by the aforementioned equation.

b. Manufacturers shall equalize emission debits within one model-year by earning VECs in an amount equal to their previous model-year's total of VEDs, or by submitting a commensurate amount of VECs to the Executive Officer that were earned previously or acquired from another manufacturer.

c. The VECs earned in any given model-year shall retain full value through the subsequent model-year.

d. The value of any VECs not used to equalize the previous model-year's debit, shall be discounted by 50% at the beginning of second model-year after being earned, discounted to 25% of its original value if not used by the beginning of the third model-year after being earned, and will have no value if not used by the beginning of the fourth model-year after being earned.

e. Only ZEVs certified as MDVs can be included in the calculation of VECs.

(13) Manufacturers shall demonstrate compliance with the above standards for NMOG, CO and NOx at 50 degrees F, according to the procedure specified in the California Exhaust Emission Standards and Test Procedures for 1988 and Subsequent Model Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles, Adopted: May 20, 1987, Amended: December 20, 1989, Amended: January 22, 1990, Amended: ______. For diesel vehicles, compliance with the particulate standard shall also be demonstrated.

4. Initial Requirements

a. Application for Certification

In paragraph 86.088-21, ~~and~~ 86.090-21, and 86.091-21:

1. Amend subparagraph (b)(1)(i) to read:

(i) Identification and description of the vehicles (or engines) covered by the application and a description (including a list and part numbers of all major emission control system parts and fuel system components) of their engine (vehicles only) emission control system and fuel system components, including if applicable, the turbocharger and intercooler. This shall include a detailed description of each auxiliary emission control device (AECD) to be installed in or on any certification test vehicle (or certification test engine).

2. Amend subparagraph (b)(2) to read:

(2) For 1992 and subsequent model-year TLEVs, LEVs, and ULEVs not powered exclusively by gasoline, projected California sales data and fuel economy data two years prior to the end of the certification process, and projected California sales data for all vehicles, regardless of operating fuel or vehicle emission category, sufficient to enable the Executive Officer to select a test fleet representative of the vehicles (or engines) for which certification is requested at the time of certification.

In paragraph 86.088-21 and 86.090-21:

3. Amend subparagraph (b)(4)(iii)(C)(1) and (C)(2) to read:

(1) A statement of maintenance and procedures consistent with the restrictions imposed under subparagraph 86.085-25(a)(1), necessary to assure that the vehicles (or engines) covered by a certificate of conformity in operation in normal use to conform to the regulations, and a description of the program for training of personnel for such maintenance, and the equipment required.

(2) A statement that the vehicles sold comply with the California high-altitude emission requirements as specified in Section 11.b. (High Altitude Requirements) in these procedures.

b. Required Data

In paragraph 86.085-23, 86.087-23, 86.088-23, and 86.091-23:

1. Amend subparagraph (a) by adding the following paragraph which reads:

Zero-emission vehicles (including electric vehicles which do not utilize auxiliary fuel fired heaters) shall be exempt from emission testing and durability requirements. All series hybrid electric vehicle emission testing shall be conducted while operating the vehicle's auxiliary engine continuously over the CVS-75 test cycle (as specified in paragraphs 86.135-90 and 86.137-90) at maximum regulated engine speed and load conditions or other operation to be determined by the Executive Officer as resulting in the worst case emissions. All parallel hybrid electric vehicle emission testing shall be conducted while the vehicle is operating solely through use of its combustion engine over the CVS-75 test cycle (as specified in paragraphs 86.135-90 and 86.137-90), or as close to pure engine operation as is feasible. All battery assisted combustion engine vehicles shall be tested in accordance with the test procedures specified (40 CFR Part 86) for vehicles which operate solely by use of a combustion engine. All hybrid electric vehicles shall be tested in accordance with paragraphs 86.129-80.

2. Amend (c)(1) by adding the following paragraph which reads:

In the case of electric vehicles (or other zero-emission vehicles) which use fuel fired heaters, the manufacturer shall determine the exhaust emissions per mile produced by the auxiliary fuel fired heater, when certifying electric vehicles (or other zero-emission vehicles) which utilize this type of heater. This shall be accomplished by determining heater emissions per minute when operating at maximum heating capacity, and multiplying that number by 3.6 minutes per mile (the number of minutes in the CVS-75 test cycle divided by the number of miles in the CVS-75 test cycle.) A statement of the standards to which the vehicle complies based on the emissions from the heater shall be required for vehicle certification.

3. Amend (c)(1) by adding the following paragraph which reads:

For all TLEVs, LEVs, and ULEVs, manufacturers shall provide a total NMOG exhaust emission value multiplied by the appropriate reactivity adjustment factor in g/mile to demonstrate compliance with the applicable emission standards. Manufacturers requesting to certify to existing standards utilizing an adjustment factor unique to its vehicle/fuel system must follow the data requirements described in Appendix VIII of these test procedures. A separate formaldehyde emission value in mg/mile shall also be provided for demonstrating compliance with emission standards for formaldehyde.

bc. Test Vehicles and Test Engines; Assigned Deterioration Factors (DFs)

In paragraphs 86.085-24 and 86.090-24:

1. Delete subparagraph (b) (Emission-data vehicle selection provisions)

   REPLACE WITH:

   (b) Emission-data vehicles shall be selected according to the provisions of Appendix II. Selection shall be based on highest sales volume and will require only two emission-data vehicles for certification testing per engine family. (For fifty-state families, the reference in the federal procedures to configuration or sales shall mean California configurations and sales rather than total family configurations and sales.)
   The Executive Officer will accept data from California (or fifty-state) configuration vehicles or from federal vehicles which meet the requirements of subparagraph 4.b.4. Federal vehicles may be reconfigured to California versions and tested to show compliance with California emission standards. The Executive Officer will also allow the manufacturer to reconfigure California vehicles.

2. Delete subparagraph (e)(1) (Reduced number of test vehicles)

   REPLACE WITH:

   (1) Any manufacturer whose projected California annual sales for the model year in which certification is sought is less than a combined total of 3,000 passenger cars, light-duty trucks, medium-duty vehicles, and heavy-duty engines may request a reduction in the number of test vehicles determined in accordance with the foregoing provisions of this paragraph. The Executive Officer may agree to such lesser numbers as he or she determines would meet the objectives of this procedure.

3. Delete subparagraph (e)(2) (Assigned deterioration factors)

   REPLACE WITH:

   (2)(i) Any manufacturer may request to certify engine families using assigned DFs for a combined total of 3,000 projected annual California sales of passenger cars, light-duty trucks, medium-duty vehicles, and heavy-duty engines per manufacturer regardless of total sales.

   (2)(ii) Assigned DFs shall be used only where specific mileage accumulation data do not exist (i.e., if a vehicle manufacturer uses an engine/system combination where DFs derived from exhaust emission testing exist, then the assigned factors cannot be used).

Assigned DFs shall be used in lieu of data from durability vehicle(s) only when a manufacturer demonstrates that it has control over design specifications, can provide development data, has in-house testing capabilities including accelerated aging of components/systems, and has evaluation criteria to ensure emission control system (ECS) durability for the vehicle's useful life. The applying manufacturer must demonstrate engine durability and that the emission control system(s) developed or adapted for the particular engine will be durable and comply with the applicable emission standards for the engine's or vehicle's useful life. In evaluating any information provided, all relevant test data and design factors shall be considered, including but not limited to: vehicle application, engine design, catalyst loading and volume, space velocity in the catalyst, engine exhaust gas concentrations and catalyst temperatures for various operating modes, and the durability of any emission control system components which may have been used in other vehicle applications. The assigned DFs shall be applied only to entire families.

If emission control parts from other certified vehicles are utilized, then parameter comparisons of the above data must also be provided including part numbers where applicable. Emission control durability may include special in-house specifications.

(2)(iii) The criteria for evaluating assigned DFs for evaporative families are the same as those for exhaust families. However, in determining evaporative family DFs the "California Evaporative Emission Standards and Test Procedures for 1978 and Subsequent Model Liquefied Petroleum Gas- or Gasoline- or Methanol-Fueled Motor Vehicles" require that an evaporative family DF be determined by averaging DFs obtained from durability vehicle testing and from bench testing. Therefore, if a manufacturer meets the criteria as specified above in (e)(2)(i) and (e)(2)(ii), the Executive Officer may grant assigned DFs for either (or both) the durability vehicle DF or the bench DF.

Assigned DFs for bench test requirements do not depend upon the 3,000 maximum sales limit. The assigned bench DF is applicable only to evaporative emission control systems which are similar to those used by the manufacturer for 1980 or later model-year vehicles and where an evaporative vehicle DF was determined. In evaluating a request for an assigned bench DF, all relevant information shall be considered, including but not limited to: fuel tank capacity, fuel tank temperatures, carburetor bowl "capacity", underhood temperatures, canister capacity and location, and any other comparisons to the certified application.

4. Amend subparagraph (f) and (h)(1)(v) by adding the following additional requirement which reads:

The durability or emission data submitted may be from vehicles previously certified by ARB. For 1993 through 1996 model-year passenger cars and light-duty trucks, the manufacturer shall submit durability data from only California (or fifty-state) configuration vehicles unless the durability data was generated from a vehicle certified by EPA or ARB prior to the 1993 model year. For 1997 and subsequent model-year vehicles, durability data shall be submitted from only California (or fifty-state) configuration vehicles. For 1993 and subsequent model-year vehicles, the Executive Officer shall permit the use of federal durability data vehicles if he or she determines that the federal data will adequately represent the durability characteristics of the California configuration. This determination shall be based upon similarity of catalyst location and configuration; similarity of fuel metering system; similarity of major features of emission control system logic and design; and similarity of any other features determined by the Executive Officer to be likely to affect durability. If data from a federal durability data vehicle is used, the requirements of subparagraph 6.b.5. (durability vehicles must meet emission standards) will refer to the federal emissions standards in effect for the model year for which the durability data was generated.

ed. Compliance with the Inspection and Maintenance Program

All 1993 and subsequent model-year emission-data vehicles shall be required to be tail-pipe tested at 4,000 miles and demonstrate compliance with the California Inspection and Maintenance emission standards in place at the time of certification as specified in the "Mandatory Exhaust Emissions Inspection Standards and Test Procedures", Title 16, California Code of Regulations, Section 3340.42. Test vehicles shall undergo preconditioning procedures prior to the tail-pipe test which consist of idle conditions for a minimum period of ten minutes after the thermostat is open. Preconditioning and test procedures shall be conducted at an ambient temperature from 68 to 86 degrees, Fahrenheit. The manufacturer shall, in accordance with good engineering practice, attest that such test vehicles will meet the requirements of this section when preconditioned and tested at ambient temperatures from 35 to 68 degrees Fahrenheit.

5. Maintenance Requirements

a. Maintenance[1]

Delete paragraph 86.090-25.

Delete paragraph 86.088-25.

Delete paragraph 86.087-25.

In paragraph 86.085-25:

1. Amend the title and first sentence of subparagraph (a) to read:

(a) Light-duty vehicles. Paragraph (a) of this section applies to passenger cars, light-duty trucks, and medium-duty vehicles.

2. Amend subparagraph (a)(1) to read:

(1) Scheduled maintenance on the engine, emission control system, and fuel system of durability vehicles shall, unless otherwise provided pursuant to paragraph (a)(5)(iii), be restricted as set forth in the following provisions. If a manufacturer must revise the maintenance schedule, prior approval by the Executive Officer is required. Unscheduled maintenance must not render a durability vehicle nonrepresentative of the production vehicles. The unscheduled maintenance must not be likely to be required in the normal use of the vehicle. Unauthorized or unjustifiable unscheduled maintenance may be cause for disqualification of a durability vehicle.

Manufacturers must submit durability maintenance logs to the Executive Officer. The maintenance logs shall include the mileage where maintenance occurred, the nature of the maintenance, and the name and part numbers of all fuel system and emission control parts involved with the maintenance. Manufacturers of series hybrid electric vehicles and parallel hybrid electric vehicles shall be required to incorporate into the vehicles a separate odometer or other device subject to the approval of the Executive Officer which can accurately gauge the mileage accumulation on the engines which are used in these vehicles.

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1. These requirements are for vehicles certified to the primary 50,000 mile and 100,000 *or 120,000* mile standards. Requirements for the vehicles certified to the optional 100,000 mile standards are found in section 10 (Optional 100,000 Mile Certification Procedure) of these procedures.

(i)(A) For otto-cycle vehicles and hybrid electric vehicles which use otto-cycle engines, maintenance shall be restricted to the inspection, replacement, cleaning, adjustment, and/or service of the following items at intervals no more frequent than indicated:

(1) Drive belts on engine accessories (tension adjustment only); (30,000 miles of engine operation).

(2) Valve lash (15,000 miles of engine operation).

(3) Spark plugs (30,000 miles of engine operation).

(4) Air filter (30,000 miles of engine operation).

(5) Exhaust gas sensor (30,000 miles of engine operation). Provided that:

(a) the manufacturer shall equip the vehicle with a maintenance indicator consisting of a light or flag, which shall be preset to activate automatically by illuminating in the case of a light or by covering the odometer in the case of a flag the first time the minimum maintenance interval established during certification testing is reached and which shall remain activated until reset. After resetting, the maintenance indicator shall activate automatically when the minimum maintenance interval, when added to the vehicle mileage at the time of resetting, is again reached and shall again remain activated until reset. When the maintenance indicator consists of a light, it shall also activate automatically in the engine-run key position before engine cranking to indicate that it is functioning. The maintenance indicator shall be located in the instrument panel and shall, when activated, display the words "oxygen sensor" or may display such other words determined by the Executive Officer to be likely to cause the vehicle owner to seek oxygen sensor replacement. The maintenance indicator shall be separate from the malfunction indicator light required by Section 1968, Title 13, California Code of Regulations;

(b) the manufacturer shall provide free replacement of the oxygen sensor, including both parts and labor, and shall reset the maintenance indicator without any charge, the first time the maintenance interval established during certification testing is reached for vehicles certified with scheduled sensor maintenance before 50,000 miles. If the oxygen sensor is replaced pursuant to the warranty provisions of Section 2037, Title 13, California Code of Regulations, before the first maintenance interval is reached, the manufacturer shall also replace the oxygen sensor and reset the maintenance indicator at the mileage point determined by adding the maintenance interval to the vehicle's mileage at the time of the warranty replacement. If the calculated mileage point for a second oxygen sensor replacement would exceed 50,000 miles, no free second replacement shall be required;

(c) The maintenance indicator shall be resettable. The maintenance instructions required by section 5.b. of these procedures shall provide instructions for the resetting of the maintenance indicator, and shall specify that the maintenance indicator shall be reset each time the oxygen sensor is replaced; and

(d) Notwithstanding the provisions of Section 2037(c), Title 13, California Code of Regulations; the oxygen sensor, including any replacement required pursuant to this section, shall be warranted for the applicable warranty period of the vehicle or engine in accordance with Section 2037(a), Title 13, California Code of Regulations. If such oxygen sensor fails during this period, it shall be replaced by the manufacturer in accordance with Section 2037(d), Title 13, California Code of Regulations.

(6) Choke (cleaning or lubrication only); (30,000 miles of engine operation).

(7) Positive crankcase ventilation valve (50,000 miles of engine operation).

(8) Ignition wires (50,000 miles of engine operation).

(9) In addition, adjustment of the engine idle speed (curb idle and fast idle), valve lash, and engine bolt torque may be performed once during the first 5,000 miles of scheduled driving, provided the manufacturer makes a satisfactory showing that the maintenance will be performed on vehicles in use. For hybrid electric vehicles, these adjustments may only be performed once during the first 5,000 miles of engine operation.

(i)(B) For diesel vehicles and hybrid electric vehicles which use diesel engines, maintenance shall be restricted to the following items at intervals no more frequently than every 12,500 miles of engine operation ~~scheduled driving~~, provided that no maintenance may be performed within 5,000 miles of the final test point:

(1) Adjust low idle speed.

(2) Adjust valve lash if required.

(3) Adjust injector timing.

(4) Adjust governor.

(5) Clean and service injector tips.

(6) Adjust drive belt tension on engine accessories.

(7) Check engine bolt torque and tighten as required.

(ii) Change of engine and transmission oil, change or service of oil filter and, for diesel vehicles only, change or service of fuel filter and air filter, will be allowed at the mileage intervals specified in the manufacturer's maintenance instructions.

(iii) Maintenance shall be conducted in a manner consistent with service instructions and specifications provided by the manufacturer for use by customer service personnel.

3. Delete subparagraph (a)(3) (Service of exhaust gas recirculation system).

4. Delete subparagraph (a)(4) (Service of catalytic converter).

5. Amend subparagraph (a)(5), by adding a new subparagraph (iv) to read:

(iv) When a part has to be replaced while conducting unscheduled maintenance, a similarly aged part shall be used for those parts that affect emissions, unless it is impractical and unnecessary to age a part and prior approval has been obtained from the Executive Officer for use of the part without aging. In either case, an engineering report on the nature of the problem with the probable cause and corrective action shall be supplied to the Executive Officer.

6. Delete subparagraph (b) (Maintenance of light-duty trucks and heavy-duty engines).

b. Maintenance Instructions

Delete paragraph 86.087-38.

In paragraph 86.085-38:

1. Amend subparagraph (a) to read:

(a) The manufacturer shall furnish or cause to be furnished to the purchaser of each new motor vehicle subject to the standards prescribed in Section 3 of these procedures, written instructions for the maintenance and use of the vehicle by the purchaser as may be reasonable and necessary to assure the proper functioning of emission control systems in normal use. Such instructions shall be consistent with and not require maintenance in excess of the restrictions imposed under subparagraph 86.085-25(a)(1) as amended above, except that the instructions may, subject to approval by the Executive Officer, require additional maintenance for vehicles operated under extreme conditions. In addition, subject to approval by the Executive Officer, the instructions may require inspections necessary to insure safe operation of the vehicle in use.

In addition to any maintenance which may be required pursuant to the preceding paragraph, the instructions may also recommend such inspections, maintenance, and repair as may be reasonable and necessary for the proper functioning of the vehicle and its emission control systems. If the instructions recommend maintenance in addition to that which may be required pursuant to the preceding paragraph, they shall distinguish clearly between required and recommended maintenance.

2. Amend both subparagraphs (c)(1) and (d)(1) to read:

(1) Such instructions shall specify the performance of all scheduled maintenance performed by the manufacturer under subparagraph 86.085-25(a)(1).

c. Submission of Maintenance Instructions

Amend subparagraph 86.079-39(a) to read:

(a) The manufacturer shall provide to the Executive Officer, no later than the time of the submission required by paragraph 86.088-23 <u>or 86.091-23</u>, a copy of the maintenance instructions which the manufacturer proposes to supply to the ultimate purchaser in accordance with subparagraph 86.085-38(a). The Executive Officer will review such instructions to determine whether they are consistent with California requirements, and to determine whether the instructions for required maintenance are consistent with the restrictions imposed under subparagraph 86.085-25(a)(1). The Executive Officer will notify the manufacturer of his or her determinations.

6. Demonstrating Compliance

a. Mileage and Service Accumulation; Emission Measurements

In paragraphs 86.084-26 and 86.090-26:

1. Amend (a)(2) to read:

The procedure for mileage accumulation shall be the Durability Driving Schedule as specified in Appendix IV to Part 86 of the Code of Federal Regulations. A modified procedure may also be used if approved in advance by the Executive Officer. <u>All passenger cars, light-duty trucks and pre-1995</u> model year medium-duty vehicles shall accumulate mileage at a measured curb weight which is within 100 pounds of the estimated curb weight. All 1995 and subsequent model-year medium-duty vehicles shall accumulate mileage at a loaded *weight that is within 100 pounds of the average of the vehicle's curb weight and gross vehicle weight. If the vehicle weight is within 100 pounds of being included in the next higher inertia weight class, the manufacturer may elect to conduct the respective emission tests at the higher weight.* All mileage accumulation of series hybrid electric vehicles shall be conducted utilizing constant operation of the auxiliary engines. Parallel hybrid electric vehicles shall accumulate all mileage while operating with as much use of the combustion engine as is possible.

2.[~~1.~~] Amend (a)(3)(i) and (a)(3)(ii) (Emission-data vehicle mileage accumulation) by adding the following additional requirement which reads:

The Executive Officer will accept the manufacturer's determination of the mileage at which the engine-system combination is stabilized for emission data testing if (prior to testing) a manufacturer determines that the interval chosen yields emissions performance which is stable and representative of design intent. Sufficient mileage should be accumulated to reduce the possible effects of any emissions variability that is the result of insufficient vehicle operation. Of primary importance in making this determination is the behavior of the catalyst, EGR valve, trap oxidizer or any other part of the ECS which may have non-linear aging characteristics. In the alternative, the manufacturer may elect to accumulate 4,000 mile +/- 250 mile on each test vehicle within an engine family without making a determination.

3.[~~2.~~] Amend (a)(4)(i) and (a)(4)(ii) (Durability-data vehicle mileage accumulation) by adding the following new subparagraphs (A), (B), (C), and (D) to read:

(A) For otto-cycle and diesel vehicles and battery assisted combustion engine vehicles which use otto-cycle or diesel engines:

(1) Passenger cars, light-duty trucks and medium-duty vehicles certifying to exhaust emissions standards only on a 50,000 mile durability basis and selected by the Executive Officer or elected by the manufacturer under 86.085-24(c)(1) or 86.090-24(c)(1) shall be driven, with all emission control systems installed and operating, for 50,000 miles or such lesser distance as the Executive Officer may agree to as meeting the objective of this procedure.

(2) Prior to initiation of mileage accumulation in a durability-data vehicle, manufacturers must establish the mileage test interval for durability-data vehicle testing of the engine family. Once testing has begun on a durability-data vehicle, the durability test interval for that family may not be changed. At a minimum, multiple tests must be

performed at 5,000 miles, 50,000 miles, and the final mileage point as long as they meet the requirements of Appendix III. The Executive Officer will accept durability test interval schedules determined by the manufacturer. The testing must provide a DF confidence level equal to or better than the confidence level using the former fixed mileage test and scheduled maintenance intervals. The procedure for making this determination is also given in Appendix III. The mileage intervals between test points must be approximately of equal length. The +/- 250 mile test point tolerance and the requirement that tests be conducted before and after scheduled maintenance is still mandatory. Emission control systems for otto-cycle engines which have step function changes designed into the control system must use the 5,000 mile test interval schedule.

(3) Testing before and after scheduled (or unscheduled) maintenance points must be conducted, and these data are to be included in the deterioration factor calculation.[2]

The number of tests before and after scheduled maintenance and the mileage intervals between test points should be approximately equal. Durability test interval schedules with multiple testing at test points within 10,000 miles of or at the 50,000 mile and the final mileage test point must be submitted for approval. Multiple testing at maintenance mileage tests points within 10,000 miles of the 50,000 mile and the final mileage test points may be approved if it can be demonstrated by previously generated data that the emission effects of the maintenance are insignificant.

(4) For engine families which are to be certified to the full useful life emission standards, each exhaust emission durability-data vehicle shall be driven with all emission control systems installed and operating, for the full useful life or such lesser distance as the Executive Officer may agree to as meeting the objective of this procedure. Durability tests shall be at every 5,000 miles, from 5,000 miles to the full useful life, however, the above procedures may be used to determine alternate test intervals subject to the following.

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2. Testing before unscheduled maintenance may be omitted with the prior consent of the Executive Officer when testing would be dangerous to a vehicle or an operator.

For engine families which are to be certified to the full useful life emission standards, durability vehicles may accumulate less than the full useful life if the manufacturer submits other data or information sufficient to demonstrate that the vehicle is capable of meeting the applicable emission standards for the full useful life. At a minimum, 75% of the full useful life shall be accumulated. Alternative durability plans may also be used if the manufacturer provides a demonstration that the alternative plan provides equal or greater confidence that the vehicles will comply in-use with the emission standards. The demonstration shall include, but not be limited to, bench test data and engineering data. A manufacturer's in-use emission data may also be used. All alternative durability plans, including the use of durability vehicles which accumulate less than the full useful life are subject to approval in advance by the Executive Officer.

(B) For diesel vehicles equipped with periodically regenerating trap oxidizer systems, at least four regeneration emission tests (see 86.106 through 86.145) shall be made.[3] With the advance approval of the Executive Officer, the manufacturer may install (1) a manual override switch capable of preventing (i.e. delaying until the switch is turned off) the start of the regeneration process and (2) a light which indicates when the system would initiate regeneration if it had no override switch. Upon activation of the override switch the vehicle will be operated on a dynamometer to precondition it for the regeneration emission test in accordance with section 86.132-82 or 86.132-90 and section 9.b. of these procedures. The Urban Dynamometer Driving Schedule (UDDS) which is in progress at the time when the light comes on shall be completed and the vehicle shall proceed to the prescribed soak period followed by testing. With the advance approval of the Executive Officer, the manual override switch will be turned off at some predetermined point in the testing sequence permitting the regeneration process to proceed without further manual interaction. The mileage intervals between test points shall be approximately equal. The first regeneration emission test shall be made at the 5,000 mile point. The regeneration emission tests must provide a deterioration factor confidence level equal to or better than the confidence level achieved by performing regeneration emission tests at the following mileage point: 5,000;

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3. Included in Appendix V are the pollutant mass emission calculation procedures for vehicles equipped with periodically regenerating trap oxidizer systems.

20,000; 35,000; and 50,000. The procedure for making this determination is shown in Appendix IV.

(C) For gasoline-, gaseous-, and methanol-fueled vehicles, the "California Evaporative Emission Standards and Test Procedures for 1978 and Subsequent Model Liquefied Petroleum Gas- or Gasoline- or Methanol-Fueled Motor Vehicles," as incorporated in Title 13, California Code of Regulations, Section 1976, specify evaporative durability testing at 5,000, 10,000, 20,000, 30,000, 40,000 and 50,000 mile test points. These requirements are also applicable to hybrid electric vehicles. With the exception of fuel-flexible vehicles, a manufacturer may conduct evaporative testing at test points used for exhaust emission durability testing provided that the same deterioration confidence level for the evaporative emission DF determination is retained (see Appendix III).

(D) For fuel-flexible vehicles, the test schedule must include exhaust emission tests at 5,000, 10,000, and every 10,000 miles thereafter to the final mileage point. The results of these exhaust emission tests will be used by the Executive Officer to evaluate the vehicle's emission control deterioration with various fuels (M85, M35, and unleaded gasoline; See Fuel Specifications, Section 9.a. of these procedures). Only the M85 emission results will be incorporated with other exhaust emission data in determining applicable emission deterioration factors required in Section 6.b. (Compliance with Emission Standards) of these procedures.

(E) For series hybrid electric vehicles and parallel hybrid electric vehicles, the manufacturer shall submit a test schedule to the Executive Officer which reflects the operating mileage of the engine over the full useful life of the vehicle. The test schedule shall include exhaust emission tests at 5,000, 10,000, and every 10,000 miles of engine operation thereafter to the final mileage point corresponding to operating mileage of the engine over the full useful life of the vehicles.

~~(E)~~(F) The Executive Officer may determine under 86.085-24(f) or 86.090-24(f) that no testing is required.

4.3~~.~~ Amend subparagraph (a)(5)(i) by adding the following requirement which reads:

In addition, the emission tests performed on emission-data vehicles and durability-data vehicles shall be non-regeneration emission tests for diesel passenger cars, light-duty trucks, and medium-duty vehicles equipped with periodically regenerating trap oxidizer systems. For any of these vehicles equipped with continually regenerating trap oxidizer systems, manufacturers may use the provisions applicable to periodically regenerating trap oxidizer systems as an option.

If such an option is elected, all references in these procedures to vehicles equipped with periodically regenerating trap oxidizer systems shall be applicable to the vehicles equipped with continually regenerating trap oxidizer systems.

5.[4.] Amend subparagraph (a)(8) to read:

(8) Once a manufacturer submits the information required in paragraphs (a)(7) of this section for a durability-data vehicle, the manufacturer shall continue to run the vehicle to 50,000 miles if the family is certified to 50,000 mile emission standards or to the full useful life if it is certified to emission standards beyond 50,000 miles (or to a lesser distance which the Executive Officer may have previously agreed to), and the data from the vehicle will be used in the calculations under 86.088-28, and 86.090-28, and 86.091-28. Discontinuation of a durability-data vehicle shall be allowed only with the consent of the Executive Officer.

6.[5.] Delete subparagraph (b) (Emission-data and durability-data mileage accumulation for light duty trucks).

b. Compliance with Emission Standards

In paragraph 86.088-28, and 86.090-28, and 86.091-28:

1. Amend subparagraph (a)(1) to read:

(1) Paragraph (a) of this section applies to light-duty vehicles (passenger cars, light-duty trucks and medium-duty vehicles).

2. Amend Subparagraph (a)(3) to read:

(3) Since it is expected that emission control efficiency will change with mileage accumulation on a vehicle, the emission level of a vehicle which has accumulated 50,000 miles will be used as the basis for determining compliance with the 50,000 mile emission standards.

3. Amend subparagraph (a)(4)(i) to read:

(i) Separate emission deterioration factors shall be determined from the exhaust emission results of the durability-data vehicle(s) for each engine-system combination. A separate factor shall be established for exhaust HC (non-methanol vehicles, non-TLEVs, non-LEVs, and non-ULEVs), exhaust OMHCE (methanol vehicles that are not TLEVs, LEVs, or ULEVs), exhaust NMOG (all TLEVs, LEVs, and ULEVs), exhaust formaldehyde (methanol vehicles, TLEVs, LEVs, and ULEVs), exhaust CO, exhaust NOx, and exhaust particulate (diesel vehicles only) for each engine-system combination. A separate evaporative emission deterioration factor shall be determined for each evaporative emission family-evaporative emission control system combination from the testing conducted by the manufacturer (gasoline- and methanol-fueled vehicles only).

Separate emission correction factors (diesel passenger cars, light-duty trucks, and medium-duty vehicles equipped with periodically regenerating trap oxidizer systems only) shall be determined from the exhaust emission results of the durability-data vehicle(s) for each engine-system combination. A separate factor shall be established for exhaust HC (non-methanol vehicles, non-TLEVs, non-LEVs, and non-ULEVs), exhaust OMHCE (methanol vehicles that are not TLEVs, LEVs, or ULEVs), exhaust NMOG (TLEVs, LEVs, and ULEVs), exhaust CO, exhaust NOx, and exhaust particulate for each engine-system combination.

4. Delete subparagraph (a)(4)(i)(A)(4) (Outlier test point procedure).

REPLACE WITH:

(4) The manufacturer must use the California outlier identification procedure entitled "Calculation of t-Statistic for Deterioration Data Outlier Test", dated December 17, 1976 and set forth in Appendix VII, to test for irregular data from a durability-data set. If any data point is identified as a statistical outlier, the Executive Officer shall determine, on the basis of an engineering analysis of the causes of the outlier submitted by the manufacturer, whether the outlier is to be rejected. The outlier shall be rejected only if the Executive Officer determines that the outlier does not reflect representative characteristics of the emission control system i.e., the outlier is a result of an emission control system anomaly, test procedure error, or an extraordinary circumstance not expected to recur. Only the identified outlier shall be eliminated; other data at that test point (i.e., data for other pollutants) shall not be eliminated unless the Executive Officer determines, based on the engineering analysis, that they also do not reflect representative characteristics of the emission control system. Where the manufacturer chooses to apply both the outlier procedure and averaging (as allowed under 86.084-26(b)(6)(i) and 86.090-26(a)(6)(1) to the same data set, the outlier procedure shall be completed prior to applying the averaging procedure. All durability test data, including any outliers and the manufacturer's engineering analysis, shall be submitted with the final application.

5. Amend subparagraph (a)(4)(i)(B) (durability vehicles must meet emissions standards) to read:

(B) All applicable exhaust emission results shall be plotted as a function of the mileage on the system, rounded to the nearest mile, and the best fit straight lines, fitted by the method of least squares, shall be drawn through all these data points. The emission data will be acceptable for use in the calculation of the deterioration factor only if the interpolated 4,000-mile, 50,000-mile, and full useful life points on this line are within the emission standards given in subparagraph 3. or within the federal emission standards if a federal durability data vehicle is approved in accordance with subparagraph 4.b.4., as applicable. For hybrid electric vehicles, the emission data will be acceptable for use in the calculation of the deterioration factor only if the engine mileage points corresponding to the interpolated 4,000 mile, 50,000 mile, and full useful life points of the vehicle on this line are within the emission standards given in subparagraph 3. or within the federal emission standards if a federal durability data vehicle is approved in accordance with subparagraph 4.b.4., as applicable. The engine mileage points shall be determined based on the test schedule submitted to the Executive Officer as required in paragraphs 86.084-26 and 86.090-26. As an exception, the Executive Officer will review the data on a case-by-case basis and may approve its use in those instances where the best fit straight line crosses an applicable standard but no data point exceeds the standard or when the best fit straight line crosses the applicable standard at the 4,000-mile point but the 5,000-mile actual test point and the 50,000 mile and full useful life interpolated points are both below the standards. A multiplicative exhaust emission deterioration factor shall be calculated for each engine system combination as follows:

(1) For engine families certified to 50,000 mile emissions standards:

$Factor_1$ = Exhaust emissions interpolated to 50,000 miles divided by exhaust emissions interpolated to 4,000 miles.

(2) For engine families certified to full useful life emissions standards beyond 50,000 miles:

$Factor_2$ = Exhaust emissions interpolated to the full useful life divided by exhaust emissions interpolated to 4,000 miles.

6. Add subparagraph (a)(4)(i)(D) to read:

(D) The regeneration exhaust emission data (diesel passenger cars, light-duty trucks, and medium-duty vehicles equipped with periodically regenerating trap oxidizer systems only) from the tests required under 86.084-26(a)(4) or ~~86.088-26(a)(4)~~ 86.090-26(a)(4) shall be used to determine the regeneration exhaust emissions interpolated to the 50,000-mile point. The regeneration exhaust emission results shall be plotted as a function of the mileage on the system, rounded to the nearest mile, and the best fit straight lines, fitted by the method of least squares, shall be drawn through all these data points. The interpolated 50,000-mile point of this line shall be used to calculate the multiplicative exhaust emission correction factor for each engine-system combination as follows:

$$\text{Factor} = 1 + \frac{R-1}{4505} n$$

where, R = the ratio of the regeneration exhaust emissions interpolated to 50,000 miles to the non-regeneration exhaust emissions interpolated to 50,000 miles.

n = the number of complete regenerations which occur during the durability test.

These interpolated values shall be carried out to a minimum of four places to the right of the decimal point before dividing one by the other to determine the correction factor. The results shall be rounded to three places to the right of the decimal point in accordance with ASTM E 29-67. For applicability to gaseous emission standards under the 100,000 mile option, R will be determined based upon projected 100,000 mile emissions.

7. Amend subparagraph (a)(4)(ii)(A) to read:

(A) The official exhaust emission test results for each emission-data vehicle at the 4,000 mile test point shall be multiplied by the appropriate deterioration factor, and correction factor (diesel passenger cars, light-duty trucks, and medium-duty vehicles equipped with periodically regenerating trap oxidizer systems only): Provided: that if a deterioration factor as computed in paragraph (a)(4)(i)(B) of this section or a correction factor as computed in paragraph (a)(4)(i)(D) of this section is less than one, that deterioration factor or correction factor shall be one for the purposes of this paragraph.

8. Delete subparagraph (b) (Compliance provisions for light-duty trucks).

7. Small-Volume Manufacturer's Certification Procedures

a. In paragraphs 86.084-14 and ~~86.088-14~~ 86.090-14:

1. Amend subparagraph (b)(1) to read:

(1) The optional small-volume manufacturers certification procedures apply to light-duty vehicles (passenger cars, light-duty trucks, and medium-duty vehicles), produced by manufacturers with California sales (for the model year in which certification is sought) of fewer than 3,000 units (PC, LDT and MDV combined).

2. Amend subparagraph (c)(4) to read:

(4) A small-volume manufacturer shall include in its records all of the information that ARB requires ~~on~~ in 86.088-21 or 86.091-21. This information will be considered part of the manufacturer's application for certification and must be submitted to the Executive Officer.

3. Delete subparagraph (c)(7)(i)(A) (Worst-case selection of emission-data vehicles).

4. Amend subparagraph (c)(11)(ii)(D)(1) to show the 3,000 total vehicle sales limit applicable to California for determining a small-volume manufacturer.

8. Alternative Procedures for Notification of Additions and Changes

a. Amend subparagraph 86.082-34(a) by adding the following additional requirements which read:

A manufacturer must notify the Executive Officer within 10 working days of making an addition of a vehicle to a certified engine family or a change in a vehicle previously covered by certification.

The manufacturer shall also submit, upon request of the Executive Officer, the following items:

(1) service bulletin.
(2) driveability statement.
(3) test log.
(4) maintenance log.

All running changes and field fixes which do not adversely affect the system durability are deemed approved unless disapproved by the Executive Officer within 30 days of the receipt of the running change or field fix request. A change not specifically identified in the manufacturer's application must also be reported to the Executive Officer if the change may adversely affect engine or emission control system durability. Examples of such changes include any change that could affect durability, thermal characteristics, deposit formation, or exhaust product composition i.e., combustion chamber design, cylinder head material, camshaft profile, computer modifications, turbocharger, intercooler wastegate characteristics, and transmission or torque converter specifications. Running changes and field fixes meeting the definitions contained in Appendix VI shall be automatically deemed approved by the Executive Officer, as long as the conditions set forth in Appendix VI are satisfied.

The manufacturer is required to update and submit to the Executive Officer the "supplemental data sheet" for all running changes and field fixes implemented with the change notification. The manufacturer shall submit, on a monthly basis, by engine family, a list of running changes/field fixes giving the document number date submitted and a brief description of the change.

9. Test Requirements

a. Fuel Specifications

In paragraph 86.113-90:

1. Delete subparagraph (a)(3) (Methanol test fuel for otto-cycle vehicles).

2. Delete subparagraph (a)(4) (Alternative methanol test fuels for otto-cycle vehicles).

3. Amend subparagraph (a)(5) to read:

(5) The specification range of the fuels to be used under paragraph (a)(2) of this section shall be reported in accordance with 86.090-21(b)(3) or 86.091-21(b)(3).

4. Delete subparagraph (b)(4) (Methanol test fuel for diesel vehicles).

5. Delete subparagraph (b)(5) (Alternative methanol test fuels for diesel vehicles).

6. Amend subparagraph (b)(6) to read:

(6) The specification range of the fuels to be used under paragraphs (b)(2) and (b)(3) of this section shall be reported in accordance with 86.090-21(b)(3) or 86.091-21(b)(3).

7. Replace subparagraph (d) with:

(d) Methanol-Gasoline Fuel Specifications. Various methanol-gasoline fuel blends will be used according to the type of methanol-fueled vehicle being certified and the particular aspect of the certification procedure being conducted, as specified below. Gasoline used for blending fuel for use in mileage accumulation shall be representative of commercial regular unleaded gasoline which will be generally available through retail outlets. Gasoline used for blending fuel for use in emission testing shall conform with the unleaded gasoline specification noted in paragraph (a) above.

Fuel additives and ignition improvers intended for use in methanol test fuels shall be subject to the approval of the Executive Officer. In order for such approval to be granted, a manufacturer must demonstrate that emissions will not be adversely affected by the use of the fuel additive or ignition improver.

(1) Otto-cycle methanol vehicles and hybrid electric vehicle which use otto-cycle methanol engines

Mileage-accumulation fuel: For methanol vehicles and hybrid electric vehicle which use otto-cycle methanol engines a methanol-gasoline blend composed of 85-percent methanol which is representative of commercially available methanol and 15-percent unleaded gasoline as noted above.

Emission-testing fuel: For vehicles certifying on methanol, a methanol-gasoline blend composed of 85 percent chemical grade methanol and 15-percent unleaded gasoline as noted above.

(2) Methanol-fueled diesel vehicles and hybrid electric vehicles which use methanol-fueled diesel engines

Mileage-accumulation fuel: For methanol vehicles and hybrid electric vehicles which use methanol-fueled diesel engines, commercially available methanol fuel.

Emission-testing fuel: chemical grade methanol.

(3) Fuel-flexible vehicles

Mileage-accumulation fuel: For both durability-data vehicles and emission-data vehicles, mileage accumulation shall be conducted with one ~~two~~ fuel~~s~~. For vehicles designed to operate on methanol, ~~(1)~~ a methanol-gasoline blend composed of 85-percent methanol and 15-percent unleaded gasoline both of which are representative of commercially available fuels~~;~~ shall be used. ~~and (2) unleaded gasoline. The vehicles shall be refueled with these two fuels, alternating from one fuel to the other after every two tankfuls.~~

Emission-test fuel: Case (1) For regular emission testing, methanol-gasoline blend composed of 85-percent chemical grade methanol and 15-percent unleaded gasoline.

Case (2) For the testing required under 6.a.2.(D). of these procedures, exhaust emission tests (exhaust OMHCE for non-TLEVs, non-LEVs, and non-ULEVs, exhaust NMOG for TLEVs, LEVs, and ULEVs, exhaust formaldehyde, exhaust CO, and exhaust NO_x) shall be conducted at the specified mileage intervals using 85-percent chemical grade methanol and 15-percent unleaded gasoline, and 35-percent chemical grade methanol and 65-percent unleaded gasoline. In addition, complete sets of emission tests shall be conducted at 5,000 miles, 50,000 miles and the final mileage point with unleaded gasoline.

(4) Other methanol fuels may be used for testing and service accumulation provided: (i) they are commercially available; (ii) information, acceptable to the Executive Officer, is provided to show that only the designated fuel would be used in customer service; (iii) use of a fuel listed in this section would not have a detrimental effect on emissions or durability; (iv) written approval from the Executive Officer of the fuel specifications must be provided prior to the start of testing.

(5) The specification of the fuels to be used under paragraphs (d)(1), (d)(2), and (d)(3) of this section shall be reported in accordance with 86.090-21(b)(3) or 86.091-21(b)(3).

2. Add new subparagraph (e) to read:

(1) Gaseous fuels representative of commercial gaseous fuels which will be generally available through retail outlets in California or liquid petroleum gas having the ASTM D1835 or NGPA HD-5 specification shall be used in service accumulation.

(2) Liquid petroleum gas having the ASTM D1835 or NGPA HD-5 specification shall be used for exhaust and evaporative emission testing.

(3) Natural gas representative of commercial natural gas which will be generally available through retail outlets in California shall be used for exhaust emission testing.

(4) Written approval from the Administrator of the fuel specifications must be provided prior to the start of the testing.

(5) For dedicated gaseous- and dual-fueled vehicles and for hybrid electric vehicles which use gaseous-fueled engines, the mileage accumulation fuel for both durability-data vehicles and emission-data vehicles shall be conducted with one fuel. For vehicles designed to operate on natural gas, natural gas which meets the requirements of (3) shall be used. For vehicles designed to operate on liquified petroleum gas, liquified petroleum gas which meets the requirements of (2) shall be used.

b. *Road Load Power Test Weight*

In paragraph 86.129-80:

1. *Amend subparagraph (a) to add:*

ROAD LOAD POWER TEST WEIGHT AND INERTIA WEIGHT CLASS DETERMINATION

ROAD LOAD POWER AT 50 mi/hr-LIGHT DUTY TRUCKS	LOADED WEIGHT (POUNDS)[5]	EQUIVALENT TEST WEIGHT (POUNDS)	INERTIA WEIGHT CLASS (POUNDS)
	10001 to 10250	10000	10000
	10251 to 10750	10500	10500
	10751 to 11250	11000	11000
	11251 to 11750	11500	11500
	11751 to 12250	12000	12000
	12251 to 12750	12500	12500
	12751 to 13250	13000	13000
	13251 to 13750	13500	13500
	13751 to 14000	14000	14000

[5] *For 1995 and subsequent medium-duty vehicles, "Loaded Weight" shall be the average of the vehicle's curb weight and gross vehicle weight.*

2. *Add subparagraph (d) to read:*

(d) Power absorption unit adjustment- medium-duty vehicles. (1) The power absorption unit shall be adjusted to reproduce road load power at 50 mph true speed. The dynamometer power absorption shall take into account the dynamometer friction, as discussed in paragraph 86.118-78.

(2) The dynamometer road load setting is determined from the loaded test weight, the reference frontal area, vehicle protuberances, and an aerodynamic drag coefficient as determined appropriate by the Executive Officer. The vehicle manufacturer shall submit the procedure by which the aerodynamic drag coefficient was determined in the test vehicle information section in the certification application. The dynamometer road load setting shall be determined by the following equation.

(i) For medium-duty vehicles to be tested on twin or single, large roll dynamometers.

$$Hp = (0.00182)V((0.015)(W)+(0.0375)(Cd)(A)(V^2)/(32.2ft/s^2))+P$$

where:

Hp=the dynamometer power absorber setting at 50 mph (horsepower).
0.00182=conversion factor to horsepower.
V=velocity in feet/sec.
0.015=coefficient of rolling resistance.
W=loaded vehicle weight in pounds.
0.0375=air density in lbm/cubic ft.
Cd=aerodynamic drag coefficient
A=reference frontal area in square ft.
32.2 ft/s^2=gravitational acceleration
P=protuberance power (horsepower)

(ii) The protuberance power, P shall be determined per subparagraph 86.129-80 (c)(2)(i).

(iii) The dynamometer power absorber setting for medium-duty vehicles shall be rounded to the nearest 0.1 horsepower.

(3) The road load power calculated above shall be used or the vehicle manufacturer may determine the road load power by an alternate procedure requested by the manufacturer and approved in advance by the Executive Officer.

(4) Where it is expected that more than 33 percent of a vehicle line within an engine-system combination will be equipped with air conditioning, per subparagraph ~~86.080-24(g)(2)~~ 86.090-24(g)(2), the road load power as determined in paragraph (d) (2) or (3) of this section shall be increased by 10 percent up to a maximum increment of 1.4 horsepower, for testing all test vehicles of that vehicle line within that engine-system combination if those vehicles are intended to be offered with air conditioning in production. This power increment shall be added to the indicated dynamometer power absorption setting prior to rounding off this value.

c. Test Sequence: General Requirements

Amend paragraph 86.130-78 to read:

The test sequence shown in figure B78-10 shows the steps encountered as the test vehicle undergoes the procedures subsequently described to determine conformity with the standards set forth. Ambient temperature levels shall not be less than 68°F (20°C) nor more than 86°F (30°C). For purposes of determining conformity with standards set forth at 50 degrees F, ambient temperature levels encountered by the test vehicle shall not be less than 45°F (7°C) nor more than 55°F (13°C). The temperatures monitored during testing must be representative of those experienced by the test vehicle. The vehicle shall be approximately level during all phases of the test sequence to prevent abnormal fuel distribution.

d. ~~c.~~[~~b.~~] Vehicle Preconditioning

In paragraphs 86.132-82 and 86.132-90:

1. Amend subparagraph (a)(2) to read:

(2) Within one hour of being fueled the vehicle shall be placed, either by being driven or pushed, on a dynamometer and operated through one Urban Dynamometer Driving Schedule (UDDS) test procedure, see 86.115 and Appendix I of the federal procedures.

The UDDS performed prior to a non-regeneration emission test shall not contain a regeneration (diesel passenger cars, light-duty trucks, and medium-duty vehicles equipped with periodically regenerating trap oxidizer systems only). A gasoline fueled test vehicle may not be used to set dynamometer horsepower.

2. Amend subparagraph (a)(3) to read:

(3) For those unusual circumstances where additional preconditioning is desired by the manufacturer, such preconditioning may be allowed with the advance approval of the Executive Officer. The Executive Officer may also choose to conduct or require the conduct of additional preconditioning to insure that the evaporative emission control system is stabilized in the case of otto-cycle engines, or to insure that the exhaust system is stabilized in the case of diesel engines. The additional preconditioning shall consist of an initial one hour minimum soak and, one, two, or three driving cycles of the UDDS (or more in the case of a diesel vehicle equipped with a periodically regenerating trap oxidizer system, which is being preconditioned for a regeneration emission test), as described in paragraph (a)(2) of this section, each followed by a soak of at least one hour with engine off, engine compartment cover closed and cooling fan off. The vehicle may be driven off the dynamometer following each UDDS for the soak period.

e. ~~d.~~[~~c.~~] Regeneration Recording Requirements

Amend paragraph 86.142-82 by adding the following subparagraph (r) which reads:

(r) The manufacturer shall record in the durability-data vehicle log book, the number of regenerations which occur during the 50,000 mile durability test of each diesel passenger car, light-duty truck and medium-duty vehicle equipped with a periodically regenerating trap oxidizer system. The manufacturer shall include, for each regeneration: the date and time of the start of regeneration, the duration of the regeneration, and the accumulated mileage at the start and the end of regeneration. The number of regenerations will be used in the calculation of the correction factor in 40 CFR Part 86, Section 28.

Amend paragraph 86.142-90 by adding the following subparagraph (s) which reads:

(s) The manufacturer shall record in the durability-data vehicle log book, the number of regenerations which occur during the 50,000 mile durability test of each diesel-~~cycle~~ passenger car, light-duty truck and medium-duty vehicle equipped with a periodically regenerating trap oxidizer system. The manufacturer shall include, for each regeneration: the date and time of the start of regeneration, the duration of the regeneration, and the accumulated mileage at the start and the end of regeneration. The number of regenerations will be used in the calculation of the correction factor in 40 CFR Part 86, Section 28.

10. Optional 100,000 Mile Certification Procedure

The following provisions and alternate emission standards shown in section (3) of these procedures shall apply to any engine section family certified to the optional 100,000 mile certification standards.[4]

a. General Guidelines for Implementation

1. Designation

The manufacturer shall designate in the preliminary application for certification those engine families that will be certified to the 100,000 mile procedures. In order to allow the manufacturer as much flexibility as possible, the manufacturer may at any time designate additional engine families or remove any designated engine family. Families originally intended for 50,000 mile certification may be designated as 100,000 mile families after the start of durability testing and vice versa. The Executive Officer must be notified within ten working days of any such changes. Manufacturers are cautioned that any engine family certified to the 100,000 mile certification procedure must comply with the allowable maintenance provisions of section 10.b in these procedures during the engine mileage accumulation.

2. Mileage Accumulation

All durability vehicles must be run to at least 50,000 miles for established emission control systems, early termination of mileage accumulation may be requested by the manufacturer if sufficient evidence as described below is provided to satisfy the Executive Officer that further testing is unnecessary.

Testing beyond 50,000 miles must be conducted in accordance with the certification test procedures applicable prior to 50,000 miles. Exhaust emissions tests shall be performed at every 5,000

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4. The additional criteria outlined in Section 6.a. (Mileage and Service Accumulation: Emission Measurements) shall be used to determine the durability-data testing schedule and the emission-data 4,000 mile test point.

mile interval starting with the 55,000 mile point and ending with the 100,000 mile point, and before and after all scheduled maintenance.

The Executive Officer may, upon request by the manufacturer waive any exhaust emission testing beyond 50,000 miles, if he or she finds that (1) the extrapolated 100,000 mile points and interpolated 4,000 mile points on the least squares lines comply with the line crossing provisions of section 10.b. of the procedures, and (2) the system and engine designs, on the basis of previous engineering experience, would not be expected to exceed the applicable standards after 100,000 miles. For example, a diesel vehicle that shows a flat deterioration curve (D.F. = 1.0) for the first 50,000 miles and which is not equipped with any add-on emission control system (such as EGR) may be eligible for such a waiver. The Executive Officer will evaluate each request on a case-by-case basis. The manufacturer must submit its request to the Executive Officer to stop testing within ten working days after the last emission test.

If a durability vehicle accumulates less than 100,000 miles the manufacturer shall submit evidence that the engine is capable of meeting the applicable emission standards for 100,000 miles. Such evidence shall include engineering data on piston rings, piston, valves, cylinder head, fuel system ignition system, etc., as applicable.

Any decision to stop mileage accumulation before 100,000 miles does not relieve the manufacturer from its warranty and recall obligations.

For the last 50,000 miles, the Executive Officer may, upon the request of the manufacturer, allow driving schedules different from the standard AMA driving cycle for accelerated mileage accumulation and a reduced test frequency. The evaluation of alternate test programs will be based on the type of emission control system involved and the characteristic of the cumulative emission control system deterioration.

3. Scheduled Maintenance

A vehicle manufacturer who initially intends to certify a vehicle to the 50,000 mile procedure may not change to the 100,000 mile option after mileage accumulation unless the manufacturer starts initial mileage accumulation using, for each maintenance item, the most stringent maintenance schedule of either the 100,000 mile option or the 50,000 mile certification requirements.

4. Unscheduled Maintenance

The Executive Officer will follow the provisions of section 5.a of these procedures, in evaluating any manufacturer's request for unscheduled maintenance. Manufacturers shall obtain the Executive Officer's approval before performing any unscheduled emission control component/system maintenance. In all cases, the degree of system degradation must not be improved by any inspection or repairs. Emission tests must be performed before and after all unscheduled maintenance and be used in the DF calculation.[5]

5. Evaporative Compliance Criteria

If a manufacturer conducts evaporative emission testing (gasoline- and methanol-fueled vehicles only) in conjunction with exhaust durability testing, the vehicle manufacturer is required to show compliance with the evaporative emission standard for 50,000 miles. If the manufacturer wishes to conduct testing beyond 50,000 miles, all data must be submitted to the Executive Officer. The Executive Officer will not use any evaporative emission standard. However, the manufacturer must warrant the evaporative emission control system for 10 years or 100,000 miles.

b. Specific Guidelines for Compliance

Each exhaust emission durability data vehicle shall be driven, with all emission control systems installed and operating, for 100,000 miles or such lesser distance as the Executive Officer may agree to as meeting the objectives of this procedure. Emission tests performed on emission-data vehicles and durability-data vehicles (for determination of the deterioration factors) shall be non-regeneration emission tests for diesel passenger cars, light-duty trucks and medium-duty vehicles equipped with periodically regenerating trap oxidizer systems. Compliance with the emission standards shall be established as follows:

1. The linear regression line for all pollutants shall be established by use of all required data from tests of the durability vehicle at every 5,000 mile interval from 5,000 to 100,000 miles. The requirements in subparagraph 86.088-28(a)(4)(i)(B), ~~and~~ 86.090-28(a)(4)(i)(B), and 86.091-28(a)(4)(i)(B) (durability vehicles must meet emissions standards) refer, for each pollutant, to the California 100,000 mile emission standards.

2. Compliance with the hydrocarbon and carbon monoxide standards shall be determined as follows:

   i. For Option 1:

      A. The interpolated 4,000 and 50,000 mile points on the linear regression line in section b.1. shall not exceed the appropriate hydrocarbon and carbon monoxide standards, except as in B. below.

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5. Testing before unscheduled maintenance may be omitted with the prior consent of the Executive Officer when testing would be dangerous to a vehicle or an operator.

B. The linear regression line in section b.1. may exceed the standard provided that no data point exceeds the standard.

C. The hydrocarbon and carbon monoxide data from the 4,000 mile test point of the emission data vehicle shall be multiplied by the deterioration factor computed by dividing the interpolated 50,000 mile point by the interpolated 4,000 mile point, and the appropriate exhaust emission correction factor (diesel passenger cars, light-duty trucks, and medium-duty vehicles equipped with periodically regenerating trap oxidizer systems only). These values shall not exceed the appropriate hydrocarbon and carbon monoxide standards.

ii. For Option 2:

A. The interpolated 4,000 and 100,000 mile points on the linear regression line in section b.1. shall not exceed the appropriate hydrocarbon and carbon monoxide standards, except as in B. below.

B. The linear regression line in section b.1. may exceed the standard provided that no data point exceeds the standard.

C. The hydrocarbon and carbon monoxide data from the 4,000 mile test point of the emission data vehicle shall be multiplied by the deterioration factor computed by dividing the interpolated 100,000 mile point by the interpolated 4,000 mile point, and the appropriate exhaust emission correction factor (diesel passenger cars, light-duty trucks, and medium-duty vehicles equipped with periodically regenerating trap oxidizer systems only). These values shall not exceed the appropriate 100,000 mile hydrocarbon and carbon monoxide standards.

3. Compliance with the oxides of nitrogen standard for Options 1 and 2 shall be determined as follows:

i. the interpolated 4,000 and 100,000 mile points on the linear regression line in section b.1. shall not exceed the appropriate 100,000 mile oxides of nitrogen standard, except as in ii. below.

ii. the linear regression line in section b.1. may exceed the standard provided that no data point exceeds the standard.

iii. the oxides of nitrogen data from the 4,000 mile test point of the emission data vehicle shall be multiplied by the deterioration factor computed by dividing the interpolated 100,000 mile point by the interpolated 4,000 mile point, and the appropriate exhaust emission correction factor (diesel passenger cars, light-duty trucks, and medium-duty vehicles equipped with periodically regenerating trap oxidizer systems only). These values shall not exceed the appropriate 100,000 mile oxides of nitrogen standard.

4. Compliance with the particulate standard for options 1 and 2 shall be determined as follows:

   i. the interpolated 4,000 and 50,000 mile points on the linear regression line in section b.1. shall not exceed the appropriate particulate, except as in ii. below.

   ii. the linear regression line in section b.1. may exceed the standard provided that no data point exceeds the standard.

   iii. the particulate data from the 4,000 mile test point of the emission data vehicle shall be multiplied by the deterioration factor computed by dividing the interpolated 50,000 mile point by the interpolated 4,000 mile point, and the appropriate exhaust emission correction factor (diesel passenger cars, light-duty trucks, and medium-duty vehicles equipped with periodically regenerating trap oxidizer systems only). These values shall not exceed the appropriate particulate standard.

5. All references in these test procedures to "useful life", 5 years, and 50,000 miles shall mean "total life", 10 years, and 100,000 miles, respectively, except in section 10.b.2.

c. Maintenance

Only the following scheduled maintenance shall be allowed under subparagraph 86.085-25 (a)(1)(i).

1. 25(a)(1)(i) Option 1. For 1988 model otto-cycle or diesel vehicles, and 1989 and later model otto-cycle or diesel light-duty trucks and medium-duty vehicles 3751 L.V.W. and greater, and 1993 and subsequent diesel light-duty trucks and medium-duty vehicles 3751 L.V.W. and greater, maintenance shall be restricted to the inspection, replacement, cleaning, adjustment, and/or service of the following items at intervals no more frequent that indicated.

   (1) Drive bent tension on engine accessories (30,000 miles).
   (2) Valve lash (15,000 miles).
   (3) Spark plugs (30,000 miles).
   (4) Air filter (30,000 miles).
   (5) Exhaust gas sensor (30,000 miles): Provided that:

      (a) the manufacturer shall equip the vehicle with a maintenance indicator consisting of a light or flag, which shall be preset to activate automatically by illuminating in the case of a light or by covering the odometer in the case of a flag the first time the minimum maintenance interval established during certification testing is reached and which shall remain activated until reset. After resetting, the maintenance indicator shall activate automatically when the minimum maintenance interval, when added to the vehicle mileage at the time of resetting, is again reached and shall again remain activated until reset. When the maintenance indicator consists of a light, it shall also activate automatically in the engine-run key position before engine cranking to indicate that it is functioning. The maintenance indicator shall be located on the instrument panel and shall, when activated, display the words "oxygen sensor" or may display such other words determined by the Executive Officer to be likely to cause the vehicle owner to seek oxygen sensor replacement. The maintenance indicator shall be separate from the malfunction indicator light required by Section 1968, Title 13, California Code of Regulations;

(b) the manufacturer shall provide free replacement of the oxygen sensor, including both parts and labor, and shall reset the maintenance indicator without any charge, the first time the maintenance interval established during certification testing is reached for vehicles certified with scheduled sensor maintenance before 50,000 miles. If the oxygen sensor is replaced pursuant to the warranty provisions of Section 2037, Title 13, California Code of Regulations, before the first maintenance interval is reached, the manufacturer shall also replace the oxygen sensor and reset the maintenance indicator at the oxygen sensor and reset the maintenance indicator at the mileage point determined by adding the maintenance interval to the vehicle's mileage at the time of the warranty replacement. If the calculated mileage point for a second oxygen sensor replacement would exceed 50,000 miles, no free second replacement shall be required;

(c) the maintenance indicator shall be resettable. The maintenance instructions required by paragraph 5.b. of these procedures shall provide instructions for the resetting of the maintenance indicator, and shall specify that the maintenance indicator shall be reset each time the oxygen sensor is replaced; and

(d) notwithstanding the provisions of Section 2037(c), Title 13, California Code of Regulations, the oxygen sensor, including any replacement required pursuant to this section, shall be warranted for the applicable warranty period of the vehicle or engine in accordance with Section 2037(a), Title 13, California Code of Regulations. If such oxygen sensor fails during this period, it shall be replaced by the manufacturer in accordance with Section 2037(d), Title 13, California Code of Regulations.

(6) Choke, cleaning or lubrication only (30,000 miles).
(7) Idle speed (30,000 miles).
(8) Fuel Filter (30,000 miles).
(9) Injection timing (30,000 miles).

Option 2. For 1981-1988 and later model otto-cycle vehicles or 1988 and later diesel vehicles, maintenance shall be restricted to the inspection, replacement, cleaning, adjustment, and/or service of the following items at intervals no more frequent than indicated:

(1) Drive belt tension on engine accessories (30,000 miles).
(2) Valve lash (15,000 miles).
(3) Spark plugs (30,000 miles).
(4) Air filter (30,000 miles).
(5) Fuel Filter (30,000 miles).
(6) Idle speed (30,000 miles).
(7) Injection timing (30,000 miles).

2. In addition, adjustment of the engine idle speed (curb idle and fast idle), valve lash, and engine bolt torque may be performed once during the first 5,000 miles of scheduled driving, provided the manufacturer makes a satisfactory showing that the maintenance will be performed on vehicles in use.

d. The manufacturer shall agree to apply to vehicles certified under this paragraph the provision of Section 43204 of the California Health and Safety Code for a period of ten years or 100,000 miles, whichever first occurs.

11. Additional Requirements

a. In order to qualify for the alternative durability program, in addition to the requirements of paragraph 86.085-13, the algorithm requirements of Appendix III shall be met and only the first 50,000 miles (or 100,000 miles, as applicable) of data or its equivalent shall be used.

b. For otto-cycle vehicles or hybrid electric vehicles which use otto-cycle engines, evidence shall be supplied showing that the air/fuel metering system or secondary air injection system is capable of providing sufficient oxygen to theoretically allow enough oxidation to attain the CO emission standards at barometric pressures equivalent to those expected at altitudes ranging from sea level to 6000 feet elevations.

A vehicle will be deemed in compliance with the above requirement if the manufacturer demonstrates that the tailpipe air/fuel ratio (TAFR) is, at elevations up to 6000 feet, stoichiometric or leaner in each of several driving modes. However, if a vehicle operates in a given driving mode at sea level with a TAFR richer than stoichiometric, then for that particular driving mode the manufacturer is only required to show that the TAFR is, at elevations up to 6000 feet, no richer than the TAFR at sea level. The driving modes selected for testing shall be representative of the full range of normal driving conditions, and shall include the following three steady-state modes: idle, 30 mph road load cruise, 50 mph road load cruise. Assuming the use of dry air and indolene fuel (hydrogen to carbon atom ratio of 1.85), a TAFR of 14.6 shall be considered a stoichiometric ratio.

The vehicle manufacturer may correct this value for different fuels and/or humidity, subject to approval by the Executive Officer.

For fuel injected vehicles or hybrid electric vehicles which use fuel-injected engines, compliance may be demonstrated upon a showing by the manufacturer that the fuel injection system distributes fuel based on air mass flow, rather than volume flow, and is therefore self-compensating. All submitted test proposals will be evaluated on their acceptability by the Executive Officer.

As an alternative to the demonstration described above, a manufacturer may demonstrate compliance by testing California vehicle configurations as part of its federal high altitude certification requirements. Engine families which meet all the applicable California low altitude emission standards when tested at the EPA test elevation are deemed to be in compliance.

Exemptions to the high altitude provisions as allowed by the federal government in 86.087-8, 86.088-8, 86.088-9, 86.090-8, and 86.090-9, and 86.091-9 shall not be approved.

c. The exhaust emissions shall be measured from all exhaust emission data vehicles tested in accordance with the federal Highway Fuel Economy Test (HWFET; 40 CFR Part 600, Subpart B). The oxides of nitrogen emissions measured during such tests shall be multiplied by the oxides of nitrogen deterioration factor computed in accordance with paragraph 86.088-28, and 86.090-28, and 86.091-28, and then rounded and compared with the standard as set forth in section 3 preceding. All data obtained pursuant to this paragraph shall be reported in accordance with procedures applicable to other exhaust emissions data required pursuant to these procedures.

In the event that one or more of the manufacturer's emission data vehicles fail the HWFET standard listed in section 3, the manufacturer may submit to the Executive Officer engineering data or other evidence showing that the system is capable of complying with the standard. If the Executive Officer finds, on the basis of an engineering evaluation, that the system can comply with the HWFET standard, he or she may accept the information supplied by the manufacturer in lieu of vehicle test data.

d. Labeling required pursuant to paragraph 86.088-35, and 86.090-35, and 86.091-35 and Section 1965, Chapter 3, Title 13 of the California Code of Regulations shall conform with the requirements specified in the "California Motor Vehicle Emission Control Label Specifications."

e. The manufacturer shall submit to the Executive Officer a statement that those vehicles for which certification is requested have driveability and performance characteristics which satisfy that manufacturer's customary driveability and performance requirements for vehicles sold in the United States. This statement shall be based on driveability data and other evidence showing compliance with the manufacturer's performance criteria. This statement shall be supplied with the manufacturer's final application for certification, and with all running changes for which emission testing is required.

If the Executive Officer has evidence to show that in-use vehicles demonstrate poor performance that could result in wide-spread tampering with the emission control systems, he or she may request all driveability data and other evidence used by the manufacturer to justify the performance statement.

f. For all vehicles subject to the provisions of Section 1968, Title 13, California Code of Regulations, the manufacturer shall submit with its application for certification a description of the malfunction and diagnostic system to be installed on the vehicles. (The vehicles shall not be certified unless the Executive Officer finds that the malfunction and diagnostic system complies with the requirements of Section 1968).

g. The provisions of the incorporated federal test procedures which allow manufacturers to omit methanol and formaldehyde emission testing of 1990 through 1994 methanol-fueled vehicles shall not be applicable in California.

h. The emission testing required under 6.a.2.(D) (Fuel-flexible vehicle special emission testing) shall be made part of the regular certification program and submitted to the Executive Officer for review. Certification shall be denied unless the exhaust emission values resulting from testing with 35-percent methanol and 65-percent unleaded gasoline at the required mileage intervals, and with unleaded gasoline at 5,000 miles, 50,000 miles and the final mileage point, comply with the applicable standards.

i. Certification, if granted, is effective only for the vehicle/engine family described in the original manufacturer's certification application. Modifications by a secondary manufacturer to vehicles/engines shall be deemed not to increase emissions above the standards under which those vehicles/engines were certified and to be within the original certification if such modifications do not: (1) increase vehicle weight more than 10 percent above the curb weight, increase frontal area more than 10 percent, or result in a combination increase of weight plus frontal area of more than 14 percent; or (2) include changes in axle ratio, tire size, or tire type resulting in changes in the drive train ratio of more than 5 percent; or (3) include any modification to the emission control system. No originally certified vehicle/engine which is modified by a secondary manufacturer in a manner described in items (1) through (3) of the preceding sentence may be sold to an ultimate purchaser, offered or delivered for sale to an ultimate purchaser, or registered in California unless the modified vehicle/engine is certified by the state board in accordance with applicable test procedures to meet emission standards for the model year for which the vehicle/engine was originally certified.

For the purposes of this subsection, "secondary manufacturer" means any person, other than the original manufacturer, who modifies a new motor vehicle prior to sale to the ultimate purchaser.

j. A statement must be supplied that the production vehicles shall be in all material respects the same as those for which certification is granted.

k. Following a 12 to 36 hour cold soak at 45 to 55 F, emissions of NMOG (multiplied by the reactivity adjustment factor for fuels other than conventional gasoline), CO, NOx, and formaldehyde measured on the Federal Test Procedure (40 CFR Part 86), conducted at a test temperature of 45 to 55 F, shall not exceed the above standards for vehicles of the same emission category and vehicle type subject to a cold soak and emission test at 68 to 86 F. For diesel vehicles, compliance with the particulate standard applicable to the corresponding vehicle emission category and vehicle type must also be demonstrated. Manufacturers shall demonstrate compliance with this requirement each year by testing at least three PC or LDT and three MDV emission data and/or engineering development vehicles (with at least 4000 miles) which are representative of the array of technologies available in that model-year. It is not necessary to apply deterioration factors (DFs) to the 50 F test results to comply with this requirement.
The following schedule outlines the parameters to be considered for vehicle selection:
1. Fuel control system (e.g., multiport fuel injection, throttle body electronic fuel injection, sequential multiport electronic fuel injection, etc.)
2. Catalyst system (e.g., electrically heated catalyst, close-coupled catalyst, underfloor catalyst, etc.)
3. Control system type (e.g., mass-air flow, speed density, etc.)
4. Vehicle category (e.g., TLEV, LEV, ULEV)
5. Fuel type (e.g., gasoline, methanol, CNG, etc.)

The same engine family shall not be selected in the succeeding two years unless the manufacturer produces fewer than three engine families.

l. For each engine family, manufacturers shall submit with the certification application, an engineering evaluation demonstrating that a discontinuity in emissions of non-methane organic gases, carbon monoxide, oxides of nitrogen and formaldehyde measured on the Federal Test Procedure (40 CFR Part 86) does not occur in the temperature range of 20 to 86 degrees F. For diesel vehicles, compliance with the applicable particulate standard shall also be demonstrated.

12. Identification of New Clean Fuels to be Used in Certification Testing.

Any person may petition the state board to establish by regulation certification testing specifications for a new clean fuel for which specifications are not specifically set forth in paragraph 86.113-90 as amended herein. Prior to adopting such specifications, the state board shall consider the relative cost-effectiveness of use of the fuel in reducing emissions compared to the use of other fuels. Whenever the state board adopts specifications for a new clean fuel for certification testing, it shall also establish by regulation specifications for the fuel as it is sold commercially to the public.

(a) If the proposed new clean fuel may be used to fuel existing motor vehicles other than low-emission vehicles certified on the primary designated clean fuel, the state board shall not establish certification specifications for the fuel unless the petitioner has demonstrated that:

(1) Use of the new clean fuel in such existing motor vehicles would not increase emissions of NMOG (on a reactivity-adjusted basis), NOx, CO, benzene, 1,3-butadiene, formaldehyde, acetadehyde, and diesel particulate, as determined pursuant to the procedures set forth in "California Test Procedures for Evaluating the Emission Impacts of Substitute Fuels or New Clean Fuels." In the case of fuel-flexible vehicles or dual-fuel vehicles which were not certified on the new clean fuel but are capable of being operated on it, emissions during operation with the new clean fuel shall not increase emissions during vehicle operation on gasoline, and

(2) Use of the new clean fuel in such existing motor vehicles would not result in increased deterioration of the vehicle and would not void the warranties of any such vehicles.

(b) Whenever the state board designates a new clean fuel pursuant to this section, the state board shall also establish by regulation required specifications for the new clean fuel.

APPENDIX I

List of Sections of Subparts A and B, Part 86, Title 40, Code of Federal Regulations, Incorporated by Reference

This Appendix sets forth the sections of Subparts A and B, Part 86, Title 40, Code of Federal Regulations, as adopted or amended or proposed by the U.S. Environmental Protection Agency (EPA) on the date listed for each section, which are incorporated by reference in "California Exhaust Emission Standards and Test Procedures for 1988 and Subsequent Model Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles.

All of the incorporated federal provisions were in effect or proposed as of April 11, 1989. ~~Seven additional sections applicable to 1991 and subsequent model vehicles are not included: Sections 86.91-2, 86.91-21, 86.91-23, 86.91-28, 86.91-29, 86.91-30, and 86.91-35. However, the terms of these sections as they pertain to passenger cars, light-duty trucks, and medium-duty vehicles are identical to the corresponding incorporated federal sections applicable commencing with 1988 model year vehicles: Sections 86.88-2, 86.88-21, 86.88-23, 86.88-28, 86.88-29, 86.88-30, and 86.88-35.~~

Subpart A - General Provisions for Emission Regulations for 1977 and Later Model Year New Light-Duty Vehicles, ~~1977 and Later Model Year~~ New Light-Duty Trucks, and Heavy-Duty Engines, and for 1985 and Later Model Year New Gasoline-Fueled and Methanol-Fueled Heavy-Duty Vehicles.

86.085-1	General applicability. July 7, 1986.
~~86.088-1~~	~~General applicability. August 29, 1986.~~
86.082-2	Definition. November 2, 1982.
86.084-2	Definition. December 10, 1984.
86.085-2	Definition. November 26, 1983.
86.088-2	Definition. August 29, 1986.
86.078-3	Abbreviations. January 21, 1980.
~~86.088-3~~	~~Abbreviations. August 29, 1986.~~
86.084-4	Section numbering; construction. September 25, 1980.
86.084-5	General standards; increase in emissions; unsafe conditions. November 3, 1982.
86.078-7	Maintenance of records; submitted information; right of entry. November 2, 1982.
86.087-8	Emission standards for 1987 light-duty vehicles. January 24, 1984.
~~86.088-8~~	~~Emission standards for 1987 light-duty vehicles. August 29, 1986.~~
86.090-8	Emission standards for 1990 and later model year light-duty vehicles. April 11, 1989.
86.088-9	Emission standards for 1987 model light-duty trucks. August 29, 1986.
86.090-9	Emission standards for 1990 and later model year light-duty trucks. April 11, 1989.
86.091-9	Emission standards for 1991 and later model year light-duty trucks. April 11, 1989.
86.080-12	Alternative certification procedures. April 17, 1980.
86.085-13	Alternative durability program. May 19, 1983.
86.084-14	Small-volume manufacturers certification procedures. January 31, 1985.

~~86.088-14 Small-volume manufacturer certification procedures. August 29, 1986.~~
86.090-14 Small-volume manufacturer certification procedures. April 11, 1986.
86.085-20 Incomplete vehicles. January 12, 1983.
86.088-21 Application for certification. March 15, 1985.
86.090-21 Application for certification. April 11, 1989.
86.091-21 Application for certification. April 11, 1989.
86.085-22 Approval of application for certification; test fleet selection, etc. July 7, 1986.
~~86.088-22 Approval of application for certification; test fleet selection, etc. August 29, 1986.~~
86.088-23 Required data. August 29, 1986.
86.091-23 Required data. April 11, 1989.
86.085-24 Test vehicles and engines. January 31, 1985.
~~86.088-24 Test vehicles and engines. August 29, 1986.~~
86.090-24 Test vehicles and engines. April 11, 1989.
86.085-25 Maintenance. July 7, 1986.
86.088-25 Maintenance. July 7, 1986.
86.090-25 Maintenance. April 11, 1989.
86.084-26 Mileage and service accumulation; emission measurements. July 7, 1986.
~~86.088-26 Mileage and service accumulation; emission measurements. August 29, 1986.~~
86.090-26 Mileage and service accumulation; emission requirements. April 11, 1989.
86.085-27 Special test procedures. January 12, 1983.
~~86.088-27 Special test procedures. August 29, 1986.~~
~~86.088-28 Compliance with emission standards. August 29, 1986.~~
86.090-28 Compliance with emission standards. April 11, 1989.
86.091-28 Compliance with emission standards. April 11, 1989.
86.088-29 Testing by the Administrator. August 29, 1986.
86.088-30 Certification. August 29, 1986.
86.079-31 Separate certification. September 8, 1984.
86.079-32 Addition of a vehicle or engine after certification. September 8, 1977.
86.079-33 Changes to a vehicles or engine covered by certification. September 8, 1977.
86.082-34 Alternative procedures for notification of addition and changes. November 2, 1982.
86.088-35 Labeling. August 29, 1986.
86.090-35 Labeling. April 11, 1989.
86.091-35 Labeling. April 11, 1989.
86.079-36 Submission of vehicle identification numbers. November 14, 1978.
86.085-37 Production vehicles and engines. January 12, 1983.
86.085-38 Maintenance instructions. November 16, 1983.
86.087-38 Maintenance instructions. July 7, 1986.
86.079-39 Submission of maintenance instructions. September 8, 1977.
86.084-40 Automatic expiration of reporting and record keeping requirements. September 25, 1980.

Subpart B-Emission Regulations for 1977 and Later Model Year New Light-Duty Vehicles and New Light-Duty Trucks; Test Procedures.

86.101 General applicability. June 28, 1977.
86.102 Definitions. March 5, 1980.

86.103 Abbreviations. March 5, 1980.
86.104 Section numbering, construction. August 29, 1986.
86.105 Introduction; structure of subpart. August 29, 1986.
86.106-82 Equipment required. March 5, 1980.
~~86.106~~-88 ~~Equipment required; overview. August 29, 1986.~~
86.107-78 Sampling and analytical system, evaporative emissions. June 28, 1977.
~~86.107~~-88 ~~Sampling and analytical system, evaporative emissions. August 29, 1986.~~
86.108-79 Dynamometer. September 12, 1977.
86.109-82 Exhaust gas sampling system; gasoline-fueled vehicles. March 5, 1980.
~~86.109~~-88 ~~Exhaust gas sampling system; gasoline-fueled and throttled methanol-fueled vehicles. August 29, 1986.~~
86.110-82 Exhaust gas sampling system; diesel vehicles. October 13, 1981.
~~86.110~~-88 ~~Exhaust gas sampling system; diesel-fueled and non-throttled methanol-fueled vehicles. August 29, 1986.~~
86.111-82 Exhaust gas analytical-system. March 5, 1980.
~~86.111~~-88 ~~Exhaust gas analytical-system. August 29, 1986.~~
86.112-82 Weighing chamber (or room) and microgram balance specifications. March 5, 1980.
~~86.113~~-87 ~~Fuel Specification. July 7, 1986.~~
~~86.113~~-88 ~~Fuel Specification. August 29, 1986.~~
86.113-90 Fuel Specification. April 11, 1989.
86.114-79 Analytical gases. November 14, 1978.
86.115-78 EPA urban dynamometer driving schedules. June 28, 1977.
86.116-82 Calibrations, frequency and overview. March 5, 1980.
~~86.116~~-88 ~~Calibrations, frequency and overview. August 29, 1986~~
86.117-78 Evaporative emission enclosure calibrations. June 28, 1977.
~~86.117~~-88 ~~Evaporative emission enclosure calibrations. August 29, 1986.~~
86.118-78 Dynamometer calibration. June 28, 1977.
86.119-78 CVS calibration. June 28, 1977.
~~86.119~~-88 ~~CVS calibration. August 29, 1986.~~
86.120-82 Gas meter or flow instrumentation calibration, particulate measurement. March 5, 1980.
86.121-82 Hydrocarbon analyzer calibration. March 5, 1980.
~~86.121~~-88 ~~Hydrocarbon analyzer calibration. August 29, 1986.~~
86.122-78 Carbon monoxide analyzer calibration. June 28, 1977.
86.123-78 Oxides of nitrogen analyzer calibration. September 12, 1977.
86.124-78 Carbon dioxide analyzer calibration. June 28, 1977.
86.126-78 Calibration of other equipment. June 28, 1977.
~~86.126~~-88 ~~Calibration of other equipment. August 29, 1986.~~
86.127-82 Test procedures; overview. March 5, 1980.
~~86.127~~-88 ~~Test procedures; overview. August 29, 1986.~~
86.128-79 Transmission. November 14, 1978.
86.129-80 Road load power test weight and inertia weight class determination. November 14, 1978.
86.130-78 Test sequence; general requirements. November 14, 1978.
86.131-78 Vehicle preparation. June 28, 1977.
~~86.131~~-88 ~~Vehicle preparation. August 29, 1986.~~
86.132-82 Vehicle preconditioning. March 5, 1980.
~~86.132~~-88 ~~Vehicle preconditioning. August 29, 1986.~~
86.132-90 Vehicle preconditioning. April 11, 1989.
86.133-78 Diurnal breathing loss test. November 16, 1983.
~~86.133~~-88 ~~Diurnal breathing loss test. August 29, 1986.~~
86.134-78 Running loss test. December 10, 1984.

86.135-82 Dynamometer procedure. December 10, 1984.
~~86.135-88 Dynamometer procedure. August 29, 1986.~~
86.135-90 Dynamometer procedure. April 11, 1989.
86.136-82 Engine starting and restarting. March 5, 1980.
~~86.136-88 Engine starting and restarting. August 29, 1986.~~
86.137-82 Dynamometer test run, gaseous and particulate emissions. March 5, 1980.
~~86.137-88 Dynamometer test run, gaseous and particulate emissions. August 29, 1986.~~
86.137-90 Dynamometer test run, gaseous and particulate emissions. April 11, 1989.
86.138-78 Hot soak test. June 28, 1977.
~~86.138-88 Hot soak test. August 29, 1986.~~
86.139-82 Diesel particulate filter handling and weighing. March 5, 1980.
~~86.139-88 Diesel particulate filter handling and weighing. August 29, 1986.~~
86.140-82 Exhaust sample analysis. March 5, 1980.
~~86.140-88 Exhaust sample analysis. August 29, 1986.~~
86.142-82 Records required. March 5, 1980.
~~86.142-88 Records required. August 29, 1986~~
86.142-90 Records required. April 11, 1989.
86.143-78 Calculations; evaporative emissions. March 15, 1985.
~~86.143-88 Calculations; evaporative emissions. August 29, 1986.~~
86.144-78 Calculations; exhaust emissions. December 10, 1984.
~~86.144-88 Calculations; exhaust emissions. August 29, 1986.~~
86.145-82 Calculations; particulate emissions. October 13, 1981.

APPENDIX II

Exhaust Emission-Data Vehicle Selection Criteria For Passenger Cars, Light-Duty Trucks and Medium-Duty Vehicles

I. Selection of Exhaust Emission-Data Vehicles (see flow diagram on page II-4)

A. Item 1 of the attached emission-data vehicle selection worksheet (page II-5) shall be prepared with the highest projected sales engine displacement-system combination first and the remainder in order of decreasing projected sales volume.

B. For engine families with a single engine displacement-exhaust emission control system combination representing 70 percent or more of the projected sales.

1. The first vehicle selection will be determined as follows:

a. The engine displacement-exhaust emission control system combination shall be the one with the highest projected sales. (Item 1, on worksheet.)

b. Using the data entered in Item 2 of the worksheet and the formula shown below, the equivalent test weight of the vehicle is determined from the calculated sales weighted equivalent test weight for that engine displacement-exhaust emission control system combination.

Sales Weighted Test Weight

Determine the sales weighted test weight as follows:

T_i = Test weight of i'th class

S_i = Sales volume of i'th class

N = Number of test weight classes

SWTW = Sales Weighted Test Weight

$$SWTW = \frac{\sum_{i=1}^{N} S_i T_i}{\sum_{i=1}^{N} S_i}$$

Select the equivalent test weight that includes the calculated SWTW. If the SWTW is exactly between two equivalent test weights, select the higher equivalent test weight. Similarly, if there are no vehicles with the desired displacement-exhaust emission control system combination in the same equivalent test weight that includes the calculated SWTW, the next higher equivalent test weight that contains such a vehicle will be specified.

c. The transmission will be the class with the highest sales for the engine displacement-exhaust emission control system combination (Item 3, worksheet). If the highest sales transmission class is not available in the equivalent test weight determined in (b), above, the next higher equivalent test weight with the highest sales transmission class will be selected. If manual transmissions are the highest selling class, the transmission configuration with the highest sales should generally be selected (Item 4, worksheet). If the manufacturer wishes to test a vehicle with an M-4 transmission both as an M-4 vehicle and an M-3 vehicle, use of the vehicle with an M-4 transmission will be allowed provided the first three gear ratios are identical in both transmissions. Similarly, use of an M-5 will be allowed to represent both an M-5 vehicle and an M-4 vehicle, providing the first four gear ratios are identical in both transmissions.

d. The highest selling engine code within the engine displacement-exhaust emission control system-equivalent test weight-transmission class combination will be specified (Item 5, worksheet).

e. The highest selling body style within the engine displacement-exhaust emission control system-equivalent test weight-transmission class-engine code combination will be specified (Item 6, worksheet.)

f. The N/V ratio will be the standard ratio (standard tire and axle ratio combination) for the vehicle selected (Item 7, worksheet).

g. Standard or optional equipment that can reasonably be expected to influence emissions (Item 8, worksheet) and is expected to be installed on more than 33 percent of the vehicles in the car line within the engine-system combination shall be specified (and the full estimated weight of those items should be included in the curb weight computation) unless an item is not available on the particular vehicle specified. Other standard or optional equipment expected to be installed on more than 33 percent of the vehicles in the car line within the engine-system combination shall have their full estimated weight included in the curb weight computation and be included in the specified vehicle's weight. Overdrive units are considered transmission configurations and not items of optional equipment. The weight of an overdrive unit should be included in the curb weight computation of vehicles with such units. (In other words, the weight of overdrive units should not be disregarded when car line sales of such items are 33 percent or less.)

2. The second vehicle will be determined as follows.

a. The transmission class, from Item 3 of worksheet, with the second highest sales will be specified if this transmission class has projected sales of more than 30 percent of the engine displacement-exhaust emission control system combination. The equivalent test weight, engine code body style, N/V ratio, and optional equipment specified for the second vehicle are determined by criteria in Section 1.

b. If the second transmission class does not meet the criteria of 2.a. above, the second vehicle will be the worst case vehicle selected from the family.

c. For engine families with multiple displacement-emission control system combinations, the first vehicle selection will be highest sales combination, and the second vehicle selection will be second highest sales combination. Other vehicle configuration details will be as in Section B.1.b. through B.1.g.

d. An exception to the two maximum emission-data vehicles may occur for engine families with vehicles in multiple standard classifications, i.e., loaded vehicle weight classifications for light-duty trucks and/or medium-duty vehicles. The first vehicle selection will be determined as above in B.1. in the highest sales loaded vehicle weight classification, and the subsequent vehicle selection(s) will be a worst case vehicle(s) in the other loaded vehicle weight classification(s).

Emission-Data Vehicle Selection Worksheet

Manufacturer ______________________ Date __________

Engine Family ______________________

1. Engine Displacement / Emission Control System / Unit / Percent / Cummulative%

Engine Displacement	Emission Control System	Unit	Percent	Cummulative%
a)				
b)				
c)				
d)				

2. Sales Weighted Test Weight

Total projected sales______________________

Test Weight - lb.	Sales Volume
a)	
b)	
c)	
d)	

Calculated SWTW______________lbs. Equivalent Test Weight______lbs.

3. Transmission Selection

Class	Sales Volumes	Percentage Sales	High Sales
a)			
b)			

4. Transmission Configuration

Configuration	Sales Volumes	High Sales
a)		
b)		
c)		

5. Engine Code (within 1, 2, 3, and 4 above)	Sales Volumes	High Sales
a)______	______	______
b)______	______	______
c)______	______	______
d)______	______	______

6. Body Style (within 1, 2, 3, 4, and 5 above)	Sales Volumes	High Sales
a)______	______	______
b)______	______	______
c)______	______	______
d)______	______	______
e)______	______	______
f)______	______	______

7. STD Axle______ STD N/V______.

8. Options over 33 percent

9. Second and Subsequent Selections Vehicles

a) High Sales Engine Displacement-Exhaust Emission Control System______

b) Second-Highest Selling Transmission Class______

Designated Second and Subsequent Selections Vehicles

Disp.	Eng. Code	Evap. Code	Model	Trans.	ETW	Axle	N/V

APPENDIX III

Determination of Acceptable Durability Test Schedule*

A manufacturer may determine mileage test intervals for durability-data vehicles subject to the conditions specified in 40 CFR 86.084-26 or 86.088-26. The following procedure shall be used to determine if the schedule is acceptable to the Executive Officer.

1. Select exhaust system mileage test points and maintenance mileage test points for proposed (prop) schedule.

2. Calculate the sums of the squares corrected to the mean of the system mileages at the proposed test points:

$$A_{prop} = [\Sigma(X_p)^2 - (\Sigma X_p)^2/N_p]_{prop}$$

   Where:

   X = Individual mileages at which the vehicle will be tested.

   N = Total number of tests (including before and after maintenance tests).

   (Subscript "p" refers to proposed test schedule).

3. Determine exhaust system mileage test points and maintenance mileage test points based on testing at five thousand mile intervals from 5,000 miles through the final testing point and maintenance mileage test points selected for the proposed schedule in section 1. This schedule will be designated as the standard (std) test schedule.

4. Calculate the sums of squares corrected to the mean of the standard schedule.

$$B_{std} = [\Sigma(X_s)^2 - (\Sigma X_s)^2/N_s]_{std}$$

* For diesel vehicles equipped with periodically regenerating trap oxidizer systems (or those with continuously regenerating trap oxidizer systems elected to be certified to the provisions of diesel vehicles with periodically regenerating trap oxidizer systems), additional test schedule requirements for regeneration tests must be met as outlined in subparagraphs 6.a.2. and 6.b.3. in these procedures.

Where:

X = Individual mileages at which the vehicle will be tested.

N = Total number of tests (including before and after maintenance).

(Subscript "s" refers to standard test schedule).

5. Refer to Table I and determine t_p at $(N_p-2)_{prop}$ degrees of freedom and t_s at $(N_s-2)_{std}$.

If $$\sqrt{A_{prop}} \geq \frac{t_p}{t_s} \times \sqrt{B_{std}}$$

the proposed plan is acceptable.

Table I

Degrees of freedom N-2	t
1	6.314
2	2.920
3	2.353
4	2.132
5	2.015
6	1.943
7	1.895
8	1.860
9	1.833
10	1.812
11	1.796
12	1.782
13	1.771
14	1.761
15	1.753
16	1.746
17	1.740
18	1.734
19	1.729
20	1.725
21	1.721
22	1.717
23	1.714
24	1.711
25	1.708

APPENDIX IV

Procedure for Determining An Acceptable Exhaust Regeneration Durability-Data Test Schedule for Diesel Cycle Vehicles, Equipped with Periodically Regenerating Traps Oxidizer Systems.

1. Select exhaust system mileage test points for proposed (prop) schedule.

2. Calculate the sums of the squares corrected to the mean of the system mileages at the proposed test points:

$$A_{prop} = [\Sigma(X_p)^2 - (\Sigma X_p)^2/N_p]_{p\,prop}$$

Where:

X = Individual mileages at which the vehicle will be tested.

N = Total number of tests (including before and after maintenance tests).

(Subscript "p" refers to proposed test schedule).

3. The exhaust system mileage tests points at 5,000, 20,000, 35,000 and 50,000 miles will be designated as the standard (std) test schedule.

4. Calculate the sums of square corrected to the mean of the standard tests schedule.

$$B_{std} = [\Sigma(X_s)^2 - (\Sigma X_s)^2/N_s]_{s\,std}$$

Where:

X = Individual mileages at which the vehicle will be tested.

N = Total number of regeneration emission tests.

(Subscript "s" refers to standard test schedule)

5. Refer to Table I and determine t_p at $(N_p-2)_{prop}$ degrees of freedom and t_s at $(N_s-2)_{std}$ degrees of freedom.

If $$A_{prop} \geq \frac{t_p}{t_s} \times B_{std}$$

the proposed plan is acceptable.

Table I

Degrees of freedom N-2	t
1	6.314
2	2.920
3	2.353
4	2.132
5	2.015
6	1.943
7	1.895
8	1.860
9	1.833
10	1.812
11	1.796
12	1.782
13	1.771
14	1.761
15	1.753

APPENDIX V

Pollutant Mass Emissions Calculation Procedure for Gaseous-Fueled Vehicles and for Vehicles Equipped with Periodically Regenerating Trap Oxidizer Systems *

I. Gaseous-Fueled Vehicle Pollutant Mass Emission Calculation Procedure

These calculation procedures are to be used in lieu of those in subparagraph 86.144-88, Part 86, Title 40, Code of Federal Regulations (CFR) when calculating the mass emissions from vehicles fueled with either liquefied petroleum gas or compressed natural gas. This calculation procedure is based on the "Positive Displacement Pump- Constant Volume Sampler (PDP-CVS)" exhaust sampling system.

The reported test results shall be computed by use of the following formulas:

CO_{conc} = Carbon monoxide concentration of the dilute exhaust sample corrected for background, water vapor, and CO_2 extraction in ppm.

CO_{dm} = Carbon monoxide concentration of the dilution air sample as measured, in ppm.

CO_d = Carbon monoxide concentration of the dilution air corrected for water vapor extraction, in ppm.

CO_e = Carbon monoxide concentrations of the dilute exhaust sample volume corrected for water vapor and carbon dioxide extraction, in ppm. The calculation assumes the carbon to hydrogen ratio of the fuel to be 1:3.802 for natural gas and 1:2.658 for LPG.

CO_{em} = Carbon monoxide concentration of the dilute exhaust sample as measured, in ppm.

CO_{mass} = Carbon monoxide emissions, in grams per test phase.

$CO_{2_{conc}}$ = Carbon dioxide concentration of the dilute exhaust sample corrected for background and water vapor, in percent.

CO_{2_e} = Carbon dioxide concentration of the dilute exhaust sample, in percent.

$CO_{2_{mass}}$ = Carbon dioxide emissions, in grams per test phase.

* These calculation procedures are based on the Federal CVS-1975 Test Procedure.

$Density_{CO}$	=	Density of carbon monoxide is 32.97 g/ft^3 at 68^oF and 760 mm. Hg pressure.
$Density\ CO_2$	=	Density of carbon dioxide is 51.81 g/ft^3 68^oF and 760 mm. Hg pressure.
$Density_{HC}$	=	Density of hydrocarbons is 18.64 g/ft^3 for natural gas and 17.28 g/ft^3 for LPG assuming an average carbon to hydrogen ratio of 1:3.802 for natural gas and 1:2.658 for LPG, at 68^oF and 760 mm Hg pressure.
$Density_{NO_2}$	=	Density of oxides of nitrogen is 54.16 $9/ft^3$ assuming they are in the form of nitrogen dioxide, at 68^oF and 760 mm Hg pressure.
DF	=	Dilution Factor
H	=	Absolute humidity in grains of water per pound of dry air.
HC_{conc}	=	Hydrocarbon concentration for the dilute exhaust sample corrected for background, in ppm carbon equivalent, i.e. equivalent propane X 3.
HC_d	=	Hydrocarbon concentration of the dilution air as measured, in ppm carbon equivalent.
HC_e	=	Hydrocarbon concentration of the dilute exhaust sample, in ppm carbon equivalent.
HC_{mass}	=	Hydrocarbon emissions, in grams per test phase.
K_H	=	Humidity correction factor
N	=	Number of revolutions of the positive displacement pump during the test phase while samples are being collected.
$NO_{x_{conc}}$	=	Oxides of nitrogen concentration of the dilute exhaust sample corrected for background, in ppm.
NO_d	=	Oxides of nitrogen concentration of the dilute air as measured, in ppm.
NO_{x_e}	=	Oxides of nitrogen concentration of the dilute exhaust sample as measured, in ppm.
$NO_{x_{mass}}$	=	Oxides of nitrogen emissions, in grams per test phase.
P_B	=	Barometric pressure, in mm. Hg.
P_d	=	Saturated vapor pressure, in mm. Hg at ambient dry bulb temp.

P_i = Pressure depression below atmospheric measured at the inlet to the positive displacement pump.

T_p = Average temperature of dilute exhaust entering positive displacement pump during test while samples are being collected, in degrees Rankine.

R_a = Relative humidity of the ambient air, in percent.

V_{mix} = Total dilute exhaust volume in cubic feet per test phase corrected to standard conditions ($528^{o}R$ and 760 mm. Hg).

V_o = Volume of gas pumped by the positive displacement pump, in cubic feet per revolution. This volume is dependent on the pressure differential across the positive displacement pump.

Y_{ct} = Mass emissions as calculated from the "transient" phase of the cold start test, in grams per test phase.

Y_{ht} = Mass emissions as calculated from the "transient" phase of the hot start test, in grams per test phase.

Y_s = Mass emissions as calculated from the "stabilized" phase of the cold start test, in grams test phase.

Y_{wm} = Weighted mass emissions of each pollutant, i.e., HC, CO, or NOx, in grams per vehicle mile.

D_{ct} = The measured driving distance from the "transient" phase of the cold start test, in miles.

D_{ht} = The measured distance from the "transient" phase of the hot start test, in miles.

D_s = The measured driving distance from the "stabilized" phase of the cold start test, in miles.

For passenger cars, light duty trucks, and medium duty vehicles:

(a) The mass emissions of each pollutant in grams per mile is

$$Y_{wm} = 0.43\ ((Y_{ct} + Y_s)/(D_{ct} + D_s)) + 0.57\ ((Y_{ht} + Y_s)/(D_h + D_s))$$

(b) The mass of each pollutant for each phase of both the cold start test and the hot start test is determined from the following:

(1) Hydrocarbon mass:

$$HC_{mass} = V_{mix} \times Density_{HC} \times (HC_{conc}/1{,}000{,}000)$$

(2) Oxides of nitrogen mass:

$$NOx_{mass} = V_{mix} \times Density_{NO_2} \times K_H \times (NOx_{conc}/1{,}000{,}000)$$

K_H = humidity correction factor

(3) Carbon monoxide mass:

$$CO_{mass} = V_{mix} \times Density_{CO} \times (CO_{conc}/1{,}000{,}000)$$

(4) Carbon dioxide mass:

$$CO_{2_{mass}} = V_{mix} \times Density_{CO_2} \times (CO_{2_{conc}}/100)$$

$$V_{mix} = \frac{V_o \times N \times (P_b - P_i) \times 528}{(760)(T_p)}$$

$$HC_{conc} = HC_e - HC_d\,(1-1/DF)$$

$$NOx_{conc} = NOx_e - NOx_d\,(1-1/DF)$$

$$CO_{conc} = CO_e - CO_d\,(1-1/DF)$$

$$CO_e = (1-0.02901\,CO_{2_e} - 0.000323\,R_a)\,CO_{em} \text{ for natural gas}$$

$$CO_e = (1-0.02328\,CO_{2_e} - 0.000323\,R_a)\,CO_{em} \text{ for LPG}$$

$$CO_d = (1-0.000323\,R_a)\,CO_{dm}$$

$$K_H = \frac{1}{1-0.0047(H-75)}$$

$$H = \frac{(43.478R\ )(P_d)}{P_B - \dfrac{P_d \times R_a}{1}}$$

$$DF = \frac{9.77}{CO_{2_e} + (HC_e + CO_e) \times 10^{-4}} \quad \text{for natural gas}$$

$$DF = \frac{11.7}{CO_{2_e} + (HC_e + CO_e) \times 10^{-4}} \quad \text{for LPG}$$

II. Pollutant Mass Emissions Calculation Procedure for Vehicles Equipped with Periodically Regenerating Trap Oxidizer Systems

Exhaust Emissions

Amend subparagraph 86.144-88(a) in Part 86, Title 40, Code of Federal Regulations (CFR) to read:

The final reported test results shall be computed by the use of the following formula:

(a) For light-duty vehicles and light-duty trucks:

$$Ywm = 0.43\ ((Yct + Ys)/(Dct + Ds)) + 0.57\ ((Yht + Ys)/(Dht + Ds))$$

For purposes of adjusting emissions for regeneration:

$$Re = ((Yr1 - Yct) + (Yr2 - Ys) + (Yr3 - Yht))/(Dct + Ds + Dht)$$

$$Yr = Ywm^{*} + Re$$

Where:

Ywm = Weighted mass emissions of each pollutant, i.e., HC, CO, NOx or CO_2, in grams per vehicle mile.*

Yct = Mass emissions as calculated from the "transient" phase of the cold start test, in grams per test phase.

Yht = Mass emissions as calculated from the "transient" phase of the hot start test in grams per test phase.

Ys = Mass emissions as calculated from the "stabilized" phase of the cold start test, in grams per test phase.

Dct = The measured driving distance from the "transient" phase of the cold start test, in miles.

Dht = The measured distance from the "transient" phase of the hot start test, in miles.

Ds = The measured driving distance from the "stabilized" phase of the cold start test, in miles.

Yr = Regeneration emission test.

Re = Mass emissions of each pollutant attributable to regeneration in grams per mile.

---

* Ywm is derived using the emission data from a test with no regeneration.

Yr1 = Mass emissions, during a regeneration emission test, as calculated from the "transient" phase of the cold start test, in grams per test phase.

Yr2 = Mass emissions, during a regeneration emission test, as calculated from the "stabilized" phase of the cold start test, in grams per test phase.

Yr3 = Mass emissions, during a regeneration emission test, as calculated from the "transient" phase of the hot start test in grams per test phase.

Particulate Emissions

Amend subparagraph 86.145-82(a) in Part 86, Title 40, Code of Federal Regulations (CFR) to read:

(a) The final reported test results for the mass particulate (Mp) in grams/mile shall be computed as follows.

For purposes of adjusting emissions for regeneration:

$$Mp = 0.43(Mp1 + Mp2)/(Dct + Ds) + 0.57\ (Mp3 + Mp2/(Dht + Ds)$$

$$Re = ((Mpr1 - Mp1) + (Mpr2 - Mp2) + (Mpr3 - Mp3))/(Dct+Ds+Dht)$$

$$Mpr = Mp^* + Re$$

Where:

(1) Mp1 = Mass of particulate determined from the "transient" phase of the cold start test, in grams per test phase. (See 86.110-82(c)(1) and 86.110-88(d)(1) for determination.)

(2) Mp2 = Mass of particulate determined from the "stabilized" phase of the cold start test, in grams per test phase. (See 86.110-82(c)(1) and 86.110-88(d)(1) for determination.)

(3) Mp3 = Mass of particulate determined from the "transient" phase of the hot start test, in grams per test phase. (See 86.110-82(c)(1) and 86.110-88(d)(1) for determination.)

(4) Dct = The measured driving distance from the "transient" phase of the cold start test, in miles.

(5) Ds = The measured driving distance from the "stabilized" phase of the cold start test, in miles.

(6) Dht = The measured driving distance from the "transient" phase of the hot start test, in miles.

(7) Mpr = Regeneration emission test

(8) Re = Mass of particulate attributable to regeneration in grams/mile.

---

* Mp is derived using the emission data from a test with no regeneration.

(9) Mpr1 = Mass of particulate determined, during a regeneration emission test, from the "transient" phase of the cold start test in grams per test phase.
(See 86.110-82(c)(1) and 86.110-88(d)(1) for determination.)

(10) Mpr2 = Mass of particulate determined, during a regeneration emission test, from "stabilized" phase of the cold start test, in grams per test phase.
(See 86.110-82(c)(1) and 86.110-88(d)(1) for determination.)

(11) Mpr3 = Mass of particulate determined, during a regeneration emission test, from the "transient" phase of the hot start test, in grams per test phase.
(See 86.110-82(c)(1) and 86.110-88(d)(1) for determination.)

III. Fuel Economy Calculations for Gaseous Fuels Based on the Cold Start CVS-1975 Federal Test Procedure

Assume the fuel meets HD-5 specifications (95% C_3H_8, 5% nC_4H_{10}, by volume)

1. <u>Physical constants of Propane and Normal Butane</u>

Component	Mol. Wt.	Sp. Gr.	Liquid Density lb/gal @ 60°F				Liquid Density of HD-5 lb/gal at 60°F
C_3H_8	44.094	0.508	4.235	x	(0.95)	=	4.0233
nC_4H_{10}	58.12	0.584	4.868	x	(0.05)	=	.2434
							4.2667

2. <u>Density of the HD-5 fuel</u>

$(0.95 \times 4.235) + (0.05 \times 4.868) = 4.267$ lb/gal @ 60°F

3. <u>Molecular Weights</u>

Species	Mol. Wt.
C	12.01115
H	1.00797
O	15.9994
CO	28.01055
CO_2	44.00995
$*CH_{2.658}$	14.6903

*Average ratio of Hydrogen to carbon atoms in HD-5 fuel.

C_3H_8	$\frac{8}{3}$	= 2.666 x 0.95 (% propane)	=	2.533
nC_4H_{10}	$\frac{10}{4}$	= 2.5 x 0.05 (% Butane)	=	.125
				2.658

4. <u>Weight of Carbon in:</u>

CO = wt. of CO x (12.01115/28.01055) = wt CO x (0.429)

CO_2 = wt. of CO_2 x (12.01115/44.00995) wt CO_2 x (0.273)

$CH_{2.658}$ = wt. of $CH_{2.658}$ x (12.01115/14.6903) = wt $CH_{2.658}$ x (0.818)

5. <u>Wt. of Carbon per gallon of LPG</u>

wt. of carbon = 4.2667 lbs/gal x 453.59 gms/lb x 0.818 = 1583 grams C/gal HD-5

6. Fuel economy:

$$\frac{\text{grams C/gal}}{\text{grams C in exhaust/mi}} = \text{miles/gal.}$$

$$LPG = \frac{1583 \text{ gms C/gal}}{(0.818)(HC) + (0.429)(CO) + (0.273)\ (CO_2)}$$

HC = CVS HC in grams/mile
CO = CVS CO in grams/mile
CO_2 = CVS CO_2 in grams/mile

$$\text{For gasoline} = \frac{2421}{(0.866)\ HC + (0.429)\ CO + (0.273)\ CO_2}$$

$$\text{For Natural Gas} = \frac{1535}{(0.759)\ HC + (0.429)\ CO + (0.273)\ CO_2}$$

APPENDIX VI

Blanket Approval of Running Changes and Field Fixes

Running changes and field fixes meeting the following definitions shall be granted automatic or "blanket" approval by the Executive Officer provided that notification of changes listed in paragraph 1. below are received by the ARB at least five working days before implementation, and notification of changes listed in 2. through 13. below are received by the ARB within two working days after implementation. Such automatic approvals shall be effective when they are a proved by EPA.

For passenger cars, light-duty trucks and medium-duty vehicles:

1. The addition of new models to an engine family where the new models differ from previously certified models only in model name and curb weight (same inertia weight class), and where the exhaust, evaporative and fill pipe emission control system specifications do not change.

2. Changes in axle ratio, tire size or tire type, providing that changes to the N/V ratio and/or load horsepower are within 5% of the originally certified values. This includes re-classification of base and optional axle ratios or tires.

3. The deletion of models or vehicle configurations.

4. Changes in fuel tank capacity of less than 10 percent of the originally certified capacity, providing there is no other modification of the evaporative emission control system.

5. Changes to the fuel filler system leaded fuel nozzle restrictor, where EPA preemption is involved.

6. Advance certification of models in the next higher inertia weight class, for use if needed later.

7. Changes in tailpipe length of less than ten inches.

8. The following changes involving spark plugs:

    a. The addition of resistor-type spark plugs if nonresistor spark plugs are standard, or vice-versa, providing the secondary circuit resistance changes less than 5 percent.

    b. The addition of alternate heat ranges within one range of the originally certified spark plugs.

    c. The change of spark plug gap within 15 percent of originally certified spark plug gap.

9. Changes to component part numbers when there are no changes in the materials used or to the performance specifications (e.g. distributor advance curves, carburetor flow curves, fuel pump supply pressure, etc.). These changes may be the result of parts consolidation, changes in supplier, addition/deletion of peripheral items such as brackets, and minor dimensional changes where the durability and performance are not affected.

10. Changes in the crankcase emission control system where EPA preemption is involved, excluding revisions that could have an interaction effect on exhaust emissions (e.g., PCV purge flow changes).

11. Changes submitted under the alternate or concurrent notification procedure in 40 CFR 86 which would otherwise qualify for automatic or "blanket" status.

12. Changes in the physical location of a vacuum hose connection with no change in the relationship between vacuum, speed, load, or any other vacuum-related parameter, provided that the changes do not render the vacuum hose routing diagram unrepresentative.

13. Changes in exhaust system cross sectional area, if this area equals or exceeds the minimum area in the system.

APPENDIX VII

Calculation of t-Statistic for Deterioration Data Outlier Test

Residual normal deviates to indicate outliers are used routinely and usefully in analyzing regression data, but suffer theoretical deficiencies if statistical significance tests are required. Consequently, the procedure for testing for outliers outlined by Snedecor and Cochran, 6th ed., Statistical Methods, pp. 157-158, will be used. The method will be described generally, then by appropriate formulae, and finally a numerical example will be given.

Linearity is assumed (as in the rest of the deterioration factor calculation procedure), and each contaminant is treated separately. The procedure is as follows:

> Calculate the deterioration factor regression as usual, and determine the largest residual in absolute value. Then recalculate the regression with the suspected outlier omitted. From the new regression line calculate the residual at the deleted point, denoted as $(y_i - y_i')$. Obtain a statistic by dividing $(y_i - y_i')$ by the square root of the estimated variance of $(y_i - y_i')$. Find the tailed probability, p, from the t-distribution corresponding to the quotient (double-tailed), with n-3 degrees of freedom, with n the original sample size.
>
> This probability, p, assumes the suspected outlier is randomly selected, which is not true. Therefore, the outlier will be rejected only if $1-(1-p)^n \leq .05$.
>
> The procedure will be repeated for each contaminant individually until the above procedure indicates no outliers are present.
>
> When an outlier is found, the vehicle test-log will be examined. If an unusual vehicle malfunction is indicated, data for all contaminants at that test-point will be rejected; otherwise, only the identified outlier will be omitted in calculating the deterioration factor.

Procedure for the calculation of the t-Statistic for Deterioration Data Outlier Test.

Given a set of n points, $(x_1, y_1), (x_2, y_2)...(x_n, y_n)$.

where

> x_i is the mileage of the i^{th} data point.
> y_i is the emission of the i^{th} data point.

Assume model:

$$y = \alpha + \beta(x - \bar{x}) + \epsilon$$

I.

i) Calculate the regression line,

$$\hat{y} = a + b\ (x - \bar{x})$$

ii) Suppose the absolute value of the i^{th} residual $(y_i - \hat{y}_i)$ is the largest.

II.

i) Calculate the regression line with the i^{th} point deleted.

$$\hat{y}' = a' + b'\ (x - \bar{x})$$

ii) Let $t = (y_i - \hat{y}_i') \quad \hat{var}\ (y_i - \hat{y}_i')$

where y_i is the observed suspected outlier.

$\hat{y}_i'$ is the predicted value with the suspected outlier deleted.

$$\hat{var}\ (y_i - \hat{y}_i') = S^2 \left(1 + \frac{1}{n-1} + \frac{(x_i - \bar{x})^2}{\sum_{j=1, j \neq i}^{n} (x_j - \bar{x})^2}\right)$$

($\bar{x}$ is calculated without the suspected outlier)

$$S^2 = \sum_{j=1, j \neq i}^{n} (y_j - \hat{y}_j')^2 / n-3$$

iii) Find p from the t-statistic table

where

$p = prob(\ |t(n-3)| \geq t)$
$t(n-3)$ is a t-distributed variable with n-3 degrees of freedom.

iv) y_i is an outlier if $1-(1-p)^n < .05$

Example:

x	y	$\hat{y}$	$y-\hat{y}$
8	59	56.14	2.86
6	58	58.17	-0.17
11	56	53.10	2.90
-22	53	41.96	11.04
14	50	50.06	-0.06
17	45	47.03	-2.03
18	43	46.01	-3.01
24	42	39.94	2.06
19	39	45.00	-6.00
23	38	40.95	-2.95
26	30	37.91	-7.91
40	27	23.73	3.27

Assume model:

$$y = \alpha + \beta(x - \bar{x}) + \epsilon$$

$$\hat{y} = 45 - 1.013\ (x - \bar{x})$$

Suspected outlier

Suspected point out of regression:

$$\hat{y}' = 44.273 - 1.053\ (x - \bar{x})$$

$$\hat{y}_i' = 44.273 - 1.053\ (22 - 18.727) = 40.827$$

$$y_i - \hat{y}_i' = 12.173$$

$$\hat{var}(y_i - \hat{y}_i') = S^2\ (1 + \frac{1}{11} + \frac{10.711}{914.182})$$

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APPENDIX VIII

Procedure for Determining Vehicle Emission Control Technology Category/ Fuel Reactivity Adjustment Factors

The following procedure shall be used by the Executive Officer to determine the reactivity adjustment factor for exhaust emissions of non-methane organic gases (NMOG), for the purpose of certifying a vehicle of specific emission control technology category and fuel for sale in California. The NMOG emissions from Transitional Low-Emission Vehicles (TLEVs), Low-Emission Vehicles (LEVs), and Ultra-Low-Emission Vehicles (ULEVs) designed to operate on any available fuel other than conventional gasoline, including fuel-flexible and dual-fuel vehicles when operating on any available fuel other than conventional gasoline, shall be numerically-adjusted to establish a NMOG exhaust mass emission level equivalent to a conventional gasoline-fueled vehicle of the same vehicle emission control technology category.

(1) The Executive Officer shall determine the representative speciated NMOG exhaust emission profile for all light- and medium-duty conventional gasoline-fueled TLEVs, LEVs, and ULEVs according to the following conditions.

a. All testing will be conducted using a specified gasoline blend representative of commercial gasoline.

b. The speciated NMOG profile shall be calculated from a statistically valid number of TLEVs, LEVs, and ULEVs.

c. The speciated NMOG profile shall identify and quantify as many constituents as possible, such that a minimum of 95% of the total g/mile of NMOG emissions measured is accounted for, and shall be provided in units of g/mile.

d. The speciated NMOG profile shall include at a minimum, the g/mile NMOG emission values of all oxygenated organic gases containing five or fewer carbon atoms (i.e., aldehydes, ketones, alcohols, ethers, etc.), and all known alkanes, alkenes, alkynes and aromatics containing 12 or fewer carbon atoms.

(2) The 'g ozone potential per mile' of each NMOG identified in the speciated profile shall be determined by multiplying the 'g/mile NMOG' emission value of the constituent NMOG by its maximum incremental reactivity.

(3) The 'total g ozone potential per mile' of NMOG exhaust emissions from the vehicle/fuel system shall be the sum of all the constituent NMOG 'g ozone potential per mile' values calculated in step (2).

(4) The 'g ozone potential per g NMOG' for the vehicle/fuel system shall be determined by dividing the 'total g ozone potential per mile' value calculated in step (3) by the 'total g/mile of NMOG emissions'.

(5) For light- and medium-duty candidate vehicle/fuel systems not powered by conventional gasoline, the Executive Officer shall establish 'reactivity adjustment factors' calculated from exhaust emission profiles derived by the same conditions specified in parts b, c, and d of step (1).

(6) The 'g ozone potential per g NMOG' for candidate vehicle/fuel systems not powered by conventional gasoline shall be determined according to steps (2), (3), and (4).

(7) The candidate vehicle/fuel 'reactivity adjustment factor' shall be determined by dividing the 'g ozone potential per g NMOG' calculated in step (6) by the 'g ozone potential per g NMOG' value for the vehicle in the same emission control technology category operated on the specified gasoline blend.

(8) A vehicle manufacturer may request an adjustment factor unique to its vehicle/fuel system from the Executive Officer provided that:

a. The manufacturer submits a speciated NMOG exhaust emission profile to the Executive Officer averaged from emission tests of a statistically valid number of different vehicles utilizing the same emission control technology and fuel. Emission levels of each constituent NMOG shall be measured according to the "California Non-Methane Organic Gas Test Procedures."

b. The 'reactivity adjustment factor' calculated from the 'g ozone potential per g NMOG' value determined from the aforementioned speciated profile differs from the 'reactivity adjustment factor' calculated by the Executive Officer for vehicles of the same or similar emission control technology and fuel by 25% or more.

c. The speciated profile is provided to the Executive Officer two years prior to certification of the vehicle.

(9) Table of (draft) maximum incremental reactivities to be used in step (2):

NMOG Constituent	Maximum Incremental Reactivity ($g\ O_3/g$ NMOG)
Alkanes	
Methane	0.0102
Ethane	0.147
Propane	0.33
n-Butane	0.64
n-Pentane	0.64
n-Hexane	0.61
n-Heptane	0.48
n-Octane	0.41
n-Nonane	0.29
n-Decane	0.25
n-Undecane	0.21
n-Dodecane	0.19
n-Tridecane	0.17
n-Tetradecane	0.16
n-Pentadecane	0.144
Isobutane	0.85
Lumped C4-C5 Alkanes	0.78
Branched C5 Alkanes	0.88
Iso-Pentane	0.88
Neopentane	0.19
2-Methylpentane	0.91
3-Methylpentane	0.95
Branched C6 Alkanes	0.91
2,3-Dimethyl Butane	0.74
2,2-Dimethyl Butane	0.41
Lumped C6+ Alkanes	0.70
2,4-Dimethyl Pentane	1.07
3-Methyl Hexane	0.85
4-Methyl Hexane	0.85
Branched C7 Alkanes	0.85
2,3-Dimethyl Pentane	0.96
Iso-Octane	0.70
4-Methyl Heptane	0.72
Branched C8 Alkanes	0.72
Branched C9 Alkanes	0.68
4-Ethyl Heptane	0.68
Branched C10 Alkanes	0.60
4-Propyl Heptane	0.60
Branched C11 Alkanes	0.72
Branched C12 Alkanes	0.75
Branched C13 Alkanes	0.57
Branched C14 Alkanes	0.44
Branched C15 Alkanes	0.41
Cyclopentane	1.6
Methylcyclopentane	1.7
C6 Cycloalkanes	0.84
Cyclohexane	0.84
C7 Cycloalkanes	1.17
Methylcyclohexane	1.17
Ethylcyclohexane	1.36
C8 Cycloalkanes	1.36
C9 Cycloalkanes	1.6
C10 Cycloalkanes	1.31
C11 Cycloalkanes	1.23
C12 Cycloalkanes	1.20
C13 Cycloalkanes	0.94
C14 Cycloalkanes	0.88
C15 Cycloalkanes	0.85

NMOG Constituent	Maximum Incremental Reactivity ($g\ O_3/g$ NMOG)
Alkenes	
Ethene	5.3
Propene	6.6
1-Butene	6.1
1-Pentene	4.2
3-Methyl-1-Butene	4.2
1-Hexene	3.0
C6 Terminal Alkenes	3.0
C7 Terminal Alkenes	2.4
C8 Terminal Alkenes	1.9
C9 Terminal Alkenes	1.6
C10 Terminal Alkenes	1.32
C11 Terminal Alkenes	1.15
C12 Terminal Alkenes	1.03
C13 Terminal Alkenes	0.93
C14 Terminal Alkenes	0.86
C15 Terminal Alkenes	0.80
Isobutene	4.2
2-Methyl-1-Butene	3.7
trans-2-Butene	7.3
cis-2-Butene	7.3
2-Methyl-2-Butene	5.0
C5 Internal Alkenes	6.2
2,3-Dimethyl-2-Butene	3.7
C6 Internal Alkenes	5.3
C7 Internal Alkenes	4.4
C8 Internal Alkenes	3.6
C9 Internal Alkenes	3.2
C10 Internal Alkenes	2.8
C11 Internal Alkenes	2.5
C12 Internal Alkenes	2.3
C13 Internal Alkenes	2.1
C14 Internal Alkenes	1.9
C15 Internal Alkenes	1.8
1,3-Butadiene	7.7
Isoprene	6.5
Cyclopentene	4.0
Cyclohexene	3.3
a-Pinene	1.9
b-Pinene	1.9

NMOG Constituent	Maximum Incremental Reactivity ($g\ O_3/g$ NMOG)
1,3,5-Trimethyl Benzene	7.5
1,2,3-Trimethyl Benzene	7.4
1,2,4-Trimethyl Benzene	7.4
C10 Trialkyl Benzenes	6.7
C11 Trialkyl Benzenes	6.1
C12 Trialkyl Benzenes	5.6
Tetralin	0.73
Naphthalene	0.87
Methyl Naphthalene	2.4
2,3-Dimethyl Naphthalene	3.7
Alkynes	
Acetylene	0.37
Alcohols	
Methanol	0.40
Ethanol	0.79
n-Propyl Alcohol	1.33
Isopropyl Alcohol	0.37
Isobutyl Alcohol	0.72
n-Butyl Alcohol	1.6
t-Butyl Alcohol	0.29
Ethylene Glycol	1.13
Propylene Glycol	0.92
Aldehydes	
Formaldehyde	6.2
Acetaldehyde	3.8
Propionaldehyde	4.6
Ketones	
Acetone	0.39
C4 Ketones	0.76
Aromatic Oxygenates	
Benzaldehyde	- 0.54
Phenol	0.79
Cresols	1.6

NMOG Constituent	Maximum Incremental Reactivity ($g\ O_3/g$ NMOG)
Aromatic Hydrocarbons	
Benzene	0.28
Toluene	1.9
Ethyl Benzene	1.8
n-Propyl Benzene	1.44
Isopropyl Benzene	1.5
s-Butyl Benzene	1.29
C10 Monoalkyl Benzenes	1.28
C11 Monoalkyl Benzenes	1.16
C12 Monoalkyl Benzenes	1.06
m-Xylene	6.0
o-Xylene	5.2
p-Xylene	5.2
C9 Dialkyl Benzenes	5.3
C10 Dialkyl Benzenes	4.8
C11 Dialkyl Benzenes	4.3
C12 Dialkyl Benzenes	3.9

NMOG Constituent	Maximum Incremental Reactivity ($g\ O_3/g$ NMOG)
Ethers	
Methyl t-Butyl Ether	0.47
Ethyl t-Butyl Ether	1.33

APPENDIX E-2: HEAVY-DUTY DIESEL TEST PROCEDURES

PROPOSED

State of California
AIR RESOURCES BOARD

CALIFORNIA EXHAUST EMISSION STANDARDS AND TEST PROCEDURES FOR 1985 AND SUBSEQUENT MODEL HEAVY-DUTY DIESEL-ENGINES AND VEHICLES

Adopted: April 8, 1985
Amended: July 29, 1986
Amended: January 22, 1990
Amended: [ ]
Amended: ____________

NOTE: This document is printed in a style to indicate amendments to the standards and test procedures as adopted February 20, 1990. The amendments originally proposed in the present rulemaking are shown in underline to indicate additions to the text and strikeout to indicate deletions.

On June 14, 1990, the Board approved amendments to various sections in the Code of Federal Regulations to establish new regulations for medium-duty vehicles. These amendments have not yet been formally approved by the Office of Administrative Law. The amendments made by the medium-duty rulemaking are identified here by *italics*, with deletions shown in [~~*italicized strikeouts in brackets*~~]. The amendments pertaining to the June 14, 1990 medium-duty rulemaking are not a part of the present proposal made available at this time; however, some of the amendments in this proposal modify or otherwise affect the language from the medium-duty rulemaking. Deletions to the June 14, 1990 medium-duty rulemaking, proposed in this rulemaking, are shown in ~~*italicized strikeouts*~~.

This document incorporates by reference various sections of the Code of Federal Regulations, some with modifications. California provisions which replace specific federal provisions are denoted by the words "DELETE" for the federal language and "REPLACE WITH" for the new California language. The symbols "*****" and "..." mean that the remainder of the federal text for a specific section, which is not shown in these procedures, has been included by reference, with only the printed text changed. For those portions of federal provisions proposed for incorporation in this document with modifications, the new federal provisions are underlined and the modifications to those provisions are displayed in double underline and strikeout to indicate proposed additions to and deletions from the federal language. Federal regulations which are not listed are not part of the procedures.

CALIFORNIA EXHAUST EMISSION STANDARDS AND TEST PROCEDURES
FOR 1985 AND SUBSEQUENT MODEL
HEAVY-DUTY DIESEL-ENGINES AND VEHICLES

The following provisions of Subparts A, I, and N, Part 86, Title 40, Code of Federal Regulations, as adopted or amended by the U.S. Environmental Protection Agency on the date listed, and only to the extent they pertain to the testing and compliance of exhaust emissions from heavy-duty Diesel-engines and vehicles, are adopted and incorporated herein by this reference as the California Exhaust Emission Standards and Test Procedures for 1985 and Subsequent Model Heavy-Duty Diesel-Engines and Vehicles, except as altered or replaced by the provisions set forth below.

The federal regulations contained in the Subparts identified above which pertain to oxides of nitrogen emission averaging shall not be applicable to these procedures. The federal regulations contained in the Subparts identified above which pertain to particulate emission averaging shall not be applicable to these procedures for 1996 and later model engines and vehicles. The smoke exhaust test procedures shall be applicable to California petroleum-fueled, liquefied-petroleum gas-fueled, and compressed natural gas-fueled heavy-duty Diesel engines and vehicles for 1988 and later model years.

Starting with the 1990 model year, these regulations shall be applicable to all heavy-duty Diesel natural-gas-fueled and liquefied-petroleum gas-fueled engines (and vehicles) including those engines derived from existing Diesel engines. For any engine which is not a distinctly Diesel engine nor derived from such, the Executive Officer shall determine whether the engine shall be subject to these regulations or alternatively to the heavy-duty Otto-cycle engine regulations, in consideration of the relative similarity of the engine's torque-speed characteristics and vehicle applications with those of Diesel and Otto-cycle engines.

The regulations concerning the certification of methanol-fueled diesel urban bus engines are not applicable in California until 1991 and subsequent model years. The regulations concerning the certification of all other methanol-fueled diesel engines and vehicles are not applicable in California until 1993 and subsequent model years.

Regulations concerning the certification of incomplete medium-duty diesel low-emission vehicles and engines and ultra-low-emission vehicles and engines operating on any fuel are applicable for the 1992 and subsequent model years.

Subpart A, General Provisions for Emission Regulations for 1977 and Later Model Year New Light-Duty Vehicles, Light-Duty Trucks, and Heavy-Duty Engines, and for 1985 and later Model Year New Gasoline-Fuel and Methanol-Fueled Heavy-Duty Vehicles.

86.085-1 General Applicability. March 15, 1985.

* * * * *

(b) ...*may request to certify any pre-1996 model year heavy-duty vehicle 10,000 pounds* GVWR or less to the medium-duty vehicle exhaust emission standards. Heavy-duty...

* * * * *

(e) ...projected combined California sales of passenger cars, light-duty trucks, medium-duty vehicles and heavy-duty engines in its product line are fewer than 3,000 units for the model...

86.090-1 General Applicability. April 11, 1986.

(a)... heavy-duty engines. Starting with the 1990 model year, the provisions of this subpart are also applicable to all dedicated gaseous-fuel, dual-fuel and multi-fuel diesel engines (or vehicles) including those engines derived from existing Diesel engines. Any reference to Diesel engines and vehicles shall also apply to gaseous-fuel engines and vehicles, except where specifically noted. <u>Starting with the 1992 model year, the provisions of this subpart are also applicable to incomplete medium-duty diesel low-emission vehicles and engines and ultra-low-emission vehicles and engines operating on any fuel.</u>

(b) ...Gross Vehicle Weight Rating or less to the medium-duty vehicle exhaust emission standards. Heavy-duty...

* * * * *

(e) ...projected combined California sales of passenger cars, light-duty trucks, medium-duty vehicles, and heavy-duty engines in its product line are fewer than 3,000 units for the model...

86.085-2 Definitions. November 16, 1983.

* * * * *

"Administrator" DELETE
REPLACE WITH:
"Administrator" means the Executive Officer of the Air Resources Board.

* * * * *

"Certificate of Conformity" DELETE
REPLACE WITH:
"Certificate of Conformity" means "Executive Order" certifying vehicles for sale in California.

"Certification" DELETE
REPLACE WITH:
"Certification" means certification as defined in Section 39018 of the Health and Safety Code.

* * * * *

"Heavy-Duty Engine" DELETE
REPLACE WITH:
"Heavy-duty engine" means an engine which is used to propel a heavy-duty vehicle.

"Heavy-Duty Vehicle" DELETE
REPLACE WITH:
"Heavy-duty vehicle" means any motor vehicle having a manufacturer's gross vehicle weight rating greater than 6,000 pounds, except passenger cars.

* * * * *

"Medium-duty vehicle" means any *pre-1995 model-year* heavy-duty vehicle having a manufacturer's gross vehicle weight rating of 8,500 pounds or less, any 1992 and subsequent model-year heavy-duty low-emission vehicle or ultra-low-emission vehicle having a manufacturer's gross vehicle weight rating of 14,000 pounds or less, *or any 1995 or subsequent model year heavy-duty vehicle having a manufacturer's gross vehicle weight rating of 14,000 pounds or less.*

* * * * *

"Useful life" means:

* * * * *

(f) DELETE
REPLACE WITH:
(f) The useful-life period for purposes of the emissions defect warranty shall be a period of 5 years/100,000 miles, whichever first occurs, for all heavy-duty Diesel*[-cycle]* engines. However, in no case may this period be less than the manufacturer's basic mechanical warranty period for the engine family.

* * * * *

86.088-2 Definitions. March 15, 1985.

86.090-2 Definitions. April 11, 1989.

86.091-2 Definitions. March 15, 1985.

* * * * *

"Gaseous Fuel" means compressed natural gas or liquefied petroleum gas fuel for use in motor vehicles and engines.

"Dedicated Gaseous-Fuel Engine" means any gaseous-fuel engine that is engineered and designed to be operated solely on a gaseous fuel.

"Dual-Fuel Engine" means any gaseous-fuel engine that is engineered and designed to be operated on either a gaseous fuel or a petroleum fuel.

"Multi-Fuel Engine" means any gaseous-fuel engine that is engineered and designed to be operated with a gaseous fuel simultaneously with a petroleum fuel.

86.078-3 Abbreviations. January 21, 1980.

86.090-3 Abbreviations. April 11, 1986.

86.084-4 Section numbering; construction. September 25, 1980.

86.084-5 General Standards; increase in emissions; unsafe conditions. November 2, 1982.

86.090-5 General Standards; increase in emissions; unsafe conditions. April 11, 1989.

86.078-7 Maintenance of records; submittal of information; right of entry. November 2, 1982.

86.085-11 Emission standards for 1985 and later model year diesel heavy-duty engines. November 16, 1983.

* * * * *

(a)(1)(iii) Oxides of Nitrogen. 5.1 grams per ...

* * * * *

(b) DELETE
REPLACE WITH:
(b) At the option of the manufacturer, the standards set forth in Section 86.088-11, paragraph (a)(1) can replace the standards set forth in paragraph (a)(1), applicable to new 1987 model year diesel heavy-duty engines only.

* * * * *

(d)...in Subpart N of this part to ascertain.

* * * * *

86.088-11 Emission standards for 1988 and later model year diesel heavy-duty engines. March 15, 1985.

86.090-11 Emission standards for 1990 and later model year diesel heavy-duty engines and vehicles. April 11, 1989.

* * * * *

(b)(1) The opacity of smoke emission from new 1990 and later model year petroleum-fueled diesel heavy-duty engines shall not exceed:

* * * * *

86.091-11 Emission standards for 1991 and later model year diesel heavy-duty engines and vehicles. April 11, 1989.

* * * * *

(a)(1)(iv)(C) A manufacturer may elect to include all or some of its diesel heavy-duty engine families in the appropriate heavy-duty particulate averaging program (petroleum or methanol or gaseous fuel), provided that engines produced for sale in California or in 49-state areas may be averaged only within each of those areas. Dual-fuel and multi-fuel engines may not be included in the diesel particulate averaging program. With *[~~one~~]* the exceptions regarding methanol-fueled or gaseous-fuel diesel urban bus engines as noted below, averaging is not permitted between fuel types. Non-methanol-fueled and non-gaseous-fuel engines for use in urban buses may not be included in either heavy-duty particulate averaging program. Emissions from methanol-fueled and dedicated gaseous-fuel urban bus engines certified to 0.10 grams per brake horsepower-hour particulates may be included in the averaging program for petroleum fueled engines other than urban bus engines. Averaging is limited to engines within a given primary service class as defined in 86.085-2. Averaging across primary service classes is not permitted. If the manufacturer elects to participate in either averaging program, individual family particulate limits may not exceed 0.60 gram per brake horsepower-hour (0.22 grams per megajoule). Heavy-duty diesel engines converted to methanol fuel or gaseous fuel may be used to comply with the urban bus particulate standard and may be used in the diesel particulate averaging program. Such engines must comply with all applicable heavy-duty diesel engine emission standards and test procedures in this Part.

* * * * *

(a)(2) Manufacturers may choose to certify diesel and incomplete medium-duty vehicles from 8501-14,000 pounds, gross vehicle weight to the emission standards and test procedures specified below as an alternative to the primary standards and test procedures specified in Section 1960.1, Title 13, California Code of Regulations. Manufacturers certifying medium-duty vehicles to these optional heavy-duty standards and test procedures shall reimburse the cost of in-use procurement and compliance testing as specified in Sections 2136 through

2140, Title 13, California Code of Regulations. Exhaust emissions from new 1995 ~~and later~~ through 2000 model year medium-duty vehicles certifying to the optional heavy-duty engine test procedures shall not exceed the following:

(i) Carbon Monoxide. 14.4 grams per brake horsepower-hour, as measured under transient operating conditions.

(ii) Non-methane Hydrocarbon and Oxides of Nitrogen. 3.9 grams per brake horsepower-hour total, as measured under transient operating conditions.

(iii) Particulate Emissions. 0.10 grams per brake horsepower-hour, as measured under transient operating conditions.

(a)(3) Manufacturers may choose to certify incomplete medium-duty low-emission and ultra-low-emission vehicles from 8501-14,000 pounds, gross vehicle weight to the emission standards and test procedures specified below as an alternative to the primary standards and test procedures specified in Section 1960.1, Title 13, California Code of Regulations. Manufacturers certifying medium-duty low-emission and ultra-low-emission vehicles to these optional heavy-duty standards and test procedures shall specify, in the application for certification, an in-use compliance test procedure, as provided in Section 2139(c), Title 13, California Code of Regulations. Exhaust emissions from new 1992 and later model year medium-duty low-emission (LEV) and ultra-low-emission (ULEV) vehicles certifying to the optional heavy-duty engine test procedures shall not exceed the following:

(i) Carbon Monoxide. 14.4 grams per brake horsepower-hour for LEVs and 7.2 grams per brake horsepower-hour for ULEVs, as measured under transient operating conditions.

(ii) Non-methane Hydrocarbon and Oxides of Nitrogen. 3.5 grams per brake horsepower-hour total for LEVs and 2.5 grams per brake horsepower-hour total for ULEVs, as measured under transient operating conditions.

(iii) Particulate Emissions. 0.10 grams per brake horsepower-hour for LEVs and 0.05 grams per brake horsepower-hour for ULEVs, as measured under transient operating conditions.

(iv) Formaldehyde Emissions. 0.050 grams per brake horsepower-hour for LEVs and 0.025 grams per brake horsepower-hour for ULEVs, as measured under transient operating conditions.

[~~(2)~~] ~~(3)~~ (4) The standards set forth in paragraphs (a)(1), ~~and~~ (a)(2), and (a)(3) ....

* * * * *

(b)(1) The opacity of smoke emission from new 1991 and later model year petroleum-fueled diesel heavy-duty engines shall not exceed:

*　*　*　*　*

86.094-11 Emission standards for 1994 and later model year diesel heavy-duty engines and vehicles. April 11, 1989.

*　*　*　*　*

(a)(1)(iv)(B) A manufacturer may elect to include all or some of its diesel heavy-duty engine families in the appropriate heavy-duty particulate averaging program (petroleum or methanol or gaseous fuel), provided that engines produced for sale in California or in 49-state areas may be averaged only within each of those areas. Dual-fuel and multi-fuel engines may not be included in the diesel particulate averaging program. With *[~~one~~]* the exceptions regarding methanol-fueled or gaseous-fuel diesel urban bus engines as noted below, averaging is not permitted between fuel types. Non-methanol-fueled and non-gaseous-fuel engines for use in urban buses may not be included in either heavy-duty particulate averaging program. Emissions from methanol-fueled and dedicated gaseous-fuel urban bus engines certified to 0.10 grams per brake horsepower-hour particulates may be included in the averaging program for petroleum fueled engines other than urban bus engines. Averaging is limited to engines within a given primary service class as defined in 86.085-2. Averaging across primary service classes is not permitted. If the manufacturer elects to participate in either averaging program, individual family particulate limits may not exceed 0.60 gram per brake horsepower-hour (0.22 grams per megajoule). Heavy-duty diesel engines converted to methanol fuel or gaseous fuel may be used to comply with the urban bus particulate standard and may be used in the diesel particulate averaging program. Such engines must comply with all applicable heavy-duty diesel engine emission standards and test procedures in this Part.

*　*　*　*　*

(b)(1) The opacity of smoke emission from new 1994 and later model year petroleum-fueled diesel heavy-duty engines shall not exceed:

*　*　*　*　*

86.080-12 Alternative certification procedures. April 17, 1980.

86.084-14 Small-volume manufacturers certification procedures. January 31, 1985.

*　*　*　*　*

(b)(1)...produced by manufacturers with California sales (for the model year in which certification is sought) of fewer than 3,000 units (PC, LDT, MDV, and HDE combined).

* * * * *

(c)(4) DELETE
REPLACE WITH:
(c)(4) Small volume manufacturers shall include in *[its]* their records all of the information that EPA requires in 86.084-21. This information will be considered part of the manufacturer's application for certification.

* * * * *

(c)(7)(i)(C)...determines and prescribes based on design specifications or sufficient control over design specifications, development data, in-house testing procedures, and in-use experience. However,...

* * * * *

(c)(11)(ii)(D)(1)...We project the total California sales of vehicles (engines) subject to this subpart to be fewer than 3,000 units.

* * * * *

(c)(13)(ii)...affect vehicle emissions. All running changes which do not adversely affect emissions or the emissions control system durability are deemed approved unless disapproved by the Executive Officer within 30 days of the implementation of the running change. This...

* * * * *

86.090-14 Small-volume manufacturers certification procedures. April 11, 1989.

* * * * *

(b)(1)...produced by manufacturers with California sales (for the model year in which certification is sought) of fewer than 3,000 units (PC, LDT, MDV, and HDE combined).

* * * * *

(c)(4) DELETE
REPLACE WITH:
(c)(4) The manufacturer shall include in its records all of the information that EPA requires in 86.088-21 of this subpart. This information will be considered part of the manufacturer's application for certification.

* * * * *

(c)(7)(i)(C)...determines and prescribes based on design specifications or sufficient control over design specifications, development data, in-house testing procedures, and in-use experience. However...

* * * * *

(c)(11)(ii)(D)(1)...We project the total California sales of vehicles (engines) subject to this subpart to be fewer than 3,000 units.

* * * * *

(c)(13)(ii)...affect vehicle emissions. All running changes which do not adversely affect emissions or the emissions control system durability are deemed approved unless disapproved by the Executive Officer within 30 days of the implementation of the running change. This ...

86.085-20 Incomplete vehicles, classification. January 12, 1983.

86.085-21 Application for certification. December 10, 1984.

86.087-21 Application for certification. November 16, 1983.

86.088-21 Application for certification. March 15, 1989.

86.090-21 Application for certification. April 11, 1989.

86.091-21 Application for certification. April 11, 1989.

<u>*</u> <u>*</u> <u>*</u> <u>*</u> <u>*</u>

<u>(b)(2) For 1992 and subsequent model-year low-emission and ultra-low-emission vehicles and engines not powered exclusively by diesel, projected California sales data and fuel economy estimates two years prior to certification, and</u> projected California sales data <u>for all vehicles and engines, regardless of operating fuel or vehicle emission category,</u> sufficient to enable the Executive Officer to select a test fleet representative of the vehicles (or engines) for which certification is requested <u>at the time of certification</u>.

<u>*</u> <u>*</u> <u>*</u> <u>*</u> <u>*</u>

86.085-22 Approval of application for certification; test fleet selections; determinations of parameters subject to adjustment for certification and Selective Enforcement Audit, adequacy of limits, and physically adjustable ranges. August 30, 1985.

DELETE any reference to Selective Enforcement Audit.

86.090-22 Approval of application for certification; test fleet selections; determinations of parameters subject to adjustment for certification and Selective Enforcement Audit, adequacy of limits, and physically adjustable ranges. April 11, 1989.

DELETE any reference to Selective Enforcement Audit.

86.085-23 Required data. March 15, 1985.

* * * * *

(b)(1)(ii)...useful life of the engine. Such data shall be submitted to the Executive Officer for review. If the durability test method is accepted by EPA, it shall also be accepted by ARB, subject to the following condition. If, after certification for the first model year in which the method is used, the Executive Officer determines that a manufacturer's durability test procedures do not conform with good engineering practices, the Executive Officer may require changes to that manufacturer's durability test procedures for subsequent model years. The manufacturer's revised durability test procedures shall be submitted to the Executive Officer for review and approval.

* * * * *

86.087-23 Required data. March 15, 1985.

* * * * *

(b)(1)(ii)...useful life of the engine. Such data shall be submitted to the Executive Officer for review. If the durability test method is accepted by EPA, it shall also be accepted by ARB, subject to the following condition. If, after certification for the first model year in which the method is used, the Executive Officer determines that a manufacturer's durability test procedures do not conform with good engineering practices, the Executive Officer may require changes to that manufacturer's durability test procedures for subsequent model years. The manufacturer's revised durability test procedures shall be submitted to the Executive Officer for review and approval.

* * * * *

86.088-23 Required data. July 19, 1985.

* * * * *

(b)(1)(ii)...useful life of the engine. Such data shall be submitted to the Executive Officer for review. If the durability test method is accepted by EPA, it shall also be accepted by ARB, subject to the following condition. If, after certification for the first model year in which the method is used, the Executive Officer determines that a manufacturer's durability test procedures do not conform with good engineering practices, the Executive Officer may require changes to that manufacturer's durability test procedures for subsequent model years. The manufacturer's revised durability test procedures shall be submitted to the Executive Officer for review and approval.

* * * * *

(f) DELETE

* * * * *

86.090-23 Required data. April 11, 1989

* * * * *

(b)(1)(ii)...useful life of the engine. Such data shall be submitted to the Executive Officer for review. If the durability test method is accepted by EPA, it shall also be accepted by ARB, subject to the following condition. If, after certification for the first model year in which the method is used, the Executive Officer determines that a manufacturer's durability test procedures do not conform with good engineering practices, the Executive Officer may require changes to that manufacturer's durability test procedures for subsequent model years. The manufacturer's revised durability test procedures shall be submitted to the Executive Officer for review and approval.

* * * * *

(c)...as required under 86.090-26(a)(3)(i) or 86.090-26(a)(3)(ii). In lieu of providing emission data on idle CO emissions or particulate emissions from methanol-fueled diesel certification vehicles...

* * * * *

(f) DELETE

* * * * *

86.091-23 Required data. April 11, 1989.

* * * * *

(b)(1)(ii)...useful life of the engine. Such data shall be submitted to the Executive Officer for review. If the durability test method is accepted by EPA, it shall also be accepted by ARB, subject to the following condition. If, after certification for the first model year in which the method is used, the Executive Officer determines that a manufacturer's durability test procedures do not conform with good engineering practices, the Executive Officer may require changes to that manufacturer's durability test procedures for subsequent model years. The manufacturer's revised durability test procedures shall be submitted to the Executive Officer for review and approval.

* * * * *

(c)...as required under 86.090-26(a)(3)(i) or 86.090-26(a)(3)(ii). In lieu of providing emission data on idle CO emissions or particulate emissions from methanol-fueled diesel certification vehicles...

* * * * *

86.085-24 Test vehicles and engines. December 10, 1984.

* * * * *

(e)(1)(i) DELETE
REPLACE WITH:
(e)(1)(i) a combined total of 3,000 California passenger cars, light-duty trucks, medium-duty vehicles, and heavy-duty engines,
(e)(1)(ii) DELETE
(e)(1)(iii) DELETE
(e)(1)(iv) DELETE
(e)(1)(v) DELETE
(e)(1)(vi) may request a reduction in the number of test vehicles (or engines) ...

(e)(2)...total sales of fewer than 3,000...

* * * * *

(f)...submitted. Durability data submitted may be from engines previously certified by the EPA or the Air Resources Board.

* * * * *

86.090-24 Test vehicles and engines. April 11, 1989.

* * * * *

(e)(1)(i) DELETE
REPLACE WITH:
(e)(1)(i) A combined total of 3,000 California passenger cars, light-duty trucks, medium-duty vehicles, and heavy-duty engines,

(e)(1)(ii); (e)(1)(iii); (e)(1)(iv); (e)(1)(v) DELETE

(e)(1)(vi) may request a reduction in the number of test vehicles (or engines)...

(e)(2) ... total sales of fewer than 3,000...

* * * * *

(f)...submitted. Durability data submitted may be from engines previously certified by the EPA or the Air Resources Board.

*　*　*　*　*

86.085-25 Maintenance. November 16, 1983.

86.087-25 Maintenance. March 15, 1985.

86.088-25 Maintenance. March 15, 1985.

86.090-25 Maintenance. April 11, 1989.

86.084-26 Mileage and service accumulation; emission measurements. October 19, 1983.

86.090-26 Mileage and service accumulation; emission measurements. April 11, 1989.

86.085-27 Special test procedures. January 12, 1983.

86.090-27 Special test procedures. April 11, 1989.

86.085-28 Compliance with emission standards. January 24, 1985.

86.087-28 Compliance with emission standards. March 15, 1985.

86.088-28 Compliance with emission standards. March 15, 1985.

86.090-28 Compliance with emission standards. April 11, 1989.

*　*　*　*　*

(c)(4)(ii)...and exhaust particulate. For petroleum-fueled diesel smoke testing...

(c)(4)(iii)(B)(1)...For transient HC (OMHCE), formaldehyde (methanol-fueled engines and vehicles, low-emission vehicles and engines, and ultra-low-emission vehicles and engines ~~only~~), CO, and NOx, the official exhaust emission...

(c)(4)(iii)(B)(2)...For transient HC (OMHCE), formaldehyde (methanol-fueled engines and vehicles, low-emission vehicles and engines, and ultra-low-emission vehicles and engines ~~only~~), CO, and NOx, the official exhaust emission...

(c)(4)(iii)(B)(3) Petroleum-fueled diesel heavy-duty engines only.

*　*　*　*　*

86.091-28 Compliance with emission standards. April 11, 1989.

*　*　*　*　*

(c)(4)(ii)..and exhaust particulate. For petroleum-fueled diesel smoke testing...

(c)(4)(iii)(B)(1)...For transient HC (OMHCE), formaldehyde (methanol-fueled engines and vehicles, low-emission vehicles and engines, and ultra-low-emission vehicles and engines ~~only~~), CO, and NOx, the official exhaust emission...

(c)(4)(iii)(B)(2)...For transient HC (OMHCE), formaldehyde (methanol-fueled engines and vehicles, low-emission vehicles and engines, and ultra-low-emission vehicles and engines ~~only~~), CO, and NOx, the official exhaust emission...

(c)(4)(iii)(B)(3) Petroleum-fueled diesel heavy-duty engines only.

* * * * *

86.085-29 Testing by the Administrator. January 24, 1984.

86.087-29 Testing by the Administrator. January 24, 1984.

86.088-29 Testing by the Administrator. March 15, 1985.

86.090-29 Testing by the Administrator. April 11, 1989.

86.091-29 Testing by the Administrator. April 11, 1989.

86.085-30 Certification. January 24, 1984.

86.087-30 Certification. August 30, 1985.

86.088-30 Certification. March 15, 1985.

86.090-30 Certification. April 11, 1989.

86.091-30 Certification. April 11, 1989.

86.079-31 Separate certification. September 8, 1977.

86.079-32 Addition of a vehicle or engine after certification. September 8, 1977.

86.079-33 Changes to a vehicle or engine covered by certification. September 8, 1977.

86.082-34 Alternative procedure for notification of additions and changes. November 2, 1982.

86.085-35 Labeling. Labels shall comply with the requirements set forth in the "California Motor Vehicle Emission Control Label Specifications", as last amended ______________.

86.085-37 Production vehicles and engines. January 12, 1983.

86.085-38 Maintenance instructions. November 16, 1983.

86.087-38 Maintenance instructions. March 15, 1985.

86.084-40 Automatic expiration of reporting and recordkeeping requirements. September 25, 1980.

Subpart I - Emission Regulations for New Diesel Heavy-Duty Engines; Smoke Exhaust Test Procedure

86.884-1 General Applicability. April 11, 1989.

The provisions of this subpart are applicable to new petroleum-fueled diesel heavy-duty engines beginning with the 1984 model year.

The provisions of this subpart are not applicable to new heavy-duty Diesel gaseous-fuel engines and those gaseous-fuel engines derived from Diesel engines, except dual-fuel and multi-fuel engines which use petroleum fuel.

86.884-2 Definitions. November 16, 1983.

86.884-3 Abbreviations. November 16, 1983.

86.884-4 Section numbering. November 16, 1983.

86.884-5 Test Procedures. April 11, 1989.

86.884-6 Fuel specifications. April 11, 1989.

86.884-7 Dynamometer operation cycle for smoke emission tests. November 16, 1983.

86.884-8 Dynamometer and engine equipment. November 16, 1983.

86.884-9 Smoke measurement system. November 16, 1983.

86.884-10 Information. November 16, 1983.

86.884-11 Instrument checks. November 16, 1983.

86.884-12 Test run. November 16, 1983.

86.884-13 Data analysis. November 16, 1983.

86.884-14 Calculations. November 16, 1983.

Subpart N, Emission Regulations for New Otto-Cycle and Diesel Heavy-Duty Engines; Gaseous and Particulate Exhaust Test Procedures

86.1301-84 Scope; applicability. November 16, 1983.

86.1301-88 Scope; applicability. March 15, 1985.

86.1301-90 Scope; applicability. April 11, 1989.

86.1302-84 Definitions. November 16, 1983.

86.1303-84 Abbreviations. November 16, 1983.

86.1304-84 Section numbering; construction. November 16, 1983.

86.1304-90 Section numbering; construction. April 11, 1989.

86.1305-84 Introduction; structure of subpart. November 16, 1983.

86.1305-90 Introduction; structure of subpart. April 11, 1989.

86.1306-84 Equipment required and specifications; overview. November 16, 1983.

86.1306-88 Equipment required and specifications; overview. March 15, 1985.

86.1306-90 Equipment required and specifications; overview. April 11, 1989.

86.1308-84 Dynamometer and engine equipment specifications. December 10, 1984.

~~86.1309-84 Exhaust gas sampling system; gasoline-fueled engines.~~ November 16, 1983.

86.1309-90 Exhaust gas sampling system; gasoline-fueled and throttled methanol-fueled engines. April 11, 1989.

86.1309-90 Exhaust gas sampling system; gasoline-fueled and methanol-fueled Otto-cycle engines. April 11, 1989.

* * * * *

(a)(3)...For methanol-fueled engines, the sample lines for the methanol and formaldehyde samples are heated to 235^{o} +/- 15^{o}F (113^{o} +/- 8^{o}C).

* * * * *

86.1310-84 Exhaust gas sampling and analytical system; diesel-fueled engines. December 10, 1984.

86.1310-88 Exhaust gas sampling and analytical system; diesel engines. March 15, 1985.

86.1310-90 Exhaust gas sampling and analytical system; petroleum-fueled and methanol-fueled diesel engines. April 11, 1989.

* * * * *

(a)(3)...samples collected for these purposes (Figure N90-2 and N90-3).

* * * * *

86.1311-84 Exhaust gas analytical system, CVS bag sample. November 16, 1983.

86.1311-90 Exhaust gas analytical system, CVS bag sample. April 11, 1989.

86.1312-88 Weighing chamber and microgram balance specifications. March 15, 1985.

86.1313-84 Fuel specifications. December 10, 1984.

86.1313-90 Fuel specifications. April 11, 1989.

* * * * *

(b)(4) Methanol fuel used in service accumulation of methanol-fueled diesel engines shall be representative of commercially available methanol fuel. Methanol used in fuel for exhaust emission testing shall be chemical grade methanol.

Fuel additives and ignition improvers intended for use in methanol test fuels shall be subject to the approval of the Executive Officer. In order for such approval to be granted, a manufacturer must demonstrate that emissions will not be adversely affected by the use of the fuel additive or ignition improver.

* * * * *

[~~(d)(6) DELETE~~
~~REPLACE WITH:~~
~~(D)(6) Natural Gas.~~]

ADD SUBPARAGRAPH (E) TO READ:
(e) Natural Gas and Liquefied Petroleum Gas Test Fuel.
(e)(1) Natural Gas Test Fuel. Natural gas used in service accumulation shall be representative of commercial natural gas which is generally available. Natural gas meeting the specifications below, or substantially equivalent specifications approved by the Executive Officer, shall be used in exhaust emission testing.

Natural Gas Emission Test Fuel Specification

Specification	Value	Tolerance	Calculation Method

Wobbe Number	1350	+/- 0.5%	ASTM D 1945 Using AGA Bulletin No. 36

Hydrocarbons (expressed as percent of total organic carbon present)

Methane	88%	+/- 0.5%	ASTM D 1945
Ethane	8%	+/- 0.3%	ASTM D 1945
C_3 and higher HC	4%	+/- 0.2%	ASTM D 1945
C_6 and higher HC	0.5%	maximum	ASTM D 1945
Total unsaturated HC	0.5	maximum	ASTM D 2650

Other Species (expressed as mole percent)

Hydrogen	0.1%	maximum	ASTM D 2650
Carbon Monoxide	0.1%	maximum	ASTM D 2650

Other Requirements

1. Free from liquids over the entire range of temperatures and pressures encountered in the engine and fuel system.
2. Free from solid particulate matter.

(e)(2)
Liquefied Petroleum Gas Test Fuel. Liquefied petroleum gas used in service accumulation shall be representative of commercial liquefied petroleum gas which is generally available through retail outlets. Liquefied petroleum gas used in exhaust and evaporative emission testing shall conform to NGPA HD-5 specification.

(e)(3)
The specification range of the fuels to be used under paragraphs (e)(1) and (e)(2) of this section shall be reported in accordance with 86.090-21(b)(3).

86.1314-84 Analytical gases. December 10, 1984.

86.1316-84 Calibration; frequency and overview. December 10, 1984.

86.1316-90 Calibration; frequency and overview. April 11, 1989.

86.1318-84 Engine dynamometer system calibrations. December 10, 1984.

86.1319-84 CVS calibration. December 10, 1984.

86.1319-90 CVS calibration. April 11, 1989.

86.1320-88 Gas meter or flow instrumentation calibration, particulate measurement. March 15, 1985.

86.1320-90 Gas meter or flow instrumentation calibration; particulate, methanol, and formaldehyde measurement. April 11, 1989.

86.1321-84 Hydrocarbon analyzer calibration. December 10, 1984.

86.1321-90 Hydrocarbon analyzer calibration. April 11, 1989.

86.1322-84 Carbon monoxide analyzer calibration. November 16, 1983.

86.1323-84 Oxides of nitrogen analyzer calibration. December 10, 1984.

86.1324-84 Carbon dioxide analyzer calibration. November 16, 1983.

86.1326-84 Calibration of other equipment. November 16, 1983.

86.1326-90 Calibration of other equipment. April 11, 1989.

86.1327-84 Engine dynamometer test procedures; overview. December 10, 1984.

86.1327-88 Engine dynamometer test procedures; overview. March 15, 1985.

86.1327-90 Engine dynamometer test procedures; overview. April 11, 1989.

* * * * *

(a)...sample collection impingers (or capsules) for formaldehyde (HCHO). A bag or continuous sample of the dilution air...

* * * * *

86.1330-84 Test sequence, general requirements. November 16, 1983.

86.1330-90 Test sequence, general requirements. April 11, 1989.

86.1332-84 Engine mapping procedures. December 10, 1984.

86.1332-90 Engine mapping procedures. April 11, 1989.

86.1333-84 Transient test cycle generation. November 16, 1983.

86.1333-90 Transient test cycle generation. April 11, 1989.

86.1334-84 Pre-test engine and dynamometer preparation. December 10, 1984.

86.1335-84 Optional forced cool-down procedure. December 10, 1984.

86.1335-90 Optional forced cool-down procedure. April 11, 1989.

86.1336-84 Engine starting and restarting. March 15, 1985.

86.1337-84 Engine dynamometer test run. November 16, 1983.

86.1337-88 Engine dynamometer test run. March 15, 1985.

86.1337-90 Engine dynamometer test run. April 11, 1989.

86.1338-84 Emission measurement accuracy. November 16, 1983.

86.1339-88 Diesel particulate filter handling and weighing. March 15, 1985.

86.1339-90 Particulate filter handling and weighing. April 11, 1989.

86.1340-84 Exhaust sample analysis. December 10, 1984.

86.1340-90 Exhaust sample analysis. April 11, 1989.

86.1341-84 Test cycle validating criteria. March 15, 1985.

86.1341-90 Test cycle validating criteria. April 11, 1989.

86.1342-84 Calculations; exhaust emissions. March 15, 1985.

86.1342-90 Calculations; exhaust emissions. April 11, 1989.

* * * * *

(d) Meaning of symbols:

* * * * *

(1)(ii) . . . (101.3 kPa) pressure; or, if gaseous fuels are being used, 18.64 g/ft^3 for natural gas and 17.28 g/ft^3 for liquefied petroleum gas, assuming an average carbon to hydrogen ratio of 1:3.803 for natural gas and 1:2.656 for liquefied petroleum gas, at 68^oF and 760 mm Hg pressure. The Executive Officer may approve other density values deemed appropriate by a manufacturer.

* * * * *

(3)(v)(A) $CO_e = (1-0.01925CO_{2e} - 0.000323R)C)_{em}$ for gasoline and petroleum diesel fuel, with hydrogen to carbon ratio of 1.85:1.

(3)(v)(B) $CO_e = [1-(0.01 + 0.005HCR)CO_{2e} - 0.00323R]CO_{em}$ for methanol fuel, where HCR is hydrogen to carbon ratio as measured for the fuel used. For natural gas and liquefied petroleum gas, HCR is assumed to be 2.656 and 3.802 respectively.

* * * * *

(8)(i) K_H = Humidity correction factor.

* * * * *

(iii) For petroleum-fueled, gaseous-fuel, and methanol-fueled diesel engines: $K_H = 1/[1-0.0026(H-75)]$ (or for SI units, . . .

*   *   *   *   *

86.1343-88 Calculations; particulate exhaust emissions (including diesel gaseous-fuel, dual-fuel and multi-fuel engines). April 11, 1989.

86.1344-84 Required information. November 16, 1983.

86.1344-88 Required information. March 15, 1985.

86.1344-90 Required information. April 11, 1989.

Appendix I - Urban Dynamometer Schedules.

(f)(2) EPA Engine Dynamometer Schedule for Heavy-Duty Diesel Engines. December 10, 1984.

Additional Requirements

1. Any reference to vehicle or engine sales throughout the United States shall mean vehicle or engine sales in California.

2. Regulations concerning EPA hearings, EPA inspections, and specific language on the Certificate of Conformity, shall not be applicable to these procedures.

3. Any reference made to Selective Enforcement Auditing (SEA) shall not be applicable to these procedures.

4. Methanol-fueled engines and vehicles shall comply with the "California Evaporative Emission Standards and Test Procedures for 1978 and Subsequent Model Liquefied Petroleum Gas- or Gasoline- or Methanol-Fueled Motor Vehicles," as incorporated in Title 13, California Code of Regulations, Section 1976.

5. In addition to the standards and provisions specified in CFR Section 86.091-11 and 86.094-11 (emission standards for diesel-fuel and Diesel*[-cycle]* methanol heavy-duty engines and vehicles), the following formaldehyde emission levels as measured under transient operating conditions shall not be exceeded for methanol-fueled engines and vehicles:

Model Year	Formaldehyde (g/bhp-hr)
1993-1995	.10
1996 and Subsequent	0.05

The following formaldehyde emission levels as measured under transient operating conditions shall not be exceeded for 1992 and subsequent low-emission and ultra-low-emission vehicles and engines used in low-emission and ultra-low-emission vehicles operating on any fuel.

	(g/bhp-hr)
1992 and Subsequent Low-Emission Vehicles and Engines	0.050
1992 and Subsequent Ultra-Low-Emission Vehicles and Engines	0.025

6. All dedicated gaseous-fuel, dual-fuel, and multi-fuel Diesel engines (and vehicles), including those engines derived from existing Diesel engines shall comply with the requirements which are applicable to heavy-duty Diesel engines, except where otherwise noted.

7. Nonmethane hydrocarbon emissions shall be measured in accordance with the "California Nonmethane Hydrocarbon Test Procedures".

8. For dual-fuel or multi-fuel gaseous engines and vehicles, the noted deterioration factors shall be determined separately for operation on each type of fuel or combination of fuels that the engine is designed to use. For certification to be granted, the provisions of 86.091-28(c) must be met separately for emissions using each type and combination of fuels.

APPENDIX E-3: HEAVY-DUTY OTTO-CYCLE TEST PROCEDURES

PROPOSED

State of California
AIR RESOURCES BOARD

CALIFORNIA EXHAUST EMISSION STANDARDS AND TEST PROCEDURES FOR 1987 AND SUBSEQUENT MODEL HEAVY-DUTY OTTO-CYCLE ENGINES AND VEHICLES

Adopted: April 25, 1986
Amended: June 2, 1988
Amended: January 22, 1990
Amended: [ ]
Amended: ____________

NOTE: This document is printed in a style to indicate amendments to the standards and test procedures as adopted February 20, 1990. The amendments originally proposed in the present rulemaking are shown in underline to indicate additions to the text and strikeout to indicate deletions.

On June 14, 1990, the Board approved amendments to various sections in the Code of Federal Regulations to establish new regulations for medium-duty vehicles. These amendments have not yet been formally approved by the Office of Administrative Law. The amendments made by the medium-duty rulemaking are identified here by *italics*, with deletions shown in [~~*italicized strikeouts in brackets*~~]. The amendments pertaining to the June 14, 1990 medium-duty rulemaking are not a part of the present proposal made available at this time; however, some of the amendments in this proposal modify or otherwise affect the language from the medium-duty rulemaking. Deletions to the June 14, 1990 medium-duty rulemaking, proposed in this rulemaking, are shown in ~~*italicized strikeouts*~~.

This document incorporates by reference various sections of the Code of Federal Regulations, some with modifications. California provisions which replace specific federal provisions are denoted by the words "DELETE" for the federal language and "REPLACE WITH" for the new California language. The symbols "*****" and "..." mean that the remainder of the federal text for a specific section, which is not shown in these procedures, has been included by reference, with only the printed text changed. For those portions of federal provisions proposed for incorporation in this document with modifications, the new federal provisions are underlined and the modifications to those provisions are displayed in double underline and strikeout to indicate proposed additions to and deletions from the federal language. Federal regulations which are not listed are not part of the procedures.

CALIFORNIA EXHAUST EMISSION STANDARDS AND TEST PROCEDURES FOR 1987 AND SUBSEQUENT MODEL HEAVY-DUTY OTTO-CYCLE ENGINES AND VEHICLES

The following provisions of Subparts A, L, N, and P, Part 86, Title 40, Code of Federal Regulations, as adopted or amended by the U.S. Environmental Protection Agency on the date listed, and only to the extent they pertain to the testing and compliance of exhaust emissions from heavy-duty gasoline-*[powered]* Otto-cycle engines and vehicles, are adopted and incorporated herein by this reference as the California Exhaust Emission Standards and Test Procedures for 1987 and Subsequent Model Heavy-Duty Otto-Cycle Engines and Vehicles, except as altered or replaced by the provisions set forth below.

The federal regulations contained in the subparts identified above which pertain to evaporative emissions and oxides of nitrogen emission averaging shall not be applicable to these procedures. Regulations pertaining to evaporative emissions are contained in "California Evaporative Emission Standards and Test Procedures for 1978 and Subsequent Model Liquefied Petroleum Gas- or Gasoline- or Methanol-Fueled Motor Vehicles," as incorporated in Title 13, California Code of Regulations, Section 1976.

The federal regulations contained in the subparts identified above which pertain to nonconformance penalty shall be applicable for the 1988 model year. The Executive Officer shall not implement a nonconformance fee schedule until it is established that payment of nonconformance fees in California may substitute, on the basis of each heavy-duty engine or vehicle certified for sale in California, for payment of nonconformance fees to the federal government.

Starting with the 1990 model year, these regulations shall be applicable to all heavy-duty Otto-cycle natural-gas-fueled and liquefied-petroleum-gas-fueled engines (and vehicles) except those engines derived from existing Diesel engines. For any engine which is not a distinctly Otto-cycle engine nor derived from such, the Executive Officer shall determine whether the engine shall be subject to these regulations or alternatively to the heavy-duty Diesel engine regulations, in consideration of the relative similarity of the engine's torque-speed characteristics and vehicle applications with those of Otto-cycle and Diesel engines.

The regulations concerning the certification of methanol-fueled vehicles and engines including dedicated methanol and fuel-flexible vehicles and engines are not applicable in California until the 1993 and subsequent model years.

Regulations concerning the certification of incomplete medium-duty Otto-cycle low-emission vehicles and engines and ultra-low-emission vehicles and engines operating on any fuel are applicable for the 1992 and subsequent model years.

Subpart A, General Provisions for Emission Regulations for 1977 and Later Model Year New Light-Duty Vehicles, Light-Duty Trucks, and Heavy-Duty Engines, and for 1985 and Later Model Year Gasoline-Fueled and Methanol-Fueled Heavy-Duty Vehicles.

86.085-1 General Applicability. March 15, 1985.

* * * * *

(b) ...GVWR or less to the medium-duty vehicle...

* * * * *

(e) ...projected combined California sales of passenger cars, light-duty trucks, medium-duty vehicles and heavy-duty engines in its product line are fewer than 3,000 units for the model...

* * * * *

86.090-1 General Applicability. April 11, 1989.

(a) ... heavy-duty engines. Starting with the 1990 model year, the provisions of this subpart are also applicable to all Otto-cycle dedicated gaseous-fuel, dual-fuel and multi-fuel engines (or vehicles) except those engines derived from existing Diesel engines. Any reference to Otto-cycle heavy-duty engines and vehicles shall also apply to gaseous-fuel engines and vehicles, except where specifically noted. Starting with the 1992 model year, the provisions of this subpart are also applicable to all Otto-cycle low-emission vehicles and engines and ultra-low-emission vehicles and engines operating on any fuel.

* * * * *

(b) ...*may request to certify any pre-1996 model-year heavy-duty vehicle of 10,000 pounds* Gross Vehicle Weight Rating or less to the medium-duty vehicle...

* * * * *

(e) ...projected combined California sales of passenger cars, light-duty trucks, medium-duty vehicles and heavy-duty engines in its product line are fewer than 3,000 units for the model...

* * * * *

86.085-2 Definitions. November 16, 1983.

"Administrator" DELETE
REPLACE WITH:
"Administrator" means the Executive Officer of the Air Resources Board.

* * * * *

"Certificate of Conformity" DELETE
REPLACE WITH:
"Certificate of Conformity" means "Executive Order" certifying vehicles for sale in California.

"Certification" DELETE
REPLACE WITH:
"Certification" means certification as defined in Section 39018 of the Health and Safety Code.

* * * * *

"EPA Enforcement Officer" DELETE
REPLACE WITH:
"EPA Enforcement Officer" means the Executive Officer or his delegate.

* * * * *

"Heavy-Duty Engine" DELETE
REPLACE WITH:
"Heavy-duty engine" means an engine which is used to propel a heavy-duty vehicle.
"Heavy-Duty Vehicle" DELETE
REPLACE WITH:
"Heavy-duty vehicle" means any motor vehicle having a manufacturer's gross vehicle weight rating greater than 6,000 pounds, except passenger cars.

* * * * *

"Medium-duty vehicle" means any *pre-1995 model-year* heavy-duty vehicle having a manufacturer's gross vehicle weight rating of 8,500 pounds or less, any 1992 and subsequent model-year heavy-duty low-emission vehicle or ultra-low-emission vehicle having a manufacturer's gross vehicle weight rating of 14,000 pounds or less, *or any 1995 or subsequent model year heavy-duty vehicle having a manufacturer's gross vehicle weight rating of 14,000 pounds or less.*

* * * * *

86.088-2 Definitions. March 15, 1985.

* * * * *

86.090-2 Definitions. April 11, 1989.

* * * * *

"Dedicated Methanol Vehicle" means any methanol-fueled motor vehicle that is engineered and designed to be operated solely on methanol.

"Dedicated Methanol Engine" means any methanol-fueled heavy-duty engine that is engineered and designed to be operated solely on methanol.

"Flexible-Fuel Vehicle (or Engine)" or "Fuel-Flexible Vehicle (or Engine)" means . . .

86.091-2 Definitions. March 15, 1985.

* * * * *

"Gaseous Fuels" means compressed natural gas or liquefied petroleum gas fuel for use in motor vehicles and engines.

"Dedicated Gaseous-Fuel Engine" means any gaseous-fuel engine that is engineered and designed to be operated solely on a gaseous fuel.

"Dual-Fuel Engine" means any gaseous-fuel engine that is engineered and designed to be operated on either a gaseous fuel or petroleum fuel.

"Multi-Fuel Engine" means any gaseous-fuel engine that is engineered and designed to be operated with a gaseous fuel simultaneously with a petroleum fuel.

86.078-3 Abbreviations. January 21, 1980.

86.090-3 Abbreviations. April 11, 1989.

86.084-4 Section numbering; construction. September 25, 1980.

86.084-5 General Standards; increase in emissions; unsafe conditions. November 2, 1982.

86.090-5 General Standards; increase in emissions; unsafe conditions. April 11, 1989.

86.078-7 Maintenance of records; submittal of information; right ofentry. November 2, 1982.

86.087-10 Emission standards for 1987 and later model year gasoline-fueled heavy-duty engines and vehicles. November 16, 1983.

86.088-10 Emission standards for 1988 and 1989 model year gasoline-fueled heavy-duty engines and vehicles. March 15, 1985.

86.090-10 Emission standards for 1990 and later model year Otto-cycle heavy-duty engines and vehicles. April 11, 1989.

86.091-10 Emission standards for 1991 and later model year Otto-cycle heavy-duty engines and vehicles. April 11, 1989.

* * * * *

(a)(2) Manufacturers may choose to certify incomplete medium-duty vehicles from 8501-14,000 pounds, gross vehicle weight to the emission standards and test procedures specified below as an alternative to the primary standards and test procedures specified in Section 1960.1, Title 13, California Code of Regulations. Manufacturers certifying medium-duty vehicles to these optional heavy-duty standards and test procedures shall specify, in the application for certification, an in-use compliance test procedure, as provided in Section 2139(c), Title 13, California Code of Regulations. Exhaust emissions from new 1995 ~~and later~~ through 2000 model year incomplete medium-duty vehicles certifying to the optional heavy-duty engine test procedures shall not exceed the following:

(i) Carbon Monoxide. 14.4 grams per brake horsepower-hour, as measured under transient operating conditions.

(ii) Non-methane Hydrocarbon and Oxides of Nitrogen. 3.9 grams per brake horsepower-hour total, as measured under transient operating conditions.

(a)(3) Manufacturers may choose to certify incomplete medium-duty low-emission and ultra-low-emission vehicles from 8501-14,000 pounds, gross vehicle weight to the emission standards and test procedures specified below as an alternative to the primary standards and test procedures specified in Section 1960.1, Title 13, California Code of Regulations. Manufacturers certifying medium-duty low-emission and ultra-low-emission vehicles to these optional heavy-duty standards and test procedures shall specify, in the application for certification, an in-use compliance test procedure, as provided in Section 2139(c), Title 13, California Code of Regulations. Exhaust emissions from new 1992 and later model year incomplete medium-duty low-emission (LEV) and ultra-low-emission (ULEV) vehicles certifying to the optional heavy-duty engine test procedures shall not exceed the following:

(i) Carbon Monoxide. 14.4 grams per brake horsepower-hour for LEVs and 7.2 grams per brake horsepower-hour for ULEVs, as measured under transient operating conditions.

(ii) Non-methane Hydrocarbon and Oxides of Nitrogen. 3.5 grams per brake horsepower-hour total for LEVs and 2.5 grams per brake horsepower-hour total for ULEVs, as measured under transient operating conditions.

(iii) Formaldehyde Emissions. 0.050 grams per brake horsepower-hour for LEVs and 0.025 grams per brake horsepower-hour for ULEVs, as measured under transient operating conditions.

[~~(2)~~] ~~(3)~~ (4) The standards set forth in paragraphs (a)(1), ~~and~~ (a)(2), and (a)(3)...

[~~(3)~~] ~~(4)~~ (5) A manufacturer...

* * * * *

86.080-12 Alternative certification procedures. April 17, 1980.

86.084-14 Small-volume manufacturers certification procedures. January 31, 1985.

* * * * *

(b)(1) ... produced by manufacturers with California sales (for the model year in which certification is sought) of fewer than 3,000 units (PC, LDT, MDV, and HDE combined).

* * * * *

(c)(4) DELETE
REPLACE WITH:
(c)(4) The manufacturer shall include in its records all of the information that EPA requires in 86.084-21 of this subpart. This information will be considered part of the manufacturer's application for certification.

* * * * *

(c)(7)(i)(C) ... determines and prescribes based on design specifications or sufficient control over design specifications, development data, in-house testing procedures, and in-use experience. However, ...

* * * * *

(c)(11)(ii)(D)(1)...We project the total California sales of vehicles (engines) subject to this subpart to be fewer than 3,000 units.

* * * * *

(c)(13)(ii)...affect vehicle emissions. All running changes which do not adversely affect emissions or the emissions control system durability are deemed approved unless disapproved by the Executive Officer within 30 days of the implementation of the running change. This ...

* * * * *

86.090-14 Small-volume manufacturers certification procedures. April 11, 1989.

* * * * *

(b)(1)...produced by manufacturers with California sales (for the model year in which certification is sought) of fewer than 3,000 units (PC, LDT, MDV, and HDE combined).

* * * * *

(c)(4) DELETE
REPLACE WITH:
(c)(4) The manufacturer shall include in its records all of the information that EPA requires in 86.088-21 of this subpart. This information will be considered part of the manufacturer's application for certification.

* * * * *

(c)(7)(i)(C)...determines and prescribes based on design specifications or sufficient control over design specifications, development data, in-house testing procedures, and in-use experience.However,...

* * * * *

(c)(11)(ii)(D)(1)...We project the total California sales of vehicles (engines) subject to this subpart to be fewer than 3,000 units.

* * * * *

(c)(13)(ii)...affect vehicle emissions. All running changes which do not adversely affect emissions or the emissions control system durability are deemed approved unless disapproved by the Executive Officer within 30 days of the implementation of the running change. This...

86.085-20 Incomplete vehicles, classification. January 12, 1983.

86.087-21 Application for certification. November 16, 1983.

86.088-21 Application for certification. March 15, 1985.

86.090-21 Application for certification. April 11, 1989.

86.091-21 Application for certification. April 11, 1989.

* * * * *

(b)(2) For 1992 and subsequent model-year low-emission and ultra-low-emission vehicles and engines not powered exclusively by gasoline, projected California sales data and fuel economy estimates two years prior to certification, and projected California sales data for all vehicles and engines, regardless of operating fuel or vehicle emission category, sufficient to enable the Executive Officer to select a test fleet representative of the vehicles (or engines) for which certification is requested at the time of certification.

* * * * *

86.085-22 Approval of application for certification; test fleet selections; determinations of parameters subject to adjustment for certification and Selective Enforcement Audit, adequacy of limits, and physically adjustable ranges. August 30, 1985.

DELETE any reference to Selective Enforcement Audit.

86.090-22 Approval of application for certification; test fleet selections; determinations of parameters subject to adjustment for certification and Selective Enforcement Audit, adequacy of limits, and physically adjustable ranges. April 11, 1989.

DELETE any references to Selective Enforcement Audit.

86.087-23 Required data. March 15, 1985.

* * * * *

(b)(1)(ii) ... useful life of the engine. Such data shall be submitted to the Executive Officer for review. If the durability test method is accepted by EPA, it shall also be accepted by ARB, subject to the following condition. If, after certification for the first model year in which the method is used, the Executive Officer determines that a manufacturer's durability test procedures do not conform with good engineering practices, the Executive Officer may require changes to that manufacturer's durability test procedures for subsequent model years. The manufacturer's revised durability test procedures shall be submitted to the Executive Officer for review and approval.

* * * * *

86.088-23 Required data. July 19, 1985.

* * * * *

(b)(1)(ii) ... useful life of the engine. Such data shall be submitted to the Executive Officer for review. If the durability test method is accepted by EPA, it shall also be accepted by ARB, subject to the following condition. If, after certification for the first model year in which the method is used, the Executive Officer determines that a manufacturer's durability test procedures do not conform with good engineering practices, the Executive Officer may require changes to that manufacturer's durability test procedures for subsequent model years. The manufacturer's revised durability test procedures shall be submitted to the Executive Officer for review and approval.

* * * * *

86.090-23 Required data. April 11, 1989.

* * * * *

(b)(1)(ii) ... useful life of the engine. Such data shall be submitted to the Executive Officer for review. If the durability test method is accepted by EPA, it shall also be accepted by ARB, subject to the following condition. If, after certification for the first model year in which the method is used, the Executive Officer determines that a manufacturer's durability test procedures do not conform with good engineering practices, the Executive Officer may require changes to that manufacturer's durability test procedures for subsequent model years. The manufacturer's revised durability test procedures shall be submitted to the Executive Officer for review and approval.

* * * * *

86.091-23 Required data. April 11, 1989.

* * * * *

(b)(1)(ii) ... useful life of the engine. Such data shall be submitted to the Executive Officer for review. If the durability test method is accepted by EPA, it shall also be accepted by ARB, subject to the following condition. If, after certification for the first model year in which the method is used, the Executive Officer determines that a manufacturer's durability test procedures do not conform with good engineering practices, the Executive Officer may require changes to that manufacturer's durability test procedures for subsequent model years. The manufacturer's revised durability test procedures shall be submitted to the Executive Officer for review and approval.

* * * * *

86.085-24 Test vehicles and engines. December 10, 1984.

* * * * *

(e)(1)(i) DELETE
REPLACE WITH:
(e)(1)(i) a combined total of 3000 California passenger cars, light-duty trucks, medium-duty vehicles, and heavy-duty engines,

(e)(1)(ii) DELETE
(e)(1)(iii) DELETE
(e)(1)(iv) DELETE
(e)(1)(v) DELETE
(e)(1)(vi) may request a reduction in the number of test vehicles (or engines) . . .

(e)(2)...total sales of fewer than 3,000...

* * * * *

(f) ...submitted. Durability data submitted may be from engines previously certified by the EPA or the Air Resources Board.

* * * * *

86.090-24 Test vehicles and engines. April 11, 1989.

* * * * *

(e)(1)(i) DELETE
REPLACE WITH:
(e)(1)(i) A combined total of 3,000 California passenger cars, light-duty trucks, medium-duty vehicles, and heavy-duty engines,

(e)(1)(ii); (e)(1)(iii); (e)(1)(iv); (e)(1)(v); DELETE

(e)(1)(vi) may request a reduction in the number of test vehicles (or engines)...

(e)(2)...total sales of fewer than 3,000...

* * * * *

(f)...submitted. Durability data submitted may be from engines previously certified by the EPA or the Air Resources Board.

* * * * *

86.087-25 Maintenance. March 15, 1985.

86.088-25 Maintenance. March 15, 1985.

86.090-25 Maintenance. April 11, 1989.

86.084-26 Mileage and service accumulation; emission measurements. October 19, 1983.

86.090-26 Mileage and service accumulation; emission measurements. April 11, 1989.

86.085-27 Special test procedures. January 12, 1983.

86.090-27 Special test procedures. April 11, 1989.

86.087-28 Compliance with emission standards. March 15, 1985.

86.088-28 Compliance with emission standards. March 15, 1985.

86.090-28 Compliance with emission standards. April 11, 1989.

* * * * *

(c)(4)(iii)(A)(1) . . . For transient HC (OMHCE), formaldehyde (methanol-fueled engines and vehicles, low-emission vehicles and engines, and ultra-low-emission vehicles and engines ~~only~~), CO, and NOx, the official exhaust emission . . .

(c)(4)(iii)(A)(2) . . . For transient HC (OMHCE), formaldehyde (methanol-fueled engines and vehicles, low-emission vehicles and engines, and ultra-low-emission vehicles and engines ~~only~~), CO, and NOx, the official exhaust emission . . .

*   *   *   *   *

86.091-28 Compliance with emission standards. April 11, 1989.

*   *   *   *   *

(c)(4)(iii)(A)(1) . . . For transient HC (OMHCE), formaldehyde (methanol-fueled engines and vehicles, low-emission vehicles and engines, and ultra-low-emission vehicles and engines ~~only~~), CO, and NOx, the official exhaust emission . . .

(c)(4)(iii)(A)(2) . . . For transient HC (OMHCE), formaldehyde (methanol-fueled engines and vehicles, low-emission vehicles and engines, and ultra-low-emission vehicles and engines ~~only~~), CO, and NOx, the official exhaust emission . . .

*   *   *   *   *

86.087-29 Testing by the Administrator. January 24, 1984.

86.088-29 Testing by the Administrator. March 15, 1985.

86.090-29 Testing by the Administrator. April 11, 1989.

86.091-29 Testing by the Administrator. April 11, 1989.

86.087-30 Certification. August 30, 1985.

86.088-30 Certification. March 15, 1985.

86.090-30 Certification. April 11, 1989.

86.091-30 Certification. April 11, 1989.

86.079-31 Separate certification. September 8, 1977.

86.079-32 Addition of a vehicle or engine after certification. September 8, 1977.

86.079-33 Changes to a vehicle or engine covered by certification. September 8, 1977.

86.082-34 Alternative procedure for notification of additions and changes. November 2, 1982.

86.087-35 Labeling. Labels shall comply with the requirements set forth in the "California Motor Vehicle Emission Control Label Specifications", as last amended ______________.

86.085-37 Production vehicles and engines. January 12, 1983.

86.087-38 Maintenance instructions. March 15, 1985.

86.084-40 Automatic expiration of reporting and recordkeeping requirements. September 25, 1980.

Subpart L - Nonconformance Penalties for Gasoline-Fueled and Diesel Heavy-Duty Engines and Heavy-Duty Vehicles, Including Light-Duty Trucks

86.1101-87 Applicability. August 30, 1985.

* * * * *

...applicable for 1988 and later model year gasoline and diesel heavy-duty engines and heavy-duty vehicles.

* * * * *

86.1102-87 Definitions. August 30, 1985.

86.1103-87 Criteria for availability of nonconformance penalties. August 30, 1985.

86.1104-87 Determination of upper limits. August 30, 1985.

86.1105-87 Emission standards for which nonconformance penalties are available. December 31, 1985.

86.1106-87 Production compliance auditing. August 30, 1985.

* * * * *

(b) A 50-state engine or vehicle configuration with engines available for sale in California fails a Selective Enforcement...

* * * * *

(c) A 50-state engine or vehicle configuration with engines available for sale in California, for which an NCP has been previously...

* * * * *

86.1107-87 Testing by the Administrator. August 30, 1985.

86.1108-87 Maintenance of records. August 30, 1985.

86.1109-87 Entry and access. August 30, 1985.

86.1110-87 Sample selection. August 30, 1985.

86.1111-87 Test procedures for PCA testing. August 30, 1985.

86.1112-87 Determining the compliance level and reporting of test results. August 30, 1985.

86.1113-87 Calculation and payment of penalty. December 31, 1985.

* * * * *

(a)(3)(iv)...not affect the previous year's penalty. In calculating AAFi for the California heavy-duty engines, it shall be equal to the value of n as is used federally.

* * * * *

(g)(1)(ii)...payable to: Air Pollution Control Fund, c/o Executive Officer, Air Resources Board, P.O. Box 2815, Sacramento, CA 95812.

* * * * *

(g)(3)...date to: Chief, Mobile Source Division, Air Resources Board, 9528 Telstar Avenue, El Monte, CA 91731 and Director, Manufacturers Operations...

* * * * *

(h)...PCA take place. The refund to manufacturers shall be made from the Air Pollution Control Fund. The amount refunded will be as follows...

* * * * *

86.1114-87 Suspension and voiding of certificates of conformity. August 30, 1985.

Subpart N, Emission Regulations for New Otto-cycle and Diesel Heavy-Duty Engines; Gaseous and Particulate Exhaust Test Procedures

86.1301-84 Scope; applicability. November 16, 1983.

86.1301-88 Scope; applicability. March 15, 1985.

86.1301-90 Scope; applicability. April 11, 1989.

86.1302-84 Definitions. November 16, 1983.

86.1303-84 Abbreviations. November 16, 1983.

86.1304-84 Section numbering; construction. November 16, 1983.

86.1304-90 Section numbering; construction. April 11, 1989.

86.1305-84 Introduction; structure of subpart. November 16, 1983.

86.1305-90 Introduction; structure of subpart. April 11, 1989.

86.1306-84 Equipment required and specification; overview. November 16, 1983.

86.1306-88 Equipment required and specification; overview. March 15, 1985.

86.1306-90 Equipment required and specification; overview. April 11, 1989.

86.1308-84 Dynamometer and engine equipment specifications. December 10, 1984.

86.1309-84 Exhaust gas sampling system; gasoline-fueled engines. November 16, 1983.

86.1309-90 Exhaust gas sampling system; gasoline-fueled and methanol-fueled Otto-cycle engines. April 11, 1989.

* * * * *

(a)(3)...For methanol-fueled engines, the sample lines for the methanol and formaldehyde samples are heated to 235° +/- 15°F (113° +/- 8°C).

* * * * *

86.1311-84 Exhaust gas analytical system; CVS bag sample. November 16, 1983.

86.1311-88 Exhaust gas analytical system; CVS bag sample. August 29, 1986.

86.1313-84 Fuel specifications. December 10, 1984.

86.1313-90 Fuel specifications. April 11, 1989.

* * * * *

(a)(3) Methanol fuel used in service accumulation of methanol-fueled otto-cycle engines shall be representative of commercially available methanol fuel. Methanol used in fuel for exhaust emission testing shall be chemical grade methanol. For fuel-flexible vehicles and engines, the gasoline used for blending fuel for use in service accumulation shall be representative of commercial regular unleaded gasoline which will be generally available through retail outlets. Gasoline used for blending fuel for use in emission testing shall conform with the unleaded gasoline specification noted in paragraph (a) above.

Fuel additives and ignition improvers intended for use in methanol test fuels shall be subject to the approval of the Executive Officer. In order for such approval to be granted, a manufacturer must demonstrate that emissions will not be adversely affected by the use of the fuel additive or ignition improver.

*   *   *   *   *

ADD SUBPARAGRAPH (e) TO READ:
(e) Natural Gas and Liquefied Petroleum Gas Test Fuel.
(e)(1) Natural Gas Test Fuel. Natural gas used in service accumulation shall be representative of commercial natural gas which is generally available. Natural gas meeting the specifications below, or substantially equivalent specifications approved by the Executive Officer, shall be used in exhaust emission testing.

Natural Gas Emission Test Fuel Specification

Specification	Value	Tolerance	Calculation Method
Wobbe Number	1350	+/- 0.5%	ASTM D 1945 Using AGA Bulletin No. 36
Hydrocarbons (expressed as percent of total organic carbon present)			
Methane	88%	+/- 0.5%	ASTM D 1945
Ethane	8%	+/- 0.3%	ASTM D 1945
C_3 and higher HC	4%	+/- 0.2%	ASTM D 1945
C_6 and higher HC	0.5%	maximum	ASTM D 1945
Total unsaturated HC	0.5	maximum	ASTM D 2650
Other Species (expressed as mole percent)			
Hydrogen	0.1%	maximum	ASTM D 2650
Carbon Monoxide	0.1%	maximum	ASTM D 2650

Other Requirements

1. Free from liquids over the entire range of temperatures and pressures encountered in the engine and fuel system.
2. Free from solid particulate matter.

(e)(2)
Liquefied Petroleum Gas Test Fuel. Liquefied petroleum gas used in service accumulation shall be representative of commercial liquefied petroleum gas which is generally available through retail outlets. Liquefied petroleum gas used in exhaust and evaporative emission testing shall conform to NGPA HD-5 specification.

(e)(3)
The specification range of the fuels to be used under paragraphs (e)(1) and (e)(2) of this section shall be reported in accordance with 86.090-21(b)(3).

86.1314-84 Analytical gases. December 10, 1984.

86.1316-84 Calibration; frequency and overview. December 10, 1984.

86.1316-90 Calibration; frequency and overview. April 11, 1989.

86.1318-84 Engine dynamometer system calibrations. November 16, 1983.

86.1319-84 CVS calibration. December 10, 1984.

86.1319-90 CVS calibration. April 11, 1989.

86.1320-88 Gas meter or flow instrumentation calibration; particulate measurement. December 16, 1987.

86.1320-90 Gas meter or flow instrumentation calibration; particulate, methanol, and formaldehyde measurement. April 11, 1989.

86.1321-84 Hydrocarbon analyzer calibration. December 10, 1984.

86.1321-90 Hydrocarbon analyzer calibration. April 11, 1989.

86.1322-84 Carbon monoxide analyzer calibration. November 16, 1983.

86.1323-84 Oxides of nitrogen analyzer calibration. December 10, 1984.

86.1324-84 Carbon dioxide analyzer calibration. November 16, 1983.

86.1326-84 Calibration of other equipment. November 16, 1983.

86.1326-90 Calibration of other equipment. April 11, 1989.

86.1327-84 Engine dynamometer test procedures; overview. December 10, 1984.

86.1327-88 Engine dynamometer test procedures; overview. March 15, 1985.

86.1327-90 Engine dynamometer test procedure; overview. April 11, 1989.

* * * * *

(a)...sample collection impingers (or capsules) for formaldehyde (HCHO). A bag or continuous sample of the dilution air...

* * * * *

86.1330-84 Test sequence, general requirements. November 16, 1983.

86.1330-90 Test sequence, general requirements. April 11, 1989.

86.1332-84 Engine mapping procedures. December 10, 1984.

86.1332-90 Engine mapping procedures. April 11, 1989.

86.1333-84 Transient test cycle generation. November 16, 1983.

86.1333-90 Transient test cycle generation. April 11, 1989.

86.1334-84 Pre-test engine and dynamometer preparation. December 10, 1984.

86.1335-84 Optional forced cool-down procedure. December 10, 1984.

86.1335-90 Optional forced cool-down procedure. April 11, 1989.

86.1336-84 Engine starting and restarting. March 15, 1985.

86.1337-84 Engine dynamometer test run. November 16, 1983.

86.1337-88 Engine dynamometer test run. March 15, 1985.

86.1337-90 Engine dynamometer test run. April 11, 1989.

86.1338-84 Emission measurement accuracy. November 16, 1983.

86.1340-84 Exhaust sample analysis. December 10, 1984.

86.1340-90 Exhaust sample analysis. April 11, 1989.

86.1341-84 Test cycle validation criteria. March 15, 1985.

86.1341-90 Test cycle validation criteria. April 11, 1989.

86.1342-84 Calculations; exhaust emissions. March 15, 1985.

86.1342-90 Calculations; exhaust emissions. April 11, 1989.

* * * * *

(d) Meaning of symbols:

* * * * *

(1)(ii) . . . (101.3 kPa) pressure; or, if gaseous fuels are being used, 18.64 g/ft^3 for natural gas and 17.28 g/ft^3 for <u>liquefied petroleum gas, assuming an average carbon to hydrogen</u> ratio of 1:3.803 for natural gas and 1:2.656 for liquefied petroleum gas, at 68^{o}F and 760 mm Hg pressure. The Executive Officer may approve other density values deemed appropriate by a manufacturer.

*   *   *   *   *

(3)(v)(A) $CO_e = (1-0.01925CO_{2e} - 0.000323R)C)_{em}$ for gasoline and petroleum diesel fuel, with hydrogen to carbon ratio of 1.85:1.

(3)(v)(B) $CO_e = [1-(0.01 + 0.005HCR)CO_{2e} - 0.00323R]CO_{em}$ for methanol fuel, where HCR is hydrogen to carbon ratio as measured for the fuel used. For natural gas and liquefied petroleum gas, HCR is assumed to be 2.656 and 3.802 respectively.

*   *   *   *   *

(8)(i) K_H = Humidity correction factor.

(ii) For gasoline-fueled, gaseous-fuel, and methanol-fueled diesel engines: $K_H = 1/[1-0.0047(H-75)]$ (or for SI units, ...

*   *   *   *   *

86.1344-84 Required information. December 10, 1984.

86.1344-88 Required information. March 15, 1985.

86.1344-90 Required information. April 11, 1989.

Subpart P - Emission Regulations for New Gasoline-Fueled and Methanol-Fueled Otto-Cycle Heavy-Duty Engines and New Gasoline-Fueled and Methanol-Fueled Otto-Cycle Light-Duty Trucks; Idle Test Procedures

86.1501-84 Scope, applicability. December 10, 1984.

86.1501-90 Scope, applicability. April 11, 1989.

86.1502-84 Definitions. November 16, 1983.

86.1503-84 Abbreviations. November 16, 1983.

86.1504-84 Section numbering; construction. November 16, 1983.

86.1504-90 Section numbering; construction. April 11, 1989.

86.1505-84 Introduction; structure of subpart. November 16, 1983.

86.1505-90 Introduction; structure of subpart. April 11, 1989.

86.1506-84 Equipment required and specifications; overview. November 16, 1983.

86.1506-90 Equipment required and specifications; overview. April 11, 1989.

86.1509-84 Exhaust gas sampling system. November 16, 1983.

86.1511-84 Exhaust gas analysis system. November 16, 1983.

86.1513-84 Fuel specifications. *[~~July 7, 1986~~]* November 16, 1983.

86.1513-87 Fuel specifications. July 7, 1986.

86.1513-90 Fuel specifications. January 8, 1988.

86.1514-84 Analytical gases. November 16, 1983.

86.1516-84 Calibration; frequency and overview. November 16, 1983.

86.1519-84 CVS calibration. November 16, 1983.

86.1522-84 Carbon monoxide analyzer calibration. November 16, 1983.

86.1524-84 Carbon dioxide analyzer calibration. November 16, 1983.

86.1526-84 Calibration of other equipment. November 16, 1983.

86.1527-84 Idle test procedure; overview. November 16, 1983.

86.1530-84 Test sequence; general requirements. November 16, 1983.

86.1537-84 Idle test run. November 16, 1983.

86.1540-84 Idle exhaust sample analysis. November 16, 1983.

|| 86.1542-84 Information required. December 10, 1984.

86.1544-84 Calculation; idle exhaust emissions. March 15, 1985.

Appendix I-Urban Dynamometer Schedules.

(f)(1) EPA Engine Dynamometer Schedule for Heavy-Duty Gasoline-Fueled Engines. December 10, 1984.

Appendix XII - Tables for Production Compliance Auditing of Heavy-Duty Engines and Heavy-Duty Vehicles.

Additional Requirements

1. Any reference to vehicle or engine sales throughout the United States shall mean vehicle or engine sales in California.

2. Regulations concerning EPA hearings, EPA inspections, and specific language on the Certificate of Conformity, shall not be applicable to these procedures.

3. Any reference made to Selective Enforcement Auditing (SEA) shall not be applicable to these procedures except as explicitly stated in regards to nonconformance penalties.

4. In addition to the standards and provisions specified in CFR Section 86.091-10 (emission standards for 1991 and later model year otto-cycle heavy-duty engines and vehicles), the following formaldehyde emission levels as measured under transient operating conditions shall not be exceeded for dedicated methanol and fuel-flexible vehicles and engines:

	(g/bhp-hr)
1993-1995	0.10
1996 and Subsequent	0.05

The following formaldehyde emission levels as measured under transient operating conditions shall not be exceeded for 1992 and subsequent low-emission vehicles and ultra-low-emission vehicles operating on any fuel.

	(g/bhp-hr)
1992 and Subsequent Low-Emission Vehicles	0.050
1992 and Subsequent Ultra-Low-Emission Vehicles	0.025

5. All dedicated methanol-fueled and fuel-flexible vehicles and engines shall comply with the requirements which are applicable to heavy-duty gasoline-fueled Otto-cycle vehicles and engines, except where otherwise noted. In particular, for fuel-flexible vehicles and engines, a manufacturer's proposed durability demonstration program, as required in sections 86.091-21(b)(4)(iii)(A) and 86.091-23(b)(1)(ii), shall provide for the assessment of the durability of the engine in operation with methanol and gasoline, as well as intermediate mixtures of both fuels. A manufacturer's proposed mileage and service accumulation, as required in section ~~86.088-24(c)~~ 86.090-24(c), shall be conducted on methanol ~~in such a manner to simulate the alternating use of both fuels~~ .

The provisions of section 86.091-28(c), "Compliance with emissions standards," shall be used to determine the compliance requirements with the emission standards. For fuel-flexible vehicles and engines, the noted deterioration factors shall be determined from testing conducted with gasoline fuel. However, as an assurance that fuel-flexible vehicles and engines will comply with applicable exhaust emission standards throughout their useful lives when operated on methanol fuel, the manufacturer shall demonstrate that exhaust emissions tests conducted with methanol fuel at the beginning, middle, and end of the durability service accumulation schedule do not exceed the applicable exhaust emission standards. For certification to be granted, the vehicle or engine may not exceed applicable certification exhaust emission standards.

6. All dedicated gaseous-fuel, dual-fuel, and multi-fuel Otto-cycle engines (and vehicles), except engines derived from existing Diesel engines, shall comply with the requirements which are applicable to heavy-duty Otto-cycle engines, except where otherwise noted.

7. Nonmethane hydrocarbon emissions shall be measured in accordance with the "California Nonmethane Hydrocarbon Test Procedures".

8. For dual-fuel or multi-fuel gaseous engines and vehicles, the noted deterioration factors shall be determined separately for operation on each type of fuel or combination of fuels that the engine is designed to use. For certification to be granted, the provisions of 86.091-28(c) must be met separately for emissions using each type and combination of fuels.

APPENDIX E-4: NON-METHANE ORGANIC GAS TEST PROCEDURES

PROPOSED

State of California
AIR RESOURCES BOARD

CALIFORNIA NON-METHANE ORGANIC GAS TEST PROCEDURES

Adopted: ________________

State of California

AIR RESOURCES BOARD

California Non-Methane Organic Gas Test Procedures

With the establishment of non-methane organic gas (NMOG) standards, sampling and analytical procedures for non-methane hydrocarbons (NMHC) will be supplemented to include procedures for measuring oxygenated hydrocarbons. Analytical procedures utilizing gas or high pressure liquid chromatography, developed by the Monitoring and Laboratory Division of the Air Resources Board (ARB) are described for use as the standard operating procedures for measuring alcohols, NMHCs, and carbonyls. These procedures are described in detail in accompanying chapters designated M.L.D. No. 101, 102, 103A and 104. Alternate procedures may be used if shown to yield equivalent results, and if approved in advance by the Executive Officer of the ARB. The 'California Non-Methane Organic Gas Test Procedures' consist of the aforementioned M.L.D. procedures and the 'California Non-Methane Hydrocarbon Procedures.'

For manufacturers which choose to utilize the reactivity adjustment factors determined by the ARB for different vehicle/fuel systems, the following analyses shall be performed to determine emissions of NMOG:

Fuel	NMHC*	NMHC by GC	Alcohols	Carbonyls
Gasoline	X			X
Alcohol	X		X	X
LPG+	X			X
CNG+		X		X
Diesel		X		X

(*) NMHC -- requires 'California Non-Methane Hydrocarbon Test Procedures' be used to quantify emissions of NMHC.

Carbonyls -- requires emissions of aldehydes and ketones be quantified according to M.L.D. No. 104.

Alcohols -- requires emissions of alcohols be quantified according to M.L.D. 101.

NMHC by GC -- requires emissions of non-methane hydrocarbons be quantified according to M.L.D. No. 102 and 103A.

(+) LPG = Liquified Petroleum Gas; CNG = Compressed Natural Gas.

For manufacturers of gasoline-, alcohol-, LPG- or CNG-fueled vehicles, which choose to develop reactivity adjustment factors unique to their vehicle/fuel system, exhaust NMOG emissions would need to be fully speciated. These requirements would also apply to flexible- or dual-fueled vehicles, and hybrid electric vehicles which utilize a combustion engine as a range extender. Gaseous hydrocarbon samples would be analyzed according to M.L.D. No. 102 and 103A; all non-oxygenated hydrocarbons and ethers containing 12 or fewer carbon atoms would need to be identified and measured. Exhaust emissions of alcohols and carbonyls would be collected in impingers and analyzed according to M.L.D. No. 101 and 104, respectively. Only vehicles powered by alcohol fuels or gasoline containing alcohol would be required to perform tests for alcohols.

For diesel-fueled vehicles, the development of speciated hydrocarbon emission profiles is of concern from a technical standpoint. To facilitate the process of identifying a test procedure, and reactivity adjustment factor for certifying vehicles, manufacturers are encouraged to provide comments and/or suggestions on sampling and analytical procedures. At present, sampling and analysis procedures would be developed according to the following interim guidelines:

> A sample of motor vehicle diesel exhaust at an elevated temperature would be passed through a porous polymer sample tube (XAD-2 or equivalent). The sample tube would be extracted with a solvent (methylene chloride or equivalent), concentrated and introduced into a gas chromatograph/flame ionization detector (GC/FID) with a high temperature capillary column (SE-30 or similar) for analysis. Other methods may be utilized but should be submitted to the Board for prior approval. See also Technical Reports: EPA/AA/CTAB/PA/80-5 (September, 1980) "Comparison of Gas Phase Hydrocarbon from Light-Duty Gasoline Vehicles and Light-Duty Vehicles Equipped with Diesel Engines," and F. Black and L. High (SAE No. 790422) "Methodology for Determining Particulate and Gaseous Diesel Hydrocarbon Emissions."

Because the composition of the exhaust emissions from diesel-fueled vehicles is highly complex, complete identification of each hydrocarbon species is not practical. The staff recommends reporting of data grouped according to carbon number rather than fully speciated data. Additional complexity is recognized for hydrocarbons that would be identified from the n-C15 and n-C25 peaks, which are known to coexist in the vapor and particulate stages. Hydrocarbons which are larger than n-C25 are generally found only in the particulate form.

It is recognized that the speciation of hydrocarbons in the vapor stage does not address the composition of the particulate portion of the sample. Specifically, the soluble organic fraction of the diesel particulates would not be subject to speciated analysis. Emission profiles from diesel-fueled vehicles would also need to include measurements of carbonyls according to M.L.D. No. 104.

State of California
AIR RESOURCES BOARD

CALIFORNIA NON-METHANE HYDROCARBON TEST PROCEDURES

Adopted: May 24, 1978

California Non-Methane Hydrocarbon
Test Procedures

I. Introduction

This procedure describes a method for determining the non-methane hydrocarbon exhaust emissions from motor vehicles. A gas chromatograph combined with a flame ionization detector is the basic instrument package specified in this procedure for direct measurement of methane concentrations. An example of the system is shown in figure 1. The SAE Recommended Practice J1151 is a reference on generally accepted GC principles and analytical techniques for this specific application. Other applicable forms of instrumentation such as those described in SAE J1151 which prove to yield equivalent results to those specified in this procedure may be used subject to the approval of the Executive Officer.

II. Instruments

A gas chromatograph (GC) along with a flame ionization detector (FID) shall be used for measuring the methane (CH_4) concentrations of exhaust samples collected in bags from a constant volume sampler (CVS). The instrument performance specifications shall be in compliance with the principles established in SAE Recommended Practice J1151.

III. Sampling Procedures

A 10-minute warm-up period shall be allowed for the GC/FID and recorder. A calibration of the instrument with a 1.0% gravimetric CH_4 in air, traceable to the National Bureau of Standards (NBS), shall be done immediately before and after each CVS-75 test analysis. Exhaust samples for CH_4 analysis shall be taken from the sample bags of the CVS unit. Either the syringe method or the continuous method may be used.

A. Syringe Method

Two samples (30 cc each) from each exhaust gas bag and one 30 cc sample from each background bag (for a total of 9 samples for each cold start CVS test) shall be taken with laboratory quality syringes. The analysis for each syringe sample shall be performed in the following sequence:

1. Calibrate instrument for anticipated range.
2. Inject 10 cc of sample from the syringe into the sample loop of the GC.
3. Push sample through columns and read instrument response.
4. Backflush column.
5. Verify calibration point.

Steps 2 through 4 shall be repeated until all 9 syringe samples have been analyzed.

B. Continuous Sampling Method

An independent sampling system for CH_4 analysis is required. This sampling system may be integral with the existing CVS sampling train.

1. Component Parts

The CH_4 sampling system consists of the following component parts:

a) A pump to transfer gas samples from CVS sample bags to the GC.

b) A filter to remove particulate matter from the sample gases.

c) A flow control valve (V_1) to regulate gas flow to the GC.

d) A selector valve (V_2) for directing either sample or calibration gas to the GC.

e) A recorder to provide permanent records of calibration gas and sample gas measurements.

f) A control panel

- to start or stop the sample pump;
- to operate the selector valve;
- to start or stop the recorder.

2. Sampling Sequence

a) Calibrate instrument for anticipated range.

b) Connect sample bag to quick-connector.

c) Start pump to fill sample loop of the GC.

d) Push sample through column and read instrument response.

e) Backflush.

f) Stop pump.

g) Disconnect sample bag.

h) Verify calibration point.

Perform steps (b) through (g) for all 6 sample bags.

IV. Instrument Calibration

A series of standard gases (1.0% gravimetric CH_4 in air) traceable to NBS, covering the range of concentrations within which sample gases may be expected to fall, should be used for calibration. The calibration procedures, operating parameters and instrument performance specifications should be in compliance with principles established in SAE J1151, Sections 7.3, 7.4, 8 and 9.

V. Sample Analysis

The response of the GC recorder is in millimeters of peak height. Divide peak height by the mm/ppm from the calibration data to obtain ppm methane.

The non-methane hydrocarbon emissions shall be computed as follows:

(1) Definitions

HC_e = Hydrocarbon exhaust bag concentration in PPM carbon equivalent.

HC_d = Hydrocarbon ambient bag concentration in PPM carbon equivalent.

CH_{4_e} = Methane exhaust bag concentration in PPM carbon equivalent.

CH_{4_d} = Methane ambient bag concentration in PPM carbon equivalent.

CO_e = CO exhaust bag concentration in PPM (uncorrected for CO_2 and H_2O removal).

CO_{2_e} = CO_2 exhaust bag concentration in PPM.

D_{phase} = Distance per phase (calculated from roll count).

HC_{mass} = Mass in grams of hydrocarbon per test phase.

CH_{4mass} = Mass in grams of methane per test phase.

$NMHC_{mass}$ = Mass in grams of non-methane hydrocarbon per test phase.

V_{mix} = Total dilute exhaust volume in cubic feet per test phase corrected to 68°F and 760 mm Hg.

$$DF = \frac{13.4}{(HC_e + CO_e + CO_{2e}) \times 10^{-4}}$$

$$W_f = 1 - \frac{1}{DF}$$

HC = Density of Hydrocarbon in grams/ft^3 (16.33 gm/ft^3 @ 68°F + 760 mm Hg assuming a C:H ratio of 1:1.85)

$$HC_{conc} = HC_e - W_f\,(HC_d)$$

$$CH_{4conc} = CH_{4e} - W_f\,(CH_{4d})$$

$$NMHC_{conc} = HC_{conc} - CH_{4conc}$$

$$NMHC_{mass} = \frac{NMHC_{conc} \times HC \times V_{mix}}{10^6}$$

$NMHC_{wm}$ = Weighted Mass of Non-Methane Hydrocarbon in grams/mile

$$NMHC_{Wm} = 0.43\,\frac{(NMHC_{mass_1} + NMHC_{mass_2})}{(D_{phase_1} + D_{phase_2})} + 0.57\,\frac{(NMHC_{mass_3} + NMHC_{mass_2})}{(D_{phase_3} + D_{phase_2})}$$

(2) Sample Calculation

Data	HC_e	HC_d	CH_{4e}	CH_{4d}	CO_e	CO_{2e}	V_{mix}	D_{phase}
1. Cold Trans.	49.3	20.3	10.74	2.20	152.0	15466	2713.2	3.598
2. Cold Stab.	25.2	19.1	7.23	2.20	23.0	9845	4650.5	3.902
3. Hot Trans.	27.7	18.5	7.79	2.20	46.6	13626	2707.9	3.589

$$DF_1 = \frac{13.4}{(49.3 + 152.0 + 15466) \times 10^{-4}} = 8.553$$

$$W_{f_1} = 1 - \frac{1}{8.553} = 0.883$$

$$HC_{conc_1} = 49.3 - 0.883(20.3) = 31.375 \text{ ppm}$$

$$CH_{4conc_1} = 10.74 - 0.883\ (2.2) = 8.797 \text{ ppm}$$

$$NMHC_{conc_1} = (31.375 - 8.797) = 22.578 \text{ ppm}$$

$$NMHC_{mass_1} = \frac{22.578 \times 16.33 \times 2713.2}{10^6} = 1.000 \text{ grams}$$

Similarly,

$$NMHC_{mass_2} = 0.176 \text{ grams}$$

$$NMHC_{mass_3} = 0.233 \text{ grams}$$

$$NMHC_{W_m} = 0.43 \times \frac{(1.00 + 0.176)}{(3.598 + 3.902)} + 0.57 \times \frac{(0.233 + 0.176)}{(3.589 + 3.902)}$$

$$NMHC_{W_m} = .099 \text{ gm/mi}$$

ARB System for
Continuous Sampling
of Methane

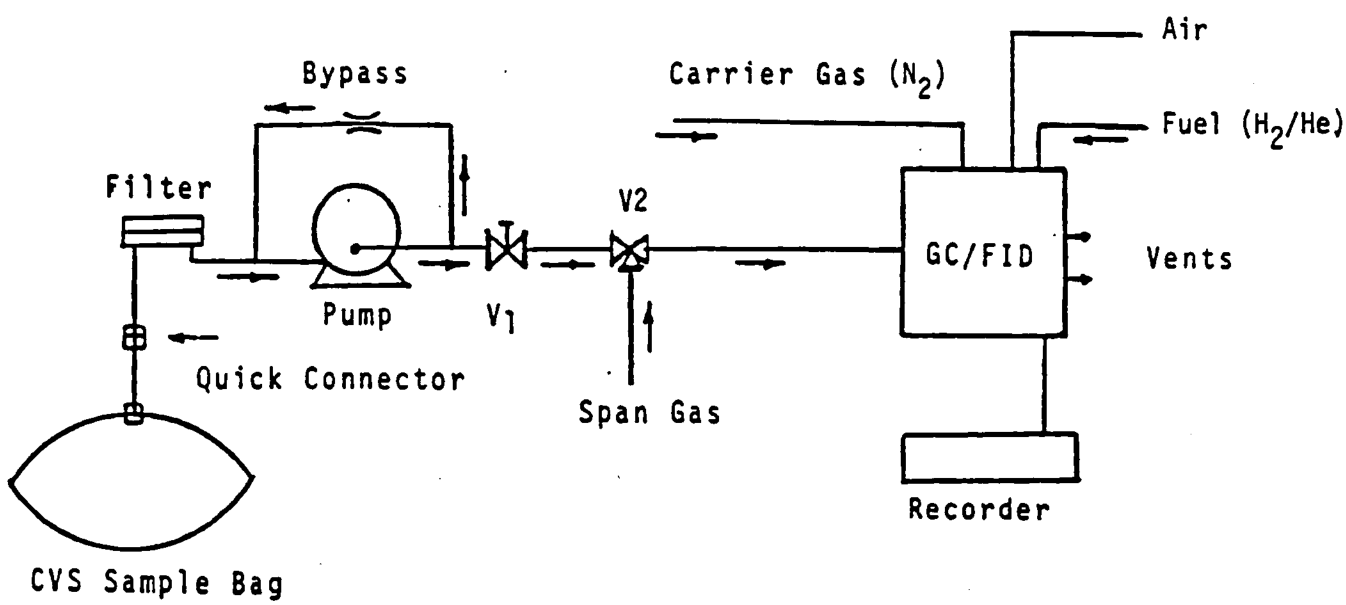


Figure 1

07837

November 1989

AIR RESOURCES BOARD

PROCEDURE FOR THE ANALYSIS OF AUTOMOTIVE EXHAUST FOR METHANOL AND ETHANOL

SOP NO. MLD 101

Southern Laboratory Branch
Monitoring and Laboratory Division
State of California
9528 Telstar Avenue
El Monte, CA 91731

CALIFORNIA AIR RESOURCES BOARD
MONITORING AND LABORATORY DIVISION

Procedure for the Analysis of Automotive Exhaust for Methanol and Ethanol

1 <u>Introduction</u>

1.1 This document describes a method of analyzing automotive exhaust for methanol and ethanol in the range of 4 to 1200 micrograms per 15 mL of solution.

1.2 This procedure is based on a method developed by the EPA[1] which involves flowing diluted engine exhaust through deionized water contained in glass impingers and analyzing this solution by gas chromatography.

Lower alcohol concentrations may be analyzed by increasing the volume of exhaust sampled.

1.4 Higher concentrations may be determined by quantitatively diluting the aqueous impinger solution with deionized water or extending the calibration curve to include higher standard concentrations.

1.5 There are no known chemical interferences with this method.

2 <u>Method</u>

2.1 The sampling procedure is conducted according to the Federal Test Procedure (FTP), specified in the Code of Federal Regulations[2].

2.2 Two impingers, each containing 15 mL deionized water, are used for each mode of the FTP Constant Volume Sampler (CVS) test.

2.3 Upon completion of the CVS test, the impinger samples are analyzed by gas chromatography.

3 <u>Apparatus</u>

3.1 The analytical system is comprised of the following:

3 — Varian model 3400 or 6000 gas chromatagraph (GC), equipped with DB-Wax Megabore column and flame ionization detector (FID).

3.1.2 Varian model 8000 autosampler.

3.1.3 Perkin Elmer LIMS (or similar) data system.

4 <u>Reagents</u>

4.1 Methanol, 99.9%, HPLC grade, EM Science or equivalent.

4.2 Ethanol, absolute.

4.3 ASTM Type I deionized water.

4.4 A stock solution of 1% methanol and 1% ethanol is prepared by diluting 1.00 mL each of methanol and ethanol to 100.0 mL with deionized water.

4.4.1 A working standard of 50 ppm is prepared by successive dilutions of the stock solution. Figure 1 illustrates a typical chromatogram.

4.4.2 A control standard is also prepared by successive dilutions of the stock solution. The concentration should be approximately that of the samples, typically 25 to 35 ppm.

4.4.3 All standards should be refrigerated during storage.

4.5 If other alcohols are found in the exhaust, standards containing these additional compounds should be prepared, as above.

5 <u>Procedure</u>

5.1 Each of six graduated fritted midget impingers is filled with 15 mL of deionized water.

5.2 The six impingers are divided into three sets of two; a seventh is used as a trap. Each set is connected in series and placed in an ice bath (fig. 2). Dilute exhaust is drawn through the three pairs of impingers during FTP modes 1, 2, and 3, respectively.

5.3 The impingers are allowed to warm to room temperature and the solution contained in each impinger is transferred to a vial and sealed.

5.3.1 Samples should be refrigerated (ca. 40°F or lower) if immediate analysis is not feasible or if reanalysis at a later date may be required.

5.4 A 1 microliter aliquot of each unmodified sample is injected via autosampler into a gas chromatograph, configured as follows:

Column:	DB-wax, 30 m, 0.53 mm ID, 1.0 micron film thickness
Carrier gas:	Helium at 5 mL/min
Make-up gas:	Helium at 25 mL/min
Detector:	FID, Hydrogen at 30 mL/min and Air at 300 mL/min
Injector:	Packed column injector with megabore adapter insert; on-column injection.
Temperature:	50°C (1 min), 50°C to 100°C (5°C/min), 100°C(1 min)
Data system:	LIMS data system

5.4.1 Two calibration standards, one control standard, and one water blank are analyzed daily at the beginning of each set of samples.

5.4.2 A replicate analysis is performed on one of every ten samples, or at least once per day.

5.4.3 The calibration standard is repeated every ten samples and again at the end.

5.5 The above procedure may be modified for analysis of higher alcohols by increasing the final temperature and adjusting the temperature ramping to achieve good separation of the desired components. In addition, a less polar impinger solution would be required to capture alcohols above C_5.

6 Calculations

6.1 The concentration of each alcohol is determined by comparing the sample peak area with that of an external standard:

$$\text{Concentration}_{sample} = \frac{\text{Concentration}_{standard} \times \text{Area}_{sample}}{\text{Area}_{standard}}$$

6.1.1 This concentration is then used to calculate the total amount of methanol in each impinger:

Mass (ug) = Concentration (ppm) x 15 mL x density (g/mL)

6.2 A multi-point calibration wa conducted on May 24, 1989, to determine the linearity of r.sponse of the FID.

6.2.1

	Conc	Area Counts				Std.	%
	(PPM)	Run #1	Run #2	Run #3	Mean	Dev.	RSD
Methanol:	0.5	112	106	--	109	--	--
	1.0	224	208	--	216	--	--
	5.0	1142	1117	1101	1120	14.6	1.30
	10	2285	2349	2336	2323	23.9	1.03
	50	11997	11776	11539	11770	162	1.38
	100	23530	23486	23038	23351	192	0.824

	(PPM)	Run #1	Run #2	Run #3	Mean	Dev.	RSD
Ethanol:	0.5	163	144	--	153.5	--	--
	1.0	323	310	--	316.5	--	--
	5.0	1642	1638	1619	1633	8.69	0.532
	10	3267	3357	3325	3316	32.3	0.973
	50	17053	16739	16378	16723	239	1.43
	100	33555	33561	33110	33409	183	0.547

Note that only two analyses of the 0.5 and 1.0 ppm solutions were successfully completed on this date.

6.2.2 Linear plots of the multi-point data are shown in figs. 3 and 4. For methanol:

slope (m) = 234.02 Area Counts/ppm
intercept (b) = -12.54 Area Counts
correlation coefficient = 0.9999

For ethanol:

slope (m) = 334.41 Area Counts/ppm
intercept (b) = -21.32 Area Counts
correlation coefficient = 1.000

6.3 The precision of the GC analysis and data reduction is shown in the table below and the corresponding plots (figs. 5 and 6) for the 50 ppm standard, analyzed May 25, 1989.

Run #	MeOH Area Counts	EtOH Area Counts
1	11446	16266
2	12006	17040
3	12000	17034
4	11958	16982
5	11699	16618
6	11811	16864
7	11459	16282
8	11632	16598
9	11930	16934
10	11914	16922
Mean	11786	16754
Std. dev.	203.8	280.8
% RSD	1.73 %	1.68 %

6.4 The limit of detection (LOD) is determined from the multi-point data (6.2). Since at least three data points are required for the calculation, the 5.0 ppm standard is used.

$$LOD = \frac{|b| + (3)(\text{std. dev.})}{m}$$

$$LOD_{MeOH} = \frac{|-12.54| + (3)(20.7)}{234} = 0.32 \text{ ppm}$$

$$LOD_{EtOH} = \frac{|-21.32| + (3)(12.3)}{334.41} = 0.17 \text{ ppm}$$

The LOD could be lowered by obtaining more data points at the 0.5 or 1.0 ppm level.

7 Quality Control

7.1 Calibration and control standards (working standards) are prepared every six months and analyzed daily.

7.2 Quality Control (Q.C.) charts are maintained for both calibration and control standards.

7.2.1 The calibration standard Q.C. chart is used to monitor both instrument response and standard stability. Examples are shown in figures 7 and 8. (Note: the injection port septum was replaced following the 17th data point.)

For methanol:

Mean	=	7679
Std. dev.	=	102
% RSD	=	1.33
n	=	20

For ethanol:

Mean	=	10511
Std. dev.	=	151
% RSD	=	1.44
n	=	20

7.2.2 The control standard Q.C. chart is used to monitor the precision of results measured on different days. This will be maintained and updated daily.

7.3 A recent Chevron[3] study indicates that the stability of methanol in impinger solutions is best preserved by refrigerating or freezing the samples until such time as analysis is feasible, or if preservation of the sample is required following analysis. The Air Resources Board is currently conducting a study of the relative stability of these solutions at different temperatures. Until the completion of this study, all samples not immediately analyzed are refrigerated.

7.3.1 A 24-hour stability test was conducted following a routine dyno test. According to the above procedure, the impingers were allowed to warm to room temperature. A portion of each impinger solution was then anlyzed by GC. Meanwhile, the remaining mode 1 primary impinger solution was divided into several autosampler vials. These vials were then refrigerated. At two to three-hour intervals, a vial was removed from the refrigerater, allowed to warm to room temperature, and subsequently analyzed by GC. One vial remained in the refrigerater overnight and was analyzed the following day. In addition, the last vial analyzed had been left at room temperature for the preceding 12 hours. A plot of concentration versus the time difference between sampling and analysis is shown in fig. 9.

Mean = 2.13
Std. dev. = 0.0582
% RSD = 2.73

This study seems to indicate that refrigeration preserves the stability of impinger solutions for at least 24 hours. Further study is required to determine the stability of samples left at room temperature.

7.4 Replicate samples are run for every ten samples analyzed. For those that vary by more than 10%, all samples run that day are reanalyzed.

$$\% \text{ Difference} = \frac{\text{Difference (ppm)}}{\text{Average (ppm)}} \times 100$$

7.5 A water blank is analyzed daily to check the analytical system for contamination.

7.5.1 If the blank shows a peak (>LOD) in the region of interest, the blank is repeated.

7.5.2 If the peak area is consistent, the blank is subtracted from the standards and samples.

7.5.3 If the peak area is not consistent, the Q.C. coordinator should be consulted to determine the source of the peak, such as carry-over from a sample of high concentration.

7.6 A multi-point calibration is performed semi-annually. At this time, the precision and LOD of the method are determined.

7.6.1 A multi-point calibration is also performed when the column is changed, major instrument repair or modification is performed, or analysis of additional compounds is required.

7.7 Additional compounds may be identified by GC/Mass Spectroscopy (GC/MS) or GC/Fourier Transform Infrared Spectroscopy (GC/FTIR).

7.7.1 The presence of alcohol in samples which show an interference or an unidentified peak may be confirmed by GC/MS, GC/FTIR, or by a second GC method.

7.8 Recovery tests have not been performed, due to the instability and resulting unavailability of gas phase methanol standards.

7.10 Quality control of the sampling procedure is overseen by Mobile Sources Division.

8 References

8.1 "Characterization of Exhaust Emissions from Methanol and Gasoline Fueled Automobiles", EPA 460/3-82-004.

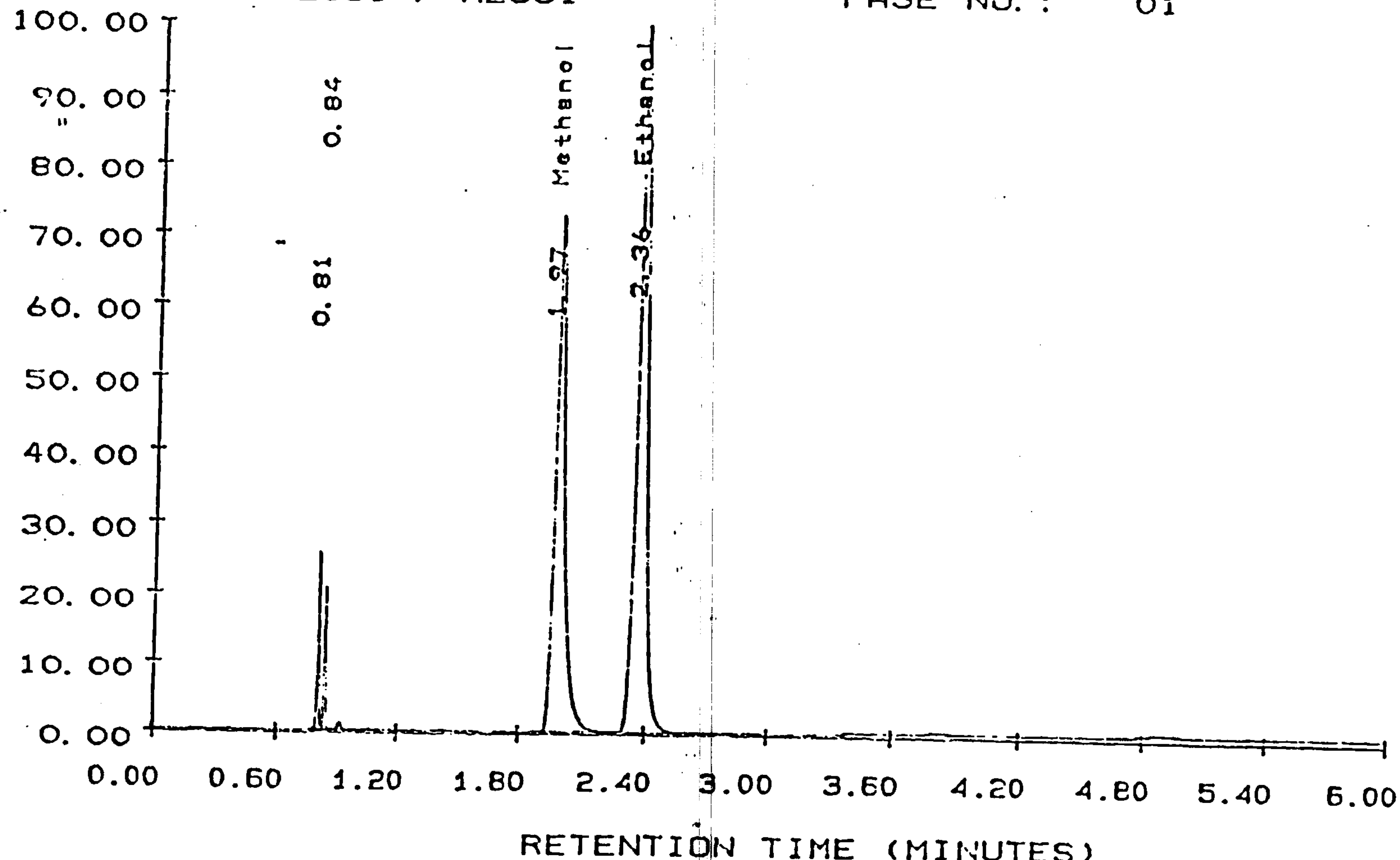
8.2 Code of Federal Regulations, Title 40, Part 86.

8.3 Horn, Jerome C., "Methanol-Fueled Light-Duty Vehicle Exhaust Emissions", Chevron Research Company internal report, 1989.

Figure 1: 50 PPM METHANOL STANDARD

SAMPLE NO. : 89005893.01
TEST NO. : ALCOH
METHOD NO. : ALC01 / ALC01

INSTRUMENT: 18
DATE TIME: 05/25/89 14:13:25
PAGE NO. : 01

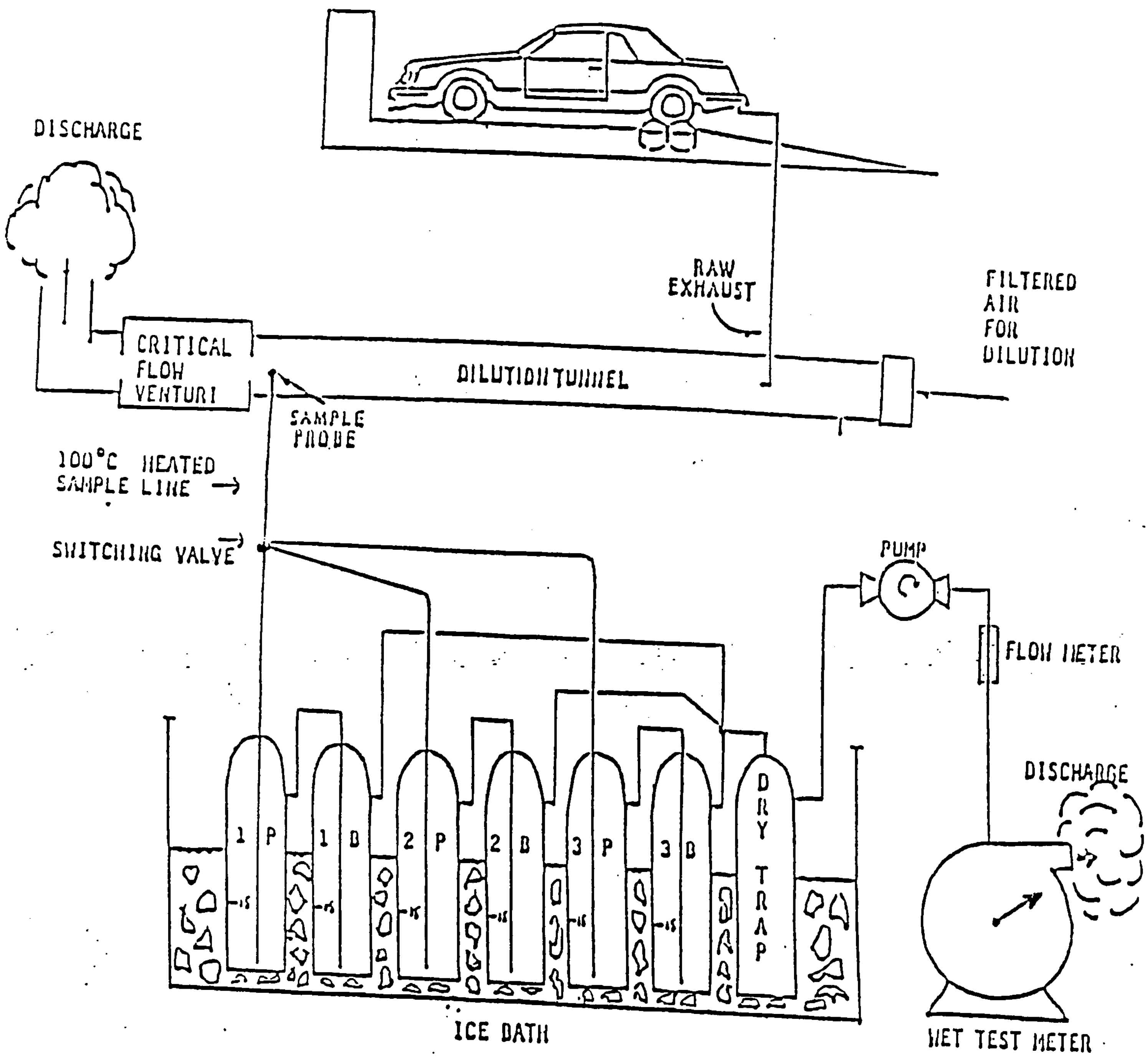


Y MAXIMUM: 545.
Y MINIMUM: 54.

START TIME: 0.00
END TIME: 6.00

Figure 2: METHANOL SAMPLING

SCHEMATIC DIAGRAM



1P = Phase #1, Primary
2P = Phase #2, Primary
3P = Phase #3, Primary

1B = Phase #1, Back up
2B = Phase #2, Back up
3B = Phase #3, Back up

Figure 3: METHANOL

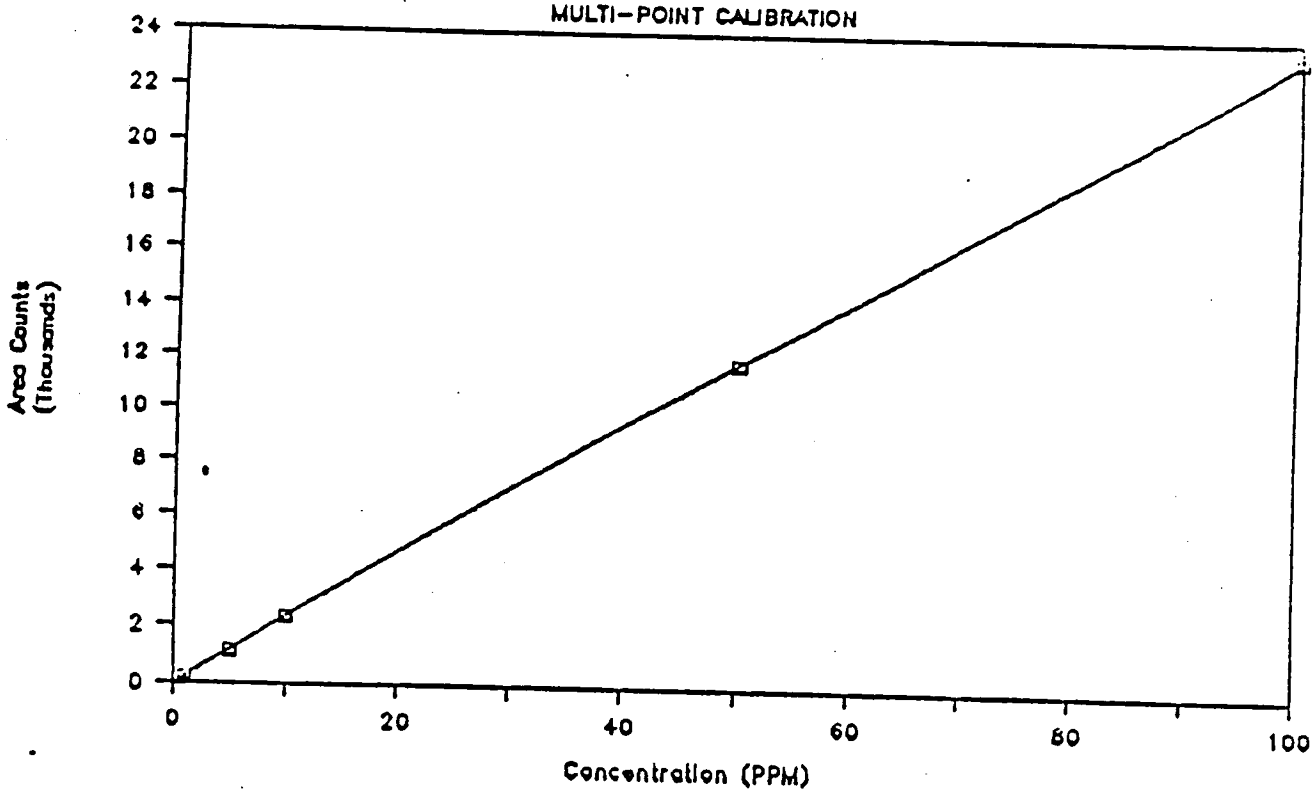
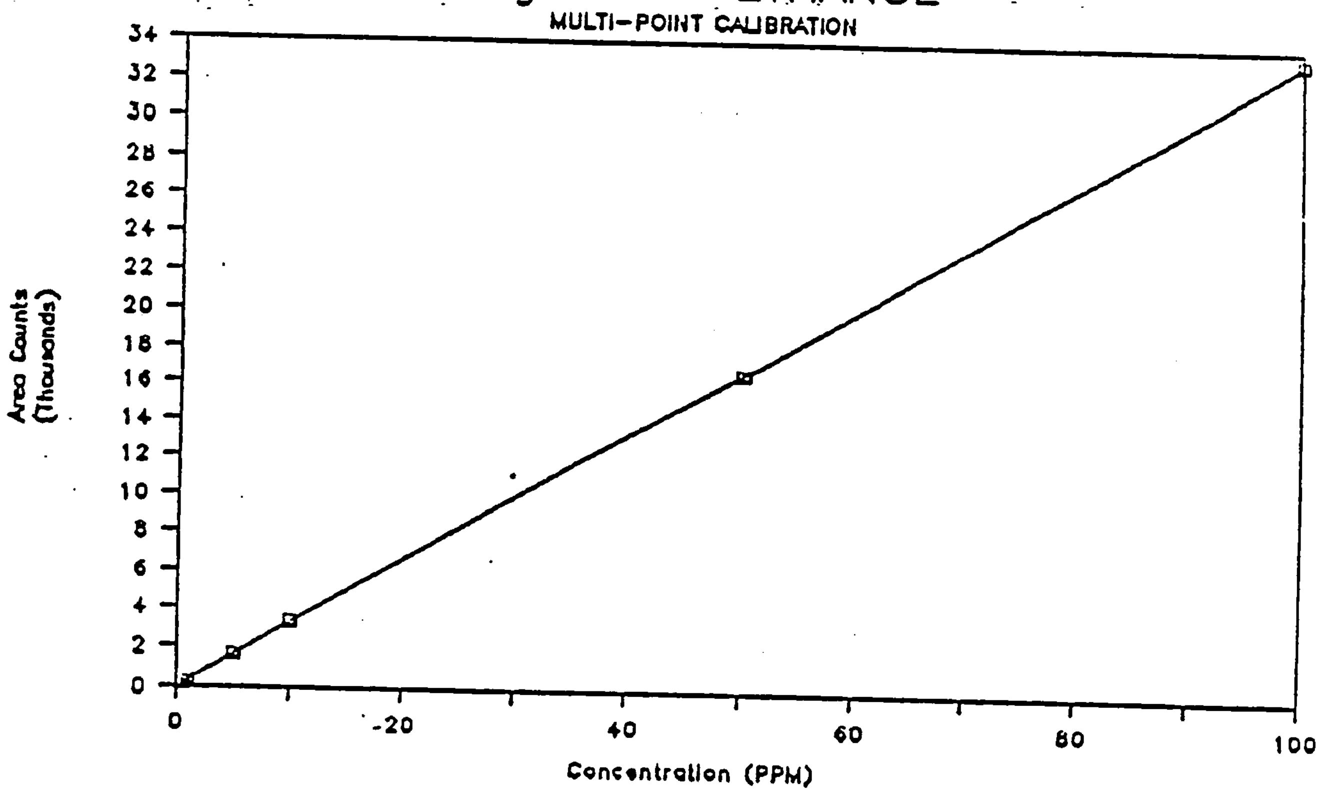


Figure 4: ETHANOL



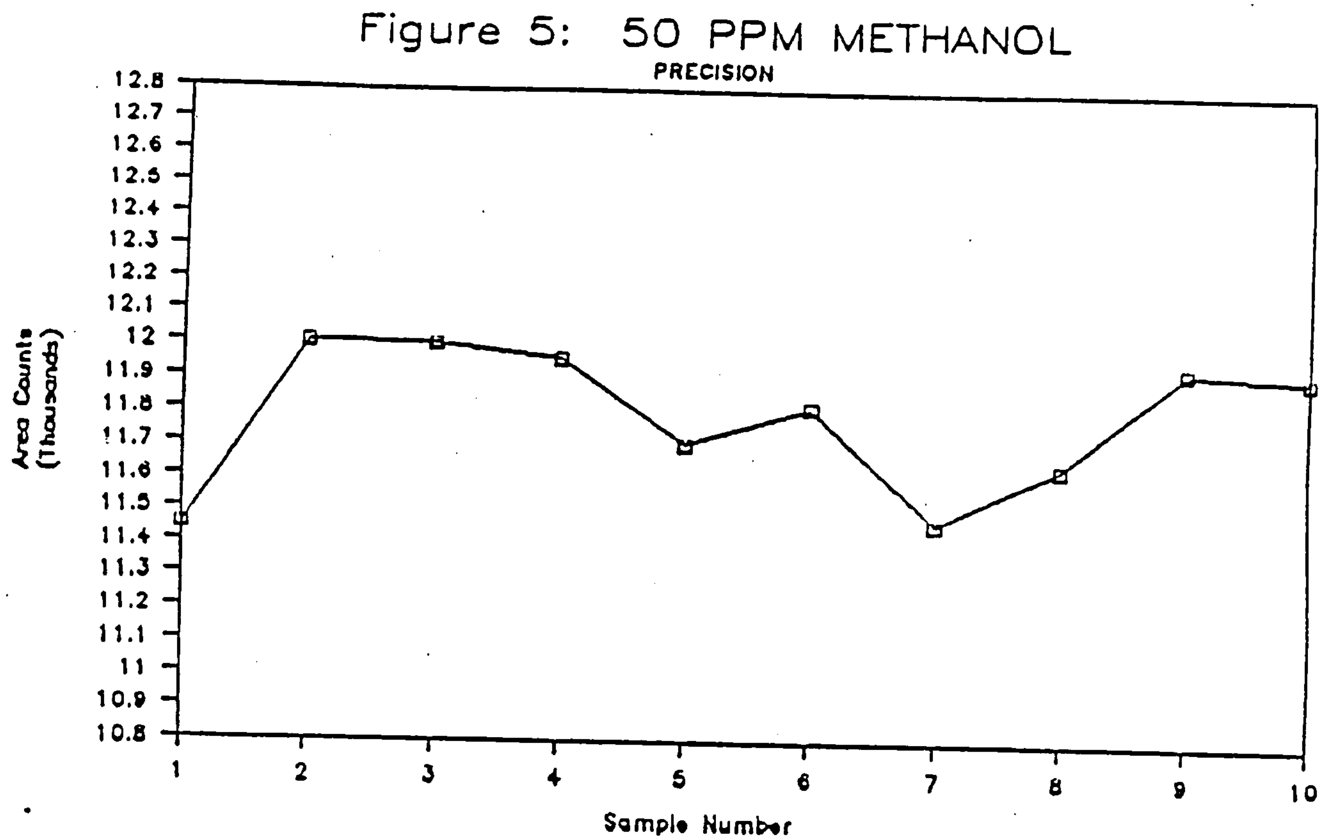


Figure 5: 50 PPM METHANOL
PRECISION
Area Counts (Thousands)
Sample Number

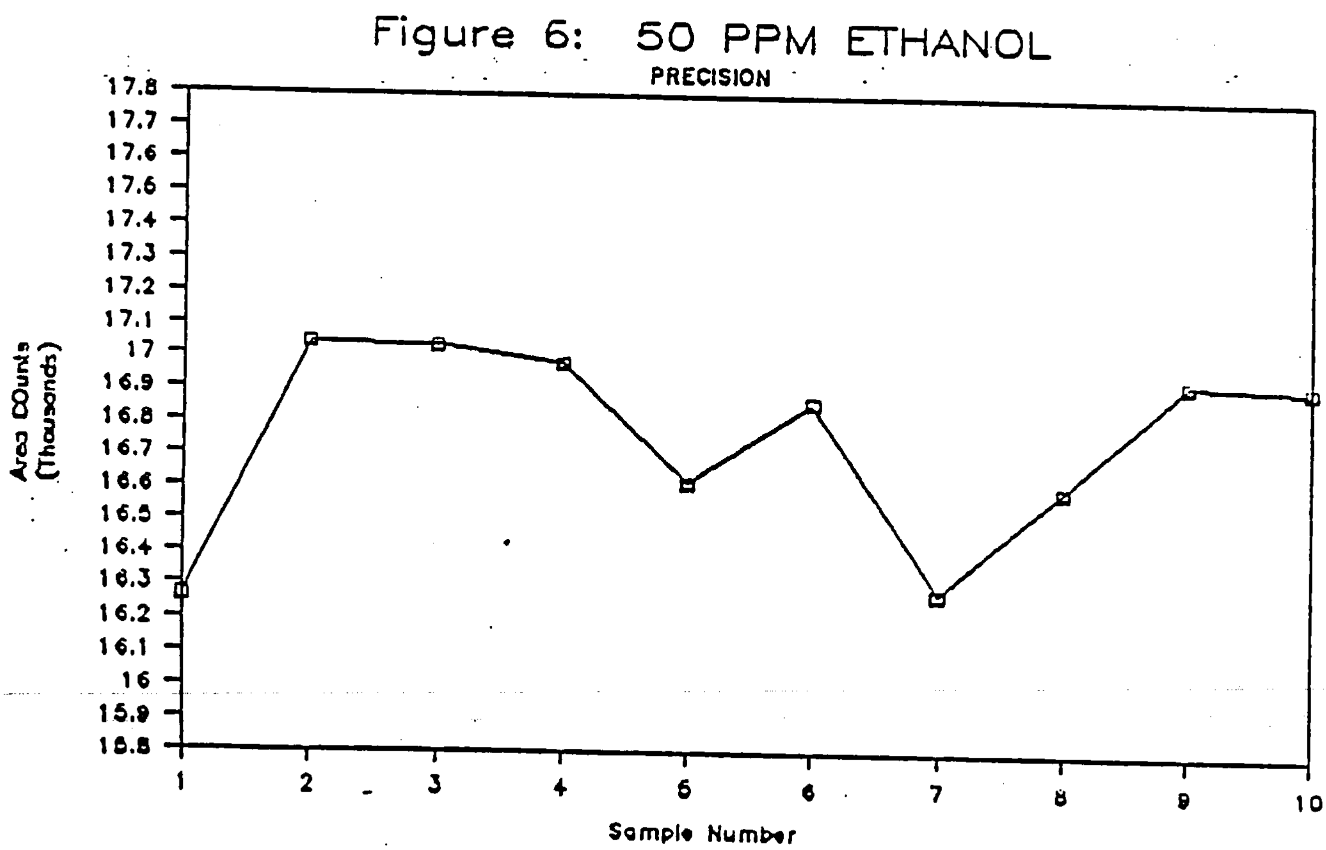


Figure 6: 50 PPM ETHANOL
PRECISION
Area COunts (Thousands)
Sample Number

07849

Figure 7: 50 PPM METHANOL

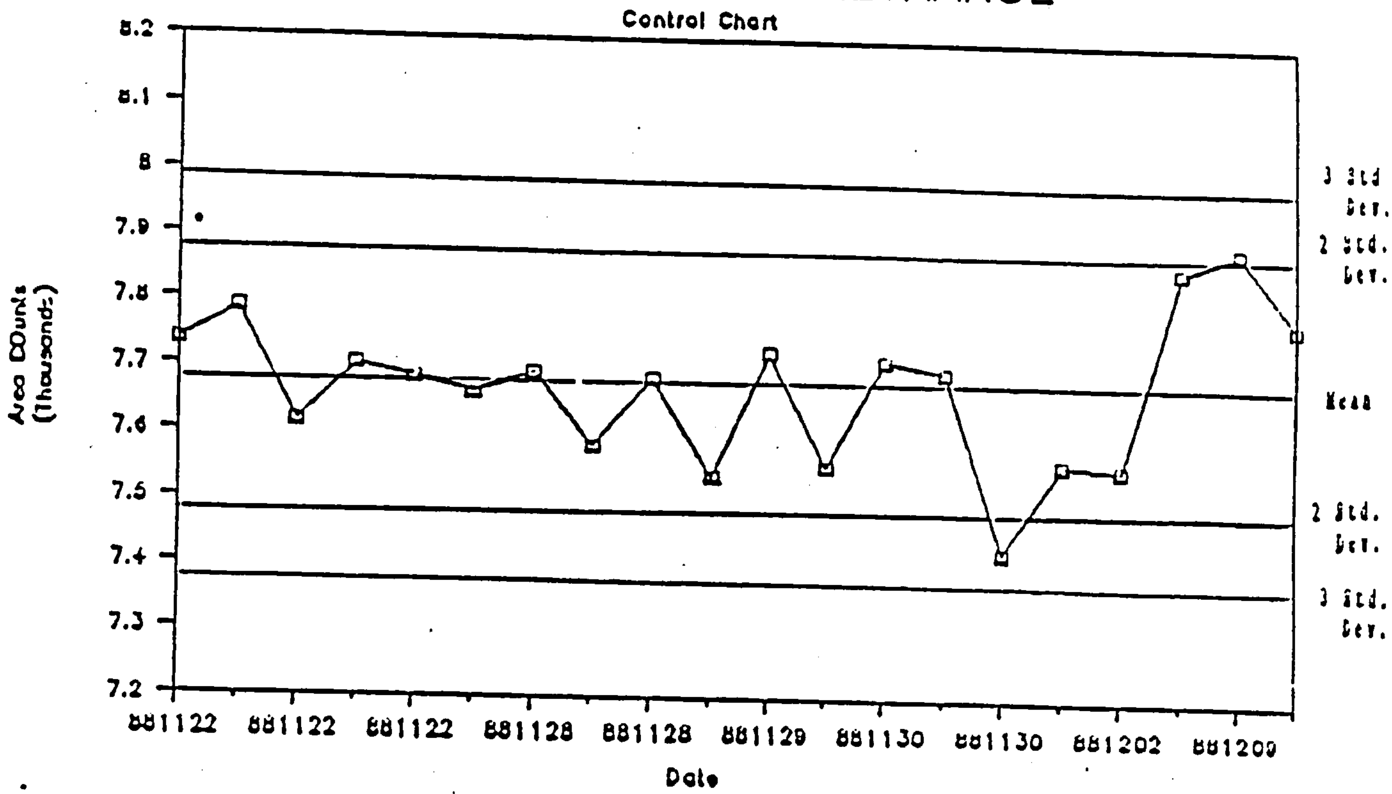


Figure 8: 50 PPM ETHANOL

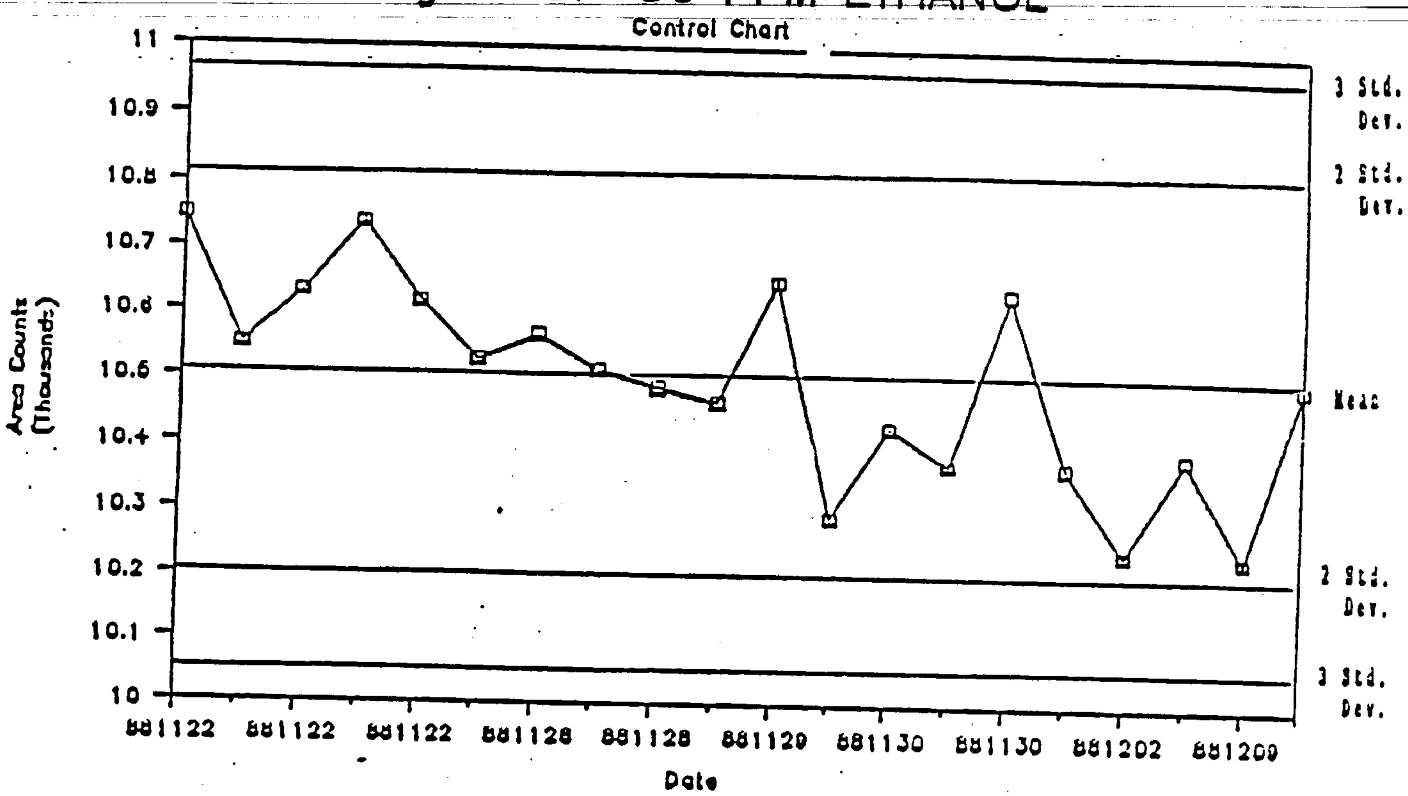


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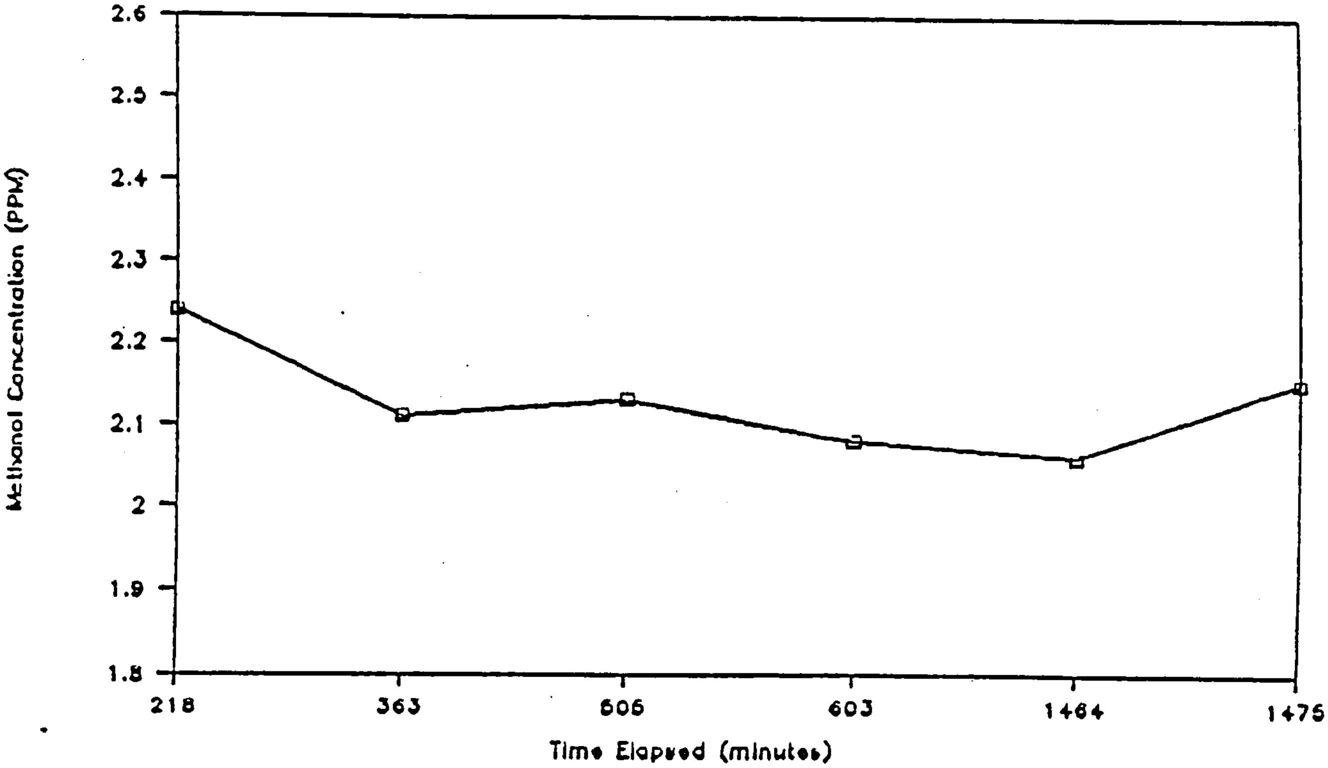
Figure 9: IMPINGER SAMPLE STABILITY



07851

November 1989

AIR RESOURCES BOARD

PROCEDURE FOR THE DETERMINATION OF C_2 TO C_5 HYDROCARBONS IN AUTOMOTIVE SOURCES SAMPLES BY GC

S.O.P. NO. MLD 102

Southern Laboratory Branch
Monitoring and Laboratory Division
State of California
9528 Telstar Avenue
El Monte, CA 91731

CALIFORNIA AIR RESOURCES BOARD
MONITORING AND LABORATORY DIVISION

PROCEDURE FOR THE DETERMINATION OF C_2 TO C_5 HYDROCARBONS IN AUTOMOTIVE SOURCES SAMPLES BY GC

1. INTRODUCTION

1.1 This procedure describes a method of determining C_2 to C_5 hydrocarbons (light-end hydrocarbons) in the range of parts per billion carbon (ppbC) from automotive sources samples. The method does not include sampling procedure.

2. METHOD SUMMARY

2.1 This is a rapid method intended for routine analysis.

2.2 A portion of the sample, received by the lab in Tedlar bags, is transferred by syringe to a gas chromatograph (GC).

2.3 The gas chromatographic analysis is performed on a packed column operated isothermally at 35 ^{o}C. Flame ionization (FID) is used for detection with pure oxygen supplied to the hydrogen to enhance its sensitivity.

2.4 The sample is injected into the GC by means of gas sampling valves. Separation of the sample hydrocarbon mixture into its component constituents takes place in the chromatographic column.

2.5 The GC data system identifies the peaks and quantifies the hydrocarbon contents by integrating the peak areas and calculating concentrations from factors determined during calibrations with standards.

3. INTERFERENCES AND LIMITATIONS

3.1 Any component (e.g., Freon group) present in the sample having a retention time very similar to that of the hydrocarbons being measured and under the operating conditions described in this method is an interference. Therefore, proof of chemical identity may require confirmation by other methods and instrumentation, e.g., GC/MS.

3.2 The concentration of hydrocarbons in the range of interest is stable for at least 72 hours in the Tedlar sampling bags (Table 1), provided the sample bags do not leak and are not exposed to bright light or excessive heat. Sampling bags must be shielded from direct sunlight to avoid losses from reaction of the reactive hydrocarbons.

4. INSTRUMENTS AND APPARATUS

4.1 Ground glass syringes (100 mL capacity) are used to transfer gaseous samples from Tedlar bags to the sample inlet of the GC.

4.2 Tedlar bags, 2 mil thickness, nominally 10 to 25 liters capacity and equipped with quick-connect fittings, are used to contain the sample from the dyno train.

4.3 A gas chromatograph (VARIAN 3300) equipped with a gas sampling valve system (Figure 1) is required. A flame ionization detector (FID) is used.

4.4 A stainless steel column (6 ft x 1/8 in) packed with phenylisocyanate Durapak 80/100 mesh is used.

4.5 A U-shaped stainless steel sample trap (10 in x 1/4 in) packed with stainless steel chips is used.

4.6 An analog recorder (SOLTEC 1241) and an electronic integrator (Perkin-Elmer LIMS 3212) for quantitation of peak areas are required.

4.7 Dewar flasks (250 mL) are used to contain liquid nitrogen or hot water.

5. REAGENTS AND MATERIALS

5.1 All gases used to support the GC analysis shall be of the highest commercial purity available.

5.2 Helium shall have a minimum purity of 99.995 % and pass through a trap immersed in liquid nitrogen to ensure purity before entering the GC.

5.3 Hydrogen shall have a minimum purity of 99.995 %.

5.4 Oxygen shall have a minimum purity of 99.6 %.

5.5 A high calibration standard in the ppmC range containing 11 hydrocarbons is prepared in a 48.5 liter glass flask. Methylbutane and pentane are introduced by means of a fixed volume liquid injection valve, while the nine other compounds are introduced in gasous form using a gas sampling valve. The concentrations of these compounds in the high calibration standard are as follows:

COMPOUND	CONC.(ppmC)	CONC.(ppm)
ethane	47.4	23.7
ethene	47.4	23.7
propane	71.1	23.7
ethyne	47.4	23.7
methylpropane	94.8	23.7
butane	94.8	23.7
propene	71.1	23.7
methylbutane	215.0	43.0
pentane	215.0	43.0
1-butene	94.8	23.7
2-methylpropene	94.8	23.7

5.6 A low calibration standard in ppbC range is prepared by transferring 50 mL of the high calibration standard into a second flask of 50 L capacity and filling with nitrogen to accomplish a 1:1000 dilution. Concentrations of compounds in the low calibration standard are as follows:

COMPOUND	CONC.(ppbC)
ethane	47.4
ethene	47.4
propane	71.1
ethyne	47.4
methylpropane	94.8
butane	94.8
propene	71.1
methylbutane	215.0
pentane	215.0
1-butene	94.8
2-methylpropene	94.8

5.7 Liquid nitrogen is used to cool the U-shaped sample cryogenic trap.

6. PROCEDURES

6.1 The air sample is analyzed for C_2 to C_5 hydrocarbons by using a cryogenic preconcentration method.

6.2 Standard operating conditions for the gas chromatograph are:

Helium carrier gas flow:	60 mL/min
Hydrogen gas flow:	40 mL/min
Oxygen gas flow:	200 mL/min
Sample valve temperature:	ambient
Heating bath temperature:	60 - 80 ^{o}C
Injector temperature:	35 ^{o}C
Column temperature:	35 ^{o}C (isothermal)
Detector temperature:	200 ^{o}C

6.3 Immerse the sample trap in liquid nitrogen and allow temperature to stabilize. The temperature equilibrium is achieved when liquid nitrogen stops boiling.

6.4 Withdraw exactly 100 mL from the sample bag with a 100 mL syringe and inject the sample into the freeze-out sample trap.

6.5 Refill the syringe with another 20 mL of helium and flush the 20 mL through the trap; then flush helium through the loop for three minutes to flush out the condensed oxygen.

6.6 Isolate the cryogenic trap by using the isolation valve, which prevents loss of sample when the trap is heated.

6.7 Replace the liquid nitrogen Dewar with a Dewar containing hot water at about 60-80 ^{o}C.

6.8 Allow sufficient time for the temperature of the trap to rise until the ice accumulated on the surface of the trap is melted completely.

6.9 Introduce the sample into the carrier gas stream by means of the injection valve.

6.10 Each separated component exits from the column through the flame ionization detector, where a reponse is generated.

6.11 Concentrations of hydrocarbons are calculated by an electronic integrator device, which has been calibrated using low calibration standard.

6.12 The peak integrations are corrected as necessary in the data system. Any misplaced baseline segments are corrected in the reconstructed chromatogram.

6.13 The peak identifications provided by the computer are checked and corrected if necessary.

6.14 The maximum retention time in this analysis is set to be 15 minutes.

6.15 After each run, the column is back-flushed with helium while the column temperature is raised and kept at 60 ^{o}C. for 20 minutes.

6.16 Before the next run, 15 minutes is needed after back-flush of column to re-establish the required temperature of the column.

6.17 The total run time is about 50 minutes.

7. CALCULATIONS

7.1 The hydrocarbon concentrations, in ppbC, are calculated by the data system using an external standard method.

Concentration = Peak Area x Calibration Factor

7.2 The calibration factor (CF) is calculated during the calibration by:

$$CF = \frac{\text{Concentration of standard}}{\text{Area of standard}}$$

7.3 Only the low calibration standard (in ppbC range) is used in the calibration run.

8. QUALITY CONTROL

8.1 A blank (pure nitrogen or helium) run is performed before the analysis of samples.

8.2 One run of the low calibration standards (Figure 2) is performed before the analysis of samples. The set of calibration factors generated by calibration run is used for quantitating sample analyses.

8.3 A duplicate run of one sample is performed daily.

8.4 A quality control chart (Figure 3) of one compound (ethane, for example) in the low calibration standard is maintained, showing into which zone the current calibration falls. (Ref 9.3):

		ethane area (count)
the upper control limit	(mean + 3*SD)	4005
the upper warning limit	(mean + 2*SD)	3808
the average value	(mean)	3414
the lower warning limit	(mean - 2*SD)	3020
the lower control limit	(mean - 3*SD)	2823

(SD stands for standard deviation)

8.5 The standard and control standard will be changed as they become available to contain more components other than ethane covering the whole range of C_2 to C_5.

8.6 A multi-point calibration is performed for 11 compounds at least annually. Ethane (Figure 4), for example:

MULTI-POINT CALIBRATION FOR ETHANE

Ethane (ppbC)	Respone Area Count
4.74	466/304/326
47.40	3185/3500/3765
474.00	31974/32379/32772
4740.00	319394/319642/323078
47400.00	2851985/2905773/2917903

The linear regression equation derived from multi-point calibration is

area count = 67.595 (concentration) + 305.81

The standard deviation for the lowest concentration level (4.74) is

87.87

The LOD of ethane equals three times standard deviation divided by slope of the linear equation (Ref 9.3).

LOD (ethane) = 3 * 87.87 / 67.595

= 3.90 ppbC

8.7 The precision test was performed for ethane (47.4 ppbC) with the following response area counts:
(3281/3311/3485/3310/3686/3350/3252/3349/3686/3759/3241/3421 3281/3229/3727/3544/3135)

population:	17
average value:	3414.53
standard deviation:	196.90
relative standard deviation:	5.77%

8.8 A stability test was performed for the eleven hydrocarbons occuring in an automotive source sample (Table 1 and 3.2). The stability test for ethane is shown as an example (Figure 5). The test result suggests that the hydrocarbons are stable for at least 72 hours in the Tedlar sampling bags.

8.9 The samples are run as soon as they arrive or within three days.

9. REFERENCE

9.1 ARB Method 104

9.2 Standard Test Method for C_1 Through C_5 Hydrocarbons in the Atmosphere by Gas Chromatography, ASTM Standards on Chromatography (1981).

9.3 Compendium of Methods for the Determinatin of Toxic Organic Compounds in Ambient Air, EPA manual (1984).

Table 1 Stability test for eleven light-end hydrocarbons

CALIFORNIA AIR RESOURCES BOARD
MONITORING AND LABORATORY
ORGANIC ANALYSIS SECTION

Test Name : LIGHT END HYDROCARBONS
Instrument : VARIAN GC-3300 (FID) WITH LIMS

Project Code : MS22SAL
Analyst : CHIN LAI

Logged-in Date : 06/05/89
Analysis Date : 06/05/89
Report Date : 06/13/89

LIMS Sample Number : 89006238
Client's Sample ID : 6/5 STABILITY

No.	Compound Name	0 PPBC	2 PPBC	8 PPBC	90 PPBC
		TIME (HR.)			
1.	ETHANE	170	180	170	190
2.	ETHENE (ETHYLENE)	1600	1600	1600	1600
3.	PROPANE	49	47	49	51
4.	ETHYNE (ACETYLENE)	420	390	450	430
5.	METHYLPROPANE (ISOBUTANE)	71	71	82	87
6.	BUTANE	310	300	320	330
7.	PROPENE (PROPYLENE)	670	640	700	610
8.	METHYLBUTANE (ISOPENTANE)	500	520	570	510
9.	PENTANE	330	320	360	320
10.	1-BUTENE	130	130	140	120
11.	2-METHYLPROPENE (ISOBUTYLENE)	240	240	180	190
11	Compounds Measured Total	4490	4438	4621	4438

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Figure 1 Diagram of gas sampling valve system

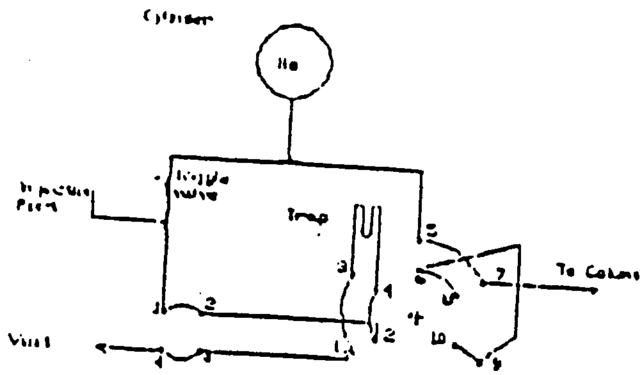


Fig. 1 (A) Sample

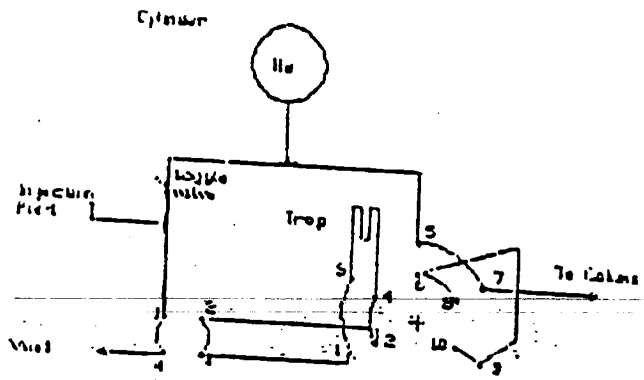


Fig. 1 (B) Isolate

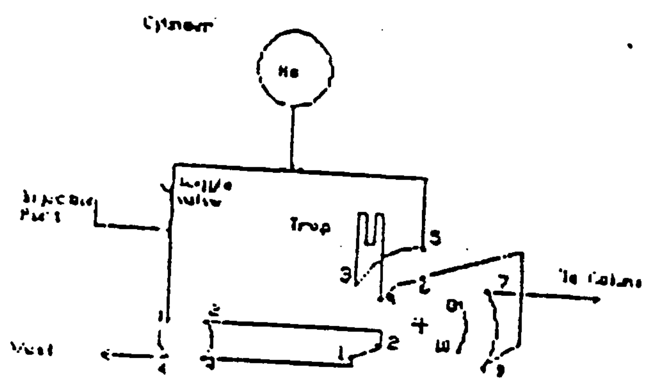


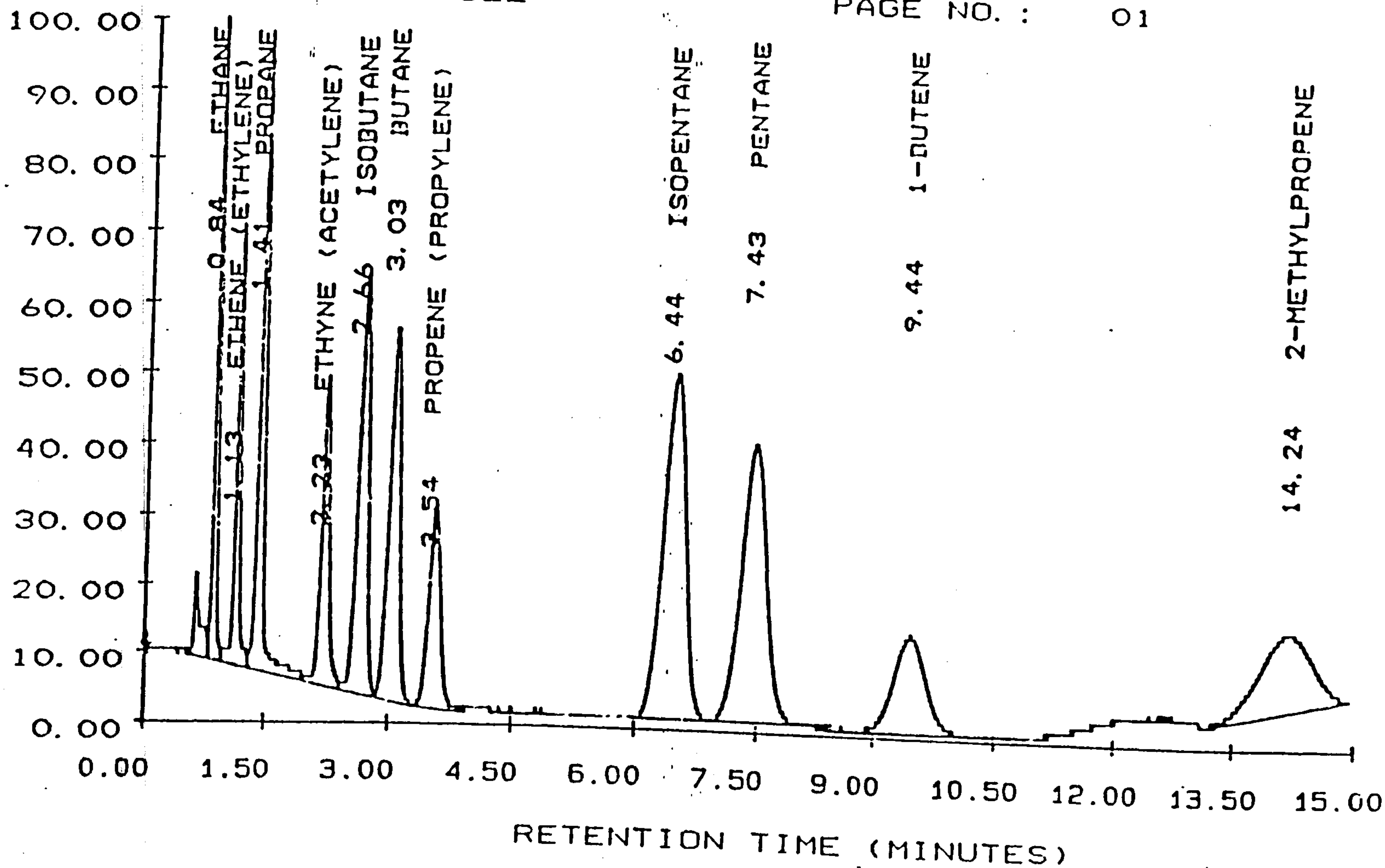
Fig. 1 (C) Inject

Figure 2

6/13 CAL2 (Low Calibration)

SAMPLE NO. : 89006601.01
TEST NO. : LEHC1
METHOD NO. : CL2 / CL2

INSTRUMENT: 30
DATE TIME: 06/13/89 09:30:05
PAGE NO. : 01



Y MAXIMUM: 196.
Y MINIMUM: 71.

START TIME: 0.00
END TIME: [illegible]

Figure 3 Quality control chart for ethane

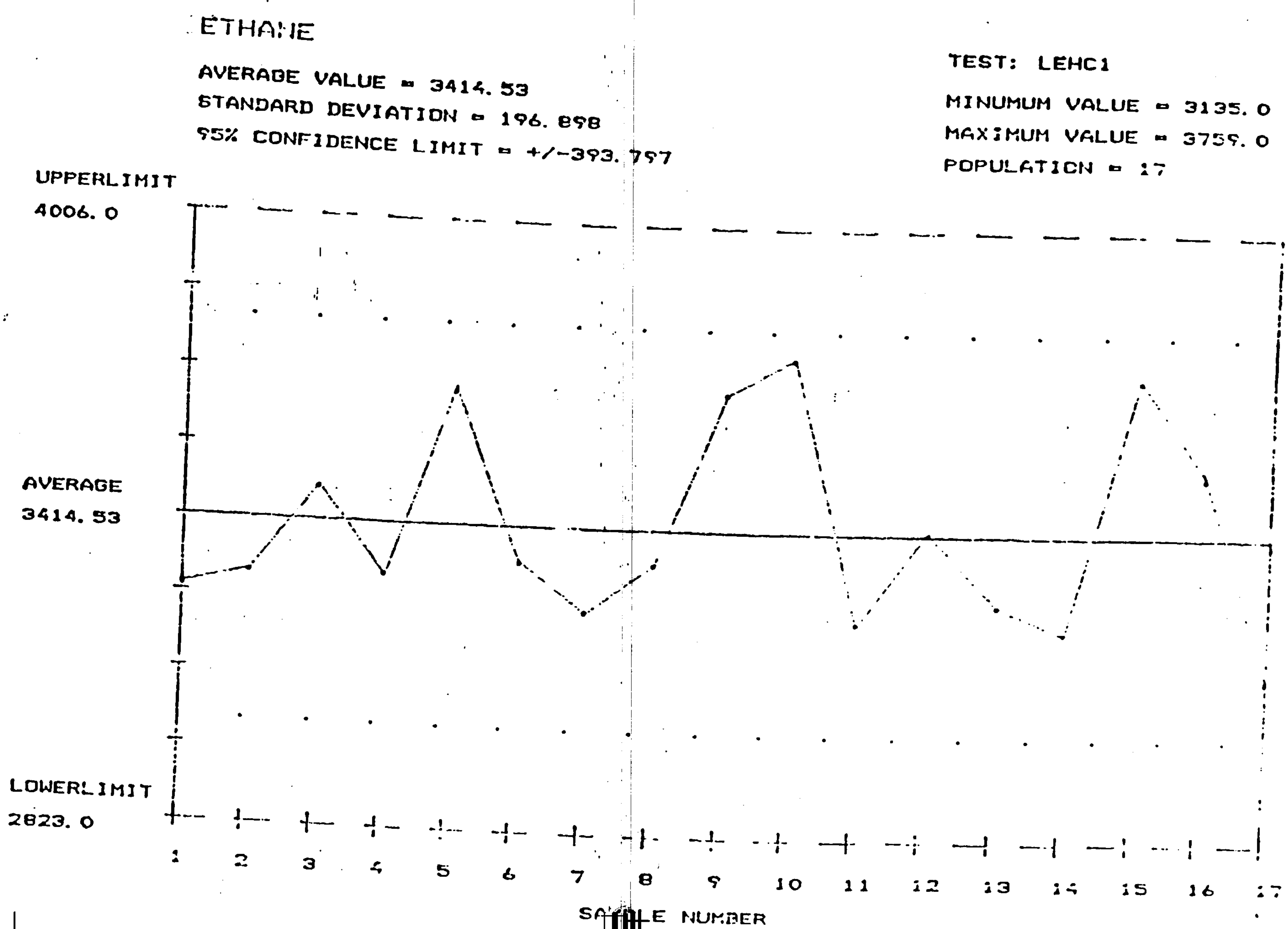
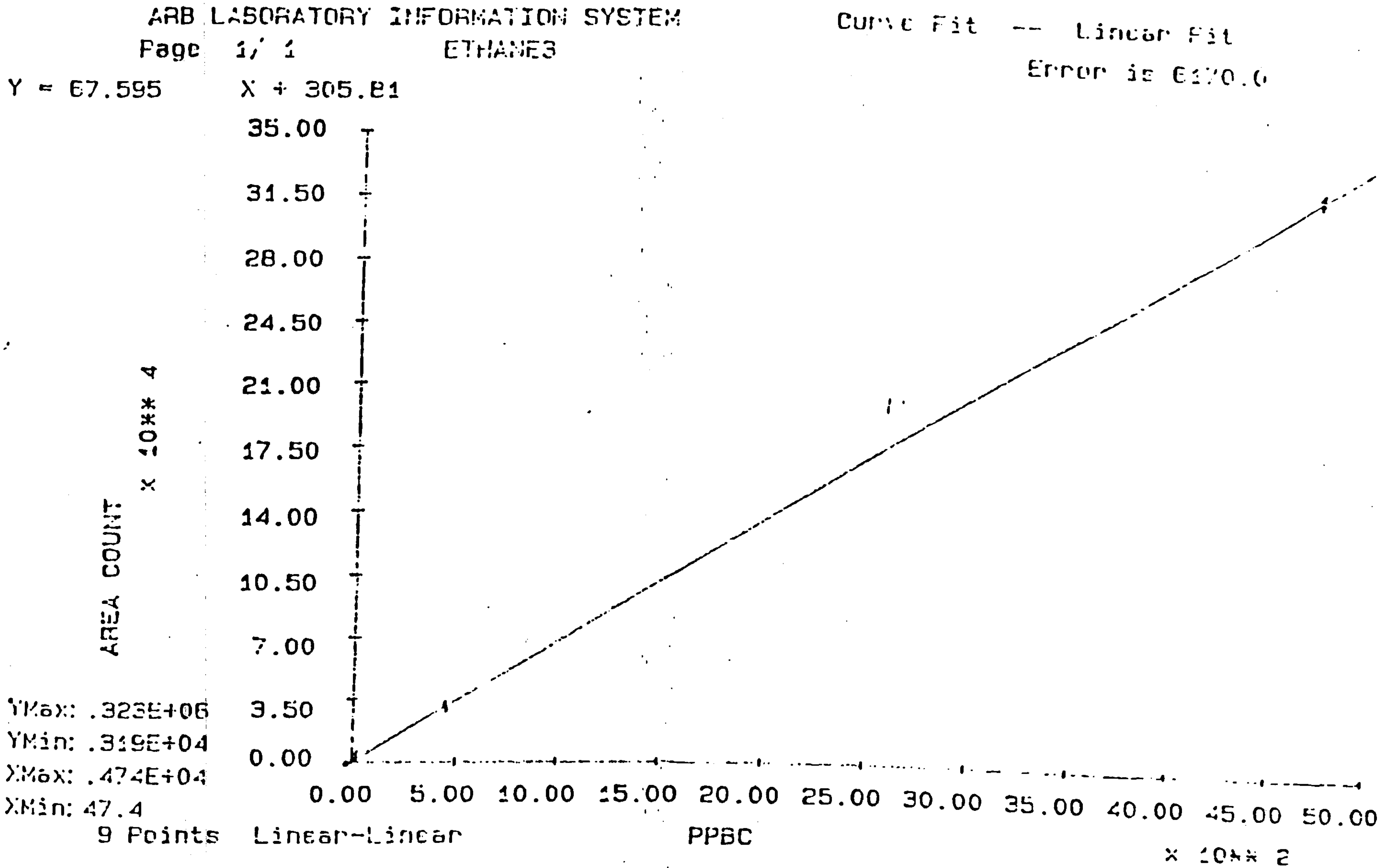


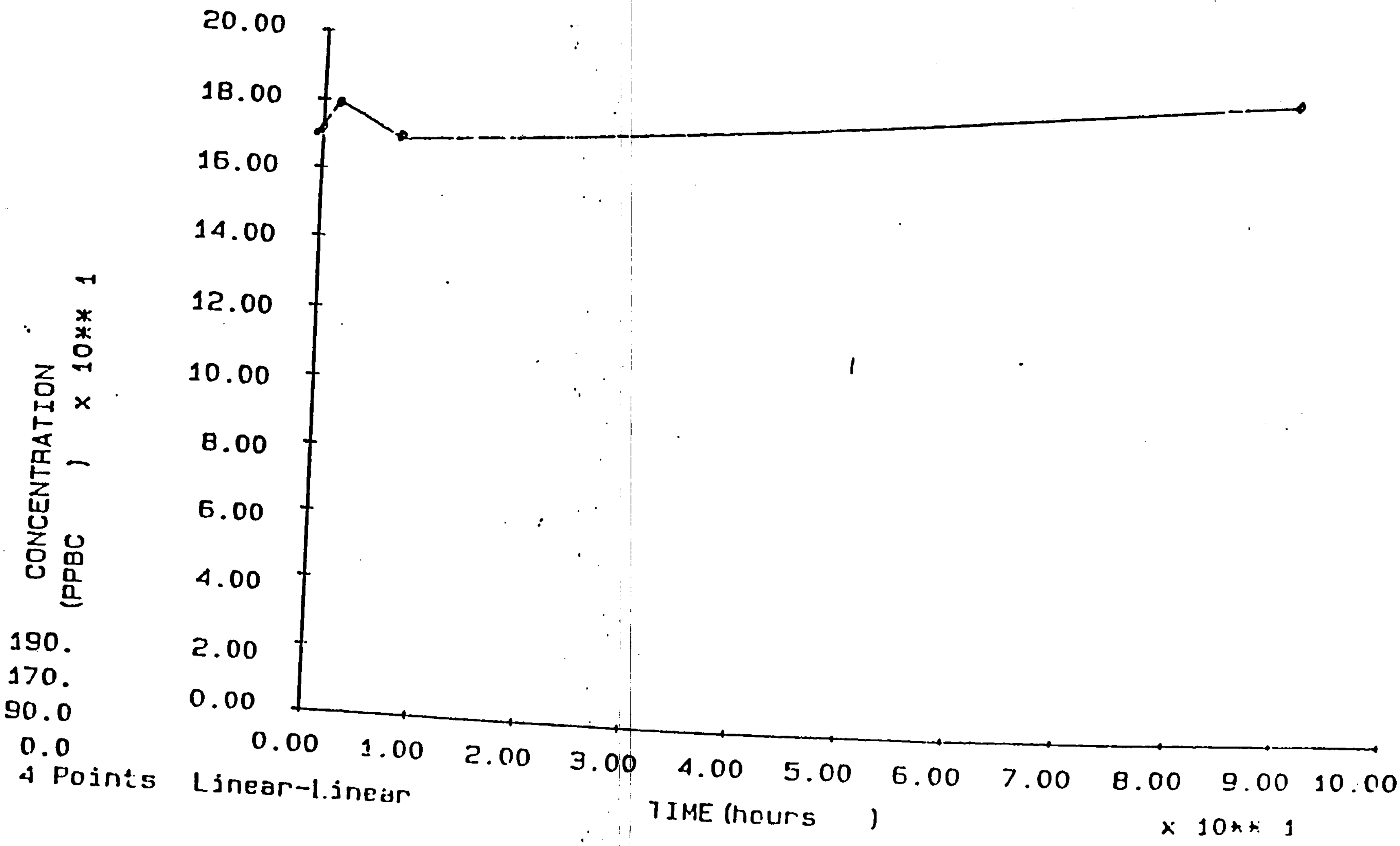
Figure 4 Multi-point calib[redacted]n for ethane



ARB LABORATORY INFORMATION SYSTEM
Page 1/ 1

STABILITY TEST (ETHANE)

Curve Fit -- Linear Segments



YMax: 190.
YMin: 170.
XMax: 90.0
XMin: 0.0
4 Points Linear-Linear

07866

APRIL 1990

AIR RESOURCES BOARD

PROCEDURE FOR THE DETERMINATION OF MIDRANGE HYDROCARBONS

IN AUTOMOTIVE EXHAUST BY GC

Interim
S.O.P. No. MLD 103A

Southern Laboratory Branch
Monitoring & Laboratory Division
State of California
9528 Telstar Avenue
El Monte, CA 91731

CALIFORNIA AIR RESOURCES BOARD
MONITORING & LABORATORY DIVISION

PROCEDURE FOR THE DETERMINATION OF MIDRANGE HYDROCARBONS IN AUTO EXHAUST by BY GC.

1. INTRODUCTION.

1.1 This procedure describes a method of analyzing midrange hydrocarbons in automotive source samples.

1.2 The source could be a diluted dynamometer Constant Volume Sampler (CVS) auto exhaust or a sealed housing for evaporative determination (SHED test) (Ref.: 9.2)

2. METHOD SUMMARY.

2.1. A portion of the sample is transferred by syringe to a gas chromatograph (GC).

2.2. The sample is introduced into the GC by means of a cryogenic trap and a sampling valve. (FIGURE 1)

2.3. The GC data system quantifies the hydrocarbon contents by integrating the peak area and calculating concentrations from factors determined during calibrations with standards.

3. APPARATUS/INSTRUMENTATION

3.1. The samples are collected in Tedlar bags and transported to the laboratory.

3.2. Ground glass syringes (B.D. Multfit, 50 ml. capacity or equivalent) are required to transfer the gaseous samples from Tedlar bags to the sample inlet of the G.C.

3.3 The gas chromatograph (Varian model 3400 or equivalent) used is equipped with a flame ionization detector (FID) and a gas sampling valve system connected to a cryogenic trap.

3.4. A capillary column (60 m x 0.32 mm. ID, DB-1, film thickness 1.0 u, cat.No.1231063 or equivalent), is used.

3.5. An analog recorder (Soltec, Model 1241 or equivalent) and an electronic integrator (Perkin Elmer Laboratory Information Management System series 3000 or equivalent) are required for the quantitation of peak areas.

4. REAGENTS.

4.1. All gases used to support the GC analysis shall equal or exceed the following purity:

4.2. Helium shall have a minimum purity of 99.995 %

4.3. Hydrogen shall have a minimum purity of 99.995 %

4.4. Air shall be zero grade

4.5. Nitrogen shall have a minimum purity of 99.9 %

4.6. Hydrocarbon standard and control samples:

4.6.1. The calibration standard is a NIST standard containing n-hexane, benzene, toluene, n-octane, m-xylene and n-decane at 98, 103, 100, 51, 49 and 26 ppb in nitrogen respectively.

4.6.2. The control sample used for quality control purposes is a cylinder containing benzene, 2,2,4-trimethylpentane, toluene and n-nonane purchased from Scott Specialty Gases.

4.7. Liquid nitrogen to cool down the cryogenic trap and the GC oven.

5. PROCEDURE.

5.1. Using the cryotrap method described below, the sample is analyzed for hydrocarbons whose boiling points range from that of n-butane to n-undecane.

5.1.1. A Valco rotary valve is connected to a cryogenic sample concentration system. A schematic of the valve system is shown in FIGURE 1.

5.1.2. An aliquot of the sample is tranferred from the sample bag via a 50 ml. syringe and concentrated in the cryogenic trap.

5.1.3. The cryogenic trap is flushed, first using 80 mL of helium from a clean syringe, then flushed for an additional 2 minutes with helium at a flow rate of 60 mL/min.

5.1.4. The analysis begins by pressing the start button on the GC and the data acquisition system simultaneously. An external event signal triggers the turning of the sample valve, thereby diverting carrier gas through the cryogenic trap. The Dewer of liquid nitrogen in which the trap is immersed is immediately replaced by a Dewer of boiling water. This vaporizes and transfers the sample through a heated entrance port into the capillary column, where the sample is reconcentrated into a narrow band.

5.1.5. Typical operating conditions for the GC are:

He carrier gas flow	2.9 mL/min
He or N2 make-up gas flow	70 mL/min.
H2 gas flow (for FID)	50 mL/min.
Zero air gas flow (for FID)	500 mL/min.

Autozero FID at 0.0 min.
Range 11, Attenuation 1

Sample valve temperature:	140° C
Detector temperature:	250° C
Column Entrance Port:	95° C

Column temperature:
Initial temperature -60° C,
hold for 1 minutes, then to -20° C at 40° C/min. to 10° C at 3° C/min., to 100°C at 4° C/min., to 180° C at 6° C/min and hold for 16 minutes.

5.1.6. Each separated component passes through the flame ionization detector where a response is generated.

5.1.7. Any misplaced baseline segments are corrected in the reconstructed chromatogram so that peaks will be correctly integrated. A typical chromatogram of a CVS exhaust analysis is shown in FIGURES 2A and 2B.

5.1.8 The peak identification provided by the computer are judged and, if necessary, corrected using the following procedure and criteria:

5.1.8.1. The relative retention indices from GC/MS analyses are used to confirm peak identifications.

5.1.8.2. The primary peak idenification is done by the computer using the relative retention times based on reference runs.

5.1.8.3. Compare the fingerprint of the sample run with the reference run.

5.1.8.4. Compare the relative retention time of the sample peaks with those of reference runs.

5.1.8.5. Any peak with a reasonable doubt is labeled 'Unidentified'.

5.1.9. The concentrations of the hydrocarbons may be calculated by an electronic integrator device.

6. CALCULATIONS

6.1. The calculation of all the hydrocarbon concentrations is based on the responses of the compounds in the calibration standard.

6.2. The concentration is calculated by the data system using an external standard method.

Concentration = Area x Calibration Factor

6.3. The Calibration Factor (CF) is calculated during daily calibration with a NIST calibration standard (4.6.1)

$$CF = \frac{\text{Concentration of the standard}}{\text{area of standard}}$$

The CF used is the average of the CF's for each of the components in the standard. Replicate calibrations are averaged and the arithmetic mean is stored as the CF to be used in subsequent analyses.

6.4. Linearity of the instrument response should be checked annually by multipoint calibration.

6.5. The Limit of Detection (LOD) is calculated using the formula:

$$LOD = 3S/m \qquad \text{(Ref. 9.3)}$$

S = sample standard devation of the lowest concentration level.
m = slope linear regression line

7. QUALITY CONTROL.

7.1. The samples are run as soon as they arrive or within two days.

7.2. Stability studies for some components in a CVS sample are documented in Method MLD 103. The sample appeared to be stable over two days in the Tedlar bag.

7.3. The NIST calibration standard is run daily.

7.4. After running a sample which contains unusually high peaks, the analyst should run a blank before proceeding to the next sample if, based upon previous experience, he suspects sample carryover.

7.5. A control standard is also run daily. This control standard is another cylinder containing benzene, 2,2,4-trimethylpentane, toluene and n-nonane. (4.6.2)

7.6. A quality control chart of the control standard is maintained showing the mean value, warning limit of mean - +/-2SD, action limit of mean +/- 3SD.

7.7. The precision of the instrument response should be determined annually by replicate analysis. The level should be appropriate for the samples normally analyzed.

8. CRITIQUE AND COMMENTS.

8.1. Some peaks are incompletely resolved.

8.2. Any organic compound, responsive to the FID, present in the sample having a retention time very similar to that of the hydrocarbons being measured and under the operating conditions described in this method is an interference. Therefore, proof of chemical identity requires confirmation by other means.

8.3. Alcohols, sometimes present in auto exhaust, may interfere with the analysis of the co-eluting hydrocarbons.

9. REFERENCE

9.1. ARB Method 104
9.2. C.F.R. 40 paragraphs 86.133-78 and 86.138-78
9.3. Anal. Chem. 55 (1983) 2217

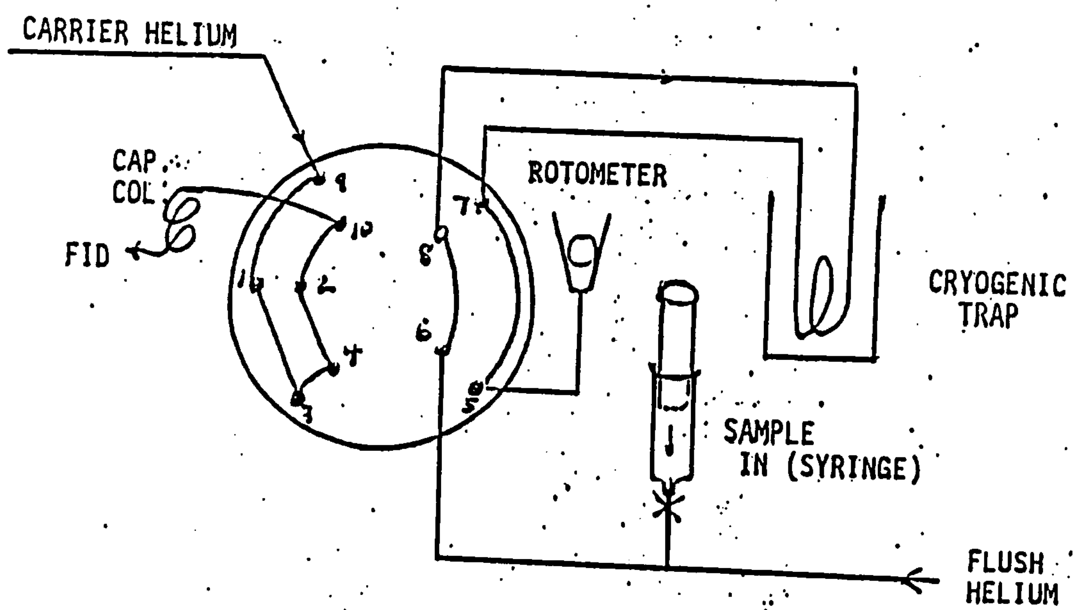


FIG. 1(A) SAMPLE CONCENTRATION

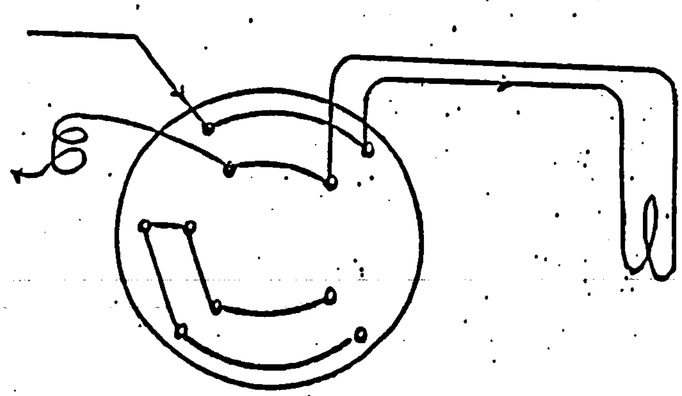


FIG. 1(B) SAMPLE INJECTION

Data File = G:MEHCJ12.PTS Printed on 04-06-1990 at 15:52:10
Start time: 7.00 min. Stop time: 47.00 min. Offset: 0 mv.
Low Value: 5372 uv High Value: 13437 uv Scale factor: 6.0

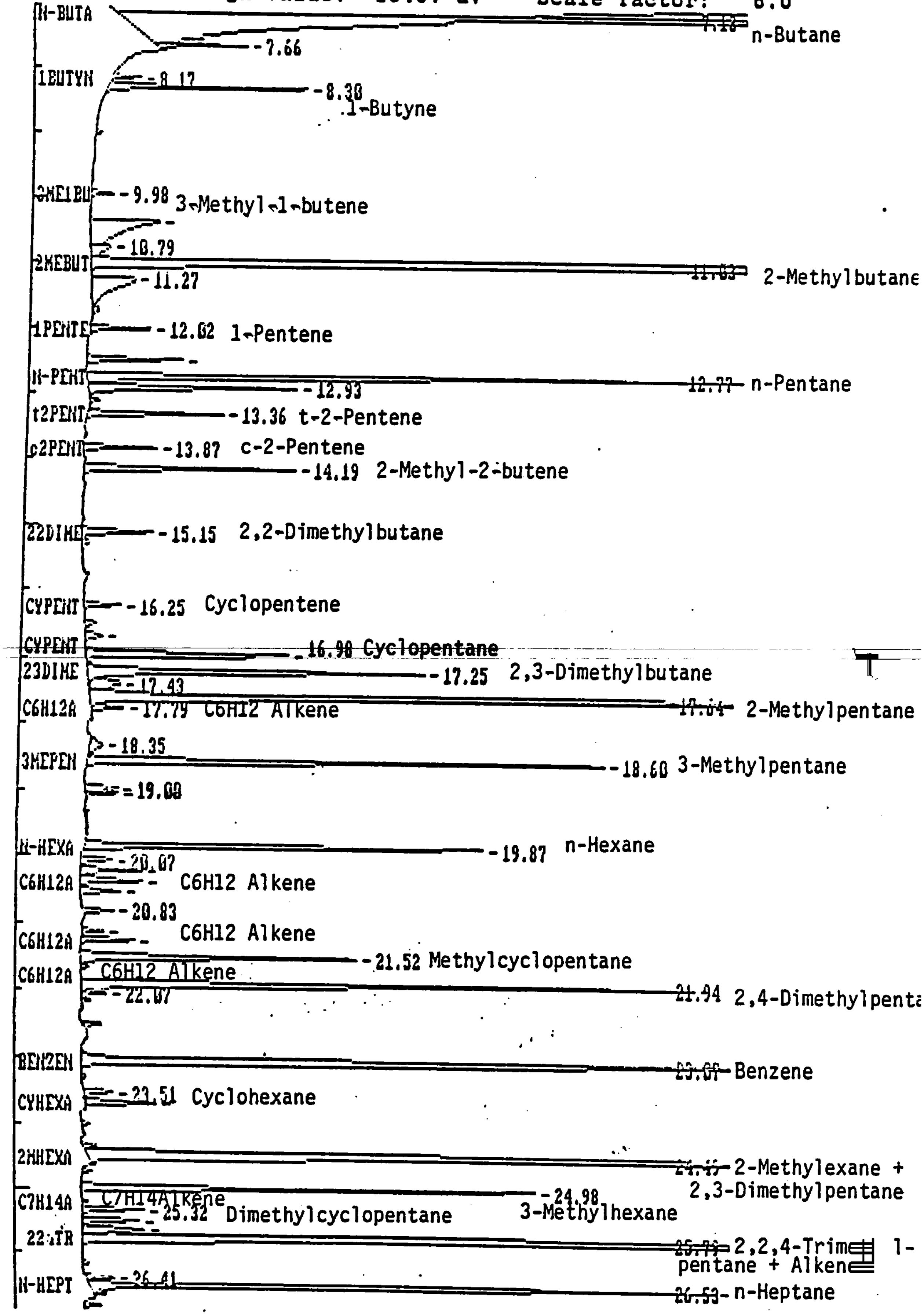


FIGURE 2A

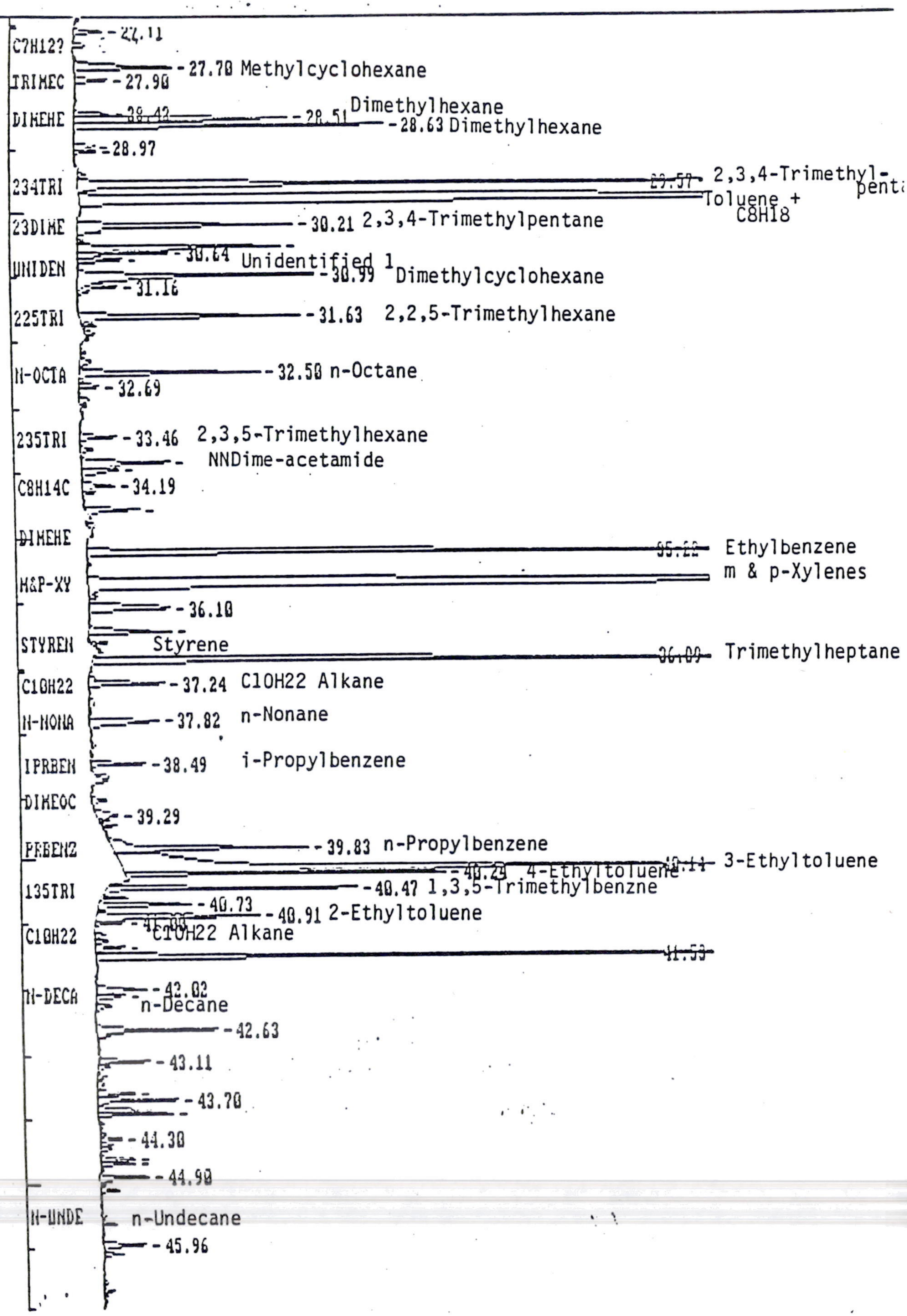

C7H12?
TRIMEC
DIMEHE
234TRI
23DIME
UNIDEN
225TRI
N-OCTA
235TRI
C8H14C
DIMEHE
M&P-XY
STYREN
C10H22
N-NONA
IPRBEN
DIMEOC
PRBENZ
135TRI
C10H22
N-DECA
N-UNDE
27.70 Methylcyclohexane
27.90
28.51 Dimethylhexane
28.63 Dimethylhexane
28.97
29.57 2,3,4-Trimethylpenta
Toluene + C8H18
30.21 2,3,4-Trimethylpentane
30.64 Unidentified 1
30.99 Dimethylcyclohexane
31.16
31.63 2,2,5-Trimethylhexane
32.50 n-Octane
32.69
33.46 2,3,5-Trimethylhexane
NNDime-acetamide
34.19
Ethylbenzene
m & p-Xylenes
36.10
Styrene
Trimethylheptane
37.24 C10H22 Alkane
37.82 n-Nonane
38.49 i-Propylbenzene
39.29
39.83 n-Propylbenzene
3-Ethyltoluene
4-Ethyltoluene
40.47 1,3,5-Trimethylbenzne
40.73
40.91 2-Ethyltoluene
C10H22 Alkane
42.02
n-Decane
42.63
43.11
43.70
44.30
44.90
n-Undecane
45.96

FIGURE 2B

November 1989

AIR RESOURCES BOARD

PROCEDURE FOR THE ANALYSIS OF AUTOMOTIVE EXHAUST FOR FORMALDEHYDE AND OTHER CARBONYL COMPOUNDS

SOP NO. MLD 104

Southern Laboratory Branch
Monitoring & Laboratory Division
State of California
9528 Telstar Avenue
El Monte, CA 91731

CALIFORNIA AIR RESOURCES BOARD
MONITORING & LABORATORY DIVISION

Procedure for the Analysis of Automotive Engine Exhaust for Formaldehyde and Other Carbonyl Compounds

1 Introduction

1.1 This procedure describes a method of sampling and analyzing automotive engine exhaust for formaldehyde (and other carbonyl compounds) in the range of 0.2 to 200 micrograms per 15 ml of 2,4-dinitrophenylhydrazine (DNPH) absorbing solution.

1.2 This procedure is derived from a method used by Hull[1].

1.3 Lower concentrations may be analyzed by increasing the exhaust sample volume through the impingers. Samples collected by use of DNPH-coated silica gel cartridges[2] may also be analyzed by a variation of this method.

1.4 Higher concentrations may be analyzed by using a smaller exhaust sample volume or by dilution of the concentrated solution with acetonitrile.

2 Method

2.1 The sampling procedure is conducted according to the Code of Federal Regulations[3].

2.2 Two impingers, each containing 15 ml DNPH absorbing solution, are used for each mode of the CVS test.

2.3 Upon completion of the dyno test, the impinger samples are analyzed by liquid chromatography.

3 **Apparatus**

3.1 Each sampling train consists of two 30 ml. graduated fritted midget impingers plus a dry impinger, pulse dampener, rotameter, pump and a wet test meter.

3.2 The HPLC system consists of the following:

Waters dual model 510 high pressure pumps

Waters model 680 Automated Gradient Controller

Waters model 712 WISP sample processor

Du Pont Zorbax ODS columns

Kratos SF769 Variable Wavelength Spectrophotometer

Perkin Elmer LIMS Data System, or equivalent

4 **Reagents**

4.1 Acetonitrile, HPLC grade, Burdick and Jackson or equivalent

4.2 Water, HPLC grade, Burdick and Jackson or equivalent

4.3 2,4-Dinitrophenylhydrazine (DNPH), Eastman or equivalent, recrystallized twice from acetonitrile.

4.3.1 The recrystallized DNPH is checked for contaminants by injecting a dilute solution of DNPH in contaminant-free acetonitrile into the HPLC.

4.3.2 An absorbing solution is prepared by dissolving 0.11 - 0.13 g of recrystallized DNPH in 1 liter of HPLC grade acetonitrile. After all the crystals are dissolved, 0.1 ml of concentrated sulfuric acid is added.

The acetonitrile used in this procedure is checked for oxygenated impurities by addition of contaminant-free dilute solution of DNPH.

4.3.3 A typical 100 ml acetonitrile standard stock solution contains:

14.8 mg formaldehyde/2,4-dinitrophenylhydrazone
8.4 mg acetaldehyde/2,4-dinitrophenylhydrazone
6.0 mg acrolein/2,4-dinitrophenylhydrazone
5.7 mg acetone/2,4-dinitrophenylhydrazone
4.7 mg propionaldehyde/2,4-dinitrophenylhydrazone

4.3.4 A working standard of 1:25 dilution of the stock solution is used (Figure 1).

4.4 Sulfuric acid, reagent grade, Baker Analyzed or equivalent

4.5 Synthesized 2,4-dinitrophenylhydrazones[4] are:

4.5.1 Formaldehyde/2,4-dinitrophenylhydrazone, recrystallized 3X from 95% ethanol, m.p. 163-165° C

4.5.2 Acetaldehyde/2,4-dinitrophenylhydrazone, recrystallized 3X from 95% ethanol, m.p. 147-149° C

4.5.3 Acrolein/2,4-dinitrophenylhydrazone, recrystallized from acetonitrile and 95% ethanol, m.p. 158-159.5° C

4.5.4 Acetone/2,4-dinitrophenylhydrazone, recrystallized 3X from 95% ethanol, m.p. 123-125° C

4.5.5 Propionaldehyde/2,4-dinitrophenylhydrazone, recrystallized 3X from 95% ethanol, m.p. 136-138° C

5 Procedure

5.1 Pipet 15 ml of the DNPH absorbing solution into each of seven 30 ml graduated fritted midget impingers, keeping the seventh impinger as a reagent blank.

5.2 Connect pairs of these impingers in series and cap the open ends to prevent contamination. (These sets of impingers are transferred to the automotive test personnel for sampling).

5.3 After the sampling has been completed and the impingers have been capped and returned to the laboratory, place the six impingers plus the reagent blank impinger in a preheated water bath at 70-80° C for 30 minutes.

5.4 Remove the seven impingers from the water bath and cool to room temperature. Replace any lost solvent by adding acetonitrile to the 15 ml mark.

5.5 Transfer three milliliters of the solution from each impinger to 4 ml glass vials and seal with new septum screw caps.

5.6 Place the vials containing blank, working standard and samples in the WISP autosampler for subsequent injection into the HPLC system.

5.7 The following HPLC conditions or equivalent are used:

Columns - 4.6 mm ID x 250 mm x 1/4 in OD Dupont Zorbax ODS or equivalent-two column in series

Guard column - 2 cm long packed with LC18 5um pellicular or equivalent

Detector - UV-VIS at 360 nm

Sample volume - 20 uL

Solvent A - acetonitrile
Solvent B - water

Flow - 1.5 ml per minute

Program[5] -	60%A to 75%A	0-20 minutes
	75%A to 100%A	20-25 "
	100%A	25-30 "
	100%A to 60%A	30-31 "
	60%A	31-40 "

Data System: The outputs from the spectrophotometric detector are sent to a Perkin Elmer LIMS data system or equivalent system for data reduction.

6 Calculations

6.1. The concentrations of formaldehyde (and other carbonyl compounds) are calculated using an electronic integrator to measure peak areas and compute concentrations using an external standard method.

6.1.1 The carbonyl/2,4-dinitrophenylhydrazone species are determined in the analysis.

6.1.2 The amount of carbonyl (ug) in 15 ml of absorbing solution is:

6.1.3 Amount (ug) = Area x Response Factor x 15 ml x B

where B is the ratio of the molecular weight of formaldehyde (or other carbonyl compounds) to its 2,4-dinitrophenylhydrazone.

6.1.4 Response Factor is calculated during calibration by the equation:

$$RF = \frac{\text{concentration (ug/ml)}}{\text{Area}}$$

6.2 A calibration curve for formaldehyde/2,4 dinitrophenylhydrazone (HCHO/DNPH) was determined by diluting an appropriate amount of standard stock solution of HCHO/DNPH in acetonitrile. Results of such a calibration are as follows:

HCHO/DNPH

	.0464 ug/ml	0.232 ug/ml	1.16 ug/ml	5.80 ug/ml
	Area	Area	Area	Area
	1420	4515	19542	97577
	1217	4359	20627	98120
	946	4269	19404	90145
	972	3931	19998	95350
	1413	4711	21249	101716
	790	4086	19874	95992
mean	1126	4312	20116	96483
SD	263	283	701	3820
% RSD	23.4	6.6	3.5	4.0

% RSD is SD divided by the mean times 100%.

6.3 The limit of detection (LOD)[6] for formaldehyde is calculated by the following formula:

$$LOD = \frac{3 \times SD}{m}$$

Where:

SD = standard deviation near the lowest detectable concentration

m = slope of calibration curve

6.3.1 Based on the calibration curve, y = 16550x + 561, the LOD was determined to be 0.05 ug/ml HCHO/DNPH. This corresponds to a concentration of 0.1 ug formaldehyde in 15 ml of DNPH solution.

7 Quality Control

7.1 The solvents used are of the highest HPLC grade and are checked for impurities by conducting blank analyses.

7.2 The 2,4-dinitrophenylhydrazones are checked for purity by their melting points and their chromatograms.

7.3 The quality control procedures followed during analysis are:

7.3.1 Analysis of blank absorbing solution each analysis day.

7.3.2 Analyses of working standard and control sample each anaylsis day.

7.3.3 Maintenance of control charts for formaldehyde and other carbonyl compounds of interest.

7.3.4 Semi-annual linearity check of the instrument by multipoint calibration (Figure 3).

7.3.5 A 43 day stability study of formaldehyde/2,4-dinitrophenylhydrazine in acetonitrile absorbing solution showed no significant change in concentration over this time period (Figure 4).

8 <u>References</u>

8.1. Hull, L.A., "Procedures for 2,4-Dinitrophenylhydrazone Aldehyde-Ketone Air Analysis", internal report while on leave at U.S. EPA.

8.2. Tejada, S.B. "DNPH-Coated Silica Cartridges for Sampling Carbonyl Compounds in Air abd Analysis by High Performance Liquid Chromatography", EPA/MSERB internal report, 1985 and Tejada, S.B., "Evaluation of Silica Gel Cartridges Coated in Situ with Acidified 2,4-Dinitrophenylhydrazine for Sampling Aldehydes and Ketones in Air", Intern. J. Environ. Anal. Chem., 1986, Vol. 26, pp. 167-185

8.3 Code of Federal Regulations, Title 40, Part 86

8.4 Shriner, R.L. and Fuson, R.C., "Identification of Organic Compounds" 2nd. Ed., John Wiley and Sons, Inc., 1940, p. 143.

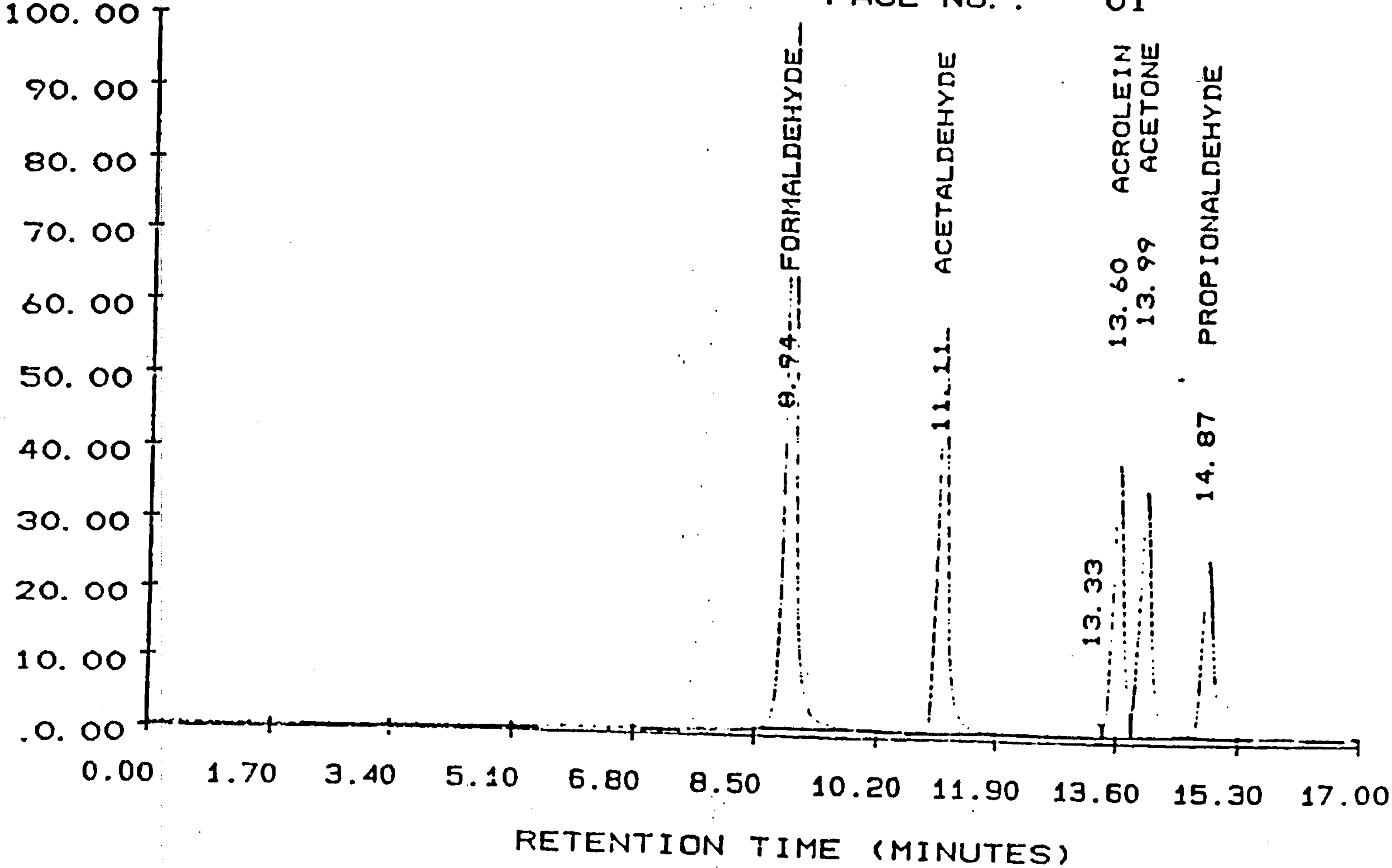
8.5 EPA/MSERB "Round Robin" procedure, 1988.

8.6 Long, G.L. and Winefordner, J.D., Anal. Chem. <u>55</u>, 712A (1983).

CALIB. STD 9/8-H

SAMPLE NO. : 89000913.01
TEST NO. : RCHO1
METHOD NO. : RCHO1 / RCHO1

INSTRUMENT: 05
DATE TIME: 02/02/89 10:07:35
PAGE NO. : 01



Y MAXIMUM: 1125.
Y MINIMUM: 116.

START TIME: 0.00
END TIME: 17.00

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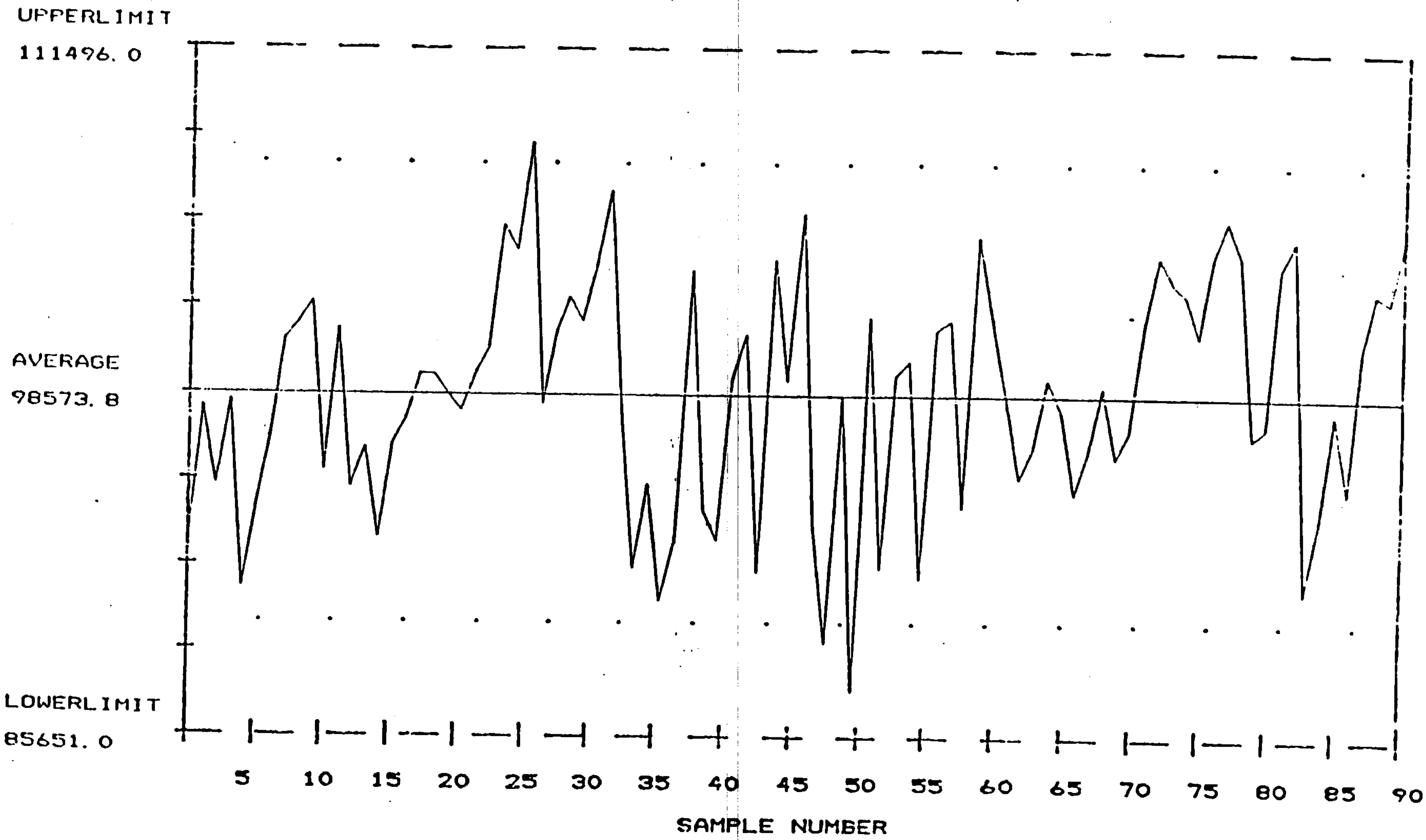
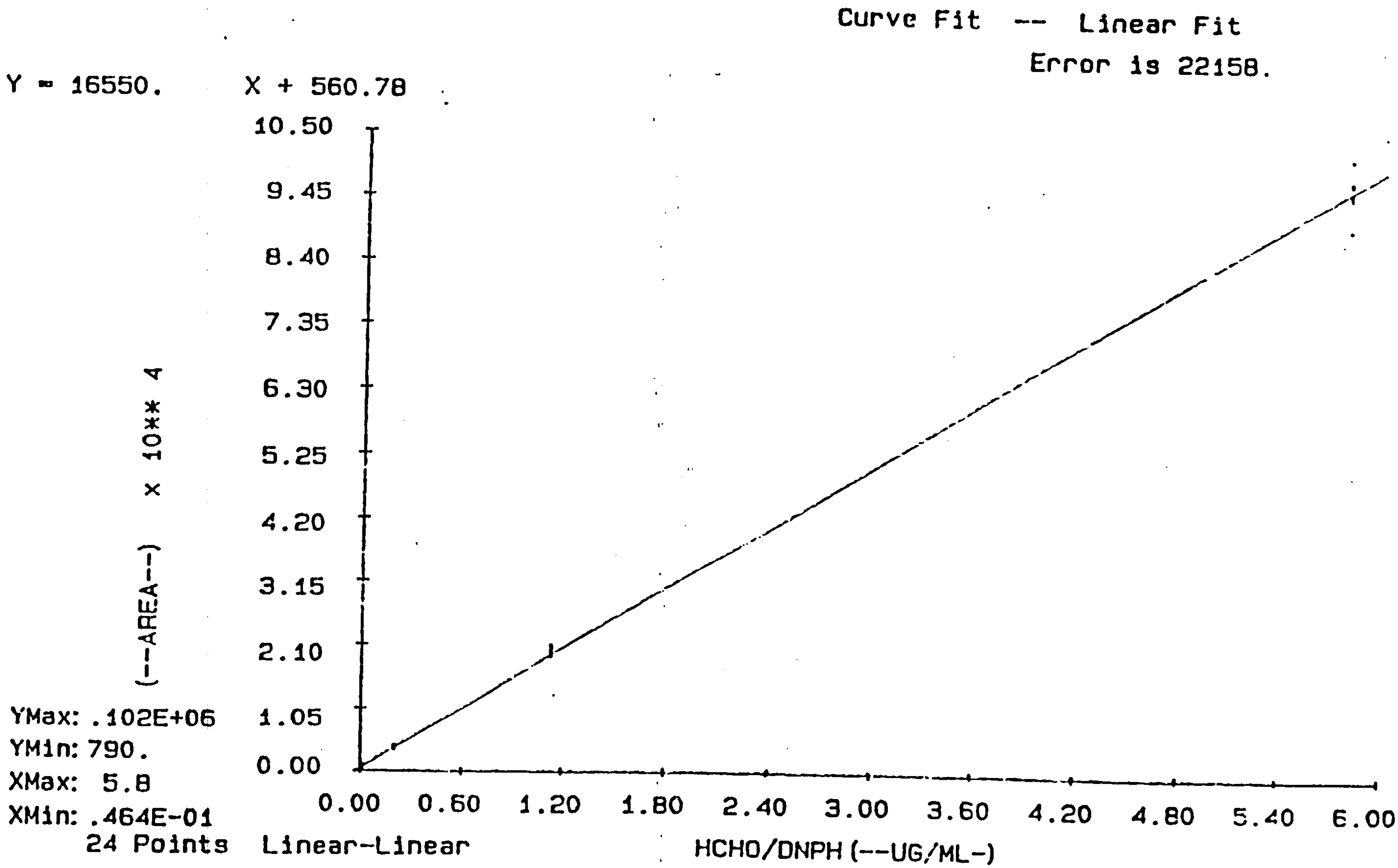
FORMALDEHYDE-2, 4DINITROPHENYLHYDRAZONE TEST: GC100

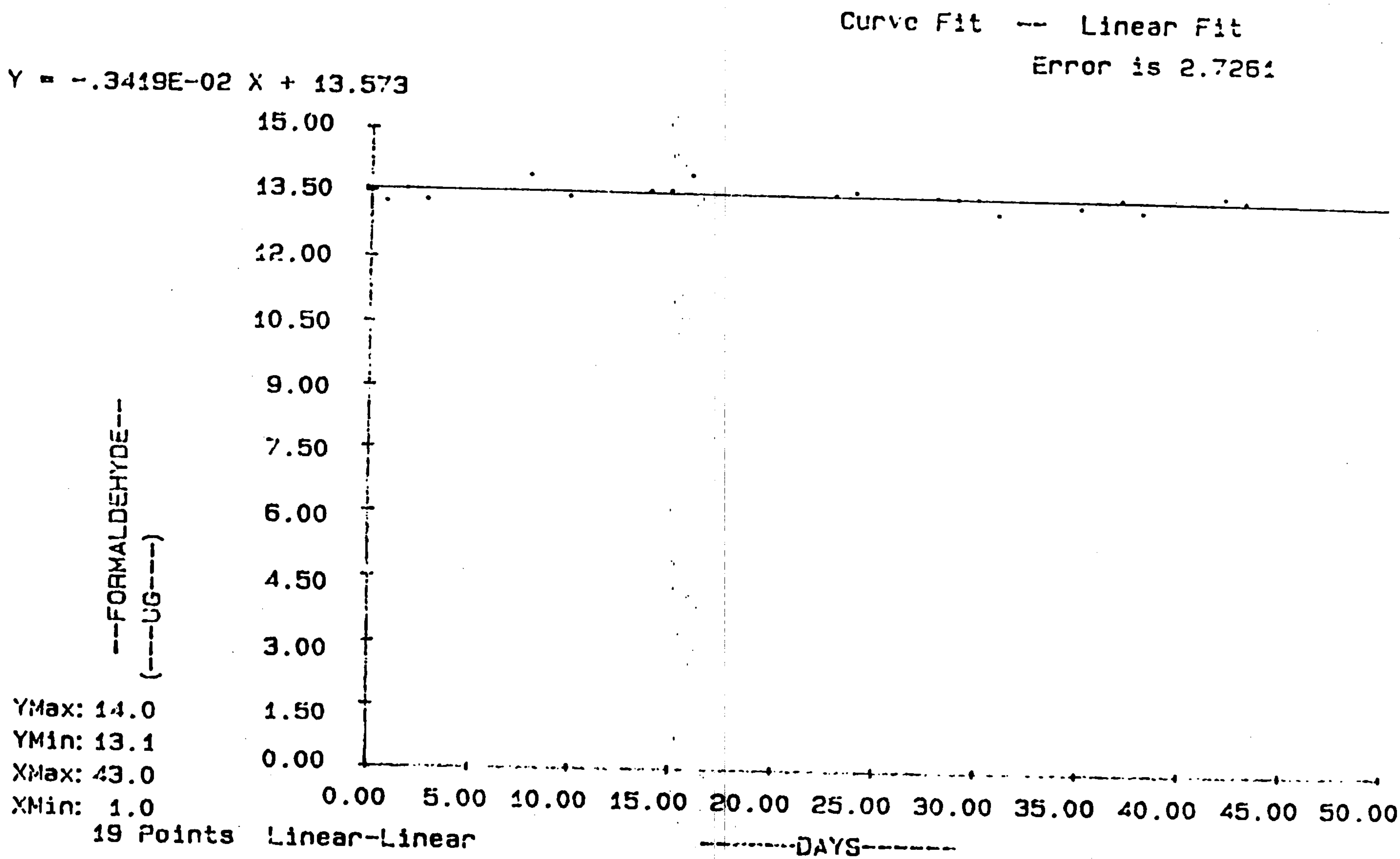
AVERAGE VALUE = 98573. 8
STANDARD DEVIATION = 4307. 61
95% CONFIDENCE LIMIT = +/-8615. 23

MINUMUM VALUE = 87367. 0
MAXIMUM VALUE = 108010. 0
POPULATION = 90





Curve Fit -- Linear Fit
Error is 22158.
Y = 16550. X + 560.78
10.50
9.45
8.40
7.35
6.30
5.25
4.20
3.15
2.10
1.05
0.00
(--AREA--) x 10** 4
YMax: .102E+06
YMin: 790.
XMax: 5.8
XMin: .464E-01
24 Points
Linear-Linear
0.00
0.60
1.20
1.80
2.40
3.00
3.60
4.20
4.80
5.40
6.00
HCHO/DNPH (--UG/ML-)



Curve Fit -- Linear Fit
Error is 2.7261
Y = -.3419E-02 X + 13.573
15.00
13.50
12.00
10.50
9.00
7.50
6.00
4.50
3.00
1.50
0.00
--FORMALDEHYDE--
(---UG---)
0.00 5.00 10.00 15.00 20.00 25.00 30.00 35.00 40.00 45.00 50.00
--------DAYS-------
YMax: 14.0
YMin: 13.1
XMax: 43.0
XMin: 1.0
19 Points
Linear-Linear

APPENDIX E-5: LABELING PROCEDURES

State of California
AIR RESOURCES BOARD

CALIFORNIA MOTOR VEHICLE
EMISSION CONTROL LABEL SPECIFICATIONS

Adopted: March 1, 1978
Amended: June 16, 1982
Amended: April 26, 1984
Amended: April 8, 1985
Amended: April 25, 1986
Amended: June 2, 1988
Amended: July 21, 1988
Amended: January 22, 1990
Amended: ______________

NOTE: These procedures are printed in a style to indicate the amendments as currently proposed. The underlying text is shown in normal type with single underline to indicate additions to and strikeout to indicate deletions from, the existing regulatory language.

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State of California

AIR RESOURCES BOARD

California Motor Vehicle Emission Control Label Specifications

1. Purpose. The Air Resources Board recognizes that certain emissions-critical or emissions-related parts must be properly identified and maintained in order for vehicles and engines to meet the applicable emission standards. The purpose of these specifications is to require motor vehicle or motor vehicle engine manufacturers to affix a label (or labels) on each production vehicle in order to provide the vehicle owner and service mechanic with information necessary for the proper maintenance of these parts in customer use. These Label Specifications are adopted pursuant to Section 1965, Title 13, California Code of Regulations.

2. Applicability.

   (a) These specifications shall apply to ~~each~~ all new 1979 and subsequent model-year passenger cars, light-duty trucks, medium-duty vehicles, heavy-duty ~~otto-cycle engine, and heavy-duty diesel~~ engines, and to ~~each~~ all new 1982 and subsequent model year motorcycles certified to the applicable emission standards pursuant to Health and Safety Code Sections 43100 and 43107. ~~sold or offered for sale in California. These specificationa shall apply to all new 1991 and subsequent model heavy-duty urban bus engines and to all new 1993 and subsequent model heavy-duty dedicated methanol and fuel-flexible engines and vehicles sold or offered for sale in California. These specifications shall also~~

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~~apply to all new 1993 and subsequent model dedicated methanol and fuel-flexible passenger cars, light-duty trucks, and medium-duty vehicles.~~

<u>(b)</u> Any vehicles or classes of vehicles exempt from exhaust emission standards pursuant to Article 2, <u>Subchapter 1,</u> Chapter 3, Title 13 of the California Code of Regulations shall also be exempt from the requirements of these specifications <u>except Zero-Emission Vehicles (ZEVs) certified by the Air Resources Board for use in California</u>.

<u>(c)</u> The responsibility for compliance with these specifications shall rest with the motorcycle, light-duty vehicle, medium-duty vehicle, or heavy-duty engine manufacturer who certified such vehicles or engines.

3. Label Content and Location. A plastic or metal tune-up label, and in accordance with Section 3b, a machine-readable vehicle emission configuration (VEC) bar-code label made of paper, plastic, metal, or other permanent material, shall be welded, riveted or otherwise permanently attached to an area within the engine compartment (if any) or to the engine in such a way that it will be readily visible to the average person after installation of the engine in a vehicle. In accordance with Section 3b, a machine-readable vehicle identification number (VIN) bar-code label made of paper, plastic, metal, or other permanent material shall be affixed in a readily visible location to either the door-latch post next to the driver's seating position, the door edge that meets this door-latch post, or above the instrument panel in a location clearly visible through the lower left corner of the windshield.

In selecting an acceptable location, the manufacturer shall consider the possibility of accidental damage (e.g., possibility of tools or sharp instruments coming in contact with the label) and accessibility for a bar-code scanner, as applicable. Each label shall be affixed in such a manner that it cannot be removed without destroying or defacing the label, and shall not be affixed to any part which is likely to be replaced during the vehicle's useful life. For motorcycles, passenger cars, light-duty trucks, and medium-duty vehicles, the label(s) shall not be affixed to any equipment which is easily detached from the vehicle.

(a) The tune-up label shall contain the following information lettered in the English language in block letters and numerals which shall be of a color that contrasts with the background of the label:

i. The label heading shall read:

"Vehicle Emission Control Information" for passenger cars and motorcycles;

"Important Vehicle Information" for light-duty and medium-duty trucks; and

"Important Engine Information" for heavy-duty engines.

ii. Full corporate name and trademark of the manufacturer.

iii. The statement "This _______ (specify vehicle or engine, as applicable) is certified to operate on ________ (specify operating fuel[s])".

~~iii~~ iv. Engine family identification, model designation ~~(for heavy-duty diesel~~ engines~~)~~, engine displacement (in cubic centimeters or liters), and for all 1992 and subsequent model-year vehicles the statement, "This vehicle meets _______ (specify OBD I or OBD II, as applicable) requirements" or

"OBD Exempt" for all 1990 and subsequent model-year passenger cars, light-duty trucks, and medium-duty vehicles which do not have an Air Resources Board approved on-board diagnostic system. ZEVs are exempt from these requirements.

iv v. Identification of the Exhaust Emission Control System: Abbreviations may be used and shall be in accordance with revised SAE J1930, July 1990, consist of including the following nomenclature (ZEVs are exempt from these requirements):

OC - Oxidation Catalyst Only;

TWC - Three-Way Catalyst;

TWC+OC- Three-Way Catalyst with Oxidation Catalyst;

* EHOC - Electrically Heated Oxidation Catalyst;

* EHTWC - Electrically Heated Three-Way Catalyst;

WUTWC - Warm-Up Catalyst with Three-Way Catalyst;

WUOC - Warm-Up Catalyst with Oxidation Catalyst;

AIR - Secondary Air Injection (Pump);

PAIR - Pulsed Secondary Air Injection;

CAC - Charge Air Cooler;

SC - Supercharger;

TC - Turbocharger;

DI - Direct Injection (Diesel);

IDI - Indirect Diesel Injection;

TOC - Trap Oxidizer Continuous;

TOP - Trap Oxidizer Periodic;

* FFS - Flexible Fuel Sensor;

O2S - Oxygen Sensor;

HO2S - Heated Oxygen Sensor;

EGR - Exhaust Gas Recirculation;

EM - Engine Modification;

CIS - Continuous Fuel Injection;

MPI - Multipoint Electronic Fuel Injection;

TBI - Throttle Body Electronic Fuel Injection;

SMPI - Sequential Multipoint Electronic Fuel Injection;

SPL - Smoke Puff Limiter; and

TR - Thermal Reactor.

* - Pending confirmation as SAE protocol

The Executive Officer shall recommend abbreviations for components not listed in revised SAE J1930, July 1990.

v vi. For otto-cycle engines the tune-up specifications and adjustments recommended by the manufacturer, including, if applicable: valve lash, ignition timing, idle air fuel mixture setting procedure and value (e.g., idle CO, idle speed drop), and high idle speed. For diesel engines the specifications and adjustments recommended by the manufacturer, including, if applicable: initial injection timing, and fuel rate (in mm^3/stroke) at advertised horsepower. For the specifications listed above, which are not recommended by the manufacturer for adjustment, the manufacturer shall include in lieu of the "specifications" the single statement "no other adjustments needed". These specifications shall indicate the proper transmission position during tune-up and what accessories, if any (e.g., air conditioner), should be in operation, and what systems, if any (e.g., vacuum advance, air pump), should be disconnected during the tune-up. For ~~otto-cycle~~ all vehicles except ZEVs, the instructions for tune-up adjustments shall be sufficiently clear on the label so as to preclude the need for a mechanic or vehicle owner to refer to another document in order to correctly perform the adjustments.

~~vi~~ vii. For motorcycles only, any specific fuel or engine lubricant requirements (e.g., lead content, research octane number, engine lubricant type).

~~vii~~viii. For heavy-duty engines, the date of engine manufacture (month and year). A manufacturer may, in lieu of printing the month of manufacture on the engine label, maintain a record of the month of engine manufacture. The manufacturer shall submit this record to the Executive Officer upon request.

~~viii~~ ix. An unconditional statement of compliance with the appropriate model-year California regulations; for example, "This vehicle (or engine, as applicable) conforms to California regulations applicable to ______ model-year new ______ (for 1992 and subsequent model-years, specify TLEV, LEV, ULEV, or ZEV, as applicable) ______ (specify motorcycles, passenger cars, light-duty trucks, medium-duty vehicles, heavy-duty otto-cycle engines, or heavy-duty diesel engines, as applicable)." For federally certified vehicles certified for sale in California the statement must include the phrase "conforms to U.S. EPA regulations and is certified for sale in California." For Class III motorcycles for sale in California, the statement must include the phrase "is certified to ______ HC engine family exhaust emission standard in California." For incomplete light-duty truck and incomplete medium-duty vehicles the label shall contain the following statement in lieu of the above:

"This vehicle conforms to California regulations applicable to _____ model-year new _____ (for 1992 and subsequent model-years specify LEV or ULEV as applicable) vehicles when completed at a maximum curb weight of ____ pounds and a maximum frontal area of _____ square feet."

~~ix~~ x. For 1985 and subsequent model year heavy-duty diesel engines and 1987 and subsequent model year heavy-duty otto-cycle engines ~~(including methanol heavy-duty engines starting in 1991),~~ if the manufacturer is provided an alternate useful life period under the provisions of 40 CFR 86.085-21(f), 86.087-21(f), 86.088-21(f), 86.090-21(f), or 86.091-21(f) the prominent statement: "This engine has been certified to meet California standards for a useful life period of __ years or ______ miles of operation, whichever occurs first. This engine's actual life may vary depending on its service application." The manufacturer may alter this statement only to express the assigned alternate useful life in terms other than years or miles (e.g., hours, or miles only).

~~x~~ xi. For 1985 and subsequent model year heavy-duty diesel engines ~~(including methanol-fueled engines starting in 1991),~~ the prominent statement: "This engine has a primary intended service application as a ________ heavy-duty engine." (The primary intended service applications are light, medium, and heavy, as defined in 40 CFR 86.085-2.)

~~xi~~ xii. For 1987 and subsequent model year heavy-duty otto-cycle engines ~~(including methanol-fueled engines starting in 1991),~~ one of the following prominent statements as applicable:

(1) For engines certified to the emission standards under 40 CFR 86.087-10(a)(1)(i), 86.088-10(a)(1)(i), 86.090-10(a)(1)(i), 86.090-10(a)(1)(iii), 86.091-10(a)(1)(i), and 86.091-10(a)(1)(iii) the statement: "This engine is certified for use in all heavy-duty vehicles."

(2) For engines certified under the provisions of 40 CFR 86.087-10(a)(3)(i), 86.088-10(a)(3)(i), 86.090-10(a)(3)(i), 86.090-10(a)(3)(ii), 86.091-10(a)(3)(i), or 86.091-10(a)(3)(ii) the statement, "This engine is certified for use in all heavy-duty vehicles. It is certified to the emission standards applicable to heavy-duty vehicles with a gross vehicle weight rating above 14,000 lbs. and to U.S. EPA regulations applicable in California."

(3) For engines certified to the emission standards under 40 CFR 86.087-10(a)(1)(ii), 86.088-10(a)(1)(ii), 86.090-10(a)(1)(ii), 86.090-10(a)(1)(iv), 86.091-10(a)(1)(ii), or 86.091-10(a)(1)(iv) the statement: "This engine is certified for use only in heavy-duty vehicles with a gross vehicle weight rating above 14,000 lbs."

~~xii~~xiii. For 1988 model heavy-duty otto-cycle engines and vehicles for which nonconformance penalties are to be paid in accordance with 86.1113-87(b), the following prominent statement: "The manufacturer of this engine/vehicle will pay a nonconformance penalty to be allowed to introduce it into commerce at an emission level higher than the applicable emission standard. The compliance level (or new emission standard) for this engine/vehicle is _________." (The manufacturer shall insert the applicable pollutant and compliance level calculated in accordance with 86.1112-87(a).)

(1) The above statement shall be printed on the label required in these specifications or on a separate permanent legible label in the English language and located in proximity to the label required in these specifications. The manufacturer shall begin labeling production engines or vehicles within ten days after the completion of the Production Compliance Audit (PCA).

(2) If a manufacturer introduces an engine or vehicle into commerce prior to the compliance level determination of 86.1112-87(a), it shall provide the engine or vehicle owner with a label as described above to be affixed in a location in proximity to the label required in these specifications within 30 days of the completion of the PCA.

Such statements shall not be used on labels placed on vehicles or engines which, in fact, do not comply with all applicable California regulations, including assembly-line test requirements, if any.

(b) The machine-readable VEC bar code and the machine-readable VIN bar code shall be designed in accordance with SAE standards J1892 and SAE J1877 as appropriate for the label material. These labeling requirements shall be applicable to 1990 and subsequent model-year

~~passenger cars,~~ ~~light-duty trucks,~~ ~~medium-duty~~ vehicles~~,~~ and ~~heavy-duty otto-cycle~~ engines except ZEVs, diesel-fueled vehicles and diesel engines. The Executive Officer may, as necessary, specify new character codes for the VEC label (as part of the "ECS Component Combination" table, Section 4.1.3., SAE J1892) to designate new emission control systems or components as they are introduced for use in motor vehicles subject to the label requirements.

The eighth character of the VEC bar-code label is the code for the Emission Control System (ECS) Combination and the engine ignition frequency. Coding for this character is as follows:

Ignition Frequency	Label Code	Air Injection	EGR	OBD II
One ignition frequency per two engine revolutions	A	none	none	yes
	B	yes	none	yes
	C	none	yes	yes
	D	yes	yes	yes
	E	none	none	no
	F	yes	none	no
	G	none	yes	no
	H	yes	yes	no
One ignition frequency per one engine revolution	S	none	none	yes
	T	yes	none	yes
	U	none	yes	yes
	V	yes	yes	yes
	W	none	none	no
	X	yes	none	no
	Y	none	yes	no
	Z	yes	yes	no

For label identification, the VEC and VIN labels shall include the heading "VEC" and "VIN", respectively, above the bar coded information. If the VEC or VIN label is incorporated as part of the tune-up label or the federal certification label required pursuant to the Federal Motor Vehicle Safety Regulations No. 567, respectively, or at the location above the instrument panel, no heading shall be required. The heading shall be printed in block letters in the English language and printed pursuant to Section 5 of these procedures.

(c) The tune-up label shall include a vacuum hose routing diagram showing all emissions-related and emissions-critical parts that are actuated by vacuum and the correct routing of vacuum hoses if one or more vacuum hoses are employed. This diagram shall contain no more than two different vacuum hose routing patterns; if there are two routings on a single diagram each routing must be easily understandable. The hose diagram may be separated from the tune-up label provided that the vacuum hose diagram is placed in a visible and accessible position as provided in this section. If a separate label is used, it shall be of a permanent type; however the destruction limits in this section do not apply. ZEVs are exempt from these requirements.

(d) The manufacturer of any ~~dedicated methanol or fuel-flexible~~ vehicle equipped with an emission control device which the Executive Officer has determined will be significantly impaired by the use of leaded gasoline shall:

i. At the time of vehicle manufacture, affix two or more permanent legible labels specifying the appropriate operating fuel(s) (for example ~~reading "Methanol Fuel Only" to such dedicated methanol vehicle at the time of its manufacture and~~ "Methanol Fuel or Unleaded Gasoline Only" for ~~to such~~ fuel-flexible vehicles) ~~at the time of its manufacture~~, as follows:

(1) One label shall be located on the instrument panel so as to be readily visible to the operator of the vehicle: Provided, however, that the required statement may be

incorporated into the design of the instrument panel rather than provided on a separate label; and

(2) One label shall be located immediately adjacent to each fuel tank filler inlet, outside of any filler inlet compartment, and shall be located so as to be readily visible to any person introducing fuel to such filler inlet: Provided, however, that the Executive Officer may, upon application from a motor vehicle manufacturer, approve other label locations that achieve the purpose of this paragraph.

(3) Such labels shall be in the English language in block letters which shall be of a color that contrasts with their background.

ii. For purposes of this section a motor vehicle shall be deemed to be equipped with an emission control device which will be significantly impaired by the use of leaded gasoline if ~~neat methanol~~ any alcohol fuel, ~~or~~ unleaded gasoline, or a blend of these fuels was used in any testing or service accumulation relating to the emission certification of said motor vehicles or engines installed therein.

4. The provisions of these specifications shall not prevent a manufacturer from also reciting on the label that such vehicle or engine conforms to any applicable federal emission standards for new motor vehicles or new motor vehicle engines or any other information that such manufacturer deems necessary for, or useful to, the proper operation and satisfactory maintenance of the vehicle or engine.

5. As used in these specifications, readily visible to the average person shall mean that the label shall be readable from a distance of eighteen

inches (46 centimeters) without any obstructions from vehicle or engine parts (including all manufacturer available optional equipment) except for flexible parts (e.g., vacuum hoses, ignition wires) that can be moved out of the way without disconnection. Alternatively, information required by these specifications to be printed on the label shall be no smaller than 8 point type size provided that no vehicle or engine parts, (including all manufacturer available optional equipment), except for flexible parts, obstruct the label. For the VEC and VIN labels, sufficient clearance shall be provided to use a non-contact bar-code scanner.

6. For the tune-up label and vacuum hose routing diagram label, the labels and any adhesives used shall be designed to withstand, for the vehicle's total expected life, typical vehicle environmental conditions in the area where the label is attached. Typical vehicle environmental conditions shall include, but are not limited to, exposure to engine lubricants and coolants (e.g., gasoline, motor oil, brake fluids, water, ethylene glycol), underhood temperatures, steam cleaning, and paints or paint solvents. The manufacturer shall submit, with its certification application, a statement attesting that its labels comply with this requirement.

VEC and VIN machine-readable labels shall meet the applicable functional test specifications contained in SAE standards J1892 and J1877.

7. The manufacturer shall obtain approval from the Executive Officer for all label formats and locations prior to use. Approval of the specific tune-up settings is not required; however, the format for all such settings and tolerances, if any, is subject to review. If the Executive Officer finds that the information on the label is vague or

subject to misinterpretation, or that the location does not comply with these specifications, he or she may require that the label or its location be modified accordingly.

8. Samples of all actual production labels used within an engine family shall be submitted to the Executive Officer within thirty days after the start of production.

9. The Executive Officer may approve alternate label locations or may, upon request, waive or modify the label content requirements provided that the intent of these specifications is met.

10. If the Executive Officer finds any motor vehicle or motor vehicle engine manufacturer using labels which are different from those approved or which do not substantially comply with the readability or durability requirements set forth in these specifications, the Executive Officer may invoke Section 2109, Article 2, Subchapter 2, Chapter 3, Title 13, California Code of Regulations.

APPENDIX E-6: CERTIFICATION GUIDELINES FOR FEDERAL LIGHT-DUTY VEHICLES

State of California
AIR RESOURCES BOARD

GUIDELINES FOR CERTIFICATION OF 1983 AND SUBSEQUENT MODEL-YEAR FEDERALLY CERTIFIED LIGHT-DUTY MOTOR VEHICLES FOR SALE IN CALIFORNIA

Adopted: July 20, 1982
Amended: September 16, 1983
Amended: December 15, 1983
Amended: September 16, 1985
Amended: July 8, 1987
Amended: December 20, 1989
Amended: ________________

NOTE: These Guidelines are printed to identify proposed changes from the Guidelines as amended July 8, 1987. Language proposed to be added is underlined and language proposed to be deleted is struck out. Headings are underlined in the existing Guidelines and are not new additions.

GUIDELINES FOR CERTIFICATION OF 1983 AND SUBSEQUENT MODEL-YEAR FEDERALLY CERTIFIED LIGHT-DUTY MOTOR VEHICLES FOR SALE IN CALIFORNIA

I. APPLICABILITY

These guidelines adopted pursuant to Section 43102(b) of the California Health and Safety Code are applicable to 1983 and subsequent model year federally certified light-duty motor vehicles proposed for sale in California. These guidelines are not applicable to medium-duty trucks, motorcycles, heavy-duty engines, heavy-duty vehicles, emergency vehicles, or vehicles with engines having a displacement less than 50 cubic inches.

II. DEFINITIONS

For the purposes of these guidelines:

1. "Light-duty motor vehicle" means a vehicle having a manufacturer's maximum gross vehicle weight rating of under 6,001 pounds (California Health and Safety Code Section 39035).
2. "California vehicle" means a motor vehicle originally certified in California by an Executive Order.
3. "Loaded Vehicle Weight (LVW)" has the meaning set forth in subparagraph 86.082(b), Title 40, Code of Federal Regulations, as last amended November 2, 1982.
4. "Federal vehicle" means a motor vehicle originally certified federally by a Certificate of Conformity.
5. "Model" means a unique combination of car line, basic engine, and transmission class, or as defined by a manufacturer with the approval of the Executive Officer.
6. "Car Line" means a name denoting a group of vehicles within a make or car division which has a degree of commonality

inconstruction (e.g., body, chassis). Car line does not consider any level of decor or opulence and is not generally distinguished by characteristics as roof line, number of doors, seats, or windows, except for station wagons or light-duty trucks. Station wagons and light-duty trucks are considered to be different car lines than passenger cars.

7. "Basic Engine" means a unique combination of manufacturer, engine displacement, number of cylinders, fuel system (as distinguished by use of carburetor or fuel injection), and catalyst usage.

8. "Transmission Class" means a group of transmissions having the following common features: basic transmission type (manual, automatic, or semi-automatic), number of forward speeds (e.g., manual four-speed, three-speed automatic, two-speed semi-automatic).

III. CERTIFICATION OF FEDERAL VEHICLES

To receive certification for federal vehicle sales in California, a manufacturer shall:

A. Provide to the Executive Officer evidence of federal certification, and a statement that the model(s) for which certification is requested are not available in California.

B. Provide a warranty on emission-related parts in accordance with Sections 2035 et seq., Title 13, California Code of Regulations, as they apply to vehicles certified under the primary California standards. However, federal vehicles which are offset by California vehicles certified to a 100,000-mile optional standard shall provide a ten-year/100,000-mile warranty.

C. Provide: 1) certification emission levels of federal models intended for sale in California, 2) quarterly production reports, by model and engine family, of vehicles intended for sale or sold in California, and 3) other information which the Executive Officer deems necessary to calculate emissions offset credits, emission deficits, or air quality impacts.

D. Label each vehicle on the assembly-line with the statement "conforms to federal regulations and is certified for sale in California" to distinguish federal vehicles certified for sale in California from other federal and California vehicles.

IV. <u>ASSEMBLY-LINE AND ENFORCEMENT TESTING</u>

A. All federal vehicles certified and intended for sale in California shall comply with all provisions of the applicable California Assembly-Line Test Procedures, except that:

1. The Executive Officer, at his or her discretion, may accept quality audit emissions data from other sources in lieu of a 2 percent quality audit of federal vehicle production intended for sale in California.

2. Manufacturers which have projected sales of less than 1,000 federal vehicles per model year in California shall be exempt from the 2 percent quality audit requirement. However, such manufacturers shall submit to the Executive Officer any other similar data which may be available.

3. Data submitted in lieu of 2 percent quality audit data shall be accompanied either by a statement that the data were generated according to California Assembly-Line Test Procedures, or by a description of how the testing and

analysis procedures used depart from California Assembly-Line Test Procedures.

B. All federal vehicles certified for sale in California shall be subject to the compliance testing requirements of Title 13, California Code of Regulations.

V. OFFSETTING PROCEDURE

A. Emissions offsetting shall be limited as follows:

1. By manufacturer. A manufacturer shall not trade, sell, transfer, or in any other manner exchange emissions credits with another manufacturer, except that a manufacturer which supplies engines to a vehicle manufacturer may also supply offsetting emission credits if the vehicle manufacturer's total production for California is less than 200 units per model year.

2. By vehicle category. Vehicle categories are: (a) passenger cars and (b) light-duty trucks (less than 6,001 pounds gross vehicle weight rating). Emission credits from vehicles in one category shall not offset vehicles in the other category.

3. By fuel type. For vehicles produced prior to the 1994 model year, offsetting shall be conducted only among vehicles with like fuels (e.g., gasoline to gasoline, diesel to diesel, etc.).

4. By durability option. Federal vehicles which are offset by California vehicles with higher durability demonstration mileage requirements ~~certified to the optional 100,000-mile emission standards~~ must demonstrate equivalent ~~100,000-~~

~~mile~~ durability~~,~~ ~~or the equivalent,~~ subject to the approval of the Executive Officer.

5. By model. No federally certified vehicle shall be certified or sold in California if a comparable California model of the same manufacturer is offered in the same model year.

6. By pollutant. Hydrocarbons~~,~~ and oxides of nitrogen (NOx) ~~and particulates~~ are the only pollutants which may be offset for passenger cars. Hydrocarbons, carbon monoxide~~,~~ and NOx~~, and particulates~~ may be offset for light-duty trucks. ~~Particulates may be offset for passenger cars and light-duty trucks only for the 1985 model year.~~ Evaporative hydrocarbons and particulates are not eligible for offsets. Total hydrocarbon data shall be compared directly to non-methane hydrocarbon data or NMOG data, as applicable, for purposes of calculating offsets.

B. Each manufacturer shall submit to the Executive Officer by October 1 of each year, or as soon thereafter as is practicable: (1) an estimate of the emissions credits which it will accrue based upon California certified emissions levels and projected sales of California vehicles; and (2) an estimate of the emissions credits which it will use based upon federal certification emissions levels and estimated sales of federal vehicles in California. These estimates may be changed at any time within the model year, subject to the approval of the Executive Officer. A change shall be deemed approved unless the Executive Officer disapproves the change in writing within 30 days of the Executive Officer's receipt of the change.

C. Within the bounds of Part A, emissions credits that can be accrued by a California certified vehicle shall be the difference between the applicable California standard and the certification emissions level.

$$\text{Estimated Credits} = \sum_{i=1}^{m} \text{Calsales}\ (\text{Calstd} - \text{Calcert})_i$$

Where: m = Number of California engine families certified to a set of California standards (passenger cars~~, 0-3750 pounds LVW trucks, 3751-5750 pounds LVW~~ and light-duty trucks) for a given manufacturer.

Calsales = Manufacturer's projected sales by engine family.

Calstd = Applicable California standard.

Calcert = California engine family certification level listed on the Executive Order for the applicable engine family.

D. Within the bounds of Part A, the emissions required to offset a federal vehicle shall be the difference between the federal certification level and the sales-weighted mean certification level of all California engine families (Calmean). For model years prior to 1994, Calmean shall be calculated as of February 1 of the previous model year for passenger cars or the appropriate light-duty truck group as applicable. If a new standard is implemented, an estimated Calmean shall be determined at 80 percent of the new standard. For model years prior to 1994, the estimated Calmean shall be applicable, for the initial model year under the new standard only. In order to accomodate multiple standards, Calmean for the 1994 through 2003 model years is provided in the following table:

Calmean (g/mi)
(derived from 50K stds)

Model Year	Passenger Cars		Light-Duty Trucks					
	HC	NOx	HC		CO		NOx	
			T1	T2	T1	T2	T1	T2
1994	0.200	0.320	0.200	0.256	2.72	3.89	0.320	0.776
1995	0.185	0.320	0.185	0.236	2.72	3.52	0.320	0.764
1996	0.180	0.320	0.180	0.230	2.72	3.52	0.320	0.752
1997	0.162	0.277	0.162	0.208	2.70	3.49	0.277	0.670
1998	0.126	0.234	0.126	0.164	2.64	3.49	0.234	0.550
1999	0.090	0.194	0.090	0.120	2.64	3.49	0.194	0.430
2000	0.058	0.157	0.058	0.079	2.64	3.49	0.157	0.320
2001	0.056	0.152	0.056	0.078	2.52	3.43	0.152	0.320
2002	0.054	0.152	0.054	0.076	2.45	3.34	0.152	0.320
2003	0.050	0.144	0.050	0.074	2.25	3.26	0.144	0.320

where: T1 indicates 0-3750 LVW category
T2 indicates 3751-5750 LVW category

$$\text{Estimated Withdrawals} = \sum_{j=1}^{n} \text{Fedsales}_j (\text{Fedcert}_j - \text{Calmean})$$

Where: n = Number of unavailable passenger car and light-duty trucks by model types.

Fedsales = Estimated sales of unavailable federal model types in California for a given model year.

Fedcert = Federal certification level of the engine family containing the unavailable model. Federal certification level shall be taken as the highest level, for each pollutant, of any emission data vehicle in an engine family.

Calmean = Sales weighted mean certification emission level of all California engine families (industry-wide) within the appropriate standards category.

E. The estimates referred to in Parts B, C, and D shall be updated at the end of the model year production period to final estimates using vehicle production data and, to the extent available, assembly-line emissions data. Within 60 days after the end of the model year production period, the manufacturer shall submit final estimates for the model year.

F. For the purposes of withdrawals, the 3,750 lbs. and 3,751 to 5,750 lbs. LVW groups may be combined for light-duty trucks.

G. Manufacturers shall individually be limited to withdrawing the following percentages of accrued credits for offsetting federal vehicles:

Passenger Car HC	-	7% (1993 and subsequent model years)
Passenger Car NOx	-	8% (1983 through 1988 model years)
Passenger Car NOx	-	16% (1989 model year)
Passenger Car NOx	-	26% (1990 through 1992 model years)
Passenger Car NOx	-	15% (1993 and subsequent model years)
Passenger Car Particulate	-	11% (1985 model year only)
Light-Duty Truck HC	-	74% (1983 through 1992 model years)
Light-Duty Truck HC	-	50% (1993 and subsequent model years)
Light-Duty Truck CO	-	17% (1983 through 1992 model years)
Light-Duty Truck CO	-	50% (1993 and subsequent model years)
Light-Duty Truck NOx	-	39% (1983 through 1988 model years)
Light-Duty Truck NOx	-	65% (1989 model year)

Light-Duty Truck NOx - 82% (1990 through 1992 model years)

Light-Duty Truck NOx - 42% (1993 and subsequent model years)

Light-Duty Truck Particulate - 45% (1985 model year only)

Withdrawal limits for the 1994 through 2003 model years are as follows:

Model Yr	Passenger Cars		Light-Duty Trucks		
	HC	NOx	HC	CO	NOx
1994	6	15	47	32	41
1995	8	15	54	36	42
1996	8	15	56	36	43
1997	10	19	66	37	54
1998	16	24	95	37	75
1999	26	31	100	37	100
2000	46	41	100	37	100
2001	49	43	100	40	100
2002	50	43	100	42	100
2003	56	46	100	46	100

H. Using calculation methods consistent with those used for the 1994 through 2003 model years, the withdrawal limits shall be revised by the Executive Officer if California or Federal standards change for the 1994 through 2003 model years.

HI. An emission deficit in the final estimate for a model year caused by misjudging sales of California vehicles shall be carried over and offset in the next model year.

~~I~~J. A manufacturer with an emission deficit for the same vehicle category for two consecutive model years based on final estimates shall not receive certification under these guidelines for any federal vehicles within that vehicle category produced during a 12-month period commencing 15 days after receipt of written notification from the Executive Officer. The manufacturer shall during the 12-month period offset all emissions deficits accumulated for the vehicle category. The manufacturer shall not receive certification under these guidelines for any federal vehicles within the vehicle category produced after the end of the 12-month period but before all of the accumulated emissions deficits are offset. A manufacturer with an emission deficit existing for the vehicle category after the 12-month period shall be subject to a maximum civil penalty of $500 per vehicle pursuant to Section 43016 of the Health and Safety Code. The number of federal vehicles on which the penalty shall be calculated shall be computed as follows:

$$\text{No. of federal vehicles} = \frac{\text{Emission deficit after the suspension period}}{\text{Fed assy - Calmean}}$$

where Fed assy = federal assembly-line or certification emission level of the engine family containing the unavailable model taken as the mean of the engine family quality audit of the preceding model year.

Calmean = sales weighted mean certification emission level of all California engine families within the appropriate standards taken on the preceding model year.

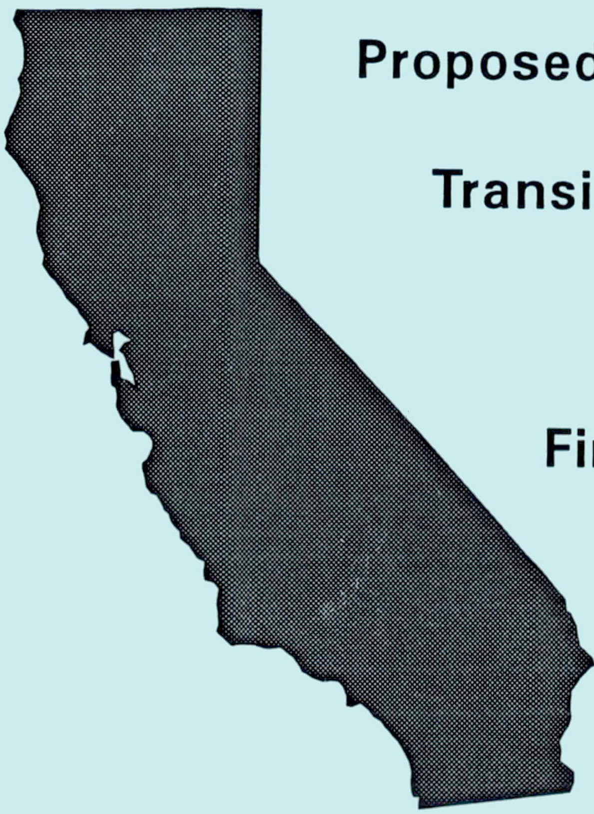
~~J~~K. A manufacturer shall be subject to a maximum civil penalty of $5,000 per vehicle pursuant to Section 43154 of the Health and Safety Code under either of the following situations:

a. Sales of federal vehicles in excess of a manufacturer's final estimate regardless of whether or not a deficit was incurred.

b. Sales of federal vehicles which under Section V.I. are not entitled to certification under these guidelines.

KL. Vehicles with engine family certification emission levels which are equal to or less than the appropriate 'Calmean' value are not eligible for offsetting.

California Air Resources Board



Proposed Reactivity Adjustment Factors for Transitional Low-Emission Vehicles

Final Statement of Reasons

Release Date: September 1992

State of California
Air Resources Board

State of California
AIR RESOURCES BOARD

Final Statement of Reasons for Rulemaking Including Summary of Comments and Agency Response

PUBLIC HEARING TO CONSIDER AMENDMENTS TO REGULATIONS REGARDING THE CALCULATION AND USE OF REACTIVITY ADJUSTMENT FACTORS FOR LOW-EMISSION VEHICLES AND THE ADOPTION OF INITIAL REACTIVITY ADJUSTMENT FACTORS FOR PASSENGER CARS AND LIGHT-DUTY TRUCKS CERTIFYING TO TRANSITIONAL LOW-EMISSION VEHICLE EXHAUST EMISSION STANDARDS

September 1992

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State of California
AIR RESOURCES BOARD

Final Statement of Reasons for Rulemaking Including Summary of Comments and Agency Response

PUBLIC HEARING TO CONSIDER AMENDMENTS TO REGULATIONS REGARDING THE CALCULATION AND USE OF REACTIVITY ADJUSTMENT FACTORS FOR LOW-EMISSION VEHICLES AND THE ADOPTION OF INITIAL REACTIVITY ADJUSTMENT FACTORS FOR PASSENGER CARS AND LIGHT-DUTY TRUCKS CERTIFYING TO TRANSITIONAL LOW-EMISSION VEHICLE EXHAUST EMISSION STANDARDS

Public Hearing Date: November 14, 1991
Agenda Item No.: 91-10-2

I. GENERAL

Following a public hearing on September 27-28, 1990, the California Air Resources Board (the Board or ARB) adopted the Low-Emission Vehicles and Clean Fuels (LEV/CF) regulations which establish exhaust emission standards for four progressively more stringent categories of light-duty vehicles: Transitional Low-Emission Vehicle (TLEV), Low-Emission Vehicle (LEV), Ultra-Low Emission Vehicle (ULEV) and Zero-Emission Vehicle (ZEV). For the first time, the standards considered the reactivity or "ozone forming potential" of exhaust emissions from alternative fuel vehicles in order to reflect the phenomenon that organic gases (or hydrocarbons) emitted by vehicles operating on alternative and reformulated fuels can form less ozone than conventional gasoline vehicles. In order to equalize the ozone impacts of alternative fuel and gasoline vehicles, the LEV/CF regulations established a procedure for determining reactivity adjustment factors (RAFs).

On November 14, 1991, the Board conducted a public hearing to consider amendments to the LEV/CF regulations (hereafter RAF rulemaking or RAF amendments). As initially proposed, the amendments would revise the provisions for calculating and using RAFs for low-emission vehicles, and also identify initial RAFs for passenger cars and light-duty trucks certifying to TLEV exhaust emission standards. The regulatory provisions affected by the amendments were Section 1960.1 of Title 13, California Code of Regulations, and the "California Exhaust Emission Standards and Test Procedures for 1988 and Subsequent Model Passenger Cars, Light-Duty Trucks and Medium-Duty Vehicles" (hereafter the LDV/MDV Standards and Test Procedures), which is incorporated by reference in Section 1960.1.

The Board approved the RAF amendments by adopting Resolution 91-53. As approved, the regulations included a number of modifications to the originally proposed text. Most of the modifications reflected suggestions made by the staff at the November 14, 1991 hearing. The Board directed the Executive Officer to incorporate the approved modifications into the originally proposed text with such conforming amendments as may be appropriate, and to conduct an informal workshop on the modified language if warranted. In accordance with Government Code section 11346.8(c), the Resolution directed the Executive Officer to then make the modified regulatory text available to the public for a supplemental comment period of 15 days. He was then directed either to adopt the modified regulations with such additional modifications as may be appropriate in light of the comments received, or to present them to the Board for further consideration if he determined such an action was warranted by the comments.

The staff held an informal public workshop on February 3 and 4, 1992 to receive input on proposed modified regulatory language.[1] The modified regulatory text was then made available to the public on April 21, 1992 for a supplemental 15-day comment period. At the same time, additional documents and information were made available for public inspection pursuant to 1 C.C.R. section 45. Several written comments were received. After considering the comments, the Executive Officer issued Executive Order G-769 amending 13 C.C.R. section 1960.1 and the incorporated standards and test procedures.

The Staff Report: Initial Statement of Reasons for Rulemaking (Staff Report) for this rulemaking was available for public inspection on September 27, 1991. On the same date, the staff made available a Technical Support Document (TSD). The Staff Report and TSD included the texts of the regulations and amendments as initially proposed by the staff, along with extensive descriptions of the rationale for the proposal. The Staff Report and TSD are incorporated by reference herein. This Final Statement of Reasons updates the Staff Report by identifying and explaining the modifications made to the originally proposed texts. The Final Statement of Reasons also contains a summary of the comments the Board received on the proposed regulations during the formal rulemaking process and the ARB's responses to the comments.

The amended LDV/MDV Standards and Test Procedures is incorporated by reference in 13 C.C.R. section 1960.1. The LDV/MDV Standards and Test Procedures in turn incorporate certification test procedures adopted by the U.S. Environmental Protection Agency (EPA) and contained in Title 40, Code of Federal Regulations, Part 86.

Title 13, C.C.R. section 1960.1 identifies the incorporated ARB document by title and date. The ARB document is readily available from the ARB upon request and was made available in the context of the subject rulemaking in the manner provided in Government Code section 11346.7(a). The Code of Federal Regulations is published by the Office of the Federal

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1. The workshop notice stated that comments made at the workshop would not be considered part of the rulemaking record and that to be formally considered as part of the record comments should be submitted during the subsequent 15-day comment period.

Register, National Archives and Records Administration, and is therefore reasonably available to the affected public from a commonly known source.

The LDV/MDV Standards and Test Procedures is incorporated by reference because it would be impractical to print it in the California Code of Regulations. Existing ARB administrative practice has been to have test procedures incorporated by reference rather than printed in the California Code of Regulations. These procedures are highly technical and complex. They include "nuts and bolts" engineering protocols and have a very limited audience. Because the ARB has never printed test procedures in the California Code of Regulations, the affected public is accustomed to the incorporation format utilized herein. The ARB's test procedures as a whole are extensive and it would be both cumbersome and expensive to print these lengthy, technically complex procedures with a limited audience in the California Code of Regulations. Printing portions of the ARB's test procedures in the California Code of Regulations when the bulk of the test procedures are incorporated by reference would be unnecessarily confusing to the affected public.

The LDV/MDV Standards and Test Procedures incorporates portions of the Code of Federal Regulations because the ARB requirements are substantially based on the federal regulations. Manufacturers typically certify vehicles and engines to both the federal and state emissions standards and test procedures. Incorporation of the federal regulations by reference makes it easier for manufacturers to know when the two sets of requirements are identical and when they differ.

The Board has determined that this regulatory action will not result in a mandate to any local agency or school district the costs of which are reimbursable by the state pursuant to Part 7 (commencing with section 17500), Division 4, Title 2 of the Government Code.

The Board has further determined that no alternative considered by the agency would be more effective in carrying out the purpose for which the regulatory action was proposed or would be as effective and less burdensome to affected private persons than the action taken by the Board.

II. SUMMARY OF MODIFICATIONS

This section summarizes the modifications made to the originally proposed regulatory text. All of the substantive modifications were made to the LDV/MDV Standards and Test Procedures; all section citations refer to that document.

A. Withdrawal of Proposed RAFs for CNG and LPG; Assignment of RAF for M85

In Section 13.(a)(1), the originally proposed RAF of 0.36 for methanol TLEVs was changed to 0.41, and the originally proposed RAFs for compressed natural gas (CNG) and liquified petroleum gas (LPG) of 0.50 and 0.18, respectively, were deleted from the regulatory text. The revised RAF of 0.41 for methanol reflects the updated maximum incremental reactivity scale (see II.G. below) and a 10 percent correction for potential modeling and protocol biases. RAFs for CNG and LPG were dropped because of inconsistencies and limitations in the vehicle emission data. See also the responses to Comments 15 and 44 below.

B. Baseline RAF

In Section 13.(d)(1), the 'g ozone potential per g NMOG' for passenger cars and light-duty trucks 0-5750 lbs. LVW certified to TLEV standards was changed from 3.44 to 3.42 to reflect the modifications to the maximum incremental reactivity scale.

C. Adjustment to RAF for Methanol and LPG

In Appendix VIII, at the end of note (7), language was added to require that, for candidate vehicle/fuel systems powered by methanol or LPG, the RAFs be adjusted upward by 10 percent to account for potential modeling and protocol biases. See also the response to Comments 15 and 26 below.

D. Engine-Family-Specific RAFs

The Board deleted the requirement in Appendix VIII(8)b. for a 25 percent difference between the manufacturer-derived RAF and the ARB-established factor in order to provide vehicle manufacturers a greater opporutnity to use engine-family-specific RAFs. Several vehicle manufacturers had requested elimination of the 25 percent provision. (see Comment 33.) At the same time, the Board added several new requirements for engine-family-specific RAFs in Appendix VIII(8)a. to help assure that these RAFs accurately reflect the ability of an emission control system to reduce ozone. Vehicle manufacturers will be required to submit speciated NMOG exhaust emission profiles from at least four vehicles representative of the engine family. The emission data vehicle(s) for the engine family will have to be included in the vehicle test sample, and the speciated profile(s) from the emission data vehicle(s) must be obtained from the same test(s) used to derive the official 4000 mile exhaust certification data. One speciated profile is required from each test vehicle. An "undeteriorated reactivity adjustment factor" is calculated for each vehicle, and the "undeteriorated reactivity adjustment factor" for the engine family is derived by taking the arithmetic mean. To limit the amount of variability in the data, the 95 percent upper confidence bound of the mean undeteriorated reactivity adjustment factor can be no more than 15 percent greater than the value of the mean factor.

E. Reactivity Deterioration Factor

A procedure for determining a "reactivity deterioration factor" was added in Appendix VIII(8)b. to ensure that the engine-family specific RAFs are valid over the life of the vehicles. A manufacturer is required to obtain at least two speciated NMOG exhaust emission profiles from at least one durability data vehicle at each mileage interval normally used to determine deterioration factors for mass emissions. The mean reactivity adjustment factor is calculated at each interval, and from this information, a deterioration factor for reactivity is obtained. No reactivity deterioration factor can be less than 1.00. The mean undeteriorated reactivity adjustment factor derived for the engine family is multiplied by the reactivity deterioration factor to obtain the reactivity adjustment factor used to determine compliance with the NMOG standards.

F. Leadtime

Because the data from emission data vehicles are typically not generated until just prior to submittal of the certification application, the provision requiring a two-year leadtime for submitting speciated profiles in Appendix VIII(8)c. was changed to require that speciated profiles, RAFs, and reactivity deterioration factors be submitted with the certification application.

G. Maximum Incremental Reactivities

In Appendix VIII(9), the maximum incremental reactivity values were revised to reflect updates to the maximum incremental reactivity scale.

III. SUMMARY OF PUBLIC COMMENTS AND AGENCY RESPONSES

Prior to or at the hearing, oral and written comments were received from the California Energy Commission (CEC), Association of International Automobile Manufacturers (AIAM), Nissan, Toyota, Motor Vehicle Manufacturers Association (MVMA), Western States Petroleum Association (WSPA), ARCO, Chevron U.S.A. Inc. (Chevron), Western Liquid Gas Association (WLGA), California Renewable Fuels Council (CRFC), Ford Motor Company (Ford), General Motors (GM), Chrysler, Sacramento Metropolitan Air Quality Management District (SMAQMD), South Coast Air Quality Management District (SCAQMD), and California Natural Gas Vehicle Coalition (NGVC). Written testimony was received from Ultramar. During the 15-day comment period, written comments were received from WSPA, Chevron, Toyota, GM, and Ford.

A. Use of MIR Scale and Revisions to Specific MIRs

1. General Appropriateness of the MIR Approach

1. Comment: There has been no critical peer review of the derivation and use of the MIR scale by the scientific community. (Chevron)

The method used to produce a single reactivity scale was chosen as a means to an end and its validity has never been demonstrated nor has it been subject to a peer review. (WSPA)

Agency Response: The commenters' characterizations are not accurate. The Board adopted the LEV/CF regulations following the September 1990 hearing. However, because the choice of the MIR scale was controversial, the ARB committed itself to a comprehensive year-long evaluation of the MIR approach. During this time, the ARB staff hosted an international conference on reactivity, prepared a protocol document, conducted four meetings of the ad hoc Reactivity Advisory Panel, and funded research projects with Dr. William Carter, Dr. Michael Gery and Professor Armistead Russell. Several industry groups funded research projects with Professor Harvey Jeffries and with Systems Applications International.

While a great deal of research was accomplished, by the summer of 1991 it had become clear that more time was needed. Accordingly the planned public hearing was postponed for two months until November 1991. At this time we believe that every significant concern has been resolved (1) by showing that the uncertainties in the atmospheric chemistry have a negligible effect on the RAFs, (2) by improving the model used to calculate the reactivity scale, and (3) by adjusting the RAFs to reflect the airshed modeling results. Dr. Carter will not be able to implement a major update to the SAPRC90 mechanism before 1993 at the earliest, so this task has been put off until the scheduled 1994 update to the reactivity scale.

2. Comment: Due to the complex nature of atmospheric chemistry and variable atmospheric conditions, it is not scientifically possible to define

a single reactivity scale that is valid under all typical urban conditions. (Chevron)

The concept of a single RAF is flawed; there is no single RAF value for a vehicle/fuel combination that will produce a "level playing field" for all vehicle/fuel combinations. Reactivities are a function of environmental conditions and are clearly not the same over an entire region. Before the models can be assumed to predict a balance in the real world, more evidence is needed than is shown in studies of this phenomenon to date. (WSPA)

Agency Response: The LEV/CF regulations are "fuel neutral" to allow all alternatively-fueled vehicles to compete in the marketplace as long as they meet NMOG exhaust emission standards equivalent or lower in ozone forming potential (or "reactivity") to those set for vehicles fueled with conventional gasoline. The exhaust compositions of most alternatively-fueled vehicles are simply too different from conventional gasoline-fueled vehicles to assume that they have the same ozone-forming potential per unit of mass emissions. Reactivity adjustment factors appear to be the only way to assure fair and equitable treatment for both manufacturers of motor vehicles and for producers of gasoline and all cleaner burning fuels.

In the initial LEV/CF rulemaking the Board adopted the MIR scale, developed by Dr. Carter, for calculation of the RAFs. The principal advantage of this scale is that it defines reactivity in areas where hydrocarbon control has its greatest benefits--the upwind areas where the highest emission densities are found. Hydrocarbon control is complementary to California's NOx control program, which has its greatest benefits in the downwind, peak ozone areas.

There is little to be gained in designing a reactivity scale that is applicable only to areas where hydrocarbon control has little or no benefit in reducing ambient ozone levels. Additional advantages of the MIR scale over other approaches include the ease of RAF calculations, the availability of a single scale for use in the statewide regulations, and a framework that can easily incorporate chemical mechanism updates.

While it is not possible to derive a single RAF that yields precisely equal air quality benefits in all places at all times, the RAF has proven to be a stable quantity for places where hydrocarbon control is important, i.e., MIR conditions. This conclusion is supported by the consistency in the RAFs among all thirty-nine cities used in the derivation of the scale, and the agreement between the MIR scale and the airshed modeling results both for individual hydrocarbons and the RAFs.

3. Comment: Ozone episodes in California typically last for two to three days. However, the MIR scale is derived from single-day EKMA (Empirical Kinetics Modeling Approach) model simulations, which underestimate the contribution of slowly reacting compounds to ozone formation. This in turn leads to an allowance in the RAF for increased mass emissions from alternative fueled vehicles. (Chevron)

The RAFs as currently proposed will not contribute to improved air quality. The reactivity factors have been determined on the basis of reaction speed rather than on overall reaction potential. Consequently, low-reactivity pollutants that may contribute to multi-day episodes may be under-represented. Likewise, daily pollutant carryover may well be underestimated. (Ultramar)

Agency Response: The MIR and MOIR scales were calculated with an EKMA-like, chemically detailed, one-dimensional model that operates with one-day simulations and lacks physical detail. At issue is whether this is an adequate representation of actual ozone episodes, which tend to extend over several days in California and whose severity is strongly dependent on meteorological conditions.

Professor Russell and his co-workers addressed this issue by computing incremental reactivities with a physically detailed, three-dimensional airshed model for a severe, three-day stagnation episode in Los Angeles when the daily ozone maximum was limited by the availability of NOx. Despite large differences in the physical details and NOx availability of the two modeling approaches, the agreement between the airshed modeling and the MIR scale is within 15 percent for most organic gases. These results suggest that the RAFs are a valid means to provide a common basis for comparing exhaust emissions, even for multi-day ozone episodes. The RAFs take into account both reaction speed and ozone formation after the initiation step on overall reaction potential.

4. Comment: When one species in the urban mixture is changed, many other species in the mixture can contribute as much as half of the ozone to the change that occurs. Compositional variation can change the chemical composition significantly when compared to the simple constant compound single day models used by Dr. Carter. They could change conditions that influence reactivities. The MIR scale is derived from an overly simplistic single day model using constant VOC compositions which compositions have been proved to be incorrect. (WSPA)

Agency Response: The good agreement between the MIR scale and the airshed modeling results indicates that this is not an issue. Changes in the emissions of one species affects radical levels, and thus, reaction rates for other species. Whether one attributes reactivity to radical level changes, or to the many species that react with those radicals to produce ozone, is beside the point. As long as the chemical mechanisms account for species interdependencies, we should be able to calculate reactivities over a range of compositions of the hydrocarbon mix. This has been fully confirmed--the airshed model includes hydrocarbon compositions that vary geographically and over the course of the three-day simulation. If compositional variations greatly influenced reactivity, then we would not observe the close agreement found between the airshed modeling and the MIR scale.

5. Comment: Applying RAFs that are developed using the MIR approach would lead to increased ozone formation by vehicles operating on alternative fuels because the MIR factors overestimate reactivity differences among organic compounds compared to alternative reactivity scales. The MIR scale expands the reactivity credit more than any other scale, giving the lowest RAFs of any of the 10 alternative scales. A more realistic set of VOC reactivities needs to be developed than those in the single, averaged MIR scale. (WSPA)

Agency Response: The use of the maximum reactivity criterion has been criticized because it means that reactivity scales are calculated for conditions where NOx levels are higher than those where peak ozone levels occur. Some argue that alternative approaches, such as basing the scale on conditions where peak ozone levels occur or on averages of airshed conditions regardless of sensitivity of ozone levels to hydrocarbon controls, are more appropriate.

The principle behind use of the maximum reactivity criterion is that, in California, hydrocarbon controls are being implemented in conjunction with stringent NOx controls. Nitrogen oxides controls are being implemented to reduce ozone under conditions that are sensitive to NOx, and hydrocarbon controls are being implemented to reduce ozone under conditions sensitive to hydrocarbons. The maximum reactivity criterion is the most appropriate to use in this context. Even though all hydrocarbons eventually react, there is little to be gained in designing a reactivity scale that is applicable only to areas where hydrocarbon control has little or no benefit. This theory is supported by the airshed modeling results, which clearly show the greatest agreement with the MIR scale, and not the alternative scales that have been considered. While airshed models are only an approximation to reality, they do embody all that has been learned in the last forty years about the atmospheric processes leading to ozone formation.

6. Comment: Can the reactivity of a complex mixture be adequately represented by summing the incremental reactivities of the individual species? (Chevron)

Agency Response: Incremental reactivities are, by definition, mathematically additive, but at issue is how large an emission change is considered an "increment". Calculations by Chang and Rudy with an EKMA-type model indicate that individual emission increments appear to be additive for up to a 30 percent substitution of organic gas emissions in an airshed. In the airshed modeling, the RAFs were applied to the entire motor vehicle fleet. This corresponds to 21 and 13 percent of the NMOG inventory in 1987 and 2010, respectively. This assumption of complete conversion of the fleet to TLEVs is not realistic, but the agreement between the airshed modeling and the MIR scale shows that the incremental reactivities are additive for even the largest possible change in motor vehicle emissions.

7. Comment: What type of aggregation approach should be used to define the reactivity scale? (Chevron) The simple arithmetic averaging of partial derivatives determined in thirty-nine different scenarios from all over the United States to produce a single set of MIR and MOIR values has not been subject to peer review and furthermore has no scientific meaning. The methodology and protocol for determining MIR and RAF values needs to be improved with an added emphasis on methods for combining results from different scenarios. (WSPA)

Agency Response: Given the relatively small variations in the RAFs among all thirty-nine cities used in the derivation of the scale, and the agreement between the MIR scale and the airshed modeling results--both for individual hydrocarbons and the RAFs--this is not an issue.

8. Comment: How should exceptional compounds such as aldehydes and toluene be handled due to their varying reactivities? (Chevron)

Agency Response: Chevron's concern applies to the base case, not to MIR conditions. Base-case conditions are relatively insensitive to hydrocarbon control, and whether a chemical mechanism simulates toluene reactivity as slightly positive or slightly negative should not matter. Under MIR conditions, the three chemical mechanisms examined led to very similar reactivity estimates for toluene and formaldehyde.

9. Comment: If the Board adopts the MIR scale, it should be conditioned on a continuing evaluation of the methodology. There should be experimental verification of the reactivity impacts of key individual species as well as exhaust mixtures from clean-fueled vehicles. (GM) There will be a continuing need to improve the models and factors used to calculate the RAFs. (Chrysler)

Agency Response: For the long term, the Board will continue to sponsor laboratory studies and chemical mechanism development to reduce uncertainties in the MIR scale still further--particularly for aromatic hydrocarbons--and to review research sponsored by other organizations. The Board plans to update the MIR scale every three years.

2. Chemical Mechanism

10. Comment: Several of the changes to Dr. Carter's SAPRC90 chemical mechanism that were suggested by Dr. Gery in his peer review for the ARB have not been incorporated. For instance: update formaldehyde absorption cross sections, update rate constants of reactions which lead to PAN formation, improve the photolysis assumptions for aromatic reaction intermediates. When the mechanism was modified, it was less able to predict the experimental ozone smog chamber results suggesting that the SAPRC90 mechanism contains internal, compensatory errors that need to be identified and corrected. Rather than fix the errors in the mechanism, the ARB has

decided, because of lack of time, to use the older rate constants--which caused the mechanism to agree somewhat better with observations. An unbiased mechanism, free of identified errors, should be used to calculate TLEV RAFs. (Chevron, WSPA)

Agency Response: While the SAPRC90 chemical mechanism is considered to be the best available for deriving reactivity scales, an ARB-funded peer review by Dr. Gery indicated several areas where updates were desirable. Dr. Carter concurred with most of Dr. Gery's recommendations, but some of the modifications to the mechanism resulted in a significant bias in simulations of the environmental chamber data base. This bias may be due to either the chemical mechanism or the representation of chamber conditions.

EPA has funded a project, conducted by Professor Jeffries with support from Dr. Carter, Dr. Gery and others, to review and evaluate the environmental chamber base. This project was (and continues to be) well behind schedule, as was a component to develop a chemical mechanism evaluation protocol. Based on the recommendations of Dr. Gery, Professor Jeffries and other modeling experts on the ad hoc Reactivity Advisory Panel, we decided that it would be more prudent to calculate the RAFs using a mechanism that has already been evaluated and documented in the referenced literature. Accordingly, changes to the mechanism were restricted to only those affecting individual NMOG species for which there is no significant evaluation data base. A major update to the SAPRC90 mechanism will not be completed before 1993 at the earliest, and will be used for the scheduled 1994 update to the reactivity scale. Concerns about the correctness of the mechanism are partially alleviated by the minor effect (less than 8 percent) on the RAFs of previous major updates to the mechanism.

11. Comment: Too much reliance has been placed on indoor smog chamber experiments. The ARB should wait for the results of the EPA project that is investigating both the indoor smog chamber experiments, and for Dr. Jeffries outdoor smog chamber experiments. (Chevron)

Full quality assurance procedures should be performed on the SAPRC chamber data, simulation inputs for the mechanism testing should be adjusted to account for changes due to the quality assurance procedures, and the University of North Carolina (UNC) outdoor chamber data should be added to the chemical mechanism. The agreement between predictions and observations from chamber data needs to be reevaluated and the results should be made available for peer review. (WSPA)

Agency Response: See the response to the preceding comment.

12. Comment: There are differences between the SAPRC90 mechanism and the CMU airshed model. These need to be reviewed and the differences resolved. (Chevron) There has been no discussion of what happens when you compare differences in the mechanisms such as the U.S. EPA mechanism and SAPRC90. (WSPA)

Agency Response: The SAPRC90 chemical mechanism was specifically developed by Dr. Carter for deriving reactivity scales. The Carbon Bond IV (CB4) and LCC (a 1987 predecessor of SAPRC90) mechanisms, while not as suitable for reactivity calculations, produced RAFs within 8 percent of those derived with SAPRC90.

3. Airshed Modeling

13. Comment: Use of the MIR approach may provide too much credit for alternative fuels under stagnant air and/or carryover conditions. At present the ARB has determined that the MIR approach is the appropriate methodology. However, given the unknowns associated with this approach, adoption of the MIR scale should be conditioned on the continuing evaluation of both scales using airshed modeling. The staff should continue to evaluate both MIR and MOIR scales using airshed modeling and decide on a scale only when sufficient information is available. (MVMA)

Agency Response: Professor Russell and his co-workers were retained by the ARB to address the issue of which reactivity scale is most appropriate to assure equal ozone impacts from vehicles operating on alternative fuels. They computed incremental reactivities with a physically detailed, three-dimensional airshed model for a severe, three-day stagnation episode in Los Angeles when the daily ozone maximum was limited by the availability of NOx. Despite large differences in the physical details and NOx availability of the two modeling approaches, the agreement between the airshed modeling and the MIR scale is within 15 percent for most organic gases. Poorer agreement was found with the MOIR scale, with differences larger than 25 percent for most organic gases. On the basis of these results, we believe that the MIR scale is appropriate for use in computing RAFs.

14. Comment: The protocol that defines when MIR or MOIR is judged non-discriminatory and fair to all potential fuels should not be an arbitrary percentage cutoff factor but rather the cutoff should be based on expected model uncertainty. (MVMA) The criteria by which RAFs will be evaluated/validated using airshed modeling must be clearly defined and agreed upon. On what basis will the airshed modeling results be used to choose between the MIR scale vs. the MOIR or other scale? How will the metrics for ozone--peak concentration, areal extent and population exposure --be prioritized? How closely must the model results and RAF predictions agree? What constitutes validation? How will the model results be used to "fine-tune" the RAFs? (Chevron)

Agency Response: The modeling protocol document established that the one-hour basin peak concentrations and ozone geographic dosage (in units of ppm-hours summed over all hours in all surface grid cells over land with absolute ozone concentrations above 0.09 ppm) should be within 25 percent. Later, it was decided that the 25 percent criterion was inadequate, and that the dosage should be population-weighted. The most stringent criterion was selected-equal ozone impacts, without exception. See also the responses to comment nos. 13 and 15.

15. Comment: What is the scientific justification for a 10 percent "fudge" factor? (Chevron) The results of the null test for the 1982 ozone episode indicate that the reactivity credit provided by Carter MIR values is too large. Every alternative fuel produced more ozone. The 10 percent correction factor reflects an arbitrary and unjustified assumption, especially the extension of the adjustment to other fuels besides M85. Suggesting a 10 percent correction factor across the board for all alternative fuels is equivalent to saying that all of the individual reactivities of all of the species in the Carter scale are wrong by 10 percent. The 10 percent upward adjustment factor for M85 does not provide an adequate margin of safety. (WSPA)

Agency Response: Professor Russell evaluated the MIR scale with the Southern California Air Quality Study (SCAQS) database, among other modeling applications. He found very good agreement for individual hydrocarbons, but noted some deviations (approximately a 10 percent bias in the results for population-weighted dosage estimates for the higher 1982 episode) from the equal ozone impacts for any vehicle/fuel combination required by the regulations. These deviations appear to be due to differences in spatial and temporal patterns of emissions between vehicle fleets, rather than a problem with the MIR approach. Thus only the RAFs--and not the MIR scale--need to be changed by 10 percent.

The fleet with the highest cold-start emissions (M85), which has emissions concentrated over a shorter time in comparison to the conventional gasoline fleet, had higher null test results, while the fleet with the highest running emissions (CNG), which are more spread over time, had the lowest null test results. Thus, the RAFs need to be adjusted to account for these differences in the spatial and temporal patterns of emissions between the alternative fuels and conventional gasoline. The only formally established RAF to date--a value of 0.41 for M85-fueled TLEVs--includes a 10 percent increase based on the airshed modeling. Manufacturers which elect to determine their own RAFs for their M85 engine families must also adjust the RAFs upward by 10 percent. The 10 percent correction factor applies to RAFs calculated for LPG vehicles as well. However, the correction to the RAF may be different for other fuels (e.g., CNG), and, accordingly, the LDV/MDV Standards and Test Procedures do not identify a correction factor for fuels other than M85 and LPG.

16. Comment: It is not clear whether other alternative fuels will be adjusted in the same way as was done for M85. (WSPA)

Agency Response: As noted in the response to the previous comment, the 10 percent adjustment factor applies to M85 and LPG. When more vehicle test data become available for the other alternative fuels, we plan to perform airshed modeling to determine whether a fuel-specific RAF correction is appropriate.

17. Comment: When compared to the other scales, the MIR scale gives the lowest RAFs and the largest reactivity credits to vehicles operating on alternative fuels. The MIR scale appears to disagree with the CMU grid model results for ozone episodes with stagnation and carryover of pollutants from one day to the next. (GM)

Agency Response: The MIR scale clearly agrees with the airshed model results as shown in Attachment III of the 15-Day Notice.

18. Comment: There should be additional grid modeling with the models being used to develop attainment plans under the California and Federal Clean Air Acts. Do these models show a level-playing field if light-duty vehicles switch from one fuel to another? (GM) Even though the reactivity control program is a statewide program, the modeling is based on a three-day episode in the South Coast Air Basin. Gridded airshed modeling should be done for other areas as well. (Chevron)

Agency Response: The primary focus of the ARB's motor vehicle control program is to improve the situation in Los Angeles, because it has the worst ozone problem and is home to the most vehicles in California (as well as in the United States). Not by coincidence, Los Angeles has been the subject of the most airshed modeling studies. However, the MIR scale was developed using a range of conditions observed in California and the rest of the United States; if this generalized scale agrees with the situation in Los Angeles, it should follow that it will also agree with other cities in California. Nonetheless it is the ARB staff's intention to compare the MIR scale with airshed model applications in other cities when they reach the same level of sophistication as those performed in Los Angeles.

19. Comment: The results of the Carnegie Mellon study should be made available to the public for peer review. (MVMA) The numbers are changing too fast and without peer review. Did changing the MEK (methyl ethyl ketone) mechanism slightly cause the model to go from 20-30 percent overprediction to only a 10 percent overprediction? (WSPA)

Agency Response: The airshed model results are available for peer review in Attachment III of the 15-Day Notice. In addition, the study performed by Professor Russell of Carnegie Mellon University has resulted in two peer reviewed papers, one already published and another one recently submitted.

The modification fix to the MEK mechanism was the result of peer review, and generally resulted in a 5 percent improvement.

4. Uncertainty

20. Comment: The scientific and technical basis on which the TLEV RAFs are based is not well founded. There are uncertainties regarding the most appropriate method for developing a single reactivity scale for all of California, uncertainties in the photochemical model used to calculate the MIRs, and uncertainties in the vehicles test data. No effort has been made to explicitly account for the uncertainties in the calculation of reactivity scale for individual compounds or in the RAFs themselves. (WSPA)

Additional study is needed to address uncertainties in the proposed methodology for determining the ozone-forming potential of organic gases. It is imperative that the scientific foundation used in determining RAFs be reliable enough to assure that the increased mass emissions which will be allowed with some fuels do not exacerbate California's air quality problems. (Nissan)

Agency Response: Uncertainties in the underlying science have always been present in the move toward solutions to environmental problems. The key issue is not that there are uncertainties, but how much those uncertainties contribute to uncertainties in outcomes. The approach of the ARB staff, Dr. Carter and Professor Russell was to gauge the effect of these uncertainties on the RAFs for the alternative fuels of interest. The results are encouraging.

While significant uncertainties remain in our understanding of atmospheric chemistry, the RAFs for several alternative fuels changed by less than 8 percent in sensitivity studies on the effect of the last three years of chemical mechanism development. The RAFs are also relatively insensitive to uncertainties in the representation of airshed conditions used in the derivation of the MIR scale.

Dr. Carter performed a series of sensitivity tests to investigate the effects of uncertainties in nitrous acid (HONO) levels, photolysis rates and ambient NMOG speciation on the MIR and MOIR scales. The largest effect on a RAF was a 5 percent decrease for E85 when photolysis rates were computed at the surface. The reactivities (relative to the ambient NMOG speciation profile) of many slower reacting organic gases also drop with the use of surface photolysis rates, while the relative reactivity of formaldehyde increases when HONO is set to zero, especially for MIR conditions.

Professor Russell's evaluation of the MIR scale with airshed modeling showed very good agreement for individual hydrocarbons, but indicated some deviation (less than 10 percent) from the equal ozone impacts for any vehicle/fuel combination required by the regulations. These deviations are more likely due to differences in spatial and temporal patterns of emissions between vehicle fleets, rather than a problem with the MIR approach. Uncertainties in emission inventories and meteorological conditions were addressed with the four scenarios simulated in the airshed modeling.

21. Comment: By picking the low end of the range of technical uncertainty, there is a risk of overestimating the reactivity credit and thereby increasing ozone. A more conservative approach would be to take a scale in the middle or towards the upper end of the available scales. (WSPA) Choosing the MIR scale does not seem appropriate given the uncertainties in knowledge of atmospheric reactivity, uncertainties in chemical mechanisms, and uncertainties in emissions from future production alternative-fueled vehicles. (GM)

Agency Response: There are many sources of uncertainty in the RAF that could favor either alternative fuels or the base gasoline. What to do about these uncertainties depends on one's viewpoint on whether alternative fuels should compete on an equal basis with gasoline or if the status quo should be favored until we are more certain about the RAFs. The Board has made it clear that it wants to use the best technical information in its decisions, so that all fuel suppliers and vehicle manufacturers are treated equally.

22. Comment: A 10 percent change in the reactivity factor for M85 would amount to a 30 percent change in the allowable balance of emissions from the vehicle. (ARCO)

Agency Response: The only formally adopted RAF to date--a value of 0.41 for M85-fueled vehicles--includes a 10 percent increase based on the airshed modeling results. Obviously the emissions from these vehicles will be 30 percent less than would have been the case had not the Board incorporated a 10 percent increase in the RAF.

23. Comment: Using statistical analysis of both the new and the old MIR scales, it was found that RAFs of 0.51 and 0.56, respectively, for M85 would ensure that 95 percent and 99 percent of M85 vehicles meeting the reactivity adjusted NMOG standard would do so without increasing ozone. Based on this analysis, the M85 RAF should be increased to 0.54. (WSPA)

Agency Response: This comment is based on an analysis by ARCO that did not use statistical methods correctly. The data provide information on two components of variation in the reactivity of each of the fuels: (i) variation between vehicles; and (ii) variation between repeated tests on the same vehicle. These components will be referred to as between-vehicle and within-vehicle variation, respectively. Both of these components are well-defined in terms of random variation encountered in the gathering of data of this type.

ARCO has proposed a statistical model for these data that ignores the collection of data from different vehicles and therefore ignores between-vehicle variation. Generally, between-vehicle variability is substantially larger than within-vehicle variability in fuels data. Mixing the two types of variability together therefore gives a very misleading representation of the variability in the data which cannot be extrapolated reliably to other data sets. An additional argument for including between-vehicle variability in a model for these data is that the numbers of tests on each vehicle are unlikely to be proportional to the numbers of vehicles of that type in the population, or to anything else relevant.

Other problems with ARCO's analysis include: (i) a large amount of data has been "manufactured" from very little data--of course this "large" amount of data is an illusion, and there can be no more information in the "large" database than there was in the original data; and (ii) the computation of relative reactivities from pairs of unrelated vehicles does not correspond to any plausible way of analyzing the data or to any plausible statistical model, since the defects in the data set invalidate any statistical results obtained from it.

5. Ethanol

24. Comment: It is unclear how ARB arrived at the MIR values assigned to acetaldehyde, formaldehyde, methanol and ethanol. Due to the extreme variability and uncertainty in ethanol and acetaldehyde reactivities, it is premature to adopt MIRs for these compounds. A study performed by Systems Application International (SAI) found a 4 percent variation in reactivity for methanol and a greater than 40 percent variation for ethanol for the nine scenarios investigated. The reactivity of formaldehyde varied 15 percent while the reactivity of acetaldehyde varied over 70 percent. (CRFC)

Agency Response: Reactivity scales calculated by Dr. Gary Whitten of SAI for trajectories from airshed model simulations in Kern County, San Diego and Ventura differ greatly from the MIR scale of Dr. Carter. However, Dr. Whitten's results are more consistent with NOx-limited conditions, and there is some question as to whether he is correctly simulating MIR conditions. We are still attempting to obtain Dr. Whitten's scenarios so that Dr. Carter can verify his calculations. Since none of the E85-fueled vehicles met all the TLEV standards, the ethanol reactivity was not used in any of the RAFs.

B. Procedure and Protocol for Establishing Reactivity Adjustment Factors

25. Comment: The ARB should use a mass basis for compliance until an equitable, reliable and viable set of RAFs can be developed. (WSPA)

Agency Response: Mass-based standards do not reflect the phenomenon that organic gases (or hydrocarbons) emitted by vehicles powered by alternative and reformulated fuels can lead to lower ozone formation than vehicles operating on conventional gasoline. Such an approach would provide an unfair advantage for gasoline since some alternate fuels may emit more mass emissions than gasoline, but because each unit of mass is much less reactive than gasoline, the overall contribution to ozone would be lower than for gasoline. We believe that the regulatory approach we have taken is equitable, reliable and viable since CMU (Carnegie-Mellon University) modeling runs have verified the correctness of the adopted protocols.

26. Comment: Mass emission increases from alternative-fueled vehicles which are allowed by the proposed RAFs are excessive and may exacerbate ozone formation. Because of the uncertainties in atmospheric chemistry and automotive emissions and lack of adequate technical foundation, a conservative set of RAFs should be developed to guard against increased ozone formation. (Chevron, WSPA)

The direction the ARB is heading with respect to producing a level playing field between alternative fuels and conventional gasoline is leading to a bias in favor of alternative fuels by exaggerating the performance of alternative fuels. In order to compensate for this bias, it would be appropriate to use the 95% confidence limit on the emission data used to calculate RAFs. (ARCO)

Agency Response: The goal of the RAFs is to equalize the air quality impacts of all alternative fuels based on their ozone forming potential. In determining the protocol for establishing RAFs, the ARB formed an ad hoc Reactivity Advisory Panel to assure a reasonable and appropriate approach was used. To further evaluate the appropriateness of the adopted RAF protocol, sophisticated air quality modeling runs were conducted by CMU to determine if the ozone produced from gasoline would compare to ozone produced from equivalent amounts of methanol vehicle exhaust using a proposed RAF for methanol. The same evaluation was conducted for LPG. Because modeling runs yielded nearly equivalent air quality impacts using the proposed RAFs (within 10 percent), the RAF protocol appears to be quite reliable. The 10 percent upward adjustment for M85 and LPG RAFs provides an adequate assurance that the regulations will not exacerbate ozone formation.

27. Comment: To preserve air quality, the RAFs should ensure that all cars meet the adjusted NMOG specifications. Using a mean RAF ensures that only 50% of the cars in that data set will meet NMOG specifications. A more conservative approach would be to require that 95% or 99% of the cars meet the NMOG specification. This would account for vehicle, experimental and reactivity variability. (WSPA, ARCO)

Agency Response: Since the 1970s, the ARB has been determining compliance with emission standards for gasoline vehicles based on average emission levels. Using the average exhaust emissions of an engine family is an appropriate and reasonable approach on which to base in-use compliance with the emission standards. The current procedure for determining in-use compliance is to test ten vehicles from an engine family and then to take the average of their emissions. If a normal distribution of emission performance is assumed throughout the vehicle population, then 50 percent of the vehicles would be below the standards and 50 percent would be above them, but on average the vehicles would meet the standards. It is important to note, however, that on average the vehicles must meet the standards.

This may mean that more than 50% of the vehicle population is required to be below the standard in order to pass the in-use compliance. Adopting a more conservative approach that requires 95% to 99% of all alternative fueled vehicles to meet the standards would create an unfair bias against alternative fuel vehicles. This is contrary to the goal of the LEV/CF regulations to create a level playing field for all alternative vehicle/fuel systems.

28. Comment: Since both the fuel and the emission control system used by a vehicle impact the reactivity of the vehicle's exhaust emissions, the ozone forming potential of current technology vehicles using conventional gasoline should be the baseline factor for each of the low-emission categories. This would give manufacturers credit for both the lower reactivity of clean fuels as well as for the enhanced performance of the emission control system. (Nissan, Toyota)

Agency Response: The technological feasibility of each of the categories of low-emission vehicles was demonstrated using advanced emission control systems such as heated catalyst systems and conventional gasoline. Thus it is expected that manufacturers will need to develop emission control hardware at least as effective as that used to demonstrate technological feasibility--except they can be given credit for using a cleaner fuel through the RAF process. Manufacturers should not, however, be given additional credit for selecting the technology already identified by the ARB as likely to be needed to meet the very low standards since providing an adjustment credit relative to current technology vehicles would lessen the stringency of the adopted standards. Should manufacturers select a technology that is more effective in reducing the ozone production of vehicle exhaust than the technologies identified by the ARB (e.g. heated catalysts), then the RAF for the vehicle would automatically account for the improved technology in the RAF setting process.

29. Comment: The potential-ozone-formed-per-mile is strongly recommended as the basis for evaluation and qualification. Dividing the ozone per mile by mass of organic gases to define a fictitious reactivity in grams ozone per gram organic gases is superfluous and misleading. An improved RAF could be the ratio of ozone per mile as determined from speciated emissions tests to the comparable figure for conventional vehicles of the same class. (WLGA)

Agency Response: The approach being recommended--basically setting "ozone per mile" emission standards--would require that every emission test be fully speciated into more than one hundred compounds. Not all manufacturers or all of their testing facilities will possess this complex measurement capability. Therefore setting mass emission standards based on adjustment by suitably derived RAF factors is more reasonable, providing the opportunity to demonstrate compliance with emission standards using routinely available measurement equipment. Any routine assembly line testing requirement or in-use surveillance testing program would be unnecessarily costly and time consuming if the commenter's suggestions were followed.

30. Comment: Using the RAFs as a rating system rather than as a weighting system does a disservice to the public. (WLGA)

Agency Response: The RAF for a given vehicle/fuel system should not be used to "rate" the relative cleanliness of a particular fuel. Such a comparison would be valid only if the alternative-fueled vehicles emit equal amounts of exhaust emission mass. Thus, although some vehicle/fuel systems may have lower ozone forming potential per gram of exhaust emissions when compared to gasoline, the overall impact on ozone may not be improved if they produce more exhaust mass.

31. Comment: The staff did not generate the proposed RAFs by using the 95 percent requirement identified in Appendix VIII of the LDV/MDV Standards and Test Procedures; instead they emphasized reactive mass. The technically correct approach is to measure all the hydrocarbons irrespective of the reactivity, compare the sum of species with the total g/mi of NMOG measured, and then make the reactivity calculations. Limiting the number of species reported may bias the RAFs especially at lower and lower NMOG levels. (GM)

Agency Response: The requirement that a minimum of 95 percent of the total g/mile NMOG emissions measured be accounted for was adopted in the LEV/CF regulations in 1990. This requirement was not modified in the current rulemaking. However, the 95 percent provision in Appendix VIII(1)c. has frequently been misunderstood by GM (and other manufacturers). The confusion arises because there are two different procedures for measuring NMOG mass emissions. The common misconception is that the regulations require a 95 percent correlation in the mass of the NMOG emissions which are measured using the two different procedures. Actually, the regulations do not require that 95 percent of the NMOG mass emissions which are measured by one procedure are accounted for using the other procedure. Rather, the regulations require the manufacturer to identify 95 percent of the NMOG species which are contained in the mass measurement.

32. Comment: If the data submitted by manufacturers for development of their own RAFs show that the default RAFs established by the ARB should be lower, the ARB should modify its regulations to reflect the lower RAF. (AIAM)

Agency Response: As modified, the regulatory text adequately addresses the commenter's concern. Section 13.c. of the LDV/MDV Standards and Test Procedures authorizes the Executive Officer to revise any RAF if a revised RAF would be more representative of the ozone forming potential of vehicle NMOG emissions based on the best available scientific knowledge and sound engineering judgment.

C. Engine-Family-Specific RAFs

33. Comment: The 25% difference between the RAF as determined by the manufacturer and the RAF as determined by the ARB eliminates any incentive for a manufacturer to develop a system that lowers exhaust reactivity especially since the ARB-generated factors are based on technology that may be substantially different from production vehicles. Any difference considered significant enough for the manufacturer to undertake development should be sufficient grounds to warrant approval. (MVMA, GM, WLGA, Nissan, Ford, Chrysler)

Agency Response: The requirement for a 25% percent difference between the manufacturer derived RAF and the RAF established by the ARB established has been deleted in the modified text of the LDV/MDV Standards and Test Procedures.

34. Comment: Manufacturers should be allowed to develop engine family specific RAFs and they should be allowed to choose ARB-assigned RAFs or manufacturer-developed RAFs. (AIAM, Nissan, Toyota, MVMA, GM, Chrysler, Ford)

Agency Response: Section 13.d. of the LDV/MDV Standards and Test Procedures has been modified to allow manufacturers to use a unique reactivity adjustment factor for a specific vehicle emission control technology category and fuel in appropriate circumstances.

35. Comment: In order for a manufacturer to develop an engine family specific RAF, the ARB needs to issue a guideline on specific RAF determination that includes the HC speciation measurement method, a reference gasoline specification and application format. (Toyota)

A simple automated test method should be developed for speciating exhaust emissions. (Nissan)

Agency Response: The California Non-Methane Organic Gas Test Procedures, incorporated by reference in Appendix VIII (8) of the LDV/MDV Standards and Test Procedures, describes the sampling and analytical procedures for non-methane hydrocarbons as well as procedures for measuring oxygenated hydrocarbons. While these procedures have been shown to be adequate in tests of ARB vehicles, refinement of measurement techniques and exploration of uncertainties is proceeding. There is no simple automated test method available at this time for speciating exhaust emissions. Manufacturers choosing to use generic RAFs, however, would not need to conduct the relatively complex speciation evaluations in order to certify their vehicles. Even though the ARB will conduct all the baseline testing to determine both generic and engine family RAFs (which means the vehicle manufacturer will never need to test using baseline gasoline), we are planning an additional rulemaking hearing late this year to insert into

Appendix VIII the reference gasoline specifications which were contained in the TSD for the LEV/CF regulations.

36. Comment: The ARB should have a workshop to develop quality assurance procedures, measurement system parameters, sensitivity, testing requirements, confirmatory testing and correlation among test facilities. (Chrysler)

Agency Response: See the response to the preceding comment. In an effort to further fine-tune the procedures, the ARB is participating in the Environmental Research Consortium with Ford, GM, Chrysler and Navistar to address quality control issues, and to better define measurement system parameters, testing requirements and sensitivity issues. New approaches to emission measurement are also expected to emerge which provide improved emission measurement capability at low emission levels. The ARB is currently developing a cross check with several manufacturers to evaluate the procedures across multiple laboratories. Any further improvements needed will be incorporated in future review hearings before the Board on the LEV/CF regulations.

37. Comment: The procedure for qualifying alternative RAFs should be based on strict statistical analysis. (ARCO)

Agency Response: As modified, Section 8.a. of Appendix VIII provides that a vehicle manufacturer will not be allowed to use a specific RAF for an engine family unless the 95% upper confidence bound of the engine-family-specific RAF set of test values is less than or equal to 115% of the mean of these values. This statistical requirement will ensure that the data are uniform and reliable.

38. Comment: The ARB should require annual reporting of new data in each of the relevant areas relating to RAFs, together with an analysis of the impact of the new data on the existing program. Further, an independent technical review committee should be set up to review the RAFs generated by auto manufacturers. (SCAQMD)

Agency Response: We believe that the procedures outlined in Appendix VIII of the LDV/MDV Standards and Test Procedures provide sufficient assurance that RAFs will be correctly calculated by manufacturers. Any unusual RAFs which emerge during the certification application review can trigger confirmatory testing of certification vehicles by the ARB. The ARB's Research Division is committed to reviewing and proposing updates for the factors used in determining RAFs as necessary and the staff feels that the biennial review process provides an adequate opportunity to review the protocol and the values of factors used in generating the RAFs. The expected level of potential changes in the factors used to generate the RAFs are unlikely to significantly affect the RAF calculations.

39. Comment: Given the proposed approach for engine family specific reactivity factors, the need to establish default RAFs at this time is questionable. (WSPA)

Agency Response: Establishing default RAFs allows those vehicle manufacturers that do not have speciation capability the option of using ARB-generated RAFs.

40. Comment: The Board's plan to develop generic RAFs pursuant to the current regulation without further Board approval is an issue of concern. (MVMA)

Agency Response: The ARB plans to have nearly all RAFs identified and presented to the Board for approval by the end of 1992. Although the Executive Officer is authorized by Appendix VIII of the LDV/MDV Standards and Test Procedures to establish RAFs according to the procedures and criteria in the Appendix, we continue to expect that most of the RAFs will be set by the Board in rulemakings. However, it would be unreasonable to present the Board with every new fuel/vehicle combination that emerges since the protocol is well defined and already adopted by the Board. Should any interested party wish to provide further comment on an Executive Officer decision, the matter could be addressed during the biennial reviews or by petitioning the Board.

41. Comment: There are insufficient data on the emissions from the alternatively-fueled vehicles to permit a statistical treatment of the variations. It is therefore premature to promulgate RAFs unless equivalent certification procedures are made available. (WLGA)

Agency Response: Sufficient data were available from testing of methanol vehicles in the TLEV emission category to reliably determine the RAF for these vehicles. For LPG and CNG, the Board concluded that insufficient data existed to enable setting the initially proposed RAFs. For setting engine family specific RAFs, the required test protocol, number of test vehicles, and statistical evaluation to be utilized is specified in Section 8.a of Appendix VIII. Further, in terms of setting generic RAFs, when additional data from more vehicles become available, the generic RAFs can be updated.

D. Selection of Vehicles Used in the Determination of RAFs

42. Comment: The nine vehicles tested by the ARB to determine baseline data on emissions with conventional gasoline are not representative of the mix of vehicles and emission control technology in the marketplace. A better vehicle selection method is referenced in the Federal Register, Volume 56, Number 31 (Toyota, Nissan) The vehicles tested are not production versions of TLEVs and may not represent emissions profiles of actual in-use vehicles. (Chevron, GM, WSPA, MVMA)

Agency Response: The vehicles tested were selected because they were able to meet on average all the emission standards for TLEVs and were the only ones available. Because the reactivity of NMOG emissions can vary with vehicle technology, using data from vehicles whose emission performance is representative of TLEVs provides the only appropriate approximation to the reactivity of emissions from actual TLEVs. Although the commenters suggest using vehicles more representative of the current fleet, this suggestion would generate higher than appropriate RAFs because the ozone per gram of these vehicles would be higher than lower emitting vehicles in the TLEV category. This would, in effect, result in less stringent emission standards. The ARB consistently requested that vehicle manufacturers supply additional test vehicles representing TLEV technology, but nearly all refused to do so.

We have checked vol. 56, no. 31 of the Federal Register (February 14, 1991). The only entries for the U.S. EPA in that issue pertain to a meeting of the Scientific Advisory Board and a regulation on hiring consultants. We can find nothing pertaining to vehicle selection procedures.

43. Comment: Although the nine vehicles were tested at several laboratories, the ARB does not address the issue of correlation among the labs. In order to minimize error all baseline testing should be conducted at the same lab using the same batch of fuel. (Toyota)

Agency Response: The variability of the emissions results from the gasoline and M85 vehicles tested at the various laboratories was approximately 20 percent and 5 percent, respectively. We therefore concluded that combining the data from the different laboratories was appropriate for the purposes of determining RAFs. The staff is confident that the quality control and analysis procedures used by the other laboratories (Chevron and Auto/Oil) were reliable and accurate. In fact, follow-up studies performed by the Auto/Oil program yielded a virtually identical baseline RAF, which furthers our confidence in the reliability of the emission results.

44. Comment: The TLEV RAFs for M-85, CNG and LPG were not determined from a statistically valid number of vehicles. (Chevron, WSPA, GM, MVMA)

Agency Response: The ARB used all available vehicles in the testing; because there was only 5 percent variability in the data for methanol and 20 percent for baseline gasoline, we are confident that the RAF for M85 is adequate. The proposed RAFs for CNG and LPG were deferred until another rulemaking hearing to be conducted later this year so that more vehicles could be tested. As additional data become available, we plan to continue to revise and update the database to ensure that the RAFs accurately reflect the ozone forming potential of the vehicles.

45. Comment: The tested vehicles have low mileage and it is erroneous to assume that deterioration in emission control systems will occur uniformly across different types of LEVs. (Chevron, WSPA)

Agency Response: The full useful life (100,000 and 120,000 mile) standards contained in the low-emission vehicle regulations limit the extent to which emission control systems can deteriorate. In order to ensure compliance with full useful life standards (or else be subject to costly recalls), vehicle manufacturers must design emission control systems that are able to maintain low emissions throughout the full life of the vehicle. Therefore, emissions cannot deteriorate very much, and emission profiles are not likely to change substantially with age. Even so, recent data shows that RAFs are more likely to slightly decrease with mileage rather than increase. The staff will continue to review durability results to evaluate whether the RAFs remain uniform over the life of the vehicle.

46. Comment: The staff should consider allowing a negative deterioration factor to RAFs. (Ford, GM)

Agency Response: The staff will be looking at this possibility in the future as production vehicles accumulate mileage in-use. Such a provision could apply to engine family specific RAFs if found to be warranted in a subsequent rulemaking.

E. The Timing of the Board's Actions

47. Comment: Manufacturers that lack the technical expertise to speciate exhaust emissions depend on the ARB's timely development of RAFs for LEVs and ULEVs in order to make accurate product decisions. RAFs for LEVs and ULEVs need to be established as soon as possible. (AIAM, Toyota, Chrysler, Ford)

Agency Response: On numerous occasions the ARB has requested LEV and ULEV prototype vehicles from manufacturers. These requests have almost uniformly been denied, even though the vehicles existed in the manufacturers' development fleets. The ARB staff have had to resort to retrofitting prototype vehicles on its own in order to develop RAFs for LEVs and ULEVs. This project has been further delayed by industry's insistence that a special certification fuel specification be used for emission testing which is more tightly specified than in-use commercial gasoline. Such fuel was requested to minimize testing variability due to varying fuel composition when evaluating vehicle emission performance. Additional time was needed to achieve consensus between industry and ARB on the appropriate fuel specification.

The new certification specifications were approved by the Board at an August 14, 1992 rulemaking hearing. The ARB staff expects to develop additional RAFs for consideration by the Board before the end of 1992. There will be ample time between the Board's consideration of the proposed

RAFs and the development of 1994 and later model year vehicles. Even so, in the case of Phase 2 gasoline (the most likely clean fuel to be used by industry, since we expect that over 90 percent of the vehicles will be certified using this fuel), manufacturers have been testing gasoline formulations closely matching the proposed Phase 2 gasoline certification specifications. Therefore industry already has a good estimate of the advantage that Phase 2 certification gasoline will provide in meeting LEV and ULEV emission standards.

48. Comment: The proposed amendments will allow a manufacturer to request an engine family specific RAF provided that the speciated HC profile is submitted two years prior to certification of the vehicle. At this late date it will be impossible to request a RAF for the 1994 model year TLEV. (Toyota, MVMA, Ford, Chrysler) The time period for an RAF request should be eliminated entirely or, at a minimum, reduced to no more than one year prior to certification, instead of two. (MVMA)

Agency Response: In Appendix VIII, Section 8.c., the provision requiring two-years lead time for submitting speciated profiles has been deleted in the modifications made available for the supplemental 15-day comment period. Under the modifications, manufacturers seeking to use engine-specific-RAFs will be required to submit speciated profiles, reactivity adjustment factors, and reactivity deterioration factors with the certification application.

49. Comment: In order to review the uncertainties in the scientific data, adoption of the regulations should be delayed for nine months to one year. This would reduce the risk of making major investments and product changes which later prove to be detrimental to air quality. The risk must be reduced to a level that is acceptable to the scientific community. (WSPA, Chevron)

Agency Response: We are confident that the RAF adopted for M-85 is based on an adequate technical foundation. The staff, in conjunction with the ad hoc Reactivity Advisory Panel, has thoroughly reviewed the technical uncertainties and their impact on the calculation of RAFs and has concluded that the vast majority of the uncertainties will have very little impact on the RAFs. However, the staff is continuing to address these data and information gaps and will provide the revised information when it becomes available. Further, the staff does not believe that delaying the implementation of the regulations for nine months to a year will allow consensus to develop in the scientific community. See also the agency response to Comment 26.

50. Comment: Due to the long lead time of the auto industry, it is very important to adopt RAFs as soon as possible. (MVMA, Ford, GM, Chrysler)

Agency Response: We agree. As indicated in the response to Comment 47, we are making every effort to establish RAFs in a timely fashion. In addition, the modifications regarding the establishment of engine-family-specific RAFs will allow manufacturers adequate development time.

51. Comment: A RAF needs to developed for CNG as soon as possible. (NGVC)

Agency Response: The Board concluded that the available data were insufficient to establish scientifically supportable RAFs for CNG in this rulemaking. The staff is planning to present a TLEV RAF for CNG to the Board before the end of 1992. CNG RAFs for LEVs and ULEVs will be presented as soon as that data are available.

52. Comment: All RAFs should be in effect for three years. (ARCO)

Agency Response: Generic RAFs will be updated, if needed, every three years. Once updated, manufacturers will be permitted to change to the new factors immediately, or to continue using the present factors for an additional three years. Manufacturers using engine family specific RAFs based on unrevised MIRs will be able to continue using them until a new durability vehicle is certified. These provisions are necessary and appropriate to provide adequate predictability and lead time.

F. Legal Issues

53. Comment: Health and Safety Code section 43013 requires that motor vehicle emission standards and motor vehicle fuel specifications must be "necessary, cost-effective, and technologically feasible." Section 43018 directs the ARB to "endeavor to achieve the maximum degree of emission reduction possible from vehicular and other mobile sources to accomplish the attainment of the state's standards at the earliest practicable date." Further, the California Administrative Procedure Act (APA) requires that regulations adopted by state agencies meet a "necessity" requirement which must be met by a record which "demonstrates by substantial evidence the need for a regulation." (Gov. Code § 11344.) The proposed regulations do not satisfy these requirements in two basic respects.

First, as WSPA has pointed out in its technical comments, there remain fundamental unresolved questions with the scientific technology used in establishing the RAFs. By establishing RAFs for TLEVs based on incomplete data which may be seriously flawed, and which may in fact make the air quality worse rather than better, the ARB is violating both sections 43013 and 43018 of the Health and Safety Code and the necessity requirement in the APA.

Second, since only RAFs for TLEVs certified on a limited number of clean fuels are being established, the regulations are incomplete and fail to satisfy the "necessity" requirement. OAL's approval of the LEV/CF regulations was premised in part on the representation that RAFs would be established for all clean fuels and vehicles by Fall of 1991. This has not happened. (WSPA)

Agency Response: As discussed in the responses to the comments in III.A. and III.H.1. of this Final Statement of Reasons, we believe that there is an adequate and reasoned scientific basis for the amendments adopted in this rulemaking. The final amendments establish a RAF only for M85 TLEVs, and provide that RAFs for vehicles powered by M85 or LPG be adjusted upward by 10 percent to account for potential modeling and protocol biases. With this adjustment we believe that the regulations take a conservative approach on RAFs and will not result in any worsening of air quality. We believe that the careful documentation in the Staff Report, the TSD, and the Final Statement of Reasons fully demonstrates the necessity for these amendments. The original LEV/CF regulations already provided for the application of RAFs for fuels other than conventional gasoline, and the present rulemaking is fully consistent with the already-established regulatory approach.

Secondly, we do not believe the LEV/CF regulations are incomplete either before or after this rulemaking. As amended by the LEV/CF rulemaking, the LDV/MDV Standards and Test Procedures--most particularly Appendix VIII--establishes a complete and self-contained process for the establishment and application of RAFs for low-emission vehicles operating on fuels other than conventional gasoline. The Board did not identify any specific RAFs in the initial LEV/CF rulemaking because the RAFs for specific vehicle/fuel combinations meeting the TLEV, LEV, and ULEV standard could not be established until tests are conducted on vehicles that meet the TLEV, LEV, and ULEV standards. We are moving ahead on that process as quickly as possible, as discussed in the response to Comment 47. OAL's approval of the LEV/CF regulations was based on the actual terms of the regulatory provisions rather that any representations of the ARB's plans for subsequent rulemakings. For completeness, the Final Statement of Reasons for the LEV/CF regulations is incorporated by reference.

54. Comment: The Staff Report itself states, at page 7, that "although the staff is proposing the use of the MIR approach at the present time, a final evaluation cannot be made until the air shed modeling is completed on October 19, 1991", with the result to be presented at the Phase 2 gasoline hearing on November 21-22, 1991. At the least, a substantial period of time should be allowed for evaluation of that data. (WSPA)

Agency Response: The Staff Report indicated that the additional airshed modeling data would be presented at the November hearing of this rulemaking, and it was. We believe that we have complied with all of the notice requirements in the APA, and the commenter has identified no specific notice requirement claimed to be violated. A rulemaking agency is not precluded from considering at the hearing additional data that have been generated since issuance of the notice. Further, the 15-day Notice specifically identified the additional documents and information being considered by the Board, and the public was provided a 15-day period in which to comment on these data.

55. Comment: The amendments unlawfully discriminate against reformulated (Phase 2) gasoline because there is no rational basis for excluding reformulated gasoline from the fuels for which RAFs are being established at this time. It is well established that government regulation that is "arbitrary and unreasonable" violates the principles of due process. (See, e.g., Village of Euclid, Ohio v. Ambler Realty Co., 272 U.S. 365 (1925).) (WSPA)

Agency Response: There is a rational basis--indeed a compelling basis --for the decision not to establish a RAF for Phase 2 reformulated gasoline in this rulemaking. The reasons are identified in the response to Comment 59.

56. Comment: It appears from the staff document that additional RAFs for other vehicle classes and fuels will be adopted as part of this rulemaking, but at a later time and without the opportunities for public comment and hearing provided in this proceeding. We submit that the adoption or updating of new RAFs must be accompanied by formal notice and comment procedures. (Government Code § 11347.5 ("No state agency shall issue, utilize, enforce or attempt to enforce any . . . standard of general application, or other rule . . . unless [it] has been adopted as a regulation and filed with the Secretary of State pursuant to [the APA]"; See also Stauffer Chemical Co. v. California Air Resources Board, 128 Cal. App.3d 789, 794 (1982); Armistead v. State Personnel Board, 22 Cal.3d 198, 204 (1978).)

Closely related to the above point is our concern that these proposed regulations unlawfully delegate rulemaking authority to the Executive Officer; see the discussion on pages 21-22 of the Staff Report. The real rule will not be established until all of the RAFs on different vehicle classes tested on different clean fuels are established. Much of the detail of the final reactivity regulation is left to the Executive Officer. This in turn has fundamental consequences. To start with, while the ARB has authority to delegate broad implementation powers to the Executive Officer, a perusal of the provisions of the code concerning rulemaking leaves little doubt that the Legislature intended rulemaking to be done by the Board. To the best of our knowledge, the Executive Officer has never been given the function of making rules.

Delegating this power to the Executive Officer has a further consequence in that when the Executive Officer determines the RAFs for different vehicle categories operating on different fuels, he is providing the very basis of the rule itself. That, in turn, means that all of the statutory precautions, i.e., notice, hearing, opportunity for comment and the like, are required before this can be done. (WSPA)

Agency Response: The commenter is apparently operating under a fundamental misconception regarding the structure of the LEV/CF regulations and the authority of the Executive Officer. Appendix VIII expressly authorizes the Executive Officer to establish RAFs without the need for a further rulemaking. Although the ARB has chosen to establish the initial RAF by rulemaking, and may use the rulemaking process to establish other RAFs in the future, Appendix VIII clearly authorizes the Executive Officer to establish RAFs administratively without an additional regulatory proceeding.

Appendix VIII does not represent an unlawful delegation of rulemaking authority. The Appendix establishes a clearly defined procedure the Executive Officer is to use in determining RAFs. While in certain instances the Executive Officer is directed to make specific determinations in implementing the regulations, Appendix VIII provides well-defined standards and criteria for those determinations. The approach is analogous to a regulatory permit program, in which the Executive Officer would make specific permit determinations based on the criteria in the regulations.

The Stauffer Chemical case has no bearing on this proceding--it concerned the procedures the ARB is to follow when assuming the powers of an air pollution control district pursuant to Health and Safety Code sections 41500 et. seq. The Armistead case is inapposite. In that case the agency applied standards without adopting them in a noticed rulemaking. In administering the low-emission vehicle regulations, the Executive Officer will apply standards which have been duly adopted as regulations.

WSPA's claim that the Legislature did not intend the Board to have the authority to delegate rulemaking to the Executive Officer is not relevant because no such delegation has been made. However, it should be noted that Health and Safety Code 39515 expressly authorizes the Board to delegate any of its duties to the Executive Officer. Based on that express and clear authority, the Executive Officer has in the past on numerous occasions adopted or amended regulations following a delegation from the Board.

G. Miscellaneous

57. Comment: Exhaust-only adjustment factors do not adequately reflect the real world impact of alternative-fueled vehicles. Carbon monoxide (CO), methane, evaporative and refueling and distribution emissions significantly impact ozone formation and should be included in determining the ozone forming potential of a vehicle. (MVMA, ARCO, WLGA, Ford, Chrysler, Chevron, Ultramar)

Agency Response: Because other separate regulations address control of these emissions, there would be little benefit in adding CO, methane or evaporative emissions to the RAF determination. Evaporative emissions are less reactive than exhaust emissions and newly adopted evaporative test procedures require that beginning in 1995 evaporative emissions will be virtually zero under normal driving conditions. Further, second generation on-board diagnostic system (OBD II) requirements being implemented beginning in 1994 will ensure that any malfunctions or leaks in the evaporative control system are detected and repaired.

The emission control technology that will be required to meet the LEV and ULEV standards will also ensure that CO levels will be uniformly below the applicable standards of the future regardless of which fuel is utilized, so that inclusion of CO emissions in the RAF determination would not significantly alter the relative reactivities of the various vehicle/fuel systems.

Methane is generally considered to have an insignificant impact on ozone formation so that its inclusion in the calculation would not significantly alter the RAF except perhaps in CNG vehicles meeting ULEV emission levels. Because of expected improvements in catalyst formulation, however, methane emissions from future CNG ULEVs will probably be low.

Due to the complexity of adding these emissions to the regulations with little if any effect, it is not worthwhile at this time to include them. However, the staff will be tracking this issue further in the future to determine whether unexpected differences in emissions will occur in actual production low-emission vehicles. Finally, the ARB has initiated a study to examine the effects of fuel cycle emissions on ozone formation.

58. Comment: The ozone contribution of methane is significant for CNG vehicles and should therefore be added to the calculation of NMOG. (WLGA)

Agency Response: As stated in the response to the preceding comment, methane is generally considered to have an insignificant impact on ozone formation. Even though methane emissions constitute the largest portion of exhaust emissions for present CNG vehicles, the overall reactivity of CNG vehicles is still very low. In addition, advanced CNG vehicles may by equipped with methane specific catalysts which would substantially reduce methane emissions compared to current levels. ARB staff will monitor the progress of these developments and will propose regulatory changes during the biennial reviews if appropriate.

59. Comment: The proposal discriminates against reformulated (Phase 2) gasoline and could effectively eliminate it from consideration as a fuel for the TLEV market. To propose RAFs for M85, CNG, and LPG while not doing so for reformulated gasoline at the same time upsets the level playing field, which is contrary to the intent of this rulemaking. (WSPA)

RAFs for Phase 2 reformulated gasoline should be determined as soon as possible (MVMA, Ultramar, GM, Ford, Chrysler)

Agency Response: The Board cannot begin the process for establishing RAFs for Phase 2 reformulated gasoline until the specifications for that gasoline are established. The Board approved specifications for commercial Phase 2 gasoline at a November 21-22, 1991 public hearing. Specifications for Phase 2 certification gasoline were approved by the Board at an August 14, 1992 hearing. The staff is planning to present RAFs for Phase 2 gasoline to the Board before the end of 1992, which should allow ample opportunity for manufacturers to design vehicles using this cleaner gasoline.

60. Comment: Basing RAFs on an industry-average gasoline (RF-A) instead of Phase 2 gasoline would accredit excessive reactivity benefits to alternative fuels. Phase 2 will be the typical in-use fuel of the future. To allow a reactivity credit for Phase 2 gasoline amounts to a relaxation of the NMOG standard. (Chevron)

Agency Response: Using RF-A provides an incentive for industry to develop cleaner-burning vehicle and fuel systems as well as providing a constant gauge against which the reactivity of future vehicle emissions can be compared. The technological feasibility of the LEV program was established using advanced technology vehicles and conventional (RF-A) gasoline. Phase 2 gasoline was unavailable when the regulations were developed, whereas advanced technology (heated catalysts) was available.

61. Comment: Harmonization of RAFs between the ARB and EPA is essential should it become relevant in the future. (Nissan)

Agency Response: Section 249 of the federal Clean Air Act, added as part of the 1990 amendments, establishes a California pilot program to demonstrate the effectiveness of clean-fuel vehicles in controlling air pollution. Section 241(3) and (4) directs EPA to use the California methods for making reactivity adjustments in establishing the federal low-emission vehicle standards. Accordingly the ARB and EPA requirements will be consistent. The ARB will continue to share information with EPA as the LEV program progresses to ensure a consistent approach to regulating emissions from advanced vehicles using clean fuels.

H. Comments Made During the 15-Day Comment Period

1. Use of MIR Scale and Revisions to Specific MIRs

(a) Airshed Modeling

62. Comment: In view of the significant omissions, errors, and questionable approximations that the staff acknowledges were tolerated in the airshed simulations in order to be able to make the calculations, we find it difficult to accept any "corrections" to the RAFs at this time. We seriously doubt that the large-scale computer simulations that are incapable

of performing realistic aerochemical calculations on detailed emission spectra can provide a reliable test, let alone a tune-up or refinement of the proposed protocol for vehicle certification. (WLGA)

Agency Response: We do not acknowledge, nor are we aware of, any omissions, errors, and questionable approximations in the airshed simulations. Some approximations were made in the spirit of bounding the problem because of the large range of meteorological conditions, baseline emission inventories, and alternative fuels that are possible in the future. While airshed models are, and always will be, only an approximation of reality, they do embody all that has been learned in the last forty years about the atmospheric processes leading to ozone formation.

63. Comment: The airshed "null" test should be performed using RAFs based on the MOIR scale to determine if this scale would be more appropriate for use in regulation than the MIR scale. (WSPA)

Agency Response: The airshed modeling showed that the M85 and LPG-fueled vehicle exhausts were relatively more reactive over the three-day periods. One possible explanation for these results is that the slower-reacting species of the two alternative fuels have more time to react and will have a greater impact on ozone than predicted by the MIR scale. This explanation would favor the use of RAF calculations with the MOIR scale, derived at lower NOx conditions similar to those observed in multi-day episodes.

However, the null test results for CNG, which has the slowest reacting species and a 28 percent higher MOIR-calculated RAF, are inconsistent with this explanation. In addition, the airshed model results for individual hydrocarbons showed much better agreement with the MIR scale than the MOIR scale. The deviations from unity for the null test are more likely attributable to differences in spatial and temporal patterns of emissions between vehicle fleets, rather than a problem with the MIR approach. The fleet with the highest cold-start emissions (M85), which has emissions concentrated over a shorter time in comparison to the conventional gasoline fleet, had higher null test results, while the fleet with the highest running emissions (CNG), which are more spread over time, had the lowest null test results.

64. Comment: The atmospheric chemistry of ozone formation is notoriously non-linear. There is no reason to believe that a 10 percent adjustment in emission mass would translate to a 10 percent adjustment in peak ozone. (Chevron)

The ARB neglected to perform an airshed "null" test of the upward adjusted M85 TLEV RAF of 0.41 to ensure that its use would not lead to increased ozone formation. (WSPA)

Agency Response: While ozone formation is non-linear for changes in the hydrocarbon to NOx ratio, it has been shown to be a linear process for hydrocarbon emission substitutions. Separate calculations by Carter, Chang and Rudy, and Dunker indicate that ozone formation is linear for up to a 30 percent change in basin-wide hydrocarbon emissions. In the airshed modeling performed by Professor Russell and his coworkers, the RAFs were applied to the entire motor vehicle fleet, corresponding to 21 and 13 percent of the NMOG inventory in 1987 and 2010, respectively. Since the null test results are normalized to the situation of no motor vehicle hydrocarbon emissions, a 10 percent RAF adjustment corresponds to a change on the order of a few percent in total hydrocarbon emissions, well within the limit where ozone formation has been shown to be a linear process.

65. Comment: We have never seen a detailed report from CMU which describes their modeling activities and gives a full accounting of the results. (Chevron) A full report on the details of the model inputs should be made available to the technical community before the biennial review. (GM) The final report of the CMU study must be made available for public review since it seems to set the basis for the 10 percent adjustment. (WSPA)

Agency Response: Full details of the airshed modeling process were available in both a protocol document and Attachment III. A. of the 15-Day Notice. In addition, the airshed modeling was discussed during several meetings of the ad hoc Reactivity Advisory Panel. A formal paper, with more detailed information, has been prepared and will soon be submitted to the Journal of the Air & Waste Management Association. We anticipate a publication date early next year.

66. Comment: Additional testing of the MIR and other scales is necessary if we are to assure that the reactivity adjustments are as technically sound as possible. In particular, we would like to see additional grid modeling with the models that are being used to develop attainment plans under the California and Federal Clean Air Acts. (GM)

Agency Response: We concur, and it is the ARB staff's intent to compare the MIR scale with airshed model applications in other cities when they reach the same level of sophistication as those performed in Los Angeles.

67. Comment: In Attachment III. A. of the 15-Day Notice, it is stated that hydrocarbon control is implemented to reduce ozone under conditions sensitive to hydrocarbons, and NOx controls are being implemented to reduce ozone under conditions that are sensitive to NOx. Although control of either precursor may reduce ozone, simultaneous control of both is very inefficient at reducing ozone. As the grid modeling tests of the MIR and other scales are carried out, ARB should investigate the spatial effects on ozone to test whether the simplistic view espoused in Attachment III. A. is born out. (GM)

Agency Response: The general question of whether control of hydrocarbons only, NOx only, or both is the most effective ozone control strategy has been investigated with field measurements, laboratory studies, trend analysis, and modeling for the past forty years, and still has not been resolved to everyone's satisfaction. The Board's policy for the last fifteen years has been to control both precursors; and ozone levels have been reduced substantially as a result. However, we will continue to devote resources to investigating this issue into the foreseeable future.

(b) **Uncertainty**

68. Comment: In Attachment III. of the 15-Day Notice, data are presented to indicate that changes in chemical mechanisms and changes in reactivity scales have little impact upon calculated RAFs. In contrast, recent work based upon results from the Auto/Oil Program suggest that these changes are significant. Work by Auto/Oil (papers by Messrs. C. H. Schleyer, A. M. Dunker, G. Z. Whitten, and A. K. Pollack will be presented at the AWMA meeting in June, 1992) shows that for a Los Angeles episode (year 2010), the ozone impacts of fuel compositional changes are in best agreement with airshed model results when calculated using the MOIR reactivity scale and the CB-IV chemical mechanism. Much poorer agreement was found when using the ARB-approved protocol of MIR reactivity scale and SAPRC90 chemical mechanism. (Chevron)

Agency Response: We received the Auto/Oil paper with a letter dated June 11, 1992, well after the November 14, 1991 Board hearing and the May 6, 1992 deadline for comments on the 15-Day Notice. Accordingly, we are not including the Auto/Oil paper in the rulemaking file. We do note that the Auto/Oil results are interesting, and certainly will warrant consideration during the scheduled 1994 update to the reactivity scale, if adequate information is made available to ARB before that time.

69. Comment: At the November 14, 1991 Board Hearing, we presented an approach which would make maximal use of available data and takes account of uncertainties in the various components of the RAF calculation in a systematic and well defined manner. (WSPA)

Agency Response: This comment is based on an analysis by ARCO that does not correctly use statistical methods for the reasons stated in the response to Comment 23.

70. Comment: Attachment III. to the 15-Day Notice gives the false impression that the RAFs are insensitive to uncertainties and changes in chemical mechanism, environmental conditions, HONO, etc. The report fails to adequately consider that the apparent insensitivity of RAFs to various changes could be due to internal compensating errors that might be present in components of RAF calculations, such as the chemical mechanism. (WSPA)

Agency Response: It is extremely unlikely that internal compensating errors could mask sensitivities over such a large range of environmental conditions.

(c) **Miscellaneous**

71. Comment: We would like to see experimental verification of the reactivity impacts of both key individual species and exhaust mixtures from clean-fuel vehicles. (GM)

Agency Response: For the long term, the Board will continue to sponsor laboratory studies and chemical mechanism development to reduce uncertainties in the MIR scale still further, particularly for aromatic hydrocarbons, and to review research sponsored by other organizations. The Board is currently sponsoring two additional experimental studies, and is closely following a third study funded by the Coordinating Research Council.

72. Comment: The MIR scale is a maximally expanded reactivity measure which gives too much credit compared with typical airshed conditions. The MIR scale calculates the largest reactivity differences among VOC species that would ever be expected. (WSPA)

Agency Response: Professor Armistead Russell and his coworkers at Carnegie Mellon University were retained by ARB to address the issue of which of several reactivity scales was most appropriate to assure equal ozone impacts from alternatively-fueled vehicles. They computed incremental reactivities with a physically detailed, three-dimensional airshed model for a severe, three-day stagnation episode in Los Angeles when the daily ozone maximum was limited by the availability of NOx. Despite large differences in the physical details and NOx availability of the two modeling approaches, the agreement between the airshed modeling and the MIR scale is within 15 percent for most organic gases. Poorer agreement was found with the MOIR scale, with differences larger than 25 percent for most organic gases. On the basis of these results, the MIR scale was selected to compute the RAFs.

Another point to keep in mind is that the reactivity scales are used to compare the relative reactivities of the alternative fuels with conventional gasoline, and not to compute absolute differences. The MIR scale is not predisposed toward higher RAFs than other scales; it depends on the compositional make-up of the fuels. For some fuels (M85 is a prominent example), the MIR-calculated RAFs are virtually the same as those computed with the MOIR scale, while for other fuels (e.g. CNG, E85), the RAFs can differ by almost 30 percent.

73. Comment: The RAFs were computed using an incremental reactivity scale based on a largely unexamined averaging process. The simple arithmetic averaging method used to produce a single reactivity scale was

chosen as a means to an end and its validity has never been demonstrated. (WSPA)

Agency Response: This is not an issue because of the relatively small variations in the RAFs among all thirty-nine cities used in the derivation of the scale, and the agreement between the MIR scale and the airshed modeling results, both for individual hydrocarbons and the RAFs.

74. Comment: Systems Applications International (SAI) sent a letter on January 16, 1992 pointing out some inconsistencies in the November 1991 MIRs. Although the updates for the four compounds suggested would probably not make a significant difference when calculating MIR reactivities for total exhaust, we believe the suggested changes should be made to assure the technical correctness of the MIR list. (GM)

Agency Response: SAI's suggested changes did not result in any changes in the RAFs. However, we concur that there were a few inconsistencies, and have proposed that the present MIR list be replaced with a more general list at the biennial review rulemaking hearing scheduled to be conducted by the end of 1992.

Reactivity and reactivity modeling is an evolving field. The Board has acknowledged this in calling for regular reviews and updates as research results become available. So far, none of the new data incorporated has led to major changes in RAFs or to the underlying rationale for using the MIR approach.

2. The Procedure and Protocol for Establishing RAFs

75. Comment: Adjusting RAFs for M85 and LPG TLEVs upward by 10 percent to account for potential modeling and protocol biases is arbitrary. There is no scientific basis for this adjustment. Modeling studies must be undertaken to determine whether this 10 percent mass adjustment is appropriate. (Chevron, WSPA)

Agency Response: There is no clear scientific methodology for determining what adjustments should be applied to calculated RAFs. However, airshed modeling is the best scientific approach currently available for evaluating the impact of vehicle emissions on atmospheric ozone formation. Accordingly, airshed modeling was conducted to determine whether the use of unadjusted RAFs for M85, LPG, and CNG would increase ozone formation. The results of these analyses indicated that public exposure to ozone actually could increase if unadjusted RAFs for M85 and LPG were adopted. There was no indication that the use of an unadjusted RAF for CNG would increase ozone. In the scenarios which represent the greatest public exposure to atmospheric ozone, the ozone formed from M85 and LPG vehicles was shown to be a few percent higher than the ozone which would be formed by using conventional gasoline. This was the basis for requiring a 10 percent adjustment to the calculated RAFs for M85 and LPG.

76. Comment: While the Board correctly concludes that data from only two LPG vehicles are not sufficient to establish a RAF for LPG TLEVs, it indicated this same data was adequate to set a 10 percent upward adjustment for LPG RAFs. This action is inconsistent; adjustments to RAFs to account for modeling and protocol biases should be based on data from statistically valid numbers of vehicles. (WSPA)

Agency Response: It was necessary to adopt a protocol for developing engine-specific RAFs for LPG TLEVs to allow manufacturers to begin vehicle certification. Even though the need for a 10 percent upward adjustment for LPG TLEVs was demonstrated using data from only two vehicles, the Board decided to err on the side of conservativeness by requiring that a 10 percent adjustment be applied unilaterally for all LPG TLEVs. This action was taken to ensure that ozone would not be increased by the use of RAFs. As more data become available, the staff will re-assess the applicability of the 10 percent adjustment of RAFs for LPG TLEVs.

77. Comment: There is no scientific justification set forth that the 10 percent adjustment be applied to the RAFs for LPG TLEVs and not to the CNG RAF. (WLGA)

Agency Response: Although there is evidence from airshed modeling analyses that the 10 percent adjustment is needed for RAFs for TLEVs operating on LPG, the results of the airshed modeling analyses run by CMU indicate that no correction factor is needed for calculated RAFs for CNG TLEVs. As more representative NMOG species profiles from low-emission CNG vehicles become available, a generic RAF for CNG TLEVs will be calculated and airshed modeling analyses will be rerun to re-evaluate whether an adjustment factor is needed. Appendix VIII of the LDV/MDV Standards and Test Procedures can then be amended as appropriate.

78. Comment: It is not known whether RAFs for fuels other than M85 and LPG will require any adjustment for protocol and modeling bias. (GM)

Agency Response: As RAFs are developed for other fuels, airshed modeling analyses will be conducted to determine whether adjustments are needed. Correction factors will be developed and incorporated into the regulations if they are needed.

79. Comment: RAFs should also be determined from 50°F testing rather than from 75°F testing because at lower temperatures exhaust emissions are known to increase and emission profiles are also expected to change. (Chevron, WSPA)

Agency Response: The purpose of the 50°F test requirement in the LDV/MDV Standards and Test Procedures is to demonstrate that no discontinuity exists in the emission control strategy at temperatures below 68°F (i.e. that no "defeat device" is used). Because this requirement is not meant to be a rigorous emission requirement, manufacturers are only required to demonstrate compliance with 50°F emission standards using low mileage vehicles; there is no in-use compliance liability associated with the requirement. Development of RAFs based on the 50°F test would, therefore, not be warranted until the temperature range for meeting the emission standards is changed from the present 68°F to 86°F.

80. Comment: Because the auto manufacturers must submit deterioration factors for RAFs, the ARB should have established a deterioration factor for the RAF of 0.41 for M85 TLEVs. The ARB should be required to follow equitable procedures and requirements. (WSPA)

Agency Response: A deterioration factor was not established for the generic M85 RAF because of a lack of time and resources. Establishment of a deterioration factor for the M85 RAF would have required the accumulation of 100,000 miles on each of the nine methanol test vehicles. This would have taken many months if not years. Because the ARB does not own any of the methanol vehicles which were used for RAF development, any significant mileage accumulation by the ARB on these vehicles would not be feasible.

Nonetheless, the lack of a deterioration factor for the RAF of 0.41 for M85 TLEVs should not result in an increase in ozone formation. Because the mass standards for low-emission vehicles are so tight, mass emissions will not be able to increase very much with age. Therefore the emission profiles which determine the reactivity of vehicular exhaust are not likely to change substantially with age and the RAF of 0.41 for M85 TLEVs should still be applicable in use. As more data become available, the staff will examine how RAFs change with vehicle age and, if needed, initiate the appropriate actions to set a deterioration factor for the generic RAF for M85.

81. Comment: The proposed regulatory text in Section 13.a. of the LDV/MDV Standards and Test Procedures indicates that the Executive Officer may establish new RAFs by executive order with thirty days notice. We suggest that ninety days notice be provided. GM and other auto makers traditionally close their operations for nearly two weeks during the year-end holiday season, and European operations often close for a month in the summer. Also, a longer comment period would lead to more robust data and decisions. (GM)

Agency Response: We believe the commenter is referring to the notice provision in Section 13.b. of the LDV/MDV Standards and Test Procedures. The 30 days refers to the time frame within which the Executive Officer must notify manufacturers after a new RAF is established or a previously established RAF is revised. After a RAF is revised, manufacturers are provided with 3 years lead time before they are required to use the new RAF. This should provide adequate lead time to enable manufacturers to accommodate any vehicle design changes which might be needed because of the change in the RAF. Moreover, if a manufacturer is having a planned shutdown over a holiday period, during that time it would not be engaged in work that could be affected by a new RAF. Finally, the 30-day notice provision applies to the effective date of a new or revised RAF, not a comment period. Accordingly there is no need to have the manufacturer operating during the 30-day period so that it can provide comments. We note, however, that we anticipate the Executive Officer will seek input from the manufacturers prior to the final establishment of a new or revised RAF pursuant to Appendix VIII.

3. Engine-Family-Specific RAFs

82. Comment: In Appendix VIII, Section 8.b., the protocol for the separation of ozone-forming potential from NMOG and calculation of separate deterioration factors is not technically correct. A more correct method would be to calculate a single deterioration factor based on the product of NMOG and ozone-forming potential (i.e., an "ozone DF") for each test conducted. (GM, Toyota, Ford)

Agency Response: The approach of calculating separate deterioration factors for ozone-forming potential and NMOG should not be characterized as technically incorrect. Rather, industry's objection to the modified protocol is that it does not allow RAF deterioration factors to be less than 1. This conservative approach was taken because there are insufficient test data available to confirm that the reactivity of vehicle exhaust might actually decrease as mileage accumulates. Once more data become available, we are willing to consider allowing the use of RAF deterioration factors which are less than 1. This would be embodied in the process being recommended by industry where deterioration factors are based on the product of NMOG and ozone-forming potential. However, enforcement of emission standards in use would be cumbersome and expensive if ozone DFs are used. Verification of compliance with in-use standards using ozone DFs would require the speciation of in-use surveillance testing data. The protocol for calculating deterioration factors based on the product of NMOG and ozone-forming potential will be re-examined at a subsequent rulemaking hearing to be conducted by the end of 1992.

83. Comment: GM requests that another 15-day notice be provided to enable staff to address the GM proposal (for using ozone-forming potential as the basis for deterioration factors) and to enable manufacturers to comment on it. (GM)

Agency Response: Because we have decided not to adopt GM's proposal at this time for the reasons set forth in the response to the preceding comment, issuance of another 15-day notice to solicit comments on the proposal would not be appropriate.

84. Comment: The statistical variability limit that is proposed for manufacturer-determined RAFs is very restrictive. The Board should defer final consideration of the RAF variability criteria until sufficient data

are developed to ensure the reasonableness and validity of such limits. In the meantime, we recommend an interim criteria employing a 20 percent difference between the 95 percent upper confidence bound and the mean. (Ford)

The basis for the requirement that the 95 percent upper confidence bound for the engine family shall be less than or equal to 115 percent of the engine family RAF is not provided. The staff should provide estimates of test-to-test and vehicle-to-vehicle variance at TLEV, LEV, and ULEV levels, and answer the question as to whether the requirement can be satisfied with current analytical precision. (GM)

Agency Response: A RAF variability criterion is needed now to allow manufacturers to develop engine-specific RAFs. The 15 percent difference between the 95 percent upper confidence bound and the mean which is allowed by the regulations was chosen because it is stringent enough to statistically guarantee the accuracy of a RAF, yet it allows for normal test variability. All of the gasoline TLEVs which were used to establish the baseline for TLEV RAFs met the 15 percent variability criterion. These data were included in the TSD for this rulemaking, as were data used to establish the RAF for methanol TLEVs. Data were also provided with the 15-day Notice. The staff is continuing to test TLEVs as well as LEVs and ULEVs for the purpose of establishing additional RAFs. This data will also be made available to the public. We do not believe that test-to-test and vehicle-to-vehicle variability will be sufficient to prevent compliance with the 15 percent variability criterion, even at LEV and ULEV levels. Manufacturers can compensate for test-to-test and vehicle-to-vehicle variability by increasing the number of tests conducted per vehicle and/or by increasing the number of vehicles tested.

4. Need for Subsequent Rulemaking Actions

85. Comment: If further information becomes available which indicates that the RAFs for M85 and LPG should be adjusted, the Board should propose new correction factors. (Chevron, WSPA)

Agency Response: The established RAFs provide a minimum level of adjustment (for at least three years) which manufacturers may use to design their vehicles. The staff will continue to evaluate new information as it becomes available to ensure that the protocol used to establish RAFs is representative of real world conditions. RAFs will be updated accordingly.

86. Comment: The specifications for Phase 2 certification fuel need to be determined as soon as possible. (GM)

Agency Response: See the response to Comment 59.

87. Comment: Manufacturers need "g ozone potential per g NMOG" values for LEVs and ULEVs in order to be able to evaluate the technological feasibility of these vehicles. (GM)

Agency Response: Because manufacturers will not need to produce LEVs until the 1997 model year and ULEVs until the 2000 model year, there is still considerable time in which to adopt "g ozone potential per g NMOG" values for LEVs and ULEVs. The baseline gasoline "g ozone potential per g NMOG" values for LEVs and ULEVs will be presented to the Board at a rulemaking hearing before the end of 1992. Manufacturers may develop engine-specific "g ozone potential per g NMOG" values for LEVs and ULEVs using cleaner fuels such as Phase 2 gasoline. RAFs can then be developed by comparing the engine-specific and the baseline "g ozone potential per g NMOG". Manufacturer assistance would expedite the development of generic "g ozone potential per g NMOG" values for the various fuels, but little data have been offered by them to develop these values.

88. Comment: It is not clear from the 15-day Notice when a generic RAF for CNG will be submitted to the Board for approval. (GM)

Agency Response: A generic RAF for CNG TLEVs was not established in this rulemaking due to lack of availability of low-emission CNG test vehicles. Efforts to obtain suitable test vehicles are continuing. When qualified vehicles become available for testing, a generic RAF for CNG TLEVs will be developed.

5. Legal Issues

89. Comment: By establishing RAFs for TLEVs based on incomplete data which may be seriously flawed, and which may in fact make the air quality worse rather than better, the ARB's proposed modifications violate the general principals [sic] of administrative law which prohibit an agency from making arbitrary and capricious decisions. (WSPA)

Agency Response: See the response to Comment 53. For the reasons stated there, we do not believe these amendments are arbitrary or capricious.

90. Comment: In effect, the real RAF rule will not be established until all of the RAFs on different vehicle classes tested on different clean fuels are established. Much of the detail of the final reactivity regulation is left to the Executive Officer. This appears to be an unlawful delegation to the Executive Officer.

To start with, while the ARB has authority to delegate broad implementation powers to the Executive Officer, a perusal of the provisions of the code concerning rulemaking leaves little doubt that the Legislature intended rulemaking to be done by the Board. To the best of our knowledge, the Executive Officer has never been given the function of making rules.

Delegating this power to the Executive Officer has a further consequence in that when the Executive Officer determines the RAFs for different vehicle categories operating on different fuels, he is providing the very basis of the rule itself. That, in turn, means that all of the statutory precautions, i.e., notice, hearing, opportunity for comment and the like, are required before this can be done. We submit that the adoption or updating of new RAFs must be accompanied by formal notice and comment procedures. (Government Code § 11347.5 ("No state agency shall issue, utilize, enforce or attempt to enforce any . . . standard of general application, or other rule . . . unless [it] has been adopted as a regulation and filed with the Secretary of State pursuant to [the APA]"; See also Stauffer Chemical Co. v. California Air Resources Board, 128 Cal. App.3d 789, 794 (1982); Armistead v. State Personnel Board, 22 Cal.3d 198, 204 (1978).) (WSPA)

Agency Response: See the response to Comment 56.

91. Comment: The proposed modifications authorize vehicle manufacturers to establish "unique" RAFs for vehicle emission control technology and fuel, subject only to approval by the Executive Officer. This provision again appears to circumvent the required procedural safeguards for the establishment of an administrative standard or rule of general application. (See Gov. Code § 11347.5) As with the establishment of or revision of RAFs by the Executive Officer, both the establishment of a unique RAF by a manufacturer, and its approval by the Executive Officer, must be accompanied by formal notice and comment procedures. (See Stauffer Chemical Co. v. California Air Resources Board, 128 Cal. App.3d 789, 794 (1982).) However, allowing manufacturers to create their own RAFs takes the delegation problem one step further. The ARB, in effect, is delegating its rulemaking power to private parties, and such delegation is prohibited. (see Bayside Timber Co. v. Board of Supervisors, 20 Cal.App.2d 31, 10-11 (1971).) (WSPA)

Agency Response: See the response to Comment 56. Allowing manufacturers to apply for an engine-family-specific RAF based on criteria established in the LDV/MDV Standards and Test Procedures is no more an unlawful delegation than is the long-established practice of allowing the Executive Officer to certify engine families as meeting the California motor vehicle emission standards based on testing and a certification application submitted by the manufacturer.

92. Comment: The California Clean Air Act requires the ARB to adopt vehicular air pollution control regulations "which will result in the most cost-effective combination of control measures on all classes of motor vehicles and motor vehicle fuel." (Health and Safety Code § 43018(c).) Moreover, the ARB is required to consider the effect of any such regulations

on the economy of the state. (Health and Safety Code § 43013(e).) Although the Board makes bare statements of compliance with these requirements in its resolution adopting the proposed modifications, it does not appear that such statements are supported by any type of study or analysis. It is well established that agencies must actually assess the potential cost impacts and make such assessments available for public comment. (See, e.g., Corrosion Proof Fittings v. Environmental Protection Agency, 947 F.2d 1201, 1214 (5th Cir. 1991).) (WSPA)

Agency Response: The Staff Report addressed the cost impacts at page 23. All this rulemaking does is to establish a RAF for M85 TLEVs and to make various revisions to the procedures and criteria for the establishment of RAFs and the use of engine-family-specific RAFs. It does not require vehicle manufacturers to produce any different mix of vehicles than they had previously planned under the regulations. The commenter has not identified any way that it believes the amendments will have an adverse cost impact.

6. Miscellaneous

93. Comment: As emissions decrease, it is possible that the ozone impact of the low-emission vehicles decrease and for there to be more variability in the data. There is also an inherent measurement accuracy problem associated with decreased emissions. For these reasons, it is important to use total reactive organic emissions (including methane, CO and evaporative emissions), instead of NMOG as the basis for the ozone adjusted emission standards. (WLGA) Instead of the fictitious "RAFs" (based only on NMOG), the total "Maximum Incremental Reactivities" (MIRs) corresponding to the total reactive organic gases should be considered. (WLGA)

Agency Response: See the responses to Comments 57 and 58.

94. Comment: We urge the Board to retain all possible openness and flexibility in the certification regulations to ensure the "clean-air" potential of gaseous-fueled low-emission vehicles are recognized. (WLGA)

Agency Response: We readily acknowledge the emission reductions which may be achieved from using gaseous-fueled vehicles. The Board will continue to maintain a fuel-neutral approach to reducing emissions from motor vehicles to allow manufacturers to take advantage of the benefits of all alternative fuels.

95. Comment: Results from the Auto/Oil program on the comparison of methanol flexible fuel vehicles (FFVs) and gasoline vehicles should be used in assessing the appropriateness of the present RAF for M85 LEVs. (Chevron)

Agency Response: The Auto/Oil analysis which compares methanol FFVs and gasoline vehicles does not provide an accurate indication of the relative reactivity of low-emission vehicles. This is primarily due to differences in the level and maturity of the technology used in the FFVs compared to the gasoline vehicles. As stated in Technical Bulletin No. 7 issued by the Auto/Oil Program, the FFVs used in this study utilized 1989 technology and are not representative of the technology which would be required for production vehicles to be produced in 1997 and subsequent model years. In contrast, the gasoline vehicles tested in this study were selected from production vehicles having the lowest emissions and use technology which is likely to remain in production through the mid-1990s.

96. Comment: The absence of ARB-determined RAFs for Phase 2 gasoline, CNG and LPG places those fuels at a disadvantage for consideration as a fuel for low-emission vehicles and slows down our process of identifying vehicle/fuel systems to certify to low-emission vehicle standards. (Ford)

Agency Response: Delays in the establishment of Phase 2 gasoline specifications and the lack of availability of CNG and LPG TLEVs prevented development of RAFs for these fuels at this time. A RAF for Phase 2 gasoline will be considered for adoption at a rulemaking hearing to be conducted before the end of 1992. RAFs for CNG and LPG vehicles will be established as soon as possible provided suitable vehicles are available for testing. Meanwhile, manufacturers can establish engine-specific RAFs and can also concentrate their efforts on the development of advanced emission control technology (such as advanced catalysts) which could reduce vehicle emissions regardless of the fuel used.

The delays which have occurred in establishing RAFs for Phase 2 gasoline, CNG, and LPG should also not impede manufacturers' efforts to develop low-emission vehicles for other reasons as well. First, the manufacturers have already concluded that Phase 2 gasoline will be the primary fuel used in low-emission vehicles, and have been conducting emission tests with gasoline which is very similar to Phase 2 certification gasoline. Therefore, manufacturers know what the likely RAF for Phase 2 gasoline TLEVs will be. Furthermore, CNG and LPG vehicles appear capable of meeting TLEV standards even without application of a RAF, so little slowing of progress should occur. Nonetheless, the manufacturers have indicated they are unlikely to build significant numbers of CNG or LPG vehicles in the foreseeable future, regardless of the RAF value.

97. Comment: It is not clear whether state-of-the-art speciation technology can fulfill the requirement at LEV and ULEV levels that a minimum of 95 percent of the total mass of NMOG emissions measured be accounted for. The results obtained by the ARB need to be included in the regulatory materials to show that this requirement can be met. (GM)

Agency Response: The 95 percent requirement was not established or amended in this rulemaking--it is contained in Appendix VIII Section 1.c. of the LDV/MDV Standards and Test Procedures and was adopted as part of the initial LEV/CF rulemaking. Nonetheless, because this requirement appears to have been misunderstood by GM (and other manufacturers), we will explain again what is required. The confusion arises because there are two different procedures for measuring NMOG mass emissions. Some manufacturers have apparently assumed that Appendix VIII requires a 95 percent correlation in the mass of the NMOG emissions which are measured using the two different procedures. However, the Appendix does not require that 95 percent of the NMOG mass emissions which are measured by one procedure are accounted for using the other procedure. Rather, 95 percent of the NMOG species which are contained in the mass measurement must be identified.

98. Comment: We are not aware of the ARB considering the impact of the proposed regulations on the economy of the state. The standards and regulations adopted by the Board do not result in the most cost-effective combination of control measures on all classes of motor vehicles and motor vehicle fuels as required in Resolution 91-53. (Chevron, WSPA)

Agency Response: See the response to Comment 92.

The adoption of RAFs should not have a measurable impact on California's economy. In fact, RAFs will help allow automobile manufacturers to meet increasingly stringent emission standards in the most cost-effective manner, thereby maintaining the lowest possible new vehicle prices to consumers. RAFs are designed to reflect the relative ozone-forming potential of different vehicle/fuel systems. Use of RAFs would allow clean fuel vehicles to emit more mass emissions than conventional gasoline vehicles, provided the effect on ozone formation would be the same. This approach allows manufacturers the option of using clean alternative fuels to help meet increasingly stringent emission standards with less complex and costly emission control hardware than is needed by conventional gasoline vehicles. Manufacturers could, therefore, choose the most cost-effective strategy for reducing vehicle emissions.

In spite of the adoption of a RAF for M85 TLEVs, it does not appear likely that many alternative fuel vehicles will be sold in California. Current indications are that more than 90 percent of the low-emission vehicles which will be sold in California will operate on Phase 2 reformulated gasoline, which will be the commercial gasoline sold in California beginning March 1, 1996. Because of the magnitude of the refinery investments which will be required to meet Phase 2 specifications, it is anticipated that the cost of Phase 2 reformulated gasoline and M85 would likely converge. LPG and CNG are less costly than current and Phase 2 gasolines, but initial vehicle costs are higher. Therefore, regardless of fuel and vehicle choices made by the automotive industry in response to the RAFs which are being adopted, the overall economic impact of RAF development on California's economy will be insignificant.

99. Comment: There has been no study done which demonstrates the cost-effectiveness of this regulation. (Chevron, WSPA)

Agency Response: This rulemaking essentially builds on the LEV/CF regulations which were adopted after a September, 1990 hearing. Because the RAF approach and the procedure for establishing RAFs was part of the LEV/CF regulations, the cost-effectiveness of RAFs was examined within the context of the LEV/CF regulations prior to their adoption by the Board in September, 1990. The adoption of RAFs should help enable vehicle manufacturers to use the most cost-effective means for reducing vehicular emissions. See also the response to the preceding comment.

100. Comment: Resolution 91-53 states that "...action not be adopted as proposed where it will have significant adverse environmental impacts...." A likely adverse environmental impact of this proposed action is increased ozone formation in Los Angeles, which will result from an erroneously low RAF for M85 TLEVs. The RAF of 0.41 for M85 TLEVs is too liberal and could result in increased ozone formation from such vehicles. (Chevron, WSPA)

Agency Response: Resolution 91-53 included a finding that the amendments will not have any significant adverse environmental impacts. The airshed modeling analyses which were conducted examined scenarios which would provide the best indication of the level of public exposure to ozone. These analyses compared the ozone which would be formed from M85, LPG, and CNG vehicles (assuming unadjusted RAFs were used) compared to vehicles which operated on commercial gasoline. (see also the response to Comment 75.) Based on these results, the staff took a conservative approach and adjusted the proposed RAFs upward to ensure that public exposure to ozone would not increase under any likely conditions. The 10 percent upward adjustment of calculated RAFs based on the maximum incremental reactivity scale should also address any uncertainties in the protocol. If data become available which indicate that the RAFs and/or protocol which have been adopted are somehow not representative of the vehicle fleet, they will be modified accordingly.

101. Comment: Based on Auto/Oil data, the California mandated motor vehicle emission standards for M85 may be less protective of public health and welfare than the federal standard. (Chevron, WSPA)

Agency Response: California's non-methane organic gas emission standards for TLEVs, LEVs, and ULEVs are 50, 70, and 84 percent lower, respectively, than federal Tier 1 standards. Because California's low-emission vehicle standards are significantly lower than Tier 1 standards, even if there was a slight miscalculation in the RAF for M85 TLEVs, the reactivity-adjusted TLEV standards will still result in lower mass emissions than federal Tier 1 standards. Furthermore, there are no federal standards to control formaldehyde emissions from methanol vehicles. Control of formaldehyde is critical for protection of public health due to the toxic nature of formaldehyde and the tendency of methanol vehicles to emit high quantities of formaldehyde if inadequate emission control technology is used.

Proposed Reactivity Adjustment Factors for Transitional Low-Emission Vehicles

Technical Support Document

Release Date: Sept. 27, 1991

Mobile Source Division
Research Division
California Air Resources Board

PROPOSED REACTIVITY ADJUSTMENT FACTORS FOR TRANSITIONAL LOW-EMISSION VEHICLES

--TECHNICAL SUPPORT DOCUMENT--

Mobile Source Division
Research Division

State of California
Air Resources Board

September 27, 1991

PROPOSED REACTIVITY ADJUSTMENT FACTORS FOR TRANSITIONAL LOW-EMISSION VEHICLES

--TECHNICAL SUPPORT DOCUMENT--

Date of Board Meeting: November 14, 1991

Air Resources Board
P.O. Box 2815
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APPENDICES

INTRODUCTION

On September 28, 1990, the Air Resources Board (ARB) adopted California's first reactivity-based motor vehicle emission standards. In addition to establishing stringent emission standards for light- and medium-duty vehicles, the "Low-Emission Vehicles and Clean Fuels" (LEV/CF) regulations were designed to reflect the ozone-forming potential of the exhaust of various vehicle/fuel systems by applying reactivity adjustment factors (RAFs) to the non-methane organic gas (NMOG) exhaust mass emissions of the system.

This report presents technical information in support of the ARB staff's proposed RAFs for transitional low-emission vehicles. The report consists of:

-- Part A, concerning the ARB staff's proposed regulation for RAFs;

-- Part B, concerning the staff's proposed protocol for determining RAFs for exhaust emissions from low-emission[1] vehicles powered by different fuels;

-- several appendices providing greater detail on the above subjects.

The proposed regulations are appended to another document, Proposed Reactivity Adjustment Factors for Transitional Low-Emission Vehicles -- Staff Report, September 27, 1991.

The RAFs for low-emission vehicles would augment the LEV/CF regulations. (For a more detailed description of these regulations, refer to Proposed Regulations for Low-Emission Vehicles and Clean Fuels, staff report and technical support document, released on August 13, 1990.)

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1. In this report, the term "low-emission vehicle(s)" is used to refer to any vehicle(s) certified to the transitional low-emission vehicle, low-emission vehicle, ultra-low-emission vehicle, or zero-emission vehicle standards, not just those certified to the low-emission vehicle category.

PART A: REACTIVITY ADJUSTMENT FACTORS

I.

THE PROPOSED PROGRAM

This chapter presents reactivity adjustment factors (RAFs) for transitional low-emission vehicles and contains a discussion of the development of these factors. Proposed RAFs, the parameters used in the development of these factors (including test vehicles/fuels used and hydrocarbon compounds included in RAF calculations), and the criteria and leadtime for revising established RAFs are discussed in detail.

A. REACTIVITY ADJUSTMENT FACTORS

1. Adoption of Reactivity-Based Emission Standards

In September, 1990, California adopted its first reactivity-based emission standards for light- and medium-duty vehicles. Prior to these "Low-Emission Vehicles and Clean Fuels" (LEV/CF) regulations, hydrocarbon emissions were represented in terms of non-methane hydrocarbons (NMHC), which provided an adequate representation of organic gas emissions from conventional gasoline and diesel fueled vehicles. However, the NMHC measurement does not include oxygenated compounds (such as formaldehyde) which contribute to exhaust reactivity and which may be present in significant amounts in some alternative-fueled vehicles (e.g., alcohol-fueled vehicles). To provide a more accurate comparison of the reactivities of exhaust emissions of the various vehicle/fuel systems, the individual reactivities of all measurable hydrocarbon species in an exhaust sample need to be considered. Hence, the LEV/CF regulations established emission standards for non-methane organic gases. Non-methane organic gases (NMOG) consist of the full, unadjusted mass of all measurable non-oxygenated hydrocarbons (except methane) containing 12 or fewer carbon atoms, and all ketones, aldehydes, alcohols, and ethers containing 5 or fewer carbon atoms.

2. Basis for Reactivity Adjustment Factors

The LEV/CF regulations establish performance-based emission standards for 1994 and subsequent model-year transitional low-emission vehicles (TLEVs), low-emission vehicles (LEVs), ultra-low-emission vehicles (ULEVs), and zero emission vehicles (ZEVs). Although the numerical values of the standards for the low-emission vehicle categories were based on conventional gasoline vehicle technologies, NMOG emission rates of alternative-fueled vehicles would be multiplied by the applicable RAF to determine compliance with the conventional gasoline-based NMOG standards. Table I-1 summarizes exhaust emission standards at 50,000 miles for passenger cars (PCs), light-duty trucks (LDTs), and medium-duty vehicles (MDVs).

Table I-1: Exhaust Emission Standards (g/mi) at 50,000 Miles

(The NMOG standards will be adjusted for reactivity; standards for formaldehyde (HCHO) apply to all vehicles; standards for particulate matter (PM) apply only to diesel vehicles and engines; 100,000 mile standards for PCs and LDTs and 120,000 mile standards for MDVs are given in parentheses.)

PCs and LDTs ≤ 3750 lbs. Loaded Vehicle Weight

Cat.	NMOG	CO	NOx	PM	HCHO
TLEV	0.125 (0.156)	3.4 (4.2)	0.4 (0.6)	(0.08)	0.015 (0.018)
LEV	0.075 (0.090)	3.4 (4.2)	0.2 (0.3)	(0.08)	0.015 (0.018)
ULEV	0.040 (0.055)	1.7 (2.1)	0.2 (0.3)	(0.04)	0.008 (0.011)

LDTs 3751 ≤ Loaded Vehicle Weight ≤ 5750 lbs.

Cat.	NMOG	CO	NOx	PM	HCHO
TLEV	0.160 (0.200)	4.4 (5.5)	0.7 (0.9)	(0.08)	0.018 (0.023)
LEV	0.100 (0.130)	4.4 (5.5)	0.4 (0.5)	(0.08)	0.018 (0.023)
ULEV	0.050 (0.070)	2.2 (2.8)	0.4 (0.5)	(0.04)	0.009 (0.013)

MDVs ≤ 3750 lbs. Test Weight

Cat.	NMOG	CO	NOx	PM	HCHO
LEV	0.125 (0.180)	3.4 (5.0)	0.4 (0.6)	(0.08)	0.015 (0.022)
ULEV	0.075 (0.107)	1.7 (2.5)	0.2 (0.3)	(0.04)	0.008 (0.012)

MDVs 3751 ≤ Test Weight ≤ 5750 lbs.

Cat.	NMOG	CO	NOx	PM	HCHO
LEV	0.160 (0.230)	4.4 (6.4)	0.7 (1.0)	(0.10)	0.018 (0.027)
ULEV	0.100 (0.143)	2.2 (3.2)	0.4 (0.5)	(0.05)	0.009 (0.013)

MDVs 5751 ≤ Test Weight ≤ 8500 lbs

Cat.	NMOG	CO	NOx	PM	HCHO
LEV	0.195 (0.280)	5.0 (7.3)	1.1 (1.5)	(0.12)	0.022 (0.032)
ULEV	0.117 (0.167)	2.5 (3.7)	0.6 (0.8)	(0.06)	0.011 (0.016)

MDVs 8501 ≤ Test Weight ≤ 10,000 lbs

Cat.	NMOG	CO	NOx	PM	HCHO
LEV	0.230 (0.330)	5.5 (8.1)	1.3 (1.8)	(0.12)	0.028 (0.040)
ULEV	0.138 (0.197)	2.8 (4.1)	0.7 (0.9)	(0.06)	0.014 (0.021)

Table I-1 (cont.): Exhaust Emission Standards (g/mi) at 50,000 Mi.

MDVs 10,001 ≤ Test Weight ≤ 14,000 lbs.

Cat.	NMOG	CO	NOx	PM	HCHO
LEV	0.300 (0.430)	7.0 (10.3)	2.0 (2.8)	(0.12)	0.036 (0.052)
ULEV	0.180 (0.257)	3.5 (5.2)	1.0 (1.4)	(0.06)	0.018 (0.026)

Incomplete MDVs and Diesel Engines* (g/bhp-hr)

Cat.	NMHC + NOx	CO	PM	HCHO
LEV	3.5	14.4	0.10	0.050
ULEV	2.5	7.2	0.05	0.025

* Includes engines derived from diesel-fueled engines powered by fuels other than diesel.

To quantify the ozone-forming potential of NMOG emissions for RAF development, the ARB staff focused efforts on two methodologies: "maximum incremental reactivity" (MIR) and "maximum ozone reactivity" (MOR). These scales, developed by Dr. W.P.L. Carter of the Statewide Air Pollution Research Center at the University of California-Riverside, involve the determination of maximum reactivities of individual hydrocarbon species based on smog chamber experiments that simulate environmental conditions representative of ozone episodes in California. (A more detailed discussion of the development of MIRs and MORs is presented in Part B, and the numerical values of MIR and MOR factors for various hydrocarbon species are listed in Appendix A-1.) The MIR (or MOR) factors are applied to fully speciated NMOG exhaust emission profiles from each vehicle/fuel system to determine the total ozone impact of each gram of NMOG emissions of the system. To calculate the RAF, this result is then divided by the ozone per gram of NMOG of the baseline vehicle/fuel system.

Ozone formation in the atmosphere is largely influenced by the HC/NOx ratio, and the MIR scale and the MOR scale each depict a different set of conditions. MIRs are determined based on atmospheric conditions in which small changes in hydrocarbon concentrations most greatly affect ozone formation. The MOR approach, however, is more indicative of conditions in which ozone formation is primarily controlled by atmospheric NOx concentrations. Together, the MIR and MOR scales bracket the range of conditions under which hydrocarbon reactivity could be appropriately defined. To reflect the conditions where HC control has the greatest impact on ozone formation, the ARB staff is recommending that MIR procedures be used for RAF development. The appropriateness of this recommendation is currently being verified at Carnegie Mellon University, where Professor A. Russell has been contracted to run airshed models using both the MIR and MOR scales. RAFs have been calculated for TLEVs using both the MIR and the MOR scales, and results of these calculations are provided in Table I-2.

Although staff originally intended to develop RAFs for ethanol, no dedicated ethanol vehicles were available for testing. Furthermore, none of the flexible-fueled vehicles tested using ethanol were able to meet TLEV standards. Hence, ethanol RAFs are not being proposed at this time due to lack of test data. Details of the ethanol testing are discussed in more detail in Section B - "Reactivity Adjustment Factor Development Parameters."

Table I-2: Summary of Reactivity Adjustment Factors for TLEV Passenger Cars and Light-Duty Trucks

Calculation Methodology	M85	E85[1]	LPG	CNG
MIR	0.36	na.	0.50	0.18
MOR[2]	0.38	na.	0.59	0.24

na.: not available

[1]Although RAFs are not currently being proposed for E85 TLEVs at this time, indication is the MIR and MOR-based RAFs would be 0.63 and 0.77, respectively.

[2]RAFs calculated based on the MOR scale are presented for informational purposes only.

3. Protocol for Calculating RAFs

In order to calculate the RAF for a particular vehicle/fuel system, a speciated emission profile is needed to determine the ozone-forming potential of the NMOG emissions from that system. A speciated emission profile contains a listing of the different organic gases present in the exhaust and the rate, in grams or milligrams per mile, at which they are emitted.

Once the speciated profile is obtained for a particular vehicle/fuel system, a RAF may be calculated for that system by using the following procedure:

1. Multiply the gram per mile emission rates of each individual NMOG species (including aldehydes, ethers, ketones, and alcohols) by its maximum incremental reactivity value. The sum of these products constitutes the gram ozone per mile or "ozone per mile" of the exhaust emissions. The ozone per mile value is indicative of the ozone impact for each mile that the vehicle travels.

2. Divide the ozone per mile of the exhaust by the grams per mile NMOG emission rate of the vehicle. This gives the gram ozone potential per gram NMOG or "ozone per gram" for the vehicle/fuel system.

3. The RAF for a particular vehicle/fuel system is obtained by dividing the ozone per gram of that particular vehicle/fuel system by the ozone per gram of a conventional gasoline vehicle operating on the base gasoline.

4. Criteria and Leadtime for Revising RAFs

The RAFs presented in Table I-2 provide a minimum level of adjustment (for at least three years) which manufacturers may use to design their vehicles. Established RAFs may be revised under the following conditions: (1) the MIR factors used to calculate the RAFs change, (2) ARB revises a RAF to reflect changes in vehicle technology or compiles more representative data, or (3) a manufacturer proposed RAF for an emission/fuel category is approved.

MIRs will be reevaluated every three years by the ARB. RAFs may be revised to reflect these changes if they are shown to be substantially different (as determined by the Executive Officer). As mentioned above, RAFs may also be adjusted by the ARB to reflect changes in vehicle technology or because more representative data became available. If RAFs are revised, the ARB would notify manufacturers of the revised RAFs at least three years prior to the model-year in which the revised RAFs would become effective. Manufacturers would be allowed to continue to use the original RAF for three years to ensure adequate leadtime is available for implementation of the revised RAF in vehicle designs. In addition, if a manufacturer certifies an engine family based on the most current applicable RAF and subsequently the RAF is revised, the manufacturer would be allowed to continue to use the original RAF until the engine family is recertified based on a new durability data vehicle. If a revised RAF represents a relatively lower ozone-forming potential than the established RAF, manufacturers would be given the option of using the revised RAF for certifying any new engine families immediately after the establishment of the revised RAF.

Although RAFs will be supplied by the ARB, manufacturers may utilize RAFs that are different than those specified, upon approval of the Executive Officer. The conditions by which a new RAF would be approved were adopted in the LEV/CF regulations. These regulations require a 25 percent difference in the established factor and the proposed factor. This feature was included in the regulations to limit the number of RAFs developed by manufacturers to only vehicle/fuel technologies with significantly different emission profiles than those used by the ARB.

Manufacturers applying for a revised RAF must submit representative exhaust emission profiles for the vehicle/fuel system to the Executive Officer of the ARB two years prior to submittal of the application for certification. In addition, manufacturers must provide the ARB assurance that the speciation techniques used to obtain these data are consistent with the speciation techniques used by the ARB in the development of previously established RAFs.

B. REACTIVITY ADJUSTMENT FACTOR DEVELOPMENT PARAMETERS

1. Fuels and Vehicles

a. Baseline Gasoline

To determine the exhaust emission profile for vehicles operating on base gasoline, the staff has tested vehicles operating on the gasoline blend used in the Auto/Oil Air Quality Improvement Research Program. This gasoline blend, "RF-A," was chosen as the baseline fuel to reflect the benefits of clean fuels compared to gasoline representative of currently available commercial gasoline. The specifications for "RF-A" are presented in Table I-3.

The vehicles tested to determine the exhaust emission profiles for base gasoline are late model-year production vehicles obtained from the ARB vehicle fleet, rental fleets, and directly from manufacturers. These vehicles, listed in Table I-4, were identified as potential candidates for RAF testing based on certification data. Vehicles tested as part of the Auto/Oil Air Quality Improvement Research Program which met low-emission vehicle standards were also included in the database, as well as data received from Chevron Research and Technology Company. Descriptions of the emission control technologies used on these vehicles are presented in Table I-5.

Table I-3: Specifications of Baseline Gasoline Used As Basis for Reactivity Adjustment

API Gravity	57.8
Sulfur, ppm	317
Color	Purple
Benzene, vol. %	1.35
Reid Vapor Pressure	8.7
Driveability	1195
Antiknock Index	87.3
<u>Distillation, D-86°F</u>	
IBP	92
10%	126
50%	219
90%	327
EP	414
<u>Hydrocarbon Type, Vol. % FIA</u>	
Aromatics	30.9
Olefins	8.2
Saturates	60.9

Table I-4: Baseline Gasoline Test Vehicles

Vehicle	Mileage
1991 Ford Tempo	7,000
1991 Cadillac DeVille	5,000
1990 Toyota Celica	5,500
1990 Buick LeSabre	10,850
1991 Mercury Cougar	10,200
1991 Mercedes 300 E	2,700
1990 Chevrolet Cavalier (Chevron)	21,000
1989 Oldsmobile Delta 88 (Auto/Oil)	11,700
1989 Dodge Shadow (Auto/Oil)	10,800

Table I-5: Descriptions of Gasoline Vehicle Technology

Vehicle	Emission Control System
1991 Ford Tempo	2.3L, 4 cyl., underbody three-way catalyst, heated oxygen sensor, EGR, electronic multipoint fuel injection
1991 Cadillac DeVille	4.9L, 8 cyl., underbody three-way catalyst, oxygen sensor, EGR, sequential electronic multipoint fuel injection
1990 Buick LeSabre	3.8L, 6 cyl., underbody three-way catalyst, oxygen sensor, EGR, sequential electronic multipoint fuel injection
1991 Mercedes 300 E	3.0L, 6 cyl., underbody three-way catalyst using secondary air injection, heated oxygen sensor, EGR, continuous fuel injection
1990 Chevrolet Cavalier	2.2L, 4 cyl., underbody three-way catalyst, oxygen sensor, EGR, throttle body electronic fuel injection
1989 Oldsmobile Delta 88	3.8L, 6 cyl., underbody three-way catalyst, oxygen sensor, EGR, electronic port fuel injection
1989 Dodge Shadow	2.5L, 4 cyl., underbody three-way catalyst, heated oxygen sensor, EGR, throttle body electronic fuel injection
1990 Toyota Celica	2.2L, 4 cyl., 2 three-way catalysts (1 manifold, 1 underbody), oxygen sensor, EGR, electronic multipoint fuel injection
1991 Mercury Cougar	5.0L, 8 cyl., dual warm-up (close-coupled) three-way catalysts, underbody three-way catalyst using secondary air injection, dual heated oxygen sensors, EGR, sequential electronic multipoint fuel injection

b. Alcohol Fuels

To determine the exhaust emission profile for vehicles operating on M85 (85 percent methanol, 15 percent unleaded gasoline), vehicles were tested on a blend of methanol and RF-A. RF-A was selected as the gasoline component of the M85 test fuel primarily because RF-A is representative of the gasoline most likely to be used in M85 fuel prior to the implementation of Phase 2 gasoline requirements in 1996. However, the vapor pressure of the RF-A blending fuel was lowered to 7.8 RVP to reflect the specifications for commercial gasoline beginning in 1992. Vehicles operating on E85 (85 percent ethanol, 15 percent unleaded gasoline) were tested using E85 which contained RVP adjusted RF-A as 11 percent of the gasoline component of the blend. However, 4 percent of the E85 blend is an unknown unleaded gasoline used to denature the ethanol for transport purposes. Table I-6 contains results of a fuel composition analysis for RVP adjusted RF-A. Table I-7 lists characteristics of the M85 and E85 test fuels.

All of the vehicles tested in the development of RAFs for M85 and E85 are prototype or preproduction flexible-fuel vehicles (FFVs), indicative of the types of alcohol-fueled vehicles expected to be available in the mid-1990s. A list of these vehicles is included in Table I-8; descriptions of vehicle technologies are in Table I-9.

Table I-6: Specifications of the Gasoline Component Used in Alcohol Fuel Blends

Specific Gravity	0.7563
Sulfur, ppm	269
Benzene, vol. %	1.02
Reid Vapor Pressure	7.8
Research Octane #	92.6
Motor Octane #	83.0
Antiknock Index	87.8
<u>Distillation, D-86°F</u>	
IBP	105
10%	149
50%	221
90%	331
EP	417
<u>Hydrocarbon Type, Vol. % FIA</u>	
Aromatics	33.7
Olefins	9.3
Saturates	57.0

Table I-7: Alcohol Fuel Specifications

	M85	E85
Specific Gravity, 60/60	0.7891	0.7836
Reid Vapor Pressure	7.5	7.5
Methanol, vol.%	84.3	-----
Ethanol, vol.%	----	84.62
Butane added, vol.%	----	0.83[1]
Distillation, D-86°F		
IBP	120	116
10%	143	163
50%	148	173
90%	150	174
EP	368	177

[1]According to the records of the fuel vendor, the 0.83 vol.% butane was added to the E85 test fuel to raise the RVP. However, since butane concentrations at this low level probably would not greatly affect RVP, the actual amount added could be higher.

Table I-8: Alcohol Fuel Test Vehicles

Vehicle	Mileage	Fuel
1991 VW Jetta FFV	9,100	M85/E85
1991 Chevrolet Lumina VFV	9,300	M85/E85
1990 Dodge Spirit FFV (Auto/Oil)	9,900	M85
1990 Chevrolet Lumina VFV (Auto/Oil)	11,000	M85
1990 Chevrolet Lumina VFV (Auto/Oil)	11,500	M85
1989 Dodge Caravan FFV (Auto/Oil)	9,600	M85
1988 Dodge Caravan FFV (Auto/Oil)	16,650	M85
1988 Chevrolet Corsica VFV (Auto/Oil)	10,600	M85
1988 Chevrolet Corsica VFV (Auto/Oil)	10,900	M85

Table I-9: Descriptions of Alcohol-Fueled Vehicle Technology

Vehicle	Emission Control System
1991 VW Jetta FFV	flexible-fueled vehicle, 1.8L, 4 cyl., underbody three-way catalyst, oxygen sensor, EGR, electronic multipoint fuel injection
1991 Chevrolet low emission Lumina VFV	variable fueled vehicle, 3.1L, 6 cyl., underbody three-way catalyst, oxygen sensor, EGR, electronic multipoint fuel injection, low thermal mass exhaust manifold
1990 Chevrolet Lumina VFVs	two variable fueled vehicles, 3.1L, 6 cyl., underbody three-way catalyst, oxygen sensor, EGR, electronic multipoint fuel injection
1989 Dodge Caravan FFV	flexible-fueled vehicle, 2.5L, 4 cyl., underbody three-way catalyst, heated oxygen sensor, no EGR, sequential electronic multipoint fuel injection
1988 Dodge Caravan FFV	flexible-fueled vehicle, 2.5L, 4 cyl., underbody three-way catalyst, heated oxygen sensor, no EGR, sequential electronic multipoint fuel injection
1988 Chevrolet Corsica VFVs	two variable fueled vehicles, 2.8L, 6 cyl., underbody three-way catalyst, oxygen sensor, EGR, electronic multipoint fuel injection
1990 Dodge Spirit FFV	flexible-fueled vehicle, 2.5L, 4 cyl., close-coupled three-way catalyst, heated oxygen sensor, no EGR, sequential electronic multipoint fuel injection

c. Compressed Natural Gas (CNG)

The exhaust emission profile for vehicles operating on CNG was determined by testing a single vehicle using commercial grade natural gas. The pipeline gas used to develop RAFs for CNG vehicles meets the specifications which have been proposed for commercially available natural gas. A composition analysis of this fuel is contained in Table I-10.

Since no CNG vehicles produced by an auto manufacturer were available for RAF testing, the exhaust emission profile for CNG vehicle/fuel systems is based on a retrofit conversion of a conventional gasoline vehicle. This vehicle is listed in Table I-11, and its emission control technology is described in Table I-12.

Table I-10: CNG Fuel Composition

Component	Fuel A[1] Mole percent	Fuel B Mole percent
Methane	86.915	93.578
Ethane	2.724	2.947
Propane	0.451	0.491
iso-Butane	0.050	0.056
n-Butane	0.087	0.101
iso-Pentane	0.026	0.031
n-Pentane	0.023	0.028
C6 and higher HC	0.056	0.065
Carbon Dioxide	0.518	0.426
Oxygen	1.091	0.034
Nitrogen	8.059	2.242

[1] Fuel sample "A," taken from the tank of the LeSabre on August 19, 1991, appears to have been contaminated by atmospheric gases during the sampling process. The suspected cause of contamination was insufficient purge of the sampling vessel which accounts for the high oxygen and nitrogen content of Fuel A. Consistency in the speciated test results using Fuel A and Fuel B support the assumption that Fuel A was contaminated during sampling. The ARB staff has estimated the true composition of Fuel A by assuming reductions in the oxygen and nitrogen content of Fuel A to levels comparable to Fuel B and normalizing the mole percentages of the components to account for these reductions. This yields the following results (in terms of mole percent): methane (93.331%), ethane (2.925%), C3 and higher HC (0.744%), C6 and higher HC (0.060%), inert gases (3.00%).

Table I-11: CNG Test Vehicle

Vehicle	Mileage
1990 Buick LeSabre	10,800

Table I-12: Description of CNG Vehicle Technology

Vehicle	Emission Control System
1990 Buick LeSabre	dual-fuel vehicle, 3.8L, 6 cyl., underbody three-way catalyst, open loop, EGR, ANGI carburetion system.

d. Liquefied Petroleum Gas (LPG)

The LPG used to determine exhaust emission profiles for LPG vehicles meets the Propane HD-5 specifications of the Gas Processors Association Standard 2140. (These composition specifications are equivalent to the ASTM D 1835 Special-Duty Propane standards.) This fuel also meets the specifications being proposed for commercially available LPG.

LPG vehicles tested by the ARB are displayed in Table I-13. As with CNG, no test vehicles were available from an original equipment manufacturer. Consequently, retrofit conversions of gasoline vehicles were used to establish RAFs for LPG vehicle/fuel systems. Descriptions of the retrofit systems used in the test vehicles and applicable emission control technologies are contained in Table I-14.

Table I-13: LPG Test Vehicles

Vehicle	Mileage
1989 Oldsmobile Delta 88	28,900
1989 Pontiac 6000 LE	38,400

Table I-14: Descriptions of LPG Vehicle Technology

Vehicle	Emission Control System
1989 Oldsmobile Delta 88	dual-fuel vehicle, 3.8L, 6 cyl., underbody three-way catalyst, oxygen sensor, EGR, IMPCO carburetion system
1989 Pontiac 6000 LE	dual-fuel vehicle, 3.1L, 6 cyl., underbody three-way catalyst, oxygen sensor, EGR, IMPCO carburetion system

e. Diesel

Because there are currently no test procedures to obtain speciated profiles from diesel exhaust, development of RAFs for diesel vehicle/fuel systems has been delayed to a future date. Although it is possible to speciate the gas-phase NMOG (up to about C12) from diesel vehicles, current procedures are inadequate for heavy hydrocarbons (C12 to C20). The C12 to C20 compounds can exist in either gaseous or particulate forms, depending on the temperature of the sample and the CVS dilution rate. This variation in the form of the heavy hydrocarbon compounds prevents reliable measurement of speciated profiles from diesel exhaust. Additional information is also needed to determine whether C12 through C20 hydrocarbon compounds contribute significantly to the ozone-forming potential of diesel exhaust. This information will determine the extent of speciation required for C12 to C20 hydrocarbons, if needed at all.

The ARB is working with diesel engine and vehicle manufacturers to develop speciation procedures for diesel-fueled vehicles and to resolve issues related to the contribution of heavy hydrocarbons to diesel exhaust reactivity.

2. Compounds Included in Exhaust Profiles

Exhaust emission profiles used by the ARB to develop RAFs are composed of light-end hydrocarbons (C2 to C4), mid-range hydrocarbons (C5 to C12), and oxygenated compounds (alcohols, aldehydes, etc.). The identification of mid-range species is generally limited to the 50 species listed in Table I-15. The list of mid-range hydrocarbons was shortened because approximately 98 percent of the mid-range hydrocarbon exhaust reactivity is represented by these 50 compounds. Since mid-range hydrocarbons represent approximately one-half of the total reactivity in gasoline exhaust, the reactivity of the abbreviated list when added to the reactivity of the light-end and oxygenated compounds represents roughly 99 percent of the total exhaust reactivity regardless of the vehicle fuel. (Mid-range species typically make up a larger fraction of total NMOG in gasoline exhaust than in any alternative fuel.) Although the abbreviated mid-range list is the primary focus of analytical efforts, other mid-range species are reported if a chromatogram contains a peak not represented by this list of compounds.

Table I-15: Abbreviated List of Mid-range Hydrocarbons

m & p-Xylenes	n-Propylbenzene
3&4-Ethyltoluene	C9H18 Alkene 1
Toluene + C8H18	3-Methylpentane
1,2,4-Trimethylbenzene	3-Methylhexane
2,2,4-Trimethylpentane	n-Heptane
O-Xylene	Methylcyclohexane
1,3,5-Trimethylbenzene	c-2-Pentene
Ethylbenzene	5-Ethylcyclopentane
2-Ethyltoluene	C6H12 Alkene 3
2-Methylpentane	2,2,5-Trimethylhexane
2-Methylhexane	1-Pentene
t-2-Butene	t-2-Hexene
2-Methyl-2-Butene	Dimethylcyclopentane
Styrene	2,3-Dimethylhexane
c-2-Butene	Methylheptane
2,4-Dimethylpentane	C6H12 Alkene 5
2,3-Dimethylbutane	C8H14 Cycloalkene
2,3,4-Trimethylpentane	3-Methyl-1-Butene
Dimethylhexane	4-Methyl-1-Pentene
t-2-Pentene	n-Hexane
Benzene	3-Hexene
Dimethylcyclohexane	C9H20 Alkane
2-Methyl-1-Butene	i-Propylbenzene
2-Methyl-1,3-Butadiene	Cyclopentene
C6H12 Alkene 4	C10 Cycloalkane

II.

VEHICLE TEST PROTOCOL

This chapter presents the test protocol used by the ARB in the development of reactivity adjustment factors for low-emission vehicles. The preconditioning cycle and dynamometer test procedures used to identify and measure the hydrocarbon components of exhaust NMOG are included in the discussion.

A. VEHICLE PRECONDITIONING

1. Vehicle Preparation After Changing Fuel Types

When a vehicle operating on one fuel (fuel x) is scheduled to be tested using a different fuel (fuel y), the vehicle must first undergo a preconditioning cycle designed to remove remnants of the original fuel from the vehicle system. The preconditioning cycle also allows the vehicle fuel system to adjust to the new fuel through adaptive learning of the vehicle computer prior to testing. Since adaptive learning is affected by the driving cycle over which a vehicle operates, preconditioning includes both highway and LA-4 cycles. The following preconditioning procedure was used by the ARB between fuel changes during RAF testing.

Step 1 - Drain tank of original fuel (fuel x) and refuel with new fuel (fuel y).

Step 2 - Drive a minimum of 20 miles on the freeway or two highway cycles on the dynamometer (10.2 miles each).

Step 3 - Drain tank (fuel y) and refuel (fuel y).

Step 4 - Drive two LA-4 cycles on the dynamometer.

Step 5 - Cold soak vehicle in accordance with the Federal Test Procedure (FTP) in Title 40 of the Code of Federal Regulations (CFR), Part 86.

2. Vehicle Preparation for Replicate Tests

When replicate tests are to be conducted on a vehicle using the same fuel, the preconditioning procedure used between vehicle tests is not as rigorous since the adaptive learning function has already adjusted for operation on the test fuel. Thus, a shortened version of the vehicle preconditioning procedure is adequate.

Step 1 - Drain tank and refuel with same fuel.

Step 2 - Drive two LA-4 cycles on the dynamometer.

Step 3 - Cold soak vehicle in accordance with the FTP in 40 CFR Part 86.

B. EXHAUST GAS SAMPLING AND ANALYSIS

1. Dynamometer Test Procedures

The procedure outlined in Appendix A-2 describes the method used by the ARB to collect and analyze exhaust emissions from light-duty vehicles to determine NMOG speciation profiles. The procedure is not intended to provide specific details on all tasks required to perform the FTP. Rather, it describes how the ARB performs those functions not explicitly described in the FTP in 40 CFR Part 86.

This procedure references both 40 CFR Part 86, subpart B, as it applies to dynamometer vehicle testing and exhaust sample collection, and the relevant Standard Operating Procedures (SOP) currently used by the ARB to perform speciated hydrocarbon, alcohol, and carbonyl analyses. The format used provides reference to those sections of the CFR outlining the FTP that allow some discretion in the performance of a particular task and provides details as to how that task is performed at the ARB. Those sections of the CFR pertaining to the FTP which contain an adequate description of the required task and need no further clarification to determine how they are performed by the ARB are not referenced in Appendix A-2.

2. Measurement of 1,3-Butadiene

Because of the unstable nature of 1,3-butadiene, it quickly decays within the sample tedlar bags, preventing a reliable measurement using the current speciation procedures. However, it is important to include this compound in the development of RAFs because of its high reactivity. To minimize the degradation of 1,3-butadiene prior to measurement, samples are collected from the individual bags and analyzed using a dedicated gas chromatograph (GC) immediately after completion of each test segment. The ARB is developing a new speciation procedure for low-end hydrocarbons that will provide an accurate measurement of 1,3-butadiene. Staff is planning to modify the LEV/CF regulations in 1992 to require that for the purpose of developing RAFs, manufacturers measure 1,3-butadiene by use of a GC or an equivalent accurate procedure (to be approved by the Executive Officer of the ARB) in the interim, until this new speciation procedure for low-end hydrocarbons has been finalized. The ARB's current method of analyzing for 1,3-butadiene is described in Appendix A-3. (Although measurement of 1,3-butadiene is also possible with Fourier Transform Infra-Red analysis (FTIR), the detection limit for the FTIR is higher than that of the GC. As a result, FTIR is less accurate than the GC for measuring 1,3-butadiene.)

III.

SPECIATED EMISSION RESULTS

This chapter presents the hydrocarbon species profiles used in developing reactivity adjustment factors. The tables that follow are grouped according to fuel type, and a summary of the FTP results for each fuel precedes the species profiles. The tables are numbered according to the following scheme:

Table III-1: FTP Summary for Baseline Gasoline Vehicles
Tables III-1a to s: Speciated Data for Gasoline Tests

Table III-2: FTP Summary for Methanol-Fueled Vehicles
Tables III-2a to i: Speciated Data for Methanol Tests

Table III-3: FTP Summary for Ethanol-Fueled Vehicles
Tables III-3a to e: Speciated Data for Ethanol Tests

Table III-4: FTP Summary for LPG-Fueled Vehicles
Tables III-4a to d: Speciated Data for LPG Tests

Table III-5: FTP Summary for CNG-Fueled Vehicles
Tables III-5a to d: Speciated Data for CNG Tests

A. BASELINE GASOLINE VEHICLES

Data for the baseline gasoline vehicles were collected from late model-year production vehicles that meet TLEV emission standards. The majority of vehicles were tested by the ARB at the Haagen-Smit Laboratory in El Monte, California. In addition, data received from the Chevron Research and Technology Company and test results from the Auto/Oil Air Quality Improvement Research Program were included in developing the baseline ozone/NMOG ratio.

B. METHANOL-FUELED VEHICLES

Data for methanol vehicles were collected from pre-production fuel-flexible vehicles (FFVs). Two vehicles were tested by the ARB, and each was subjected to four emission tests. Auto/Oil data from seven FFVs were also obtained. However, exhaust speciation was only performed on a single test for five of the vehicles, while two vehicles were subjected to duplicate speciation tests (vehicles 03M and 17M).

C. ETHANOL-FUELED VEHICLES

To generate emission profiles for ethanol-fueled vehicles, the ARB conducted emission tests on the fuel-flexible Jetta and Lumina included in the methanol testing. Although these vehicles were designed primarily to operate on methanol/gasoline mixtures, no dedicated ethanol vehicles could be obtained for testing. These data are included here for informational purposes; no RAF for ethanol is being proposed at this time.

D. LPG-FUELED VEHICLES

Two vehicles were tested by the ARB in developing the RAF for LPG. Both vehicles were retrofit conversions of gasoline vehicles; however, these systems are thought to be reasonably representative of the technology that might be available from manufacturers in the next several years.

E. CNG-FUELED VEHICLES

Only a single CNG vehicle (dual-fuel) was obtained by the ARB for RAF testing. As with the LPG vehicles, this was a conventional gasoline vehicle converted to operate on natural gas. A total of eight repeat tests were performed, and results were very consistent among tests. However, results from this series of tests are dramatically different than previous tests conducted by the ARB on the same vehicle. Staff believes that this inconsistency is partially attributable to differing preconditioning procedures between sets of emission tests. (The negligible mid-range species in this series of tests seems to indicate a low hydrocarbon loading of the evaporative canister.) Before the November hearing, additional tests will be performed on this and other CNG vehicles to improve the robustness of the data.

Table III-1

Summary of Test Results for Baseline Gasoline Vehicles

Vehicle	Test #	Species Table #	Test Date	NMOG (g/mi)	CH4 (g/mi)	CO (g/mi)	NOx (g/mi)
Cadillac DeVille	18C3	III-1a	07/17/91	.114	.053	1.91	.373
	18C4	III-1a	07/18/91	.110	.041	1.38	.488
	18C5	III-1b	07/23/91	.141	.046	1.78	.391
	18C6	III-1b	07/24/91	.113	.046	1.34	.503
	18C7	III-1c	07/26/91	.125	.048	2.15	.417
	18C8	III-1c	07/30/91	.120	.044	1.45	.438
			Mean:	.121	.046	1.67	.435
Buick LeSabre	26C1	III-1d	08/01/91	.130	.030	1.82	.379
	26C2	III-1d	08/02/91	.119	.028	1.39	.448
	26C3	III-1e	08/06/91	.117	.030	1.69	.480
	26C5	III-1e	08/09/91	.140	.022	1.35	.386
			Mean:	.127	.028	1.56	.423
Ford Tempo	13C5	III-1f	07/18/91	.076	.036	1.28	.344
	13C6	III-1f	07/19/91	.111	.042	1.74	.385
	13C7	III-1g	07/23/91	.108	.039	1.37	.374
	13C8	III-1g	07/24/91	.119	.039	1.71	.329
			Mean:	.104	.039	1.52	.358
Mercedes 300 E	25C2	III-1h	08/01/91	.108	.035	.78	.076
	25C3	III-1h	08/02/91	.121	.035	.84	.070
	25C4	III-1i	08/06/91	.116	.030	.70	.063
	25C5	III-1i	08/07/91	.075	.031	.62	.083
	25C6	III-1j	08/08/91	.068	.035	.62	.087
			Mean:	.098	.033	.71	.076
Toyota Celica	19C1	III-1k	07/16/91	.113	.020	.91	.167
	19C2	III-1k	07/17/91	.080	.018	.82	.196
	19C3	III-1l	07/18/91	.090	.018	.79	.136
	19C4	III-1l	07/23/91	.093	.019	.85	.126
				.094	.019	.84	.156
Mercury Cougar	27C2	III-1m	08/13/91	.117	.064	2.92	.214
	27C3	III-1m	08/14/91	.125	.070	2.86	.199
	27C4	III-1n	08/15/91	.117	.071	3.14	.197
	27C5	III-1n	08/16/91	.115	.060	2.13	.206
	27C6	III-1o	08/23/91	.123	.056	2.04	.221
	27C7	III-1o	08/28/91	.114	.060	2.48	.258
			Mean:	.119	.064	2.60	.216
Chevrolet Cavalier (Chevron)	50993	III-1p	03/28/91	.072	.021	2.28	.215
	51011	III-1p	04/17/91	.076	.024	2.36	.202
	51114	III-1q	08/07/91	.086	.023	2.25	.194
	51116	III-1q	08/08/91	.087	.026	2.33	.244
	51117	III-1r	08/09/91	.091	.026	2.47	.191
			Mean:	.082	.024	2.34	.209
Shadow Delta (Auto/Oil)	2702AA	III-1s	04/19/90	.103	.026	2.44	.267
	3010AA	III-1s	04/26/90	.095	.022	2.21	.453
			Mean:	.099	.024	2.33	.360

Table III-1a

Speciated FTP Results
Cadillac Deville, RF-A

Light-End Species	mg Ozone/ mg NMOG MIR	MOR	Test 18C3, 7/17/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR	Test 18C4, 7/18/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR
Ethane	.26	.18	6.65	1.73	1.20	4.82	1.25	.87
Ethene	7.28	3.15	11.10	80.78	34.95	9.67	70.40	30.46
Propane	.48	.31	.26	.12	.08	.26	.12	.08
Ethyne	.51	.34	3.74	1.91	1.27	4.84	2.47	1.64
Methylpropane	1.21	.73	1.74	2.11	1.27	.18	.22	.13
Butane	1.02	.66	5.56	5.67	3.67	5.35	5.45	3.53
Propene	9.39	3.77	2.78	26.09	10.47	3.93	36.88	14.81
Methylbutane	1.38	.87	5.41	7.46	4.70	4.14	5.71	3.60
Pentane	1.03	.68	3.83	3.95	2.61	2.96	3.05	2.01
1-Butene	8.90	3.51	.48	4.28	1.69	.49	4.32	1.70
2-Methylpropene	5.29	1.93	2.61	13.81	5.04	.31	1.62	.59
Light-End HC Subtotal			44.15	147.90	66.95	36.93	131.49	59.43

Mid-Range Species	mg Ozone/ mg NMOG MIR	MOR	Test 18C3, 7/17/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR	Test 18C4, 7/18/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR
1,3-butadiene	10.88	4.16	.59	6.37	2.44	.44	4.76	1.82
2-Methyl-1,3-butadiene	9.07	3.41	.21	1.88	.71	.00	.00	.00
t-2-Pentene	8.79	3.30	.17	1.47	.55	.00	.00	.00
2,2-Dimethylbutane	.82	.51	.69	.57	.35	1.19	.97	.61
Cyclopentane	2.37	1.41	.00	.00	.00	1.03	2.43	1.45
2,3-Dimethylbutane	1.07	.67	1.92	2.06	1.29	.18	.20	.12
2-Methylpentane	1.53	.90	4.98	7.62	4.48	6.13	9.38	5.52
C6H12 Alkene 2	5.54	2.12	.00	.00	.00	.27	1.48	.57
3-Methylpentane	1.52	.94	2.71	4.12	2.55	1.43	2.18	1.35
C6H12 Alkene 3	5.54	2.12	.00	.00	.00	.12	.66	.25
n-Hexane	.98	.64	2.59	2.54	1.66	1.56	1.52	1.00
t-2-Hexene	6.67	2.50	.12	.79	.30	.00	.00	.00
c-2-Hexene	6.67	2.50	.16	1.06	.40	.00	.00	.00
C6H12 Alkene 5	5.54	2.12	.12	.66	.25	.00	.00	.00
Methylcyclopentane	2.82	1.55	1.08	3.03	1.67	.66	1.86	1.02
C7H16 Alkane	1.40	.83	1.28	1.79	1.06	1.08	1.51	.89
Benzene	.42	.14	7.80	3.28	1.09	9.33	3.92	1.31
Cyclohexane	1.28	.74	.12	.15	.09	.17	.21	.12
2-Methylhexane +Dimethylpentane	1.40	.83	3.80	5.32	3.16	2.07	2.89	1.72
3-Methylhexane	1.40	.83	1.98	2.77	1.64	1.87	2.62	1.55
2,2,4-Trimethylpentane + Alkene	2.59	1.11	4.38	11.34	4.86	4.21	10.91	4.67
n-Heptane	.81	.53	1.62	1.31	.86	1.62	1.31	.86
Methylcyclohexane	1.84	1.00	.49	.89	.49	.67	1.24	.67
Dimethylhexane	1.20	.70	1.24	1.49	.87	.41	.49	.29
2,3,4-Trimethylpentane	1.20	.70	1.03	1.24	.72	1.03	1.24	.72
Toluene + C8H18	2.72	.63	9.53	25.93	6.01	12.05	32.79	7.59
2,3-Dimethylhexane	1.20	.70	.25	.30	.17	.38	.46	.27
Methylheptane	1.20	.70	1.06	1.27	.74	1.21	1.45	.85
Dimethylcyclohexane	1.94	1.02	1.20	2.34	1.23	.13	.26	.14
2,2,5-Trimethylhexane	1.13	.64	.33	.37	.21	.44	.50	.28
n-Octane	.61	.41	.52	.32	.21	.63	.39	.26
C9H18 Alkene	3.40	1.31	.09	.32	.12	.16	.54	.21
Ethylbenzene	2.90	.72	2.48	7.19	1.78	3.28	9.50	2.36
m & p-Xylenes	7.47	2.24	6.09	45.47	13.64	7.99	59.67	17.89
C9H20 Alkane	1.13	.64	.19	.22	.12	.33	.37	.21
Styrene	2.20	-.29	.58	1.28	-.17	.78	1.71	-.23
o-Xylene	6.68	2.00	2.06	13.79	4.13	2.71	18.08	5.41
n-Nonane	.54	.36	.12	.06	.04	.18	.10	.06
i-Propylbenzene	2.41	.60	.09	.22	.05	.14	.35	.09

Table III-1a (Cont.)

Mid-Range Species (Cont.)	mg Ozone/ mg NMOG MIR	MOR	Test 18C3, 7/17/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR	Test 18C4, 7/18/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR
n-Propylbenzene	2.27	.56	.24	.55	.14	.39	.87	.22
3-Ethyltoluene	7.20	2.17	1.11	7.96	2.40	1.52	10.97	3.31
4-Ethyltoluene + C10cycloalkane	4.49	1.55	.44	1.96	.68	.67	3.00	1.04
1,3,5-Trimethylbenzene	10.11	3.06	.59	5.98	1.81	.00	.00	.00
2-Ethyltoluene	7.20	2.17	.05	.33	.10	.54	3.88	1.17
1,2,4-Trimethylbenzene	8.59	2.51	1.47	12.67	3.70	1.52	13.04	3.81
n-Undecane	.42	.28	.13	.06	.04	.14	.06	.04
Mid-Range HC Subtotal			67.70	190.36	68.64	70.65	209.77	71.48

Oxygenates	mg Ozone/ mg NMOG MIR	MOR	Test 18C3, 7/17/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR	Test 18C4, 7/18/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR
Formaldehyde	7.14	2.08	1.02	7.28	2.12	1.04	7.42	2.16
Acetaldehyde	5.51	2.17	.74	4.10	1.61	.71	3.91	1.54
Acrolein	6.76	2.59	.07	.45	.17	.08	.52	.20
Acetone	.56	.20	.13	.07	.03	.15	.08	.03
Propionaldehyde	6.53	2.50	.21	1.37	.53	.20	1.33	.51
Oxygenates Subtotal			2.17	13.27	4.46	2.18	13.26	4.44

NMOG Summary		Test 18C3, 7/17/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR	Test 18C4, 7/18/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR
Light-End Species		44.15	147.90	66.95	36.93	131.49	59.43
Mid-Range Species		67.70	190.36	68.64	70.65	209.77	71.48
Oxygenates		2.17	13.27	4.46	2.18	13.26	4.44
Total		114.02	351.53	140.05	109.75	354.53	135.34
Ozone/NMOG			3.08	1.23		3.23	1.23

Table III-1b

Speciated FTP Results
Cadillac Deville, RF-A

Light-End Species	mg Ozone/ mg NMOG MIR	mg Ozone/ mg NMOG MOR	Test 18C5, 7/23/91 NMOG (mg/mi)	Test 18C5 Ozone (mg/mi) MIR	Test 18C5 Ozone (mg/mi) MOR	Test 18C6, 7/24/91 NMOG (mg/mi)	Test 18C6 Ozone (mg/mi) MIR	Test 18C6 Ozone (mg/mi) MOR
Ethane	.26	.18	5.82	1.51	1.05	4.80	1.25	.86
Ethene	7.28	3.15	11.80	85.89	37.16	16.68	121.45	52.55
Propane	.48	.31	3.31	1.59	1.03	.12	.06	.04
Ethyne	.51	.34	4.43	2.26	1.51	4.02	2.05	1.37
Methylpropane	1.21	.73	5.60	6.78	4.09	1.40	1.70	1.02
Butane	1.02	.66	4.95	5.04	3.26	2.67	2.72	1.76
Propene	9.39	3.77	9.48	89.01	35.74	2.35	22.07	8.86
Methylbutane	1.38	.87	6.32	8.72	5.50	3.43	4.74	2.99
Pentane	1.03	.68	3.73	3.84	2.53	2.79	2.87	1.90
1-Butene	8.90	3.51	.58	5.18	2.04	.58	5.18	2.04
2-Methylpropene	5.29	1.93	2.51	13.29	4.85	2.15	11.39	4.16
Light-End HC Subtotal			58.54	223.12	98.76	41.01	175.48	77.55

Mid-Range Species	mg Ozone/ mg NMOG MIR	mg Ozone/ mg NMOG MOR	Test 18C5, 7/23/91 NMOG (mg/mi)	Test 18C5 Ozone (mg/mi) MIR	Test 18C5 Ozone (mg/mi) MOR	Test 18C6, 7/24/91 NMOG (mg/mi)	Test 18C6 Ozone (mg/mi) MIR	Test 18C6 Ozone (mg/mi) MOR
1,3-butadiene	10.88	4.16	.51	5.51	2.11	.43	4.67	1.79
t-2-Pentene	8.79	3.30	.19	1.65	.62	.00	.00	.00
2,2-Dimethylbutane	.82	.51	1.01	.83	.51	.00	.00	.00
4-Methyl-1-pentene	4.41	1.74	.25	1.10	.43	.00	.00	.00
2,3-Dimethylbutane	1.07	.67	1.72	1.84	1.15	3.51	3.76	2.35
2-Methylpentane	1.53	.90	5.31	8.12	4.78	8.74	13.37	7.87
3-Methylpentane	1.52	.94	3.07	4.67	2.89	4.62	7.03	4.34
C6H12 Alkene 3	5.54	2.12	.16	.88	.34	.00	.00	.00
n-Hexane	.98	.64	2.93	2.87	1.88	2.49	2.44	1.59
t-2-Hexene	6.67	2.50	.17	1.16	.44	.00	.00	.00
c-2-Hexene	6.67	2.50	.15	1.02	.38	.00	.00	.00
Methylcyclopentane	2.82	1.55	1.05	2.96	1.63	1.34	3.77	2.07
C7H16 Alkane	1.40	.83	1.76	2.46	1.46	1.08	1.51	.90
Benzene	.42	.14	8.21	3.45	1.15	2.00	.84	.28
Cyclohexane	1.28	.74	.15	.19	.11	.00	.00	.00
2-Methylhexane +Dimethylpentane	1.40	.83	4.64	6.49	3.85	.00	.00	.00
3-Methylhexane	1.40	.83	2.36	3.30	1.96	2.51	3.51	2.08
2,2,4-Trimethylpentane + Alkene	2.59	1.11	5.37	13.90	5.96	3.26	8.44	3.62
n-Heptane	.81	.53	2.05	1.66	1.09	.59	.47	.31
Methylcyclohexane	1.84	1.00	.59	1.09	.59	.57	1.04	.57
Dimethylhexane	1.20	.70	1.44	1.73	1.01	1.90	2.28	1.33
2,3,4-Trimethylpentane	1.20	.70	1.25	1.50	.87	.58	.69	.40
Toluene + C8H18	2.72	.63	11.47	31.19	7.22	12.14	33.01	7.65
2,3-Dimethylhexane	1.20	.70	.42	.50	.29	1.46	1.75	1.02
Methylheptane	1.20	.70	.87	1.05	.61	.72	.86	.50
Dimethylcyclohexane	1.94	1.02	1.13	2.19	1.15	.73	1.41	.74
2,2,5-Trimethylhexane	1.13	.64	.48	.54	.30	.00	.00	.00
n-Octane	.61	.41	.67	.41	.28	.43	.26	.18
C9H18 Alkene	3.40	1.31	.12	.40	.15	.00	.00	.00
Ethylbenzene	2.90	.72	3.21	9.30	2.31	1.00	2.91	.72
m & p-Xylenes	7.47	2.24	7.59	56.70	17.00	9.35	69.88	20.95
C9H20 Alkane	1.13	.64	.28	.32	.18	.30	.34	.19
Styrene	2.20	-.29	.52	1.15	-.15	.30	.66	-.09
o-Xylene	6.68	2.00	2.53	16.92	5.06	.89	5.97	1.79
n-Nonane	.54	.36	.14	.07	.05	2.54	1.37	.91
i-Propylbenzene	2.41	.60	.10	.25	.06	.00	.00	.00
n-Propylbenzene	2.27	.56	.31	.70	.17	.38	.87	.21
3-Ethyltoluene	7.20	2.17	1.84	13.23	3.99	2.89	20.81	6.27
4-Ethyltoluene + C10cycloalkane	4.49	1.55	.56	2.52	.87	.00	.00	.00
1,3,5-Trimethylbenzene	10.11	3.06	.72	7.23	2.19	.92	9.29	2.81

Table III-1b (Cont.)

Mid-Range Species (Cont.)	mg Ozone/ mg NMOG MIR	MOR	Test 18C5, 7/23/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR	Test 18C6, 7/24/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR
2-Ethyltoluene	7.20	2.17	.05	.37	.11	.58	4.16	1.25
1,2,4-Trimethylbenzene	8.59	2.51	2.04	17.53	5.12	2.85	24.50	7.16
n-Undecane	.42	.28	.16	.07	.04	.00	.00	.00
Mid-Range HC Subtotal			79.53	231.02	82.22	71.09	231.89	81.79

Oxygenates	mg Ozone/ mg NMOG MIR	MOR	Test 18C5, 7/23/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR	Test 18C6, 7/24/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR
Formaldehyde	7.14	2.08	2.07	14.75	4.30	.79	5.67	1.65
Acetaldehyde	5.51	2.17	.89	4.93	1.94	.36	2.00	.79
Acrolein	6.76	2.59	.10	.67	.26	.07	.44	.17
Oxygenates Subtotal			3.06	20.35	6.49	1.22	8.12	2.61

NMOG Summary		Test 18C5, 7/23/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR	Test 18C6, 7/24/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR
Light-End Species		58.54	223.12	98.76	41.01	175.48	77.55
Mid-Range Species		79.53	231.02	82.22	71.09	231.89	81.79
Oxygenates		3.06	20.35	6.49	1.22	8.12	2.61
Total		141.12	474.48	187.47	113.33	415.49	161.95
Ozone/NMOG			3.36	1.33		3.67	1.43

Table III-1c

Speciated FTP Results
Cadillac Deville, RF-A

Light-End Species	mg Ozone/ mg NMOG MIR	MOR	Test 18C7, 7/26/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR	Test 18C8, 7/30/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR
Ethane	.26	.18	7.15	1.86	1.29	4.28	1.11	.77
Ethene	7.28	3.15	12.53	91.21	39.46	14.34	104.37	45.16
Propane	.48	.31	.32	.15	.10	2.23	1.07	.69
Ethyne	.51	.34	5.43	2.77	1.85	5.46	2.78	1.86
Methylpropane	1.21	.73	5.19	6.28	3.79	1.54	1.86	1.12
Butane	1.02	.66	5.67	5.79	3.74	4.52	4.62	2.99
Propene	9.39	3.77	.63	5.87	2.36	3.30	30.98	12.44
Methylbutane	1.38	.87	5.77	7.96	5.02	4.80	6.63	4.18
Pentane	1.03	.68	3.81	3.93	2.59	3.59	3.69	2.44
1-Butene	8.90	3.51	.22	1.92	.76	.45	4.00	1.58
2-Methylpropene	5.29	1.93	3.61	19.12	6.98	2.58	13.64	4.98
Light-End HC Subtotal			50.33	146.86	67.93	47.08	174.75	78.20

Mid-Range Species	mg Ozone/ mg NMOG MIR	MOR	Test 18C7, 7/26/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR	Test 18C8, 7/30/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR
1,3-butadiene	10.88	4.16	.56	6.09	2.33	.39	4.28	1.64
t-2-Pentene	8.79	3.30	.27	2.35	.88	.20	1.72	.64
2,2-Dimethylbutane	.82	.51	.68	.56	.35	.77	.63	.39
2,3-Dimethylbutane	1.07	.67	1.48	1.59	.99	1.18	1.26	.79
2-Methylpentane	1.53	.90	4.99	7.64	4.49	4.37	6.69	3.94
C6H12 Alkene 2	5.54	2.12	.16	.87	.33	.17	.92	.35
3-Methylpentane	1.52	.94	2.73	4.15	2.57	2.52	3.82	2.36
C6H12 Alkene 3	5.54	2.12	.13	.70	.27	.12	.68	.26
n-Hexane	.98	.64	3.01	2.95	1.93	2.66	2.61	1.70
c-2-Hexene	6.67	2.50	.20	1.30	.49	.17	1.16	.43
Methylcyclopentane	2.82	1.55	.89	2.50	1.37	.75	2.11	1.16
C7H16 Alkane	1.40	.83	.96	1.34	.80	1.84	2.57	1.52
Benzene	.42	.14	8.55	3.59	1.20	7.52	3.16	1.05
Cyclohexane	1.28	.74	.12	.15	.09	.08	.11	.06
2-Methylhexane +Dimethylpentane	1.40	.83	3.83	5.36	3.18	4.21	5.90	3.49
3-Methylhexane	1.40	.83	2.02	2.82	1.67	2.11	2.95	1.75
2,2,4-Trimethylpentane + Alkene	2.59	1.11	4.64	12.02	5.15	5.08	13.16	5.64
n-Heptane	.81	.53	1.66	1.35	.88	1.82	1.47	.96
Methylcyclohexane	1.84	1.00	.54	.98	.54	.51	.94	.51
Dimethylhexane	1.20	.70	1.23	1.47	.86	1.17	1.41	.82
2,3,4-Trimethylpentane	1.20	.70	.75	.90	.52	1.15	1.39	.81
Toluene + C8H18	2.72	.63	10.64	28.94	6.70	10.87	29.55	6.85
2,3-Dimethylhexane	1.20	.70	.26	.31	.18	.25	.30	.18
Methylheptane	1.20	.70	.81	.98	.57	.78	.94	.55
Dimethylcyclohexane	1.94	1.02	.99	1.93	1.01	.90	1.75	.92
2,2,5-Trimethylhexane	1.13	.64	.35	.40	.23	.33	.37	.21
n-Octane	.61	.41	.59	.36	.24	.41	.25	.17
C9H18 Alkene	3.40	1.31	.11	.38	.15	.19	.64	.25
Ethylbenzene	2.90	.72	3.02	8.75	2.17	2.74	7.95	1.97
m & p-Xylenes	7.47	2.24	7.08	52.87	15.86	6.89	51.47	15.44
C9H20 Alkane	1.13	.64	.43	.49	.28	.25	.29	.16
Styrene	2.20	-.29	.62	1.36	-.18	.71	1.57	-.21
o-Xylene	6.68	2.00	2.42	16.18	4.84	2.24	14.99	4.49
n-Nonane	.54	.36	.11	.06	.04	.12	.07	.04
i-Propylbenzene	2.41	.60	.10	.25	.06	.09	.22	.06
n-Propylbenzene	2.27	.56	.31	.69	.17	.24	.54	.13
3-Ethyltoluene	7.20	2.17	1.82	13.12	3.95	1.46	10.55	3.18
4-Ethyltoluene + C10cycloalkane	4.49	1.55	.51	2.29	.79	.43	1.94	.67
1,3,5-Trimethylbenzene	10.11	3.06	.71	7.21	2.18	.56	5.67	1.71

Table III-1c (Cont.)

Mid-Range Species	mg Ozone/ mg NMOG MIR	MOR	Test 18C7, 7/26/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR	Test 18C8, 7/30/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR
2-Ethyltoluene	7.20	2.17	.38	2.75	.83	.28	2.02	.61
1,2,4-Trimethylbenzene	8.59	2.51	1.86	15.96	4.66	1.74	14.96	4.37
n-Undecane	.42	.28	.16	.07	.05	.13	.05	.04
Mid-Range HC Subtotal			72.68	216.04	75.67	70.41	205.01	72.07

Oxygenates	mg Ozone/ mg NMOG MIR	MOR	Test 18C7, 7/26/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR	Test 18C8, 7/30/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR
Formaldehyde	7.14	2.08	1.13	8.08	2.35	1.52	10.87	3.17
Acetaldehyde	5.51	2.17	.81	4.46	1.76	.72	3.99	1.57
Acrolein	6.76	2.59	.06	.41	.16	.05	.33	.13
Oxygenates Subtotal			2.00	12.95	4.27	2.30	15.19	4.86

NMOG Summary		Test 18C7, 7/26/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR	Test 18C8, 7/30/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR
Light-End Species		50.33	146.86	67.93	47.08	174.75	78.20
Mid-Range Species		72.68	216.04	75.67	70.41	205.01	72.07
Oxygenates		2.00	12.95	4.27	2.30	15.19	4.86
Total		125.01	375.84	147.87	119.79	394.95	155.13
Ozone/NMOG			3.01	1.18		3.30	1.30

Table III-1d

Speciated FTP Results
Buick LeSabre, RF-A

Light-End Species	mg Ozone/ mg NMOG MIR	mg Ozone/ mg NMOG MOR	Test 26C1, 8/01/91 NMOG (mg/mi)	Test 26C1 Ozone (mg/mi) MIR	Test 26C1 Ozone (mg/mi) MOR	Test 26C2, 8/02/91 NMOG (mg/mi)	Test 26C2 Ozone (mg/mi) MIR	Test 26C2 Ozone (mg/mi) MOR
Ethane	.26	.18	2.82	.73	.51	2.95	.77	.53
Ethene	7.28	3.15	9.12	66.42	28.74	9.24	67.23	29.09
Propane	.48	.31	.06	.03	.02	.07	.03	.02
Ethyne	.51	.34	4.30	2.19	1.46	4.12	2.10	1.40
Methylpropane	1.21	.73	.06	.07	.04	.31	.37	.22
Butane	1.02	.66	5.28	5.38	3.48	5.15	5.26	3.40
Propene	9.39	3.77	4.79	44.94	18.04	4.85	45.59	18.30
Methylbutane	1.38	.87	4.05	5.59	3.52	4.36	6.02	3.80
Pentane	1.03	.68	2.98	3.07	2.03	3.28	3.38	2.23
1-Butene	8.90	3.51	.89	7.93	3.13	.74	6.56	2.59
2-Methylpropene	5.29	1.93	2.84	15.02	5.48	3.36	17.78	6.49
Light-End HC Subtotal			37.18	151.37	66.45	38.43	155.09	68.07

Mid-Range Species	mg Ozone/ mg NMOG MIR	mg Ozone/ mg NMOG MOR	Test 26C1, 8/01/91 NMOG (mg/mi)	Test 26C1 Ozone (mg/mi) MIR	Test 26C1 Ozone (mg/mi) MOR	Test 26C2, 8/02/91 NMOG (mg/mi)	Test 26C2 Ozone (mg/mi) MIR	Test 26C2 Ozone (mg/mi) MOR
1,3-butadiene	10.88	4.16	.61	6.63	2.53	.71	7.71	2.95
2,2-Dimethylbutane	.82	.51	.00	.00	.00	.54	.45	.28
Cyclopentene	7.65	2.78	.00	.00	.00	1.20	9.15	3.33
~~C6H12 Alkene 1~~	~~5.54~~	~~2.12~~	~~.75~~	~~4.13~~	~~1.58~~	~~.00~~	~~.00~~	~~.00~~
2-Methylpentane	1.53	.90	1.24	1.89	1.11	.00	.00	.00
3-Methylpentane	1.52	.94	.95	1.44	.89	.76	1.16	.72
n-Hexane	.98	.64	1.37	1.35	.88	1.42	1.39	.91
Methylcyclopentane	2.82	1.55	.29	.81	.45	.85	2.39	1.31
C7H16 Alkane	1.40	.83	.96	1.35	.80	1.09	1.53	.90
Benzene	.42	.14	7.97	3.35	1.12	4.77	2.00	.67
Cyclohexane	1.28	.74	4.25	5.45	3.15	2.24	2.87	1.66
2-Methylhexane +Dimethylpentane	1.40	.83	2.31	3.24	1.92	3.34	4.67	2.77
3-Methylhexane	1.40	.83	.65	.91	.54	1.71	2.39	1.42
2,2,4-Trimethylpentane + Alkene	2.59	1.11	8.00	20.72	8.88	6.31	16.35	7.01
n-Heptane	.81	.53	1.76	1.42	.93	1.55	1.25	.82
Methylcyclohexane	1.84	1.00	.92	1.70	.92	.51	.94	.51
Dimethylhexane	1.20	.70	1.57	1.89	1.10	.93	1.11	.65
2,3,4-Trimethylpentane	1.20	.70	.31	.37	.22	1.04	1.25	.73
Toluene + C8H18	2.72	.63	18.57	50.50	11.70	14.55	39.57	9.16
2,3-Dimethylhexane	1.20	.70	.00	.00	.00	.35	.43	.25
Methylheptane	1.20	.70	.39	.47	.28	1.33	1.60	.93
Dimethylcyclohexane	1.94	1.02	1.38	2.68	1.41	1.37	2.66	1.40
2,2,5-Trimethylhexane	1.13	.64	.30	.34	.19	.22	.25	.14
n-Octane	.61	.41	.82	.50	.34	.49	.30	.20
Ethylbenzene	2.90	.72	4.77	13.83	3.43	4.72	13.68	3.40
m & p-Xylenes	7.47	2.24	13.34	99.62	29.87	7.95	59.35	17.80
C9H20 Alkane	1.13	.64	.00	.00	.00	4.35	4.92	2.79
Styrene	2.20	-.29	.25	.55	-.07	.55	1.20	-.16
o-Xylene	6.68	2.00	4.00	26.72	8.00	3.57	23.84	7.14
n-Nonane	.54	.36	.19	.10	.07	.00	.00	.00
n-Propylbenzene	2.27	.56	.64	1.45	.36	.38	.87	.21
3-Ethyltoluene	7.20	2.17	1.86	13.41	4.04	2.78	19.98	6.02
4-Ethyltoluene + C10cycloalkane	4.49	1.55	1.41	6.31	2.18	.00	.00	.00
1,3,5-Trimethylbenzene	10.11	3.06	1.41	14.21	4.30	1.75	17.74	5.37
2-Ethyltoluene	7.20	2.17	.89	6.44	1.94	.54	3.85	1.16
1,2,4-Trimethylbenzene	8.59	2.51	4.12	35.37	10.33	2.62	22.46	6.56
n-Decane	.47	.31	.00	.00	.00	.97	.46	.30
Mid-Range HC Subtotal			88.24	329.14	105.39	77.44	269.76	89.30

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Table III-1g (Cont.)

Mid-Range Species (Cont.)	mg Ozone/ mg NMOG MIR	MOR	Test 13C7, 7/23/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR	Test 13C8, 7/24/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR
n-Nonane	.54	.36	.18	.10	.06	.21	.12	.08
i-Propylbenzene	2.41	.60	.18	.42	.11	.00	.00	.00
n-Propylbenzene	2.27	.56	.54	1.22	.30	.18	.41	.10
3-Ethyltoluene	7.20	2.17	3.14	22.64	6.82	4.60	33.15	9.99
4-Ethyltoluene + C10cycloalkane	4.49	1.55	1.46	6.55	2.26	.00	.00	.00
1,3,5-Trimethylbenzene	10.11	3.06	.00	.00	.00	1.63	16.50	4.99
2-Ethyltoluene	7.20	2.17	.84	6.07	1.83	.00	.00	.00
1,2,4-Trimethylbenzene	8.59	2.51	4.24	36.45	10.65	4.91	42.19	12.33
n-Decane	.47	.31	.00	.00	.00	1.11	.52	.35
n-Undecane	.42	.28	.16	.07	.05	.13	.05	.04
Mid-Range HC Subtotal			77.63	297.81	96.95	86.12	339.93	109.51

Oxygenates	mg Ozone/ mg NMOG MIR	MOR	Test 13C7, 7/23/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR	Test 13C8, 7/24/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR
Formaldehyde	7.14	2.08	1.02	7.28	2.12	.82	5.88	1.71
Acetaldehyde	5.51	2.17	.74	4.10	1.61	.75	4.12	1.62
Acrolein	6.76	2.59	.07	.45	.17	.04	.30	.11
Acetone	.56	.20	.13	.07	.03	.00	.00	.00
Propionaldehyde	6.53	2.50	.21	1.37	.53	.00	.00	.00
Oxygenates Subtotal			2.17	13.27	4.46	1.61	10.29	3.45

NMOG Summary		Test 13C7, 7/23/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR	Test 13C8, 7/24/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR
Light-End Species		27.99	117.46	51.20	31.56	121.89	53.87
Mid-Range Species		77.63	297.81	96.95	86.12	339.93	109.51
Oxygenates		2.17	13.27	4.46	1.61	10.29	3.45
Total		107.78	428.53	152.60	119.30	472.11	166.83
Ozone/NMOG			3.98	1.42		3.96	1.40

Table III-1h

Speciated FTP Results
Mercedes 300E, RF-A

Light-End Species	mg Ozone/ mg NMOG		Test 25C2, 8/01/91			Test 25C3, 8/02/91		
	MIR	MOR	NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR	NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR
Ethane	.26	.18	3.96	1.03	.71	3.45	.90	.62
Ethene	7.28	3.15	6.08	44.24	19.14	7.58	55.22	23.89
Propane	.48	.31	.11	.05	.03	.02	.01	.01
Ethyne	.51	.34	2.45	1.25	.83	2.27	1.16	.77
Methylpropane	1.21	.73	.26	.32	.19	.32	.39	.23
Butane	1.02	.66	4.70	4.79	3.10	5.00	5.10	3.30
Propene	9.39	3.77	2.92	27.41	11.01	3.11	29.19	11.72
Methylbutane	1.38	.87	4.48	6.19	3.90	4.28	5.91	3.73
Pentane	1.03	.68	3.28	3.38	2.23	3.24	3.33	2.20
1-Butene	8.90	3.51	.54	4.83	1.90	.53	4.73	1.87
2-Methylpropene	5.29	1.93	1.84	9.71	3.54	2.02	10.71	3.91
Light-End HC Subtotal			30.62	103.21	46.60	31.84	116.65	52.25

Mid-Range Species	mg Ozone/ mg NMOG		Test 25C2, 8/01/91			Test 25C3, 8/02/91		
	MIR	MOR	NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR	NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR
1,3-butadiene	10.88	4.16	.33	3.61	1.38	.30	3.21	1.23
2,2-Dimethylbutane	.82	.51	.00	.00	.00	.76	.63	.39
4-Methyl-1-pentene	4.41	1.74	.00	.00	.00	.21	.94	.37
2,3-Dimethylbutane	1.07	.67	.00	.00	.00	2.26	2.41	1.51
2-Methylpentane	1.53	.90	.00	.00	.00	5.30	8.11	4.77
C6H12 Alkene 2	5.54	2.12	.00	.00	.00	.15	.84	.32
3-Methylpentane	1.52	.94	1.62	2.46	1.52	2.56	3.90	2.41
C6H12 Alkene 3	5.54	2.12	.00	.00	.00	.10	.56	.21
n-Hexane	.98	.64	1.44	1.41	.92	2.68	2.63	1.72
c-2-Hexene	6.67	2.50	.00	.00	.00	.15	1.01	.38
Methylcyclopentane	2.82	1.55	.00	.00	.00	1.22	3.45	1.89
2,4-Dimethylpentane	1.78	.99	.00	.00	.00	.10	.17	.10
C7H16 Alkane	1.40	.83	1.42	1.99	1.18	1.28	1.79	1.06
Benzene	.42	.14	4.97	2.09	.70	6.08	2.55	.85
Cyclohexane	1.28	.74	4.29	5.49	3.17	.08	.11	.06
2-Methylhexane +Dimethylpentane	1.40	.83	2.29	3.20	1.90	4.69	6.56	3.89
3-Methylhexane	1.40	.83	2.85	3.99	2.37	2.22	3.11	1.85
2,2,4-Trimethylpentane + Alkene	2.59	1.11	7.42	19.21	8.23	7.32	18.97	8.13
n-Heptane	.81	.53	2.16	1.75	1.15	2.27	1.84	1.20
Methylcyclohexane	1.84	1.00	.62	1.13	.62	1.05	1.92	1.05
Dimethylhexane	1.20	.70	1.82	2.18	1.27	2.70	3.24	1.89
2,3,4-Trimethylpentane	1.20	.70	2.71	3.25	1.90	2.09	2.50	1.46
Toluene + C8H18	2.72	.63	12.65	34.42	7.97	11.52	31.34	7.26
2,3-Dimethylhexane	1.20	.70	.41	.49	.29	.96	1.15	.67
Methylheptane	1.20	.70	.98	1.18	.69	1.66	1.99	1.16
Dimethylcyclohexane	1.94	1.02	1.49	2.88	1.52	1.71	3.31	1.74
2,2,5-Trimethylhexane	1.13	.64	.27	.31	.17	.39	.44	.25
n-Octane	.61	.41	.57	.35	.23	.96	.59	.39
C9H18 Alkene	3.40	1.31	.48	1.64	.63	.11	.38	.15
Ethylbenzene	2.90	.72	3.23	9.37	2.33	2.78	8.06	2.00
m & p-Xylenes	7.47	2.24	8.61	64.30	19.28	8.33	62.23	18.66
C9H20 Alkane	1.13	.64	1.56	1.76	1.00	.92	1.03	.59
Styrene	2.20	-.29	.42	.93	-.12	.49	1.09	-.14
o-Xylene	6.68	2.00	2.43	16.23	4.86	3.01	20.12	6.02
n-Nonane	.54	.36	.31	.17	.11	.13	.07	.05
i-Propylbenzene	2.41	.60	.00	.00	.00	.09	.23	.06
n-Propylbenzene	2.27	.56	.25	.57	.14	.25	.57	.14
3-Ethyltoluene	7.20	2.17	3.21	23.12	6.97	1.91	13.77	4.15
4-Ethyltoluene + C10cycloalkane	4.49	1.55	.64	2.86	.99	.52	2.34	.81
1,3,5-Trimethylbenzene	10.11	3.06	.00	.00	.00	.70	7.10	2.15

Table III-1h (Cont.)

Mid-Range Species (Cont.)	mg Ozone/ mg NMOG MIR	MOR	Test 25C2, 8/01/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR	Test 25C3, 8/02/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR
2-Ethyltoluene	7.20	2.17	.38	2.75	.83	.28	2.01	.60
1,2,4-Trimethylbenzene	8.59	2.51	1.55	13.34	3.90	1.88	16.19	4.73
n-Undecane	.42	.28	.00	.00	.00	.13	.05	.04
Mid-Range HC Subtotal			73.38	228.43	78.08	84.33	244.54	88.22

Oxygenates	mg Ozone/ mg NMOG MIR	MOR	Test 25C2, 8/01/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR	Test 25C3, 8/02/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR
Formaldehyde	7.14	2.08	.42	3.00	.87	1.13	8.03	2.34
Acetaldehyde	5.51	2.17	.95	5.25	2.07	1.13	6.22	2.45
Acrolein	6.76	2.59	.16	1.10	.42	.18	1.21	.47
Acetone	.56	.20	2.26	1.27	.45	1.94	1.09	.39
Propionaldehyde	6.53	2.50	.35	2.31	.88	.33	2.17	.83
Butylaldehyde	5.26	2.01	.10	.54	.21	.12	.63	.24
Oxygenates Subtotal			4.25	13.47	4.91	4.82	19.35	6.71

NMOG Summary		Test 25C2, 8/01/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR	Test 25C3, 8/02/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR
Light-End Species		30.62	103.21	46.60	31.84	116.65	52.25
Mid-Range Species		73.38	228.43	78.08	84.33	244.54	88.22
Oxygenates		4.25	13.47	4.91	4.82	19.35	6.71
Total		108.26	345.11	129.59	120.99	380.54	147.19
Ozone/NMOG			3.19	1.20		3.15	1.22

Table III-1i

Speciated FTP Results
Mercedes 300E, RF-A

Light-End Species	mg Ozone/ mg NMOG MIR	MOR	Test 25C4, 8/06/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR	Test 25C5, 8/07/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR
Ethane	.26	.18	3.21	.83	.58	2.37	.62	.43
Ethene	7.28	3.15	6.18	44.96	19.45	6.77	49.25	21.31
Propane	.48	.31	.56	.27	.17	.09	.04	.03
Ethyne	.51	.34	2.82	1.44	.96	2.09	1.06	.71
Methylpropane	1.21	.73	.45	.54	.33	.31	.38	.23
Butane	1.02	.66	4.65	4.75	3.07	4.19	4.28	2.77
Propene	9.39	3.77	2.66	24.95	10.02	2.66	24.95	10.02
Methylbutane	1.38	.87	3.97	5.48	3.45	4.01	5.53	3.49
Pentane	1.03	.68	2.90	2.99	1.98	2.81	2.89	1.91
1-Butene	8.90	3.51	.52	4.66	1.84	.58	5.19	2.05
2-Methylpropene	5.29	1.93	2.07	10.97	4.00	2.06	10.89	3.97
Light-End HC Subtotal			29.99	101.84	45.85	27.94	105.09	46.91

Mid-Range Species	mg Ozone/ mg NMOG MIR	MOR	Test 25C4, 8/06/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR	Test 25C5, 8/07/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR
1,3-butadiene	10.88	4.16	.50	5.39	2.06	.45	4.88	1.87
t-2-Pentene	8.79	3.30	.00	.00	.00	.17	1.51	.57
2,2-Dimethylbutane	.82	.51	.00	.00	.00	.66	.54	.34
Cyclopentene	7.65	2.78	3.06	23.39	8.50	.00	.00	.00
4-Methyl-1-pentene	4.41	1.74	.20	.86	.34	.19	.85	.34
2,3-Dimethylbutane	1.07	.67	.00	.00	.00	1.20	1.28	.80
2-Methylpentane	1.53	.90	.00	.00	.00	3.38	5.17	3.04
C6H12 Alkene 2	5.54	2.12	.00	.00	.00	.13	.70	.27
3-Methylpentane	1.52	.94	.00	.00	.00	1.59	2.42	1.49
C6H12 Alkene 3	5.54	2.12	.15	.83	.32	.08	.43	.17
n-Hexane	.98	.64	4.02	3.93	2.57	1.98	1.94	1.27
c-2-Hexene	6.67	2.50	.00	.00	.00	.14	.92	.34
Methylcyclopentane	2.82	1.55	1.09	3.06	1.68	.61	1.73	.95
C7H16 Alkane	1.40	.83	1.36	1.91	1.13	.67	.94	.56
Benzene	.42	.14	8.61	3.61	1.20	3.60	1.51	.50
Cyclohexane	1.28	.74	.00	.00	.00	.06	.08	.05
2-Methylhexane +Dimethylpentane	1.40	.83	5.45	7.63	4.52	1.93	2.70	1.60
3-Methylhexane	1.40	.83	2.65	3.70	2.20	.97	1.36	.81
2,2,4-Trimethylpentane + Alkene	2.59	1.11	7.47	19.34	8.29	2.96	7.68	3.29
n-Heptane	.81	.53	1.66	1.35	.88	.82	.66	.43
Methylcyclohexane	1.84	1.00	.59	1.08	.59	.35	.64	.35
Dimethylhexane	1.20	.70	1.09	1.31	.76	.80	.96	.56
2,3,4-Trimethylpentane	1.20	.70	1.14	1.37	.80	.55	.66	.38
Toluene + C8H18	2.72	.63	13.55	36.86	8.54	4.51	12.27	2.84
2,3-Dimethylhexane	1.20	.70	.21	.26	.15	.25	.31	.18
Methylheptane	1.20	.70	1.47	1.76	1.03	.56	.68	.40
Dimethylcyclohexane	1.94	1.02	1.44	2.80	1.47	.67	1.30	.68
2,2,5-Trimethylhexane	1.13	.64	.27	.31	.17	.21	.24	.14
n-Octane	.61	.41	.52	.32	.21	.30	.18	.12
C9H18 Alkene	3.40	1.31	.00	.00	.00	.06	.20	.08
Ethylbenzene	2.90	.72	4.48	12.99	3.22	1.65	4.77	1.19
m & p-Xylenes	7.47	2.24	9.81	73.29	21.98	4.70	35.08	10.52
C9H20 Alkane	1.13	.64	.00	.00	.00	.16	.18	.10
Styrene	2.20	-.29	.67	1.48	-.19	.00	.00	.00
o-Xylene	6.68	2.00	3.60	24.04	7.20	1.33	8.87	2.65
n-Nonane	.54	.36	.00	.00	.00	.09	.05	.03
i-Propylbenzene	2.41	.60	.00	.00	.00	.07	.16	.04
n-Propylbenzene	2.27	.56	.51	1.16	.29	.19	.42	.10
3-Ethyltoluene	7.20	2.17	2.65	19.08	5.75	.94	6.78	2.04
4-Ethyltoluene + C10cycloalkane	4.49	1.55	.00	.00	.00	.33	1.50	.52

Table III-1i (Cont.)

Mid-Range Species (Cont.)	mg Ozone/ mg NMOG MIR	MOR	Test 25C4, 8/06/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR	Test 25C5, 8/07/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR
1,3,5-Trimethylbenzene	10.11	3.06	1.05	10.58	3.20	.44	4.40	1.33
2-Ethyltoluene	7.20	2.17	.00	.00	.00	.20	1.42	.43
1,2,4-Trimethylbenzene	8.59	2.51	2.74	23.56	6.88	1.36	11.66	3.41
n-Undecane	.42	.28	.00	.00	.00	.11	.05	.03
Mid-Range HC Subtotal			81.99	287.23	95.74	41.41	130.09	46.81

Oxygenates	mg Ozone/ mg NMOG MIR	MOR	Test 25C4, 8/06/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR	Test 25C5, 8/07/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR
Formaldehyde	7.14	2.08	.85	6.05	1.76	1.45	10.36	3.02
Acetaldehyde	5.51	2.17	1.10	6.07	2.39	1.19	6.57	2.59
Acrolein	6.76	2.59	.19	1.30	.50	.18	1.22	.47
Acetone	.56	.20	1.64	.92	.33	2.17	1.22	.43
Propionaldehyde	6.53	2.50	.28	1.82	.70	.32	2.11	.81
Butylaldehyde	5.26	2.01	.09	.49	.19	.10	.55	.21
Benzylaldehyde	-.56	-1.23	.11	-.06	-.13	.00	.00	.00
Oxygenates Subtotal			4.27	16.60	5.73	5.43	22.04	7.53

NMOG Summary		Test 25C4, 8/06/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR	Test 25C5, 8/07/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR
Light-End Species		29.99	101.84	45.85	27.94	105.09	46.91
Mid-Range Species		81.99	287.23	95.74	41.41	130.09	46.81
Oxygenates		4.27	16.60	5.73	5.43	22.04	7.53
Total		116.25	405.66	147.32	74.78	257.22	101.24
Ozone/NMOG			3.49	1.27		3.44	1.35

Table III-1j

Speciated FTP Results
Mercedes 300E, RF-A

Light-End Species	mg Ozone/ mg NMOG MIR	MOR	Test 13C6, 8/08/91 NMOG (mg/mi)	Ozone (mg/mi MIR	MOR
Ethane	.26	.18	3.38	.88	.61
Ethene	7.28	3.15	6.15	44.76	19.37
Propane	.48	.31	.13	.06	.04
Ethyne	.51	.34	2.07	1.05	.70
Methylpropane	1.21	.73	.24	.29	.17
Butane	1.02	.66	3.83	3.91	2.53
Propene	9.39	3.77	2.61	24.55	9.86
Methylbutane	1.38	.87	4.48	6.18	3.89
Pentane	1.03	.68	2.59	2.67	1.76
1-Butene	8.90	3.51	.53	4.72	1.86
2-Methylpropene	5.29	1.93	1.91	10.12	3.69
Light-End HC Subtotal			27.92	99.19	44.49

Mid-Range Species	mg Ozone/ mg NMOG MIR	MOR	Test 13C6, 8/08/91 NMOG (mg/mi)	Ozone (mg/mi MIR	MOR
1,3-butadiene	10.88	4.16	.21	2.31	.88
2,2-Dimethylbutane	.82	.51	.73	.60	.37
4-Methyl-1-pentene	4.41	1.74	.10	.42	.17
2,3-Dimethylbutane	1.07	.67	1.11	1.19	.74
2-Methylpentane	1.53	.90	3.11	4.76	2.80
C6H12 Alkene 2	5.54	2.12	.11	.61	.23
3-Methylpentane	1.52	.94	1.64	2.49	1.54
C6H12 Alkene 3	5.54	2.12	.07	.40	.15
n-Hexane	.98	.64	1.57	1.54	1.01
Methylcyclopentane	2.82	1.55	.45	1.26	.69
C7H16 Alkane	1.40	.83	.63	.88	.52
Benzene	.42	.14	3.19	1.34	.45
2-Methylhexane +Dimethylpentane	1.40	.83	2.42	3.39	2.01
3-Methylhexane	1.40	.83	1.25	1.75	1.04
2,2,4-Trimethylpentane + Alkene	2.59	1.11	2.50	6.47	2.77
n-Heptane	.81	.53	.81	.66	.43
Methylcyclohexane	1.84	1.00	.32	.59	.32
Dimethylhexane	1.20	.70	.78	.93	.54
2,3,4-Trimethylpentane	1.20	.70	.54	.64	.38
Toluene + C8H18	2.72	.63	4.04	10.99	2.55
2,3-Dimethylhexane	1.20	.70	.22	.26	.15
Methylheptane	1.20	.70	.53	.64	.37
Dimethylcyclohexane	1.94	1.02	.63	1.23	.64
2,2,5-Trimethylhexane	1.13	.64	.17	.20	.11
n-Octane	.61	.41	.36	.22	.15
Ethylbenzene	2.90	.72	.81	2.36	.59
m & p-Xylenes	7.47	2.24	4.00	29.85	8.95
C9H20 Alkane	1.13	.64	.13	.14	.08
Styrene	2.20	-.29	.27	.60	-.08
Trimethylheptane	1.01	.56	.00	.00	.00
o-Xylene	6.68	2.00	1.08	7.21	2.16
n-Nonane	.54	.36	.07	.04	.03
i-Propylbenzene	2.41	.60	.05	.13	.03
n-Propylbenzene	2.27	.56	.16	.37	.09
3-Ethyltoluene	7.20	2.17	.77	5.56	1.67
4-Ethyltoluene + C10cycloalkane	4.49	1.55	.30	1.36	.47
1,3,5-Trimethylbenzene	10.11	3.06	.41	4.17	1.26

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Table III-1j (Cont.)

Mid-Range Species (Cont.)	mg Ozone/ mg NMOG MIR	MOR	Test 13C6, 8/08/91 NMOG (mg/mi)	Ozone (mg/mi MIR	MOR
2-Ethyltoluene	7.20	2.17	.16	1.17	.35
1,2,4-Trimethylbenzene	8.59	2.51	.87	7.43	2.17
n-Undecane	.42	.28	.08	.04	.02
Mid-Range HC Subtotal			36.67	106.20	38.83

Oxygenates	mg Ozone/ mg NMOG MIR	MOR	Test 13C6, 8/08/91 NMOG (mg/mi)	Ozone (mg/mi MIR	MOR
Formaldehyde	7.14	2.08	1.70	12.13	3.53
Acetaldehyde	5.51	2.17	1.12	6.17	2.43
Acrolein	6.76	2.59	.19	1.26	.48
Acetone	.56	.20	.26	.15	.05
Propionaldehyde	6.53	2.50	.32	2.11	.81
Butylaldehyde	5.26	2.01	.10	.55	.21
Benzylaldehyde	-.56	-1.23	.10	-.06	-.12
Oxygenates Subtotal			3.79	22.30	7.39

NMOG Summary		Test 13C6, 8/08/91 NMOG (mg/mi)	Ozone (mg/mi MIR	MOR
Light-End Species		27.92	99.19	44.49
Mid-Range Species		36.67	106.20	38.83
Oxygenates		3.79	22.30	7.39
Total		68.39	227.70	90.71
Ozone/NMOG			3.33	1.33

Table III-1k

Speciated FTP Results
Toyota Celica, RF-A

Light-End Species	mg Ozone/ mg NMOG MIR	MOR	Test 19C1, 7/16/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR	Test 19C2, 7/17/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR
Ethane	.26	.18	2.51	.65	.45	2.48	.65	.45
Ethene	7.28	3.15	5.26	38.32	16.58	6.07	44.16	19.11
Propane	.48	.31	.69	.33	.21	.19	.09	.06
Ethyne	.51	.34	6.10	3.11	2.07	6.85	3.50	2.33
Methylpropane	1.21	.73	.23	.28	.17	.10	.12	.07
Butane	1.02	.66	5.37	5.48	3.54	4.13	4.22	2.73
Propene	9.39	3.77	2.79	26.18	10.51	2.79	26.23	10.53
Methylbutane	1.38	.87	3.81	5.26	3.32	4.09	5.64	3.56
Pentane	1.03	.68	2.92	3.01	1.98	3.08	3.18	2.10
1-Butene	8.90	3.51	.47	4.18	1.65	.44	3.92	1.54
2-Methylpropene	5.29	1.93	.35	1.86	.68	.36	1.89	.69
Light-End HC Subtotal			30.51	88.66	41.17	30.59	93.59	43.17

Mid-Range Species	mg Ozone/ mg NMOG MIR	MOR	Test 19C1, 7/16/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR	Test 19C2, 7/17/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR
1-Pentene	6.22	2.46	.12	.78	.31	2.11	13.13	5.19
1,3-butadiene	10.88	4.16	.29	3.16	1.21	.38	4.18	1.60
2-Methyl-1,3-butadiene	9.07	3.41	.45	4.06	1.53	.00	.00	.00
t-2-Pentene	8.79	3.30	.00	.00	.00	.41	3.57	1.34
c-2-Pentene	8.79	3.30	.65	5.72	2.15	.00	.00	.00
2-Methyl-2-butene	6.40	2.30	.18	1.16	.42	.00	.00	.00
2,2-Dimethylbutane	.82	.51	1.07	.88	.55	.00	.00	.00
Cyclopentane	2.37	1.41	.00	.00	.00	1.08	2.57	1.53
2,3-Dimethylbutane	1.07	.67	2.38	2.55	1.60	3.55	3.79	2.38
C6H12 Alkene 1	5.54	2.12	.17	.96	.37	.00	.00	.00
2-Methylpentane	1.53	.90	5.63	8.61	5.06	.78	1.19	.70
C6H12 Alkene 2	5.54	2.12	.41	2.25	.86	.00	.00	.00
3-Methylpentane	1.52	.94	2.68	4.08	2.52	2.42	3.67	2.27
C6H12 Alkene 3	5.54	2.12	.13	.71	.27	.13	.73	.28
n-Hexane	.98	.64	2.79	2.73	1.78	.41	.40	.26
Methylcyclopentane	2.82	1.55	.82	2.31	1.27	.73	2.07	1.14
C7H16 Alkane	1.40	.83	1.67	2.34	1.39	.80	1.12	.67
Benzene	.42	.14	6.44	2.70	.90	4.79	2.01	.67
Cyclohexane	1.28	.74	.17	.22	.13	.00	.00	.00
2-Methylhexane +Dimethylpentane	1.40	.83	1.82	2.55	1.51	1.61	2.25	1.33
3-Methylhexane	1.40	.83	1.95	2.73	1.62	1.66	2.32	1.38
2,2,4-Trimethylpentane + Alkene	2.59	1.11	5.44	14.10	6.04	1.58	4.08	1.75
n-Heptane	.81	.53	2.27	1.84	1.20	1.51	1.22	.80
Methylcyclohexane	1.84	1.00	1.26	2.32	1.26	.43	.80	.43
Dimethylhexane	1.20	.70	.60	.72	.42	.25	.30	.18
2,3,4-Trimethylpentane	1.20	.70	1.41	1.69	.99	.63	.75	.44
Toluene + C8H18	2.72	.63	12.52	34.07	7.89	8.87	24.13	5.59
2,3-Dimethylhexane	1.20	.70	.51	.62	.36	.25	.30	.18
Methylheptane	1.20	.70	1.07	1.28	.75	.74	.89	.52
Dimethylcyclohexane	1.94	1.02	.39	.76	.40	.81	1.58	.83
2,2,5-Trimethylhexane	1.13	.64	.44	.50	.28	.28	.31	.18
n-Octane	.61	.41	.93	.56	.38	.44	.27	.18
C9H18 Alkene	3.40	1.31	.17	.57	.22	.19	.63	.24
Ethylbenzene	2.90	.72	4.24	12.30	3.05	2.51	7.29	1.81
m & p-Xylenes	7.47	2.24	8.97	66.97	20.08	.98	7.34	2.20
C9H20 Alkane	1.13	.64	.44	.50	.28	.24	.27	.15
Styrene	2.20	-.29	.55	1.22	-.16	.33	.72	-.09
o-Xylene	6.68	2.00	2.92	19.52	5.84	2.12	14.16	4.24
n-Nonane	.54	.36	.22	.12	.08	.13	.07	.05
i-Propylbenzene	2.41	.60	.16	.39	.10	.10	.24	.06

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Table III-1k (Cont.)

Mid-Range Species (Cont.)	mg Ozone/ mg NMOG MIR	MOR	Test 19C1, 7/16/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR	Test 19C2, 7/17/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR
n-Propylbenzene	2.27	.56	.49	1.11	.27	1.47	3.33	.82
3-Ethyltoluene	7.20	2.17	2.00	14.43	4.35	.51	3.65	1.10
4-Ethyltoluene + C10cycloalkane	4.49	1.55	.85	3.82	1.32	.80	3.59	1.24
2-Ethyltoluene	7.20	2.17	.72	5.20	1.57	.49	3.52	1.06
1,2,4-Trimethylbenzene	8.59	2.51	2.27	19.51	5.70	1.51	12.99	3.80
n-Undecane	.42	.28	.13	.06	.04	.09	.04	.03
Mid-Range HC Subtotal			80.81	254.64	88.14	48.12	135.51	48.51

Oxygenates	mg Ozone/ mg NMOG MIR	MOR	Test 19C1, 7/16/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR	Test 19C2, 7/17/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR
Formaldehyde	7.14	2.08	.36	2.58	.75	.68	4.87	1.42
Acetaldehyde	5.51	2.17	.44	2.40	.95	.78	4.29	1.69
Acrolein	6.76	2.59	.00	.00	.00	.07	.49	.19
Acetone	.56	.20	.13	.07	.03	.07	.04	.01
Oxygenates Subtotal			.93	5.06	1.72	1.60	9.68	3.31

NMOG Summary		Test 19C1, 7/16/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR	Test 19C2, 7/17/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR
Light-End Species		30.51	88.66	41.17	30.59	93.59	43.17
Mid-Range Species		80.81	254.64	88.14	48.12	135.51	48.51
Oxygenates		.93	5.06	1.72	1.60	9.68	3.31
Total		112.25	348.36	131.04	80.31	238.78	94.98
Ozone/NMOG			3.10	1.17		2.97	1.18

Table III-1l

Speciated FTP Results
Toyota Celica, RF-A

Light-End Species	mg Ozone/ mg NMOG		Test 19C3, 7/18/91			Test 19C4, 7/23/91		
	MIR	MOR	NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR	NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR
Ethane	.26	.18	1.90	.49	.34	2.56	.66	.46
Ethene	7.28	3.15	4.07	29.65	12.83	4.96	36.12	15.63
Propane	.48	.31	.08	.04	.02	.12	.06	.04
Ethyne	.51	.34	3.30	1.68	1.12	4.25	2.17	1.45
Methylpropane	1.21	.73	.09	.11	.07	.31	.38	.23
Butane	1.02	.66	3.24	3.30	2.14	4.23	4.32	2.79
Propene	9.39	3.77	1.84	17.26	6.93	2.25	21.10	8.47
Methylbutane	1.38	.87	3.16	4.36	2.75	4.16	5.74	3.62
Pentane	1.03	.68	2.35	2.42	1.60	3.04	3.13	2.06
1-Butene	8.90	3.51	.25	2.24	.88	.38	3.38	1.33
2-Methylpropene	5.29	1.93	.24	1.26	.46	1.39	7.37	2.69
Light-End HC Subtotal			20.52	62.81	29.14	27.65	84.43	38.77

Mid-Range Species	mg Ozone/ mg NMOG		Test 19C3, 7/18/91			Test 19C4, 7/23/91		
	MIR	MOR	NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR	NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR
1,3-butadiene	10.88	4.16	.26	2.84	1.09	.33	3.58	1.37
2-Methyl-1,3-butadiene	9.07	3.41	.24	2.14	.81	.00	.00	.00
~~t-2-Pentene~~	~~8.79~~	~~3.30~~	~~.00~~	~~.00~~	~~.00~~	~~.40~~	~~3.55~~	~~1.33~~
c-2-Pentene	8.79	3.30	.43	3.80	1.43	.20	1.80	.68
2-Methyl-2-butene	6.40	2.30	.14	.86	.31	.00	.00	.00
2,2-Dimethylbutane	.82	.51	.41	.34	.21	.69	.57	.35
4-Methyl-1-pentene	4.41	1.74	.00	.00	.00	.18	.78	.31
2,3-Dimethylbutane	1.07	.67	1.51	1.61	1.01	1.34	1.43	.90
C6H12 Alkene 1	5.54	2.12	.00	.00	.00	1.54	8.51	3.26
2-Methylpentane	1.53	.90	3.58	5.47	3.22	4.13	6.32	3.72
C6H12 Alkene 2	5.54	2.12	.11	.61	.23	.00	.00	.00
3-Methylpentane	1.52	.94	2.29	3.48	2.15	2.42	3.67	2.27
C6H12 Alkene 3	5.54	2.12	.12	.64	.25	.16	.87	.33
n-Hexane	.98	.64	2.00	1.96	1.28	2.25	2.21	1.44
t-2-Hexene	6.67	2.50	.00	.00	.00	.17	1.13	.42
c-2-Hexene	6.67	2.50	.00	.00	.00	.14	.95	.36
Methylcyclopentane	2.82	1.55	.51	1.45	.80	.83	2.33	1.28
C7H16 Alkane	1.40	.83	1.34	1.88	1.12	1.40	1.96	1.16
Benzene	.42	.14	4.30	1.81	.60	4.32	1.81	.60
Cyclohexane	1.28	.74	.00	.00	.00	.10	.12	.07
2-Methylhexane +Dimethylpentane	1.40	.83	1.98	2.77	1.64	3.63	5.08	3.01
3-Methylhexane	1.40	.83	2.16	3.02	1.79	1.85	2.59	1.53
2,2,4-Trimethylpentane + Alkene	2.59	1.11	4.92	12.73	5.46	4.14	10.73	4.60
n-Heptane	.81	.53	2.01	1.63	1.06	1.63	1.32	.86
Methylcyclohexane	1.84	1.00	.46	.84	.46	.49	.89	.49
Dimethylhexane	1.20	.70	.26	.31	.18	1.10	1.32	.77
2,3,4-Trimethylpentane	1.20	.70	1.29	1.55	.90	1.01	1.21	.71
Toluene + C8H18	2.72	.63	11.21	30.49	7.06	8.32	22.63	5.24
2,3-Dimethylhexane	1.20	.70	.30	.36	.21	.26	.31	.18
Methylheptane	1.20	.70	.63	.76	.44	.72	.86	.50
Dimethylcyclohexane	1.94	1.02	.78	1.52	.80	.86	1.67	.88
2,2,5-Trimethylhexane	1.13	.64	.30	.34	.19	.30	.34	.19
n-Octane	.61	.41	.52	.32	.21	.41	.25	.17
C9H18 Alkene	3.40	1.31	.13	.45	.17	.10	.35	.13
Ethylbenzene	2.90	.72	3.47	10.07	2.50	2.65	7.69	1.91
Trimethylcyclohexane	2.30	1.18	.00	.00	.00	.00	.00	.00
m & p-Xylenes	7.47	2.24	8.64	64.54	19.35	6.21	46.39	13.91
C9H20 Alkane	1.13	.64	.30	.34	.19	.21	.24	.13
Styrene	2.20	-.29	.38	.83	-.11	.30	.66	-.09
o-Xylene	6.68	2.00	3.15	21.05	6.30	2.18	14.56	4.36

Table III-1l (Cont.)

Mid-Range Species (Cont.)	mg Ozone/ mg NMOG MIR	mg Ozone/ mg NMOG MOR	Test 19C3, 7/18/91 NMOG (mg/mi)	Test 19C3 Ozone (mg/mi) MIR	Test 19C3 Ozone (mg/mi) MOR	Test 19C4, 7/23/91 NMOG (mg/mi)	Test 19C4 Ozone (mg/mi) MIR	Test 19C4 Ozone (mg/mi) MOR
n-Nonane	.54	.36	.16	.09	.06	.13	.07	.05
i-Propylbenzene	2.41	.60	.13	.30	.08	.09	.22	.05
n-Propylbenzene	2.27	.56	.41	.93	.23	.31	.70	.17
3-Ethyltoluene	7.20	2.17	1.91	13.73	4.14	1.71	12.32	3.71
4-Ethyltoluene + C10cycloalkane	4.49	1.55	.72	3.23	1.12	.93	4.16	1.44
1,3,5-Trimethylbenzene	10.11	3.06	.00	.00	.00	.72	7.26	2.20
2-Ethyltoluene	7.20	2.17	.62	4.44	1.34	.38	2.77	.83
C10H22 Alkane 4	1.01	.56	.00	.00	.00	.00	.00	.00
1,2,4-Trimethylbenzene	8.59	2.51	2.81	24.18	7.07	2.05	17.57	5.14
n-Undecane	.42	.28	.25	.10	.07	.21	.09	.06
Mid-Range HC Subtotal			67.13	229.83	77.41	63.49	205.86	73.01

Oxygenates	mg Ozone/ mg NMOG MIR	mg Ozone/ mg NMOG MOR	Test 19C3, 7/18/91 NMOG (mg/mi)	Test 19C3 Ozone (mg/mi) MIR	Test 19C3 Ozone (mg/mi) MOR	Test 19C4, 7/23/91 NMOG (mg/mi)	Test 19C4 Ozone (mg/mi) MIR	Test 19C4 Ozone (mg/mi) MOR
Formaldehyde	7.14	2.08	.36	2.58	.75	.46	3.25	.95
Acetaldehyde	5.51	2.17	.26	1.42	.56	1.36	7.47	2.94
Acetone	.56	.20	1.62	.91	.32	.00	.00	.00
Oxygenates Subtotal			2.24	4.90	1.63	1.81	10.72	3.89

NMOG Summary		Test 19C3, 7/18/91 NMOG (mg/mi)	Test 19C3 Ozone (mg/mi) MIR	Test 19C3 Ozone (mg/mi) MOR	Test 19C4, 7/23/91 NMOG (mg/mi)	Test 19C4 Ozone (mg/mi) MIR	Test 19C4 Ozone (mg/mi) MOR
Light-End Species		20.52	62.81	29.14	27.65	84.43	38.77
Mid-Range Species		67.13	229.83	77.41	63.49	205.86	73.01
Oxygenates		2.24	4.90	1.63	1.81	10.72	3.89
Total		89.88	297.54	108.19	92.95	301.02	115.67
Ozone/NMOG			3.31	1.20		3.24	1.24

Table III-1m

Speciated FTP Results
Mercury Cougar, RF-A

Light-End Species	mg Ozone/ mg NMOG MIR	MOR	Test 27C2, 8/13/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR	Test 27C3, 8/14/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR
Ethane	.26	.18	8.39	2.18	1.51	9.37	2.44	1.69
Ethene	7.28	3.15	11.83	86.13	37.27	12.06	87.80	37.99
Propane	.48	.31	.58	.28	.18	.56	.27	.17
Ethyne	.51	.34	1.52	.78	.52	2.35	1.20	.80
Methylpropane	1.21	.73	.37	.45	.27	.21	.26	.15
Butane	1.02	.66	8.10	8.26	5.34	8.44	8.60	5.57
Propene	9.39	3.77	3.05	28.66	11.51	3.21	30.11	12.09
Methylbutane	1.38	.87	7.46	10.29	6.49	7.40	10.21	6.44
Pentane	1.03	.68	5.32	5.48	3.62	5.21	5.37	3.55
1-Butene	8.90	3.51	.65	5.78	2.28	.60	5.34	2.11
2-Methylpropene	5.29	1.93	2.17	11.50	4.20	2.09	11.07	4.04
Light-End HC Subtotal			49.44	159.78	73.18	51.49	162.66	74.58

Mid-Range Species	mg Ozone/ mg NMOG MIR	MOR	Test 27C2, 8/13/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR	Test 27C3, 8/14/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR
1,3-butadiene	10.88	4.16	.16	1.71	.66	.33	3.61	1.38
t-2-Pentene	8.79	3.30	.10	.89	.33	.00	.00	.00
2,2-Dimethylbutane	.82	.51	.87	.71	.44	.00	.00	.00
Cyclopentene	7.65	2.78	.00	.00	.00	2.29	17.51	6.36
2,3-Dimethylbutane	1.07	.67	2.58	2.76	1.73	.00	.00	.00
2-Methylpentane	1.53	.90	6.95	10.63	6.25	.00	.00	.00
3-Methylpentane	1.52	.94	3.55	5.40	3.34	.00	.00	.00
C6H12 Alkene 3	5.54	2.12	.07	.38	.14	.00	.00	.00
n-Hexane	.98	.64	3.54	3.47	2.26	2.69	2.64	1.72
Methylcyclopentane	2.82	1.55	.90	2.55	1.40	.88	2.47	1.36
C7H16 Alkane	1.40	.83	1.62	2.27	1.35	1.03	1.45	.86
Benzene	.42	.14	10.45	4.39	1.46	16.07	6.75	2.25
Cyclohexane	1.28	.74	.07	.09	.05	1.27	1.63	.94
2-Methylhexane +Dimethylpentane	1.40	.83	4.02	5.62	3.33	3.67	5.14	3.05
3-Methylhexane	1.40	.83	2.03	2.85	1.69	1.54	2.15	1.28
2,2,4-Trimethylpentane + Alkene	2.59	1.11	5.55	14.37	6.16	8.62	22.32	9.57
n-Heptane	.81	.53	1.37	1.11	.73	1.68	1.36	.89
Methylcyclohexane	1.84	1.00	.38	.70	.38	.60	1.11	.60
Dimethylhexane	1.20	.70	1.23	1.48	.86	1.31	1.57	.92
Trimethylcyclopentane 1	1.94	1.02	.00	.00	.00	.00	.00	.00
2,3,4-Trimethylpentane	1.20	.70	.84	1.00	.58	.92	1.10	.64
Toluene + C8H18	2.72	.63	5.99	16.30	3.78	11.19	30.43	7.05
2,3-Dimethylhexane	1.20	.70	.45	.54	.32	.47	.57	.33
Methylheptane	1.20	.70	.78	.93	.54	1.23	1.47	.86
Dimethylcyclohexane	1.94	1.02	1.34	2.60	1.37	1.21	2.34	1.23
2,2,5-Trimethylhexane	1.13	.64	.45	.51	.29	.39	.44	.25
n-Octane	.61	.41	.52	.32	.21	.67	.41	.27
C9H18 Alkene	3.40	1.31	.07	.24	.09	.00	.00	.00
Ethylbenzene	2.90	.72	1.17	3.41	.85	2.19	6.35	1.58
Trimethylcyclohexane	2.30	1.18	.00	.00	.00	.00	.00	.00
m & p-Xylenes	7.47	2.24	4.11	30.69	9.20	6.15	45.92	13.77
C9H20 Alkane	1.13	.64	.48	.54	.31	.33	.38	.21
Styrene	2.20	-.29	.52	1.15	-.15	.51	1.12	-.15
o-Xylene	6.68	2.00	1.09	7.30	2.19	2.01	13.45	4.03
n-Nonane	.54	.36	.49	.27	.18	.00	.00	.00
n-Propylbenzene	2.27	.56	.14	.32	.08	.23	.52	.13
3-Ethyltoluene	7.20	2.17	.60	4.30	1.30	1.36	9.77	2.94
4-Ethyltoluene + C10cycloalkane	4.49	1.55	.25	1.13	.39	.00	.00	.00
1,3,5-Trimethylbenzene	10.11	3.06	.39	3.94	1.19	.63	6.33	1.92

Table III-1m (Cont.)

Mid-Range Species (Cont.)	mg Ozone/ mg NMOG MIR	MOR	Test 27C2, 8/13/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR	Test 27C3, 8/14/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR
2-Ethyltoluene	7.20	2.17	.15	1.08	.33	.00	.00	.00
1,2,4-Trimethylbenzene	8.59	2.51	1.39	11.97	3.50	1.33	11.43	3.34
n-Undecane	.42	.28	.08	.03	.02	.00	.00	.00
Mid-Range HC Subtotal			66.75	149.95	59.13	72.79	201.73	69.58

Oxygenates	mg Ozone/ mg NMOG MIR	MOR	Test 27C2, 8/13/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR	Test 27C3, 8/14/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR
Formaldehyde	7.14	2.08	.45	3.23	.94	.38	2.70	.79
Acetaldehyde	5.51	2.17	.57	3.14	1.24	.38	2.10	.83
Acrolein	6.76	2.59	.04	.26	.10	.03	.19	.07
Acetone	.56	.20	.11	.06	.02	.11	.06	.02
Oxygenates Subtotal			1.17	6.69	2.30	.90	5.05	1.71

NMOG Summary		Test 27C2, 8/13/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR	Test 27C3, 8/14/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR
Light-End Species		49.44	159.78	73.18	51.49	162.66	74.58
Mid-Range Species		66.75	149.95	59.13	72.79	201.73	69.58
Oxygenates		1.17	6.69	2.30	.90	5.05	1.71
Total		117.36	316.42	134.60	125.18	369.44	145.87
Ozone/NMOG			2.70	1.15		2.95	1.17

Table III-1n

Speciated FTP Results
Mercury Cougar, RF-A

Light-End Species	mg Ozone/ mg NMOG		Test 27C4, 8/15/91			Test 27C5, 8/16/91		
	MIR	MOR	NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR	NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR
Ethane	.26	.18	10.57	2.75	1.90	7.96	2.07	1.43
Ethene	7.28	3.15	11.39	82.90	35.87	8.60	62.59	27.08
Propane	.48	.31	.49	.23	.15	.31	.15	.09
Ethyne	.51	.34	1.52	.77	.52	1.73	.88	.59
Methylpropane	1.21	.73	.02	.02	.01	.19	.23	.14
Butane	1.02	.66	8.85	9.03	5.84	6.77	6.91	4.47
Propene	9.39	3.77	3.81	35.75	14.35	2.38	22.32	8.96
Methylbutane	1.38	.87	7.36	10.16	6.40	5.80	8.00	5.05
Pentane	1.03	.68	5.22	5.38	3.55	4.25	4.37	2.89
1-Butene	8.90	3.51	.73	6.51	2.57	.59	5.21	2.05
2-Methylpropene	5.29	1.93	1.85	9.81	3.58	1.62	8.60	3.14
Light-End HC Subtotal			51.81	163.32	74.75	40.18	121.32	55.89

Mid-Range Species	mg Ozone/ mg NMOG		Test 27C4, 8/15/91			Test 27C5, 8/16/91		
	MIR	MOR	NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR	NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR
1,3-butadiene	10.88	4.16	.26	2.81	1.07	.18	1.96	.75
2,2-Dimethylbutane	.82	.51	.00	.00	.00	4.38	3.60	2.24
2,3-Dimethylbutane	1.07	.67	1.32	1.41	.89	3.42	3.66	2.29
~~2-Methylpentane~~	~~1.53~~	~~.90~~	~~4.50~~	~~6.88~~	~~4.05~~	~~.00~~	~~.00~~	~~.00~~
3-Methylpentane	1.52	.94	2.22	3.38	2.09	.75	1.14	.70
n-Hexane	.98	.64	2.25	2.20	1.44	.00	.00	.00
Methylcyclopentane	2.82	1.55	.00	.00	.00	.93	2.63	1.44
C7H16 Alkane	1.40	.83	.00	.00	.00	1.03	1.45	.86
Benzene	.42	.14	14.76	6.20	2.07	14.43	6.06	2.02
2-Methylhexane +Dimethylpentane	1.40	.83	2.66	3.73	2.21	4.32	6.05	3.58
3-Methylhexane	1.40	.83	1.34	1.88	1.12	2.16	3.02	1.79
2,2,4-Trimethylpentane + Alkene	2.59	1.11	5.00	12.96	5.55	8.40	21.76	9.33
n-Heptane	.81	.53	1.04	.84	.55	1.77	1.43	.94
Methylcyclohexane	1.84	1.00	.00	.00	.00	.66	1.21	.66
Dimethylhexane	1.20	.70	1.06	1.27	.74	1.45	1.74	1.02
2,3,4-Trimethylpentane	1.20	.70	.89	1.07	.63	1.03	1.24	.72
Toluene + C8H18	2.72	.63	10.61	28.85	6.68	11.41	31.04	7.19
2,3-Dimethylhexane	1.20	.70	.00	.00	.00	.53	.64	.37
Methylheptane	1.20	.70	1.03	1.24	.72	1.39	1.67	.98
Dimethylcyclohexane	1.94	1.02	1.10	2.13	1.12	1.60	3.11	1.64
2,2,5-Trimethylhexane	1.13	.64	.00	.00	.00	.45	.50	.29
n-Octane	.61	.41	.00	.00	.00	.64	.39	.26
Ethylbenzene	2.90	.72	2.86	8.29	2.06	2.31	6.69	1.66
m & p-Xylenes	7.47	2.24	4.94	36.87	11.05	2.15	16.05	4.81
C9H20 Alkane	1.13	.64	.00	.00	.00	.33	.38	.21
Styrene	2.20	-.29	.00	.00	.00	.51	1.12	-.15
o-Xylene	6.68	2.00	1.64	10.93	3.27	2.13	14.20	4.25
3-Ethyltoluene	7.20	2.17	1.33	9.60	2.89	1.85	13.33	4.02
1,3,5-Trimethylbenzene	10.11	3.06	.00	.00	.00	.81	8.17	2.47
2-Ethyltoluene	7.20	2.17	.00	.00	.00	.50	3.57	1.08
1,2,4-Trimethylbenzene	8.59	2.51	1.33	11.45	3.35	1.70	14.56	4.26
Mid-Range HC Subtotal			62.14	153.99	53.55	73.21	172.35	61.67

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Table III-1n (Cont.)

Oxygenates	mg Ozone/ mg NMOG MIR	MOR	Test 27C4, 8/15/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR	Test 27C5, 8/16/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR
Formaldehyde	7.14	2.08	.90	6.39	1.86	.65	4.61	1.34
Acetaldehyde	5.51	2.17	.86	4.74	1.87	.64	3.50	1.38
Acrolein	6.76	2.59	.04	.30	.12	.05	.34	.13
Acetone	.56	.20	1.05	.59	.21	.16	.09	.03
Oxygenates Subtotal			2.85	12.02	4.05	1.49	8.54	2.88

NMOG Summary		Test 27C4, 8/15/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR	Test 27C5, 8/16/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR
Light-End Species		51.81	163.32	74.75	40.18	121.32	55.89
Mid-Range Species		62.14	153.99	53.55	73.21	172.35	61.67
Oxygenates		2.85	12.02	4.05	1.49	8.54	2.88
Total		116.80	329.32	132.35	114.88	302.22	120.44
Ozone/NMOG			2.82	1.13		2.63	1.05

Table III-1o

Speciated FTP Results
Mercury Cougar, RF-A

Light-End Species	mg Ozone/ mg NMOG MIR	mg Ozone/ mg NMOG MOR	Test 27C6, 8/23/91 NMOG (mg/mi)	Test 27C6 Ozone (mg/mi) MIR	Test 27C6 Ozone (mg/mi) MOR	Test 27C7, 8/28/91 NMOG (mg/mi)	Test 27C7 Ozone (mg/mi) MIR	Test 27C7 Ozone (mg/mi) MOR
Ethane	.26	.18	8.49	2.21	1.53	.00	.00	.00
Ethene	7.28	3.15	8.77	63.83	27.62	8.21	59.79	25.87
Propane	.48	.31	.60	.29	.19	.79	.38	.25
Ethyne	.51	.34	1.49	.76	.51	2.02	1.03	.69
Methylpropane	1.21	.73	.56	.68	.41	.19	.23	.14
Butane	1.02	.66	8.01	8.17	5.29	7.85	8.00	5.18
Propene	9.39	3.77	3.07	28.80	11.56	3.04	28.56	11.47
Methylbutane	1.38	.87	7.66	10.57	6.66	6.39	8.82	5.56
Pentane	1.03	.68	4.97	5.12	3.38	4.23	4.35	2.87
1-Butene	8.90	3.51	.63	5.61	2.21	.58	5.17	2.04
2-Methylpropene	5.29	1.93	1.70	8.97	3.27	1.68	8.90	3.25
Light-End HC Subtotal			45.95	135.01	62.63	34.98	125.23	57.30

Mid-Range Species	mg Ozone/ mg NMOG MIR	mg Ozone/ mg NMOG MOR	Test 27C6, 8/23/91 NMOG (mg/mi)	Test 27C6 Ozone (mg/mi) MIR	Test 27C6 Ozone (mg/mi) MOR	Test 27C7, 8/28/91 NMOG (mg/mi)	Test 27C7 Ozone (mg/mi) MIR	Test 27C7 Ozone (mg/mi) MOR
1,3-butadiene	10.88	4.16	.24	2.56	.98	.21	2.28	.87
Cyclopentene	7.65	2.78	.85	6.46	2.35	.00	.00	.00
C6H12 Alkene 3	5.54	2.12	.12	.67	.26	.12	.67	.26
n-Hexane	.98	.64	4.56	4.47	2.92	4.64	4.55	2.97
t-2-Hexene	6.67	2.50	.20	1.33	.50	.18	1.21	.45
Methylcyclopentane	2.82	1.55	1.97	5.56	3.05	1.59	4.49	2.47
C7H16 Alkane	1.40	.83	1.42	1.99	1.18	1.85	2.59	1.54
Benzene	.42	.14	12.32	5.17	1.72	16.07	6.75	2.25
Cyclohexane	1.28	.74	.18	.23	.13	.16	.21	.12
2-Methylhexane +Dimethylpentane	1.40	.83	5.10	7.14	4.23	5.33	7.46	4.42
3-Methylhexane	1.40	.83	2.63	3.68	2.18	2.73	3.83	2.27
2,2,4-Trimethylpentane + Alkene	2.59	1.11	7.10	18.38	7.88	7.48	19.37	8.30
n-Heptane	.81	.53	1.65	1.34	.88	1.97	1.60	1.05
Methylcyclohexane	1.84	1.00	.60	1.11	.60	.55	1.01	.55
Dimethylhexane	1.20	.70	1.68	2.02	1.18	1.58	1.89	1.10
2,3,4-Trimethylpentane	1.20	.70	1.29	1.55	.90	1.61	1.93	1.12
Toluene + C8H18	2.72	.63	10.09	27.44	6.35	10.30	28.01	6.49
2,3-Dimethylhexane	1.20	.70	.53	.64	.37	.61	.74	.43
Methylheptane	1.20	.70	1.49	1.78	1.04	1.39	1.66	.97
Dimethylcyclohexane	1.94	1.02	.45	.88	.46	.84	1.63	.86
2,2,5-Trimethylhexane	1.13	.64	.62	.70	.40	.59	.67	.38
n-Octane	.61	.41	.79	.48	.32	.71	.43	.29
C9H18 Alkene	3.40	1.31	.13	.46	.18	.12	.42	.16
Ethylbenzene	2.90	.72	2.28	6.61	1.64	1.74	5.06	1.26
m & p-Xylenes	7.47	2.24	7.31	54.62	16.38	6.25	46.69	14.00
C9H20 Alkane	1.13	.64	.47	.53	.30	.39	.44	.25
Styrene	2.20	-.29	.43	.95	-.13	.43	.96	-.13
o-Xylene	6.68	2.00	1.84	12.29	3.68	1.56	10.44	3.12
n-Nonane	.54	.36	.21	.11	.07	.18	.10	.07
n-Propylbenzene	2.27	.56	.31	.71	.18	.23	.52	.13
3-Ethyltoluene	7.20	2.17	1.30	9.39	2.83	.89	6.41	1.93
4-Ethyltoluene + C10cycloalkane	4.49	1.55	.55	2.46	.85	.37	1.65	.57
1,3,5-Trimethylbenzene	10.11	3.06	.78	7.91	2.39	.55	5.56	1.68
2-Ethyltoluene	7.20	2.17	.47	3.38	1.02	.31	2.26	.68
1,2,4-Trimethylbenzene	8.59	2.51	2.08	17.85	5.21	1.15	9.90	2.89
Mid-Range HC Subtotal			74.03	212.82	74.49	74.71	183.40	65.78

Table III-1o (Cont.)

Oxygenates	mg Ozone/ mg NMOG MIR	MOR	Test 27C6, 8/23/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR	Test 27C7, 8/28/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR
Formaldehyde	7.14	2.08	1.11	7.95	2.32	.93	6.62	1.93
Acetaldehyde	5.51	2.17	.73	4.01	1.58	.67	3.68	1.45
Acrolein	6.76	2.59	.06	.38	.14	.00	.00	.00
Acetone	.56	.20	.99	.55	.20	2.72	1.52	.54
Oxygenates Subtotal			2.88	12.90	4.24	4.32	11.83	3.92

NMOG Summary		Test 27C6, 8/23/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR	Test 27C7, 8/28/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR
Light-End Species		45.95	135.01	62.63	34.98	125.23	57.30
Mid-Range Species		74.03	212.82	74.49	74.71	183.40	65.78
Oxygenates		2.88	12.90	4.24	4.32	11.83	3.92
Total		122.86	360.73	141.36	114.01	320.46	127.01
Ozone/NMOG			2.94	1.15		2.81	1.11

Table III-1p

Speciated FTP Results
Chevrolet Cavalier, RF-A
(Data Obtained from Chevron Research)

Hydrocarbon Species	mg Ozone/ mg NMOG		Test 50993, 3/28/91			Test 51011, 4/17/91		
	MIR	MOR	NMOG (mg/mi)	Ozone (mg/mi) MIR	Ozone (mg/mi) MOR	NMOG (mg/mi)	Ozone (mg/mi) MIR	Ozone (mg/mi) MOR
Ethylene	7.28	3.15	8.72	63.48	27.47	9.84	71.67	31.01
Acetylene	.51	.34	1.46	.75	.50	1.79	.92	.61
Ethane	.26	.18	3.33	.87	.60	3.91	1.02	.70
Propylene	9.39	3.77	1.67	15.69	6.30	2.03	19.04	7.64
Propane	.48	.31	.25	.12	.08	.31	.15	.10
Allene	7.28	3.15	.84	6.15	2.66	1.08	7.84	3.39
2-Me-Propane	1.21	.73	.09	.11	.07	.11	.14	.08
1-Butene/i-Butene	7.10	2.72	.59	4.17	1.60	.83	5.90	2.26
n-Butane	1.02	.66	2.07	2.11	1.36	2.47	2.52	1.63
t-2-Butene	9.93	3.75	.01	.11	.04	.14	1.41	.53
c-2-Butene	9.93	3.75	.00	.00	.00	.05	.52	.20
3-Me-1-Butene	6.22	2.46	.00	.00	.00	.06	.35	.14
2-Me-Butane	1.38	.87	1.88	2.59	1.63	3.25	4.49	2.83
1-Pentene	6.22	2.46	.04	.23	.09	.00	.00	.00
2-Me-1-Butene	4.89	1.90	.07	.36	.14	.02	.11	.04
n-Pentane	1.03	.68	.92	.95	.62	.10	.10	.07
t-2-Pentene	8.79	3.30	.06	.50	.19	.04	.38	.14
c-2-Pentene	8.79	3.30	.05	.40	.15	.03	.27	.10
2-Me-2-Butene	6.40	2.30	.70	4.46	1.60	.45	2.86	1.03
2,2-Di-Me-Butane	.82	.51	.80	.66	.41	.77	.63	.39
Cyclopentene	7.65	2.78	.07	.50	.18	.08	.59	.21
Cyclopentane	2.37	1.41	.14	.33	.20	.18	.44	.26
2,3-Di-Me-Butane	1.07	.67	.79	.85	.53	.90	.96	.60
2-Me-Pentane	1.53	.90	2.17	3.32	1.95	2.57	3.93	2.31
3-Me-Pentane	1.52	.94	1.12	1.71	1.06	1.43	2.17	1.34
1-Hexene/	4.41	1.74	.10	.44	.17	.07	.31	.12
n-Hexane	.98	.64	.43	.42	.28	.82	.81	.53
t-2-Hexene	6.67	2.50	1.13	7.51	2.81	.05	.37	.14
3-Me-t-2-Pentene	6.67	2.50	.09	.63	.24	.13	.87	.32
2-Me-2-Pentene	6.67	2.50	.14	.92	.35	.14	.93	.35
c-2-Hexene	6.67	2.50	.04	.26	.10	.03	.19	.07
3-Me-c-2-Pentene	6.67	2.50	.08	.56	.21	.04	.29	.11
Me-Cyclopentane	2.82	1.55	.52	1.47	.81	.59	1.67	.92
2,4-Di-Me-Pentane	1.78	.99	.53	.95	.53	.62	1.09	.61
1-Me-Cyclopentene	5.65	2.20	.16	.93	.36	.19	1.10	.43
Benzene	.42	.14	4.94	2.07	.69	4.92	2.07	.69
Cyclohexane	1.28	.74	.05	.06	.04	.07	.08	.05
2-Me-Hexane	1.40	.83	1.35	1.89	1.12	1.66	2.32	1.37
3-Me-Hexane	1.40	.83	.74	1.03	.61	.80	1.12	.67
c-1,3-Di-Me-Cypentane	2.54	1.38	.18	.44	.24	.16	.42	.23
t-1,3-Di-Me-Cypentane	2.54	1.38	.15	.38	.20	.16	.40	.22
224-Tri-Me-Pentane	.87	.51	1.84	1.60	.94	1.98	1.72	1.01
n-Heptane	.81	.53	.64	.52	.34	.66	.53	.35
Me-Cyclohexane	1.84	1.00	.28	.51	.28	.37	.68	.37
2,5-Di-Me-Hexane	1.20	.70	.30	.36	.21	.33	.39	.23
2,4-Di-Me-Hexane	1.20	.70	.35	.42	.24	.36	.43	.25
124-Tri-Me-Cypentane	1.94	1.02	.07	.14	.07	.05	.10	.05
234-Tri-Me-Pentane	1.20	.70	.42	.51	.30	.46	.55	.32
233-Tri-Me-Pentane	1.20	.70	.31	.37	.22	.34	.40	.24
Toluene	2.72	.63	6.55	17.82	4.13	7.33	19.93	4.62
2,3-Di-Me-Hexane	1.20	.70	.20	.24	.14	.21	.25	.15
2-Me-Heptane	1.20	.70	.54	.64	.38	.64	.77	.45
3-Me-Heptane	1.20	.70	.68	.81	.47	.67	.80	.47
225-Tri-Me-Hexane	1.13	.64	.31	.35	.20	.33	.37	.21
n-Octane	.61	.41	.42	.26	.17	.44	.27	.18
244-Tri-Me-Hexane	1.13	.64	.02	.02	.01	.01	.02	.01
235-Tri-Me-Hexane	1.13	.64	.03	.03	.02	.02	.02	.01
2,4-Di-Me-Heptane	1.13	.64	.09	.10	.06	.07	.08	.04
3,5-Di-Me-Heptane	1.13	.64	.12	.14	.08	.10	.12	.07
Ethyl-Benzene	2.90	.72	1.69	4.91	1.22	2.05	5.94	1.47

Table III-1p (Cont.)

Hydrocarbon Species	mg Ozone/ mg NMOG MIR	mg Ozone/ mg NMOG MOR	Test 50993, 3/28/91 NMOG (mg/mi)	Test 50993, 3/28/91 Ozone (mg/mi) MIR	Test 50993, 3/28/91 Ozone (mg/mi) MOR	Test 51011, 4/17/91 NMOG (mg/mi)	Test 51011, 4/17/91 Ozone (mg/mi) MIR	Test 51011, 4/17/91 Ozone (mg/mi) MOR
m-Xylene	8.15	2.46	3.60	29.38	8.87	4.36	35.55	10.73
p-Xylene	8.15	2.46	.83	6.75	2.04	1.00	8.17	2.47
2-Me-Octane	1.13	.64	.21	.24	.13	.24	.27	.16
3-Me-Octane	1.13	.64	.15	.17	.09	.18	.20	.12
Styrene	2.20	-.29	.32	.69	-.09	.39	.86	-.11
o-Xylene	6.68	2.00	1.53	10.22	3.06	1.97	13.15	3.94
n-Nonane	.54	.36	.12	.07	.04	.12	.06	.04
Cumene	2.41	.60	.05	.13	.03	.05	.12	.03
n-Propyl Benzene	2.27	.56	.17	.39	.10	.20	.46	.11
1-Et-3-Me-Benzene	7.20	2.17	.75	5.39	1.62	.86	6.19	1.87
1-Et-4-Me-Benzene	7.20	2.17	.25	1.81	.54	.29	2.08	.63
135-Tri-Me-Benzene	10.11	3.06	.33	3.32	1.00	.38	3.87	1.17
1-Et-2-Me-Benzene	7.20	2.17	.23	1.66	.50	.26	1.90	.57
124-Tri-Me-Benzene	8.59	2.51	.47	4.04	1.18	.30	2.56	.75
n-Decane	.47	.31	.00	.00	.00	.01	.00	.00
123-Tri-Me-Benzene	8.61	2.51	.04	.33	.10	.01	.06	.02
Indan	1.04	.13	.07	.07	.01	.08	.08	.01
Unidentified HC	3.50	1.40	2.70	9.46	3.79	1.97	6.90	2.76
Formaldehyde	7.14	2.08	3.21	22.90	6.67	1.72	12.29	3.58
Acetaldehyde	5.51	2.17	1.82	10.01	3.94	1.28	7.03	2.77
Acrolein	6.76	2.59	.53	3.59	1.38	.20	1.38	.53
Acetone	.56	.20	.99	.55	.20	.52	.29	.10
Total			71.69	271.31	102.87	75.70	279.31	107.18
Ozone/NMOG				3.78	1.43		3.69	1.42

Table III-1q

Speciated FTP Results
Chevrolet Cavalier, RF-A
(Data Obtained from Chevron Research)

Hydrocarbon Species	mg Ozone/ mg NMOG MIR	mg Ozone/ mg NMOG MOR	Test 51114, 8/07/91 NMOG (mg/mi)	Test 51114 Ozone (mg/mi) MIR	Test 51114 Ozone (mg/mi) MOR	Test 51116, 8/08/91 NMOG (mg/mi)	Test 51116 Ozone (mg/mi) MIR	Test 51116 Ozone (mg/mi) MOR
Ethylene	7.28	3.15	8.97	65.28	28.24	8.38	61.01	26.40
Acetylene	.51	.34	1.60	.82	.54	1.37	.70	.46
Ethane	.26	.18	4.48	1.17	.81	3.65	.95	.66
Propylene	9.39	3.77	1.61	15.14	6.08	1.49	14.02	5.63
Propane	.48	.31	.26	.12	.08	.33	.16	.10
Allene	7.28	3.15	.80	5.82	2.52	.83	6.01	2.60
2-Me-Propane	1.21	.73	.23	.28	.17	.13	.16	.10
1-Butene/i-Butene	7.10	2.72	1.38	9.80	3.75	.64	4.53	1.74
n-Butane	1.02	.66	2.93	2.99	1.93	2.78	2.84	1.84
t-2-Butene	9.93	3.75	.02	.17	.07	.02	.24	.09
c-2-Butene	9.93	3.75	.04	.45	.17	.04	.40	.15
3-Me-1-Butene	6.22	2.46	.06	.38	.15	.06	.39	.15
2-Me-Butane	1.38	.87	4.37	6.03	3.80	4.47	6.18	3.89
1-Pentene	6.22	2.46	.59	3.69	1.46	.04	.27	.11
2-Me-1-Butene	4.89	1.90	.10	.50	.19	.10	.49	.19
n-Pentane	1.03	.68	1.28	1.32	.87	1.24	1.28	.84
t-2-Pentene	8.79	3.30	.02	.15	.06	.02	.20	.07
c-2-Pentene	8.79	3.30	.03	.29	.11	.02	.16	.06
2-Me-2-Butene	6.40	2.30	.33	2.10	.76	.24	1.51	.54
2,2-Di-Me-Butane	.82	.51	.75	.61	.38	.85	.69	.43
Cyclopentene	7.65	2.78	.06	.45	.16	.10	.78	.28
4-Me-1-Pentene/	4.41	1.74	.02	.11	.04	.00	.00	.00
Cyclopentane	2.37	1.41	.15	.35	.21	.18	.42	.25
2,3-Di-Me-Butane	1.07	.67	.90	.97	.61	1.01	1.08	.67
MTBE	.62	.40	.00	.00	.00	.00	.00	.00
2-Me-Pentane	1.53	.90	2.28	3.48	2.05	2.79	4.28	2.52
3-Me-Pentane	1.52	.94	1.19	1.81	1.12	1.80	2.73	1.69
1-Hexene/	4.41	1.74	.20	.88	.35	.29	1.27	.50
n-Hexane	.98	.64	.44	.43	.28	.86	.85	.55
t-2-Hexene	6.67	2.50	.10	.69	.26	.14	.90	.34
3-Me-t-2-Pentene	6.67	2.50	.13	.89	.33	.13	.89	.33
2-Me-2-Pentene	6.67	2.50	.09	.63	.23	.16	1.06	.40
c-2-Hexene	6.67	2.50	.02	.16	.06	.05	.30	.11
3-Me-c-2-Pentene	6.67	2.50	.05	.33	.12	.09	.59	.22
Me-Cyclopentane	2.82	1.55	.39	1.11	.61	.50	1.42	.78
2,4-Di-Me-Pentane	1.78	.99	.48	.85	.47	.58	1.04	.58
1-Me-Cyclopentene	5.65	2.20	.15	.83	.32	.26	1.45	.56
Benzene	.42	.14	5.40	2.27	.76	5.65	2.37	.79
Cyclohexane	1.28	.74	.10	.13	.08	.10	.12	.07
2-Me-Hexane	1.40	.83	1.65	2.32	1.37	1.84	2.58	1.53
3-Me-Hexane	1.40	.83	.84	1.18	.70	.93	1.30	.77
c-1,3-Di-Me-Cypentane	2.54	1.38	.18	.46	.25	.14	.36	.19
t-1,3-Di-Me-Cypentane	2.54	1.38	.15	.38	.20	.13	.32	.17
224-Tri-Me-Pentane	.87	.51	2.22	1.93	1.13	2.47	2.15	1.26
n-Heptane	.81	.53	.59	.48	.31	.65	.52	.34
Me-Cyclohexane	1.84	1.00	.27	.50	.27	.35	.64	.35
2,5-Di-Me-Hexane	1.20	.70	.30	.36	.21	.36	.43	.25
2,4-Di-Me-Hexane	1.20	.70	.37	.45	.26	.44	.52	.31
124-Tri-Me-Cypentane	1.94	1.02	.07	.14	.07	.07	.14	.07
234-Tri-Me-Pentane	1.20	.70	.47	.57	.33	.52	.63	.37
233-Tri-Me-Pentane	1.20	.70	.35	.42	.24	.39	.46	.27
Toluene	2.72	.63	6.72	18.27	4.23	7.68	20.88	4.84
2,3-Di-Me-Hexane	1.20	.70	.20	.24	.14	.21	.25	.15
2-Me-Heptane	1.20	.70	.69	.82	.48	.72	.86	.50
3-Me-Heptane	1.20	.70	.69	.83	.48	.78	.93	.55
225-Tri-Me-Hexane	1.13	.64	.38	.43	.25	.40	.45	.26
n-Octane	.61	.41	.45	.27	.18	.49	.30	.20
244-Tri-Me-Hexane	1.13	.64	.02	.03	.02	.02	.02	.01
235-Tri-Me-Hexane	1.13	.64	.02	.02	.01	.02	.02	.01
2,4-Di-Me-Heptane	1.13	.64	.07	.08	.05	.13	.15	.08

Table III-1q (Cont.)

Hydrocarbon Species	mg Ozone/ mg NMOG MIR	MOR	Test 51114, 8/07/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR	Test 51116, 8/08/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR
3,5-Di-Me-Heptane	1.13	.64	.15	.17	.10	.22	.25	.14
Ethyl-Benzene	2.90	.72	1.83	5.31	1.32	1.96	5.68	1.41
m-Xylene	8.15	2.46	3.82	31.15	9.40	4.07	33.14	10.00
p-Xylene	8.15	2.46	.88	7.16	2.16	.93	7.62	2.30
2-Me-Octane	1.13	.64	.25	.28	.16	.33	.37	.21
3-Me-Octane	1.13	.64	.17	.19	.11	.20	.23	.13
Styrene	2.20	-.29	.42	.92	-.12	.49	1.07	-.14
o-Xylene	6.68	2.00	1.64	10.98	3.29	1.78	11.92	3.57
n-Nonane	.54	.36	.15	.08	.06	.16	.09	.06
Cumene	2.41	.60	.06	.15	.04	.07	.16	.04
n-Propyl Benzene	2.27	.56	.19	.43	.11	.20	.46	.11
1-Et-3-Me-Benzene	7.20	2.17	.80	5.77	1.74	.86	6.23	1.88
1-Et-4-Me-Benzene	7.20	2.17	.28	2.03	.61	.31	2.23	.67
135-Tri-Me-Benzene	10.11	3.06	.35	3.49	1.06	.31	3.13	.95
1-Et-2-Me-Benzene	7.20	2.17	.24	1.73	.52	.27	1.93	.58
124-Tri-Me-Benzene	8.59	2.51	.54	4.62	1.35	.53	4.56	1.33
123-Tri-Me-Benzene	8.61	2.51	.04	.37	.11	.05	.44	.13
Indan	1.04	.13	.35	.36	.05	.07	.07	.01
Unidentified HC	3.50	1.40	5.13	17.95	7.18	4.23	14.79	5.92
Formaldehyde	7.14	2.08	7.62	54.38	15.84	4.37	31.20	9.09
Acetaldehyde	5.51	2.17	1.72	9.49	3.74	1.42	7.84	3.09
Acrolein	6.76	2.59	.28	1.91	.73	1.38	9.34	3.58
Acetone	.56	.20	.28	.15	.06	1.53	.86	.31
Propionaldehyde	6.53	2.50	.00	.00	.00	.21	1.35	.52
Crotonaldehyde	5.41	2.07	.00	.00	.00	.18	.96	.37
Benzaldehyde	-.56	-1.23	.32	-.18	-.40	.36	-.20	-.44
Pentanaldehyde	4.40	1.68	.00	.00	.00	.18	.81	.31
Total			86.27	322.57	120.61	86.77	304.15	115.30
Ozone/NMOG				3.74	1.40		3.51	1.33

Table III-1r

Speciated FTP Results
Chevrolet Cavalier, RF-A
(Data Obtained from Chevron Research)

Hydrocarbon Species	mg Ozone/ mg NMOG MIR	MOR	Test 51117, 8/09/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR
Ethylene	7.28	3.15	9.18	66.83	28.92
Acetylene	.51	.34	1.50	.77	.51
Ethane	.26	.18	4.57	1.19	.82
Propylene	9.39	3.77	1.68	15.75	6.32
Propane	.48	.31	.24	.12	.08
Allene	7.28	3.15	.73	5.34	2.31
2-Me-Propane	1.21	.73	.13	.15	.09
1-Butene/i-Butene	7.10	2.72	.69	4.87	1.87
n-Butane	1.02	.66	2.62	2.67	1.73
t-2-Butene	9.93	3.75	.02	.21	.08
c-2-Butene	9.93	3.75	.03	.26	.10
3-Me-1-Butene	6.22	2.46	.06	.36	.14
2-Me-Butane	1.38	.87	8.91	12.29	7.75
1-Pentene	6.22	2.46	.04	.25	.10
2-Me-1-Butene	4.89	1.90	.10	.48	.19
n-Pentane	1.03	.68	1.16	1.20	.79
t-2-Pentene	8.79	3.30	.03	.30	.11
c-2-Pentene	8.79	3.30	.02	.17	.06
2-Me-2-Butene	6.40	2.30	.35	2.24	.81
2,2-Di-Me-Butane	.82	.51	.79	.64	.40
Cyclopentene	7.65	2.78	.06	.46	.17
4-Me-1-Pentene/	4.41	1.74	.03	.11	.05
Cyclopentane	2.37	1.41	.17	.39	.23
2,3-Di-Me-Butane	1.07	.67	1.07	1.14	.72
2-Me-Pentane	1.53	.90	2.81	4.30	2.53
3-Me-Pentane	1.52	.94	1.57	2.39	1.48
1-Hexene/	4.41	1.74	.09	.41	.16
n-Hexane	.98	.64	.61	.60	.39
t-2-Hexene	6.67	2.50	.14	.96	.36
3-Me-t-2-Pentene	6.67	2.50	.12	.79	.30
2-Me-2-Pentene	6.67	2.50	.15	1.00	.37
c-2-Hexene	6.67	2.50	.02	.16	.06
3-Me-c-2-Pentene	6.67	2.50	.05	.33	.12
Me-Cyclopentane	2.82	1.55	.62	1.76	.97
2,4-Di-Me-Pentane	1.78	.99	.69	1.23	.68
1-Me-Cyclopentene	5.65	2.20	.15	.85	.33
Benzene	.42	.14	5.81	2.44	.81
Cyclohexane	1.28	.74	.06	.08	.05
2-Me-Hexane	1.40	.83	1.91	2.67	1.58
3-Me-Hexane	1.40	.83	.88	1.24	.73
c-1,3-Di-Me-Cypentane	2.54	1.38	.18	.46	.25
t-1,3-Di-Me-Cypentane	2.54	1.38	.12	.31	.17
224-Tri-Me-Pentane	.87	.51	2.47	2.15	1.26
n-Heptane	.81	.53	.69	.56	.37
Me-Cyclohexane	1.84	1.00	.30	.56	.30
2,5-Di-Me-Hexane	1.20	.70	.33	.39	.23
2,4-Di-Me-Hexane	1.20	.70	.39	.46	.27
124-Tri-Me-Cypentane	1.94	1.02	.07	.13	.07
234-Tri-Me-Pentane	1.20	.70	.57	.69	.40
233-Tri-Me-Pentane	1.20	.70	.42	.51	.30
Toluene	2.72	.63	8.09	22.02	5.10
2,3-Di-Me-Hexane	1.20	.70	.27	.32	.19
2-Me-Heptane	1.20	.70	.71	.85	.50
3-Me-Heptane	1.20	.70	.76	.92	.54
225-Tri-Me-Hexane	1.13	.64	.40	.45	.25
n-Octane	.61	.41	.43	.26	.17
244-Tri-Me-Hexane	1.13	.64	.02	.02	.01
235-Tri-Me-Hexane	1.13	.64	.02	.02	.01
2,4-Di-Me-Heptane	1.13	.64	.07	.08	.04
3,5-Di-Me-Heptane	1.13	.64	.13	.15	.08

Table III-1r (Cont.)

Hydrocarbon Species	mg Ozone/ mg NMOG MIR	MOR	Test 51117, 8/09/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR
Ethyl-Benzene	2.90	.72	2.02	5.86	1.46
m-Xylene	8.15	2.46	4.22	34.39	10.38
p-Xylene	8.15	2.46	.97	7.91	2.39
2-Me-Octane	1.13	.64	.35	.40	.22
3-Me-Octane	1.13	.64	.24	.27	.15
Styrene	2.20	-.29	.35	.77	-.10
o-Xylene	6.68	2.00	1.78	11.88	3.56
n-Nonane	.54	.36	.15	.08	.05
Cumene	2.41	.60	.08	.18	.05
n-Propyl Benzene	2.27	.56	.21	.49	.12
1-Et-3-Me-Benzene	7.20	2.17	.94	6.74	2.03
1-Et-4-Me-Benzene	7.20	2.17	.32	2.31	.70
135-Tri-Me-Benzene	10.11	3.06	.36	3.65	1.11
1-Et-2-Me-Benzene	7.20	2.17	.29	2.09	.63
124-Tri-Me-Benzene	8.59	2.51	.49	4.19	1.22
n-Decane	.47	.31	.01	.01	.00
123-Tri-Me-Benzene	8.61	2.51	.04	.31	.09
Indan	1.04	.13	.07	.08	.01
Unidentified HC	3.50	1.40	6.89	24.12	9.65
Formaldehyde	7.14	2.08	2.59	18.46	5.38
Acetaldehyde	5.51	2.17	1.30	7.16	2.82
Acrolein	6.76	2.59	.24	1.59	.61
Acetone	.56	.20	.78	.44	.16
Benzaldehyde	-.56	-1.23	.43	-.24	-.52
Total			91.42	303.85	117.94
Ozone/NMOG				3.32	1.29

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Table III-1s

Speciated FTP Results
Data Obtained from Auto/Oil Program, Fuel RF-A

Hydrocarbon Species	mg Ozone/ mg NMOG MIR	mg Ozone/ mg NMOG MOR	Dodge Shadow Test 2702AA, 4/19/90 NMOG (mg/mi)	Dodge Shadow Ozone (mg/mi) MIR	Dodge Shadow Ozone (mg/mi) MOR	Olds Delta 88 Test 3010AA 4/26/90 NMOG (mg/mi)	Olds Delta 88 Ozone (mg/mi) MIR	Olds Delta 88 Ozone (mg/mi) MOR
ETHENE	7.28	3.15	11.99	87.32	37.78	8.00	58.23	25.20
ETHYNE	.51	.34	6.61	3.37	2.25	3.29	1.68	1.12
ETHANE	.26	.18	2.85	.74	.51	1.65	.43	.30
PROPENE	9.39	3.77	4.56	42.81	17.19	3.92	36.78	14.77
PROPADIENE	7.28	3.15	.53	3.84	1.66	.00	.00	.00
2-METHYLPROPENE	5.29	1.93	2.04	10.79	3.94	1.27	6.73	2.46
1-BUTENE	8.90	3.51	.00	.00	.00	.62	5.50	2.17
1,3-BUTADIENE	10.88	4.16	.64	6.95	2.66	.53	5.74	2.20
N-BUTANE	1.02	.66	4.62	4.72	3.05	5.37	5.48	3.55
T-2-BUTENE	9.93	3.75	.51	5.08	1.92	.34	3.33	1.26
2-METHYLBUTANE	1.38	.87	3.49	4.82	3.04	4.36	6.02	3.79
N-PENTANE	1.03	.68	2.39	2.46	1.63	2.53	2.61	1.72
T-2-PENTENE	8.79	3.30	.34	2.96	1.11	.30	2.65	.99
2-METHYL-2-BUTENE	6.40	2.30	.58	3.71	1.33	.56	3.60	1.30
2,2-DIMETHYLBUTANE	.82	.51	.55	.45	.28	.59	.48	.30
2,3-DIMETHYLBUTANE	1.07	.67	.89	.95	.59	.69	.74	.47
2-METHYLPENTANE	1.53	.90	3.09	4.73	2.78	3.09	4.73	2.78
3-METHYLPENTANE	1.52	.94	1.65	2.51	1.55	1.62	2.47	1.53
HEXANE	.98	.64	1.52	1.49	.97	1.58	1.55	1.01
METHYLCYCLOPENTANE	2.82	1.55	.52	1.47	.81	.53	1.50	.82
2,4-DIMETHYLPENTANE	1.78	.99	.54	.96	.54	.53	.95	.53
BENZENE	.42	.14	7.36	3.09	1.03	7.97	3.35	1.12
2-METHYLHEXANE	1.40	.83	.69	.97	.57	.76	1.06	.63
2,3-DIMETHYLPENTANE	1.51	.90	.77	1.16	.69	.79	1.19	.71
3-METHYLHEXANE	1.40	.83	.76	1.06	.63	.80	1.12	.67
2,2,4-TRIMETHYLPENTANE	.87	.51	2.48	2.16	1.26	3.91	3.40	1.99
HEPTANE	.81	.53	.45	.36	.24	.60	.48	.32
2,5-DIMETHYLHEXANE	1.20	.70	.26	.31	.18	.31	.37	.22
2,4-DIMETHYLHEXANE	1.20	.70	.35	.42	.25	.42	.50	.29
2,3,4-TRIMETHYLPENTANE	1.20	.70	.91	1.09	.64	.95	1.15	.67
METHYLBENZENE (TOLUENE)	2.72	.63	9.75	26.53	6.15	10.17	27.66	6.41
2,3-DIMETHYLHEXANE	1.20	.70	.28	.33	.19	.00	.00	.00
2-METHYLHEPTANE	1.20	.70	.23	.28	.16	.26	.32	.18
3-METHYLHEPTANE	1.20	.70	.58	.70	.41	.63	.76	.44
2,2,5-TRIMETHYLHEXANE	1.13	.64	.00	.00	.00	.30	.34	.19
N-OCTANE	.61	.41	.40	.24	.16	.39	.24	.16
ETHYLBENZENE	2.90	.72	2.80	8.11	2.01	3.02	8.75	2.17
1,3-DIMETHYLBENZENE (M-XYLEN	8.15	2.46	7.42	60.45	18.25	7.14	58.21	17.57
4-METHYLOCTANE	1.13	.64	.41	.46	.26	.30	.34	.19
STYRENE	2.20	-.29	.31	.68	-.09	.48	1.05	-.14
1,2-DIMETHYLBENZENE (O-XYLEN	6.68	2.00	2.19	14.65	4.39	2.43	16.22	4.86
2,4-DIMETHYLOCTANE	1.01	.56	.00	.00	.00	.63	.64	.35
N-PROPYLBENZENE	2.27	.56	.36	.82	.20	.40	.91	.22
1-METHYL-3-ETHYLBENZENE	7.20	2.17	1.69	12.15	3.66	1.63	11.74	3.54
1-METHYL-4-ETHYLBENZENE	7.20	2.17	.75	5.43	1.64	.71	5.10	1.54
1,3,5-TRIMETHYLBENZENE	10.11	3.06	.74	7.52	2.28	.71	7.13	2.16
1-ETHYL-2-METHYLBENZENE	7.20	2.17	.59	4.27	1.29	.55	3.99	1.20
1,2,4-TRIMETHYLBENZENE	8.59	2.51	1.83	15.75	4.60	1.96	16.79	4.91
1,2,3-TRIMETHYLBENZENE	8.61	2.51	.46	3.93	1.15	.42	3.59	1.05
1,4-DIETHYLBENZENE	6.44	1.94	.00	.00	.00	.25	1.61	.48
N-BUTYLBENZENE	1.87	.43	.47	.88	.20	.61	1.13	.26
NAPHTHALENE	1.16	.10	.00	.00	.00	.29	.34	.03
FORMALDEHYDE	7.14	2.08	1.81	12.92	3.76	1.15	8.18	2.38
ACETALDEHYDE	5.51	2.17	1.39	7.66	3.02	.76	4.20	1.65
ACROLEIN	6.76	2.59	.30	2.03	.78	.11	.73	.28
ACETONE	.56	.20	1.51	.85	.30	1.02	.57	.20
PROPIONALDEHYDE	6.53	2.50	1.01	6.61	2.53	.00	.00	.00
CROTONALDEHYDE	5.41	2.07	.53	2.89	1.11	.00	.00	.00
N-BUTYRALDEHYDE	5.26	2.01	.06	.30	.12	.10	.52	.20
BUTANONE	1.18	.55	1.10	1.30	.61	.00	.00	.00
BENZALDEHYDE	-.56	-1.23	.00	.00	.00	.08	-.05	-.10
P-TOLUALDEHYDE	-.56	-1.23	.07	-.04	-.09	.65	-.37	-.80
Total			103.00	400.46	150.11	95.03	344.47	126.45
Ozone/NMOG				3.89	1.46		3.62	1.33

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Table III-2

Summary of Test Results for Methanol-Fueled Vehicles

Vehicle	Test #	Species Table #	Test Date	NMOG (g/mi)	CH4 (g/mi)	CO (g/mi)	NOx (g/mi)
ARB DATA							
Volkswagon Jetta	56C11	III-2a	08/27/91	.266	.011	2.03	.050
	56C12	n/a*	08/28/91	.256	.015	2.55	.062
	56C13	III-2b	08/29/91	.283	.017	2.57	.066
	56C14	n/a*	08/30/91	.301	.020	3.23	.067
			Mean:	.277	.016	2.59	.061
Chevrolet Lumina	52C16	III-2c	08/20/91	.311	.020	2.28	.257
	52C17	n/a*	08/21/91	.277	.021	2.90	.241
	52C18	III-2d	08/22/91	.244	.017	2.32	.220
	52C19	III-2d	08/23/91	.240	.022	2.36	.233
			Mean:	.268	.020	2.46	.238
AUTO/OIL DATA							
Spirit	6801MZ	III-2e	08/10/90	.149	.009	.96	.516
Caravan	0404MZ	III-2e	07/25/90	.153	.011	1.11	.453
Caravan	5403MZ	III-2f	07/02/90	.141	.009	1.00	.339
Caravan	7403MZ	III-2f	07/18/90	.130	.010	1.09	.390
			Mean:	.143	.010	1.04	.425
Corsica	8914MZ	III-2g	08/11/90	.317	.018	2.15	.318
Corsica	8517MZ	III-2h	09/04/90	.319	.016	2.49	.162
Corsica	0517MZ	III-2h	08/26/90	.263	.015	2.12	.195
Lumina	1719MZ	III-2i	06/07/90	.246	.024	2.98	.316
Lumina	0620MZ	III-2i	08/28/90	.236	.017	1.74	.346
			Mean:	.276	.018	2.30	.267

* Speciated results from these tests are not available.

Table III-2a

Speciated FTP Results
Volkswagen Jetta, M85

Light-End Species	mg Ozone/ mg NMOG MIR	mg Ozone/ mg NMOG MOR	Test 56C11, 8/27/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	Ozone (mg/mi) MOR
Ethane	.26	.18	1.46	.38	.26
Ethene	7.28	3.15	2.15	15.68	6.78
Propane	.48	.31	.11	.05	.03
Ethyne	.51	.34	.38	.20	.13
Methylpropane	1.21	.73	.00	.00	.00
Butane	1.02	.66	.77	.79	.51
Propene	9.39	3.77	.88	8.29	3.33
Methylbutane	1.38	.87	.31	.43	.27
Pentane	1.03	.68	.17	.17	.12
1-Butene	8.90	3.51	.08	.75	.30
2-Methylpropene	5.29	1.93	.60	3.19	1.16
Light-End HC Subtotal			6.93	29.92	12.89

Mid-Range Species	mg Ozone/ mg NMOG MIR	mg Ozone/ mg NMOG MOR	Test 56C11, 8/27/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	Ozone (mg/mi) MOR
1,3-butadiene	10.88	4.16	.09	1.02	.39
2,2-Dimethylbutane	.82	.51	.41	.34	.21
n-Hexane	.98	.64	.35	.34	.22
Methylcyclopentane	2.82	1.55	.19	.54	.30
C7H16 Alkane	1.40	.83	.27	.37	.22
Benzene	.42	.14	1.79	.75	.25
2-Methylhexane +Dimethylpentane	1.40	.83	.57	.80	.48
3-Methylhexane	1.40	.83	.29	.41	.24
2,2,4-Trimethylpentane + Alkene	2.59	1.11	1.81	4.70	2.01
n-Heptane	.81	.53	.20	.16	.10
Dimethylhexane	1.20	.70	.45	.53	.31
2,3,4-Trimethylpentane	1.20	.70	.65	.78	.46
Toluene + C8H18	2.72	.63	6.51	17.70	4.10
2,2,5-Trimethylhexane	1.13	.64	.17	.19	.11
Ethylbenzene	2.90	.72	.52	1.50	.37
m & p-Xylenes	7.47	2.24	1.64	12.25	3.67
o-Xylene	6.68	2.00	.52	3.46	1.04
3-Ethyltoluene	7.20	2.17	.33	2.41	.73
1,3,5-Trimethylbenzene	10.11	3.06	.23	2.28	.69
1,2,4-Trimethylbenzene	8.59	2.51	.56	4.85	1.42
Mid-Range HC Subtotal			17.54	55.39	17.32

Oxygenates	mg Ozone/ mg NMOG MIR	mg Ozone/ mg NMOG MOR	Test 56C11, 8/27/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	Ozone (mg/mi) MOR
Methanol	.56	.28	221.29	123.92	61.96
Formaldehyde	7.14	2.08	17.57	125.44	36.54
Acetaldehyde	5.51	2.17	.72	3.96	1.56
Acetone	.56	.20	1.64	.92	.33
Oxygenates Subtotal			241.22	254.24	100.39

Table III-2a (Cont.)

NMOG Summary		Test 56C11, 8/27/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR
Light-End Species		6.93	29.92	12.89
Mid-Range Species		17.54	55.39	17.32
Oxygenates		241.22	254.24	100.39
Total		265.70	339.56	130.60
Ozone/NMOG			1.28	.49

Table III-2b

Speciated FTP Results
Volkswagen Jetta, M85

Light-End Species	mg Ozone/ mg NMOG MIR	mg Ozone/ mg NMOG MOR	Test 56C13, 8/29/91 NMOG (mg/mi)	Test 56C13, 8/29/91 Ozone (mg/mi) MIR	Test 56C13, 8/29/91 Ozone (mg/mi) MOR
Ethane	.26	.18	1.78	.46	.32
Ethene	7.28	3.15	1.39	10.10	4.37
Propane	.48	.31	.10	.05	.03
Ethyne	.51	.34	.90	.46	.30
Methylpropane	1.21	.73	.12	.15	.09
Butane	1.02	.66	.62	.63	.41
Propene	9.39	3.77	.99	9.30	3.73
Methylbutane	1.38	.87	.95	1.31	.83
Pentane	1.03	.68	.56	.57	.38
1-Butene	8.90	3.51	.10	.87	.34
2-Methylpropene	5.29	1.93	.54	2.84	1.03
Light-End HC Subtotal			8.03	26.73	11.84

Mid-Range Species	mg Ozone/ mg NMOG MIR	mg Ozone/ mg NMOG MOR	Test 56C13, 8/29/91 NMOG (mg/mi)	Test 56C13, 8/29/91 Ozone (mg/mi) MIR	Test 56C13, 8/29/91 Ozone (mg/mi) MOR
1,3-butadiene	10.88	4.16	.14	1.56	.60
n-Hexane	.98	.64	.51	.50	.33
Methylcyclopentane	2.82	1.55	.21	.59	.33
C7H16 Alkane	1.40	.83	.33	.46	.27
Benzene	.42	.14	2.08	.87	.29
2-Methylhexane +Dimethylpentane	1.40	.83	.75	1.05	.62
3-Methylhexane	1.40	.83	.35	.50	.29
2,2,4-Trimethylpentane + Alkene	2.59	1.11	1.40	3.64	1.56
n-Heptane	.81	.53	.36	.29	.19
2,3,4-Trimethylpentane	1.20	.70	.28	.34	.20
Toluene + C8H18	2.72	.63	3.66	9.97	2.31
Methylheptane	1.20	.70	.23	.27	.16
Dimethylcyclohexane	1.94	1.02	.18	.35	.19
Ethylbenzene	2.90	.72	1.33	3.86	.96
m & p-Xylenes	7.47	2.24	2.94	21.93	6.58
Styrene	2.20	-.29	.19	.42	-.06
o-Xylene	6.68	2.00	.82	5.48	1.64
n-Propylbenzene	2.27	.56	.17	.39	.10
3-Ethyltoluene	7.20	2.17	.61	4.38	1.32
4-Ethyltoluene + C10cycloalkane	4.49	1.55	.23	1.03	.36
1,3,5-Trimethylbenzene	10.11	3.06	.34	3.43	1.04
2-Ethyltoluene	7.20	2.17	.18	1.31	.40
1,2,4-Trimethylbenzene	8.59	2.51	.91	7.84	2.29
Mid-Range HC Subtotal			18.23	70.50	21.96

Oxygenates	mg Ozone/ mg NMOG MIR	mg Ozone/ mg NMOG MOR	Test 56C13, 8/29/91 NMOG (mg/mi)	Test 56C13, 8/29/91 Ozone (mg/mi) MIR	Test 56C13, 8/29/91 Ozone (mg/mi) MOR
Methanol	.56	.28	233.05	130.51	65.25
Formaldehyde	7.14	2.08	18.71	133.57	38.91
Acetaldehyde	5.51	2.17	1.64	9.02	3.55
Acetone	.56	.20	3.07	1.72	.61
Oxygenates Subtotal			256.47	274.82	108.33

Table III-2b (Cont.)

NMOG Summary		Test 56C13, 8/29/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR
Light-End Species		8.03	26.73	11.84
Mid-Range Species		18.23	70.50	21.96
Oxygenates		256.47	274.82	108.33
Total		282.73	372.05	142.13
Ozone/NMOG			1.32	.50

Table III-2c

Speciated FTP Results
Chevrolet Lumina, M85

Light-End Species	mg Ozone/ mg NMOG MIR	MOR	Test 52C16, 8/20/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR
Ethane	.26	.18	.70	.18	.13
Ethene	7.28	3.15	.84	6.11	2.64
Propane	.48	.31	.01	.01	.00
Ethyne	.51	.34	.38	.19	.13
Methylpropane	1.21	.73	.06	.07	.04
Butane	1.02	.66	1.06	1.08	.70
Propene	9.39	3.77	1.09	10.22	4.11
Methylbutane	1.38	.87	1.18	1.62	1.02
Pentane	1.03	.68	.82	.84	.56
1-Butene	8.90	3.51	.21	1.91	.75
2-Methylpropene	5.29	1.93	.73	3.89	1.42
Light-End HC Subtotal			7.08	26.13	11.50

Mid-Range Species	mg Ozone/ mg NMOG MIR	MOR	Test 52C16, 8/20/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR
1,3-butadiene	10.88	4.16	.12	1.27	.49
Cyclopentene	7.65	2.78	1.11	8.47	3.08
n-Hexane	.98	.64	1.15	1.13	.74
~~Methylcyclopentane~~	~~2.82~~	~~1.55~~	~~1.09~~	~~3.07~~	~~1.69~~
C7H16 Alkane	1.40	.83	.40	.56	.33
Benzene	.42	.14	3.23	1.36	.45
2-Methylhexane +Dimethylpentane	1.40	.83	1.71	2.39	1.42
3-Methylhexane	1.40	.83	1.13	1.59	.94
2,2,4-Trimethylpentane + Alkene	2.59	1.11	1.93	5.01	2.15
n-Heptane	.81	.53	.46	.38	.25
Methylcyclohexane	1.84	1.00	.36	.66	.36
Dimethylhexane	1.20	.70	.51	.62	.36
2,3,4-Trimethylpentane	1.20	.70	.41	.49	.29
Toluene + C8H18	2.72	.63	5.16	14.02	3.25
Methylheptane	1.20	.70	.42	.50	.29
Dimethylcyclohexane	1.94	1.02	.34	.66	.35
2,2,5-Trimethylhexane	1.13	.64	.21	.24	.13
n-Octane	.61	.41	.21	.13	.09
Ethylbenzene	2.90	.72	1.26	3.65	.91
m & p-Xylenes	7.47	2.24	3.77	28.14	8.44
Styrene	2.20	-.29	.20	.45	-.06
o-Xylene	6.68	2.00	1.13	7.53	2.26
n-Propylbenzene	2.27	.56	.21	.49	.12
3-Ethyltoluene	7.20	2.17	.79	5.66	1.70
4-Ethyltoluene + C10cycloalkane	4.49	1.55	.30	1.35	.47
1,3,5-Trimethylbenzene	10.11	3.06	.44	4.41	1.34
2-Ethyltoluene	7.20	2.17	.24	1.70	.51
1,2,4-Trimethylbenzene	8.59	2.51	1.09	9.37	2.74
Mid-Range HC Subtotal			29.36	105.27	35.05

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Table III-2c (Cont.)

Oxygenates	mg Ozone/ mg NMOG MIR	MOR	Test 52C16, 8/20/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR
Methanol	.56	.28	255.98	143.35	71.67
Formaldehyde	7.14	2.08	16.31	116.45	33.92
Acetaldehyde	5.51	2.17	.88	4.87	1.92
Acrolein	6.76	2.59	.08	.57	.22
Acetone	.56	.20	1.22	.68	.24
Oxygenates Subtotal			274.47	265.92	107.98

NMOG Summary		Test 52C16, 8/20/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR
Light-End Species		7.08	26.13	11.50
Mid-Range Species		29.36	105.27	35.05
Oxygenates		274.47	265.92	107.98
Total		310.92	397.32	154.53
Ozone/NMOG			1.28	.50

Table III-2d

Speciated FTP Results
Chevrolet Lumina, M85

Light-End Species	mg Ozone/ mg NMOG MIR	mg Ozone/ mg NMOG MOR	Test 52c18, 8/22/91 NMOG (mg/mi)	Test 52c18 Ozone (mg/mi) MIR	Test 52c18 Ozone (mg/mi) MOR	Test 52c19, 8/23/91 NMOG (mg/mi)	Test 52c19 Ozone (mg/mi) MIR	Test 52c19 Ozone (mg/mi) MOR
Ethane	.26	.18	.64	.17	.12	1.09	.28	.20
Ethene	7.28	3.15	2.15	15.69	6.79	2.19	15.92	6.89
Propane	.48	.31	.09	.04	.03	.11	.05	.03
Ethyne	.51	.34	.41	.21	.14	.17	.09	.06
Methylpropane	1.21	.73	.46	.55	.33	.05	.07	.04
Butane	1.02	.66	1.00	1.02	.66	.95	.97	.63
Propene	9.39	3.77	1.20	11.27	4.52	1.25	11.70	4.70
Methylbutane	1.38	.87	.96	1.32	.83	1.34	1.86	1.17
Pentane	1.03	.68	.77	.79	.52	.87	.89	.59
1-Butene	8.90	3.51	.22	1.99	.79	.23	2.09	.82
2-Methylpropene	5.29	1.93	.67	3.52	1.28	.74	3.90	1.42
Light-End HC Subtotal			8.57	36.57	16.01	8.99	37.82	16.55

Mid-Range Species	mg Ozone/ mg NMOG MIR	mg Ozone/ mg NMOG MOR	Test 52c18, 8/22/91 NMOG (mg/mi)	Test 52c18 Ozone (mg/mi) MIR	Test 52c18 Ozone (mg/mi) MOR	Test 52c19, 8/23/91 NMOG (mg/mi)	Test 52c19 Ozone (mg/mi) MIR	Test 52c19 Ozone (mg/mi) MOR
1,3-butadiene	10.88	4.16	.17	1.89	.72	.11	1.19	.46
Cyclopentene	7.65	2.78	.84	6.45	2.34	.00	.00	.00
n-Hexane	.98	.64	.80	.78	.51	.70	.68	.45
Methylcyclopentane	2.82	1.55	.35	.98	.54	.33	.94	.51
C7H16 Alkane	1.40	.83	.39	.54	.32	.45	.64	.38
Benzene	.42	.14	3.94	1.66	.55	3.24	1.36	.45
2-Methylhexane +Dimethylpentane	1.40	.83	1.07	1.50	.89	.97	1.36	.81
3-Methylhexane	1.40	.83	.51	.72	.43	.46	.65	.39
2,2,4-Trimethylpentane + Alkene	2.59	1.11	1.58	4.10	1.76	1.44	3.72	1.59
n-Heptane	.81	.53	.51	.42	.27	.44	.35	.23
2,3,4-Trimethylpentane	1.20	.70	.36	.44	.25	.33	.39	.23
Toluene + C8H18	2.72	.63	3.91	10.65	2.47	4.39	11.95	2.77
Methylheptane	1.20	.70	.25	.30	.17	.23	.27	.16
Dimethylcyclohexane	1.94	1.02	.26	.50	.26	.22	.42	.22
2,2,5-Trimethylhexane	1.13	.64	.25	.28	.16	.23	.26	.15
Ethylbenzene	2.90	.72	1.17	3.38	.84	1.03	2.99	.74
m & p-Xylenes	7.47	2.24	2.58	19.30	5.79	2.58	19.28	5.78
Styrene	2.20	-.29	.19	.42	-.06	.16	.36	-.05
o-Xylene	6.68	2.00	.99	6.64	1.99	.86	5.75	1.72
n-Propylbenzene	2.27	.56	.20	.45	.11	.18	.41	.10
3-Ethyltoluene	7.20	2.17	.41	2.92	.88	.61	4.36	1.32
4-Ethyltoluene + C10cycloalkane	4.49	1.55	.26	1.17	.40	.24	1.07	.37
1,3,5-Trimethylbenzene	10.11	3.06	.38	3.83	1.16	.34	3.41	1.03
2-Ethyltoluene	7.20	2.17	.21	1.50	.45	.18	1.31	.39
1,2,4-Trimethylbenzene	8.59	2.51	.63	5.42	1.58	.82	7.07	2.06
Mid-Range HC Subtotal			22.21	76.23	24.79	20.54	70.22	22.27

Oxygenates	mg Ozone/ mg NMOG MIR	mg Ozone/ mg NMOG MOR	Test 52c18, 8/22/91 NMOG (mg/mi)	Test 52c18 Ozone (mg/mi) MIR	Test 52c18 Ozone (mg/mi) MOR	Test 52c19, 8/23/91 NMOG (mg/mi)	Test 52c19 Ozone (mg/mi) MIR	Test 52c19 Ozone (mg/mi) MOR
Methanol	.56	.28	196.18	109.86	54.93	192.32	107.70	53.85
Formaldehyde	7.14	2.08	12.59	89.86	26.18	14.89	106.34	30.98
Acetaldehyde	5.51	2.17	.91	5.03	1.98	.83	4.57	1.80
Acrolein	6.76	2.59	.07	.50	.19	.07	.50	.19
Acetone	.56	.20	3.26	1.82	.65	2.22	1.24	.44
Oxygenates Subtotal			213.01	207.08	83.93	210.33	220.35	87.26

Table III-2d (Cont.)

NMOG Summary		Test 52c18, 8/22/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR	Test 52c19, 8/23/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR
Light-End Species		8.57	36.57	16.01	8.99	37.82	16.55
Mid-Range Species		22.21	76.23	24.79	20.54	70.22	22.27
Oxygenates		213.01	207.08	83.93	210.33	220.35	87.26
Total		243.79	319.88	124.74	239.87	328.38	126.08
Ozone/NMOG			1.31	.51		1.37	.53

Table III-2e

Speciated FTP Results
Auto/Oil Dodges, M85

Hydrocarbon Species	mg Ozone/ mg NMOG		Dodge Spirit, Veh 01M Test 6801MZ, 8/10/90			Dodge Caravan, Veh 04M Test 0404MZ, 7/25/90		
	MIR	MOR	NMOG (mg/mi)	Ozone (mg/mi) MIR	Ozone (mg/mi) MOR	NMOG (mg/mi)	Ozone (mg/mi) MIR	Ozone (mg/mi) MOR
ETHENE	7.28	3.15	1.53	11.13	4.82	1.45	10.59	4.58
ETHYNE	.51	.34	1.58	.81	.54	.94	.48	.32
PROPENE	9.39	3.77	.42	3.92	1.57	.62	5.79	2.32
N-BUTANE	1.02	.66	1.22	1.24	.80	4.58	4.68	3.03
2-METHYLBUTANE	1.38	.87	1.14	1.58	1.00	1.64	2.27	1.43
N-PENTANE	1.03	.68	.97	1.00	.66	1.00	1.02	.68
2-METHYLPENTANE	1.53	.90	.62	.95	.56	.58	.88	.52
3-METHYLPENTANE	1.52	.94	.36	.54	.33	.27	.42	.26
HEXANE	.98	.64	.29	.28	.18	.00	.00	.00
BENZENE	.42	.14	1.42	.60	.20	2.61	1.10	.37
2,2,4-TRIMETHYLPENTANE	.87	.51	.46	.40	.24	.57	.50	.29
METHYLBENZENE (TOLUENE)	2.72	.63	2.40	6.52	1.51	2.52	6.86	1.59
ETHYLBENZENE	2.90	.72	.63	1.84	.46	.73	2.13	.53
1,3-DIMETHYLBENZENE (M-XYLEN	8.15	2.46	1.61	13.13	3.96	1.86	15.17	4.58
1,2-DIMETHYLBENZENE (O-XYLEN	6.68	2.00	.58	3.88	1.16	.72	4.78	1.43
1-METHYL-3-ETHYLBENZENE	7.20	2.17	.56	4.03	1.22	.59	4.26	1.28
1-METHYL-4-ETHYLBENZENE	7.20	2.17	.28	2.02	.61	.00	.00	.00
1,3,5-TRIMETHYLBENZENE	10.11	3.06	.23	2.28	.69	.00	.00	.00
1,2,4-TRIMETHYLBENZENE	8.59	2.51	.69	5.90	1.72	.00	.00	.00
N-BUTYLBENZENE	1.87	.43	.41	.76	.18	.00	.00	.00
1,2-DIETHYLBENZENE	6.44	1.94	.28	1.82	.55	.00	.00	.00
N-UNDECANE	.42	.28	.22	.09	.06	.00	.00	.00
NAPHTHALENE	1.16	.10	.30	.35	.03	.00	.00	.00
FORMALDEHYDE	7.14	2.08	3.37	24.09	7.02	5.67	40.45	11.78
ACETONE	.56	.20	.13	.07	.03	.94	.53	.19
CROTONALDEHYDE	5.41	2.07	.41	2.22	.85	.00	.00	.00
METHANOL	.56	.28	127.16	71.21	35.60	126.00	70.56	35.28
Total			149.27	162.67	66.54	153.30	172.46	70.46
Ozone/NMOG				1.09	.45		1.12	.46

08043

Table III-2f

Speciated FTP Results
Auto/Oil Dodges, M85

Hydrocarbon Species	mg Ozone/ mg NMOG MIR	mg Ozone/ mg NMOG MOR	Dodge Caravan, Veh 03M Test 5303MZ, 7/02/90 NMOG (mg/mi)	Ozone (mg/mi) MIR	Ozone (mg/mi) MOR	Dodge Caravan, Veh 03M Test 7403MZ, 7/18/90 NMOG (mg/mi)	Ozone (mg/mi) MIR	Ozone (mg/mi) MOR
ETHENE	7.28	3.15	1.15	8.40	3.63	1.75	12.73	5.51
ETHYNE	.51	.34	.77	.39	.26	.83	.42	.28
PROPENE	9.39	3.77	.50	4.73	1.90	.38	3.60	1.45
N-BUTANE	1.02	.66	1.66	1.69	1.09	1.44	1.47	.95
2-METHYLBUTANE	1.38	.87	.73	1.00	.63	.72	1.00	.63
N-PENTANE	1.03	.68	.49	.50	.33	.66	.68	.45
CYCLOPENTANE	2.37	1.41	.49	1.17	.70	.00	.00	.00
2-METHYLPENTANE	1.53	.90	.55	.84	.49	.63	.97	.57
3-METHYLPENTANE	1.52	.94	.35	.53	.33	.26	.40	.25
BENZENE	.42	.14	1.00	.42	.14	1.07	.45	.15
3-METHYL-1-HEXENE	3.48	1.37	.00	.00	.00	.84	2.93	1.15
2,2,4-TRIMETHYLPENTANE	.87	.51	.45	.39	.23	.31	.27	.16
METHYLBENZENE (TOLUENE)	2.72	.63	1.78	4.84	1.12	1.65	4.48	1.04
ETHYLBENZENE	2.90	.72	.63	1.82	.45	.22	.65	.16
1,3-DIMETHYLBENZENE (M-XYLEN	8.15	2.46	1.23	10.01	3.02	.00	.00	.00
1,2-DIMETHYLBENZENE (O-XYLEN	6.68	2.00	.47	3.17	.95	.00	.00	.00
1,2,3,4-TETRAMETHYLBENZENE	9.05	2.74	3.45	31.22	9.45	.00	.00	.00
FORMALDEHYDE	7.14	2.08	8.14	58.09	16.92	3.33	23.80	6.93
ACETONE	.56	.20	.11	.06	.02	.38	.21	.08
BENZALDEHYDE	-.56	-1.23	.44	-.25	-.55	.00	.00	.00
METHANOL	.56	.28	116.64	65.32	32.66	115.42	64.63	32.32
Total			141.04	194.35	73.79	129.91	118.70	52.07
Ozone/NMOG				1.38	.52		.91	.40

Table III-2g

Speciated FTP Results
Auto/Oil Chevrolet Corsica, M85

Hydrocarbon Species	mg Ozone/ mg NMOG MIR	MOR	Chevy Corsica, Veh 14M Test 8914MZ, 8/11/90 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR
ETHENE	7.28	3.15	4.80	34.91	15.11
ETHYNE	.51	.34	1.42	.72	.48
ETHANE	.26	.18	1.09	.28	.20
PROPENE	9.39	3.77	1.79	16.81	6.75
2-METHYLPROPENE	5.29	1.93	1.13	5.95	2.17
1,3-BUTADIENE	10.88	4.16	.38	4.09	1.57
N-BUTANE	1.02	.66	5.83	5.94	3.85
2-METHYLBUTANE	1.38	.87	2.52	3.47	2.19
N-PENTANE	1.03	.68	2.06	2.12	1.40
2,2-DIMETHYLBUTANE	.82	.51	.49	.40	.25
CYCLOPENTANE	2.37	1.41	.74	1.75	1.04
2,3-DIMETHYLBUTANE	1.07	.67	.58	.62	.39
2-METHYLPENTANE	1.53	.90	2.27	3.47	2.04
3-METHYLPENTANE	1.52	.94	.83	1.27	.78
HEXANE	.98	.64	.85	.84	.55
METHYLCYCLOPENTANE	2.82	1.55	.47	1.32	.73
2,4-DIMETHYLPENTANE	1.78	.99	.36	.64	.36
BENZENE	.42	.14	3.50	1.47	.49
2-METHYLHEXANE	1.40	.83	.45	.63	.37
2,3-DIMETHYLPENTANE	1.51	.90	.51	.77	.46
3-METHYLHEXANE	1.40	.83	.49	.68	.41
2,2,4-TRIMETHYLPENTANE	.87	.51	1.25	1.09	.64
HEPTANE	.81	.53	.36	.29	.19
2,3,4-TRIMETHYLPENTANE	1.20	.70	.72	.86	.50
METHYLBENZENE (TOLUENE)	2.72	.63	4.34	11.81	2.74
2-METHYLHEPTANE	1.20	.70	.24	.29	.17
3-METHYLHEPTANE	1.20	.70	.45	.53	.31
2,3,5-TRIMETHYLHEXANE	1.13	.64	1.36	1.53	.87
ETHYLBENZENE	2.90	.72	1.32	3.82	.95
1,3-DIMETHYLBENZENE (M-XYLEN	8.15	2.46	3.34	27.25	8.23
3-METHYLOCTANE	1.13	.64	.59	.67	.38
STYRENE	2.20	-.29	.22	.49	-.06
1,2-DIMETHYLBENZENE (O-XYLEN	6.68	2.00	1.21	8.08	2.42
2,4-DIMETHYLOCTANE	1.01	.56	.38	.39	.21
N-PROPYLBENZENE	2.27	.56	.27	.61	.15
1-METHYL-3-ETHYLBENZENE	7.20	2.17	.96	6.91	2.08
1-METHYL-4-ETHYLBENZENE	7.20	2.17	.44	3.15	.95
1,3,5-TRIMETHYLBENZENE	10.11	3.06	.50	5.07	1.53
1-ETHYL-2-METHYLBENZENE	7.20	2.17	.39	2.84	.86
FORMALDEHYDE	7.14	2.08	9.77	69.74	20.32
ACETALDEHYDE	5.51	2.17	.26	1.44	.57
ACETONE	.56	.20	.23	.13	.05
METHANOL	.56	.28	255.41	143.03	71.51
Total			316.56	378.20	157.12
Ozone/NMOG				1.19	.50

08045

Table III-2h

Speciated FTP Results
Auto/Oil Chevrolet Corsica, M85

Hydrocarbon Species	mg Ozone/ mg NMOG MIR	MOR	Chevy Corsica, Veh 17M Test 8517MZ, 9/04/90 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR	Chevy Corsica, Veh 17M Test 0517MZ, 8/26/90 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR
ETHENE	7.28	3.15	2.56	18.65	8.07	2.44	17.79	7.70
ETHYNE	.51	.34	1.17	.59	.40	.62	.32	.21
PROPENE	9.39	3.77	1.60	14.98	6.01	1.51	14.15	5.68
2-METHYLPROPENE	5.29	1.93	.78	4.11	1.50	.70	3.73	1.36
1,3-BUTADIENE	10.88	4.16	.24	2.66	1.02	.32	3.50	1.34
N-BUTANE	1.02	.66	3.45	3.52	2.28	3.63	3.70	2.40
2-METHYLBUTANE	1.38	.87	1.81	2.49	1.57	2.15	2.97	1.87
N-PENTANE	1.03	.68	.81	.83	.55	1.15	1.18	.78
2-METHYL-2-BUTENE	6.40	2.30	.42	2.68	.96	.32	2.03	.73
2,2-DIMETHYLBUTANE	.82	.51	.43	.36	.22	.32	.27	.16
CYCLOPENTANE	2.37	1.41	.00	.00	.00	.41	.97	.58
2,3-DIMETHYLBUTANE	1.07	.67	.51	.54	.34	.47	.51	.32
2-METHYLPENTANE	1.53	.90	1.78	2.72	1.60	1.83	2.80	1.65
3-METHYLPENTANE	1.52	.94	.73	1.11	.69	.74	1.12	.69
HEXANE	.98	.64	.70	.68	.45	.51	.50	.33
METHYLCYCLOPENTANE	2.82	1.55	.30	.85	.47	.00	.00	.00
BENZENE	.42	.14	4.34	1.82	.61	2.11	.88	.29
2-METHYLHEXANE	1.40	.83	.38	.53	.31	.30	.42	.25
2,3-DIMETHYLPENTANE	1.51	.90	.49	.75	.44	.42	.63	.37
3-METHYLHEXANE	1.40	.83	.43	.60	.36	.37	.52	.31
2,2,4-TRIMETHYLPENTANE	.87	.51	1.18	1.03	.60	1.01	.87	.51
HEPTANE	.81	.53	.34	.28	.18	.00	.00	.00
2,3,4-TRIMETHYLPENTANE	1.20	.70	.56	.68	.40	.63	.75	.44
METHYLBENZENE (TOLUENE)	2.72	.63	3.62	9.84	2.28	3.64	9.91	2.30
2-METHYLHEPTANE	1.20	.70	.22	.26	.15	.22	.26	.15
3-METHYLHEPTANE	1.20	.70	.25	.30	.17	.00	.00	.00
2,2,5-TRIMETHYLHEXANE	1.13	.64	.00	.00	.00	1.25	1.41	.80
ETHYLBENZENE	2.90	.72	1.20	3.47	.86	.92	2.66	.66
1,3-DIMETHYLBENZENE (M-XYLEN	8.15	2.46	3.26	26.55	8.01	2.99	24.40	7.36
STYRENE	2.20	-.29	.24	.52	-.07	.21	.45	-.06
1,2-DIMETHYLBENZENE (O-XYLEN	6.68	2.00	1.21	8.07	2.41	1.13	7.54	2.26
2,4-DIMETHYLOCTANE	1.01	.56	.30	.31	.17	.32	.32	.18
N-PROPYLBENZENE	2.27	.56	.30	.69	.17	.24	.55	.14
1-METHYL-3-ETHYLBENZENE	7.20	2.17	.69	4.94	1.49	1.03	7.41	2.23
1-METHYL-4-ETHYLBENZENE	7.20	2.17	.33	2.38	.72	.43	3.11	.94
1,3,5-TRIMETHYLBENZENE	10.11	3.06	.42	4.21	1.27	.47	4.76	1.44
1-ETHYL-2-METHYLBENZENE	7.20	2.17	.33	2.36	.71	.00	.00	.00
1,2,4-TRIMETHYLBENZENE	8.59	2.51	1.22	10.52	3.07	1.28	11.02	3.22
1,2,3,4-TETRAMETHYLBENZENE	9.05	2.74	.00	.00	.00	3.00	27.12	8.21
NAPHTHALENE	1.16	.10	.39	.45	.04	.35	.40	.03
FORMALDEHYDE	7.14	2.08	17.34	123.82	36.07	15.12	107.94	31.44
ACETALDEHYDE	5.51	2.17	.35	1.93	.76	.00	.00	.00
ACETONE	.56	.20	.57	.32	.11	.00	.00	.00
METHANOL	.56	.28	261.37	146.37	73.18	208.04	116.50	58.25
Total			318.61	409.77	160.63	262.59	385.38	147.52
Ozone/NMOG				1.29	.50		1.47	.56

Table III-21

Speciated FTP Results
Auto/Oil Chevrolet Luminas, M85

Hydrocarbon Species	mg Ozone/ mg NMOG		Chevy Lumina, Veh 19M Test 1719MZ, 6/07/90			Chevy Lumina, Veh 20M Test 0620MZ, 8/28/90		
	MIR	MOR	NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR	NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR
ETHENE	7.28	3.15	4.44	32.29	13.97	3.08	22.43	9.70
ETHYNE	.51	.34	.70	.35	.24	1.09	.56	.37
ETHANE	.26	.18	1.06	.28	.19	.00	.00	.00
PROPENE	9.39	3.77	1.96	18.43	7.40	1.57	14.78	5.93
2-METHYLPROPENE	5.29	1.93	.98	5.21	1.90	.74	3.93	1.43
1,3-BUTADIENE	10.88	4.16	.29	3.10	1.19	.00	.00	.00
N-BUTANE	1.02	.66	4.50	4.59	2.97	4.17	4.25	2.75
2-METHYLBUTANE	1.38	.87	4.24	5.85	3.69	1.77	2.44	1.54
N-PENTANE	1.03	.68	1.66	1.71	1.13	1.17	1.20	.79
2-METHYL-2-BUTENE	6.40	2.30	.00	.00	.00	.38	2.44	.88
2,2-DIMETHYLBUTANE	.82	.51	.00	.00	.00	.37	.30	.19
CYCLOPENTANE	2.37	1.41	.00	.00	.00	1.70	4.04	2.40
2,3-DIMETHYLBUTANE	1.07	.67	.29	.31	.20	.39	.41	.26
2-METHYLPENTANE	1.53	.90	1.67	2.56	1.51	1.57	2.40	1.41
3-METHYLPENTANE	1.52	.94	.54	.81	.50	.61	.93	.57
HEXANE	.98	.64	.47	.46	.30	.52	.51	.33
BENZENE	.42	.14	.00	.00	.00	1.87	.78	.26
2-METHYLHEXANE	1.40	.83	.00	.00	.00	.25	.35	.21
2,3-DIMETHYLPENTANE	1.51	.90	.35	.53	.31	.36	.55	.33
3-METHYLHEXANE	1.40	.83	.00	.00	.00	.30	.42	.25
2,2,4-TRIMETHYLPENTANE	.87	.51	1.24	1.08	.63	1.02	.89	.52
METHYLBENZENE (TOLUENE)	2.72	.63	4.70	12.78	2.96	3.54	9.62	2.23
ETHYLBENZENE	2.90	.72	1.14	3.30	.82	.85	2.48	.61
1,3-DIMETHYLBENZENE (M-XYLEN	8.15	2.46	2.89	23.56	7.11	2.05	16.68	5.03
1,2-DIMETHYLBENZENE (O-XYLEN	6.68	2.00	1.78	11.91	3.56	.83	5.54	1.66
N-PROPYLBENZENE	2.27	.56	.00	.00	.00	3.31	7.50	1.85
1-METHYL-3-ETHYLBENZENE	7.20	2.17	1.41	10.15	3.06	.34	2.42	.73
1,3,5-TRIMETHYLBENZENE	10.11	3.06	.00	.00	.00	.30	3.01	.91
1,2,4-TRIMETHYLBENZENE	8.59	2.51	.74	6.40	1.87	.69	5.95	1.74
1,2,3,4-TETRAMETHYLBENZENE	9.05	2.74	.00	.00	.00	.32	2.87	.87
FORMALDEHYDE	7.14	2.08	13.37	95.49	27.82	15.89	113.43	33.04
ACETALDEHYDE	5.51	2.17	.24	1.35	.53	.37	2.01	.79
ACROLEIN	6.76	2.59	.28	1.89	.72	.16	1.10	.42
ACETONE	.56	.20	.11	.06	.02	.32	.18	.06
BUTANONE	1.18	.55	.25	.30	.14	.00	.00	.00
P-TOLUALDEHYDE	-.56	-1.23	.51	-.28	-.62	.00	.00	.00
HEXANALDEHYDE	3.79	1.45	.00	.00	.00	2.32	8.79	3.36
METHANOL	.56	.28	193.87	108.57	54.28	181.54	101.66	50.83
Total			245.69	353.03	138.40	235.73	346.84	134.28
Ozone/NMOG				1.44	.56		1.47	.57

Table III-3

Summary of Test Results for Ethanol-Fueled Vehicles

Vehicle	Test #	Species Table #	Test Date	NMOG (g/mi)	CH4 (g/mi)	CO (g/mi)	NOx (g/mi)
Volkswagen Jetta	56C15 56C16 56C17	III-3a III-3a III-3b	09/04/91 09/05/91 09/06/91	.294 .314 .298	.055 .060 .062	3.58 4.25 4.29	.057 .065 .060
			Mean:	.302	.059	4.04	.061
Chevrolet Lumina	52C20 52C21 52C22 52C23 52C24	III-3c III-3c III-3d III-3d III-3e	08/27/91 08/28/91 08/29/91 08/30/91 09/04/91	.205 .240 .301 .252 .318	.057 .059 .057 .064 .067	1.66 1.76 1.69 1.75 1.63	.272 .259 .238 .276 .274
			Mean:	.263	.061	1.70	.264

Table III-3a

Speciated FTP Results
Volkswagen Jetta, E85

Light-End Species	mg Ozone/ mg NMOG MIR	MOR	Test 56C15, 9/4/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR	Test 56C16, 9/5/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR
Ethane	.26	.18	3.87	1.01	.70	2.80	.73	.50
Ethene	7.28	3.15	15.70	114.29	49.45	14.64	106.61	46.13
Propane	.48	.31	1.76	.85	.55	.26	.13	.08
Ethyne	.51	.34	7.16	3.65	2.44	6.87	3.51	2.34
Methylpropane	1.21	.73	.10	.12	.07	.56	.67	.41
Butane	1.02	.66	2.34	2.39	1.55	2.06	2.11	1.36
Propene	9.39	3.77	1.32	12.42	4.99	1.23	11.53	4.63
Methylbutane	1.38	.87	1.61	2.22	1.40	1.38	1.91	1.20
Pentane	1.03	.68	1.59	1.63	1.08	1.42	1.47	.97
1-Butene	8.90	3.51	.21	1.88	.74	.17	1.54	.61
2-Methylpropene	5.29	1.93	.78	4.12	1.50	.71	3.74	1.36
Light-End HC Subtotal			36.45	144.59	64.46	32.12	133.94	59.59

Mid-Range Species	mg Ozone/ mg NMOG MIR	MOR	Test 56C15, 9/4/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR	Test 56C16, 9/5/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR
1,3-butadiene	10.88	4.16	.21	2.26	.86	.17	1.85	.71
n-Hexane	.98	.64	1.07	1.05	.69	.97	.95	.62
Methylcyclopentane	2.82	1.55	.46	1.29	.71	.45	1.28	.70
C7H16 Alkane	1.40	.83	.28	.39	.23	.36	.50	.30
~~Benzene~~	~~.42~~	~~.14~~	~~2.60~~	~~1.09~~	~~.36~~	~~2.77~~	~~1.16~~	~~.39~~
Cyclohexane	1.28	.74	.18	.23	.14	.18	.23	.13
2-Methylhexane +Dimethylpentane	1.40	.83	.89	1.25	.74	.80	1.11	.66
3-Methylhexane	1.40	.83	.51	.72	.43	.45	.63	.37
2,2,4-Trimethylpentane + Alkene	2.59	1.11	1.39	3.61	1.55	1.46	3.79	1.63
n-Heptane	.81	.53	.51	.41	.27	.46	.37	.24
Methylcyclohexane	1.84	1.00	.30	.55	.30	.26	.48	.26
2,3,4-Trimethylpentane	1.20	.70	.27	.33	.19	.24	.28	.16
Toluene + C8H18	2.72	.63	3.07	8.35	1.93	3.21	8.74	2.02
Methylheptane	1.20	.70	.22	.26	.15	.19	.23	.13
Dimethylcyclohexane	1.94	1.02	.21	.40	.21	.19	.36	.19
Ethylbenzene	2.90	.72	.78	2.25	.56	.73	2.11	.52
Trimethylcyclohexane	2.30	1.18	.00	.00	.00	.00	.00	.00
m & p-Xylenes	7.47	2.24	2.47	18.46	5.53	3.22	24.03	7.21
Styrene	2.20	-.29	.00	.00	.00	.15	.32	-.04
o-Xylene	6.68	2.00	.69	4.61	1.38	.60	4.01	1.20
3-Ethyltoluene	7.20	2.17	.52	3.75	1.13	.52	3.73	1.12
4-Ethyltoluene + C10cycloalkane	4.49	1.55	.20	.92	.32	.19	.85	.29
1,3,5-Trimethylbenzene	10.11	3.06	.30	3.03	.92	.27	2.75	.83
2-Ethyltoluene	7.20	2.17	.17	1.22	.37	.16	1.12	.34
1,2,4-Trimethylbenzene	8.59	2.51	.74	6.34	1.85	.65	5.56	1.62
Mid-Range HC Subtotal			18.05	62.78	20.82	18.64	66.45	21.63

Oxygenates	mg Ozone/ mg NMOG MIR	MOR	Test 56C15, 9/4/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR	Test 56C16, 9/5/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR
Ethanol	1.33	.72	210.56	280.04	151.60	235.86	313.70	169.82
Formaldehyde	7.14	2.08	6.42	45.86	13.36	5.16	36.82	10.73
Acetaldehyde	5.51	2.17	21.49	118.38	46.62	21.83	120.29	47.37
Acrolein	6.76	2.59	.10	.70	.27	.07	.50	.19
Acetone	.56	.20	.71	.40	.14	.44	.25	.09
Propionaldehyde	6.53	2.50	.18	1.16	.44	.17	1.10	.42
Oxygenates Subtotal			239.45	446.54	212.44	263.53	472.66	228.62

Table III-3a (Cont.)

NMOG Summary		Test 56C15, 9/4/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR	Test 56C16, 9/5/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR
Light-End Species		36.45	144.59	64.46	32.12	133.94	59.59
Mid-Range Species		18.05	62.78	20.82	18.64	66.45	21.63
Oxygenates		239.45	446.54	212.44	263.53	472.66	228.62
Total		293.95	653.91	297.72	314.29	673.05	309.84
Ozone/NMOG			2.22	1.01		2.14	.99

Table III-3b

Speciated FTP Results
Volkswagen Jetta, E85

Light-End Species	mg Ozone/ mg NMOG MIR	MOR	Test 56C17, 9/6/91 NMOG (mg/mi)	Ozone (mg/mi MIR	MOR
Ethane	.26	.18	4.19	1.09	.75
Ethene	7.28	3.15	15.68	114.16	49.40
Propane	.48	.31	.25	.12	.08
Ethyne	.51	.34	7.60	3.88	2.59
Methylpropane	1.21	.73	.10	.13	.08
Butane	1.02	.66	2.24	2.28	1.48
Propene	9.39	3.77	1.14	10.75	4.32
Methylbutane	1.38	.87	2.28	3.15	1.99
Pentane	1.03	.68	1.14	1.17	.77
1-Butene	8.90	3.51	.48	4.24	1.67
2-Methylpropene	5.29	1.93	.75	3.98	1.45
Light-End HC Subtotal			35.87	144.95	64.57

Mid-Range Species	mg Ozone/ mg NMOG MIR	MOR	Test 56C17, 9/6/91 NMOG (mg/mi)	Ozone (mg/mi MIR	MOR
1,3-butadiene	10.88	4.16	.14	1.48	.57
n-Hexane	.98	.64	.89	.87	.57
~~Methylcyclopentane~~	~~2.82~~	~~1.55~~	~~.44~~	~~1.24~~	~~.68~~
C7H16 Alkane	1.40	.83	.23	.33	.19
Benzene	.42	.14	1.99	.83	.28
Cyclohexane	1.28	.74	.18	.23	.14
2-Methylhexane +Dimethylpentane	1.40	.83	.73	1.02	.61
3-Methylhexane	1.40	.83	.44	.61	.36
2,2,4-Trimethylpentane + Alkene	2.59	1.11	.93	2.41	1.03
n-Heptane	.81	.53	.41	.33	.22
Methylcyclohexane	1.84	1.00	.23	.42	.23
2,3,4-Trimethylpentane	1.20	.70	.21	.25	.15
Toluene + C8H18	2.72	.63	2.14	5.83	1.35
Ethylbenzene	2.90	.72	.62	1.79	.44
m & p-Xylenes	7.47	2.24	1.58	11.81	3.54
Styrene	2.20	-.29	.18	.39	-.05
o-Xylene	6.68	2.00	.46	3.09	.93
3-Ethyltoluene	7.20	2.17	.33	2.41	.73
4-Ethyltoluene + C10cycloalkane	4.49	1.55	.23	1.03	.36
1,3,5-Trimethylbenzene	10.11	3.06	.32	3.25	.98
2-Ethyltoluene	7.20	2.17	.19	1.38	.41
1,2,4-Trimethylbenzene	8.59	2.51	.41	3.55	1.04
Mid-Range HC Subtotal			13.28	44.56	14.74

Oxygenates	mg Ozone/ mg NMOG MIR	MOR	Test 56C17, 9/6/91 NMOG (mg/mi)	Ozone (mg/mi MIR	MOR
Ethanol	1.33	.72	220.44	293.19	158.72
Formaldehyde	7.14	2.08	2.70	19.31	5.62
Acetaldehyde	5.51	2.17	21.61	119.08	46.90
Acrolein	6.76	2.59	.08	.57	.22
Acetone	.56	.20	3.46	1.94	.69
Propionaldehyde	6.53	2.50	.15	.98	.37
Oxygenates Subtotal			248.45	435.06	212.52

Table III-3b (Cont.)

NMOG Summary		Test 56C17, 9/6/91 NMOG (mg/mi)	Ozone (mg/mi MIR	MOR
Light-End Species		35.87	144.95	64.57
Mid-Range Species		13.28	44.56	14.74
Oxygenates		248.45	435.06	212.52
Total		297.60	624.57	291.83
Ozone/NMOG			2.10	.98

Table III-3c

Speciated FTP Results
Chevrolet Lumina, E85

Light-End Species	mg Ozone/ mg NMOG		Test 52C20, 8/27/91			Test 52C21, 8/28/91		
	MIR	MOR	NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR	NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR
Ethane	.26	.18	.77	.20	.14	7.51	1.95	1.35
Ethene	7.28	3.15	7.63	55.57	24.04	12.17	88.60	38.34
Propane	.48	.31	.73	.35	.23	.00	.00	.00
Ethyne	.51	.34	1.43	.73	.49	4.23	2.16	1.44
Methylpropane	1.21	.73	.05	.06	.04	.22	.27	.16
Butane	1.02	.66	2.30	2.35	1.52	4.62	4.72	3.05
Propene	9.39	3.77	.62	5.85	2.35	1.33	12.46	5.00
Methylbutane	1.38	.87	1.11	1.54	.97	2.64	3.64	2.30
Pentane	1.03	.68	1.09	1.13	.74	2.11	2.17	1.43
1-Butene	8.90	3.51	.21	1.85	.73	.24	2.17	.86
2-Methylpropene	5.29	1.93	.40	2.12	.77	.47	2.48	.90
Light-End HC Subtotal			16.35	71.74	32.01	35.54	120.62	54.83

Mid-Range Species	mg Ozone/ mg NMOG		Test 52C20, 8/27/91			Test 52C21, 8/28/91		
	MIR	MOR	NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR	NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR
1,3-butadiene	10.88	4.16	.21	2.32	.89	.20	2.15	.82
2,2-Dimethylbutane	.82	.51	.00	.00	.00	1.32	1.08	.67
3-Methylpentane	1.52	.94	.00	.00	.00	1.71	2.59	1.60
Methylcyclopentane	2.82	1.55	.00	.00	.00	.67	1.88	1.03
C7H16 Alkane	1.40	.83	.00	.00	.00	.38	.54	.32
Benzene	.42	.14	.00	.00	.00	1.83	.77	.26
Cyclohexane	1.28	.74	.00	.00	.00	.28	.35	.20
2-Methylhexane +Dimethylpentane	1.40	.83	.00	.00	.00	1.12	1.56	.93
3-Methylhexane	1.40	.83	.00	.00	.00	.68	.95	.56
2,2,4-Trimethylpentane + Alkene	2.59	1.11	.00	.00	.00	1.36	3.52	1.51
n-Heptane	.81	.53	.00	.00	.00	.68	.55	.36
Methylcyclohexane	1.84	1.00	.00	.00	.00	.34	.62	.34
2,3,4-Trimethylpentane	1.20	.70	.00	.00	.00	.32	.38	.22
Toluene + C8H18	2.72	.63	1.24	3.38	.78	2.64	7.17	1.66
Methylheptane	1.20	.70	.00	.00	.00	.23	.28	.16
Dimethylcyclohexane	1.94	1.02	.00	.00	.00	.21	.42	.22
Ethylbenzene	2.90	.72	.00	.00	.00	.77	2.22	.55
m & p-Xylenes	7.47	2.24	.00	.00	.00	1.98	14.81	4.44
o-Xylene	6.68	2.00	.00	.00	.00	.63	4.21	1.26
3-Ethyltoluene	7.20	2.17	.00	.00	.00	.43	3.07	.92
1,3,5-Trimethylbenzene	10.11	3.06	.00	.00	.00	.21	2.11	.64
1,2,4-Trimethylbenzene	8.59	2.51	.00	.00	.00	.59	5.06	1.48
Mid-Range HC Subtotal			1.46	5.71	1.67	18.56	56.29	20.17

Oxygenates	mg Ozone/ mg NMOG		Test 52C20, 8/27/91			Test 52C21, 8/28/91		
	MIR	MOR	NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR	NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR
Ethanol	1.33	.72	163.13	216.96	117.45	159.86	212.62	115.10
Formaldehyde	7.14	2.08	5.09	36.37	10.60	4.35	31.09	9.06
Acetaldehyde	5.51	2.17	17.69	97.49	38.39	20.59	113.45	44.68
Acrolein	6.76	2.59	.08	.57	.22	.10	.69	.27
Acetone	.56	.20	.98	.55	.20	.29	.16	.06
Propionaldehyde	6.53	2.50	.15	.98	.38	.22	1.46	.56
Oxygenates Subtotal			187.13	352.92	167.23	185.42	359.47	169.72

Table III-3c (Cont.)

NMOG Summary		Test 52C20, 8/27/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR	Test 52C21, 8/28/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR
Light-End Species		16.35	71.74	32.01	35.54	120.62	54.83
Mid-Range Species		1.46	5.71	1.67	18.56	56.29	20.17
Oxygenates		187.13	352.92	167.23	185.42	359.47	169.72
Total		204.94	430.37	200.92	239.52	536.38	244.72
Ozone/NMOG			2.10	.98		2.24	1.02

Table III-3d

Speciated FTP Results
Chevrolet Lumina, E85

Light-End Species	mg Ozone/ mg NMOG MIR	MOR	Test 52C22, 8/29/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR	Test 52C23, 8/30/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR
Ethane	.26	.18	8.79	2.28	1.58	6.72	1.75	1.21
Ethene	7.28	3.15	11.84	86.21	37.30	13.49	98.17	42.48
Propane	.48	.31	.13	.06	.04	.23	.11	.07
Ethyne	.51	.34	4.13	2.10	1.40	3.84	1.96	1.31
Methylpropane	1.21	.73	.15	.19	.11	.08	.10	.06
Butane	1.02	.66	5.74	5.86	3.79	5.41	5.52	3.57
Propene	9.39	3.77	1.37	12.86	5.16	1.55	14.52	5.83
Methylbutane	1.38	.87	3.28	4.53	2.86	3.50	4.83	3.04
Pentane	1.03	.68	2.77	2.85	1.88	3.05	3.15	2.08
1-Butene	8.90	3.51	.30	2.63	1.04	.31	2.74	1.08
2-Methylpropene	5.29	1.93	.56	2.94	1.07	.61	3.24	1.18
Light-End HC Subtotal			39.05	122.52	56.24	38.79	136.08	61.91

Mid-Range Species	mg Ozone/ mg NMOG MIR	MOR	Test 52C22, 8/29/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR	Test 52C23, 8/30/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR
1,3-butadiene	10.88	4.16	.27	2.94	1.12	.09	.94	.36
2-Methylpentane	1.53	.90	1.82	2.79	1.64	1.64	2.52	1.48
n-Hexane	.98	.64	1.45	1.42	.93	1.27	1.24	.81
Benzene	.42	.14	1.19	.50	.17	.00	.00	.00
2,2,4-Trimethylpentane + Alkene	2.59	1.11	1.16	3.01	1.29	1.07	2.78	1.19
Toluene + C8H18	2.72	.63	2.14	5.83	1.35	1.77	4.80	1.11
m & p-Xylenes	7.47	2.24	1.60	11.94	3.58	1.30	9.73	2.92
Mid-Range HC Subtotal			9.63	28.42	10.08	7.14	22.02	7.88

Oxygenates	mg Ozone/ mg NMOG MIR	MOR	Test 52C22, 8/29/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR	Test 52C23, 8/30/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR
Ethanol	1.33	.72	222.35	295.72	160.09	173.68	230.99	125.05
Formaldehyde	7.14	2.08	5.20	37.15	10.82	6.19	44.23	12.88
Acetaldehyde	5.51	2.17	21.14	116.45	45.86	24.15	133.09	52.41
Acrolein	6.76	2.59	.10	.69	.27	.10	.70	.27
Acetone	.56	.20	3.17	1.78	.63	1.52	.85	.30
Propionaldehyde	6.53	2.50	.21	1.40	.54	.23	1.47	.56
Oxygenates Subtotal			252.17	453.19	218.21	205.87	411.33	191.48

NMOG Summary		Test 52C22, 8/29/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR	Test 52C23, 8/30/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR
Light-End Species		39.05	122.52	56.24	38.79	136.08	61.91
Mid-Range Species		9.63	28.42	10.08	7.14	22.02	7.88
Oxygenates		252.17	453.19	218.21	205.87	411.33	191.48
Total		300.85	604.13	284.53	251.81	569.43	261.27
Ozone/NMOG			2.01	.95		2.26	1.04

Table III-3e

Speciated FTP Results
Chevrolet Lumina, E85

Light-End Species	mg Ozone/ mg NMOG MIR	MOR	Test 52C24, 9/4/91 NMOG (mg/mi)	Ozone (mg/mi MIR	MOR
Ethane	.26	.18	3.99	1.04	.72
Ethene	7.28	3.15	16.18	117.79	50.97
Propane	.48	.31	.24	.12	.07
Ethyne	.51	.34	3.98	2.03	1.35
Methylpropane	1.21	.73	.00	.01	.00
Butane	1.02	.66	4.90	5.00	3.23
Propene	9.39	3.77	1.53	14.34	5.76
Methylbutane	1.38	.87	2.68	3.70	2.33
Pentane	1.03	.68	2.56	2.64	1.74
1-Butene	8.90	3.51	.37	3.26	1.29
2-Methylpropene	5.29	1.93	.93	4.90	1.79
Light-End HC Subtotal			37.35	154.81	69.25

Mid-Range Species	mg Ozone/ mg NMOG MIR	MOR	Test 52C24, 9/4/91 NMOG (mg/mi)	Ozone (mg/mi MIR	MOR
1,3-butadiene	10.88	4.16	.21	2.24	.86
n-Hexane	.98	.64	1.91	1.87	1.22
Methylcyclopentane	2.82	1.55	.77	2.18	1.20
C7H16 Alkane	1.40	.83	.51	.71	.42
Benzene	.42	.14	1.34	.56	.19
Cyclohexane	1.28	.74	.26	.34	.20
2-Methylhexane +Dimethylpentane	1.40	.83	1.35	1.88	1.12
3-Methylhexane	1.40	.83	.74	1.04	.62
2,2,4-Trimethylpentane + Alkene	2.59	1.11	1.57	4.08	1.75
n-Heptane	.81	.53	.74	.60	.39
Methylcyclohexane	1.84	1.00	.39	.71	.39
Dimethylhexane	1.20	.70	.44	.53	.31
2,3,4-Trimethylpentane	1.20	.70	.38	.46	.27
Toluene + C8H18	2.72	.63	2.99	8.12	1.88
Methylheptane	1.20	.70	.30	.36	.21
Dimethylcyclohexane	1.94	1.02	.27	.52	.27
2,2,5-Trimethylhexane	1.13	.64	.17	.19	.11
n-Octane	.61	.41	.19	.11	.08
Ethylbenzene	2.90	.72	.99	2.87	.71
m & p-Xylenes	7.47	2.24	2.45	18.32	5.49
Styrene	2.20	-.29	.17	.37	-.05
o-Xylene	6.68	2.00	.77	5.17	1.55
n-Propylbenzene	2.27	.56	.17	.39	.10
3-Ethyltoluene	7.20	2.17	.61	4.36	1.32
4-Ethyltoluene + C10cycloalkane	4.49	1.55	.23	1.05	.36
1,3,5-Trimethylbenzene	10.11	3.06	.31	3.15	.95
2-Ethyltoluene	7.20	2.17	.18	1.31	.39
1,2,4-Trimethylbenzene	8.59	2.51	.78	6.69	1.96
Mid-Range HC Subtotal			21.19	70.20	24.25

Table III-3e (Cont.)

Oxygenates	mg Ozone/ mg NMOG MIR	MOR	Test 52C24, 9/4/91 NMOG (mg/mi)	Ozone (mg/mi MIR	MOR
Ethanol	1.33	.72	229.24	304.89	165.05
Formaldehyde	7.14	2.08	5.35	38.18	11.12
Acetaldehyde	5.51	2.17	22.89	126.14	49.68
Acrolein	6.76	2.59	.10	.69	.26
Acetone	.56	.20	1.32	.74	.26
Propionaldehyde	6.53	2.50	.19	1.21	.46
Oxygenates Subtotal			259.09	471.85	226.85

NMOG Summary		Test 52C24, 9/4/91 NMOG (mg/mi)	Ozone (mg/mi MIR	MOR
Light-End Species		37.35	154.81	69.25
Mid-Range Species		21.19	70.20	24.25
Oxygenates		259.09	471.85	226.85
Total		317.64	696.87	320.35
Ozone/NMOG			2.19	1.01

Table III-4

Summary of Test Results for LPG-Fueled Vehicles

Vehicle	Test #	Species Table #	Test Date	NMOG (g/mi)	CH4 (g/mi)	CO (g/mi)	NOx (g/mi)
Oldsmobile Delta 88	1C6	III-4a	08/06/91	.108	.043	2.38	.109
	1C7	III-4a	08/07/91	.110	.041	2.56	.108
	1C8	III-4b	08/08/91	.103	.046	2.85	.104
	1C9	III-4b	08/09/91	.121	.050	2.94	.109
			Mean:	.111	.045	2.68	.108
Pontiac 6000LE	3C4	III-4c	08/20/91	.064	.045	.85	.275
	3C5	III-4c	08/23/91	.152	.038	.70	.318
	3C6	III-4d	08/27/91	.091	.037	.66	.283
	3C7	III-4d	08/28/91	.095	.040	.65	.291
			Mean:	.101	.040	.72	.292

Table III-4a

Speciated FTP Results
Oldsmobile Delta 88, LPG

Light-End Species	mg Ozone/ mg NMOG MIR	MOR	Test 1C6, 8/06/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR	Test 1C7, 8/07/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR
Ethane	.26	.18	4.34	1.13	.78	3.78	.98	.68
Ethene	7.28	3.15	9.77	71.10	30.76	9.47	68.92	29.82
Propane	.48	.31	73.59	35.32	22.81	72.32	34.71	22.42
Ethyne	.51	.34	3.37	1.72	1.14	2.81	1.43	.95
Methylpropane	1.21	.73	1.03	1.24	.75	1.77	2.14	1.29
Butane	1.02	.66	1.48	1.51	.98	1.68	1.71	1.11
Propene	9.39	3.77	4.67	43.89	17.62	4.26	40.05	16.08
Methylbutane	1.38	.87	1.18	1.63	1.03	1.86	2.57	1.62
Pentane	1.03	.68	.58	.60	.39	.99	1.02	.67
1-Butene	8.90	3.51	.17	1.51	.59	.25	2.22	.88
2-Methylpropene	5.29	1.93	.31	1.63	.60	.44	2.31	.84
Light-End HC Subtotal			100.48	161.27	77.46	99.63	158.08	76.37

Mid-Range Species	mg Ozone/ mg NMOG MIR	MOR	Test 1C6, 8/06/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR	Test 1C7, 8/07/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR
1,3-butadiene	10.88	4.16	.03	.34	.13	.11	1.15	.44
Cyclopentene	7.65	2.78	.00	.00	.00	.47	3.60	1.31
2,3-Dimethylbutane	1.07	.67	.18	.20	.12	.00	.00	.00
~~2-Methylpentane~~	~~1.53~~	~~.90~~	~~.44~~	~~.67~~	~~.40~~	~~.00~~	~~.00~~	~~.00~~
3-Methylpentane	1.52	.94	.24	.37	.23	.00	.00	.00
n-Hexane	.98	.64	.25	.25	.16	.61	.59	.39
Methylcyclopentane	2.82	1.55	.22	.62	.34	.54	1.52	.83
C7H16 Alkane	1.40	.83	.07	.10	.06	.00	.00	.00
Benzene	.42	.14	.35	.15	.05	1.19	.50	.17
2-Methylhexane +Dimethylpentane	1.40	.83	.81	1.13	.67	.52	.73	.43
3-Methylhexane	1.40	.83	.45	.63	.37	.36	.50	.30
2,2,4-Trimethylpentane + Alkene	2.59	1.11	.54	1.39	.60	.00	.00	.00
n-Heptane	.81	.53	.15	.12	.08	.30	.24	.16
Toluene + C8H18	2.72	.63	1.15	3.12	.72	1.90	5.17	1.20
C9H18 Alkene	3.40	1.31	.00	.00	.00	.18	.62	.24
Ethylbenzene	2.90	.72	.10	.29	.07	.19	.55	.14
m & p-Xylenes	7.47	2.24	.34	2.50	.75	1.83	13.69	4.10
o-Xylene	6.68	2.00	.10	.64	.19	.19	1.29	.39
3-Ethyltoluene	7.20	2.17	.08	.55	.17	.00	.00	.00
4-Ethyltoluene + C10cycloalkane	4.49	1.55	.11	.49	.17	.00	.00	.00
1,2,4-Trimethylbenzene	8.59	2.51	.06	.52	.15	.00	.00	.00
Mid-Range HC Subtotal			5.65	14.08	5.43	8.38	30.14	10.09

Oxygenates	mg Ozone/ mg NMOG MIR	MOR	Test 1C6, 8/06/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR	Test 1C7, 8/07/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR
Formaldehyde	7.14	2.08	.76	5.44	1.58	1.23	8.79	2.56
Acetaldehyde	5.51	2.17	.61	3.39	1.33	.60	3.32	1.31
Acrolein	6.76	2.59	.00	.00	.00	.00	.00	.00
Acetone	.56	.20	.85	.48	.17	.11	.06	.02
Oxygenates Subtotal			2.23	9.30	3.09	1.94	12.17	3.89

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Table III-4a (Cont.)

NMOG Summary		Test 1C6, 8/06/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR	Test 1C7, 8/07/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR
Light-End Species		100.48	161.27	77.46	99.63	158.08	76.37
Mid-Range Species		5.65	14.08	5.43	8.38	30.14	10.09
Oxygenates		2.23	9.30	3.09	1.94	12.17	3.89
Total		108.36	184.65	85.98	109.95	200.39	90.34
Ozone/NMOG			1.70	.79		1.82	.82

Table III-4b

Speciated FTP Results
Oldsmobile Delta 88, LPG

Light-End Species	mg Ozone/ mg NMOG MIR	mg Ozone/ mg NMOG MOR	Test 1C8, 8/08/91 NMOG (mg/mi)	Test 1C8 Ozone (mg/mi) MIR	Test 1C8 Ozone (mg/mi) MOR	Test 1C9, 8/09/91 NMOG (mg/mi)	Test 1C9 Ozone (mg/mi) MIR	Test 1C9 Ozone (mg/mi) MOR
Ethane	.26	.18	3.49	.91	.63	4.16	1.08	.75
Ethene	7.28	3.15	9.55	69.52	30.08	8.32	60.56	26.21
Propane	.48	.31	68.36	32.81	21.19	79.75	38.28	24.72
Ethyne	.51	.34	1.96	1.00	.67	2.94	1.50	1.00
Methylpropane	1.21	.73	1.75	2.12	1.28	1.98	2.40	1.45
Butane	1.02	.66	1.51	1.54	1.00	1.51	1.54	1.00
Propene	9.39	3.77	3.61	33.90	13.61	3.75	35.20	14.13
Methylbutane	1.38	.87	2.28	3.15	1.98	1.51	2.09	1.32
Pentane	1.03	.68	.91	.93	.62	.83	.86	.57
1-Butene	8.90	3.51	.22	1.96	.77	.24	2.15	.85
2-Methylpropene	5.29	1.93	.31	1.62	.59	.35	1.83	.67
Light-End HC Subtotal			93.95	149.47	72.42	105.34	147.49	72.65

Mid-Range Species	mg Ozone/ mg NMOG MIR	mg Ozone/ mg NMOG MOR	Test 1C8, 8/08/91 NMOG (mg/mi)	Test 1C8 Ozone (mg/mi) MIR	Test 1C8 Ozone (mg/mi) MOR	Test 1C9, 8/09/91 NMOG (mg/mi)	Test 1C9 Ozone (mg/mi) MIR	Test 1C9 Ozone (mg/mi) MOR
1,3-butadiene	10.88	4.16	.04	.39	.15	.06	.68	.26
2,3-Dimethylbutane	1.07	.67	.24	.26	.16	.25	.27	.17
2-Methylpentane	1.53	.90	.57	.87	.51	.72	1.11	.65
3-Methylpentane	1.52	.94	.33	.50	.31	.41	.62	.39
n-Hexane	.98	.64	.29	.28	.19	.46	.45	.30
Methylcyclopentane	2.82	1.55	.29	.83	.46	.29	.83	.46
C7H16 Alkane	1.40	.83	.08	.11	.07	.09	.13	.08
Benzene	.42	.14	.41	.17	.06	.58	.24	.08
2-Methylhexane +Dimethylpentane	1.40	.83	.95	1.33	.79	1.20	1.69	1.00
3-Methylhexane	1.40	.83	.57	.79	.47	.70	.98	.58
2,2,4-Trimethylpentane + Alkene	2.59	1.11	.64	1.65	.71	.92	2.39	1.02
n-Heptane	.81	.53	.16	.13	.08	.57	.46	.30
Methylcyclohexane	1.84	1.00	.00	.00	.00	.13	.25	.13
Dimethylhexane	1.20	.70	.10	.11	.07	.06	.07	.04
Toluene + C8H18	2.72	.63	1.30	3.54	.82	2.10	5.71	1.32
Methylheptane	1.20	.70	.08	.09	.05	.09	.10	.06
Dimethylcyclohexane	1.94	1.02	.00	.00	.00	.07	.15	.08
Ethylbenzene	2.90	.72	.40	1.17	.29	.53	1.52	.38
m & p-Xylenes	7.47	2.24	.10	.75	.22	2.67	19.92	5.97
o-Xylene	6.68	2.00	.54	3.60	1.08	.32	2.15	.64
3-Ethyltoluene	7.20	2.17	.14	.97	.29	.33	2.38	.72
4-Ethyltoluene + C10cycloalkane	4.49	1.55	.18	.79	.27	.00	.00	.00
1,2,4-Trimethylbenzene	8.59	2.51	.04	.32	.09	.13	1.11	.33
Mid-Range HC Subtotal			7.43	18.66	7.14	12.70	43.22	14.95

Oxygenates	mg Ozone/ mg NMOG MIR	mg Ozone/ mg NMOG MOR	Test 1C8, 8/08/91 NMOG (mg/mi)	Test 1C8 Ozone (mg/mi) MIR	Test 1C8 Ozone (mg/mi) MOR	Test 1C9, 8/09/91 NMOG (mg/mi)	Test 1C9 Ozone (mg/mi) MIR	Test 1C9 Ozone (mg/mi) MOR
Formaldehyde	7.14	2.08	1.29	9.24	2.69	1.95	13.92	4.05
Acetaldehyde	5.51	2.17	.40	2.21	.87	.69	3.81	1.50
Acetone	.56	.20	.09	.05	.02	.11	.06	.02
Oxygenates Subtotal			1.78	11.50	3.58	2.75	17.79	5.58

Table III-4b (Cont.)

NMOG Summary		Test 1C8, 8/08/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR	Test 1C9, 8/09/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR
Light-End Species		93.95	149.47	72.42	105.34	147.49	72.65
Mid-Range Species		7.43	18.66	7.14	12.70	43.22	14.95
Oxygenates		1.78	11.50	3.58	2.75	17.79	5.58
Total		103.16	179.63	83.14	120.80	208.49	93.18
Ozone/NMOG			1.74	.81		1.73	.77

Table III-4c

Speciated FTP Results
Pontiac 6000LE, LPG

Light-End Species	mg Ozone/ mg NMOG MIR	MOR	Test 3C4, 8/20/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR	Test 3C5, 8/23/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR
Ethane	.26	.18	6.44	1.67	1.16	7.91	2.06	1.42
Ethene	7.28	3.15	.24	1.75	.76	10.52	76.60	33.14
Propane	.48	.31	44.27	21.25	13.72	113.33	54.40	35.13
Ethyne	.51	.34	.30	.15	.10	2.15	1.09	.73
Methylpropane	1.21	.73	.65	.78	.47	1.77	2.14	1.29
Butane	1.02	.66	.31	.32	.21	.72	.74	.48
Propene	9.39	3.77	.85	7.99	3.21	6.78	63.69	25.57
Methylbutane	1.38	.87	.98	1.35	.85	1.57	2.17	1.37
Pentane	1.03	.68	.46	.47	.31	.61	.62	.41
1-Butene	8.90	3.51	.11	.94	.37	.33	2.97	1.17
2-Methylpropene	5.29	1.93	.10	.55	.20	.32	1.67	.61
Light-End HC Subtotal			54.70	37.22	21.36	146.01	208.15	101.33

Mid-Range Species	mg Ozone/ mg NMOG MIR	MOR	Test 3C4, 8/20/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR	Test 3C5, 8/23/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR
1,3-butadiene	10.88	4.16	.01	.09	.04	.07	.80	.31
Methylcyclopentane	2.82	1.55	.24	.69	.38	.00	.00	.00
Benzene	.42	.14	.42	.18	.06	.00	.00	.00
2-Methylhexane +Dimethylpentane	1.40	.83	.21	.29	.17	.00	.00	.00
Toluene + C8H18	2.72	.63	.35	.95	.22	.00	.00	.00
m & p-Xylenes	7.47	2.24	.12	.89	.27	.00	.00	.00
Mid-Range HC Subtotal			1.35	3.09	1.13	.07	.80	.31

Oxygenates	mg Ozone/ mg NMOG MIR	MOR	Test 3C4, 8/20/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR	Test 3C5, 8/23/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR
Formaldehyde	7.14	2.08	4.69	33.45	9.75	4.36	31.15	9.08
Acetaldehyde	5.51	2.17	1.19	6.55	2.58	1.15	6.33	2.49
Acrolein	6.76	2.59	.15	1.02	.39	.08	.57	.22
Acetone	.56	.20	2.20	1.23	.44	.54	.30	.11
Propionaldehyde	6.53	2.50	.00	.00	.00	.16	1.02	.39
Oxygenates Subtotal			8.23	42.26	13.16	6.29	39.38	12.29

NMOG Summary		Test 3C4, 8/20/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR	Test 3C5, 8/23/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR
Light-End Species		54.70	37.22	21.36	146.01	208.15	101.33
Mid-Range Species		1.35	3.09	1.13	.07	.80	.31
Oxygenates		8.23	42.26	13.16	6.29	39.38	12.29
Total		64.28	82.57	35.65	152.38	248.33	113.92
Ozone/NMOG			1.28	.55		1.63	.75

Table III-4d

Speciated FTP Results
Pontiac 6000LE, LPG

Light-End Species	mg Ozone/ mg NMOG		Test 3C6, 8/27/91			Test 3C7, 8/28/91		
			NMOG	Ozone (mg/mi)		NMOG	Ozone (mg/mi)	
	MIR	MOR	(mg/mi)	MIR	MOR	(mg/mi)	MIR	MOR
Ethane	.26	.18	25.41	6.61	4.57	6.96	1.81	1.25
Ethene	7.28	3.15	4.42	32.19	13.93	5.87	42.72	18.49
Propane	.48	.31	43.14	20.71	13.37	64.18	30.81	19.90
Ethyne	.51	.34	1.03	.52	.35	1.74	.89	.59
Methylpropane	1.21	.73	.00	.00	.00	.70	.84	.51
Butane	1.02	.66	.50	.51	.33	.56	.57	.37
Propene	9.39	3.77	6.96	65.33	26.23	5.41	50.78	20.39
Methylbutane	1.38	.87	.36	.50	.31	.84	1.16	.73
Pentane	1.03	.68	.27	.27	.18	.49	.50	.33
1-Butene	8.90	3.51	.28	2.50	.99	.44	3.92	1.54
2-Methylpropene	5.29	1.93	.33	1.75	.64	.21	1.13	.41
Light-End HC Subtotal			82.69	130.89	60.90	87.39	135.12	64.51

Mid-Range Species	mg Ozone/ mg NMOG		Test 3C6, 8/27/91			Test 3C7, 8/28/91		
			NMOG	Ozone (mg/mi)		NMOG	Ozone (mg/mi)	
	MIR	MOR	(mg/mi)	MIR	MOR	(mg/mi)	MIR	MOR
1,3-butadiene	10.88	4.16	.04	.40	.15	.05	.54	.21
n-Hexane	.98	.64	.34	.33	.22	.00	.00	.00
Methylcyclopentane	2.82	1.55	.30	.85	.47	.00	.00	.00
C7H16 Alkane	1.40	.83	.11	.15	.09	.00	.00	.00
Benzene	.42	.14	.33	.14	.05	.00	.00	.00
2-Methylhexane +Dimethylpentane	1.40	.83	.32	.45	.26	.00	.00	.00
3-Methylhexane	1.40	.83	.18	.26	.15	.00	.00	.00
2,2,4-Trimethylpentane + Alkene	2.59	1.11	.17	.45	.19	.00	.00	.00
n-Heptane	.81	.53	.13	.11	.07	.00	.00	.00
Toluene + C8H18	2.72	.63	.44	1.19	.28	.00	.00	.00
m & p-Xylenes	7.47	2.24	.19	1.41	.42	.80	6.00	1.80
Mid-Range HC Subtotal			2.54	5.73	2.35	.85	6.55	2.01

Oxygenates	mg Ozone/ mg NMOG		Test 3C6, 8/27/91			Test 3C7, 8/28/91		
			NMOG	Ozone (mg/mi)		NMOG	Ozone (mg/mi)	
	MIR	MOR	(mg/mi)	MIR	MOR	(mg/mi)	MIR	MOR
Formaldehyde	7.14	2.08	4.27	30.45	8.87	4.28	30.56	8.90
Acetaldehyde	5.51	2.17	1.11	6.10	2.40	1.06	5.82	2.29
Acrolein	6.76	2.59	.12	.79	.30	.12	.79	.30
Acetone	.56	.20	.14	.08	.03	1.65	.92	.33
Propionaldehyde	6.53	2.50	.12	.77	.29	.11	.73	.28
Oxygenates Subtotal			5.75	38.19	11.90	7.22	38.83	12.11

NMOG Summary		Test 3C6, 8/27/91			Test 3C7, 8/28/91		
		NMOG	Ozone (mg/mi)		NMOG	Ozone (mg/mi)	
		(mg/mi)	MIR	MOR	(mg/mi)	MIR	MOR
Light-End Species		82.69	130.89	60.90	87.39	135.12	64.51
Mid-Range Species		2.54	5.73	2.35	.85	6.55	2.01
Oxygenates		5.75	38.19	11.90	7.22	38.83	12.11
Total		90.99	174.81	75.15	95.46	180.50	78.63
Ozone/NMOG			1.92	.83		1.89	.82

Table III-5

Summary of Test Results for CNG-Fueled Vehicles

Vehicle	Test #	Species Table #	Test Date	NMOG (g/mi)	CH4 (g/mi)	CO (g/mi)	NOx (g/mi)
Buick LeSabre	1C4	III-5a	08/09/91	.104	1.76	.08	.439
	1C6	III-5a	08/14/91	.104	1.94	.05	.447
	1C7	III-5b	08/15/91	.104	1.72	.06	.445
	1C8	III-5b	08/16/91	.093	1.84	.08	.507
	1C9	III-5c	08/20/91	.087	1.70	.13	.431
	1C10	III-5c	08/21/91	.076	1.77	.09	.444
	1C11	III-5d	08/22/91	.077	1.85	.10	.476
	1C12	III-5d	08/23/91	.092	1.69	.14	.453
			Mean:	.092	1.78	.09	.455

Table III-5a

Speciated FTP Results
Buick LeSabre, CNG

Light-End Species	mg Ozone/ mg NMOG		Test 1C4, 8/09/91			Test 1C6, 8/14/91		
	MIR	MOR	NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR	NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR
Ethane	.26	.18	88.52	23.02	15.93	92.24	23.98	16.60
Ethene	7.28	3.15	1.69	12.31	5.33	1.83	13.29	5.75
Propane	.48	.31	4.27	2.05	1.32	5.16	2.48	1.60
Ethyne	.51	.34	.24	.12	.08	.19	.10	.06
Methylpropane	1.21	.73	.22	.27	.16	.19	.23	.14
Butane	1.02	.66	.56	.57	.37	.60	.61	.39
Propene	9.39	3.77	.16	1.52	.61	.18	1.69	.68
Methylbutane	1.38	.87	.22	.31	.19	.31	.42	.27
Pentane	1.03	.68	.16	.17	.11	.19	.19	.13
1-Butene	8.90	3.51	.07	.61	.24	.03	.23	.09
2-Methylpropene	5.29	1.93	.07	.35	.13	.09	.49	.18
Light-End HC Subtotal			96.19	41.29	24.48	100.99	43.70	25.89

Mid-Range Species	mg Ozone/ mg NMOG		Test 1C4, 8/09/91			Test 1C6, 8/14/91		
	MIR	MOR	NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR	NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR
1,3-butadiene	10.88	4.16	.01	.09	.03	.07	.79	.30
2-Methylpentane	1.53	.90	.16	.25	.15	.00	.00	.00
3-Methylpentane	1.52	.94	.11	.17	.10	.00	.00	.00
n-Hexane	.98	.64	.12	.12	.08	.00	.00	.00
Methylcyclopentane	2.82	1.55	.12	.33	.18	.00	.00	.00
Benzene	.42	.14	.08	.03	.01	.00	.00	.00
2-Methylhexane +Dimethylpentane	1.40	.83	1.04	1.45	.86	.00	.00	.00
3-Methylhexane	1.40	.83	.52	.73	.43	.00	.00	.00
2,2,4-Trimethylpentane + Alkene	2.59	1.11	.98	2.55	1.09	.00	.00	.00
n-Heptane	.81	.53	.34	.28	.18	.00	.00	.00
Toluene + C8H18	2.72	.63	1.32	3.60	.83	.00	.00	.00
Ethylbenzene	2.90	.72	.39	1.13	.28	.00	.00	.00
m & p-Xylenes	7.47	2.24	.47	3.54	1.06	.00	.00	.00
o-Xylene	6.68	2.00	.14	.95	.29	.00	.00	.00
Mid-Range HC Subtotal			5.82	15.23	5.59	.07	.79	.30

Oxygenates	mg Ozone/ mg NMOG		Test 1C4, 8/09/91			Test 1C6, 8/14/91		
	MIR	MOR	NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR	NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR
Formaldehyde	7.14	2.08	1.43	10.20	2.97	2.40	17.12	4.99
Acetaldehyde	5.51	2.17	.52	2.88	1.13	.21	1.13	.45
Acetone	.56	.20	.05	.03	.01	.00	.00	.00
Oxygenates Subtotal			2.00	13.10	4.11	2.60	18.26	5.43

NMOG Summary		Test 1C4, 8/09/91			Test 1C6, 8/14/91		
		NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR	NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR
Light-End Species		96.19	41.29	24.48	100.99	43.70	25.89
Mid-Range Species		5.82	15.23	5.59	.07	.79	.30
Oxygenates		2.00	13.10	4.11	2.60	18.26	5.43
Total		104.00	69.62	34.18	103.66	62.75	31.62
Ozone/NMOG			.67	.33		.61	.31

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Table III-5b

Speciated FTP Results
Buick LeSabre, CNG

Light-End Species	mg Ozone/ mg NMOG MIR	MOR	Test 1C7, 8/15/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR	Test 1C8, 8/16/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR
Ethane	.26	.18	92.05	23.93	16.57	82.98	21.57	14.94
Ethene	7.28	3.15	1.43	10.39	4.49	1.80	13.12	5.68
Propane	.48	.31	5.22	2.51	1.62	4.61	2.21	1.43
Ethyne	.51	.34	.28	.14	.10	.16	.08	.06
Methylpropane	1.21	.73	.30	.37	.22	.22	.27	.16
Butane	1.02	.66	.64	.65	.42	.48	.49	.31
Propene	9.39	3.77	.12	1.08	.44	.18	1.69	.68
Methylbutane	1.38	.87	.30	.42	.26	.36	.49	.31
Pentane	1.03	.68	.13	.13	.09	.19	.19	.13
1-Butene	8.90	3.51	.04	.39	.15	.05	.43	.17
2-Methylpropene	5.29	1.93	.08	.41	.15	.10	.50	.18
Light-End HC Subtotal			100.59	40.43	24.51	91.12	41.06	24.05

Mid-Range Species	mg Ozone/ mg NMOG MIR	MOR	Test 1C7, 8/15/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR	Test 1C8, 8/16/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR
1,3-butadiene	10.88	4.16	.06	.66	.25	.02	.23	.09
Mid-Range HC Subtotal			.06	.66	.25	.02	.23	.09

Oxygenates	mg Ozone/ mg NMOG MIR	MOR	Test 1C7, 8/15/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR	Test 1C8, 8/16/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR
Formaldehyde	7.14	2.08	2.88	20.53	5.98	1.23	8.81	2.57
Acetaldehyde	5.51	2.17	.24	1.35	.53	.59	3.27	1.29
Acetone	.56	.20	.30	.17	.06	.00	.00	.00
Oxygenates Subtotal			3.42	22.05	6.57	1.83	12.08	3.86

NMOG Summary		Test 1C7, 8/15/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR	Test 1C8, 8/16/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR
Light-End Species		100.59	40.43	24.51	91.12	41.06	24.05
Mid-Range Species		.06	.66	.25	.02	.23	.09
Oxygenates		3.42	22.05	6.57	1.83	12.08	3.86
Total		104.07	63.13	31.34	92.97	53.37	27.99
Ozone/NMOG			.61	.30		.57	.30

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Table III-5c

Speciated FTP Results
Buick LeSabre, CNG

Light-End Species	mg Ozone/ mg NMOG MIR	MOR	Test 1C9, 8/20/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR	Test 1C10, 8/21/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR
Ethane	.26	.18	76.63	19.92	13.79	64.29	16.71	11.57
Ethene	7.28	3.15	.00	.00	.00	1.15	8.40	3.64
Propane	.48	.31	4.80	2.30	1.49	4.67	2.24	1.45
Ethyne	.51	.34	.12	.06	.04	.07	.04	.02
Methylpropane	1.21	.73	.20	.25	.15	.16	.20	.12
Butane	1.02	.66	.61	.62	.40	.65	.66	.43
Propene	9.39	3.77	.18	1.73	.69	.26	2.47	.99
Methylbutane	1.38	.87	.37	.51	.32	.47	.64	.41
Pentane	1.03	.68	.21	.21	.14	.27	.28	.18
1-Butene	8.90	3.51	.05	.47	.18	.06	.53	.21
2-Methylpropene	5.29	1.93	.07	.34	.13	.07	.38	.14
Light-End HC Subtotal			83.24	26.42	17.34	72.13	32.56	19.16

Mid-Range Species	mg Ozone/ mg NMOG MIR	MOR	Test 1C9, 8/20/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR	Test 1C10, 8/21/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR
1,3-butadiene	10.88	4.16	.02	.17	.07	.03	.32	.12
Mid-Range HC Subtotal			.02	.17	.07	.03	.32	.12

Oxygenates	mg Ozone/ mg NMOG MIR	MOR	Test 1C9, 8/20/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR	Test 1C10, 8/21/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR
Formaldehyde	7.14	2.08	2.69	19.19	5.59	3.25	23.18	6.75
Acetaldehyde	5.51	2.17	.47	2.57	1.01	.43	2.40	.94
Acetone	.56	.20	.62	.35	.12	.06	.03	.01
Oxygenates Subtotal			3.78	22.11	6.73	3.74	25.61	7.71

NMOG Summary		Test 1C9, 8/20/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR	Test 1C10, 8/21/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR
Light-End Species		83.24	26.42	17.34	72.13	32.56	19.16
Mid-Range Species		.02	.17	.07	.03	.32	.12
Oxygenates		3.78	22.11	6.73	3.74	25.61	7.71
Total		87.03	48.70	24.13	75.90	58.48	26.99
Ozone/NMOG			.56	.28		.77	.36

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Table III-5d

Speciated FTP Results
Buick LeSabre, CNG

Light-End Species	mg Ozone/ mg NMOG MIR	MOR	Test 1C11, 8/22/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR	Test 1C12, 8/23/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR
Ethane	.26	.18	68.25	17.75	12.29	81.94	21.30	14.75
Propane	.48	.31	3.01	1.44	.93	4.80	2.30	1.49
Ethyne	.51	.34	.09	.05	.03	.08	.04	.03
Methylpropane	1.21	.73	.21	.25	.15	.50	.60	.36
Butane	1.02	.66	.30	.31	.20	.69	.71	.46
Propene	9.39	3.77	.16	1.54	.62	.22	2.11	.85
Methylbutane	1.38	.87	.19	.26	.17	.58	.80	.50
Pentane	1.03	.68	.24	.25	.16	.30	.31	.20
1-Butene	8.90	3.51	.05	.41	.16	.05	.47	.18
2-Methylpropene	5.29	1.93	.08	.43	.16	.07	.39	.14
Light-End HC Subtotal			72.59	22.69	14.87	89.24	29.03	18.97

Mid-Range Species	mg Ozone/ mg NMOG MIR	MOR	Test 1C11, 8/22/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR	Test 1C12, 8/23/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR
1,3-butadiene	10.88	4.16	.02	.19	.07	.03	.28	.11
Mid-Range HC Subtotal			.02	.19	.07	.03	.28	.11

Oxygenates	mg Ozone/ mg NMOG MIR	MOR	Test 1C11, 8/22/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR	Test 1C12, 8/23/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR
Formaldehyde	7.14	2.08	3.38	24.14	7.03	1.64	11.70	3.41
Acetaldehyde	5.51	2.17	.38	2.10	.83	.44	2.41	.95
Acetone	.56	.20	.52	.29	.10	.82	.46	.16
Oxygenates Subtotal			4.28	26.53	7.96	2.90	14.56	4.52

NMOG Summary		Test 1C11, 8/22/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR	Test 1C12, 8/23/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR
Light-End Species		72.59	22.69	14.87	89.24	29.03	18.97
Mid-Range Species		.02	.19	.07	.03	.28	.11
Oxygenates		4.28	26.53	7.96	2.90	14.56	4.52
Total		76.89	49.41	22.90	92.17	43.88	23.60
Ozone/NMOG			.64	.30		.48	.26

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PART B: DETERMINATION OF REACTIVITY SCALE

INTRODUCTION

The staff of the Air Resources Board (ARB or Board) proposes to use the "maximum incremental reactivity" (MIR) of each hydrocarbon to develop hydrocarbon reactivity adjustment factors (RAF) for the low-emission vehicle/clean fuel regulations. The MIR scale, developed by Dr. William Carter of the Statewide Air Pollution Research Center at the University of California at Riverside, defines reactivity where hydrocarbon control has its greatest benefits: in upwind areas where the highest emission densities are found. This is complementary to nitrogen oxides (NO_x) control, which has its greatest benefits in downwind, peak ozone areas. Even though all hydrocarbons eventually react far downwind of urban areas, there is little to be gained by designing a reactivity scale for areas where hydrocarbon control has little or no benefit.

In addition to the MIR scale, Dr. Carter developed the maximum ozone reactivity (MOR) scale for maximum ozone conditions. The MIR and MOR scales bracket the range of conditions where it is relevant to define reactivity for hydrocarbon emission controls, but it is still not clear which scale is more appropriate for controlling ozone in urban areas where both hydrocarbon and NO_x controls are important. Professor Armistead Russell of Carnegie Mellon University will resolve this issue by the end of October. Professor Russell will use the Southern California Air Quality Study (SCAQS) and other airshed model applications to evaluate if the regulations will have the intended effect of equal ozone impacts for any vehicle/fuel combination.

For the foreseeable future, the Board will continue to sponsor laboratory studies to reduce uncertainties in incremental reactivities, particularly for aromatic compounds, and to review research sponsored by other organizations. The Board plans to update the reactivity scale every three years.

In the following chapter a brief discussion of the fundamentals of ozone formation is provided. The next chapter summarizes the issues on reactivity scales that surfaced during the past year and how Dr. Carter and the ARB staff resolved them. The final chapter provides a protocol to compare the MIR and MOR scales with airshed modeling. Separate appendices contain the peer review of Dr. Carter's chemical mechanism and a protocol to compute the uncertainty in the reactivity adjustment factors (RAF).

IV.

OZONE FORMATION

The fundamentals of ozone formation in the troposphere have been described elsewhere (Finlayson-Pitts and Pitts 1986; Atkinson 1990), and only the key points are summarized here.

A. NITROGEN OXIDES VERSUS HYDROCARBON CONTROL

Nitrogen oxides are required for ozone formation. If NO_x were not emitted, ozone formation would not occur. Hydrocarbons greatly enhance the build-up of ozone from NO_x. If hydrocarbons were absent, ozone concentrations would remain acceptably low. Nitrogen oxides have a shorter lifetime in the atmosphere than hydrocarbons, and their natural emissions are negligible. Therefore, man-made emissions of NO_x ultimately limit how much ozone will be formed. Controlling NO_x increases the rate of initial ozone formation, and may cause higher ozone near the source, where ozone concentrations are well below their peak values.

Controlling hydrocarbons slows the rate at which ozone builds up. The benefits of controlling hydrocarbons are greatest near the source, and less for the peak ozone concentrations downwind. Any comprehensive ozone control strategy needs to reduce emissions of both NO_x and hydrocarbons.

B. REACTIVITY

The most basic definition of reactivity is the tendency of an organic gas to contribute to the build-up of ozone in atmospheres containing NO_x. Carter and Atkinson (1987) have approximated reactivity as the product of two components, the fraction of the hydrocarbon that reacts over the course of a day (kinetic reactivity) and the amount of ozone formed by the fraction reacted (mechanistic reactivity).

For most hydrocarbons, reaction with hydroxyl radicals is the only significant route towards ozone formation. Therefore, kinetic reactivity can be calculated from hydroxyl radical rate constants and radical levels. Hydroxyl radical rate constants have been measured (Atkinson 1989) or can be estimated (Atkinson 1987) for most hydrocarbons. Reactions of alkenes with ozone, and photolysis of aldehydes and ketones are alternate routes toward ozone formation. These rates of reaction are also known (Atkinson 1990).

In contrast to the kinetic reactivities, the mechanistic reactivities are uncertain for most hydrocarbons (Atkinson 1990). Suitable laboratory data are available for testing the mechanisms of only a limited number of hydrocarbons, and the mechanisms for most other compounds are based on estimates and extrapolations (see Table IV-1). The mechanistic reactivities for higher molecular weight hydrocarbons are particularly uncertain.

An additional complication is that laboratory (Carter and Atkinson 1987) and modeling studies (Dodge 1984; Carter and Atkinson 1989) show that mechanistic reactivity is a complicated function of environmental conditions, particularly NO_x levels. Some hydrocarbons that are normally considered to be highly reactive, such as aromatics, can even slightly suppress ozone build-up under low NO_x conditions.

Table IV-1: Status of Ability to Model Mechanistic Reactivities (Carter 1990b)

Mechanisms for these compounds are estimated from basic kinetic and mechanistic knowledge:

- methane
- ethane
- propane
- ethanol

Experimentally-tested mechanisms exist for the following, although there are some uncertainties:

- n-butane
- formaldehyde
- methanol
- ethene
- acetaldehyde
- acetone
- propene
- propionaldehyde
- methyl ethyl ketone

Experimentally-tested mechanisms are available for the following, but there are major uncertainties:

- several C_{5+} alkanes
- benzene
- napthalene
- toluene
- 2,3-dimethyl napthalene
- several C_{4+} alkenes
- xylenes
- 1,3,5-trimethylbenzene

Mechanisms for all other organic gases are approximated by those of chemically similar compounds.

V.

ISSUES

Several ARB and industry-sponsored reviews of the MIR approach over the past year, including the Reactivity Conference in Irvine, California on April 8 and 9, identified a number of issues related to both the development and application of the reactivity scale.

A. CRITERIA USED IN DERIVING REACTIVITY SCALES

Perhaps the most important objective of the work done on the reactivity scale over the past year has been to establish a general set of principles and criteria for reactivity assessment that can be used not only for calculation of the present set of RAF values, but for those in the future. Future changes in the criteria used to derive the reactivity scale are much more likely to cause large changes in reactivity scales than advances in the knowledge of atmospheric chemistry or airshed conditions.

1. "Equal Air Quality" Criteria

The principle behind the RAF concept is that equal impacts on air quality will result from reactivity-adjusted emissions that just meet the standard. But what is meant by "equal air quality"? Unless all vehicles emit exactly the same types of hydrocarbons, it is not possible to derive a single RAF that yields equal air quality impacts in all places at all times. A RAF determined so that two vehicles have equal impacts on peak ozone will, in general, be different from a RAF derived so that the vehicles have equal impacts on integrated ozone. Therefore, specific criteria of what is meant by equal air quality must be established. Since the main reason for regulating ozone is to reduce impacts on human health, it is more appropriate for medical experts, not atmospheric chemists or modelers, to determine these criteria.

Two issues need to be addressed in relation to setting equal air quality criteria for the ozone reactivity scale. First, which of several criteria should be used to judge equal air quality for the purpose of calculating reactivity scales? Second, how should the areas of ozone decreases and increases that result when two fuel/vehicle combinations are compared in the airshed model evaluation of the reactivity scale be weighted? The ARB health effects staff has consulted with other experts on ozone health and welfare effects studies, including staff from the EPA. The staff's conclusion is that both peak exposures and cumulative exposures are important. Since the national and California ambient air quality standards (AAQS) for ozone are not expected to change from the current form of one-hour peak exposure, and the California standard is protective of cumulative exposures, the reactivity scales will be derived based on ozone peaks. The airshed model evaluation will demonstrate a successful reactivity scale if two fuel/vehicle combinations result in equal one-hour basin peak concentrations and equal ozone exposure (in units of ppm-hours for all hours in all grid cells with ozone concentrations above 0.09 ppm).

2. "Pollution Scenario" Criteria

The second major issue is the set of criteria used to establish which models for airshed conditions, or "pollution scenarios", are used to calculate the reactivity scale. The MIR scale was developed using the criteria that: (1) accurate representation of the chemical mechanism and the chemical environment is more important to reactivity calculations than accurate representations of physical characteristics of the scenarios; (2) approximate representation of a wide variety of airshed conditions is more important than accurate representation of any single scenario; and (3) the scenarios employed be those where hydrocarbon emissions have the largest effect on ozone. The reasons for using these criteria are discussed in detail in Carter's reports (e.g., Carter 1991) and in the ARB staff's earlier Technical Support Document (ARB 1990).

An alternative to the first two of these criteria is the principle of using scenarios that are as physically realistic as possible, i.e., to use grid models. However, no one has proposed developing a complete reactivity scale based on grid model calculations, since separate simulations would be required for each of more than one hundred hydrocarbons. It is not impractical, however, to derive RAF values for given vehicles using this method, which requires only direct calculations of reactivities of whole exhaust mixtures. It is more difficult to do this for a comprehensive variety of conditions, since grid models are set up for only a limited number of scenarios. In addition, because of uncertainties in emissions inventories, one has no real assurance that a grid model is any more accurate in representing chemical effects than the physically much simpler Empirical Kinetics Modeling Approach (EKMA). Given the uncertainty in emissions and other airshed conditions, the ARB staff has judged that the criterion of using a wide variety of scenarios be adopted.

3. Maximum Reactivity Criterion

The most controversial of the criteria behind the MIR scale is the principle of basing the scale on environmental conditions where hydrocarbons have the greatest effect on ozone, i.e., the "maximum reactivity" criterion. The use of this criterion has been criticized because it means that reactivity scales are calculated for conditions where NO_x levels are higher than those where peak ozone levels occur. Many believe that basing the scale on conditions where peak ozone levels occur, or on averages of airshed conditions regardless of sensitivity of ozone to hydrocarbons would be more appropriate. The principle behind the use of the maximum reactivity criterion is that hydrocarbon controls are being implemented in conjunction with NO_x controls. NO_x controls are being implemented to reduce ozone under conditions that are sensitive to NO_x, and hydrocarbon controls to reduce ozone under conditions sensitive to hydrocarbons. The ARB staff believes that the maximum reactivity criterion is the most appropriate in this context. Perhaps additional assessments of the appropriateness of the maximum reactivity criterion are needed, but such assessments must take the role of NO_x control into account. This has been missing in previous critiques of the MIR approach.

B. UNCERTAINTY IN UNDERSTANDING OF ATMOSPHERIC CHEMISTRY

Computer model calculations are required to estimate hydrocarbon reactivities under atmospheric conditions. The reliability of such calculations depends on the reliability of the chemical mechanism used in such models. The MIR and MOR scales were calculated using the chemical mechanism developed by Carter (1990a). The mechanism includes measured or estimated rate constants and other mechanistic parameters for most of the more than one hundred different hydrocarbons found in vehicle emissions, allowing their reactivities to be calculated. Carter believes that his mechanism represents the state of knowledge of atmospheric reactions of hydrocarbons as of 1990. However, mechanisms for many of the hydrocarbons in Carter's mechanism are somewhat speculative, and only those for approximately twenty of the hydrocarbons have been fully tested against environmental chamber data. Even in these cases, there are many uncertainties concerning details of the individual reactions and products, and in some cases (particularly for aromatics) empirical mechanisms with adjustable parameters have to be used to "fit" smog-chamber data. The mechanisms for the rest of the hydrocarbons are based on extrapolations and interpolations from mechanisms of those twenty hydrocarbons, or estimates based on laboratory data and theoretical considerations.

1. Comparison of Carter with Other Mechanisms

It was noted at the Reactivity Conference that Carter's mechanism contains a number of estimates that are, in effect, his "personal opinion", and that others have made different estimates. However, only Dr. Richard Derwent has made a comparable attempt to estimate the atmospheric reactions of a comprehensive set of hydrocarbons for the purpose of reactivity calculations. All other current mechanisms, such as Carbon Bond IV (CB4) and RADM-II (RADM), are condensed mechanisms designed primarily to simulate reactions of complete atmospheric mixtures, rather than for calculations of reactivities of individual hydrocarbons. They can, however, be used to calculate reactivities for any hydrocarbon for which "lumping" rules have been derived. But only reactivity calculations for species which can be represented without "lumping" can have potential claim to chemical accuracy comparable to those of detailed mechanisms such as Carter's or Derwent's.

The reactivity scale calculated by Derwent has significant differences from both the MIR and MOR scales calculated using Carter's mechanism, but this may be due more to differences in the scenarios employed rather than the mechanisms. The CB4 is the only mechanism that has been compared with Carter's using the same scenarios. The results showed some similarities and some differences, with the greatest differences being toluene and formaldehyde reactivities in MOR conditions. However, as shown on Table V-1, the differences between these two mechanisms in calculations of RAF values are not great, although this may not be the case with all possible future fuel/vehicle combinations. A detailed sensitivity analysis (Milford et al. 1991) to compare the CB4 and LCC (a predecessor of the Carter mechanism) chemical mechanisms identified the sources of the differences in the toluene and formaldehyde reactivities. In CB4, the radical intermediate produced in the reaction of toluene and the hydroxyl radical (OH) is assumed to either react with nitrogen oxide (NO) to produce nitrogen dioxide (NO_2) and a dicarbonyl, or to rearrange, producing a cresol. The cresol species is significantly less reactive than the dicarbonyl species. In LCC, only the reaction with NO occurs, causing the LCC to have a higher toluene reactivity. The LCC includes a reaction between formaldehyde and hydroperoxy radical (HO_2). The products of this reaction are less reactive than those produced from formaldehyde photolysis. In CB4, the reaction with HO_2 does not occur, causing CB4 to have a higher formaldehyde reactivity.

Table V-1: Effect of Different Reactivity Scales on RAFs for Vehicles that Meet the TLEV Standards.

Vehicle Type	SAPRC-90 MIR	SAPRC-90 MOR	CB4 MIR	CB4 MOR
CFV	1.00	1.00	1.00	1.00
CNG	0.18	0.24	0.17	0.22
LPG	0.50	0.59	0.53	0.66
M85	0.36	0.38	0.38	0.39

2. Peer Review of the Carter Mechanism

The ARB staff considers Carter's mechanism to be the most appropriate of the currently available mechanisms for calculating reactivity scales. Unlike Derwent's mechanism, it was tested as much as possible against chamber data and, unlike CB4 and RADM, it was specifically designed for calculating reactivities of individual hydrocarbons. However, it is clear that the assumptions underlying Carter's mechanism should undergo thorough peer review, and that a systematic estimate of effects of chemical uncertainties on its reactivity predictions be carried out. Dr. Michael Gery, a recognized expert in the field of atmospheric chemistry, was contracted by ARB staff to peer review the Carter mechanism (see Appendix B-1). The review was done on two levels; theoretical and operational. The theoretical level review examined the principles and assumptions behind the Carter mechanism. Gery focused on what was reasonable for Carter to have done given the state of the science (i.e., considering the limitations in chemistry knowledge, smog chamber data and the need for condensed mechanisms because of computer limitations). The operational level review checked that Carter had correctly translated his chemical mechanism into computer code.

In his peer review of the Carter (1990a) mechanism, Gery found that while the mechanism was basically sound, there were several areas where updates would be desirable. Those characterized as "needed updates" included (1) updates to the formaldehyde absorption cross sections; (2) updates to the rate constants involved in PAN formation reactions; (3) re-examinations of assumptions used in representing unknown portions of the aromatic mechanisms; (4) addition of several new NMOG species; and (5) fix several minor errors found in the program and data used to derive the mechanistic parameters for the alkanes. The recommendations given lower priority included (6) re-examine the assumptions used to derive nitrate yields from the alkanes; (7) use measured OH radical rate constants for alkanes where available, rather than estimates; (8) re-examine the method used to represent cycloalkenes; (9) re-examine the method used to represent isoprene; (10) update several NO_3 + alkene rate constants; and (11) update the products from the NO_3 + HO_2 reaction. Gery had a number of other "significant concerns" regarding treatments of many areas of uncertainty in the mechanism where he might have made different assumptions, or where further work is clearly needed. However, he recognized that addressing these latter concerns is a longer term research need which cannot be addressed in this calculation of the RAFs, and recommended the present effort be restricted to the priority items listed above.

3. Updates to the Carter Mechanism

Carter concurs with most of Gery's recommendations, and will find his review of major utility when updating the mechanism in the coming six to nine months. Unfortunately, there was insufficient time to make all the modifications to the mechanism that Gery characterized as "needed updates" prior to the calculation of the RAFs. This is because major modifications of the mechanism which would significantly affect its predictions would require its re-evaluation against the chamber data used in its development. In particular, it was found when the formaldehyde and PAN kinetics updates were incorporated, the mechanism exhibited a significant positive bias (on the order of 25%) in simulations of the chamber runs. This may be due to a need to re-examine the chamber model in light of these new data, but there was insufficient time to work on this. After discussions with Gery, and with Dr. Harvey Jeffries and other modeling experts on the Reactivity Advisory Panel, it was decided that it was more prudent to calculate the RAFs using a mechanism which has already been evaluated and documented, rather than to make partial updates without time to adequately evaluate their effects. Therefore, because there was insufficient time for such an evaluation, the changes to the mechanism were restricted to those only affecting individual NMOG for which there is no significant evaluation data base.

It should be noted that there are a few cases where Carter disagreed with Gery's recommendations. Carter did not think it was advisable to make major changes to the representation of the uncertain portions of the aromatic mechanisms without incorporating new information concerning the effects of aromatic product yields on NOx, and completely evaluating the consequences of these changes. There was insufficient time available to do this. In addition, Carter does not agree with Gery (and Jeffries) that the shape of the action spectrum used for the unknown products will necessarily introduce a bias into the simulations. These products probably include unsaturated carbonyls, which may be similar in some respects to acrolein. Carter found that using the action spectrum for acrolein (with unit photodecomposition quantum yields) to represent those unknown products gives essentially the same results in simulating the chamber data, including outdoor chamber runs, as the spectrum used in the Carter (1990a) model. Therefore, while the true action spectra for these products are unknown, he does not feel the representation in the present model is sufficiently unreasonable that it needs to be immediately updated.

As noted above, Gery had a number of recommendations for updates for individual NMOG which could be implemented. Other updates not noted by Gery were also made. The errors in the alkane parameter calculation program were corrected, and the measured alkane + OH rate constants were used whenever available. Rate constants for the reactions of alkenes with NO3 radicals, ozone, and O(3P) atoms were updated. (No significant updates were found to be needed for the alkene + OH reactions.) The representation of the ozone + cycloalkene reaction was corrected so the overall radical yield was assumed to be the same as for other internal alkenes. (The parameterization in the previous mechanism caused the fragmentation yield to be half as much as other alkenes, which is not what would be estimated.) Errors found by Gery concerning some of the higher alcohols were also corrected -- though none of these are needed for the RAFs. A number of alkane and alkene species were added to the list of NMOG which could be separately represented. Therefore, although the common portions of the mechanism which affect reactivities of all NMOG were not significantly changed, there are a number of updates concerning reactions of individual NMOG.

4. Assessment of Effects of Chemical Uncertainties

The assessment of chemical uncertainties on a NMOG's reactivity can be aided by considering separately the uncertainties in a NMOG's "kinetic reactivity" and its "mechanistic reactivity". The kinetic reactivity of a NMOG is the ratio of emitted NMOG which undergoes reaction in the ozone episode, while mechanistic reactivity is the amount of ozone formed when a given amount of the NMOG reacts. The kinetic reactivity is determined by rate constants for the NMOG's initial reactions in the atmosphere. These are not considered to be the most important uncertainty in most cases, but their uncertainties are relatively easy to quantify, since evaluations of kinetic data generally give uncertainty ranges for the measured values. Translating uncertainties in rate constants to uncertainties in reactivities (specifically in "kinetic reactivities") is relatively straightforward, and can be done without having to explicitly recalculate all reactivities.

Determination of uncertainties in mechanistic reactivities is much more difficult, since it depends on a large number of parameters, environmental as well as mechanistic. Without carrying out a systematic evaluation of the effects of all these parameters (and making guesses as to their ranges of uncertainty), the only approach we could use was to make largely subjective estimates of likely uncertainty ranges. These are given on Table V-2. These estimates are based in part on (1) the estimated uncertainty ranges of parameters which are important in affecting mechanistic reactivity and the reactivities of "pure mechanism" species corresponding to these parameters (Carter and Atkinson, 1989); (2) sensitivity calculations on effects of alternative assumptions on mechanisms of the NMOG; (3) differences between mechanistic reactivities for the Carbon Bond IV and the Carter mechanism for those species which the Carbon Bond mechanism represents explicitly; and on (4) an arbitrarily assumed minimum uncertainty of 20% for all mechanistic reactivities of all NMOG. For some NMOG whose mechanistic reactivities are determined by combinations of mechanistic characteristics which have opposing effects on reactivity, such as the alkanes and the aromatics under maximum ozone conditions, it is more meaningful to express uncertainties in terms of an absolute number of ozone per NMOG reacted, rather than a relative factor.

Professor Russell developed an approach to determine the uncertainty in the RAF due to chemical uncertainties (see Appendix B-2). If an alternatively-fueled vehicle exhaust contains many of the same NMOG species as gasoline-fueled vehicle exhaust, the uncertainty in the RAF can be less than the individual uncertainties because of intercorrelation.

5. Updates to Reactivities Every Three Years

Of course, assessing the uncertainties in Carter's mechanism and comparing its predictions to other mechanisms will not solve the underlying problems causing these uncertainties. These can only be addressed by fundamental studies aimed at improving the knowledge of the atmospheric reactions of hydrocarbons, and environmental chamber experiments to test the models for these reactions. Research of this type is being sponsored by the Board and others, so the knowledge in these areas will continue to advance, and the mechanisms will improve accordingly. The ARB staff welcomes industry involvement in such research.

Table V-2: Mechanistic Reactivity Uncertainty Estimates for MIR and MOR Conditions (expressed as standard deviations)

NMOG Class	Mechanistic Reactivity Uncertainty (Moles O3 per mole C NMOG [a])	
	MIR	MOR
CO	15%	20%
Alkanes		
C1 to C8	greater of (20% or 0.5/nC)	greater of (20% or 0.2/nC)
C9 and above	0.5/nC [b]	0.25/nC [b]
cycloalkanes	0.6/nC [b]	0.3/nC [b]
Alkenes		
ethene	20%	20%
propene	25%	25%
C4	30%	30%
C5 and above	40%	50%
dialkenes	50% [c]	50% [c]
cycloalkenes	50%	50%
Alkynes	50%	50%
Aromatics	30%	0.35 [d]
styrene	50%	0.2 [d]
Oxygenates		
methanol	20%	20%
ethanol	20%	20%
formaldehyde	40% [e]	30% [e]
acetaldehyde	40%	30%
propionaldehyde	40%	30%
acetone	40%	30%
acrolein	50% [c]	50% [c]
MTBE	20%	30%
ETBE	40%	30%

[a] Relative uncertainties given unless indicated otherwise.
[b] Absolute uncertainty. nC = number of carbons in alkane.
[c] Uncertainty primarily due to inappropriateness of mechanism. More accurate mechanisms can be derived for 1,3-butadiene, isoprene and acrolein, but were not used in these calculations.
[d] Absolute uncertainty.
[e] High uncertainty primarily due to sensitivity to base NMOG mechanisms.

Because of uncertainties in the chemical mechanisms, the reactivity scale will be subject to re-calculation at three-year intervals using the mechanism reflecting the available knowledge. It is expected that changes in the chemical mechanism alone will not greatly change the RAF values for vehicles whose emissions are dominated by a few species, such as ethene, methanol or formaldehyde, whose mechanisms are already well tested. However, industry must be prepared to anticipate and deal with the changes that may occur, since the Board intends to base all of its regulations on the best available knowledge.

C. REPRESENTATION OF ENVIRONMENTAL CONDITIONS

1. California Conditions

A criticism of the application of the MIR scale to California motor vehicle regulations is that it was developed from EKMA scenarios throughout the United States which may not necessarily be representative of conditions in California. Professor Russell will address this issue by evaluating the MIR and MOR scales with an airshed model application in the South Coast Air Basin.

2. Effect of Emission Inventory Biases

Another potential weakness of relying on current modeling results is that they use existing emission inventories that may contain biases. For example, Pierson et al. (1990) have claimed that on-road motor vehicle emission inventories for hydrocarbons and carbon monoxide are underestimated by factors of four and three, respectively. This large bias could affect the airshed model evaluation of the reactivity scale because the model will be biased to maximum reactivity conditions (lower hydrocarbon to NO_x ratios). This issue will be addressed with the airshed modeling by using a model application where the emission inputs are adjusted so that the model predictions match the observed hydrocarbon to NO_x ratios.

3. Ambient Formaldehyde and Nitrous Acid

The reactivity calculated for formaldehyde is dependent on the ambient concentration assumed for that pollutant. Carter's previous calculations used the EKMA-recommended default value of two percent mass for formaldehyde and three percent mass for higher aldehydes. These default values are not measurement-based. Dr. Carter used the SCAQS measurements of one percent for both formaldehyde and acetaldehyde.

Professor James Pitts has noted that nitrous acid (HONO), an important radical initiator, is not included in the initial conditions for the models being used to calculate the reactivity scale. A constant HONO to NO_x ratio of 0.02 was used to specify initial conditions, with a ratio of 0.001 for emissions.

The results of sensitivity studies to investigate the effects of uncertainties in HONO and formaldehyde levels, as well as photolysis rates, are shown in Table V-3. Reactive species, such as alkenes, aromatics and formaldehyde were sensitive to the HONO concentration. However, RAF calculations on a set of older hydrocarbon profiles showed less than a 7% effect of assuming zero HONO concentrations. The effect of the assumed light intensity is variable, but smaller than that due to changes in the HONO concentration. There is virtually no sensitivity to the EPA ROG ambient profile, which has double the formaldehyde and acetaldehyde of the standard conditions, but no higher aldehydes.

Table V-3: Reactivities Relative to Base ROG, Averaged Conditions Scenario: Effect of HONO, Light Intensity, Base ROG. [a]

Compound or Mixture	Incremental Reactivity (g O3/g VOC) Standard	No HONO	Ground hv	EPA ROG
Maximum Incremental Reactivity				
Propane	0.17	0.16	0.145	0.18
n-Butane	0.35	0.32	0.30	0.37
n-Octane	0.21	0.18	0.17	0.22
Ethene	2.6	2.5	2.5	2.6
Propene	3.0	2.9	3.0	3.0
trans-2-Butene	3.0	3.1	3.1	2.9
Benzene	0.145	0.138	0.134	0.146
Toluene	0.88	0.87	0.88	0.88
m-Xylene	2.6	2.6	2.8	2.6
Methanol	0.21	0.20	0.19	0.22
Ethanol	0.44	0.40	0.38	0.45
Formaldehyde	2.2	2.7	2.4	2.1
Acetaldehyde	1.7	1.7	1.7	1.7
Maximum Ozone Reactivity				
Propane	0.25	0.24	0.23	0.25
n-Butane	0.49	0.48	0.46	0.50
n-Octane	0.29	0.27	0.25	0.30
Ethene	3.0	2.9	3.0	3.0
Propene	3.2	3.2	3.2	3.2
trans-2-Butene	3.1	3.2	3.2	3.1
Benzene	0.119	0.111	0.109	0.116
Toluene	0.53	0.50	0.52	0.53
m-Xylene	2.2	2.2	2.3	2.2
Methanol	0.26	0.26	0.25	0.27
Ethanol	0.51	0.49	0.46	0.52
Formaldehyde	2.0	2.3	2.2	1.9
Acetaldehyde	1.8	1.8	1.7	1.8

[a] "Standard" = Conditions of current reactivity calculations: HONO = 2% initial NOx; 640 meter light intensity; New base ROG.
"No HONO" = No initial or emitted HONO.
"Ground hv" = Ground level light intensity.
"EPA ROG" = All city average mixture with EPA assumed aldehydes.

D. APPLICATION OF REACTIVITY SCALES

1. Weighting of Three Phases of FTP

The low-emission vehicle regulations require hydrocarbon speciation information from the United States Environmental Protection Agency's (EPA's) Federal Test Procedure (FTP). Diluted exhaust emissions from the cold transient, cold stabilized and hot transient phases (Bags 1, 2 and 3, respectively) of the FTP are collected in separate bags that undergo hydrocarbon speciation analyses. The ARB regulation currently requires that EPA's 1978 FTP composite weighting be used to determine the RAF. Systems Applications, International (SAI) (Smylie et al. 1990), the Western States Petroleum Association (WSPA) and others have contended that the FTP weighting is quite different from that used in emission inventories, and that the FTP weighting unfairly penalizes gasoline-fueled vehicles. The analysis below shows that the FTP weighting is quite representative of current emission inventories, but current emission inventories are not representative of emissions from alternatively-fueled vehicles (AFV).

As shown in Table V-4, there is close agreement between the miles per start used by the FTP and the emission inventory. The disagreement in the hot starts per cold start is not important, because hot start exhaust emissions are small relative to the cold start and running exhaust emissions.

Table V-4: Comparison of Activity Data by Weighting Scheme.

Weighting Scheme	Miles per Start	Hot Starts per Cold Start
FTP	7.5	1.33
Emission Inventory [a]		
1987	8.3	0.73
2010	9.8	0.66

[a] EMFAC7E and BURDEN models applied to the South Coast Air Basin.

Table V-5 shows a comparison of the emission inventory and actual emission results for tests of three vehicles that meet the TLEV standards. The exhaust emissions data are distributed into the three modes used in the emission inventory. The data for the conventionally-fueled vehicle (CFV) agrees quite closely with the emission inventory. This result may be a coincidence as the emission inventory uses speed and temperature corrections for conditions that are not replicated by the FTP. However, the exhaust emission distributions for the compressed natural gas (CNG) and 85% methanol-fueled (M85) vehicles are quite different from the emission inventory distribution. Thus, it is not correct to apply the emission inventory weighting to AFV such as CNG and M85 vehicles.

Since the FTP is the method for determining compliance with the mass emission standards, the FTP weighting scheme will continue to be the method employed to calculate the reactivity adjustment factor. However, an important issue that still needs to be addressed is whether or not the FTP simulates on-road conditions, particularly for heavy accelerations. Emissions due to heavy accelerations is the subject of several on-going ARB in-house and extramural research projects.

The previous discussion does raise an important issue in the use of the exhaust emissions distribution from the current emission inventory to evaluate the impacts of AFV. Previous airshed modeling studies by Russell et al. (1991) and Dunker et al. (1991) have assumed the same distribution of cold start, running and hot start exhaust emissions for CNG and M85 vehicles as for CFV, which Table V-5 has shown to be incorrect. Future airshed modeling studies should use the actual mass emissions for all AFV. A currently unresolved issue is what temperature and speed corrections need to be applied to the FTP data before it is used in the airshed modeling.

Table V-5: Comparison of Exhaust Emissions Distribution for Emission Inventory with Test Data for Vehicles that Meet the TLEV Standards.

Vehicle Type	Percent of Mass in Each Exhaust Mode [a] Cold Start	Running	Hot Start
Emission Inventory [b]	50	45	5
CFV [c]	58	38	4
CNG [d]	17	81	2
M85 [d]	93	6	1

[a] Using Auto/Oil emissions processing procedure and 2010 emission inventory data in Table V-4.
[b] Based on 2010 EMFAC7E/BURDEN weighting in South Coast Air Basin.
[c] Heimrich (1990)
[d] Rieger and McMahon (1990)

2. Linearity

Calculations by Carter (1991), Chang and Rudy (1990) and Dunker (1980) indicate that the linearity assumption implicit in incremental reactivity appears valid up to a thirty percent change in basin-wide hydrocarbon emissions. This issue will also be addressed by the airshed model evaluation. The year 2010 scenarios will indicate the effects of large changes in the emissions, spatial distribution and composition of both mobile and stationary sources.

E. INPUT FROM THE PUBLIC AND INDUSTRY

Participation from the public and industry has been valuable in improving the reactivity approach. However, some industry members have pointed out that they have not had the opportunity to comment on the work-in-progress, only the final products. This issue has been addressed with the mechanisms summarized below.

1. Reactivity Conference

The California Air Resources Board and the South Coast Air Quality Management District hosted a two-day conference on the scientific issues and potential regulatory applications of reactivity-based hydrocarbon controls. The conference took place at the Beckman Center of the National Academies of Science and Engineering in Irvine, California on April 8 and 9, 1991.

The first day of the conference addressed scientific issues, and included a peer review of the MIR scale. Other talks addressed chemical mechanism uncertainties and scales for pollutants other than ozone. The second day of the conference focused on fuel/vehicle regulations and other potential applications of reactivity-based hydrocarbon controls, as well as obstacles to implementation. Professors Laurence Caretto, John Seinfeld and Arthur Winer served as moderators for the conference, and supplied summaries and recommendations. A transcript of the conference is available now in WordPerfect4.2 format, and a conference proceedings document will be available in the fall.

2. Reactivity Advisory Panel

The ARB staff is also receiving input from the ad hoc Reactivity Advisory Panel (RAP), with representatives from the California Energy Commission (Michael McCormack), South Coast Air Quality Management District (Chung Liu), Auto/Oil Air Quality Improvement Program (Charles H. Schleyer), Motor Vehicle Manufacturers Association (Alan M. Dunker), Western States Petroleum Association (S. Kent Hoekman), California Natural Gas Vehicle Coalition (Leo B. Thomason), American Methanol Institute (Larry Marigold), California Renewable Fuels Council (Neil Koehler) and Western Liquid Gas Association (Alvin Lowi, Jr.). The RAP held five meetings. These meetings were open to the public.

VI.

AIRSHED MODEL EVALUATION PROTOCOL

A. MODEL APPLICATIONS

Professor Russell will compare the MIR, MOR and base case reactivity scales with the results of his airshed model for the August 27 to 29, 1987 SCAQS episode. The modeling simulations will address concerns as to which reactivity scale is more appropriate for controlling ozone in urban areas. The primary evaluation will be for the year 2010 with the Tier I controls assumed in the South Coast Air Quality Management District's Air Quality Management Plan (AQMP) using test data from vehicles that meet the new TLEV standards. Since motor vehicle emissions are such a small part (eight percent) of the total hydrocarbon inventory in year 2010, an additional evaluation will be made in 2010 with AQMP Tier II controls. Because of concerns that the low hydrocarbon to NO_x ratios predicted by airshed models will bias the comparison in favor of the MIR scale, in some runs the hot exhaust emission inputs for hydrocarbons and carbon monoxide will be multiplied by three so that the model values of hydrocarbon to NO_x ratios reflect the estimates from some recent ambient measurements.

The August 30 to September 1, 1982 episode will also be simulated to provide a different set of meteorological conditions. The first task in this effort will be to assure that the latest emission inventories are being implemented. A constant HONO to NO_x ratio of 0.001 will be used for emissions. It is still unresolved if biogenic emissions and chemistry will be included.

B. MOTOR VEHICLE PROFILES

Only profiles from vehicles at or near the TLEV standards will be used. At this time, simulations are planned for vehicles fueled with the U.S. industry average gasoline, compressed natural gas (CNG), an 85% methanol/15% gasoline (M85) blend, and a reformulated gasoline. These four fuels lead to very different exhaust profiles, and will provide a very stringent test of the reactivity scale. Data from testing programs conducted by ARB and the Auto/Oil Program are currently being considered.

The Auto/Oil Program protocol for processing the hydrocarbon emission profiles will be followed. The main departure from previous work is that a more realistic distribution of mass emissions between cold start, running and hot start exhaust emissions will be used. A currently unresolved issue is what temperature and speed corrections need to be applied to the FTP data before it is used in the airshed modeling. Evaporative emission rates and speciation profiles will not be changed from the baseline vehicle fleet. Carbon monoxide and NO_x emissions will be set to the level of the TLEV standards. These assumptions are not realistic, but do allow a fair test of the way the reactivity scale is being applied in the low-emission vehicle regulations.

C. NULL TEST

The so-called "null test" will be performed. That is two, reactivity-adjusted vehicle fleets at the TLEV NMOG standard should lead to the equivalent air quality impact in the airshed model simulations. One-hour basin peak concentrations and ozone geographic dosage (in units of ppm-hours for all hours in all grid cells with absolute ozone concentrations above 0.09 ppm) should be equivalent. The RAP has recommend that "equivalent" be defined as within 25%. The MIR scale (based on the same LCC mechanism implemented in the airshed model) will be tested first. The MOR scale will only be tested if needed. Tests of the MIR scale for individual slow-reacting species are also possible.

REFERENCES

Atkinson, R. (1987) A structure-activity relationship for the estimation of rate constants for the gas-phase reactions of OH radicals with organic compounds. **Int. J. Chem. Kinet., 19, 799-828.**

Atkinson, R. (1989) Kinetics and mechanisms of the gas-phase reactions of the hydroxyl radical with organic compounds. **J. Phys. Chem. Ref. Data, Monograph No. 1.**

Atkinson, R. (1990) Gas-phase tropospheric chemistry of organic compounds: A review. **Atmos. Environ., 24A, 1-41.**

Baugues, K. (1991) Personal communication. May 13.

California Air Resources Board (1990) Proposed regulations for Low-Emission Vehicles and Clean Fuels: Staff report and technical support document. State of California Air Resources Board, Sacramento, CA, August 13.

Carter W. P. L. (1990a) A detailed mechanism for the gas-phase atmospheric reactions of organic compounds. **Atmos. Environ., 24A, 481-518.**

Carter, W. P. L. (1990b) Development of ozone reactivity scales for volatile organic compounds. Draft final report to EPA, contract no. CR-814396-01-0, November.

Carter W. P. L. (1990c) Personal communication.

Carter W. P. L. and R. Atkinson (1987) An experimental study of incremental hydrocarbon reactivity. **Environ. Sci. Technol., 21, 670-679.**

Carter W. P. L. and R. Atkinson (1989) A computer modeling study of incremental hydrocarbon reactivity. **Environ. Sci. Technol., 23, 864-880.**

Chang, T. Y. and S. J. Rudy (1990) Ozone-forming potential of organic emissions from alternative-fueled vehicles. **Atmos. Environ.,** submitted.

Dodge, M. (1984) Combined effects of organic reactivity and $NMHC/NO_x$ ratio on photochemical oxidant formation -- A modeling study. **Atmos. Environ., 18, 1657-1665.**

Dunker, A. M. (1980) The response of an atmospheric reaction-transport model to changes in input functions. **Atmos. Environ., 14, 671-679.**

Dunker, A. M. (1991) Reactivity calculations for the Auto/Oil Program. Presented at the conference Reactivity-Based Hydrocarbon Controls: Scientific Issues and Potential Regulatory Applications, Irvine, California, April 8-9.

Finlayson-Pitts, B. J. and J. N. Pitts, Jr. (1986) Atmospheric Chemistry: Fundamentals and Experimental Techniques, Wiley, New York.

Heimrich, M. J. (1990) Control of benzene emissions from light-duty motor vehicles. Draft final report to State of California Air Resources Board, contract no. A6-204-32, October.

Milford, J. B., D. Gao, A. G. Russell and G. J. McRae (1991) Use of sensitivity analysis to compare chemical mechanisms for air quality modeling. Environ. Sci. Technol., submitted.

Pierson, W. R., A. W. Gertler and R. L. Bradow (1990) Comparison of the SCAQS tunnel study with other on-road vehicle emission data. J. Air Waste Manage. Assoc., 40, 1495-1504.

Rieger, P. and W. McMahon (1991) Speciation and reactivity determination of exhaust emissions from low emission gasoline and clean fueled vehicles. Paper 91-107.3 presented at the 84th Annual Meeting of the Air & Waste Management Association, Vancouver, British Columbia, Canada, June 16-21.

Russell, A. G., L. A. McNair, M. T. Odman and N. Kumar (1991) Organic compound reactivities and the use of alternative fuels. Draft final report to ARB, contract no. A832-112, May.

Smylie, G. M., G. Z. Whitten, R. E. Morris, J. L. Fieber and K. O'Connor (1990) Technical analysis of the ARB staff proposal for hydrocarbon reactivity adjustment factors for Clean Fuel/Low Emission Vehicle regulations. Final report to Western States Petroleum Association, SYSAPP-90/092, September 21.

Winer A. M., H. W. Biermann, T. Dinoff, L. Parker and M. P. Poe (1989) Measurements of nitrous acid, nitrate radicals, formaldehyde and nitrogen dioxide for the Southern California Air Quality Study by differential optical absorption spectroscopy. Final report, Statewide Air Pollution Research Center, University of California, Riverside, CA 92521, prepared for the California Air Resources Board, ARB Contract No. A6-146-32, December.

APPENDIX A-1: MAXIMUM INCREMENTAL REACTIVITIES AND MAXIMUM OZONE REACTIVITIES

MIR AND MOR (grams ozone per grams NMOG) ASSIGNMENTS

COMPOUND[1]	MIR ($g\ O_3/g$ NMOG)	MOR ($g\ O_3/g$ NMOG)
ALKANES		
Normal Alkanes		
Methane	0.01	0.01
Ethane	0.26	0.18
Propane	0.48	0.31
n-Butane	1.02	0.66
n-Pentane	1.03	0.68
n-Hexane	0.98	0.64
n-Heptane	0.81	0.53
n-Octane	0.61	0.41
n-Nonane	0.54	0.36
n-Decane	0.47	0.31
n-Undecane	0.42	0.28
n-Dodecane	0.38	0.25
Branched Alkanes		
2-Methylpropane	1.21	0.73
2,2-Dimethylpropane	0.37	0.22
2-Methylbutane	1.38	0.87
2,2-Dimethylbutane	0.82	0.51
2,3-Dimethylbutane	1.07	0.67
2-Methylpentane	1.53	0.90
3-Methylpentane	1.52	0.94
2,2,3-Trimethylbutane	1.32	0.78
2,2-Dimethylpentane	1.40	0.83
2,3-Dimethylpentane	1.51	0.90
2,4-Dimethylpentane	1.78	0.99
3,3-Dimethylpentane	0.71	0.46
2-Methylhexane	1.08	0.68
3-Methylhexane	1.40	0.83
2,2,4-Trimethylpentane	0.87	0.51
2,3,4-Trimethylpentane	1.60	0.92
2,2-Dimethylhexane	1.20	0.70
2,3-Dimethylhexane	1.31	0.78
2,4-Dimethylhexane	1.50	0.86
2,5-Dimethylhexane	1.63	0.93
3,3-Dimethylhexane	1.20	0.70
2-Methylheptane	0.96	0.59
3-Methylheptane	0.99	0.62
4-Methylheptane	1.20	0.70
2,4-Dimethylheptane	1.33	0.75
2,2,5-Trimethylhexane	0.97	0.58
Trimethylheptane	1.01	0.56
Other Branched C9H20 Alkanes	1.13	0.64
Branched C10H22 Alkane	1.01	0.56

Cyclo Alkanes

Cyclopentane	2.37	1.41
Methylcyclopentane	2.82	1.55
Cyclohexane	1.28	0.74
Dimethylcyclopentanes	2.54	1.38
Methylcyclohexane	1.84	1.00
Ethylcyclopentane	2.31	1.29
1c,2t,3-Trimethylcyclopentane	1.94	1.02
Dimethylcyclohexanes	1.94	1.02
Ethylcyclohexane	1.94	1.02

ALKENES

Ethene	7.28	3.15
Propene	9.39	3.77
1-Butene	8.90	3.51
2-Butenes	9.93	3.75
2-Methylpropene	5.29	1.93
1-Pentene	6.22	2.46
2-Pentenes	8.79	3.30
2-Methyl-1-Butene	4.89	1.90
3-Methyl-1-Butene	6.22	2.46
2-Methyl-2-Butene	6.40	2.30
1-Hexene	4.41	1.74
2-Hexenes	6.67	2.50
3-Hexene	6.67	2.50
Methyl-1-Pentenes	4.41	1.74
Methyl-2-Pentenes	6.67	2.50
3,3-Dimethyl-1-Butene	4.41	1.74
1-Heptene	3.48	1.37
2-Heptenes	5.52	2.07
3-Heptenes	5.52	2.07
3-Ethyl-2-Pentenes	5.52	2.07
2,3-Dimethyl-2-Pentene	5.52	2.07
3-Methyl-1-Hexene	3.48	1.37
2-Methyl-2-Hexenes	5.52	2.07
3-Methyl-3-Hexenes	5.52	2.07
1-Octene	2.68	1.07
2-Octenes	5.27	1.99
3-Octenes	5.27	1.99
4-Octenes	5.27	1.99
2,4,4-Trimethyl-1-Pentene	2.68	1.07
1-Nonene	2.22	0.89
Propadiene	7.28	3.15
1,3-Butadiene	10.88	4.16
2-Methyl-1,3-Butadiene	9.07	3.41
Cyclopentadiene	7.65	2.78
Cyclopentene	7.65	2.78
3-Methylcyclopentene	5.65	2.20
Cyclohexene	5.65	2.20

ALKYNES		
Ethyne	0.51	0.34
Propyne	4.10	2.17
1-Butyne	9.23	3.64
2-Butyne	9.23	3.64
AROMATIC HYDROCARBONS		
Benzene	0.42	0.14
Toluene	2.72	0.63
Ethylbenzene	2.90	0.72
o-Xylene	6.68	2.00
m & p-Xylenes	8.15	2.46
n-Propylbenzene	2.27	0.56
i-Propylbenzene	2.41	0.60
Methylethylbenzenes	7.20	2.17
1,2,3-Trimethylbenzene	8.61	2.51
1,2,4-Trimethylbenzene	8.59	2.51
1,3,5-Trimethylbenzene	10.11	3.06
Indan (C9H10)	1.04	0.13
n-Butylbenzene	1.87	0.43
s-Butylbenzene	2.04	0.51
Diethylbenzenes	6.44	1.94
Tetramethylbenzenes	9.05	2.74
1-Methyl-4-Isobutylbenzene	5.83	1.76
Styrene	2.20	-0.29
Naphthalene	1.16	0.10
AROMATIC OXYGENATES		
Benzaldehyde	-0.56	-1.23
p-Tolualdehyde	-0.56	-1.23
OXYGENATES		
Alcohols		
Methanol	0.56	0.28
Ethanol	1.33	0.72
Aldehydes		
Formaldehyde	7.14	2.08
Acetaldehyde	5.51	2.17
Propionaldehyde	6.53	2.50
Acrolein	6.76	2.59
n-Butyraldehyde	5.26	2.01
Crotonaldehyde	5.41	2.07
Pentanaldehyde	4.40	1.68
Hexanaldehyde	3.79	1.45

Ethers

Methyl t-Butyl Ether	0.62	0.40
Ethyl t-Butyl Ether	1.98	1.03

Ketones

Acetone	0.56	0.20
Butanone	1.18	0.55

[1] This is a partial list of compounds. Additional compounds will be included at a later date.

APPENDIX A-2: DYNAMOMETER TEST PROCEDURES

California Air Resources Board

EXHAUST GAS SAMPLING

Dynamometer Test Procedures
for Determination of Hydrocarbon Reactivity
Factors for Low-Emission Vehicles

Introduction

This procedure describes the methods presently used by the Air Resources Board (ARB) to collect and analyze exhaust emissions from light-duty vehicles to determine NMOG speciation profiles. This procedure is not intended to provide specific details on all tasks required to perform the Federal Test Procedure (FTP). Rather, it describes how the ARB performs those functions not explicitly described in the FTP in Title 40 of the Code of Federal Regulations (CFR), Part 86.

This procedure references both 40 CFR Part 86, subpart B, as it applies to dynamometer vehicle testing and exhaust sample collection, and the relevant Standard Operating Procedures (SOP) currently used by the ARB to perform speciated hydrocarbon, alcohol, and carbonyl analyses. The format used provides reference to those sections of the CFR outlining the FTP that allow some discretion in the performance of a particular task and provides details as to how that task is performed at the ARB. Those sections of the CFR pertaining to the FTP which contain an adequate description of the required task and need no further clarification to determine how they are performed by the ARB are not referenced in this procedure.

1. 86.109-90 Exhaust gas sampling system; Otto-cycle vehicles

1.1 86.109-90 (a)(2)(iii)

For alcohol-fueled vehicles, exhaust gas dilution is accomplished by using a dilution tee located approximately two feet from the vehicle tailpipe exit.

Connection to the CVS from the point of exhaust dilution is provided via smooth bore silicon tubing, 4 inches in diameter.

1.2 86.109-90 (c)(4)

For non-alcohol-fueled vehicles CVS flow rate is controlled by a single critical flow venturi with a nominal flow rate of 350 SCFM.

For alcohol-fueled vehicles CVS flow rate is controlled by two venturies in parallel with a combined nominal flow rate of 600 SCFM.

1.3 86.109-90 (c)(5)

The size of the sample collection bags for speciated hydrocarbon analysis are approximately 0.5 cf.

Speciated hydrocarbon sample bag conditioning and sampling methods are outlined in attachment 1.

1.4 86.109-90 (c)(6)

Impinger volume used for both alcohol and carbonyls sampling is 30 ml.

2. 86.111-90 Exhaust gas analytical system.

3. 86.113-90 Fuel specifications.

3.1 86.113-90 (a)(3)

The methanol/gasoline fuel mixture used to determine hydrocarbon reactivity factors for M85 consists of 85 percent by volume of chemical grade methanol and 15 percent by volume of RF-A gasoline. The mixture is adjusted to 7.8 reid vapor pressure.

The ethanol/gasoline fuel mixture used to determine hydrocarbon reactivity factors for E85 consists of 85 percent by volume of anhydrous ethanol and 15 percent by volume of RF-A gasoline. The mixture is adjusted to 7.8 reid vapor pressure.

4. **86.116-90 Calibrations, frequency and overview.**

4.1 Instrument calibrations and their frequency, as performed by the ARB, meet or exceed the requirements of this section.

5. **86.119-90 CVS calibration.**

5.1 **86.119-90 (c)**

CVS system verification for non-alcohol testing is performed with a critical flow orifice using chemical grade propane.

5.2 **86.119-90 (c)(1)**

CVS system verification for methanol recovery is performed using the gravimetric technique using a cylinder charged with chemical grade methanol and heated to 170°F.

6. **86.121-90 Hydrogen analyzer calibration.**

6.1 **86.121-90 (c)(1)**

FID response factor to methanol is determined using a primary standard gas bottle with a known concentration of methanol. Different concentrations spanning the instrument range used for analysis are generated by a gas divider.

6.2 **86.121-90 (c)(3)**

The FID response factor, r, is calculated as follows:

r = FIDppm/DIVppm

Where:
r = FID response factor
FIDppm = FID reading in ppmC
DIVppm = methanol concentration of divider in ppmC

7. **86.137-90 Dynamometer test run, gaseous and particulate emissions.**

7.1 **86.137-90 (b)(6)(i)**

The flow rate for gaseous bag samples is 0.33 CFM.

7.2 **86.137-90 (b)(6)(ii)**

The flow rate for the methanol sample collection system is 0.5 l/min, using 25 ml impingers.

7.3 86.137-90 (b)(6)(iii)

The flow rate for the carbonyls sample collection system is 1.0 l/min, using 25 ml impingers.

7.4 86.137-90 (b)(13)

Alcohol and carbonyls sample analyses are performed within 24 hours of the completion of the cold transient phase.

7.5 86.137-90 (b)(15)

Alcohol and carbonyls sample analyses are performed within 24 hours of the completion of the cold stabilized phase.

7.6 86.137-90 (b)(20)

Alcohol and carbonyls sample analyses are performed within 24 hours of the completion of the hot transient phase.

8. 86.140-90 Exhaust sample analysis.

8.1 86.140-90 (c)

Alcohol sample analysis is performed using the procedure outlined in SOP No. MLD 101.

Carbonyls sample analysis is performed using the procedure outlined in SOP No. MLD 104.

1,3-butadiene analysis is performed using the procedure outlined in SOP No. MLD 114.

1,3-butadiene sample bags are maintained in a dark environment prior to analysis due to its reactive nature. The analysis is performed immediately after collection.

C2 to C5 hydrocarbons (light-end hydrocarbons) analyses are performed using the procedure outlined in SOP No. MLD 102.

Mid-range hydrocarbons analyses are performed using the procedure outlined in SOP No. MLD 103A.

9. 86.144-90 Calculations; exhaust emissions.

NMHC for non-CNG-fueled vehicles is calculated using the procedures outlined in "California Non-Methane Hydrocarbon Test Procedures" amended May 15, 1990.

Attachment 1

ARB Standard Protocol
Speciation Sample Bag Conditioning
and Speciation Bag Sampling

This protocol shall be utilized to precondition sample bags for hydrocarbon speciation of exhaust and evaporative emissions. This procedure has been developed to eliminate any contaminant emitted by the bag.

1. Construct the bags two or more days before using them. Construction includes cutting the tedlar material to the proper size and sealing three of the four sides.

2. One day before using the bags, construction shall be completed (in the morning before 8 am) by inserting the snap-on fitting to the center of one side of the bag and sealing the fourth side.

3. Each bag shall then be evacuated and filled with nitrogen, evacuated again, and filled with nitrogen. All bags shall be soaked while filled with nitrogen.

4. After 3 pm on the same day each bag shall be evacuated, filled with nitrogen, evacuated again, and filled with nitrogen. The bags shall be soaked overnight while filled with nitrogen.

5. On the next day before 8 am, the bags shall be evacuated, filled with nitrogen, evacuated again, filled with nitrogen again, evacuated again, and then filled with emission sample.

6. After each phase of the CVS-75 test, two speciation bags shall be filled with dilute exhaust from the CVS sample bags and delivered immediately to the lab for analysis.

7. A single background sample is taken by simultaneously drawing emission samples from the three CVS background sample bags.

APPENDIX A-3: 1,3-BUTADIENE STANDARD OPERATING PROCEDURE

DRAFT

April 1990

Air Resources Board

PROCEDURE FOR THE ANALYSIS OF 1,3-BUTADIENE IN AUTOMOTIVE EXHAUST

S.O.P. No. MLD 114

Southern Laboratory Branch
Monitoring and Laboratory Division
State of California
9528 Telstar Avenue
El Monte, CA. 91731

PROCEDURE FOR THE ANALYSIS OF 1,3-BUTADIENE IN AUTOMOTIVE EXHAUST

I. Introduction

1.1 This procedure describes a method of analyzing 1,3-butadiene in automotive exhaust in the range of 0.2 to 50 parts per billion concentrations by gas chromatography (GC) with a photo-ionization detector (PID).

1.2 Lower concentrations may be analyzed by preconcentrating a larger sample volume.

1.3 Higher concentrations may be analyzed by direct injection of a diluted sample or a smaller volume of sample through the cryogenic trap.

II. Method

2.1 A portion of the sample from a Tedlar bag is transferred by syringe to the heated volumetric sample loop or the cryogenic freeze-out trap of a gas chromatograph.

2.2 The sample is introduced into the chromatograph by means of a gas injection valve and analyzed by a photo-ionization detector.

2.3 The GC data system quantifies the 1,3-butadiene by integrating the peak area and calculating concentration from a factor determined during calibration with the 1,3-butadiene standard.

III. Apparatus

3.1 Tedlar bags, 2 mil thick, nominally of 10 to 100 liter capacity, and equipped with Quick-Connect fittings are used to contain the sample.

3.2 A gas chromatograph is equipped with a gas injection valve, loop/freeze-trap inlet system, and a PID.

3.3 The columns used are stainless steel column (6' x 1/8 inch O.D.) packed with 0.19% picric acid on 80/100 mesh Carbopack-C coupled with second column (6' x 1/8 inch O.D.) packed with 80/100 mesh Durapak N-octane Porasil-C. These columns can be substituted by other columns which are capable of resolving 1,3-butadiene from other organic compounds with similar physical and retention properties.

3.4 An analog recorder and an electronic integrator are used to quantify peak areas.

3.5 Ground glass syringes (20, 50, 100, 250 ml) or other suitable devices are needed to transfer gas samples from Tedlar bags to the sample inlet of the gas chromatograph.

3.6 Steel Dewars holding hot water (ca 95 deg. C) and liquid nitrogen.

IV. Gases

4.1 All gases used to support the GC analysis shall be of the highest purity, commercially available.

4.2 Helium shall have a minimum purity of 99.995%.

4.3 A Scott-Marin 1,3-butadiene cylinder is used as the control standard.

4.4 A NBS prepared 1,3-butadiene cylinder is used as the primary standard for daily calibration.

V. Procedure

5.1 The gaseous sample is analyzed for 1,3-butadiene by using either the loop method or the cryogenic freeze-out method. The freeze-out method is used for measurement of low concentrations of 1,3-butadiene.

5.2 The procedure for the loop method follows:

5.2.1 The sample is transferred from the sample bag to sample inlet and injected into the sample loop of the gas chromatograph by means of a syringe fitted with Luer-Lok to a Quik-Connect adaptor.

5.2.2 The gas sampling valve is equipped with a 1 mL loop at 100 deg. C.

5.2.3 After the gas sampling valve is rotated, the sample enters the GC for analysis.

5.2.4 The 1,3-butadiene is separated from other organic compounds under the following GC operating conditions:

40 ml/min. helium carrier gas flow
50 deg C sample valve temperature
200 deg C detector temperature
50 deg C injector temperature
60 deg C isothermal column temperature

5.2.5 Concentrations of 1,3-butadiene are calculated by a Perkin Elmer 2600 chromatographic data system or similar chromatographic integration systems.

5.3 The procedure for the freeze-out method follows:

5.3.1 Immerse the sample trap in liquid nitrogen (LN_2) and allow the trap to cool down to liquid nitrogen temperature.

5.3.2 After discarding 50 ml of the standard or sample, withdraw exactly 100 ml sample from the Tedlar bag with a 100 ml syringe and transfer the sample into the trap.

5.3.3 Back fill the syringe with another 20 ml of helium and flush the 20 ml through the trap; then pass helium through the trap for 3 minutes at 100 ml/min to flush out any liquified air or methane.

5.3.4 Rotate the valve to isolate the cyrogenic trap and to allow the carrier gas to by-pass the trap.

5.3.5 Replace the liquid nitrogen Dewar with a Dewar containing hot boiling water (approx. 95 degrees C).

5.3.6 Allow the trap to warm up.

5.3.7 Rotate the valve and allow the carrier gas stream to flush the sample into the gas chromatograph.

5.3.8 The instrument operating conditions are the same as those described in Section 5.2.4 above.

VI. Calculations

6.1 The 1,3-butadiene concentration in ppb (parts per billion) is calculated by the data system using the external standard method:

concentration = Area x Calibration Factor

6.2 The calibration factor (CF) is calculated during calibration by the equation

$$CF = \frac{concentration}{area}$$

The replicate calibrations are averaged and the arithmetic mean is stored as the CF to be used in subsequent analyses.

VII. Quality Control

7.1 Calibrations are performed daily with working and traceable standards.

7.1.1 An NBS reference material of 520 ppb and 6.4 ppb 1,3-butadiene in nitrogen is used as the calibration standards.

7.1.2 A control standard is used daily to check the GC performance.

7.1.3 An assurance audit of the standards is performed quarterly.

7.2 Calibrations are performed on a daily schedule.

7.2.1 The daily calibration of GC performance consists of at least two runs for automotive exhaust analysis.

7.2.2 The calibrations are repeated on both quality control calibration standards if the response of the quality control check changes by more than 2 sigma standard deviation. If the calibrations fail on both standards, the GC system will be completely checked and a corrective action will be taken to bring the system under the control before any sample analysis.

7.2.3 If the lamp voltage is adjusted, allow time for the lamp to stabilize and repeat the calibrations.

7.2.4 A record is kept for the lamp voltage settings and all preventative maintenance procedures, i.e. lamp replacement, cleaning of lamp window.

7.2.5 Blank samples are run daily between calibrations and sample analyses as necessary.

7.3 Linearity is checked annually.

7.3.1 A gas chromatographic linearity check is performed with standards of at least four different concentrations. The concentrations must cover the anticipated range of sample concentrations.

7.3.2 Multipoint calibration

(See Appendix 1)

7.3.3 Any region of concentration that deviates more than 5% from the least square line is considered non-linear.

7.3.4 Samples are analyzed only in the linear range. (Figure 1).

7.4 Limits of detection are established.

7.4.1 The limit of detection (LOD) is calculated by the following equations:

(i) if b>o, LOD = 3 s/m

(ii) if b<o, $LOD = \frac{|b|}{m} + \frac{3\ s}{m}$

LOD = 0.22 ppb

b,m = intercept, slope of calibration - curve near the LOD.

S = standard deviation of replicates.

7.4.2 The LOD should be determined at least on an annual basis.

7.4.3 If the calibration factor changes by more than 10%, the instrument must be checked and the LOD re-determined.

7.5 GC column condition parameters should be checked and documented.

7.5.1 All GC parameters should be checked daily and recorded.

7.5.2 The efficiency and resolution of the column should be checked frequently. If there is more than 10% change, the column needs replacement.

7.5.3 If the headpressure required to maintain a specified flow through the column increases by more than 100%, the column needs replacement.

7.5.4 If the drift of retention times of the peaks results in peak misidentification, all instrument parameters need to be checked.

7.6 Replicate analyses are performed daily.

7.6.1 A duplicate analysis is performed on at least for one ambient sample. A duplicate analysis is not performed with exhaust samples due to the high reactivity and decay of 1,3-butadiene in the exhaust environment.

7.6.2 If the duplicate analysis differs by more than 20% and if the concentration of the sample is higher than 3 x LOD, then an additional analysis is run.

7.6.3 If the relative standard deviation (RSD) of the replicate analyses is greater than 15% and if the concentration of the sample is greater than 3 x LOD, none of the analyses for that day are acceptable.

7.6.4 If the range is within 20%, the mean and the standard deviation are reported.

7.7 Compound confirmation is required in quality control procedure.

7.7.1 At least 10% of the analyses are to be confirmed by a different analytical system. e.g. different columns or detector (GC/MS).

VIII. Critique and Comments

8.1 The minimum measurable concentration of 1,3-butadiene has been determined to be 0.2. ppb using this method with 100 ml sample.

8.2 Any organic compound present in the sample having a retention time similar to that of 1,3-butadiene under operating condition described in this method may interfere with the quantification.

8.3 Proof of chemical identity for 1,3-butadiene requires confirmation by other means.

8.4 This method has been proven to be applicable in analyzing ambient air or vehicle emission exhaust samples.

8.5 Exhaust samples must be analyzed as soon as received as 1,3-butadiene is extremely reactive and decays in the exhaust media. Most of the 1,3-butadiene is in Mode 1 of the dyno CVS samples. That sample is to be run within 5 minutes after receipt. The initiation of taking of the sample and the analytical times are to be recorded.

Appendix 1

CALCULATION OF LIMIT OF DETECTION (LOD)

I. Name of Compound 1,3 - Butadiene

II. Multipoint Calibration Date 9-10-91
Note: The instrument zero or blank should be measured to obtain net measurement values but (0,0) is not included as a calibration point.

121505
127908
125556
131486
129039
123186

	y = Net absorbance or area count*	x = concentration
1. (Low conc.) Avg.	126,447 **	11.2 ppb
2.	429,977	36.0
3.	664,840	60.0
4.	817,935	72.0
5.	1,031,650	84.0
6.	1,122,146	96.0
7.	1,368,851	120.0
8.		

* Net measurement after correction for zero or blank
** Mean measurement for lowest concentration standard

Slope m = 11,592
Intercept b = 1,027 units area count/ppb
Correlation coefficient r = 0.9976

III. Replicate Measurements of Low Concentration Standard Date 9-10-91

Number of Replicates 6

Standard Deviation s = 3,744 units area count

IV. $LOD = \frac{|b|}{m} + 3\frac{s}{m}$ *

$$= 0 + \frac{3(857)}{11{,}592} = 0.22$$ units ppb

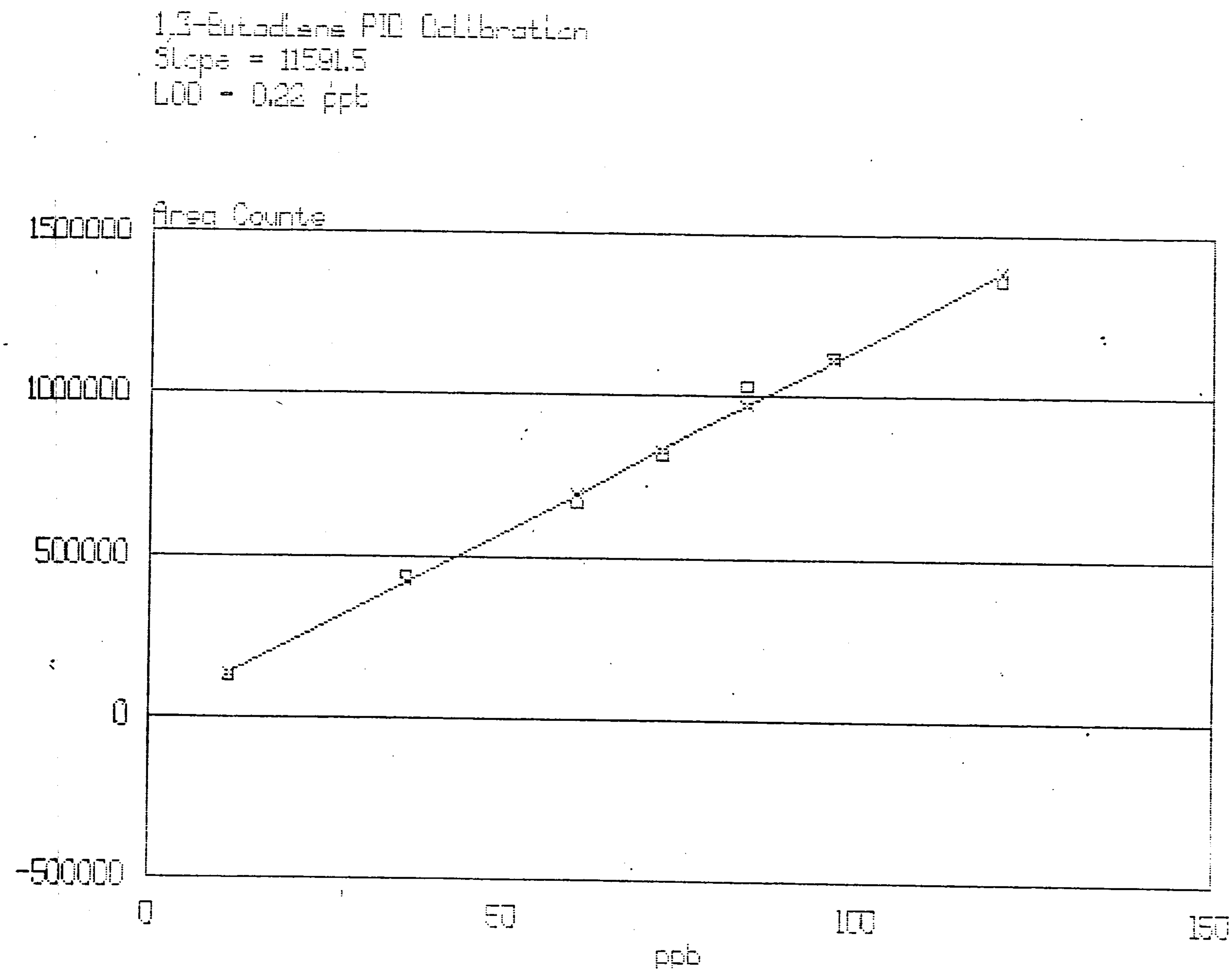
NOTE: If a 2nd degree curve fit is performed, replace "m" with the linear term and "b" with the constant term and show the regression equation below.

V. Comments *Replicates at 1.12 ppb performed 9/8/91:

12128, 10154, 11570, 11707. $\bar{x}$ = 11,390: s* = 857

Chemist ______________ Date ______________

08112



Multipoint Calibration

Figure 1

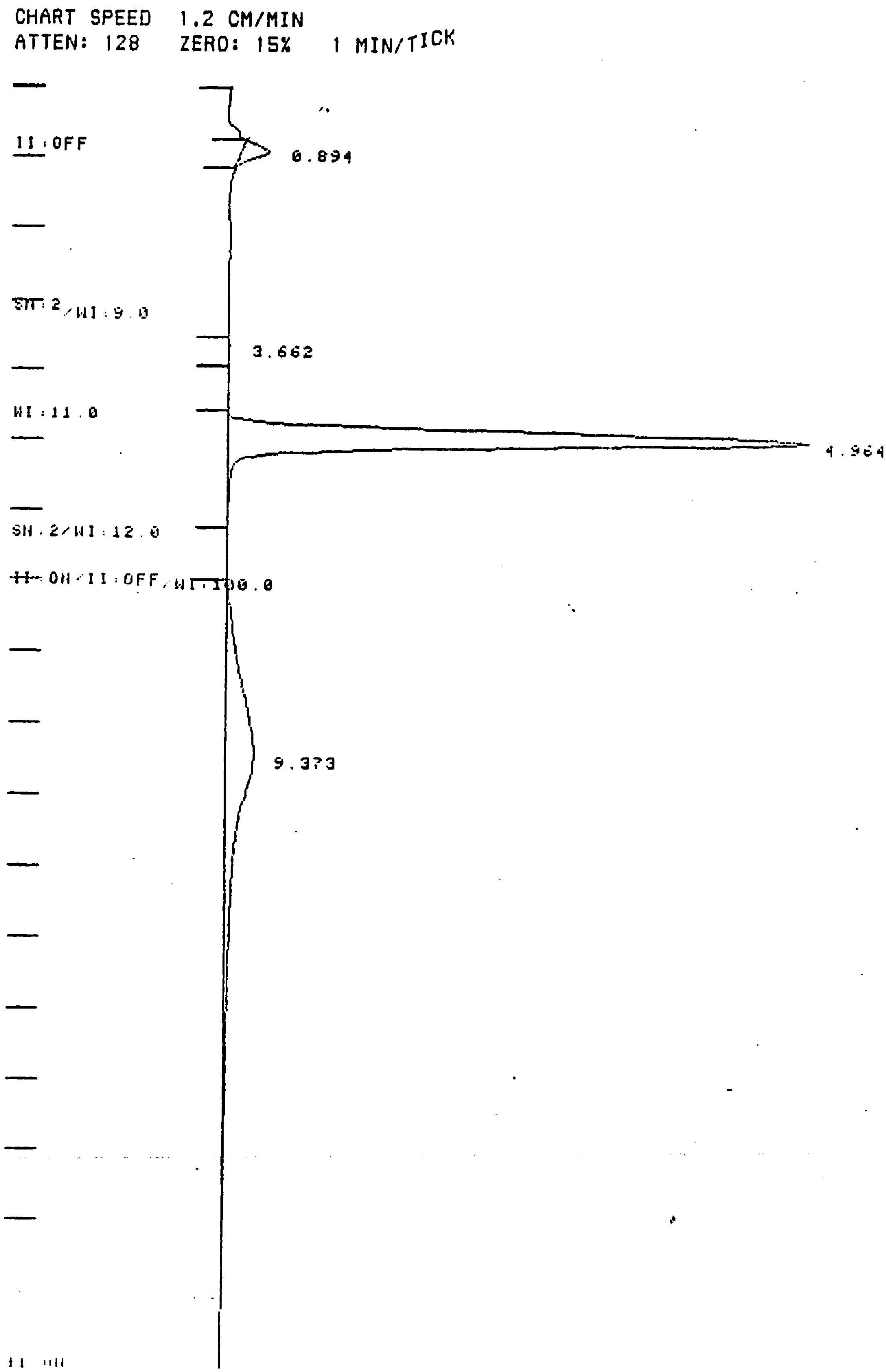


Figure 2
Sample Calibration Chromatogram

APPENDIX B-1: REVIEW OF THE SAPRC-90 CHEMICAL MECHANISM

Review of the SAPRC-90 Chemical Mechanism

by Michael W. Gery

1. CONCLUSIONS AND RECOMMENDATION

Provided that a few major improvements are adequately implemented (see below) and uncertainties and limitation are acknowledged, I conclude that the SAPRC-90 Mechanism is a reasonable choice for proceeding with reactivity calculations at this time. My recommendation is based on the fact that kinetic and mechanistic data is current and because the theoretical formulation is as sound and comprehensive as can be expected (given current gaps in chemical knowledge and the limitations of chemical solvers). As noted in the following sections, however, there are a few difficult updates and concerns that must yet be accomplished.

2. MAJOR IMPROVEMENTS AND UPDATES

The SAPRC-90 Mechanism contains basic information dating from about 1989, with many significant updates based on 1990 publications and pre-prints. In that sense, it is probably the newest mechanism available for use. Most of the above sub-sections include a discussion of 'Necessary Updates.' These updates are all important but there are only a few that require immediate attention (noted below). Immediate attention is warranted because data now available is significantly different from that included in the present SAPRC-90. As I discuss below, however, inclusion of this information in the SAPRC-90 could cause different ambient simulation characteristics.

The needed updates are:

Update formaldehyde absorption cross section.

Update kinetics of acetylperoxy radical reactions with NO and NO_2. [Based on the logic of CAR-90, this probably will also include updates to the chemistry of larger acyl peroxy radicals.]

Improve the AFG1 and AFG2 photolysis assumptions. Remove the constant absorption cross section and evaluate the radical generating characteristics in ambient light.

Address the apparent inconsistency in mono-functional aromatic kinetics and observed chamber reactivity. This may best be done through improved product yields.

Include new species in the product parameter tables for various VOC groups. Some new species have been suggested for aromatics, alkanes (included in the new, enclosed ALKANE.ALL file), ethers, and alkenes. Of course, the main concern at this time is to be able to accurately represent all important species in the scenario mixtures. Thus, some suggestions can be ignored for now if they are not important, while any VOCs that I have missed should be included.

Verify the updates I have made to the new ALKANE.ALL file.

Fix the coding 'bug' in ALKSUB subroutine of the ALKANE program and re-run the program to generate new product parameters.

3. MINOR UPDATES

Because of time constraints, I suggest only those additional updates that appear to be simple be performed at this time. However, all updates in the 'Possible Improvements' sections should be reviewed. In my opinion, the minor updates that could now be performed include:

Improve the nitrate formation algorithm for alkenes.

If available, measured k_{OH} values for alkanes should supersede estimates.

Check and update if necessary the substituent code for 'Unspeciated C≥5 internal alkenes'.

Check and update if necessary the substituent codes for cycloalkenes. [It seems that the codes should sum to 2.]

Check and update if necessary the substituent codes for isoprene. According to the logic in CAR-90, it seems that the codes are based on the wrong bond.

Check and update if necessary the reaction rate constants for NO_3 plus 2,3-dimethyl-2-butene, cyclohexene, and cyclopentene.

Update products of $HO_2 + NO_3$ reaction.

Include minor updates to the ALKANE program as noted above.

4. SIGNIFICANT CONCERNS, UNCERTAINTIES, AND LIMITATIONS:

These issues may not be able to be completely addressed within the current time frame. However, at the least they should be recognized as significant uncertainties and, in the case of the next point, the changes must be made and evaluated.

<u>Present Concerns:</u>

The effects of <u>major kinetic and product updates</u> on the predictive capacity of SAPRC-90 is very uncertain. The combination of these and the other updates suggested above could affect SAPRC-90 predictions in unanticipated ways. The continued accuracy of mechanism predictions must be verified before the mechanism is used.

I am particularly concerned that the process of correctly performing these needed updates may require more than simple changes of mechanistic parameters. The changes will probably affect the smog chamber simulation statistics, indicating that some other (as yet unidentified) mechanistic errors were inadvertently included to compensate for the original inaccuracies in the updated parameters. At this point, the best circumstance would be if Dr. Carter could identify a few changes (hopefully, in the way the chamber processes were described) that would allow the new formulation to again fit the chambers. However, if the statistical divergence is significant and no simple improvements are found, credible remedial action could potentially be extensive and well beyond the time constraints of this project. In such a case, it may be necessary to select the 'best' mechanism available, and acknowledge the limitations. As far as I can see, the choices would then be to use: (1) the old formulation with known inaccuracies in key mechanistic parameters, or (2) the updated formulation, assuming that the compensating errors are in the chamber portion of the mechanism, which will be discarded for ambient simulation. Given the intricate chemical calculations required of this project, I am uncomfortable with either choice.

Product resolution is poor. This significantly affects the quality of calculations once a scenario changes from emissions-dominated to transport conditions. For aromatics, the measured yields of dicarbonyls are ignored for many species. In addition, for alkenes, alcohols, and alkanes, MEK is used for an extremely high fraction of the reactive product carbon that is not determined to be one of the explicit products (HCHO, CCHO, or ACET). For alkanes, this represents almost all remaining product carbon. In general, for alkenes, alcohols, and alkanes, such products as alcohols, acids, ketones, stabilized biradicals and products (esters and acids) are all represented by MEK. The use of multiple MEKs to represent multiple carbonyls and alcohols on difunctional products becomes a carbon-bond type of approach, since molecular integrity is lost in favor of representing functional groups. At some point (probably the afternoon of the first day of a simulation), a significant amount of product resolution will be lost in favor of generic MEK chemistry. It would seem useful to devise some additional product surrogate species, such as an alcohol, to address this issue.

Significant amounts of reactive product carbon is ignored ('lost') for some individual compounds or classes. This is because the surrogate product molecules (RCHO, MEK, and RNO3) must assume a fixed structure. Extra carbons are discarded. This could also lead to predictive biases between individual compounds. The tables given in the report show significant losses for some species in all classes. Aromatics, alkanes, and alkenes lose carbons when the chain length of alkyl groups is too long to be represented by these fixed-length products. In addition, some alcohols and acetylene also apportion product carbons incompletely.

In a few cases, product mass is created by some rather strange product algorithms. As far as I can tell, these cases are limited to butane (must create 1 carbon for every 5-carbon RNO3 formed), propylene glycol (forms 4-carbon MEK as a product), and a few alkenes using the [C(C)CO_2] biradical product algorithm.

Given the inability of the mechanism to completely describe difunctional chemistry and the significant amount of lost carbon in the terpene species, I would expect significant inaccuracies in the mechanistic representation of biogenic compounds. Such problems would also occur if a-pinene or isoprene were used to represent terpenes in general.

Later Concerns:

These and the above items should be considered during the next stage of mechanism improvement.

It may be necessary to expand the peroxy operator mechanism, at least in the case of RCO3. This is because: (1) approximations associated with peroxy + peroxy representation in SAPRC-90 may require more explicit RCO3 chemistry, and (2) new data (products and kinetics) on peroxy + peroxy radical reactions does not appear to conform with any simple organic operator scheme like the one used in the SAPRC-90.

The number, types, and quality of smog chamber data experiments used in mechanism development and evaluation must be improved.

Chemistry solvers should be improved to allow more detailed and intricate organic lumping schemes. The limitations to mechanism representation should always be in the experimental data, not solver constraints.

While mechanism rate constants and stoichiometry are based on a 'representative' emissions profile, transported mixture compositions will differ significantly from that profile and are not well-represented.

5. GENERAL UNCERTAINTY SCALES

Below are a few scales of predictive uncertainty for the SAPRC-90 Mechanism. These are based solely on my subjective assessment of the mechanism content. The scales span from most uncertain to more certain.

Hydrocarbon Class:

1. Aromatics. The large uncertainty is due to a general lack of critical experimental data. In addition, SAPRC-90 neglects

detail and lost carbon, and (3) inappropriate mechanism stoichiometry and kinetics.

Mechanistic Uncertainty:

1. Multi-functional VOCs, such as biogenic alkenes, cannot be easily represented in the lumping scheme of SAPRC-90. Only one functional group can be addressed. Thus, only mono-functional products are formed (for isoprene, MEK must be formed instead of the much more reactive methacrolein and methylvinyl ketone products). This category also includes aromatics with long or multiple alkyl side chains.

2. The chemistry of longer chain VOCs is generally more uncertain that for smaller molecules. This is because: (1) less is known about product chemistry, especially H-shift isomerization, (2) multifunctional products cannot be represented well, (3) carbon in large products must be 'lost' to produce fixed-carbon surrogates, and (4) there are fewer or no smog chamber experiments available for more complex VOCs.

3. Slower reacting VOCs have a much smaller range of experimental conditions under which meaningful oxidation can be observed in a one-day smog chamber experiment. Hence, chamber simulation is less helpful in 'tuning' a mechanism for these species. In particular, alkanes and some aromatics suffer in this regard.

4. The 'detail' of the mechanism is overstated. Although it is possible to create a set of reactions for every VOC in a mixture, the products are often generic (RCHO, RNO3, and MEK) and quite a bit of potentially reactive product carbon mass is ignored. In addition, because of aggregation of individual VOCs with different reaction rates into a few groups, much detail is lost due to averaging. Further, as the dynamics of a VOC mixture changes, the rates and stoichiometries remain fixed.

measured dicarbonyl yields, cannot easily differentiate between products of similar aromatic groups, and has significant questions concerning AFG2 photolysis in ambient light.

2. Alkanes. The product yields of these species are based on a rather extensive set of radical chain-degradation assumptions. The assumptions seem sound, but are not yet well-verified by experimental data. For larger alkanes, both the kinetic assumptions and the product apportionment are more uncertain. In addition, because alkanes are relatively less reactive than alkenes and aromatics, there are far fewer smog chamber experiments available that are useful in verifying mechanism formulation.

3. Alkenes. At least parts of the alkene chemistry are reasonably well established. However, significant concerns still exist regarding biradical chemistry and biogenic (difunctional) chemistry.

Scenarios:

1. High ozone concentrations at night. Under these conditions, it is quite possible that the peroxy steady-state approximation will not hold due to low NO concentrations. Thus, product yields will be incorrect for RO2s. Also, if NO_x is available, additional uncertainties will arise because of: (1) the uncertainty associated with the $N_2O_5 + H_2O$ reaction, (2) the fact that the products of alkene oxidation by NO_3 assume NO is available, and (3) the 'out-of-time' problems associated with decoupling RO2 chemistry (operators) and mass (stable products).

2. Transport conditions. By definition, transport conditions lack significant new emissions and are driven by VOC product chemistry. Therefore, at least three problems become important: (1) the above-noted poor product resolution, (2) the issue of lost carbon, and (3) the fact that the mechanism kinetics and stoichiometry are based on one 'representative' profile of emissions unlike the transported oxidation products. All three problems significantly limit the mechanism's range of focus. With respect to reactivity assessment calculations, I believe any scenario beyond a single-day, daytime, urban-like, emissions-dominated environment will enter conditions for which the calculations will be highly uncertain.

3. Afternoon transport conditions with high O_3 and low NO_x. VOC species that have not reacted rapidly in the mid-day period will be reacting in conditions approaching those stated in 1 and 2 above. Therefore, some problems associated with those scenarios may begin to occur. The reactivity calculations of such species could be biased because the chemical environment of the model is very uncertain. Specifically, I refer to the uncertainties in: (1) the $N_2O_5 + H_2O$ reaction, (2) poor product

APPENDIX B-2: PROTOCOL FOR CALCULATING UNCERTAINTY IN REACTIVITIES AND RAFS

Protocol for Calculating Uncertainties in Reactivities and RAF

A. Uncertainties in Reactivities

Carter and Atkinson (1987) have approximated incremental reactivity (IR) as the product of two components, the fraction of the hydrocarbon that reacts over the course of a day, kinetic reactivity (KR), and the amount of ozone formed by the fraction reacted, mechanistic reactivity (MR):

$$IR = KR \times MR \tag{B1}$$

1. Kinetic Reactivity Uncertainty

For most hydrocarbons, reaction with the hydroxyl radical (OH) is the only significant route towards ozone formation. Therefore, their kinetic reactivity can be calculated from the hydroxyl radical rate constant and radical levels. The hydroxyl radical rate constant has been measured (Atkinson, 1989) or can be estimated (Atkinson, 1987) for most hydrocarbons. Reactions of alkenes with ozone, and photolysis of aldehydes and ketones are alternate routes toward ozone formation. These rates of reaction are also known (Atkinson, 1990).

The kinetic reactivity is given as:

$$KR = 1 - e^{-(kOH \times IntOH)} \tag{B2}$$

where kOH is the OH rate constant and IntOH is the integrated OH concentration.

Assuming that we know the standard deviations in the OH rate constant and the integrated OH concentration, statistical analysis gives a method to calculate the variance of the kinetic reactivity. For a quantity, ω, which is a function of multiple independent variables, x_i (i=1, 2, ... , N):

$$\omega = f(x_1, x_2, \ldots, x_N) \tag{B3}$$

the variance, V_ω, defined as the square of the standard deviation in ω, can be approximated by:

$$V_\omega \equiv \sigma_\omega^2 = \sum_{i=1}^{N} \left(\frac{\partial \omega}{\partial x_i}\right)^2 V_{x_i} \tag{B4}$$

where V_{xi} is the variance of x_i, the partial derivative is evaluated at the mean values of x_i and higher order terms are assumed small enough to be ignored. Substituting (B2) into (B4) and computing the partial derivatives gives:

$$V_{KR} = (1 - KR)^2 \left[IntOH^2 \, V_{kOH} + kOH^2 \, V_{IntOH}\right] \tag{B5}$$

The standard deviations in the OH rate constants have been estimated by Atkinson (1989), with an upper-limit of 25 percent.

2. Mechanistic Reactivity Uncertainty

In contrast to the kinetic reactivities, the mechanistic reactivities are uncertain for most hydrocarbons (Atkinson, 1990). Suitable laboratory data are available for testing the mechanisms of only a limited number of hydrocarbons, and the mechanisms for most other compounds are based on estimates and extrapolations. The mechanistic reactivities for higher molecular weight hydrocarbons are particularly uncertain.

3. Incremental Reactivity Uncertainty

If we know the uncertainty in the kinetic and mechanistic reactivities, we can use (B1) and (B4) to calculate the variance of the incremental reactivity:

$$V_{IR} = MR^2 \times V_{KR} + KR^2 \times V_{MR} \tag{B6}$$

B. Uncertainties in Reactivity Adjustment Factor

First, define the reactivity adjustment factor (RAF) as:

$$RAF = \frac{\text{Mass-Normalized Reactivity of Test Fuel } (MNR_A)}{\text{Mass-Normalized Reactivity of Base Fuel } (MNR_B)} \tag{B7}$$

$$= \frac{\sum_{i=1}^{N} F_{A,i}\, R_i}{\sum_{i=1}^{N} F_{B,i}\, R_i} \tag{B8}$$

where $F_{A,i}$ is the mass fraction of compound i in the exhaust from the test fuel, $F_{B,i}$ is the mass fraction of compound i in the exhaust from the base fuel, and R_i is the reactivity of compound i.

Substituting (B8) into (B4) and computing the partial derivatives gives:

$$V_{RAF} = \sum_{i=1}^{N} \frac{1}{MNR_B^2} \left[(F_{A,i} - F_{B,i}\, RAF)^2\, V_{R_i} + R_i^2 \left(V_{F_{A,i}} + V_{F_{B,i}}\, RAF^2\right) \right] \tag{B9}$$

To determine whether or not higher order terms are important, a Monte Carlo approach can be used to estimate V_{RAF} for comparison with (B9).

Initial Statement of Proposed Rulemaking

Reactivity Adjustment Factors for Transitional Low-Emission Vehicles

Mobile Source Division
Research Division

Air Resources Board
P.O. Box 2815
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Date of Release: September 27, 1991

CONTENTS

08126

TABLES

APPENDICES

SUMMARY OF STAFF RECOMMENDATION

In September, 1990, the Air Resources Board ("Board") approved the "low-emission vehicles and clean fuels" regulations, which set forth stringent exhaust emission standards for new vehicles sold in California beginning in the mid-1990's. An important aspect of these regulations involves the use of "reactivity adjustment factors" to correct or adjust the emissions from clean fuel vehicles to levels comparable, based on ozone-forming potential, to conventional gasoline-fueled vehicles.

Because representative reactivity adjustment factors cannot be developed without appropriate data, the Board included the procedure to establish reactivity adjustment factors as part of the low-emission vehicle regulations and directed its staff to return to the Board with a proposal for initial reactivity adjustment factors in the fall of 1991. Over the past year, the staff has conducted extensive research and testing programs to obtain the necessary data to develop reactivity adjustment factors for transitional low-emission vehicles.

Based on the results of these programs, the staff recommends that the Board adopt the revised maximum incremental reactivity scale developed by Dr. W.P.L. Carter and that the following reactivity adjustment factors be established for light-duty transitional low-emission vehicles operating on the specified fuel:

Methanol (M85)	0.36
Liquified Petroleum Gas	0.50
Compressed Natural Gas	0.18[1]

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1. The proposed reactivity adjustment factor for compressed natural gas vehicles may be revised pending the verification of the vehicle data used in its derivation. Any revisions to the reactivity adjustment factor will be proposed by the staff at the November, 1991 hearing.

The staff also recommends that the Board adopt various revisions to the low-emission vehicle regulations to clarify and better define the means by which the reactivity adjustment factors are established, revised, and applied. The regulatory amendments proposed by the staff are included as Appendices B and C of this report.

During the time period prior to the November hearing, the staff will continue collecting data to ensure the robustness of the reactivity adjustment factors. Any additional information obtained by the staff will be presented to the Board at the hearing in November. The staff intends to work closely with the affected industries in implementing the proposed regulations and identifying any changes that may need to be made.

I. INTRODUCTION

Because of their considerable contribution to California's air quality problems, controlling mobile source emissions has been a key aspect of the Air Resources Board's ("ARB" or "Board") overall air pollution control strategy. In recent years, the ARB has adopted various measures to reduce mobile source emissions through better control of in-use emissions and more stringent emission standards. This process was furthered in September, 1990 with the Board approval of the so-called "low-emission vehicles and clean fuels" regulations (Resolution 90-58), which were approved by the California Office of Administrative Law on August 30, 1991.

The low-emission vehicles and clean fuels regulations, an integral part of the ARB's Long-Range Motor Vehicle Plan, established stringent, reactivity-based exhaust emission standards for new passenger cars, light-duty trucks, and medium-duty vehicles and required that any clean alternative fuels needed by these vehicles be made available to the public. The proposed regulations contained in this report build upon the vehicle aspect of the low-emission vehicles and clean fuels regulations by setting forth "reactivity adjustment factors" for alternative fuel vehicle systems expected to be sold in the early to mid-1990's. Use of these reactivity adjustment factors will ensure that low-emission vehicles powered by alternative fuels receive proper credit for the lower reactivity, or ozone-forming potential, of their emissions compared to conventional gasoline-fueled vehicles.

A. Summary of Low-Emission Vehicle Standards

Under the low-emission vehicle regulations, four categories of low-emission vehicles, each certified to a particular set of exhaust emission standards, will be phased-in in the mid-1990's. In order of increasing stringency, the vehicle categories are

- Transitional Low-Emission Vehicle ("TLEV")
- Low-Emission Vehicle ("LEV")
- Ultra-Low-Emission Vehicle ("ULEV")
- Zero-Emission Vehicle ("ZEV")

The standards for all four categories of low-emission vehicles[2] represent significant reductions in emissions compared to previous standards, as can be seen from Table I-1, which summarizes the 50,000 mile certification standards for passenger cars and small light-duty trucks. The regulations also promulgated emission standards for light-duty trucks above 3750 lbs. loaded vehicle weight ("LVW") and for medium-duty vehicles and engines. More information on the low-emission vehicle certification standards and phase-in requirements can be found in the regulations contained in Appendices B and C.[3]

Table I-1. 50,000 Mile Certification Standards for Passenger Cars and Light-Duty Trucks ≤ 3750 lbs. LVW (g/mi).

Category	NMOG[a]	CO[b]	NOx[c]	HCHO[d]
Conventional	0.25[e]	3.4	0.4	0.015[f]
~~TLEV~~	~~0.125~~	~~3.4~~	~~0.4~~	~~0.015~~
LEV	0.075	3.4	0.2	0.015
ULEV	0.040	1.7	0.2	0.008
ZEV	zero	zero	zero	zero

[a] NMOG: Non-methane organic gases
[b] CO: Carbon monoxide
[c] NOx: Oxides of nitrogen
[d] HCHO: Formaldehyde
[e] Standard is for non-methane hydrocarbons
[f] Applies to methanol vehicles only

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2. In this report, the term "low-emission vehicle(s)" is used to refer to any vehicle(s) certified to the TLEV, LEV, ULEV, or ZEV standards, not just those certified to the LEV standards.

3. Also refer to "Proposed Regulations for Low-Emission Vehicles and Clean Fuels," staff report and technical support document, released on August 13, 1990, and final statement of reasons, released July, 1991.

B. Reactivity Considerations

Compliance with the low-emission vehicle standards can be achieved with advanced emission control technology alone or in combination with cleaner-burning fuels. The low-emission vehicles and clean fuels regulations are unique in that they consider the vehicle and its fuel as two components of a single system--a vehicle/fuel system. Past regulations have generally established requirements for the vehicle and fuel separately. However, since emissions result from the interaction of vehicle technology and fuel, a unified systems approach provides the most cost-effective means of control.

Consistent with the systems concept, the regulations for low-emission vehicles are structured to accommodate a variety of different technologies and fuels. For the first time, the ozone-forming potential, or reactivity, of organic gas emissions will be considered. Certification standards have historically been based on mass emission rates, that is, on the grams of pollutants emitted each mile that the vehicle travels. However, mass-based standards do not reflect the phenomenon that the organic gases (or hydrocarbons) emitted by vehicles powered by alternative and reformulated fuels can lead to lower ozone formation than conventional gasoline vehicles. Therefore, to allow all vehicle/fuel systems to be compared on an equal air quality basis, a so-called "level playing field," the ARB approved the concept of developing "reactivity adjustment factors" for vehicles which operate on fuels other than conventional gasoline.

C. About This Report

This report contains the ARB staff's proposed reactivity adjustment factors for TLEVs powered by methanol (M85), liquified petroleum gas ("LPG"), and compressed natural gas ("CNG") based on two different reactivity approaches. It summarizes the regulations that established the way the factors are derived and applied and describes the data and analyses used by the staff to determine the factors. Additional details on the test data and the derivation of the reactivity adjustment factors can be found in a separate technical support document, which is available from the ARB upon request. Reactivity adjustment factors for LEVs and ULEVs will be established at a future date.

II. PROTOCOL

The protocol for developing reactivity adjustment factors was approved by the Board at the September, 1990 hearing. The procedure involves the application of the maximum incremental reactivity scale to speciated vehicle emission profiles to determine the ozone-forming potential of exhaust hydrocarbon emissions. To develop the reactivity adjustment factors, the ARB staff has conducted extensive programs to refine the maximum incremental reactivity scale and obtain representative emission profiles.

A. Developing the Reactivity Scale

Over the past several years, a number of researchers have developed various chemical mechanisms for calculating hydrocarbon reactivity scales. The ARB staff recommended the chemical mechanism developed by Dr. W.P.L. Carter of the Statewide Air Pollution Research Center at the University of California-Riverside as the most appropriate of the currently available mechanisms. Dr. Carter's mechanism has been tested against smog chamber data and as it was specifically designed for calculating the reactivities of individual hydrocarbons, can be easily applied to speciated emission data. Further, over the past year, Dr. Carter's work has been thoroughly peer reviewed by Dr. Michael Gery, a recognized expert in the field of atmospheric chemistry, and by the *ad hoc* Reactivity Advisory Panel, comprised of members of the scientific[4] community, auto and oil industries, government agencies, and public. These efforts have resulted in the development of the updated "maximum

4. The Reactivity Advisory Panel met three times over the past year in order to comment and provide input on the development of an appropriate reactivity scale. A list of the members of the Panel is provided in Appendix A.

incremental reactivity" ("MIR") scale proposed in this rulemaking. (The basis for the revisions to the previously adopted MIR scale is described in detail in the technical support document.)

1. Maximum Incremental Reactivity ("MIR") and Maximum Ozone Reactivity ("MOR")

As part of the low-emission vehicle regulations, the Board approved the concept of using an MIR scale to establish reactivity adjustment factors. The MIR of a particular compound is determined under conditions in which the maximum change in ozone results from the addition of a small amount of hydrocarbons. The main advantage of this approach is that it defines reactivity where hydrocarbon control has its greatest benefits, that is, in upwind areas where emissions are generated and, for Los Angeles and other metropolitan areas, where population density is greatest.

The MIR approach is complementary to the maximum ozone reactivity or MOR approach, which has been recommended by some members of the Reactivity Advisory Panel for use in deriving the reactivity adjustment factors. The MOR scale is determined by adding a small amount of hydrocarbons under environmental conditions in which ozone levels are at their peak, that is, in downwind, high-ozone areas. (For the South Coast Air Basin, MOR conditions occur in the East San Gabriel and Pomona Valleys.) However, under these conditions, hydrocarbons have relatively lower reactivity, and NOx levels have a greater effect on ozone formation. Therefore, an MOR scale would yield conservative estimates of hydrocarbon reactivity. Together, the MIR and MOR scales bracket the range of conditions where it is appropriate to define reactivity for hydrocarbon emission control.

2. Staff Proposal

In the staff's view, the MIR approach is the appropriate methodology for establishing reactivity adjustment factors at this time. It seems sensible to base the hydrocarbon reactivity adjustment factors on conditions where hydrocarbon control is most beneficial. Additionally, because the low-emission vehicle regulations also include stringent standards for NOx, implementing MIR-based reactivity adjustment factors should result in ozone reductions in all areas of the California, including those areas that experience peak ozone conditions.

To verify that this occurs, Professor A. Russell of Carnegie Mellon University has been retained to perform several airshed modeling runs using both the MIR and MOR scales. Therefore, although the staff is proposing the use of the MIR approach at the present time, a final evaluation cannot be made until the airshed modeling is completed in October, 1991. The results of the airshed modeling will be presented at the hearing in November, 1991, and the Board can assess these additional data in considering the staff proposal. For the Board's information, reactivity adjustment factors derived using the MOR scale are also included in this report.[5]

The proposed MIR scale for selected compounds is listed in Table II-1, and for comparison, the corresponding values for MOR are also provided in the table. (The complete lists can be found in the technical support document.) Although uncertainties remain for many hydrocarbons, the scales shown reflect the best current understanding of atmospheric chemistry. The ARB will continue to sponsor laboratory studies to reduce uncertainties in incremental reactivities, particularly for aromatic compounds, and will review research sponsored by other organizations. The staff plans to update the reactivities for individual hydrocarbons every three years.

B. Calculating Reactivity Adjustment Factors

Once the reactivity scale is established, a speciated emission profile is needed to determine the ozone-forming potential of the NMOG emissions from a particular vehicle/fuel system. A speciated emission profile contains a listing of the different organic gases present in the exhaust and the rate, in grams or milligrams per mile, at which they are emitted. An example of a speciated NMOG emission profile is shown in Table II-2.

After obtaining the speciated profiles, the gram per mile emission rate of each individual NMOG species is multiplied by its MIR or MOR value. The sum of these products constitutes the *gram ozone potential per mile* or "*ozone per mile*" of the exhaust emissions. The *ozone per mile* value is indicative of the amount of ozone formed each mile that the vehicle travels.

For comparison with emission standards, however, it is useful to calculate the total ozone impact of each gram of NMOG emitted by the vehicle. The *gram ozone potential per gram NMOG* or "*ozone per gram*" is determined by dividing the *ozone per mile* by the gram per mile NMOG emission rate of the vehicle.

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5. Although there are substantial differences for individual organic gases between the MIR and MOR scales, as a practical matter, the reactivity adjustment factors calculated using the two scales are very similar (see Table III-2). Because the reactivity adjustment factors are calculated using the ratio of complete vehicle emission profiles consisting of dozens of organic gases, the differences in individual compound reactivities are minimized.

Table II-1. Abbreviated List of Maximum Incremental Reactivity and Maximum Ozone Reactivity Scales (units: grams ozone per gram NMOG).

MIR	MOR	NMOG Species
0.26	0.18	Ethane
7.28	3.15	Ethene
0.48	0.31	Propane
0.51	0.34	Ethyne
1.21	0.73	Methylpropane
1.02	0.66	n-Butane
9.39	3.77	Propene
1.03	0.68	n-Pentane
8.90	3.51	1-Butene
5.29	1.93	2-Methylpropene
9.93	3.75	t-2-Butene
9.23	3.64	1-Butyne
6.22	2.46	3-Methyl-1-butene
4.89	1.90	2-Methyl-1-butene
10.88	4.16	1,3-Butadiene
6.40	2.30	2-Methyl-2-butene
0.82	0.51	2,2-Dimethylbutane
7.65	2.78	Cyclopentene
2.37	1.41	Cyclopentane
1.07	0.67	2,3-Dimethylbutane
1.53	0.90	2-Methylpentane
1.52	0.94	3-Methylpentane
0.98	0.64	n-Hexane
2.82	1.55	Methylcyclopentane
1.78	0.99	2,4-Dimethylpentane
0.42	0.14	Benzene
1.28	0.74	Cyclohexane
1.40	0.83	3-Methylhexane
0.81	0.53	n-Heptane
1.84	1.00	Methylcyclohexane
2.72	0.63	Toluene
0.61	0.41	n-Octane
2.90	0.72	Ethylbenzene
7.47	2.24	m&p-Xylenes
2.20	-0.29	Styrene
6.68	2.00	o-Xylene
0.54	0.36	n-Nonane
2.27	0.56	n-Propylbenzene
10.11	3.06	1,3,5-Trimethylbenzene
8.59	2.51	1,2,4-Trimethylbenzene
0.47	0.31	n-Decane
0.42	0.28	n-Undecane
0.56	0.28	Methanol
1.33	0.72	Ethanol
7.14	2.08	Formaldehyde
5.51	2.17	Acetaldehyde
0.56	0.20	Acetone

Table II-2. Example of a Speciated NMOG Emission Profile (1991 Cadillac DeVille, Test 18C4).

LIGHT-END SPECIES	mg/mi	LIGHT-END SPECIES	mg/mi
Ethane	4.82	Propene	3.93
Ethene	9.67	Methylbutane	4.14
Propane	.26	Pentane	2.96
Ethyne	4.84	1-Butene	.49
Methylpropane	.18	2-Methylpropene	.31
Butane	5.35		

MID-RANGE SPECIES	mg/mi	MID-RANGE SPECIES	mg/mi
1,3-butadiene	.44	Toluene + C8H18	12.05
2,2-Dimethylbutane	1.19	2,3-Dimethylhexane	.38
Cyclopentane	1.03	Methylheptane	1.21
2,3-Dimethylbutane	.18	Dimethylcyclohexane	.13
2-Methylpentane	6.13	2,2,5-Trimethylhexane	.44
C6H12 Alkene 2	.27	n-Octane	.63
3-Methylpentane	1.43	C9H18 Alkene	.16
C6H12 Alkene 3	.12	Ethylbenzene	3.28
n-Hexane	1.56	m & p-Xylenes	7.99
Methylcyclopentane	.66	C9H20 Alkane	.33
C7H16 Alkane	1.08	Styrene	.78
Benzene	9.33	o-Xylene	2.71
Cyclohexane	.17	n-Nonane	.18
2-Methylhexane+Dimethylpentane	2.07	i-Propylbenzene	.14
3-Methylhexane	1.87	n-Propylbenzene	.39
2,2,4-Trimethylpentane+Alkene	4.21	3-Ethyltoluene	1.52
n-Heptane	1.62	4-Ethyltoluene+C10cycloalkane	.67
Methylcyclohexane	.67	2-Ethyltoluene	.54
Dimethylhexane	.41	1,2,4-Trimethylbenzene	1.52
2,3,4-Trimethylpentane	1.03	n-Undecane	.14

OXYGENATES	mg/mi
Formaldehyde	1.03
Acetaldehyde	.71
Acrolein	.08
Acetone	.15
Propionaldehyde	.20

TOTAL NMOG SPECIES	mg/mi
Light-end HC Subtotal	36.93
Mid-range HC Subtotal	70.64
Oxygenates Subtotal	2.18
Total NMOG	109.75

The reactivity adjustment factor ("RAF") for a particular vehicle/fuel system is then calculated by dividing the *ozone per gram* of that vehicle/fuel system by the *ozone per gram* of a comparable conventional gasoline vehicle, that is,

$$\text{RAF} \equiv \frac{\textit{ozone per gram} \text{ of clean fuel vehicle}}{\textit{ozone per gram} \text{ of comparable vehicle on base gasoline}}$$

Therefore, the reactivity adjustment factor adjusts or corrects the NMOG emissions of a clean fuel vehicle based on its ozone impact. This allows the NMOG emission rates of clean fuel vehicles to be directly compared with conventional gasoline vehicles: to demonstrate compliance with an emission standard, the measured NMOG emission rate of the clean fuel vehicle multiplied by the reactivity adjustment factor must be lower than the NMOG standard for that particular low-emission vehicle category. Furthermore, from a regulatory viewpoint, use of reactivity adjustment factors allows the ARB to establish the same numerical emission standards for all vehicles within a low-emission vehicle category while encouraging the use of fuels and emission control strategies that lead to less ozone formation.

C. Test Vehicles and Fuels

1. Conventional Gasoline

To determine the denominator of the reactivity adjustment factors proposed in this rulemaking--the *ozone per gram* of the conventional or base gasoline vehicle--several late model production gasoline cars were tested. Although the adjustment factors apply just to NMOG, only vehicles that were able to meet, on average, all the emission standards for TLEVs (that is, standards for NMOG, CO, NOx, and formaldehyde) were selected for testing. Because the reactivity of NMOG emissions may vary according to the emission control technology used, emission profiles obtained from vehicles able to meet all the TLEV standards will best represent the reactivity of emissions from actual production TLEVs.

The qualifying vehicles were obtained primarily from the ARB's own test fleet and local rental car agencies, with one vehicle provided by Mercedes-Benz. In addition, the staff was able to use data from the Auto/Oil Air Quality Improvement Research Program ("Auto/Oil"), currently being conducted by the domestic automobile manufacturers and oil companies, and data provided by Chevron Research and Technology Company. A brief description of all the vehicles used to determine the reactivity of conventional gasoline TLEVs is provided in Table II-3.

Table II-3. Conventional Gasoline Test Vehicles.

Year/Make/Model	Operator	Miles	Displ.	Fuel/Catalyst System
1991 Mercedes 300E	Mercedes	2,700	3.0L	CIS, 1UF TWC
1991 Cadillac DeVille	rental	5,000	4.9L	SMPI, 1UF TWC
1990 Toyota Celica	ARB	5,500	2.2L	MEFI, 1CC TWC+1UF TWC
1991 Ford Tempo	ARB	7,000	2.3L	MEFI, 1UF TWC
1991 Mercury Cougar	rental	10,300	5.0L	SMPI, 2CC TWC+1UF TWC
1990 Buick LeSabre	ARB	11,000	3.8L	SMPI, 1UF TWC
1990 Chev. Cavalier	Chevron	21,000	2.2L	TBI, 1UF TWC
1989 Dodge Shadow	Auto/Oil	10,800	2.5L	TBI, 1UF TWC
1989 Olds. Delta 88	Auto/Oil	11,700	3.8L	MEFI, 1UF TWC

#CC: Number of close-coupled (catalysts)
CIS: Continuous fuel injection
MEFI: Multipoint electronic fuel injection
SMPI: Sequential electronic multipoint fuel injection
TBI: Throttle body electronic fuel injection
TWC: Three-way catalyst(s)
#UF: Number of underfloor (catalysts)

The formulation of conventional gasoline used in the testing was the blend determined by the Auto/Oil study to best represent industry average commercial gasoline. The specifications of this fuel, known as "reformulated fuel A" ("RF-A"), are based on the results of a nationwide fuel survey and are similar to typical gasolines currently sold in California. Although the specifications of gasoline sold commercially in California will change with the adoption of the Phase 2 reformulated gasoline regulations (scheduled for Board consideration in November, 1991), RF-A will remain the baseline fuel for calculating reactivity adjustment factors. Not only will this approach provide an incentive for industry to develop cleaner-burning vehicle and fuel systems, it also provides a constant gauge against which the reactivity of future vehicle emissions can be compared. Further information on the conventional gasoline test vehicles and fuel is found in the technical support document.

2. Methanol (M85)

To develop a reactivity adjustment factor for methanol TLEVs, several fuel-flexible vehicles ("FFVs") were tested: two by the ARB, seven by Auto/Oil. FFVs are capable of operating on gasoline, methanol, or any mixture of the two fuels. (FFVs are also capable of operating on ethanol.) At present, FFVs are produced for California on an experimental basis, and therefore, model availability, particularly for advanced vehicles, is very limited. However, the FFV models identified by the ARB staff as able to meet the TLEV standards are preproduction prototypes, and are thus representative of FFVs likely to be sold in California in the mid-1990's. A brief description of these vehicles is provided in Table II-4.

Table II-4. Methanol Test Vehicles.

Year/Make/Model	Operator	Miles	Displ.	Fuel/Catalyst System
1991 VW Jetta	SCAQMD	9,100	1.8L	MEFI, 1UF TWC
1991 Chev. Lumina	SCAQMD	9,300	3.1L	MEFI, 1UF TWC
1990 Dodge Spirit(1M)	Auto/Oil	9,900	2.5L	SMPI, 1CC TWC
1989 Dodge Caravan(3M)	Auto/Oil	9,600	2.5L	SMPI, 1UF TWC
1988 Dodge Caravan(4M)	Auto/Oil	16,650	2.5L	SMPI, 1UF TWC
1988 Chev. Corsica(14M)	Auto/Oil	10,600	2.8L	MEFI, 1UF TWC
1988 Chev. Corsica(17M)	Auto/Oil	10,900	2.8L	MEFI, 1UF TWC
1990 Chev. Lumina(19M)	Auto/Oil	11,000	3.1L	MEFI, 1UF TWC
1990 Chev. Lumina(20M)	Auto/Oil	11,500	3.1L	MEFI, 1UF TWC

#CC: Number of close-coupled (catalysts)
MEFI: Multipoint electronic fuel injection
SCAQMD: South Coast Air Quality Management District
SMPI: Sequential electronic multipoint fuel injection
TWC: Three-way catalyst(s)
#UF: Number of underfloor (catalysts)

The fuel used for the testing was composed of 85% chemical grade methanol and 15% RF-A and was specially blended to represent commercial methanol fuel expected to be available in the early to mid-1990's. The Reid vapor pressure of the overall blend was 7.5 psi. This and other properties of the M85 test fuel fall within the proposed specifications for in-use M85 fuel scheduled for consideration by the Board in December, 1991.

3. Liquified Petroleum Gas ("LPG")

Because preproduction prototypes are not available for LPG, two retrofitted vehicles able to meet the TLEV emission standards were selected for testing, as shown in Table II-5. The vehicles are dual-fuel, that is, they are able to operate on LPG or gasoline, both of which are stored separately on board the vehicle.

Although the test vehicles are retrofits, their emission results should be representative of LPG vehicles sold in California in the mid-1990's. Several original equipment manufacturers have indicated that any LPG vehicles they sell would likely be equipped with retrofit kits installed at the factory.

The test fuel used was commercially available LPG in accordance with the proposed specifications for commercial LPG scheduled for consideration by the Board in December, 1991.

Table II-5. LPG Test Vehicles.

Year/Make/Model	Operator	Miles	Displ.	Emission Controls
1989 Olds. Delta 88	IMPCO	28,900	3.8L	IMPCO, 1UF TWC, EGR
1991 Pontiac 6000 LE	WLGA	38,400	2.8L	IMPCO, 1UF TWC, EGR

EGR: Exhaust gas recirculation
IMPCO: IMPCO carburetion system
#UF: Number of underfloor (catalysts)
TWC: Three-way catalyst(s)
WLGA: Western Liquid Petroleum Gas Association

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4. Compressed Natural Gas ("CNG")

For CNG, emission profiles from only one vehicle--a retrofitted dual-fuel Buick LeSabre (Table II-6)--were found to be representative of CNG TLEVs that may be produced in the near future. Locating qualified vehicles for CNG was particularly difficult because of the limited number of available vehicles in the light-duty sector and the high NOx emissions of many test cars.

Table II-6. CNG Test Vehicle.

Year/Make/Model	Operator	Miles	Displ.	Emission Controls
1990 Buick LeSabre	SDG&E	10,800	3.8L	ANGI, 1UF TWC, EGR

ANGI: ANGI carburetion system
EGR: Exhaust gas recirculation
SDG&E: San Diego Gas & Electric Company
#UF: Number of underfloor (catalysts)
TWC: Three-way catalyst(s)

The same Buick LeSabre dual-fuel vehicle was tested by the ARB staff on two different occasions. Testing was conducted in July, 1990, and again in August, 1991. Because of the disparity in the emission results for the two test dates (which may be due to differences in the preconditioning of the vehicle), the staff will re-examine the LeSabre data and attempt to procure other CNG vehicles for emission testing prior to the Board hearing in November. (See chapter III, section A.4 for further discussion on this subject.)

The test fuel used in the testing was commercial CNG obtained from Southern California Gas Company. The properties of the fuel are consistent with the proposed specifications for CNG commercial fuel.

5. Ethanol (E85)

Testing on ethanol was conducted with the same Lumina and Jetta FFVs operated by the South Coast Air Quality Management District used in the methanol testing (Table II-4). These vehicles were calibrated to operate primarily on methanol and gasoline and not on ethanol, but the staff was unable to procure any vehicles specifically designed to run on ethanol. The reactivity-adjusted NMOG emissions of both FFVs exceeded the TLEV standards.[6] Consequently, a reactivity adjustment factor for ethanol TLEVs cannot be proposed at the present time.

6. The data used by the staff to make this determination are summarized in Table III-1 and described in detail in the technical support document.

III. REACTIVITY ADJUSTMENT FACTOR VALUES

A. Results

All of the vehicle testing was conducted in accordance with federal and California test procedures. The majority of the vehicles were tested at the ARB's Haagen-Smit Laboratory; the remaining vehicles were tested by Auto/Oil and Chevron. A summary of the average emissions of the vehicles, together with the *ozone per mile* and *ozone per gram* values for their NMOG emissions based on the MIR scale is provided in Table III-1[7] (the MOR values are given in parentheses). Although the ethanol test vehicles did not meet the TLEV standards, their emission data are also summarized in the table.

Based on these results, reactivity adjustment factors for TLEVs operating on methanol, CNG, and LPG were calculated as shown in Table III-2. The reactivity adjustment factor for base gasoline is, by definition, 1.00. As seen from the table, the corresponding factors determined by using the MOR scale, given in parentheses in Table III-2, are very similar to the MIR-derived values.

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7. Four or more profiles were obtained for the cars tested at ARB and Chevron. However, in most cases, only one or two profiles were available for the Auto/Oil vehicles, and the speciated data were generally not as robust as the ARB or Chevron data. Therefore, the staff calculated the average emission and reactivity data from Auto/Oil vehicles of the same or similar technology before averaging those results with data from the rest of the vehicle test fleet. This was done in order to avoid weighting the data for the vehicles tested by Auto/Oil proportionally more than for the other test vehicles. Copies of all the speciated profiles and additional information on vehicle testing and data analysis are found in the technical support document.

Table III-1. Summary of TLEV Emission and Reactivity Data.

CONVENTIONAL GASOLINE (RF-A)

Vehicle	NMOG (g/mi)	CO (g/mi)	NOx (g/mi)	HCHO (mg/mi)	Ozone/mile MIR (MOR)	Ozone/gram MIR (MOR)
Mercedes	0.098	0.71	0.076	1.11	0.323 (0.123)	3.32 (1.28)
Cadillac	0.121	1.67	0.435	1.26	0.395 (0.155)	3.28 (1.28)
Celica	0.094	0.84	0.154	0.47	0.297 (0.113)	3.16 (1.20)
Tempo	0.104	1.53	0.358	1.02	0.393 (0.142)	3.79 (1.38)
Cougar	0.119	2.43	0.216	0.74	0.333 (0.134)	2.81 (1.13)
LeSabre	0.127	1.56	0.423	1.20	0.477 (0.174)	3.76 (1.37)
Cavalier	0.082	2.78	0.209	3.90	0.296 (0.113)	3.61 (1.37)
Shadow[a]	0.103	2.44	0.267	1.8	0.400 (0.150)	3.89 (1.46)
Delta	0.095	2.21	0.453	1.1	0.344 (0.126)	3.62 (1.33)
AVERAGE	**0.106**	**1.73**	**0.279**	**1.39**	**0.361 (0.137)**	**3.44 (1.30)**

METHANOL (M85)

Vehicle	NMOG (g/mi)	CO (g/mi)	NOx (g/mi)	HCHO (mg/mi)	Ozone/mile MIR (MOR)	Ozone/gram MIR (MOR)
Jetta	0.277	2.60	0.061	17.38	0.342 (0.133)	1.24 (0.48)
Lumina	0.268	2.47	0.238	14.49	0.336 (0.131)	1.26 (0.49)
Spirit[a]	0.149	0.96	0.516[b]	3.37	0.163 (0.067)	1.09 (0.45)
Caravan(3M)	0.136	1.04	0.364	5.73	0.157 (0.063)	1.15 (0.46)
Caravan(4M)	0.153	1.11	0.453	5.66	0.172 (0.070)	1.12 (0.46)
Corsica(14M)[a]	0.317	2.15	0.318	9.76	0.378 (0.157)	1.19 (0.50)
Corsica(17M)	0.319	2.30	0.178	16.22	0.398 (0.155)	1.38 (0.53)
Lumina(19M)	0.246	2.98	0.316	13.37	0.353 (0.138)	1.44 (0.56)
Lumina(20M)	0.236	1.74	0.355	15.88	0.347 (0.134)	1.47 (0.57)
AVERAGE	**0.242**	**2.10**	**0.259**	**12.65**	**0.303 (0.119)**	**1.25 (0.49)**

Table III-1 (continued)

LIQUIFIED PETROLEUM GAS (LPG)

Vehicle	NMOG (g/mi)	CO (g/mi)	NOx (g/mi)	HCHO (mg/mi)	Ozone/mile MIR (MOR)	Ozone/gram MIR (MOR)
Delta 88	0.111	0.85	0.108	1.31	0.193 (0.068)	1.75 (0.80)
Pontiac	0.101	0.72	0.292	4.40	0.172 (0.076)	1.68 (0.74)
AVERAGE	**0.106**	**0.79**	**0.200**	**2.86**	**0.183 (0.072)**	**1.72 (0.77)**

COMPRESSED NATURAL GAS (CNG)

Vehicle	NMOG (g/mi)	CO (g/mi)	NOx (g/mi)	HCHO (mg/mi)	Ozone/mile MIR (MOR)	Ozone/gram MIR (MOR)
LeSabre	0.092	0.09	0.455	2.37	0.056 (0.028)	0.61 (0.31)

ETHANOL (E85) (Vehicles Do Not Qualify as TLEVs)

Vehicle	NMOG (g/mi)	CO (g/mi)	NOx (g/mi)	HCHO (mg/mi)	Ozone/mile MIR (MOR)	Ozone/gram MIR (MOR)
Lumina	0.263	1.70	0.264	5.24	0.567 (0.262)	2.16 (1.00)
Jetta	0.302	4.04	0.061	4.76	0.651 (0.300)	2.16 (0.99)
AVERAGE	**0.283**	**2.87**	**0.163**	**5.00**	**0.609 (0.281)**	**2.16 (1.00)**

[a] Data from each of these groups of vehicles were averaged together prior to determining the average results for all test vehicles operating on the specified fuel.

[b] Average NOx emissions for the Spirit, based on two tests, was 0.435 g/mi.

Table III-2. Summary of Reactivity Adjustment Factors for Passenger Cars and Light-Duty Trucks (0-5750 lbs LVW) in the TLEV Emission Control Category.[8]

FUEL	REACTIVITY ADJUSTMENT FACTOR MIR	(MOR)
Base Gasoline	1.00	(1.00)
Methanol (M85)	0.36	(0.38)
Liquified Petroleum Gas	0.50	(0.59)
Compressed Natural Gas	0.18	(0.24)

Although only passenger cars were tested, the reactivity adjustment factors for light-duty trucks under 5750 lbs. LVW are not expected to be substantially different. Therefore, the staff recommends that the reactivity adjustment factors summarized in Table III-2 be applicable to both passenger cars and light-duty trucks, unless additional data indicate that the reactivity adjustment factors should be different. These data will be obtained by testing available light-duty trucks operating on conventional gasoline and alternative fuels and soliciting data from industry following the November Board hearing.

Additional discussion on the proposed reactivity adjustment factor for each of the fuels comprise the remainder of this section.

1. Conventional Gasoline

Based on the nine vehicles tested, the *ozone per gram* value for conventional gasoline vehicles was found to be 3.44 using the MIR scale. Although emissions from all of the test vehicles were at or below the TLEV standards, the technology used on the vehicles were of varying degrees of advancement. In particular, two of the test

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8. For ethanol (E85), the MIR- and MOR-based reactivity adjustment factors would be 0.63 and 0.77, respectively. However, the test vehicles when operated on ethanol did not comply with the TLEV emission standards, and thus, no reactivity adjustment factor is being proposed for TLEV ethanol vehicles at this time.

vehicles--the Celica and the Cougar--utilized catalysts mounted close to the engine manifold, while the remaining vehicles were equipped with underfloor catalyst systems. The average *ozone per gram* value of these two vehicles was about 15% lower than for the underfloor catalyst vehicles.

Since close-coupled catalyst systems are expected to be needed on all gasoline-powered TLEVs to ensure compliance with TLEV standards in-use, it may be more appropriate to establish the reactivity of conventional gasoline TLEVs by using only data from these types of vehicles. This could result in numerically higher reactivity adjustment factors for vehicles powered by alternative and reformulated fuels. However, additional data are needed before a representative *ozone per gram* value for close-coupled catalyst vehicles can be developed. The staff will continue testing to obtain the needed data.

2. Methanol

The reactivity adjustment factor for methanol TLEVs was calculated to be 0.36 based on the MIR scale (0.38 if the MOR scale were used), which is a lower value than expected by many. However, this factor is fairly consistent for all the available data. To get a sense of the variability in the data, it is useful to compare the effective range of reactivity adjustment factors for the vehicles tested. For the cleanest vehicle tested--the Dodge Spirit, the reactivity adjustment factor would be 0.32. For the most reactive vehicle tested--the Chevrolet Lumina (20M), the reactivity adjustment factor would be 0.43. Therefore, based on the nine vehicles tested, the range of reactivity adjustment factors is 0.11.

It is also interesting to examine separately the reactivity of the Dodge Spirit, which is equipped with a close-coupled catalyst and sequential electronic multipoint fuel injection, technologies which the staff envisions will be needed to attain compliance with in-use standards for TLEVs, particularly for formaldehyde. When the *ozone per gram* of its NMOG emissions is divided by the *ozone per gram* of the NMOG emissions from the two close-coupled catalyst conventional gasoline vehicles, an effective reactivity adjustment factor of 0.37 is obtained. Therefore, when comparing similarly advanced technologies for methanol and gasoline, the reactivity adjustment factor proposed by the staff for Board adoption, 0.36, appears to remain applicable.

3. Liquified Petroleum Gas

Although the data used to establish the reactivity adjustment factor for LPG-fueled vehicles were not as extensive as those used for conventional gasoline or methanol, the mass and reactivity of the emissions from the two vehicles tested by the ARB showed very good agreement. A reactivity adjustment factor of 0.50 based on MIR (0.59 for MOR) was calculated.

4. Compressed Natural Gas

For CNG, only one vehicle was used to determine the reactivity adjustment factor. A total of eight repeat tests were performed on the LeSabre in August, 1991, with very good consistency among tests. The same vehicle was tested in July, 1990, and the results from these tests were markedly different from the August, 1991 results. Instead of the proposed reactivity adjustment factor of 0.18, using the data generated from the July, 1990 tests would result in a factor of about 0.6. The staff believes that the difference may be due to inconsistencies in the preconditioning of the vehicle and will verify the validity of the August, 1991 results prior to the November hearing. In addition, the staff will attempt to procure other CNG vehicles for emission testing to improve the robustness of the data. The Board can assess these additional data in evaluating the proposed reactivity adjustment factor for CNG. If no additional data are available, or if the data are inconsistent, the Board may wish to consider the appropriateness of adopting a reactivity adjustment factor for CNG with these data limitations.

B. Establishing New Reactivity Adjustment Factors

Because of the difficulty of procuring advanced vehicles for testing, not all the reactivity adjustment factors can be established during this rulemaking. For those vehicle/alternative fuel systems for which reactivity adjustment factors are not currently proposed, the ARB Executive Officer will determine the factors once sufficient speciated profiles are available, in accordance with the low-emission vehicle regulations and the amendments to those regulations proposed in this rulemaking.[9] Reactivity adjustment factors for Phase 2 reformulated gasoline and for any new clean fuels that may emerge will also be established by the Executive Officer when appropriate. As Phase 2 reformulated gasoline is likely to become the new gasoline certification fuel for 1995 model-year vehicles, the staff expects that reactivity adjustment factors for Phase 2 gasoline-powered low-emission vehicles will be established no later than summer, 1992.[10] In addition, the Executive Officer will establish reactivity adjustment factors for medium-duty vehicles prior to their implementation in 1998. To

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9. Refer to Section 13 and Appendix VIII of "California Exhaust Emission Standards and Test Procedures for 1988 and Subsequent Model Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles."

10. The staff also expects to propose reactivity adjustment factors for alcohol fuels blended with Phase 2 gasoline at the same time. These factors could then be used for certifying 1995 model-year alcohol fuel vehicles.

ensure that the affected parties are aware of the establishment of any new reactivity adjustment factors, the proposed regulations require the Executive Officer to notify manufacturers of the new factors within 30 days of their establishment.

C. Revising the Reactivity Adjustment Factors.

In addition to testing new vehicle/fuel systems for reactivity, the ARB staff will continue testing to verify the applicability of existing reactivity adjustment factors. As additional preproduction or production clean fuel vehicles become available, the reactivity of their emissions will be evaluated. If, based on the data accumulated, the Executive Officer finds that an established reactivity adjustment factor is no longer representative of actual production vehicles, the reactivity adjustment factor will be revised. An amendment to the regulations is proposed to ensure that the affected industries and public will be notified at least three years before the new adjustment factor becomes effective, although vehicle manufacturers would have the option of using the revised reactivity adjustment factor immediately after its establishment for certifying any new engine families. Furthermore, to mitigate the time and expense of recertifying the engine family, the proposed regulations allow manufacturers to continue using the original reactivity adjustment factor until new durability data are generated.

Additionally, manufacturers may request separate reactivity adjustment factors for specific vehicle/fuel systems. To calculate the reactivity adjustment factor, the proposed regulations require manufacturers to divide the *ozone per gram* value for their light-duty vehicle/fuel systems by 3.44, which is the *ozone per gram* value determined by the staff for conventional gasoline and the value used to calculate all the reactivity adjustment factors proposed in this rulemaking. As specified in the low-emission vehicle regulations, manufacturers applying for specific reactivity adjustment factors must submit appropriate supporting data to the ARB Executive Officer two years prior to certification of the engine family. Validated applications would be approved if the difference between the requested reactivity adjustment factor and the one already established for the same or similar vehicle/fuel system is 25 percent or greater. Further discussion on this subject can be found in chapter IV, section F of this report.

D. Impacts

Because of the way the regulations are structured, use of reactivity adjustment factors should have no environmental or cost impacts. The concept of reactivity adjustment is an important aspect of the low-emission vehicle regulations, which established very stringent certification standards for new vehicles. Use of reactivity adjustment factors is intended to equalize the ozone impact of different vehicle/fuel systems certified to the low-emission vehicle standards. Thus, while the reactivity adjustment factors could allow clean fuel vehicles to emit a greater mass of NMOG, the net effect on ambient ozone should be no different for a clean fuel vehicle than for a conventional gasoline vehicle certified to the same emission category.

For the same reason, the reactivity adjustment factor regulations will have no adverse cost impacts. The use of reactivity adjustment factors may reduce the costs of alternative fuel vehicles, which are currently more expensive to produce than conventional gasoline vehicles. However, manufacturers are not required to build alternative fuel vehicles to meet the requirements of the low-emission vehicle regulations.

IV. ISSUES OF CONTROVERSY

During discussions with the ARB staff, representatives from the affected industries and public have expressed concern with several aspects of the proposed reactivity adjustment factor regulations. In the following section, these issues of controversy are identified, and the staff's responses are discussed.

A. The Reactivity Scale Is Uncertain for Many Hydrocarbons.

The reliability of the reactivity scale depends on the reliability of the chemical mechanism used to derive the scale. The MIR and MOR scales were calculated using the chemical mechanism developed by Dr. W.P.L. Carter. The Carter chemical mechanism is the most appropriate of the currently available mechanisms for calculating reactivity scales. It was tested as much as possible against experimental data and was specifically designed for calculating reactivities of individual hydrocarbons. Furthermore, the assumptions underlying Carter's mechanism have undergone a thorough peer review, and estimates of the effects of chemical uncertainties on its reactivity predictions have been made.

Of course, assessing the uncertainties in Carter's mechanism does not solve the underlying problems causing these uncertainties. These can only be addressed by fundamental studies aimed at improving the knowledge of the atmospheric reactions of hydrocarbons, and environmental chamber experiments to test the models for these reactions. Research of this type is being sponsored by the ARB and others, so knowledge in these areas will continue to advance, and the mechanisms will improve accordingly.

Because of uncertainties in the chemical mechanisms, the staff plans to propose revisions to the reactivity scale at three-year intervals, and the reactivity scale may be recalculated using the mechanism reflecting the available knowledge. It is expected that changes in the chemical mechanism alone will not greatly change the reactivity adjustment factors for vehicles whose emissions are dominated by a few species, such as ethane, methanol, or formaldehyde, whose mechanisms are already well tested. However, industry must be prepared to anticipate and deal with the changes that may occur, since the ARB intends to base its regulations on the best available knowledge.

The results of the uncertainty analysis can help guide industry in anticipating possible changes in the scale due to advances in scientific knowledge of the atmospheric reactions of hydrocarbons. If they keep abreast of advances in the field and conduct their own uncertainty studies when decisions need to be made, they should not be caught by surprise when the time comes to recalculate the reactivity scale.

B. The Reactivity Adjustment Factors May Not Ensure Equal Ozone Impacts in All Areas of California.

The principle behind the reactivity adjustment factor concept is that equal impacts on air quality will result from reactivity-adjusted emissions that just meet the standard. But what is meant by "equal air quality"? Unless all vehicles emit exactly the same types of hydrocarbons, it is not possible to derive a single reactivity adjustment factor that yields equal air quality impacts in all places at all times. A reactivity adjustment factor determined so that two vehicles have equal impacts on peak ozone will, in general, be different from one derived so that the vehicles have equal impacts on integrated ozone. Since the main reason for regulating ozone is to reduce impacts on human health, medical experts have been consulted to determine the "equal air quality" criteria. Modeling has been performed under a range of airshed conditions to assure that two reactivity-adjusted vehicle fleets at the same NMOG standard will lead to the same one-hour basin peak concentrations and exposure above the state ambient air quality standard.

C. The Reactivity Adjustment Factors Are Based on Limited Data.

Because development of reactivity adjustment factors requires testing of vehicles that meet future emission standards, the reactivity adjustment factors are necessarily based on only a limited number of test vehicles. In procuring advanced vehicles for testing, the ARB staff identified qualifying vehicles from its and other state and local test fleets, conducted a search of local rental car agencies, and solicited vehicles and/or data from the affected industries. These efforts have resulted in the data contained in this report.

The data for alternative fuel vehicles are especially limited as these technologies are still in their prototype or experimental stages, and advanced production vehicles are not yet available. However, rather than delay implementation of alternative fuel low-emission vehicles, reactivity adjustment factors were calculated using the best available data. These reactivity adjustment factors offer a guaranteed minimum level of adjustment upon which manufacturers can base their vehicle designs. If it turns out that the reactivity adjustment factors do not accurately represent the emissions from actual production vehicles, the factors can be revised. The ARB Executive Officer can establish new reactivity adjustment factors, provided that the affected industries and public are given three years advance notice. Moreover, manufacturers may request reactivity adjustment factors specific to their designs by submitting the appropriate data two years prior to certification.

D. The Reactivity Adjustment Factors May Not Be Applicable to In-Use Vehicles.

Because the emission profiles were obtained primarily from low-mileage vehicles, generally between 4000 and 10,000 miles, the applicability of reactivity adjustment factors to vehicles at 50,000 or 100,000 miles has been questioned. The effect of component deterioration on emission profiles has not been well studied, and some have surmised that as emission control systems age, emission profiles, and therefore reactivity, may vary considerably.

However, the full useful life (100,000 and 120,000 mile) standards contained in the low-emission vehicle regulations will limit the extent to which emission control systems can deteriorate. In order to ensure compliance with full useful life standards (or else be subject to costly recalls), vehicle manufacturers must design emission control systems that are able to maintain low emissions throughout the full life of the vehicle. Therefore, emissions cannot deteriorate very much, and emission profiles are not likely to change substantially with age.

E. The Reactivity Adjustment Factors Should Include Evaporative Hydrocarbon, Carbon Monoxide, Methane, Oxides of Nitrogen, and Marketing and Refining Emissions.

Throughout the rulemaking process, various parties have questioned the ARB's decision to base reactivity adjustment factors solely on exhaust NMOG emissions. Because other emissions associated with vehicle use also contribute to ozone formation, they argue, the reactivity of total vehicle and fuel system emissions should be incorporated into the reactivity adjustment factor.

In general, all of these proposals to include other considerations in the exhaust NMOG reactivity adjustment factor add additional complexity to the regulations. The staff would need to more fully evaluate the impacts of including these considerations before it can recommend that amendments to the existing protocol be adopted by the Board. An assessment of the importance of including total vehicle and fuel system emissions will be performed in the next year, and if warranted, a regulatory proposal will be made at the 1994 review hearing for the low-emission vehicle regulations.

The staff's initial reactions on the importance of including each of the different types of emissions are provided below.

1. <u>Evaporative hydrocarbons</u>

In the near term, including evaporative hydrocarbon emissions could benefit vehicles powered by gaseous fuels such as CNG, which have little or no evaporative emissions[11]. However, with the implementation of the newly adopted evaporative test procedures (which require multiple day, high temperature diurnals, and measurement of running losses) beginning with 1995 model-year cars, evaporative emissions should be near zero under normal driving conditions. Furthermore, second generation on-board diagnostic, or OBD II, requirements will ensure that any malfunctions in evaporative control systems are quickly detected and repaired. Thus, these regulations, coupled with the fact that evaporative emissions are generally less reactive than exhaust emissions, will minimize the impact of evaporative emissions from low-emission vehicles in the future. However, the staff will conduct a more thorough assessment of this issue during the next year.

2. <u>Carbon monoxide</u>

Although the low-emission vehicle standards currently allow proportionally greater emissions of CO than NMOG, the disparity in the actual mass of CO emitted by vehicles certified to the LEV or ULEV standards should be minimal. In establishing the LEV and ULEV CO standards, the ARB allowed some latitude for fuel system calibration in the rich direction to meet the lower NOx standard. However, the technology needed to comply with the low-emission NMOG standards should also ensure that vehicles have CO emissions well below the applicable standards. The ARB can consider lowering the CO emission standards in the future to minimize any possible ozone effects.

3. <u>Methane</u>

The Board has long recognized the extremely low ozone contribution of methane, as evidenced by the adoption of hydrocarbon emission standards that explicitly exclude methane. The methane emissions from most current technology vehicles are less than a tenth of

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11. Reactivity adjustment of evaporative emissions for methanol vehicles is less of a concern because their evaporative emissions are measured in terms of "organic material hydrocarbon equivalent" (or "OMHCE"). OMHCE standards already incorporate a simplified reactivity correction.

a gram per mile. CNG vehicles, however, can exceed one gram of methane emissions per mile. For the CNG dual-fuel LeSabre, which had 1.5 g/mi of methane emissions, the ozone-forming potential of the methane emissions was about 15% of the *ozone per mile* of the NMOG emissions. For a more advanced CNG vehicle[12], methane accounted for about 8% of its *ozone per mile*. In the staff's view, the methane contribution to ozone for CNG vehicles is not significant. However, if the Board does not agree, or if it finds that the global warming impact of methane is important, the staff recommends that standards be established to limit the methane emissions from CNG vehicles.

4. Oxides of nitrogen

Because NOx and reactivity-based hydrocarbon controls are complementary, NOx and hydrocarbons cannot be traded off for one another. NOx control is most beneficial in areas where hydrocarbon control is not, and vice versa. Thus, a general reactivity adjustment factor that includes both hydrocarbons and NOx may result in ozone increases in some areas and ozone decreases in others. Control of both pollutants is needed to reduce ozone levels in all areas of California. Moreover, including NOx in the reactivity adjustment factor would have little effect on the types of low-emission vehicles certified since no particular vehicle/fuel system is inherently capable of achieving significantly lower NOx levels compared to any other vehicle/fuel system.

5. Marketing and refining

Quantifying the emissions associated with the production and distribution of motor vehicle fuels would require consideration of many factors, including refinery location, method of transport, frequency of delivery, frequency of refueling, spillage, fuel composition, weather conditions, etc. Furthermore, the reactivity of the emissions associated with each phase of the marketing and refining process must be determined. Thus, including the ozone impact of marketing and refining emissions would add complexity to the reactivity adjustment factor calculation. The staff will need additional time to evaluate the importance of including fuel cycle emissions, and if appropriate, to formulate protocol to include them in the reactivity adjustment factor.

12. A dedicated CNG 1991 Grumman postal truck. The vehicle had average methane emissions of 0.20 g/mi.

F. Manufacturers Should Be Allowed To Develop Reactivity Adjustment Factors Specific to Their Engine Families.

Rather than having them established by the ARB, or having the ARB Executive Officer approve manufacturers' requests under certain conditions, some have suggested that manufacturers should be allowed to develop reactivity adjustment factors specific to their engine families during the certification process. The ARB would establish "default" reactivity adjustment factors which manufacturers could use if they chose not to develop their own.

The ARB staff does not support engine family specific reactivity adjustment factors for two main reasons. First of all, the administrative complexity of having a variety of slightly different reactivity adjustment factors for the same basic vehicle technology/fuel system would create a burden on staff resources. Secondly, not all manufacturers have the capacity to perform speciated emission testing for certification. (Speciating hydrocarbon emissions is a costly and time-consuming procedure, requiring fairly complex laboratory instruments and the skills of several analytical chemists.) Since the value of the reactivity adjustment factors could potentially determine whether an engine family passes or fails in-use recall testing, manufacturers that cannot perform speciated testing could be at a competitive disadvantage to those manufacturers that can develop reactivity adjustment factors that allow greater mass emissions.

However, one aspect of the low-emission vehicle regulations that may warrant reconsideration is the criteria for approving manufacturers' requests for engine family specific reactivity adjustment factors. The regulations state that such requests will be approved if the data can be verified and if the requested factor differs from the one established for the particular vehicle/fuel system by 25 percent or more. The staff believes it may be more appropriate to revise the 25 percent criterion to reflect the uncertainty and differences in the established reactivity adjustment factors. For example, the criterion could be based on the variability in the data used to derive the reactivity adjustment factor: a manufacturer's requested factor would be approved if it is at least two standard deviations different from the existing reactivity adjustment factor. Alternatively, the criterion could be based on the minimum percent difference among the various reactivity adjustment factors established for a low-emission vehicle category. For instance, if there were four reactivity adjustment factors in the LEV category with values of 0.85, 0.75, 0.55, and 0.30, each corresponding to a particular fuel system, the minimum difference is between the 0.85 and 0.75 values, which is equal to 12 percent. Therefore, the criterion for approving new reactivity adjustment factors would be a 12 percent difference. However, in the absence of sufficient data, amendments to this aspect of the regulations will by necessarily have to be made in the future, at the earliest during the biennial review hearing for the low-emission vehicle regulations scheduled for spring, 1992.

G. The Reactivity Adjustment Factors Should Be Based on the Weighting Factors Used in the Emission Inventory, Not in the Federal Test Procedure.

All vehicles certified for sale in California and throughout the nation are tested according to the United States Environmental Protection Agency's ("EPA") Federal Test Procedure ("FTP"). The FTP driving cycle consists of three distinct phases: (1) the cold transient (or cold start) phase, (2) the cold stabilized phase, and (3) the hot transient (or hot start) phase. Diluted exhaust emissions from the three phases of the FTP are collected in separate bags and analyzed. The results for each bag are then combined by using weighting factors that reflect the time spent in that phase based on vehicle driving patterns. This composite FTP emission rate is then compared with the applicable emission standards to determine whether the vehicle is in compliance.

To develop reactivity adjustment factors, the low-emission vehicle regulations require that EPA's FTP composite weighting factors, which were established in 1978, be applied to speciated emission data from each phase of the FTP cycle. Some have contended that the FTP weighting factors are quite different from those used in current emission inventory models, and that the FTP weighting unfairly penalizes gasoline-fueled vehicles. However, this contention may result from a poor understanding of the issue. The FTP weighting factors are quite representative of current emission inventory models, but current emission inventory models are not representative of emissions from alternative fuel vehicles. This is not surprising, as the emission inventory models were developed from tests of conventional gasoline vehicles, not alternative fuel vehicles. When the mass of emissions from alternate fuel vehicles is properly adjusted in the emission inventory, the FTP and inventory weighting approaches yield very similar results.

Since the FTP is the method for determining compliance with the NMOG certification standards, the FTP weighting scheme is appropriately the method employed to calculate the reactivity adjustment factor. However, an important issue that still needs to be addressed is whether the FTP cycle adequately simulates actual driving patterns, particularly hard accelerations. This is the subject of several on-going ARB in-house and extramural research projects.

APPENDIX A

Members of the Reactivity Advisory Panel

Members of the *ad hoc* Reactivity Advisory Panel

Alan M. Dunker
Motor Vehicle Manufacturers Association

S. Kent Hoekman
Western States Petroleum Association

Neil Koehler
California Renewable Fuels Council

Chung Liu
South Coast Air Quality Management District

Alvin Lowi, Jr.
Western Liquid Gas Association

Larry Marigold
American Methanol Institute

Michael McCormack
California Energy Commission

Charles H. Schleyer
Auto/Oil Air Quality Improvement Program

Leo B. Thomason
California Natural Gas Vehicle Coalition

APPENDIX B

Modified Text of Title 13, California Code of Regulations, Section 1960.1

SECTION 1960.1, TITLE 13, CCR

Amend Title 13, California Code of Regulations, section 1960.1 to read as follows:[1]

1960.1. **Exhaust Emission Standards and Test Procedures - 1991 and Subsequent Model Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles.**

(a) through (d) [No Change]

(e)(1) and (e)(2) [No Change]

(e)(3) The exhaust emissions from 1992 and subsequent model-year transitional low-emission vehicles, low-emission vehicles, and ultra-low-emission vehicles, including fuel-flexible and dual-fuel vehicles, shall meet all the requirements of (g)(1) and (h)(2) with the following additions:

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1. The regulatory amendments proposed in this rulemaking are shown in underline to indicate additions and ~~strikeout~~ to indicate deletions from the existing regulations.

EXHAUST EMISSION STANDARDS FOR
TRANSITIONAL LOW-EMISSION VEHICLES, LOW-EMISSION VEHICLES,
AND ULTRA-LOW-EMISSION VEHICLES IN THE
LIGHT-DUTY AND MEDIUM-DUTY VEHICLE WEIGHT CLASSES (5)(6)(7)
["milligrams per mile" (or "mg/mi")]

Vehicle Type (1)	Vehicle Weight (lbs.)(2)	Durability Vehicle Basis (mi)	Vehicle Emission Category(3)	Formaldehyde (mg/mi)(4)(5)
PC and LDT	All 0-3750	50,000	TLEV	15 (23)
			LEV	15 (15)
			ULEV	8 (12)
		100,000	TLEV	18
			LEV	18
			ULEV	11
LDT	3751-5750	50,000	TLEV	18 (27)
			LEV	18 (18)
			ULEV	9 (14)
		100,000	TLEV	23
			LEV	23
			ULEV	13
MDV	0-3750	50,000	LEV	15 (15)
			ULEV	8 (12)
		120,000	LEV	22
			ULEV	12
MDV	3751-5750	50,000	LEV	18 (18)
			ULEV	9 (14)
		120,000	LEV	27
			ULEV	13
MDV	5751-8500	50,000	LEV	22 (22)
			ULEV	11 (17)
		120,000	LEV	32
			ULEV	16
MDV	8501-10,000	50,000	LEV	28 (28)
			ULEV	14 (21)
		120,000	LEV	40
			ULEV	21
MDV	10,001-14,000	50,000	LEV	36 (36)
			ULEV	18 (27)
		120,000	LEV	52
			ULEV	26

(1) "PC" means passenger cars.
"LDT" means light-duty trucks.
"MDV" means medium-duty vehicles.

(2) For light-duty or medium-duty vehicles, Vehicle Weight shall mean "Loaded Vehicle Weight" (or "LVW") or "Test Weight" (or "TW"), respectively.

(3) "TLEV" means transitional low-emission vehicle.
"LEV" means low-emission vehicle.
"ULEV" means ultra-low-emission vehicle.

(4) Formaldehyde exhaust emission standards apply to vehicles designed certified to operate on any available fuel, including fuel-flexible and dual-fuel vehicles.

(5) The standards in parentheses are intermediate compliance standards for 50,000 miles.

a. For PCs and LDTs from 0-5750 lbs. LVW, including fuel-flexible and dual-fuel vehicles, intermediate compliance standards shall apply to TLEVs through the 1995 model year, LEVs and ULEVs through the 1998 model year. Compliance with standards beyond 50,000 miles shall be waived through 1995 for TLEVs, and through 1998 for LEVs and ULEVs.

b. For MDVs from 0-14,000 lbs. TW, including fuel-flexible and dual-fuel vehicles, intermediate compliance standards shall apply to LEVs and ULEVs through the 1999 model year. Compliance with standards beyond 50,000 miles shall be waived through the 1999 model year for LEVs and ULEVs.

(6) Manufacturers shall demonstrate compliance with the above standards for formaldehyde at 50 degrees F according to the procedures specified in section 11k of the "California Exhaust Emission Standards and Test Procedures for 1988 and Subsequent Model Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles" as adopted May 20, 1987 and last amended [INSERT] July 12, 1991, which is incorporated herein by reference.

(7) In-use compliance testing shall be limited to PCs and LDTs with fewer than 75,000 miles and MDVs with fewer than 90,000 miles.

(f)(1) and (f)(2) [No Change]

(g)(1) The exhaust emissions from new 1992 and subsequent model-year light-duty transitional low-emission vehicles, low-emission vehicles, and ultra-low-emission vehicles shall not exceed:

EXHAUST EMISSION STANDARDS
FOR TRANSITIONAL LOW-EMISSION VEHICLES, LOW-EMISSION VEHICLES
AND ULTRA-LOW-EMISSION VEHICLES IN PASSENGER CAR
AND LIGHT-DUTY TRUCK VEHICLE CLASSES (6)(7)(8)(9)
[grams per mile (or "g/mi")]

Vehicle Type (1)	Loaded Vehicle Weight (lbs.)	Durability Vehicle Basis (mi)	Vehicle Emission Category (2)	Non-Methane Organic Gases (3)(4)	Carbon Monoxide	Oxides of Nitrogen (5)
PC and LDT	All 0-3750	50,000	TLEV	0.125 (0.188)	3.4 (3.4)	0.4 (0.4)
			LEV	0.075 (0.100)	3.4 (3.4)	0.2 (0.3)
			ULEV	0.040 (0.058)	1.7 (2.6)	0.2 (0.3)
		100,000	TLEV	0.156	4.2	0.6
			LEV	0.090	4.2	0.3
			ULEV	0.055	2.1	0.3
LDT	3751-5750	50,000	TLEV	0.160 (0.238)	4.4 (4.4)	0.7 (0.7)
			LEV	0.100 (0.128)	4.4 (4.4)	0.4 (0.5)
			ULEV	0.050 (0.075)	2.2 (3.3)	0.4 (0.5)
		100,000	TLEV	0.200	5.5	0.9
			LEV	0.130	5.5	0.5
			ULEV	0.070	2.8	0.5

(1) "PC" means passenger cars.
"LDT" means light-duty trucks.

(2) "TLEV" means transitional low-emission vehicle.
"LEV" means low-emission vehicle.
"ULEV" means ultra-low-emission vehicle.

(3) "Non-Methane Organic Gases" (or "NMOG") shall mean the total mass of oxygenated and non-oxygenated hydrocarbon emissions. To demonstrate compliance with an NMOG standard, NMOG emissions shall be measured in accordance with the "California Non-Methane Organic Gas Test Procedures" as adopted July 12, 1991, which is incorporated herein by reference. For TLEVs, LEVs, and ULEVs ~~designed~~ certified to operate exclusively on any fuel other than conventional gasoline, and for fuel-flexible and dual-fuel TLEVs, LEVs, and ULEVs when certifying on a fuel other than conventional gasoline, manufacturers shall multiply ~~the measured~~ NMOG mass emissions levels at 50,000 and 100,000 miles by the applicable reactivity adjustment factor set forth in section 13 of the "California Exhaust Emission Standards and Test Procedures for 1988 and Subsequent Model Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles" as adopted May 20, 1987 and last amended [INSERT], which is incorporated herein by reference, or established by the Executive Officer pursuant to Appendix VIII of the foregoing test procedures. The product of the NMOG mass emission level and the reactivity adjustment factor shall be compared to the exhaust NMOG

mass emission standards established for the particular vehicle emission category to determine compliance. ~~established for the particular vehicle emission category and fuel combination in the application for certification. The Executive Officer shall determine the reactivity adjustment factor according to the procedure described in Appendix VIII of the "California Exhaust Emission Standards and Test Procedures for 1988 and Subsequent Model Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles" as adopted May 20, 1987 and last amended July 12, 1991, which is incorporated herein by reference.~~

a. Each manufacturer shall certify PCs or LDTs to meet the exhaust mass emission standards for TLEVs, LEVs, ULEVs, or the exhaust emission standards of sections 1960.1 (e)(1), 1960.1 (f)(1), or 1960.1 (f)(2), Title 13, California Code of Regulations, or as Zero-Emission Vehicles such that the manufacturer's fleet average NMOG values for California-certified PCs and LDTs from 0-3750 lbs. "Loaded Vehicle Weight" (or "LVW"), and LDTs from 3751-5750 lbs. LVW sold in California are less than or equal to the requirement for the corresponding Model Year, Vehicle Type, and LVW Class in section 1960.1 (g)(2), Title 13, California Code of Regulations.

(4) Fuel-flexible and dual-fuel PCs and LDTs from 0-5750 lbs. LVW shall be certified to exhaust mass emission standards for NMOG established for the operation of the vehicle on any available fuel other than conventional gasoline, and conventional gasoline.

a. For TLEVs, LEVs, and ULEVs, when certifying for operation on a fuel other than conventional gasoline, manufacturers shall multiply ~~the measured~~ NMOG mass emissions levels at 50,000 and 100,000 miles by the applicable reactivity adjustment factor ~~in the application for certification at 50,000 and 100,000 miles~~.

b. For PCs and LDTs from 0-3750 lbs. LVW, the applicable exhaust mass emission standard for NMOG when certifying the vehicle for operation on conventional gasoline shall be:

(i) For TLEVs, 0.25 g/mi and 0.31 g/mi for 50,000 and 100,000 miles, respectively.

(ii) For LEVs, 0.125 g/mi and 0.156 g/mi for 50,000 and 100,000 miles, respectively.

(iii) For ULEVs, 0.075 g/mi and 0.090 g/mi for 50,000 and 100,000 miles, respectively.

c. For LDTs from 3751-5750 lbs. LVW, the applicable exhaust mass emission standard for NMOG when certifying the vehicle for operation on conventional gasoline shall be:

(i) For TLEVs, 0.32 g/mi and 0.40 g/mi for 50,000 and 100,000 miles, respectively.

(ii) For LEVs, 0.160 g/mi and 0.200 g/mi for 50,000 and 100,000 miles, respectively.

(iii) For ULEVs, 0.100 g/mi and 0.130 g/mi for 50,000 and 100,000 miles, respectively.

(5) The maximum projected emissions of "Oxides of Nitrogen" (or "NOx") measured on the federal Highway Fuel Economy Test (HWFET; 40 CFR 600 Subpart B) shall be not greater than 1.33 times the applicable light-duty vehicle standards shown in the table. Both the projected emissions and the HWFET standard shall be rounded in accordance with ASTM E29-67 to the nearest 0.1 g/mi before being compared.

(6) The standards in parentheses are intermediate compliance standards for 50,000 miles. For PCs and LDTs from 0-5750 lbs. LVW, including fuel-flexible and dual-fuel vehicles when operating on any available fuel other than conventional gasoline, intermediate compliance standards shall apply to TLEVs through the 1995 model year, and LEVs and ULEVs through the 1998 model year. Compliance with standards beyond 50,000 miles shall be waived through the 1995 model year for TLEVs, and through the 1998 model year for LEVs and ULEVs.

a. For TLEVs, LEVs, and ULEVs designed to operate on any fuel other than conventional gasoline, including fuel-flexible and dual-fuel vehicles when operating on any fuel other than conventional gasoline, measured NMOG mass emissions levels shall be multiplied by the applicable reactivity adjustment factor to determine compliance with intermediate compliance standards for NMOG.

b. For fuel-flexible and dual-fuel PCs and LDTs from 0-3750 lbs. LVW, intermediate compliance standards for NMOG emissions at 50,000 miles, when the vehicle is operated on conventional gasoline, shall be 0.32 g/mi, 0.188 g/mi, and 0.100 g/mi for TLEVs, LEVs, and ULEVs, respectively.

c. For fuel-flexible and dual-fuel PCs and LDTs from 3751-5750 lbs. LVW, intermediate compliance standards for NMOG emissions at 50,000 miles, when the vehicle is operated on conventional gasoline, shall be 0.41 g/mi, 0.238 g/mi, and 0.128 g/mi for TLEVs, LEVs, and ULEVs, respectively.

(7) Manufacturers of diesel vehicles shall also certify to particulate standards at 100,000 miles. For all PCs and LDTs from 0-5750 lbs LVW, the particulate standard is 0.08 g/mi, 0.08 g/mi, and 0.04 g/mi for TLEVs, LEVs and ULEVs, respectively.

(8) Manufacturers shall demonstrate compliance with the above standards for NMOG, CO, and NOx at 50 degrees F according to the procedure specified in section 11k of the "California Exhaust Emission Standards and Test Procedures for 1988 and Subsequent Model Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles" as adopted May 20, 1987 and last amended [INSERT] July 12, 1991, which is incorporated herein by reference. For diesel vehicles, compliance with the particulate standard shall also be demonstrated as specified in section 11k of the foregoing test procedures.

(9) In-use compliance testing shall be limited to vehicles with fewer than 75,000 miles.

(g)(2) and (h)(1) [No Change]

(h)(2) The exhaust emissions from new 1992 and subsequent model-year medium-duty low-emission vehicles, and ultra-low-emission vehicles shall not exceed:

EXHAUST EMISSION STANDARDS FOR LOW-EMISSION VEHICLES,
AND ULTRA-LOW-EMISSION VEHICLES IN THE
MEDIUM-DUTY VEHICLE WEIGHT CLASS (8)(9)(10)(11)(12)(13)(14)
[grams per mile (or "g/mi")]

Test Weight lbs.) (1)	Durability Vehicle Basis (mi)	Vehicle Emission Category (2)	Non-Methane Organic Gases (3)(4)	Carbon Monoxide	Oxides of Nitrogen (5)	Particulates (6)(7)
0-3750	50,000	LEV	0.125 (0.188)	3.4 (3.4)	0.4 (0.4)	n/a
		ULEV	0.075 (0.100)	1.7 (2.6)	0.2 (0.3)	n/a
	120,000	LEV	0.180	5.0	0.6	0.08
		ULEV	0.107	2.5	0.3	0.04
3751-5750	50,000	LEV	0.160 (0.238)	4.4 (4.4)	0.7 (0.7)	n/a
		ULEV	0.100 (0.128)	2.2 (3.3)	0.4 (0.5)	n/a
	120,000	LEV	0.230	6.4	1.0	0.10
		ULEV	0.143	3.2	0.5	0.05
5751-8500	50,000	LEV	0.195 (0.293)	5.0 (5.0)	1.1 (1.1)	n/a
		ULEV	0.117 (0.156)	2.5 (3.8)	0.6 (0.8)	n/a
	120,000	LEV	0.280	7.3	1.5	0.12
		ULEV	0.167	3.7	0.8	0.06
8501-10000	50,000	LEV	0.230 (0.345)	5.5 (5.5)	1.3 (1.3)	n/a
		ULEV	0.138 (0.184)	2.8 (4.2)	0.7 (1.0)	n/a
	120,000	LEV	0.330	8.1	1.8	0.12
		ULEV	0.197	4.1	0.9	0.06
10,001-14000	50,000	LEV	0.300 (0.450)	7.0 (7.0)	2.0 (2.0)	n/a
		ULEV	0.180 (0.240)	3.5 (5.3)	1.0 (1.5)	n/a
	120,000	LEV	0.430	10.3	2.8	0.12
		ULEV	0.257	5.2	1.4	0.06

(1) "Test Weight" (or "TW") shall mean the average of the vehicle's curb weight and gross vehicle weight.

(2) "LEV" means low-emission vehicle.
"ULEV" means ultra-low-emission vehicle.

(3) "Non-Methane Organic Gases" (or "NMOG") shall mean the total mass of oxygenated and non-oxygenated hydrocarbon emissions. To determine compliance with an NMOG standard, NMOG emissions shall be measured in accordance with "California Non-Methane Organic Gas Test Procedures" as adopted July 12, 1991, which is incorporated herein by reference.

a. For LEVs and ULEVs ~~designed~~ certified to operate on any available fuel other than conventional gasoline, including fuel-flexible or dual-fuel vehicles when certifying on a fuel other than conventional gasoline, manufacturers shall multiply ~~measured~~ NMOG mass emissions levels at 50,000 and 120,000 miles by the applicable reactivity adjustment factor set forth in section 13 of the "California Exhaust Emission Standards and Test Procedures for 1988 and Subsequent Model Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles" as adopted May 20, 1987 and last amended [INSERT], which is incorporated herein by reference, or established by the Executive Officer pursuant to Appendix VIII of the foregoing test procedures. The product of the NMOG mass emission levels and the reactivity adjustment factor shall be compared to the exhaust NMOG mass emission standard established for the particular vehicle emission category to determine compliance. ~~appropriate to the vehicle emission category and fuel combination in the application for certification. The reactivity adjustment factor shall be determined by the Executive Officer according to the procedure described in Appendix VIII of the "California Exhaust Emission Standards and Test Procedures for 1988 and Subsequent Model Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles" as adopted May 20, 1987 and last amended July 12, 1991, which is incorporated herein by reference.~~

(4) Fuel-flexible and dual-fuel medium-duty vehicles (or "MDVs") from 0-14,000 lbs. TW shall be certified to exhaust mass emission standards for NMOG established for the operation of the vehicle on any fuel other than conventional gasoline, and conventional gasoline.

a. For LEVs and ULEVs, manufacturers shall multiply ~~measured~~ NMOG mass emissions levels at 50,000 and 120,000 miles by the ~~appropriate~~ applicable reactivity adjustment factor ~~in the application for certification~~.

b. For MDVs from 0-3750 lbs. TW, the applicable exhaust mass emission standard for NMOG when certifying the vehicle for operation on conventional gasoline shall be:
   (i) For LEVs, 0.25 g/mi and 0.36 g/mi for 50,000 and 120,000 miles, respectively.
   (ii) For ULEVs, 0.125 g/mi and 0.190 g/mi for 50,000 and 120,000 miles, respectively.

c. For MDVs from 3751-5750 lbs. TW, the applicable exhaust mass emission standard for NMOG when certifying the vehicle for operation on conventional gasoline shall be:
   (i) For LEVs, 0.32 g/mi and 0.46 g/mi for 50,000 and 120,000 miles, respectively.
   (ii) For ULEVs, 0.160 g/mi and 0.230 g/mi for 50,000 and 120,000 miles, respectively.

d. For MDVs from 5751-8500 lbs. TW, the applicable exhaust mass emission standard for NMOG when certifying the vehicle for operation on conventional gasoline shall be:
   (i) For LEVs, 0.39 g/mi and 0.56 g/mi for 50,000 and 120,000 miles, respectively.
   (ii) For ULEVs, 0.195 g/mi and 0.280 g/mi for 50,000 and 120,000 miles, respectively.

e. For MDVs from 8501-10,000 lbs. TW, the applicable exhaust mass emission standard for NMOG when certifying the vehicle for operation on conventional gasoline shall be:
   (i) For LEVs, 0.46 g/mi and 0.66 g/mi for 50,000 and 120,000 miles, respectively.
   (ii) For ULEVs, 0.230 g/mi and 0.330 g/mi for 50,000 and 120,000 miles, respectively.

f. For MDVs from 10,001-14,000 lbs. TW, the applicable exhaust mass emission standard for NMOG when certifying the vehicle for operation on conventional gasoline shall be:
   (i) For LEVs, 0.60 g/mi and 0.86 g/mi for 50,000 and 120,000 miles, respectively.

(ii) For ULEVs, 0.300 g/mi and 0.430 g/mi for 50,000 and 120,000 miles, respectively.

(5) The maximum projected emissions of "Oxides of Nitrogen" (or "NOx") measured on the federal Highway Fuel Economy Test (HWFET; 40 CFR Part 600 Subpart B) shall not be greater than 2.00 times the applicable MDV standards shown in the table. Both the projected emissions and the HWFET standard shall be rounded in accordance with ASTM E29-67 to the nearest 0.1 g/mi before being compared.

(6) Particulate standards are only applicable for diesel vehicles and shall be determined on a 120,000 mile basis.

(7) "n/a" means not applicable.

(8) Manufacturers have the option of certifying engines used in incomplete and diesel MDVs to the heavy-duty engine standards and test procedures set forth in section 1956.8(h), Title 13, California Code of Regulations. Manufacturers certifying incomplete or diesel MDVs to the heavy-duty engine standards and test procedures shall specify in the application for certification an in-use compliance procedure as provided in section 2139(c), Title 13, California Code of Regulations.

(9) The standards in parenthesis are intermediate compliance standards for 50,000 miles. For MDVs from 0-14,000 lbs. TW, including fuel-flexible and dual-fuel vehicles when operating on any available fuel other than conventional gasoline, intermediate compliance standards shall apply to LEVs and ULEVs through the 1999 model year. Compliance with standards beyond 50,000 miles shall be waived through the 1999 model year for LEVs and ULEVs.

a. For LEVs and ULEVs designed to operate on any available fuel other than conventional gasoline, including fuel-flexible and dual-fuel vehicles when operating on any available fuel other than conventional gasoline, ~~measured~~ NMOG emissions levels shall be multiplied by the ~~appropriate~~ applicable reactivity adjustment factor.

b. For fuel-flexible and dual-fuel MDVs from 0-3750 lbs. TW, intermediate compliance standards for NMOG emissions at 50,000 miles, when the vehicle is operated on conventional gasoline, shall be 0.32 g/mi and 0.188 g/mi for LEVs and ULEVs, respectively.

c. For fuel-flexible and dual-fuel MDVs from 3751-5750 lbs. TW, intermediate compliance standards for NMOG emissions at 50,000 miles, when the vehicle is operated on conventional gasoline, shall be 0.41 g/mi and 0.238 g/mi for LEVs and ULEVs, respectively.

d. For fuel-flexible and dual-fuel MDVs from 5751-8500 lbs. TW, intermediate compliance standards for NMOG emissions at 50,000 miles, when the vehicle is operated on conventional gasoline, shall be 0.49 g/mi and 0.293 g/mi for LEVs and ULEVs, respectively.

e. For fuel-flexible and dual-fuel MDVs from 8501-10,000 lbs. TW, intermediate compliance standards for NMOG emissions at 50,000 miles, when the vehicle is operated on conventional gasoline, shall be 0.58 g/mi and 0.345 g/mi for LEVs and ULEVs, respectively.

f. For fuel-flexible and dual-fuel MDVs from 10,001-14,000 lbs. TW, intermediate compliance standards for NMOG emissions at 50,000 miles, when the vehicle is operated on conventional gasoline, shall be 0.75 g/mi and 0.450 g/mi for LEVs and ULEVs, respectively.

(10) Each manufacturer's MDV fleet shall be defined as the total number of MDVs from 0-14,000 lbs. TW certified and sold in California.

a. Manufacturers of MDVs shall certify an equivalent of 25% of their MDV fleet to LEV standards in the 1998 model year, 50% of their MDV fleet to LEV standards in the 1999 model year, 75% of their MDV fleet to LEV standards in the 2000 model year, 95% of their MDV fleet to LEV standards in the 2001 model year, 90% of their MDV fleet to LEV standards in the 2002 model year, and 85% of their MDV fleet to LEV standards in the 2003 and subsequent model years.

b. Manufacturers of MDVs shall certify an equivalent of 2% of their MDV fleet to ULEV standards in each model year from 1998 through 2000, 5% of their MDV fleet to ULEV standards in the 2001 model year, 10% of their MDV fleet to ULEV standards in the 2002 model year, and 15% of their MDV fleet to ULEV standards in the 2003 and subsequent model years.

(11) For the purpose of calculating "Vehicle Equivalent Credits" (or "VECs"), the contribution of hybrid electric vehicles (or "HEVs") will be calculated based on the range of the HEV without the use of the engine. For the purpose of calculating the contribution of HEVs to the VECs, the following definitions shall apply:

"Type A HEV" shall mean an HEV which achieves a minimum range of 60 miles over the Dynamometer Driving Cycle as defined by the "Federal Highway Fuel Economy Test Procedure" (HWFET; 40 CFR Part 600 Subpart B) without the use of the engine. Use of vehicle accessories cannot lower the battery-only range below 60 miles. This definition shall also apply to vehicles which have no tailpipe emissions, but use fuel fired heaters, regardless of the operating range of the vehicle.

"Type B HEV" shall mean an HEV which achieves a range of 40 - 59 miles over the Dynamometer Driving Cycle as defined by the "Federal Highway Fuel Economy Test Procedure" (HWFET; 40 CFR Part 600 Subpart B) without the use of the engine. Use of vehicle accessories cannot lower the battery-only range below 40 miles.

"Type C HEV" shall mean an HEV which achieves a range of 0 - 39 miles over the Dynamometer Driving Cycle as defined by the "Federal Highway Fuel Economy Test Procedure" (HWFET; 40 CFR Part 600 Subpart B) without the use of the engine, an HEV which enables the vehicle operators to control the engine time and modes of operation either directly or indirectly, an HEV which can be operated solely through the use of the engine, and all other HEVs excluding "Type A" and "Type B" HEVs.

(12) In 1992 and subsequent model years, manufacturers that sell MDVs in excess of the equivalent requirements for LEVs and/or ULEVs shall receive VECs calculated as: {[(No. of LEVs Sold excluding HEVs) + (No. of "Type C HEV" LEVs Sold)] + [(No. of "Type B HEV" LEVs Sold) x (1.1)] + [(No of "Type A HEV" LEVs Sold) x (1.2)] - (Equivalent No. of LEVs Required to be Sold)} + {[(No. of ULEVs Sold excluding HEVs) x (1.4)] + [(No. of "Type C HEV" ULEVs Sold) x (1.4)] + [(No. of "Type B HEV" ULEVs Sold) x (1.5)] + [(No. of "Type A HEV" ULEVs Sold) x (1.7)] - (Equivalent No. of ULEVs Required to be Sold)} + [(No. of ZEVs Sold as MDVs) x (2.0)].

a. Manufacturers that fail to sell the equivalent quantity of MDVs certified to LEV and/or ULEV exhaust emission standards, shall receive "Vehicle-Equivalent Debits" (or "VEDs") equal to the amount of negative VECs determined by the aforementioned equation.
b. Manufacturers shall equalize emission debits within one model year by earning VECs in an amount equal to their previous model-year's total of VEDs, or by submitting a commensurate amount of VECs to the Executive Officer that were earned previously or acquired from another manufacturer.
c. The VECs earned in any given model year shall retain full value through the subsequent model year.
d. The value of any VECs not used to equalize the previous model-year's debit, shall be discounted by 50% at the beginning of second model year after being earned, discounted to 25% of its original value if not depleted by the beginning of the third model year after being earned, and will have no value if not depleted by the beginning of the fourth model year after being earned.
e. Only ZEVs certified as MDVs shall be included in the calculation of VECs.

(13) Manufacturers shall demonstrate compliance with the above standards for NMOG, carbon monoxide, and oxides of nitrogen at 50 degrees F according to the procedure specified in section 11k of the "California Exhaust Emission Standards and Test Procedures for 1988 and Subsequent Model Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles" as adopted May 20, 1987 and last amended ~~July 12, 1991~~ [INSERT], which is incorporated herein by reference. For diesel vehicles, compliance with the particulate standard shall also be demonstrated as specified in section 11k of the foregoing test procedures.

(14) In-use compliance testing shall be limited to vehicles with fewer than 90,000 miles.

(i) and (j) [No Change]

(k) The test procedures for determining compliance with these standards are set forth in "California Exhaust Emission Standards and Test Procedures for 1981 through 1987 Model Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles", adopted by the ~~S~~state ~~B~~board on November 23, 1976, as last amended May 20, 1987, and in "California Exhaust Emission Standards and Test Procedures for 1988 and Subsequent Model Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles", adopted by the state board on May 20, 1987 as last amended ~~July 12, 1991~~ [INSERT], both of which are incorporated herein by reference.

(l) through (o) [No Change]

NOTE: Authority cited: Sections 39600, 39601, 43013, 43018, 43101, 43104, and 43105, Health and Safety Code. Reference: Sections 39002, 39003, 43000, 43009.5, 43013, 43018, 43100, 43101, 43101.5, 43102, 43103, 43104, 43105, 43106, 43107, 43204-43205.5, Health and Safety Code.

APPENDIX C

Modified Text of California Test Procedures
for Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles

PROPOSED

State of California
AIR RESOURCES BOARD

CALIFORNIA EXHAUST EMISSION STANDARDS AND TEST PROCEDURES FOR 1988 AND SUBSEQUENT MODEL PASSENGER CARS, LIGHT-DUTY TRUCKS, AND MEDIUM-DUTY VEHICLES

Adopted: May 20, 1987
Amended: December 20, 1989
Amended: January 22, 1990
Amended: December 26, 1990
Amended: July 12, 1991
Amended: [INSERT]

NOTE: Amendments to the standards and test procedures proposed in this rulemaking are shown in underline to indicate additions to the text and strikeout to indicate deletions.

This document incorporates by reference various sections of the Code of Federal Regulations, some with modifications. In numerous instances, this document states that incorporated federal regulations are to be varied in some way. Where the directions introducing the variation (e.g. "amend paragraph 86.085-1 to read ...") are not entirely underlined the variation is displayed in an underline and strikeout form showing changes from the referenced federal regulation as previously incorporated in the California test procedures. Where the directions introducing the variation are entirely underlined, the federal language which will be modified is underlined and the modifications are displayed in double underline and strikeout to indicate additions to or deletions from the federal language.

The numbering convention employed in this document, in order or priority, is: 1.a.1.i.A. Any references within specific sections in the Code of Federal Regulations are denoted in order of priority as: (a)(1)(i)(A) - the same numbering system employed in the Code of Federal Regulations.

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Appendices

CALIFORNIA EXHAUST EMISSION STANDARDS AND TEST PROCEDURES FOR 1988 AND SUBSEQUENT MODEL PASSENGER CARS, LIGHT-DUTY TRUCKS AND MEDIUM-DUTY VEHICLES

The provisions of Subparts A and B, Part 86, Title 40, Code of Federal Regulations as set forth in Appendix I, to the extent they pertain to Passenger Cars, Light-Duty Trucks and Medium-Duty Vehicles, are hereby adopted as the California Exhaust Emission Standards and Test Procedures for 1988 and Subsequent Model Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles, with the following exceptions and additions.

1. Applicability

a. through g. [No Change]

2. Definitions

a. through Am. [No Change]

An. "Reactivity adjustment factor" means a fraction applied to the mass of NMOG emissions from a vehicle powered by a fuel other than conventional gasoline for the purpose of determining a gasoline-equivalent NMOG emission value ~~level~~. The reactivity adjustment factor is defined as the ozone-forming potential of the exhaust from a vehicle powered by a fuel other than conventional gasoline divided by the ozone-forming potential of conventional gasoline vehicle exhaust.

Ao. [No Change]

3. Standards

The following standards represent the maximum projected exhaust emissions for the useful life of the vehicle.

a. through c. [No Change]

d. The exhaust emission levels from 1992 and subsequent model-year transitional low-emission vehicles, low-emission vehicles, and ultra-low-emission vehicles, including fuel-flexible and dual-fuel vehicles, shall meet all the requirements of g and j with the following additions:

EXHAUST EMISSION STANDARDS
FOR TRANSITIONAL LOW-EMISSION VEHICLES, LOW-EMISSION VEHICLES,
AND ULTRA-LOW-EMISSION VEHICLES IN THE
LIGHT-DUTY AND MEDIUM-DUTY VEHICLE WEIGHT CLASSES (5)(6)
["milligrams per mile" (or "mg/mi")]

Vehicle Type (1)	Vehicle Weight (lbs.)(2)	Durability Vehicle Basis (mi)	Vehicle Emission Category(3)	Formaldehyde (mg/mi)(4)
PC and LDT	All 0-3750	50,000	TLEV	15 (23)
			LEV	15 (15)
			ULEV	8 (12)
		100,000	TLEV	18
			LEV	18
			ULEV	11
LDT	3751-5750	50,000	TLEV	18 (27)
			LEV	18 (18)
			ULEV	9 (14)
		100,000	TLEV	23
			LEV	23
			ULEV	13
MDV	0-3750	50,000	LEV	15 (15)
			ULEV	8 (12)
		120,000	LEV	22
			ULEV	12
MDV	3751-5750	50,000	LEV	18 (18)
			ULEV	9 (14)
		120,000	LEV	27
			ULEV	13
MDV	5751-8500	50,000	LEV	22 (22)
			ULEV	11 (17)
		120,000	LEV	32
			ULEV	16
MDV	8501-10,000	50,000	LEV	28 (28)
			ULEV	14 (21)
		120,000	LEV	40
			ULEV	21
MDV	10,001-14,000	50,000	LEV	36 (36)
			ULEV	18 (27)
		120,000	LEV	52
			ULEV	26

(1) "PC" means passenger cars.
"LDT" means light-duty trucks.
"MDV" means medium-duty vehicles.

(2) For light-duty or medium-duty vehicles, Vehicle Weight shall mean "Loaded Vehicle Weight" (or "LVW") or "Test Weight" (or "TW"), respectively.

(3) "TLEV" means transitional low-emission vehicle.
"LEV" means low-emission vehicle.
"ULEV" means ultra-low-emission vehicle.

(4) The standards in parentheses are intermediate compliance standards for 50,000 miles.

a. For PCs and LDTs from 0-5750 lbs. LVW, including fuel-flexible and dual-fuel vehicles, intermediate compliance standards shall apply to TLEVs through the 1995 model year, and LEVs and ULEVs through the 1998 model year. Compliance with standards beyond 50,000 miles shall be waived through the 1995 model year for TLEVs and through the 1998 model year for LEVs and ULEVs.

b. For MDVs from 0-14,000 lbs. TW, including fuel-flexible and dual-fuel vehicles, intermediate compliance standards shall apply to LEVs and ULEVs through the 1999 model year. Compliance with standards beyond 50,000 miles shall be waived through the 1999 model year for LEVs and ULEVs.

(5) Manufacturers shall demonstrate compliance with the above standards for formaldehyde at 50 degrees F, according to the procedure specified in Section 11k of the "California Exhaust Emission Standards and Test Procedures for 1988 and Subsequent Model Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles, as ~~A~~adopted~~:~~ May 20, 1987, ~~Amended: December 20, 1989, Amended: January 22, 1990, Amended: December 26, 1990, Amended: July 12, 1991~~ and last amended [INSERT]."

(6) In-use compliance testing shall be limited to PCs and LDTs with fewer than 75,000 miles and MDVs with fewer than 90,000 miles.

e. and f. [No Change]

g. The exhaust emissions from new 1992 and subsequent model-year transitional low-emission vehicles, low-emission vehicles, and ultra-low-emission vehicles shall not exceed:

EXHAUST MASS EMISSION STANDARDS
FOR TRANSITIONAL LOW-EMISSION VEHICLES, LOW-EMISSION VEHICLES,
AND ULTRA-LOW-EMISSION VEHICLES IN PASSENGER CAR
AND LIGHT-DUTY TRUCK VEHICLE CLASSES (6)(7)(8)(9)
["grams per mile" (or "g/mi")]

Vehicle Type (1)	Loaded Vehicle Weight (lbs.)	Durability Vehicle Basis (mi)	Vehicle Emission Category (2)	Non-Methane Organic Gases (3)(4)	Carbon Monoxide	Oxides of Nitrogen (5)
PC and LDT	All 0-3750	50,000	TLEV	0.125 (0.188)	3.4 (3.4)	0.4 (0.4)
			LEV	0.075 (0.100)	3.4 (3.4)	0.2 (0.3)
			ULEV	0.040 (0.058)	1.7 (2.6)	0.2 (0.3)
		100,000	TLEV	0.156	4.2	0.6
			LEV	0.090	4.2	0.3
			ULEV	0.055	2.1	0.3
LDT	3751-5750	50,000	TLEV	0.160 (0.238)	4.4 (4.4)	0.7 (0.7)
			LEV	0.100 (0.128)	4.4 (4.4)	0.4 (0.5)
			ULEV	0.050 (0.075)	2.2 (3.3)	0.4 (0.5)
		100,000	TLEV	0.200	5.5	0.9
			LEV	0.130	5.5	0.5
			ULEV	0.070	2.8	0.5

(1) "PC" means passenger cars.
"LDT" means light-duty trucks.

(2) "TLEV" means transitional low-emission vehicle.
"LEV" means low-emission vehicle.
"ULEV" means ultra-low-emission vehicle.

(3) "Non-Methane Organic Gases" (or "NMOG") shall mean the total mass of oxygenated and non-oxygenated hydrocarbon emissions. To demonstrate compliance with an NMOG standard, NMOG emissions shall be measured in accordance with the "California Non-Methane Organic Gas Test Procedures~~.~~", as adopted July 12, 1991. For TLEVs, LEVs, and ULEVs ~~designed~~ certified to operate on any fuel other than conventional gasoline, including fuel-flexible and dual-fuel vehicles when certifying on any fuel other than conventional gasoline, manufacturers shall multiply ~~the measured~~ NMOG mass emission levels at 50,000 and 100,000 miles by the applicable reactivity adjustment factor ~~established for the particular vehicle emission category and fuel combination in the application for certification. The Executive Officer shall determine the reactivity adjustment factor according to the procedure described in Appendix VIII~~ set forth in Section 13 of these test procedures, or established by the Executive Officer pursuant to Appendix VIII of these test procedures. The product of the NMOG mass emission levels and the reactivity adjustment factor shall be compared with the exhaust NMOG mass emission standards established for the particular vehicle emission category and fuel to determine compliance.

a. Each manufacturer shall certify PCs or LDTs to meet the exhaust mass emission standards for TLEVs, LEVs, ULEVs, or to the exhaust emission standards of Sections b, e, or f of these test procedures, or as Zero-Emission Vehicles such that the manufacturer's fleet average NMOG values for California-certified PCs and LDTs from 0-3750 lbs. "Loaded Vehicle Weight" (or "LVW"), and LDTs from 3751-5750 lbs. LVW sold in California are less than or equal to the requirement for the corresponding Model-Year, Vehicle Type, and LVW Class in Section h.

(4) Fuel-flexible and dual-fuel PCs and LDTs from 0-5750 lbs. LVW shall be certified to exhaust mass emission standards for NMOG established for the operation of the vehicle on any available fuel other than conventional gasoline, and conventional gasoline.

a. For TLEVs, LEVs, and ULEVs, when certifying for operation on a fuel other than conventional gasoline, manufacturers shall multiply ~~the measured~~ NMOG mass emission levels by the applicable reactivity adjustment factor ~~in the application for certification at 50,000 and 100,000 miles~~.

b. For PCs and LDTs from 0-3750 lbs. LVW, the applicable exhaust mass emission standard for NMOG when certifying the vehicle for operation on conventional gasoline shall be:

(i) For TLEVs, 0.25 g/mi and 0.31 g/mi for 50,000 and 100,000 miles, respectively.

(ii) For LEVs, 0.125 g/mi and 0.156 g/mi for 50,000 and 100,000 miles, respectively.

(iii) For ULEVs, 0.075 g/mi and 0.090 g/mi for 50,000 and 100,000 miles, respectively.

c. For LDTs from 3751-5750 lbs. LVW, the applicable exhaust mass ~~emission standard for NMOG when certifying the vehicle for~~ operation on conventional gasoline shall be:

(i) For TLEVs, 0.32 g/mi and 0.40 g/mi for 50,000 and 100,000 miles, respectively.

(ii) For LEVs, 0.160 g/mi and 0.200 g/mi for 50,000 and 100,000 miles, respectively.

(iii) For ULEVs, 0.100 g/mi and 0.130 g/mi for 50,000 and 100,000 miles, respectively.

(5) The maximum projected emissions of "Oxides of Nitrogen" (or "NOx") measured on the federal Highway Fuel Economy Test (HWFET; 40 CFR 600 Subpart B) shall not be greater than 1.33 times the applicable light-duty vehicle standards shown in the table. Both the projected emissions and the HWFET standard shall be rounded in accordance with ASTM E29-67 to the nearest 0.1 g/mi before being compared.

(6) The standards in parentheses are intermediate compliance standards for 50,000 miles. For PCs and LDTs from 0-5750 lbs. LVW, including fuel-flexible and dual-fuel vehicles when operating on any available fuel other than conventional gasoline, intermediate compliance standards shall apply to TLEVs through the 1995 model year and to LEVs and ULEVs through the 1998 model year. Compliance with standards beyond 50,000 miles shall be waived through the 1995 model year for TLEVs, and through the 1998 model year for LEVs and ULEVs.

a. For TLEVs, LEVs, and ULEVs designed to operate on any fuel other than conventional gasoline, including fuel-flexible and dual-fuel vehicles when operating on any fuel other than conventional gasoline, ~~measured~~ NMOG mass emission levels shall be multiplied by the reactivity adjustment factor to determine compliance with intermediate compliance standards for NMOG.

b. For fuel-flexible and dual-fuel PCs and LDTs from 0-3750 lbs. LVW, intermediate compliance standards for NMOG emissions at 50,000 miles, when the vehicle is operated on conventional gasoline, shall be 0.32, 0.188 and 0.100 for TLEVs, LEVs and ULEVs, respectively.

c. For fuel-flexible and dual-fuel PCs and LDTs from 3751-5750 lbs. LVW, intermediate compliance standards for NMOG emissions at 50,000 miles, when the vehicle is operated on conventional gasoline, shall be 0.41, 0.238 and 0.128 for TLEVs, LEVs and ULEVs, respectively.

(7) Manufacturers of diesel vehicles shall also certify to particulate standards at 100,000 miles. For all PCs and LDTs from 0-5750 lbs, the particulate standard is 0.08 g/mi, 0.08 g/mi, and 0.04 g/mi for TLEVs, LEVs, and ULEVs, respectively.

(8) Manufacturers shall demonstrate compliance with the above standards for NMOG, carbon monoxide and NOx at 50 degrees F, according to the procedure specified in Section 11k of the California Exhaust Emission Standards and Test Procedures for 1988 and Subsequent Model Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles, as ~~A~~adopted~~:~~ May 20, 1987, ~~Amended December 20, 1989, Amended: January 22, 1990, Amended: December 26, 1990, Amended: July 12, 1991~~ and last amended [INSERT]. For diesel vehicles, compliance with the particulate standard shall also be demonstrated as specified in Section 11k of the foregoing test procedures.

(9) In-use compliance testing shall be limited to vehicles with fewer than 75,000 miles.

h. and i. [No Change]

j. The exhaust emission levels from new 1992 and subsequent model-year medium-duty low-emission vehicles and ultra-low-emission vehicles shall not exceed:

EXHAUST EMISSION STANDARDS FOR LOW-EMISSION VEHICLES
AND ULTRA-LOW-EMISSION VEHICLES IN THE
MEDIUM-DUTY VEHICLE WEIGHT CLASS (8)(9)(10)(11)(12)(13)(14)
[grams per mile (or "g/mi")]

Test Weight (lbs.) (1)	Durability Vehicle Basis (mi)	Vehicle Emission Category (2)	Non-Methane Organic Gases (3)(4)	Carbon Monoxide	Oxides of Nitrogen (5)	Particulates (6)(7)
0-3750	50,000	LEV	0.125 (0.188)	3.4 (3.4)	0.4 (0.4)	n/a
		ULEV	0.075 (0.100)	1.7 (2.6)	0.2 (0.3)	n/a
	120,000	LEV	0.180	5.0	0.6	0.08
		ULEV	0.107	2.5	0.3	0.04
3751-5750	50,000	LEV	0.160 (0.238)	4.4 (4.4)	0.7 (0.7)	n/a
		ULEV	0.100 (0.128)	2.2 (3.3)	0.4 (0.5)	n/a
	120,000	LEV	0.230	6.4	1.0	0.10
		ULEV	0.143	3.2	0.5	0.05
5751-8500	50,000	LEV	0.195 (0.293)	5.0 (5.0)	1.1 (1.1)	n/a
		ULEV	0.117 (0.156)	2.5 (3.8)	0.6 (0.8)	n/a
	120,000	LEV	0.280	7.3	1.5	0.12
		ULEV	0.167	3.7	0.8	0.06
8501-10000	50,000	LEV	0.230 (0.345)	5.5 (5.5)	1.3 (1.3)	n/a
		ULEV	0.138 (0.184)	2.8 (4.2)	0.7 (1.0)	n/a
	120,000	LEV	0.330	8.1	1.8	0.12
		ULEV	0.197	4.1	0.9	0.06
10,001-14000	50,000	LEV	0.300 (0.450)	7.0 (7.0)	2.0 (2.0)	n/a
		ULEV	0.180 (0.240)	3.5 (5.3)	1.0 (1.5)	n/a
	120,000	LEV	0.430	10.3	2.8	0.12
		ULEV	0.257	5.2	1.4	0.06

(1) "Test Weight" (or "TW") shall mean the average of the vehicle's curb weight and gross vehicle weight.

(2) "LEV" means low-emission vehicle.
"ULEV" means ultra-low-emission vehicle.

(3) "Non-Methane Organic Gases" (or "NMOG") shall mean the total mass of oxygenated and non-oxygenated hydrocarbon emissions. To determine compliance with an NMOG standard, NMOG emissions shall be measured in accordance with "California Non-Methane Organic Gas Test Procedures." as adopted July 12, 1991.

a. For LEVs and ULEVs certified ~~designed~~ to operate ~~exclusively~~ on any available fuel other than conventional gasoline, including fuel-flexible or dual-fuel vehicles when certifying on a fuel other than conventional gasoline, manufacturers shall multiply ~~measured~~ NMOG mass emission levels at 50,000 and 120,000 miles by the applicable reactivity adjustment factor set forth in Section

13 of these test procedures or established ~~appropriate to the vehicle emission category and fuel combination in the application for certification. The reactivity adjustment factor shall~~ be ~~determined~~ by the Executive Officer pursuant to ~~according to the procedure described in~~ Appendix VIII of these test procedures.

(4) Fuel-flexible and dual-fuel "Medium-Duty Vehicles" (or "MDVs") from 0-14,000 lbs. TW shall be certified to exhaust mass emission standards for NMOG established for the operation of the vehicle on any fuel other than conventional gasoline, and conventional gasoline.

a. For LEVs and ULEVs, manufacturers shall multiply ~~measured~~ NMOG mass emission levels at 50,000 and 120,000 miles by the ~~appropriate~~ applicable reactivity adjustment factor ~~in the application for certification~~.

b. For MDVs from 0-3750 lbs. TW, the applicable exhaust mass emission standard for NMOG when certifying the vehicle for operation on conventional gasoline shall be:

(i) For LEVs, 0.25 g/mi and 0.36 g/mi for 50,000 and 120,000 miles, respectively.

(ii) For ULEVs, 0.125 g/mi and 0.190 g/mi for 50,000 and 120,000 miles, respectively.

c. For MDVs from 3751-5750 lbs. TW, the applicable exhaust mass emission standard for NMOG when certifying the vehicle for operation on conventional gasoline shall be:

(i) For LEVs, 0.32 g/mi and 0.46 g/mi for 50,000 and 120,000 miles, respectively.

(ii) For ULEVs, 0.160 g/mi and 0.230 g/mi for 50,000 and 120,000 miles, respectively.

d. For MDVs from 5751-8500 lbs. TW, the applicable exhaust mass emission standard for NMOG when certifying the vehicle for operation on conventional gasoline shall be:

(i) For LEVs, 0.39 g/mi and 0.56 g/mi for 50,000 and 120,000 miles, respectively.

(ii) For ULEVs, 0.195 g/mi and 0.280 g/mi for 50,000 and 120,000 miles, respectively.

e. For MDVs from 8501-10,000 lbs. TW, the applicable exhaust mass emission standard for NMOG when certifying the vehicle for operation on conventional gasoline shall be:

(i) For LEVs, 0.46 g/mi and 0.66 g/mi for 50,000 and 120,000 miles, respectively.

(ii) For ULEVs, 0.230 g/mi and 0.330 g/mi for 50,000 and 120,000 miles, respectively.

f. For MDVs from 10,001-14,000 lbs. TW, the applicable exhaust mass emission standard for NMOG when certifying the vehicle for operation on conventional gasoline shall be:

(i) For LEVs, 0.60 g/mi and 0.86 g/mi for 50,000 and 120,000 miles, respectively.

(ii) For ULEVs, 0.300 g/mi and 0.430 g/mi for 50,000 and 120,000 miles, respectively.

(5) The maximum projected emissions of "Oxides of Nitrogen" (or "NOx") measured on the federal Highway Fuel Economy Test (HWFET; 40 CFR Part 600 Subpart B) shall not be greater than 2.00 times the applicable MDV standards shown in the table. Both the projected emissions and the HWFET standard shall be rounded in accordance with ASTM E29-67 to the nearest 0.1 g/mi before being compared.

(6) Particulate standards are only applicable for diesel vehicles and shall be determined on a 120,000 mile basis.

(7) "n/a" means not applicable.

(8) Manufacturers have the option of certifying engines used in incomplete and diesel MDVs to the heavy-duty engine standards and test procedures set forth in Section 1956.8(h), Title 13, California Code of Regulations. Manufacturers certifying incomplete or diesel MDVs to the heavy-duty engine standards and test procedures shall specify in the application for certification an in-use compliance procedure as provided in Section 2139(c), Title 13, California Code of Regulations.

(9) The standards in parenthesis are intermediate compliance standards for 50,000 miles. For MDVs from 0-14,000 lbs. TW, including fuel-flexible and dual-fuel vehicles when operating on any available fuel other than conventional gasoline, intermediate compliance standards shall apply to LEVs and ULEVs through the 1999 model year. Compliance with standards beyond 50,000 miles shall be waived through the 1999 model year for LEVs and ULEVs.

a. For LEVs and ULEVs designed to operate on any available fuel other than conventional gasoline, including fuel-flexible and dual-fuel vehicles when operating on any available fuel other than conventional gasoline, ~~measured~~ NMOG mass emissions levels shall be multiplied by the ~~appropriate~~ applicable reactivity adjustment factor.

b. For fuel-flexible and dual-fuel MDVs from 0-3750 lbs. TW, intermediate compliance standards for NMOG emissions at 50,000 miles, when the vehicle is operated on conventional gasoline, shall be 0.32 and 0.188 for LEVs and ULEVs, respectively.

c. For fuel-flexible and dual-fuel MDVs from 3751-5750 lbs. TW, ~~intermediate compliance standards for NMOG emissions at 50,000~~ miles, when the vehicle is operated on conventional gasoline, shall be 0.41 and 0.238 for LEVs and ULEVs, respectively.

d. For fuel-flexible and dual-fuel MDVs from 5751-8500 lbs. TW, intermediate compliance standards for NMOG emissions at 50,000 miles, when the vehicle is operated on conventional gasoline, shall be 0.49 and 0.293 for LEVs and ULEVs, respectively.

e. For fuel-flexible and dual-fuel MDVs from 8501-10,000 lbs. TW, intermediate compliance standards for NMOG emissions at 50,000 miles, when the vehicle is operated on conventional gasoline, shall be 0.58 and 0.345 for LEVs and ULEVs, respectively.

f. For fuel-flexible and dual-fuel MDVs from 10,001-14,000 lbs. TW, intermediate compliance standards for NMOG emissions at 50,000 miles, when the vehicle is operated on conventional gasoline, shall be 0.75 and 0.450 for LEVs and ULEVs, respectively.

(10) Each manufacturer's MDV fleet shall be defined as the total number of California certified MDVs from 0-14,000 lbs. TW sold in California.

a. Manufacturers of MDVs shall certify an equivalent of 25% of their MDV sales to LEV standards in the 1998 model year, 50% of their MDV sales to LEV standards in the 1999 model year, 75% of their MDV sales to LEV standards in the 2000 model year, 95% of their MDV sales to LEV standards in the 2001 model year, 90% of their MDV sales to LEV standards in the 2002 model year, and 85% of their MDV sales to LEV standards in the 2003 and subsequent model years.

b. Manufacturers of MDVs shall certify an equivalent of 2% of their MDV sales to ULEV standards in each model year from 1998 to 2000, 5% of their MDV sales to ULEV standards in the 2001 model year, 10% of their MDV sales to ULEV standards in the 2002 model year, and 15% of their MDV sales to ULEV standards in the 2003 and subsequent model years.

c. The percentages shall be applied to the manufacturers' total sales of California-certified medium-duty vehicles.

(11) For the purpose of calculating "Vehicle Equivalent Credits" (or "VECs"), the contribution of hybrid electric vehicles (or "HEVs") will be calculated based on the range of the HEV without the use of the engine. For the purpose of calculating the contribution of HEVs to the VECs, the following definitions shall apply.

"Type A HEV" shall mean a hybrid electric vehicle (or "HEV") which achieves a minimum range of 60 miles over the Dynamometer Driving Cycle as defined by the "Federal Highway Fuel Economy Test Procedure" (HWFET; 40 CFR Part 600 Subpart B) without the use of the engine. Usê of vehicle accessories cannot lower the battery-only range below 60 miles. This definition shall also apply to vehicles which have no tailpipe emissions, but use fuel fired heaters, regardless of the operating range of the vehicle.

"Type B HEV" shall mean an HEV which achieves a range of 40 - 59 miles over the Dynamometer Driving Cycle as defined by the "Federal Highway Fuel Economy Test Procedure" (HWFET; 40 CFR Part 600 Subpart B) without the use of the engine Use of vehicle accessories cannot lower the battery-only range below 40 miles.

"Type C HEV" shall mean an HEV which achieves a range of 0 - 39 miles over the Dynamometer Driving Cycle as defined by the "Federal Highway Fuel Economy Test Procedure" (HWFET; 40 CFR Part 600 Subpart B) without the use of an auxiliary engine, an HEV which allows the operator of the vehicle to control the engine time and modes of operation either directly or indirectly, an HEV which can be operated solely through the use of the engine, and all other HEVs excluding "Type A" and "Type B" HEVs.

(12) In 1992 and subsequent model years, manufacturers that sell MDVs in excess of the equivalent requirements for LEVs and/or ULEVs, shall receive "Vehicle-Equivalent Credits" (or "VECs") calculated as: {[(No. of LEVs Sold excluding HEVs) + (No. of "Type C HEV" LEVs Sold)] + [(No. of "Type A HEV" LEVs Sold) x (1.2)] + [(No of "Type B HEVs" LEVs Sold) x (1.1)] - (Equivalent No. of LEVs Required to be Sold)} + {(1.4) x [(No. of ULEVs Sold excluding HEVs) + (No. of "Type C HEV" ULEVs Sold)] + [(1.7) x (No. of "Type A HEV" ULEVs Sold)] + [(1.5) x (No. of "Type B HEV" ULEVs Sold)] - (Equivalent No. of ULEVs Required to be Sold)} + [(2.0) x (No. of ZEVs Sold as MDVs)].

a. Manufacturers which fail to sell the equivalent quantity of MDVs certified to LEV and/or ULEV exhaust emission standards, shall receive "Vehicle-Equivalent Debits" (or "VEDs") equal to the amount of negative VECs determined by the aforementioned equation.

b. Manufacturers shall equalize emission debits within one model year by earning VECs in an amount equal to their previous model-year's total of VEDs, or by submitting a commensurate amount of VECs to the Executive Officer that were earned previously or acquired from another manufacturer.

c. The VECs earned in any given model year shall retain full value through the subsequent model year.

d. The value of any VECs not used to equalize the previous model-year's debit, shall be discounted by 50% at the beginning of second model year after being earned, discounted to 25% of its original value if not used by the beginning of the third model year after being earned, and will have no value if not used by the beginning of the fourth model year after being earned.

e. Only ZEVs certified as MDVs can be included in the calculation of VECs.

(13) Manufacturers shall demonstrate compliance with the above standards for NMOG, carbon monoxide, and oxides of nitrogen at 50 degrees F, according to the procedure specified in Section 11k of the "California Exhaust Emission Standards and Test Procedures for 1988 and Subsequent Model Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles as ~~,~~ ~~A~~adopted~~:~~ May 20, 1987, ~~Amended: December 20, 1989, Amended: January 22, 1990, Amended: December 26, 1990, Amended: July 12, 1991~~ and last amended: [INSERT]". For diesel vehicles, compliance with the particulate standard shall also be demonstrated as specified in Section 11k of the foregoing test procedures.

(14) In-use compliance testing shall be limited to vehicles with fewer than 90,000 miles.

4. Initial Requirements

[No Change]

5. Maintenance Requirements

[No Change]

6. Demonstrating Compliance

[No Change]

7. Small-Volume Manufacturer's Certification Procedures

[No Change]

8. Alternative Procedures for Notification of Additions and Changes

[No Change]

9. Test Requirements

[No Change]

10. Optional 100,000 Mile Certification Procedure

[No Change]

11. Additional Requirements

[No Change]

12. Identification of New Clean Fuels to be Used in Certification Testing

[No Change]

13. Reactivity Adjustment Factors

For the purpose of complying with the NMOG exhaust emission standards in Section 1960.1, Title 13, California Code of Regulations, the mass of NMOG emissions from a vehicle certified to operate on a fuel other than conventional gasoline, including fuel-flexible and dual-fuel vehicles when operated on a fuel other than conventional gasoline, shall be multiplied by the reactivity adjustment factor applicable to the vehicle emission control technology category and fuel. The product of the NMOG mass emission value and the reactivity adjustment factor shall be compared to the NMOG exhaust emission standards to determine compliance with the standards.

(a) The following reactivity adjustment factors have been established pursuant to the criteria in Appendix VIII of these test procedures:

(1) Passenger cars and light-duty trucks 0-5750 lbs. LVW

Vehicle Emission Control Technology Category	Fuel	Reactivity Adjustment Factor
1993 and subsequent model-year TLEVs	85% methanol, 15% gasoline blends	0.36
1993 and subsequent model-year TLEVs	compressed natural gas	0.18
1993 and subsequent model-year TLEVs	liquified petroleum gas	0.50

(b) The Executive Officer may establish by executive order new reactivity adjustment factors pursuant to Appendix VIII of these test procedures in addition to those listed in Section 13.(a). The Executive Officer shall notify manufacturers in writing of the new reactivity adjustment factors within 30 days of their establishment.

(c) The Executive Officer may revise any reactivity adjustment factor listed in Section 13.(a) or established by the Executive Officer pursuant to Appendix VIII of these test procedures if he or she determines that the revised reactivity adjustment factor is more representative of the ozone-forming potential of vehicle NMOG emissions based on the best available scientific knowledge and sound engineering judgement. The Executive Officer shall notify manufacturers in writing of any such reactivity adjustment factor at least 3 years prior to January 1 of the calendar year which has the same numerical designation as the model year for which the revised reactivity adjustment factor first become effective. However, manufacturers may use the revised reactivity adjustment factor in certifying any new engine family whose certification application is submitted following such notification, if they so choose. Manufacturers may also continue to use the original reactivity adjustment factor for any existing engine family previously certified with that reactivity adjustment factor until a new durability data vehicle is tested for that engine family.

(d) Manufacturers may request the use of a reactivity adjustment factor unique to a specific vehicle emission control technology category and fuel. The Executive Officer shall approve such requests in accordance with the conditions and procedures of Appendix VIII of these test procedures. For the purpose of calculating the reactivity adjustment factor as specified in Appendix VIII, the 'g ozone potential per g NMOG' value for the vehicle emission control technology category and fuel system for which the manufacturer is requesting the use of an unique reactivity adjustment factor shall be divided by the 'g ozone potential per g NMOG' value for a conventional gasoline-fueled vehicle established for the vehicle emission control technology category. The following 'g ozone potential per g NMOG' values for conventional gasoline-fueled vehicle emission control technology categories have been established:

(1) Passenger cars and light-duty trucks 0-5750 lbs. LVW

Vehicle Emission Control Technology Category	'g ozone potential per g NMOG' for conventional gasoline
All TLEVs	3.44

Appendix I through VII [No Change]

APPENDIX VIII

Procedure for Determining Vehicle Emission Control Technology Category/Fuel Reactivity Adjustment Factors

The following procedure shall be used by the Executive Officer to establish ~~determine~~ the reactivity adjustment factor for exhaust emissions of non-methane organic gases (NMOG), for the purpose of certifying a vehicle of specific emission control technology category and fuel for sale in California. The NMOG emissions from Transitional Low-Emission Vehicles (TLEVs), Low-Emission Vehicles (LEVs), and Ultra-Low-Emission Vehicles (ULEVs) designed to operate on any available fuel other than conventional gasoline, including fuel-flexible and dual-fuel vehicles when operating on any available fuel other than conventional gasoline, shall be numerically-adjusted to establish a NMOG exhaust mass emission value ~~level~~ equivalent to the NMOG exhaust mass emissions from a conventional gasoline-fueled vehicles of the same vehicle emission control technology category.

(1) The Executive Officer shall determine the representative speciated NMOG exhaust emission profile for all light- and medium-duty conventional gasoline-fueled TLEVs, LEVs, and ULEVs according to the following conditions.
   a. All testing will be conducted using a specified gasoline blend representative of commercial gasoline.
   b. The speciated NMOG profile shall be calculated from a statistically valid number of TLEVs, LEVs, and ULEVs.
   c. The speciated NMOG profile shall identify and quantify as many constituents as possible, such that a minimum of 95% of the total g/mile of NMOG emissions measured is accounted for, and shall be provided in units of g/mile or mg/mile.
   d. The speciated NMOG profile shall include at a minimum, the g/mile NMOG emission values of all oxygenated organic gases containing five or fewer carbon atoms (i.e., aldehydes, ketones, alcohols, ethers, etc.), and all known alkanes, alkenes, alkynes and aromatics containing twelve or fewer carbon atoms.

(2) The 'g ozone potential per mile' of each NMOG identified in the speciated profile shall be determined by multiplying the 'g/mile NMOG' emission value of the constituent NMOG by its maximum incremental reactivity given in step (9).

(3) The 'total g ozone potential per mile' of NMOG exhaust emissions from the vehicle/fuel system shall be the sum of all the constituent NMOG 'g ozone potential per mile' values calculated in step (2).

(4) The 'g ozone potential per g NMOG' for the vehicle/fuel system shall be determined by dividing the 'total g ozone potential per mile' value calculated in step (3) by the 'total g/mile of NMOG emissions'.

(5) For light- and medium-duty candidate vehicle/fuel systems not powered by conventional gasoline, the Executive Officer shall establish 'reactivity adjustment factors' calculated from exhaust emission profiles derived by the same conditions specified in parts b, c, and d of step (1).

(6) The 'g ozone potential per g NMOG' for candidate vehicle/fuel systems not powered by conventional gasoline shall be determined according to steps (2), (3), and (4).

(7) The candidate vehicle/fuel 'reactivity adjustment factor' shall be determined by dividing the 'g ozone potential per g NMOG' calculated in step (6) by the 'g ozone potential per g NMOG' value for the vehicle in the same emission control technology category operated on the specified gasoline blend.

(8) The Executive Officer shall assign a factor unique to a specific vehicle/fuel system at the request of a vehicle manufacturer provided that:

a. The manufacturer submits a speciated NMOG exhaust emission profile to the Executive Officer averaged from emission tests of a statistically valid number of different vehicles utilizing the same emission control technology and fuel. Emission levels of each constituent NMOG shall be measured according to the "California Non-Methane Organic Gas Test Procedures" as adopted July 12, 1991.

b. The 'reactivity adjustment factor' calculated from the 'g ozone potential per g NMOG' value determined from the aforementioned speciated profile differs from the 'reactivity adjustment factor' calculated by the Executive Officer for vehicles of the same or similar emission control technology and fuel by 25% or more.

c. The speciated profile is provided to the Executive Officer two years prior to certification of the vehicle.

(9) Table of ~~(draft)~~ maximum incremental reactivities to be used in step (2):

ALKANES

Normal Alkanes

NMOG Constituent	Maximum Incremental Reactivity (g O_3/g NMOG)
Methane	0.01
Ethane	0.26
Propane	0.48
n-Butane	1.02
n-Pentane	1.03
n-Hexane	0.98
n-Heptane	0.81
n-Octane	0.61
n-Nonane	0.54
n-Decane	0.47
n-Undecane	0.42
n-Dodecane	0.38

Branched Alkanes

NMOG Constituent	Maximum Incremental Reactivity (g O_3/g NMOG)
2-Methylpropane	1.21
2,2-Dimethylpropane	0.37
2-Methylbutane	1.38
2,2-Dimethylbutane	0.82
2,3-Dimethylbutane	1.07
2-Methylpentane	1.53
3-Methylpentane	1.52
2,2,3-Trimethylbutane	1.32
2,2-Dimethylpentane	1.40
2,3-Dimethylpentane	1.51
2,4-Dimethylpentane	1.78
3,3-Dimethylpentane	0.71
2-Methylhexane	1.08
3-Methylhexane	1.40
2,2,4-Trimethylpentane	0.87
2,3,4-Trimethylpentane	1.60

Branched Alkanes

NMOG Constituent	Maximum Incremental Reactivity (g O_3/g NMOG)
2,2-Dimethylhexane	1.20
2,3-Dimethylhexane	1.31
2,4-Dimethylhexane	1.50
2,5-Dimethylhexane	1.63
3,3-Dimethylhexane	1.20
2-Methylheptane	0.96
3-Methylheptane	0.99
4-Methylheptane	1.20
2,4-Dimethylheptane	1.33
2,2,5-Trimethylhexane	0.97
Other Branched C9H20 Alkanes	1.13
Branched C10H22 Alkanes	1.01

Cyclo Alkanes

NMOG Constituent	Maximum Incremental Reactivity (g O_3/g NMOG)
Cyclopentane	2.37
Methylcyclopentane	2.82
Cyclohexane	1.28
Dimethylcyclopentanes	2.54
Methylcyclohexane	1.84
Ethylcyclopentane	2.31
1c,2t-3-Trimethylcyclopentane	1.94
Dimethylcyclohexanes	1.94
Ethylcyclohexane	1.94

NMOG Constituent	Maximum Incremental Reactivity (g O_3/g NMOG)
ALKENES	
Ethene	7.28
Propene	9.39
1-Butene	8.90
2-Butenes	9.93
2-Methylpropene	5.29
1-Pentene	6.22
2-Pentenes	8.79
2-Methyl-1-Butene	4.89
3-Methyl-1-Butene	6.22
2-Methyl-2-Butene	6.40
1-Hexene	4.41
2-Hexenes	6.67
3-Hexenes	6.67
Methyl-1-Pentenes	4.41
Methyl-2-Pentenes	6.67
3,3-Dimethyl-1-Butene	4.41
1-Heptene	3.48
2-Heptenes	5.52
3-Heptenes	5.52
3-Ethyl-2-Pentenes	5.52
2,3-Dimethyl-2-Pentene	5.52
3-Methyl-1-Hexene	3.48
2-Methyl-2-Hexenes	5.52
3-Methyl-3-Hexenes	5.52
1-Octene	2.68
2-Octenes	5.27
3-Octenes	5.27
4-Octenes	5.27
2,4,4-Trimethyl-1-Pentene	2.68
1-Nonene	2.22

NMOG Constituent	Maximum Incremental Reactivity (g O_3/g NMOG)
Propadiene	7.28
1,3-Butadiene	10.88
2-Methyl-1,3-Butadiene	9.07
Cyclopentadiene	7.65
Cyclopentene	7.65
3-Methylcyclopentene	5.65
Cyclohexene	5.65
ALKYNES	
Ethyne	0.51
Propyne	4.10
1-Butyne	9.23
2-Butyne	9.23

NMOG Constituent	Maximum Incremental Reactivity ($g\ O_3/g$ NMOG)
AROMATIC HYDROCARBONS	
Benzene	0.42
Toluene	2.72
Ethylbenzene	2.90
o-Xylene	6.68
m&p-Xylenes	8.15
n-Propylbenzene	2.27
i-Propylbenzene	2.41
Methylethylbenzenes	7.20
1,2,3-Trimethylbenzene	8.61
1,2,4-Trimethylbenzene	8.59
1,3,5-Trimethylbenzene	10.11
Indan (C9H10)	1.04
n-Butylbenzene	1.87
s-Butylbenzene	2.04
Diethylbenzenes	6.44
Tetramethylbenzenes	9.05
1-Methyl-4-Isobutylbenzene	5.83
Styrene	2.20
Napthalene	1.16
AROMATIC OXYGENATES	
Benzaldehyde	-0.56
p-Tolualdehyde	-0.56

NMOG Constituent	Maximum Incremental Reactivity ($g\ O_3/g$ NMOG)
OXYGENATES	
Alcohols	
Methanol	0.56
Ethanol	1.33
Aldehydes	
Formaldehyde	7.14
Acetaldehyde	5.51
Propionaldyde	6.53
Acrolein	6.76
n-Butyraldehyde	5.26
Crotonaldehyde	5.41
Pentanaldehyde	4.40
Hexanaldehyde	3.79
Ethers	
Methyl t-Butyl Ether	0.62
Ethyl t-Butyl Ether	1.98
Ketones	
Acetone	0.56
Butanone	1.18

NMOG Constituent	Maximum Incremental Reactivity ($g\ O_3/g$ NMOG)
Alkanes	
Methane	0.0102
Ethane	0.147
Propane	0.33
n-Butane	0.64
n-Pentane	0.64
n-Hexane	0.61
n-Heptane	0.48
n-Octane	0.41
n-Nonane	0.29
n-Decane	0.25
n-Undecane	0.21
n-Dodecane	0.19
n-Tridecane	0.17
n-Tetradecane	0.16
n-Pentadecane	0.144
Isobutane	0.85
Lumped C4-C5 Alkanes	0.78
Branched C5 Alkanes	0.88
Iso-Pentane	0.88
Neopentane	0.19
2-Methylpentane	0.91
3-Methylpentane	0.95
Branched C6 Alkanes	0.91
2,3-Dimethyl Butane	0.74
2,2-Dimethyl Butane	0.41
Lumped C6+ Alkanes	0.70
2,4-Dimethyl Pentane	1.07
3-Methyl Hexane	0.85
4-Methyl Hexane	0.85

NMOG Constituent	Maximum Incremental Reactivity ($g\ O_3/g$ NMOG)
Branched C7 Alkanes	0.85
2,3-Dimethyl Pentane	0.96
Iso-Octane	0.70
4-Methyl Heptane	0.72
Branched C8 Alkanes	0.72
Branched C9 Alkanes	0.68
4-Ethyl Heptane	0.68
Branched C10 Alkanes	0.60
4-Propyl Heptane	0.60
Branched C11 Alkanes	0.72
Branched C12 Alkanes	0.75
Branched C13 Alkanes	0.57
Branched C14 Alkanes	0.44
Branched C15 Alkanes	0.41
Cyclopentane	1.6
Methylcyclopentane	1.7
C6 Cycloalkanes	0.84
Cyclohexane	0.84
C7 Cycloalkanes	1.17
Methylcyclohexane	1.17
Ethylcyclohexane	1.36
C8 Cycloalkanes	1.36
C9 Cycloalkanes	1.6
C10 Cycloalkanes	1.31
C11 Cycloalkanes	1.23
C12 Cycloalkanes	1.20
C13 Cycloalkanes	0.94
C14 Cycloalkanes	0.88
C15 Cycloalkanes	0.85

NMOG Constituent	Maximum Incremental Reactivity (g O_3/g NMOG)
Alkenes	
Ethene	6.3
Propene	6.6
1-Butene	6.1
1-Pentene	4.2
3-Methyl-1-Butene	4.2
1-Hexene	3.0
C6 Terminal Alkenes	3.0
C7 Terminal Alkenes	2.4
C8 Terminal Alkenes	1.9
C9 Terminal Alkenes	1.6
C10 Terminal Alkenes	1.32
C11 Terminal Alkenes	1.15
C12 Terminal Alkenes	1.03
C13 Terminal Alkenes	0.93
C14 Terminal Alkenes	0.86
C15 Terminal Alkenes	0.80
Isobutene	4.2
2-Methyl-1-Butene	3.7
trans-2-Butene	7.3
cis-2-Butene	7.3
2-Methyl-2-Butene	5.0
C5 Internal Alkenes	6.2
2,3-Dimethyl-2-Butene	3.7
C6 Internal Alkenes	5.3
C7 Internal Alkenes	4.4
C8 Internal Alkenes	3.6
C9 Internal Alkenes	3.2
C10 Internal Alkenes	2.8
C11 Internal Alkenes	2.5
C12 Internal Alkenes	2.3
C13 Internal Alkenes	2.1
C14 Internal Alkenes	1.9
C15 Internal Alkenes	1.8
1,3-Butadiene	7.7
Isoprene	6.5
Cyclopentene	4.0
Cyclohexane	3.3
a-Pinene	1.9
b-Pinene	1.9

NMOG Constituent	Maximum Incremental Reactivity (g O_3/g NMOG
1,3,5-Trimethyl Benzene	7.5
1,2,3-Trimethyl Benzene	7.4
1,2,4-Trimethyl Benzene	7.4
C10 Trialkyl Benzenes	6.7
C11 Trialkyl Benzenes	6.1
C12 Trialkyl Benzenes	5.6
Tetralin	0.73
Naphthalene	0.87
Methyl Naphthalene	2.4
2,3-Dimethyl Naphthalene	3.7
Alkynes	
Acetylene	0.37
Alcohols	
Methanol	0.40
Ethanol	0.79
n-Propyl Alcohol	1.33
Isopropyl Alcohol	0.37
Isobutyl Alcohol	0.72
n-Butyl Alcohol	1.6
t-Butyl Alcohol	0.29
Ethylene Glycol	1.13
Propylene Glycol	0.92
Aldehydes	
Formaldehyde	6.2
Acetaldehyde	3.8
Propionaldehyde	4.6
Ketones	
Acetone	0.39
C4 Ketones	0.76
Aromatic Oxygenates	
Benzaldehyde	- 0.54
Phenol	0.79
Cresols	1.6

NMOG Constituent	Maximum Incremental Reactivity (g O_3 /g NMOG)
Aromatic Hydrocarbons	
Benzene	0.28
Toluene	1.9
Ethyl Benzene	1.9
n-Propyl Benzene	1.44
Isopropyl Benzene	1.5
s-Butyl Benzene	1.29
C10 Monoalkyl Benzenes	1.28
C11 Monoalkyl Benzenes	1.16
C12 Monoalkyl Benzenes	1.06
m-Xylene	6.0
o-Xylene	5.2
p-Xylene	5.2
C9 Dialkyl Benzenes	5.3
C10 Dialkyl Benzenes	4.8
C11 Dialkyl Benzenes	4.3
C12 Dialkyl Benzenes	3.9

NMOG Constituent	Maximum Incremental Reactivity (g O_3 /g NMOG)
Ethers	
Methyl t-Butyl Ether	0.47
Ethyl t-Butyl Ether	1.33

State of California
AIR RESOURCES BOARD

Notice of Public Availability of Modified Text
and Supporting Documents and Information

PUBLIC HEARING TO CONSIDER AMENDMENTS TO REGULATIONS REGARDING THE CALCULATION AND USE OF REACTIVITY ADJUSTMENT FACTORS FOR LOW-EMISSION VEHICLES AND THE ADOPTION OF INITIAL REACTIVITY ADJUSTMENT FACTORS FOR PASSENGER CARS AND LIGHT-DUTY TRUCKS CERTIFYING TO TRANSITIONAL LOW-EMISSION VEHICLE EXHAUST EMISSION STANDARDS

Public Hearing Date: November 14, 1991
Public Availability Date: April 21, 1992
Deadline for Public Comment: May 6, 1992

At a public hearing held November 14, 1991, the Air Resources Board ("ARB" or "Board") considered amendments to regulations concerning the calculation and use of reactivity adjustment factors ("RAFs") and the adoption of initial RAFs for transitional low-emission vehicles ("TLEVs"). The amendments affect section 1960.1, Title 13, California Code of Regulations ("CCR") and the "California Exhaust Emission Standards and Test Procedures for 1988 and Subsequent Model Passenger Cars, Light-Duty Trucks and Medium-Duty Vehicles," (hereafter "LD/MD Test Procedures") which is incorporated by reference in section 1960.1. The proposed regulatory action is described in detail in the Staff Report and Technical Support Document released to the public on September 27, 1991.

At the hearing, the Board approved the regulations proposed by the staff with various modifications, some of which were suggested by the staff at the hearing. The modifications made to the original staff proposal include:

- Establish a baseline "gram ozone per gram NMOG" value of 3.42 for conventional gasoline TLEVs

- Delete the originally proposed RAFs for compressed natural gas ("CNG") and liquified petroleum gas ("LPG") TLEVs

- Establish a RAF of 0.41 for methanol-fueled TLEVs

- Numerically adjust RAFs for methanol and LPG vehicles upward by 10 percent to account for potential protocol or modeling biases

- Include a procedure for manufacturers to establish RAFs for individual engine families

- Delete the requirement that a 25 percent difference exist between ARB and manufacturer-derived RAFs

- Update the maximum incremental reactivity scale for use in calculating the ozone-forming potential of exhaust emissions

Appended as Attachment I is a copy of Board Resolution 91-53, which sets forth the Board's action. Appended as Attachment II-A is a detailed summary of the proposed modifications. Attachments II-B and II-C contain the modified regulatory text of section 1960.1, Title 13, CCR and the LD/MD Test Procedures, respectively. In preparing the modified text, an informal public workshop was conducted by the staff on February 3, 1992. Except for a revision to the statistical criteria for manufacturer-derived RAFs and various minor clarifying amendments, the proposed modified text is essentially unchanged from the draft version discussed at the workshop.

In addition, the staff has added to the rulemaking record the following documents and information:

- B.E. Croes, "Development and Evaluation of Ozone Reactivity Scale for Low-Emission Vehicles and Clean Fuels Regulations", California Air Resources Board Research Division, April 2, 1992

- Speciated emission data from testing of CNG vehicles

Copies of these materials are included in Attachment III, which is appended to this notice.

In accordance with section 11346.8 of the Government Code, Resolution 91-53 directs the Executive Officer to adopt section 1960.1 and the LD/MD Test Procedures, as approved, after making the modified regulatory language and additional supporting documents and information available to the public for comment for a period of at least 15 days, provided that the Executive Officer shall consider such written comments as may be submitted during this period, shall make such modifications as may be appropriate in light of the comments received, and shall present the regulations to the Board for further consideration if he determines that this is warranted.

Written comments must be submitted to the Board Secretary, Air Resources Board, P.O. Box 2815, Sacramento, California 95812, no later than May 6, 1992 for consideration by the Executive Officer prior to final action. Only comments relating to the modifications or supporting documents and information described in this notice will be considered by the Executive Officer. As noted in the announcement of the informal public workshop conducted February 3, 1992, comments made at the workshop are not part of the record of this rulemaking.

Sincerely,

for K. D. Drachand, Chief
Mobile Source Division

Attachments

ATTACHMENT I

Board Resolution 91-53

State of California
AIR RESOURCES BOARD

Resolution 91-53

November 14, 1991

Agenda Item No.: 91-10-2

WHEREAS, sections 39600 and 39601 of the Health and Safety Code authorize the Air Resources Board (the "Board") to adopt standards, rules and regulations and to do such acts as may be necessary for the proper execution of the powers and duties granted to and imposed upon the Board by law;

WHEREAS, in section 43000 of the Health and Safety Code the Legislature has declared that the emission of air contaminants from motor vehicles is the primary cause of air pollution in many parts of the state;

WHEREAS, section 43018(a) of the Health and Safety Code, enacted by the California Clean Air Act of 1988, directs the Board to endeavor to achieve the maximum degree of emission reduction possible from vehicular and other mobile sources in order to accomplish the attainment of the state ambient air quality standards at the earliest practicable date;

WHEREAS, section 43018(b) of the Health and Safety Code directs the Board no later than January 1, 1992 to take whatever actions are necessary, cost-effective, and technologically feasible in order to achieve, by December 31, 2000, a reduction of reactive organic gases ("ROG") of at least 55 percent and a 15 percent reduction in the emissions of oxides of nitrogen ("NOx") from motor vehicles, and the maximum feasible reductions in particulates ("PM"), carbon monoxide ("CO"), and toxic air contaminants from vehicular sources;

WHEREAS, section 43018(c) of the Health and Safety Code provides that in carrying out section 43018, the Board shall adopt standards and regulations which will result in the most cost-effective combination of control measures on all classes of motor vehicles and motor vehicle fuel, including but not limited to reductions in motor vehicle exhaust and evaporative emissions, reductions in in-use vehicular emissions through durability and performance improvements, requiring the purchase of low-emission vehicles by state fleet operators, and specification of vehicular fuel composition;

WHEREAS, section 43101 of the Health and Safety Code directs the Board to adopt and implement emission standards for new motor vehicles which the Board has found to be necessary and technologically feasible to carry out the purposes of Division 26 of the Health and Safety Code;

WHEREAS, section 43104 of the Health and Safety Code directs the Board to adopt test procedures for determining whether new motor vehicles are in compliance with the emission standards established by the Board;

WHEREAS, following a hearing on September 27-28, 1990, the Board in Resolution 90-58 approved the Low-Emission Vehicles and Clean Fuels regulations which require the production of low-emission light- and medium-duty vehicles and require that alternative fuels used by these vehicles be made reasonably available to motorists; at the direction of the Board these regulations were subsequently adopted by the Executive Officer in Executive Order G-604;

WHEREAS, the Low-Emission Vehicles and Clean Fuels regulations establish emission standards for low-emission vehicles which require the application of reactivity adjustment factors ("RAFs") to the non-methane organic gas exhaust mass emissions from transitional low-emission vehicles ("TLEVs"), low-emission vehicles, and ultra-low-emission vehicles operating on fuels other than conventional gasoline, to determine compliance with applicable emission standards;

WHEREAS, the Low-Emission Vehicles and Clean Fuels regulations include a protocol under which the Executive Officer can establish RAFs for representative vehicle/fuel combinations by applying a reactivity scale based on the maximum incremental reactivity ("MIR") of individual hydrocarbon species to hydrocarbon exhaust speciation profiles;

WHEREAS, the portions of the Low-Emission Vehicles and Clean Fuels regulations pertaining to low-emission vehicle standards, the establishment and application of RAFs, and the certification of new motor vehicles to the low-emission standards are contained in Title 13, California Code of Regulations, section 1960.1 and the California Exhaust Emission Standards and Test Procedures for 1988 and Subsequent Model Passenger Cars, Light-Duty Trucks and Medium-Duty Vehicles (the "Standards and Test Procedures"), which is incorporated by reference in section 1960.1;

WHEREAS, the staff initially proposed regulatory amendments which would establish RAFs for TLEVs which operate on methanol ("M85"), compressed natural gas ("CNG"), and liquefied petroleum gas ("LPG"), to be used to determine compliance with the TLEV exhaust emission standards;

WHEREAS, the staff has also proposed regulatory amendments which would make various changes regarding the calculation and use of RAFs for low-emission vehicles; these changes include revisions to the MIRs of individual hydrocarbon species, revisions to the treatment and applicability of updated RAFs, and identification of a value for the gram ozone potential per gram non-methane organic gases for light-duty TLEVs operating on conventional gasoline;

WHEREAS, the proposal would be effected by amendments to Title 13, California Code of Regulations, section 1960.1, and the incorporated Standards and Test Procedures, as set forth in Attachments A and B hereto;

WHEREAS, the California Environmental Quality Act and Board regulations require that an action not be adopted as proposed where it will have significant adverse environmental impacts if feasible alternatives or mitigation measures are available which would substantially reduce or avoid such impacts;

WHEREAS, the Board has considered the impact of the proposed regulations on the economy of the state;

WHEREAS, a public hearing and other administrative proceedings have been held in accordance with the provisions of Chapter 3.5 (commencing with section 11340), Part 1, Division 3, Title 2 of the Government Code; and

WHEREAS, the Board finds that:

The RAF approved herein for light-duty TLEVs operating on M85 is appropriately based on application of the criteria in the regulatory protocol for setting RAFs as modified herein;

There are insufficient data available to establish technically sound RAFs for light-duty TLEVs operating on CNG or LPG at this time;

The revisions approved herein to the identification of the MIRs of individual hydrocarbon species in the Standards and Test Procedures appropriately reflect the peer review and compilation of new data that has occurred over the past year;

The regulatory amendments approved herein pertaining to the use of RAFs are necessary and appropriate to clarify the regulatory requirements and to specify how updated RAFs are to be used;

Use of an MIR scale in determining RAFs is appropriate because the scale reflects the conditions where hydrocarbon control has the greatest impact on ozone formation; the ten percent correction factor included in the modifications to the original proposal will eliminate any overcrediting of reactivity benefits for M85 and LPG in high ozone episodes due to application of the scale, and will provide a margin of safety against such overcrediting during moderate ozone episodes;

The modifications to the original proposal pertaining to the assignment of a RAF for a specific engine family at the request of a manufacturer is necessary to assure that appropriate RAFs will be available on a timely basis for all vehicles; the modifications include additional elements which will minimize the possibility that the RAF will not accurately reflect the emissions of in-use higher mileage vehicles;

The amendments approved herein should contribute to a more cost-effective means of reducing motor vehicle emissions by adjusting emission standards to reflect the ozone-forming potential of clean fuel/vehicle systems;

The amendments approved herein will not have any significant adverse environmental impacts.

NOW, THEREFORE, BE IT RESOLVED that the Board hereby approves the amendments to section 1960.1, Title 13, California Code of Regulations, and the incorporated California Exhaust Emission Standards and Test Procedures for 1988 and Subsequent Model Passenger Cars, Light-Duty Trucks and Medium-Duty Vehicles, as set forth in Attachments A and B hereto, with the modifications described in Attachment C hereto, and with a further modification to eliminate the requirement that a vehicle manufacturer wishing to have a unique RAF assigned to a specific vehicle/fuel system must submit a speciated profile two years prior to certification of the vehicle.

BE IT FURTHER RESOLVED that the Board directs the Executive Officer (1) to incorporate into the approved amendments the modifications described in Attachment C hereto, with such other conforming modifications as may be appropriate; (2) to conduct an informal workshop on the modified language if warranted; and (3) to adopt the amendments approved herein, after making the modified regulatory language available for public comment for a period of 15 days, provided that the Executive Officer shall consider such written comments regarding the modifications as may be submitted during this period, shall make additional modifications if deemed appropriate after consideration of supplemental comments received, and shall present the regulations to the Board for further consideration if he determines that this is warranted.

BE IT FURTHER RESOLVED that the Board hereby determines that the amendments approved herein will not cause California motor vehicle emission standards, in the aggregate, to be less protective of public health and welfare than applicable federal standards.

BE IT FURTHER RESOLVED that the Board hereby finds that separate California emission standards and test procedures are necessary to meet compelling and extraordinary conditions.

BE IT FURTHER RESOLVED that the Board finds that the California emission standards and test procedures as amended herein will not cause the California requirements to be inconsistent with section 202(a) of the Clean

Air Act and raise no new issues affecting previous waiver determinations of the Administrator of the Environmental Protection Agency pursuant to section 209(b) of the Clean Air Act.

BE IT FURTHER RESOLVED that the Executive Officer shall, upon adoption, forward the amendments to the Environmental Protection Agency with a request for a waiver or confirmation that the amendments are within the scope of an existing waiver of federal preemption pursuant to section 209(b) of the Clean Air Act, as appropriate.

BE IT FURTHER RESOLVED, that the Board directs the Executive Officer to identify and propose correction factors for RAFs for fuels other than M85 and LPG to eliminate potential overcrediting of reactivity benefits when adequate data become available.

I hereby certify that the above is a true and correct copy of Resolution 91-53, as adopted by the Air Resources Board.

Pat Hutchens, Board Secretary

Resolution 91-53

November 14, 1991

Identification of Attachments to the Resolution

Attachment A: Amendments to Title 13, California Code of Regulations, section 1960.1, as set forth in Appendix B to the Staff Report.

Attachment B: Amendments to the California Exhaust Emission Standards and Test Procedures for 1988 and Subsequent Model Passenger Cars, Light-Duty Trucks and Medium-Duty Vehicles, as set forth in Appendix C to the Staff Report.

Attachment C: Staff's Suggested Changes to the Proposed RAF Amendments (Distributed at the hearing on November 14, 1991).

PUBLIC HEARING ON REACTIVITY ADJUSTMENT FACTORS

NOVEMBER 14, 1991

STAFF'S SUGGESTED CHANGES TO THE PROPOSAL

The staff report and technical support document on the proposed regulations regarding the calculation and use of reactivity adjustment factors for low-emission vehicles and the adoption of initial reactivity adjustment factors for transitional low-emission vehicles were released to the public on September 27, 1991. Based on further analyses conducted by the Air Resources Board staff and comments received on these documents and the regulations contained therein, the staff is recommending that the following modifications to the proposed regulations be considered by the Air Resources Board at this hearing.

1. Withdrawal of Proposed RAFs for CNG and LPG

Upon further evaluation of the CNG and LPG data, the staff recommends that reactivity adjustment factors (RAFs) for these fuels not be adopted at this time. For CNG, the staff has conducted additional exhaust emission testing after the release of the staff report. Because of the high uncertainty of the new CNG data, the staff cannot propose a RAF for CNG with any confidence. Because the LPG database consists of only two vehicles, the staff also recommends that the Board not adopt a RAF for LPG at this time. Therefore, the staff recommends that no RAFs be adopted for LPG and CNG at this hearing.

2. Engine Family Specific RAFs

Section Affected: "California Exhaust Emission Standards and Test Procedures for 1988 and Subsequent Model Passenger Cars, Light-Duty Trucks and Medium-Duty Vehicles", which is incorporated by reference in Title 13, California Code of Regulations, section 1960.1.

Because the staff is unable to propose generic RAFs for all potential TLEV technologies at this hearing, the staff is proposing that the regulations be amended to facilitate the development of engine family specific RAFs. Previously adopted regulations allow vehicle manufacturers to apply for RAFs specific to their vehicle/fuel system. The Executive

Officer would approve such requests provided that appropriate supporting data are submitted and that there is at least a 25 percent difference between the requested factor and the one already established for the same or similar vehicle/fuel system.

The staff is proposing that the 25 percent criterion be deleted. Vehicle manufacturers would thus be permitted to develop engine family specific RAFs by following the procedure outlined in the test procedures and the additional requirements described below. The staff envisions that durability vehicles for each of the families would have to be emission tested at regular intervals, in accordance with current practice or other approved accelerated durability programs, to generate a deterioration factor for NMOG mass changes and one for changes in the RAF. Neither deterioration factor would be allowed to be less than 1.00. The NMOG mass and RAF deterioration factors would be multiplied together to come up with an overall adjustment factor to apply to in-use vehicle NMOG levels for determining compliance with applicable NMOG emission standards. To confirm that the results from the durability vehicle(s) are reliable, at least 4 emission data vehicles and/or similar qualifying vehicles would also have to be tested using the FTP cycle to determine speciated NMOG emission profiles and attendant RAFs. A statistical process would be used to demonstrate that the data vehicles as a group exhibit similar profiles. In the future, the staff intends to examine further measures to verify that vehicles in-use comply with the intent of the reactivity adjustment process.

3. <u>Correction of Bias in Protocol for Determining RAFs</u>

Section Affected: "California Exhaust Emission Standards and Test Procedures for 1988 and Subsequent Model Passenger Cars, Light-Duty Trucks and Medium-Duty Vehicles", which is incorporated by reference in Title 13, California Code of Regulations, section 1960.1.

Following the release of the staff report, airshed modeling analyses conducted by Carnegie Mellon University for the ARB have been completed. The results suggest that there may be a bias in the maximum incremental reactivity scale (MIR) which results in RAFs which are numerically higher than they should be. This bias was found to be 10 percent for M85 and LPG under worst case conditions. Therefore, the staff is recommending that any RAFs developed for M85 or LPG, either by the ARB or by manfacturers, be adjusted upward by 10 percent. Accordingly, the staff recommends that the RAF for M85 be revised from the originally proposed value of 0.36 to 0.41. This adjustment should address any potential biases in the MIR scale as well as other uncertainties in protocol. The staff will determine whether a bias correction is needed for CNG once more representative vehicle emission data become available.

4. Revised MIR Scale

Section Affected: "California Exhaust Emission Standards and Test Procedures for 1988 and Subsequent Model Passenger Cars, Light-Duty Trucks and Medium-Duty Vehicles", which is incorporated by reference in Title 13, California Code of Regulations, section 1960.1.

Subsequent to the release of the staff report, Dr. W.P.L. Carter has made additional updates to the maximum incremental reactivity (MIR) scale. Furthermore, the staff has included the MIRs of compounds which were previously omitted from the regulations. The updated MIR scale which the staff is recommending for Board adoption is included as an attachment to this document. Additions to the originally proposed scale are shown in double-underline, and deletions are shown in strike-out. The revised MIR scale is reflected in the proposed RAF for M85.

NMOG Constituent	Maximum Incremental Reactivity (g O_3/g NMOG)	
ALKANES		
Normal Alkanes		
Methane	0.0148	
Ethane	~~0.26~~	0.25
Propane	0.48	
n-Butane	1.02	
n-Pentane	~~1.03~~	1.04
n-Hexane	0.98	
n-Heptane	0.81	
n-Octane	0.61	
n-Nonane	0.54	
n-Decane	0.47	
n-Undecane	0.42	
n-Dodecane	0.38	
n-Tridecane	0.35	
n-Tetradecane	0.32	
n-Pentadecane	0.29	
Branched Alkanes		
2-Methylpropane	1.21	
2,2-Dimethylpropane	0.37	
2-Methylbutane	1.38	
2,2-Dimethylbutane	0.82	
2,3-Dimethylbutane	1.07	
2-Methylpentane	1.53	
3-Methylpentane	1.52	
2,2,3-Trimethylbutane	1.32	
2,2-Dimethylpentane	1.40	
2,3-Dimethylpentane	1.51	
2,4-Dimethylpentane	1.78	
3,3-Dimethylpentane	0.71	
2-Methylhexane	1.08	
3-Methylhexane	1.40	
2,2,4-Trimethylpentane	~~0.87~~	0.93
2,3,3-Trimethylpentane	1.20	
2,3,4-Trimethylpentane	1.60	
Branched Alkanes		
2,2-Dimethylhexane	1.20	
2,3-Dimethylhexane	~~1.31~~	1.32
2,4-Dimethylhexane	1.50	
2,5-Dimethylhexane	1.63	
3,3-Dimethylhexane	1.20	
2-Methylheptane	0.96	
3-Methylheptane	0.99	
4-Methylheptane	1.20	
2,4-Dimethylheptane	~~1.33~~	1.34
2,2,5-Trimethylhexane	0.97	
Other Branched C9H20 Alkanes	~~1.13~~	1.14
Branched C10H22 Alkanes	1.01	
Branched C11 Alkanes	1.17	
Branched C12 Alkanes	1.23	
Cyclo Alkanes		
Cyclopentane	~~2.37~~	2.38
Methylcyclopentane	2.82	
Cyclohexane	1.28	
t-1,2-Dimethylcyclopentane	1.85	
1,3-Dimethylcyclopentanes	~~2.54~~	2.55
Methylcyclohexane	~~1.84~~	1.85
Ethylcyclopentane	2.31	
Ethylmethylcyclopentane	1.94	
1c,2t-3-Trimethylcyclopentane	1.94	
1,2,4-Trimethylcyclopentane	1.94	
Dimethylcyclohexanes	1.94	
Ethylcyclohexane	1.94	
Ethylmethylcyclohexane	2.30	
Trimethylcyclohexane	2.30	
C10 Cycloalkanes	1.78	
C11 Cycloalkanes	1.91	
C12 Cycloalkanes	1.68	

NMOG Constituent	Maximum Incremental Reactivity ($g\ O_3/g$ NMOG)	
ALKENES		
Ethene	~~7.28~~	7.29
Propene	~~9.39~~	9.40
1-Butene	~~8.90~~	8.91
2-Butenes	~~9.93~~	9.94
2-Methylpropene	~~5.29~~	5.31
1-Pentene	6.22	
2-Pentenes	~~8.79~~	8.80
2-Methyl-1-Butene	~~4.89~~	4.90
3-Methyl-1-Butene	6.22	
2-Methyl-2-Butene	~~6.40~~	6.41
1-Hexene	~~4.41~~	4.42
2-Hexenes	~~6.67~~	6.69
3-Hexenes	~~6.67~~	6.69
Methyl-1-Pentenes	~~4.41~~	4.42
Methyl-2-Pentenes	~~6.67~~	6.69
3,3-Dimethyl-1-Butene	~~4.41~~	4.42
1-Heptene	3.48	
2-Heptenes	~~5.52~~	5.53
3-Heptenes	~~5.52~~	5.53
3-Ethyl-2-Pentenes	~~5.52~~	5.53
2,3-Dimethyl-2-Pentene	~~5.52~~	5.53
3-Methyl-1-Hexene	3.48	
2-Methyl-2-Hexenes	~~5.52~~	5.53
4-Methyl-2-Hexene	5.53	
2-Methyl-3-Hexene	5.53	
3-Methyl-3-Hexenes	~~5.52~~	5.53
1-Octene	~~2.68~~	2.69
2-Octenes	~~5.27~~	5.29
3-Octenes	~~5.27~~	5.29
4-Octenes	~~5.27~~	5.29
2,4,4-Trimethyl-1-Pentene	~~2.68~~	2.69
2,4,4-Trimethyl-2-Pentene	5.29	
1-Nonene	~~2.22~~	2.23
Propadiene	~~7.28~~	7.29
1,3-Butadiene	~~10.88~~	10.89
2-Methyl-1,3-Butadiene	~~9.07~~	9.08
Cyclopentadiene	~~7.65~~	7.66
Cyclopentene	~~7.65~~	7.66
1-Methylcyclopentene	5.67	
3-Methylcyclopentene	~~5.66~~	5.67
Cyclohexene	~~5.66~~	5.67
a-Pinene	3.28	
b-Pinene	4.41	
ALKYNES		
Ethyne	~~0.51~~	0.50
Propyne	4.10	
1-Butyne	~~9.23~~	9.24
2-Butyne	~~9.23~~	9.24

NMOG Constituent	Maximum Incremental Reactivity ($g\ O_3/g$ NMOG)	
AROMATIC HYDROCARBONS		
Benzene	0.42	
Toluene	~~2.72~~	2.73
Ethylbenzene	~~2.90~~	2.70
o-Xylene	~~6.68~~	6.46
~~m&p-Xylenes~~	~~8.15~~	
m-Xylene	8.16	
p-Xylene	6.60	
n-Propylbenzene	~~2.27~~	2.12
i-Propylbenzene	~~2.41~~	2.24
Methylethylbenzenes	7.20	
1,2,3-Trimethylbenzene	~~8.61~~	8.85
1,2,4-Trimethylbenzene	~~8.59~~	8.83
1,3,5-Trimethylbenzene	~~10.11~~	10.12
n-Butylbenzene	1.87	
s-Butylbenzene	~~2.04~~	1.89
Diethylbenzenes	~~6.44~~	6.45
1-Methyl-2-Propylbenzene	6.45	
1-Methyl-3-Propylbenzene	6.45	
C10 Trialkyl Benzenes	9.07	
Tetramethylbenzenes	~~9.06~~	9.07
C11 Monoalkyl Benzenes	1.70	
1-Methyl-4-Isobutylbenzene	~~5.83~~	5.84
C11 Dialkyl Benzenes	5.84	
C11 Trialkyl Benzenes	8.21	
C12 Monoalkyl Benzenes	1.55	
C12 Dialkyl Benzenes	5.34	
C12 Trialkyl Benzenes	7.50	
Indan (C9H10)	~~1.04~~	1.06
Methyl Indan	1.06	
Napthalene	~~1.16~~	1.18
Tetralin	0.95	
Methyl Naphthalenes	3.27	
2,3-Dimethyl Naphthalene	5.13	
Styrene	~~2.20~~	2.22
AROMATIC OXYGENATES		
Phenol	1.13	
Cresols	2.31	
Benzaldehyde	~~-0.56~~	-0.55
p-Tolualdehyde	~~-0.56~~	3.32

NMOG Constituent	Maximum Incremental Reactivity ($g\ O_3/g$ NMOG)	
OXYGENATES		
Alcohols		
Methanol	0.56	
Ethanol	~~1.33~~	1.34
n-Propyl Alcohol	2.26	
Isopropyl Alcohol	0.54	
n-Butyl Alcohol	2.69	
Isobutyl Alcohol	1.92	
t-Butyl Alcohol	0.42	
Aldehydes		
Formaldehyde	~~7.14~~	7.15
Acetaldehyde	~~5.51~~	5.52
Propionaldyde	6.53	
Acrolein	~~6.76~~	6.77
n-Butyraldehyde	5.26	
Crotonaldehyde	~~5.41~~	5.42
Pentanaldehyde	~~4.40~~	4.41
Hexanaldehyde	3.79	
C7 Aldehydes	3.32	
Ethers		
Methyl t-Butyl Ether	0.62	
Ethyl t-Butyl Ether	1.98	
Ketones		
Acetone	0.56	
Butanone	1.18	

ATTACHMENT II

A. Summary of modifications

B. Modified regulatory text of section 1960.1, Title 13, California Code of Regulations

C. Modified text of the "California Exhaust Emission Standards and Test Procedures for 1988 and Subsequent Model Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles"

SUMMARY OF 15-DAY MODIFICATIONS

Substantive modifications affect the document "California Exhaust Emission Standards and Test Procedures for 1988 and Subsequent Model Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles" only. All section citations included in this summary refer to these test procedures. Additional non-substantive modifications were made to section 1960.1, Title 13, California Code of Regulations. However, these modifications are of an editorial nature and are not summarized in this document.

1. In section 13.(a)(1), the originally proposed reactivity adjustment factor of 0.36 for methanol TLEVs has been changed to 0.41, and the originally proposed reactivity adjustment factors for compressed natural gas and liquified petroleum gas have been deleted from the regulations. As set forth in the staff report, reactivity adjustment factors of 0.36, 0.50, and 0.18 were originally proposed for methanol, liquified petroleum gas, and compressed natural gas, respectively. The revised reactivity adjustment factor of 0.41 for methanol reflects the updated maximum incremental reactivity scale (refer to item 7 of this summary) and a 10 percent correction for potential modeling and protocol biases. Reactivity adjustment factors for compressed natural gas and liquified petroleum gas have been dropped because of inconsistencies and limitations in the vehicle emission data. The Executive Officer will establish the factors in accordance with the test procedures once sufficient representative data are available.

2. In section 13.(d)(1), the 'g ozone potential per g NMOG' for conventional gasoline TLEVs has been changed from 3.44 to 3.42 to reflect the revisions to the maximum incremental reactivity scale (refer to item 7 of this summary).

3. In Appendix VIII, at the end of note (7), language has been added stating that any reactivity adjustment factors calculated for methanol and liquified petroleum gas are to be adjusted upward by 10 percent to account for potential modeling and protocol biases.

4. In Appendix VIII, note (8)a., additional requirements for engine family specific reactivity adjustment factors have been added. Specifically, vehicle manufacturers are required to submit speciated NMOG exhaust emission profiles from at least four vehicles representative of the engine family. The emission data vehicle(s) for the engine family must be included in the vehicle test sample, and the speciated profile(s) from the emission data vehicle(s) must be obtained from the same

test(s) used to derive the official 4000 mile exhaust certification data. One speciated profile is required from each test vehicle. An "undeteriorated reactivity adjustment factor" is calculated for each vehicle, and the "undeteriorated reactivity adjustment factor" for the engine family is derived by taking the arithmetic mean. To limit the amount of variability in the data, the 95 percent upper confidence bound of the mean reactivity adjustment factor can be no more than 15 percent greater than the value of the mean factor.

5. In Appendix VIII, note (8)b., the requirement for a 25 percent difference between the manufacturer derived reactivity adjustment factor and the ARB established factor has been deleted. In its place, the procedure for determining a "reactivity deterioration factor" has been added. A manufacturer is required to obtain at least two speciated NMOG exhaust emission profiles from at least one durability data vehicle at each mileage interval normally used to determine deterioration factors for mass emissions. The mean reactivity adjustment factor is calculated at each interval, and from this information, a deterioration factor for reactivity is obtained. No reactivity deterioration factor can be less than 1.00. The mean undeteriorated reactivity deterioration factor derived for the engine family is multiplied by the reactivity deterioration factor to obtain the reactivity adjustment factor used to determine compliance with the NMOG standards.

6. In Appendix VIII, note (8)c., the provision requiring a two-year leadtime for submitting speciated profiles has been changed to requiring that speciated profiles, reactivity adjustment factors, and reactivity deterioration factors be submitted with the certification application.

7. In Appendix VIII, note (9), the previous list of maximum incremental reactivities has been replaced with the updated list distributed at the Board hearing. This updated list includes the revisions made to the maximum incremental reactivity scale by Dr. William Carter just prior to the Board hearing.

SECTION 1960.1, TITLE 13, CCR

Amend Title 13, California Code of Regulations, section 1960.1 to read as follows:[1]

1960.1. **Exhaust Emission Standards and Test Procedures - 1991 and Subsequent Model Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles.**

(a) through (d) [No Change]

(e)(1) and (e)(2) [No Change]

(e)(3) The exhaust emissions from 1992 and subsequent model-year transitional low-emission vehicles, low-emission vehicles, and ultra-low-emission vehicles, including fuel-flexible and dual-fuel vehicles, shall meet all the requirements of (g)(1) and (h)(2) with the following additions:

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1. The regulatory amendments originally proposed in this rulemaking are shown in underline to indicate additions and ~~strikeout~~ to indicate deletions from existing regulations. Modifications to the originally noticed text are designated by double underline and slash out to represent additions and deletions, respectively.

EXHAUST EMISSION STANDARDS FOR
TRANSITIONAL LOW-EMISSION VEHICLES, LOW-EMISSION VEHICLES,
AND ULTRA-LOW-EMISSION VEHICLES IN THE
LIGHT-DUTY AND MEDIUM-DUTY VEHICLE WEIGHT CLASSES (5)(6)(7)
["milligrams per mile" (or "mg/mi")]

Vehicle Type (1)	Vehicle Weight (lbs.)(2)	Durability Vehicle Basis (mi)	Vehicle Emission Category(3)	Formaldehyde (mg/mi)(4)(5)
PC and LDT	All 0-3750	50,000	TLEV	15 (23)
			LEV	15 (15)
			ULEV	8 (12)
		100,000	TLEV	18
			LEV	18
			ULEV	11
LDT	3751-5750	50,000	TLEV	18 (27)
			LEV	18 (18)
			ULEV	9 (14)
		100,000	TLEV	23
			LEV	23
			ULEV	13
MDV	0-3750	50,000	LEV	15 (15)
			ULEV	8 (12)
		120,000	LEV	22
			ULEV	12
MDV	3751-5750	50,000	LEV	18 (18)
			ULEV	9 (14)
		120,000	LEV	27
			ULEV	13
MDV	5751-8500	50,000	LEV	22 (22)
			ULEV	11 (17)
		120,000	LEV	32
			ULEV	16
MDV	8501-10,000	50,000	LEV	28 (28)
			ULEV	14 (21)
		120,000	LEV	40
			ULEV	21
MDV	10,001-14,000	50,000	LEV	36 (36)
			ULEV	18 (27)
		120,000	LEV	52
			ULEV	26

(1) "PC" means passenger cars.
"LDT" means light-duty trucks.
"MDV" means medium-duty vehicles.

(2) For light-duty or medium-duty vehicles, Vehicle Weight shall mean "Loaded Vehicle Weight" (or "LVW") or "Test Weight" (or "TW"), respectively.

(3) "TLEV" means transitional low-emission vehicle.
"LEV" means low-emission vehicle.
"ULEV" means ultra-low-emission vehicle.

(4) Formaldehyde exhaust emission standards apply to vehicles ~~designed~~ certified to operate on any available fuel, including fuel-flexible and dual-fuel vehicles.

(5) The standards in parentheses are intermediate compliance standards for 50,000 miles.

a. For PCs and LDTs from 0-5750 lbs. LVW, including fuel-flexible and dual-fuel vehicles, intermediate compliance standards shall apply to TLEVs through the 1995 model year, LEVs and ULEVs through the 1998 model year. Compliance with standards beyond 50,000 miles shall be waived through 1995 for TLEVs, and through 1998 for LEVs and ULEVs.

b. For MDVs from 0-14,000 lbs. TW, including fuel-flexible and dual-fuel vehicles, intermediate compliance standards shall apply to LEVs and ULEVs through the 1999 model year. Compliance with standards beyond 50,000 miles shall be waived through the 1999 model year for LEVs and ULEVs.

(6) Manufacturers shall demonstrate compliance with the above standards for formaldehyde at 50 degrees F according to the procedures specified in section 11k of the "California Exhaust Emission Standards and Test Procedures for 1988 and Subsequent Model Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles" as ~~adopted May 20, 1987 and last amended~~ INSERT ~~July 12, 1991, which is~~ incorporated ~~herein~~ by reference in section 1960.1(k).

(7) In-use compliance testing shall be limited to PCs and LDTs with fewer than 75,000 miles and MDVs with fewer than 90,000 miles.

(f)(1) and (f)(2) [No Change]

(g)(1) The exhaust emissions from new 1992 and subsequent model-year light-duty transitional low-emission vehicles, low-emission vehicles, and ultra-low-emission vehicles shall not exceed:

EXHAUST EMISSION STANDARDS
FOR TRANSITIONAL LOW-EMISSION VEHICLES, LOW-EMISSION VEHICLES
AND ULTRA-LOW-EMISSION VEHICLES IN PASSENGER CAR
AND LIGHT-DUTY TRUCK VEHICLE CLASSES (6)(7)(8)(9)
[grams per mile (or "g/mi")]

Vehicle Type (1)	Loaded Vehicle Weight (lbs.)	Durability Vehicle Basis (mi)	Vehicle Emission Category (2)	Non-Methane Organic Gases (3)(4)	Carbon Monoxide	Oxides of Nitrogen (5)
PC and LDT	All 0-3750	50,000	TLEV	0.125 (0.188)	3.4 (3.4)	0.4 (0.4)
			LEV	0.075 (0.100)	3.4 (3.4)	0.2 (0.3)
			ULEV	0.040 (0.058)	1.7 (2.6)	0.2 (0.3)
		100,000	TLEV	0.156	4.2	0.6
			LEV	0.090	4.2	0.3
			ULEV	0.055	2.1	0.3
LDT	3751-5750	50,000	TLEV	0.160 (0.238)	4.4 (4.4)	0.7 (0.7)
			LEV	0.100 (0.128)	4.4 (4.4)	0.4 (0.5)
			ULEV	0.050 (0.075)	2.2 (3.3)	0.4 (0.5)
		100,000	TLEV	0.200	5.5	0.9
			LEV	0.130	5.5	0.5
			ULEV	0.070	2.8	0.5

(1) "PC" means passenger cars.
"LDT" means light-duty trucks.

(2) "TLEV" means transitional low-emission vehicle.
"LEV" means low-emission vehicle.
"ULEV" means ultra-low-emission vehicle.

(3) "Non-Methane Organic Gases" (or "NMOG") shall mean the total mass of oxygenated and non-oxygenated hydrocarbon emissions. To demonstrate compliance with an NMOG standard, NMOG emissions shall be measured in accordance with the "California Non-Methane Organic Gas Test Procedures" as adopted July 12, 1991, which is incorporated herein by reference. For TLEVs, LEVs, and ULEVs ~~designed~~ certified to operate exclusively on any fuel other than conventional gasoline, and for fuel-flexible and dual-fuel TLEVs, LEVs, and ULEVs when certifying on a fuel other than conventional gasoline, manufacturers shall multiply ~~the measured~~ NMOG mass emissions levels at 50,000 and 100,000 miles by the applicable reactivity adjustment factor set forth in section 13 of the "California Exhaust Emission Standards and Test Procedures for 1988 and Subsequent Model Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles" as ~~adopted May 20, 1987 and last amended INSERT which is~~ incorporated ~~herein~~ by reference in section 1960.1(k), or established by the Executive Officer pursuant to Appendix VIII of the foregoing test procedures. The product of the NMOG mass emission level and the reactivity adjustment factor shall be

compared to the exhaust NMOG mass emission standards established for the particular vehicle emission category to determine compliance. ~~established for the particular vehicle emission category and fuel combination in the application for certification. The Executive Officer shall determine the reactivity adjustment factor according to the procedure described in Appendix VIII of the "California Exhaust Emission Standards and Test Procedures for 1988 and Subsequent Model Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles" as adopted May 20, 1987 and last amended July 12, 1991, which is incorporated herein by reference.~~

a. Each manufacturer shall certify PCs or LDTs to meet the exhaust mass emission standards for TLEVs, LEVs, ULEVs, or the exhaust emission standards of sections 1960.1 (e)(1), 1960.1 (f)(1), or 1960.1 (f)(2), Title 13, California Code of Regulations, or as Zero-Emission Vehicles such that the manufacturer's fleet average NMOG values for California-certified PCs and LDTs from 0-3750 lbs. "Loaded Vehicle Weight" (or "LVW"), and LDTs from 3751-5750 lbs. LVW sold in California are less than or equal to the requirement for the corresponding Model Year, Vehicle Type, and LVW Class in section 1960.1 (g)(2), Title 13, California Code of Regulations.

(4) Fuel-flexible and dual-fuel PCs and LDTs from 0-5750 lbs. LVW shall be certified to exhaust mass emission standards for NMOG established for the operation of the vehicle on any available fuel other than conventional gasoline, and conventional gasoline.

a. For TLEVs, LEVs, and ULEVs, when certifying for operation on a fuel other than conventional gasoline, manufacturers shall multiply ~~the measured~~ NMOG mass emissions levels at 50,000 and 100,000 miles by the applicable reactivity adjustment factor ~~in the application for certification at 50,000 and 100,000 miles~~.

b. For PCs and LDTs from 0-3750 lbs. LVW, the applicable exhaust mass emission standard for NMOG when certifying the vehicle for operation on conventional gasoline shall be:
   - (i) For TLEVs, 0.25 g/mi and 0.31 g/mi for 50,000 and 100,000 miles, respectively.
   - (ii) For LEVs, 0.125 g/mi and 0.156 g/mi for 50,000 and 100,000 miles, respectively.
   - (iii) For ULEVs, 0.075 g/mi and 0.090 g/mi for 50,000 and 100,000 miles, respectively.

c. For LDTs from 3751-5750 lbs. LVW, the applicable exhaust mass emission standard for NMOG when certifying the vehicle for operation on conventional gasoline shall be:
   - (i) For TLEVs, 0.32 g/mi and 0.40 g/mi for 50,000 and 100,000 miles, respectively.
   - (ii) For LEVs, 0.160 g/mi and 0.200 g/mi for 50,000 and 100,000 miles, respectively.
   - (iii) For ULEVs, 0.100 g/mi and 0.130 g/mi for 50,000 and 100,000 miles, respectively.

(5) The maximum projected emissions of "Oxides of Nitrogen" (or "NOx") measured on the federal Highway Fuel Economy Test (HWFET; 40 CFR 600 Subpart B) shall be not greater than 1.33 times the applicable light-duty vehicle standards shown in the table. Both the projected emissions and the HWFET standard shall be rounded in accordance with ASTM E29-67 to the nearest 0.1 g/mi before being compared.

(6) The standards in parentheses are intermediate compliance standards for 50,000 miles. For PCs and LDTs from 0-5750 lbs. LVW, including fuel-flexible and dual-fuel vehicles when operating on any available fuel other than conventional gasoline, intermediate compliance standards shall apply to TLEVs through the 1995 model year, and LEVs and ULEVs through the 1998 model year. Compliance with standards beyond 50,000 miles shall be waived through the 1995 model year for TLEVs, and through the 1998 model year for LEVs and ULEVs.

a. For TLEVs, LEVs, and ULEVs designed to operate on any fuel other than conventional gasoline, including fuel-flexible and dual-fuel vehicles when operating on any fuel other than conventional gasoline, ~~measured~~ NMOG mass emissions levels shall be multiplied by the applicable reactivity adjustment factor to determine compliance with intermediate compliance standards for NMOG.

b. For fuel-flexible and dual-fuel PCs and LDTs from 0-3750 lbs. LVW, intermediate compliance standards for NMOG emissions at 50,000 miles, when the vehicle is operated on conventional gasoline, shall be 0.32 g/mi, 0.188 g/mi, and 0.100 g/mi for TLEVs, LEVs, and ULEVs, respectively.

c. For fuel-flexible and dual-fuel PCs and LDTs from 3751-5750 lbs. LVW, intermediate compliance standards for NMOG emissions at 50,000 miles, when the vehicle is operated on conventional gasoline, shall be 0.41 g/mi, 0.238 g/mi, and 0.128 g/mi for TLEVs, LEVs, and ULEVs, respectively.

(7) Manufacturers of diesel vehicles shall also certify to particulate standards at 100,000 miles. For all PCs and LDTs from 0-5750 lbs LVW, the particulate standard is 0.08 g/mi, 0.08 g/mi, and 0.04 g/mi for TLEVs, LEVs and ULEVs, respectively.

(8) Manufacturers shall demonstrate compliance with the above standards for NMOG, CO, and NOx at 50 degrees F according to the procedure specified in section 11k of the "California Exhaust Emission Standards and Test Procedures for 1988 and Subsequent Model Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles" as ~~adopted May 20, 1987 and last amended~~ INSERT ~~July 12, 1991,~~ incorporated ~~herein~~ by reference in section 1960.1(k). For diesel vehicles, compliance with the particulate standard shall also be demonstrated as specified in section 11k of the foregoing test procedures.

(9) In-use compliance testing shall be limited to vehicles with fewer than 75,000 miles.

(g)(2) and (h)(1) [No Change]

(h)(2) The exhaust emissions from new 1992 and subsequent model-year medium-duty low-emission vehicles, and ultra-low-emission vehicles shall not exceed:

EXHAUST EMISSION STANDARDS FOR LOW-EMISSION VEHICLES, AND ULTRA-LOW-EMISSION VEHICLES IN THE MEDIUM-DUTY VEHICLE WEIGHT CLASS (8)(9)(10)(11)(12)(13)(14)
[grams per mile (or "g/mi")]

Test Weight lbs.) (1)	Durability Vehicle Basis (mi)	Vehicle Emission Category (2)	Non-Methane Organic Gases (3)(4)	Carbon Monoxide	Oxides of Nitrogen (5)	Particulates (6)(7)
0-3750	50,000	LEV	0.125 (0.188)	3.4 (3.4)	0.4 (0.4)	n/a
		ULEV	0.075 (0.100)	1.7 (2.6)	0.2 (0.3)	n/a
	120,000	LEV	0.180	5.0	0.6	0.08
		ULEV	0.107	2.5	0.3	0.04
3751-5750	50,000	LEV	0.160 (0.238)	4.4 (4.4)	0.7 (0.7)	n/a
		ULEV	0.100 (0.128)	2.2 (3.3)	0.4 (0.5)	n/a
	120,000	LEV	0.230	6.4	1.0	0.10
		ULEV	0.143	3.2	0.5	0.05
5751-8500	50,000	LEV	0.195 (0.293)	5.0 (5.0)	1.1 (1.1)	n/a
		ULEV	0.117 (0.156)	2.5 (3.8)	0.6 (0.8)	n/a
	120,000	LEV	0.280	7.3	1.5	0.12
		ULEV	0.167	3.7	0.8	0.06
8501-10000	50,000	LEV	0.230 (0.345)	5.5 (5.5)	1.3 (1.3)	n/a
		ULEV	0.138 (0.184)	2.8 (4.2)	0.7 (1.0)	n/a
	120,000	LEV	0.330	8.1	1.8	0.12
		ULEV	0.197	4.1	0.9	0.06
10,001-14000	50,000	LEV	0.300 (0.450)	7.0 (7.0)	2.0 (2.0)	n/a
		ULEV	0.180 (0.240)	3.5 (5.3)	1.0 (1.5)	n/a
	120,000	LEV	0.430	10.3	2.8	0.12
		ULEV	0.257	5.2	1.4	0.06

(1) "Test Weight" (or "TW") shall mean the average of the vehicle's curb weight and gross vehicle weight.

(2) "LEV" means low-emission vehicle.
"ULEV" means ultra-low-emission vehicle.

(3) "Non-Methane Organic Gases" (or "NMOG") shall mean the total mass of oxygenated and non-oxygenated hydrocarbon emissions. To determine compliance with an NMOG standard, NMOG emissions shall be measured in accordance with "California Non-Methane Organic Gas Test Procedures" as adopted July 12, 1991, which is incorporated herein by reference.

a. For LEVs and ULEVs ~~designed~~ certified to operate on any available fuel other than conventional gasoline, including fuel-flexible or dual-fuel vehicles when certifying on a fuel other than conventional gasoline, manufacturers shall multiply ~~measured~~ NMOG mass emissions levels at 50,000 and 120,000 miles by the applicable reactivity adjustment factor set forth in section 13 of the "California Exhaust Emission Standards and Test Procedures for 1988 and Subsequent Model Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles" as ~~adopted May 20, 1987 and last amended~~

~~INSERT/ which is~~ incorporated ~~herein~~ by reference in section 1960.1(k), or established by the Executive Officer pursuant to Appendix VIII of the foregoing test procedures. The product of the NMOG mass emission levels and the reactivity adjustment factor shall be compared to the exhaust NMOG mass emission standard established for the particular vehicle emission category to determine compliance. ~~appropriate to the vehicle emission category and fuel combination in the application for certification. The reactivity adjustment factor shall be determined by the Executive Officer according to the procedure described in Appendix VIII of the "California Exhaust Emission Standards and Test Procedures for 1988 and Subsequent Model Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles" as adopted May 20, 1987 and last amended July 12, 1991, which is incorporated herein by reference.~~

(4) Fuel-flexible and dual-fuel medium-duty vehicles (or "MDVs") from 0-14,000 lbs. TW shall be certified to exhaust mass emission standards for NMOG established for the operation of the vehicle on any fuel other than conventional gasoline, and conventional gasoline.

a. For LEVs and ULEVs, manufacturers shall multiply ~~measured~~ NMOG mass emissions levels at 50,000 and 120,000 miles by the ~~appropriate~~ applicable reactivity adjustment factor ~~in the application for certification~~.

b. For MDVs from 0-3750 lbs. TW, the applicable exhaust mass emission standard for NMOG when certifying the vehicle for operation on conventional gasoline shall be:
   (i) For LEVs, 0.25 g/mi and 0.36 g/mi for 50,000 and 120,000 miles, respectively.
   (ii) For ULEVs, 0.125 g/mi and 0.190 g/mi for 50,000 and 120,000 miles, respectively.

c. For MDVs from 3751-5750 lbs. TW, the applicable exhaust mass emission standard for NMOG when certifying the vehicle for operation on conventional gasoline shall be:
   (i) For LEVs, 0.32 g/mi and 0.46 g/mi for 50,000 and 120,000 miles, respectively.
   (ii) For ULEVs, 0.160 g/mi and 0.230 g/mi for 50,000 and 120,000 miles, respectively.

d. For MDVs from 5751-8500 lbs. TW, the applicable exhaust mass emission standard for NMOG when certifying the vehicle for operation on conventional gasoline shall be:
   (i) For LEVs, 0.39 g/mi and 0.56 g/mi for 50,000 and 120,000 miles, respectively.
   (ii) For ULEVs, 0.195 g/mi and 0.280 g/mi for 50,000 and 120,000 miles, respectively.

e. For MDVs from 8501-10,000 lbs. TW, the applicable exhaust mass emission standard for NMOG when certifying the vehicle for operation on conventional gasoline shall be:
   (i) For LEVs, 0.46 g/mi and 0.66 g/mi for 50,000 and 120,000 miles, respectively.
   (ii) For ULEVs, 0.230 g/mi and 0.330 g/mi for 50,000 and 120,000 miles, respectively.

f. For MDVs from 10,001-14,000 lbs. TW, the applicable exhaust mass emission standard for NMOG when certifying the vehicle for operation on conventional gasoline shall be:
   (i) For LEVs, 0.60 g/mi and 0.86 g/mi for 50,000 and 120,000 miles, respectively.

(ii) For ULEVs, 0.300 g/mi and 0.430 g/mi for 50,000 and 120,000 miles, respectively.

(5) The maximum projected emissions of "Oxides of Nitrogen" (or "NOx") measured on the federal Highway Fuel Economy Test (HWFET; 40 CFR Part 600 Subpart B) shall not be greater than 2.00 times the applicable MDV standards shown in the table. Both the projected emissions and the HWFET standard shall be rounded in accordance with ASTM E29-67 to the nearest 0.1 g/mi before being compared.

(6) Particulate standards are only applicable for diesel vehicles and shall be determined on a 120,000 mile basis.

(7) "n/a" means not applicable.

(8) Manufacturers have the option of certifying engines used in incomplete and diesel MDVs to the heavy-duty engine standards and test procedures set forth in section 1956.8(h), Title 13, California Code of Regulations. Manufacturers certifying incomplete or diesel MDVs to the heavy-duty engine standards and test procedures shall specify in the application for certification an in-use compliance procedure as provided in section 2139(c), Title 13, California Code of Regulations.

(9) The standards in parenthesis are intermediate compliance standards for 50,000 miles. For MDVs from 0-14,000 lbs. TW, including fuel-flexible and dual-fuel vehicles when operating on any available fuel other than conventional gasoline, intermediate compliance standards shall apply to LEVs and ULEVs through the 1999 model year. Compliance with standards beyond 50,000 miles shall be waived through the 1999 model year for LEVs and ULEVs.

a. For LEVs and ULEVs designed to operate on any available fuel other than conventional gasoline, including fuel-flexible and dual-fuel vehicles when operating on any available fuel other than conventional gasoline, ~~measured~~ NMOG emissions <u>levels</u> shall be multiplied by the ~~appropriate~~ <u>applicable</u> reactivity adjustment factor.

b. For fuel-flexible and dual-fuel MDVs from 0-3750 lbs. TW, intermediate compliance standards for NMOG emissions at 50,000 miles, when the vehicle is operated on conventional gasoline, shall be 0.32 g/mi and 0.188 g/mi for LEVs and ULEVs, respectively.

c. For fuel-flexible and dual-fuel MDVs from 3751-5750 lbs. TW, intermediate compliance standards for NMOG emissions at 50,000 miles, when the vehicle is operated on conventional gasoline, shall be 0.41 g/mi and 0.238 g/mi for LEVs and ULEVs, respectively.

d. For fuel-flexible and dual-fuel MDVs from 5751-8500 lbs. TW, intermediate compliance standards for NMOG emissions at 50,000 miles, when the vehicle is operated on conventional gasoline, shall be 0.49 g/mi and 0.293 g/mi for LEVs and ULEVs, respectively.

e. For fuel-flexible and dual-fuel MDVs from 8501-10,000 lbs. TW, intermediate compliance standards for NMOG emissions at 50,000 miles, when the vehicle is operated on conventional gasoline, shall be 0.58 g/mi and 0.345 g/mi for LEVs and ULEVs, respectively.

f. For fuel-flexible and dual-fuel MDVs from 10,001-14,000 lbs. TW, intermediate compliance standards for NMOG emissions at 50,000 miles, when the vehicle is operated on conventional gasoline, shall be 0.75 g/mi and 0.450 g/mi for LEVs and ULEVs, respectively.

(10) Each manufacturer's MDV fleet shall be defined as the total number of MDVs from 0-14,000 lbs. TW certified and sold in California.

a. Manufacturers of MDVs shall certify an equivalent of 25% of their MDV fleet to LEV standards in the 1998 model year, 50% of their MDV fleet to LEV standards in the 1999 model year, 75% of their MDV fleet to LEV standards in the 2000 model year, 95% of their MDV fleet to LEV standards in the 2001 model year, 90% of their MDV fleet to LEV standards in the 2002 model year, and 85% of their MDV fleet to LEV standards in the 2003 and subsequent model years.

b. Manufacturers of MDVs shall certify an equivalent of 2% of their MDV fleet to ULEV standards in each model year from 1998 through 2000, 5% of their MDV fleet to ULEV standards in the 2001 model year, 10% of their MDV fleet to ULEV standards in the 2002 model year, and 15% of their MDV fleet to ULEV standards in the 2003 and subsequent model years.

(11) For the purpose of calculating "Vehicle Equivalent Credits" (or "VECs"), the contribution of hybrid electric vehicles (or "HEVs") will be calculated based on the range of the HEV without the use of the engine. For the purpose of calculating the contribution of HEVs to the VECs, the following definitions shall apply:

"Type A HEV" shall mean an HEV which achieves a minimum range of 60 miles over the Dynamometer Driving Cycle as defined by the "Federal Highway Fuel Economy Test Procedure" (HWFET; 40 CFR Part 600 Subpart B) without the use of the engine. Use of vehicle accessories cannot lower the battery-only range below 60 miles. This definition shall also apply to vehicles which have no tailpipe emissions, but use fuel fired heaters, regardless of the operating range of the vehicle.

"Type B HEV" shall mean an HEV which achieves a range of 40 - 59 miles over the Dynamometer Driving Cycle as defined by the "Federal Highway Fuel Economy Test Procedure" (HWFET; 40 CFR Part 600 Subpart B) without the use of the engine. Use of vehicle accessories cannot lower the battery-only range below 40 miles.

"Type C HEV" shall mean an HEV which achieves a range of 0 - 39 miles over the Dynamometer Driving Cycle as defined by the "Federal Highway Fuel Economy Test Procedure" (HWFET; 40 CFR Part 600 Subpart B) without the use of the engine, an HEV which enables the vehicle operators to control the engine time and modes of operation either directly or indirectly, an HEV which can be operated solely through the use of the engine, and all other HEVs excluding "Type A" and "Type B" HEVs.

(12) In 1992 and subsequent model years, manufacturers that sell MDVs in excess of the equivalent requirements for LEVs and/or ULEVs shall receive VECs calculated as: {[(No. of LEVs Sold excluding HEVs) + (No. of "Type C HEV" LEVs Sold)] + [(No. of "Type B HEV" LEVs Sold) x (1.1)] + [(No of "Type A HEV" LEVs Sold) x (1.2)] - (Equivalent No. of LEVs Required to be Sold)} + {[(No. of ULEVs Sold excluding HEVs) x (1.4)] + [(No. of "Type C HEV" ULEVs Sold) x (1.4)] + [(No. of "Type B HEV" ULEVs Sold) x (1.5)] + [(No. of "Type A HEV" ULEVs Sold) x (1.7)] - (Equivalent No. of ULEVs Required to be Sold)} + [(No. of ZEVs Sold as MDVs) x (2.0)].

a. Manufacturers that fail to sell the equivalent quantity of MDVs certified to LEV and/or ULEV exhaust emission standards, shall receive "Vehicle-Equivalent Debits" (or "VEDs") equal to the amount of negative VECs determined by the aforementioned equation.
b. Manufacturers shall equalize emission debits within one model year by earning VECs in an amount equal to their previous model-year's total of VEDs, or by submitting a commensurate amount of VECs to the Executive Officer that were earned previously or acquired from another manufacturer.
c. The VECs earned in any given model year shall retain full value through the subsequent model year.
d. The value of any VECs not used to equalize the previous model-year's debit, shall be discounted by 50% at the beginning of second model year after being earned, discounted to 25% of its original value if not depleted by the beginning of the third model year after being earned, and will have no value if not depleted by the beginning of the fourth model year after being earned.
e. Only ZEVs certified as MDVs shall be included in the calculation of VECs.

(13) Manufacturers shall demonstrate compliance with the above standards for NMOG, carbon monoxide, and oxides of nitrogen at 50 degrees F according to the procedure specified in section 11k of the "California Exhaust Emission Standards and Test Procedures for 1988 and Subsequent Model Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles" as ~~adopted May 20, 1987, and last amended July 12, 1991~~ ~~[INSERT], which is~~ incorporated ~~herein~~ by reference in section 1960.1(k). For diesel vehicles, compliance with the particulate standard shall also be demonstrated as specified in section 11k of the foregoing test procedures.

(14) In-use compliance testing shall be limited to vehicles with fewer than 90,000 miles.

(i) and (j) [No Change]

(k) The test procedures for determining compliance with these standards are set forth in "California Exhaust Emission Standards and Test Procedures for 1981 through 1987 Model Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles", adopted by the ~~S~~state ~~B~~board on November 23, 1976, as last amended May 20, 1987, and in "California Exhaust Emission Standards and Test Procedures for 1988 and Subsequent Model Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles", adopted by the state board on May 20, 1987 as last amended ~~July 12, 1991~~ [INSERT], both of which are incorporated herein by reference.

(l) through (o) [No Change]

NOTE: Authority cited: Sections 39600, 39601, 43013, 43018, 43101, 43104, and 43105, Health and Safety Code. Reference: Sections 39002, 39003, 43000, 43009.5, 43013, 43018, 43100, 43101, 43101.5, 43102, 43103, 43104, 43105, 43106, 43107, 43204-43205.5, Health and Safety Code.

PROPOSED

State of California
AIR RESOURCES BOARD

CALIFORNIA EXHAUST EMISSION STANDARDS AND TEST PROCEDURES FOR 1988 AND SUBSEQUENT MODEL PASSENGER CARS, LIGHT-DUTY TRUCKS, AND MEDIUM-DUTY VEHICLES

Adopted: May 20, 1987
Amended: December 20, 1989
Amended: January 22, 1990
Amended: December 26, 1990
Amended: July 12, 1991
Amended: [INSERT]

NOTE: Unless otherwise indicated, amendments to the standards and test procedures originally proposed in this rulemaking are shown in underline to indicate additions to the text and ~~strikeout~~ to indicate deletions. Modifications to the originally-noticed text are indicated in double-underline and slash out to represent additions and deletions, respectively.

The numbering convention employed in this document, in order of priority, is: 1.a.1.i.A. Any references within specific sections in the Code of Federal Regulations are denoted in order of priority as: (a)(1)(i)(A) - the same numbering system employed in the Code of Federal Regulations.

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Appendices

CALIFORNIA EXHAUST EMISSION STANDARDS AND TEST PROCEDURES FOR 1988 AND SUBSEQUENT MODEL PASSENGER CARS, LIGHT-DUTY TRUCKS AND MEDIUM-DUTY VEHICLES

The provisions of Subparts A and B, Part 86, Title 40, Code of Federal Regulations as set forth in Appendix I, to the extent they pertain to Passenger Cars, Light-Duty Trucks and Medium-Duty Vehicles, are hereby adopted as the California Exhaust Emission Standards and Test Procedures for 1988 and Subsequent Model Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles, with the following exceptions and additions.

1. Applicability

   [No Change]

2. Definitions

   [No Change from Originally Noticed Text]

3. Standards

   [No Change from Originally Noticed Text]

4. Initial Requirements

   [No Change]

5. Maintenance Requirements

   [No Change]

6. Demonstrating Compliance

   [No Change]

7. Small-Volume Manufacturer's Certification Procedures

   [No Change]

8. Alternative Procedures for Notification of Additions and Changes

   [No Change]

9. Test Requirements

   [No Change]

10. Optional 100,000 Mile Certification Procedure

[No Change]

11. Additional Requirements

[No Change]

12. Identification of New Clean Fuels to be Used in Certification Testing

[No Change]

13. Reactivity Adjustment Factors

For the purpose of complying with the NMOG exhaust emission standards in Section 1960.1, Title 13, California Code of Regulations, the mass of NMOG emissions from a vehicle certified to operate on a fuel other than conventional gasoline, including fuel-flexible and dual-fuel vehicles when operated on a fuel other than conventional gasoline, shall be multiplied by the reactivity adjustment factor applicable to the vehicle emission control technology category and fuel. The product of the NMOG mass emission value and the reactivity adjustment factor shall be compared to the NMOG exhaust emission standards to determine compliance with the standards.

(a.) The following reactivity adjustment factors have been established pursuant to the criteria in Appendix VIII of these test procedures:

(1.) Passenger cars and light-duty trucks 0-5750 lbs. LVW

Vehicle Emission Control Technology Category	Fuel	Reactivity Adjustment Factor
1993 and subsequent model-year TLEVs	85% methanol, 15% gasoline blends	~~0.36~~ 0.41
~~1993 and subsequent model-year TLEVs~~	~~compressed natural gas~~	~~0.18~~
~~1993 and subsequent model-year TLEVs~~	~~liquified petroleum gas~~	~~0.50~~

(b.) The Executive Officer may establish by executive order new reactivity adjustment factors pursuant to Appendix VIII of these test procedures in addition to those listed in Section 13.(a).

The Executive Officer shall notify manufacturers in writing of the new reactivity adjustment factors within 30 days of their establishment.

(c.) The Executive Officer may revise any reactivity adjustment factor listed in Section 13.(a). or established by the Executive Officer pursuant to Appendix VIII of these test procedures if he or she determines that the revised reactivity adjustment factor is more representative of the ozone-forming potential of vehicle NMOG emissions based on the best available scientific knowledge and sound engineering judgement. The Executive Officer shall notify manufacturers in writing of any such reactivity adjustment factor at least 3 years prior to January 1 of the calendar year which has the same numerical designation as the model year for which the revised reactivity adjustment factor first becomes effective. However, manufacturers may use the revised reactivity adjustment factor in certifying any new engine family whose certification application is submitted following such notification, if they so choose. Manufacturers may also continue to use the original reactivity adjustment factor for any existing engine family previously certified with that reactivity adjustment factor until a new durability data vehicle is tested for that engine family.

(d.) Manufacturers may request the use of a unique reactivity adjustment factor for ~~unique to~~ a specific vehicle emission control technology category and fuel. The Executive Officer shall approve such requests in accordance with the conditions and procedures of Appendix VIII of these test procedures. For the purpose of calculating the reactivity adjustment factor as specified in Appendix VIII, the 'g ozone potential per g NMOG' value for the vehicle emission control technology category and fuel system for which the manufacturer is requesting the use of a~~n~~ unique reactivity adjustment factor shall be divided by the 'g ozone potential per g NMOG' value for a conventional gasoline-fueled vehicle established for the vehicle emission control technology category. The following 'g ozone potential per g NMOG' values for conventional gasoline-fueled vehicle emission control technology categories have been established:

(1.) Passenger cars and light-duty trucks 0-5750 lbs. LVW

Vehicle Emission Control Technology Category	'g ozone potential per g NMOG' for conventional gasoline
All TLEVs	~~3.44~~ 3.42

Appendix I through VII

[No Change]

APPENDIX VIII

Procedure for Determining Vehicle Emission Control Technology Category/Fuel Reactivity Adjustment Factors

The following procedure shall be used by the Executive Officer to establish ~~determine~~ the reactivity adjustment factor for exhaust emissions of non-methane organic gases (NMOG), for the purpose of certifying a vehicle of specific emission control technology category and fuel for sale in California. The NMOG emissions from Transitional Low-Emission Vehicles (TLEVs), Low-Emission Vehicles (LEVs), and Ultra-Low-Emission Vehicles (ULEVs) designed to operate on any available fuel other than conventional gasoline, including fuel-flexible and dual-fuel vehicles when operating on any available fuel other than conventional gasoline, shall be numerically-adjusted to establish a NMOG exhaust mass emission value ~~level~~ equivalent, in terms of ozone-forming potential, to the NMOG exhaust mass emissions from a conventional gasoline-fueled vehicles of the same vehicle emission control technology category.

(1) The Executive Officer shall determine the representative speciated NMOG exhaust emission profile for all light- and medium-duty conventional gasoline-fueled TLEVs, LEVs, and ULEVs according to the following conditions.

a. All testing will be conducted using a specified gasoline blend representative of commercial gasoline.

b. The speciated NMOG profile shall be calculated from a statistically valid number of TLEVs, LEVs, and ULEVs.

c. The speciated NMOG profile shall identify and quantify as many constituents as possible, such that a minimum of 95% of the total g/mile of NMOG emissions measured is accounted for, and shall be provided in units of g/mile or mg/mile.

d. The speciated NMOG profile shall include at a minimum, the g/mile NMOG emission values of all oxygenated organic gases containing five or fewer carbon atoms (i.e., aldehydes, ketones, alcohols, ethers, etc.), and all known alkanes, alkenes, alkynes and aromatics containing twelve or fewer carbon atoms.

(2) The 'g ozone potential per mile' of each NMOG identified in the speciated profile shall be determined by multiplying the 'g/mile NMOG' emission value of the constituent NMOG by its maximum incremental reactivity given in step (9).

(3) The 'total g ozone potential per mile' of NMOG exhaust emissions from the vehicle/fuel system shall be the sum of all the constituent NMOG 'g ozone potential per mile' values calculated in step (2).

(4) The 'g ozone potential per g NMOG' for the vehicle/fuel system shall be determined by dividing the 'total g ozone potential per mile' value calculated in step (3) by the 'total g/mile of NMOG emissions'.

(5) For light- and medium-duty candidate vehicle/fuel systems not powered by conventional gasoline, the Executive Officer shall establish 'reactivity adjustment factors' calculated from exhaust emission profiles derived ~~by~~ according to the same conditions specified in parts b, c, and d of step (1).

(6) The 'g ozone potential per g NMOG' for candidate vehicle/fuel systems not powered by conventional gasoline shall be determined according to steps (2), (3), and (4).

(7) The candidate vehicle/fuel 'reactivity adjustment factor' shall be determined by dividing the 'g ozone potential per g NMOG' calculated in step (6) by the 'g ozone potential per g NMOG' value for the vehicle in the same emission control technology category operated on the specified conventional gasoline blend. The 'g ozone potential per g NMOG' values for conventional gasoline vehicles are listed in Section 13.d. of these test procedures or shall be established by the Executive Officer pursuant to Appendix VIII of these test procedures. For candidate vehicle/fuel systems powered by methanol or liquified petroleum gas, the quotient calculated above shall be multiplied by 1.1. The resulting value shall constitute the 'reactivity adjustment factor' for the methanol or liquified petroleum gas-powered vehicle/fuel system.

(8) The Executive Officer shall assign a reactivity adjustment factor unique to a specific engine family ~~vehicle/fuel system~~ at the request of a vehicle manufacturer provided that each of the following occurs:

a. The manufacturer submits ~~a~~ speciated NMOG exhaust emission profiles to the Executive Officer ~~averaged~~ obtained from emission testings of a minimum of four ~~statistically valid number of~~ different vehicles representative of vehicles that will be certified in the engine family ~~utilizing the same emission control technology and fuel~~. The test vehicles shall include the official emission data vehicle(s) for the engine family, and the mileage accumulation of each vehicle shall be at or greater than 4,000 miles. One speciated profile shall be submitted for each test vehicle. Emission levels of each constituent NMOG shall be measured according to the "California Non-Methane Organic Gas Test Procedures" as adopted July 12, 1991. For the emission data vehicle(s), the speciated profile(s) shall be obtained from the same test used to obtain the official exhaust emission test results for the emission data vehicle at the 4,000 mile test point. The manufacturer shall calculate 'g ozone potential per g NMOG' values for each speciated NMOG exhaust emission profile in accordance with the procedures specified in steps (2), (3), and (4) above. By using these 'g ozone potential per g NMOG' values, the manufacturer shall calculate an 'undeteriorated reactivity adjustment factor' for each test vehicle in accordance with the procedure for calculating the 'reactivity adjustment factor' specified in step (7) above. An 'undeteriorated reactivity adjustment factor' for the engine family shall be calculated by taking the arithmetic mean of the 'undeteriorated reactivity adjustment factors' obtained for each test vehicle. The 95 percent upper confidence bound (95% UCB) shall be calculated according to the equation:

$$95\%\ UCB = RAF_m + 1.96 \times [\sum_{i=1}^{n}(RAF_i - RAF_m)^2 / (n-1)]^{1/2}$$

where RAF_m = mean 'undeteriorated reactivity adjustment factor' calculated for the engine family

RAF_i = 'undeteriorated reactivity adjustment factor' calculated for the ith test vehicle

n = number of test vehicles

The 95 percent upper confidence bound of the 'undeteriorated reactivity adjustment factor' for the engine family shall be less than or equal to 115 percent of the engine family 'undeteriorated reactivity adjustment factor.'

b. The manufacturer submits a 'reactivity deterioration factor' for the 'undeteriorated reactivity adjustment factor' calculated for the engine family. To determine the 'reactivity deterioration factor', the manufacturer shall perform two tests at each mileage interval for one or more durability vehicle(s) tested in accordance with the procedures and conditions specified in Section 6 of these test procedures. The Executive shall approve the use of other mileage intervals and procedures if the manufacturer can demonstrate that equivalently representative 'reactivity deterioration factors' are obtained.

One speciated profile shall be submitted for each test. Emission levels of each constituent NMOG shall be measured according to the "California Non-Methane Organic Gas Test Procedures" as adopted July 12, 1991. A mean 'undeteriorated 'reactivity adjustment factor' shall be calculated at each mileage interval by taking the arithmetic mean of the 'undeteriorated reactivity adjustment factors' calculated from the speciated profiles obtained at that mileage interval. The 'reactivity deterioration factor' shall be calculated in accordance with the procedures in Section 6 of these test procedures except that the mean 'undeteriorated reactivity adjustment factor' determined at each mileage interval shall be used in place of measured mass emissions. If the 'reactivity deterioration factor' is determined to be less than 1.00, the 'reactivity deterioration factor' shall be assigned a value of 1.00. The 'reactivity deterioration factor' shall be multiplied to the mean 'undeteriorated reactivity adjustment factor' for the engine family to obtain the 'reactivity adjustment factor' used to determine compliance with the NMOG emission standards. ~~The 'reactivity adjustment factor' calculated from the 'g ozone potential per g NMOG' value determined from the aforementioned speciated profile differs from the 'reactivity adjustment factor' calculated by the Executive Officer for vehicles of the same or similar emission control technology and fuel by 25% or more.~~

c. The speciated profiles, mean 'undeteriorated reactivity adjustment factor' for the engine family, and 'reactivity deterioration factor' are ~~is~~ provided to the Executive Officer ~~two years prior to~~ with the certification application for the engine family ~~of the vehicle~~.

(9) Table of ~~(draft)~~ maximum incremental reactivities to be used in step (2):[1]

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1. For this table only, additions to the originally-noticed text are indicated in double-underline, and deletions are indicated in ~~strike-out~~. Deletions made as part of the originally-noticed text, which are shown on pages 11 - 13, are also indicated in ~~strike-out~~.

NMOG Constituent	Maximum Incremental Reactivity ($g\ O_3/g$ NMOG)	
ALKANES		
Normal Alkanes		
Methane	0.0148	
Ethane	~~0.26~~	0.25
Propane	0.48	
n-Butane	1.02	
n-Pentane	~~1.03~~	1.04
n-Hexane	0.98	
n-Heptane	0.81	
n-Octane	0.61	
n-Nonane	0.54	
n-Decane	0.47	
n-Undecane	0.42	
n-Dodecane	0.38	
n-Tridecane	0.35	
n-Tetradecane	0.32	
n-Pentadecane	0.29	

NMOG Constituent	Maximum Incremental Reactivity ($g\ O_3/g$ NMOG)	
Branched Alkanes		
2.2-Dimethylhexane	1.20	
2.3-Dimethylhexane	~~1.31~~	1.32
2.4-Dimethylhexane	1.50	
2.5-Dimethylhexane	1.63	
3.3-Dimethylhexane	1.20	
2-Methylheptane	0.96	
3-Methylheptane	0.99	
4-Methylheptane	1.20	
2.4-Dimethylheptane	~~1.33~~	1.34
2.2.5-Trimethylhexane	0.97	
Other Branched C9H20 Alkanes	~~1.13~~	1.14
Branched C10H22 Alkanes	1.01	
Branched C11 Alkanes	1.17	
Branched C12 Alkanes	1.23	

NMOG Constituent	Maximum Incremental Reactivity ($g\ O_3/g$ NMOG)	
Branched Alkanes		
2-Methylpropane	1.21	
2.2-Dimethylpropane	0.37	
2-Methylbutane	1.38	
2.2-Dimethylbutane	0.82	
2.3-Dimethylbutane	1.07	
2-Methylpentane	1.53	
3-Methylpentane	1.52	
2.2.3-Trimethylbutane	1.32	
2.2-Dimethylpentane	1.40	
2.3-Dimethylpentane	1.51	
2.4-Dimethylpentane	1.78	
3.3-Dimethylpentane	0.71	
2-Methylhexane	1.08	
3-Methylhexane	1.40	
2.2.4-Trimethylpentane	~~0.87~~	0.93
2.3.3-Trimethylpentane	1.20	
2.3.4-Trimethylpentane	1.60	

NMOG Constituent	Maximum Incremental Reactivity ($g\ O_3/g$ NMOG)	
Cyclo Alkanes		
Cyclopentane	~~2.37~~	2.38
Methylcyclopentane	2.82	
Cyclohexane	1.28	
t-1.2-Dimethylcyclopentane	1.85	
1.3-Dimethylcyclopentanes	~~2.54~~	2.55
Methylcyclohexane	~~1.84~~	1.85
Ethylcyclopentane	2.31	
Ethylmethylcyclopentane	1.94	
1c.2t-3-Trimethylcyclopentane	1.94	
1.2.4-Trimethylcyclopentane	1.94	
Dimethylcyclohexanes	1.94	
Ethylcyclohexane	1.94	
Ethylmethylcyclohexane	2.30	
Trimethylcyclohexane	2.30	
C10 Cycloalkanes	1.78	
C11 Cycloalkanes	1.91	
C12 Cycloalkanes	1.68	

NMOG Constituent	Maximum Incremental Reactivity (g O_3/g NMOG)	
ALKENES		
Ethene	~~7.28~~	7.29
Propene	~~9.39~~	9.40
1-Butene	~~8.90~~	8.91
2-Butenes	~~9.93~~	9.94
2-Methylpropene	~~5.29~~	5.31
1-Pentene	6.22	
2-Pentenes	~~8.79~~	8.80
2-Methyl-1-Butene	~~4.89~~	4.90
3-Methyl-1-Butene	6.22	
2-Methyl-2-Butene	~~6.40~~	6.41
1-Hexene	~~4.41~~	4.42
2-Hexenes	~~6.67~~	6.69
3-Hexenes	~~6.67~~	6.69
Methyl-1-Pentenes	~~4.41~~	4.42
Methyl-2-Pentenes	~~6.67~~	6.69
3.3-Dimethyl-1-Butene	~~4.41~~	4.42
1-Heptene	3.48	
2-Heptenes	~~5.52~~	5.53
3-Heptenes	~~5.52~~	5.53
3-Ethyl-2-Pentenes	~~5.52~~	5.53
2.3-Dimethyl-2-Pentene	~~5.52~~	5.53
3-Methyl-1-Hexene	3.48	
2-Methyl-2-Hexenes	~~5.52~~	5.53
4-Methyl-2-Hexene	5.53	
2-Methyl-3-Hexene	5.53	
3-Methyl-3-Hexenes	~~5.52~~	5.53
1-Octene	~~2.68~~	2.69
2-Octenes	~~5.27~~	5.29
3-Octenes	~~5.27~~	5.29
4-Octenes	~~5.27~~	5.29
2.4.4-Trimethyl-1-Pentene	~~2.68~~	2.69
2.4.4-Trimethyl-2-Pentene	5.29	
1-Nonene	~~2.22~~	2.23

NMOG Constituent	Maximum Incremental Reactivity (g O_3/g NMOG)	
Propadiene	~~7.28~~	7.29
1.3-Butadiene	~~10.88~~	10.89
2-Methyl-1.3-Butadiene	~~9.07~~	9.08
Cyclopentadiene	~~7.65~~	7.66
Cyclopentene	~~7.65~~	7.66
1-Methylcyclopentene	5.67	
3-Methylcyclopentene	~~5.66~~	5.67
Cyclohexene	~~5.66~~	5.67
a-Pinene	3.28	
b-Pinene	4.41	
ALKYNES		
Ethyne	~~0.51~~	0.50
Propyne	4.10	
1-Butyne	~~9.23~~	9.24
2-Butyne	~~9.23~~	9.24

NMOG Constituent	Maximum Incremental Reactivity ($g\ O_3/g$ NMOG)	
AROMATIC HYDROCARBONS		
Benzene	0.42	
Toluene	~~2.72~~	2.73
Ethylbenzene	~~2.90~~	2.70
o-Xylene	~~6.68~~	6.46
~~m&p-Xylenes~~	~~8.15~~	
m-Xylene	8.16	
p-Xylene	6.60	
n-Propylbenzene	~~2.27~~	2.12
i-Propylbenzene	~~2.41~~	2.24
Methylethylbenzenes	7.20	
1,2,3-Trimethylbenzene	~~8.61~~	8.85
1,2,4-Trimethylbenzene	~~8.69~~	8.83
1,3,5-Trimethylbenzene	~~10.11~~	10.12
n-Butylbenzene	1.87	
s-Butylbenzene	~~2.04~~	1.89
Diethylbenzenes	~~6.44~~	6.45
1-Methyl-2-Propylbenzene	6.45	
1-Methyl-3-Propylbenzene	6.45	
C10 Trialkyl Benzenes	9.07	
Tetramethylbenzenes	~~9.05~~	9.07
C11 Monoalkyl Benzenes	1.70	
1-Methyl-4-Isobutylbenzene	~~6.83~~	5.84
C11 Dialkyl Benzenes	5.84	
C11 Trialkyl Benzenes	8.21	
C12 Monoalkyl Benzenes	1.55	
C12 Dialkyl Benzenes	5.34	
C12 Trialkyl Benzenes	7.50	
Indan (C9H10)	~~1.04~~	1.06
Methyl Indan	1.06	
Napthalene	~~1.16~~	1.18
Tetralin	0.95	
Methyl Naphthalenes	3.27	
2,3-Dimethyl Naphthalene	5.13	
Styrene	~~2.20~~	2.22
AROMATIC OXYGENATES		
Phenol	1.13	
Cresols	2.31	
Benzaldehyde	~~-0.56~~	-0.55
p-Tolualdehyde	~~-0.56~~	3.32

NMOG Constituent	Maximum Incremental Reactivity ($g\ O_3/g$ NMOG)	
OXYGENATES		
Alcohols		
Methanol	0.56	
Ethanol	~~1.33~~	1.34
n-Propyl Alcohol	2.26	
Isopropyl Alcohol	0.54	
n-Butyl Alcohol	2.69	
Isobutyl Alcohol	1.92	
t-Butyl Alcohol	0.42	
Aldehydes		
Formaldehyde	~~7.14~~	7.15
Acetaldehyde	~~5.51~~	5.52
Propionaldyde	6.53	
Acrolein	~~6.76~~	6.77
n-Butyraldehyde	5.26	
Crotonaldehyde	~~5.41~~	5.42
Pentanaldehyde	~~4.40~~	4.41
Hexanaldehyde	3.79	
C7 Aldehydes	3.32	
Ethers		
Methyl t-Butyl Ether	0.62	
Ethyl t-Butyl Ether	1.98	
Ketones		
Acetone	0.56	
Butanone	1.18	

NMOG Constituent	Maximum Incremental Reactivity ($g\ O_3/g$ NMOG)
Alkanes	
Methane	0.0102
Ethane	0.147
Propane	0.33
n-Butane	0.64
n-Pentane	0.64
n-Hexane	0.61
n-Heptane	0.48
n-Octane	0.41
n-Nonane	0.29
n-Decane	0.25
n-Undecane	0.21
n-Dodecane	0.19
n-Tridecane	0.17
n-Tetradecane	0.16
n-Pentadecane	0.144
Isobutane	0.85
Lumped C4-C5 Alkanes	0.78
Branched C5 Alkanes	0.88
Iso-Pentane	0.88
Neopentane	0.19
2-Methylpentane	0.91
3-Methylpentane	0.95
Branched C6 Alkanes	0.91
2,3-Dimethyl Butane	0.74
2,2-Dimethyl Butane	0.41
Lumped C6+ Alkanes	0.70
2,4-Dimethyl Pentane	1.07
3-Methyl Hexane	0.85
4-Methyl Hexane	0.85

NMOG Constituent	Maximum Incremental Reactivity ($g\ O_3/g$ NMOG)
Branched C7 Alkanes	0.85
2,3-Dimethyl Pentane	0.96
Iso-Octane	0.70
4-Methyl Heptane	0.72
Branched C8 Alkanes	0.72
Branched C9 Alkanes	0.68
4-Ethyl Heptane	0.68
Branched C10 Alkanes	0.60
4-Propyl Heptane	0.60
Branched C11 Alkanes	0.72
Branched C12 Alkanes	0.75
Branched C13 Alkanes	0.57
Branched C14 Alkanes	0.44
Branched C15 Alkanes	0.41
Cyclopentane	1.6
Methylcyclopentane	1.7
C6 Cycloalkanes	0.84
Cyclohexane	0.84
C7 Cycloalkanes	1.17
Methylcyclohexane	1.17
Ethylcyclohexane	1.36
C8 Cycloalkanes	1.36
C9 Cycloalkanes	1.6
C10 Cycloalkanes	1.31
C11 Cycloalkanes	1.23
C12 Cycloalkanes	1.20
C13 Cycloalkanes	0.94
C14 Cycloalkanes	0.88
C15 Cycloalkanes	0.85

NMOG Constituent	Maximum Incremental Reactivity (g O_3/g NMOG)
Alkenes	
Ethene	5.3
Propene	6.6
1-Butene	6.1
1-Pentene	4.2
3-Methyl-1-Butene	4.2
1-Hexene	3.0
C6 Terminal Alkenes	3.0
C7 Terminal Alkenes	2.4
C8 Terminal Alkenes	1.9
C9 Terminal Alkenes	1.6
C10 Terminal Alkenes	1.32
C11 Terminal Alkenes	1.15
C12 Terminal Alkenes	1.03
C13 Terminal Alkenes	0.93
C14 Terminal Alkenes	0.86
C15 Terminal Alkenes	0.80
Isobutene	4.2
2-Methyl-1-Butene	3.7
trans-2-Butene	7.3
cis-2-Butene	7.3
2-Methyl-2-Butene	5.0
C5 Internal Alkenes	6.2
2,3-Dimethyl-2-Butene	3.7
C6 Internal Alkenes	5.3
C7 Internal Alkenes	4.4
C8 Internal Alkenes	3.6
C9 Internal Alkenes	3.2
C10 Internal Alkenes	2.8
C11 Internal Alkenes	2.5
C12 Internal Alkenes	2.3
C13 Internal Alkenes	2.1
C14 Internal Alkenes	1.9
C15 Internal Alkenes	1.8
1,3-Butadiene	7.7
Isoprene	6.5
Cyclopentene	4.0
Cyclohexene	3.3
a-Pinene	1.9
b-Pinene	1.9

NMOG Constituent	Maximum Incremental Reactivity (g O_3/g NMOG
1,3,5-Trimethyl Benzene	7.5
1,2,3-Trimethyl Benzene	7.4
1,2,4-Trimethyl Benzene	7.4
C10 Trialkyl Benzenes	6.7
C11 Trialkyl Benzenes	6.1
C12 Trialkyl Benzenes	5.6
Tetralin	0.73
Naphthalene	0.87
Methyl Naphthalene	2.4
2,3-Dimethyl Naphthalene	3.7
Alkynes	
Acetylene	0.37
Alcohols	
Methanol	0.40
Ethanol	0.79
n-Propyl Alcohol	1.33
Isopropyl Alcohol	0.37
Isobutyl Alcohol	0.72
n-Butyl Alcohol	1.6
t-Butyl Alcohol	0.29
Ethylene Glycol	1.13
Propylene Glycol	0.92
Aldehydes	
Formaldehyde	6.2
Acetaldehyde	3.8
Propionaldehyde	4.6
Ketones	
Acetone	0.39
C4 Ketones	0.76
Aromatic Oxygenates	
Benzaldehyde	- 0.54
Phenol	0.79
Cresols	1.6

NMOG Constituent	Maximum Incremental Reactivity $(g\ O_3/g\ NMOG)$
Aromatic Hydrocarbons	
Benzene	0.28
Toluene	1.9
Ethyl Benzene	1.9
n-Propyl Benzene	1.44
Isopropyl Benzene	1.5
s-Butyl Benzene	1.29
C10 Monoalkyl Benzenes	1.28
C11 Monoalkyl Benzenes	1.16
C12 Monoalkyl Benzenes	1.06
m-Xylene	6.0
o-Xylene	5.2
p-Xylene	5.2
C9 Dialkyl Benzenes	5.3
C10 Dialkyl Benzenes	4.8
C11 Dialkyl Benzenes	4.3
C12 Dialkyl Benzenes	3.9

NMOG Constituent	Maximum Incremental Reactivity $(g\ O_3/g\ NMOG)$
Ethers	
Methyl t-Butyl Ether	0.47
Ethyl t-Butyl Ether	1.33

ATTACHMENT III

A. "Development and Evaluation of Ozone Reactivity Scale for Low-Emission Vehicles and Clean Fuels Regulations"

B. Speciated emission data from testing of CNG vehicles

Development and Evaluation of Ozone Reactivity Scale for Low-Emission Vehicles and Clean Fuels Regulations

California Air Resources Board
Research Division

April 2, 1992

I. Summary

On September 27, 1990, the California Air Resources Board (ARB or Board) adopted the Low-Emission Vehicles and Clean Fuels (LEV/CF) regulations applicable to light- and medium-duty vehicles (ARB 1990, 1991a). The regulations are "fuel neutral" in that all alternatively-fueled vehicles can compete in the marketplace as long as they meet nonmethane organic gas (NMOG) exhaust emission standards equivalent or lower in ozone forming potential, or "reactivity", as those set for vehicles fueled with conventional gasoline. Reactivity adjustment factors (RAFs) appear to be the only way to assure fair and equitable treatment for both manufacturers of motor vehicles and for producers of gasoline and all cleaner burning fuels. The exhaust compositions of most alternatively-fueled vehicles are too different from conventional gasoline-fueled vehicles to assume that they have the same ozone-forming potential per unit of mass emissions.

The Board adopted the maximum incremental reactivity (MIR) scale, developed by Dr. William Carter (1991), for calculation of the RAFs. The principal advantage of this scale is that it defines reactivity in areas where hydrocarbon control has its greatest benefits, the upwind areas where the highest emission densities are found. This is complementary to California's NO_x control program, which has its greatest benefits in the downwind, peak ozone areas. Even though all hydrocarbons eventually react, there is little to be gained in designing a reactivity scale that is applicable only to areas where hydrocarbon control has little or no benefit in reducing ambient ozone levels. More advantages of the MIR scale over other approaches include the ease of RAF calculations, a single scale for use in the statewide regulations, and a framework that can easily incorporate chemical mechanism updates.

Several ARB and industry-sponsored reviews of the MIR approach over the past year, including the Reactivity Conference in Irvine, California in April 1991 (Croes et al. 1992) and four meetings of the ad hoc Reactivity Advisory Panel, revealed that the atmospheric chemists and modelers were not in unanimous agreement on the underlying science of a reactivity scale. On the other hand, the regulators made it clear that, given the frequency and magnitude of violations of the air quality standards, regulations will move ahead even without full resolution of all the scientific issues, provided that there is no demonstration that there is a fatal flaw in doing so. Uncertainties in the underlying science have always been present in the move toward solutions to environmental problems. The key issue is not that there are uncertainties, but how much they contribute to uncertainties in outcomes. The approach of the ARB staff and Carter was to

gauge the effect of these uncertainties on the RAFs for the alternative fuels of interest. The results are encouraging.

While significant uncertainties remain in our understanding of atmospheric chemistry, the RAFs for several alternative fuels changed by less than 10% in sensitivity studies of the effect of the last three years of chemical mechanism development. The RAFs are also relatively insensitive to uncertainties in the representation of airshed conditions used in the derivation of the MIR scale.

Professor Armistead Russell evaluated the MIR scale with the Southern California Air Quality Study (SCAQS) database and other modeling applications (McNair et al. 1992). He found very good agreement for individual hydrocarbons, but noted some deviations (less than 10%) from the equal ozone impacts for any vehicle/fuel combination required by the regulations. These deviations are more likely due to differences in spatial and temporal patterns of emissions between vehicle fleets, rather than a problem with the MIR approach. The only formally adopted RAF to date, a value of 0.41 for 85% methanol/15% gasoline (M85)-fueled vehicles, includes a 10% increase based on the airshed modeling.

For the long term, the Board will continue to sponsor laboratory studies and chemical mechanism development to reduce uncertainties in the MIR scale still further, particularly for aromatic hydrocarbons, and to review research sponsored by other organizations. The Board plans to update the MIR scale every three years.

The following section provides background information on the reactivity-based motor vehicle standards. The next section summarizes the key technical issues that Dr. Carter and the ARB staff resolved over the past year. The final section describes Professor Russell's evaluation of the MIR approach with airshed modeling.

II. Background

The LEV/CF regulations include a reactivity adjustment to encourage the use of cleaner burning fuels while avoiding a fuel mandate. This establishes the so-called "level playing field".

A. Low-Emission Vehicles and Clean Fuels Regulations

The regulations adopted by the Board establish increasingly stringent vehicle certification standards for emissions of hydrocarbons, NO_x, carbon monoxide (CO) and formaldehyde (HCHO). Hydrocarbon emission standards are redefined in terms of nonmethane organic gases (NMOG), requiring the measurement of aldehydes, alcohols and other oxygenated compounds in addition to NMHC. A unique feature of the regulations are the use of a RAF to normalize the mass of NMOG emissions according to its ozone-forming potential. The determination of the RAF is based on complete speciation of the exhaust and conversion of each NMOG component to an appropriate mass of ozone using the MIR scale. Transitional-Low Emission Vehicles (TLEV), Low Emission Vehicles (LEV), Ultra-Low Emission Vehicles (ULEV) and Zero Emission Vehicles (ZEV) would certify at 50,000 miles to the standards presented in Table I. Standards at 100,000 miles are slightly higher.

Table I Low-Emission Vehicle exhaust emission standards for passenger cars at 50,000 miles.

Vehicle Category	Grams/Mile by Pollutant			
	NMOG[a]	NO_x	CO	HCHO
Current	0.390	0.4	7.0	none
1993	0.250	0.4	3.4	0.015[b]
TLEV	0.125	0.4	3.4	0.015
LEV	0.075	0.2	3.4	0.015
ULEV	0.040	0.2	1.7	0.008
ZEV[c]	0.000	0.0	0.0	0.000

[a]NMHC for current and 1993 standards, NMOG with reactivity adjustment for others.
[b]Methanol-fueled vehicles only.
[c]Does not include power generation emissions.

The regulations require vehicle manufacturers to meet fleet average NMOG standards that begin at 0.250 grams/mile in 1994 and are progressively reduced to a level of 0.062 grams/mile in 2003. Any combination of TLEV, LEV, ULEV, ZEV and 1993 conventional vehicles can be used to meet the fleet average standards. A separate requirement for the production of small percentages of ZEV begins in 1998. It is entirely up to the vehicle manufacturers whether to build cars fueled with alternative fuels or not. The manufacturers also receive a reactivity credit for California's reformulated gasoline specifications, called Phase II gasoline, that goes into effect in 1994.

B. Reactivity Adjustment

The Low-Emission Vehicles and Clean Fuels regulations use reactivity adjustments to encourage the use of cleaner burning fuels without mandating any particular fuel. Reactivity credits appear to be the only way to assure fair and equitable treatment for both manufacturers of motor vehicles and for producers of all cleaner burning fuels. The exhausts of most alternatively-fueled vehicles are too different from conventional gasoline-fueled vehicles to assume that they have the same ozone-forming potential per unit of mass emissions.

The downside in all this is readily apparent: first, determining a universal reactivity scale is a matter of considerable complexity. Second, enforcing standards for a wide range of certified fuels and vehicle technologies may turn out to be an even more complex matter. Third, there have been virtually no studies of emission control system durability for newer technologies and the effect of catalyst aging on the reactivity of exhaust emissions.

The regulations use the MIR scale to define reactivity. The principal advantage of this scale is that it defines reactivity where hydrocarbon control has its greatest benefits, in the upwind areas where the highest emission densities are found. This is complementary to California's NO_x control program, which has its greatest benefit in the downwind, peak ozone areas. Even though all hydrocarbons eventually react, there is little to be gained in designing a reactivity scale that is applicable only to areas where hydrocarbon control has little or no benefit. More advantages of the MIR scale over other approaches are the ease of RAF calculations, a single scale for use in the statewide regulations, and a framework to easily incorporate chemical mechanism updates.

III. Technical Issues

Several ARB and industry-sponsored reviews of the MIR approach over the past year, including the Reactivity Conference in Irvine, California in April 1991 and six meetings of the ad hoc Reactivity Advisory Panel, identified a number of key technical issues related to the development of the reactivity scale.

A. Criteria Used in Deriving Reactivity Scales

Perhaps the most important objective of the work done over the past year has been to establish a general set of principles and criteria for reactivity assessment that can be used not only for calculation of the present scale, but for those in the future. Changes in the criteria used to derive the reactivity scale would be much more likely to cause large changes in the RAFs than advances in the knowledge of atmospheric chemistry or airshed conditions.

1. "Equal Air Quality" Criteria

The principle behind the RAF concept is that equal impacts on air quality will result from reactivity-adjusted emissions that just meet the emissions standard. But what is meant by "equal air quality"? Unless all vehicles emit exactly the same types of hydrocarbons, it is not possible to derive a single RAF that yields equal air quality impacts in all places at all times. A RAF determined so that two vehicles have equal impacts on peak ozone will, in general, be different from a RAF derived so that the vehicles have equal impacts on integrated ozone. Therefore, specific criteria of what is meant by "equal air quality" have been established. Since the main reason for regulating ozone is to reduce impacts on human health, medical experts, not atmospheric chemists or modelers, have determined these criteria.

Two questions need to be addressed in relation to setting "equal air quality" criteria for the ozone reactivity scale. First, which of several criteria should be used to judge "equal air quality" for the purpose of calculating reactivity scales? Second, how should the areas of ozone decreases and increases that result when two fuel/vehicle combinations are compared in the airshed model evaluation of the reactivity scale be weighted? The ARB health effects staff has consulted with other experts on ozone health and welfare effects studies, including staff from the Environmental Protection Agency (EPA). The ARB staff's conclusion is that both peak exposures and cumulative exposures are important. Since the national and California ambient air quality standards for ozone are not expected to change from the current form of one-hour peak exposure, and because the California one-hour standard is protective of cumulative exposures, the reactivity scales will be derived based on ozone peaks. The airshed model evaluation will demonstrate a successful reactivity scale when two fuel/vehicle combinations result in equal one-hour basin peak concentrations and equal ozone geographic dosage (in units of ppm-hours for all hours in all surface grid cells over land with absolute ozone concentrations above 0.09 ppm).

2. "Pollution Scenario" Criteria

The second major issue is the set of criteria used to establish which models for airshed conditions, or "pollution scenarios", are used to calculate the reactivity scale. The MIR scale was developed using the criteria that: (1) accurate representation of the chemical mechanism and the chemical environment is more important to reactivity calculations than accurate representations of physical characteristics of the scenarios; (2) that approximate representation of a wide variety of airshed conditions was more important than accurate representation of any single scenario; and (3) that the scenarios employed be those in which hydrocarbon emissions have the largest effect on ozone.

An alternative to the first two of these criteria is the principle of using scenarios that are as physically realistic as possible, i.e., using grid models. However, no one has proposed developing a complete reactivity scale based on grid model calculations, since separate simulations would be required for each of the more than one hundred hydrocarbons. It is not impractical, however, to derive RAFs for given vehicles using this method, which requires only direct calculations of reactivities of whole exhaust mixtures. It is more difficult to do this for a comprehensive variety of airshed conditions, since grid models are set up for only a limited number of scenarios. In addition, because of biases and uncertainties in emissions inventories, one has no real assurance that a grid model is any more accurate in representing chemical effects than the physically much simpler Empirical Kinetics Modeling Approach (EKMA). In fact, just the opposite could be the case. Given the uncertainty in emissions and representation of other airshed conditions, the ARB staff judged that the criterion of using a wide variety of scenarios be adopted.

3. Maximum Reactivity Criterion

The most controversial of the criteria underlying the MIR approach is the principle of basing the scale on airshed conditions where hydrocarbons have the greatest effect on ozone, i.e., the "maximum reactivity" criterion. The use of this criterion has been criticized because it means that reactivity scales are calculated for conditions where NO_x levels are higher than those where peak ozone levels occur. Many believe that alternatives, such as basing the scale on conditions where peak ozone levels occur or on averages of airshed conditions regardless of sensitivity of ozone levels to hydrocarbon controls, are more appropriate. The principle behind use of the maximum reactivity criterion is that, in California, the hydrocarbon controls are being implemented in conjunction with NO_x controls. NO_x controls are being implemented to reduce ozone under conditions that are sensitive to NO_x, and hydrocarbon controls to reduce ozone under conditions sensitive to hydrocarbons. The ARB staff believes that the maximum reactivity criterion is the most appropriate in this context. Even though all hydrocarbons eventually react, there is little to be gained in designing a reactivity scale that is applicable only to areas where hydrocarbon control has little or no benefit. This aspect has been missing in previous critiques of the MIR approach.

In addition to the MIR scale, Carter developed the maximum ozone reactivity (MOIR) scale for maximum ozone conditions. If this alternative had provided a better fit to the airshed modeling results than the MIR scale, the ARB staff would have recommended its use for calculating the RAFs.

B. Uncertainty in Understanding of Atmospheric Chemistry

Computer model calculations can be used to estimate hydrocarbon reactivities. The reliability of these calculations depends on the accuracy of the chemical mechanism used in the model. Atkinson (1990) has recently reviewed and discussed the status (as of mid-1989) of the knowledge of the atmospheric chemistry of organic gases. While there are numerous areas of uncertainty, major uncertainties concern the reaction mechanisms of alkanes with five or more carbon atoms and aromatic hydrocarbons with the hydroxyl radical, and of alkenes with ozone. The MIR and MOIR scales were calculated using the chemical mechanism developed by Carter (1990), commonly called the SAPRC90 mechanism. The mechanism includes measured or estimated rate constants and other mechanistic parameters for the more than one hundred organic gases that comprise the bulk of vehicle emissions, allowing their reactivities to be calculated. Detailed mechanisms for approximately twenty species have been tested against environmental chamber data. Even in these cases, there are many uncertainties concerning details of the individual reactions and products, and in some cases (particularly for aromatic hydrocarbons) empirical mechanisms with adjustable parameters have to be used to "fit" the environmental chamber data. The mechanisms for the other organic gases are based on interpolations and extrapolations from the mechanisms for the twenty well-studied species, or on estimates that rely on laboratory data and theoretical considerations.

The uncertainties in the chemical mechanisms do not have much effect on reactivity determinations for fuels whose emissions are dominated by a few species, such as ethene, methanol, or formaldehyde, with well-tested mechanisms. The major uncertainty concerns the reactivity of the conventional gasoline against which alternative fuels will be compared. One important benefit of the interest in reactivity-based hydrocarbon controls is that it has served as a catalyst for increased support of kinetic, product, and mechanistic studies by government agencies and industry research groups.

1. Comparison of SAPRC90 with Other Chemical Mechanisms

It was noted at the Reactivity Conference that SAPRC90 contains a number of estimates that are, in effect, Carter's "personal opinion", and that others have made different estimates. Only Derwent and Jenkin (1991) have made a comparable attempt to estimate the atmospheric reactions of a comprehensive set of hydrocarbon for the purpose of reactivity calculations. Their reactivity scale has significant differences from both the MIR and MOIR scales calculated using SAPRC90, but it is not clear if this is attributable to differences in the mechanisms or to differences in the airshed scenarios. All other current mechanisms, such as Carbon Bond IV (CB4), LCC (a 1987 predecessor of SAPRC90) and RADM-II, are condensed mechanisms designed primarily to simulate reactions of complete atmospheric mixtures, rather than for calculations of reactivities of individual hydrocarbons. They can, in principle, be used to calculate reactivities for any hydrocarbon for which "lumping" rules have been derived. But only reactivity calculations for species which they can represent without "lumping" can have a potential claim to chemical accuracy comparable to those of detailed mechanisms such as Carter's or Derwent's.

The CB4 and LCC are the only mechanisms that have been compared with SAPRC90 using the same scenarios. The CB4 reactivity scales showed many similarities and a few differences with those derived using SAPRC90, with the greatest differences being for toluene and formaldehyde reactivities under MOIR conditions. As shown on Table II, the differences between these two mechanisms in calculations of the RAF range from 0 to 8% for MIR conditions and 3 to 12% for MOIR conditions. The differences between SAPRC90 and LCC are even smaller.

Table II Effect of different chemical mechanisms on RAFs.

Fuel[a]	Reactivity Adjustment Factors					
	MIR			MOIR		
	SAPRC90 (1990)	CB4 (1990)	LCC[b] (1987)	SAPRC90 (1990)	CB4 (1990)	LCC[b] (1987)
Base	1.00	1.00	1.00	1.00	1.00	1.00
M85	0.37	0.39	0.37	0.39	0.40	0.38
LPG	0.50	0.54	0.50	0.59	0.66	0.60
CNG	0.18	0.18	0.17	0.23	0.22	0.22
E85	0.63	0.64	0.62	0.77	0.82	0.70

[a]Composite speciation profiles from vehicles that met the TLEV standards (ARB 1991b):
Base - U.S. industry average gasoline
M85 - 85% methanol/15% U.S. industry average gasoline blend
LPG - Liquefied petroleum gas
CNG - Compressed natural gas
E85 - 85% ethanol/15% U.S. industry average gasoline blend
(did not meet TLEV NMOG standard)
[b]Computed with surface photolysis rates. Others rates at 640 meters.

2. Peer Review of SAPRC90

The ARB staff considers SAPRC90 to be the most appropriate of the currently available mechanisms for calculating reactivity scales. Unlike Derwent's mechanism, it was tested as much as possible against environmental chamber data and, unlike CB4, LCC and RADM-II, it was specifically designed for calculating reactivities of individual organic gases. However, it was clear that the assumptions underlying SAPRC90 should undergo thorough peer review, and that a systematic estimate of effects of chemical uncertainties on its reactivity predictions be carried out. Dr. Michael Gery, a recognized expert in the field of atmospheric chemistry, was retained by ARB staff to review and critique SAPRC90. The review was done on two levels, theoretical and operational. The theoretical level review examined the principles and assumptions behind the mechanism. Gery focused on what was reasonable for Carter to have done, given the state of the science (i.e., considering the limitations in chemistry knowledge, environmental chamber data and the need for condensed mechanisms because of computer limitations). The operational level review was to assure that Carter had correctly translated his chemical mechanism into computer code.

In his peer review, Gery (1991) found that, while the mechanism was basically sound, there were several areas where updates would be desirable. Those characterized as "needed updates" included: (1) updates to the formaldehyde ultraviolet absorption cross sections; (2) updates to the rate constants involved in the peroxyacetyl nitrate (PAN) formation reactions; (3) re-examination of assumptions used in representing unknown portions of the aromatic mechanisms; (4) addition of several organic gases; and (5) fixes of several minor errors found in the program and data used to derive the mechanistic parameters for the alkanes.

The recommendations given lower priority included: (6) re-examination of assumptions used to derive nitrate yields from the alkanes; (7) use of measured OH radical rate constants for alkanes where available, rather than estimates; (8) re-examination of the method used to represent cycloalkenes; (9) re-examination of the method used to represent isoprene; (10) updates of several nitrate radical (NO_3) + alkene rate constants; and (11) update of products from the NO_3 + HO_2 reaction.

Gery had a number of other "significant concerns" regarding treatments of many areas of uncertainty in the mechanism where he might have made different assumptions, or where further work is clearly needed. However, he recognized that addressing these latter concerns is a longer term research need that cannot be addressed in this round of the RAF calculations, and recommended that the present effort be restricted to the priority items listed above.

3. Updates to SAPRC90

Carter concurs with most of Gery's recommendations, and will find his review of major utility when updating the mechanism in the coming years. Unfortunately, there was insufficient time to make all the modifications to the mechanism that Gery characterized as "needed updates" prior to the calculation of the RAFs. This is because major modifications of the mechanism which would significantly affect its predictions would require re-evaluation against the environmental chamber data used in the mechanism's development. In particular, it was found when the formaldehyde and PAN kinetics updates were incorporated, the mechanism exhibited a significant positive bias (on the order of 25%) in simulations of the chamber runs. This bias may be due to either the chemical mechanism or the representation of chamber conditions. An EPA-funded project, conducted by Professor Harvey Jeffries, with support from Carter, Gery and others, to review and evaluate the environmental chamber base was (and continues to be) well behind schedule, as was a component to develop a chemical mechanism evaluation protocol.

Based on the recommendations of Gery, Jeffries and other modeling experts on the ad hoc Reactivity Advisory Panel, it was decided that it would be more prudent to calculate the RAFs using a mechanism which has already been evaluated and documented in the refereed literature, rather than to make partial updates without time to adequately evaluate their effects. Therefore, the changes to the mechanism were restricted to only those affecting individual NMOG for which there is no significant evaluation data base. A major update to the SAPRC90 mechanism will not be completed before 1993 at the earliest, and will be used for the scheduled 1994 update to the reactivity scale. Concerns about the correctness of the mechanism are partially alleviated by the minor effect on the RAFs of previous major updates to the mechanism (see Table II).

It should be noted that there are a few cases where Carter disagreed with Gery's recommendations. Carter did not think it was advisable to make major changes to the representation of the uncertain portions of the aromatic mechanisms without incorporating new information concerning the effects of aromatic product yields on NO_x, and completely evaluating the consequences of these changes. There was insufficient time available to do this. In addition, Carter does not agree with Gery (and Jeffries) that the shape of the action spectrum used for the unknown products will necessarily introduce a bias into the simulations. These products probably include unsaturated carbonyl compounds, which may be similar in some respects to acrolein. Carter found that using the action spectrum for acrolein (with unit photodecomposition quantum yields) to represent those unknown products gives essentially the same results in simulating the environmental chamber data, including outdoor chamber runs, as the spectrum used in SAPRC90. Therefore, while the true action spectra for these products are unknown, Carter did not believe the representation in the present model needed to be updated before proceeding with the RAF calculations.

As noted above, Gery made a number of recommendations for updates for individual NMOG which could be implemented. Other updates not noted by Gery were also made. The errors in the alkane parameter calculation program were corrected, and the measured alkane + OH rate constants were used whenever available. Rate constants for the reactions of alkenes with NO_3, ozone, and $O(^3P)$ atoms were updated. (No significant updates were found to be needed for the alkene + OH reactions.) The representation of the ozone + cycloalkene reaction was corrected so the overall radical yield was assumed to be the same as for other internal alkenes. (The parameterization in the previous mechanism caused the fragmentation yield to be half as much as other alkenes, which is not what would be estimated.) Errors found by Gery concerning some of the higher alcohols were also corrected, although none of these are needed for the RAF calculations. A number of alkane and alkene species were added to the list of NMOG which could be separately represented. Therefore, although the common portions of the mechanism which affect reactivities of all NMOG were not significantly changed, there are a number of updates concerning reactions of individual NMOG.

4. Assessment of Effects of Chemical Uncertainties

The assessment of chemical uncertainties on a NMOG's reactivity can be aided by considering separately the uncertainties in a NMOG's "kinetic reactivity" and its "mechanistic reactivity". The kinetic reactivity of a NMOG is the fraction of emitted NMOG which undergoes reaction in the ozone episode; mechanistic reactivity is the amount of ozone formed when a given amount of the NMOG reacts. The kinetic reactivity is determined by rate constants for the NMOG's initial reactions in the atmosphere. The uncertainties in the kinetic reactivities are easy to quantify, since evaluations of kinetic data generally give uncertainty ranges for the measured values. Translating uncertainties in rate constants to uncertainties in kinetic reactivities is relatively straightforward, and can be done without having to explicitly recalculate all reactivities.

Determination of uncertainties in mechanistic reactivities is much more difficult, since it depends on a large number of parameters, environmental as well as mechanistic. Without carrying out a systematic evaluation of the effects of all these parameters (and making guesses as to their ranges of uncertainty), the only approach Carter could use was to make largely subjective estimates of likely uncertainty ranges. These are given in

Table III. These estimates are based in part on: (1) the estimated uncertainty ranges of parameters which are important in affecting mechanistic reactivity and the reactivities of "pure mechanism" species corresponding to these parameters (Carter and Atkinson, 1989); (2) sensitivity calculations on effects of alternative assumptions on mechanisms of the NMOG; (3) differences between mechanistic reactivities for CB4 and SAPRC90 for those species which CB4 represents explicitly; and (4) an arbitrarily assumed minimum uncertainty of 20% for all mechanistic reactivities of all NMOG. For some NMOG whose mechanistic reactivities are determined by combinations of mechanistic characteristics which have opposing effects on reactivity, such as the alkanes and the aromatic hydrocarbons under maximum ozone conditions, it is more meaningful to express uncertainties in terms of an absolute number of ozone per NMOG reacted, rather than a relative factor.

5. Updates to MIR Scale Every Three Years

Of course, assessing the uncertainties in SAPRC90 and comparing its predictions to other mechanisms will not solve the underlying problems causing these uncertainties. These can only be addressed by fundamental studies aimed at improving the knowledge of the atmospheric reactions of hydrocarbons, and environmental chamber experiments to test the models for these reactions. Research of this type is being sponsored by the Board and others, so the knowledge in these areas will continue to advance, and the mechanisms will improve accordingly. The ARB staff welcomes involvement by other interested parties in such research.

Because of the residual uncertainties in the chemical mechanisms, the reactivity scale will be subject to re-calculation at three-year intervals using the mechanism reflecting the current knowledge. It is expected that changes in the chemical mechanism alone will not greatly change the RAFs for vehicles whose emissions are dominated by a few species, such as ethene, methanol or formaldehyde, whose mechanisms are already well tested. However, industry must be prepared to anticipate and deal with the changes that may occur, since the Board intends to base all of its regulations on the best available kinetic and mechanistic data.

C. Representation of Airshed Conditions

1. EKMA Conditions

The EPA provided EKMA model inputs for the 1986 to 1988 ozone design values for thirty-nine cities across the United States (Baugues 1991). The initial NMHC and NO_x concentrations were based on the median of levels measured during all days exceeding 0.124 ppm or the top ten episodes if more than ten exceedances were measured during the NMHC sampling period. Ozone concentrations aloft were based on downwind measurements made just after the morning increase in the mixing height. Hourly emissions by county were obtained from the 1985 National Acid Precipitation Assessment Program inventory. These represent weekday emissions for the appropriate season of the year. Motor vehicle emissions were computed using MOBILE3.9 using seasonal activity levels, but annual-average temperature. Biogenic hydrocarbon emission estimates were also included. EPA is preparing an update with day-specific motor vehicle emissions (based on MOBILE4 with day-specific temperatures and county vehicle miles traveled), but the results were not available in time for the reactivity calculations.

Table III Mechanistic reactivity uncertainty estimates for MIR and MOIR conditions.

Organic Gas Class	Mechanistic Reactivity Uncertainty (moles ozone/mole C)[a]	
	MIR	MOIR
CO	15%	20%
Alkanes		
C_1 to C_8	greater of 20% and 0.5/#C	greater of 20% and 0.2/#C
C_9 and above	0.5/#C[b]	0.25/#C[b]
cycloalkanes	0.6/#C[b]	0.3/#C[b]
Alkenes		
ethene	20%	20%
propene	25%	25%
C_4	30%	30%
C_5 and above	40%	50%
dialkenes	50%[c]	50%[c]
cycloalkenes	50%	50%
Alkynes	50%	50%
Aromatic Hydrocarbons	30%	0.35[d]
styrene	50%	0.2[d]
Oxygenates		
methanol	20%	20%
ethanol	20%	20%
formaldehyde	40%[e]	30%[e]
acetaldehyde	40%	30%
propionaldehyde	40%	30%
acetone	40%	30%
acrolein	50%[c]	50%[c]
methyl *t*-butyl ether	20%	30%
ethyl *t*-butyl ether	40%	30%

[a]Relative uncertainties unless otherwise indicated.
[b]Absolute uncertainty. #C is the number of carbons in the alkane.
[c]Uncertainty primarily due to inappropriateness of mechanism. More accurate mechanisms can be derived for 1,3-butadiene, isoprene and acrolein, but were not used in these calculations.
[d]Absolute uncertainty.
[e]High uncertainty primarily due to sensitivity to ambient NMOG speciation.

Several changes were made to the EKMA scenarios. Professor James N. Pitts has noted that nitrous acid (HONO), an important radical initiator, is not normally included in EKMA and other photochemical models. A constant HONO to NO_x ratio of 0.02 was used to specify initial conditions, with a ratio of 0.001 for emissions. These ratios represent typical values found in urban areas. Initial and transported conditions for methane were set at the current global background estimate of 1.79 ppm. Zero NO_x was used aloft instead on EPA's value of 2 ppb. The SAPRC90 mechanism for biogenic emissions of isoprene and α-pinene was used with unknown biogenic hydrocarbons treated as α-pinene. Parameters to calculate photolysis rates at 640 meters, the approximate average mid-point of the mixed layer during daylight hours, were provided by Jeffries.

Dr. William Lonneman of EPA made extensive speciated NMHC measurements around the country in 1987 and 1988, including the 1987 Southern California Air Quality Study (SCAQS). The 1987-88 all-city average profile was found to be similar to the 1987 SCAQS profile. The all-city average was used since it is a more robust data base. Previous calculations by Carter (1991) used the EKMA-recommended default value of a two percent mass fraction for formaldehyde and a three percent mass fraction for acetaldehyde. These default values are not measurement-based. The current calculations used the SCAQS measurements of one percent for both formaldehyde and acetaldehyde. The SCAQS data base is the only one in an urban area with higher ($>C_3$) aldehyde measurements. The existence of higher aldehydes in ambient air has been confirmed by gas chromatography/mass spectrometer measurements in other parts of California. The SCAQS higher aldehyde measurements, reduced by a factor of two because of problems with the blank corrections, were used in all thirty-nine cities.

2. Sensitivity Tests of Reactivity Scales

Carter performed a series of sensitivity tests to investigate the effects of uncertainties in HONO levels, photolysis rates and ambient NMOG speciation on the MIR and MOIR scales. The results are shown in Table IVab. The largest effect on a RAF was a 5% decrease for E85 when photolysis rates were computed at the surface. The reactivities (relative to the ambient NMOG speciation profile) of many slower reacting organic gases also drop with the use of surface photolysis rates, while the relative reactivity of formaldehyde increases when HONO is set to zero, especially for MIR conditions.

Table IVa Effect of HONO, photolysis and ambient NMOG on RAFs.[a]

Fuel	Reactivity Adjustment Factors							
	MIR				MOIR			
	Base	HONO	hv	NMOG	Base	HONO	hv	NMOG
Base	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
M85	0.39	0.40	0.38	0.39	0.41	0.43	0.42	0.41
LPG	0.51	0.52	0.50	0.52	0.60	0.60	0.59	0.60
CNG	0.18	0.18	0.17	0.18	0.21	0.22	0.21	0.21
E85	0.63	0.62	0.60	0.64	0.70	0.70	0.67	0.71

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Table IVb Effect of HONO, photolysis and ambient NMOG on relative reactivities of individual organic gases.[a]

Organic Gas	Reactivity Relative to Base Ambient NMOG Speciation Profile (mass basis)							
	MIR				MOIR			
	Base	HONO	hv	NMOG	Base	HONO	hv	NMOG
Carbon Monoxide	0.022	0.020	0.018	0.022	0.038	0.037	0.036	0.039
Methane	0.0058	0.0053	0.0049	0.0060	0.0085	0.0085	0.0081	0.0087
Propane	0.17	0.16	0.145	0.18	0.25	0.24	0.23	0.25
n-Butane	0.35	0.32	0.30	0.37	0.49	0.48	0.46	0.50
n-Octane	0.21	0.18	0.17	0.22	0.29	0.27	0.25	0.30
Branched C_8 Alkanes	0.39	0.35	0.33	0.40	0.48	0.46	0.44	0.50
Ethene	2.6	2.5	2.5	2.6	3.0	2.9	3.0	3.0
Propene	3.0	2.9	3.0	3.0	3.2	3.2	3.2	3.2
Isobutene	1.7	1.7	1.8	1.7	1.7	1.8	1.9	1.7
trans-2-Butene	3.0	3.1	3.1	2.9	3.1	3.2	3.2	3.1
Benzene	0.145	0.138	0.134	0.146	0.119	0.111	0.109	0.116
Toluene	0.88	0.87	0.88	0.88	0.53	0.50	0.52	0.53
m-Xylene	2.6	2.6	2.8	2.6	2.2	2.2	2.3	2.2
1,3,5-Trimethylbenzene	3.2	3.3	3.4	3.1	2.8	2.9	3.1	2.8
Methanol	0.21	0.20	0.19	0.22	0.26	0.26	0.25	0.27
Ethanol	0.44	0.40	0.38	0.45	0.51	0.49	0.46	0.52
Formaldehyde	2.2	2.7	2.4	2.1	2.0	2.3	2.2	1.9
Acetaldehyde	1.7	1.7	1.7	1.7	1.8	1.8	1.7	1.8

[a]Using "average conditions" scenario (Carter 1991).

<u>Conditions for Sensitivity Tests</u>

Base - Conditions of current reactivity calculations with HONO = 2% of initial NO_x and 0.1% of NO_x emissions; photolysis rates computed at 640 meters; EPA all-city NMOG with SCAQS measured aldehydes.

HONO - No initial or emitted HONO.

hv - Photolysis rates computed at surface.

NMOG - EPA all-city NMOG with EPA assumed aldehydes.

IV. Airshed Model Evaluations of the MIR Approach

A. Evaluation of Individual Reactivities

The MIR scale was calculated with an EKMA-like, chemically detailed, one-dimensional model that operates with one-day simulations and lacks physical detail. At issue is whether this is an adequate representation of actual ozone episodes, which tend to extend over several days in California, and whose severity is strongly dependent on meteorological conditions. Russell and coworkers (McNair et al. 1992) addressed this issue by computing incremental reactivities with a physically detailed, three-dimensional airshed model for a severe, three-day stagnation episode in Los Angeles when the daily ozone maximum was limited by the availability of NO_x. Because airshed models are, of necessity, formulated with condensed chemical mechanisms, incremental reactivities were derived for only eleven individual and "lumped" organic gases. As shown in Table V, despite large differences in the physical details and NO_x availability of the two modeling approaches, the agreement between the airshed modeling and the MIR scale is within 15% for most organic gases. Poorer agreement was found with the MOIR scale, with differences larger than 25% for most organic gases.

Table V Comparison of CMU airshed model results with Carter reactivity scales.

Organic Gas Class	Incremental Reactivity Relative to CO (mass basis)		
	Airshed Model	Carter Reactivity Scale	
	Exp>0.12 ppm	MIR	MOIR
CO	1	1	1
Alkanes C_4 and above	27	24[a]	21[a]
Alkenes ethene C_3 and above	 120 154	 135 163[b]	 83 90[b]
Aromatic Hydrocarbons toluene xylenes and above	 57 198	 51 156[c]	 12 67[c]
Oxygenates methanol ethanol formaldehyde higher aldehydes methyl ethyl ketone methyl *t*-butyl ether	 11 17 175 85 23 13	 10 25 132 102[d] 22 11	 7 19 55 57[d] 14 11

[a]Averaged reactivities of *n*-butane, branched C_5 alkanes and branched C_6 alkanes.
[b]Averaged reactivities of propene, C_4 alkenes and C_5 alkenes.
[c]Averaged reactivities of xylenes and trimethylbenzenes.
[d]Reactivity for acetaldehyde.

B. Evaluation of RAFs

There have been concerns expressed as to whether the MIR scale will lead to fuel-neutral RAFs. This issue can be addressed by implementing the regulation in an airshed model using the so-called "null test". That is, if an increased amount (based on the RAF) of less reactive organic emissions is substituted for conventional gasoline in the baseline emission inventory, then the ozone should remain unchanged.

1. Model Applications

Russell evaluated the RAFs with the results of his airshed model for the August 27 to 29, 1987 SCAQS episode. The modeling simulations were performed with two different emission inventories. The 2010 emission inventory with Tier I controls represents a low hydrocarbon to NO_x ratio. Because of concerns that the low hydrocarbon to NO_x ratios predicted by airshed models will bias the comparison in favor of the MIR scale, the 1987 emission inventory with motor vehicle hydrocarbon exhaust multiplied by two was also used. The August 30 to September 1, 1982 episode was also simulated with the 1987 and 2010 emission inventories to provide a different set of meteorological conditions. HONO emissions were not added to either episode because the model creates HONO with night-time reactions. Biogenic hydrocarbon emissions and chemistry were not included because of their negligible contribution to ozone concentrations in the South Coast Air Basin.

2. Motor Vehicle Profiles

Only profiles from vehicles that met the TLEV emission standards (ARB 1991b) were processed. Simulations were performed for vehicles fueled with the U.S. industry average gasoline, CNG, M85 and LPG. These four fuels lead to very different exhaust profiles, and provide a very stringent test of the reactivity scale. Data from testing programs conducted by ARB, the Auto/Oil Program and Chevron Research and Technology were averaged to create composite profiles.

The Auto/Oil Program protocol for processing the hydrocarbon emission profiles was followed. The main departure from previous work (Russell et al. 1991; Smylie et al. 1990; Dunker 1991) is that a more realistic distribution of mass emissions between cold start, running and hot start exhaust emissions was used (see Tables VIab). Temperature and speed corrections to the data were not available. Evaporative emission rates and speciation profiles were not changed from the baseline vehicle fleet. Carbon monoxide and NO_x emissions were unchanged from the base case. These assumptions are not realistic, but did allow a fair test of the way the reactivity scale is being applied in the ARB regulations.

The emission inventories for each fuel were adjusted by the proposed RAF (ARB 1991b). While the airshed model uses a different chemical mechanism than that used to calculate the MIR scale, Table VII shows that the LCC mechanism gives virtually the same RAFs, except for E85. The results do not depend on whether ambient or emission inventory speciation is used.

Table VIa Exhaust emissions distribution for test data for TLEVs.

Vehicle Type	Percent of Mass in Each Exhaust Mode					
	1987 Activity Data			2010 Activity Data		
	Cold	Run	Hot	Cold	Run	Hot
Base	72	22	6	71	24	5
M85	95	4	1	95	4	1
LPG	60	26	14	59	28	13
CNG	7	91	2	7	92	1

Table VIb Exhaust reactivity-weighted emissions distribution for test data for TLEVs.

Vehicle Type	Percent of Reactivity in Each Exhaust Mode					
	1987 Activity Data			2010 Activity Data		
	Cold	Run	Hot	Cold	Run	Hot
Base	78	17	5	77	19	4
M85	87	11	2	86	12	2
LPG	71	21	8	70	23	7
CNG	33	65	2	31	67	2

Table VII RAFs for reactivity scales based on SAPRC90 and LCC.

Fuel	Reactivity Adjustment Factors					
	MIR			MOIR		
	SAPRC90	LCC[a]	LCC w/EI[a]	SAPRC90	LCC[a]	LCC w/EI[a]
Base	1.00	1.00	1.00	1.00	1.00	1.00
M85	0.37	0.36	0.37	0.38	0.38	0.38
LPG	0.50	0.50	0.50	0.59	0.60	0.59
CNG	0.18	0.17	0.17	0.23	0.21	0.21
E85	0.63	0.60	0.58	0.77	0.69	0.67

[a]Computed with surface photolysis rates, airshed model uses higher values aloft. MEK + OH reaction not fixed.

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3. Null Test Results

The air quality impacts were calculated relative to a case with no TLEV NMOG emissions. A null test result of 1.00 in Tables VIIIab indicates no bias. A result greater than one indicates a bias against the base gasoline, while a result less than one indicates a bias against the alternative fuel. The modeling protocol document established that the one-hour basin peak concentrations and ozone geographic dosage (in units of ppm-hours summed over all hours in all surface grid cells over land with absolute ozone concentrations above 0.09 ppm) should be within 25%. Later, it was decided that the 25% criterion was too loose, and that the dosage should be population-weighted. The null test results for the more typical 1987 episode, with some deviations (less than 10%) from equal ozone impacts, are very encouraging. The deviations in the peak ozone results are not important, since the ozone peaks are relatively insensitive to changes in NMOG emissions. The ozone peaks were predicted far downwind near the eastern boundary of the modeling domain (past Palm Springs, more than 100 miles from the major source areas). Distant downwind areas are relatively insensitive to hydrocarbon emission changes, so the null test results are the ratios of two very small numbers.

In early November, 1991, it was found that the LCC mechanism documentation incorrectly states one of the products of the methyl ethyl ketone (MEK) reaction with OH. The consequence of this mistake is that the reactivity of MEK will be overstated by about a factor of two and the reactivity of alkanes and MTBE will be overstated by a lesser amount. Only one of the cases (1982 episode, 2010 inventory) has been run with the MEK mechanism fixed, which generally resulted in a 5% improvement. Because of the good agreement between the MIR scale and the airshed modeling results for individual and lumped organic gases, these deviations from unity for the null test are more likely due to differences in spatial and temporal patterns of emissions between vehicle fleets, rather than a problem with the MIR approach. The fleet with the highest cold-start emissions (M85), which have longer to react in comparison to the conventional gasoline fleet, had the highest null test results, while the fleet with the lowest cold-start emissions (CNG), had the lowest null test results. Russell plans to investigate this issue further.

The approximately 10% bias in the population-weighted dosage results for the higher 1982 episode are of concern. The only formally adopted RAF to date, a value of 0.41 for M85 vehicles, includes a 10% increase based on the airshed modeling results. When more vehicle test data become available for the other alternative fuels, airshed modeling will be performed to determine a fuel-specific RAF correction.

V. References

Atkinson, R. (1990) Gas-phase tropospheric chemistry of organic compounds: A review. *Atmos. Environ.*, **24A:** 1.

Baugues, K. (1991) Personal communication. May 13.

California Air Resources Board (1990) Proposed Regulations for Low-Emission Vehicles and Clean Fuels--Staff Report and Technical Support Document. State of California, Air Resources Board, P.O. Box 2815, Sacramento, CA 95812, August 13.

California Air Resources Board (1991a) Proposed Regulations for Low-Emission Vehicles and Clean Fuels--Final Statement of Reasons. State of California, Air Resources Board, July.

California Air Resources Board (1991b) Proposed Reactivity Adjustment Factors for Transitional Low-Emission Vehicles--Staff Report and Technical Support Document. State of California Air Resources Board, Sacramento, CA, September 27.

Carter W. P. L. and R. Atkinson (1989) Computer modeling study of incremental hydrocarbon reactivity. *Environ. Sci. Technol.*, **23:** 864.

Carter, W. P. L. (1990) A detailed mechanism for the gas-phase atmospheric reactions of organic compounds. *Atmos. Environ.*, **24A:** 481.

Carter, W. P. L. (1991) Development of Ozone Reactivity Scales for Volatile Organic Compounds. Final Report prepared for United States Environmental Protection Agency, EPA 600/3-91/050, August.

Croes, B. E., J. R. Holmes and A. C. Lloyd (1992) ARB/SCAQMD conference on reactivity-based hydrocarbon controls: Scientific issues and potential regulatory applications. *J. Air Waste Manage. Assoc.*, in press.

Derwent, R. G. and M. E. Jenkin (1991) Hydrocarbons and the long-range transport of ozone and PAN across Europe. *Atmos. Environ.*, **25A:** 1661.

Dunker, A. M. (1991) Reactivity Calculations for the Auto/Oil Program. Presented at the conference Reactivity-Based Hydrocarbon Controls: Scientific Issues and Potential Regulatory Applications, Irvine, California, April 8-9.

Gery, M. W. (1991) Review of the SAPRC-90 Chemical Mechanism. Draft Final Report prepared for the California Air Resources Board, Contract No. A132-055, August 8.

McNair, L., A. Russell and M. T. Odman (1992) Airshed calculation of the sensitivity of pollutant formation to organic compound classes and oxygenates associated with alternative fuels. *J. Air Waste Manage. Assoc.*, **42:** 174.

Russell, A. G., L. A. McNair, M. T. Odman and N. Kumar (1991) Organic Compound Reactivities and the Use of Alternative Fuels. Draft Final Report to the California Air Resources Board, Agreement #A832-112, May.

Smylie, G. M., G. Z. Whitten, R. E. Morris, J. L. Fieber and K. O'Connor (1990) Technical Analysis of the ARB Staff Proposal for Hydrocarbon Reactivity Adjustment Factors for Clean Fuel/Low Emission Vehicle Regulations. Final Report SYSAPP-90/092 prepared for Western States Petroleum Association, 505 North Brand Blvd., Glendale, CA 91203, September 21.

Table VIIIa Null test results for CMU airshed model simulations of 1987 episode.

Ozone Statistic	Null Test Result					
	1987 Inventory[a,b]			2010 Inventory[b]		
	M85	LPG	CNG	M85	LPG	CNG
Basin peak[c]	1.24	1.36	1.18	0.91	1.36	1.73
Grid hours > 0.09 ppm	1.02	1.02	0.84	1.01	1.14	0.84
Grid hours > 0.12 ppm	1.05	1.07	0.89	1.01	1.12	0.92
ppm-hours > 0.09 ppm	1.04	1.05	0.90	1.00	1.15	0.91
ppm-hours > 0.12 ppm	1.05	1.09	0.93	1.00	1.16	0.97
10^6 Person-ppm-hours > 0.09 ppm	1.03	1.00	0.77	1.02	1.09	0.74
10^6 Person-ppm-hours > 0.12 ppm	1.05	1.03	0.79	1.01	1.14	0.83

Table VIIIb Null test results for CMU airshed model simulations of 1982 episode.

Ozone Statistic	Null Test Result					
	1987 Inventory[a,b]			2010 Inventory		
	M85	LPG	CNG	M85	LPG	CNG
Basin peak[c]	1.10	1.13	1.08	1.12	1.29	0.94
Grid hours > 0.09 ppm	1.23	1.21	1.18	1.14	1.09	0.94
Grid hours > 0.12 ppm	1.18	1.19	1.16	1.14	1.11	1.04
ppm-hours > 0.09 ppm	1.20	1.22	1.17	1.13	1.12	1.01
ppm-hours > 0.12 ppm	1.18	1.20	1.15	1.12	1.12	1.06
10^6 Person-ppm-hours > 0.09 ppm	1.05	1.02	0.89	1.10	1.05	0.86
10^6 Person-ppm-hours > 0.12 ppm	1.07	1.05	0.89	1.10	1.05	0.86

[a]With motor vehicle hydrocarbon exhaust multiplied by two.
[b]MEK + OH reaction not fixed, null test results likely to be smaller.
[c]Far downwind ozone peak near boundary (past Palm Springs). Peak relatively insensitive to hydrocarbon emission changes, so ratio of two small numbers.

Summary of Test Results
for CNG-Fueled Vehicles

Vehicle	Test #	Species Table #	Test Date	NMOG (mg/mi)	CH4 (g/mi)	CO (g/mi)	NOx (g/mi)
Ford Taurus (Impco)	3C1	III-5e	10/22/91	55.81	1.298	1.16	0.392
	3C2	III-5e	10/23/91	43.44	1.185	1.03	0.386
	3C3	III-5f	10/29/91	40.24	1.208	0.94	0.516
			Mean	46.49	1.230	1.04	0.431
Ford Taurus (S&S)	4C1	III-5g	10/25/91	38.62	0.832	2.88	0.158
	4C2	III-5g	10/29/91	31.60	0.797	2.56	0.251
	4C3	III-5h	10/30/91	40.78	0.797	2.25	0.289
	4C4	III-5h	10/31/91	51.83	0.825	2.35	0.328
			Mean	40.71	0.813	2.51	0.257
Chevrolet Astrovan	1C6	III-5i	10/29/91	108.65	2.099	1.07	0.162
	1C7	III-5i	10/30/91	95.75	2.067	0.87	0.197
	1C8	III-5j	10/31/91	129.36	2.082	0.66	0.255
			Mean	111.25	2.083	0.87	0.207

Table III-5j
Speciated FTP Results
Chevrolet Astrovan

Light-End Species	mg Ozone/ mg NMOG MIR	mg Ozone/ mg NMOG MOR	Test 1C8A, 10/31/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	Ozone (mg/mi) MOR	
Ethane	0.25	0.17	88.73	22.18	15.08	
Ethene	7.29	3.16	11.98	87.30	37.84	
Propane	0.48	0.31	10.42	5.00	3.23	
Ethyne	0.50	0.33	0.38	0.19	0.12	
Methylpropane	1.21	0.73	0.91	1.11	0.67	
Butane	1.02	0.66	1.85	1.88	1.22	
Propene	9.40	3.77	2.62	24.65	9.88	
Methylbutane	1.38	0.87	0.58	0.80	0.50	
Pentane	1.04	0.68	0.47	0.49	0.32	
1-Butene	8.91	3.51	0.66	5.91	2.33	
2-Methylpropene	5.31	1.93	1.24	6.60	2.40	
Light-End HC Subtotal			119.84	156.11	73.60	

Mid-Range Species	mg Ozone/ mg NMOG MIR	mg Ozone/ mg NMOG MOR	Test 1C8A, 10/31/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	Ozone (mg/mi) MOR	
1,3-butadiene	10.89	4.16	0.03	0.27	0.10	
2-Methylpentane	1.53	0.90	0.17	0.26	0.15	
n-Hexane	0.98	0.65	0.20	0.20	0.13	
Benzene	0.42	0.14	0.54	0.23	0.08	
2,2,4-Trimethylpentane + Alkene	2.59	1.11	0.27	0.70	0.30	
Toluene + C8H18	2.73	0.63	0.34	0.92	0.21	
2,2,5-Trimethylhexane	0.97	0.58	0.11	0.11	0.06	
m & p-Xylenes	7.38	2.22	0.12	0.85	0.26	
Mid-Range HC Subtotal			1.77	3.53	1.29	

Oxygenates	mg Ozone/ mg NMOG MIR	mg Ozone/ mg NMOG MOR	Test 1C8A, 10/31/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	Ozone (mg/mi) MOR	
Formaldehyde	7.15	2.08	6.09	43.55	12.67	
Acetaldehyde	5.52	2.17	0.81	4.46	1.75	
Acrolein	6.77	2.59	0.21	1.45	0.56	
Acetone	0.56	0.20	0.48	0.27	0.10	
Propionaldehyde	6.53	2.50	0.16	1.07	0.41	
Oxygenates Subtotal			7.76	50.80	15.48	

NMOG Summary		Test 1C8A, 10/31/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	Ozone (mg/mi) MOR	
Light-End Species		119.84	156.11	73.60	
Mid-Range Species		1.77	3.53	1.29	
Oxygenates		7.76	50.80	15.48	
Total		129.36	210.43	90.38	
Ozone/NMOG			1.63	0.70	

Table III-5i
Speciated FTP Results
Chevrolet Astrovan

Light-End Species	mg Ozone/ mg NMOG		Test 1C6, 10/29/91			Test 1C7, 10/30/91		
			NMOG	Ozone (mg/mi)		NMOG	Ozone (mg/mi)	
	MIR	MOR	(mg/mi)	MIR	MOR	(mg/mi)	MIR	MOR
Ethane	0.25	0.17	74.90	18.73	12.73	55.06	13.77	9.36
Ethene	7.29	3.16	8.14	59.31	25.71	9.68	70.60	30.60
Propane	0.48	0.31	8.05	3.86	2.49	9.00	4.32	2.79
Ethyne	0.50	0.33	0.31	0.15	0.10	0.38	0.19	0.13
Methylpropane	1.21	0.73	0.96	1.17	0.70	0.72	0.87	0.52
Butane	1.02	0.66	1.73	1.76	1.14	0.89	0.91	0.59
Propene	9.40	3.77	2.07	19.42	7.79	2.66	24.98	10.02
Methylbutane	1.38	0.87	0.59	0.81	0.51	0.10	0.13	0.08
Pentane	1.04	0.68	0.33	0.34	0.23	0.25	0.26	0.17
1-Butene	8.91	3.51	0.12	1.10	0.43	0.17	1.55	0.61
2-Methylpropene	5.31	1.93	0.87	4.59	1.67	1.28	6.78	2.46
Light-End HC Subtotal			98.06	111.25	53.51	80.19	124.36	57.34

Mid-Range Species	mg Ozone/ mg NMOG		Test 1C6, 10/29/91			Test 1C7, 10/30/91		
			NMOG	Ozone (mg/mi)		NMOG	Ozone (mg/mi)	
	MIR	MOR	(mg/mi)	MIR	MOR	(mg/mi)	MIR	MOR
1,3-butadiene	10.89	4.16	0.03	0.29	0.11	0.00	0.00	0.00
Cyclopentane	2.38	1.41	0.41	0.97	0.58	0.00	0.00	0.00
2-Methylpentane	1.53	0.90	0.16	0.24	0.14	0.00	0.00	0.00
n-Hexane	0.98	0.65	0.21	0.21	0.14	0.00	0.00	0.00
Benzene	0.42	0.14	0.53	0.22	0.07	0.18	0.18	0.12
3-Methylhexane	1.40	0.83	0.16	0.22	0.13	0.56	0.24	0.08
2,2,4-Trimethylpentane + Alkene	2.59	1.11	0.31	0.79	0.34	0.15	0.22	0.13
Toluene + C8H18	2.73	0.63	0.41	1.12	0.26	0.31	0.80	0.34
2,2,5-Trimethylhexane	0.97	0.58	0.00	0.00	0.00	0.31	0.84	0.19
m & p-Xylenes	7.38	2.22	0.15	1.14	0.34	0.14	0.14	0.08
1,2,4-Trimethylbenzene	8.83	2.67	0.49	4.30	1.30	0.00	0.00	0.00
Mid-Range HC Subtotal			2.85	9.51	3.41	1.65	2.41	0.94

Oxygenates	mg Ozone/ mg NMOG		Test 1C6, 10/29/91			Test 1C7, 10/30/91		
			NMOG	Ozone (mg/mi)		NMOG	Ozone (mg/mi)	
	MIR	MOR	(mg/mi)	MIR	MOR	(mg/mi)	MIR	MOR
Formaldehyde	7.15	2.08	6.02	43.05	12.52	11.47	82.03	23.86
Acetaldehyde	5.52	2.17	0.92	5.10	2.01	1.42	7.86	3.09
Acrolein	6.77	2.59	0.22	1.50	0.58	0.29	1.96	0.75
Acetone	0.56	0.20	0.41	0.23	0.08	0.41	0.23	0.08
Propionaldehyde	6.53	2.50	0.17	1.09	0.42	0.31	2.00	0.77
Oxygenates Subtotal			7.75	50.98	15.60	13.91	94.09	28.55

NMOG Summary		Test 1C6, 10/29/91			Test 1C7, 10/30/91		
		NMOG	Ozone (mg/mi)		NMOG	Ozone (mg/mi)	
		(mg/mi)	MIR	MOR	(mg/mi)	MIR	MOR
Light-End Species		98.06	111.25	53.51	80.19	124.36	57.34
Mid-Range Species		2.85	9.51	3.41	1.65	2.41	0.94
Oxygenates		7.75	50.98	15.60	13.91	94.09	28.55
Total		108.65	171.73	72.53	95.75	220.85	86.83
Ozone/NMOG			1.58	0.67		2.31	0.91

Table III-5h
Speciated FTP Results
Ford Taurus (S+S), CNG

Light-End Species	mg Ozone/ mg NMOG MIR	MOR	Test 4C3 , 10/30/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR	Test 4C4 , 10/31/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR
Ethane	0.25	0.17	25.308	6.33	4.30	31.93	7.98	5.43
Ethene	7.29	3.16	5.508	40.15	17.41	7.293	53.17	23.05
Propane	0.48	0.31	2.9627	1.42	0.92	4.1141	1.97	1.28
Ethyne	0.50	0.33	1.1774	0.59	0.39	1.5296	0.76	0.50
Methylpropane	1.21	0.73	0.4001	0.48	0.29	0.5888	0.71	0.43
Butane	1.02	0.66	0.9041	0.92	0.60	0.7926	0.81	0.52
Propene	9.40	3.77	0.9665	9.09	3.64	0.7411	6.97	2.79
Methylbutane	1.38	0.87	0.2805	0.39	0.24	0.3567	0.49	0.31
Pentane	1.04	0.68	0.2094	0.22	0.14	0.2662	0.28	0.18
1-Butene	8.91	3.51	0.0451	0.40	0.16	0.1231	1.10	0.43
2-Methylpropene	5.31	1.93	0.0773	0.41	0.15	0.1316	0.70	0.25
Light-End HC Subtotal			37.84	60.40	28.24	47.87	74.94	35.18

Mid-Range Species	mg Ozone/ mg NMOG MIR	MOR	Test 4C3 , 10/30/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR	Test 4C4 , 10/31/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR
1,3-butadiene	10.89	4.16	0.0045	0.05	0.02	0	0.00	0.00
Benzene	0.42	0.14	0	0.00	0.00	0.1187	0.05	0.02
Toluene + C8H18	2.73	0.63	0	0.00	0.00	0.1227	0.33	0.08
Mid-Range HC Subtotal			0.00	0.05	0.02	0.24	0.38	0.09

Oxygenates	mg Ozone/ mg NMOG MIR	MOR	Test 4C3 , 10/30/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR	Test 4C4 , 10/31/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR
Formaldehyde	7.15	2.08	2.65	18.96	5.52	3.24	23.16	6.74
Acetaldehyde	5.52	2.17	0.28	1.54	0.61	0.33	1.85	0.73
Acetone	0.56	0.20	0.00	0.00	0.00	0.15	0.08	0.03
Oxygenates Subtotal			2.93	20.51	6.12	3.72	25.09	7.49

NMOG Summary		Test 4C3 , 10/30/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR	Test 4C4 , 10/31/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR
Light-End Species		37.84	60.40	28.24	47.87	74.94	35.18
Mid-Range Species		0.00	0.05	0.02	0.24	0.38	0.09
Oxygenates		2.93	20.51	6.12	3.72	25.09	7.49
Total		40.78	80.96	34.38	51.83	100.41	42.76
Ozone/NMOG			1.99	0.84		1.94	0.83

Table III-5g
Speciated FTP Results
Ford Taurus (S+S), CNG

Light-End Species	mg Ozone/ mg NMOG MIR	mg Ozone/ mg NMOG MOR	Test 4C1A, 10/25/91 NMOG (mg/mi)	Test 4C1A Ozone (mg/mi) MIR	Test 4C1A Ozone (mg/mi) MOR	Test 4C2A, 10/29/91 NMOG (mg/mi)	Test 4C2A Ozone (mg/mi) MIR	Test 4C2A Ozone (mg/mi) MOR
Ethane	0.25	0.17	26.36	6.59	4.48	15.50	3.87	2.63
Ethene	7.29	3.16	4.58	33.42	14.48	4.74	34.52	14.96
Propane	0.48	0.31	2.24	1.07	0.69	4.82	2.31	1.50
Ethyne	0.50	0.33	1.04	0.52	0.34	0.86	0.43	0.28
Methylpropane	1.21	0.73	0.44	0.53	0.32	0.47	0.57	0.34
Butane	1.02	0.66	0.53	0.54	0.35	0.48	0.49	0.31
Propene	9.40	3.77	0.47	4.42	1.77	0.47	4.41	1.77
Methylbutane	1.38	0.87	0.14	0.19	0.12	0.11	0.16	0.10
Pentane	1.04	0.68	0.19	0.19	0.13	0.35	0.36	0.24
1-Butene	8.91	3.51	0.04	0.39	0.15	0.01	0.05	0.02
2-Methylpropene	5.31	1.93	0.08	0.42	0.15	0.07	0.37	0.13
Light-End HC Subtotal			36.11	48.29	23.00	27.86	47.53	22.29

Mid-Range Species	mg Ozone/ mg NMOG MIR	mg Ozone/ mg NMOG MOR	Test 4C1A, 10/25/91 NMOG (mg/mi)	Test 4C1A Ozone (mg/mi) MIR	Test 4C1A Ozone (mg/mi) MOR	Test 4C2A, 10/29/91 NMOG (mg/mi)	Test 4C2A Ozone (mg/mi) MIR	Test 4C2A Ozone (mg/mi) MOR
1,3-butadiene	10.89	4.16	0.01	0.15	0.06	0.01	0.12	0.05
2-Methylpentane	1.53	0.90	0.37	0.57	0.34	0.00	0.00	0.00
3-Methylpentane	1.52	0.94	0.05	0.08	0.05	0.00	0.00	0.00
n-Hexane	0.98	0.65	0.05	0.05	0.03	0.00	0.00	0.00
Methylcyclopentane	2.82	1.55	0.20	0.56	0.31	0.00	0.00	0.00
Benzene	0.42	0.14	0.03	0.01	0.00	0.05	0.02	0.01
Toluene + C8H18	2.73	0.63	0.03	0.09	0.02	0.00	0.00	0.00
m & p-Xylenes	7.38	2.22	0.08	0.62	0.19	0.00	0.00	0.00
3-Ethyltoluene	7.20	2.16	0.05	0.33	0.10	0.00	0.00	0.00
1,2,4-Trimethylbenzene	8.83	2.67	0.05	0.48	0.15	0.00	0.00	0.00
Mid-Range HC Subtotal			0.94	2.95	1.24	0.06	0.14	0.05

Oxygenates	mg Ozone/ mg NMOG MIR	mg Ozone/ mg NMOG MOR	Test 4C1A, 10/25/91 NMOG (mg/mi)	Test 4C1A Ozone (mg/mi) MIR	Test 4C1A Ozone (mg/mi) MOR	Test 4C2A, 10/29/91 NMOG (mg/mi)	Test 4C2A Ozone (mg/mi) MIR	Test 4C2A Ozone (mg/mi) MOR
Formaldehyde	7.15	2.08	1.36	9.71	2.82	3.32	23.77	6.91
Acetaldehyde	5.52	2.17	0.17	0.94	0.37	0.28	1.53	0.60
Acetone	0.56	0.20	0.05	0.03	0.01	0.08	0.04	0.02
Oxygenates Subtotal			1.57	10.67	3.20	3.68	25.34	7.53

NMOG Summary		Test 4C1A, 10/25/91 NMOG (mg/mi)	Test 4C1A Ozone (mg/mi) MIR	Test 4C1A Ozone (mg/mi) MOR	Test 4C2A, 10/29/91 NMOG (mg/mi)	Test 4C2A Ozone (mg/mi) MIR	Test 4C2A Ozone (mg/mi) MOR
Light-End Species		36.11	48.29	23.00	27.86	47.53	22.29
Mid-Range Species		0.94	2.95	1.24	0.06	0.14	0.05
Oxygenates		1.57	10.67	3.20	3.68	25.34	7.53
Total		38.62	61.91	27.44	31.60	73.01	29.87
Ozone/NMOG			1.60	0.71		2.31	0.95

Table III-5f
Speciated FTP Results
Ford Taurus (IMPCO), CNG

Light-End Species	mg Ozone/ mg NMOG MIR	mg Ozone/ mg NMOG MOR	Test 3C3 , 10/29/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	Ozone (mg/mi) MOR	
Ethane	0.25	0.17	29.32	7.33	4.98	
Ethene	7.29	3.16	7.13	51.97	22.53	
Ethyne	0.50	0.33	0.27	0.13	0.09	
Methylpropane	1.21	0.73	0.32	0.39	0.23	
Butane	1.02	0.66	0.82	0.84	0.54	
Propene	9.40	3.77	0.25	2.34	0.94	
Methylbutane	1.38	0.87	0.14	0.19	0.12	
Pentane	1.04	0.68	0.14	0.14	0.09	
1-Butene	8.91	3.51	0.03	0.24	0.10	
2-Methylpropene	5.31	1.93	0.04	0.22	0.08	
Light-End HC Subtotal			38.45	63.80	29.70	

Mid-Range Species	mg Ozone/ mg NMOG MIR	mg Ozone/ mg NMOG MOR	Test 3C3 , 10/29/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	Ozone (mg/mi) MOR	
1,3-butadiene	10.89	4.16	0.01	0.14	0.05	
Mid-Range HC Subtotal			0.01	0.14	0.05	

Oxygenates	mg Ozone/ mg NMOG MIR	mg Ozone/ mg NMOG MOR	Test 3C3 , 10/29/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	Ozone (mg/mi) MOR	
Formaldehyde	7.15	2.08	1.48	10.57	3.07	
Acetaldehyde	5.52	2.17	0.18	0.97	0.38	
Acetone	0.56	0.20	0.13	0.07	0.03	
Oxygenates Subtotal			1.78	11.61	3.48	

NMOG Summary		Test 3C3 , 10/29/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	Ozone (mg/mi) MOR	
Light-End Species		38.45	63.80	29.70	
Mid-Range Species		0.01	0.14	0.05	
Oxygenates		1.78	11.61	3.48	
Total		40.24	75.55	33.24	
Ozone/NMOG			1.88	0.83	

Table III-5e
Speciated FTP Results
Ford Taurus (IMPCO), CNG

Light-End Species	mg Ozone/ mg NMOG MIR	MOR	Test 3C1A, 10/22/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR	Test 3C2A, 10/23/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR
Ethane	0.25	0.17	42.37	10.59	7.20	33.14	8.29	5.63
Ethene	7.29	3.16	1.24	9.01	3.91	1.20	8.73	3.79
Propane	0.48	0.31	5.91	2.84	1.83	4.78	2.29	1.48
Ethyne	0.50	0.33	0.25	0.12	0.08	0.19	0.09	0.06
Methylpropane	1.21	0.73	0.50	0.60	0.36	0.37	0.45	0.27
Butane	1.02	0.66	0.85	0.87	0.56	0.82	0.83	0.54
Propene	9.40	3.77	0.20	1.92	0.77	0.21	1.93	0.77
Methylbutane	1.38	0.87	0.15	0.21	0.13	0.28	0.38	0.24
Pentane	1.04	0.68	0.22	0.23	0.15	0.12	0.13	0.08
1-Butene	8.91	3.51	0.01	0.12	0.05	0.04	0.31	0.12
2-Methylpropene	5.31	1.93	0.02	0.11	0.04	0.01	0.07	0.02
Light-End HC Subtotal			51.73	26.63	15.09	41.15	23.51	13.02

Mid-Range Species	mg Ozone/ mg NMOG MIR	MOR	Test 3C1A, 10/22/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR	Test 3C2A, 10/23/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR
1,3-butadiene	10.89	4.16	0.00	0.05	0.02	0.01	0.10	0.04
2-Methylpentane	1.53	0.90	0.13	0.19	0.11	0.01	0.02	0.01
3-Methylpentane	1.52	0.94	0.05	0.08	0.05	0.00	0.00	0.00
n-Hexane	0.98	0.65	0.10	0.10	0.07	0.05	0.05	0.03
Methylcyclopentane	2.82	1.55	0.07	0.21	0.11	0.00	0.00	0.00
Benzene	0.42	0.14	0.09	0.04	0.01	0.02	0.01	0.00
2,2,4-Trimethylpentane + Alkene	2.59	1.11	0.21	0.55	0.24	0.00	0.00	0.00
Toluene + C8H18	2.73	0.63	0.50	1.36	0.31	0.15	0.42	0.10
m & p-Xylenes	7.38	2.22	0.15	1.12	0.34	0.10	0.76	0.23
Styrene	2.22	-0.30	0.05	0.12	-0.02	0.00	0.00	0.00
1,2,4-Trimethylbenzene	8.83	2.67	0.00	0.00	0.00	0.19	1.64	0.50
n-Undecane	0.42	0.28	0.64	0.27	0.18	0.06	0.02	0.02
Mid-Range HC Subtotal			2.01	4.09	1.43	0.59	3.02	0.92

Oxygenates	mg Ozone/ mg NMOG MIR	MOR	Test 3C1A, 10/22/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR	Test 3C2A, 10/23/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR
Formaldehyde	7.15	2.08	1.64	11.71	3.41	1.41	10.11	2.94
Acetaldehyde	5.52	2.17	0.35	1.91	0.75	0.29	1.60	0.63
Acetone	0.56	0.20	0.09	0.05	0.02	0.00	0.00	0.00
Oxygenates Subtotal			2.08	13.68	4.18	1.70	11.70	3.57

NMOG Summary		Test 3C1A, 10/22/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR	Test 3C2A, 10/23/91 NMOG (mg/mi)	Ozone (mg/mi) MIR	MOR
Light-End Species		51.73	26.63	15.09	41.15	23.51	13.02
Mid-Range Species		2.01	4.09	1.43	0.59	3.02	0.92
Oxygenates		2.08	13.68	4.18	1.70	11.70	3.57
Total		55.81	44.39	20.69	43.44	38.24	17.51
Ozone/NMOG			0.80	0.37		0.88	0.40

REFERENCES

1. California Air Resources Board (1992) "Proposed Regulations for Low-Emission Vehicles and Clean Fuels--15 Days Notice, "State of California, Air Resources Board, April 21.

2. Chang, T.Y.; Rudy, S.J. (1990) "Ozone-forming potential of organic emissions from alternative-fueled vehicles," Atmos. Environ., 24A: 2421.

3. Fujita, E.M., Croes, B.E.; Bennett, C. L.; Lawson, D.R.; Lurmann, F.W.; Main, H.H. (1992) "Comparison of emission inventory and ambient concentration ratios of CO, NMOG, and NOx in California's South Coast Air Basin," J. Air Waste Manage. Assoc., 42:264-76.

4. Harley, R.A.; Russell, A.G.; McRae, G.J.; McNair, L.A.; Winner, D.A.; Odman, M.T.; Dabdub, D.; Cass, C.R.; Seinfeld, J.H. (1992) "Continued Development of a Photochemical Model and Application to the Southern California Air Quality Study (SCAQS) Intensive Monitoring Periods: Phase I," Final Report to the Coordinating Research Council.

5. Pierson, W.R.; Gertler, A.W.; Bradow, R.L. (1990) "Comparison of the SCAQS tunnel study with other on-road vehicle emission data," J. Air Waste Manage. Assoc., 40: 1495-1504.

6. Russell A.G.; St. Pierre, D.; Milford, J.B. (1990) "Ozone control, and methanol fuel use," Science, 247, 201-5.

7. Harley, R.A.; Russell, A.G.; McRae, G.J.; Cass, G.R.; Seinfeld, J.H. (1993) Photochemical modeling of the Southern California Air Quality Study," Environ. Sci. Technol., 27: 378-88.

8. McNair, L.; Russell, A.; Odman, M.T. (1992) "Airshed calculation of the sensitivity of pollutant formation to organic compound classes and oxygenates associated with alternative fuels," J. Air Waste Manage. Assoc., 42: 174-8.

9. National Research Council (1991) Rethinking the Ozone Problem in Urban and Regional Air Pollution, National Academy Press, Washington, D.C.