WSPA
Western States Petroleum Association

Douglas F. Henderson
Executive Director

Air Resources Board
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November 24, 1992

Mr. James D. Boyd
Executive Officer
California Air Resources Board
2020 L Street
P. O. Box 2815
Sacramento, CA 95812

Subject: Low-Emission Vehicle Regulatory Review Hearing

Dear Jim,

On November 13, 1992, your agency issued a Supplement to the Staff Report for the Low-Emission Vehicle Regulatory Review Hearing scheduled for December 10, 1992. At the same time, however, we were advised that the modeling runs necessary to determine the Reactivity Adjustment Factor for reformulated gasoline were not complete and the information would not be available until less than 45 days prior to the December 10 hearing.

As we discussed last week, WSPA must object to this failure to follow the notice and comment provisions found in section 11346.4 of the Administrative Procedures Act. WSPA would appreciate postponement of the December 10 hearing which would allow these procedural requirements to be met.

If you have any questions, please feel free to give me a call.

DH:va

ccs: Jan Sharpless
Donna Black

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WSPA
Western States Petroleum Association

Douglas F. Henderson
Executive Director

December 22, 1992

Mr. James D. Boyd
Executive Officer
Air Resources Board
2020 L Street
P. O. Box 2815
Sacramento, CA 95812

Re: <u>Low Emission Vehicle Regulatory Review Hearing</u>

Dear Jim:

On December 16, 1992, WSPA received the Modeling Protocol and Final Results for the Low-Emission Vehicle Regulatory Review Hearing scheduled for January 14, 1993. Although labeled "Final Results," the document indicates that certain Ford and GM data still is not included, and that this information will be added into the RAF calculation for Phase 2 gasoline at some unspecified time prior to the hearing scheduled for January 14, 1993. This suggests that the RAFs of 1.06 and 0.99 for TLEVs and LEVs, respectively, may well change.

In addition, during a recent meeting with the Air Resources Board ("ARB") Mobile Source Division, held on December 9, 1992 in El Monte, WSPA learned of various errors or inaccuracies in the ARB's testing procedures for development of the Phase 2 RAFs, and the reporting of test data resulting from those procedures. For example, some vehicles apparently were mislabeled in the September 1992 Staff Report (<u>e.g.</u>, the Lexus 300 was actually the Cougar) and some of the testing which should have been done using Phase 2 fuel was done using RF-A.

Numerous technical inequities have also been identified by WSPA's technical consultant, Sierra Research. These include the ARB's use of test fuels that did not comply with the agency's own regulations regarding fuel composition, the use of test vehicles that were not representative of the vehicle fleet to which the RAFs will be applied in terms of manufacturer, emission control system equipment and vehicle type, and the agency's use of different test fleets to determine the specific reactivity of TLEV and LEV emissons on conventional gasoline and Phase 2 gasoline.

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Thus, although WSPA was provided with additional information in the supplemental report received from the ARB on December 16, there are significant problems with and inadequacies in the data. Logic and common sense strongly suggest that the ARB is not ready to go forward with the Phase 2 gasoline RAF portion of the Board hearing on January 14, 1993, and that it would be in the best interests of all concerned to postpone the matter until these concerns are resolved and WSPA has had sufficient time to analyze and comment on the final proposal. We urge that you seriously consider a postponement of the hearing.

If you have any questions, please feel free to give me a call.

Doug [signature]

DH:va

cc: Ms. Jan Sharpless

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WSPA
Western States Petroleum Association

STATE OF CALIFORNIA
AIR RESOURCES BOARD
RECEIVED 10-15-92
BY BOARD SECRETARY

11/12/92
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XC: Bd Mbr
JS TAC
JD MSD
JB Legal

Douglas F. Henderson
Executive Director

October 9, 1992

Ms. Jananne Sharpless
Chairwoman
California Air Resources Board
2020 "L" Street
Sacramento, CA 95814

Subject: RAF's for Phase 2 Reformulated Gasoline
November 12, 1992 Public Hearing

Dear Jan:

In reviewing the notice of the November 12 public hearing to consider amendments to vehicle certification requirements, we are concerned that CARB has proposed interim Phase 2 gasoline reactivity adjustment factors (RAF's) of 1.0 and 0.95 for TLEV and LEV's, respectively, based on a flawed analysis of limited and "very preliminary" test data. Essentially, little or no reactivity benefit is being assigned to Phase 2 gasoline which will cost the petroleum industry an estimated $5-8 billion in investment.

The Staff Report states, "due to delays in obtaining the correct Phase 2 certification fuel and the amount of testing required, the test program has not been completed as of the date of publication of this notice. Pending the receipt of additional test data, the Staff is proposing interim RAF's ...; modified values based on actual testing will be proposed at the Board hearing." Unfortunately, last-minute modifications prior to the hearing will not provide the public with an adequate and meaningful opportunity to review the final proposed RAF's and analyses of the bulk of supporting data.

This placeholder proposal violates both the spirit and intent of the 45-day public notice requirements. As you are aware, the government code requires that the public have at least 45 days' notice of a proposed action. While the report indicates that the Staff intends to provide the additional data to the public when they are available, the information on the final proposed RAF's will not have been available for a 45-day review period.

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Accordingly, we request that the Board hearing on this subject be delayed to allow for a complete 45-day review of the final proposed RAF's along with the support evidence. In our view, CARB has an obligation to provide time for a complete and adequate review of a rule that can have a staggering impact on our industry, the auto industry, and the economy of the state.

Very truly yours,

DH:va

1/14/93
93-1-3 (1)

STATEMENT OF THE ASSOCIATION OF INTERNATIONAL AUTOMOBILE MANUFACTURERS, INC. BEFORE THE CALIFORNIA AIR RESOURCES BOARD REGARDING CHANGES TO THE LOW EMISSION VEHICLE/CLEAN FUELS PROGRAM

JANUARY 14, 1993

Good Morning, I am Dale Kardos representing the Association of International Automobile Manufacturers (AIAM). AIAM is a non-profit trade association that represents U.S. importers and distributors of passenger cars and light trucks made both here and abroad.[1] We welcome the opportunity to appear before you today to comment on the proposed modifications to the low emission vehicle/clean fuels program being considered today.

First, we would like to offer our support to changes suggested by the staff regarding zero-emission vehicles (ZEVs). These include: 1) changing the ZEV regulation from a sales mandate to a requirement to produce and deliver vehicles for sale, 2) eliminating the 0.25 g/mi NMHC phase-in requirement for 1994, and 3) allowing ZEVs with fuel-fired heaters to qualify as ZEVs. Each of these provisions will help reduce the burdens of the program. However, we must still express to you our members' concerns regarding the saleability of ZEVs absent a tremendous breakthrough in battery technology. Therefore, AIAM strongly urges the ARB allow series hybrid electric vehicles to qualify as ZEVs for a limited period of time.

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[1] AIAM represents: American Honda Motor Company, Inc.; American Suzuki Motor Corporation; BMW of North America, Inc.; Daihatsu Motor Co., Ltd.; Fiat Auto U.S.A., Inc.; Hyundai Motor America; Isuzu Motors of America, Inc.; Mazda Motors of America, Inc.; Mitsubishi Motor America, Inc.; Nissan North America, Inc.; Peugeot Motors of America, Inc.; Porsche Cars North America, Inc.; Rolls Royce Motor Cars, Inc.; Rover Group USA Inc.; Saab Cars U.S.A., Inc.; Subaru of America, Inc.; Toyota Motor Sales U.S.A., Inc.; Volkswagen of America, Inc.; and Volvo North America Corporation.

Another issue we raised with staff once in a public workshop and later in a private meeting is the modification of the rules regarding the movement of a manufacturer from small to intermediate volume manufacturer status based on sales fluctuation. The staff's proposal suggests that if a manufacturer exceeds the small volume sales limit, that four years leadtime be given to meet the new requirements. If a manufacturer falls below the limit, the change to less stringent requirements would be immediate.

While this seems to be a fair proposition, there is one potential case where it is not. If a small volume manufacturer exceeds the 3,000 vehicle sales limit in the year 1999, that manufacturer would have four years leadtime to go from not having to plan for or produce ZEVs to producing 10 percent of its fleet as ZEVs. This simply is not enough time for a manufacturer with limited resources to develop an entirely new power train technology. We suggest that in the case of a manufacturer that would be forced from non-ZEV production to ZEV production, at least eight years leadtime be given before ZEV production is required.

At the August 3, 1992 workshop, the staff introduced a new requirement, functional testing of evaporative emission control systems during assembly line testing. Comments raised at the workshop pointed out numerous potential problems with this requirement. Most of these related to the difficult access to canister location on vehicles and how this would reduce vehicle throughput in the testing. Such a requirement also may require significant facility modifications to attempt to regain some of the lost throughput time that would occur from the imposition of this requirement. We are also concerned about the removal of the lines from the evaporative canister creating possible leaks in vehicles in-use.

We have followed with interest the petition filed by the Western States Petroleum Association (WSPA) and the subsequent lawsuit regarding reactivity adjustment factors (RAFs). While we are not in a position to provide detailed technical analysis on the RAF supporting data, we are concerned that the absence of RAFs will reduce the options a manufacturer has to comply with the LEV requirements.

We still do not believe that the ultimate feasiblity of either the LEV or ULEV standards has been proven. Given this fact, the RAFs provide an option to move toward a different fuel that **may** permit a manufacturer to achieve the required levels with sufficient compliance margin. Elimination of the RAFs would take away that option.

Thank you for the opportunity to provide our views today. If you have any questions, I would be happy to answer them.

(2)

SM-2318

General Motors Statement at the January 14, 1993 California Air Resources Board Hearing Regarding the Low Emission Vehicle/Clean Fuel Regulations

Good morning. My name is Sam Leonard, Director of Automotive Emission Control, General Motors Environmental and Energy Staff. General Motors has worked closely with the Staff on a number of the regulatory changes being proposed today, including the 50°F cold temperature requirement and the assembly-line audit canister loading requirement and supports the resolution of those issues being proposed today.

A major issue also being addressed today is reactivity adjustment factors, or RAFs. GM believes the Air Resources Board took a very important step toward improved emission control regulation in the Low Emission Vehicle/Clean Fuels program by the introduction of RAFs to control ozone emissions.

Although the science behind ozone formation is still evolving, it is clear that the different hydrocarbon species present in exhaust vary widely in their tendencies toward forming ozone. Standards based on ozone forming tendency, as well as mass, are clearly a step forward. GM initiated and has strongly supported this effort in the past.

With reactivity now part of the standard, it is essential that industry know early in the vehicle development process what the RAFs will be. The Staff has made considerable effort on the difficult and ground breaking task of developing RAFs. However, there remains considerable disagreement between the Staff and the industry about the development of the RAFs and the baseline specific reactivity values (the denominator of the RAF equation) being proposed today. Perhaps the concerns of industry might be resolved through further discussions with the Staff and the accumulation of additional data. However, the time constraints of the development process preclude that approach for the near term model years.

For that reason, we have agreed with your Staff to comply with interim RAFs and denominators for the 1997 and earlier model years on Phase 2 gasoline. We and the Staff have made this agreement with these understandings:

First, interim values for medium-duty vehicles will be established promptly, and will also apply through the 1997 model year;

Second, a rulemaking process will be undertaken with industry participation to evaluate the RAF process, including RAF denominators, for 1998 and later model years; and

Third, values for 1998 and later Phase 2 RAFs and RAF denominators for passenger cars/light-duty trucks and medium-duty vehicles will be adopted by March 1994.

The Staff has proposed interim RAF/denominator values of 1.03/3.42 for TLEVs and 0.99/3.13 for LEVs/ULEVs. In order to arrive at these values, the Staff has adjusted the originally calculated RAFs based on modelling. The Staff adjusted the TLEV RAF up 5% and the LEV/ULEV RAF up 4%. General Motors does not believe these specific adjustments are appropriate, either for the generic RAFs proposed here or for manufacturer-generated engine-family-specific RAFs.

The intent of the grid model test of the RAF methodology is to identify any substantial bias in the methodology. If a substantial bias exists, then a model-based correction factor may be necessary to maintain the "level-playing field" concept inherent in the formulation of the regulation. The results of testing the composite profiles for TLEVs and LEVs operating on Phase 2 gasoline as tested in the Carnegie Mellon University grid model are summarized in Tables VI and VII of the December 15, 1992 report.[1] The results in Table VII show no consistent bias one way or the other. Over a range of meteorological conditions, emission inventories, and ambient VOC/NOx ratios, the results are consistently close to 1.0 for a wide range of peak and exposure measures. Almost all the results are within plus or minus five percent of 1.0. Thus, the grid model shows no substantial bias for Phase 2 gasoline RAFs. In other words, within the scenarios modelled, the observed difference is insignificant, it is within the error-band, or "noise" of the model.

The scenarios modelled were designed to test the substitution of a significant portion of the inventory with the alternative reactivity profiles. By limiting the interim factors to model years 1997 and earlier, the fraction of the inventory that will be affected by the Board's decisions today is much smaller than the fraction of the inventory substituted in the CMU modelling. The practical implication of setting the Phase 2 gasoline correction factor at 1.0 is thus much smaller. The ozone differences among fuels shown in Table VIa to VId are plus or minus a part per billion at most. So the Staff's own worst case ozone impact of setting the Phase 2 correction factor at 1.0 rather than at 1.05 and 1.04, as proposed by the Staff, would be much smaller than a part per billion of ozone. We would note that California only reports its ozone measurements to the nearest 10 parts per billion. Therefore, we urge that the Board, as a matter of policy, use a modelling adjustment of 1.0 whenever the model factor would be within ± 10% of 1.0. For the Phase 2 generic and engine family specific RAFs, the adjustment would therefore be 1.0 and, thus the generic RAF for TLEVs will be 0.98 and the generic RAF for LEVs and ULEVs will be 0.95. We; at GM, can support interim RAFs at these levels.

As you saw earlier, the Staff proposed interim reactivity adjustment factors for Phase 2 gasoline of about one. This is

[1] California Air Resources Board, Research Division Report, Establishment of Corrections to Reactivity Adjustment Factors for Transitional Low-Emission Vehicles and Low-Emission Vehicles Operating on Phase 2 Reformulated Gasoline: Modeling Protocol and Final Results, December 15, 1992.

discouraging because we had hoped Phase 2 gasoline would have lower reactivity. Specifically, control of the multi-alkyl aromatics would have resulted in lower reactivity and therefore reduced ozone. However, during the Phase 2 gasoline rulemaking, the Board chose not to control these aromatics, based on the costs of such control not being worth the clean air benefit, perhaps rightly from a societal cost-benefit perspective.

For these same reasons, and to be consistent with its actions in the Phase 2 gasoline rulemaking, as well as complying with the California Clean Air Act, the Board must examine the Low Emission Vehicle program in the same manner, that is, incrementally. It must look at the costs versus the benefits of each step of the Low Emission Vehicle program, from conventional vehicle standards to TLEVs, from TLEVs to LEVs, from LEVs to ULEVs, and from ULEVs to ZEVs. The Board has never seen this type of evaluation of the Low Emission Vehicle program. General Motors requests that the Board direct the Staff to conduct this type of evaluation with industry participation, and that it be completed by March 1994. The results of this study of the incremental cost-effectiveness of the Low Emission Vehicle program would be used in the next review of both the Phase 2 gasoline controls and the Low Emission Vehicle program.

Thank you for your time. I would be glad to answer any questions at this time.

(2)

GM

General Motors
Environmental and Energy Staff
30500 Mound Road, Box 9055
Warren, Michigan 48090-9055
Fax: (313) 947-1797

January 11, 1993
SM-2317

Mr. James D. Boyd
Executive Officer
California Air Resources Board
2020 L Street
P.O. Box 2815
Sacramento, California 95812

Re: Low-Emission Vehicles and Clean Fuels

Dear Mr. Boyd:

At the June 1992 meeting of the Air Resources Board to consider the development of technologies needed to meet low-emission vehicle/clean fuels ("LEV/CF") standards, GM and other organizations proposed a cooperative effort by the ARB staff and the industry to evaluate the long-run costs, benefits and incremental cost-effectiveness of the LEV/CF program. At the time of our proposal, the staff was noncommittal in its response. I am writing to you now to restate our proposal, in the hope that the staff will be able to respond to our suggestion at the Board's hearing on the LEV/CF program later this week.

The need for the type of cooperative study we sought to undertake last June with the staff has grown in recent months. GM and other manufacturers are reaching the stages of LEV/CF vehicle development that will involve huge capital expenditures from our industry, which will ultimately have to be borne by California consumers. Before the most costly stages of work on the LEV/CF program begin, we think it is important for the Board to reexamine whether the public is obtaining the most cost-effective and timely possible control of mobile source emissions, so that it can consider making any appropriate adjustments.

In addition, the passage of time since last June has improved significantly the chances that a cooperative study can accurately forecast the costs, benefits and incremental cost-effectiveness of the LEV/CF program. The Board's "Phase 2" reformulated gasoline rules, which will have a major impact on the mobile-source inventory in California, are now fully defined and in final regulatory form. Moreover, last November the staff advised the Board that an updated version of the EMFAC model would be available this spring.

We would hope to use the updated EMFAC model, along with EPA's MOBILE5 model, to assess the emissions performance of vehicles in the LEV/CF program. We believe that the study must also include credible and independent estimates of the refinery costs of "Phase 2" gasolines, and apply the latest available ozone atmospheric chemistry models to the conditions of concern.

GM is prepared to devote substantial resources to this project, as we have in other cooperative work with the staff in recent years, such as the joint study that supported the "Phase 2" fuel volatility rule and the enhanced real-time evaporative emissions test procedure. We would like to begin work on the project this month and to complete the final stages of work on ozone inventory modelling by September 1993. By that time, we would hope that vehicle technology and refinery modification activities would have advanced to the stage where relatively precise updated cost estimates of the LEV/CF program can be included in the analysis. We hope that other organizations inside and outside the automobile industry would also provide support to the effort. Nevertheless, as with our fuel-volatility and enhanced evaporative emissions technical efforts, we are prepared to proceed alone, provided we have the cooperation of the ARB staff.

I look forward to the staff's response to this renewed proposal for a joint study of the LEV/CF program at this week's hearing. In the meantime, please contact me at 313/947-0043 if you would like additional details regarding our suggestion.

Sincerely,

Samuel A. Leonard, Director
Automotive Emission Control

mlsl0111a

cc: Chairwoman Sharpless
Members of the Board
Board Secretary

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Statement of Michael J. Schwarz
Ford Motor Company
On
The California Air Resources Board Proposed Amendments to Regulations for Low Emissions Vehicles And Clean Fuels
January 14, 1993

Good Morning/Afternoon. My name is Mike Schwarz. I am the Manager of Emissions Control Analysis at Ford Motor Company. Before discussing Ford's concerns with the proposed amendments, I would like to commend the Staff for the work it has done in several areas. We feel that a great deal of productive effort has been spent by the Staff on the following issues: determining an acceptable multiplier for the 50 degree F NMOG and formaldehyde emission requirements; providing a means by which manufacturers might avoid costly and time consuming evaporative canister loading for assembly-line testing; refining the ZEV credit system; implementing a reasonable Cold CO implementation schedule; and improving the HEV procedures.

Ford is aggressively pursuing product developments in many areas including advanced gasoline engines, alternative fuels, advanced catalyst systems, and electric vehicles. We are involved in several consortia with other manufacturers through the United States Council for Automotive Research (USCAR) and Southwest Research Institute (SWRI) as well as having extensive internal programs to meet the technical challenges of the Low Emission Vehicles/Clean Fuels (LEV/CF) regulations. In addition, we are pursuing the development of new on-board diagnostic systems for 1994 and later models, and the development of high temperature, multiple day evaporative emission systems for the 1995 and later models. It is apparent that a great deal of work remains; we will continue to apprise the Board of our progress.

Ford takes great pride in its achievements in the reduction of motor vehicle emissions. We have certified the 1993 1.9 liter Escort/Tracer as a TLEV. The 1993 Taurus 3.0 liter Flexible Fuel Vehicle (FFV) has also been certified recently as a TLEV, which not only is a major accomplishment in emission reduction but demonstrates a milestone in the development of alternative fuel vehicles.

We will begin shipping small numbers of the Ford Ecostar, a Zero Emission Vehicle (ZEV), at the end of the second quarter 1993. The first hybrid Ecostars are planned to be shipped to California beginning in late 1993. These vehicles constitute a pilot/demo program to be used in gathering valuable data to determine the product and market feasibility of electric vehicles -- a major open issue.

Despite these successes, we continue to have major concerns about the feasibility and cost effectiveness of the program and to question the Board's June, 1992 finding that development of LEV and ULEV technology is on course to support 1997 production. We also worry that ZEVs will not be sufficiently marketable to meet mandatory sales levels starting in 1998. Our corporate lead time schedules, which are designed to assure the orderly introduction of reliable and durable vehicles, required us to select systems six months ago for 1997 production. Neither the testing by the Staff nor our own has carried us to the point where we can identify the systems which should at this point be "on the shelf", or production ready, for LEV and ULEV standards. Although we are actively pursuing these technologies, we just are not there yet. We also have issues concerning the proposed reactivity adjustment factors (RAFs), on-board diagnostics (OBD II), and potential changes to CARB's evaporative emissions requirements.

The reactivity adjustment factors recently proposed by the Staff are disappointing in that the scarcity of low-emitting vehicles has resulted in a very small database. For instance, the proposed RAF for LEVs operated on Phase 2 gasoline is based on just six vehicles tested with the baseline fuel and nine tested with the clean fuel. These data are predominantly from low-mileage prototype vehicles equipped with "pre-start" electrically heated catalysts -- a technology which the Staff no longer believes will have wide applicability for vehicles in the LEV category. The results of this testing are scattered, exhibiting little tendency to cluster around the average level. We also question the proposed modeling-based correction factors for Phase II gasoline. We believe that the four and five percent correction factors computed by the Staff are smaller than the inherent uncertainties in the model itself and thus should be considered de minimus.

Despite these concerns, Ford believes that the use of RAFs to take reactivity into account and thus provide a level playing field for competing fuels, is technically valid. Therefore, we propose to enter into a cooperative program with the Staff and the rest of the industry to improve the representativeness of the database and consider modifications to the analytical methods used to compute RAFs. In particular, we believe the Staff should consider adopting a single baseline reactivity value (RAF denominator) for all categories of vehicles. This baseline reactivity would be determined from a fleet of current vehicles tested on current gasoline. In this manner, all future improvements in exhaust emissions reactivity occurring due to advances in vehicle or fuel technology would be fully reflected. We believe such a cooperative study could be completed, and appropriate Board action taken, in time to affect RAFs and baseline reactivities (used in determining engine family - specific RAFs) for the 1998 model year. With a commitment from the Board to support such a study, Ford would accept the Staff-proposed Phase II gasoline RAFs (without modeling corrections) and baseline reactivities through the 1997 model year.

ARB's OBDII regulations, when coupled with the LEV standards, currently present an insurmountable task for the industry. It is generally recognized by industry and the Staff that compliance with the LEV standards will require drastic reductions in emissions in the first few seconds after vehicle start-up, and this will necessitate some type of small close-coupled and/or heated light-off catalyst. ARB regulations specify that the use of such catalysts, however, requires that the catalysts be monitored by the OBDII system. Unfortunately, the only known method of inferring catalyst efficiency (oxygen storage technique) will not work on a small catalyst, as the high flow rates and small catalysts size do not yield a measurable level of oxygen storage. Thus, the technology most likely to aid in compliance with the LEV standards is in direct conflict with the OBDII regulations. The Staff is aware of this conflict and advises that it is their intent that any technology that cannot comply with the OBDII rules should not be considered for LEV compliance. Unfortunately, while we understand the Staff's motives and do not necessarily disagree with them, that approach obviates the use of the technology that is generally recognized as necessary for compliance with the LEV requirements. Until these conflicting regulatory requirements can be resolved we see no way to comply with them and thus be able to offer LEVs for sale in California after 1995. Because the two regulations are so strongly related, we recommend that Staff include a comprehensive review of both regulations when it conducts its review of the OBD requirements for LEVs, which is tentatively scheduled for Board action this fall.

Ford is also very concerned about possible changes to ARB's high temperature multiple day evaporative emission regulation due to current EPA action. The major differences between EPA's and CARB's regulations include different drive cycles in the running loss test and EPA's addition of a "short" test emphasizing a rapid purge of the canisters. If the ARB regulation is changed, development of new purge strategies will most likely be required, adding to the lead time and feasibility problems for TLEVs, LEVs and ULEVs. Also, a major change to these rules would greatly increase the likelihood of substantial evaporative/exhaust interaction.

Ford will continue to work hard to extend the limits of current technology and to develop new technology to meet the LEV/CF program's requirements. To date, this work has yielded some encouraging results and some not so encouraging. In concluding, we make the following recommendations:

1. Establish a rulemaking process to enhance the database and evaluate new analytical methods for establishing RAFs for the 1998 and later model years. Adopt the Staff-proposed RAFs and baseline reactivities, without modeling corrections, for model years prior to 1998.
2. Schedule a comprehensive review of the LEV/CF regulations in conjunction with the review of the OBDII regulations for LEVs by the fall of 1993.

This concludes my statement. I will be glad to answer your questions.

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CHRYSLER CORPORATION

Chrysler Corporation

Statement by Frederick C. Maloney, Emissions Planning Specialist, Environmental and Energy Affairs, Chrysler Corporation

California Air Resources Board Public Hearing to Consider Amendments to Certification Requirements and Procedures for Low-Emission Passenger Cars, Light-Duty Trucks and Medium-Duty Vehicles

Sacramento, California January 14, 1993

Chrysler appreciates this opportunity to comment on the proposed revisions to the California Low Emissions Vehicle program. Although we continue to have many concerns with the LEV program such as leadtime and feasibility, I would like to address just two issues today: reactivity adjustment factors (RAFs) and electric vehicle incentives.

Chrysler believes that the issue of RAFs, including ozone forming potential (OFP) of baseline vehicles and fuel, and the method for their determination, need to be established so that manufacturers can get on with the development and certification of all classes of low emission vehicles. Also, incentives for electric vehicle sales need to be put in place now to ensure that vehicles are purchased in the numbers the regulations require beginning in the 1998 model year.

RAFs and OFP

Chrysler supports the use of interim RAFs and OFPs through the 1997 model year proposed here today. Since the science for determining RAFs is still in the developmental stage, Chrysler believes that the RAF values should not be

06347

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Auburn Hills MI 48326-2757

adjusted for the proposed modelling-based correction factor. We recommend that the RAFs for Phase II gasoline be

0.98 for TLEVs, and

0.95 for LEVs and ULEVs

Although we do not believe the ozone forming potential of LEVs and ULEVs should be 3.13, we accept the values through 1997 provided that CARB agrees to the proposed 50 car/15 truck test program. The program should establish a baseline OFP from vehicles certified to 0.39 g/mi NMHC and 0.25 g/mi NMOG standards so that the effect of technology, as well as fuel, is accounted for in emission control development.

Interim RAFs are also needed for MDVs so that manufacturers have established procedures and emission levels to which to design and certify. Chrysler is currently in the process of certifying our CNG van to the MDV LEV standards for the 1994 MY. Because of the lack of an RAF for this class of vehicles, the process of obtaining an Executive Order has been very tedious.

The possibility of the RAFs or the OFPs changing from model year to model year results in effectively revising the emission standards. Such modifications are likely to violate leadtime constraints or could necessitate a costly change in our product plan.

Early determination of OFP and RAF values provide the industry with stability for planning purposes. Additionally, stability in standards and increased leadtime provide the much needed development time to maximize cost efficiency of the hardware.

Electric Vehicle Sales Mandate

The LEV regulations require manufacturers to "certify, produce, and deliver for sale in California" ZEVs beginning in 1998. While there are still many shortcomings of the electric vehicle, we are trying hard to meet the standards and customer requirements for an acceptable vehicle. Competition among the manufacturers to produce an acceptable electric vehicle is evidenced by Chrysler's recent announcements of a quick-charge electrical system. Cooperation among manufacturers and between government and industry has been displayed by the formation of various consortia. Despite this level of activity, there is still no guarantee there will be sales in the numbers required by these regulations, which even the Air Resources Board says is technology forcing. We need CARB participation, as well as participation from other state agencies, to assure that there will be a market large enough to meet the sales requirements of the regulations. Government incentives, such as reasonable tax incentives and subsidies, government purchases, a recharging infrastructure and a general communication program to reinforce the environmental benefits of EVs are necessary to ensure that EVs are sold in the number required. Suggestions to change the regulation allowing manufacturers merely to have to "make available for sale" should be closely scrutinized to assure that the important partnership between manufacturer and government is not lost.

In summary, we support the concept of interim RAFs and a CARB/industry test program to develop RAFs for 1998 and beyond. We also urge CARB to support industry in its efforts to sell electric vehicles.

*   *   *

WSPA
Western States Petroleum Association

Gina Grey
Senior Coordinator
Downstream Issues

1/14/93
93-1-3

STATE OF CALIFORNIA
AIR RESOURCES BOARD
RECEIVED 1-13-93
BY BOARD SECRETARY

XC: Bd Mbrs
JS TAC
JD MSD
JB Legal

January 12, 1993

Ms. Pat Hutchins
Board Secretary
California Air Resources Board
2020 "L" Street
Sacramento, CA 95814

Dear Ms. Hutchins:

Please find the attached WSPA comments on CARB's proposed amendments to the low-emission vehicle program.

Yours truly,

Gina Grey

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06350

WSPA Written Comments on CARB's Proposed Amendments to the Low-Emission Vehicle Program

These comments are submitted by the Western States Petroleum Association (WSPA), a trade association of companies whose members conduct much of the producing, refining, transportation and marketing of petroleum and petroleum products in the western United States. WSPA appreciates the opportunity to comment on the California Air Resources Board's (CARB) Initial Statement of Proposed Rulemaking, Amendments to the Low-Emission Vehicle Program, dated September 25, 1992 and amended on November 13, 1992 and on their report on the Establishment of Corrections to Reactivity Adjustment Factors for Transitional Low-Emission Vehicle and Low-Emission Vehicles Operating on Phase 2 Reformulated Gasoline, dated November 24, 1992 and revised on December 15, 1992.

CARB staff has indicated its intention to adopt reactivity adjustment factors (RAF's) for Phase 2 gasoline Transitional Low-Emission Vehicles (TLEV's) and Low-Emission Vehicles (LEV's) at the January 14-15, 1993 hearing. The proposed RAFs are 1.03 for Phase 2 gasoline-fueled TLEVs and 0.99 for Phase 2 gasoline-fueled LEVs.

WSPA has filed a legal challenge to the underlying methodology for determining RAF's as adopted at the November 14, 1991 hearing. In addition, WSPA has serious concerns with the setting of the specific reactivities for the base gasoline and the reactivity adjustment factors (RAF's) for Phase 2 gasoline. We believe that better scientific support and thorough peer review should be required for these important rules.

In view of the decisions made last year that will cost Californian's several billions of dollars to produce Phase 2 gasoline, we contend that CARB has an obligation to assess rigorously and scientifically the reactivity benefits of Phase 2 gasoline. As explained in more detail in the attachments, we believe CARB has violated this obligation in using a controversial and uncertain reactivity adjustment methodology combined with a questionable comparison of limited data from inadequate test vehicles.

Our detailed comments are included in the following three attachments:

1) "WSPA Comments on CARB's Proposed Amendments to the Low-Emission Vehicle Program"

2) "A review of the Vehicle Test Data and Methodologies Used by CARB in Establishing RAFs"

3) "Legal Comments Regarding Proposed Amendments to Certification Requirements and Procedures for Low-Emission Passenger Cars, Light Duty Trucks and Medium Duty Vehicles"

Some of the key process and technical concerns are summarized in the following discussion.

In terms of adequate process, at least 45 days are required to afford adequate opportunity for public comment and review. While staff has recognized some of the deficiencies and postponed the hearing twice, the fact remains that the final proposed Phase 2 RAF's, along with the modeling correction factor and certain revisions to the vehicle test data have not been provided to the general public and were not communicated to WSPA until January 5, 1993. The modeling protocol and other test results were not available until shortly before Christmas. This last minute release of key information does not satisfy due process rights and the statutorily mandated 45-day notice requirement.

In developing specific reactivities and RAF's, CARB's technical approach and analyses are questionable because it:

- Includes vehicles tested with reference fuel rather than Phase 2 fuel.

- Uses off-spec test fuels.

- Mislabels test vehicles.

- Uses test vehicles that do not represent the vehicle or technology mix expected to be in the marketplace.

- Ignores minimum mileage requirements for the test vehicles.

- Fails to demonstrate in-use durability of the test fleet.

- Fails to evaluate inter-lab variability.

- Fails to statistically evaluate the variability of the data.

- Uses test protocols that are much less rigorous than CARB demands of the auto manufacturers.

- Compares the performance of Phase 2 and reference gasoline in different test fleets.

For these and the other reasons documents in the attachments, WSPA contends that the Staff's proposed specific reactivities and RAF's for Phase 2 should not be forced through and adopted by the Board. Instead, WSPA recommends that CARB postpone this matter and a more thorough and sound test program be conducted to methodically establish scientifically correct specific reactivities and RAF's.

WSPA Comments on CARB's Proposed Amendments to the Low-Emission Vehicle Program

January 14, 1993

These comments are submitted by the Western States Petroleum Association (WSPA), a trade association of companies whose members conduct much of the producing, refining, transportation and marketing of petroleum and petroleum products in the western United States. WSPA appreciates the opportunity to comment on the California Air Resources Board's (CARB) Initial Statement of Proposed Rulemaking, Amendments to the Low-Emission Vehicle Program, dated September 25, 1992 and amended on November 13, 1992 and on their report on the Establishment of Corrections to Reactivity Adjustment Factors for Transitional Low-Emission Vehicles and Low-Emission Vehicles Operating on Phase 2 Reformulated Gasoline, dated November 24, 1992 and revised on December 15, 1992.

MIR METHODOLOGY

WSPA has long maintained that the approach for calculating reactivity adjustment factors (RAFs), as set forth in CARB's Clean-Fuel/Low-Emission Vehicle regulation and as applied in the present rulemaking, is fundamentally flawed. The flaw is not only in the choice of any particular reactivity scale, but also in the notion that there can be one reactivity scale that would be applicable to all urban atmospheric conditions. It is scientifically possible to calculate a reactivity scale for a given set of environmental conditions; however, different environmental situations will yield different reactivity scales. The concept of averaging scales across different conditions to derive a single reactivity scale that would be applicable to all situations is fundamentally wrong. Thus, the choice of a single value must be arbitrary and may be detrimental to air quality in parts of an air basin on many days compared to requiring the same mass reductions of all vehicles.

Another key flaw in the current reasoning about reactivity scales is the notion that reactivity is a property of a particular VOC species. This is only partly true. Reactivity is a property of the entire reacting system, the environment in which the reactions of a particular VOC are taking place. WSPA sponsored analyses by Professor Harvey Jeffries of the University of North Carolina clearly show that up to one half of the ozone change that occurs when one species is changed can be caused by the change in the ozone that all other species contribute; that is, all other species in a VOC mix contribute to the change in ozone when one species is changed. Thus, it is very important that the chemical composition of the environment be properly characterized and that the chemical mechanism used to calculate reactivities accurately account for the species' interdependencies. The chemical mechanism, SAPRC90, used by CARB is known to be incorrect; deficiencies pointed out in a CARB-sponsored review by Dr. Michael Gery have never been corrected.

Furthermore, Professor Jeffries' analysis shows that, in today's urban areas, more than half of the photochemical production of ozone comes from the reactions of CO, methane, and paraffin species in the air. These are compounds traditionally thought of as being either unreactive or as having low reactivity. The inclusion of a methane RAF for CNG vehicles in the present rulemaking acknowledges that methane can play a role in ozone formation. In the case of other fuels, methane's role is admittedly less significant, but a similar argument can be made for its inclusion. The ozone forming potential of CO and evaporative emissions should also be taken into account. This suggests that reduction of total carbon mass and/or reduction of NOx may be the best way to reduce the ozone forming potential of vehicle emissions.

TECHNICAL EQUITY

In developing specific reactivities used in promulgating the M85 TLEV RAF and used in establishing the proposed Phase 2 TLEV and LEV RAFs, CARB has employed a double-standard in that CARB uses a methodology that is far less stringent than the one which it requires of auto manufacturers who seek to qualify engine family specific RAFs. In particular:

- Manufacturers are required to determine RAFs using vehicles to which the RAFs will actually apply; CARB uses a few low-mileage vehicles, often jury-rigging emission control systems onto rental cars, to develop RAFs which will be applied to vehicles spanning many engine families.

- Manufacturers must conduct more vehicle tests to develop an RAF for one engine family than CARB has conducted in developing their RAFs, which are applied to many engine families.

- Vehicles tested by manufacturers must comply with emission standards throughout their useful lives (100,000 miles); CARB tested vehicles only at low mileage (typically less than 10,000 miles).

- Vehicles tested by manufacturers must comply with specific minimum mileage requirements, which are ignored by CARB.

- Manufacturers must conduct tests to account for changes in the reactivity of emissions as vehicles age; CARB does not perform such tests.

- Manufacturers are required to subject their data to strict tests to determine the statistical validity of such data; CARB does not test the statistical validity of its data.

Specific examples in support of these points are documented in a report for WSPA by Sierra Research, Incorporated, which is attached.

WSPA feels that there is no logical reason why there should be one set of criteria, which is very lenient and applies only to CARB, and another set of criteria, which is very stringent and applies only to vehicle manufacturers. In fact, since the CARB derived RAFs are to be applied to many engine families, the protocols for CARB derived RAFs should be much <u>more</u> stringent than those for a RAF for a single engine family. Furthermore, such CARB-specific protocols should explicitly state how statistically valid and representative vehicle data would be obtained and processed; without such a written protocol, CARB's actions in developing RAFs will continue to be ad hoc, arbitrary, and inconsistent.

STATISTICALLY VALID AND REPRESENTATIVE DATA

The main problem facing CARB in determining RAFs is that the vehicles, whose emissions they are attempting to characterize, do not exist. Consequently, CARB is forced to use low-mileage conventional vehicles, often jury-rigged with ad hoc experimental emission control components (such as EHCs), to represent production low-emission vehicles that may not be built for several years. This approach has not, and probably cannot, be used to accurately characterize the emissions of future low-emission vehicles.

In the present rulemaking effort to develop RAFs for TLEVs and LEVs operating on Phase 2 gasoline, CARB is relying on data from tests conducted on a small number of very low mileage vehicles. CARB is using data from tests on 12 TLEVs operating on Phase 2 gasoline to establish an uncorrected RAF of 1.00 for such vehicles. However, five of these vehicles were tested by General Motors; CARB made no assessment of the importance of inter-laboratory variability on the test results and has provided no information on the emission control systems used on these vehicles. Lab-to-lab variation may or may not be important; however, the Phase 2 TLEV RAF based on the CARB data alone would be 1.04, whereas, the RAF based on the GM data alone would be

0.96. Statistical tests should be performed to characterize the statistical validity of these data.

The denominator in the expression used to determine RAFs for TLEVs was set by CARB in 1991 to be 3.42 g ozone/g NMOG. Vehicle manufacturers "are given the option of determining the numerator for individual engine families." WSPA feels it is not proper to combine an auto manufacturer's numerator with CARB's denominator without ever having conducted cross correlation checks to verify that measurements from the different laboratories are comparable. Furthermore, the RAF denominator of 3.42 is based on emissions from a particular fleet of "pseudo-TLEV" gasoline vehicles which were tested in 1991. This value should not be used with the new set of vehicles now being tested to establish RAFs for Phase 2 gasoline in TLEVs, nor should an auto manufacturer be allowed to use this value when certifying an individual engine family. Any RAF for TLEVs should be determined by testing both Phase 2 certification gasoline and fuel RFA in the same vehicles.

WSPA questions CARB's selection of LEVs for determining the specific reactivity of LEVs operating on conventional gasoline and for determining the RAFs for LEVs operating on Phase 2 gasoline. To our knowledge, there are no vehicles currently available which are certified to the LEV emission standards. CARB has created "pseudo-LEVs" by retro-fitting standard vehicles with electrically heated catalysts (EHC). Clearly, this is not the same as using real LEVs. CARB measured six low-mileage vehicles equipped with EHCs to obtain a value of 3.16 for the specific reactivity of LEVs operating on conventional gasoline. There appears to be no way in which CARB can realistically claim that six vehicles retrofitted with essentially green catalysts are representative of the fleet of LEV vehicles that manufacturers will produce.

CARB is also using the data from these six vehicles to set the specific reactivity for ULEVs operating on conventional gasoline. However, while CARB has insisted that vehicles used to establish specific reactivity values and RAFs must meet all applicable standards for the vehicle class in question, none of the EHC vehicles tested by CARB meet the 50,000 mile ULEV NMOG standard of 0.040 grams per mile on conventional gasoline and only one of the six meets the ULEV standard on Phase 2 gasoline. We do not understand why CARB apparently believes that six EHC-equipped vehicles that do not comply with the ULEV standards are capable of generating a representative speciated NMOG emissions profile on conventional gasoline while, at the same time, they argue that these same vehicles cannot be used to characterize emissions on Phase 2 gasoline.

Since GM data were used by CARB in establishing the proposed Phase 2 TLEV RAF, why did CARB choose not to use data from the two advanced prototype Ford vehicles, mentioned on pages 8 and 9 of the November 13 amendments, in determining the proposed Phase 2 LEV RAF?

Finally we note that the vehicles selected by CARB to determine the specific reactivities of various vehicle/fuel combinations bear little relationship to the distribution of vehicles by manufacturers as they exist in the current vehicle fleet. Furthermore, although RAFs will be applied to light and medium duty trucks, CARB has not measured emissions from trucks for the present rulemaking.

WSPA recommends that CARB improve their RAFs by initiating a program to develop a robust set of emissions data which is based on measurements of large numbers of vehicles that are representative of expected fleets. We also encourage inter-laboratory comparisons to reduce lab-to-lab variations in test results.

AIRSHED MODELING

The December 15, 1992 report of the airshed runs performed to determine the RAF correction for TLEVs and LEVs operating on Phase 2 gasoline indicates that RAF corrections are necessary because of "differences in spatial and temporal patterns of emissions between vehicle fleets, rather than a problem with the maximum incremental (MIR) scale used to calculate the RAFs." This hypothesis should be tested; WSPA maintains that the need for a correction may indeed be due to problems with the MIR scale.

In the same report, RAFs of 1.06 and 0.99 are recommended for TLEVs and LEVs, respectively, operating on Phase 2 gasoline. However,available data from GM and Ford were not included in the calculations due to lack of time; the report indicates that they will be included in the RAF calculation when the data is reformatted. This implies that these RAFs must still be considered interim and subject to change before/at the Board hearing.

The airshed runs were performed using composite speciation profiles which do not include updated reactivity assignments for two coeluting pairs. Furthermore, they do not include available data from GM and Ford. The airshed analysis should be repeated with this additional information. Furthermore the airshed analysis should also be repeated with the corrected RAFs to ensure that the correction is appropriate.

RAF corrections of 5% and 4% are proposed for TLEVs and LEVs, respectively, operating on Phase 2 gasoline. Will these same correction factors be applied to engine-family specific RAFs or will auto manufacturer's be required to determine their own RAF corrections? Does CARB feel comfortable in applying corrections derived for RAFs around 1.0 to engine-family specific RAFs which may be around 0.7?

The CARB airshed modeling reports contain limited information on the details of the emissions inventories used in the airshed runs and the reasons for changes to the 1987 emissions inventory used previously in the 1991 evaluation of the RAFs. There is also no information provided on the performance of the CMU model with the base or modified emissions inventories. CMU model performance may not meet requirements specified in CARB guidance on photochemical modeling. Also, the future year (2010) emissions inventory, initial conditions, and boundary conditions do not appear to represent expected future conditions but instead seem to be chosen to provide a set of VOC/NOx conditions to test the sensitivity of RAFs; if this is the case, the report should make this point clear.

Table III shows that cold start fractions for RFA and Phase 2 gasoline are significantly different. While this may correctly reflect the CARB emission measurements, which were made on different vehicles, it is not clear why this should be the case in the real world. The difference in cold start fractions could have an important effect on airshed model results.

Model response to formaldehyde is non-linear and the incremental reactivity of formaldehyde decreases as more formaldehyde is added. By defining the null case as NMOG exhaust in the base inventory and then adding a large amount of formaldehyde for the M85 case, CARB may have saturated the model with respect to formaldehyde and underestimated the incremental reactivity of M85 emissions.

We also note that in Table V the fleet emissions of formaldehyde are higher for TLEVs and LEVs operating on Phase 2 gasoline than on RFA, but in Appendix C (page C-3) the formaldehyde emissions for TLEVs operating on these two fuels are about the same; what is the reason for the difference?

The CARB speciation profiles in Appendices C and D do not include MTBE even though MTBE makes up 11% of Phase 2 certification fuel. In the Auto/Oil program, fuels containing 15% MTBE averaged 4.8% MTBE in the exhaust. Since MTBE is much less reactive than the composite exhaust speciation profile, CARB may have overestimated the reactivity of Phase 2 gasoline by ignoring MTBE.

It is also puzzling why the TLEV emission results in Appendix C indicate nearly identical mass emission rates of NMOG from fuel RFA and Phase 2 gasoline. CARB has claimed that NMOG reductions of "approximately 40%" result from use of Phase 2 gasoline. Furthermore, the aromatic portions of the exhaust profiles in

Appendix C are surprising. Since Phase 2 gasoline contains approximately 27% less aromatics than fuel RFA, a similar reduction would be expected in the emission profiles. However, this is not found to be the case. The overall aromatics fractions of the two profiles are nearly equivalent, while the contribution of the highly-reactive C_8 aromatics is actually higher from Phase 2 gasoline than from RFA. This feature defies logic and probably contributes to an overestimation of the exhaust emissions from Phase 2 gasoline. An error in the distribution of aromatics in the emissions species profile would also have a significant effect on the results of the airshed modeling.

LEGAL COMMENTS REGARDING PROPOSED AMENDMENTS TO CERTIFICATION REQUIREMENTS AND PROCEDURES FOR LOW-EMISSION PASSENGER CARS, LIGHT DUTY TRUCKS AND MEDIUM DUTY VEHICLES

Submitted by the
Western States Petroleum Association

January 6, 1993

I. PRELIMINARY.

These comments are submitted on behalf of the Western States Petroleum Association ("WSPA"), a trade association of more than 40 companies whose members conduct much of the producing, refining, transporting and marketing of petroleum and petroleum products in the western United States. WSPA appreciates the opportunity to comment on the Air Resources Board's ("ARB" or "the Board") Initial Statement of Proposed Rulemaking Amendments to the Low-Emission Vehicle Program ("Proposed LEV Amendments"), dated September 15, 1992, and the "Supplement to Initial Statement of Proposed Rulemaking," dated September 25, 1992.

The Board has indicated its intention to adopt reactivity adjustment factors ("RAFs") for Phase 2 gasoline Transitional Low-Emission Vehicles ("TLEV"s) and Low-Emission Vehicles ("LEVs") at the January 14-15, 1993, hearing. The proposed RAFs are 1.03 for Phase 2 gasoline-fueled TLEVs and 0.99 for Phase 2 gasoline-fueled LEVs.

WSPA has a number of concerns with the proposed RAFs and the manner in which they have been developed. First, the ARB's final proposal, along with the modeling correction factor and certain revisions to the vehicle test data, were not communicated to WSPA until January 5, 1993. The modeling protocol and other test results were not available until shortly before Christmas. This violates basic administrative requirements of notice and opportunity for meaningful public comment. It is inconceivable that the ARB could expect to satisfy fundamental due process rights and the statutorily mandated 45-day notice provision by announcing the final proposed Phase 2 RAFs little more than a week before the January 14 hearing, particularly when the test data was still not complete and some inaccuracies in the test results still existed at that time.

Second, the RAFs for Phase 2 gasoline are based on an underlying scale of reactivity values for individual organic gases which is fundamentally flawed. This scale, known as the Maximum Incremental Reactivity ("MIR") scale, is in turn based on a chemical mechanism for determining reactivities known as "SAPRC 90." The ARB's own staff documents which accompanied the Board's adoption of an RAF for M85 admitted that the SAPRC90 mechanism and the MIR scale contain "major uncertainties." (See Initial Statement of Proposed Rulemaking-Reactivity Adjustment Factors for Transitional Low-Emission Vehicles ("Proposed Reactivity Amendments"), dated September 27, 1991, at 8, 20, 27.) Rather than attempt to remedy these uncertainties, which may actually result in more air pollution, the ARB has now proposed additional RAFs based on the same flawed chemical mechanism. Although the mechanism itself is not at issue in this rulemaking, WSPA submits that the decision to rely on the mechanism is arbitrary, capricious and not in accordance with the requirements of law.

Third, in light of the inadequate scientific basis and the uncertainty as to whether the RAFs will improve or worsen air quality, the ARB should have properly analyzed environmental impacts, alternatives and feasible mitigation measures related to the adoption of Phase 2 RAFs in compliance with the California Environmental Quality Act and the ARB's certified regulatory program. The ARB attempts to excuse its failure to do this by stating that "for the purpose of evaluating potential emission impacts, the proposed amendments are appropriately viewed as part of the larger low-emission vehicle regulatory program." (Proposed LEV Amendments at 20.) However, since the ARB did not comply with CEQA or its certified regulatory program when it adopted the prior regulations (Proposed Reactivity Amendments at 22-23), this is hardly a remedy for this deficiency.

Fourth, the ARB's proposal does not satisfy the standards of the Office of Administrative Law ("OAL") in that it is not reasonably necessary to effectuate the purpose of Division 26 of the Health & Safety Code within the meaning of Gov. Code Section 11350 because the air quality benefits are so uncertain.

Fifth, the Reactivity amendments are outside the scope of the ARB's statutory authority within the meaning of Gov. Code section 11342.1 because they are not "necessary" or "cost-effective" within the meaning of Health & Safety Code sections 43013, 43018 and 43101, and violate the ARB's own statutory mandate to achieve the "maximum possible emission reductions" (Id.).

We take up these points in order below.

II. THE ARB HAS IGNORED FUNDAMENTAL PRINCIPLES OF DUE PROCESS.

Under prevailing case law, an administrative action is invalid if the agency does not "employ fair procedures." See, e.g., Western Oil and Gas Association v. Air Resources Board (1984) 37 Cal.3d 502, 509. In addition, the Administrative Procedure Act requires agencies to provide adequate notice and opportunity to be heard on proposed actions. Gov. Code §§ 11346, 11346.4, 11346.5, 11346.53, 11346.55.

The ARB's actions are directly contrary to these requirements. Rather than propose final RAFs for Phase 2 gasoline, supported by completed and available testing data, 45 days prior to the hearing as required by Gov. Code section 11346.4(a), the ARB did not announce the final proposed RAFs until January 5, 1993. Related information, such as the modeling protocol, was not available until December 16, 1992. There is simply no way that WSPA, or other affected industries or members of the public, can present meaningful public comment at the January 14-15 hearing unless the proposal is fixed sufficiently far in advance of the hearing date to allow reasoned consideration of its validity.

III. THE PROPOSED INTERIM RAFS ARE NOT BASED ON SOUND SCIENTIFIC ANALYSIS AND DATA.

The relative reactivity of emissions produced by different motor vehicle fuels is the subject of continuing and substantial scientific uncertainty. The ARB's staff materials prepared in connection with adoption of the RAF for M85 confirm the existence of this uncertainty regarding reactivity in general and, more specifically, the MIR scale established by Dr. William Carter to fix RAFs for different fuels. In a memorandum authored by the ARB's Research Division dated April 2, 1992, on page 6, the ARB's research staff notes that there are "numerous areas of uncertainty" in the current knowledge of atmospheric chemistry of organic gases, including several "major uncertainties."

The overwhelming evidence before the ARB demonstrates that the MIR scale cannot deliver what it promises -- an accurate measure of reactivity applicable to all conditions which will, in practice, equalize the air quality impacts of low-emission vehicles powered by different fuels. In this regard, we attach as Exhibit "A" the statement by Professor Harvey Jeffries ("Jeffries Statement"), dated February 19, 1992, which was presented to the United Stated Environmental Protection Agency during a public hearing on the ARB's request for a waiver of federal preemption. The Jeffries Statement concisely summarizes many of the central criticisms of the MIR methodology adopted by the ARB in the RAF Regulations. As Professor Jeffries explains in his statement, the process is scientifically flawed because (1) the MIR scale in its current form has been proven to be inaccurate, and (2) the concept of a universal reactivity scale applicable to all conditions is scientifically suspect.

Courts have invalidated regulations based on "bad science" or inadequate technical information. In <u>Industrial Union Dept., AFL-CIO v. American Petroleum Institute</u>, 448 U.S. 607 (1980), for example, the United States Supreme Court struck down OSHA's airborne benzene standard of 1 ppm. The Court held that this extremely low standard was not supported by appropriate findings because there was no substantial evidence in the record that 1 ppm benzene exposure presented a significant health risk. The Court found OSHA's evidence inadequate even though "OSHA is not required to support its finding that a significant risk exists with anything approaching scientific certainty," and even though the

Court was willing to give OSHA "some leeway where its findings must be made on the frontiers of scientific knowledge." Id. at 656.

Courts also have invalidated EPA air quality regulations when the regulations were not based on substantial scientific evidence. In Cincinnati Gas & Electric Co. v. EPA, 578 F.2d 660 (6th Cir. 1978), cert. denied 439 U.S. 11124 (1979), the court invalidated EPA's decision to employ a pollution dispersion assumption because EPA ignored certain studies which showed that the assumption was incorrect. The court found EPA's action arbitrary and capricious, even while acknowledging that "decision-making (particularly in this highly technical area) is the primary responsibility of the agency and not the responsibility of this court." Id. at 663. And in Motor Vehicle Manufacturers' Ass'n v. EPA, 768 F.2d 385 (D.C. Cir. 1985), the court held that EPA's decision to grant a waiver of Clean Air Act restrictions for a particular methanol-gasoline blend was arbitrary and capricious because it was not based on a sound estimate of emissions.

Similarly here, the ARB's proposed RAFs for Phase 2 gasoline are not supported by substantial scientific evidence. To the contrary, the evidence suggests that the MIR scale on which the RAFs are based is flawed and, as applied to Phase 2 gasoline, that it may worsen rather than improve air quality. Under these circumstances, WSPA submits that it is arbitrary and capricious for the ARB to adopt the proposed Phase 2 RAFs.

IV. THE ARB DID NOT CONDUCT AN ENVIRONMENTAL REVIEW AS REQUIRED BY THE CALIFORNIA ENVIRONMENTAL QUALITY ACT.

The ARB presents no analysis or discussion of potential environmental impacts of adoption of the Phase 2 RAFs, but instead states simply that "for the purpose of evaluating potential emission impacts, the proposed amendments are appropriately viewed as part of the larger low-emission vehicle regulatory program." (Proposed LEV Amendments at 20.) This analysis is inadequate as a matter of law under the California Environmental Quality Act ("CEQA"), the CEQA Guidelines codified at 14 CCR §§ 14100 and the ARB's regulatory program codified at 14 CCR §§ 60005-60007.

In adopting air quality regulations, CEQA and the ARB's regulatory program require that the agency identify and assess all significant adverse environmental impacts and identify, analyze and adopt feasible mitigation measures and alternatives in order to mitigate any significant environmental impacts. The CEQA Guidelines make clear that state regulatory programs remain subject to all other provisions of CEQA "such as the policy of avoiding significant adverse effects on the environment where feasible." 14 CCR § 15250.

Courts on numerous occasions have invalidated state regulatory programs for failure to adequately evaluate environmental impacts. Recently, in Dunn Edwards v. Bay Area Air Quality Management District, ___ Cal.Rptr. ___, 1992 WL 224854 (Cal.App. 1st Dist., Sept. 17, 1992), the court invalidated two Bay Area District rules limiting the solvent content of architectural coatings for failure to adequately evaluate the environmental impacts of the rules. See also Dunn Edwards v. South Coast Air Quality Management District, L.A. Sup.Ct. No. BS004655 (July 30, 1991) (invalidating South Coast rules covering architectural coatings (Rule 1113) and aerosol paint products (Rule 1129)).

Similarly, in Mountain Lion Coalition v. California Fish and Game Commission, 214 Cal.App.3d 1043, 263 Cal.Rptr. 104 (1989), the court ruled that the California Fish and Game Commission violated CEQA by failing to analyze the environmental impacts of its proposed mountain lion hunting regulations. In Laupheimer v. State of California, 200 Cal.App.3d 440, 460-468, 246 Cal.Rptr. 82 (1988) and Environmental Protection Information Center v. Johnson, 170 Cal.App.3d 604, 624-25, 216 Cal.Rptr. 502 (1985), the California appellate courts struck down California Department of Forestry timber harvesting regulations because of failure adequately to consider environmental impacts. See also Sierra Club v. State Board of Forestry, 4 Cal.App.4th 942, __ Cal.Rptr. ___, (1992); Citizens for Non-Toxic Pest Control v. California Department of Food and Agriculture, 187 Cal.App.3d 1575, 1586, 232 Cal.Rptr. 729 (1986).

In spite of evidence that application of the MIR scale could in fact have substantial adverse effects on the environment, the ARB failed to identify or analyze those possible adverse effects at the time the mechanism was adopted. The ARB also failed to consider the cumulative impacts of RAFs generally, and to consider feasible alternatives or mitigation measures as required by CCR Section 60006 at the time or, later, when the specific RAF for M85 was adopted. Yet the ARB staff's Initial Statement now asserts that there is no need here to comply with CEQA because that was done as part of an earlier rulemaking. Clearly, that was not the case. And, even if the ARB had performed a CEQA analysis in connection with the earlier Reactivity rulemakings, that does not obviate the need to undergo a similar analysis here.

V. THE PROPOSED ARB ACTION FAILS TO COMPLY WITH STATUTORY AND ADMINISTRATIVE REQUIREMENTS.

Under Health & Safety Code section 43018, the ARB is required "to endeavor to achieve the maximum degree of emission reductions possible from vehicular and other mobile sources in order to accomplish the attainment of the state's standards at the earliest practicable date." Motor vehicle emission standards and motor vehicle fuel specifications must be "necessary, cost-effective, and technologically feasible . . . ." Health & Safety Code § 43013.

The requirement of "necessity" is spelled out not only in the Health and Safety Code but in the California Administrative Procedure Act ("APA") and in the requirements of the Office of Administrative Law ("OAL"). "Necessity" is defined in Government Code section 11349 as requiring a record which "demonstrates by substantial evidence the need for a regulation." The only function of the reactivity adjustment factors is to estimate the significance of the emissions of vehicles using the particular fuels specified. The adoption of such factors, which are to remain in effect for three years or more, based on incomplete and possibly inaccurate information, is certain to be misleading and thus, in the long run, will be conducive to less effective regulation rather than more effective regulation. It is difficult to make a convincing case for "necessity" under such circumstances.

We stress in this connection that we do not believe the inaccuracy of at least a portion of the present data to be a matter of serious dispute. In meetings between WSPA members and ARB staff, staff has admitted to such inaccuracies, as identified in work done by WSPA's technical consultant, Sierra Research, and elsewhere. For example, Sierra has established, among other things, that the ARB's test data includes vehicles tested with reference fuel rather than Phase 2 fuel, that the ARB has used off-spec test fuels, mislabeled test vehicles and used test vehicles that do not represent the vehicle or technology mix expected to be in the marketplace. Although the ARB staff claims now to have remedied some of these deficiencies, this information was not available until approximately one week before the January 14 hearing and was never adequately documented nor made available in published form.

The ARB's proposed action also violates the mandate in the Health and Safety Code that the Board take actions to achieve "the maximum degree of emission reductions possible . . . ." Given the uncertain state of the underlying science and the supporting data, the Reactivity amendments may well make the air quality situation worse rather than better. General constitutional and administrative law principles prohibit actions contrary to or outside the scope of an agency's statutory authority. See, e.g., Clean Air Constituency v. California Air Resources Board, 11 Cal. 3d 801, 816-17, 523 P.2d 617, 114 Cal. Rptr. 577 (1974); Sandstrom

06370

v. California Horse Racing Board, 31 Cal. 2d 401, 412, 189 P.2d 17, cert. denied 335 U.S. 814 (1948).

Finally, under the California Clean Air Act the ARB must also find that the proposed regulations are "cost-effective." Assessing an air quality regulation's cost-effectiveness involves comparing the relative cost that the regulation imposes, measured in dollars per pound or dollars per ton, of removing pollutants from the air. California Air Resources Board, California Clean Air Act: Cost-Effectiveness Guidance (Sept. 1990), at 3-6; see generally Del Duca, The Clean Air Act: A Realistic Assessment of Cost-Effectiveness, 5 Harv. Environ. L. Rev. 184 (1981). Thus, a cost-effectiveness evaluation of the Reactivity amendments would involve at least two components: (1) an analysis of the cost of complying with the regulations; and (2) an analysis of the emissions benefits. In addition, the relative cost-effectiveness of other environmental laws is relevant.

With regard to costs, the ARB staff simply states, at page 4 of the Proposed LEV Amendments, that the Executive Officer has determined that there will be little or no potential cost impact, as defined in Gov. Code section 11346.53(e), on private persons or businesses (other than small businesses) directly affected by the result of the proposed action. No effort has been made now or earlier, in connection with adoption of the LEV Program or the RAF for M85, to measure the cost-effectiveness of the Reactivity regulations.

V. CONCLUSION.

For all of the reasons stated above, the staff's proposed RAFs for Phase 2 gasoline should not be adopted by the Board.

Attachment A

Harvey Jeffries' Oral Statement for U.S. EPA Public Hearing for California Air Resources Board's Request for Waiver of Federal Premption.

Good Morning. My name is Dr. Harvey Jeffries. I am a Professor in the Department of Environmental Sciences and Engineering, School of Public Health, University of North Carolina, Chapel Hill. I am here as a consultant to the Western States Petroleum Association and I would like to share with you my thoughts on the ARB request. A major new factor in the ARB's proposal is the application of *reactivity adjustment factors* (RAFs) for differently fueled vehicles to adjust the mass emissions before determining compliance with emission standards. These RAFs would be derived from a combination of individual species measured in the exhaust and a reactivity scale listing each species's contribution to ozone. The particular scale used by ARB was the "maximum incremental reactivity" scale developed by Dr. Carter specifically for this purpose.

I have performed two studies of the scientific and technical issues related to the application of incremental reactivity. In the first study, conducted last year, I used a model analysis technique to explain the chemical origins of "incremental reactivity." This was done by showing that all other species in the VOC mix contributed to the change in ozone when one species was changed. This and other findings of the study were the basis of my presentation at the ARB Reactivity Workshop held at Irvine in April 1991. My written report on this portion of the work has been distributed by WSPA. In my second study which was recently completed, I compared the reactivities computed by three chemical mechanisms: one which is used by the US EPA and two other mechanisms which were used by the ARB in their studies. My reactivities were computed in scenarios which were essentially identical to those used by Dr. Carter in his calculations for the ARB. In my report I explained why the three different mechanisms gave different reactivities for several important VOC species, such as formaldehyde and toluene. The second report is attached to my complete statement and, for those interested in the details, it too is available from WSPA.

First I will state my basic position. The ARB September 27, 1991 Technical Support Document (TSD) in support of the proposed RAFs states that

> "The principle behind the RAF concept is that equal impacts on air quality will result from reactivity-adjusted emissions that just meet the standard."

Based on my studies, I have serious reservations that the methods used to calculate RAF values will produce this desired "level playing field." This is because the basic concept behind the use of a single RAF is fundamentally flawed, that is, *there is no single RAF* *value* per vehicle/fuel combination which will produce a "level playing field" across various vehicle/fuel combinations in the real world. This is because reactivities are a function of environmental conditions and are clearly not the same all over an air shed basin. Thus, the choice of a single value must be arbitrary and may be detrimental to air quality in parts of the basin on many days compared to requiring the same mass reductions of all vehicles.

Even if ARB could justify the use of a single scale, the *maximum* incremental reactivies are biased toward too much reactivity credit. This means that RAF values computed with these methods may actually aggravate the problem—the additional allowed VOC producing more ozone than would result from the direct application of a NMOG emissions standard to all vehicles. There are a number of reasons why I believe this might happen and I will briefly describe these below.

Dr. Carter, who developed the concept of incremental reactivities, has said on a number of occasions that reactivity values are environmentally dependent. Furthermore, the Technical Support Document recognized this conclusion by stating on page V-1:

> "... it is not possible to derive a single RAF that yields equal air quality impacts in all places at all times."

In discussing this "equal air quality" impact, the Technical Support Document says on page V-2:

> "The airshed model evaluation will demonstrate a successful reactivity scale if two fuel/vehicle combinations results 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)."

I learned of the results of ARB's first air shed tests of the MIR-based reactivity adjustment factor for methanol one week before the ARB's public hearing. Note that these were not tests of emissions, but instead direct tests of the MIR scale's accuracy in conditions different from those used to derive it. In two different episodes, the results showed neither equal one-hour basin peak ozone concentrations nor equal ozone exposure when RAF adjusted emissions for methanol were substituted for gasoline emissions. Since there were detrimental changes in air quality as large as 36%, I believe by ARB's own definitions and criteria that the single reactivity scale concept is a failure. The ARB staff elected not to show these air shed results at the public hearing, but instead they merely mentioned them as indicating that the RAF for methanol (M85) needed a 10% upward adjustment. The method used to compute the needed 10% adjustment has never been publicly documented and has not been externally reviewed for scientific merit. No method for performing such adjustments on other alternative fuels has been described.

There is no reason to believe that an adjustment derived for only the species in M85 exhaust is valid for species in ethanol-fueled vehicle exhaust for example.

There are a number of possible reasons the air shed tests failed and these include:

1) The RAFs used to adjust the air shed vehicle emissions were computed by a largely *unexamined averaging* process which has no underlying scientific support.
2) The averaging was performed on a *maximally expanded* reactivity measure which gives too much credit compared to typical air shed conditions.
3) The maximum reactivities were computed using a *simple* air quality model, one that is no longer allowed under the CAAA of 1990.
4) The air quality model had a *constant* composition of VOCs.
5) These constant composition VOCs were operated on by a chemistry model that was known to be *incorrectly* formulated.

Let me discuss each of these points in slightly more detail.

Because the ARB staff did not take enough time to examine all aspects of the fundamental approach taken to compute RAF's, no scientific review was done on the method for moving from reactivities computed by a model for a single day to a single reactivity value that could be used on all days. First, our basic scientific understanding of reactivity suggests that this is not possible. Second, I do not believe that the method chosen to produce a single set of IR values—the simple arithmetic averaging of partial derivatives determined in 39 different scenarios from all over the United States—has any scientific meaning. Furthermore, because most of the time in the few months before the ARB hearing was taken up in discussion of many details in Dr. Carter's mechanism and the model conditions he used, no peer review or discussion among scientists regarding the calculation of the single reactivity scale have taken place. In short, the method used to produce a single reactivity scale was chosen as a means to an end and its validity has never been demonstrated.

I believe that another reason for the failure of the air shed test is that the RAF was based on a "maximum" reactivity scale. These particular values—while easy to identify for calculation purposes—constitute the *most expanded* scale per calculation scenario (*i.e.*, the largest difference among species that would ever be expected). If such scales are used to make adjustments in emissions, then I believe they will over-estimate the benefits at typical urban conditions, and thus, the scale will result in non-equal impacts as happened in the air shed tests.

I also believe that a contributing factor to the failure of the air shed test is that the reactivity scale proposed by the ARB staff is based upon using a highly simplified one-day atmospheric model with simplified constant composition emissions operated upon by a generalized set of chemistry. My studies have shown that when one species in the urban VOC mixture is changed, the other species in the mixture contribute as much as half of the ozone change predicted by the model. In the real world (or even in grid models) the VOC mixture composition can vary from place to place (grid to grid) and from time to time. This compositional variation can change the chemical conditions significantly when compared to the simple models used by Dr. Carter and therefore would change the conditions that influence the reactivities computed for his scale.

Finally, we know that the version of the SAPRC90 mechanism used in producing the RAF values or the LCC mechanism used in the air shed test are not the best ones possible given today's knowledge and observations. In fact, we know that the SAPRC90 mechanism that was used is *flawed* in that it exhibits internal compensating errors in the test conditions used to determine its accuracy. This was revealed when, as part of the CARB's reactivity work, the mechanism was updated with the newest and most accurate rate constants and *its predictions of observations became worse.* Because of lack of time before the public hearing, rather than fix the other errors in the mechanism which resulted in the worse predictions, the ARB staff decided to use the older *and known incorrect* rate constants which caused the mechanism to agree somewhat better with chamber observations. This ignores the fact that such better agreement could only have arisen because some other part of the mechanism compensated for the incorrect rate constants. This approach is a case of hoping "two wrongs make a right" when the mechanism is applied in ambient air cases. The LCC mechanism used in the air shed is even older than the SAPRC90 mechanism and it too has incorrect rate constants and also may not be well formulated. Furthermore, after the ARB's hearing Dr. Carter and I have learned that some of most critical smog chamber experiments—those used to adjust part of the less-well-known aromatics chemistries in the SAPRC90 mechanism—have rather large inaccuracies for the measured NO_X data. In fact, the initial NO_X levels in the experiments were seriously under-reported. But, because of the tuning done on the SAPRC90 mechanism, its predictions agree very well with the incorrectly reported data, and thus the SAPRC90 mechanism will have to undergo significant revision when these data are corrected later this year.

While the CMU air shed model or the SAPRC90 mechanism are complicated, complex representations, they are much, much simpler than the real world, and it is important not to confuse such maps with the territory they represent. These models have been used mostly to suggest the *direction* of change in the real world. For me to believe that these models can predict a precise *balance* in the real world requires more evidence than I have seen in my studies of this phenomena and far more than is presented in the ARB staff's Technical Support Document.

In summary, I believe that there are shortcomings in the fundamental approach and specifics of how the RAF values were calculated, and specifically in the production of the MIR scale. Essentially no work on the uncertainties in these values was performed by Dr. Carter or the ARB staff. Very little attention has been devoted to the methods used to produce the single RAF scale. Almost no alternatives have been investigated. The chemical mechanisms that were used have admitted flaws. The most critical test data—the air shed results, which do not support the ARB's position, were not presented by the ARB staff at the public hearing. Putting the wrong numbers into regulations and leading industry and the public into acting on these numbers could be detrimental to California's air quality. Furthermore, the actions of the ARB appear capricious in the matter of setting the RAFs, especially in producing a 10% adjustment in methanol's RAF within days before the public hearing while at the same time not revealing the data supposedly supporting such adjustment. To exempt California from the requirements of the Clear Air Act Admendents under these circumstances seems improvident. I recommend that you decline to allow the use of an inaccurate and untested method in place of the requirements in the CAAA.

Comments on CARB's Request for Waiver of Federal Preemption in CAAA

I am here as consultant to Western States Petroleum Association. My comments address shortcomings in both the conceptual and technical basis for reactivity adjustments of emissions.

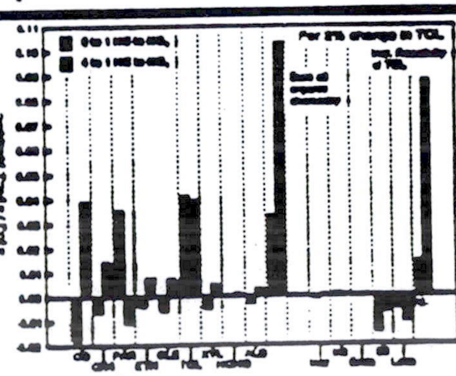
RAF: Major New Factor in CARB's Request

- application of Reactivity Adjustment Factors (RAFs) to emissions
- R(fuel) = Vehicle emissions x reactivity scale
- RAF(fuel) = R(fuel)/R(Ind. Ave. Gasoline)
- CARB's particular reactivity scale is "maximum incremental reactivity" scale developed by Dr. William Carter

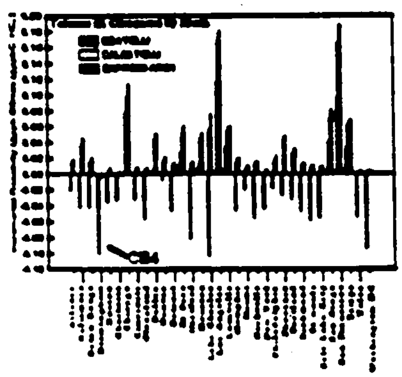
Jeffries' Two Studies on IR & MIR

- Explained chemical origins of incremental reactivities
- Explained reactivity differences among three photochemical reaction mechanisms

All Species Produce One IR



Toluene Reactivity Different



RAF Concept is Fundamentally Flawed.

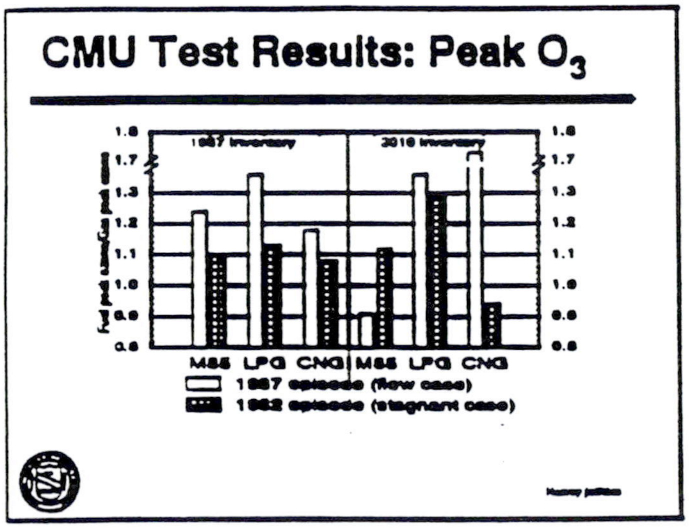
- ARB Tech Support Doc says, "The principle behind RAF concept is that equal impacts on air quality will result from reactivity-adjusted emissions that just meet the standard."
- It also says, "...it is not possible to derive a single RAF that yields equal air quality impacts in all places at all times."

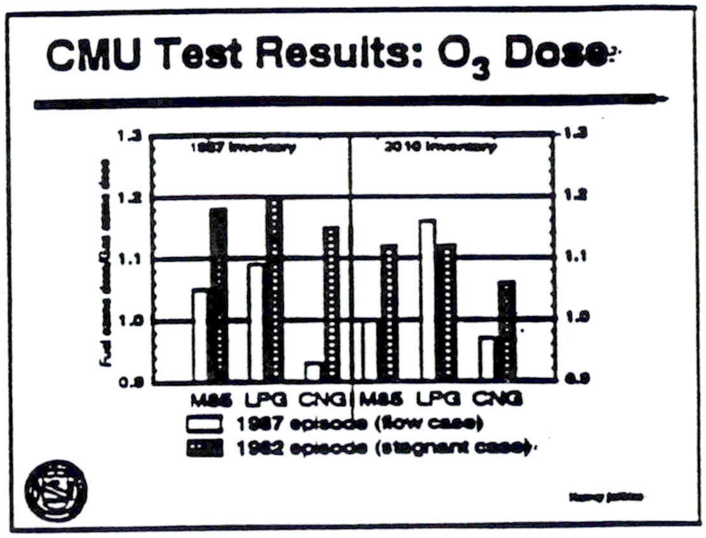
No single RAF value for any urban area.

- Reactivities are a function of environmental conditions
- Environmental conditions vary across air shed and city-to-city
- Even Carter says, "scales are environmentally dependent"
- There can not be adjustments that result in equal impacts from different mass emissions.

"Equal air quality" impacts null test with air shed model

- ARB Tech Support Doc said, "The airshed model evaluation will demonstrate a successful reactivity scale if two fuel/vehicle combinations results in equal one-hour basin peak concentrations and equal ozone exposure...for all hours in all grid cells..."


CMU Test Results: Peak O_3
1987 inventory
2010 inventory
1.8
1.7
1.3
1.2
1.1
1.0
0.9
0.8
M85 LPG CNG M85 LPG CNG
1987 episode (flow case)
1982 episode (stagnant case)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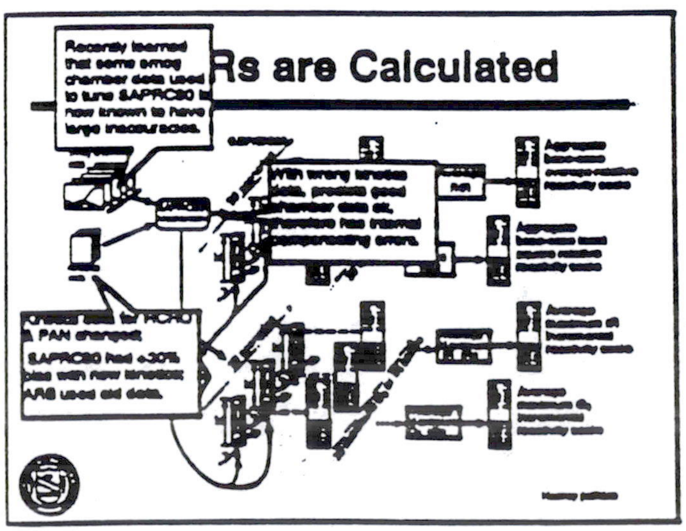
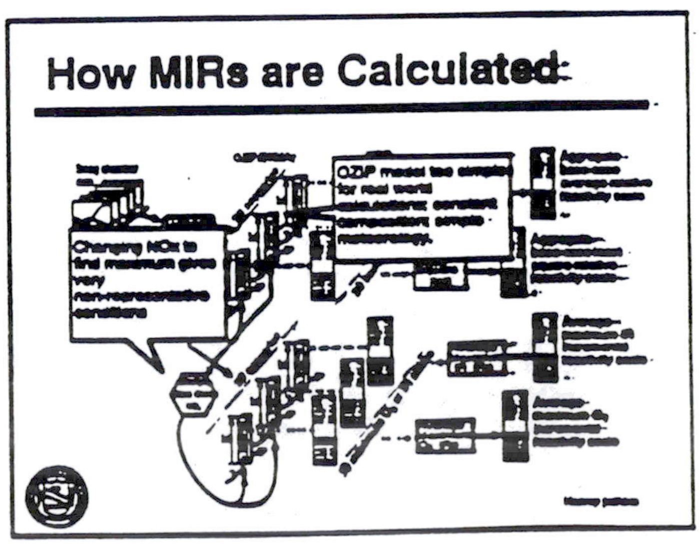
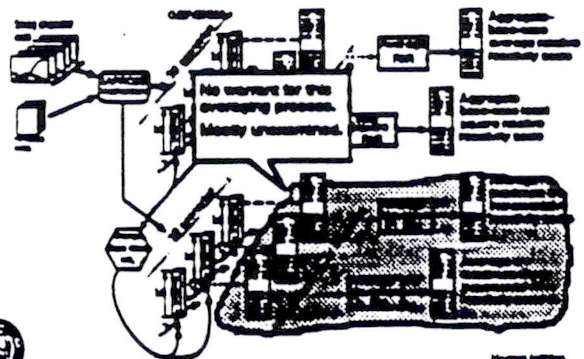
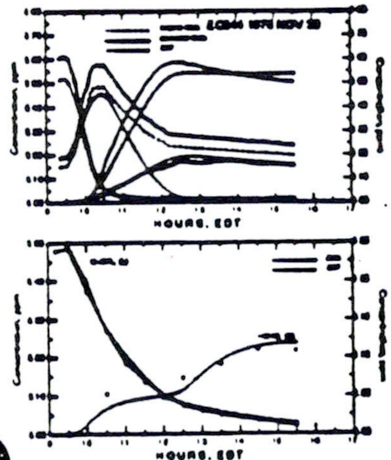

Rs are Calculated
Recently learned that some smog chamber data used to tune SAPRC90 is now known to have large inaccuracies.
PAN changed.
SAPRC90 had +30% bias with new kinetics; ARB used old data.


How MIRs are Calculated
OZIP model too simple for real world
Changing NOx to find maximum gives very non-representative conditions

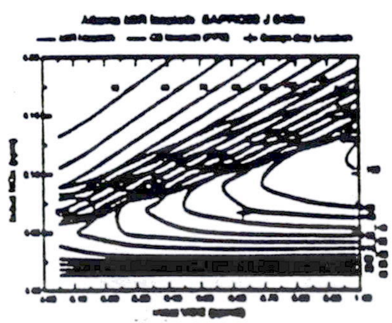
How MIRs are Calculated



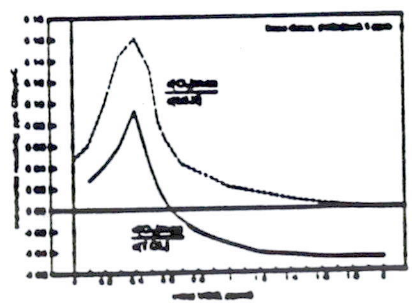
Inaccurate Chamber Data



Change NOx to Find MIR?



MIR Most Expanded Scale



Reasons for Failure

- chemistry model known to be *incorrect*
- OZIP model had *constant composition* of VOCs
- OZIP too *simple*—no longer allowed in CAAA
- a maximally *expanded scale* gives too much credit compared to typical air shed conditions
- RAF's calculated with scale computed by an *unexamined averaging process* which has no underlying scientific support

Models Not Real

- CMU air shed and SAPRC mechanism-complex maps.
- BUT, much simpler than real world!
- Important not to confuse maps with territories they represent.

Summary, I

- Shortcomings in the fundamental approach and specifics of RAFs
- Essentially no work on uncertainties
- Little attention given to producing single reactivity scale
- Chemical mechanism had admitted flaws
- Critical test data, not shown at ARB's Hearing, do not support application of RAFs

Summary, II

- Putting wrong numbers in regs & leading industry and public to act on them could be detrimental to Calif's AQ
- ARB's actions, esp. producing a 10% adjustment in M85's RAF while not revealing data to public, appear capricious.
- I recommend not allowing the use of an inaccurate and unfounded method in place of the requirements of the CAAA.

A Review of the Vehicle Test Data and Methodologies Used By CARB in Establishing Reactivity Adjustment Factors

prepared for the Western States Petroleum Association by:
James M. Lyons
and
Thomas C. Austin

Sierra Research, Inc.
November 23, 1992

Summary

At the request of the Western States Petroleum Association, Sierra has reviewed the methodology used by CARB and that which CARB requires to be used by vehicle manufacturers in developing reactivity adjustment factors (RAFs) for M85, Phase 2 gasoline, and other fuels.

RAFs are intended to account for differences in the photochemical reactivity of emissions of organic gases from vehicles operating on different fuels. Under the CARB regulations, RAFs determine the percentage by which a given type of vehicle operating on a particular fuel can exceed the applicable gram per mile NMOG emission standard without increasing the ozone-forming potential of that vehicle's emissions relative to a comparable vehicle operating on conventional gasoline. Given that the use of RAFs allows mass emissions to be increased, it is critical that RAFs be accurate, as any RAF that overstates the reactivity benefit associated with a particular fuel will lead to an increase in the ozone-forming potential of vehicular emissions. For example, a 10% error in an RAF could lead to NMOG emissions with an ozone-forming potential 10% greater than those of a vehicle operating on conventional gasoline. Therefore, the use of inaccurate RAFs could cause air quality to worsen rather than improve as a result of CARB's regulations.

Our review encompassed both the CARB rulemaking process that culminated in the adoption of the RAF value of 0.41 for M85-fueled "transitional low emission vehicles (TLEVs)" on November 14, 1991, as well the current rulemaking process in which RAFs are being proposed for various categories of "low-emission vehicles (LEVs)" operating on Phase 2 and conventional gasoline. Significant problems with the methodology used by CARB in development of RAFs have been identified and the accuracy of the proposed RAFs is therefore questionable. These problems include:

- CARB's use of unmatched test fleets, using different emission control systems, to determine the specific reactivity of TLEV and LEV emissions on conventional gasoline and Phase 2 gasoline RAFs;

- CARB's use of inconsistent testing methodologies for each vehicle/fuel combination, supported by contradictory assumptions, which, in some cases violate requirements contained in CARB's own regulations;

- CARB's use of test fuels that did not comply with the agency's own regulations regarding fuel composition; and

- CARB's use of test vehicles that were not representative of the vehicle fleet to which the RAFs will be applied in terms of manufacturer, emission control system equipment, and vehicle type (passenger car versus trucks).

<u>As explained below, the above-listed problems result in RAFs that tend to overstate the benefits of M85 relative to conventional gasoline and understate the benefits associated with Phase 2 gasoline.</u>

Another major issue is that CARB has imposed separate and unequal requirements for RAF development upon itself and vehicle manufacturers. The key differences between the requirements CARB has imposed on manufacturers and the methodologies used by the agency are summarized in Table 1. As shown in the table, the procedure used by CARB in developing RAFs is much less rigorous than the one the agency forces manufacturers to use. One key difference is that each CARB test vehicle represents approximately 100,000 to 1,000,000 vehicles with different engines and emission control systems produced by all manufacturers, while each test vehicle used by manufacturers represents approximately a few hundred to 10,000 vehicles with the same engine and emission control system. Additionally, the CARB RAFs apply to all types of vehicles, including light- and medium-duty trucks (through 5750 lbs. gross vehicle weight rating), many of which certify to less stringent emission standards than do passenger cars and, in general, utilize different types of emission controls.

In contrast to CARB RAFs, RAFs developed by manufacturers generally apply only to a single type of vehicle. Manufacturers are required to comply with a minimum mileage requirement of 4,000 on all test vehicles and accumulate a minimum of 75,000 miles (with 100,000 miles generally being the maximum) on at least one test vehicle to determine the effects of mileage on the reactivity. Manufacturers must also demonstrate that their test vehicles comply with LEV program standards over their entire useful lives, while vehicles tested by CARB are only required to comply with these standards at the time they are tested. Finally, manufacturers must determine and account for the variability associated with the RAFs they generate through the use of a statistical test, while CARB does not.

<u>As the RAFs developed by CARB and manufacturers are to be used interchangeably for the same purpose, there is no valid reason for CARB to impose less stringent requirements on itself than on manufacturers</u>. If the requirements CARB has imposed on vehicle manufacturers are necessary to ensure accurate RAFs, then the substantially less stringent criteria used by CARB cannot be expected to produce valid results.

As outlined above and discussed in detail below, serious concerns exist regarding the accuracy of RAFs developed by CARB and, therefore, the effectiveness of the "low-emission vehicle" program. One obvious solution would be to eliminate RAFs entirely and require all vehicles to comply with the mass emission limits set by CARB's standards.

Table 1

Comparison of Requirements for RAFs Developed by CARB and Vehicle Manufacturers

	CARB	Manufacturer
Number of Vehicles to Which RAF Applies	1-10 Million*	1-50 Thousand*
Number of Test Vehicles	10	5 (min.)
Number of Vehicle Tests	14-41	38 (min.)
Minimum Mileage on Test Vehicles	None	4,000
Mileage Accumulation Requirement for Test Vehicles	None	75,000
Vehicles Required to Comply with LEV Program Standards for 50,000/100,000 Miles?	No	Yes
Determine and Account for RAF Variability?	No	Yes

* Numbers are approximate and represent vehicles expected to be fueled by Phase 2 gasoline.

Overview of RAF Regulations

CARB's regulations regarding the establishment of RAFs by both CARB and vehicle manufacturers are contained 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." These regulations specify that CARB's Executive Officer is to "determine representative speciated NMOG exhaust emission profiles for light- and medium-duty conventional gasoline-fueled TLEVs, LEVs, and ultra low emission vehicles (ULEVs)." This determination is to be made using a "conventional gasoline" (fuel RF-A from the Auto/Oil Air Quality Improvement Research Program) meeting the specifications given in Table 2 and speciated NMOG profiles obtained from a "statistically valid number of TLEVs, LEVs, and ULEVs." However, no definition of "statistically valid" is provided in the CARB regulations. Additionally, the NMOG profiles must include as many NMOG species as can be identified using CARB's NMOG test procedures. From these "representative profiles", the specific reactivity of the NMOG emissions from TLEVs, LEVs, and ULEVs operating on conventional gasoline is to be calculated in terms of the total grams of ozone-forming potential per gram of NMOG emitted.

In order to determine an RAF, specific reactivity values for the vehicle/fuel combination in question must also be determined. The CARB regulations require that specific reactivity be calculated in the same manner as described above for light- and medium-duty TLEVs, LEVs, and ULEVs intended to operate on fuels other than conventional gasoline.

Table 2

CARB Specifications for "Conventional Gasoline" (RF-A)

Fuel Property	Property Limit
Sulfur (ppm by weight)	300±50
Benzene (vol. %)	1.6±0.3
RVP (psi)	8.7±0.3
Distillation Properties (°F)	
T10	115-135
T50 (maximum)	240
T90	323-333
End Point (maximum)	420
Total Aromatics (vol. %)	32±3.0
Multi-substituted Alkyl Aromatics	21±3.0
Olefins	12±3.0
Saturates	Remainder

The RAF for a given vehicle/fuel combination is calculated by taking the ratio of the specific reactivity value for the vehicle/fuel combination in question to the specific reactivity value for that type of vehicle operating on conventional gasoline. For TLEVs fueled with methanol or liquified petroleum gas, the final RAF is computed by multiplying the RAF calculated using the above methodology by 1.1. This factor of 1.1 is based on photochemical modeling results and is the source of considerable controversy because the factor should not be needed if the MIR scale used by CARB were truly accurate. CARB apparently plans to use photochemical modeling to adjust RAFs for all vehicle/fuel combinations, despite the fact that the agency's own regulations contain no provisions allowing this practice.

In addition to RAFs determined by CARB's Executive Officer, as described above, provisions also exist requiring the Executive Officer to assign engine-family-specific RAFs as part of the new vehicle certification process if manufacturers comply with certain criteria. These criteria require that manufacturers determine NMOG emission profiles for a minimum of four vehicles in each engine family for which an RAF is being sought, including the official "emissions data" vehicles used for generating emissions data required for the certification process. Additionally, each vehicle must have accumulated a minimum of 4,000 miles and the profile for the "emissions data" vehicles must be determined from the same test data used in the certification process to determine the total NMOG, CO, and NOx emissions at 4,000 miles.

Having determined NMOG emission profiles for each vehicle, manufacturers are to compute the specific reactivity of the emissions from each vehicle and calculate an RAF for each vehicle using that value and the appropriate specific reactivity value for vehicles operating on conventional gasoline, as determined by CARB's Executive Officer. The average of these RAF values is the RAF for the engine family, so long as the 95 percent upper confidence bound (UCB) of the RAF is less than or equal to 115 percent of the average RAF. The 95% UCB is to be calculated using Equation (1), where RAF_m is the average RAF for the engine family, n is the number of vehicles tested and RAF_i represents the RAF value for each vehicle.

$$95\%UCB=RAF_m+1.96\left[\sum_{i=1}^{n}(RAF_i-RAF_m)^2/(n-1)\right]^{1/2} \qquad (1)$$

Finally, vehicle manufacturers must determine an ozone deterioration factor for the engine family RAF. This requires determining the NMOG profile of the emissions from one or more durability vehicles based on two tests at each of the mileage intervals used in developing the required deterioration factors for NMOG, CO, and NOx emissions during the certification process, and computing an average specific reactivity value at each mileage point. These values are to be multiplied by the average NMOG emission rates in grams per mile at each mileage point to determine the average grams of ozone-forming potential per mile at each mileage point. These values are to be plotted as a function of mileage and a linear regression of the data is to be performed. The slope of the line determined by the linear regression factor is the ozone deterioration factor. However, under no circumstances is the ozone deterioration factor to be less than 1.00. The final RAF for the engine family is the product of the average RAF from the four or more test vehicles and the ozone deterioration factor.

Comparison of Methodology Used by CARB to Develop RAFs with Requirements for Manufacturer-derived RAFs

CARB Methodology - In establishing the specific reactivity of TLEVs operating on "conventional gasoline", CARB performed testing on a total of six vehicles. In addition, data from three other vehicles, one tested by Chevron Research and Technology Company and two from the Auto/Oil Air Quality Improvement Research Program, were also used by

CARB. All of the vehicles tested were production vehicles with model years ranging from 1989 through 1991. Seven of the nine vehicles were produced by domestic manufacturers, one vehicle was produced by a German manufacturer, and one by a Japanese manufacturer. The average mileage of the vehicles tested by CARB was 6,875 miles, with the range extending from 2,700 to 10,850 miles. The Auto/Oil vehicles had mileages of 10,800 and 11,700 and the Chevron vehicle 21,000 miles. These vehicles were selected by CARB solely based on their ability to comply with CARB's 50,000 mile TLEV standards when operated on conventional gasoline, albeit only at the very low mileages noted above. Given the language and requirements in the CARB regulations, the emission measurements made on these nine low-mileage vehicles apparently form what CARB considers a statistically valid representation of emissions from what may eventually be a total of several million TLEVs over the 100,000 mile useful life of those vehicles.

Each of the CARB vehicles and the Chevron vehicle were tested between four and six times without appreciable mileage accumulation between tests. The results of each of the multiple tests were averaged to determine the specific reactivity of NMOG emissions from each vehicle. The two Auto/Oil vehicles were tested only once and because of the lack of multiple tests, the data from the two vehicles were averaged together. A total of 36 speciated exhaust emissions measurements were made. The eight specific reactivity values calculated from the nine vehicles were then averaged to yield the value adopted by CARB of 3.42 grams of ozone-forming potential per gram of NMOG emissions from TLEVs using conventional gasoline. No statistical tests were performed to characterize the variability and uncertainty associated with the 3.42 value. Additionally, CARB made no attempt to assess the importance of and account for inter-laboratory variations in the test results for the CARB, Chevron and Auto/Oil laboratories.

Similarly, the specific reactivity of M85-fueled TLEVs was also determined using nine flexible-fuel test vehicles. However, in this case, CARB tested only two of the vehicles; the other seven vehicles were tested as part of the Auto/Oil program. These vehicles were all prototypes produced during the 1988 through 1991 model years. The mileage of these vehicles ranged from 9,100 to 16,650 miles. Again based on the language in the CARB regulations, the agency apparently believes that the emission data from these nine low-mileage vehicles forms a statistically valid representation of the emissions anticipated from all M85-fueled TLEVs throughout their 100,000 mile useful life. According to CARB, vehicles selected for testing were again required to comply with CARB's 50,000 mile TLEV standards, with the value of the M85 RAF taken into account.

In contrast to the four to six tests made on each of the gasoline-fueled vehicles by CARB, one M85 vehicle was tested three times and the other twice. Five of the seven Auto/Oil vehicles were tested only once, while two of the vehicles were tested twice. Therefore, a total of only 14 speciated tests were performed. However, rather than averaging all of the data from vehicles tested only once, as was done for the gasoline-fueled vehicles, CARB broke these seven vehicles into two groups according to vehicle manufacturer, and then averaged the data for the two groups. The average of the four specific reactivity values calculated by CARB was found to be 1.25 grams of ozone-forming potential per gram of NMOG emissions. Again, no statistical tests were performed to characterize the variability and uncertainty of the M85 value. Using the 1.25 and 3.42 values, an RAF of 0.37 was calculated for M85. This value was later adjusted to 0.41 using a multiplicative correction factor of 1.1 based on concerns regarding the accuracy of the MIR scale used to calculate the specific reactivity values. Application of the correction factor results in two of the test vehicles, both Corsicas tested as part of the Auto/Oil program, exceeding the CARB TLEV NMOG standard of 0.125 gram per mile. Based on CARB's stated vehicle selection criterion, these two vehicles should have been eliminated from the test fleet.

With regards to the current rulemaking effort to develop RAFs for TLEV and LEVs operating on Phase 2 gasoline, CARB is following the pattern of testing small numbers of very low mileage vehicles established in the earlier rulemaking. CARB has published data for 41 speciated emissions tests on 12 TLEVs operating on Phase 2 gasoline and proposed an RAF of 1.00 for Phase 2 gasoline. However, five of these vehicles were tested by General Motors; again CARB performed no assessment of the importance of inter-laboratory variability on the test results and provided no information regarding the types of emission control systems used on these vehicles. Lab-to-lab variation may or may not be important; however, the Phase 2 RAF based on only the CARB data would be 1.04, while the RAF based on the GM data would be 0.96. The mileage range of the vehicles in this second TLEV fleet was 725 to 15,300 miles, with the average being only 7,823 miles. In addition to the one vehicle with only 725 miles, another vehicle had only 3,300 miles (in contrast to the minimum of 4,000 miles required of vehicles tested by manufacturers). All of these TLEVs were passenger cars, with nine of the 12 vehicles being produced by domestic manufacturers, two being Japanese and one being German. Only one of these 12 vehicles was also used in the first test fleet used in establishing the specific reactivity of TLEVs operating on conventional gasoline and, as usual, no statistical tests have been performed to characterize the "statistical validity" of the data.

While CARB required all test vehicles in the first TLEV test fleet to comply with TLEV standards on conventional gasoline, a different selection criterion was used for the second test fleet in that vehicles were only required to comply on Phase 2 gasoline. This is significant because CARB reported that Phase 2 gasoline reduced NMOG emissions by up to 40% relative to conventional gasoline. Based on this, only two of the test vehicles used by CARB should have been retained. Using a more conservative assumption of a 25% reduction on Phase 2 gasoline, five of the 12 vehicles would have been excluded if the first selection criterion had been retained. If these vehicles are not considered, the Phase 2 TLEV specific reactivity would be 3.358 grams ozone per gram NMOG and the RAF value would shift to 0.98. It is not known how the specific reactivity value of TLEV NMOG emissions would have been altered if vehicles capable of complying on Phase 2 gasoline had not been excluded because they did not comply on conventional gasoline.

Moving on to the establishment of a specific reactivity value for LEVs operated on conventional gasoline, CARB tested six vehicles equipped with electrically heated catalysts (EHCs) to obtain a value of 3.16 grams of ozone-forming potential per gram of NMOG emissions. A total of 22 tests were performed on these six vehicles. While the mileage range of the vehicles was 7,350 to 17,500 miles, CARB has provided no information regarding the mileage which the vehicles have accumulated with the EHCs. These data are important because CARB has historically used fresh EHCs (without any mileage accumulation) in vehicle testing. This is equivalent to testing the vehicles at zero miles and could have a significant effect on emissions. Three of the six vehicles were from domestic manufacturers, two from a Japanese manufacturer and one from a German manufacturer. All six vehicles were passenger cars.

In selecting vehicles representative of LEVs, CARB required that NMOG emissions be below the 50,000 mile LEV standards of 0.075 gram per mile on conventional gasoline. Additionally, the vehicles were required to meet the 50,000 mile LEV standards for CO and NOx emissions. CARB also indicated that, since the agency had established the LEV standards based on test data from EHC-equipped vehicles, it was appropriate to use only EHC vehicles in establishing the specific reactivity value for conventional gasoline. According to CARB;

> "Although manufacturers are allowed to utilize any technology to meet the LEV standards, use of a technology less effective than EHCs at reducing specific reactivity to establish the baseline would have the effect of relaxing the stringency of the adopted LEV NMOG standard."

The selection of only EHC vehicles appears to represent a violation of the agency's own regulations that require staff to develop "representative speciated NMOG exhaust emission profiles." CARB staff has previously stated that "it now appears that heated catalysts will only be needed for larger vehicles." Based on this, there appears to be no way in which CARB can realistically claim that six EHC vehicles are representative of the fleet of LEV vehicles that manufacturers will produce.

While the assumption that all LEVs will be equipped with EHCs is in itself unreasonable, CARB has gone on to develop the Phase 2 RAF of 0.98 for LEVs based on test data for nine vehicles, four of which were not equipped with EHCs. It is impossible to see how CARB can justify or reconcile the assumptions that the "representative speciated NMOG profile" for LEVs operating on conventional gasoline should be based on an assumption of 100% EHCs, while the "representative speciated NMOG profile" on Phase 2 gasoline should be based on using the assumption that only 55% of LEVs will use EHCs. As CARB did not perform any testing on the four non-EHC vehicles on conventional gasoline, it is not known whether they would have complied with CARB's criteria that all test vehicles must meet the LEV standards while operating on conventional gasoline. Of course, there is no way to tell what the Phase 2 LEV RAF would have been had all nine vehicles been tested on both fuels. However, the Phase 2 RAF based only on the five EHC vehicles tested on both fuels would be 0.95. Given that the specific reactivity of the non-EHC vehicles was greater than the EHC vehicles, including all nine vehicles in both test fleets probably would have resulted in an RAF lower than the 0.98 value being proposed by staff.

The last action taken by CARB, with respect to RAFs, is the proposed establishment of a specific reactivity value for ULEVs operating on conventional gasoline, with no RAF proposed for ULEVs operating on Phase 2 gasoline. This proposed specific reactivity for conventional gasoline is based on the data for the same six EHC vehicles used to develop the specific reactivity value for LEVs operating on conventional gasoline. In contrast to the situation for LEVs, CARB has previously indicated that most liquid fuel ULEVs are likely to need electrically heated catalysts. However, while CARB has insisted in every other case that the vehicles used to establish specific reactivity values and RAFs meet all applicable standards for the vehicle class in question, none of the EHC vehicles tested by CARB meet the 50,000 mile ULEV NMOG standard of 0.040 grams per mile on conventional gasoline and only one of six meet the ULEV standard on Phase 2 gasoline. Additionally, CARB staff has stated that due to the lack of currently available vehicles that are representative of the technologies that will be used to meet the ULEV standards, it is premature to identify the Phase 2 gasoline ULEV specific reactivity at this time. Based on this, CARB apparently believes that six EHC-equipped vehicles that do not even comply with the ULEV standards are capable of generating a "representative speciated NMOG exhaust emission profile" on conventional gasoline, but that the same vehicles cannot be used to characterize emissions on Phase 2 gasoline. Clearly, these vehicles are either representative of ULEVs or they are not; they cannot be both. There is no way to reconcile the contradictory assumptions made by CARB in this case.

Finally, although the RAFs developed by CARB would apply to light- and medium-duty trucks (with GVWR ratings of up to 5,750 pounds) certified to less stringent standards and generally incorporating different emission control system technologies, CARB has tested only two trucks, both M85-fueled Dodge Caravans, in the course of developing RAFs. The failure of CARB to include trucks in the test fleets raises serious questions regarding the representativeness of the RAFs with respect to the vehicle fleet to which they will be applied.

As discussed above, the approach used by CARB to establish RAFs and specific reactivity values has not been consistent and has varied substantially from one vehicle/fuel combination to another. Furthermore, the assumptions used to justify the approach taken in one case are directly contradicted by the assumptions used to justify the approach taken in another case. In addition, CARB has violated several of the requirements contained in the agency's own regulations in developing RAFs. Given this, the CARB approach to RAF development can be characterized as inconsistent, at best, if not arbitrary. While staff may not have intentionally attempted to influence the RAF values for different vehicle/fuel combinations by using inconsistent methodologies and contradictory assumptions, it is clear that the CARB approach has not led to the establishment of accurate RAFs.

Methodology Required by CARB to be Used by Manufacturers - In contrast to the inconsistent approach used by CARB in establishing RAFs, the requirements imposed by CARB on vehicle manufacturers wishing to establish engine-family-specific RAFs are quite rigid and stringent. First, manufacturers must use a minimum of five identical test vehicles in establishing an RAF that will apply to thousands of vehicles, in contrast to the nine or so used by CARB in establishing RAFs applicable to millions of vehicles. The next issue is the mileage of the vehicles at the time of testing and the total number of tests performed. The CARB regulations require that all vehicles tested by manufacturers accumulate a minimum of 4,000 miles prior to being tested. CARB, on the other hand, used data from a vehicle with only 2,700 miles in establishing the specific reactivity value for NMOG emissions from TLEVs on conventional gasoline, and vehicles with only 725 and 3,300 miles in establishing the Phase 2 RAF for TLEVs. With respect to LEVs, a major issue is the amount of mileage that has been accumulated on the electrically heated catalysts (EHCs) being used by CARB on LEVs. Historically, CARB has taken brand-new EHCs, placed them on vehicles and performed emissions testing without accumulating mileage to age the catalysts. This is equivalent to testing the LEV vehicles at zero miles.

An issue related to the above is what effect mileage accumulation has on the specific reactivity of NMOG emissions from vehicles over their useful lives. While CARB requires compliance with emission standards for 100,000 miles on all types of "low-emission" vehicles, the average mileages of vehicles used by CARB in establishing RAFs is on the order of 10,000 miles. The agency has made no effort to address this issue with respect to any of the RAFs it has developed. In contrast, CARB requires manufacturers seeking engine-family-specific RAFs to accumulate at least 75,000 miles on a minimum of one durability vehicle while measuring the specific reactivity of the vehicle's emissions at 5,000-mile intervals. The sole purpose of this testing is either to assure CARB that the reactivity of the emissions from the vehicle do not increase with time or to provide a mechanism by which to adjust the specific reactivity values for the engine family to account for changes occurring with mileage accumulation.

As indicated above, in order to obtain an RAF for an engine family, a manufacturer will be required to test a minimum of four vehicles at 4,000 miles and a minimum of one vehicle at 5,000-mile intervals from 5,000 miles to 75,000 miles (for a total of 15 separate tests). Assuming that the four vehicles tested at 4,000 miles each receive two tests and noting that two tests at each mileage interval are required for the durability vehicle, a manufacturer will perform a minimum of 38 speciated emissions tests in determining an engine-family-specific RAF. The number of tests may be much higher as CARB also requires the data to meet a statistical test for variability using Equation 1, another requirement that the agency does not place on itself. The minimum of 38 speciated tests required of manufacturers for each engine family contrasts sharply with the 36 tests on conventional gasoline, 14 tests on M85, and 41 tests on Phase 2 gasoline used by CARB in establishing the M85 and Phase 2 gasoline RAFs for TLEVs for all engine families. The requirement for manufacturers to conduct 38 tests of each engine family also contrasts sharply with the 22 tests on conventional gasoline and 37 tests on Phase 2 gasoline used in developing the Phase 2 LEV RAF for all engine families.

In summary, the following major differences exist between the methodology used by CARB and that imposed by CARB upon manufacturers:

- Manufacturers must determine RAFs using the vehicles to which the RAFs will actually apply, while CARB uses a few low-mileage vehicles, often with jury-rigged emission control systems, to develop RAFs for whole classes of vehicles;

- Vehicles tested by manufacturers must comply with emission standards throughout their 100,000 mile useful lives, while the vehicles tested by CARB must comply only at low mileages (typically less than 10,000 miles);

- Manufacturers must test many more vehicles than CARB relative to the number of vehicles to which an RAF applies;

- Vehicles tested by manufacturers must comply with specific minimum mileage requirements ignored by CARB;

- Manufacturers must perform testing to account for changes in the reactivity of emissions as vehicles age, but CARB has never performed such testing; and

- Manufacturers must perform more vehicle tests to develop an RAF for one engine family than CARB has performed to develop RAFs for whole classes of vehicles.

While CARB has afforded manufacturers the option of developing engine-family-specific RAFs, the above clearly shows that to do so will require a substantial commitment in terms of time and money on the part of manufacturers. The only other option available is the use of RAFs established by CARB, something that requires no commitment of time or money on the part of a manufacturer. As RAFs developed by manufacturers and CARB are to be used in determining compliance with the same set of regulations and are, in effect, interchangeable, there is no logical reason why two sets of criteria exist. Furthermore, the appropriateness of one set of criteria being very lenient and applying only to CARB, while the second is very stringent and applies only to vehicle manufacturers, is highly questionable.

One consequence of allowing manufacturers to use either the questionable RAFs developed by CARB or more accurate engine family specific RAFs, is that manufacturers will simply choose to use the lower of the two values. This means that if the CARB RAFs underestimate the specific reactivity of emissions from a given vehicle/fuel combination, manufacturers will be allowed to use the CARB RAF even though the result will be vehicles with emissions in excess of CARB's emission standards. Clearly, the CARB RAFs could lead to poorer rather than improved air quality.

Although CARB staff has and will continue to state that they have tested as many vehicles as possible and complain about resource constraints and a lack of cooperation on the part of vehicle manufacturers in providing test data and vehicles, there are two salient facts that these arguments ignore:

1. In September 1990, CARB voluntarily undertook the obligation of developing RAFs that were not specifically required by any piece of legislation, and

2. The air quality benefits of the entire "low-emission vehicle" program hinge on the accuracy of the RAFs developed by CARB. Therefore, a slipshod approach to setting RAFs has the potential to negate the benefits of CARB's lower emission standards and cause the LEV program to lead to poorer, rather than improved, air quality.

With respect to the first point and the issue of resource constraints, CARB's annual budget for extra-mural research projects is on the order of several million dollars. Therefore, CARB was not compelled to perform RAF development at its laboratory as it could simply have contracted out the entire RAF development program to an independent research laboratory. Such an approach would probably have eliminated many of the problems of inconsistency which have plagued CARB's RAF program.

Review of Fuels Used in Developing RAFs

As noted previously, the CARB regulations specify the fuel to be used to represent conventional gasoline (see Table 1). However, the regulations do not specify the composition of fuels to be used in determining the specific reactivity of emissions resulting from the use of other fuels and therefore the RAFs for those fuels, except in the case of RAFs developed by vehicle manufacturers. Vehicle manufacturers must use fuels complying with CARB's regulations for certification fuels. Therefore, one would assume that the fuels used by CARB should also be in compliance with the applicable certification fuel specifications. This is clearly not the case for the fuels used by CARB for the November 1991 rulemaking, where even the conventional gasoline used is not in compliance with the specifications given in Table 2.

The composition of the conventional gasoline used in establishing the specific reactivity value for TLEVs in November 1991, is given on page I-6 of the technical support document[1*]. The olefin content of the fuel is listed by CARB as being 8.2 volume percent, while the proposed CARB regulations specify that the olefin content is to be 12±3.0 volume percent. Therefore, the conventional gasoline used by CARB as the basis for all TLEV RAFs does not comply with the agency's own regulations for a particularly reactive class of hydrocarbons. Correction of this problem would tend to increase the specific reactivity of TLEV emissions on conventional gasoline and lead to lower RAFs for other fuels.

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* Superscripts refer to references provided at the end of this document.

Additionally, while the CARB regulations specify that the multi-substituted alkyl aromatic (another class of very reactive hydrocarbons) content of conventional gasoline is to be 21±3.0 volume percent, the technical support document[1] does not present data regarding these compounds and, to the best of our knowledge, CARB has never published a value for the fuel in question. However, another CARB document[2] states that, with respect to the current RAF rulemaking, "A specification for multi-substituted alkyl aromatics reflecting the composition of the 'RF-A' fuel used to date, would be included." One might assume that this value is the one given in Table 2, but the discrepancy between the allowable olefinic content given in Table 2 and that reported for the November 1991 conventional gasoline does not support that assumption. Therefore, one must question if the multi-substituted alkyl aromatic content of the November 1991 fuel was ever measured and, if it was, whether it was within the limits established by CARB. Clearly, both the low olefin content and the lack of any data regarding the multi-substituted alkyl aromatic content of the first conventional gasoline raises serious questions about the validity of the 3.42 specific reactivity value adopted by CARB for TLEVs.

Moving next to the M85 fuel used by CARB in establishing the TLEV RAF of 0.41, page I-8 of the technical support document[1] states that the fuel was blended using conventional gasoline. However, the specifications for the gasoline actually used (also given on page I-8) do not comply with the CARB requirements for the RVP (the fuel RVP was 7.8 compared to the 8.7±0.3 requirement), T10 point (149°F versus the 115-135°F requirement) and benzene content (1.02 volume percent versus the 1.6±0.3 specification) of conventional gasoline. Furthermore, the 7.5 psi RVP of the M85 blend used by CARB to establish the RAF does not comply with the 8.0-8.5 RVP specification established by CARB for M85 certification fuel[3]. While CARB staff might argue that the RVP of the fuel is unimportant with respect to reactivity, low molecular weight olefins such as butenes and pentenes, which have high MIR values, would be underrepresented in the lower RVP fuel. Low butene and pentene content would be expected to result in an RAF that underestimates the reactivity of NMOG emissions from M85-fueled vehicles. In addition, the lower RVP could have had other effects on the composition of NMOG emissions from these vehicles. Finally, no information regarding the multi-substituted alkyl aromatic content of the gasoline used in blending the M85 fuel has ever been published by CARB. A lower multi-substituted alkyl aromatic content in the RF-A used for M85 blending relative to the conventional gasoline would also result in the M85 RAF being too low.

In addition to the problems noted above, the gaseous fuels used by CARB in testing performed prior to the November 1991 hearing were also out of compliance with respect to the applicable certification fuel specifications for those fuels. However, CARB has not yet established RAFs for those fuels. With respect to the current RAF rulemaking, CARB has not published any fuel property data regarding the conventional gasoline being used to establish the specific reactivity of NMOG emissions from LEVs. Finally, the benzene content of 1.1 volume percent reported for the Phase 2 gasoline being used[4] may be in violation of the 0.8-1.0 volume percent range allowed by CARB, depending on one's interpretation of a footnote contained in the CARB test procedures.

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In summary, the facts presented above demonstrate that the fuels used by CARB in establishing the specific reactivity of NMOG emissions from TLEVs, as well as the M85 RAF, did not comply with the specifications applicable to those fuels contained in CARB's own regulations. Additionally, it is not clear whether the fuels being used in the current RAF rulemaking comply with CARB's fuel specifications. Given this, the accuracy of all RAFs developed by CARB is questionable.

While CARB might argue that use of fuels that did not comply with CARB's certification fuel specifications had no effect on the RAF values, the fact is that vehicle manufacturers are required by CARB's regulations to use certification fuels in developing RAFs. Therefore, by using non-complying fuels, CARB in essence violated its own regulations. In addition, as noted above, the differences between the fuels used by CARB and the certification fuels may have had a significant impact on the RAFs developed by CARB.

Representativeness of Test Vehicles Used by CARB in RAF Development

As noted previously, according to CARB's own regulations, the vehicles tested by CARB are to be "representative" of the type of vehicles for which an RAF is being established. This problem does not exist for RAFs developed by manufacturers, as these apply only to a specific engine family. While the meaning of the term "representative" is subject to different interpretations, it does not appear that CARB has tested what could reasonably be considered a representative sample of vehicles during the development of any RAF. To illustrate this point, Table 3 compares the characteristics of the test fleet used by CARB in determining the specific reactivity of TLEVs operating on conventional gasoline and Phase 2 gasoline to the characteristics of 1991 California-certified engine families. As Table 3 shows, there were roughly 300 different engine families certified in 1991. Assuming that the number of engine families certified each year does not change appreciably over time and that, in a given model year, 50% of the engine families certified are TLEVs, CARB staff would have us believe that nine to 12 test vehicles are capable of representing the emission characteristics of about 150 different engine families. Additionally, while CARB did not test any trucks, trucks accounted for about 30% of all engine families certified in 1991. Finally, vehicles from domestic manufacturers appear to be drastically overrepresented in CARB's test fleet compared to the percentage of all engine families certified by domestic manufacturers in 1991. One must note that sales-weighted 1991 data would provide a better means of comparison than the number of engine families certified; however, CARB does not routinely publish engine-family sales data and these data are therefore unavailable. It is difficult to see how CARB staff can assert that the TLEV test fleets are representative of the anticipated actual TLEV vehicles.

A similar comparison of the LEV test fleets used by CARB with 1991 California-certified engine families is presented in Table 4. Also given is the percentage of the vehicles in each CARB test fleet equipped with EHCs. While CARB has made no quantitative predictions regarding the percentage of LEVs that will use EHCs, CARB has indicated that they

Table 3

Comparison of CARB Gasoline-Powered TLEV Test Fleets to 1991 California-Certified Engine Families

	CARB RF-A Test Fleet	CARB Phase 2 Test Fleet	1991 California-Certified Engine Families
Number of Vehicles/ Engine Families	9	12	297
% Passenger Cars	100	100	70
% Trucks	0	0	30
% Domestic Mfr.	78	75	39
% Asian Mfr.	11	17	41
% European Mfr.	11	8	20

will be needed only on "larger" vehicles. Based on this, our estimate would be that EHCs would be expected to be used on only 20 to 35% of LEVs. Federal actions such as more stringent corporate average fuel economy standards would shift production towards smaller vehicles and reduce the percentage of LEVs equipped with EHCs. Again, CARB staff apparently believes that six to nine test vehicles can be used to accurately characterize the emissions of what will be hundreds of LEV engine families certified beginning in the mid-1990s. Also, CARB has not tested any trucks, even though they will account for a significant fraction of the vehicle fleet. As noted above, it is difficult to see how six or nine vehicles can form a statistically representative sample of what will be a fleet of millions of LEV vehicles produced by over 20 different manufacturers.

In addition to the questions raised above, there are also questions regarding the types of emission controls used on the test vehicle relative to those that are anticipated to be used on TLEVs. As noted previously, in selecting test vehicles, CARB staff chose only vehicles that could meet all emission standards applicable to TLEVs. However, because the vehicles selected had low mileages, they were capable of complying with the TLEV standards at the time they were tested, but lacked the emission control equipment needed to comply with TLEV standards at 100,000 miles. For example, on page 20 of the staff report[5] for the November 1991 hearing, staff notes that "close-coupled catalyst systems are expected to be needed on all gasoline-powered TLEVs to ensure compliance with the TLEV standard in-use ..." while admitting that only "two of the test vehicles—the Celica and the Cougar—utilized catalysts mounted close to the engine manifold ..." Furthermore, with respect to the M85 vehicles tested, only one vehicle (tested as part of the Auto/Oil program) had a close-coupled catalyst and sequential electronic multipoint fuel injection which the staff states, also on page 20, are "technologies which the staff envisions will be needed

06397

Table 4

Comparison of CARB Gasoline-Powered LEV Test Fleets to 1991 California-Certified Engine Families

	CARB RF-A Test Fleet	CARB Phase 2 Test Fleet	1991 California-Certified Engine Families
Number of Vehicles/ Engine Families	6	9	297
% Passenger Cars	100	100	70
% Trucks	0	0	30
% Domestic Mfr.	50	67	39
% Asian Mfr.	33	22	41
% European Mfr.	17	11	20
% With EHCs	100	55	N/A

to attain compliance with in-use standards for TLEVs, particularly for formaldehyde." Finally, only one of the TLEVs tested on Phase 2 gasoline had a close-coupled catalyst. Therefore, it seems that even CARB staff has recognized that the vehicles they used in developing RAFs were not representative of the TLEV vehicles whose emissions they were trying to characterize. Similar arguments, outlined previously, apply to the LEV test fleets.

Variability and Uncertainty Associated with RAFs Developed by CARB

While the variability of RAFs developed by manufacturers is restricted through the use of a cap on the 95% upper confidence bound of the RAF, CARB does not restrict the data it uses based on that criterion. Additionally, in developing the specific reactivity value for TLEVs using conventional gasoline and the RAF for M85, CARB staff averaged the results from multiple tests of the same vehicle together, as well as single test results from different vehicles. However, by averaging single test results from different vehicles, CARB staff has inappropriately minimized the apparent variability associated with the RAFs it has developed. If Equation 1 is applied to the specific reactivity values from all the TLEV vehicles tested by CARB on conventional gasoline and M85, the 95% upper confidence bound values represent 120 and 122% of the average values. The 95% upper confidence bounds for the preliminary data presented by CARB to date for TLEVs and LEVs on Phase 2 gasoline represent 123% and 117% of the average values. Therefore, the variability of the data used by CARB in establishing the specific reactivity value for TLEVs on conventional gasoline and the M85 RAF exceeds the 115% criterion found in CARB's regulations. In addition, the 95% upper confidence bound of the data used to establish the specific reactivity of LEVs operating on conventional gasoline was 116%, again in excess of the 115% criterion.

Another source of variability that will affect both the TLEV and LEV RAFs for Phase 2 gasoline is CARB's use of different test fleets to determine the specific reactivities of NMOG emissions on conventional and Phase 2 gasoline. This issue is of considerable importance as the emissions of different vehicles with different emission control systems will have different specific reactivities. The use of different, and very small, test fleets also raises concerns regarding the representativness of both fleets. Two test fleets can only be deemed equivalent if the average specific reactivity on conventional gasoline is the same taking the uncertainty associated with the data into account.

As CARB has not performed testing using conventional gasoline on the second TLEV fleet, it is not known what the specific reactivity of NMOG emissions of this fleet on conventional gasoline would be based on that specific reactivity value, nor what the Phase 2 RAF would be. Even CARB appears to recognize the problem associated with using two different vehicle fleets that were selected based on different criteria, as staff has indicated[6]

> "... the staff used data from vehicles that met TLEV standards on Phase 2 gasoline even if their emission control strategies were not as effective as those used to develop the baseline TLEV specific reactivity. This apparent difference in the technologies between the baseline and Phase 2 gasoline test cars may explain why the Phase 2 gasoline RAF for TLEVs is not lower than 1.00."

Unfortunately, staff provides no reason why the same fleets were not used, nor any means by which to establish an appropriate Phase 2 RAF.

The use of separate LEV test fleets, one comprised of only EHC vehicles and the other with only about 50% EHC vehicles, is of even greater importance from the perspective of RAF variability.

References

1. "Proposed Reactivity Adjustment Factors for Transitional Low-Emission Vehicles: Technical Support Document", California Air Resources Board, September 27, 1991.

2. "Proposed New Specifications for Gasoline Certification Fuel for Motor Vehicles: Staff Report", California Air Resources Board, June 26, 1992.

3. "Notice of Public Availability of Modified Text: Public Hearing to Consider the Adoption of Specifications for Alternative Fuels for Motor Vehicles", California Air Resources Board, August 13, 1992.

4. "Initial Statement of Proposed Rulemaking Amendments to the Low-Emission Vehicle Program", California Air Resources Board, September 25, 1992.

5. "Initial Statement of Proposed Rulemaking: Reactivity Adjustment Factors for Transitional Low-Emission Vehicles", California Air Resources Board, September 27, 1991.

6. "Supplement to Initial Statement of Proposed Rulemaking (Staff Report) Amendments to the Low-Emission Program: Establishment of Reactivity Adjustment Factors" California Air Resources Board, November 13, 1992.

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Western States Petroleum Association

Douglas F. Henderson
Executive Director

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October 9, 1992

Ms. Jananne Sharpless
Chairwoman
California Air Resources Board
2020 "L" Street
Sacramento, CA 95814

Subject: RAF's for Phase 2 Reformulated Gasoline
November 12, 1992 Public Hearing

Dear Jan:

In reviewing the notice of the November 12 public hearing to consider amendments to vehicle certification requirements, we are concerned that CARB has proposed interim Phase 2 gasoline reactivity adjustment factors (RAF's) of 1.0 and 0.95 for TLEV and LEV's, respectively, based on a flawed analysis of limited and "very preliminary" test data. Essentially, little or no reactivity benefit is being assigned to Phase 2 gasoline which will cost the petroleum industry an estimated $5-8 billion in investment.

The Staff Report states, "due to delays in obtaining the correct Phase 2 certification fuel and the amount of testing required, the test program has not been completed as of the date of publication of this notice. Pending the receipt of additional test data, the Staff is proposing interim RAF's ...; modified values based on actual testing will be proposed at the Board hearing." Unfortunately, last-minute modifications prior to the hearing will not provide the public with an adequate and meaningful opportunity to review the final proposed RAF's and analyses of the bulk of supporting data.

This placeholder proposal violates both the spirit and intent of the 45-day public notice requirements. As you are aware, the government code requires that the public have at least 45 days' notice of a proposed action. While the report indicates that the Staff intends to provide the additional data to the public when they are available, the information on the final proposed RAF's will not have been available for a 45-day review period.

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Jan Sharpless
October 9, 1992
Page Two

Accordingly, we request that the Board hearing on this subject be delayed to allow for a complete 45-day review of the final proposed RAF's along with the support evidence. In our view, CARB has an obligation to provide time for a complete and adequate review of a rule that can have a staggering impact on our industry, the auto industry, and the economy of the state.

Very truly yours,

DH:va

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12 January 1993

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Manager of Planning
Planning and Services

Ms. Pat Hutchins
Board Secretary
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2020 L Street
Sacramento, CA 95814

Subject: Comments Regarding the Certification Requirements and Procedures for Low-Emission Passenger Cars, Light Duty Trucks, and Medium Duty Vehicles for the 14 January 1993 Board Hearing (Agenda Item 93-1-3).

Dear Ms. Hutchins:

The Union Oil Company of California submits these comments in regards to agenda item 93-1-3 of the California Air Resources Board monthly meeting on 14 January 1993. Please provide a copy of these comments to the Board members and appropriate CARB staff prior to the meeting. Thank you.

Sincerely,

Dennis W. Lamb/DL

Unocal Refining & Marketing Division
Unocal Corporation
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Telephone (213) 977-5974

UNOCAL 76

12 January 1993

Ms. Jananne Sharpless
Chairwoman
California Air Resources Board
2020 L Street
Sacramento, CA 95814

Dennis W. Lamb
Manager of Planning
Planning and Services

Dear Chairwoman Sharpless:

The Union Oil Company of California (Unocal) submits these comments in regards to the certification requirements and procedures for low-emission passenger cars, light-duty trucks and medium-duty vehicles proposed rulemaking. It should be noted that Unocal has been disturbed by the administrative shortcomings of this rulemaking thus far, with the data and results continuously revised by CARB staff and the postponement of the hearing on this rulemaking on two occasions.

Our comments address the following topics in detail:

- Unocal contends that CARB's approach to calculating the RAFs for Phase 2 gasoline is flawed, and the final rulemaking on this issue should be deferred.

- Unocal contends that CARB's extrapolation of limited data to represent an entire vehicle class is fundamentally flawed. Also, the approach used to calculate the baseline versus the RAF for low emission vehicles using Phase 2 gasoline is inconsistent.

- CARB should incorporate the most recent vehicle data into the model runs, and include MTBE as a component of finished gasoline in the speciation profile.

- The flexibility provided to vehicle manufacturers to certify vehicles using either CARB's generic RAF or a specific engine family RAF results in an effective relaxation of the emission standard.

Unocal would welcome any questions regarding these comments.

Sincerely,

Dennis W. Lamb /DL

06404

UNION OIL COMPANY OF CALIFORNIA (UNOCAL) COMMENTS ON CERTIFICATION REQUIREMENTS AND PROCEDURES FOR LOW EMISSION PASSENGER CARS, LIGHT-DUTY TRUCKS, AND MEDIUM-DUTY VEHICLES

RULEMAKING PROCESS

Unocal strongly objects to CARB's continued undercutting of the administrative process relative to this rulemaking. The hearing was postponed twice because the proposals were glaringly incomplete, and CARB admitted that the proposals will be changed before or at the hearing. Just days before the hearing, the proposal continued to change and the "final" modeling report advised that more data was yet to come that could change the adjustment. Based on the shortcomings of the rulemaking process thus far, last minute changes at the hearing are anticipated. Unocal contends that the regulated community has not been given the appropriate time to examine the basis for these changes, and continue to find errors and omissions in the data when the very short window of opportunity to review the details is provided.

The failure to provide adequate notice cannot be tolerated, and appropriate remedies will be sought for CARB's failure to consider the regulated community's administrative rights.

MIR METHODOLOGY

After reviewing CARB's Clean-Fuel/Low-Emission Vehicle regulation and its application in the present rulemaking, Unocal concurs with the comments submitted by the Western States Petroleum Association (WSPA) that CARB's approach for calculating reactivity adjustment factors (RAFs) is fundamentally flawed. Further, Unocal contends that the flawed rulemaking disqualifies CARB's ability to establish Phase 2 gasoline baselines and RAFs with any level of certainty or accuracy. Unocal therefore requests that CARB defer this rulemaking until such time that the MIR methodology issue is resolved.

LEV/ULEV SPECIFIC REACTIVITY BASELINES

The staff proposal would establish specific reactivity baselines for both LEV and ULEV at 3.16. Unocal maintains that those numbers have a high probability of being incorrect. There is a fundamental flaw in CARB's extrapolation of very limited data to represent an entire vehicle class.

Unocal understands that the flaw can be attributed to the insufficient time frame and resources allocated to CARB staff to assemble a representative test fleet. This flaw in the approach to establishing regulations not only affected LEV and ULEV, but also affected TLEV.

After review of the available information in the staff reports and discussion with staff, Unocal contends that the test fleets are not representative because:

1. The fleets do not represent an appropriate mix of manufacturers. A few represent many. For example, one German, two Japanese, one General Motors, and Two Fords were used to represent the entire anticipated fleet to establish the LEV standard.

2. The fleets do not represent an appropriate mix of vehicles, because no trucks were included in any of the test fleets.

3. Dozens of engine families are represented by a few vehicles with laboratory-retrofitted hardware.

4. No anticipated "sales weighting" was attempted, which severely biased the results. For example, the staff report describes the scenario that a Lexus 400 represents almost 17% of the market and a Volkswagen Jetty another 17%, which is a very unlikely and unrealistic scenario.

Staff was only able to assemble a few vehicles with emission hardware they felt would be representative of the fleet. Actually, the only component of CARB's test fleet that can be considered representative is the emission control hardware that was retrofitted onto the test vehicles. No attempt was made to make the fleet representative in the normally expected terms. With such a divergence from expected vehicle fleet, it could only be by sheer coincidence that the results from the test fleet would be representative of the real world.

Unfortunately, the one measure that was representative for the technology that is expected to be used in the actual fleet is based on a contradiction. The staff recommendation discusses "Vehicle Selection Criteria" (November 13 page 2.) and states that..

> "In order to establish the Specific Reactivity numbers for the base gasoline and the fuel being evaluated, it is important to obtain speciated emission data that are representative of the vehicles that manufacturers will actually produce." (emphasis added).

The fleet that CARB used to establish the baseline is 100% equipped with electric heated catalysts (EHCs). However, when the test fleet was assembled to establish the RAF for LEV, the report states...

"The vehicles utilized a mix of EHC and non-EHC systems." (emphasis added).

It is clear that the baseline fleet fails CARB's own criteria. In fact, CARB staff is attempting to create a new, more stringent standard by requiring manufacturers to meet an ozone per gram level generated by technology that, by its own testing, demonstrates that it is not necessary for many vehicles to meet the non-methane organic gas (NMOG) regulatory standard. As CARB staff have said on several occasions, manufacturers will not install technology onto vehicles that is not necessary to meet standards. We can fully expect at least a portion of LEVs without EHCs installed; therefore, the baseline fleet fails to represent the mix of vehicles expected to be produced.

Vehicle manufactures are not required to utilize any particular technology to attain the graduated emission standards. In the case of LEVs, CARB is attempting to set a standard based on a technology that is not necessarily required to achieve 0.075 grams per mile of NMOG. By this, the value of Phase 2 gasoline is diminished to the manufacturer.

The Baseline Specific Reactivity is non-representative as the staff admits on page 6 of the November 13 proposal:

"Due to the lack of currently available vehicles that will be used to meet the ULEV standards....".

In this case, the proposal to use the same Specific Reactivity as LEVs may prove to be not stringent enough, as none of the EHC-retrofitted vehicles tested met the ULEV standard.

Unocal believes that these flaws are so fundamental, that any RAFs based on the proposed baselines could only be accurate by "blind luck". We would reiterate that CARB defer the establishment of these baselines until truly representative fleets can be assembled.

TLEV AND LEV PHASE 2 RAFS

Despite the flawed methodology and lack of true fleet representation, CARB is proposing RAFs for TLEVs and LEVs operating on Phase 2 gasoline. Unocal also requests that CARB defer these aspects of the proposal.

Even if the methodology was appropriate and agreed to by both CARB and the regulated community, and the baseline test fleets were representative, several problems remain. Specifically, the fleets assembled for testing to establish RAFs fail all the criteria normally accepted as necessary to produce representative data. Moreover, there are significant problems with the test protocol. The standards that apply to manufacturers to establish RAFs by engine families were dramatically relaxed when CARB did its own testing. This is true even though the CARB generic RAFs could represent hundreds of thousands of vehicles and the manufacturers engine family RAFs could only represent a fraction of that total. Unocal would reiterate our understanding that the staff was not provided the necessary time and resources to do the job right. Although the report contains some errors and omissions, many of those have been corrected. What has not been corrected are the following:

1. failure to meet minimum milage standards for all vehicles, and a further failure to meet those standards once equipped with EHCs.

2. No durability testing was done to insure a useful life.

3. The number of tests was much lower than the manufacturer's standard.

4. No statistical validity criteria was applied to any of the data.

MODELING

Unocal concurs with the WSPA comments regarding CARB's application of the airshed model. Unocal would emphasize the need for CARB to check the accuracy of the MIR scale, as it relates to the determination of the RAF correction for TLEVs and LEVs operating on Phase II gasoline. Additionally, the recent Ford and General Motors data need to be incorporated into the airshed run, to ensure most up-to-date results. Finally, CARB must include MTBE into the Phase II gasoline speciation profile, since it makes up to 15 percent of finished gasoline, and would result in a more accurate appraisal of exhaust reactivity.

CONCLUSION/RECOMMENDATION

Even if the problems discussed above were corrected, Unocal is convinced that there is another fundamental flaw in the approach that calls into question the wisdom of establishing any generic RAF. Specifically, Generic RAFs combined with the freedom to establish engine family RAFs and/or the freedom to certify on indolene guarantee a de facto relaxation of the NMOG standards.

This problem can be clearly illustrated for TLEV. If we assume that 1) the methodology is correct, 2) the fleets are representative, and 3) both the baseline and RAFs are accurate, the NMOG standard of 0.125 will not be met. Vehicle manufacturers will do what is most cost-effective for them. They will choose a generic RAF for every engine family over the average Specific Reactivity and adopt engine family RAFs for each engine family under the average. The effect of this flexibility for TLEV is shown in Table 1. This table uses data provided in the proposal (Table III, page 5, November 13 version), which are also the options available to a vehicle manufacturer. The columns identify individual vehicle RAFs, and the choice of either generic (1.00 per November 13) or engine family. The table also shows the effect on the 0.125 NMOG standard. The Board's intent was to achieve 0.125 or less NMOG. The flexibility afforded to the manufacturers can now result in the relaxing of the standard to 0.129 NMOG for TLEVs, a 3.2% increase. A similar calculation can be done for LEVs. The Board could have established the standard at 0.13 (i.e. two significant figures) instead of 0.125 (three significant figures) if they did not consider 3.2 % to be important. However, the Board did establish the standard at 0.125, and therefore, it is assumed that a 3.2% difference is significant. Although CARB staff recognizes this problem, Unocal is unaware of any authorization by the Board to relax the standard to this extent.

This problem can be avoided entirely by simply requiring compliance on an engine-family-only basis. This will also address the problem regarding proper representation in the RAF calculation. However, the baseline issue remains unmitigated.

Unocal would encourage a compromise concept. Such a concept could be worked out in a short time frame and necessary testing could be completed in one year. It is Unocal's understanding that manufacturers have been exploring different ways to accomplish this fast-track, yet technically sound concept.

Unocal would not oppose the adoption of <u>interim</u> TLEV RAFs of 1.00, provided they are interim and recognized as lacking a statistical foundation. LEV and ULEV baseline and LEV RAF should be deferred until the work is completed.

TABLE 1: THE EFFECT OF USING THE LOWER OF EITHER ENGINE FAMILY OR GENERIC RAF

VEHICLE	OZONE/ GRAM	"VEHICLE RAF"	CERTIFICTION RAF *
CAMRY	3.703	1.08	1.00
LE SABRE	3.248	0.95	0.95
TEMPO	3.862	1.13	1.00
JETTA	3.681	1.08	1.00
CELICA	3.222	0.94	0.94
PONTIAC (GM)	3.625	1.06	1.00
REGAL (GM)	3.320	0.97	0.97
SATURN (GM-A)	3.175	0.93	0.93
SATURN (GM-M)	2.965	0.87	0.87
LE SABRE (GM)	3.330	0.97	0.97
T-BIRD	3.619	1.06	1.00
CROWN VIC	3.493	1.02	1.00
TLEV BASELINE	3.420	1.00	0.97
RESULTANT IN-USE NMOG		0.125	0.129

* RESULT OF MANUFACTURER'S CHOICE OF LOWER OF ENGINE FAMILY RAF OR GENERIC RAF

Chevron

Chevron U.S.A. Inc.
575 Market Street, San Francisco, CA 94105-2856

January 12, 1993

XC: Bd Mbr
JS TAC
JD MSD
JB Legal

1/14/93
93-1-3

D. B. Smith
General Manager
Strategic Planning and Business Evaluation

Ms. Pat Hutchens
Board Secretary
Air Resources Board
P.O. Box 2815
Sacramento, Ca 95812

Dear Ms. Hutchens:

On behalf of Chevron, I wish to comment on the amendments to the Low-Emission Vehicle program as proposed in the "Initial Statement of Proposed Rulemaking Amendments to the Low-Emission Vehicle Program" dated September 25, 1992, and supplemented by the November 13, 1992 Supplement and the December 15, 1992 Modeling Protocol and Final Results report.

We are concerned with the process used to develop the proposed reactivity adjustment factors (RAFs) for Phase 2 gasoline and the baseline specific reactivity for the LEVs and ULEVs. This process has resulted in the development of what we believe are incorrect RAFs for TLEVs and LEVs fueled with Phase 2 gasoline and possibly erroneous baseline specific reactivities as well.

We, in partnership with Texaco, have undertaken a substantial vehicle testing program to evaluate the impacts of Phase 2 gasoline on TLEVs and their RAFs. The specific reactivity which we determine from our vehicle fleet, when tested with the baseline fuel RF-A, is 3.92 g ozone/g NMOG. This is substantially higher than the baseline specific reactivity of 3.42 g ozone/g NMOG established by CARB. We believe that differences in both fleet selection and analytical methodologies contribute to this discrepancy.

When testing with Phase 2 gasoline, we determined a fleet average specific reactivity of 3.76 g ozone/g NMOG. This translates into a RAF of 0.96 for Phase 2 gasoline (3.76/3.92 = 0.96). While this is in good agreement with the proposed RAF of 0.98 for TLEVs fueled with Phase 2 gasoline it may be a coincidence since we and CARB used different methods to derive our RAFs.

In our experimental program, Fuel RF-A and Phase 2 gasoline were both tested in the same fleet of vehicles. By contrast CARB's staff (staff) used RF-A in one fleet of vehicles and Phase 2 gasoline in a different fleet. We strongly believe that due to significant vehicle-to-vehicle variability, it is important that the same vehicle fleet be used to test both fuels. Staff continues to insist that testing of two fleets is appropriate since different vehicle emission control technology types may be used with the two fuels: one fleet represents vehicles which achieve the TLEV standards when using RF-A, the other represents vehicles which achieve the standards when using Phase 2 gasoline. We doubt that the difference in technology types will actually be very significant and our test program did not show any significant difference.

It is very surprising to us that any modeling adjustment is needed for Phase 2 gasoline. In fact, we believe this adjustment constitutes evidence that errors were committed in the modeling process. In trying to understand these modeling results, we have scrutinized the emissions profiles staff used in their modeling. Several errors were uncovered, all of which could lead to overestimation of the reactivity of Phase 2 gasoline emissions. Two obvious mistakes were the misidentification of Isooctane and MTBE, both of which are significant species in emissions from Phase 2 gasoline. These two species have very low reactivity, but were confused with species of higher reactivity. Staff acknowledges these mistakes, but have not re-run the airshed modeling to correct the modeling adjustment factor.

Another problem we discovered concerned the aromatic distributions in the emissions profiles. With our test fleet, the highly reactive C8+ aromatics were 22% lower from Phase 2 gasoline versus RF-A. (This difference is in agreement with the compositions of the fuels themselves.) In contrast, the profiles generated by staff showed a 6% increase in C8+ aromatics from Phase 2 gasoline. These differences in aromatic profiles are very significant, and also raise questions about the validity of staff's modeling work.

We are also concerned with staff's selection of LEV vehicles and their low mileage. To our knowledge, there are no gasoline fueled vehicles currently available which are certified to the LEV emission standards. Staff has created "pseudo-LEVs" by retro-fitting standard vehicles with electrically heated catalysts (EHC) and have tested them at very low mileage. Clearly, this is not the same as using real LEVs.

In past public presentations, staff has noted that LEV technology for smaller vehicles would include improved fuel control through the use of dual oxygen sensor feedback, sequential multiport fuel injection, aerated fuel injectors and adaptive transient control. Since staff only tested EHC-equipped vehicles it is premature to set a baseline specific reactivity and RAFs for LEVs, particularly when staff believes that non-EHC LEVs will be a significant part of the LEV fleet.

Because of the uncertainties in measurement methodologies, modeling, and fleet selection we recommend that:

- RAFs for TLEVs and LEVs fueled with Phase 2 gasoline be deferred.
- Baseline specific reactivity for LEV and ULEV vehicles be deferred.
- Staff be required to work with industry (both auto and oil) to:
    - Validate procedures and ensure that measurement methodologies used by different laboratories provide equivalent results.
    - Develop new baseline specific reactivities for LEV and ULEVs and reassess the baseline specific reactivity for TLEVs. This will require significant new data and should include all applicable vehicle technologies.

- Develop new RAFs for TLEVs and LEVs fueled with Phase 2 gasoline.

- Do new modeling runs to determine if any RAF adjustment is required for Phase 2 gasoline.

We fully support CARB's acknowledgement that there are emissions associated with ZEVs (Pg 12, 3rd paragraph September 12 report). We question the comment that high ambient ozone levels are not a concern during the wintertime (Pg 12, 1st paragraph September 12 report) since Los Angeles is known to have numerous wintertime ozone exceedences. We were surprised to note that heater systems for ZEVs can only be operable to 40°F. There are a lot "cold days" in California above 40°F.

We also support the comments supplied by WSPA.

D. B. SMITH

Encls.
DAB:gp

cc: Ms. Jananne Sharpless
Mr. Tom Jennings
Mr. Ken Wiseman

Attachment 1

VEHICLE EXHAUST PROFILE

Vehicle Model	Fuel	% Of Total NMOG Benzene	Toluene	C8+Arom	Tot.Arom
1990 Chevrolet Cavalier	RF-A Phase 2	6.14 4.20	7.71 7.24	19.19 14.51	33.04 25.95
1990 Ford Taurus	RF-A Phase 2	4.85 3.08	6.91 7.31	23.47 17.77	35.23 28.16
1990 Honda Accord	RF-A Phase 2	4.66 3.34	6.85 7.36	28.13 21.61	39.64 32.31
1989 Toyota Camry	RF-A Phase 2	4.06 3.03	6.54 7.59	29.34 21.00	39.94 31.62
1991 Dodge Caravan	RF-A Phase 2	4.25 3.06	6.52 7.14	30.52 24.55	41.29 34.75
1993 Pontiac TranSport	RF-A Phase 2	4.18 3.33	7.21 6.91	27.37 20.63	38.76 30.87
1993 Ford Escort	RF-A Phase 2	6.21 3.26	4.99 6.07	16.72 15.82	27.92 25.15
1993 Pontiac Grand Am	RF-A Phase 2	6.20 3.66	6.95 7.31	18.65 15.17	31.80 26.14
1993 Ford Escort	RF-A Phase 2	6.55 3.59	6.50 6.79	19.68 17.33	32.73 27.71
Arithmetic Mean of 8-Vehicle Fleet	RF-A Phase 2	5.09 3.39	6.80 7.16	24.36 18.98	36.25 29.53
% Change vs. RF-A		-33.4	5.2	-22.1	-18.5
CARB Profiles for TLEVs*	RF-A Phase 2	6.83 3.99	10.04 9.55	17.67 18.74	34.67 32.28
% Change vs. RF-A		-41.6	-4.9	6.1	-6.9

* From Appendix C in Dec. 15, 1992 CARB report on Modeling Protocol and Final Results

Attachment 2

COMMENTS:

Modeling Protocol and Final Results Report Dated December 15, 1992

- Page 1: It is stated here (and elsewhere) that a new 1987 base emissions inventory was used, but the reasons for the change are not explained very thoroughly. What is the basis for the decrease in NMOG and increases in CO and NOx compared to the previous base inventory? Also, how could NMOG now be lower since total NMOG is doubled in the new inventory, but only motor vehicle NMOG was doubled in the old inventory? Or are all these inventory changes expressed on a "before doubling basis?"

- Page 1: Why were base emissions of NMOG and CO doubled for 1987 inventory, but not for the 2010 inventory? This seems inconsistent.

- Page 4, 4th PP: Table III does not contain "reactivity distributions" as stated in the text.

- Page 4, 3rd PP: The fact that the effects of temperature and speed upon vehicle mass distributions are unknown for alternatively-fueled vehicles is a major limitation and adds considerable uncertainty to the CARB approach for calculating RAFs.

- Page 5, 2nd PP: The definition of "Null Case" is different than previously. In earlier CARB documents, "Null Case" meant no vehicle exhaust emissions. Now it means base vehicle exhaust emissions but without doubling. This is confusing and seems inconsistent. Because of this change, is it valid to compare directly this new Null test results with previous Null test results?

- Page 5, 3rd PP: It is stated that vehicle exhaust emissions comprise 8% of total NMOG in the 1987 inventory and 22% in the 2010 inventory. This implies that huge reductions in non-motor vehicle NMOG will occur during this time period. Is this reasonable?

- Page 9, Table IV: The NOx emissions standard for LEVs is only one-half as large as for TLEVs (0.2 vs 0.4 g/mile). Yet this table indicates no difference in total NOx inventories between LEV and TLEV cases. Also, why are NMOG emissions higher for the LEV case than for the TLEV case when using Phase 2 gasoline?

- Page 9, Table V: Emissions of both aromatics and formaldehyde with fuel RF-A are higher from LEVs than from TLEVs. Also with Phase 2 gasoline, formaldehyde emissions are much higher from LEVs than from TLEVs. These findings don't seem right, and could have a major impact on the modeling adjustment factors.

- Appendix Tables: The data in Appendix C show no reduction in mass of hydrocarbon emissions from TLEVs in going from RF-A to Phase 2 gasoline (actually, a 1% increase is seen!). Also, the distribution of mass across the three FTP bags is very different between the two fuels - Bags 1 emissions are much higher with Phase 2 gasoline than with

RF-A, while Bag 2 and Bag 3 emissions are much lower with Phase 2 gasoline than with RF-A. These findings probably result from using a different vehicle fleet with each fuel, but they certainly raise a question about the validity of the emissions profiles.

The aromatics distributions in Appendix C also look unusual. Phase 2 gasoline has a much lower level of total aromatics than does RF-A (23 vol% vs 32 Vol%). Yet, other than benzene, the mass fractions of individual aromatic species are quite similar between the two fuel, with the level of highly-reactive C8+ aromatics actually being slightly higher from Phase 2 gasoline than from RF-A. These aromatic distributions do not seem reasonable and are likely contributing to an overestimation of the reactivity of emissions from Phase 2 gasoline.

An extremely unusual feature of these profiles is the complete absence of 2,2,4-Trimethylpentane (Isooctane) in the Phase 2 gasoline emissions. Phase 2 gasoline has a much higher level of Isooctane than does RF-A (9.8 vol% vs. 3.6 vol%). In fact, Isooctane is one of the largest components in Phase 2 gasoline. In emission samples, Isooctane would be expected to comprise a similarly large fraction. We now understand the reason for the erroneous entry of zero Isooctane in the exhaust emissions from Phase 2 gasoline. Due to presumed chromatographic problems, the Isooctane peak was incorrectly allocated as follows: 50% generic C8 branched paraffin, 25% internal C8 olefin, and 25% terminal C8 olefin. We note that staff has corrected this Isooctane problem for the purpose of calculating RAFs; however, the emission profiles used in modeling by CMU have not been corrected.

As a final comment about these emissions profiles, we note the Phase 2 gasoline profile contains no MTBE. This is quite surprising since the fuel itself contains approximately 11% MTBE. Although the amount of MTBE is greatly depleted in exhaust mixtures versus fuel mixtures, some MTBE is expected to be found in the exhaust. Based upon our testing of TLEVs with Phase 2 gasoline, MTBE would be expected to comprise 1-2% of total NMOG. This oversight, while admittedly small, is still disturbing in that it could lead to further overestimation of reactivity from Phase 2 gasoline. (MTBE has a very low MIR factor. Therefore misidentification of the MTBE chromatographic peak would probably result in a higher calculated reactivity).

All these questions regarding the emissions profiles highlight the need for a rigorous cross-correlation program to ensure that the measurement methodologies used by different laboratories provide equivalent results.

TESTIMONY OF

DAN FONG, MANAGER

TRANSPORTATION TECHNOLOGY AND FUELS OFFICE

ENERGY TECHNOLOGY DEVELOPMENT DIVISION

CALIFORNIA ENERGY COMMISSION

Prepared for the Public Hearing on

Proposed Amendments to

Regulations on the Low-Emission Vehicle Program

California Air Resources Board

January 14-15, 1993

06417

Introduction

The California Energy Commission (Commission) is pleased to have the opportunity to once again testify before the Board in support of amendments being proposed for the Low-Emission Vehicle and Clean Fuels Regulation adopted in September of 1990. ARB staff has worked diligently to develop the regulation and in particular to provide reactivity adjustment factors (RAFs) to the manufacturers in a timely manner. The Board and the ARB staff should both be congratulated for their efforts and the Commission continues to value the close working relationship with staff especially in developments concerning alternative fuel vehicles. My comments today primarily concern Commission views on the rule and how well it is maintaining fuel neutrality and achieving the level playing field necessary to assure fair competition among fuels and vehicles using the fuels.

State Energy Policy and Commission Programs as they relate to Low-Emission Vehicles and Clean Fuels Regulations

As you are probably aware, the Commission's principal energy planning and policy document is the California Energy Plan which we submit on a biennial basis to the legislature. The current 1992-1993 Plan contains a number of goals concerning the development and deployment of alternative fuels and alternative fuel vehicles. These goals recognize the need for fuel diversity in California's transportation sector to promote price competition and the need to displace some petroleum use for energy security in future years. I'd like to quote from Governor Wilson's preamble in the Energy Plan:

> "........*the introduction of alternative transportation fuels and vehicles must remain an essential element of our state's energy policy, and I strongly support all of the plan's recommendations in this area. In concert with improved vehicle efficiency, these new fuels offer a means of further reducing our dependency on oil and its commensurate economic and environmental uncertainties. Although our transportation system is likely to remain dependent on petroleum well into the next century, it is important that we begin transitioning now to greater fuel diversity.*"

I am pleased to be able to tell you that we are making progress in deploying alternative fuel vehicles in California as we now have over 2,800 flexible fuel vehicles in service and 2,100 of these are a part of the Commission's mandated FFV Demonstration program. This year we plan to sell an additional 4,000 to 6,000 FFVs the majority of which will be the TLEV Taurus from Ford and the Chevrolet Lumina from General Motors. Sales of these vehicles will allow us to achieve our goal of 5000 vehicles placed in service by the end of 1993. We are working with Chrysler and ARB staff to hasten the certification of the Dodge Spirit/Plymouth Acclaim as a TLEV flexible fuel vehicle as well. As you may recall, two Dodge

Spirits as well as two Chrysler Caravans were the cleanest FFVs in Phase One of the Auto/Oil study and easily achieved the TLEV NMOG emission standards at low mileage. In fact, the ARB staff used these Auto/Oil data along with additional FFV data developed by the Mobile Source Division to derive the 0.41 reactivity adjustment factor (RAF) for methanol TLEVs that was adopted in November of 1991 by the Board. The Board's adoption of the methanol RAF was crucial and necessary and the single most important action by the agency this past year to assure deployment of TLEV FFVs in 1993.

Clean Fuel Outlets/Regulations

The Commission's M-85 retail fuel network is providing some of the needed clean methanol fuel outlets which are not currently required under Clean Fuel Regulations. The 2,800 FFVs as well as remaining dedicated methanol vehicles placed in service with local agencies through earlier Commission demonstration programs have access to and depend on these facilities. Forty-one sites are currently in operation statewide and our agreements with eight oil companies call for a total of 82 to be operational by the end of 1994. These facilities and the California Fuel Methanol Reserve provide the mechanism to supply fuel through retail stations for participating fleets and private FFVs which might be purchased in the next few years. In this way, the Commission's M-85 network and fuel reserve programs provide clean fuel outlets in California in advance of requirements of the Clean Fuels Regulations. With the commitment from manufacturers to produce 20,000 vehicles for a given clean fuel, needed additional retail outlets will be available to improve fuel availablity and enhance the commercialization potential for alternative fuel vehicles. This provision of the Clean Fuels Regulations is crucial to market development and the Commission will continue in its efforts to persuade manufacturers to introduce sufficient methanol, natural gas and other clean fuel vehicles to trigger the fuel availablity requirement of the regulations.

The Appropriateness of Proposed RAFs for Phase II gasoline

Consistent with the testimony that the Commission provided at the Board's Public hearing for adoption of Reactivity Adjustment Factors for methanol Transitional Low-Emission Vehicles in November of 1991, Commission staff believes that the adopted approach of the use of the Carter Maximum Incremental Reactivity scale combined with adjustments through use of airshed modeling is the most defensible and valid approach in determining the ozone producing potential of all clean fuels and baseline fuels as well. The development and corrections (through use of the CIT airshed model) of RAFs proposed for adoption today for TLEVs and LEVs operating on phase 2 reformulated gasoline appear to be consistent with the methodology used to establish the RAF for methanol TLEVs in 1991. The Modeling Protocol and Results document prepared by the Research Division of ARB includes a discussion on how the methodology has been improved. Probably the most significant result is the verification that the methanol RAF developed in 1991 remains virtually the same, and if any revision was to be made it would require the *lowering* of the methanol TLEV RAF. ARB has not proposed to do this though, thus the methanol TLEV RAF is conservative in comparison to the newly derived RAFs for Phase 2 reformulated TLEVs and LEVs. The results also show that improvements in the correction methodology do not dramatically alter previous calculations. This provides confidence in the observation that the RAF methodology being employed by the ARB is quite refined in its existing state.

Hybrid Electric Vehicle Test Procedures

With current proposals for Hybrid Electric Vehicles (HEVs), the Commission is concerned that HEV configurations currently are slanted more toward the ICE propulsion than electric vehicles. Recent examples include the LA 301 built by CAT, Audi's and VW's HEVs, and NEVCOR's XA 100 and XA 200. All of these vehicles would not be given any HEV credits under these proposed certification procedures. The Commission agrees that credit should be given to HEVs which exceed or equal 40 miles range on battery power alone.

The ARB's proposed regulations designates three types of HEVs based on their all electric range. The Commission believes that the NMOG levels should be based on the extent of a vehicle's all electric capability. However, the Commission does not believe that Type A or B HEV should be allowed less than the full 100,000 mile durability requirement. Presumably, these types of HEVs should have easier means of achieving 100,00 mile durability standards since the auxiliary power unit would not be used as much as lower range HEVs. It would not be unreasonable to recommend 100,000 mile durability for all three types.

Level Playing Field Considerations

The ARB staff has worked hard to maintain and improve the fuel neutral aspects of the Low-Emission Vehicles and Clean Fuels Regulations. With the recent consideration of fuel cycle emissions, the ARB will level the playing field upstream of the vehicle where emissions are also generated. Alternative fuels will have reactivity benefits over conventional fuels in this regard and it is important to give appropriate reactivity credit where due. One additional area for the ARB to consider in this regard concerns the reactivity benefits that might be associated with alternative fuel evaporative and running emissions from vehicles, especially for vehicles which might certify to LEV and ULEV tailpipe standards.

In addition, Commission staff agrees with the ARB staff decision to allow an upward adjustment of the 50 Deg. F. NMOG multiplier to 2.0 for all TLEVs. By allowing this adjustment for all fuels the staff is maintaining a fuel neutral posture.

Baseline Specific Reactivities for LEVs and ULEVs

Commission staff notes that a 3.13 gram per gram specific reactivity has been calculated for "RF-A" base fuel. This lower specific reactivity for LEVs and ULEVs when compared to the baseline for TLEVs means that all fuels will have to do better in the LEV and ULEV configured vehicles in order to achieve the same RAF as they would in TLEVs. Even though the ARB database of vehicles is rather small, the derived value appears to be valid to Commission staff, absent any additional vehicles with advanced emission controls and data which might be supplied by manufacturers. These baseline values are crucial to the calculation of RAFs for all vehicles and fuel combinations and to not adopt the value will create a regulatory impediment. The Board should adopt the 3.13 value but make adjustments if necessary should the Carter factors be revised or if other changes in the calculation methodology are found to be necessary to maintain the scientific integrity of calculated baseline reactivities for the various low-emission vehicle classes.

Conclusions

In closing, I would like to emphasize again that the introduction of alternative fuels and alternative fuel vehicles is an essential element of the state's energy policy. The Commission will continue to co-operate with industry, the ARB, local air quality management districts, and other state and local agencies to bring this technology to commercial reality. Additionally, the Commission concurs with the Board's Resolution 9058 and recommends that ARB continue to conduct biennial reviews to maintain flexibility and responsiveness to new information as it is developed by the industry and the scientific community. I strongly recommend the adoption of the staff proposal and urge the ARB to continue with establishing RAFs for alternative fuel LEVs and ULEVs as vehicles become available from the manufacturers.

(1)

California
Electric
Transportation
Coalition

Statement

of the

California Electric Transportation Coalition

Los Angeles Department
of Water and Power

Pacific Gas & Electric
Company

Sacramento Municipal
Utility District

San Diego Gas & Electric
Company

Southern California Edison
Company

before the
California Air Resources Board

Public Meeting to Consider
Amendments to Certification Requirements
for
Low-Emission Passenger Cars, Light-Duty Trucks
and Medium-Duty Vehicles

David L. Modisette
Executive Director

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January 14, 1993
Sacramento, California

A non-profit association
promoting cleaner, healthier air
through the development and use of
zero-emission electric vehicles,
hybrid electric vehicles,
electric mass transit buses and rail

06422

The California Electric Transportation Coalition (CalETC) has consistently supported the California Air Resources Board (CARB) Low-Emission Vehicle (LEV) regulations specifically as they pertain to Zero-Emission Electric Vehicles (EVs) and Hybrid-Electric Vehicles (HEVs). We have previously commented on the proposed regulatory changes in these areas and we have supported the direction and conclusions of staff during this Biennial Review process. CalETC concurs with CARB staff that there has been significant progress in the past two years, both in terms of electric vehicle technology and commercial development to support the existing implementation schedule for ZEVs.

CalETC would like to note that there has also been progress in EV charging infrastructure, standardization in infrastructure technology, EV industry development efforts, and increased financial support from federal and state sources. We have also seen accelerated coordination between auto makers, utilities and government at the national, state and regional levels to prepare for the introduction of EVs. CalETC believes that these advances and activities will contribute to making the introduction of EVs an economic as well as an air quality success.

With this success in mind, we have reviewed the proposed changes and amendments to the adopted LEV regulations as those changes relate to the introduction of EVs and HEVs.

First, CalETC supports the CARB staff revised definition of a ZEV that would certify electric vehicles with certain specified fuel-fired heaters to qualify as Zero-Emission Vehicles.

Second, CalETC supports the staff proposed flexibility in meeting 1998 ZEV mandates with vehicles that exceed the light-duty vehicle weight category. We believe that allowing vans and trucks that are likely to be available and attractive to fleets, to qualify for ZEV credits and for the 1998 ZEV mandate, will reduce risk and encourage early commercialization. Electric vans in fleets is a niche where success has already been proven.

Third, CARB staff is recommending a change in the language of the adopted LEV regulations from vehicles "sold in California", implying a sales rather than a production mandate, to vehicles "produced and delivered for sale in California". CalETC is taking no position on this change at this time, but CalETC believes that in the future, CARB staff should monitor and evaluate whether there is any significant difference between the number of vehicles characterized by this regulatory change. Further, we believe that adequate vehicle tracking could be achieved through the Department of Motor Vehicle (DMV) registration lists, if DMV would add a single-digit for vehicle fuel type. We have been working with the DMV, your staff, and other agencies to put this in place.

Fourth, CalETC appreciates the clarification of the ZEV credit system and supports this incentive for the early introduction of EVs. CalETC supports the ZEV credit system component of deficit valuation which gives ZEVs the credit value of the fleet emission average for the year in which the credit is earned. As this valuation results in higher values for earlier years it both acts as an incentive for early EV commercialization and encourages competition for this early market entry.

CalETC also supports the ZEV credit system component which maintains the value of ZEV credits at the deficit valuation level attained in the year earned without discounting through 1998. Again, this valuation results in the ability to accrue higher values for years preceding the mandate and is an incentive for early EV commercialization.

Fifth, CalETC suggests continued dialog on the issue of the test procedures to determine the emissions of hybrid-electric vehicles. Members of CalETC have testified in CARB workshops and we have had several discussions with CARB staff on this issue, based upon our perception that the proposed test procedures may contain an unintended bias for certain hybrid technologies over others. The availability of Ford HEV demonstration vehicles during the next Biennial Review period will provide CARB staff with "real world" opportunities in which these test procedures can be evaluated.

CalETC shares CARB's goal of a vehicle with zero emissions and is working daily to achieve that goal. However, we believe HEV technology offers low-emission possibilities on the road to an all-electric future. CalETC believes that HEVs could: provide an efficient, low-emission vehicle that tests as a ULEV or lower for emissions; give car customers some practical experience with EV technology; result in as many or more electric miles driven than with current technology EVs; and, act as a technology bridge to an all-electric vehicle.

We also believe it is possible to address staff's concerns on the HEV emissions testing issue, and still reach agreement from auto manufacturers, utilities, and all concerned parties, on a test procedure which is technology neutral and which achieves cleaner air.

In conclusion, CalETC believes that the proposed revised text of the Low-Emission Vehicle Regulations as they relate to: the definition of a ZEV, the expansion of the weight category for ZEV mandate compliance, the ZEV credit system, and the maintained valuation of ZEV credits through 1998, will assist in the successful implementation of the 1998 ZEV mandate as well as offer an incentive to the early commercialization of ZEVs. In addition, CalETC would like to see CARB staff continue discussions with auto makers, individuals conducting HEV demonstrations and others to revise the HEV test procedure.

CalETC will continue to work with CARB staff on the issues raised in these comments.

American Automobile Manufacturers Association
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Tel. No. 313-872-4311 • Fax No. 313-872-5400

January 13, 1993

California Air Resources Board
c/o Ms. Pat Hutchens
Board Secretary
P.O. Box 2815
Sacramento, CA 95812

Dear Ms. Hutchens:

RE: Public Hearing to Consider Amendments to Certification Requirements and Procedures for Low-Emission Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles

The American Automobile Manufacturers Association (AAMA) submits the attached comments on the above subject, which is scheduled for consideration at the January 14-15, 1993 Board Meeting. AAMA (formerly MVMA) is the trade association of the domestic automobile manufacturers and presents the views of its three members on legislative and regulatory issues of concern to U.S. car and light truck manufacturers.

Please provide our comments to the Board for its consideration at the hearing and enter them into the record of these proceedings. If you have any questions regarding the attached, please call me or Mr. Gerald A. Esper at (313) 872-4311.

Sincerely,

Thomas J. Carr
Vice President
Technical Affairs

American Automobile Manufacturers Association

Comments
on the
Notice of Public Hearing to Consider Amendments to Certification Requirements and Procedures for Low-Emission Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles

The American Automobile Manufacturers Association (AAMA)* herein calls to the attention of the California Air Resources Board (CARB) members and staff a number of concerns regarding the issues that the staff originally planned to present to the Board at the November 12-13, 1992 Board Meeting. AAMA (formerly MVMA) is the trade association of the domestic automobile and light truck manufacturers and presents the views of its three members on legislative and regulatory issues.

Consideration of this topic was postponed from the November 12-13, 1992 Board Meeting and is now scheduled for the January 14-15, 1993 Board Meeting. AAMA has had several contacts with CARB staff on these issues, in the hope that we could achieve a mutually satisfactory understanding on these issues prior to the Board Meeting. AAMA sent letters dated October 20, and November 18, 1992 to CARB staff. Individuals from AAMA member companies have met with CARB staff, as have representatives of the Environmental Research Consortium (ERC). AAMA also had a conference call with CARB staff on Thursday, December 17, 1992. During the course of these contacts, CARB staff has informed us of changes to the original proposal. We support those changes, but there are still items that need to be addressed.

Our letters to CARB staff dealt with the following aspects of the CARB notice: (1) Non-Methane Organic Gas (NMOG) Test Procedures; (2) Reactivity Adjustment Factor (RAF) Determinations; (3) the Assembly-line 2 Percent Audit Canister Loading Requirement; and (4) Cold CO Standards. In raising those concerns prior to the Board Meeting, we hoped that CARB staff could address them and then we would be able to support the modifications presented to the Board.

The NMOG test procedure issues were discussed in our October 20, 1992 letter to Mr. K.D. Drachand, and during the subsequent October 29 meeting. The response from Mr. K.D. Drachand, dated December 7, 1992 addressed the majority of our testing concerns. The remaining unresolved NMOG test procedure issues involve technical methodology differences that can impact emission test results. These differences should be actively investigated by the American Industry/Government Emissions Research (AIGER) Cooperative Research & Development Agreement, which is supported by the three AAMA members, CARB and the U.S. EPA.

Likewise, we understand that the issue of the assembly-line 2 percent audit canister loading requirement has been addressed by CARB staff with modification to the regulatory text. We understand that the modified text gives manufacturers the option of using an adjustment factor based on the average difference between loaded canister and unloaded canister tests of at least ten vehicles per engine family. We find this proposal acceptable, and have no further comments at this time.

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* AAMA member companies are: Chrysler Corporation; Ford Motor Company; and General Motors Corporation.

AAMA's concerns on the issues of Reactivity Adjustment Factor (RAF) Determinations and Cold CO Standards still have not been adequately addressed. Additionally, AAMA has concerns with: (1) the Feasibility and Lack of Leadtime to meet the Low-Emission Vehicle/Clean Fuels (LEV/CF) standards; (2) the Need for a Comprehensive Review of the program including the effects of other regulatory requirements; and (3) the Need for an Incremental Cost-Effectiveness Analysis of the LEV standards as was done with Phase 2 reformulated gasoline regulations. AAMA's concerns on these issues are summarized below.

Reactivity Adjustment Factor Determinations

Introduction

California's LEV/CF regulation treats the vehicle and its fuel as a "system," and thus, recognizes the need to establish the reactivity, or ozone forming potential, of the exhaust of a baseline fuel (Industry Average Gasoline, "RF-A") in order to properly credit reactivity improvements in vehicle exhaust due to changes in fuel composition. The same need logically applies to vehicle hardware technology, by establishing a baseline set of vehicles. CARB staff is attempting to do this by emission level group (TLEV, LEV, ULEV) using a sample of today's cars, tested either in their OEM configuration or as modified by CARB staff to provide lower emission levels at low mileage. The procedure CARB is following to establish baseline fuel Ozone Forming Potentials (OFPs) currently should be changed to provide a more accurate OFP value, which will result in RAFs that take into account vehicle technology improvements as well as fuel improvements.

We submit that a baseline fuel/technology OFP (the denominator in the RAF equation) should be established. This baseline OFP would then be applied to **all** vehicle/fuel combinations. This method would credit manufacturers with vehicle reactivity improvements and thus give them the flexibility to find the most cost-effective approach to lowering the vehicle's total ozone forming potential.

"Vehicle" Reactivity

The current procedure used by CARB to set Reactivity Adjustment Factors credits the **fuel** reactivity improvements but fails to properly credit the reactivity improvements resulting from **vehicle** design changes. This inequity occurs because CARB is using the same vehicles to establish the reactivity of the baseline "RF-A" fuel as well as that of the Phase 2 gasoline. Therefore, because the fuels are tested in the same vehicle, only the contribution of the fuel's reactivity improvement is measured. CARB's current RAF equation is essentially a fuel effect term, and does not reflect the reactivity improvements from advances in vehicle technology.

Including the vehicle's reactivity in the RAF equation would be consistent with past regulations, in which the test vehicle's performance was always measured. One of the problems with the current RAF equation is that it makes the assumption that an experimental LEV measured in 1992 will reflect 1998 production technology. The current CARB procedure for determining "default" RAFs introduces this uncertainty into the numerator as well as the denominator, although CARB procedures do allow a manufacturer to determine its own engine specific RAF, albeit through extensive and costly testing, if it believes the CARB RAF does not credit unique vehicle improvements. We contend there is no reason to introduce this uncertainty into the determination of baseline ozone forming potentials. Just as CARB saw the need to establish a baseline gasoline which is an average of commercially available fuels, the same logic should be applied to the vehicle hardware. We recommend CARB establish the "baseline" vehicle as **today's** cars and light duty trucks.

The goal of setting the baseline fuel OFP should be to determine as accurately as possible the **current** fleet's OFP value using **current** fuel. CARB staff has included a large number of vehicles that exhibited TLEV emission levels at low mileage in the fleet they tested. The baseline fleet should consist only of vehicles certified to the 0.39 or 0.25 NMHC standard.

Problems with the Current Database

Setting aside AAMA's concerns with CARB's methodology, we believe the existing database, on which the CARB staff has based its proposed baseline OFPs and RAFs, has several technical shortcomings:

- The database is extremely small (for example, six vehicles for the LEV baseline OFP and nine for the LEV Phase 2 gasoline OFP).

- The data show no tendency to cluster about the proposed OFP for LEVs and ULEVs of 3.13.

- All of the LEV category baseline data and over half of the Phase 2 gasoline data were generated on low-mileage prototype vehicles (or with low-mileage components) equipped with pre-start electrically heated catalysts. CARB staff, at the June 11, 1992 Board Meeting, has already acknowledged that this technology may not have general applicability for vehicles in the LEV category. At that time the CARB staff estimated that "smaller" vehicles would not require EHCs of any kind and that "larger" vehicles would require only **post**-start EHCs.

AAMA submits that it is not appropriate to use this database to adopt baseline OFPs and Phase 2 gasoline RAFs, which would be locked in essentially "forever."

Recommendation for Industry/CARB Cooperative Study and Test Program

AAMA recommends that CARB and the affected industries implement a cooperative study and test program to review the methodology for establishing RAFs and to determine baseline fuel OFPs and RAFs.

Cold CO Requirements

The September 25, 1992 staff report proposes a 50,000-mile cold-temperature carbon monoxide (CO) compliance standard. The only basis for the new rule stated in the staff report is that "additional reductions of CO emissions are still needed in some areas of the state to achieve compliance with the National Ambient Air Quality Standard (NAAQS) for CO during winter months." See "Initial statement of Proposed Rulemaking Amendments to the Low-Emission Vehicle Program" (September 25, 1992) at 11.

The staff report's justification for this new regulatory burden in California is inadequate under the California Clean Air Act of 1988 and the Government Code. The only CO NAAQS nonattainment areas that could be predicted to encounter 20 °F temperatures are in northern California and have CO attainment deadlines of December 31, 1995, which is too early for this proposed new rule to have any effect. See U.S.C. §7512 (deadlines for compliance with CO NAAQS); 56 Fed. Reg. 56694, 56722-26 (November 6, 1992) (California CO classifications). California's southern-region CO nonattainment areas have a later NAAQS compliance deadline, but these areas do not encounter temperatures near 20 °F on a sufficiently predictable basis to justify this regulation.

Likewise, the 20 °F testing requirement cannot be justified as a measure needed to maintain compliance with the NAAQS. Federal and State vehicle emissions control measures such as the wintertime oxygenated fuels program and the enhanced motor vehicle inspection and maintenance rules will provide much more effective methods of control than the new vehicle emissions standard proposed by CARB staff. Indeed, CARB staff has not even tried to support the rule on this basis. If they did, they would need to determine whether the cold CO requirement was both "necessary" and the least-cost method of meeting the State's need for maintenance of the CO NAAQS. See California Government Code §11346.5(a)(7) (requirement to consider less-burdensome alternatives); § 11349.1(a)(1) (requirement of "necessity" for new regulations).

Finally, as stated in our November 18, 1992 letter to Mr. K.D. Drachand, AAMA objects to the fact that the proposal unnecessarily extends the applicability of the Cold CO requirements to non-gasoline vehicles not covered by U.S. EPA's regulations.

Feasibility and Lack of Leadtime

The LEV/CF regulations present some of the most significant technological challenges that automotive manufacturers have ever faced. While automotive manufacturers are aggressively working to meet these challenges, concerns exist that the current goals of the program cannot be achieved within the prescribed time frame—even taking into account the prospects for success of newly developed groups such as the Low-Emission Vehicle Technology Consortium, the Advanced Battery Consortium and the Ultra-Low Emission Engine Consortium.

When the LEV/CF regulations were adopted at the September 27-28, 1990 Board Meeting, the industry was less than three years away from the start of production for the 1994 model year. These rules provided lead time far short of standard industry practices. With current aggressive product cycles, automotive manufacturers require defined technologies ("bookshelf technology") at least four years prior to production for system prove-out. Having bookshelf technology is essential under these circumstances due to the required effective life of 100,000 miles.

Unfortunately, the process of establishing bookshelf technology is an extremely time consuming task. Candidate emission control technologies must undergo several procedures to determine product viability. Prior to system prove-out, approximately two years are spent performing initial preview testing, calibration development, and cold temperature testing. If problems occur requiring hardware redesign, the process will take longer.

Although some vehicles have been certified to the TLEV level, no known LEV-capable technologies, including electrically heated catalysts, have been developed to acceptable industry standards. Now at the point when design plans need to be finalized to meet "Job 1" timing for the 1997 model year, manufacturers throughout the world are still searching for technologies which will enable them to achieve the emission level targets that the LEV/CF regulations require.

The leadtime/feasibility issue has been further exacerbated by CARB's recently adopted changes to the evaporative emissions test procedure and the potential for further changes when the U.S. EPA finalizes its related procedures. The increased stringency of the procedure not only affects the timing in meeting the LEV and ULEV standards, but also requires the development of new purge strategies, which in itself requires adequate leadtime necessary to properly design and prove-out. CARB's On-Board Diagnostics (OBD II) regulations, still under development with respect to TLEV, LEV, and ULEV's, have the same effect.

CARB's failure to meet the original timetable to define critical program elements (Phase 2 commercial gasoline specifications, certification fuel specifications, and reactivity adjustment factors targeted for September, 1991) has also severely added to the timing burdens because it substantially reduces the time available for manufacturers to design, develop, and produce vehicles.

Lack of sufficient leadtime to properly develop the required technologies for TLEV, LEV, and ULEV will force the industry to produce and sell unproven systems. The zero emissions vehicle (ZEV) mandate carries these same risks related to immature technologies, as well as additional risks related to their marketability. A high probability exists that major problems will occur in the field. The effect will lead to customer dissatisfaction creating a negative public image of the automotive industry and of government regulation; a lose-lose situation.

Need for Review of Impact on "Vehicle Systems"

It is really not practical to assess the feasibility of the Low-Emission Vehicle/Clean Fuels regulations without also considering the interaction of these regulations with other related regulations. For example, little or no attention has yet been given to the impact of more stringent evaporative emission regulations, which will require controlled combustion of greater amounts of fuel vapor during testing. The U.S. EPA has indicated that it is about to finalize regulations which differ from CARB's, introducing uncertainty as to what will happen to CARB's regulations.

On-Board Diagnostics is another area with strong interaction with the LEV requirements. Currently, the OBD II regulation includes unique requirements for the low emission vehicles, for which no technical solution has been identified or even hypothesized. Since OBD II regulations must be met on all 1996 vehicle (no further exemptions), this situation must be resolved soon. Therefore, AAMA recommends that the Board schedule a comprehensive "systems approach" review of the LEV/CF, OBD II, and evaporative emissions regulations by the fall of 1993, at which time an OBD II review is already tentatively scheduled.

Need for Incremental Cost-Effectiveness Analysis

As we have repeatedly emphasized in the past, AAMA strongly believes a thorough analysis of the incremental cost-effectiveness of the LEV program is necessary. With each reduction in standards (i.e., from Tier 0 to Tier 1, from Tier 1 to TLEV, from TLEV to LEV, from LEV to ULEV, and from ULEV to ZEV), the amount of air quality improvement decreases while the cost of meeting the standards will increase substantially. This concept has held true since the first emission controls were installed on automobiles. Those first controls yielded the "biggest bang for the buck." The LEV/CF program's stringent LEV and ULEV categories force manufacturers to the limits of emission control technology, with potential technologies being very costly, especially given the minimal air quality benefits.

The Board needs to reconsider whether the LEV/CF program meets the criteria for mobile source regulations under the California Clean Air Act of 1988, which includes the requirement that the regulations be "cost-effective" and that they constitute "the most cost-effective combination" of available control measures for both vehicles and fuels. It is not possible to reconcile the Board's approach in the Phase 2 gasoline rulemaking in November, 1991, with the LEV rulemaking. The LEV and ULEV portions of the LEV regulations, for example, may not be nearly as cost-effective as the Phase 2 gasoline heavy aromatic control limits rejected by the Board on the basis of poor cost-effectiveness. The California Clean Air Act requires CARB to reconsider its action in the Phase 2 gasoline and LEV rulemakings, and to bring its assumptions about cost-effectiveness in the two rulemakings into line with one another.

AAMA therefore, again, requests that CARB staff be asked to develop (with industry participation) systematic, comparable estimates of the incremental cost-effectiveness of the LEV regulations. If there are differences between the two rulemakings, then either the LEV program should be modified to lower cost levels, for instance, through an adjustment to the NMOG fleet average curve, or the Phase 2 in-use gasoline specifications should be modified in order to obtain levels of control with comparable cost-effectiveness. The Board should not support cost-effectiveness levels in one part of the mobile-source rulemaking effort that are inconsistent with those applied elsewhere.

Conclusion

AAMA appreciates the opportunity to present these concerns to the Board and we are hopeful that meaningful and productive dialog on these issues will occur at the Board Meeting. We also look forward to continued discussions with CARB staff on these issues.

STATE OF CALIFORNIA
AIR RESOURCES BOARD
RECEIVED 1-13-93
BY BOARD SECRETARY

Motor Vehicle Manufacturers Association
of the United States, Inc.

1/14/93
93-1-3

XC: Bd Mbr
JS TAC
JD MSD
JB Legal

Thomas H. Hanna
President and Chief Executive Officer

October 20, 1992

Mr. K. D. Drachand
Division Chief, Mobile Source Division
State of California
Air Resources Board
Haagen-Smit Laboratory
P.O. Box 2815
Sacramento, Ca 95812

Dear Mr. Drachand:

RE: Proposed Non-Methane Organic Gas Test Procedures

The Motor Vehicle Manufacturers Association of the United States, Inc. (MVMA) have reviewed the section of the California Code of Regulations titled "California Non-Methane Organic Gas Test Procedures," issued September 25, 1992. Attached are our comments on that document.

The comments are separated into two sections. The first section summarizes the major concerns that MVMA has with the California Air Resources Board (CARB) procedures. These issues pertain to fundamental differences between the proposed procedures and those implemented and refined at our member facilities during the Auto Oil Air Quality Improvement Research Program. The second section is an attachment which addresses the specific procedural differences individually.

MVMA requests that CARB procedures be updated prior to the Board Hearing on November 12, 1992, to include the major issues discussed in the first section of these comments. Additionally, we recommend that CARB, the EPA and the Environmental Research Consortium (ERC) continue to work together to develop common procedures. Some of our members did not receive Section B (Determination of Non-Methane Hydrocarbon Mass Emissions) of the proposed test procedures, and therefore, were not able to comment on it at this time.

06432

7430 Second Avenue, Suite 300 • Detroit, Michigan 48202
Tel. No. 313-872-4311 • Fax No. 313-872-5400

Thank you for giving us the opportunity to review the procedures. If you have any questions on the attached comments please call me or Greg Walker at (313) 872-4311.

Sincerely,

Marcel L. Halberstadt, Ph.D.
Director
Environmental Department

MLH/bjt
Attach.

CC: Mr. R. J. Kenny
Mr. S. H. Mano

MVMA Comments on California Code of Regulations, Titled Section: "California Non-Methane Organic Gas Test Procedures"

October 20, 1992

The Motor Vehicle Manufacturers Association of the United States, Inc. (MVMA) members have common concerns regarding California Air Resources Board (CARB) methods, issued September 25, 1992 for measuring alcohols, carbonyls, ethers, non-methane hydrocarbon, speciated hydrocarbons and for calculating vehicle non-methane organic gas (NMOG) emissions. Though the clarity of these procedures was improved following the workshop held on September 3, 1992, the CARB procedures:

- remain significantly different from those used at our facilities,
- are not, in some instances, technically correct,
- could result in a significant cost burden to the manufacturers.

Two approaches could be taken to deal with the procedural differences between CARB, MVMA and the Environmental Protection Agency (EPA). The first approach would be to consolidate the procedures used by CARB, EPA and the automotive companies into a single set of common procedures. However, such a general commonization would be too costly to those involved and may not be possible in the short time available (less than a year). The second approach is for CARB to accept an alternate set of procedures as equivalent to CARB's procedures.

Towards resolving the procedural differences, MVMA endorses joint technical and scientific interactions which are underway with CARB, the EPA and the Environmental Research Consortium (ERC) Low Level Emissions Measurement Project. With MVMA's concurrence, the ERC will submit to CARB, for consideration the procedures that were implemented and refined at the member facilities during the Auto/Oil Air Quality Improvement Research Program (Auto/Oil). This document will also include information illustrating the accuracy, precision, and durability of these procedures. Additionally, ERC will work through the Cooperative Research and Development Agreement (CRADA) relationship to develop procedures that are common for all vehicle emissions measurements.

Prior to submission of the ERC document which demonstrates equivalence between methods, we feel that a number of major concerns need to be addressed. These major issues are summarized below in items 1 through 7. Additional detailed comments on each procedure are in the attachment.

Major issues of concern:

1) The use of benzene as the calibration standard for the mass determination of mid-range hydrocarbons is inappropriate. Propane is the standard used for low-range hydrocarbons. The use of two standards would result in two data sets which could not be combined for quality assurance checks. Specifically, the test comparing overlapping compounds between gas chromatographs (GCs) and the test comparing the GC and bench flame ionization detection (FID) (also calibrated on propane) total hydrocarbon measurements would not be possible.

2) Cryo-trap techniques, as described in CARB's procedures, are conducted manually and are very labor intensive. These techniques are not well suited to production testing environments.

3) Over the last two years, hundreds of vehicle tests have been conducted and the data validated at automotive testing facilities using straight forward quality assurance/quality control procedures. These procedures have been very successful and we feel that the duplicate tests, linearity checks, and control charting procedures proposed by CARB are not necessary.

4) Inclusion of a new procedure for the analysis of ethers is not necessary because ethers can be accurately measured by the mid-range GC. Furthermore, adding this new procedure would be redundant and incorrect because it results in doubling the mass measurement of ethers. Regarding the level of ethers in vehicle emissions, existing vehicle data, which includes CARB data to determine Phase II fuel reactivity adjustment factor (RAF), consistently shows methyl tertiary-butyl ether (MTBE) concentration levels less than 0.5 ppmC in Phase I and 0.0 ppm in Phases II or III of the Federal Test Procedure (FTP).

5) The number of hydrocarbon (HC) compounds to be determined should initially be large and decreased later, only if it is proven that a smaller library of compounds will provide the same reactivity results for all fuels and vehicles. Manufacturers should analyze sufficient HC compounds such that an accurate measurement of the vehicle's average reactivity (on a total mass basis) can be determined. At this time, we recommend the Auto/Oil Phase II list of approximately 170 compounds (C1 through C12) be used.

6) The mass determination should be based on the site FID that is calibrated on propane. The on-site FID has been, and should continue to be, the standard for mass measurements, at least at the Transitional Low Emission Vehicle (TLEV) and Low Emission Level (LEV) levels. For diesel emissions, it would be premature to shift from the accepted heated FID determination of hydrocarbons to speciation, which is unproven. For compressed natural gas (CNG) vehicles, we agree (in the interim) to using the GC for mass determination, because of the measurement problems (large methane concentration). However for the long term a faster, on-line instrument must be developed like a direct non-methane hydrocarbon (NMHC) analyzer.

7) Butane should be used, rather than hexane, for the comparison of the low and mid-range GC data because it is always present in samples from gasoline vehicles. Hexane, which CARB recommends, is not found in the ambient bag and often not present in the sample bags, including samples bags from CNG and liquid petroleum gas (LPG) vehicles.

We urge that the CARB proposed test procedures be updated prior to the Board hearing on November 12, 1992, to include these major issues. Additionally, we recommend that CARB, EPA, and the Environmental Research Consortium continue to work together to develop common procedures.

MVMA COMMENTS ON CARB'S PROPOSED METHOD

"GENERAL APPLICABILITY AND REQUIREMENTS"

3. Acceptable methods and techniques have not been developed to measure diesel hydrocarbons by gas chromatography. Hydrocarbons from diesel should continue to be measured by a heated FID.

7. Ethers can be measured by current hydrocarbon gas chromatographic methods. A separate analyzer is not required. Double counting of the ethers will take place when the separately determined ether mass is added to the FID determined NMHC.

*MVMA COMMENTS ON CARB'S PROPOSED METHOD

"DETERMINATION OF NON-METHANE HYDROCARBON MASS EMISSIONS BY FLAME IONIZATION DETECTION"

2.1 In order to obtain accurate results for NMHC, the total hydrocarbon FID should have a uniform relative response to the different hydrocarbons in the sample. The last sentence in this paragraph should be changed to: Other FID analyzer models shall be checked and adjusted, if necessary, to make the relative response factors of the various hydrocarbons as close to propane as possible.

5.2 CNG fueled vehicles should also be excluded from this section.

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* Not all members have reviewed this section.

MVMA COMMENTS ON CARB'S PROPOSED METHOD 1001

"DETERMINATION OF ALCOHOLS IN AUTOMOTIVE SOURCE SAMPLES

BY GAS CHROMATOGRAPHY"

3.1 CARB does not recommend what alternative method to use or when to use the alternative method for measuring alcohols which have interference problems.

3.2 MVMA does not agree that samples can stay stable for as long as 30 days. This should be less than seven days.

4.1 MVMA recommends that 15 ml of deionized water not be specified but rather a range be specified. Also, as approved by EPA, secondary impingers should not be required for Phase II, Phase III and background samples.

5.4 Do not specify an exact concentration for the stock solution. Allow for a range of solutions.

5.4.1 Do not specify an exact calibration standard.

5.4.3 Change 40°F to 32°F.

6.1 Should not specify that graduated fritted midget impingers must be used. Other systems are available which are as good.

6.2 No mention of background impingers. Also, as approved by EPA, secondary impingers should not be required for Phase II, Phase III and background samples.

6.4 The GC operating conditions are different between CARB and the manufacturers Agreement should be reached through the ERC committee. The "unmodified" before sample should be dropped to allow the use of an IPA internal standard similar to EPA.

6.4.2 Replicate tests are not necessary with GCs which have good measurement repeatability. Once good repeatability is established, this check is not required. The ERC Committee should develop this procedure.

6.4.3 MVMA recommends that control standards be performed once every 24 hours.

6.4.7 Our experience has been that hydrocarbon recovery is >95%. It is not necessary to include peaks below the established detection limit to have good recovery.

8.1 Calibration and control standards should be prepared monthly.

8.2 MVMA feels that this blank check is not a necessary criteria. Should develop a criteria for the blank check.

8.3 Calibrations should be performed every 24 hours.

8.4 Quality control checks should be performed after each vehicle test analysis.

8.5 Minimum acceptable levels should be specified to insure that instruments with poor precision are repaired.

8.6 Same comments as in 6.4.2.

The acceptance limits seem to be loose, based on our experience.

8.7 A check for GC FID linearity is only required when a new instrument is put into use or major repairs are performed. No need to perform linearity check on more than one compound. It is well accepted that FIDs are linear for hydrocarbons and alcohols.

A high "r" does not assure that the regression line has a small zero intercept and therefore, does not assure proportionality between area counts and sample concentration.

8.8 A check for the GC limit of detection should be performed only when new instruments are put into use or major repairs or new techniques are incorporated. The limit of detection is not needed for the replicate test criteria.

MVMA COMMENTS ON CARB'S PROPOSED METHOD 1002

"DETERMINATION OF C_2 TO C_5 HYDROCARBONS

IN AUTOMOTIVE SOURCE SAMPLES

BY GAS CHROMATOGRAPHY"

1.1 Butane, not hexane is used by the ERC members as the crossover compound. Hexane is not found in the ambient bags and often not found in the sample bags.

This list of compounds does not agree with the list used by ERC members.

MVMA recommends that a single uniform method covering instrumentation and procedures should be developed by consensus by a group such as the Environmental Research Consortium.

2.3 Temperature ramp to start at 20°C not 0°.

2.4 Cryogenic preconcentration is not necessarily required for adequate sensitivity. It has the disadvantage of requiring more equipment and more time.

3.1 Use of an alternative (not alternate) method such as gas chromatography/mass spectrometer (GC/MS) or photoionization detector (PID) is suitable for a research environment but not in a "rapid method intended for routine analysis". There is no mention of how or when to use the alternative method.

3.2 Analyzing bag no. 1 within two hours will be very difficult to achieve. A relaxed time requirement is necessary. The ozone forming potential (OFP) for 1,3-butadiene is always less than 3% of the total (generally in the 1% level). Therefore, this requirement is an unnecessary burden.

4.2 A minimum sample of 10 mℓ is not needed to meet the instrument sensitivity requirement of paragraph 8.7.

Syringe precision is less than that of fixed sample loops.

4.4 A suitable alumina PLOT column would be 50 m x 0.53 mm. A suitable wax precolumn would be 15 m x 0.53 mm. The two column diameters should be equal.

4.5 Cryogenic preconcentration is not required for adequate sensitivity. It has the disadvantage of requiring more equipment and more time.

5.1 Six 9's helium purity for automated systems is higher than usually recommended and higher than needed.

5.4 The requirement that the propane calibration standard be no higher than 60 ppbC3 places the top calibration point toward the lower end of the usable concentration range. This is bad because it increases the error for determining higher sample concentrations because of a "lever arm" effect, which multiplies small calibration errors. Sections 8.7 and 8.5 allow a 20% relative percent difference between duplicate measurements at a 60 ppbC3 concentration.

Current vehicle certification does not include a requirement that the calibration gases used must be analyzed by NIST in order to verify traceability to NIST standards.

The calibration gas mix is inconsistent with the mix used by the automotive industry. A consistent mix should be developed through the ERC committee.

5.5 The control standard checks can be performed with the calibration gases. A separate check is not required.

6.1 Cryogenic preconcentration is not required for adequate sensitivity. It has the disadvantage of requiring more equipment and more time.

6.2 What's the oxygen for? The FID should use air.

6.4 Since the total sample volume is not accurately known, it is impossible to withdraw a precisely measured sample fraction (or aliquot).

It's difficult to routinely measure gas volumes within 1% with a 100 mℓ syringe.

6.13 Precise quantitative dilution is very difficult. If a concentration is too high, a smaller sample loop should be used, or the test considered to be invalid.

6.16 Do you want to accept peaks that are <u>below</u> the limit of detection?

8.1 This many blank runs are extremely nonproductive. Other methods can be used to insure no cross-contamination such as purging the sample inlet with clean air.

8.2 The frequency of running calibration standards is undefined.

8.4 Keeping control charts on a concentration basis would not show gradual deterioration of instrument response. Perhaps control charts should be kept of "area counts per ppbC" for each target hydrocarbon.

8.5 One duplicate that is out of line for one target compound would invalidate an entire day's testing.

These duplicates are unnecessary and would greatly reduce the test productivity. Other procedures have been shown to give good results.

There should be a quality control comparison of mass by GC with mass by test site FID.

8.6 The specified linearity check would take an entire day. Flame ionization detectors are well known to be linear over a very large range of concentrations. Once linearity is shown for an instrument, there is no reason to believe that the instrument would become non-linear if no major components were changed. Normally, this linearity check need be performed only when the instrument is new. A high "r" does not assure that the regression line has a small zero intercept and therefore, does not assure proportionality between area counts and sample concentration.

8.7 For the instrument to be linear, meaning proportionality between area counts and sample concentration, "A" should not be significantly different from zero.

This procedure, as written would take an entire day to perform.

Is it really necessary to use at least four concentration levels? The standard deviation of only the lowest concentration gas standard is actually used.

The RSD is not constant nor nearly constant near the LOD, but it increases as the LOD is approached from higher concentrations. Therefore, the allowable estimation of LOD using a determination of RSD obtained at higher concentrations, underestimates the LOD.

8.8 Since hexane is not found in background bags, this is a poor choice for a crossover compound. Butane would be a better choice.

The allowable tolerance seems to be very loose.

Refering to CARB test procedure, "Determination of C_2 C_5 Hydrocarbons in Automotive Source by Gas Chromatography" Method No. 1002, Page D-10. This list is a function of the method used and differs from the list developed by the automotive industry.

MVMA COMMENTS ON

CARB'S PROPOSED METHOD 1003

"DETERMINATION OF C_4 TO C_{12} HYDROCARBONS

IN AUTOMOTIVE SOURCE SAMPLES

BY GAS CHROMATOGRAPHY"

1. MVMA recommends that a uniform method covering instrumentation and procedures should be developed by consensus by a group such as the Environmental Research Consortium.

2.3 See comments for 3.1 about the use of a PID.

3.1 Use of an alternative (not alternate) method such as GC/MS or PID is suitable for a research environment but not in a "rapid method intended for routine analysis". There is no mention of when the use of an alternative method is required.

3.2 Stability of 72 hours would need to be proven. Suggest a shorter time limit for bag analysis.

4.2 Cryogenic traps are not needed to obtain the required sensitivity (LOD).

4.3 The routine use of a PID would cut our sample throughput in half, because it would reduce our available FID signal channels by a factor of two. To the best of our knowledge, routine use of a PID/FID combination has not yet been demonstrated in a high production test environment.
Cryogenic preconcentration is not necessarily required for adequate sensitivity. It has the disadvantage of requiring more equipment and more time.

4.4 Cryogenic traps are not needed to obtain the required sensitivity (LOD).

4.5 Alternative system?

4.7 Cryogenic traps are not needed to obtain the required sensitivity (LOD).

5.1 Six 9's helium purity for automated systems is higher than usually recommended and higher than needed. Why do automated systems require higher purity than manual systems?

5.5 Changing to a benzene standard raises questions of comparability with the test site bench total hydrocarbon FID and with the light end GC, both of which are calibrated with propane. It is possible to obtain a suitable GC peak which can be quantified, with propane in a calibration standard, on this mid-range GC. In a calibration standard, in which it is known that there are no constituents which can co-elute with propane, ideal peak shape is unnecessary.

The requirement that the benzene calibration standard be no higher than 120 ppbC6 places the top calibration point toward the lower end of the usable concentration range. This is bad because it increases the error for determining higher sample concentrations because of a "lever arm" effect, which multiplies small calibration errors. Sections 8.7 and 8.5 allow a 20 % relative percent difference between duplicate measurements at a 120 ppbC6 concentration.

It would be desirable if more n-alkanes were included in the calibration standard for the purpose of qualitative verification.

Current vehicle certification does not include a requirement that the calibration gases used must be analyzed by National Institute of Standard and Technology (NIST) in order to verify traceability to NIST standards.

5.6 The specified concentration range is too low, especially for the lower molecular weight hydrocarbons. Quality control charts can be maintained with the calibration gas analysis.

5.6.3 Except for benzene, NIST-traceable standards for the specified gases are not now available. Semi-annual linearity and LOD checks should not be required.

5.7 Semi-annual linearity and LOD checks should not be required when a FID detector is used.

6.1 Cryogenic preconcentration is not needed to meet the LOD requirements.

6.2.2 Will the C_{12} hydrocarbons elute without a hold at 200°C?

6.3 No sample preconcentration is necessary, but if it were, only one technique should be developed by consensus by a group such as the Environmental Research Consortium. MVMA recommends this section be dropped.

6.3.5 The difficulty in doing all these things "simultaneously" will probably introduce retention time variability into the chromatogram. This would cause incorrect automatic peak identification.

6.4 Sample preconcentration is not necessary. MVMA recommends this section be dropped.

6.5.1 Do you want to accept peaks that are below the limit of detection?

6.5.4 Purge the system with clean gas, rather than running blanks.

6.5.5

Which is the "reference run" that has a similar fingerprint to that of the automotive sample? None of the required standards would have a similar fingerprint.

8.1 This many blank runs are not needed. Purge the system with clean gas before using.

8.4 Keeping control charts on a concentration basis would not show gradual deterioration of instrument response. Perhaps control charts should be kept of "area counts per ppbC" for each target hydrocarbon.

8.5 If one duplicate of any of the target compounds is out of line it would invalidate an entire day's testing. This check is unnecessary. Instead, each sample analysis should need validation by comparison with the test site total hydrocarbon FID.

8.6 The specified linearity check would take an entire day. Flame ionization detectors are well known to be linear over a very large range of concentrations. Once linearity is shown for an instrument, there is no reason to believe that the instrument would become non-linear if no major components were changed.

A high "r" does not assure that the regression line has a small zero intercept and therefore, does not assure proportionality between area counts and sample concentration.

8.7 For the instrument to be linear, meaning proportionality between area counts and sample concentration, "A" should not be significantly different from zero.

This procedure, as written. would take an entire day to perform. It is only needed when the instrument is first put into service.

Is it really necessary to use at least four concentration levels? The standard deviation of only the lowest concentration gas standard is actually used.

Why is the minimum LOD for the mid-range GC (which typically yields more than half of the total hydrocarbons) four times higher than the low-end GC?

8.8 The use of hexane is a poor choice as a crosscheck component. Hexane generally is not found in background bags or some sample bags. The allowable RPD (%) is different between Methods 1002 and 1003. They should be the same.

MVMA COMMENTS ON CARB'S PROPOSED METHOD 1004

"DETERMINATION OF ALDEHYDE AND KETONE COMPOUNDS

IN AUTOMOTIVE SOURCE SAMPLES BY HPLC"

1.1 The Environmental Research Consortium (ERC) members measure five additional compounds. This list should be discussed in the ERC committee meetings.

Methyl Ethyl Ketone
Methacrolein
Crotonaldehyde
Valeraldehyde
p-Tolualdehyde

Hexaldehyde should be called hexanal.

2.1 Impingers only are specified, not cartridges.

Strictly speaking, a spectrophotometer detector is not required for this analysis, only an ultraviolet detector that can be set to the desired wavelength.

3.1 Proof of chemical identity may be required by other methods. No mention of what other methods or when to use other methods.

4.1.4 Zorbax columns are specified, however, other columns have been developed to perform the analysis twice as fast. MVMA recommends that uniform instrumentation and methods be developed through the ERC committees.

4.1.5 Spectrophotometer is not required for this analysis.

5.4 MVMA recommends perchloric acid can be used instead of sulfuric acid.

5.5.1-5.5.8 Recommend that a source for carbonyl standards be identified and made available to industry and the regulatory agencies.

5.6 Recommend that concentration levels not be specified for the stock solution. This requirement is not needed.

5.7 Recommend that concentration levels not be specified. Require that top standard be above the expected test level.

5.8 Recommend control standard be used for each test analysis.

6.1.1 The 2,4-dintrophenylhydrazine (DNPH) absorbing solution does not need to be in the refrigerator. The absorbing solution should not have the acid in the solution at this time. Should mention that the cartridges should be sealed and may be stored in the refrigerator.

6.1.2 Recommend that 15 mℓ of absorbing solution not be specified. Allow a range such as 10-20 mℓ.

Recommend that 30 mℓ graduated fritted midget impingers not be specified. Allow other systems such as 10-30 mℓ bulb or midget impingers with fritted or capillary ends.

Allow perchloric or sulfuric acid.

For impinger systems, secondary impingers are not needed for Phase 2 or 3 of the FTP. Also, a secondary impinger is not needed for the background sample. EPA has agreed to these changes in their test procedures.

6.3 Do not see any benefit to heat impingers after the test. Appears to be a waste of time.

6.3.1 All carbonyls are eluted from the cartridges in 3 mℓ of acetonitrile. Suggest using 5 mℓ to elute. Ten mℓ is too much and it dilutes the sample and lowers the concentration.

6.5 Allow the proper vial size to fit the liquid chromatography (LC). For Hewlett Packard LCs, the proper vial size is 2 mℓ.

6.6 Recommend other columns (see MVMA comment on previous page 4.1.4)

Recommend that binary gradients can be used with suitable columns. VIS spectrophotometer is not required for this analysis.

6.8 What good is it to set the peak rejection below the LOD?

7.1.3 Some ratios differ slightly from what the ERC members use.

8.2 A source or vendor should be found to supply reference standards to both industry and the regulating agencies.

8.3 MVMA calibrates the LC for each vehicle test and runs the quality control sample for each test. This frequency of a calibration may not be necessary, however, we will continue to perform this method in the future. MVMA recommends calibrating the instrument at least once per 24 hour period.

8.4 Quality control vials are run for each test by ERC members. Absolute acceptance levels are required for formaldehyde and benzaldehyde. The quality control concentration levels are 1.00 ppm, the readings must be within 0.85 and 1.15 ppm.

8.5 Area counts should be plotted instead of concentration so instrument conditions can be observed. The statical process control (SPC) criteria as stated will penalize LCs that had very good precision compared to LCs that have poor precision. The ERC committee should develop uniform QC procedures.

8.8 With a good calibration and quality control procedures, the duplicate test run is not necessary. All the duplicate run provides is more work and a reduction in test capability. MVMA recommends that this step be eliminated.

8.9 MVMA does not believe that a linearity check is necessary every six months. This check should be performed when a new instrument is put into operation or when major instrument repairs are conducted. The correlation coefficient may not be sufficient for a linearity check.

8.10 MVMA does not believe that a limit of detection determination is necessary. This check could be performed for all new instruments or when major changes are made to the LC technique. MVMA recommends that the use of the level of detection number not be used for any quality control criteria. Other methods are just as good.

MVMA COMMENTS ON CARB'S PROPOSED DRAFT METHOD 1005

"DETERMINATION OF OXYGENATED COMPOUNDS IN AUTOMOTIVE EXHAUST BY GAS CHROMATOGRAPHY"

This procedure is burdensome and unnecessary. Methyl tertiary-butylether (MTBE) and ethyl tertiary-butyl ether (ETBE) can be measured with the mid-range (C_6 to C_{12}) GC method. Proper identification can be and has been obtained with the mid-range technique. A separate response factor could be developed and used for MTBE and ETBE with the mid-range method. However, MVMA does not believe that these response factors need to be used. The overall impact of the response factor would be minimal. Also the GC mass correlation to the site FID correlation would be affected. MVMA recommends that this method be dropped.

MVMA COMMENTS ON THE CARB'S PROPOSED

"DETERMINATION OF NMOG MASS EMISSIONS"

Speciated Hydrocarbon Mass Emission Calculation

2.1 Mass should be determined by the site FID or GC depending on the type of vehicle tested (refer to the chart in Step 3 in the California NMOG Test Procedures - A. General Applicability and Requirements).

Recommend ethers be determined by speciated hydrocarbon mass emission calculations.

4.1 The equations do not account for sample volumes removed and not returned to the CVS flow stream.

HC density calculation based on benzene. The HC mass has always been based on propane mass.

Alcohol Mass Emission Calculation

2.0 The use of the correction for blank impinger levels is omitted.

4.0 CARB uses a volume fraction method of measurement rather than mass concentration. The end result is the same, however, volume fraction is not a conventional method.

Carbonyl Mass Emission Calculation

1.1 The use of the correction for blank impinger levels is omitted.

4.1 CARB converts from a mass concentration to ppmC then to mass. Question why not convert directly from mass concentration to mass.

Dilution Factor Calculation

1.1.1 The x, y, and z's used to calculate the dilution factor should be obtained from measured fuel properties as opposed to theoretical.

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93-1-3

XC: Brd Mbrs
JS TAC
JB MSD
JD Legal

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January 4, 1993

Mr. K. D. Drachand
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Ford Mini-FAX Transmittal Date 7-JAN 93 Pages 7
To Kitty Howard From Ted Jensen
Bldg. Rm. Bldg. Rm.
Telephone Telephone 313-322-4598
Fax No. 916-327-8217 Fax No.
11/90 1564

Dear Mr. Drachand:

RE: Proposed Non-Methane Organic Gas Test Procedures

We thank you and your staff for providing the extensive comments in your letter of December 7, 1992, where the CARB responds to MVMA's (now AAMA) comments on the CARB NMOG and speciation procedures. The continuing discussion of unresolved issues has been passed from the AAMA group to the GC Method Subcommittee of the Low Level Emissions Measurement Group of the Environmental Research Consortium (now part of the AIGER CRADA).

The GC Method committee welcomes the opportunity to continue discussion of the NMOG and speciation procedures and recognizes the flexibility that you and your staff have demonstrated and the changes that the CARB has already included in the proposed regulations. It is our feeling that there are still areas where a mutually agreed resolution can be achieved and that there may yet remain some basic philosophy differences that will only be resolved by demonstration of equivalence.

Recent discussion with members of your staff have clarified the procedure for application for your determination of equivalence of results and we plan to utilize this procedure where necessary.

The domestic automotive industry has spent more than three years and substantial resources carefully developing emissions characterization methods that have been peer reviewed extensively and provide high quality data in a production environment. The extension of measurement capabilities at our facilities to speciate emissions has required very significant investment and it is our hope that no substantial hardware or facilities changes will become necessary to comply with methodology as specified in California or Federal regulations.

We recognize the "method format" and equivalence approach used by the CARB for the NMOG procedures and acknowledge that it can provide flexibility to the manufacturers, however, concern has been expressed within our companies that the companion to this flexibility is uncertainty. The penalty and risk to our companies of this uncertainty must be kept as near zero as possible and is the motivation for our continued efforts to reach an understanding with you of general philosophy and the method details.

In this communication (see attachment 1) we will provide some additional comments on the remaining issues, 1) Benzene Reference, 2) Butane Crossover, 3) FID versus GC for HC Mass Determination, 4) Quality Control, and 5)Additional Comments.

We appreciate the CARB staff's flexibility on technical issues over the last year. The purpose of this letter is to focus on our major concerns and to offer suggestions for ways to resolve these issues. Thank you for the efforts that have been put forth on these complex issues. A possible meeting in early January was suggested. If you find our suggestions acceptable and incorporate them into the proposed methods a meeting would not be necessary. We look forward to the opportunity to review your final method documents and where needed working with the CARB staff to establish equivalence.

Sincerely,

Trescott E. Jensen, Chairman
GC Methods Subcommittee
AIGER CRADA

Ford Research Laboratory
Analytical Sciences Department
(313) 322-4598

Attachments
cc: Steve Albu - CARB, El Monte
Angelica Cook - Navistar
Michael Epstein - ERC
Kitty Howard - CARB, Sacramento
Henry Mano - CARB, El Monte
Jeff Loo - General Motors
Carl Ryan - EPA
Jim Shikiya - CARB, El Monte
Ann Schlenker - Chrysler

ATTACHMENT 1

COMMENTS ON CARB NMOG PROCEDURES

1. Benzene Reference The Federal Procedure for the measurement of hydrocarbon is based on propane. Departure from this standard is a very significant change in the accepted method for determining hydrocarbons in emissions world-wide.

The FID response factor (RF) of many hydrocarbons differ from the average response of a paraffin (i.e. propane). It is not practical however to calibrate more than 100 compounds individually. To simplify this process, a single compound has been selected by the industry to best represent the total group of compounds. The industry has also selected propane since it is the bench FID calibration compound and allows us to validate vehicle test data by using rigorous bag-by-bag recovery criteria.

The CARB has selected benzene for the mid-range compounds since in Method 1003 you are not able to use propane and with the expectation that benzene is more representative of the compounds identified by Method 1003. Early in the Auto/Oil program, the use of propane and benzene as GC calibration compounds was discussed. Benzene would be used only for the aromatic compounds. This approach was rejected for several reasons. The bench FID was calibrated with propane. All emissions data had been collected using propane as the calibration compound. Another calibration compound increased complexity without added information. EPA was using propane as the standard for their speciation. An additional reason is given in the following discussion.

When determining the Specific Reactivity (SR) and RAF of a vehicle/fuel combination, the critical issue is the identification of the species present and their concentration relative to each other. The mass of the individual species are included in both the numerator and denominator of the SR calculation as shown below:

Where HCn is the non-oxygenated or oxygenated hydrocarbon

and MIRn is the Carter Maximum Incremental Reactivity

$$\text{SR (Gram ozone/Gram NMOG)} = \frac{\text{Summation (HCn * MIRn)}}{\text{Summation (HCn)}}$$

When another compound is used to calibrate the single GC FID used for the analysis, a scalar (G) is introduced as a result of the difference in the response factors of the two compounds and is included as a "gain" term in the equation as follows:

G = Carbon Response (Non-Propane) / Carbon Response (Propane)

$$SR\ (\text{Gram ozone/Gram NMOG}) = \frac{\text{Summation } (G * HCn * MIRn)}{\text{Summation } (G * HCn)}$$

$$= \frac{G * \text{Summation } (HCn * MIRn)}{G * \text{Summation } (HCn)}$$

$$= \frac{\text{Summation } (HCn * MIRn)}{\text{Summation } (HCn)}$$

As shown above, when a single GC method is used to determine the specific reaactivity, the calibration gas used has no effect since the gain term cancels out of the equation.

When more than one method is used to determine the concentration of the hydrocarbon species, the calibration compound does become important. Where propane has a gain term P and benzene has a gain term B the equation becomes:

$$SR\ (\text{g ozone/g NMOG}) = \frac{\text{Sum}(P * HCn * MIRn + B * HCn * MIRn)}{\text{Sum } (P * HCn + B * HCn)}$$

The gain terms P and B do not cancel, they become bias terms. Therefore, it would be difficult to show equivalence of results for the CARB and AAMA methods as presently used.

This is demonstrated in the following simplified example of a three component emission that contains ethylene, toluene, and 3-methyl propane where P=1 (low end) and B=1.1 (mid-range):

	Using Propane			Using Benzene		
Compound	NMOG (g/mi)	MIR (gO3/gVOC)	Reactivity (gO3/mi)	Gain	NMOG (g/mi)	Reactivity (gO3/mi)
Ethylene	0.1	7	0.7	1.0	0.1	0.7
Toluene	0.1	3	0.3	1.1	0.11	0.33
3M-Propane	0.1	1	0.1	1.1	0.11	0.11
	0.3		1.1		0.32	1.14

$$SR = \frac{1.1}{0.3} = 3.67 \qquad SR = \frac{1.14}{0.32} = 3.56$$

06457

This simple example demonstrates that the use of benzene as a calibration standard will not increase the reported emissions reactivity. The reactivity in this example has been reduced by about 3%. As shown by this brief example, increasing the response of the mid-range GC (by using benzene as the calibration gas) the specific reactivity has been decreased. We do not believe that this reduction in specific reactivity has any technical merit. We strongly recommend that propane remain the calibration standard.

2. Butane Crossover Samples of ambient air and vehicles emissions for any fuel tend to always contain methane and butane. This is not the case with hexane, the crossover compound chosen by CARB. In Michigan, where the automotive industry conducts their testing, hexane is below the limit of detection (LOD) in ambient air. Butane was selected as the crossover compound by the industry during development of the Auto/Oil Phase II methods because the concentration normally found in all samples, including ambient air, are large enough to compare two large numbers with respect to the method LOD. This has increased our confidence in the accuracy of the methods.

   We suggest in the CARB Methods 1002 and 1003 the designation of hexane as the crossover compound be expanded to include butane and could read . . "For each sample, hexane (or butane) shall be measured by both ..".

3. FID Versus GC for HC Mass Determination The determination of NMHC mass emissions and the non-oxygenated portion of NMOG mass emissions should be from the test site FID. The determination of specific reactivity should be from the GC and the HPLC analysis.

   We agree, at the present time, that the best way to determine the hydrocarbon (NMHC and NMOG) in compressed natural gas vehicle emissions is by GC.

4. Quality Control Quality control always comes at the cost of productivity. Having this in mind, one develops a QC/QA program that will provide data of the quality required at some desired confidence level while retaining an acceptable level of productivity.

   From an overall test system and quality control perspective, comparison of the bench FID and the GC hydrocarbon values is important. From the previous discussion of the use of benzene as a calibration standard, it is evident that the use of propane is preferred. Our confidence in the results is increased when we know that recovery of the test hydrocarbon approaches 100%. This concept is an integral part of our quality control program.

We feel that the GC linearity check and LOD check every six months are of limited value, but we will incorporate this into our program.

We agree to re-analyze alcohol samples.

Re-read of GC hydrocarbon determinations would decrease our productivity by 10% which is significant in our operations. This requirement to re-read 1 out of 10 samples is inconsistent with all other routine emissions regulations. No known precedent exist in federal, state, or foreign regulations. Variability in speciation can best be detected with a site FID to GC cross check. We QC every bag on every test using independent instrumentation (GC vs FID). In addition, variability in speciation analysis is already covered by the CARB requirement that multiple speciation tests on multiple vehicles must meet a 95% upper confidence bound.

We suggest that an alternative be inserted into Methods 1002 and 1003 that would allow use of GC vs FID validation for every bag in place of the re-read requirement. This utilizes existing information.

5. Additional Comments

Cryotrapping: We do not believe that cryotrapping hardware will provide improved data quality. The additional cost and difficulty of use are prohibitive and a substantial burden to the manufacturers. We will address this as an equivalency issue.

Re-read of Aldehydes: Equivalency of results have already been shown by the CRC round-robin for determination of aldehydes. A re-read for aldehyde determination results only in a loss of productivity.

Sample Waiting Time: You have proposed a 4 hour sample waiting time. We attempt to complete analysis of each sample within 4 hours. There are circumstances where the 4 hours can be exceeded and the data quality has not been compromised. It has been our experience that 12 hours is a good maximum waiting time.

Use of CAS Numbers: We recommend that you use CAS numbers in all documentation along with chemical compound names. This will avoid confusion where variations in nomenclature occur.

Species Identified: Several new compounds have been added to the CARB list. Most of these compounds have been analyzed by the AAMA labs and have been determined to 1) co-elute with other compounds or 2) not be present to any great degree in emissions or fuels. We suggest that all of these compounds can be deleted from the CARB list without any loss of mass identification. New compounds in the CARB list with comments are:

Ethyl Cyclopentane - Co-elutes with 2,5-DM-Hexane, out of order in CARB's list (RI=734 and neighbor in list RI=670)

1,1-DM-Cyclopentane - Co-elutes with cyclohexene

5-Ethyl Cyclopentene - Not in fuel to greater than 0.1%

4M-Octane - Co-elutes with 2M-Octane

2,2,4-TM-Heptane - Co-elutes with n-Nonane

Ethyl Methyl Cyclohexane (isomer(s)?) - 1-Ethyl-1-Methyl Cyclohexane not in fuels to greater than 0.1%

1M-4-isobutyl Benzene - Error in original A/O library, not in fuels

NISSAN RESEARCH & DEVELOPMENT, INC.

18455 South Figueroa St.
Carson, California 90248-4504
Mailing Address:
P.O. Box 47028
Gardena, California 90247-7638
Telephone: (213) 532-3111

January 14, 1993

Mr. K. D. Drachand, Chief
Mobile Source Division
State of California
Air Resources Board
9528 Telstar Avenue
El Monte, CA 91731

SUBJECT: LEV PROPOSED AMENDMENTS

Dear Mr. Drachand:

Attached are Nissan's comments on the ARB proposed amendments to the LEV regulations as described in the mail-out dated September 25, 1992 and in recent draft changes.

These comments are being submitted by Nissan Research & Development, Inc., on behalf of Nissan Motor Company, Ltd., of Tokyo, Japan.

If there are any questions regarding the attached comments, please contact me at (310) 719-5821, or Mr. A. Hashimoto at (310) 769-2081.

Sincerely,

John H. Schutz
Director, Powertrain & Emissions
General Manager, Los Angeles Office

Attachment

Nissan's Comments Concerning the Proposed Amendments to the LEV Regulations

Nissan appreciates this opportunity to comment on the CARB's proposal to amend the LEV standards based on the Board's biennial review of those standards. We have serious concerns about one portion of the proposal; the measurement procedure for non-methane organic gasses. We will be directing our comments to this issue.

NMOG Measurement Procedure

(1) The Limits of Detection for the Chemical Speciation

Nissan believes that lowering the limit of detection (LOD) for either C_2 - C_5 or C_6 - C_{12} hydrocarbons will have little effect on the final NMOG measurements, and subsequently will do almost nothing to improve ambient ozone air quality. Therefore, rather than introduce unnecessary confusion into the regulations, Nissan believes that the CARB should set a single LOD for C_2 - C_5 and C_6 - C_{12} hydrocarbons of 20 ppb.

(2) Ether Analysis

Nissan's tests have shown that ether's contribution to ozone formulation potential (SR) does not exceed 0.2%. However, in order to perform ether analysis, we must add new GC-PID to our emission testing equipment. We believe that this is an unreasonable burden given the exceedingly small effect that ether has on ozone formulation potential (SR).

(3) Carbonyl Measurement

The CARB changed the target compounds from 5 to 8 species. But Nissan believes that it would be sufficient to measure only 5 species, such as Formaldehyde, Acetaldehyde, Acrolein, Propionaldehyde and Acetone. Our tests have shown that the amounts of the other 3 species, Butylaldehyde, Hexaldehyde and Benzaldehyde, are small and that they have a small effect on ambient ozone air quality. Furthermore, limiting measurement requirements to C_1 through C_5 carbonyls will shorten measurement time and allow for more efficient use of manufacturers' R&D resources.

#101

Testimony of

Paul Wuebben

Clean Fuels Officer

South Coast Air Quality Management District

to the

California Air Resources Board

Hearing on Low-Emission Vehicle Certification Requirement

Sacramento, CA

January 14, 1993

Good Morning Madam Chairwoman and members of the Board. I am Paul Wuebben, Clean Fuels Officer for the South Coast Air Quality Management District. I am here on behalf of the District's Executive Officer to support the adoption of the Reactivity Adjustment Factors and other certification requirements, as proposed by your staff, including those for hybrid electric vehicles.

The District appreciates the ARB's previous efforts in implementing your landmark Low-Emission Vehicle/Clean Fuel (LEV/CF) Program. The LEV/CF Program is critical to the success of our Air Quality Management Plan and is a testament to the commitment of your staff and this Board to improving air quality in California. There are several issues I would like to briefly address. The proposed Reactivity Adjustment Factors for Phase II gasoline were developed through a rigorous peer review process and reflect the most up-to-date scientific understanding of ambient air photochemistry available. The District therefore strongly supports ARB's proposed RAF regulations. I would also like to compliment the staff and their consultants for the excellent job that they have performed in an extremely difficult and complex area. They have communicated with the scientific and technological community, other agencies, and the affected industries. In fact, they have literally sought help worldwide to reach the most technically defensible conclusions. I would also like to single out the Auto/Oil program participants for their extensive work in providing an excellent continuing data base that will be extremely helpful in the upcoming years.

The District agrees with ARB's continued use of maximum incremental reactivities (MIR) as the basis for the RAFs. The MIR approach is justified from the standpoint that it models areas in which hydrocarbon controls are of greatest benefit, namely, urban areas where emissions are generated and population density is greatest, such as Los Angeles and its surrounding metropolitan areas. Furthermore, coupled with ongoing stringent control of NO_x emissions, the MIR approach continues the successfully demonstrated, basin-wide ozone control strategies jointly pursued by your Board and the District.

The District also supports the proposed Specific Reactivity of Base Gasoline for Low-Emission Vehicles (LEVs) and Ultra-Low Emission Vehicles (ULEVs). These baseline reactivity levels are needed to allow auto manufacturers to expedite the development of LEV and ULEV technology such as electrically heated catalysts and alternative fuels. Without these baseline factors, manufacturers would be inhibited from seriously pursuing non-gasoline options for complying with the increasingly stringent LEV standards. While more data will inevitably be developed to refine these baseline factors, your staff have proposed reasonable initial baseline values. We also believe that your staff have been appropriately conservative by establishing a conservative baseline figure for ULEV vehicles pending the acquisition of more data.

The latest air quality modeling performed for ARB by Carnegie Mellon University also reinforces our confidence in the proposed RAFs. Your staff has been very diligent in overseeing this photochemical airshed modeling analysis. The best emissions inventories available have been used, which incorporate the latest data available from the Auto/Oil Study, Chevron Research, and separate ARB testing. Furthermore, two separate ozone episodes were used which confirm the stability of the proposed RAFs. This analysis has also been rigorous in assessing the proposed RAFs based on six different ozone statistics which reflect the wide range of chronic and acute public health issues associated with ozone exposure.

The proposed RAFs and baseline factors being considered today are a logical step in the progression of our scientific understanding of emissions reactivity. In order to continue the progress in refining the data base for Dr. Carter's MIR scale, the District is cosponsoring additional environmental chamber experiments through the Statewide Air Pollution Research Center. This effort is also being supported by the Coordinating Research Council and the ARB, demonstrating the cooperative process being used to refine this critical data base.

The testimony of the District's Chief Scientist, Dr. Alan C. Lloyd, at the original RAF adoption hearing in November of 1991 is still germane today:

> "On the basis of my experience in the science and technology of ozone control, I recommend that you not delay at this stage pending the acquisition of more data. For example, having been involved with chemical mechanism development for nearly two decades, I believe that even if we delay for an additional several years, we will still be faced with uncertainties. Each time we believe that all the science is understood, we are constantly

surprised. On the other hand, I think that we now understand the system sufficiently to avoid making serious errors."

The District therefore finds the proposed RAFs to be technically sound, timely, and well documented.

I would also like to address several important aspects of the proposed electric vehicle test procedures. The District concurs strongly with your desire to maximize the number of pure electric vehicles on the road. At the same time, we believe it is essential that you provide sufficient flexibility to stimulate the development of hybrid electric vehicles (HEVs). Your staff have proposed some very constructive changes to how HEVs are certified. I would like to take this opportunity to explain why we support these modifications.

As your staff notes, from an air quality perspective, the most desirable HEV will be one with the maximum battery-only range, relying on a small auxiliary power unit (APU) only to recharge the battery and possibly supply marginal peak power. However, in the early years of HEV commercialization, it is critical that we allow for maximum technological innovation in the design of HEVs. The proposed use of the Federal Test Procedure (FTP) on the APU-dependent driving cycle will help provide incentives for auto companies to build the cleanest auxiliary engines or turbines possible. At the same time, the existing incentives for greater battery-only range are very appropriate for HEVs.

The Board may also want to consider additional credits for manufacturers who commit to commercializing HEVs prior to 1998. For example, the NMOG credits for all-electric range could be increased by 50% if a manufacturer commits to offer 2000 HEVs annually starting in 1995. This appears to be a realistic target modeled on the 2000 flexible-fuel vehicles introduced by each of the three U.S. auto manufacturers for the 1993 model year.

The District is also pleased that the staff is recommending a shortened mileage accumulation schedule for HEV certification. The evaporative emissions from un-purged hydrocarbon cannisters clearly need to be subject to durability testing; however, given the unique aspects of electric vehicles, a shorter durability schedule is appropriate.

Also, the District agrees with your staff's recommendation that the test procedures should not be precisely patterned to the three-day Federal Test Procedure (FTP) test protocol. A single battery-only range test appears very reasonable, in contrast to the more elaborate draft procedure developed by the Society of Automotive Engineers (SAE). Also, we believe it is very constructive to provide an incentive for efficient EV air-conditioning, and the staff's proposed procedure accomplishes this important energy conservation objective.

The District therefore urges the Board to adopt the proposed Reactivity Adjustment Factors and other certification requirements as proposed by your staff. Thank you for this opportunity. I would be happy to answer any questions you may have.

PW:fp

93-1-3

JS TAC
JD MSD
JB Legal

STATE OF CALIFORNIA
AIR RESOURCES BOARD
RECEIVED 1-13-93
BY BOARD SECRETARY

TOYOTA COMMENTS TO THE CALIFORNIA AIR RESOURCES BOARD REGARDING AMENDMENTS TO CALIFORNIA REGULATIONS FOR CERTIFYING LOW-EMISSION VEHICLES

JANUARY 14, 1993

In September, 1990, CARB adopted LEV/CF regulations. Toyota is actively persuing the development of LEVs to comply with this regulation. Two years have passed since adoption, and it is now time to review this regulation. However, the regulation is so strict that it is still difficult for Toyota to comply with the regulations in their entirety. The following are general comments regarding this regulation and individual comments regarding specific items.

I. General Comments

1. TLEV

We have succeeded in developing TLEVs for limited applications and will proceed with their timely introduction. We appreciate CARB's effort to adopt regulations clarifying test fuels, NMOG measurement methods, and RAF determination.

2. LEV

We are continuing the evaluation of EHC technology (which is a key component of an LEV), but overall durability is still the biggest technical problem. Moreover, large consumption of electrical power by the EHC continues to be a problem. EHC technology has not yet reached a satisfactory level of development to forecast production. In addition, large cost increases associated with this technology continue to be a major concern. It is not proper to assess technical feasibility based upon experimental testing by CARB, or by development testing performed by potential EHC manufacturers.

3. ZEV

A ZEV requires a totally different powertrain than is the convention. Toyota has formed a new organization dedicated to developing EVs. Battery range/performance limitations continue to be the most difficult problem in EV development. Judging from the current situation, the lead-acid battery is the only candidate which appears to be feasible for the 98 MY ZEV regulations. However, ZEV performance/range is extremely poor when compared to gasoline vehicles in "real world" usage, and the cost is expected to be several times higher than gasoline vehicles. Therefore, the feasible, economical mass production of EVs is highly doubtful.

Toyota would like to reemphasize our recommendation that the California Air Resources Board take a "step-by-step" approach to the introduction of ZEVs:

lst step CARB move to establish a working group in which SCAQMD, EPA, auto manufacturers and electric utilities are full participants who will determine infrastructure and standardization of cable, connector, and battery charger. By doing this, it will be possible to uncover the problems that exist in introduction of EVs.
(e.g. battery charging method, battery control technology, development of EVs application areas)

2nd step When vehicle specifications are fully developed, vehicle manufacturers design, make prototype vehicles (with reasonable lead time) and provide them for the program. Parallel development of supporting infrastructure (e.g. recharging stations, battery recycling)

3rd step When the vehicles become commercially feasible, large scale fleet demonstration programs should be implemented.

4th step The fleet data should be evaluated, current ZEV implementation requirements should be modified to reflect market needs, and vehicles can be manufactured.

The ultimate success of EV technology will be determined by the customer. EVs introduced before they are able to meet the needs of the customer could set back EV development by decades and may ultimately be counter productive to the goal of improving air quality in California.

II. Specific Issues

1. RAF

We understand that the concept of the LEV regulation is to reduce total ozone reactivity from baseline level ('90MY) vehicles. CARB has proposed RAFs for TLEVs and LEVs fueled with Phase 2 clean gasoline. The baseline OFP (Ozone Forming Potential: ozone/g NMOG), is determined based upon conventional fuel (RF-A) and emission control systems for each category (TLEV, LEV). In this way, we feel the effect of manufacturer's technical improvements to emission control systems (conventional vehicles → TLEV → LEV) are not accurately reflected. Oil companies' and auto manufacturers' efforts should be evaluated equally. We believe CARB should revise the regulations so that manufacturers' efforts to improve exhaust emission control systems are fairly reflected. The baseline OFP for all categories should be determined based on 90 MY conventional system (NMHC = 0.39 g/mile level vehicle) and conventional fuel (RF-A).

Additionally, the equation defining RAF should be used to evaluate effects on emissions by both fuel and emission control systems. Therefore CARB should return to the original equation to define RAF:

Original Definition

$$RAF = \frac{\text{Ozone / gram of clean fuel vehicle emissions}}{\text{Ozone / gram of conventional gasoline vehicle emissions}}$$

Newly Proposed

$$RAF = \frac{\text{specific reactivity of emissions with fuel being evaluated}}{\text{baseline specific reactivity}}$$

CARB claims that to use a high baseline OFP which credits the improvement of emission control systems, lessens the effect of the regulation. However, a combination of "High OFP and Low NMOG" and "Low OFP and High NMOG" should be regarded as having the same effect on air quality, thus the choice between the two should be left to each manufacturer.

Our long-term recommendation is that baseline OFP be determined by 90 MY vehicles and RF-A; however, we propose that CARB tentatively use the TLEV OFP (=3.42) as a common baseline OFP for all categories (TLEV, LEV, ULEV). We suggest that CARB fully reexamines its determination of baseline OFP based upon the following recommendations:

- Adopt sales volume weighted average value with as many representative vehicles as possible.
- Gather the emission/OFP data from several labs (mfr.) whose correlation is confirmed by cross check.

In each category proposed, it does not seem that CARB considered "emission control system/vehicle selection which reflects the in-use market" and/or "test vehicle/system condition including mileage accumulation", thus weakening the technical justification for this proposal. Toyota believes the baseline should have sufficient scientific foundation, and it should be determined methodically.

When determining TLEV/LEV RAF, we understand that CARB used data from only 17 vehicles that were part of a larger group of 68 vehicles. CARB must clarify the apparent selective use of data to justify their conclusions.

Speaking further to the proposal for Phase 2 gasoline OFP for LEVs, our best engineering judgement does not think the appropriate value is 3.16 for reasons as follows:

(1) Vehicle Selection

- The denominator of the LEV RAF is determined by RF-A (conventional gasoline) and an LEV level vehicle equipped with EHC. On the other hand, the numerator of the LEV RAF is determined by Phase 2 (reformulated gasoline) and LEV level vehicles equipped with EHC and without EHC to represent the expected market. There are inconsistencies between the selection process for the denominator and the numerator. Furthermore, this rationale has no technical basis.
- The amount of LEV data is smaller than the amount of TLEV data. It is difficult to assume that this data will accurately reflect the market. (See Fig. 1)
- Any vehicle which complied with LEV standards by chance or as a result of being a TLEV with a compliance margin should be disqualified and not be used to determine RAF.

(2) Measurement reliability

- Phase 2 gasoline OFP is very different with the Escort (tested by CARB) and the Escort (tested by Ford) although both vehicles have the same emission control system. It is unclear whether the vehicle and/or measurement is the cause of this. (See Fig. 2)
- The data for LEV level vehicles using Phase 2 gasoline shows much variation. We suppose that the vehicle and/or the measurement may be the cause for this data variation. However, this variation makes us feel uneasy about the reliability of the data.

Vehicle / Fuel	LEV			
	w/EHC	w/o EHC		TLEV
RF-A	6 vehicles	NA		9 vehicles
Phase 2	5 vehicles	4 vehicles		12 vehicles

Fig. 1

Vehicle (Lab)	Phase 2 OFP
Escort (ARB)	Ave.(n=4) 3.446
Escort (Ford)	Ave.(n=5) 3.038

Fig. 2

In summary, as a minimum requirement, we think that reexamiantion of the data acquisition methodology is needed. Also, it is important to obtain a reliable OFP by improving measurement reliability.

Furthermore, we believe that the RAF value proposed at this time should be a tentative common value for all LEV categories, and the opportunity to revise/correct this tentative value should be scheduled. In order to obtain an accurate RAF value, we offer our full cooperation.

2. NMOG

NMOG measuring requirements are proposed in Mail-Out #92-42 and the Staff Report, but there are still many questions and obscure references that need to be clarified without delay. Many questions and references are of a highly technical nature. Therefore, we are submitting our comments on these matters as an attachment. The following are general comments on the proposed NMOG measurement requirements:

(1) In NMOG measuring method (Draft Method 1001-1005), many questions are raised and obscure references are cited. We recommend that CARB hold further workshops where their technical specialists responsible for measurement/analysis answer questions of manufacturers about details of the proposed measurement/analysis method.

We are now making an effort to comply with these requirements, as the values CARB measured are the standard values. But we believe the standard values are still unclear from a purely technical measurement viewpoint. Therefore, CARB and manufacturers should exert their best effort to develop a measurement method which provides more the best possible values.

(2) In CARB's proposal, additional analysis is required for fuels containing ethers (Phase 2 reformulated gasoline). We recommend the deletion "Ethers by GC-TID" from NMOG mass emission determination for the following reasons:

- Although lower than the other HCs, FID has sensitivity to MTBE. We believe that the result of "NMHC by FID" contains a significant ratio of ether.
- Existence ratio of Ether (MTBE) in exhaust emissions is only a few percent of total NMOG.
- It is best not to adopt an undeveloped analytical method in order to pursue theoretical accuracy for the usual certification process.

ATTACHMENT

--NMOG Measurement--

1. Use of "NMHC by FID(=THC-rCH4)" and "NMHC by GC(=Σ Speciation NMHC)"
   Toyota believes it is appropriate to use FID for NMOG mass emission measurement (for certification). We recommend that the use of GC should be clearly identified as "only for OFP determination."

2. Comment and Confirmation for Each Draft Method

   (1) Accuracy of each measuring method
   LOD criteria in Method 1002 (5.0 ppbC) is much different from that in Method 1003 (20ppbC). Toyota does not believe it is necessary to set the criteria in Method 1002 (5.0ppbC) at more stringent a level than for Method 1003(20ppbC). The same limit of the apparatus might be necessary.

   (2) Request and proposal

   - It takes three hours a day for Quality Control even if analysis cycle time is set at 45 min. (Method 1002).
     Toyota recommends that "Blank Run" and "Duplicate Run" be allowed to be conducted at least once per week.
   - In Method 1002 and Method 1003 the maximum value in actual measurement is selected as the LOD criteria.
     If the following two items are not considered, we recommend that CARB should reconsider the criteria.
     - LOD measuring repeatability
     - Data variation among several kinds of GC and the same type of plural column
   - Determination of Carbonyls (Draft Method 1004)

   -- Details of Impinger method
   If the purpose of DNPH recrystallization frequency standardization is to remove impurities, we prefer "HPLC Blank Run" or "Standardization of impurity allowable range" for that purpose.
   Also, hydrochloric acid and perchloric acid should be allowed as the oxidation reagent.

   -- Details of Cartridge method
   DNPH impregnation volume, acetonitrile flow rate, etc. should be clearly established.

3. Questions Needing Clarification

(1) LOD (Method 1002, 1003)

- Does "LOD" in Duplicate Run criteria "x(average measurement for Duplicate Run)/LOD" mean "each specific compound LOD in actual measurement" or "the maximum LOD in actual measurement" or "LOD criteria"?

(2) The range of carbon number measured as carbonyls in NMOG mass emission calculation

- Hexaldehyde (carbon number 6) and Benzaldehyde (carbon number 7) are included in target carbonyls but we understand that carbonyls whose carbon number is 5 or less only are included in NMOG definition.
  We believe that we have to calculate only from C1 to C5 for carbonyls. Is this correct?
- We request to delete Hexaldehyde and Benzaldehyde from the target carbonyl standard because NMOG definition includes carbon nubmer 5 or less only for carbonyl. If target carbonyl carbon number is changed for OFP, it should be clearly identified for both NMOG certification and RAF determination.

4. Others

(1) 29 compounds for Method 1002 and 130 compounds for Method 1003 are an extraordinary number for the target HC.
We believe that the target HC required for reporting should be reduced to as few as possible.

(2) For diesel-fueled vehicles, NMHC measurement by GC is requested for certification NMOG measurement.

- In this case, we believe that "diesel fuel" means light oil, is it correct? And for alcohol diesel-fuel vehicle, we believe that it complies with Method 1001 (Determination of Alcohol).
- We recommend that mass emission measurement for diesel-fuel should be conducted with "NMHC by heated FID" as well as gasoline and alcohol. We consider that "NMHC by GC" is very difficult for light oil which has carbon number 24 compounds.
  The reason why "NMHC measurement by GC" is adopted for diesel fuel should be identified.

VOLVO

STATE OF CALIFORNIA
AIR RESOURCES BOARD
RECEIVED 11-9-92
BY BOARD SECRETARY

Volvo Cars of North America, Inc.
Rockleigh, New Jersey

12/10/92
92-19-2

XC: Bd Mbr
JS TAC
JD MSD
JB Legal

November 3, 1992

Board Secretary
California Air Resources Board
P.O. Box 2815
Sacramento, California 95812

RE: CARB Hearing on November 12-13 Concerning LEV Review

Dear Sir/Madam:

Enclosed are ten copies of comments representing the position of the Volvo Car Corporation in Gothenburg, Sweden, and Volvo Cars of North America, Inc. in Rockleigh, New Jersey.

We are very pleased that the Board is considering this very important subject matter again, and we support the proposed changes placed before the Board today. In particular, we support the extra emission credits for hybrids with extended ranges. We believe this is a very important first step in recognition of the environmental potential of hybrids. We also believe other steps should follow.

On June 5, 1992, Volvo submitted its position to the CARB (re: series hybrids and ZEVs). That is, series hybrids should be considered ZEVs. The reasons presented then are still valid, as well as the ones which follow.

We are now even more convinced than before that the pure ZEV vehicle will face several practical problems and may meet a very low public acceptance. Drawbacks, such as the risk for no power, long charging periods, etc. are well known. You can be sure we are actively looking into these areas.

With a series connected hybrid, it is not possible to start the engine until the batteries are low. Since the engine is only connected to a generator, it runs with an ideal constant speed and can be optimized for fuel economy and emissions. For this reason, the catalyst may be placed close to the engine. Also, catalyst durability will be improved based on the fact that engine running time will be much lower than that of the vehicle because the most common way of operating the vehicle will be in the electric mode.

In conclusion, we believe that a series hybrid can be built with an engine which runs at a constant speed at a ULEV level and a very low usage time for the engine compared to the total vehicle operation. Emissions for this system will be very close to zero and we believe this hybrid system will achieve improved customer acceptance compared to the pure ZEV. This is especially true for a car in the family car market which Volvo is in. Also, it is important to mention that most of the energy to the vehicle comes from electric power supplies.

06476

Mailing Address
Volvo Drive
Rockleigh, NJ 07647-0913

Telephone
201-768-7300

In summary, we believe that this type of series hybrid should be classified as a ZEV. Our concept hybrid vehicle, Volvo ECC, which was presented at the 1992 Paris Auto Show, will be shown in Los Angeles, California in December, 1992, and January, 1993. A description of the Volvo ECC is included with this letter. We invite the Board to come and experience this vehicle when it is in California.

If you wish additional information on the foregoing, please let me know.

DRIVE SAFELY!

VOLVO CARS OF NORTH AMERICA, INC.
Product and Technical Support

William Shapiro

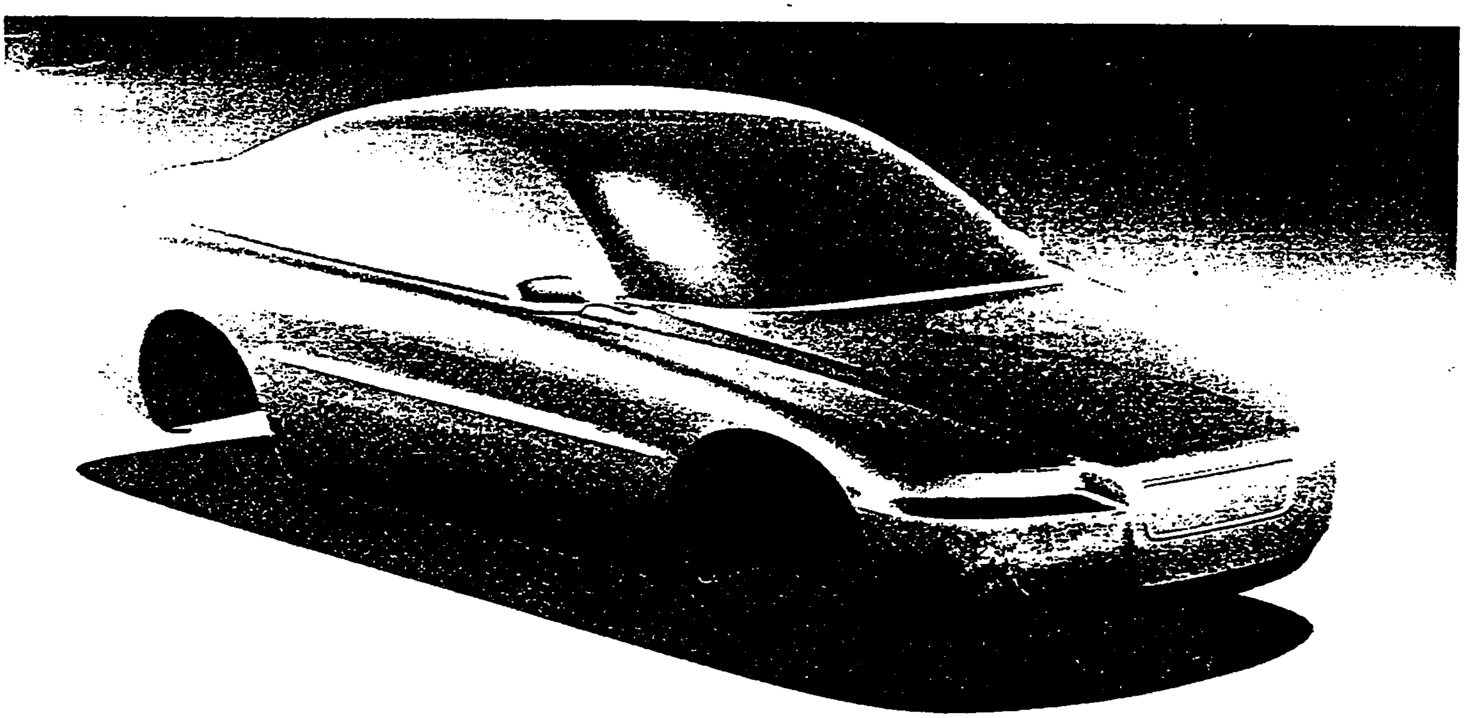
William Shapiro, P.E.
Manager, Regulations and Compliance

WS:esw

enclosure

Volvo Car Corporation

Volvo ECC
A Volvo Environmental
Concept Car



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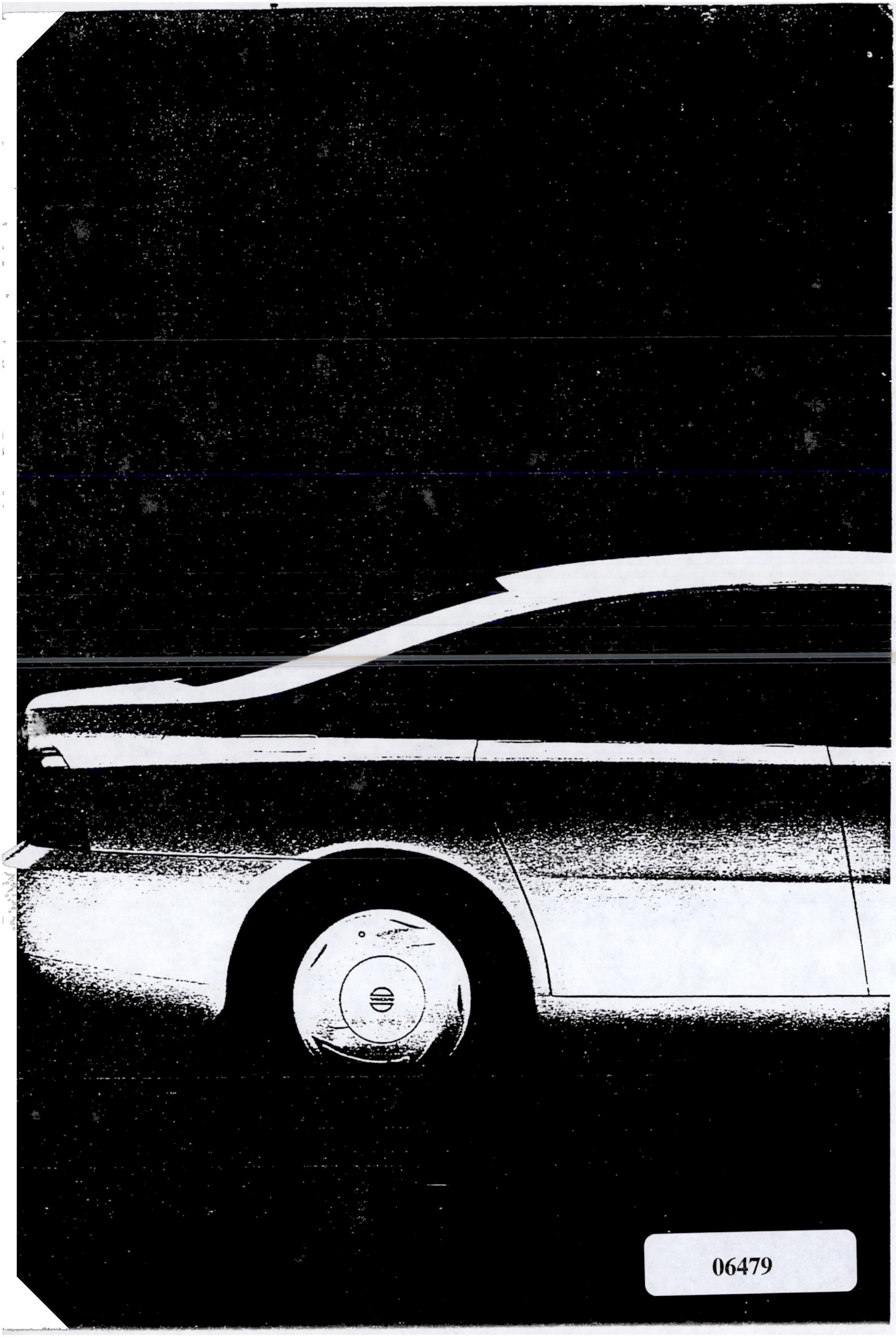
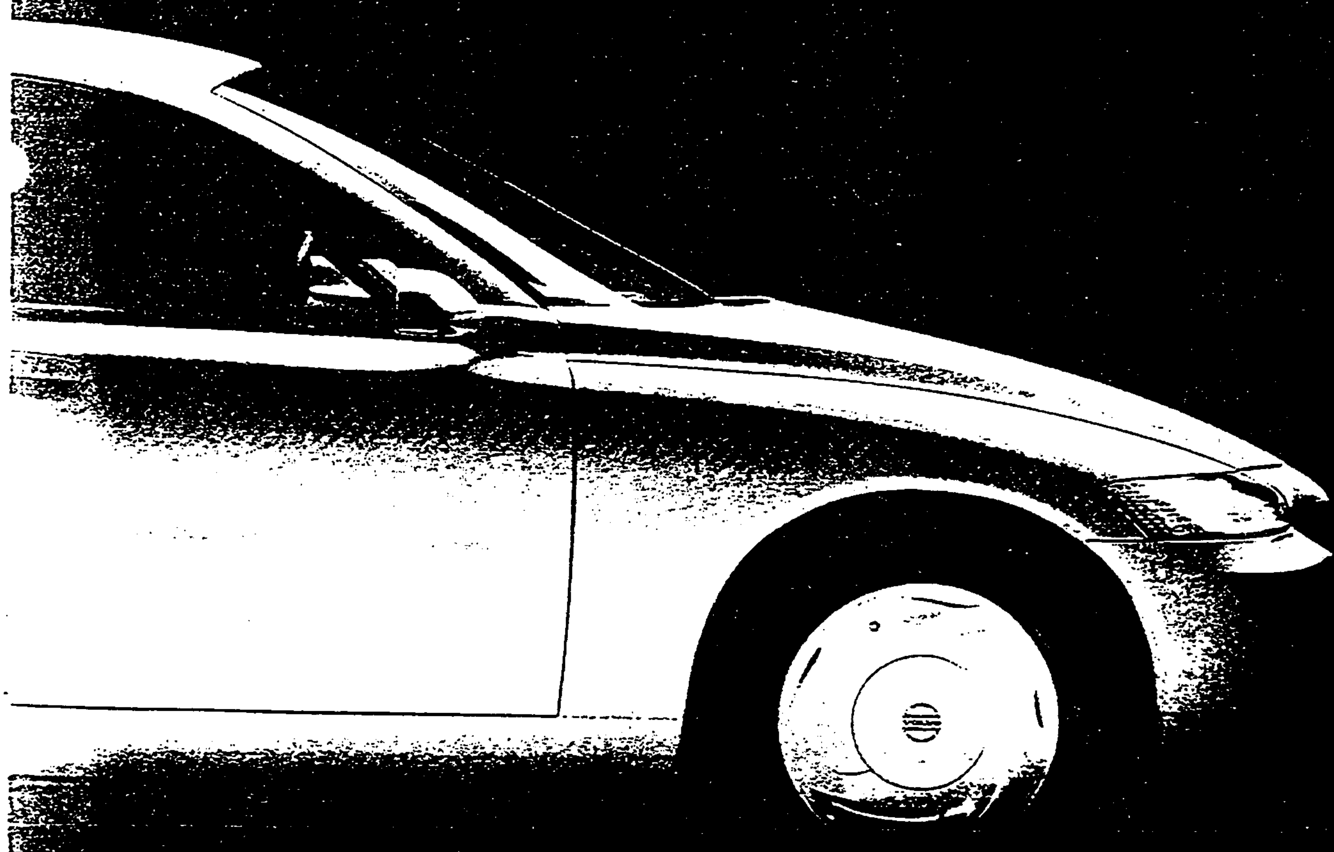
VOLVO



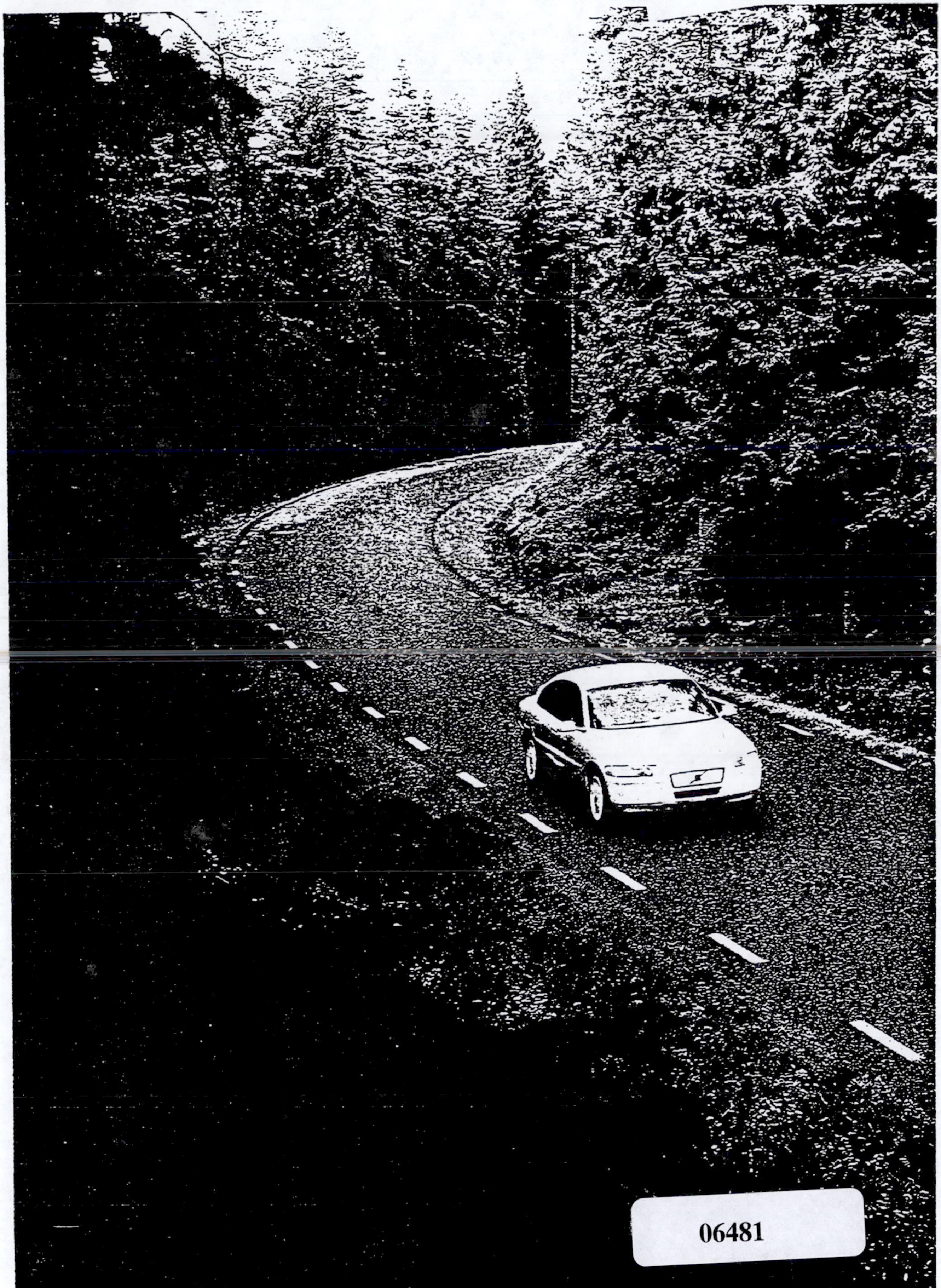
06479

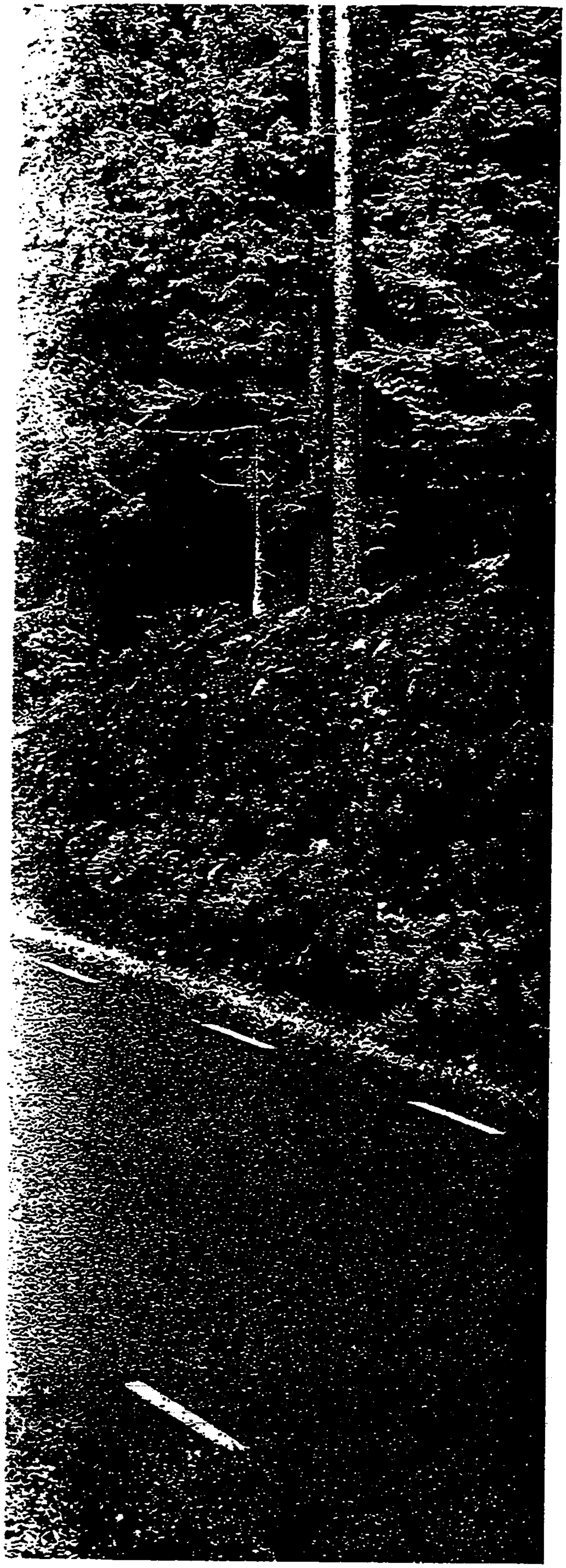
A human perspective on cars and the environment



Cars are essential to efficient family travel – and they will still be needed even in societies that are concerned about how to handle the various forms of environmental impact. The Volvo Environmental Concept Car shows the way ahead.

06480





Volvo ECC.
A realistic family car concept

What should cars look like in an environmentally-aware society?

Could you accept a small battery-powered car just for short trips, for example, or will you still need a family car designed for efficiency, versatility and safety?

The Volvo ECC is a synthesis of a number of research projects at Volvo. The common goal of all these projects is increased knowledge, aimed at making the cars of the future more environmentally sound. Volvo's vision is based on family cars – versatile cars to use in our everyday lives.

We have mapped out people's needs and expectations regarding the cars of the future on the basis of comprehensive surveys. We have weighed in the consequences of future legal requirements* in different countries. We have studied the potential of new and pro-environmental technology. We have looked at the total environmental impact of the car in an overall perspective – from the extraction of raw materials to production, use and recycling.

We see the Volvo ECC as a way of demonstrating and testing realistic requirements and solutions.

**By Model Year 1998, two per cent of all cars sold in California by manufacturers selling 35,000 cars a year must be ZEV–"zero-emission" vehicles. This figure will increase to ten per cent by model year 2003, and will apply to all major manufacturers. Similar legal requirements can be expected in other environmentally-aware countries.*

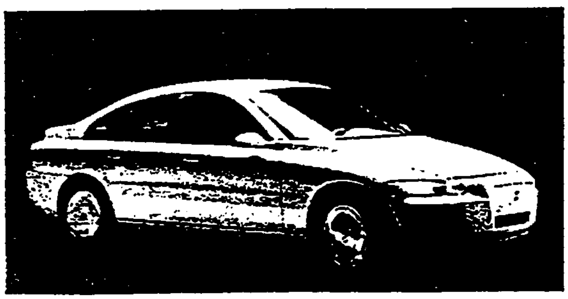
The Volvo ECC is a family-size hybrid electric car. The aerodynamic body is made of aluminium and has a low drag coefficient, while the other materials in the car have been selected with the environment and recycling in mind. The powertrain consists of a gas turbine engine and electric motor in series. This gives the car a range and performance comparable to conventional family cars of today. Using batteries alone, the car becomes a zero-emission vehicle for city traffic. Running on the gas turbine, it has extremely low emissions. Fuel consumption is also well below that of today's cars in the same size class.

In shape for the future

Many would say that the timeless and dynamic styling of the Volvo ECC has resulted in an unusually attractive car.

However, beautiful lines were not the prime object for Volvo's designers. The challenge was to realise effective design solutions on the basis of extremely detailed analyses of the requirements. This involves the use of sophisticated computer programs to build the car "from the inside out" in order to find forms that correspond to function in all respects. The dimensions and basic structure were determined on the basis of stringent safety, space and usability requirements, making the Volvo ECC a realistic family car concept.

Another prerequisite was the use of various pro-environmental materials. The body you see here, for instance, is built entirely of aluminium.



Low rolling resistance. Cd value: 0.23.

The aerodynamic streamlined form still incorporates distinctive Volvo styling.

Aerodynamics, low weight and low rolling resistance – low fuel consumption and low emissions

The streamlined form, with the short front, long rear overhang and blunt rear end, is correct from the aerodynamic point of view. The Cd figure is 0.23.

A number of design solutions contribute to the low Cd: the front-end shape, the angles of the rear surfaces in side view and plan view, the wheel-to-body relationships, the shape and smoothness of the underbody. Each part has been carefully shaped and tested in the wind tunnel to reduce air resistance. The following is a comparison between the Volvo ECC and comparable cars of today:

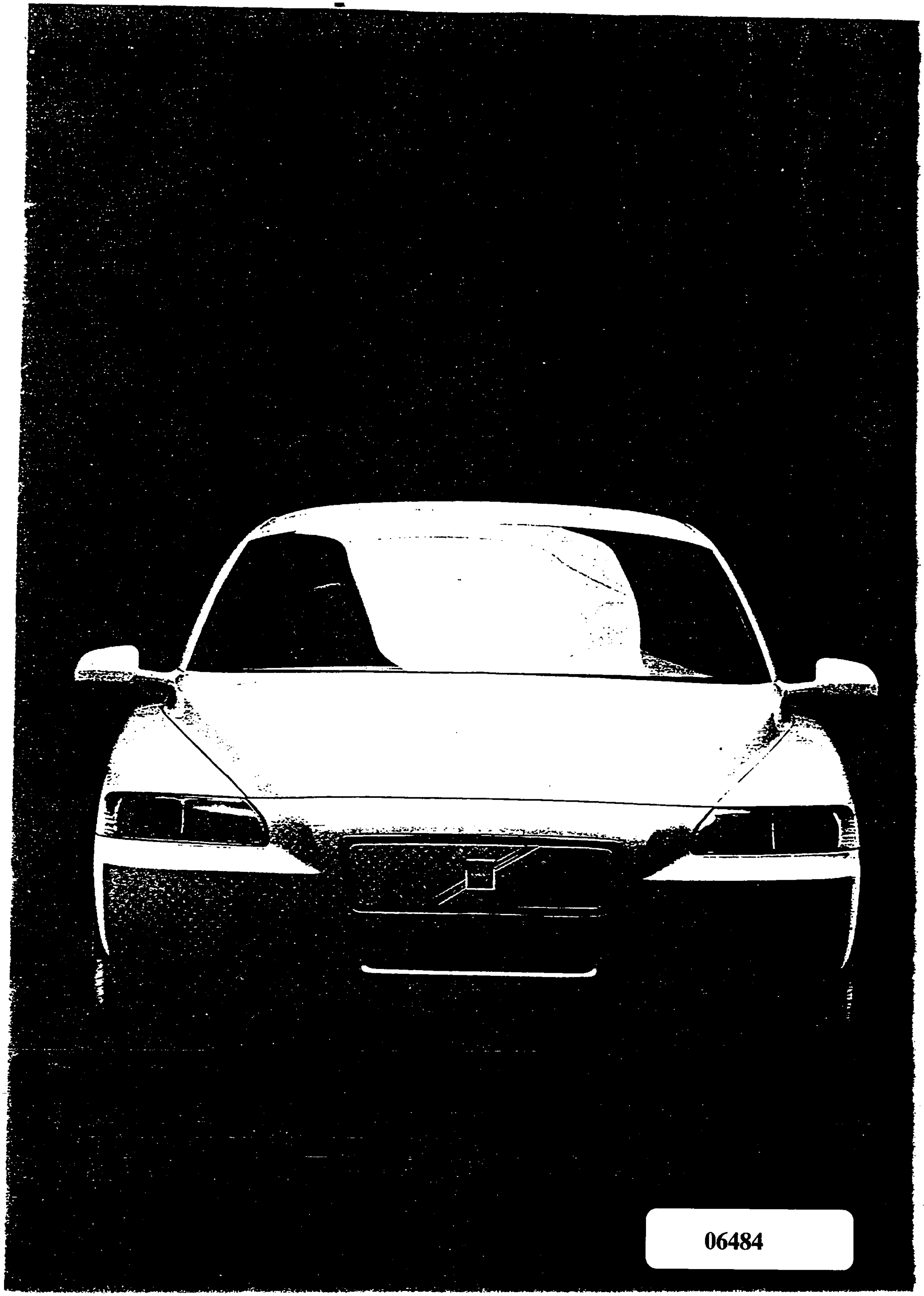
- *Aluminium is used to reduce the mass of the car by 12 per cent compared with corresponding steel-body cars.*
- *The rolling resistance is down by 50 per cent, thanks to special tires.*
- *The drag coefficient is 30 per cent lower.*

Timeless Volvo design

The design team has also captured an unmistakeable Volvo feeling, inheriting influences from the Volvo 120 and the 140, among others. This is to be seen in features such as the classic styling of the bonnet and the broad waistline.

Were you to sit behind the wheel, you would immediately feel how the warm and cosy interior underlines the impression of a highly effective and pro-environmental family car. The seats and panels are all clad in naturally treated leather. The height and width of the interior and the seating space provide the comfort you expect in a family car.

The body is built entirely of aluminium ▶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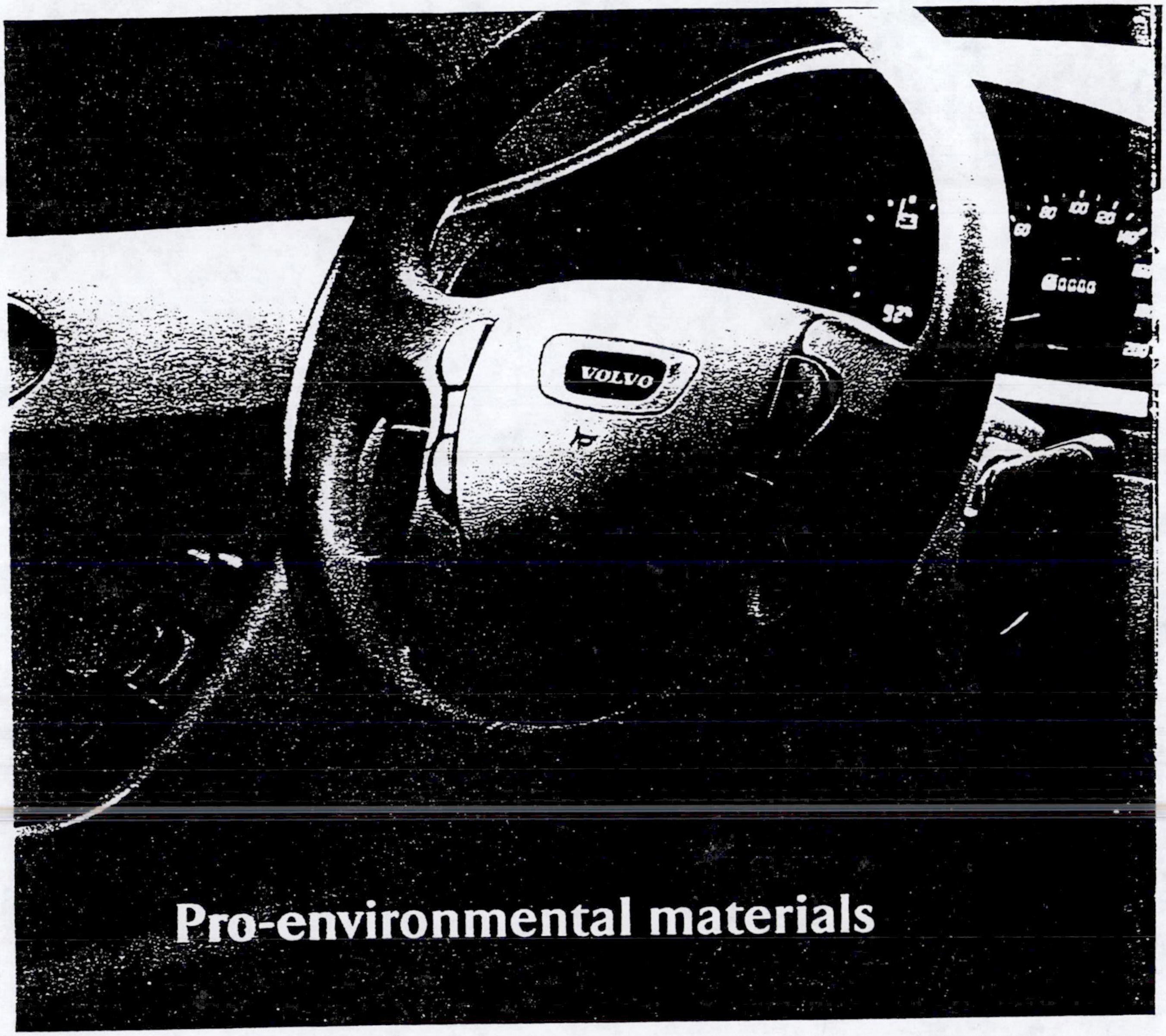


Pro-environmental materials

Take a closer look at the Volvo ECC and you will soon notice that environmental concern and motoring enthusiasm do not need to be diametrical opposites. The materials, for instance, have been chosen not just for safety and comfort and to promote good driving characteristics, but also for weight reduction and recycling.

Aluminium for lightness and recycling. The inner structure and the body are in aluminium. The total weight of the body has thereby been reduced – it weighs only about 200 kg. Aluminium which is uncontaminated by other materials can be recycled to make new car bodies.

Pro-environmental paintwork. The pearl white body is painted with waterborne paint. This is a pro-environmental production method which entails a sharp reduction in emissions of hydrocarbons, a key ingredient in smog formation.

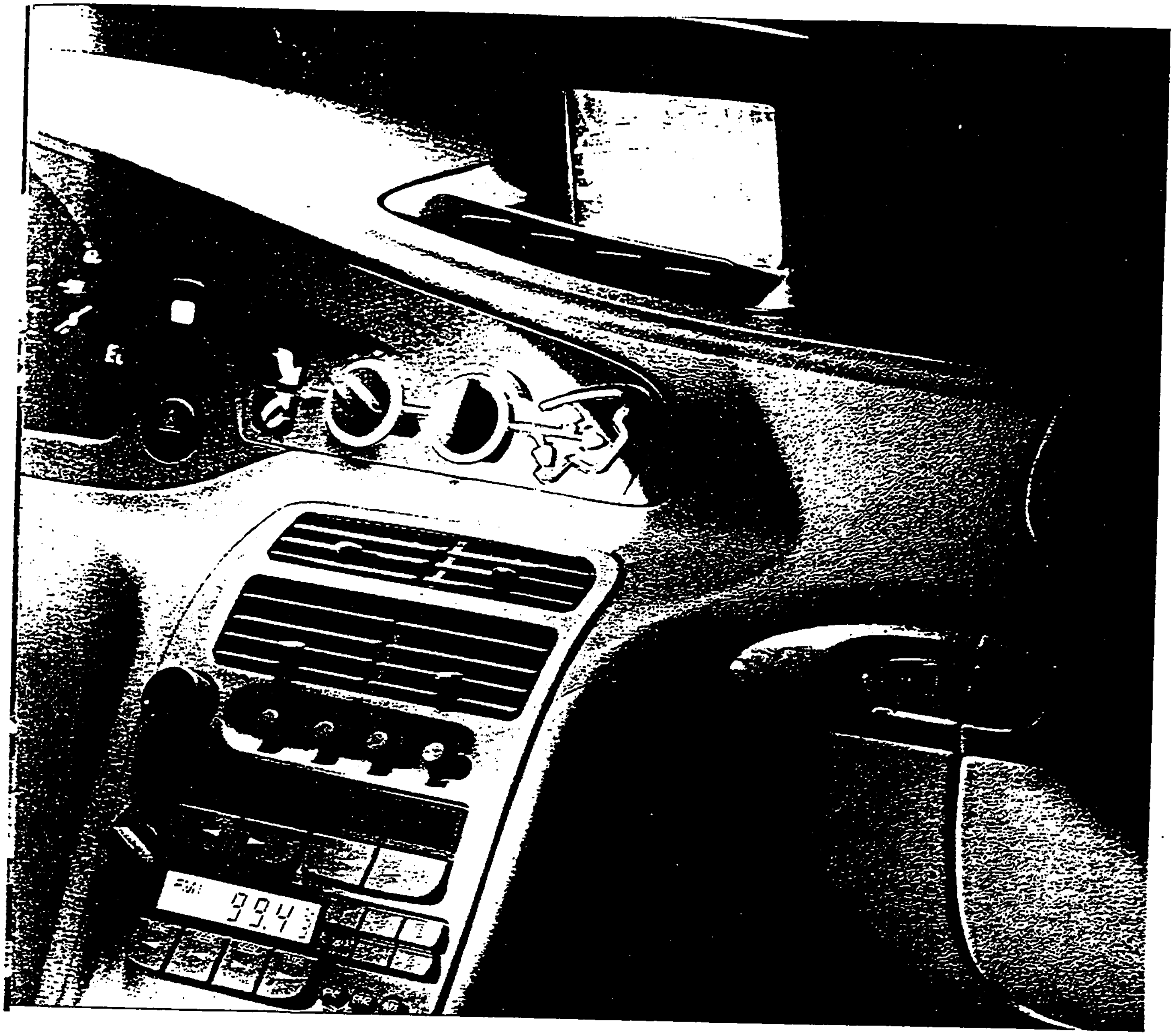
Recycling. The concept also enables recyclable plastics to be used. Take a closer look at the front end, which integrates with the bumper and grille. This not only reduces weight and saves energy but also promotes recycling.

The interior has also been designed with potential environmental impact in mind. The panels have been built to be dismantled easily. There are no metal parts or mixtures of materials that present a problem when recycling. Once again, this promotes total recycling.

The recycling of used batteries is an important area for development.

Safety evolution

The body structure provides the foundation for good crash safety. Thanks to its physical dimensions



and robust door structure the Volvo ECC offers interesting potential for developing Volvo safety even more.

The concept car has the same basic platform design as the Volvo S50. Volvo's award-winning and patented Side Impact Protection System (SIPS) and integrated child safety seat are included, of course.

The design of the driver's environment simplifies the interplay between man and machine.

Driving safety has been developed in the same way. Comprehensive studies of the way people drive have been used to develop the driver's environment. The interior has been designed in the most minute detail to facilitate fast and correct decisions behind the wheel, for instance. The design of instruments and controls is a product of ergonomics and logical function. There is a sophisticated Dyna Guide trip computer to provide the driver with road and traffic information and help him to drive efficiently.

The continued development of the hybrid-electric car of the future also demands special safety design considerations. In a collision, for instance, the electric current must be cut off reliably. The batteries must be carefully positioned. Service and maintenance impose special demands in terms of high voltage and currents.

An electric car with its own power plant

Suppose that your car had a Volvo ECC power-train today. You would be able to drive in city traffic – to and from work, perhaps – purely on electrical power. This means that the energy supplied to the motor comes solely from batteries, so there are no car emissions.

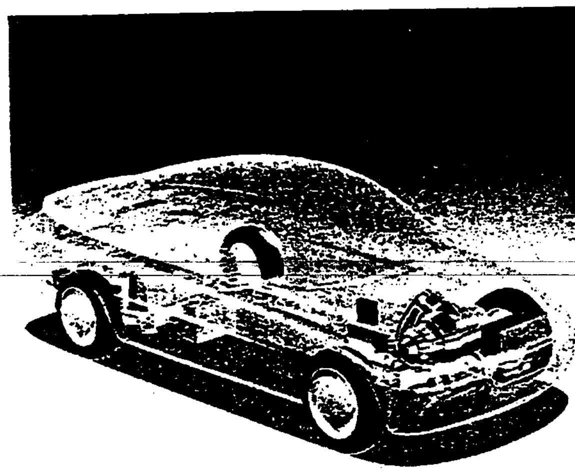
Normally you would charge the batteries from an electric outlet in your home.

You could also choose to add further energy via [gene]rator – which would also serve to charge the ba[tter]ies while driving. With this extra energy you would have the range and performance for longer trips.

Flexible hybrid technology

Instead of pure battery operation, Volvo engineers have chosen to develop an electric vehicle with advanced hybrid technology in a series configuration, which means that the power to the wheels is always supplied through the electric motor. This concept appears to be the most feasible in the immediate future for a versatile family car. Hybrid technology is, quite simply, a way of gaining the advantages of electrical operation – i.e. no harmful emissions from the tailpipe – while getting around its disadvantages, such as inferior range and an unreasonably large battery package.

When feeding the batteries from an electric outlet, the power must be generated somewhere – which means that the environmental impact is transferred from the car's exhaust pipe to a power station. However, in most cases the environmental impact from this is decreased.



Hybrid technology, tires with low rolling resistance, low weight, aerodynamic form – all these combine to make the Volvo ECC as pro-environmental as it is efficient. The gas turbine, HSG generator and electric motor are built together in a single space-saving package. The batteries are placed in a central tunnel and beneath the luggage compartment. The car has front-wheel drive and the same Delta-Link rear suspension as the Volvo 850.

The heart of the system

In the Volvo ECC the power is generated by a compact gas turbine engine with extremely efficient combustion and low emissions. This is the same type of engine that is used in aircraft, and it can be built for use with different types of fuel. In the Volvo ECC, diesel fuel is used – a sensible solution in terms of price, availability and environmentally sound management.

In the gas turbine, the diesel fuel is vaporised at a high temperature so that it burns as efficiently as natural gas. The gas turbine is less suitable as a direct power source, however, so it is integrated with a high-speed generator which makes the most of its characteristics. This integrated system, which has been developed in a joint project with Volvo Flygmotor, Asea Brown Boveri and the Swedish power supplier Vattenfall, is called HSG (High Speed Generation).

Thanks to the high-speed technology, the complete unit is extremely light and takes up very little space. It works at an even load which corresponds to the average power demand of the vehicle. This means that efficiency is good and emissions very low.

Why a gas turbine?

Hybrid technology is inherently flexible, and could well be based on the conventional spark-ignited engine used in today's cars. In the Volvo Environmental Concept Car, however, the researchers had the opportunity to carry out realistic tests with gas turbines – a type of engine that Volvo has been developing for a long time.

It is lighter, simpler and requires less space than the conventional engines of today. The gas turbine can, in principle, be adapted to all liquid and gaseous fuels. It has a good power output (approximately 40 kW). It offers reasonable performance for a family car in combination with very favourable fuel economy. It is quiet and, not least, offers realistic development potential for the future.

On-board power generation

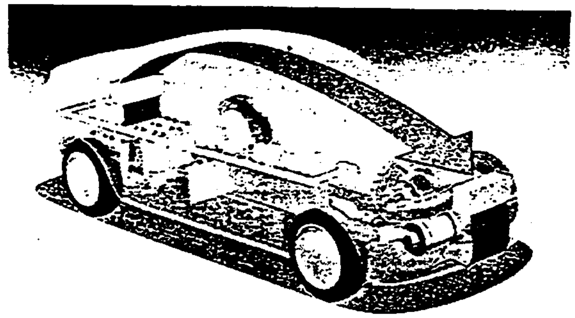
The HSG package (gas turbine and generator) is not connected to the wheels, but is a rolling power plant. The energy generated can be stored in batteries or used directly to drive the electric motor that in turn drives the wheels, all according to the series hybrid principle.

The HSG generator can even charge the batteries and drive the electric motor at the same time. This flexible process is governed by an advanced control system.

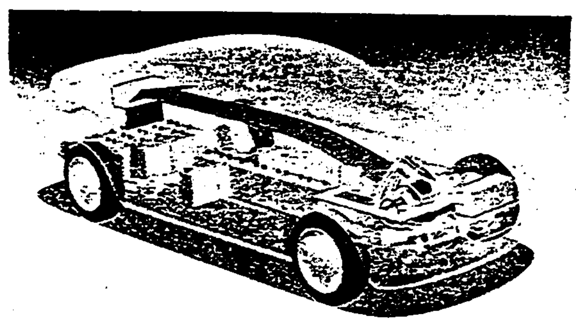
The system also includes a two-speed automatic gearbox which enables the motor speed to be optimised for maximum performance.

THREE DRIVING MODES

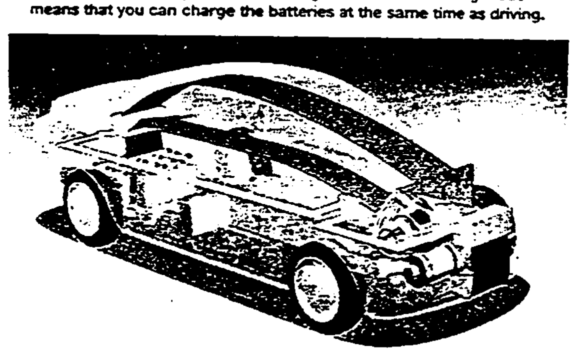
In order to create as much flexibility as possible, there are three driving modes – three different ways of providing current for the electric motor. Switching from one mode to the other can be achived either automatically or manually.



Current directly from the batteries. This driving mode is intended for city traffic with zero emissions. A fully-charged battery package has a driving range of 85 km.



Current from the gas turbine/HSG generator. This driving mode means that you can charge the batteries at the same time as driving.



Current from both the batteries and the generator. This provides good performance and long range. The total range with fully charged batteries and a full 35-litre diesel tank gives you a range of 760 km and a top speed of 175 km/h.

How do the batteries work?

The main criteria in the choice of batteries for a hybrid-electric car are good power output for high speed and acceleration and high energy content for range. The hybrid technology means that the batteries could be made much smaller than in a pure electric car. This saves both weight and space.

The battery package is placed in the central tunnel and beneath the luggage compartment. The batteries can either be charged while driving, from the gas turbine HSG generator (which takes about one and a half hours) or from a 170 V – 380 V wall outlet at home (which takes between six and fifteen hours).

If you drove this car to and from work today you could choose to run on the batteries alone and charge them at home*. For a longer weekend tour you could then add energy and performance from the gas turbine and diesel fuel.

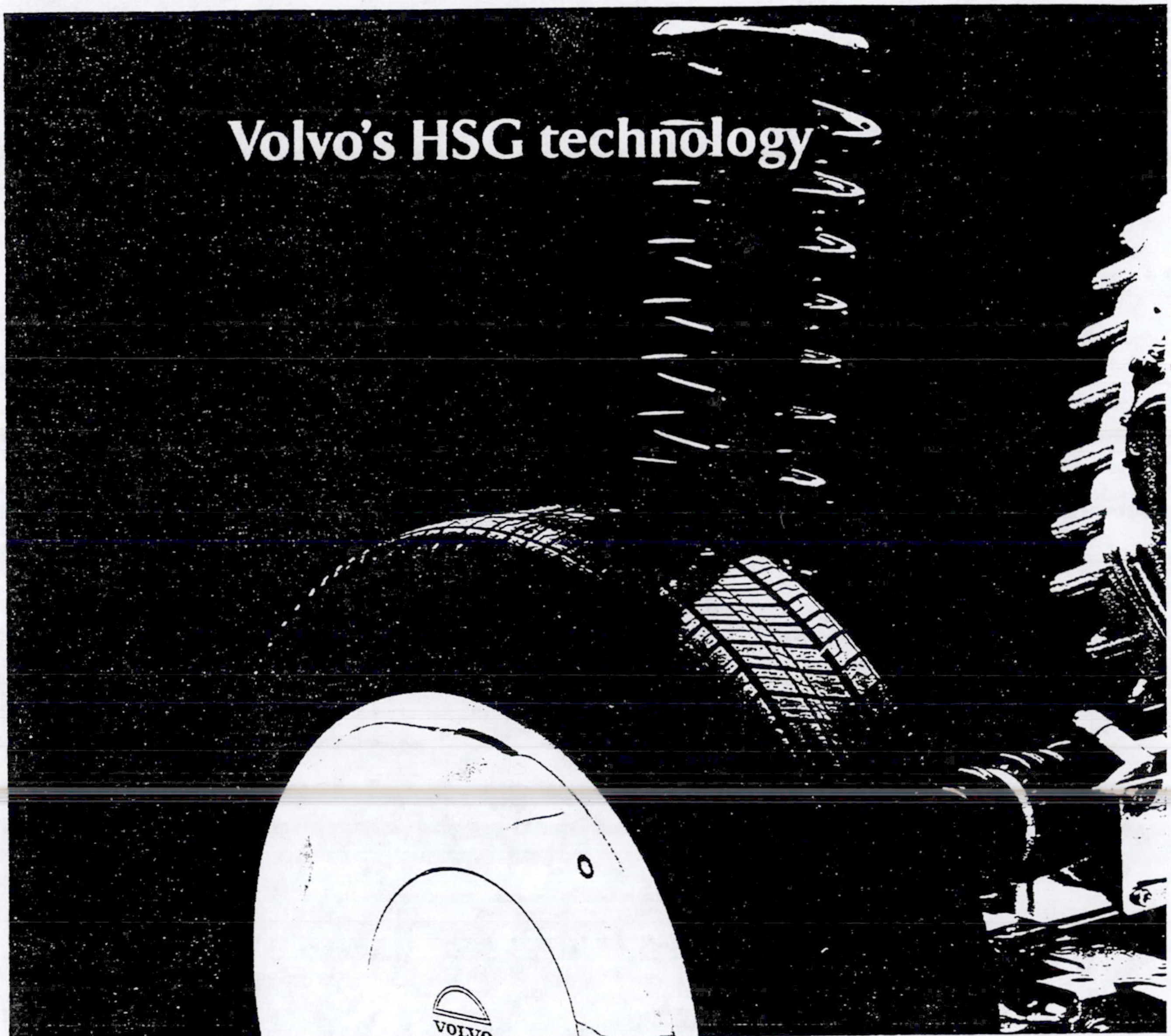
How much cleaner is the Volvo ECC than today's cars?

If you drive in city traffic using the batteries as your source of power, the Volvo ECC is designed to meet the zero emission requirements – i.e. no exhaust emissions at all. The gas turbine HSG generator drive will meet the ultra low emission standards of future California legislation (ULEV).

Hydrocarbon emissions are approximately one-tenth of California's 1992 Model Year Standards and nitrogen oxide emissions are approximately half.

*Statistics indicate that most motorists in the major population centres of the world drive about 40 km a day on weekdays, a distance that can be managed with batteries alone.

Volvo's HSG technology



HSG is a complete power package which generates electricity via a high-speed generator. It has been developed in a joint project in which Volvo is

The powertrain in a hybrid car must be compact and light in relation to the power supplied and at the same time be environmentally sound. The High Speed Generation concept is a newly developed hybrid powertrain based on high-speed technology.

By increasing the speed of the generator, both size and weight can be reduced, but the technology demands new and exclusive materials, special power electronics components and sophisticated control systems. The generator spins at speeds that are fifty times higher than with conventional technology.

Few moving parts, small energy losses and simple design. The speed of the gas turbine corresponds to that of the generator, so it has been possible to build both units together on a common shaft with common bearings.

The design of the gas turbine is simple, with a single stage radial compressor and a single stage radial turbine.

Effective combustion, low emissions. The gas turbine is fitted with a low-emission combustion chamber and a heat exchanger which transfers exhaust heat to the air that flows through the engine.

The intake air is used to cool the generator.

In addition, the unit contains a rectifier for the generator output, a converter for adjusting the system voltage, an inverter for feeding the electric motor, a start inverter which supplies alternating current to the high-speed generator when it is used as the starter motor and a control system.

In the Volvo ECC the control system is designed to govern all the signals between the gas turbine, the generator and the car's drive system, including the amount of fuel supplied to the gas turbine.

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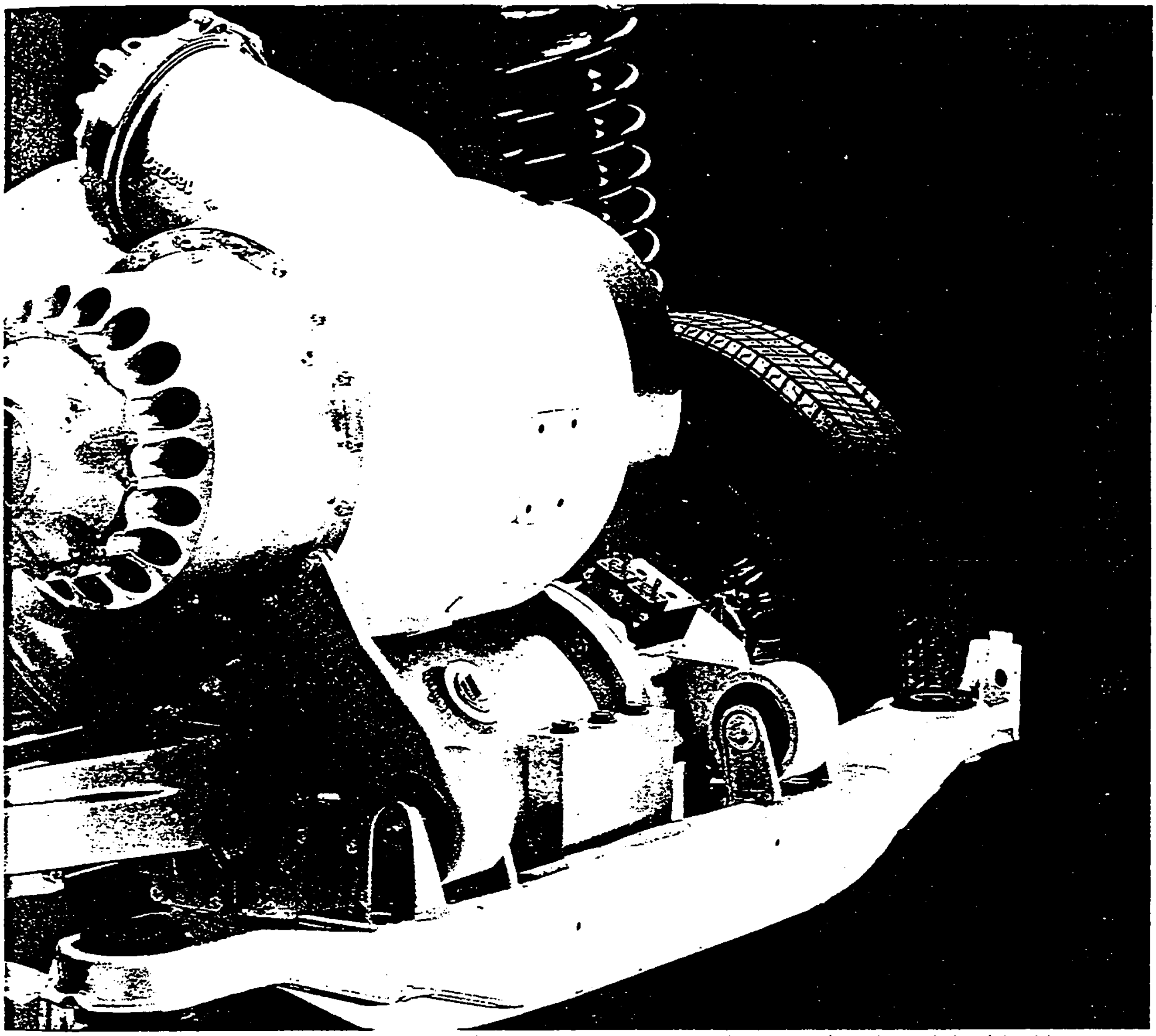
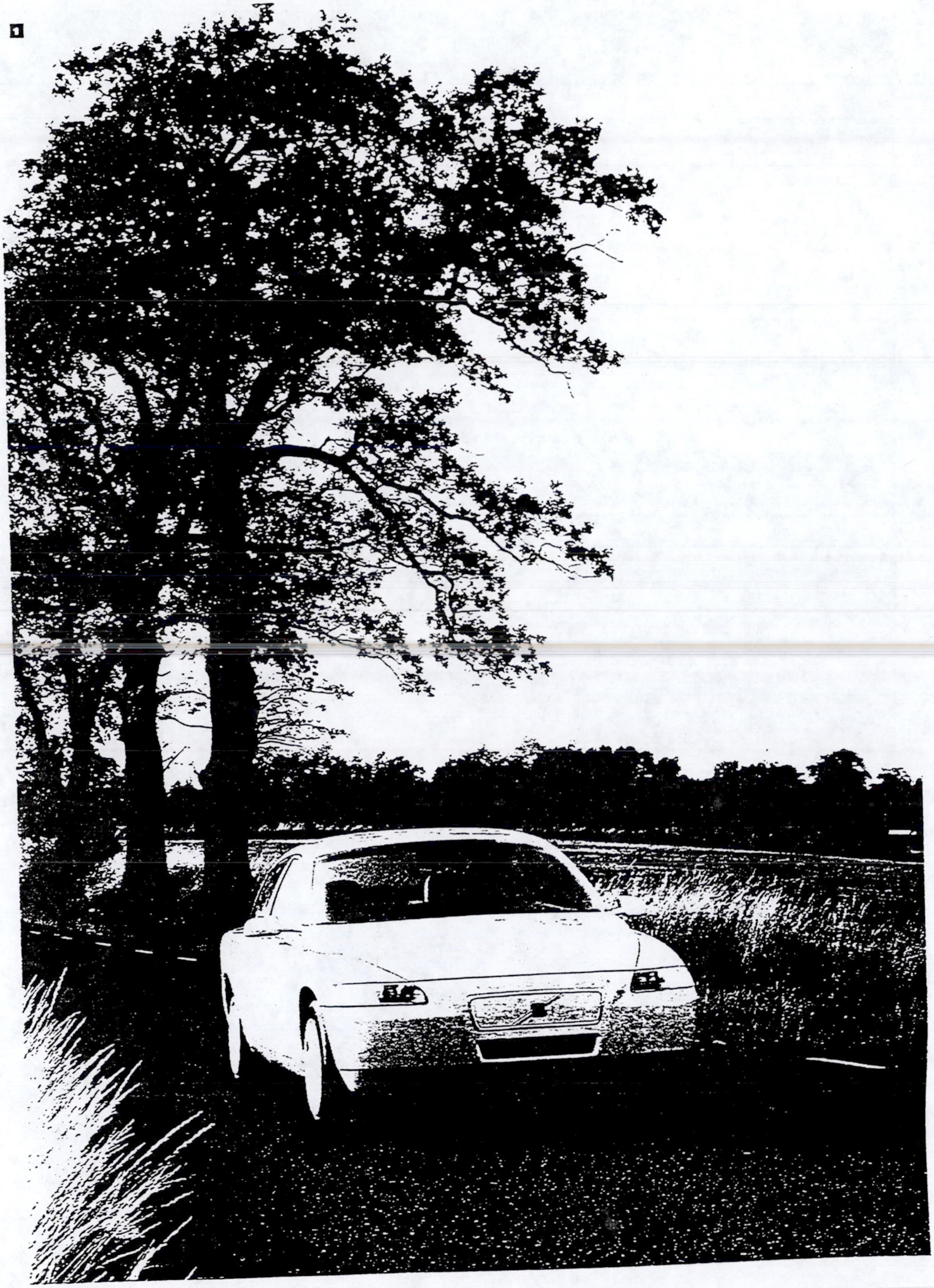


...contributing its turbine know-how. The other partners are responsible for such things as components for the generation and transmission of electricity.

Good power output. The HSG unit works at speeds of up to 90.000 rpm. providing a power output of 41 kW 56 hp. When the motor is supplied with electricity from both generator and batteries. the peak power output from the electric motor that drives the car is a full 70 kW 95 hp.

As driver you would use the following controls:

- *The ignition lock. which activates the drive system when the key is turned. A red lamp in the combination instrument indicates activation. After a few seconds a green lamp lights up to show that the Volvo ECC is ready to drive.*
- *The driving mode selector. which has three buttons for manual selection. The computerised VMU (Vehicle Management Unit) automatically ensures that you have the most efficient driving mode.*
- *The gear lever. which has the following positions: P. R. N. D. L.*
- *The accelerator which functions electrically and has a kickdown function. It also features electric motor braking – with regeneration of the braking power back to the batteries. The harder you brake. the greater the motor-brake effect (the maximum electric brake effect is about 45 kW). The VMU computer is also designed to work together with an ABS control unit.*



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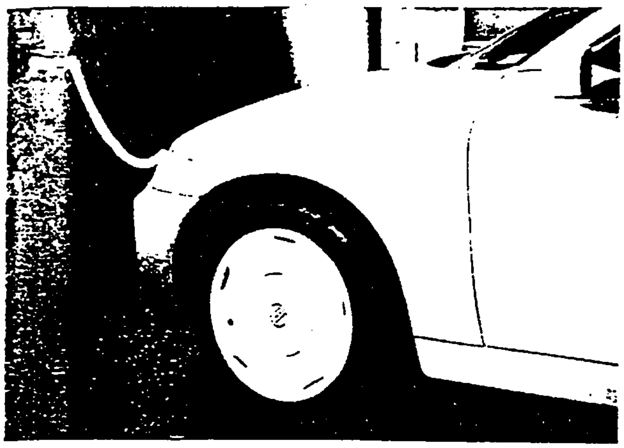


A realistic alternative

A convincing and realistic concept. The Volvo ECC design considerations cover all the features you are entitled to expect of a future-oriented, pro-environmental, efficient and safety-conscious family car.

- The Volvo Environmental Concept Car represents an overall approach to environmental concern. Materials and production methods have been chosen with their environmental impact in mind. Mass, drag and rolling resistance have all been reduced in order to minimise energy consumption while driving.
- Smart charging – taking all currents from 170 V to 380 V either in single-phase or three-phase systems.
- ZEV (zero emissions) in city traffic, ULEV (ultra-low emissions) out on the open road.
- Safe driving requires responsive power resources.
- Range and performance also for longer trips – as you would expect of a family car.

06492

A holistic approach to environmental protection

How environmentally sound is the Volvo ECC in reality?

In order to answer this, we believe that the environmental impact must be seen in a holistic perspective. One must consider a product's entire life cycle, taking into account energy use and environmental impact at all stages, from the extraction of raw materials to recycling. This approach has long characterised Volvo's environmental research and development. Our ambition has been to make an active and significant contribution to environmental improvements, particularly in the three areas that a car manufacturer can influence:

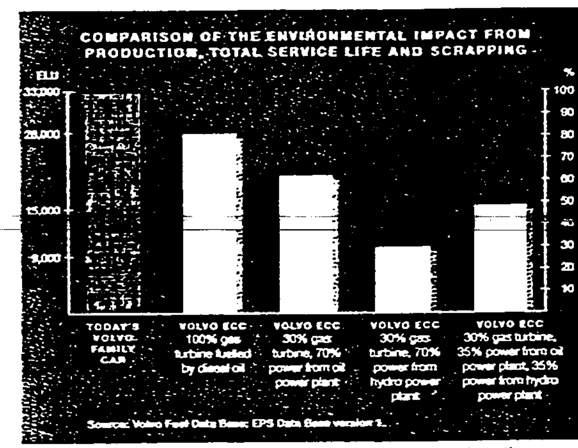
- *Production*
- *The car in operation*
- *Final destruction*

Comprehensive evaluation system

To evaluate total environmental impact, Volvo uses a special system called Environmental Priority Strategies (EPS). This has been developed by the Volvo Car Corporation in cooperation with the Federation of Swedish Industries and the Swedish Environmental Research Institute.

With this system, environmental load is expressed in Environmental Load Units (ELU). In the case of a car, the total ELU value is the sum of the ELU's for:

- *the emissions, energy use and material consumption involved in the manufacture and assembly of the car;*
- *the emissions and energy use during the car's total service life;*
- *the emissions and energy use in the destruction or recycling of the car's components in conjunction with scrapping.*



The environmental impact of a car is dependent on how the energy is generated, among other things.

To assess the total environmental impact of the Volvo ECC, we compare its ELU value with that of today's family cars of the same size. When making such a comparison it is vital to know how a series hybrid car like the Volvo ECC will be used in reality – how often gas turbine electricity generation is used, how often it is charged from the electric outlets and so on.

Another important factor is how the current used to charge the batteries is generated – from a coal power plant, an oil plant or a hydro-electric plant, for example. These different types of plants have significantly different environmental impacts.

We have evaluated a few cases using different mixes of power supply sources. The diagram above shows a possible comparison between a petrol-driven car of today and the Volvo ECC.

A supply of "unclean" electricity will, as the table shows, decrease the advantages of both hybrid cars and cars that run on electricity alone. With a reasonable supply of clean electricity, however, the environmental impact of the Volvo ECC in practical use might well be halved – at the same time as the concept makes it possible to drive with zero emissions in cities.

Technical information

	VOLVO ENVIRONMENTAL CONCEPT CAR		
DIMENSIONS			
Wheelbase	2700 mm	106.3 in	
Track front	1520 mm	59.8 in	
Track rear	1520 mm	59.8 in	
Length	4487 mm	176.6 in	
Width	1804 mm	71.0 in	
Height	1390 mm	54.7 in	
Weight, curb	1588 kg	3480 lbs	
Cd	0.23		
Frontal area (A)	2.01 m²	21.6 ft²	
Cd x A	0.46 m²		
Seating capacity	4 adults (95 percentile), one child		
POWERTRAIN AND PERFORMANCE			
Gas turbine (GT)	41 kW	55.8 hp	
Electric generator	39 kW	53.0 hp	
Electric motor peak	70 kW	95.2 hp	
Electric motor cont	56 kW	76.2 hp	
AC/DC converter + inverter			
Gearbox, 2-step automatic	1 st	3.278	
	2 nd	1.962	
	final	4.00	
Electrically driven servo pump			
Auxiliary battery	1 x 12 V		
Traction batteries			
– Type	NiCd		
– Voltage	120 V		
– Energy capacity	16.8 kWh		
– Charging	170 V – 380 V		
Max. speed	175 km/h 109 mph		
Acceleration, battery only			
– 0-100 km/h	23.0 s		
– 0-60 mph	22.0 s		
Max. acceleration (70 kW)			
– 0-100 km/h	13.0 s		
– 0-60 mph	12.5 s		
Fuel tank capacity	35 litres	9.2 US gal	
Driving range, battery only			
– at 80% DOD, urban	85 km	53 miles	
– at 80% DOD, highway	90 km	56 miles	
– at 80% DOD, 50 km/h steady-state	146 km	90.7 miles	
Driving range gas turbine only			
– at highway 90 km/h	670 km		
– at highway 55 mph	418 miles		
Fuel consumption GT			
– urban	6.0 l / 100 km		39.2 mpg
– highway	5.2 l / 100 km		45.2 mpg
EMISSIONS			
– NOx	0.17 g / mile		
– CO	0.13 g / mile		
– HC (NMOG)	0.010 g / mile		

Source of data: Volvo Car Corporation.
Actual and simulated characteristics.

06494

By people who care

A NUMBER OF COMPANIES HAVE CONTRIBUTED EXPERTISE AND COMPONENTS TO THE VOLVO ECC PROJECT IN CLOSE COOPERATION WITH THE VOLVO CAR CORPORATION.

Company:	Component:
Alpine Electronics Inc	Audio System
Alps Electric Co Ltd	Climate control
Autoliv Sverige AB	Seat belts, integrated child safety seat
Fatati-BTR SA	Carpets
Fundo AS	Wheels
General Electric Plastics	Bumpers
Hella KG Hueck & Co	Tail lamps
Iso Delta	Steering wheel
Leopold Kostal GmbH & Co KG	Switches
Perstorp Antiphon AB	Insulation
Pilkington Bilglas AB	Windows
Robert Bosch GmbH	Windscreen wipers
The GoodYear Tire & Rubber Co	Tires
Torsmaskiner AB	Exhaust system
Valeo Eclairage Signalisation	Headlamps
Yazaki Corporation	Instrumentation