EVAPORATIVE EMISSION DEVICE RETROFIT STUDY

FINAL REPORT

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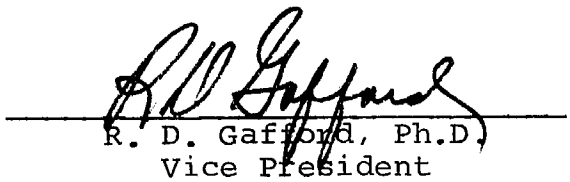

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ABSTRACT

Evaporative emission control systems have been required on light-duty vehicles beginning with the 1970 model year and on heavy-duty vehicles beginning with the 1973 model year. Due to the large number of vehicles operating in California, (roughly 10.7 million light-duty and 1.9 million heavy-duty vehicles) the evaporative emissions from the uncontrolled vehicles may be significant. This study was structured to assess the technical and economic feasibility of retrofitting or otherwise modifying these evaporative uncontrolled, pre-1970 light and heavy-duty vehicles with devices, systems, and concepts similar to those used on the production 1970 to 1973 model light-duty vehicles. The study evaluates and cost-estimates fuel tank modifications, carburetor modifications, and combinations of the two basic modifications. Effectiveness measures in terms of evaporative emissions controlled are calculated for the feasible retrofit systems as a function of vehicle model year, air basin, and total State. The cost effectiveness of various retrofit approaches is calculated and discussed.

The statements and conclusions in this report are those of the contractor and not necessarily those of the California Air Resources Board. The mention of commercial products, their source or their use in connection with material reported herein is not to be construed as either an actual or implied endorsement of such products.

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SECTION 1

SUMMARY

1.1 STUDY BACKGROUND

Previous studies have determined that two of the major contributors to air pollution in general and photochemical smog in particular are reactive hydrocarbons (HC) and oxides of nitrogen (NO_x). Other early studies have identified the gasoline-powered motor vehicle as the dominant source of uncontrolled HC and NO_x.

For vehicles without emission control systems installed, the engine crankcase blowby accounts for about 20 percent of the HC emissions, the engine exhaust for about 60 percent, and the fuel system evaporative losses for the remaining 20 percent. NO_x emissions are emitted almost totally from the engine exhaust.

The State of California has imposed various emission standards directed at the three major vehicle sources. The standards and regulations affect new vehicles on a manufacturer-installed basis, and older vehicles on an owner-installed, retrofit basis.

Engine crankcase emission controls were required on new 1961 model year, light-duty vehicles initially sold in California. The retrofit of positive crankcase ventilation (PCV) systems of pre-1961 models became mandatory soon after. For heavy-duty vehicles, crankcase controls were required beginning with the 1963 models.

The first exhaust emission standards on HC and CO (carbon monoxide) for vehicles initially sold in California began with the 1966 model, light-duty vehicles. Retrofit of exhaust controls for pre-1966 vehicles was instituted in 1972 and is required during change-of-ownership. For heavy-duty vehicles, initial HC and CO emission standards became effective with the 1970 models.

The first exhaust emission standards for NO_x were imposed on the 1971 model, light-duty vehicles. Retrofit of 1966 to 1970 vehicles for NO_x control became mandatory at change-of-ownership beginning in September, 1973.

Initial standards for the evaporative HC emissions began with the 1970 model, light-duty vehicles. For heavy-duty vehicles, evaporative emission controls were required beginning with the 1973 model year. With close to 11 million light-duty vehicles registered in California, approximately 7 million of these do not have evaporative HC controls. Additionally, with close to two million heavy-duty vehicles registered in the State, approximately one million of these do not have evaporative HC controls.

1.2 STUDY OBJECTIVE

The purpose of this study is to identify feasible methods to further reduce vehicle emissions and the related air pollution problem by installing evaporative controls on a retrofit basis. Ideally, to retrofit the pre-1970 light and heavy-duty vehicles, the same techniques and devices used on current new production, light-duty vehicles would be used.

1.3 STUDY APPROACH

The total study was structured to provide answers to the following types of questions:

- What are the major sources of evaporative emissions for pre-1970, gasoline-powered vehicles?
- What are the basic approaches to evaporative emission control as used on new production vehicles?
- Which of these approaches are technically feasible for retrofit installation?
- What is the effectiveness (emission reduction potential) of the various approaches?
- What are the vehicle owner's costs for the various retrofit systems?
- Which of the retrofit systems (alternatives) are the most cost effective?

1.4 CONCLUSIONS

Gasoline used to fuel spark-ignition engines is a volatile liquid composed of various types of hydrocarbons and some non-hydrocarbon additives. The different hydrocarbon types have varying boiling-point temperatures. The various components of a typical vehicle and its fuel experience a wide range of temperatures during a day. Results of reviewing previous studies and documents revealed that:

- The primary sources of evaporative, hydrocarbon losses are the carburetor and the fuel tank.

- Carburetor evaporative emissions basically occur during engine hot-soak, the 1-hour period immediately after engine shutdown.

- Carburetor losses are a function of fuel volatility and temperature, engine compartment temperature, and fuel bowl capacity. Evaporative losses escape via idle vents, air horn opening, throttle and choke shafts, and idle adjustment screws.

- The temperature of the fuel in the tank increases due to vehicle movement and fuel agitation, engine heat transfer to the fuel tank, and radiated heat from the pavement surface.

- Fuel tank losses are emitted from the vapor vent and the filler cap.

The evaporative emission control approaches used on the 1970 to 1973-model, light-duty vehicles were evaluated to identify various methods of limiting and controlling hydrocarbon evaporation losses. The results of this phase of the investigation indicated that:

- Vapor containment in the vehicle fuel tank is achieved by a sealed filler cap incorporating a pressure/vacuum relief valve. Provisions are made for vapor expansion by incorporating an extra integral or external tank. Vapor vent lines are directed toward a single vapor-liquid separator; and captured vapor is routed to the engine compartment.

- Vapors emanating from carburetors are limited by incorporating internally-vented carburetors and air intakes which remain closed until engine operation.

- Vapors recovered are stored in either an activated carbon canister, the engine crankcase or the carburetor air filter housing.

To establish the effectiveness of a retrofit program, the magnitude of the evaporative HC losses were determined and were a function of the following:

- There were 10,745,000 light-duty vehicles registered in California as of 31 December 1972, based on Department of Motor Vehicle (DMV) data.

- Based on historical sales records and vehicle distribution data, it was determined that 70 percent of the total light-duty vehicle registrations were pre-1970 models, as of 31 December 1972.

- For the estimated 7.5 million pre-1970 vehicles still in use, there are roughly over 2,000 types of carburetors, 600 types of fuel tank caps, and roughly 600 types of fuel tanks.

- There were 1,947,000 heavy-duty vehicles (trucks) registered in California as of 31 December 1972, based on DMV data.

- Based on historical sales records and vehicle distribution data, it was determined that roughly 5 percent of all trucks sold nationally are diesel fueled. It was established that 1,855,000 trucks

in California are gasoline powered, and 72 percent or 1,335,000 of these trucks are pre-1970 models.

- The large majority of gasoline powered trucks have fuel systems similar to light-duty vehicles.

To evaluate and compare the effectiveness of an evaporative emission control strategy, an effectiveness model was developed to represent the vehicle population affected, its expected driving patterns, and the effects of seasonal variations in dispensed-fuel characteristcs. Results of exercising the computerized model showed that:

- The pre-1970 vehicles' evaporative emissions during calendar year 1975 were estimated to be 101,000 tons. Carburetor hot-soak losses would account for 33,000 tons, or 32.6 percent; fuel tank losses during vehicle operation and hot soak would be 22,000 tons, or 21.8 percent; and diurnal cycle parking losses would be 46,000 tons, or 45.6 percent. See Figure 1-1 for the graphical display of the uncontrolled evaporative emissions from the pre-1970 light duty vehicles during the period 1975 to 1985.

- Due to normal vehicle attrition, the late 1960 models (1966 to 1969) would comprise the largest proportion of pre-1970 models in use during the next 10 years. Additionally, these vehicles would be driven proportionately more frequently with more cumulative miles during this period than the pre-1966 models. Thus, the more effective strategies involve retrofitting these vehicles. See Figure 1-2 for the estimated evaporative

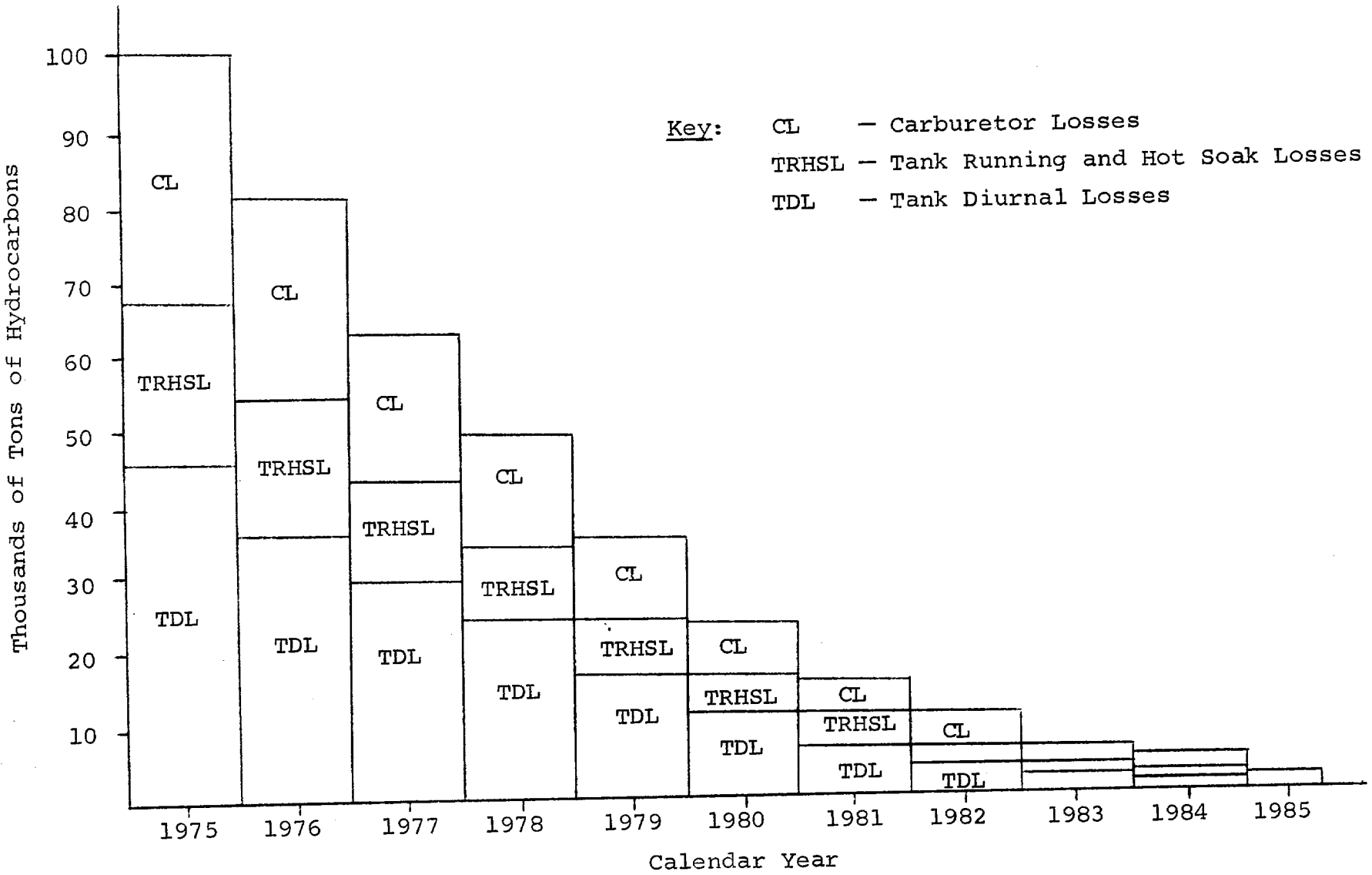

Figure 1-1. EVAPORATIVE EMISSIONS FROM PRE-1970 LIGHT-DUTY VEHICLES BY SOURCE

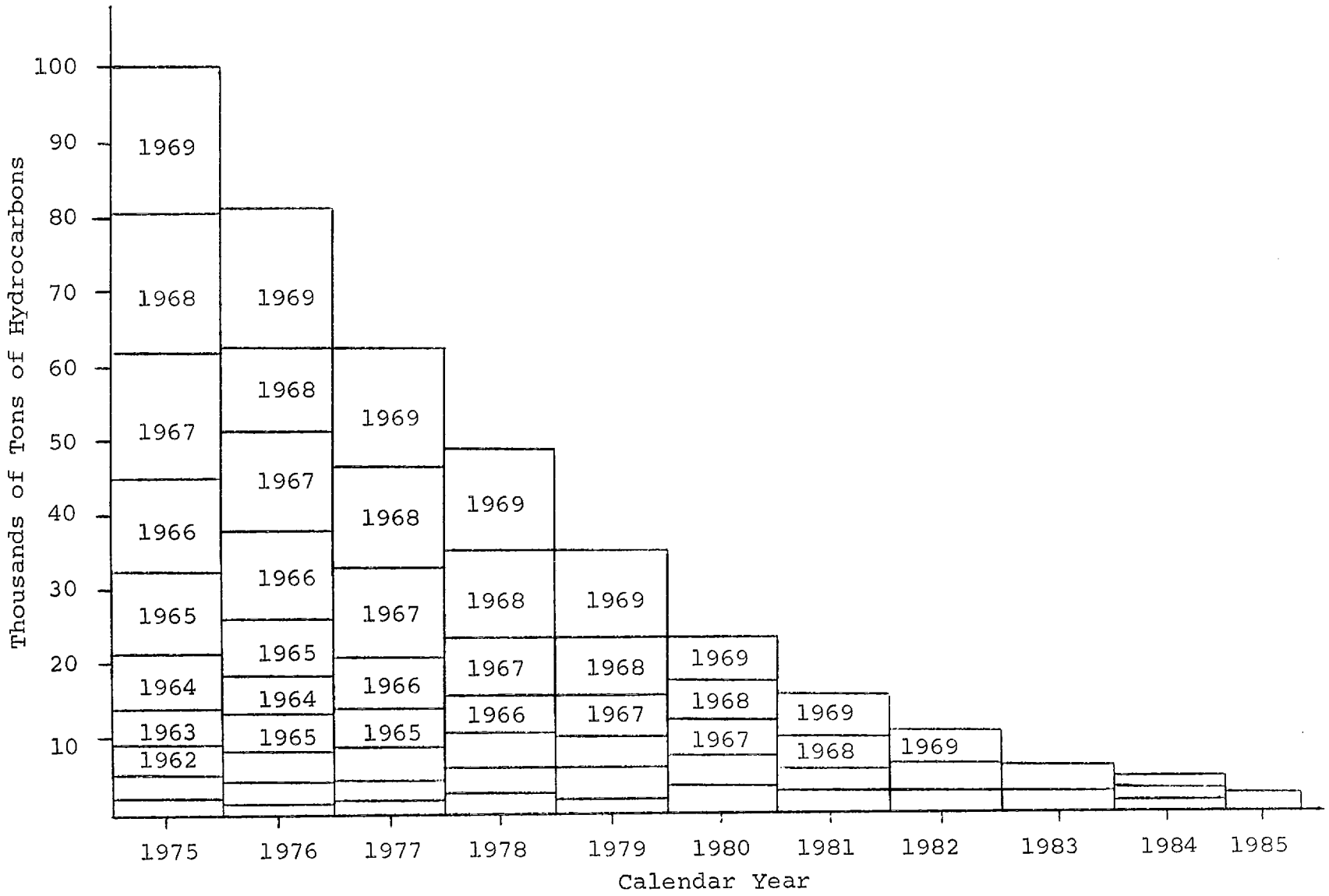

Figure 1-2. EVAPORATIVE EMISSIONS FROM PRE-1970 LIGHT-DUTY VEHICLES BY AGE GROUP

emissions from the pre-1970 vehicles as a function of age groups.

Many alternative methods of controlling evaporative emissions were evaluated. Table 1-1 lists the 11 basic approaches to limiting and containing carburetor and fuel tank vapor losses for light-duty vehicles. Besides evaluating the basic approaches, combinations of carburetor-fuel tank modifications were analyzed. The cost and effectiveness measures would be essentially additive for each of the combinations.

Table 1-2 lists the basic approaches to evaporative emission control for heavy-duty vehicles. The approaches are similar to those considered for the light-duty vehicles; however, the cost and effectiveness measures are different in most cases.

Results of the effectiveness and cost analyses indicated the following:

- The replacement of existing carburetors and/or fuel tanks with new production-type units is least cost effective. For the average vehicles, the cost would range from $170 to $330, depending on vehicle manufacturer.

- It is more cost effective to modify existing carburetors than it is to modify existing fuel tanks. Typical carburetor modifications would cost about $27 to $63; fuel tank modifications about $68 to $122.

- Of the various combined carburetor-fuel tank modifications, the most cost effective approach considered is to modify the existing carburetor

Table 1-1. BASIC APPROACHES TO EVAPORATIVE EMISSIONS CONTROL
(Pre-1970 Light-Duty Vehicles)

Alternate Approach	Vehicle Owner Average Costs[a]			Evaporative[b] Emission Controlled (pounds)	CE Index[c] ($/lb. HC)
	Parts	Labor	Total		
1. Install new internally vented fuel tank, fuel level sensing unit, vapor separator, overfill limiting valve, carbon canister, plumbing, pressure/vacuum relief filler cap.	$80 - $155	$30	$110 - $185	26	4.23 - 7.12
2. Modify existing externally vented fuel tank; add vented fuel level sensing unit, expansion chamber, vapor separator, overfill limiting valve, carbon canister, plumbing, pressure/vacuum relief cap.	55 - 91	$27 - $29	82 - 120	26	3.15 - 4.62
3. Modify existing fuel tank with vented filler tube extension; add vapor separator, overfill limiting valve, carbon canister, plumbing, pressure/vacuum relief cap.	63 - 93	13	76 - 106	26	2.92 - 4.08
4. Modify existing fuel tank with venting nipple welded to tank; add vapor separator, overfill limiting valve, carbon canister, plumbing, and pressure/vacuum relief cap.	53 - 90	30 - 32	83 - 122	26	3.19 - 4.69
5. Modify existing externally vented fuel tank; add vapor separator, overfill limiting valve, carbon canister, plumbing, and pressure/vacuum relief cap.	53 - 91	15 - 17	68 - 108	26	2.62 - 4.15
6. Install new internally vented carburetor; add adapter plate and hardware modifications.	50 - 131	10 - 15	60 - 146	17	3.53 - 8.59
7. Install rebuilt, internally vented carburetor; add adapter plate and hardware modifications.	31 - 77	10 - 15	41 - 92	17	2.41 - 5.41

Table 1-1 (continued)

Alternate Approach	Vehicle Owner Average Costs[a]			Evaporative[b] Emission Controlled (pounds)	CE Index[c] ($/lb. HC)
	Parts	Labor	Total		
8. Modify existing carburetor by venting fuel bowl to air cleaner; use modification kit including vent tube and hardware.	$12 - $ 13	$15 - $18	$ 27 - $ 31	17	1.59 - 1.82
9. Modify existing carburetor by venting fuel bowl to carbon canister used in fuel tanks vapor containment (Alternatives 1 to 5 above); use modification kit including vent tube, hose, and clamps	12 - 15	15 - 18	27 - 33	17	1.59 - 1.94
10. Modify existing carburetor by enclosing carburetor sides with shroud; use modification hardware.	16 - 21	15 - 20	31 - 41	17	1.82 - 2.41
11. Modify existing carburetor by replacing fuel bowl/air horn with internally vented bowl assembly; use retrofit kit.	19 - 35	20 - 28	39 - 63	17	2.29 - 3.71

[a] Vehicle owner average costs reflect the estimated range of values for all light-duty vehicles. Parts costs do not include State sales tax. Labor costs based on posted shop rate of $10 per hour. All costs in 1973 dollars.

[b] Evaporative emissions controlled based on a 1969 model-year vehicle, age 7 years old as of 1 January 1975, average miles driven 8,[illegible] miles, average trips 7.5 miles, total annual trips 1,145.

[c] Cost-effectiveness index expressed in unit-installed costs (dollars) divided by initial year emission reduction (pounds of hydrocarbon controlled).

Table 1-2. EVAPORATIVE EMISSION CONTROL FOR PRE-1970 GASOLINE-POWERED HEAVY-DUTY VEHICLES

Alternate Approach	Vehicle Owner Average Costs[a]			Evaporative[b] Emission Controlled (pounds)	CE Index[c] ($/lb. HC)
	Parts	Labor	Total		
1. Install new internally vented fuel tank, fuel level sensing unit, vapor separator, overfill limiting valve, carbon canister, plumbing, pressure/vacuum relief filler cap.	$125 - $155	$30	$155 - $185	40	3.88 - 4.63
2. Modify existing externally vented fuel tank, add vented fuel level sensing unit, expansion chamber, vapor separator, overfill limiting valve, carbon canister, plumbing, pressure/vacuum relief cap.	60 - 87	$27 - $29	87 - 116	40	2.18 - 2.90
3. Modify existing fuel tank with vented filler tube extension; add vapor separator, overfill limiting valve, carbon canister, plumbing, pressure/vacuum relief cap.	65 - 93	13	78 - 106	40	1.95 - 2.65
4. Modify existing fuel tank with venting nipple welded to tank; add vapor separator, overfill limiting valve, carbon canister, plumbing, and pressure/vacuum relief cap.	58 - 87	32	90 - 119	40	2.25 - 2.98
5. Modify existing externally vented fuel tank; add vapor separator, overfill limiting valve, carbon canister, plumbing, and pressure/vacuum relief cap.	58 - 87	17	75 - 104	40	1.88 - 2.60
6. Install new internally vented carburetor; add adapter plate and hardware modifications	43 - 121	10 - 15	53 - 136	39	1.36 - 3.49
7. Install rebuilt, internally vented carburetor; add adapter plate and hardware modifications.	31 - 77	10 - 15	41 - 92	39	1.05 - 2.36

Table 1-2 (continued)

Alternate Approach	Vehicle Owner Average Costs[a]			Evaporative[b] Emission Controlled (pounds)	CE Index[c] ($/lb. HC)
	Parts	Labor	Total		
8. Modify existing carburetor by venting fuel bowl to air cleaner; use modification kit including vent tube and hardware.	$ 12 - $ 13	$15 - $18	$ 27 - $ 31	39	0.69 - 0.79
9. Modify existing carburetor by venting fuel bowl to carbon canister used in fuel tank vapor containment (Alternatives 1 to 5 above); use modification kit including vent tube, hose, and clamps.	12 - 15	15 - 18	27 - 33	39	0.69 - 0.85
10. Modify existing carburetor by enclosing carburetor sides with shroud; use modification hardware.	16 - 21	15 - 20	31 - 41	39	0.79 - 1.05
11. Modify existing carburetor by replacing fuel bowl/air horn with internally vented bowl assembly; use retrofit kit.	19 - 35	20 - 28	39 - 63	39	1.00 - 1.61

[a] Vehicle owner average costs reflect the estimated range of values for all heavy-duty vehicles. Parts costs do not include State sales tax. Labor costs based on posted shop rate of $10 per hour. All costs in 1973 dollars.

[b] Evaporative emissions controlled based on a 1969 model-year vehicle, age 7 years old as of 1 January 1975, average miles drive 10,400 miles, average trips 4 miles, total annual trips 2,600.

[c] Cost-effectiveness index expressed in unit-installed-costs (dollars) divided by initial year emission reduction (pounds of hydrocarbon controlled).

by venting or enclosing all external outlets and directing the vapors to a container (air cleaner housing or carbon canister). The fuel tank is modified by enclosing all external vents, providing vents with vapor transfer lines and a vapor separator, replacing the vented filler cap with a pressure/vacuum relief cap, and collecting the vapors in the canister.

- It would cost the light-duty vehicle owner from $103 to $151 to modify the existing carburetor-fuel tank system, depending on vehicle manufacturer. The vehicle age has relatively little effect on cost, unless the components to be modified are in need of repairs prior to modification.

- In most cases, retrofitting or modifying the heavy-duty vehicles would cost more than for light-duty vehicles for similar emission control approaches. On the average, it would cost the heavy-duty vehicle owner from $105 to $160 to modify the existing carburetor and fuel tank for evaporative emission control.

- The modification of heavy-duty vehicles is more cost effective than similarly modified light-duty vehicles. Heavy-duty vehicles are driven more frequently on shorter trips and they are operated (expected useful lifetime) for a longer duration. A typical light-duty vehicle averages four trips per day with an average distance travelled of 7 miles per trip. Conversely, a typical heavy-duty vehicle averages 11 trips per day with an average distance of 4 miles per trip. Less than

2 percent of the light-duty vehicles registered are 15 years or older. However, of the heavy-duty vehicles, more than 9 percent are 15 years or older.

- Evaporative emission control devices are usually more cost effective in air basins with warmer climates.

SECTION 2

EMISSION SOURCES AND CONTROL

This section identifies the sources of vehicle evaporative emissions, quantifies the number of pre-1970 model vehicles that may be affected by a retrofit control program, and describes the evaporative control approaches used on 1970-and-newer vehicles. The various emission control techniques then are evaluated for applicability to pre-1970 model vehicles.

2.1 EVAPORATIVE EMISSION SOURCES

Automotive gasolines as used to fuel internal combustion, spark-ignition engines are essentially blends of hydrocarbons derived from petroleum (Ref. 1). These gasolines are blended to satisfy diverse automobile requirements. Additives sometimes are used to provide or enhance specific performance features. One of the prime characteristics of automotive gasoline is its volatility, or the tendency to vaporize and change from a liquid to a gaseous state.

Because gasoline is a mixture of many hydrocarbons, it does not have a single boiling point, and its vaporization is characterized by a series of temperatures at which various percentages of the liquid have evaporated. With increasing temperature, more hydrocarbons are evaporated. In a vehicle fueling system, these evaporative emissions occur continuously and are aggravated by temperature increases experienced by the vehicle as a result of engine operation and ambient environmental factors.

2.1.1 Carburetor Losses

Modern carburetors are designed with the float bowl vented either internally to the throat, externally to the atmosphere, or a combination of both (refer to Figure 2-1). This is done to relieve the internal pressure that results from the evaporation of the gasoline while the carburetor is hot. If no vents were provided, then the pressure used to meter the fuel to the engine would be exceeded. Consequently, a carburetor adjusted at one temperature would not meter correctly at other temperatures.

Carburetors vented internally represent a method of capturing the evaporative losses. However, the accumulation of vapors represents added fuel which may lead to hot starting difficulty, stalling or engine roughness during idle (Ref. 2). This early investigation (1958) into carburetor evaporation losses showed that, in general, carburetor losses increase with increasing carburetor bowl temperature and fuel volatility; but vehicle driving speed itself had no significant effect on these operating losses.

During extended city driving, however, the carburetor bowl temperatures are high enough to boil away a considerable portion of fuel. Hot-weather idling for prolonged periods tends to increase engine temperature resulting in further fuel evaporation.

Immediately after engine shutdown, the stored engine heat is dissipated to the surroundings. With an enclosed engine compartment, temperature rises of 60 to 70 degrees Farenheit are typical. The result is that residual fuel in the carburetor bowl is boiled off. The major portion of these hot soak losses, on the order of eight grams of hydrocarbons, occur during the first 30 minutes after complete shutdowns (Ref. 2).

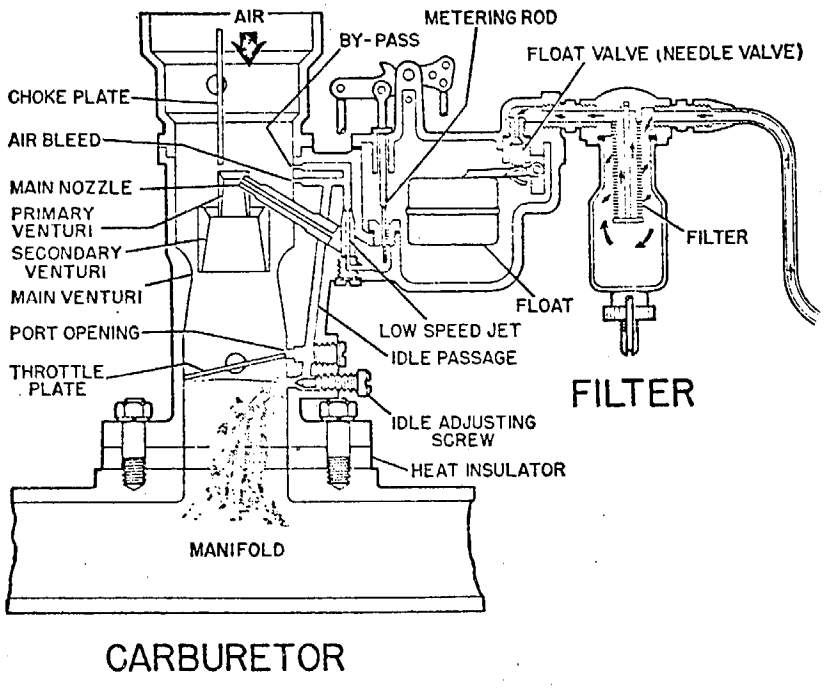

Figure 2-1. CARBURETOR VENTS

The Coordinating Research Council (CRC) concluded in a 1965 study that numerous other vapor leaks must be contended with when attempting to trap carburetor evaporative emissions. Among the sources are bowl idle vent, air horn opening, throttle and choke shafts, hot-start vents, and idle adjust screws (Ref. 3). Another investigation into the factors affecting carburetor losses supported the 1958 study previously mentioned. This subsequent study reported in 1960 (Ref. 4) showed that vapor losses are affected by carburetor bowl temperature, carburetor vent design, fuel volatility, and vehicle driving pattern. For carburetors designed with external vents, a positive pressure differential may occur across the vents during low cruising speeds and extended idling periods leading to losses. However at higher cruising speeds, this pressure differential tends to become negative thereby preventing vapor losses.

2.1.2 Fuel Tank Losses

Evaporative losses from the vehicle fuel tank occur as a result of temperature increases caused by vehicle movement (fuel agitation), ambient temperature cycle (diurnal variations), pavement radiation and heat transfer (from engine compartment to fuel system components). The amount of vapor loss is a function of: 1) vehicle factors including tank temperature, vapor volume, tank pressure, and liquid-vapor equilibration rate; and 2) fuel factors including vapor pressure, molecular weight, and density (Ref. 5). Previous investigations have estimated the fuel tank losses to be about 30 grams per day for a typical uncontrolled vehicle (Ref. 6).

Fuel tanks on vehicles not equipped specifically to control evaporative emissions include one or more of the following methods to prevent pressure/vacuum build-up caused by fuel and vapor expansion: atmospheric vent lines, anti-surge pressure

relief tank cap, or vented caps. These relief mechanisms also act as escape routes for the hydrocarbon vapors.

2.2 CANDIDATE RETROFIT VEHICLES

The study objective is to determine the feasibility of equipping pre-1970 light and heavy-duty vehicles with evaporative control devices installed on a retrofit basis. The following paragraphs define the number of vehicles that may be affected by a retrofit program, the approximate model-year vehicle mix, the geographical distribution of these vehicles as a function of intrastate air quality control region, and the physical characteristics of these vehicles in terms of carburetion and fuel containment system elements that may be modified to effect evaporative emission control.

2.2.1 Pre-1970 Light-Duty Vehicles

As of January, 1973, there were 10,745,000 automobiles and 1,945,000 trucks registered in California according to the Department of Motor Vehicles (Ref. 7). Data purchased from the Rueben H. Donnelley Corporation showed that for 1972 registrations, 6,577,000 vehicles were privately owned (Ref. 8) leaving roughly 4.2 million vehicles owned by businesses and government agencies.

The DMV does not compile registration data to show the model year distribution for vehicles-in-use. Data from R. H. Donnelley included model year distribution for the registration year 1972 for models 1962 to 1972, but only for privately-owned vehicles. Thus, some analysis was required to establish the number of vehicles of pre-1970 vintage. Appendix A includes the details of the analysis. Table 2-1 summarizes the estimated vehicle population of pre-1970 light-duty vehicles registered during 1973.

Table 2-1. ESTIMATED JANUARY, 1973, AUTOMOBILE REGISTRATION AND DISTRIBUTION*

Model Year	Vehicle Age	Total Registered	Cumulative Total	Percent of 1/73 Total	Cumulative 1/73 Total	Percent of Pre-1970	Cumulative Pre-1970
1972	1	995,800	995,800	9.27	9.27		
1971	2	1,140,900	2,136,700	10.62	19.89		
1970	3	1,056,300	3,193,000	9.83	29.72		
1969	4	1,115,000	4,308,000	10.38	40.10	14.8	14.8
1968	5	1,076,000	5,384,000	10.01	50.11	14.2	29.0
1967	6	951,700	6,335,700	8.86	58.97	12.6	41.6
1966	7	943,300	7,279,000	8.78	67.75	12.5	54.1
1965	8	938,100	8,217,100	8.73	76.48	12.4	66.5
1964	9	767,600	8,984,700	7.14	83.62	10.2	76.7
1963	10	559,500	9,554,200	5.21	88.83	7.4	84.1
1962	11	405,900	9,950,100	3.78	92.61	5.4	89.5
1961	12	246,600	10,196,700	2.29	94.90	3.3	92.8
1960	13	192,300	10,389,000	1.79	96.69	2.5	95.3
1959	14	113,800	10,502,800	1.06	97.75	1.5	96.8
1958	15	64,000	10,566,800	0.60	98.35	0.8	97.6
1957 & Older	>15	180,000	10,746,800	1.67	100.02	2.4	100.0

* See Appendix A for details.

Of the 10,746,800 automobiles registered in California, 30 percent, or 3,193,000, are 1970-and-newer vehicles. The remaining 70 percent, or 7,553,800, are of pre-1970 vintage. Recognize, of course, that the proportional contribution of pre-1970 vehicles to the total population decreases with each year.

As of January, 1973, the 1968 to 1969 model years comprise 29 percent of all pre-1970 vehicles and the 1966 to 1967 models, 25 percent. Together, the 1966 to 1969 models constitute 54 percent of the pre-1970 models. With each succeeding year, these models' proportion of pre-1970 vehicles becomes greater because of the attrition of the older models.

The 1964 to 1965 models comprise 22 percent of the pre-1970 model population; however, the 1962 to 1963 models only total 12 percent. Thus, the six model years of 1964 to 1969 constitute three-quarters of the pre-1970 models registered. With the addition of the 1962 to 1963 models to the 1964 to 1969 models, roughly 90 percent of the pre-1970 vehicles are included. In other words, vehicles manufactured in 1961 or previously comprise about 10 percent of the pre-1970 population. With respect to the overall California automobile population, the 1961-and-older models comprise about 5 percent of all automobile registrations.

2.2.2 Pre-1970 Heavy-Duty Vehicles

As was mentioned earlier, as of January 1973, a total of 1,945,000 trucks were registered in California. Data purchased from the Reuben H. Donnelly Corporation showed that 1,108,847 privately-owned trucks were registered in 1972, or 57 percent of the total truck registration.

Similar to light-duty vehicles, registration data as a function of model year distribution does not exist. For heavy-duty

vehicles, only registrations by gross vehicle weight (GVW) as a function of county population are available. Consequently, some data analysis and interpretation of historical information was essential to arrive at the vehicle model year and manufacturer distribution. This analysis is included in Appendix B.

Table 2-2 shows the gasoline-powered truck distribution as of January 1973 for 1,854,600 trucks. The diesel truck registrations were subtracted from the total registrations as a function of previous years' new-truck registration data. The entries show that as of January 1973, excluding 1973 models, 28 percent of the gasoline-powered trucks were 1970-and-newer models.

Of the pre-1970 trucks, the 1966 to 1969 models comprise 40 percent of the total. Roughly two-thirds, or 66 percent of pre-1970 trucks, are of model years 1963 to 1969. A large number of trucks, roughly 13 percent of the pre-1970 models, are older than 15 years.

Table 2-3 shows the truck distribuion as a function of model year and GVW, as determined in Appendix B. Trucks with GVW under 6000 pounds (Class 1) have maintained a fairly uniform distribution of roughly 60 percent of total sales. Trucks with GVW between 6,000 and 10,000 pounds (Class 2) slowly increased from 16 percent of total sales during the late 1950s to 18 percent in 1968. However, since 1969, these trucks have averaged about 22 percent of sales. The next higher GVW category, (Class 3) including 10,000 to 19,500 pound trucks, have experienced a sharp decline in the percentage of truck registrations since 1969, averaging about 8.5 percent previous to the 1969 and 4.5 percent since then. Trucks in the 19,501 to 26,000 pound category (GVW Class 4) have maintained a relatively uniform percentage of total registrations, remaining at about 6.8 percent during the last 15 years. Heavy-duty trucks in the

Table 2-2. JANUARY 1973 GASOLINE-POWERED TRUCKS DISTRIBUTION *

Model Year	GP Trucks Estimated	Percentage		Pre-1970 Percentage	
		Simple	Cumulative	Simple	Cumulative
1972	172,200	9.29	9.29	--	--
1971	167,700	9.04	18.33	--	--
1970	179,400	9.67	28.00	--	--
1969	168,900	9.11	37.11	12.65	12.65
1968	129,600	6.99	44.10	9.71	22.36
1967	116,300	6.27	50.37	8.71	31.07
1966	124,000	6.72	57.09	9.33	40.40
1965	126,900	6.84	63.93	9.50	49.90
1964	123,200	6.64	70.57	9.23	59.13
1963	96,200	5.19	75.76	7.20	66.33
1962	80,200	4.32	80.08	6.01	72.34
1961	57,900	3.12	83.20	4.34	76.68
1960	58,600	3.16	86.36	4.39	81.07
1959	48,800	2.63	88.99	3.65	84.72
1958	29,500	1.59	90.58	2.21	86.93
1957 & Older	174,600	9.41	99.99	13.08	100.01
Total	1,854,600				

* See Appendix B for details.

Table 2-3. ESTIMATED TRUCK DISTRIBUTION BY GROSS VEHICLE WEIGHT *

Vehicle Model Year	Estimated Truck Registration as of 1/1/73	Estimated Distribution (Units/Percent)				
		< 6,000 Pounds	6,001-10,000 Pounds	10,000-19,500 Pounds	19,501-26,000 Pounds	26,001 Pounds
1972	182,000	111,000 61.0%	40,800 22.4%	6,900 3.8%	12,400 6.8%	10,900 6.0%
1971	177,500	108,500 61.1%	40,100 22.6%	6,200 3.5%	11,500 6.5%	11,200 6.3%
1970	190,800	111,800 58.6%	43,500 22.8%	8,000 4.2%	14,100 7.4%	13,400 7.0%
1969	179,700	106,200 59.1%	39,300 21.9%	9,000 5.0%	13,300 7.4%	11,900 6.6%
1968	136,400	83,500 61.2%	24,000 17.6%	12,300 9.0%	8,600 6.3%	8,000 5.9%
1967	123,100	75,000 60.9%	21,200 17.2%	10,900 8.9%	8,000 6.5%	8,000 6.5%
1966	132,000	79,600 60.3%	22,800 17.3%	11,900 9.0%	8,600 6.5%	9,100 6.9%
1965	133,200	81,900 61.5%	22,100 16.6%	12,900 9.7%	8,000 6.0%	8,300 6.2%
1964	128,700	79,400 61.7%	21,500 16.7%	11,100 8.6%	8,500 6.6%	8,200 6.4%
1963	100,100	61,700 61.6%	16,400 16.4%	8,500 8.5%	6,700 6.7%	6,800 6.8%
1962	83,200	49,400 59.4%	13,600 16.4%	7,100 8.6%	5,700 6.9%	7,400 8.9%
1961	59,400	34,900 58.8%	9,500 16.0%	5,000 8.4%	4,200 7.0%	5,800 9.7%
1960	60,100	35,600 59.3%	9,600 16.0%	5,100 8.4%	4,100 6.8%	5,700 9.5%
1959	50,300	29,900 59.4%	8,000 16.0%	4,200 8.4%	3,400 6.7%	4,800 9.5%
1958	30,300	18,000 59.4%	4,800 15.9%	2,500 8.3%	2,100 6.8%	2,900 9.6%
1957 & Older	180,000	108,400	32,600	13,500	12,100	13,400
Totals	1,946,800	1,174,800	369,800	135,100	131,300	135,800

* See Appendix B for details.

26,001-pound-and-over category (GVW Class 5), decreased in percentage of sales from a high of 9.6 percent in 1958 down to 6.8 percent in 1962. Subsequent years have shown relatively stable percentage registrations at about 6.3 percent of total trucks.

As of January 1973 registrations, the pre-1970 trucks distribution as a function of GVW class were as follows: Class 1, 60.5 percent; Class 2, 17.6 percent; Class 3, 8.2 percent; Class 4, 6.6 percent; and Class 5, 7.1 percent.

2.2.3 Vehicle Distribuion by Air Basin

The State of California is divided into 11 air basins. Table 2-4 shows the estimated number of gasoline-powered, light and heavy-duty vehicles registered in each region as of January 1973.

2.3 EVAPORATIVE EMISSION CONTROL SYSTEMS

A simplified description of the events on evaporative emission controlled vehicles are vapor generation, vapor recovery, vapor storage, and vapor disposal (Ref. 4). On vehicles with evaporative emission controls, the losses during engine shut-down are recovered and stored for subsequent consumption during engine start up. Losses that occur during engine operation are contained and consumed during the operating period.

Evaporative emissions from the fuel tank are eliminated by sealing the tank and conducting fuel vapors to a storage container. To protect the fuel tank structure from damage caused by pressure or vacuum resulting from system malfunction, vehicles are equipped with fuel tank filler caps incorporating pressure and vacuum relief valves.

Table 2-4. VEHICLE POPULATION BY AIR BASIN

Air Basin		Light Duty		Heavy Duty	
Number	Designation	Quantity	% Total	Quantity	% Total
1	South Coast	5,532,400	51.48	796,200	40.9
2	San Francisco Bay Area	2,336,400	21.74	402,900	20.7
3	San Joaquin Valley	828,600	7.71	262,800	13.5
4	Sacramento Valley	608,300	5.66	183,000	9.4
5	San Diego	672,800	6.26	116,800	6.0
6	Southeast Desert	347,100	3.23	56,400	2.9
7	North Central Coast	188,100	1.75	44,800	2.3
8	South Central Coast	99,900	0.93	21,400	1.1
9	North Coast	95,600	0.89	40,900	2.1
10	Northeast Plateau	27,900	0.26	15,600	0.8
11	Great Basin Valley	9,700	0.09	5,800	0.3
	Totals	10,746,800	100.00	1,946,600	100.0

Evaporative emission controls on some 1970 and newer vehicles include a modified fuel tank incorporating vapor vent lines and an inner thermal expansion tank. Both design features are necessary to accommodate liquid and vapor expansion resulting from temperature increases. A vapor separator is required to contain momentary surges, and to provide a dwell time and volume for the separation of liquid from vapor (Ref. 9).

Vapors leaving the separator are routed to a storage container, either the crankcase (Ref. 9) or a canister mounted in the engine compartment as in General Motors' Evaporation Control System (Ref. 10).

Carburetor vapor is controlled by venting to the crankcase air cleaner element, as in Chrysler's Vapor Saver System or to the canister as in some General Motors vehicles.

Additional control of carburetor vapor is achieved by including a lower temperature coolant thermostat leading to a reduction of the carburetor hot-soak environment, or the installation of an insulating gasket and radiant shield under the carburetor (Ref. 10).

2.3.1 Evaporative Emission Control Configurations

The 1970 to 1973 vehicles employ a closed evaporative emission control system to prevent vapor generated during diurnal temperature variations, fuel tank venting and carburetor venting from escaping into the atmosphere. Appendix C includes the detailed configuration information on the domestic and foreign vehicles of model years 1970 to 1973.

All vehicle fuel tanks are sealed units with pressure/vacuum relief filler caps. In order to provide for thermal expansion of fluid and the vapor generated during temperature increases, manufacturers have installed expansion chambers or additional but smaller tanks. The vapor generated is vented from the tank and directed to a vapor-liquid separator. The two-way filler cap allows air to enter the tank as the fuel and/or vapor is consumed.

American Motors uses two vent lines diagonally opposed; and General Motors uses three vent lines with two in the corner and one centered. Another GM configuration is two vents in the front and one located to the rear of the tank. Both Ford Motors and Chrysler Corporation use four vent lines, one in each top corner. The fuel tank capacity does not appear to affect the number of vents, tank vapor storage device, expansion chamber configuration, or carburetor vapor storage device.

The vapor vent lines are directed to a common point where either a check valve or a liquid separator prevents liquid from entering the vapor storage device. Collected liquid is returned to the fuel tank, and the vapor is directed to either the engine crankcase or a carbon canister. Vehicles that use a liquid separator also utilize an overfill limiting valve which is placed between the separator and the storage device. This valve normally is open allowing only vapor to pass. Should the fuel tank and separator become overfilled, the valve closes preventing liquid from entering the storage device.

In 1970, American Motors and Chrysler used the engine crankcase to store the vapors, Ford Motor used a 350-gram carbon canister on most cars, with a few using the crankcase. General Motors

used two sizes of carbon canisters, 300 grams for the smaller lighter vehicles and 625 grams for the standard size.

American Motors in 1971 switched to carbon canisters for vehicles equipped with V8 and automatic transmission. However, vehicles with 6-cylinder engines continued to use the crankcase for vapor storage. Similarly, Chrysler Corporation continued to use the crankcase for all vehicles.

Both Ford and General Motors continued to use the carbon canisters in 1971, 1972, and 1973. Carbon canister capacity in general increased during these years to about 700 grams for all vehicles regardless of size, engine, or transmission. Chrysler Corporation switched to carbon canisters for 1972 and newer vehicles.

Vapors vented from the carburetor are directed to either the air cleaner, the carbon canister, or the engine crankcase. Generally, vehicles that directed fuel tank vapors to the crankcase did the same with carburetor vapors. Likewise, those that used carbon canisters for fuel tank vapors did so for carburetor vapors. Ford Motors vents the carburetors to the closed air cleaner housing.

2.4 CANDIDATE RETROFIT APPROACHES

The previous paragraphs have identified the primary sources of evaporative emissions as the carburetor and the fuel tank. Evaporative emission control systems, as incorporated in 1970 to 1973 light-duty vehicles, were determined and defined to establish feasible approaches to retrofitting pre-1970 light- and heavy-duty vehicles. In the following discussions, various

retrofit concepts for limiting and controlling evaporative emissions are provided.

2.4.1 Fuel Tank Modifications

Fuel tanks on vehicles without evaporative emission control are vented to the atmosphere. The vents are necessary to relieve the pressure caused by the vapor generated and the fuel expansion resulting from temperature increases. In order to effect a vapor control system, these external vents must be sealed off from the atmosphere, and vapors that emanate must be contained. Appendix D tabulates the types of fuel tank filler caps used on pre-1970 light-duty vehicles. Various approaches were considered for retrofitting the pre-1970 vehicles. Basically, these concepts can be categorized into: (1) total replacement with new configuration; or (2) partial modification to existing configuration. Five basic approaches were deemed feasible based on the evaluation of existing pre-1970 vehicle fuel tanks. Cost estimate ranges are derived and detailed in Appendix G, Pre-1970 Light-Duty Vehicle Retrofit Cost Estimates.

- Approach 1 — Install a new, updated fuel tank primarily designed for control of fuel vapor evaporative emissions. Average cost ranges from $109 to $187 depending on make and model, and includes a new fuel tank, fuel-level sending unit, liquid/vapor separator, overfill limiting valve, pressure/vacuum relief filler cap, carbon canister and vapor collection lines. This approach is applicable to all vehicles.

- Approach 2 — Modify the original fuel tank with a vent tube on the fuel level sending unit. Average cost ranges from $82 to $120 and includes liquid/vapor separator, overfill limiting valve, pressure/vacuum relief filler cap, carbon canister and vapor collection lines. Applicable to the large majority of vehicles, see Appendix M.
- Approach 3 — Modify the original fuel tank with a vented filler tube extension. Average cost ranges from $82 to $100 and includes liquid/vapor separator, overfill limiting valve, pressure/vacuum relief filler cap, carbon canister and vapor collection lines. Applicability same as Approach 2.
- Approach 3 alternate — Modify the original fuel tank with a side-vented pressure/vacuum filler cap. Average cost ranges between $80 and $110 and includes liquid/vapor separator, overfill limiting valve, carbon canister and vapor collection lines. Applicability same as Approach 2.
- Approach 4 — Connect originally vented tank to vapor storage unit. Average cost ranges between $84 and $122 and includes vent tube, liquid/vapor separator, overfill limiting valve and canister. Applicability same as Approach 2.
- Approach 5 — Modify original fuel tank by inserting tank vent line and connecting a liquid/vapor separator, overfill limiting valve, canister, and vapor collection

lines to close the system. Average cost ranges between $69 and $107. Applicability about 20% of vehicles. See Appendix M.

Approach 1 involves removing the original fuel tank and replacing it with a newer-type tank. The production, post-1970 vehicle fuel tanks were designed to control evaporative emissions. They incorporate an integral fuel expansion chamber or an external smaller tank to provide an air displacement area for normal fuel expansion caused by temperature changes. The tank filler cap incorporates a two-way relief valve that is normally closed under operating conditions. The newer tanks are less likely to suffer damage and fuel spillage due to vehicle collision or rollover. A typical post-1970 vehicle fuel tank is illustrated in Figure 2-2.

A vapor vent tube modification on the fuel-level sending unit of the original fuel tank does not alter the design factors or the integrity of the tank. However, the occurrence of liquid fuel losses are frequent and are greater than in the post-1970 designed fuel system. The vented sending unit modification identified as Approach 2 is illustrated in Figure 2-3.

A vented filler tube extension, defined in Approach 3, could be attached readily to the original filler neck of the vehicle and connected to an evaporative emission control system. A disadvantage is that unwanted fuel flow to the system could occur due to fuel expansion and certain vehicle parking attitude. The vented filler tube extension is illustrated in Figure 2-4.

A modified, side-vented pressure/vacuum filler cap for the original fuel tank would vent the fuel tank vapors under controlled conditions. However, the filler tube tank inlet must be above the existing liquid fuel level in the tank. Fuel flow to the

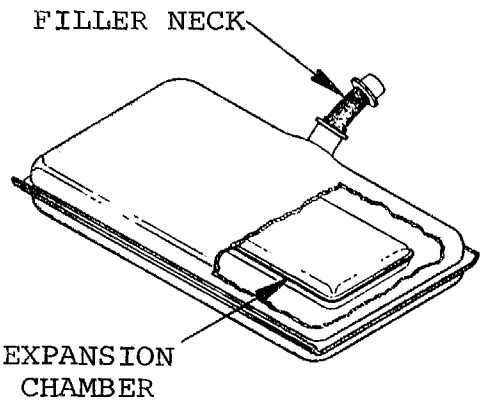

Figure 2-2. TYPICAL POST-1970 FUEL TANK

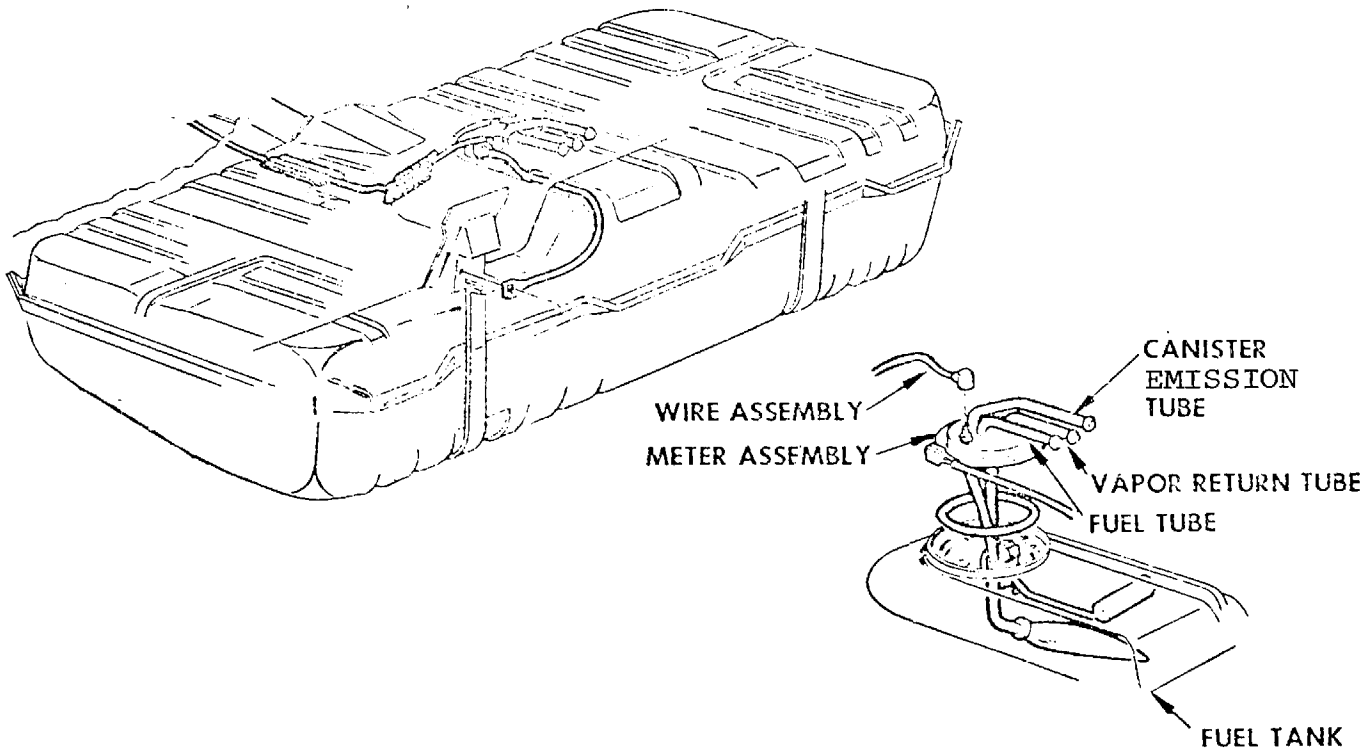

Figure 2-3. VENTED SENDING UNIT MODIFICATION

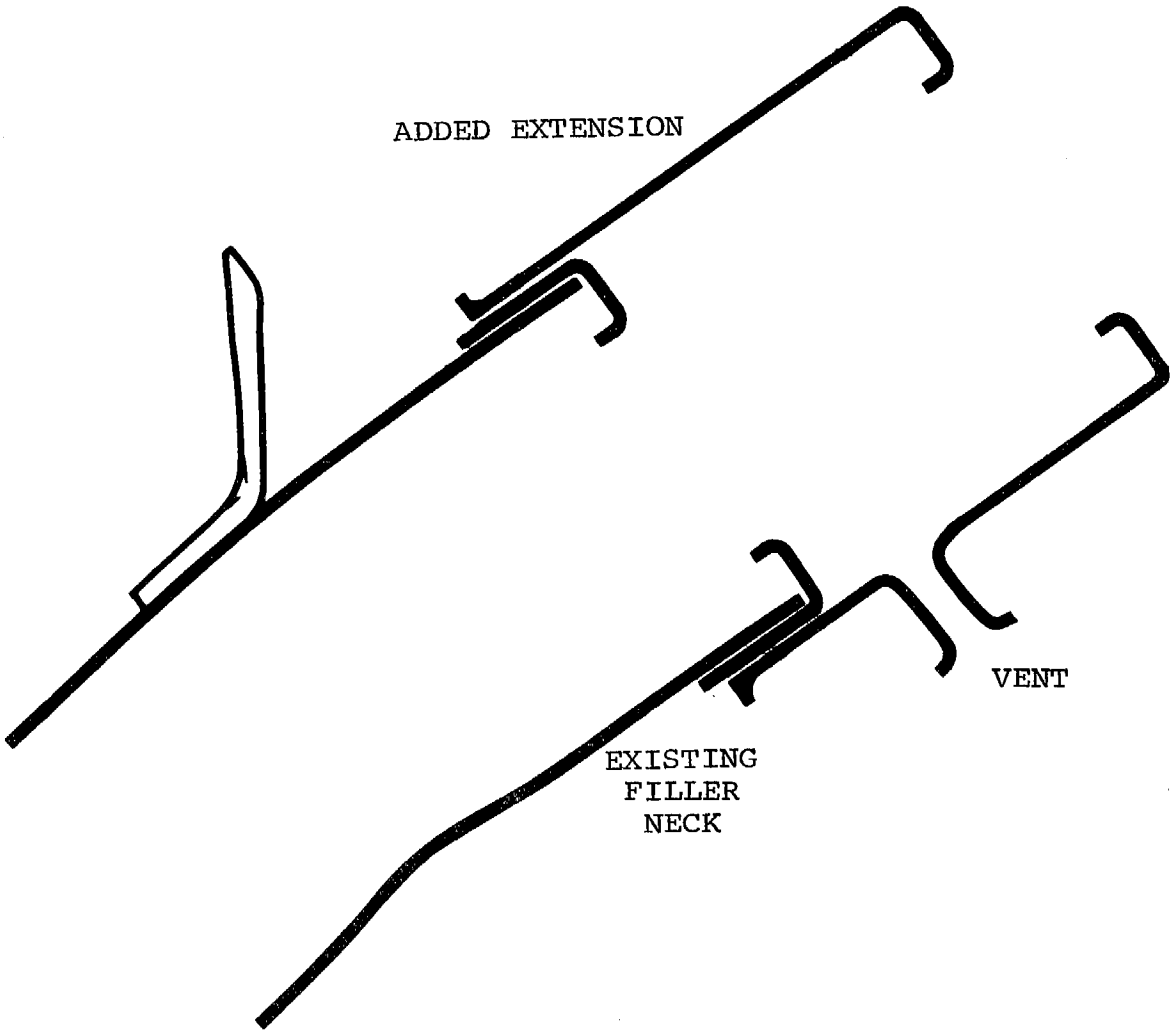

Figure 2-4. FILLER TUBE MODIFICATION

system could occur due to fuel expansion and improper vehicle parking attitude. The vented filler cap modification identified as Approach 3A, is illustrated in Figure 2-5.

A new vent tube could be welded to the top of the fuel tank above the normal fuel level. As described in Approaches 4 and 5, the tank vent would then be attached to a vapor collection and storage system. Fuel flow to the system would be inhibited by a liquid/vapor separator installed above the maximum expected fuel level of the vehicle tank. This modification is illustrated in Figure 2-6. Some vehicle fuel tanks have existing vents that would be routed to the liquid/vapor separator and tied into a vapor storage system.

Table 2-5 summarizes the fuel tank retrofit approaches.

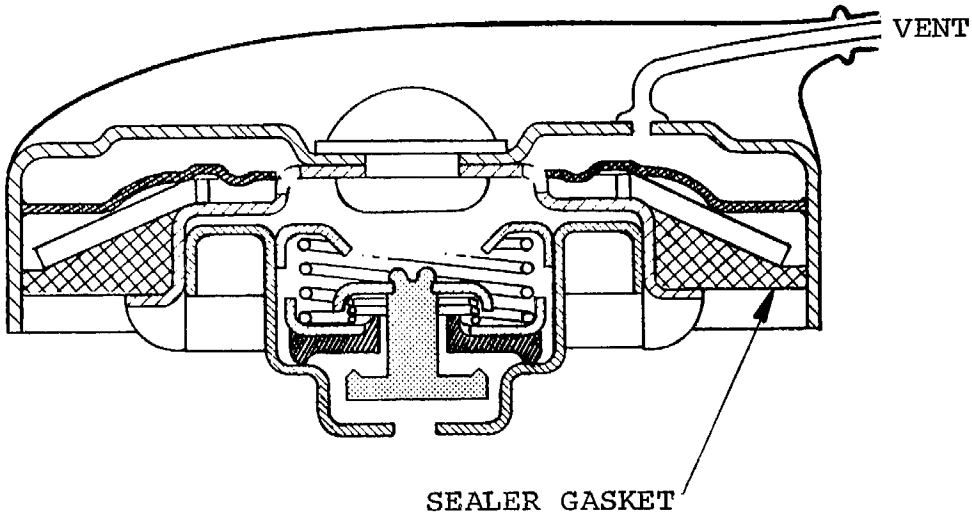

Figure 2-5. FILLER CAP MODIFICATION

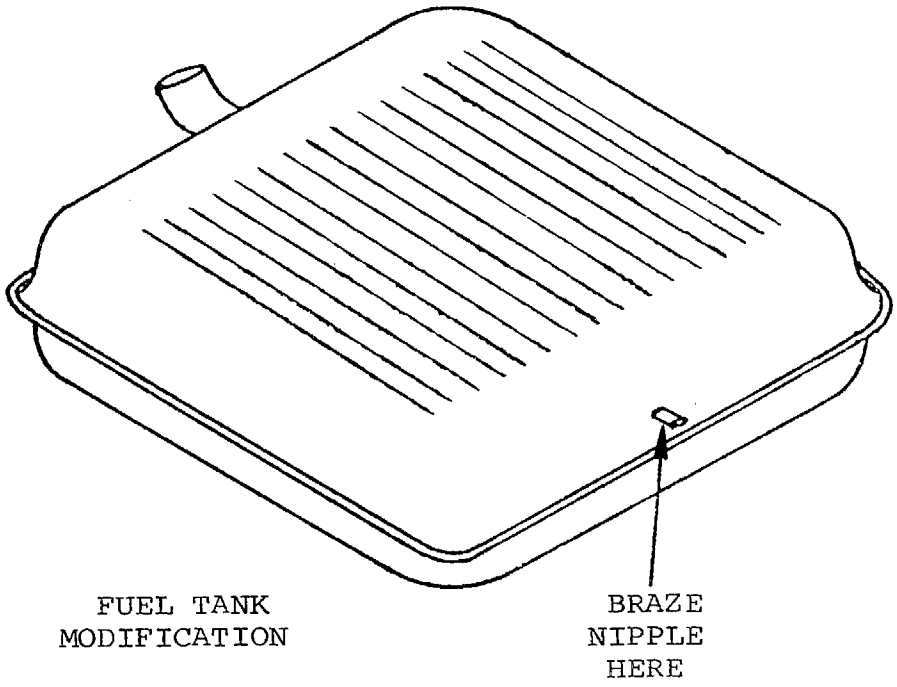

Figure 2-6. MODIFIED VENTED FUEL TANKS

Table 2-5. FUEL TANK LOSS CONTAINMENT
CANDIDATE RETROFIT CONCEPT SUMMARY

Concept	Description	Discussion
Updated Fuel Tank Fuel Sending Unit Liquid/Vapor Separator Overfill Limiting Valve Carbon Canister (Alternative 1)	The fuel tank design provides a vapor space above the fuel level. The vapor separator and overfill limiting valve prevents outflow of liquid fuel to carbon canister.	A closed fuel tank evaporative emission control system. Improved safety factor. Maximum parts and labor cost.
Vehicle Original Fuel Tank Vent Tube on Fuel Sending Unit Liquid/Vapor Separator Overfill Limiting Valve Carbon Canister (Alternative 2)	Vent tube modification of existing fuel tank/sending unit. Raw fuel vapors pass through vapor separator, overfill limiting valve and are absorbed in the carbon canister.	A closed fuel tank system modification for evaporative emission control. Replacement of fuel tank unnecessary. Pressure/vacuum filler cap required. Possibility of fuel losses due to vehicle parking attitude and fuel expansion with rising temperatures
Vehicle Original Fuel Tank Side vented pressure/vacuum filler cap Liquid/Vapor Separator Overfill Limiting Valve Carbon Canister (Alternative 3)	A vent tube modification to a pressure/vacuum filler cap. Raw fuel vapors are vented via the filler tube to the liquid/vapor separator then to the overfill limiting valve and are absorbed in the the carbon canister.	A closed fuel tank system modification. Reduced labor and parts cost. Possibility of fuel losses due to improper vehicle parking attitude and fuel expansion with rising temperatures. Readily damaged in vehicle accident.

Table 2-5. (Continued)

Concept	Description	Discussion
Vehicle Original Fuel Tank Vented Filler Tube Extension Liquid/Vapor Separator Overfill Limiting Valve Carbon Canister (Alternative 3 Alternate)	Vented filler tube modification of existing fuel tank. Raw fuel vapors are vented via the filler tube to the liquid/vapor separator then to the overfill limiting valve and are absorbed in the carbon canister.	A closed fuel tank system modification. Reduced labor and parts cost. Possibility of fuel losses due to improper vehicle parking attitude and fuel expansion with rising temperatures. Readily damaged in vehicle accident.
Vehicle Original Fuel Tank Vent Tube Welded onto Tank Liquid/Vapor Separator Overfill Limiting Valve Carbon Canister (Alternative 4)	Fuel tank vent modification of existing tank. Raw fuel vapors are vented directly from the tank to the fuel expansion chamber (liquid/vapor separator) then to the overfill limiting valve and are absorbed in the carbon canister.	A closed fuel tank system modification. Reduced parts cost only. Possibility of fuel losses due to improper vehicle parking attitude and fuel expansion with rising temperatures.
Original Vented Fuel Tank Liquid/Vapor Separator Overfill Limiting Valve Canister Filler Cap (Alternative 5)	Tank vent on existing vehicle fuel tank used for connection to vapor separator, overfill limiting valve, and carbon canister.	A closed fuel tank evaporative emission system. Reduced labor and parts cost. Susceptible to fuel losses due to improper vehicle parking attitude and fuel expansion with rising temperatures.

2.4.2 Carburetor Modifications

Carburetors on pre-1970 vehicles typically are vented externally to the atmosphere. There are several methods to controlling the vapors emanating from these vents. As in the fuel tank retrofit approaches, there are two categories of carburetor modifications: (1) replace existing carburetors with new, internally-vented carburetors; and (2) modify existing carburetor components to effect internal venting. An evaluation of the existing carburetor configurations used on pre-1970 vehicles have resulted in six concepts that appear to be feasible retrofit approaches. Carburetor analysis and results are included in Appendixes E and F. Retrofit cost estimates for the pre-1970 vehicles are detailed in Appendix G.

As noted in Appendix E, a large proportion of the 1955 to 1960 carburetors were internally vented. In the 1960s, the trends were toward lower profile vehicles, greater engine displacements, and a general lowering of the engine compartment hood. The carburetor and air cleaner housing were lowered without a corresponding lowering of the engine within the compartment. Two of the major problems encountered during this period were vapor locking and hot starting difficulties. To alleviate these problems, external venting was used on many carburetors on later models.

Appendix F lists the carburetor models for the various model-year vehicles. Note that a given year vehicle (e.g., 1960 Buick) may be equipped with one of several different carburetors. Although functionally similar, the differences in physical configuration of these carburetors may preclude direct interchange. Additionally, the same carburetor-manufacturer designation (e.g., Carter WCFB) for different model years does not imply interchangeability. Consequently, the data from both Appendixes E and F should be used with caution.

Analysis of data from automotive manuals, inspection of many carburetors, and discussions with manufacturers resulted in the following approaches:

- Approach 6 — A modern, updated carburetor installation; cost range from $53 to $146. Applicable to all vehicles. See Appendix M.
- Approach 7 — A rebuilt modern updated carburetor installation; cost range from $41 to $92. Applicable to all vehicles.
- Approach 8 — Modify the carburetor fuel bowl vent by installing a vent tube extending from the fuel bowl cover into the air cleaner interior; cost range between $26 to $30. Applicable to most vehicles using external venting. See Appendix M.
- Approach 9 — Modify the carburetor fuel bowl vent by installing a 90 degree bend vent tube extending from the fuel bowl cover to a hose connection to the canister; cost range from $27 to $32. Applicable to most vehicles, as in Approach 8.
- Approach 10 — Enclose the carburetor with a fabricated material impervious to fuel vapors; cost range from $31 to $41. Applicable to most vehicles as in Approach 8.
- Approach 11 — A modified carburetor air horn/fuel bowl cover having internal fuel vapor vents; cost range from $39 to $63. Applicable to most vehicles, as in Approach 8.

Retrofit Approaches 6 and 7 require replacing the pre-1970 vehicle carburetors with updated new and rebuilt carburetors designed to control evaporative emissions. The installation would probably require an adaptor plate to mount the carburetor to the engine intake manifold. Throttle linkage, fuel line routing and differences in carburetor air/fuel calibrations

would present modification problems. New and rebuilt carburetors are stock items.

Retrofitting the pre-1970 vehicle's existing carburetor for vapor control can be accomplished by modifying the fuel bowl vent, as defined in Approach 8. The external vent is drilled to accommodate a vent tube inserted through the fuel bowl cover (from the underside) and extends above the airhorn through the bottom of the air cleaner housing. This vents the vapors to the interior of the air cleaner housing. This retrofit concept is presented in Figure 2-7.

Approach 9 involves modifying the existing carburetor for vapor control by providing alternate fuel bowl venting. The external vent is drilled to accommodate a 90 degree elbow tube. The vent tube is inserted through the fuel bowl cover (from the underside) and extends away from the airhorn. Tubing from an installed carbon canister is attached to this vapor vent tube. This retrofit concept is presented in Figure 2-8.

Some of the pre-1970 vehicle carburetors have vents that are difficult to seal due to their nature and placement. These carburetors may be enclosed in a fabric shroud impervious to fuel vapors. The shroud would extend from the air cleaner to the base of the carburetor and vent through an opening in the air cleaner housing. The retrofit modification, Approach 10, is presented in Figure 2-9.

Retrofitting the pre-1970 vehicle carburetors with a modified airhorn/fuel bowl cover having internal fuel vapor vents as in Approach 11 could be difficult because most carburetors having external vents could not be sealed without changing the fuel bowl balance and upsetting the carburetor air/fuel flow characteristics. Carburetor retrofit kits are not available as stock items.

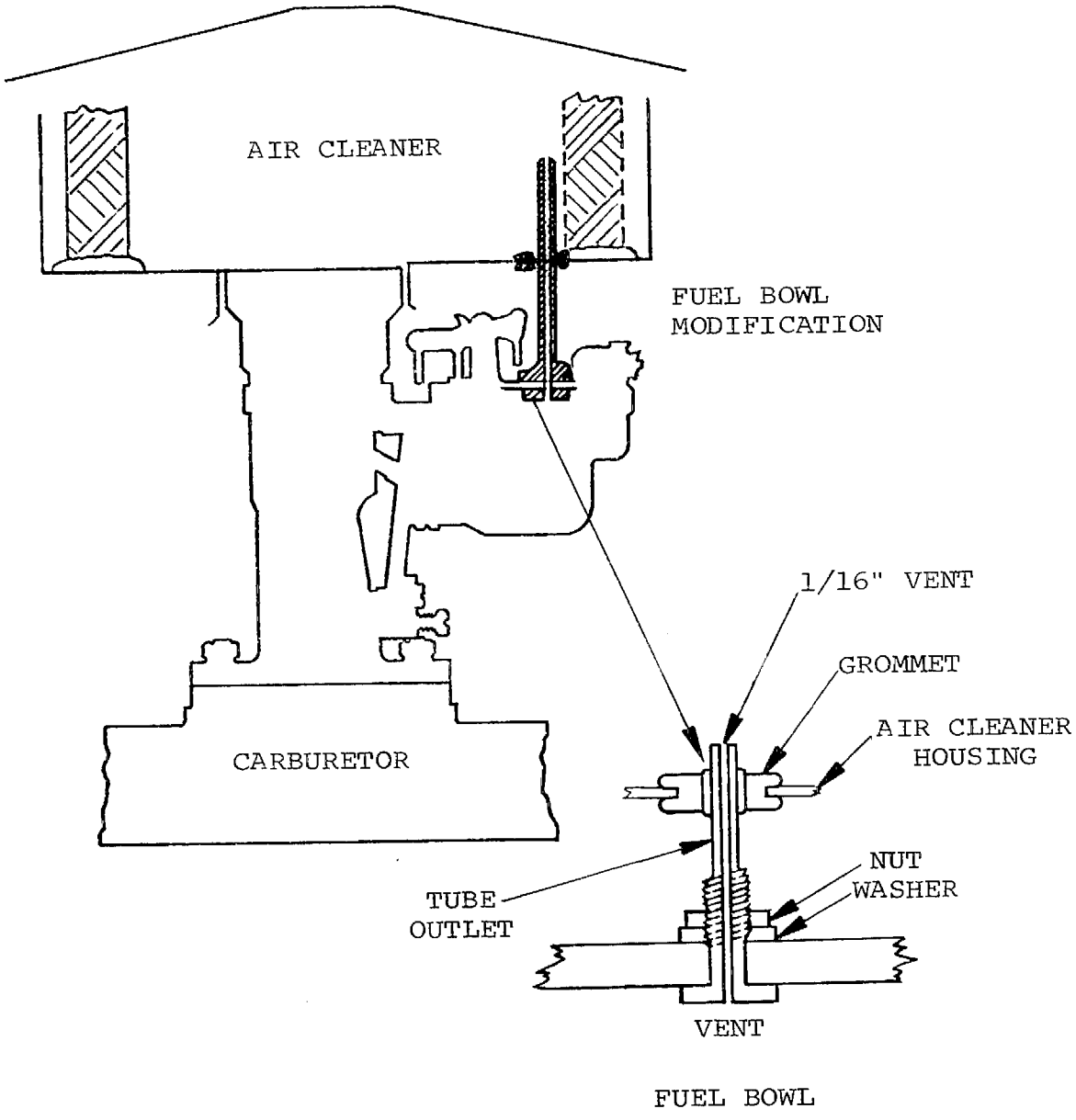

Figure 2-7. FUEL BOWL VENTED TO AIR CLEANER

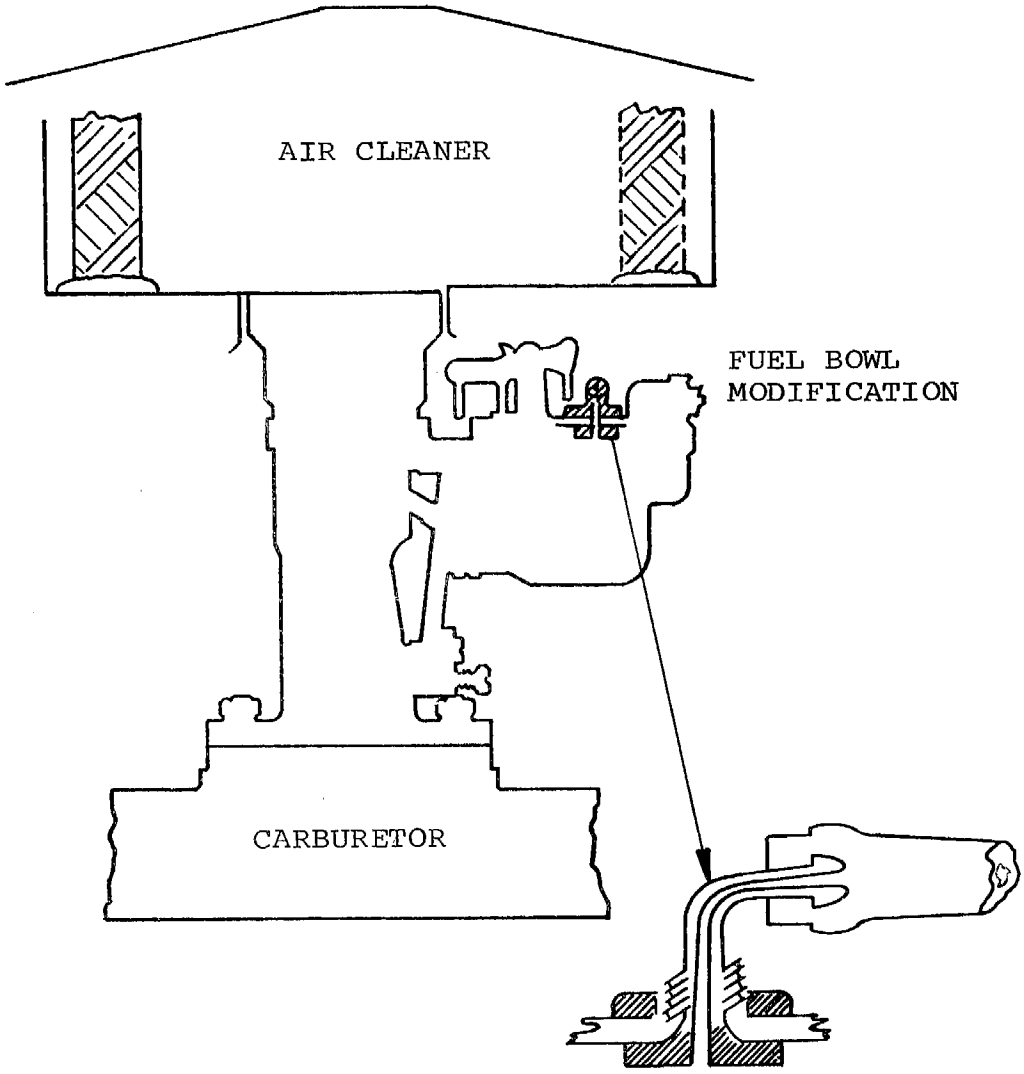

Figure 2-8. FUEL BOWL VENTED TO CONTAINER

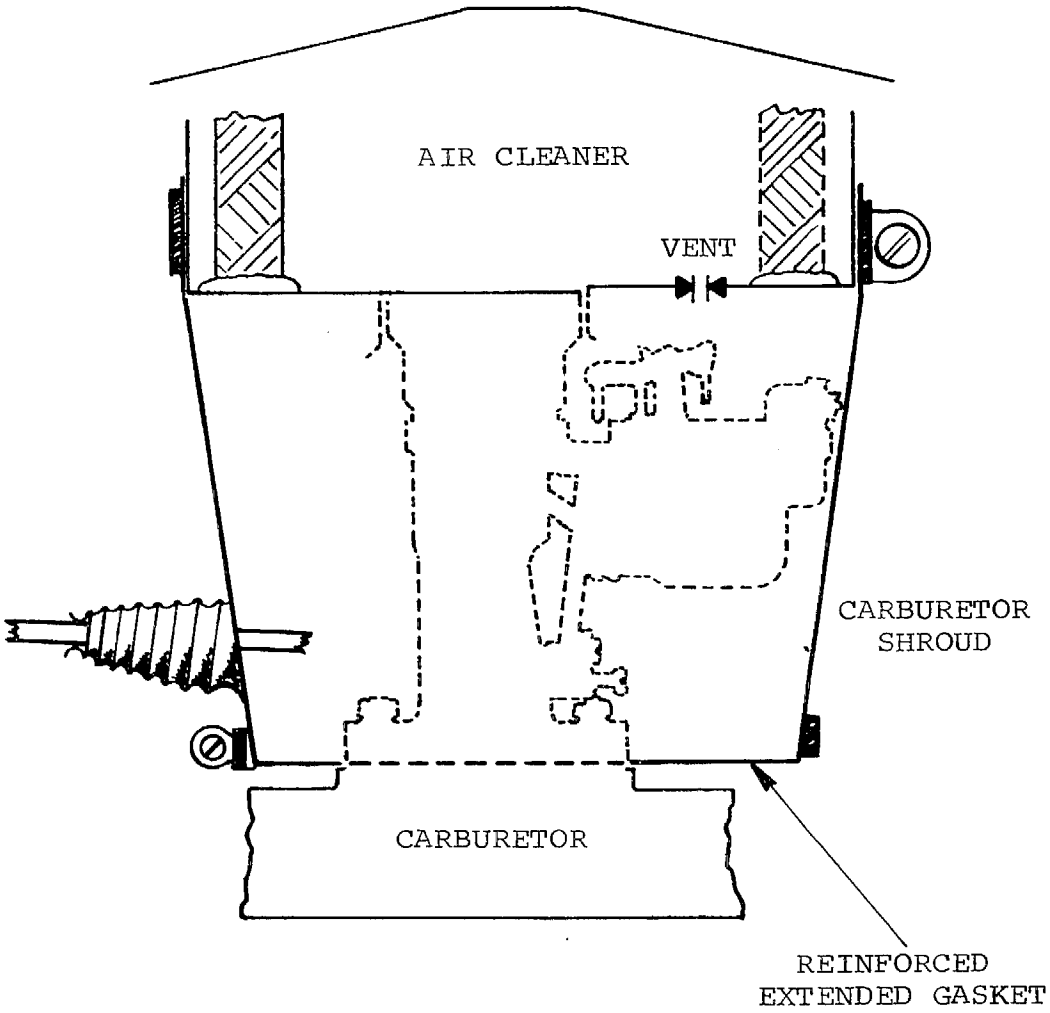

Figure 2-9. CARBURETOR SHROUD MODIFICATION

Table 2-6 summarizes the carburetor modifications.

2.4.3 Fuel Tank and Carburetor Combinations

The previous approaches addressed fuel tank and carburetor modifications individually. Inherent in these approaches is the combined control of both primary sources. Listed below are the more feasible combinations of fuel tank and carburetor evaporative emission control.

- A new (1970 to 1973) fuel tank and a new (1970 to 1973) carburetor; average cost ranges from $162 to $334.

- A new (1970 to 1973) fuel tank and carburetor retrofit modification; average cost ranges from $148 to $251.

- A new (1970 to 1973) fuel tank and shroud-enclosed carburetor; average cost ranges from $140 to $228.

- Fuel tank with vent modified fuel sending unit and new (1970 to 1973) carburetor; average cost ranges from $135 to $267.

- Fuel tank with vent modified fuel sending unit and rebuilt (1970 to 1973) carburetor; average cost ranges from $123 to $213.

- Fuel tank with vent modified fuel sending unit and carburetor retrofit modification; average cost ranges from $121 to $184.

Table 2-6. CARBURETOR LOSS CONTAINMENT
CANDIDATE RETROFIT CONCEPT SUMMARY

Concept	Description	Discussion
Modern Updated Carburetor Installation (Alternative 6)	Modern Carburetor with internal bowl venting designed for vapor recovery	Would probably require an adapter plate to mount carburetor on intake manifold of older vehicle Safe for operation Would not require state certification Could cost motorist $35 to $121 plus installation charge Shelf items May require recalibration for suitable A/F ratio and satisfactory vehicle performance
Retrofitted Replacement Carburetor (Exchange) (Alternative 7)	Post 1970 rebuilt carburetors. Suitable for evaporative emission control	Rebuilt carburetors available on the market Limited manufacturer's supply of necessary components. Retooling for old parts necessary

Table 2-6. (Continued)

Concept	Description	Discussion
Retrofit Kit Carburetor Installation (Alternative 11)	Replace carburetor airhorn and/or main body assembly to update carburetor for evaporative controls.	Retrofit kit not on market Variety of older vehicles and carburetor models must match for mounting Would require state certification in regard to safety Limited manufacturer's supply of necessary components. Retooling for old parts necessary
Fuel bowl vent: Straight tube modification (Alternative 8)	Conversion of external to internal fuel bowl venting. Tube from fuel bowl to interior of air cleaner.	Would not alter fuel bowl balance nor vehicle performance on most installations Not more than two hours installation time Would require state certification Vapor collection inside area of air cleaner

Table 2-6. (Continued)

Concept	Description	Discussion
Fuel Bowl Vent: Elbow Tube Modification Including Plunger and Metering Rod Closure (Alternative 9)	Conversion of external to internal fuel bowl venting. Tube from fuel bowl to vent to the carbon canister (current usage).	Would not alter fuel bowl balance or vehicle performance on most installations. Not more than two hours installation time. Would require state certification. Vapor collection and storage in canister.
Carburetor Enclosure (Alternative 10)	Impermeable fabric sleeve enclosing the carburetor fuel bowl (airhorn) from carburetor/manifold gasket to air cleaner housing. Vapors are vented to inner area of air cleaner.	Fire retardant/gasoline vapor resistant fabric. Would not alter fuel bowl balance. Not more than two hours installation time. Would require state certification. Vapor collection inside air cleaner. May present fire hazard in case of carburetor fuel boil or fuel outflow. May present poor idling qualities after hot soak period.

- Fuel tank with vent modified fuel sending and carburetor fuel bowl vent modification; average cost ranges from $109 to $153.

- Fuel tank with vented filler tube modification and new (1970 to 1973) carburetor; average cost ranges from $126 to $256.

- Fuel tank with vented filler tube modification and rebuilt (1970 to 1973) carburetor; average cost ranges from $114 to $202.

- Fuel tank with vented filler tube modification and carburetor retrofit modification; average cost ranges from $113 to $174.

- Fuel tank with vented filler tube modification and carburetor fuel bowl vent modification; average cost ranges from $101 to $143.

- Fuel tank with side-tube vent modification and new (1970 to 1973) carburetor; average cost ranges from $137 to $269.

- Fuel tank with side-tube vent modification and rebuilt (1970 to 1973) carburetor; average cost ranges from $125 to $215.

- Fuel tank with side-tube vent modification and carburetor retrofit (kit) modification; average cost ranges from $123 to $186.

- Fuel tank with side-tube vent modification and carburetor fuel bowl vent; average cost ranges from $111 to $155.

- Fuel tank initially fitted with vapor vent outlets used with carburetor fuel bowl modification; average cost ranges from $95 to $138.

A new (1970 to 1973) type fuel tank/new carburetor combination (Approach 1 and 6) in a closed evaporative emission control system consisting of a combination filler cap, liquid/vapor separator (fuel expansion chamber), overfill limiting valve, and carbon canister would comprise an effective vapor control assembly. This configuration is presented in Figure 2-10. Fuel vapor control with this system would reduce evaporative emissions of uncontrolled vehicles from an estimated 50 grams per test (Ref. 11) to 2 to 6 grams per test (88 percent to 96 percent reduction).

A new fuel tank/rebuilt carburetor combination (Approaches 1 and 7) in a closed evaporative emission control system would also reduce fuel vapor losses to 2 to 6 grams per test (88 percent to 96 percent reduction).

A new fuel tank/vehicle retrofit (kit) carburetor modification combination (Approaches 1 and 11) in a closed evaporative emission control system would reduce fuel vapor losses to 6 grams per test (88 percent reduction). Carburetor retrofit kits are not currently available on the automotive parts supply market.

A new fuel tank/carburetor fuel bowl vent modification (Approaches 1 and 9) in a closed evaporative emission control system would reduce fuel vapor losses to 6 grams per test (88 percent reduction).

A new (1970 to 1973) fuel tank and shroud-enclosed carburetor combination (Approaches 1 and 10) in a closed system would reduce fuel vapor losses to 6 grams to 15 grams per test.

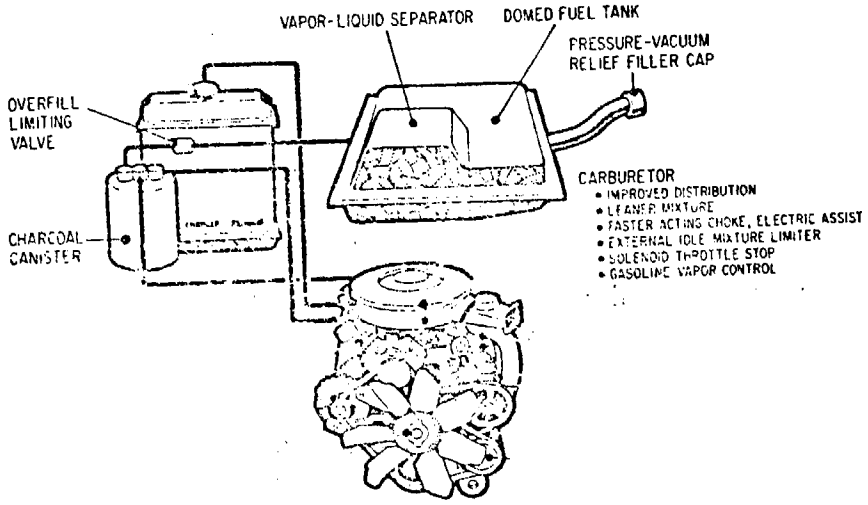

Figure 2-10. RETROFIT EVAPORATIVE EMISSION CONTROL

A shroud-enclosed carburetor would be suitable for single and small two-barrel carburetor fuel vapor containment but inadequate for four-barrel carburetors and would result in about 70 percent to 88 percent reduction.

A fuel tank vent, modified sending unit (sensor) with a new (1970 to 1973) carburetor (Approaches 2 and 6) in a closed evaporative emission system would reduce fuel vapor losses to 2 to 6 grams per test (88 percent to 96 percent reduction).

A fuel tank vent, modified sending unit (sensor) with a new (1970 to 1973) rebuilt carburetor (Approaches 2 and 7) in a closed system would reduce fuel vapor losses to 2 to 6 grams per test (88 percent to 96 percent reduction).

A fuel tank vent, modified sending unit (sensor) with a retrofit (kit) carburetor modification (Approaches 2 and 11) in a closed evaporative emission control system would reduce fuel losses to 6 grams per test (88 percent reduction).

A fuel tank vent, modified sending unit (sensor) with a carburetor fuel bowl vent modification (Approaches 2 and 9) in a closed evaporative emission control system would reduce fuel vapor losses to 6 grams per test (88 percent reduction).

Fuel tank with a vented filler-tube extension modification and a new (1970 to 1973) carburetor (Approaches 3 and 6) in a closed evaporative emission system would reduce fuel vapor losses to 6 grams per test (88 percent reduction).

Fuel tank with vented filler-tube extension modification and a rebuilt (1970 to 1973) carburetor (Approaches 3 and 7) in a closed evaporative emission control system would reduce fuel vapor losses to 6 grams per test (88 percent reduction).

Fuel tank with vented filler-tube extension modification and a carburetor retrofit modification (Approaches 3 and 11) in a closed evaporative emission control system would reduce fuel vapor losses to 2 to 6 grams per test (88 percent to 96 percent reduction).

Fuel tank with vented filler-tube extension modification and a carburetor fuel bowl vent modification (Approaches 3 and 9) in a closed evaporative emission control system would reduce fuel vapor losses to 6 grams per test (88 percent reduction).

Fuel tank with side-tube modification and new (1970 to 1973) carburetor (Approaches 4 and 6) in a closed evaporative emission control system would reduce fuel vapor losses to 2 to 6 grams per test (88 percent to 96 percent reduction).

Table 2-7 summarizes the approaches to the fuel tank-carburetor combination control concepts.

Table 2-7. TOTAL LOSSES CONTAINMENT
CANDIDATE RETROFIT CONCEPT SUMMARY

Concept	Description	Discussion
Modern Fuel Tank New Modern Carburetor (Alternatives 1 and 6)	Replacement of vehicle original fuel tank and carburetor with modern fuel tank and carburetor. To be used in conjunction with liquid/vapor separator, overfill limiting valve, pressure/vacuum filler cap, carbon canister, and connecting vapor lines.	Most effective and efficient evaporative emission control closed system. Stock items Minimum liquid fuel outflow losses due to overfilling the fuel tank and improper vehicle parking (attitude) Installed Cost per Vehicle(1) $162.14 to $333.69
Modern Fuel Tank Rebuilt Modern Carburetor (Alternatives 1 and 7)	Replacement of vehicle original fuel tank and carburetor with modern fuel tank and rebuilt modern carburetor. To be used in conjunction with liquid/vapor separator, etc.	An effective and efficient evaporative emission control closed system. Stock items Minimum liquid fuel outflow losses due to overfilling and improper vehicle parking Installed Cost per Vehicle(1) $149.79 to $279.69

(1) Depending on vehicle make and engine displacement

Table 2-7. (Continued)

Concept	Description	Discussion
Modern Fuel Tank - Modified Carburetor Fuel Bowl Vented to Air Cleaner (Alternatives 1 and 8)	Replacement of vehicle original fuel tank and modification of carburetor bowl vent. Fuel bowl vapors would be routed to the interior of the air cleaner. Fuel tank vapors would be routed to the carbon canister via the liquid/vapor separator, etc.	Fuel tank vapors would be effectively controlled Carburetor fuel bowl venting to air cleaner. Inadequate storage for 4-barrel carburetor fuel bowl vapors Minimum liquid fuel outflow losses due to overfilling and improper vehicle parking Installed Cost per Vehicle(1) $135.39 to $217.74
Modern Fuel Tank - Modified Carburetor Fuel Bowl Vented to Carbon Canister (Alternatives 1 and 9)	Replacement of vehicle original fuel tank and modification of fuel bowl vent. Fuel bowl vapors routed to carbon canister. Fuel tank vapors would be routed to carbon canister via the liquid/vapor separator, etc.	Fuel tank and carburetor fuel vapors would be effectively controlled Minimum liquid fuel outflow losses due to overfilling and improper vehicle parking Concept cost high Installed Cost per Vehicle(1) $136.09 to $219.74

(1) Depending on vehicle make and engine displacement

Table 2-7. (Continued)

Concept	Description	Discussion
Modern Fuel Tank Original Carburetor enclosed in shroud (Alternatives 1 and 10)	Replacement of vehicle original fuel tank. Carburetor to be enclosed in a vapor-tight shroud. Vapor storage may be in the interior of air cleaner (compacts) or routed to the carbon canister. Fuel tank vapors would be routed to the carbon canister via the liquid/vapor separator, etc.	Fuel tank vapors would be effectively controlled Carburetor fuel bowl vents very difficult to seal or modify due to their nature or placement. Could be controlled by enclosing the carburetor in a shroud impervious to fuel vapors. Installed Cost per Vehicle(1) $139.89 to $228.24
Modern Fuel Tank Modify Original Carburetor with Retrofit Vent Conversion Kit (Alternatives 1 and 11)	Replacement of vehicle original fuel tank. Carburetor to be rebuilt with retrofit kit. Fuel bowl, etc. to be converted to internal venting. Fuel tank vapors would be routed to the carbon canister via the liquid/vapor separator, etc.	Fuel tank and carburetor vapors would be effectively controlled. Carburetor retrofit vent conversion kits not on the market Installed Cost per Vehicle(1) $147.89 to $250.64

(1) Depending on vehicle make and engine displacement

Table 2-7. (Continued)

Concept	Description	Discussion
Fuel Tank with a Modified Vented Sending Unit and Modern Carburetor (Alternatives 2 and 6)	Vehicle fuel tank with modified-vented sending unit in combination with a new modern carburetor used in conjunction with a liquid/vapor separator, etc. of a closed evaporative emission control system	An effective evaporative emission control system Probable liquid fuel outflow losses due to overfilling and improper vehicle parking Installed Cost per Vehicle(1) $135.39 to $266.84
Fuel Tank with a Modified Vented Sending Unit and Modern Rebuilt Carburetor (Alternatives 2 and 7)	Vehicle fuel tank with modified-vented sending unit in combination with a modern rebuilt carburetor used in conjunction with a liquid/vapor separator, etc. of a closed evaporative emission control system	An effective evaporative emission control system Probable liquid fuel outflow losses due to overfilling and improper vehicle parking Installed Cost per Vehicle(1) $123.04 to $212.84

(1) Depending on vehicle make and engine displacement

Table 2-7. (Continued)

Concept	Description	Discussion
Fuel Tank with a Modified-Vented Sending Unit and Modified Carburetor with Retrofit Vent Conversion Kit (Alternatives 2 and 11)	Vehicle fuel tank with modified-vented sending unit in combination with a modified carburetor with retrofit-vent conversion kit	Fuel tank and carburetor vapors would be effectively controlled Carburetor retrofit-vent conversion kits not on the market Installed Cost per Vehicle(1) $121.14 to $183.79
Fuel Tank with a Modified-Vented Sending Unit and Carburetor with Modified Fuel Bowl Vent (Alternatives 2 and 9)	Vehicle fuel tank with modified-vented sending unit in combination with a carburetor with modified fuel bowl vent. Fuel bowl vapors routed to carbon canister. Fuel tank vapors would be routed to carbon canister via the liquid/vapor separator, etc.	Fuel tank and carburetor vapors would be effectively controlled Installed Cost per Vehicle(1) $109.34 to $152.89
Fuel Tank with Vented Filler Tube Extension Modification and New Modern Carburetor (Alternatives 3 and 6)	Vehicle fuel tank with vented filler tube extension modification in combination with a new modern carburetor used in conjunction with a liquid/vapor separator, etc. of a closed evaporative emission control system	An effective but limited evaporative emission control system Probable liquid fuel outflow losses due to overfilling and improper vehicle parking Installed Cost per Vehicle(1) $126.89 to $256.84

(1) Depending on vehicle make and engine displacement

Table 2-7. (Continued)

Concept	Description	Discussion
Fuel Tank with Vented Filler Tube Extension Modification and Rebuilt Modern Carburetor (Alternative 3 and 7)	Vehicle fuel tank with vented filler tube extension modification in combination with a modern rebuilt carburetor to be used in conjunction with liquid/vapor separator, etc.	An effective but limited evaporative emission control system Probable liquid fuel outflow losses due to overfilling and improper vehicle parking Installed Cost per Vehicle(1) $114.54 to $202.84
Fuel Tank with Vented Filler Tube Extension Modification and Original Carburetor with Retrofit Vent Conversion Kit	Vehicle fuel tank with vented filler tube extension modification in combination with a carburetor rebuilt with a retrofit kit. Fuel bowl, etc. to be converted to internal venting. Fuel tank vapors would be routed to the canister via the liquid/vapor separator, etc.	An effective but limited evaporative emission control system Probable liquid fuel outflow losses due to overfilling and improper vehicle parking Installed Cost per Vehicle(1) $112.64 to $173.79
Fuel Tank with Vented Filler Tube Extension Modification and Carburetor Modified Fuel Bowl Vented to Canister	Vehicle fuel tank with vented filler tube extension modification in combination with the original carburetor having modified fuel bowl venting to canister. Fuel tank vapors would be routed to the canister via the liquid/vapor separator, etc.	An effective but limited evaporative emission control system Probable liquid fuel outflow losses due to overfilling and improper vehicle parking Installed Cost per Vehicle(1) $100.84 to $142.89

(1) Depending on vehicle make and engine displacement

Table 2-7. (Continued)

Concept	Description	Discussion
Fuel Tank with Vent Tubulature Modification and Modern New Carburetor	Vehicle fuel tank with vent tubulature modification in combination with a new modern carburetor. Fuel vapors routed to liquid/vapor separator, etc. of a closed evaporative emission control system.	An effective evaporative emission control system Probable liquid fuel losses due to overfilling and improper vehicle parking Installed Cost per Vehicle(1) $137.14 to $268.75
Fuel Tank with Vent Tubulature Modification and Modern Rebuilt Carburetor	Vehicle fuel tank with vent tubulature modification in combination with a rebuilt modern carburetor. Fuel vapors routed to liquid/vapor separator, etc. of a closed evaporative emission control system.	An effective evaporative emission control system Probable liquid fuel losses due to overfilling and improper vehicle parking Installed Cost per Vehicle(1) $124.79 to $214.75

(1) Depending on vehicle make and engine displacement

Table 2-7. (Continued)

Concept	Description	Discussion
Fuel Tank with Vent Tubulature Modification and Original Carburetor with Retrofit Vent Conversion Kit	Vehicle fuel tank with vent tubulature modification in combination with original carburetor rebuilt with a retrofit kit. Fuel bowl, etc. to be converted to internal venting. Fuel tank vapors would be routed to liquid/vapor separator, etc. of a closed evaporative emission control system.	An effective evaporative emission control system Probable liquid fuel losses due to overfilling and improper vehicle parking Installed Cost per Vehicle(1) $122.89 to $185.70
Fuel Tank with Vent Tubulature Modification and Original Carburetor Fuel Bowl Vent Modification	Vehicle fuel tank with vent tubulature modification in combination with original carburetor fuel bowl vent modification. Fuel tank vapors would be routed to liquid/vapor separator, etc. of a closed evaporative emission control system.	An effective evaporative emission control system Probable liquid fuel losses due to overfilling and improper vehicle parking Installed Cost per Vehicle(1) $111.09 to $154.85

(1) Depending on vehicle make and engine displacement

SECTION 3

EFFECTIVENESS ANALYSIS

This section determines the effectiveness of the evaporative emission control system alternatives. Following the definition of the effectiveness measure, an effectiveness model is described which is used to calculate the levels of effectiveness associated with the various alternatives. The analysis is performed on an individual vehicle, air basin, and statewide basis. The results of the effectiveness analysis are evaluated, and the limitations of these results are presented.

3.1 EFFECTIVENESS MEASURE

Measures of effectiveness (MOE) are used to evaluate how well a particular alternative satisfies identified objectives. A primary objective of this study is to determine the technical and economic feasibility of using various control systems to limit vehicle evaporative fuel losses to the atmosphere. Consequently, program effectiveness is measured in terms of gasoline vapor containment, namely grams and tons of hydrocarbon recovered. The subsequent effectiveness modeling techniques are based on this containment, or more specifically, on containment of certain types of losses.

3.2 EFFECTIVENESS MODELING

Effectiveness can be computed in terms of recovery of evaporative losses. Hence the following can be stated:

$$\text{Effectiveness} = S_1(DE_1) + S_2(DE_2) + S_3(DE_3) + \ldots. \quad \text{(Eq. 3-1)}$$

where:

S_n = Evaporative emissions from source n

n = 1,2,3,4 ....

DE = Alternative system efficiency to recover losses from source n

The model is initially programmed to establish a baseline inventory of the various evaporative emissions. Effectiveness levels subsequently are computed based on improvements with respect to the baseline.

The first task in developing an effectiveness model is to determine specifically the major sources of evaporative emissions. A listing and description of these sources, namely carburetors and fuel tanks, is given in Section 2.1. Next, the time periods during which these emissions occur with respect to the various sources are considered. Subsequently, the main categories of the effectiveness model are defined, specifically hydrocarbon evaporative emissions emitted from a given source with respect to a given time.

3.2.1 Carburetor Hot Soak Losses

The carburetor hot soak loss category of the effectiveness model includes fuel vapors emitted from the carburetor during a one-hour period beginning immediately after the engine is turned off. A one-hour duration is chosen because the major portion of these hot-soak losses occurs during the first 30 minutes after engine shutdown because of increased engine compartment temperatures (Ref. 2).

The fuel venting system usually causes the carburetor fuel bowl to operate under a slight vacuum while the vehicle is in operation so that the evaporation of fuel from the bowl contributes only very minor amounts to the total emissions at this time. Hence carburetor losses which occur while the engine is in operation are not considered.

3.2.2 Tank Running and Hot Soak Losses

The tank running and hot soak loss category of the effectiveness model includes fuel vapors emitted from the fuel tank while the engine is operating and during the aforementioned one-hour duration initiated immediately after engine shutdown. Tank losses during engine operation and the one-hour period immediately following engine shutdown are significant because they occur largely as a result of pavement radiation, heat transfer (from the engine compartment to fuel system components) and temperature increases caused by vehicular movement (fuel agitation).

3.2.3 Diurnal Cycle Losses

The diurnal cycle loss category includes fuel vapors emitted from the fuel tank during the times not covered by the engine operation or one-hour hot soak periods. Note that carburetor losses are not considered during the diurnal cycle period in that engine compartment temperatures approximate ambient temperatures, and only small amounts of fuel remain in the carburetor fuel bowl at this time. Hence, carburetor evaporative losses are extremely minimal during this period.

3.3 MODEL FORMULATION

Based on the three major, aforementioned categories, a top-level effectiveness model can be structured like Equation 3-2.

$$MOE = \sum_{n=1}^{y} \left[(R_{chs} + R_{trhs}) \ (T_n) + (R_{dc}) \right]_n \qquad \text{(Eq. 3-2)}$$

where:

MOE = Measure of effectiveness (i.e., the amount of hydrocarbon vapor contained) measured in mass units

R_{chs} = Carburetor hot soak losses per vehicle per trip measured in mass units

R_{trhs} = Fuel tank running and hot soak losses per vehicle per trip measured in mass units

T_n = Total number of trips completed by pre-1970 vehicles per season

R_{dc} = Total diurnal losses per season measured in mass units

n = Index describing the number of seasons over which the effectiveness is measured

y = Maximum number of seasons over which the effectiveness is measured[1]

Note that carburetor and fuel tank losses are included in the previous MOE equation. This inclusion of both sources implies that a proposed system alternative controls both sources. Other levels of effectiveness are considered. For example, one alternative only includes controlling vapors from the carburetor; and tank losses, R_{trhs} and R_{dc}, are not included in the MOE equation. Consequently:

$$MOE = \sum_{n=1}^{y} (R_{chs_n}) \; T_n \qquad \text{(Eq. 3-3)}$$

Another level of effectiveness considers a proposed system alternative that controls only tank losses. Hence carburetor losses are not included in the MOE equation and the measure of effectiveness equals:

$$MOE = \sum_{n=1}^{y} (R_{trhs}) \; T_n + R_{dc_n} \qquad \text{(Eq. 3-4)}$$

---

[1] The effectiveness of alternatives is measured over an 11-year interval. Hence the upper limit of n equals 44 (11 x 4) seasons.

3.4 EFFECTIVENESS MODEL MAJOR ELEMENT VALUES

The evaporative emission loss elements were quantified via a multifaceted approach. First, the variables which strongly affect evaporative losses were determined, primarily ambient temperature and gasoline volatility (Ref. 14). Second, the values of these independent variables were ascertained as they apply to the four seasons within each air basin. Daily temperature profiles for each of the air basins were obtained from the National Oceanic and Atmospheric Administration (Ref. 13). The time of day is an important factor because temperature, regardless of the air basin, varies considerably as a function of this variable. Volatility ratings were obtained from E.I. du Pont de Nemours and Company (Ref. 14). Table 3-1 lists the temperature and volatility data.

Knowing the daily temperature profiles and gasoline volatility ratings per season and air basin, corresponding evaporative losses were then determined. Applicable values were obtained for tank running and hot soak losses in addition to carburetor hot soak losses from the Gasoline Modification Study (Ref. 15). Values of the third evaporative loss element, diurnal cycle losses, were obtained from references 19 and 20. Because of lack of comprehensive experimentation regarding this third category, specification of losses is restricted to seasonal variations only. Table 3-1 shows the estimated losses per vehicle as a function of time of day, air basin, and season.

The total number of trips completed by pre-1970 vehicles per season, T_n, is based on the distribution found in Appendix I. This describes the number of trips made as a function of vehicle age. Appendix J tabulates the proportion of total trips distributed as a function of daily time periods.

Table 3-1. EVAPORATIVE LOSSES PER VEHICLE IN EACH AIR BASIN

TIMES	TEMPERATURE AND LOSSES*	AIR BASIN	SOUTH COAST				SAN FRANCISCO BAY				SAN JOAQUIN				SACRAMENTO VALLEY				SAN DIEGO				SOUTHEAST DESERT			
		SEASON	SP	SU	FA	WI	SP	SU	FA	WI	SP	SU	FA	WI	SP	SU	FA	WI	SP	SU	FA	WI	SP	SU	FA	WI
		RVP	9.0	9.0	9.0	12.0	11.9	9.0	9.0	11.9	12.0	9.0	9.0	12.0	11.6	9.0	9.0	11.6	12.0	9.0	9.0	12.0	9.0	9.0	9.0	12.0
0600-0900	Temperature		57	68	62	52	55	58	58	51	49	70	56	42	50	61	53	41	58	66	61	51	58	75	63	49
	Carburetor Hot Soak Losses		4.5	5.7	5.0	7.5	8.0	4.6	4.6	7.5	7.1	5.9	4.5	5.8	7.2	4.9	4.1	5.4	8.7	5.4	4.9	7.3	4.6	6.7	5.0	7.1
	Tank Losses		1.7	3.3	2.5	3.5	4.0	2.0	2.0	2.6	2.5	3.7	2.0	1.3	2.6	2.4	1.5	1.1	4.1	3.0	2.4	2.8	2.0	4.8	2.7	2.5
0900-1200	Temperature		68	80	75	63	61	64	66	56	66	84	69	52	61	77	66	49	67	74	72	63	77	97	82	65
	Carburetor Hot Soak Losses		5.7	7.7	6.7	9.8	9.5	5.2	5.4	8.2	10.3	8.3	5.8	7.4	9.5	7.0	5.4	7.1	10.5	6.5	6.2	9.8	7.0	11.4	7.9	10.1
	Tank Losses		3.3	6.8	4.8	6.2	4.5	2.8	3.0	3.8	7.5	8.0	3.5	3.3	4.5	5.4	3.0	2.5	8.0	4.6	4.1	6.2	5.4	17.3	7.2	6.9
1200-1530	Temperature		69	81	76	64	60	63	65	56	77	97	81	60	71	91	77	57	68	75	73	64	85	105	89	71
	Carburetor Hot Soak Losses		5.8	7.7	6.9	9.9	9.2	5.0	5.3	8.2	12.8	11.4	7.7	9.2	11.4	9.8	7.0	8.5	10.7	6.7	6.3	9.9	8.5	13.0	9.3	11.4
	Tank Losses		3.5	6.8	5.0	6.3	4.3	2.7	2.8	4.1	14.2	17.3	6.8	4.3	9.9	12.2	5.4	4.1	8.5	4.8	4.4	6.3	8.5	22.0	11.0	9.9
1530-1800	Temperature		64	75	70	59	56	59	59	52	73	92	77	57	67	86	73	54	66	73	71	62	80	100	84	67
	Carburetor Hot Soak Losses		5.2	6.7	5.9	8.9	8.2	4.7	4.7	7.4	11.8	10.2	7.0	8.5	10.5	8.7	6.3	7.8	10.3	6.3	6.1	9.6	7.5	12.4	8.3	10.5
	Tank Losses		2.6	4.8	3.7	4.1	4.1	2.1	2.1	3.3	11.2	12.8	5.4	4.1	8.0	9.0	4.4	3.7	7.5	4.4	3.9	5.4	6.4	20.4	8.0	8.0
1800-2200	Temperature		53	62	57	48	50	53	53	47	60	77	63	47	56	69	60	45	54	63	57	46	65	82	70	55
	Carburetor Hot Soak Losses		4.1	5.0	4.5	7.0	7.2	4.1	4.1	6.6	9.2	7.0	5.0	6.6	8.2	5.8	4.8	6.2	7.8	5.0	4.5	6.3	5.3	7.9	5.9	8.0
	Tank Losses		1.5	2.5	2.0	2.5	2.6	1.5	1.5	1.8	4.3	5.4	2.8	1.8	4.1	3.5	2.2	1.8	3.7	2.7	2.0	1.8	2.8	7.2	3.7	4.0
2200-0600	Temperature		53	62	57	48	50	53	53	47	50	65	52	39	46	56	49	38	54	63	57	46	53	70	58	45
	Carburetor Hot Soak Losses		4.1	5.0	4.5	7.0	7.2	4.1	4.1	6.6	7.2	5.3	4.0	5.5	6.3	4.5	3.7	5.4	7.8	5.0	4.5	6.3	4.1	5.9	4.6	6.2
	Tank Losses		1.5	2.5	2.0	2.5	2.6	1.5	1.5	1.8	2.6	2.8	1.5	1.3	1.8	2.0	1.2	1.1	3.7	2.7	2.0	1.7	1.5	3.7	2.0	1.8
Diurnal Losses			20.0	25.0	20.0	15.0	20.0	25.0	20.0	15.0	20.0	25.0	20.0	15.0	20.0	25.0	20.0	15.0	20.0	25.0	20.0	15.0	20.0	25.0	20.0	15.0

Table 3-1. EVAPORATIVE LOSSES PER VEHICLE IN EACH AIR BASIN (Cont.)

TIMES	TEMPERATURE AND LOSSES*	AIR BASIN	NORTH CENTRAL COAST				SOUTH CENTRAL COAST				NORTH COAST				NORTHEAST PLATEAU				GREAT BASIN VALLEY			
		SEASON	SP	SU	FA	WI	SP	SU	FA	WI	SP	SU	FA	WI	SP	SU	FA	WI	SP	SU	FA	WI
		RVP	12.0	9.0	9.0	12.0	12.0	9.0	9.0	12.0	12.0	9.0	12.0	12.0	12.0	9.0	12.0	12.0	10.0	9.0	10.0	10.0
0600-0900	Temperature		53	59	55	48	56	63	59	51	48	54	52	45	39	55	41	28	42	59	43	27
	Carburetor Hot Soak Losses		7.5	4.7	4.3	7.0	8.2	5.0	4.7	7.3	7.0	4.2	7.4	6.2	5.5	4.3	5.7	3.8	5.8	4.7	6.0	3.8
	Tank Losses		3.5	2.1	1.7	2.5	4.1	2.7	2.1	2.8	2.5	1.6	3.3	8.1	1.1	1.7	1.3	0.9	1.3	2.1	1.5	0.9
0900-1200	Temperature		66	73	70	60	66	73	72	63	57	64	62	53	53	72	55	38	59	78	61	42
	Carburetor Hot Soak Losses		10.3	6.3	5.9	9.2	10.3	6.3	6.2	9.8	8.5	5.2	9.6	7.5	7.5	6.2	8.0	5.4	8.9	7.2	9.5	5.8
	Tank Losses		7.5	4.4	3.7	4.3	7.5	4.4	4.1	6.2	4.1	2.6	5.4	3.5	3.5	4.1	4.0	1.1	4.1	5.6	4.5	1.3
1200-1530	Temperature		64	71	68	59	65	72	70	62	56	63	60	52	65	88	68	46	74	95	77	56
	Carburetor Hot Soak Losses		9.9	6.1	5.7	8.9	10.1	6.2	5.9	9.6	8.2	5.1	9.2	7.4	10.1	9.1	10.7	6.3	10.1	10.9	12.8	8.2
	Tank Losses		6.4	3.9	3.3	4.1	6.9	4.1	3.7	5.4	4.1	2.4	4.3	3.3	6.9	10.4	8.5	1.8	6.9	15.6	14.2	4.1
1530-1800	Temperature		55	61	57	50	57	64	61	53	49	56	54	46	60	82	63	43	68	89	71	51
	Carburetor Hot Soak Losses		8.0	4.9	4.5	7.2	8.5	5.2	4.9	7.5	7.1	4.5	7.8	6.3	12.1	7.9	9.8	6.0	10.7	9.3	11.4	7.3
	Tank Losses		4.0	2.4	2.0	2.6	4.1	2.7	2.4	3.5	2.5	2.0	3.7	1.8	11.9	7.2	6.2	1.5	8.5	11.0	9.9	2.8
1800-2200	Temperature		43	49	45	39	48	55	49	43	42	49	46	39	46	64	48	33	50	68	52	35
	Carburetor Hot Soak Losses		6.1	3.7	3.2	5.5	7.0	4.3	3.7	6.0	5.8	3.7	6.3	5.5	6.3	5.2	7.0	4.5	7.2	5.7	7.4	4.8
	Tank Losses		1.8	1.2	1.3	1.1	2.5	1.7	1.2	1.5	1.3	1.2	1.8	1.1	1.8	2.7	2.5	1.0	2.6	3.3	3.3	1.0
2200-0600	Temperature		43	49	45	39	48	55	49	43	42	49	46	39	34	49	36	25	36	52	37	22
	Carburetor Hot Soak Losses		6.0	3.7	3.2	5.5	7.0	4.3	3.7	6.0	5.8	3.7	6.3	5.5	4.7	3.7	4.9	3.5	4.9	4.0	5.0	3.3
	Tank Losses		1.5	1.2	1.3	1.1	2.5	1.7	1.2	1.5	1.3	1.2	1.8	1.1	1.0	1.2	1.1	0.8	1.1	1.5	1.1	0.8
Diurnal Losses			20.0	25.0	20.0	15.0	20.0	25.0	20.0	15.0	20.0	25.0	20.0	15.0	20.0	25.0	20.0	15.0	20.0	25.0	20.0	15.0

* All quantities are losses per trip except diurnal losses which are emissions per day. Units of measurement are grams.

Equation 3-2 and subsequent discussions of the major model elements are simplified. Refer to Appendix K for a detailed description of this model.

3.5 EFFECTIVENESS CALCULATIONS

Section 2 identified the various retrofit alternatives. Alternatives 1 through 5 were designed such that essentially all evaporative fuel tank emissions would be recovered if any one of these solutions were installed on a vehicle. Similarly, alternatives 6 through 11 were designed such that essentially all evaporative carburetor emissions would be recovered if any one of these solutions were installed on a vehicle. The design of these alternatives allows the combination of 1 through 5 with 6 through 11 to recover essentially all evaporative emissions.

3.5.1 Effectiveness of Retrofit Approaches

The various alternative approaches and their corresponding effectiveness measures are tabulated in Tables 3-2 through 3-7. These measures assume that the respective retrofits are installed as of 1 January 1975.

Tables 3-2 and 3-3 show the evaporative emissions from carburetors and fuel tanks as determined for the total state during the calendar years 1975 to 1985 for light and heavy-duty vehicles, respectively. It is apparent that the total cumulative effects of fuel tank losses, running and diurnal, are nearly twice as much as carburetor hot-soak losses relative to light-duty vehicles. For heavy-duty vehicles, the vapors emanating from the fuel tank are nearly four times as much as carburetor losses.

Table 3-2. LIGHT-DUTY VEHICLE ALTERNATIVES' EFFECTIVENESS FOR THE STATE OF CALIFORNIA
(Losses recovered in tons of hydrocarbon)*

CALENDAR YEAR	ALTERNATIVES 6-11 (Carburetor Losses)	ALTERNATIVES 1-5 (Tank Running and Hot Soak Losses)	ALTERNATIVES 1-5 (Tank Diurnal Losses)	COMBINED (Carburetor and Fuel Tank Losses)
1975	33,430	22,030	45,670	101,130
1976	26,820	17,550	38,150	82,520
1977	20,500	13,160	31,050	64,710
1978	15,110	9,700	24,400	49,210
1979	10,790	6,920	18,770	36,480
1980	6,970	4,470	13,670	25,110
1981	4,860	3,070	10,030	17,960
1982	3,380	2,090	7,090	12,560
1983	2,270	1,400	4,760	8,430
1984	1,520	940	3,200	5,660
1985	1,150	710	2,420	4,280
Totals	126,800	82,000	199,200	408,000

* Alternative losses imply implementing one of alternatives 1 through 5, and one of alternatives 6-11. Combined losses imply implementing one from 1-5, in conjunction with one from 6-11.

Table 3-3. HEAVY-DUTY VEHICLE ALTERNATIVES' EFFECTIVENESS FOR THE STATE OF CALIFORNIA
(Losses recovered in tons of hydrocarbon)*

CALENDAR YEAR	ALTERNATIVES 6-11 (Carburetor Losses)	ALTERNATIVES 1-5 (Tank Running and Hot Soak Losses)	ALTERNATIVES 1-5 (Tank Diurnal Losses)	COMBINED (Carburetor and Fuel Tank Losses)
1975	5,160	12,790	8,640	26,590
1976	4,620	11,230	7,590	23,440
1977	3,980	9,660	6,530	20,170
1978	3,790	8,300	5,610	17,700
1979	3,190	6,950	4,700	14,840
1980	2,960	6,060	4,100	13,120
1981	2,530	5,170	3,490	11,190
1982	2,450	4,490	3,300	10,240
1983	2,210	4,040	2,730	8,980
1984	2,010	3,370	2,280	7,660
1985	1,950	3,100	2,090	7,140
Totals	34,850	75,160	51,060	161,070

* Alternative losses imply implementing one of alternatives 1 through 5, and one of alternatives 6-11. Combined losses imply implementing one from 1-5, in conjunction with one from 6-11.

This significant difference in heavy-duty vehicle carburetor losses compared to light-duty vehicles is attributed to the findings that a relatively larger proportion of heavy-duty vehicle carburetors are internally vented.

For the light-duty vehicles, if an evaporative emission control program were implemented in 1975, then during the fourth year of implementation, 1978, the program effectiveness would be essentially half as effective. The two primary reasons are: (1) attrition of older vehicles, and (2) less cumulative miles and trips for the existing pre-1970 vehicles.

Conversely, for the heavy-duty vehicles, the program effectiveness does not decrease to the 50 percent level until roughly the seventh year, 1981, assuming program initiation in 1975. The reasons for the greater program effectiveness are based on the earlier stated investigative results and assumptions: (1) heavy-duty vehicles remain in operation for a longer lifetime; and (2) vehicle age does not significantly affect annual mileage and daily trips.

3.5.2 Retrofit Effectiveness by Air Basin

Table 3-4 shows the recoverable vapor losses from carburetors and fuel tanks as emitted by the light-duty vehicle population in each air basin. Because each air basin has unique seasonal temperature profiles and corresponding dispensed fuel volatilities, the losses by air basin do not correspond in direct proportion of the air basin vehicle population to the statewide vehicle population. However, it is obvious that the South Coast Basin contributes a significant portion of the total state's vapor losses.

Table 3-4 shows that the South Coast Air Basin would be responsible for 50.6 percent of the total state evaporative emissions from pre-1970 light-duty vehicles. In Table 2-4, it was shown that the South Coast Air Basin accounts for approximately 51.5 percent of registered light-duty vehicles. For the San Joaquin Air Basin, 8.9 percent of the vapor losses occur here, whereas Table 2-4 showed that 7.7 percent of light-duty vehicles were registered in this area.

In a similar vein, Table 3-5 shows the evaporative emissions from pre-1970 heavy-duty vehicles as a function of air basins. For the South Coast Air Basin, 39.2 percent of the evaporative emissions emanate there, whereas Table 2-4 shows that 40.9 percent of pre-1970 heavy-duty vehicles are registered there. In the Southeast Desert Air Basin, 2.9 percent of the heavy-duty trucks contribute 4.2 percent of the total heavy-duty trucks evaporative emissions. This is a result of the higher temperatures and the subsequent greater losses per trip compared with other air basins.

An interesting observation from these tables is that although there were 7,554,000 pre-1970 light-duty vehicles registered in January, 1973, which would account for roughly 408,000 tons of evaporative emissions during the period 1975-1985, the 1,335,000 pre-1970 heavy-duty vehicles registered in January, 1973, would be emitting about 160,000 tons of evaporative emissions during the same period. Thus although there would be roughly three times as many light-duty vehicles in operation, the evaporative emissions would be about 2.6 times as much. As explained earlier, heavy-duty vehicles have more frequent trips and have a longer operating life as compared with the average light-duty vehicles.

Table 3-4. LIGHT-DUTY VEHICLE ALTERNATIVES' EFFECTIVENESS PER AIR BASIN (Losses recovered measured in tons of hydrocarbon)*

AIR BASIN	ALTERNATIVES 6-11 (Carburetor Losses)	ALTERNATIVES 1-5 (Tank Running and Hot Soak Losses)	(Tank Diurnal Losses)	COMBINED (Carburetor and Fuel Tank Losses)	PROPORTION OF TOTAL STATE
South Coast	62,960	40,760	102,500	206,220	0.506
San Francisco Bay	26,000	12,860	43,300	82,160	0.201
San Joaquin Valley	11,500	9,500	15,330	36,330	0.089
Sacramento Valley	7,700	5,250	11,330	24,280	0.060
San Diego	8,760	5,800	12,500	27,060	0.066
Southeast Desert	5,000	5,200	6,400	16,600	0.041
North Central Coast	2,100	1,100	3,500	6,700	0.016
South Central Coast	1,160	670	1,800	3,630	0.009
North Coast	1,110	550	1,800	3,460	0.008
Northeast Plateau	330	200	500	1,030	0.003
Great Basin Valley	131	96	179	410	0.001
Totals	126,751	81,986	199,139	407,880	1.000

* These are the losses recovered between January 1, 1975 and December 31, 1985.

Table 3-5. HEAVY-DUTY VEHICLE ALTERNATIVES' EFFECTIVENESS PER AIR BASIN
(Losses recovered measured in tons of hydrocarbon)*

AIR BASIN	ALTERNATIVES 6-11 (Carburetor Losses)	ALTERNATIVES 1-5 (Tank Running and Hot Soak Losses)	(Tank Diurnal Losses)	COMBINED (Carburetor and Fuel Tank Losses)	PROPORTION OF TOTAL STATE
South Coast	13,540	28,700	20,880	63,120	0.392
San Francisco Bay	6,690	10,860	10,570	28,120	0.175
San Joaquin Valley	5,480	14,750	6,890	27,120	0.168
Sacramento Valley	3,430	7,680	4,800	15,910	0.099
San Diego	2,260	4,900	3,060	10,220	0.063
Southeast Desert	1,220	4,120	1,480	6,820	0.042
North Central Coast	750	1,320	1,170	3,240	0.020
South Central Coast	380	720	560	1,660	0.010
North Coast	700	1,150	1,070	2,920	0.018
Northeast Plateau	290	580	410	1,280	0.008
Great Basin Valley	120	280	150	550	0.003
Totals	34,860	75,060	51,040	160,960	0.998

* These are the losses recovered between January 1, 1975 and December 31, 1985.

3.5.3 Effectiveness Measure by Model Year

Table 3-6 shows the calculated maximum effectiveness in evaporative emissions that could be controlled from pre-1970 light-duty vehicles. The calculated values take into consideration the variations in model-year carburetor and fuel tank configurations, manufacturer vehicle distribution, vehicle age and mileage accumulation, and expected vehicle attrition. Consequently, the table indicates that less effectiveness (evaporative emission control) is gained from a particular model year with each succeeding calendar year. Furthermore, the overall evaporative emissions decrease each calendar year due to normal attrition.

The tabulated data are useful in several ways. For example, data comparison between the calendar years 1975 and 1978 indicate that evaporative emission decrease by roughly 50 percent (98 tons down to 48 tons) due to vehicle attrition only. Beginning with 1978, and incrementally thereafter, model years 1955 to 1965 become relatively non-existent so that by 1985 only the 1966 to 1969 models are still registered.

The desirability of retrofitting the late 1960s models becomes apparent when evaluating the extreme right column of Table 3-6 ("Totals"). The evaporative emissions expected during the period 1975 to 1985 show that retrofitting the 1966 to 1969 models would account for about 75 percent of the total vapor losses from all pre-1970 light-duty vehicles.

Table 3-7 shows the total evaporative losses from heavy-duty vehicles by model year as a function of calendar year. Due to the fact that these vehicles remain operational for a longer duration than light-duty vehicles, the tabulated data show that

Table 3-6. COMBINATION ALTERNATIVES' EFFECTIVENESS PER MODEL YEAR FOR LIGHT-DUTY VEHICLES
(Losses recovered measured in thousands of tons of hydrocarbon)

MODEL YEAR	CALENDAR YEAR 1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	TOTALS
1969	19.2	18.2	16.2	13.3	11.7	7.3	5.6	4.1	2.7	1.4	0.7	100.4
1968	18.2	16.5	12.9	11.8	7.3	5.5	4.1	2.8	1.3	0.7	0.4	81.5
1967	16.2	13.2	11.6	7.4	5.5	4.0	2.7	1.4	0.7	0.4	0.2	63.3
1966	13.1	11.6	7.1	5.4	4.0	2.7	1.4	0.7	0.3	0.2	0.1	46.6
1965	11.1	7.4	5.2	3.9	2.6	1.3	0.7	0.4	0.2	0.1	-	32.9
1964	7.1	5.0	3.9	3.0	1.5	0.7	0.4	0.2	0.1	-	-	21.9
1963	5.1	4.1	2.6	1.5	0.8	0.3	0.2	0.1	-	-	-	14.7
1962	4.0	2.5	1.3	0.8	0.4	0.2	0.1	-	-	-	-	9.3
1961	3.0	1.7	0.7	0.4	0.2	0.1	-	-	-	-	-	6.1
1960	1.0	0.9	0.3	0.2	0.1	-	-	-	-	-	-	2.5
1959+	0.5	0.4	0.2	0.1	-	-	-	-	-	-	-	1.2
Totals	98.5	81.5	62.0	47.8	34.1	22.1	15.2	9.7	5.3	2.8	1.4	380.4

Note: Totals do not agree exactly with other data because of rounding off and not accounting for the few vehicles that remain in operation after 15 years.

Table 3-7. COMBINATION ALTERNATIVES' EFFECTIVENESS PER MODEL YEAR FOR HEAVY-DUTY VEHICLES
(Losses recovered measured in thousands of tons of hydrocarbon)

MODEL YEAR	CALENDAR YEAR 1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	TOTALS
1969	3.7	3.5	3.4	2.8	2.2	2.0	1.5	1.4	1.3	0.8	0.8	23.4
1968	3.7	3.3	2.8	2.3	1.9	1.4	1.3	1.2	0.8	0.7	0.7	20.1
1967	3.2	2.6	2.2	1.8	1.3	1.3	1.1	0.7	0.7	0.6	0.6	16.1
1966	2.7	2.1	1.8	1.4	1.2	1.2	0.8	0.7	0.7	0.6	0.6	13.8
1965	2.1	1.6	1.4	1.2	1.2	0.7	0.7	0.6	0.6	0.6	0.6	11.3
1964	1.9	1.4	1.2	1.1	0.7	0.7	0.6	0.6	0.6	0.5	0.5	9.8
1963	1.3	1.2	1.0	0.7	0.7	0.6	0.6	0.6	0.5	0.5	0.5	8.2
1962	1.2	1.2	0.6	0.6	0.6	0.5	0.5	0.5	0.4	0.4	0.4	6.9
1961	1.1	0.6	0.6	0.6	0.5	0.5	0.5	0.4	0.4	0.4	0.3	5.9
1960	0.5	0.6	0.6	0.5	0.5	0.5	0.4	0.4	0.4	0.3	0.3	5.0
1959+	4.8	4.5	4.2	4.1	4.0	3.5	3.0	3.0	2.9	2.6	2.5	39.1
Totals	26.2	22.6	19.8	17.1	15.8	12.9	11.0	10.1	9.3	8.0	7.8	160.0

Note: Totals do not agree exactly with other data because of rounding off and not accounting for the few vehicles that remain in operation after 15 years.

the 1959 and older vehicles will contribute a significant portion of the overall emissions calculated for the individual years and for the total period 1975 to 1985. However, the 1966 to 1969 vehicles would contribute about 46 percent of the total calculated evaporative emissions.

3.6 LIMITATIONS OF ANALYTICAL RESULTS

Various documents and information sources were used to arrive at data inputs to the effectiveness model. Each of the inputs have different levels of uncertainty based on the scope and limitations of the original investigation. In a few instances, precise data were not available and interpolations and extrapolations were required. The following paragraphs identify these data inputs and delineate associated assumptions.

3.6.1 Gasoline Characteristics

Temperature and gasoline volatility ratings are key variables which greatly affect the amounts of evaporative losses for a given situation (Ref. 14). The temperature data were obtained from the National Oceanic and Atmospheric Administration (Ref. 13) and from the text, Traveling Weatherwise (Ref. 23). The temperature data for an air basin is applied to one or two locations within that air basin, normally at a high population density locale. A check, however, of other locations within the same basin revealed similar temperature profiles. Hence, these profiles generally indicate representative temperature information for each air basin.

The gasoline volatility ratings used in the loss calculations coincide with the maximum values the State of California allows for each air basin and season. Whenever regulated values were not specified by the State for a given air basin and season, typical values from the E.I. du Pont de Nemours and Company report (Ref. 14) were used. These volatility ratings were derived from samples taken for various climates and seasons throughout the country.

Often du Pont and Company (Ref. 14) stated that the volatility ratings would approximate 10 to 13 RVP for a given situation. The gasoline modification study (Ref. 15) obtained experimental loss data for RVPs of 10, 8 and 5 only. Consequently, the evaporative losses for those situations where RVP over 10 was used, utilized the losses corresponding to 10 RVP. Similarly, for any situation where an RVP equal to 8 but less than 10 applied, the losses corresponding to 8 RVP were used. This technique tends to reduce the effectiveness measure of each proposed alternative.

3.6.2 Vehicle Driving Patterns

The driving patterns for light-duty vehicles were obtained from the gasoline modification study. The pattern used was derived empirically via actual counts from major traffic arteries in the Los Angeles area. This distribution was used for several reasons. First, Los Angeles traffic represents approximately one-third of the total State vehicle population. Secondly, the Systems Development Corporation study (Ref. 16) concluded that a large similarity in driving patterns exists among metropolitan areas which included six of the nation's larger population centers (New York City, Chicago, Houston, Los Angeles, Cincinnati, and

Minneapolis-St. Paul). The uncertainty occurs when applying this distribution uniformly throughout the State.

The driving patterns for the heavy-duty vehicles under consideration were derived from a study of New York City traffic (Ref. 17). A similar survey of Los Angeles traffic is being finalized and will be available in 1974. In view of the findings in the SDC report, the formulated distribution was applied to California traffic behavior.

3.6.3 Evaporative Emissions

The hot soak and running evaporative losses were based on the results of the Gasoline Modification Study (Ref. 15). Diurnal losses were based on studies oriented toward the design of evaporative emission control (Refs. 19 and 20). The number of light-duty vehicle trips was established based on mileage accumulation as a function of vehicle age (Ref. 26) and the average trip length of 7.5 miles (Refs. 16, 24, 27).

For heavy-duty vehicles, annual mileage accumulation was relatively independent of vehicle age (Ref. 22). Additionally, the average number of daily trips per vehicle, 11, was essentially the same for all heavy-duty vehicles (Refs. 17 and 22). The average trip length of 4 miles was used (Ref. 17).

The evaporative emission losses experienced per trip was assumed to be the same for both light-duty and heavy-duty vehicles. This assumption is based on the similarity of carburetor and fuel tank configurations, and fuel utilized. However, the differences in the frequency of trips and mileage accumulation will account for overall evaporative losses.

3.6.4 Vehicle Registration and Distribution

Derivations of applicable vehicle population are found in Appendixes A and B. The population per vehicle make, model year, and air basin was obtained from the California Motor Vehicle Department (Ref. 7) and R.H. Donnelley, Inc. (Ref. 8). The annual light- and heavy-duty population increases are based on statistics found in Automotive News (Ref. 12) and California Truck Facts (Ref. 22).

Vehicle distribution for model years beyond 15 years is not documented, either for light-duty or heavy-duty vehicles. Consequently, assumptions were made relative to these older vehicles. For the light-duty vehicles, it was assumed that after 15 years of existence, these models would become nonoperational on a half-life basis. That is, each succeeding year's registration beyond 15 years of age would show only half the previous year's vehicles. For example, in 1975 there may be 5,000 1960s registered; the next year, 1976, there would be 2,500 1960s; the following year, 1,250; and so on.

Heavy-duty vehicles are operated over a longer lifetime than light-duty. Instead of a half-life attrition beyond 15 years of age, it was determined that a 0.95 deterioration factor was warranted after examining historical data. The primary determinant was the fact that roughly 13 percent of total registrations are 15 years-or-older vehicles compared with about 1.5 percent of 14-year-old vehicles.

SECTION 4

COST ANALYSIS

This section provides an analysis of the consumer costs involved in implementing a program requiring evaporative emission control systems on pre-1970 vehicles. A detailed cost model is described which provides a framework for identifying and calculating the costs associated with the program. Results of the cost analysis are evaluated, and the limitation of these results are presented.

4.1 LIFE-CYCLE COST MODEL

A life-cycle cost analysis accounts for all of the individual consumer cost elements that accrue and contribute to the total cost of a system from time of purchase and installation as well as throughout the prescribed life cycle.

The first task in developing the life-cycle cost (LCC) model is to define the major categories which constitute total consumer expenditures. In this study the major categories are classified as initial investment and annually recurring system operation costs.

4.1.1 Initial Investment Costs

The initial investment includes the consumer costs incurred in the process of phasing a proposed system alternative into actual implementation status. Expenditures attributed to

system parts and installation labor comprise these initial costs. The majority of system implementation costs are related to the initial investment cost category.

4.1.2 Annually Recurring System Operation Costs

These expenditures include annually recurring costs which contribute to the objective of continually effective system operation, primarily maintenance expenditures.

4.2 MODEL FORMULATION

Based on the two major categories, a top level life-cycle cost model can be structured as given below;

$$LCC = PWF\sum_{n=1}^{y}(C_{INV_n}+C_{AM_n})N_n \qquad \text{(Eq. 4-1)}$$

where:

LCC = Discounted life-cycle consumer cost of an evaporative control system alternative from time of purchase and installation and throughout the prescribed life cycle, measured in 1974 dollars.

n = Index of years over which costs are accumulated.

y = Number of years over which costs are accumulated.

PWF = Present worth factor applied from base year 1975 to all future costs.

C_{INV} = Initial investment cost per vehicle, measured in dollars.

C_{AM} = Annually recurring system operation costs per vehicle, measured in dollars.

N = Number of vehicles under consideration during year n.

See Appendix N for detailed discussion of cost model.

4.3 COST MODEL ELEMENTS

The alternatives considered were comprised of components which were either similar or identical to ones already on the market. Hence appropriate cost values were available.

The material (parts) costs were obtained from jobber and retail price listing manuals which are normally available at parts houses and/or vehicle dealerships.

The installation costs were obtained from Motor's Flat Rate and Parts Manual (Ref. 18), a standard text used by mechanics for ascertaining such costs.

The annual maintenance costs for those approaches that involved fuel tank modifications in conjunction with adding a carbon canister have been estimated at $2.50 for replacing the canister filter once a year. There were no additional maintenance costs associated with carburetor modifications.

In determining the expected life-cycle cost of a retrofit system, future costs incurred are discounted to a present worth. Additionally, the future costs must be escalated to reflect expected price increases. In selecting the discount rate applied to future costs, the consumer's expected rate-of-return on future investments is sometimes used. Another rate often used is the lending institutions' loan rate. For this study, the consumer's return-on-investment of 4.3 percent after taxes has been used (Ref. 25). For convenience the present worth factor (PWF) is set to unity implying that the expected future price escalation equals the expected discount rate of future dollars.

4.4 ANALYTICAL RESULTS

Based on cost estimating techniques discussed in the previous section, costs were obtained for the various alternative approaches.

4.4.1 Individual Vehicle Owner Costs

The detailed costs per system corresponding to each alternative and vehicle make are given in Appendixes G and H.

An average cost per alternative can be computed from the values found in the previously mentioned appendixes and the distributions of vehicles per make and model for each air basin obtained from R. H. Donnelley, Inc. (Ref. 8). Table 4-1 shows the calculated mean value for each alternative if all applicable pre-1970 vehicles were retrofitted. Vehicle retrofit applicability is outlined in Appendix M.

The cost breakdowns for material and labor are given in Appendixes G. and H. Costs vary as a function of vehicle type and

TABLE 4-1. AVERAGE ALTERNATIVE VALUES FOR LIGHT AND HEAVY-DUTY VEHICLES (In Dollars)

Alternatives	Light-Duty Vehicles	Heavy-Duty Vehicles
1	$152.30	$176.19
2	104.78	103.88
3	95.32	94.62
3 Alternate	94.53	94.37
4	106.39	94.78
5	92.42	92.29
6	101.18	85.18
7	65.48	66.65
8	28.79	28.50
9	30.23	29.85
10	36.71	36.00
11	52.94	51.20
Alternative Combinations		
1 and 6	253.48	268.48
1 and 7	217.78	261.37
1 and 9	182.53	204.69
2 and 6	205.98	196.17
2 and 7	170.26	189.06
2 and 9	135.01	132.38
4 and 6	207.57	186.66
4 and 7	171.87	179.55
4 and 9	136.62	122.87

make. A summary of the expected range of costs for the different alternatives is given in Table 4-2. Note that the costs for the combination alternatives are merely the sum of the constituent component alternatives. For example, the cost of combination alternative 1 and 9 equals the sum of the costs associated with Approaches 1 and 9, respectively. This may be slightly high because some benefit in time savings and costs should be realizable. However, it may occur that more than one service center would be involved to retrofit the vehicle.

4.4.2 Alternatives' Costs on a Statewide Basis

The costs for implementing each alternative on a statewide basis are given for light and heavy-duty vehicles in Table 4-3. The initial investment costs were based on the distribution of each particular model vehicle within each air basin and the specific costs for the corresponding alternatives per vehicle type. In addition, these are the costs accrued from January, 1975, to December, 1985. However, note that the majority of the expenditures are incurred from the initial investments as delineated earlier in Table 4-2 for the individual vehicles.

Several other factors should be noted regarding these costs. Alternatives 1 through 5 apply to fuel tank assembly modifications. Except for Alternative 5, each alternative can be used on most pre-1970 light or heavy-duty vehicles. Alternative 5 is applicable only to vehicles with a vent located directly on the tank and not the cap and can only be used on approximately 20 percent of the light-duty and none of the heavy-duty vehicles. Appendix D specifies vehicle venting configuration.

Alternatives 6 through 11 are carburetor assembly modifications. Some vehicles use internal carburetor fuel bowl venting, especially earlier (1955 to 1960) models. Consequently, these

Table 4-2. ALTERNATIVE APPROACHES' AVERAGE COST RANGES PER SYSTEM[a]

Alternative Type	Alternative	Vehicles Owner Average Costs			Maintenance (per 12,000 miles)
		Parts	Labor	Total	
Light-Duty Vehicles					
Fuel Tank	1	$ 80 - $155	$30	$110 - $185	$2.50
	2	55 - 91	$27 - $29	82 - 120	2.50
	3	63 - 93	13	76 - 106	2.50
	4	53 - 90	30 - 32	83 - 122	2.50
	5	53 - 91	15 - 17	68 - 108	2.50
Carburetor	6	50 - 131	10 - 15	60 - 146	-0-
	7	31 - 77	10 - 15	41 - 92	-0-
	8	12 - 13	15 - 18	27 - 31	-0-
	9	12 - 15	15 - 18	27 - 33	-0-
	10	16 - 21	15 - 20	31 - 41	-0-
	11	19 - 35	20 - 28	39 - 63	-0-
Heavy-Duty Vehicles					
Fuel Tank	1	$125 - $155	$30	$155 - $185	$2.50
	2	60 - 87	$27 - $29	87 - 116	2.50
	3	65 - 93	13	78 - 106	2.50
	4	58 - 87	32	90 - 119	2.50
	5	58 - 87	17	75 - 104	2.50
Carburetor	6	43 - 121	10 - 15	53 - 136	-0-
	7	31 - 77	10 - 15	41 - 92	-0-
	8	12 - 13	15 - 18	27 - 31	-0-
	9	12 - 15	15 - 18	27 - 33	-0-
	10	16 - 21	15 - 20	31 - 41	-0-
	11	19 - 35	20 - 28	39 - 63	-0-

[a]Costs do not include State sales tax. Labor costs based on posted shop rate of $10 per hour. Prices were obtained in November, 1973.

Table 4-3. COST OF ALTERNATIVES ON A STATEWIDE BASIS
January 1975 to December 1985
(In Millions of Dollars)

ALTERNATIVES	LIGHT-DUTY VEHICLES			HEAVY-DUTY VEHICLES		
	C_{INV}	C_{AM}	C_{TOTAL}	C_{INV}	C_{AM}	C_{TOTAL}
1	873.0	47.7	920.7	185.8	13.1	198.9
2	627.0	47.7	674.7	713.1	13.1	126.2
3	572.0	47.7	619.7	104.0	13.1	117.1
4	639.0	47.7	686.7	104.0	13.1	117.1
5	95.0	8.1	103.1	--NOT APPLICABLE--		
6	457.0	0.0	457.0	22.8	0.0	22.8
7	298.0	0.0	298.0	17.8	0.0	17.8
8	131.0	0.0	131.0	8.6	0.0	8.6
9	0.0	0.0	0.0	0.0	0.0	0.0
10	168.0	0.0	168.0	10.1	0.0	10.1
11	241.0	0.0	241.0	13.0	0.0	13.0
1&6	1330.0	47.7	1377.7	208.6	13.1	221.7
1&7	1171.0	47.7	1218.7	203.6	13.1	216.7
1&9	1011.0	47.7	1058.7	194.4	13.1	207.5
2&6	1084.0	47.7	1131.7	135.9	13.1	149.0
2&7	925.0	47.7	972.7	130.9	13.1	144.0
2&9	765.0	47.7	812.7	121.7	13.1	134.8
4&6	1096.0	47.7	1143.7	126.8	13.1	139.9
4&7	937.0	47.7	984.7	121.8	13.1	134.9
4&9	777.0	47.7	824.7	112.6	13.1	125.7

vehicles would not need any carburetor modifications. Appendix F describes the carburetor venting techniques used on the 1955 to 1969 vehicles under consideration.

Based on this information the vehicle population which could use Alternatives 6 through 11 was determined. The total costs on statewide and air basin bases are determined as a function of this population.

4.4.3 Alternatives' Costs per Air Basin

As stated, the distribution of the model types within each air basin obtained from R. H. Donnelley, Inc. (Ref. 8) was used in conjunction with the specific alternatives' costs per vehicle type. Subsequently, the total costs for implementing each approach with each air basin was obtained. The results are given in Tables 4-4 and 4-5 for light and heavy-duty vehicles, respectively.

The comments made in previous discussions when observing these results are applicable here. For example, only approxiamtely 20 percent of the light-duty vehicles can utilize Alternative 5. In addition, not all vehicles can use Alternatives 6 and 11 because their carburetors may already be internally vented.

4.4.4 Costs of Alternatives per Model Year Vehicle

The vehicle population as a function of vehicle age is described in Appendixes A and B. Using these vehicle age distributions and the total California expenditures found in Table 4-3, the costs of the alternatives are found as a function of model year (i.e., vehicle age). The results are given in Tables 4-6 and 4-7 for light and heavy-duty vehicles, respectively.

Table 4-4. COST OF ALTERNATIVES PER AIR BASIN FOR LIGHT-DUTY VEHICLES
January 1975 to December 1985
(In Millions of Dollars)

Air Basins	Alternatives																		
	1	2	3	4	5	6	7	8	9[a]	10	11	1&6	1&7	1&9	2&6	2&7	2&9	4&6	4&7	4&9
South Coast	474.0	347.3	319.0	353.5	53.1	235.3	153.4	67.4	0.0	86.5	124.1	709.2	627.4	545.0	582.6	500.7	418.4	588.8	506.9	424.6
San Francisco	200.2	146.7	134.7	149.3	22.4	99.3	64.8	28.4	0.0	36.5	52.4	299.4	264.9	230.2	246.0	211.5	176.7	248.6	214.1	179.3
San Joaquin	70.9	51.9	47.7	52.9	7.9	35.2	22.9	10.1	0.0	12.9	18.6	106.1	93.8	81.5	87.1	74.9	62.6	88.1	75.8	63.5
Sacramento	52.5	38.5	35.3	39.1	5.9	26.0	17.0	7.5	0.0	9.6	13.7	78.5	69.5	60.3	64.5	55.4	46.3	65.2	56.1	47.0
San Diego	57.7	42.3	38.8	43.1	6.5	28.6	18.7	8.2	0.0	10.5	15.1	86.4	76.4	66.4	71.0	61.0	51.0	71.7	61.7	51.7
Southeast Desert	29.7	21.8	20.0	22.2	3.3	14.8	9.6	4.2	0.0	5.4	7.8	44.5	39.4	34.2	36.6	31.4	26.3	36.9	31.8	26.6
North Central Coast	15.9	11.8	10.8	12.0	1.8	8.0	5.2	2.3	0.0	2.9	4.2	24.1	21.3	18.5	19.8	17.0	14.2	20.0	17.2	14.4
South Central Coast	8.3	6.1	5.6	6.2	0.9	4.1	2.7	1.2	0.0	1.5	2.2	12.4	11.0	9.5	10.2	8.8	7.3	10.3	8.9	7.4
North Coast	8.3	6.1	5.6	6.2	0.9	4.1	2.7	1.2	0.0	1.5	2.2	12.4	11.0	9.5	10.2	8.8	7.3	10.3	8.9	7.4
Northeast Plateau	2.3	1.7	1.5	1.7	0.3	1.1	0.7	0.3	0.0	0.4	0.6	3.4	3.0	2.6	2.8	2.4	2.0	2.9	2.5	2.1
Great Basin Valley	0.8	0.6	0.6	0.6	0.1	0.4	0.3	0.1	0.0	0.2	0.2	1.2	1.1	1.0	1.0	0.9	0.7	1.0	0.9	0.7

[a]Must be supplemented with one of the fuel tank modification alternatives.

Table 4-5. COST OF ALTERNATIVES PER AIR BASIN FOR HEAVY-DUTY VEHICLES
January 1975 to December 1985
(In Millions of Dollars)

Air Basins	Alternatives																		
	1	2	3	4	5[a]	6	7	8	9	10	11	1&6	1&7	1&9	2&6	2&7	2&9	4&6	4&7	4&9
South Coast	81.3	51.6	47.9	47.9	N/A	9.3	7.3	3.5	0.0	4.1	5.3	90.7	88.6	84.9	60.9	58.9	55.1	57.2	55.2	51.4
San Francisco	41.2	26.1	24.2	24.2	N/A	4.7	3.7	1.8	0.0	2.1	2.7	45.9	44.9	43.0	30.8	29.8	27.9	29.0	27.9	26.3
San Joaquin	26.9	17.0	15.8	15.8	N/A	3.1	2.4	1.2	0.0	1.4	1.8	29.9	29.3	28.0	20.1	19.4	18.2	18.9	18.2	17.0
Sacramento	18.7	11.9	11.0	11.0	N/A	2.1	1.7	0.8	0.0	0.9	1.2	20.8	20.4	19.5	14.0	13.5	12.7	13.2	12.7	11.8
San Diego	11.9	7.6	7.0	7.0	N/A	1.4	1.1	0.5	0.0	0.6	0.8	13.3	13.0	12.4	8.9	8.6	8.1	8.4	8.1	7.5
Southeast Desert	5.8	3.7	3.4	3.4	N/A	0.7	0.5	0.2	0.0	0.3	0.4	6.4	6.3	6.0	4.3	4.2	3.9	4.1	3.9	3.6
North Central Coast	4.6	2.9	2.7	2.7	N/A	0.5	0.4	0.2	0.0	0.2	0.3	5.1	5.0	4.8	3.4	3.3	3.1	3.2	3.1	2.9
South Central Coast	2.2	1.4	1.3	1.3	N/A	0.3	0.2	0.1	0.0	0.1	0.1	2.4	2.4	2.3	1.6	1.6	1.5	1.5	1.5	1.4
North Coast	4.2	2.7	2.5	2.5	N/A	0.5	0.4	0.2	0.0	0.2	0.3	4.7	4.6	4.4	3.1	3.0	2.8	2.9	2.8	2.6
Northeast Plateau	1.6	1.0	0.9	0.9	N/A	0.2	0.1	0.1	0.0	0.1	0.1	1.8	1.7	1.7	1.2	1.2	1.1	1.1	1.1	1.0
Great Basin Valley	0.6	0.4	0.4	0.4	N/A	0.1	0.1	0.0	0.0	0.0	0.0	0.7	0.6	0.6	0.4	0.4	0.4	0.4	0.4	0.4

[a]Must be supplemented with one of the fuel tank modification alternatives.

Table 4-6. TOTAL ALTERNATIVES' COST PER MODEL YEAR FOR CALIFORNIA LIGHT-DUTY VEHICLES
(In millions of dollars)

ALTERNATIVES	MODEL YEAR										
	1969	1968	1967	1966	1965	1964	1963	1962	1961	1960	1959 & EARLIER
1	156.5	146.3	135.1	111.2	102.0	72.5	58.4	46.2	30.8	15.5	46.7
2	115.5	107.7	99.6	81.4	74.6	53.0	42.6	33.7	22.4	11.3	33.7
3	106.8	99.1	91.5	74.6	68.4	48.6	39.0	30.9	20.5	10.4	30.7
4	117.5	109.5	101.3	82.9	75.9	53.9	43.4	34.3	22.8	11.5	34.3
5	15.6	14.7	13.8	11.7	10.6	7.5	6.1	4.8	3.2	1.6	5.0
6	82.1	77.4	72.1	59.6	52.0	37.0	25.9	18.5	12.9	6.1	12.9
7	53.9	50.8	47.3	39.1	34.2	24.3	16.9	12.0	8.4	4.0	8.4
8	23.6	22.2	20.7	17.1	15.0	10.7	7.3	5.2	3.6	1.6	3.3
9	24.8	23.4	21.8	17.9	15.8	11.2	7.7	5.5	3.8	1.8	3.5
10	30.3	28.5	26.6	21.9	19.3	13.7	9.4	6.7	4.7	2.2	4.4
11	43.4	40.9	38.0	31.4	27.6	19.6	13.6	9.7	6.8	3.2	6.6
1 & 6	238.6	223.7	207.2	170.8	154.0	109.5	84.3	64.7	43.7	21.6	59.6
1 & 7	210.4	197.1	182.4	151.3	136.2	96.8	75.3	58.2	39.2	19.5	55.1
1 & 9	181.3	169.7	156.9	130.1	117.8	83.7	66.1	51.7	34.6	17.3	50.2
2 & 6	197.6	185.1	171.7	142.0	126.6	90.0	68.5	52.2	35.3	17.4	46.6
2 & 7	169.4	158.5	146.9	120.5	108.8	77.3	59.5	45.7	30.8	15.3	42.1
2 & 9	140.3	131.1	121.4	100.3	90.4	64.2	50.3	39.2	26.2	13.2	37.2
4 & 6	199.6	186.9	173.4	142.5	77.9	90.9	69.3	52.8	35.7	17.6	47.2
4 & 7	171.4	160.3	148.6	122.0	110.1	78.2	60.3	46.3	31.2	15.5	42.7
4 & 9	142.3	132.9	123.1	100.8	91.7	65.1	51.1	39.8	26.6	13.3	37.8

Table 4-7. TOTAL ALTERNATIVES' COST PER MODEL YEAR FOR CALIFORNIA HEAVY-DUTY VEHICLES
(In millions of dollars)

ALTERNATIVES	MODEL YEAR										
	1969	1968	1967	1966	1965	1964	1963	1962	1961	1960	1959 & EARLIER
1	26.5	26.4	25.6	24.0	18.4	14.8	10.2	10.3	8.0	4.4	30.3
2	18.2	17.9	16.8	15.4	11.6	9.4	6.2	6.1	4.6	2.3	18.1
3	17.1	16.8	15.7	14.3	10.8	8.5	5.7	5.6	4.1	2.1	16.5
4	17.1	16.8	15.7	14.3	10.8	8.5	5.7	5.6	4.1	2.1	16.5
5	--Generally does not apply--										
6	4.3	4.3	3.4	3.0	2.2	2.0	1.1	1.1	0.3	0.2	0.9
7	3.4	3.4	2.7	2.4	1.8	1.5	0.9	0.8	0.2	0.1	0.7
8	1.6	1.6	1.3	1.1	0.9	0.7	0.4	0.4	0.1	0.1	0.4
9	1.6	1.6	1.3	1.1	0.9	0.7	0.4	0.4	0.1	0.1	0.4
10	1.9	1.9	1.5	1.3	1.0	0.9	0.5	0.5	0.1	0.1	0.4
11	2.4	2.4	2.0	1.7	1.3	1.1	0.6	0.6	0.2	0.1	0.5
1 & 6	30.6	30.6	29.0	27.9	20.6	16.8	11.3	11.4	8.3	4.6	31.2
1 & 7	29.9	29.8	28.3	26.4	20.2	16.3	11.1	11.1	8.2	4.5	31.0
1 & 9	28.4	28.0	26.9	25.1	19.3	15.5	10.6	10.7	8.1	4.5	30.7
2 & 6	22.5	22.2	20.2	18.4	13.8	11.2	7.3	7.2	4.9	2.5	19.0
2 & 7	21.6	21.3	19.5	17.8	13.4	10.7	7.1	6.9	4.8	2.4	18.8
2 & 9	19.8	19.5	18.1	16.0	12.5	9.9	6.6	6.5	4.7	2.4	18.5
4 & 6	21.4	21.1	19.1	17.3	13.0	10.5	6.8	6.7	4.4	2.3	17.4
4 & 7	20.4	20.2	18.4	16.9	12.6	10.0	6.6	6.4	4.3	2.2	17.2
4 & 9	18.7	18.4	17.0	15.4	11.7	9.2	6.1	6.0	4.2	2.2	16.9

As in the previous cost tables, these expenditures are accrued from January, 1975 to December, 1985; and the initial investments constitute the majority of the total expenditures.

The decrease in costs as a function of vehicle age is a result of fewer older models. Again note that although values are given for Alternative 9, this approach can only be used in combination with one of the fuel tank modifications.

4.4.5 Annual Operation Cost Stream

The annual operation costs, C_{AM}, decrease with respect to time. This is due to the increasing number of pre-1970 vehicles' lifetime expiring as time progresses. Figure 4-1 shows this operation costs versus time relationship for all California pre-1970, light-duty vehicles. Note that operation expenditures apply only to fuel tank modifications (i.e., Alternatives 1 through 5).

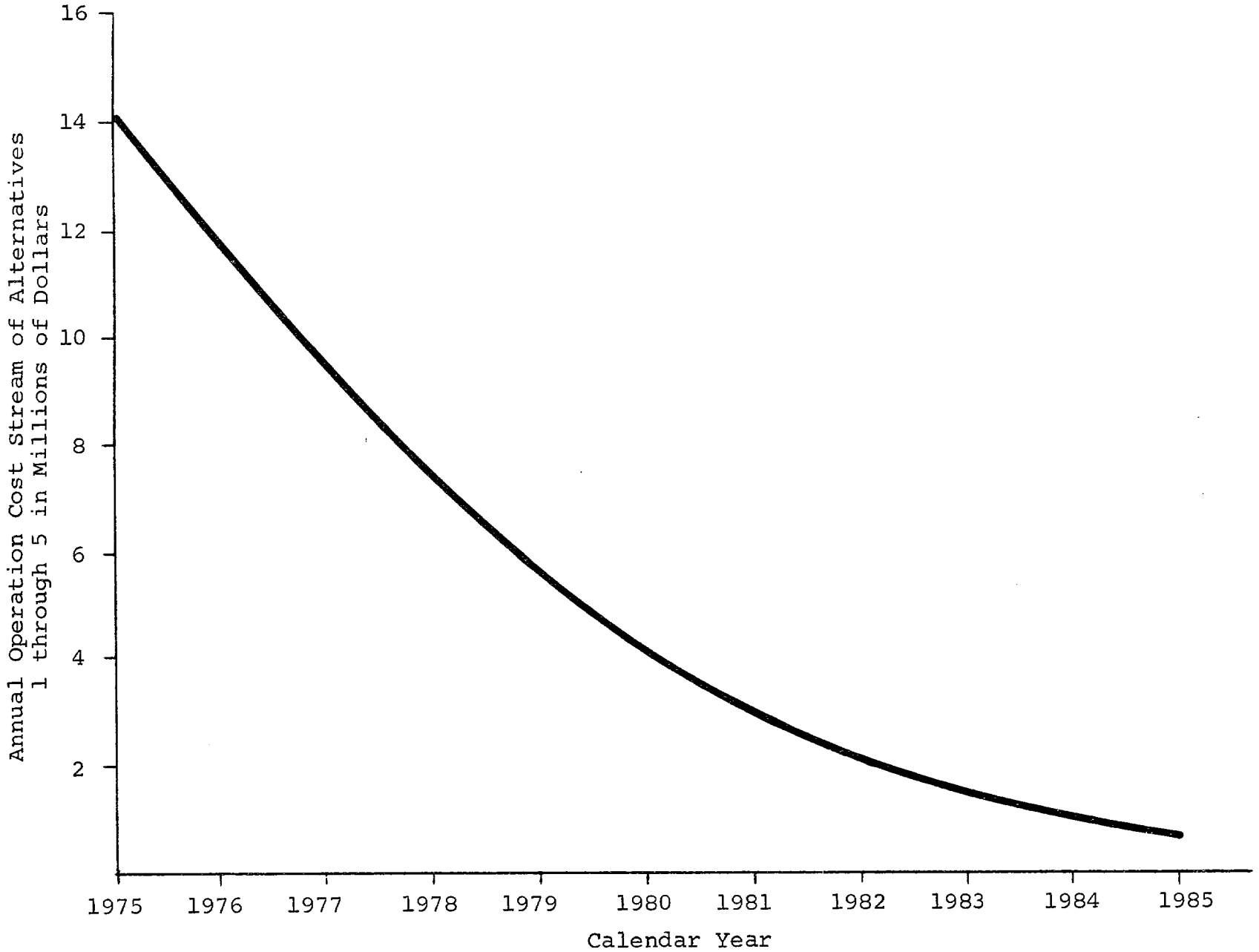

Figure 4-1. ANNUAL OPERATION COST STREAM OF ALTERNATIVES 1 THROUGH 5 vs. TIME

SECTION 5

COST EFFECTIVENESS ANALYSIS

This section describes the cost effectiveness analysis conducted to establish a measure of technical and economic feasibility of requiring pre-1970 vehicles to be equipped with evaporation emission control systems. The cost effectiveness indices are defined on a statewide, air basin, and model year bases. Furthermore, the determination is based on costs and effectiveness assuming implementation during the calendar years 1975 through 1985. These calculated indices provide quantitative measures to ascertain relative cost effectiveness of the alternatives using a consistent, repeatable procedure.

5.1 COST EFFECTIVENESS INDEX

A cost effectiveness analysis attempts to identify, define, and quantify the benefits derived from the resources and money expended. As such, it requires an appreciation and determination of the alternative program costs and the associated program objectives.

The cost analysis and results were discussed previously in Section 4. Similarly, the effectiveness of the alternative designs was calculated and discussed in Section 3. To conduct the cost effectiveness analysis, the results from these two analyses are combined.

5.1.1 Cost Effectiveness Comparisons

The cost effectiveness (CE) index is developed to quantify, evaluate, and compare the design alternatives. For each alternative, a CE index is calculated relative to each program. An evaluation of the individual CE indices provides a basis for determining relative measures of design cost effectiveness. Additionally, where past studies or future efforts encompass the same CE measure, then comparisons of results derived for other control strategies may be made.

5.1.2 Simplified Cost Effectiveness Equations

Shown below is the simplified equation to be used in determining the quantitative measure of CE.

$$\text{Cost Effectiveness Index, CE} = \frac{\text{Program Cost}}{\text{Effectiveness Measure}} \qquad \text{(Eq. 5-1)}$$

$$= \frac{\text{Dollars}}{\text{Hydrocarbon Weight}}$$

Recall that the effectiveness measures were calculated as a function of the period, beginning in 1975 and projected to 1985. Correspondingly, the alternative costs were calculated for the same time period. In effect, then, the CE index as calculated would reflect the measure of cost effectiveness during the aforementioned period.

Using the CE indices thus calculated, the design alternatives can be ranked in order of least dollar cost per unit weight of hydrocarbon vapors recovered. This does not necessarily mean that the particular alternative would realize the least

cost; nor does it imply that it would achieve the greatest recovery. The ranking of the indices serves as a means of identifying the alternative that exhibits the greatest potential for the costs incurred.

5.2 COST EFFECTIVENESS CALCULATIONS

The measures of cost effectiveness may be calculated on a statewide, air basin, and model year vehicle bases. Each CE index computed provides a quantified value of relative desirability. Neither by itself reveals the degree of acceptability (i.e., each index must be used as a means of comparing alternative concepts whose CE indices were similarly computed).

5.2.1 Statewide Cost Effectiveness Computation

On a statewide basis, the cost effectiveness index is determined as follows:

$$CE_{state} = \frac{AC}{VR} \qquad \text{(Eq. 5-2)}$$

where:

AC = Alternative approach's total consumer cost in California, measured in dollars

VR = Amount of hydrocarbon vapor recovered in California, measured in pounds

Based on the above nomenclature, the cost effectiveness indices for light and heavy-duty vehicles are given in Table 5-1.

In general, carburetor modifications are more cost effective than fuel tank modifications for both light and heavy-duty

Table 5-1. ALTERNATIVES' COST EFFECTIVENESS INDICES FOR THE TOTAL STATE
(Dollars per Pound of Hydrocarbon Contained)

Type of Modification	Alternative	Light-Duty Vehicle	Heavy-Duty Vehicle
Fuel Tank	1	3.63	2.85
	2	2.66	1.81
	3	2.44	1.68
	4	2.71	1.68
	5	2.39	a
Carburetor	6	0.81	0.09
	7	0.53	0.07
	8	0.23	0.03
	9	b	b
	10	0.30	0.04
	11	0.43	0.05
Fuel Tank and Carburetor	1 & 6	1.69	0.69
	1 & 7	1.49	0.67
	1 & 9	1.30	0.64
	2 & 6	1.39	0.46
	2 & 7	1.19	0.45
	2 & 9	1.00	0.42
	4 & 6	1.40	0.43
	4 & 7	1.21	0.42
	4 & 9	1.01	0.39

[a]Does not apply.

[b]Alternative 9 can only be used in combination with a fuel tank modification incorporating a carbon canister.

vehicles. Additionally, retrofitting heavy-duty vehicles is more cost effective than retrofitting light-duty vehicles. Although carburetor modifications are more cost effective than any combination approach, the efficacy of achieving nearly total containment as, in approach combinations 2 and 9 or 4 and 9 should be considered.

5.2.2 Cost Effectiveness Computation per Air Basin

In Section 3 it was shown that the amount of evaporative losses retained varies as a function of temperature. Since there exists significant climatic difference between the various air basins within California, cost effectiveness indices were computed for each air basin to ascertain variations as a function of air basins.

The State of California specifies volatility ratings for some warmer air basins during certain seasons as a means toward controlling evaporative emission. Data in Table 3-3 indicated that the warmer air basins still tend to have higher evaporative emission levels than other basins. By using the effectiveness measure from Section 3 and the cost data from Section 4, indices were derived as a function of air basins.

Data in Table 5-2 show that for any alternative considered, the most cost effective approaches would be to retrofit vehicles in the Southeast Desert Air Basin followed by those in the San Joaquin Valley. For the South Coast Air Basin, where over 51 percent of the State's light-duty vehicles are registered, the most cost effective fuel tank modifications would be Approaches 3 and 5, and the most cost effective carburetor modifications would be Approaches 8 and 10. For the combined approach which would realize the greatest effectiveness measure, the most cost effective approaches would be approach combinations 2 and 9, and 4 and 9. Similar types of information may

Table 5-2. COST EFFECTIVENESS INDICES OF ALTERNATIVES IN EACH AIR BASIN FOR LIGHT-DUTY VEHICLES
(Dollars per Pound of Hydrocarbon Recovered)

Air Basin	Alternatives																			
	1	2	3	4	5	6	7	8	9[a]	10	11	1&6	1&7	1&9	2&6	2&7	2&9	4&6	4&7	4&9
South Coast	1.65	1.21	1.11	1.23	0.18	1.87	1.22	0.54	0.0	0.69	0.99	1.72	1.52	1.32	1.41	1.21	1.01	1.42	1.23	1.03
San Francisco	1.78	1.31	1.20	1.33	0.20	1.91	1.25	0.55	0.0	0.70	1.01	1.82	1.61	1.40	1.50	1.29	1.08	1.51	1.30	1.09
San Joaquin	1.42	1.05	0.96	1.07	0.16	1.53	1.00	0.44	0.0	0.56	0.81	1.46	1.29	1.12	1.20	1.03	0.86	1.21	1.04	0.87
Sacramento	1.58	1.16	1.06	1.18	0.18	1.69	1.10	0.49	0.0	0.62	0.89	1.62	1.43	1.24	1.33	1.14	0.95	1.34	1.16	0.97
San Diego	1.58	1.16	1.06	1.18	0.18	1.63	1.07	0.47	0.0	0.60	0.86	1.60	1.41	1.23	1.31	1.13	0.94	1.31	1.14	0.96
Southeast Desert	1.28	0.94	0.86	0.96	0.14	1.48	0.96	0.42	0.0	0.54	0.78	1.34	1.19	1.03	1.10	0.95	0.79	1.14	0.96	0.79
North Central Coast	1.73	1.28	1.17	1.30	0.20	1.90	1.24	0.55	0.0	0.69	1.00	1.80	1.59	1.38	1.48	1.27	1.06	1.49	1.28	1.07
South Central Coast	1.68	1.23	1.13	1.25	0.19	1.77	1.16	0.51	0.0	0.65	0.94	1.71	1.51	1.31	1.40	1.21	1.01	1.42	1.22	1.02
North Coast	1.76	1.29	1.19	1.31	0.20	1.85	1.21	0.53	0.0	0.68	0.98	1.79	1.58	1.38	1.47	1.26	1.06	1.49	1.28	1.07
Northeast Plateau	1.64	1.20	1.11	1.23	0.18	1.73	1.13	0.50	0.0	0.64	0.91	1.67	1.48	1.28	1.37	1.18	0.99	1.39	1.20	1.00
Great Basin Valley	1.51	1.10	1.01	1.12	0.17	1.57	1.02	0.45	0.0	0.58	0.83	1.51	1.34	1.16	1.24	1.07	0.89	1.25	1.08	0.90

[a]Must be supplemented with one of the fuel tank modification alternatives.

be derived for each air basin using the information in Table 5-2.

Table 5-3 shows the cost effectiveness indices for retrofitting heavy-duty vehicles in the various air basins. Only the more attractive approaches are shown for each of the fuel tank, carburetor, and combined retrofit systems. Comments relative to light-duty vehicles regarding air basin temperature and fuel volatility effects on evaporative emissions also are applicable to heavy-duty vehicles.

5.2.3 Cost Effectiveness Computation by Model Year

Tables 5-4 and 5-5 show the computed CE indices for the pre-1970 model light and heavy-duty vehicles, respectively. As has been shown in Section 3, the effectiveness of a retrofit approach is related to the number of vehicle trips. Since the late 1966 to 1969 models will be the last group of pre-1970 vehicles to be phased out of operation, it is then expected that these models would be retrofitted more cost effectively than pre-1966 models.

Table 5-4 indicates this fact by noting each individual approach as a function of model years. The CE indices show that with each older model, starting with 1969 back to 1960, the cost to recover a pound of HC vapors increases.

With respect to a given model year, the CE indices indicate that carburetor modifications are more attractive than fuel tank modifications. The combination approaches of 2 and 9, and 4 and 9 would be the most cost effective retrofit fuel tank and carburetor modifications for all 1966 to 1969 model vehicles.

Table 5--3. COST EFFECTIVENESS INDICES OF ALTERNATIVES IN EACH AIR BASIN FOR HEAVY-DUTY VEHICLES
(Dollars per Pound of Hydrocarbon Recovered)

Air Basin	Alternatives																	
	1	2	3	4	5	6	7	8	9[a]	10	11	1&6	1&7	1&9	2&6	2&7	2&9	4&6	4&7	4&9
South Coast	0.82	0.52	0.48	0.48	N/A	0.33	0.26	0.16	0.0	0.16	0.19	0.72	0.70	0.67	0.48	0.47	0.44	0.45	0.44	0.41
San Francisco	0.96	0.61	0.56	0.56	N/A	0.35	0.28	0.13	0.0	0.16	0.20	0.82	0.80	0.76	0.55	0.53	0.50	0.52	0.50	0.47
San Joaquin	0.62	0.39	0.37	0.37	N/A	0.28	0.22	0.11	0.0	0.13	0.16	0.55	0.54	0.53	0.37	0.36	0.34	0.35	0.34	0.31
Sacramento	0.75	0.48	0.44	0.44	N/A	0.31	0.25	0.12	0.0	0.14	0.17	0.65	0.64	0.61	0.44	0.42	0.40	0.41	0.40	0.37
San Diego	0.75	0.48	0.44	0.44	N/A	0.31	0.24	0.11	0.0	0.13	0.17	0.65	0.64	0.61	0.44	0.42	0.40	0.41	0.40	0.37
Southeast Desert	0.52	0.33	0.30	0.30	N/A	0.27	0.21	0.10	0.0	0.12	0.15	0.47	0.46	0.44	0.32	0.31	0.28	0.30	0.29	0.26
North Central Coast	0.92	0.58	0.54	0.54	N/A	0.33	0.27	0.13	0.0	0.15	0.20	0.79	0.77	0.74	0.52	0.51	0.48	0.49	0.51	0.45
South Central Coast	0.86	0.54	0.50	0.50	N/A	0.33	0.26	0.12	0.0	0.15	0.19	0.72	0.72	0.69	0.49	0.48	0.45	0.45	0.45	0.42
North Coast	0.95	0.61	0.56	0.56	N/A	0.34	0.27	0.13	0.0	0.15	0.19	0.80	0.79	0.75	0.53	0.51	0.48	0.50	0.48	0.45
Northeast Plateau	0.81	0.51	0.47	0.47	N/A	0.31	0.25	0.12	0.0	0.14	0.18	0.70	0.66	0.66	0.47	0.45	0.42	0.44	0.42	0.39
Great Basin Valley	0.69	0.44	0.41	0.41	N/A	0.12	0.22	0.11	0.0	0.13	0.16	0.68	0.59	0.57	0.41	0.39	0.37	0.38	0.36	0.34

[a]Must be supplemented with one of the fuel tank modification alternatives.

Table 5-4. ALTERNATIVES' COST EFFECTIVENESS PER MODEL YEAR FOR CALIFORNIA LIGHT-DUTY VEHICLES
(Dollars per pound of hydrocarbon contained)

ALTERNATIVES	MODEL YEAR									
	1969	1968	1967	1966	1965	1964	1963	1962	1961	1960
2	0.895	1.013	1.013	1.327	1.646	1.789	2.113	2.895	3.567	8.309
3	0.828	0.933	1.114	1.217	1.510	1.641	1.935	2.926	3.265	7.647
8	0.335	0.400	0.504	0.576	0.799	1.053	1.193	1.486	1.915	2.424
10	0.429	0.514	0.648	0.737	1.028	1.181	1.536	1.914	2.500	3.333
2 & 9	0.699	0.804	0.959	1.076	1.374	1.466	1.711	2.107	2.147	2.640
4 & 9	0.708	0.815	0.972	1.081	1.393	1.486	1.738	2.140	2.147	2.660

Data in the table may be used to select the more cost-effective approaches for each model year. For example, the selection method may be one of the following:

- Select most cost-effective approach regardless of cost (carburetor approaches).
- Select most cost effective approach considering minimum cost (carburetor modifications).
- Select most effective approach assuming moderate cost (fuel tank modifications).
- Select most desirable approach for each model year assuming CE index will not exceed 50¢ per pound, $1 per pound.

Table 5-5 shows the computed CE indices for heavy-duty vehicles for the fuel tank, carburetor, and combination retrofit systems that exhibited the best values. The discussions on light-duty vehicles are equally applicable to heavy-duty vehicles.

5.3 COST EFFECTIVENESS ANALYSIS

Results of the cost-effectiveness analysis have indicated the following:

- Carburetor modifications generally are more cost effective than fuel tank modifications or combined fuel tank-carburetor modifications.
- Within each category of modifications, the least cost-effective approach is removing existing fuel

Table 5-5. ALTERNATIVES' COST EFFECTIVENESS PER MODEL YEAR FOR CALIFORNIA HEAVY DUTY VEHICLES
(Dollars per pound of hydrocarbon contained)

MODEL YEAR ALTERNATIVES	1969	1968	1967	1966*
2	0.557	0.614	0.675	0.734
3	0.523	0.577	0.631	0.682
8	0.120	0.138	0.175	0.176
10	0.143	0.164	0.202	0.206
2 & 9	0.423	0.485	0.562	0.580
4 & 9	0.400	0.458	0.528	0.558

* Only 1966 through 1969 vehicles are shown. However, note the pattern is similar to that of light-duty vehicles in that the older models are less cost effective than the new models.

tanks or carburetors and replacing them with new, production-type (1970 to 1973) replacements.

- Retrofitting heavy-duty vehicles is more cost effective than retrofitting similar vintage light-duty vehicles.

- It is more cost effective to retrofit 1966 to 1969 models than pre-1966 models because of vehicle utilization and attrition factors.

- Retrofitting vehicles operating in the warmer air basins is more cost effective than retrofitting those operating in cooler air basins.

5.3.1 Interpretation of Results

Because the cost-effectiveness index is a ratio of two numbers (retrofit system cost divided by HC vapors recovered), two dissimilar approaches may conceivably receive the same index value. For example, a combined retrofit system costing $250 installed and recovering 500 pounds of HC vapors (CE = $0.50 per pound HC) would be equal to a carburetor retrofit system costing $50 installed and recovering 100 pounds.

Thus, in general, the CE indices computed should be used to provide an indication of relative ranking among similar approaches. For fuel tank modifications, it is assumed that each of Approaches 1 through 5 would be equally effective in controlling fuel tank vapor losses. Then, the CE indices would establish which of the five basic approaches would be most desirable. However, in this category, Approach 5 was applicable to roughly only 20 percent of the existing fuel tank configurations. Consequently, although it exhibited the best

CE index value, the concept could not be applied universally (i.e., to all pre-1970 light-duty vehicles).

In using the CE values to compare between fuel tank and carburator modifications, the latter approaches generally are more cost effective because of lower installed cost Recognizing that more vapors emanate from the tank than the carburetor, the more effective strategy would be to control tank losses. However, tank modifications tend to be more costly because of the parts and installation labor involved

Similarly, the most effective approach would require fuel tank and carburetor modifications to effect a closed system analogous to post-1970 vehicles. While the installed cost would be slightly lower than the additive costs of fuel tank and carburetor modifications, it would still be relatively high, on the order of $100 to $200 per vehicle.

5.3.2 Vehicle Owner Considerations

For a retrofit program, the owner of a pre-1970 model vehicle may be expected to pay $80 to $120 for a fuel tank modification, $25 to $90 for a carburetor modification, or $100 to $200 for a combination fuel tank-carburetor modification. The installation time, depending on the vehicle and the modification may range between 1 and 3 hours. Additional time and associated costs may be required if parts removed during the installation and/or modification process necessitate further repairs, especially in older vehicles.

These installation and modification costs may be disproportionate to the value of the vehicle and/or the effectiveness potential of the system. That is, older vehicles have lower resale value, are used less frequently, and they are responsible for

less vapor losses. Appendix L tabulates the assessed automobile values for pre-1970 light-duty vehicles as determined in November, 1973, from data provided by the Allstate Insurance Corporation. In general, the average worth of all pre-1964 vehicles has been approximated at $150, except specialty sports cars which average about $500.

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REFERENCES

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APPENDIX A

PRE-1970 AUTOMOBILE POPULATION AND DISTRIBUTION ANALYSIS

APPENDIX A

PRE-1970 AUTOMOBILE POPULATION AND DISTRIBUTION ANALYSIS

In establishing the effectiveness of a retrofit program, a prime requisite is the definition of the vehicle quantity involved initially and the expected attrition of these vehicles over the program duration. The problem with defining the vehicle population lies in the fact that no single state agency or business concern provides this type of information for all vehicles-in-use. For example, the State of California Motor Vehicle Department compiles the data for all automobiles, trucks, trailers, and motorcycles registered in each county. However, the distribution by model-year for each registration year is not available.

Reuben H. Donnelley Corporation is allowed access to the DMV data. Information purchased from this outlet included model-year distribution for the registration year 1972, but included only privately owned vehicles. Donnelley would require additional funds to search the files and compile a listing for all registered vehicles. Because these data are not normally requested, special programming would be required.

The Automotive News Almanac (Ref. 12) issue provides national registration data along with annual model-year distributions. Presumably, the registrations include all vehicles-in-use. Data presented in the almanac issues are primarily those compiled by R. L. Polk Company. However, the data do not include a breakdown by states except in the case of annual new car registrations.

The combination of these data sources were evaluated to ascertain whether a composite analysis would provide the necessary information on total vehicles-in-use and model-year distribution. The following paragraphs identify the various data sources, describe the methodology, and define the pre-1970 vehicle population.

A.1 NATIONAL VEHICLE DISTRIBUTION

Table A-1 shows the nationwide vehicle distribution for the period 1960 to 1972 as compiled from Automotive News data (Ref. 12). The average distribution data shown in the extreme right column shows that for a given year's registration, 8.1 percent of the total registered vehicles would be of the current model year (age less than 1 year), 10.5 percent of the vehicles would be of the previous model year (age 1 to 2 years), and so forth down to 2.8 percent being greater than 15 years old.

If the California registrations are similar to the nationwide registrations, then it may be assumed that for 1972 registrations, 8.1 percent of vehicles in California were of 1972 production, 10.5 percent were of 1971, 10 percent were of 1970, and so forth. Table A-2 shows the vehicle distribution of privately-owned vehicles as provided by R. H. Donnelley (Ref. 8).

Comparing the nationwide distribution of Table A-1 with the values for California in Table A-2 shows an obvious disparity. There are several reasons. The values for Table A-1 are based on July 1 registrations; the values for Table A-2 on March 1 registrations. The nationwide distribution probably includes all vehicles-in-use; the California distribution includes only privately-owned vehicles. Thus, a method of adjusting these data will be necessary to arrive at the total state registration and model distribution.

Table A-1. NATIONAL VEHICLE DISTRIBUTION (PERCENT) BY AGE GROUP

Vehicle Age (Years)	Calendar Year[1]							Average Distribution 1960-1972[2]
	1960	1962	1964	1966	1968	1970	1972	
<1	7.23	7.48	8.85	8.75	8.20	7.81	8.29	8.1
1- 2	10.09	9.04	11.12	12.64	10.77	11.55	10.31	10.5
2- 3	7.50	10.17	10.03	10.98	11.72	10.95	10.24	10.0
3- 4	10.44	9.49	8.25	10.25	11.86	9.79	10.55	9.5
4- 5	10.22	7.02	9.28	9.22	10.17	10.61	9.95	9.1
5- 6	11.45	9.59	8.45	7.41	9.36	10.57	8.68	8.7
6- 7	7.62	9.22	6.01	8.07	8.20	8.84	9.18	8.2
7- 8	8.93	9.94	7.75	6.94	6.17	7.79	8.77	7.7
8- 9	5.12	6.15	7.08	4.27	6.12	6.28	6.85	6.5
9-10	6.30	6.46	7.13	5.08	4.44	4.06	5.45	5.9
10-11	6.23	3.29	3.98	4.31	2.26	3.45	3.87	4.2
11-12	3.57	3.68	3.74	4.05	2.64	2.10	2.11	3.4
12-13	1.67	3.53	2.69	2.07	2.13	0.99	1.63	2.7
13-14	1.15	1.88	1.95	1.79	1.98	1.23	0.93	1.8
14-15	0.57	0.88	0.89	0.83	0.98	0.98	0.45	0.9
>15	1.91	2.18	2.80	3.34	3.00	3.00	2.66	2.8

[1]Extracted and interpolated from the Automotive News, 1973 Almanac Issue.

[2]Average values modified to assure monotonic decreasing function as used in Table 3-4.

Table A-2. CALIFORNIA MARCH, 1972, REGISTRATIONS, PRIVATELY-OWNED AUTOMOBILES

Model Year	Vehicle Age	Vehicle Quantity	Percent of Total Population
1972	1	197,000	3.0
1971	1- 2	669,000	10.0
1970	2- 3	698,000	10.6
1969	3- 4	814,000	12.4
1968	4- 5	739,000	11.2
1967	5- 6	653,000	9.9
1966	6- 7	686,000	10.4
1965	7- 8	697,000	10.6
1964	8- 9	585,000	8.8
1963	9-10	472,000	7.2
1962 & Older	10 & Older	366,000	5.6

Source: Refs. 7, 8

A.2 NATIONAL VEHICLE ATTRITION

Table A-3 shows the vehicle registration for several model years as a function of age. For each of the selected model years, the data show the normalized percentage of vehicles-in-use. That is, the column data have been normalized to the year showing the highest registration. As an example, consider the model year 1955. The entries show that the greatest number of 1955-model vehicles were registered in the second year, or 1956, which shows an entry of 1. During the first year, 1955, 61.7 percent of the vehicles were registered; whereas in the third year, 1957, 99.9 percent of the 1955-model vehicles were registered. A shortcoming of this approach is that the normalized year assumes no additional, unsold or unregistered 1955 models. It should be recognized also that some 1955s purchased during the first year may not be available for registration during the second year.

Table A-3 shows that the average registration for any model year during its introductory year is roughly 67 percent of its highest registration. According to the averaged values shown, the highest vehicle registration will occur during the second and/or third year of that particular model's lifetime. The data show that model-year registration slowly declines until about seven years of existence, after which the remaining population rapidly decreases. Based on the values shown, during the seventh year of existence roughly 93 percent of a particular model are still operating. Seven years later, only 17 percent are expected to be registered.

A.3 CALIFORNIA VEHICLE POPULATION

Table A-4 shows the estimated vehicle population and model distribution for year-end 1972 or January, 1973, registration. The

Table A-3. VEHICLES-IN-USE AFTER N YEARS (NORMALIZED PERCENT)

Vehicle Age N-Years	Model Year Vehicles Still in Operation During Year N[a]											Composite Average
	1955	1956	1957	1958	1959	1960	1962	1964	1966	1968	1970	
1	0.617	0.669	0.601	0.648	0.654	0.667	0.687	0.721	0.704	0.693	0.707	0.680
2	1.000	0.998	0.991	0.995	0.991	0.995	0.996	1.000	1.000	1.000	1.000	0.997
3	0.999	0.994	1.000	0.994	1.000	1.000	1.000	0.995	0.997	0.988	0.996	0.997
4	0.991	1.000	0.994	1.000	0.994	0.999	0.999	0.995	0.993	0.986		0.995
5	0.996	0.985	0.989	0.991	0.983	0.990	0.991	0.977	0.964	0.963		0.983
6	0.976	0.973	0.973	0.965	0.960	0.967	0.966	0.961	0.938			0.964
7	0.950	9.947	0.930	0.921	0.929	0.929	0.932	0.929	0.895			0.929
8	0.904	0.887	0.854	0.844	0.851	0.851	0.876	0.853				0.865
9	0.821	0.790	0.755	0.706	0.727	0.745	0.763	0.765				0.759
10	0.704	0.671	0.604	0.547	0.575	0.601	0.645	0.641				0.624
11	0.576	0.519	0.457	0.396	0.422	0.448	0.504					0.475
12	0.431	0.380	0.332	0.275	0.291	0.328						0.340
13	0.312	0.272	0.237	0.185	0.203	0.228						0.240
14	0.223	0.192	0.166	0.131	0.138							0.170
15	0.159	0.134	0.122	0.090								0.126
>15	0.112	0.098	0.088									0.099

[a]Normalized with respect to year of highest recorded registration.

Table A-4. ESTIMATED 1972 VEHICLE REGISTRATION AND DISTRIBUTION

Model Year	Vehicle Age	Registrations During 19XX[a]	Percent Operating[b]	1972 Registrations[c]	Cumulative Registrations	Percent of Total	Cumulative Percent
1972	1	995,800	100	995,800	995,800	9.27	9.27
1971	2	938,000	99.7	1,140,900	2,136,700	10.62	19.89
1970	3	868,400	99.7	1,056,300	3,193,000	9.83	29.72
1969	4	918,500	99.5	1,115,000	4,308,000	10.38	40.10
1968	5	897,200	98.3	1,076,000	5,384,000	10.01	50.11
1967	6	809,200	96.4	951,700	6,335,700	8.86	58.97
1966	7	832,300	92.9	943,300	7,279,000	8.78	67.75
1965	8	888,900	86.5	938,100	8,217,100	8.73	76.48
1964	9	829,000	75.9	767,600	8,984,700	7.14	83.62
1963	10	734,900	62.4	559,500	9,544,200	5.21	88.83
1962	11	700,400	47.5	405,900	9,950,100	3.78	92.61
1961	12	594,400	34.0	246,600	10,196,700	2.29	94.90
1960	13	656,800	24.0	192,300	10,389,000	1.79	96.69
1959	14	548,700	17.0	113,800	10,502,800	1.06	97.75
1958	15	416,300	12.6	64,000	10,566,800	0.60	98.35
1957 & Older	>15			180,000[d]	10,746,800	1.67	100.02

[a]Registrations of new cars for model year during initial year of sale. Source: Ref. 12

[b]Percent operating is percentage of highest registration year still operating at present year, see Table A-3.

[c]Total registered is product of (new registration times 1.22 yielding highest registration times 2 except 1972 model).

[d]Estimate based on data from Table A-1.

"New Registration" entries reflect the number of new vehicles registered in California for that particular model production (Ref. 12). As an example, there were 918,000 new 1969 models registered in California during 1969.

The "Percent Operating" column shows the expected proportion of a particular model production still registered in California. This proportion is based on the ratio of the current registration year and the highest registration year. Previously discussed analyses have shown that the highest registration year occurs in the second or third year of a model's lifetime (see Table A-3). Analysis of historical data has indicated that the highest registration year is roughly 1.22 times the model year (first year) registrations. For example, the highest registration for 1969 models would be (1.22)(918,500) or 1,115,000 vehicles. This phenomenon occurs because of early registrations (Fall registrations of new models) and second-year registrations (models initially registered after current production year closeout). Second-year registrations may include dealer inventory vehicles and government-licensed vehicles receiving initial state registration plates.

The "Total Registration" column gives the number of vehicles as a function of model year as calculated from the projected highest registration and the estimated attrition. The last entry in the column reflecting vehicles older than 15 years is based on the historical nationwide distribution shown in Table A-1. Entries in the "Average Distribution" column of that table show that the cumulative total of vehicles older than 15 years is roughly equal to the model-year vehicles 13 years old.

The "Cumulative Registration" column shows that for 1972, 10,746,800 automobiles were registered in California. Of these vehicles, 30 percent were of the 1970 to 1972 model years, and 70 percent were of pre-1970 vintage, corresponding to 7,553,800 vehicles.

Table A-5 shows the breakdown of all pre-1970 light-duty vehicles as of January, 1973. The proportional distribution shows that the 1969 models comprise 14.8 percent of all pre-1970 vehicles registered, and the 1968 models comprise 14.2 percent of the pre-1970 model registrations. On a cumulative basis, the 1966 to 1969 models constitute 54 percent of all pre-1970 vehicles. Considering model years 1961 to 1969, it is estimated that over 92 percent of the pre-1970 population would be included.

A.4 CALIFORNIA DEPARTMENT OF MOTOR VEHICLES REGISTRATION

Table A-6 shows the total automobile and truck registrations for the years 1970, 1971 and 1972 as provided by the California DMV Information Office. Registration data are year-end summaries.

Table A-5. PRE-1970 VEHICLES AS OF JANUARY, 1973

Model Year	Vehicles Registered	Percentages	
		Simple	Cumulative
1969	1,115,000	14.8	14.8
1968	1,076,000	14.2	29.0
1967	951,700	12.6	41.6
1966	943,300	12.5	54.1
1965	938,100	12.4	66.5
1964	767,600	10.2	76.7
1963	559,500	7.4	84.1
1962	405,900	5.4	89.5
1961	246,600	3.3	92.8
1960	192,300	2.5	95.3
1959	113,800	1.5	96.8
1958	64,000	0.8	97.6
1957 & Older	180,000	2.4	100.0
Total	7,553,800		

Table A-6. AUTOMOBILE AND TRUCK REGISTRATIONS

Calendar Year	Automobiles	Trucks
1970	10,004,155	1,758,685
1971	10,375,354	1,835,260
1972	10,744,981	1,946,649

APPENDIX B

PRE-1970 TRUCK REGISTRATION AND DISTRIBUTION ANALYSIS

APPENDIX B

PRE-1970 TRUCK REGISTRATION AND DISTRIBUTION ANALYSIS

The pre-1970 truck population for the State of California is determined in this appendix by using various data recorded by the Department of Motor Vehicles and R. H. Donnelley, and in documents such as the Automotive News, 1972 Automobile Facts and Figures, and American Trucking Trends - 1972. Similar to the pre-1970 automobile registration data, the California truck registration as complied by DMV do not provide model year distribution. The following analysis is directed toward deriving the necessary information required to establish the effectiveness of retrofitting pre-1970 trucks.

B.1 NATIONAL TRUCK REGISTRATION

Table B-1 shows the U.S. truck registration as of July 1, 1972 (Ref. 12). The data reported include truck registration as a function of model years. Cumulative percentage totals show that the pre-1970 trucks comprise 74 percent of all trucks registered in the U.S.

B.2 CALIFORNIA NEW TRUCK REGISTRATIONS

Table B-2 shows the quantity of new trucks registered in California for the model years 1958-1972 as derived from the Automotive News Almanac issues (Ref. 12). Data in the table also indicate the proportion of new trucks registered in California range between 9-12 percent of the U.S. new truck registrations.

TABLE B-1. NATIONAL TRUCK REGISTRATION

JULY 1, 1972

Model Year	Model Registrations	Cumulative Registrations	Percent of Total	Cumulative Percent
1972	1,636,700	1,636,700	8.28	8.28
1971	1,783,500	3,400,200	9.02	17.30
1970	1,744,200	5,164,400	8.82	26.12
1969	1,858,000	7,022,400	9.40	35.52
1968	1,468,400	8,490,800	7.43	42.95
1967	1,372,000	9,862,800	6.94	49.89
1966	1,408,600	11,271,400	7.12	57.01
1965	1,259,700	12,531,100	6.37	63.38
1964	1,066,300	13,597,400	5.39	68.77
1963	877,000	14,474,400	4.44	73.21
1962	721,300	15,195,700	3.65	76.86
1961	525,400	15,721,000	2.66	79.52
1960	544,300	16,265,400	2.75	82.27
1959	470,900	16,737,300	2.38	84.65
1958	303,400	17,039,700	1.53	86.18
1957 & Older	2,733,300	19,773,000	13.82	100.00

TABLE B-2. CALIFORNIA PERCENTAGE OF NATIONAL REGISTRATION

Model Year	New Registrations in California	California Percentage of Nation Total
1972	268,100	11.12
1971	197,100	9.95
1970	195,800	10.94
1969	182,700	9.67
1968	164,900	9.29
1967	136,300	8.97
1966	150,900	9.37
1965	161,500	10.57
1964	164,400	12.07
1963	141,900	11.41
1962	123,200	11.53
1961	103,800	11.30
1960	104,200	11.05
1959	100,700	10.69
1958	72,651	10.00

If it is assumed that the average truck lifetime for the nation is relatively equal to a California truck lifetime, then the national truck registration and distribution would be similar to the California new truck registrations and distribution. That is, if in 1969 California registered 9.67 percent of U.S. truck sales, then in 1972 the number of 1969 trucks would be equal to 9.67 percent of the U.S. 1969 models registered. Thus, for calculating the number of 1969 models registered in California during the year 1972, the following steps are required:

(a) 1969 models registered in U.S. during 1972 = 1,858,000 from Table B-1.

(b) 1969 models sold new in California = 9.67 percent of total U.S. from Table B-2.

(c) 1969 models registered in 1972 in California (a x b) = 179,700

B.3 TRUCKS WITH DIESEL ENGINES

Table B-3 shows the quantity of trucks sold with diesel engines. The data show that roughly five percent of all trucks are equipped with diesel engines. Diesel trucks in the 1966-1969 period averaged about 5.5 percent of the truck population. The average for the 1962-1965 period was about four percent diesel trucks with the average dropping to about 2.8 percent for 1958-1961 trucks.

TABLE B-3. U.S. SALES OF TRUCKS WITH DIESEL ENGINES

Model Year	Total Trucks	Diesel Trucks	Percent of Diesels
1972	2,446,800	143,100	5.84
1971	2,053,100	113,200	5.51
1970	1,692,400	105,700	6.25
1969	1,923,200	114,900	5.97
1968	1,896,100	93,800	4.95
1967	1,539,500	84,000	5.46
1966	1,731,100	96,600	5.58
1965	1,751,800	82,200	4.69
1964	1,540,500	65,400	4.25
1963	1,462,700	56,400	3.86
1962	1,240,200	43,800	3.53
1961	1,133,800	28,400	2.50
1960	1,194,500	31,000	2.59
1959	1,137,400	35,500	3.12
1958	877,300	25,200	2.87

B.4 CALIFORNIA TRUCK REGISTRATIONS ESTIMATED

Table B-4 shows the estimated truck registration and model year distribution as of January 1973. The table does not include new 1973 models. Using the national truck registration data (Table B-1) and applying the expected California percentage of the national total (Table B-2), the calculated January 1973 registration of trucks as shown in the fourth column is 1,946,800. According to the California DMV the December 1972 truck registrations were 1,946,649 (reference 7).

Based on the national sales of diesel trucks (Table B-3), a percentage of trucks as a function of model year is calculated and subtracted from the total California Registration to arrive at the total gasoline-powered trucks. The entries in the last column reflect the estimated number of gasoline-powered trucks registered in California as of December 31, 1972 (January 1, 1973).

B.5 PRE-1970 TRUCKS

It has been estimated that as of January 1, 1973, there were 1,946,800 trucks registered in California, of which there were 92,200 diesels or 4.7 percent. Based on this estimate of diesels, there were then 1,854,000 gasoline-powered trucks.

Table B-5 shows the model year distribution of all trucks. The 1970-1972 model trucks total 519,300 units or 28 percent of all registered gasoline-powered (GP) trucks. This leaves 72 percent of GP trucks as being of pre-1970 vintage.

The last two columns of Table B-5 show the composition of the pre-1970 population. Roughly, half of the pre-1970 GP trucks are of the 1965-1969 model years. It is of interest to note

TABLE B-4. JANUARY 1973 REGISTRATION OF GASOLINE-POWERED TRUCKS

Model Year	National Registration	California Percentage	California Registration	National Percent Of Diesels	Calif. Gasoline Powered Trucks
1972	1,636,700	11.12	182,000	5.4	172,200
1971	1,783,500	9.95	177,500	5.51	167,700
1970	1,744,200	10.94	190,800	6.25	179,400
1969	1,858,000	9.67	179,700	5.97	168,900
1968	1,468,400	9.29	136,400	4.95	129,600
1967	1,372,000	8.97	123,00	5.46	116,300
1966	1,408,600	9.37	132,000	5.58	124,600
1965	1,259,700	10.57	133.200	4.69	126,900
1964	1,066,300	12.07	128,700	4.25	123,200
1963	877,000	11.41	100,100	3.86	96,200
1962	721,300	11.53	83,200	3.53	80,200
1961	525,400	11.30	59,400	2.50	57,900
1960	544,300	11.05	60,100	2.59	58,600
1959	470,900	10.69	50,300	3.12	48,800
1958	303,400	10.00	30,300	2.87	29,500
1957 & Older	2,733,300	6.58[a]	180,000[b]	3.00	174,600
Totals	19,773,000		1,946,800		1,854,600

[a]Estimated to approximate total registration

[b]Estimated based on 1958-1961 percentages

TABLE B-5. JANUARY 1973
GASOLINE-POWERED TRUCKS DISTRIBUTION

Model Year	GP Trucks Estimated	Percentage		Pre-1970 Percentage	
		Simple	Cumulative	Simple	Cumulative
1972	172,200	9.29	9.29	-	-
1971	167,700	9.04	18.33	-	-
1970	179,400	9.67	28.00	-	-
1969	168,900	9.11	37.11	12.65	12.65
1968	129,600	6.99	44.10	9.71	22.36
1967	116,300	6.27	50.37	8.71	31.07
1966	124,000	6.72	57.09	9.33	40.40
1965	126,900	6.84	63.93	9.50	49.90
1964	123,200	6.64	70.57	9.23	59.13
1963	96,200	5.19	75.76	7.20	66.33
1962	80,200	4.32	80.08	6.01	72.34
1961	57,900	3.12	83.20	4.34	76.68
1960	58,600	3.16	86.36	4.39	81.07
1959	48,800	2.63	88.99	3.65	84.72
1958	29,500	1.59	90.58	2.21	86.93
1957 &	174,600	9.41	99.99	13.08	100.01
Total	1,854,600				

that about 13 percent of the pre-1970 vehicles are older than 15 years (pre 1958 vintage). This compares with about 2.4 percent for automobiles of the same time period.

B.6 TRUCK DISTRIBUTION BY GVW

Table B-6 shows the estimated California truck distribution as a function of Gross Vehicle Weight. The five GVW categories correspond to those used by the DMV. Whereas, the DMV does provide breakdown by GVW and county, it does not provide model year distribution.

As indicated in Table B-6, the proportional distribution was determined from Automotive News issues which showed recent (1969-1972) purchases. The other year distribution were determined from new truck sales by vehicle manufacturers types reported in older issues. For the year 1972, the registrations were derived from data in Table B-5 and distributions were based on specific model year new truck sales.

TABLE B-6. ESTIMATED TRUCK DISTRIBUTION BY GROSS VEHICLE WEIGHT

Vehicle Model Year	Estimated Truck Registration as of 1/1/73	Estimated Distribution (Units/Percent)				
		6,000#	6,001-10,000#	10,000-19,500#	19,501-26,000#	26,001#
1972	182,000	111,000 61.0%	40,800 22.4%	6,900 3.8%	12,400 6.8%	10,900 6.0%
1971	177,500	108,500 61.1%	40,100 22.6%	6,200 3.5%	11,500 6.5%	11,200 6.3%
1970	190,800	111,800 58.6%	43,500 22.8%	8,000 4.2%	14,100 7.4%	13,400 7.0%
1969	179,700	106,200 59.1%	39,300 21.9%	9,000 5.0%	13,300 7.4%	11,900 6.6%
1968	136,400	83,500 61.2%	24,000 17.6%	12,300 9.0%	8,600 6.3%	8,000 5.9%
1967	123,100	75,000 60.9%	21,200 17.2%	10,900 8.9%	8,000 6.5%	8,000 6.5%
1966	132,000	79,600 60.3%	22,800 17.3%	11,900 9.0%	8,600 6.5%	9,100 6.9%
1965	133,200	81,900 61.5%	22,100 16.6%	12,900 9.7%	8,000 6.0%	8,300 6.2%
1964	128,700	79,400 61.7%	21,500 16.7%	11,100 8.6%	8,500 6.6%	8,200 6.4%
1963	100,100	61,700 61.6%	16,400 16.4%	8,500 8.5%	6,700 6.7%	6,800 6.8%
1962	83,200	49,400 59.4%	13,600 16.4%	7,100 8.6%	5,700 6.9%	7,400 8.9%
1961	59,400	34,900 58.8%	9,500 16.0%	5,000 8.4%	4,200 7.0%	5,800 9.7%
1960	60,100	35,600 59.3%	9,600 16.0%	5,100 8.4%	4,100 6.8%	5,700 9.5%

TABLE B-6. ESTIMATED TRUCK DISTRIBUTION BY GROSS VEHICLE WEIGHT (Cont.)

Vehicle Model Year	Estimated Truck Registration as of 1/1/73	Estimated Distribution (Units/Percent)				
		6,000#	6,001-10,000#	10,000-19,500#	19,501-26,000#	26,000#
1959	50,300	29,900 59.4%	8,000 16.0%	4,200 8.4%	3,400 6.7%	4,800 9.5%
1958	30,300	18,000 59.4%	4,800 15.9%	2,500 8.3%	2,100 6.8%	2,900 9.6%
1957 & Older	180,000	108,400	32,600	13,500	12,100	13,400
Totals	1,946,800	1,174,800	369,800	135,100	131,300	135,800

APPENDIX C

1970-1973 VEHICLES EVAPORATIVE EMISSION CONTROL SYSTEM CONFIGURATIONS

This appendix identifies the basic evaporative emission system components as used on 1970-1973 light duty vehicles, both domestic and foreign. In general, the configurations are similar. That is, vapor is prevented from entering the atmosphere by sealing the filler cap. Strategically placed vent lines allowing for liquid/vapor expansion direct the vapors through a liquid/vapor separator.

Collected vapor is directed toward the engine compartment where it is stored in the crankcase or a carbon canister. During engine operation, the stored vapors are purged from storage area and directed to the carburetor.

Vapors emanating from the carburetor after engine shutdown are collected in the air filter housing and/or the carbon canister/ crankcase storage. The following discussions highlight any significant differences between manufacturers.

DOMESTIC VEHICLES

American Motors employs 2 diagonally opposite vapor vent lines in their vehicle fuel tanks. An internal expansion tank and liquid check valve-vapor separator with expansion relief cap are provided on most models 1970-1973. Vapor storage on 1970 models was primarily the vehicle crankcase. This was continued the following year with the exception that V-8 engines with automatic transmissions employed a carbon canister. The 1973 V-8 models employed a tank-to-canister vent and the canister is connected by hoses to the carburetor ported vacuum and PCV system.

Chrysler Motors employs 4 vent lines in their vehicle fuel tanks. The 1970 model vehicles had an "overfill limiter" on top of the

main tank. The 1971 model fuel tanks had an internal expansion tank, that in 1972 model vehicles are combined with an overfill limiting valve to prevent tank overfill. The vapor separator was employed on all 1970-1973 vehicles. Vapor storage on 1970 and 1971 models was primarily the vehicle crankcase. The 1972 and 1973 models employed two types of canisters, a three-hose connection unit (from tank, from carburetor, to carburetor manifold.), and a four-hose connection unit with same connections as above plus a canister purge line.

Carburetor vapor venting on 1970 V-8 engines was directed to the crankcase by a separate line. Six cylinder engine carburetors were vented to the crankcase via the fuel pump. 1971 model V-8 engine carburetors were internally vented to the air cleaner. 1972-1973 model carburetor fuel bowl vents were vented to the carbon canister.

Ford Motors Co. used four fuel tank vents on the 1970 model vehicles. The 71-73 model vehicle fuel tanks were vented from the top center of the tank and the vapors vented directly to the vapor separator. An air space of 10-12 percent was designed into the tank to provide for fuel expansion due to temperature increases. The liquid vapor separator was provided for 1970-1973 model year vehicles.

Vapor storage on 1970-1973 models was primarily to a carbon canister. The canister activated carbon capacity was increased in the 1971 model from 350 grams to 650 grams.

Carburetor vapor venting to the air cleaner was used on 1970-1973 model vehicles.

General Motors 1970 model vehicle fuel tank had 3 vent lines, one from the center of the tank and two corner vents. The 1971-1973 models had 3 vent lines, two from the front, and one from the tank rear. The fuel tank on 1970-1973 models was designed with an air chamber allowing for fuel expansion due to temperature changes.

All 1970-1973 models used a liquid-vapor (standpipe design) located above the fuel tank.

Vapor Storage. Three types of carbon canisters were used on 1971-1973 model year vehicles. These types were: two tube for most V-8 engines, a three-tube type for all 6 cylinder engines with the third tube for canister purge, and a four-tube type (Vega) having the fourth tube connected to the carburetor fuel bowl.

IMPORTED VEHICLES

The imported vehicles used the same techniques as the domestic vehicles.

Datsun	-	no appreciable changes 1970-1973 model years.
Fiat	-	no appreciable changes 1970-1973 model years.
Jaguar E Type XJ-6	-	no appreciable changes 1970-1973 model years.
Mercedes Benz and 280-C	-	no appreciable changes except on 280. Vapor escape prevention valve is extra feature on air cleaner.
Toyota	-	1970 model vehicle fuel tank had 4 corner vent lines. The 1971 model fuel tank had only front and back vent lines.
Volkswagen	-	no appreciable changes 1970-1973 model years.
Volvo	-	no appreciable changes 1970-1973 model years.

1970 MANUFACTURER	VENT LINES/ FUEL TANK CAPACITY (GAL)	EXPANSION TANK	VAPOR SEPARATOR	VAPOR STORAGE	PRESSURE RELIEF	CARBURETOR VAPOR VENTING
AMERICAN MOTORS	2 Ventlines- Diagonally opposite	Within upper portion of fuel tank	Check Valve	Crankcase	Filler cap	
Gremlin (Six cylinder only)	21					
Hornet	16					
AMX-Javelin	16					
Rebel & Ambassador	19.5					
Rebel (2 Seat Wagon)	19.5					
Rebel (3 Seat Wagon)	17.0					
Ambassador Wagon	17.0					
CHRYSLER CORP.	4 Vent Lines- One in each corner	On top of main tank "overfill limiter" capacity = 1.4 gal.	Separator	Crankcase	Filler cap	V8s -Vented to crankcase by separate line
CHRYSLER & IMPERIAL						
Sedans	24					6 cyl From fuel pump to crankcase
Wagons	23					
DODGE						
Dart and Challenger	18					
Charger & Coronet	19					
Polara & Monaco	24					
Wagons	23					
PLYMOUTH						
Valiant & Barracuda	18					

1970 MANUFACTURER	VENT LINES/ FUEL TANK CAPACITY (GAL)	EXPANSION TANK	VAPOR SEPARATOR	VAPOR STORAGE	PRESSURE RELIEF	CARBURETOR VAPOR VENTING
PLYMOUTH						
Satellite	19					
Fury	24					
Fury Wagon	23					
FORD MOTOR CO.	4 Vent Line- 1 per corner	None Extended fill neck for air displacement	Separator	Canister (Cap: 350 gms) crank-case	From filler neck by three-way valve	To air cleaner
Fairlane	20					
Fairlane wagon	17					
Falcon	12.5					
Falcon Wagon	19					
Ford	23.1					
Ford Wagon	21.1					
Maverick	14					
Mustang	20					
Thunderbird	22.5					
Mercury	20					
Mercury Wagon	17					
GENERAL MOTORS	3 Vent- 1 center 2 corner (3/8" dia) (5/16" dia)	Upper rear of fuel tank	Separator 9 oz. chamber	canister capacities: (1) 300g (1) 625g	Filler cap	Vent to canister
Buick						
Sedans) 6 cyl Wagons)	≏ 20 ≏ 23					2 bbl. carbs. Internal Vented
V8s						
Skylark, Sportswagon Skylark 350ps, Skylark Custom and GS 455	≏ 20					
Sports Wagon	23					
Estate Wagon	24					

1970 MANUFACTURER	VENT LINES/ FUEL TANK CAPACITY (GAL)	EXPANSION TANK	VAPOR SEPARATOR	VAPOR STORAGE	PRESSURE RELIEF	CARBURETOR VAPOR VENTING
Buick						
V8s						
Lesabre, Wildcat, Electra, Riviera	25					
Cadillac						
Standard	24					
Comm. chassis	18 approx. values					
Eldorado	22					
Chevrolet						
Camaro	18					
Nova	17					
Chevelle	18					
Chevrolet	23					
wagon	20					
Oldsmobile						
All 6 cyl.	20					
V8s						
Wagons	22					
442, F85, Cutlass, Cutlass Supreme	19					
Delta 88 & 98	24					
Toronado	23					
Pontiac						
6 cyl						
Firebird	17					
Tempest	19					
Wagon	22					

1970-71 MANUFACTURER	VENT LINES/ FUEL TANK CAPACITY (GAL)	EXPANSION TANK	VAPOR SEPARATOR	VAPOR STORAGE	PRESSURE RELIEF	CARBURETOR VAPOR VENTING
Pontiac						
V8s						
Pontiac Exec. Wagon	24.5					
Pontiac Wagon	23					
Grand Prix	24					
Tempest Exec. Wagon	19					
Sta. wagon	21.5					
Firebird	17					
-1971 AMERICAN MOTORS	2 Vent Line diag. corners	Internal/ Gremlin-None	Liquid check valve	V8s with auto-trans use charcoal canister; 6 cyl. & others use crankcase	Filler cap	Internal venting to manifold
Hornet	16					
Gremlin	21.6					
Javelin	16.0					
Matador & Ambassador Sed.	19.5					
Matador (2 Seat (wagon	19.5					
(3 Seat (wagon	17.0					
Ambassador Wagon	17.0					
CHRYLSER CORP.	4 Vent lines 1 each corner	Internal	Separator	Engine crankcase	Filler cap "Pressure-Vacuum"	6 cyl. - to crankcase via fuel pump; V8s - to air cleaner
Chrysler & Imperial	23					

1971 MANUFACTURER	VENT LINES/ FUEL TANK CAPACITY (GAL)	EXPANSION TANK	VAPOR SEPARATOR	VAPOR STORAGE	PRESSURE RELIEF	CARBURETOR VAPOR VENTING
Dodge						
Dart	17					
Challenger (6 cyl & V8)	18					
Coronet & Charger (6 cyl & V8)	21					
Polara (6 cyl & V8)	23					
Monaco- V8 only	23					
Plymouth						
Valiant	17					
Barracuda	18					
Satellite	21					
Fury	23					
FORD MOTOR CO.	Vented in center of tank directly to separator	10%-12% air space designed into tank	Separator	Carbon canister	Filler cap	Internal vent to air cleaner
Pinto	11,8					
Ford wagons	22					
cars	23					
Maverick	16			Hose sizes - canister from tank- 3/8" ID; paper-flex line to air cleaner 3/4" ID		
Mustang	20					
Torino cars	20					
Wagons	18					
Ranchero	18					
Thunderbird	23					
Lincoln	23					
Mercury						
Comet	16					
Cougar	20					
Merc. cars	23					
wagons	22					
Montego	20					
wagons	18					

1971 MANUFACTURER	VENT LINES/ FUEL TANK CAPACITY (GAL)	EXPANSION TANK	VAPOR SEPARATOR	VAPOR STORAGE	PRESSURE RELIEF	CARBURETOR VAPOR VENTING
GENERAL MOTORS CORP.	3 Vent 2 front 1 rear	Air chamber for expansion	Seperator	Charcoal canister 3 Types- 1) Two tube all V8s/ except Chevrolet from fuel tank to carb. (2) Third tube purge all 6 cyl. & all Chevrolet engines (except Vega) same as above except incorporates extra purge to carb. intake. (3) Four tube purge-same as above except 4th tube is connected to carb. float bowl. (No. 3 is on Vegas only).	Filler cap	Vega- From float bowl to canister; all others internal venting
Buick						
Skylark	20					
All others	25					
Cadillac	27.5					
Chevrolet						
Vega	≃ 11					
Nova	16					
Camaro	17					
Chevelle& Monte Carlo	19					
Chevelle (Wagon)	18					
Chevrolet	24					
Chev. (Wagon)	23					
Corvette	18					
OLDSMOBILE						
6 cyl						
Wagons	22					
All others	20					
V8s						
Vista Cruiser	22					
F-85, Cutlass, Cutlass Supr., 442	19					
All Others	24					
Pontiac						
Ventura II	16					
Firebird	17					
Catalina, Broughman, Grandville						
Bonneville	24.5					

1971-73 MANUFACTURER	VENT LINES/ FUEL TANK CAPACITY (GAL)		EXPANSION TANK	VAPOR SEPARATOR	VAPOR STORAGE	PRESSURE RELIEF	CARBURETOR VAPOR VENTING
Pontiac							
Bonneville wagon	23.0						
Grand Prix	24						
T-37, LeMans, Sport, GTO	19						
LeMans Wagon	21.5						
1972-73 AMERICAN MOTORS	1972 2 Vent same	1973 lines as '71	Internal/ Gremlin no expansion other than air space	Liquid fuel check valve	V8s with auto. trans. to charcoal canister 1973-V8 2 hoses - 1) Tank to canister 2) To air cleaner 1973-6 cyl. 3 hose- (1) from tank (2) PCV vacuum (3) to carb. manifold	Filler cap	Internal venting
Hornet	16	16					
Gremlin	21	21					
Javelin	16	16					
Matador & Ambassador Sed.	19.5	19.5					
Matador	19.5						
2-Seat Wagon	19.5	20.0					
3-Seat Wagon	21.5						
Ambassador Wagon	21.5	20.0					
CHRYLSER CORP.	4 Vents	1 each corner	Overfill Limiting valve to prevent overfill	Separator	Charcoal canister no purge from canister in 1973	Filler cap	From bowl to canister
Chrylser & Imperial	23	23					
Dodge							
Dart	16	16			2 types of can-isters (1) 3 hose (a) from tank (b) from carb. (c)to carb. man.		
Challenger	16.5	18					
Coronet & Charger	21	21					
Polara & Monaco	23	23					

1972-73 MANUFACTURER	VENT LINES/FUEL TANK CAPACITY (GAL)		EXPANSION TANK	VAPOR SEPARATOR	VAPOR STORAGE	PRESSURE RELIEF	CARBURETOR VAPOR VENTING
	1972	1973					
Plymouth					(2) 4 hose high performance only same as above with purge line.		
Valiant	16	16					
Barracuda	16.5	16.5					
Satellite	21	21					
Fury	23	23					
FORD MOTOR CO.	Same As '71		Same as '71	Same as '71	Same as '71 Canister volume- 650 grams as of 1973. '72 hose sizes same as '71.	Same as '71	Same as '71
Pinto	11	11					
Ford & Meteor cars	23	22					
Wagons	22	21					
Maverick	16	15					
Mustang	20	19.5					
Torino cars	20	22.5					
Wagons	18	20.5					
Ranchero	18	-N/A					
Thunderbird	23	22.5					
Lincoln	23	22.5					
Mercury							
Comet	16	15					
Cougar	20	19.5					
Mercury Cars	23	22.5					
Wagons	22	20.5					
Montego cars	20	22					
Wagons	18	20					
GENERAL MOTORS CORP.	Same as 1971		Same as 1971	Same as 1971 Located in top center of tank.	Same as 1971	Same as 1971	Same as 1971. Bowl vent to air cleaner. Vega has external vents; all others sealed.
Buick							
Skylark & G. S. Series	20	-N/A					
Stat. Wagons	23	22					
Riviera	24	-N/A					
All Others	25	26					
Century, Luxus, Regal		22					

1972-73 MANUFACTURER	VENT LINES/FUEL TANK CAPACITY (GAL)		EXPANSION TANK	VAPOR SEPARATOR	VAPOR SOTRAGE	PRESSURE RELIEF	CARBURETOR VAPOR VENTING
	1972	1973	Same as 1971	Same as 1971	Same as 1971 Located in top center of tank	Same as 1971	Same as 1971 Bowl vent to air cleaner Vega has external vents-all others sealed
Cadillac	≏27.5	≏27.5					
Chevrolet							
Vega	≏11	11.0			Hose Sizes 3 Tube-Chev. Tank to canister 5/16" ID. PCV - 1/4" ID. Carb-3/16" ID. 2 tube-Pont. Tank to cansiter 5/16" ID. 1/4" ID. Carb.		
Nova	16	21					
Camaro	18	18					
Chevelle & Monte Carlo	19	22					
Chevelle Wagon	18	-N/A					
Chevrolet Wagon	24	26					
Corvette	23	22					
	18	18					
Oldsmobile							
All wagons	23						
F-85, Cutlass, Cutlass Supreme	20	22					
88,98, Toronado	25	26					
Omega	-N/A	21					
Pontiac							
Ventura II	16	21.5					
LeMans (Gran Am)	20	25					
Firebird	18	18					
Grand Prix	26	25					
Others Exec. Wagons	25	26					
Wagons	23	22					

MANUFACTURER 1970	VENT LINES/FUEL TANK CAPACITY	EXPANSION TANK	VAPOR SEPARATOR	VAPOR STORAGE	PRESSURE RELIEF	CARBURETOR VAPOR VENTING
Datsun (Nissan)	2 Vent Lines	Vapor/Liquid Separator Tank	External Tank (Small Capacity)	Crankcase	Flow Guide Valve (Pressure Exceeding .4" Hg)	Air Cleaner Storage to Crankcase: Sports Model Only
Fiat (Model-850) (Model-124)	2 Vent Lines (Opposite Corners)	Tank Design	2 Float Valves	Carbon Canister	Three-way Valve	Fuel Bowl to Canister
Mercedes-Benz	2 Vent Lines (Front of Tank)	External Compensating Tank	Compensating Tank	Crankcase	Pressure Relief Valve	Carbon in Air Filter Used as Storage
Toyota	4 Vent Lines (1 from each corner)	Thermal Expansion Tank	Return from Bottom of Expansion Tank	Fuel Vapor Storage Case 2 on Crown Wg & Crown Sedan	Vapor Vent	Air Filter
Volkswagen	2 Vents (Front and Rear)	External Expansion Tank	Expansion Tank Return	Charcoal Canister	Expansion Tank	Float Bowl to Air Horn (Closed and Sealed) Stored in Air Cleaner
Volvo	2 Vent Lines (1 at Filler Neck and 1 at Top of Fuel Tank)	External Expansion Tank	Venting Action from Expansion Tank	Carbon Canister	Expansion Tank	Carbon Canister

MANUFACTURER 1971	VENT LINES/FUEL TANK CAPACITY	EXPANSION TANK	VAPOR SEPARATOR	VAPOR STORAGE	PRESSURE RELIEF	CARBURETOR VAPOR VENTING
Datsun	2 Vent Lines to V/L Separator	V/L Separator (Simply a small tank) provides for expansion	Simply a tank	Crankcase	Flow Guide Valve	Air Cleaner Storage
Fiat	See 1970	Internal	None mentioned	Carbon Canister	3-Way Control Valve	See 1970
Jaguar						
E Type	3 Vent Lines	External	Valve	Carbon Canister		Vented to Air Cleaner
XJ-6	2 Separator Tanks 2 Vent Lines (Front and Back) from each	Internal	Valve	Carbon Canister		Vented to Air Cleaner
Mercedes-Benz (Non-diesel)	2 Vent Lines in Front Part of Tank	External Compensating Tank	Compensating Tank (in Trunk)	Crankcase	Pressure Relief Valve	See 1970
Toyota	2 Vapor Lines (Front and Back of Tank)	External	Breather valve and apparently expansion tank	Vapor Storage Case	Cap	See 1970
Volkswagen	2 Vapor Lines (Front and Back of Tank)	External on all models except Super Beetle and Type 2	Fuel Trap (on Super Beetles only)	Carbon Canister (Note: Air is blown into canister to purge)	Cap is non-vented	See 1970
Volvo	2 Vapor Lines					
Volvo	2 Vapor Lines (Front and Back of Tank)	External		Carbon Canister	Non-vented Cap	Line from Carburetor to Canister

MANUFACTURER 1973	VENT LINES/FUEL TANK CAPACITY	EXPANSION TANK	VAPOR SEPARATOR	VAPOR STORAGE	PRESSURE RELIEF	CARBURETOR VAPOR VENTING
Datsun	Same as 1970 system.					
Fiat	Same as 1970 system.					
Jaguar	2 Separate Tanks 2 Vent Lines (Front and Back) on Each	Exists only on J-12	None mentioned	Carbon Canister	None mentioned	
Mercedes-Benz	Same as 1970 (except on 280 and 280C, vapor escape prevention valve is extra feature on air cleaner).					
Toyota				Carbon Canister	Cap	See 1970
Corrola Sedan	2 Vent Lines		Check Valve			
Corrola Station Wagon	4 Vent Lines	External, Fuel Vapor Separator	Check Valve and Fuel Vapor Separator			
Carina	Vent Lines		Check Valve			
Celica	2 Vent Lines		Check Valve			
Corona	4 Vent Lines	External, Fuel Vapor Separator	Check Valve and Fuel Vapor Separator			
Mark II	4 Vent Lines	External Tank on Station Wagon Only	Check Valve			

MANUFACTURER 1973	VENT LINES/FUEL TANK CAPACITY	EXPANSION TANK	VAPOR SEPARATOR	VAPOR STORAGE	PRESSURE RELIEF	CARBURETOR VAPOR VENTING
Toyota (Cont)						
Crown	No longer manufactured.					
Hi Lux	2 Vent Lines	External, Fuel Vapor Separator	Check Valve and Fuel Vapor Separator			
Land Cruiser	4 Vent Lines	External, Fuel Vapor Separator	Check Valve and Fuel Vapor Separator			
Volkswagen	Same as 1971.					
Volvo	Same as 1971.					

APPENDIX D

PRE-1970 VEHICLE GAS CAP VENTING

APPENDIX D

PRE-1970 VEHICLE GAS CAP VENTING

This appendix identifies domestic and foreign vehicles of model year 1955-1969 and denotes the type of filler cap configuration, vented or nonvented. The information is used to establish the type and configuration of fuel tank venting for the various vehicles in that the vehicles which do not have a vented gas cap have a vent located directly on the tank.

APPENDIX D

VEHICLE GAS CAP VENTING

Cars and Trucks U.S. and Foreign Name--Year--Model	V or NV*
AMERICAN MOTORS	
1969-68	NV
1969 AMX	NV
1969 Rambler, Rouge All	V
1969-68 Rebel, Ambassador All	V
1968 Rambler Amer.	V
1967 All except Amer.	V
1967 Amer. (pass.), Rogue	V
1967 Amer. St. Wagon	V
1966-64 American	NV
1966-63 Classic, Ambassador (exc. 3-seater St. Wagon)	V
1966-63 Rambler Amer.	V
1962-53 All incl. Rambler American	V
Metropolitan:	
1962-54 All	V
AUSTIN	
1969-68 American Sedan	V
1964-63 A-30, 35, 40, 50, A-4011	V
AUSTIN-HEALY	
1969 Sprite	V
1968-58 Sprite, MK II, IV, 3000 BJ8 BN-4 6 cyl., BH-1 4 cyl., 100-6 6 cyl., BNZ 4 cyl.	V

Cars and Trucks U.S. and Foreign Name--Year--Model	V or NV*
BMW	
1969 2800 only	V
600 series	V
BORGWARD	
Isabella	V
BUICK	
Electra, LeSabre, Skylark, Riviera, Centurion, etc:	
1969-66 All except Est. Wagon (incl. 1970 in Calif.)	NV
1969-66 St. Wagons	V
1965 All exc. Riviera	NV
1965 Riviera	V
-57 All	V
1956-36 All	V
Special:	
1969-64 All (exc. St. Wagon)	NV
1969-64 St. Wagon	V
1963-61 All	V
CADILLAC	
1969-64 (except Eldorado)	NV
1969-67 Eldorado	V
1965-59 All	V
1958-49 All	V
CHECKER	
1969-63	V

*V = vented; NV = non-vented.

Cars and Trucks U.S. and Foreign Name--Year--Model	V or NV*
CHEVROLET	
Incl. Camero, Chevelle, Chevy II Corvair, Corvette, Vega, (Beaumount, Acadian--Canada)	
Chevrolet: (Full Size Car) Impala, Caprice, Biscayne Belair, etc.:	
1961-64 (exc. St. Wagon	NV
1969-65 St. Wag. (Incl. Kingswood Est. Wagon)	V
1964 All	V
1963-61 All	V
1960 (exc. St. Wag.)	V
1960 St. Wagon	V
1959-58 All	V
1957-53 All	V
Camero:	
1969 All	V
1968-67 All	V
Chevelle: (Monte Carlo, Malibu, etc)	
1969-64 (exc. St. Wagon)	V
1969-64 St. Wagon	V
Chevy II: (Nova)	
1969-68 All	V
1967-65 All	NV
1964-62 All	V
Corvair:	
1969-65 (exc. Greenbriar)	V
1965-61 Greenbriar and Truck	V
1964-61	V
1960	V
Corvette:	
1969-63	NV
1962-53	V

Cars and Trucks U.S. and Foreign Name--Year--Model	V or NV*
CHEVROLET (Trucks)	
1969-37	V
1969-64 El Camino	V
CHRYSLER	
Including Imperial	
Chrysler:	
1969-66 (exc. St. Wagon	NV
1969-66 St. Wag.	V
1965-60 (exc. St. Wagon)	V
1966-56 St. Wag. (exc. C body)	V
1962 300	V
1959-57 (exc. St. Wagon)	V
Imperial:	
1969-67	V
1966-64	V
DESOTO	
1961-60 (exc. St. Wagon)	V
1961-57 St. Wagon	V
1959-57 (exc. St. Wagon)	V
DIAMOND T (Trucks)	
1960-35 Partial	V
DIVCO	
1967-41	V
DODGE (Cars)	
Incl. Dart, Demon Lancer	
Dodge:	
1969-66 Coronet St. Wagon	NV
1969-65 Polara, Monaco (exc. St. Wagon)	NV
1969-68 Coronet (exc. St. Wag.)	NV

Cars and Trucks U.S. and Foreign Name--Year--Model	V or NV*
DODGE (Cars) (continued)	
Dodge:	
1969-67 Charger	V
1968-67 Polara, Monaco St. Wag.	V
1967-65 Coronet (exc. St. Wag.)	V
1965-62 St. Wags. (exc. Polara and 880)	NV
1964 All (exc. St. Wagons)	V
1964-62 880 (exc. St. Wagon)	V
1964-62 880 St. Wagon	V
1963-62 All (exc. St. Wag. and 880)	V
1961-60 All (exc. St. Wagon)	V
1961-57 St. Wags.	V
1959-57 All	V
1956-55 All	V
Dart and Demon:	
1969-67	NV
1966-63 (exc. St. Wagon)	NV
1966-62 St. Wag.	NV
1962-60 (exc. St. Wagon)	V
1961-60 St. Wag.	V
Lancer:	
1962-61	NV
DODGE (Trucks)	
FARGO (Canada)	
1969-65 Compact	V
1969-62 All light trks (exc. Compacts and Diesels, Town Sed., 1961-64 Panel)	V
1968-57 Diesels	NV

Cars and Trucks U.S. and Foreign Name--Year--Model	V or NV*
DODGE (Trucks) (continued)	
1964-61 Town Sedan and Panel	V
1961 Light and Medium	V
1960-28 (exc. underseat tanks and saddle tanks)	V
EDSEL	
1960-58 St. Wag.	V
1960 exc. St. Wag.	NV
1959 exc. St. Wag.	V
1958 exc. St. Wag.	NV
FEDERAL (Truck)	
1960-31 Partial	V
FIAT	
1967 850 Spider Coupe, Familiar	V
1967-62 1100, 1100D, 1500	V
1966-64 600, 600D; 1100 St. Wag.	V
1963-60 600, 1200, Rondette, Sedan, Cabro	V
FORD (Cars) (Canadian Meteor) Incl. Fairlane, Falcon, Maverick, Mustang, Pinto, Thunderbird, Torino	
Ford: (Full Size Model) Galaxis, Custom LTD, Broughm, Country Squire, etc.	
1969 All (incl. Country Squire, Ranch Wagon)	V
1968-65 (exc. St. Wagons)	V

Cars and Trucks U.S. and Foreign Name--Year--Model	V or NV*
Ford: (Full Size Model) (continued)	
1968-65 St. Wags.	V
1964 All	V
1963-53 (exc. St. Wag.) (1962 Sunliner, Skyliner)	NV
1963-61 St. Wag.	V
1961 St. Wag. (exc. first 10,000)	V
1960 St. Wag. (exc. first 8,500) incl. first 10,000 in 1961	NV
1959-53 St. Wag. (also first 8,500 in 1960)	V
1952-49 All	V
Fairlane:	
1969-66 (exc. St. Wag.)	NV
1969-66 St. Wag.	V
1965-62 (exc. St. Wag.)	V
1965-63 St. Wag.	V
Falcon: (Frontenac Canada)	
1969-65 St. Wag.	V
1969-60 (exc. St. Wag.) and Truck	V
Maverick and Mustang:	
1969-65 (exc. G1, Mach 1)	V
Thunderbird:	
1969-67	V
1966-61	V
1960-55	V
Torino:	
1969 All	NV

Cars and Trucks U.S. and Foreign Name--Year--Model	V or NV*
FORD (Trucks) Incl. Bronco, Econoline Ranchero	
Ford Light Trucks:	
1969-51 All under 6000# GVW F-250 etc.	V
Bronco:	
1969-66	V
Econoline:	
1969-68	V
1967-61	V
Ranchero:	
1969-61	V
FORD (English)	
1970-67½ Cortina	V
1969-53 Anglia, Consul, Cortina to '67½, Escort, Popular, Prefect, Squire, Thames, Zephyr, Zodiac	V
GMC (Trucks)	
1969-39	V
IHC (Trucks) Incl. Scout, Travelall	
1969-61 Scout, Travelall; C-100-130; 1000,1100, 1200, 1500	V
1968-67 C.O.E. 190	NV
1968-53 A, B, BC, L, R, S 100-600; VCO-205 COE; AM-80 Metro, 1200, 1500, 1700; 1600, 1700, 1800 Loadstar	V
JAGUAR	
1969 E Type 4.2	V
1967-57 3.4, 2.4 litres, MK-2, MK-E, MKX, HK, S, XKE	

Cars and Trucks U.S. and Foreign Name--Year--Model	V or NV*
KAISER JEEP (Formerly Willys)	
1969-64 Wagoneer	V
1969-45 CJ and DJ Models; MK II	V
1968-45 (exc. CJ, DJ Models and Wagoneer)	V
LINCOLN and CONTINENTAL	
1969-61 All	V
1961 Some	NV
1960-54 All	NV
MERCEDES-BENZ	
1969 280 SEL	V
1969 SL 280 Coupe	V
1969 190 and 220 Series, 250	V
MERCURY	
Incl. Capri, Comet, Courgar, Meteor	
Mercury: Marquis, Montego, Cyclone, Monterey (Full Size Car)	
1969 Montego All	V
1968-65 All (exc. St. Wagon)	V
1968-65 St. Wag.	V
1964 All, incl. St. Wagon	V
1963-61 (exc. St. Wagon)	NV
1963-61 St. Wag.	V
1960 (exc. St. Wag.)	V
1960 St. Wagon	NV
1959 All (incl. St. Wagon)	V
1958-57 All (incl. St. Wagon)	NV
Comet:	
1969-66 St. Wag.	V
1969-64 (exc. St. Wagon)	V
1965 and 1963-60 St. Wagon	V
Cougar:	
1969-67	V
Meteor:	
1963 St. Wagon	V
1963-62 (exc. St. Wagon)	V
MG	
1969 GT, Magnette, MGB, Midget	V
MONARCH (Canada) Same as U.S. Mercury	
MORRIS MINOR	
Mini Minor 850, 4 cyl.	
1000 Trav., Oxford Ser., VI Trav.	V
1957-53	V
OLDSMOBILE	
Incl. F-85 Cutlass, Toronado	
Oldsmobile: 88, 98 F-85 Toronado	
1969-64 (exc. St. Wags.)	NV
1969-64 St. Wags.	V
1963-59 All	V
1958-41 All	V
OPEL	
1969-64 Kadette	NV
PACKARD	
1958-57	V
1956 Clipper	V
1955-50 All	V
1949-41 All	V
PLYMOUTH	
Incl. Belvedere, Fury, Satellite, Baracuda, Valiant	
Baracuda:	
1966-65 All	NV

Cars and Trucks U.S. and Foreign Name--Year--Model	V or NV*
Belvedere, Satellite:	
1969-68 (exc. St. Wag.) Belv. and Satellite	NV
1969-68 Belvedere St. Wagon	NV
1969-68 Satellite St. Wagon	NV
1967 Satellite All	NV
1967-66 Belvedere All	NV
1965-62 Belvedere St. Wagon	NV
1965-63 (exc. St. Wagon)	V
1962 (exc. St. Wag. and Suburban)	V
1961-60 (exc. St. Wagon)	V
1961-57 St. Wag.	V
1959-57 (exc. St. Wag. and Suburban)	V
1956-55 All	V
Fury:	
1969-66 (exc. St. Wagon)	NV
1969-67 St. Wag.	V
1966-65 St. Wag.	V
1965 (exc. St. Wag.)	V
Valiant and Duster:	
1969-67	NV
1966-60	NV
PONTIAC	
Incl. Firebird, Le-Mans, Ventura II, Tempest	
Pontiac: Catalina, Bonneville, Grand Prix, Grandville, LeMans, etc. (Full Size Car)	
1969-65 (exc. St. Wagon)	NV
1969-65 St. Wag.	V

Cars and Trucks U.S. and Foreign Name--Year--Model	V or NV*
Pontiac: (continued)	
1965-58 All	V
1957-26 All (optional G-20A on some)	V
Firebird:	
1969-67	V
Tempest:	
1969-65 (exc. St. Wag.)	NV
1969-65 St. Wag.	V
1965 All	V
1963 (exc. St. Wagons)	V
1963 St. Wags.	NV
1962-61 All	V
RENAULT	
1969-55 Dauphine, Caravelle	V
REO (Truck)	
1961-45 Most models, 19, 20, Super V, 6 cyl., etc.	V
1961-45 Some models, 21, 22, 23, 25, E, F, etc.	V
SAAB	
To 1969 incl. 93, 95, 96 GT 850	V
STUDEBAKER (Cars)	
1966-62 Hawk, Avanti	V
1965-62 Lark all, Comm. Daytona, Cruiser, Chall.	V
1961-59 Lark St. Wagon	V
1961-59 (exc. Lark St. Wagon)	V
1958-28 All	V
STUDEBAKER (Trucks)	
1965-36 All	V

Cars and Trucks U.S. and Foreign Name--Year--Model	V or NV*
TOYOTA	
1969	V
VAUXHALL (Canada)	
1967-64 Epic, Viva	V
1964-60 Victor, Envoy	V
1960-57 Victor	V
VOLKSWAGEN	
1969-68 113 Sedan	V
1965-60 Bus, Camper St. Wagon	V
WHITE (Truck)	
1961 1500 T Compact	V
1960-44 WA, WB, WC-14 to 29, 700, 800, 3000, 9000, etc.	V

APPENDIX E

PRE-1970 LIGHT DUTY VEHICLE CARBURETOR VENTING

APPENDIX E

Carburetor Vent Summary for Light- and Heavy-Duty Vehicles

The columns within each year are:

(a) Carburetor Model

(b) Number of Carburetor Barrels (1), (2), (4)

(c) Internal (i) or External (e) Bowl Venting

(d) Carburetor Manufacturer

C - Carter
R - Rochester
F - Ford, Autolite
H - Holley
S - Stromberg

Example: 55 Dodge

W C F B	4	e	C
Carburetor Model	4 Barrels	External Venting	Carter Manufacture

APPENDIX E

CARBURETOR VENT SUMMARY FOR LIGHT- AND HEAVY-DUTY VEHICLES

CAR MAKE	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
Buick	AFB 4 i C WGD e C WW 2 i S 4GC 4 e R WCFB 4 e C AAVB i S WCD 2 e C	AFB 4 i C WGD e C WW 2 i S 4GC 4 e R WCFB 4 e C AAVB i S	AFB 4 i C WGD e C WW 2 i S 4GC 4 e R	AFB 4 i C WGD e C WW 2 i S 4GC 4 i R WCFB 4 e C	AFB 4 i C WGD e C WW 2 i S 4GC 4 e R WW7 2 e S	AFB 4 i C WGD e C 4GC 4 e R WW7 2 e S	AFB 4 i C 2GC 2 e R 4GC 4 e R WW7 2 e S	AFB 4 i C 2GC 2 e R 4GC 4 e R	AFB 4 i C 2GC 2 e R 4GC 4 e R	AFB 4 i C 2GC 2 e R 4GC 4 e R	AFB 4 i C 2GC 2 e R 4GC 4 e R BC 1 e R	AFB 4 e C 2GV 2 e R 4MC 4 e R 4GC 4 e R	AFB 4 e C 2GC 2 e R 4MV 4 e R	AFB 4 e C 2GV 2 e R MV 1 e R 4MV 4 e R	AFB 4 e C 2GV 2 e R MV 1 e R 4MV 4 e R
Special/Skylark	NONE	NONE	NONE	NONE	NONE	NONE	2GC 2 e R	2GC 2 e R 4GC 4 e R	2GC 2 e R 4GC 4 e R	2GC 2 e R 4GC 4 e R	2GC 2 e R AFB 4 e C BC 1 e R	2GC 2 e R AFB 4 e C	2GC 2 e R 4MV 4 e R	MV 1 e R 4MV 4 e R	MV 1 e R 2GV 2 e R
Cadillac	WCFB 4 e C 4GC 4 e R	WCFB 4 e C 4GC 4 e R	WCFB 4 e C 4GC 4 e R AFB 4 i C	4GC 4 e R AFB 4 i C	AFB 4 e C Triple 6 e R 4GC 4 e R	AFB 4 e C Triple 6 e F 4GC 4 e R	AFB 4 e C 4GC 4 e R	AFB 4 e C 4GC 4 e R	AFB 4 e C 4GC 4 e R	AFB 4 e C 4GC 4 e R	AFB 4 e C 4GC 4 e R	AFB 4 e C	4MV 4 e R	4MV 4 e R	4MV 4 e R
Chevrolet	WCFB 4 e C 2GC 2 i R YH 1 e C BC 1 i R	WCFB 4 e C 2GC 2 i R BC 1 i R	WCFB 4 e C 2GC 2 i R BC 1 i R 4GC 4 i R	WCFB 4 e C 2GC 2 i R BC 1 i R 4GC 4 i R	WCFB 4 e C 2GC 2 e R Triple 6 e R BC 1 i R 4GC 4 i R AFB 4 e C	WCFB 4 e C 2GC 2 e R Triple 6 e R BC 1 i R 4GC 4 e R AFB 4 e C	WCFB 4 e C 2GC 2 e R Triple 6 e R BC 1 i R 4GC 4 e R AFB 4 e C	WCFB 4 e C 2GC 2 e R BC 1 i R BV 1 e R 4GC 4 e R AFB 4 e C	WCFB 4 e C 2GC 2 e R BC 1 i R BV 1 e R 4GC 4 e R AFB 4 e C	WCFB 4 e C 2GV 2 e R BC 1 i R BV 1 e R 4GC 4 e R AFB 4 e C 4150 4 e H	WCFB 4 e C 2GV 2 e R BV 1 e R 4GC 4 e R AFB 4 e C 4150 4 e H 4MV 4 e R	AVS 4 e C 2GV 2 e R BC 1 i R BV 1 e R 4GC 4 e R 4150 4 e H	2GV 2 e R Triple 6 i H BV 1 e R 4150 4 e H 4MV 4 e R	2GV 2 e R Triple 6 i H MV 1 e R BV 1 e R 4MV 4 e R	2GV 2 e R Triple 6 i H 4MV 4 e R
CHEVELLE	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE	4GC 4 e R AFB 4 e C 2GC 2 e R BV 1 e R	4GC 4 e R AFB 4 e C 2GC 2 e R BV 1 e R	4GC 4 e R 4MV 4 e R 2GV 2 e R BV 1 e R 4150 4 e H AVS 4 e C	4MV 4 e R 2GV 2 e R BV 1 e R 4150 4 e H	4MV 4 e R 2GV 2 e R MV 1 e R 4150 4 e H	4MV 4 e R 2GV 2 e R MV 1 e R 4150 4 e H
CORVAIR VEGA	NONE	NONE	NONE	NONE	NONE	H 1 i R	H 1 i R	YH 1 e C HV 1 i R	YH 1 e C HV 1 i R	YH 1 e C HV 1 e R	YH 1 e C HV 1 e R	YH 1 e C HV 1 e P 4GC 4 e R	HV 1 e R	H 1 i R HV 1 e R 2GV 2 e R	H 1 i R HV 1 e R 2GV 2 e R
CHEVY II/NOVA	NONE	NONE	NONE	NONE	NONE	NONE	NONE	BV 1 e R	BV 1 e R	AFB 4 e C 4150 4 e H BV 1 e R	AFB 4 e C 4150 4 e H BV 1 e R 2GV 2 e R	AVS 4 e C 4150 4 e H BV 1 e R 4MV 4 e R 2GV 2 e R	4150 4 e H	M 1 e R MV 1 e R 4MV 4 e R	M 1 e R MV 1 e R 4MV 4 e R
CAMARO	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE	2GV 2 e R 4MV 4 e R BV 1 e R	2GV 2 e R 4MV 4 e R 4150 4 e H MV 1 e R	2GV 2 e R 4MV 4 e R 4150 4 e H MV 1 e R
Chrysler	BBD 2 i C B 2 C WCFB 4 e C	BBD 2 i C WCFB 4 e C	BBD 2 i C AFB 4 i C WCFB 4 e C	BBD 2 i C AFB 4 i C	BBD 2 e C AFB 4 i C	BBD 2 e C AFB 4 i C	BBD 2 e C AFB 4 i C WWC 2 e S	BBD 2 e C AFB 4 i C WWC 2 e S	BBD 2 e C AFB 4 i C WWC 2 e S	BBD 2 e C AFB 4 i C WWC 2 e S	BBD 2 e C AFB 4 i C WWC 2 e S	BBD 2 e C AFB 4 e C WWC 2 e S	BBD 2 e C AFB 4 e C WWC 2 e S	BBD 2 e C AFB 4 e C WWC 2 e S AVS 4 e C	BBD 2 e C AFB 4 e C AVS 4 e C 4150 4 e H 4166 4 e H
Dodge	WM3 i S WCFB 4 e C	WM3 i S WCFB 4 e C	WM3 i S WCFB 4 e C	BBS 1 e C AFB 4 i C WM3 i S WCFB 4 e C	BBS 1 e C AFB 4 e C WM3 i S WCFB 4 e C BBD 2 e C WW2 2 e S	WWC 2 e S AFB 4 e C 4150 4 e C 4160 4 e H WW2 2 e S	WWC 2 e S AFB 4 e C BBD 2 e C BBS 1 e C WW2 2 e S	WWC 2 e S AFB 4 e C BBD 2 e C WW2 2 e S	WWC 2 e S AFB 4 e C WA 1 e S 1920 1 e H 4150 4 e H WW2 2 e S	WWC 2 e S AFB 4 e C BBS 1 e C 1920 1 e H 4150 4 e H WW2 2 e S	WWC 2 e S AFB 4 e C BBS 1 e C 1920 1 e H 4150 4 e H WW2 2 e S	WWC 2 e S AFB 4 e C 1920 1 e H 4150 4 e H WW2 2 e S	WWC 2 e S AFB 4 e C AVS 4 e C BBD 2 e C 1920 1 e H 4150 4 e H WW2 2 e S	AVS 4 e C BBD 2 e C 1920 1 e H 4150 4 e H 4166 4 e H
Dart	NONE	NONE	NONE	NONE	NONE	BBS 1 e C AFB 4 e C BBD 2 e C WW 2 i S	BBS 1 e C AFB 4 e C WW 2 i S	BBS 1 e C 1920 1 e H	BBS 1 e C 1920 1 e H	BBS 1 e C BBD 2 e C 1920 1 e H	BBS 1 e C BBD 2 e C 1920 1 e H	BBS 1 e C AFB 4 e C BBD 2 e C 1920 1 e H 4150 4 e H	BBS 1 e C AFB 4 e C BBD 2 e C 1920 1 e H	AVS 4 e C BBD 2 e C 1920 1 e H	BBS 1 e C AVS 4 e C BBD 2 e C 1920 1 e H
Ford	4000 i H 1904 1 i H 2100 2 i H	4000 i H 2110 i H 1960 1 i H	AFB 4 i C 1904 1 i H 4150 4 e H 1960 1 i H Dual i F	AFB 4 i C 4150c 4 e H 4150 4 e H 1960 1 i H Dual i F	AFB 4 i C 4150c 4 e H 4150 4 e H 1960 1 i H Dual i F 2100 2 e F 4200 4 e F 1904 1 e H	2100 2 e F 4100 4 e F 1904 1 e H	Triple 6 e R 2100 2 e F 4100 4 e F 1904 1 e H	Triple 6 i H 1909 1 i H 1904 1 e H 2100 2 e F 4100 4 e F	Triple 6 i H 1101 1 e H 1100 1 e H 2100 2 e F 4100 4 e F	4150 4 e H 1101 1 e F 1100 1 e F 2100 2 e F 4100 4 e F	1101 1 e F 1100 1 e F 2100 2 e F 4100 4 e F	4300 4 e F 1101 1 e F 1100 1 e F 2100 2 e F 4100 4 e F	4300 4 e F	YF 1 e C 4300 4 e F	YF 1 e C 4300 4 e F 1101 1 e F 4100 4 e F

APPENDIX E

CARBURETOR VENT SUMMARY FOR LIGHT- AND HEAVY-DUTY VEHICLES (Cont.)

CAR MAKE	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
Falcon/Pinto Maverick	NONE	NONE	NONE	NONE	NONE	1904 1 e H	1904 1 e H	1909 1 e H	1100 1 e F 1101 1 e F	1100 1 e F 1101 1 e F 2100 2 e F	1100 1 e F 1101 1 e F 2100 2 e F 4100 4 e F	1100 1 e F 1101 1 e F 2100 2 e F 4100 4 e F	1100 1 e F 1101 1 e F 2100 2 e F 4100 4 e F	1100 1 e F 2100 2 e F 6200 2 e F YF 1 e C	1101 1 e F 2100 2 e F YF 1 e C
Fairlane/ Torino	NONE	NONE	NONE	NONE	NONE	NONE	NONE	1909 1 i H 2100 2 e F	1909 1 i H 2100 2 e F	1100 1 e F 1101 1 e F 2100 2 e F 4100 4 e F	1100 1 e F 1101 1 e F 2100 2 e F 4100 4 e F	1100 1 e F 1101 1 e F 2100 2 e F 4100 4 e F	1100 1 e F 1101 1 e F 2100 2 e F 4100 4 e F 4300 4 e F	1100 1 e F 2100 2 e F 4150 4 e H 4300 4 e F 6200 2 e F	2100 2 e F 4150 4 e H 4300 4 e F
Thunderbird	4000 i H	4000 i N	4BAR 4 i F	4BAR 4 i F	4BAR 4 i F AFB 4 e C	AFB 4 e C	4100 4 e F	4100 4 e F Triple 6 i H	4100 4 e F Triple 6 i H	4100 4 e F	4100 4 e F	4300 4 e F	4100 4 e F 4300 4 e F	4300 4 e F	2100 2 e F 4300 4 e F
Mustang	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE	2100 2 e F	2100 2 e F 4100 4 e F	2100 2 e F 4100 4 e F 4300 4 e F	2100 2 e F 4100 4 e F 4300 4 e F 4150 4 e H	2100 2 e F 1100 2 e F 4300 4 e F 4150 4 e H	1101 2 e F 1100 2 e F 4300 4 e F 4150 4 e H
Imperial	WCFB 4 e C	WCFB 4 e C	WCFB 4 e C	AFB 4 i C	AFB 4 i C	AFB 4 i C	AFB 4 i C	AFB 4 e C	AFB 4 e C	AFB 4 e C	AFB 4 e C	AFB 4 e C	AFB 4 e C	AFB 4 e C AVS 4 e C 4160 4 e H	AFB 4 e C AVS 4 e C 4160 4 e H 4166 e H
Lincoln	1901 i H 4000 i H EBJ H	1901 i H 4000 i H ECU H	WCFB 4 e C	4150c 4 e H	4150c 4 e H AFB 4 i C AFB 4 e C	ABD 2 e C	ABD 2 e C	ABD 2 e C	AFB 4 e C	AFB 4 e C	AFB 4 e C	AFB 4 e C	AFB 4 e C	4300 4 e F	4300 4 e F
Mercury	4000 i H ECK H	4000 i H WCFB 4 e C ECZ H	AFB 4 i C WCFB 4 e C 4150 4 e H	AFB 4 i C 4BAR 4 i F 4150 4 e H 4150c 4 e H	AFB 4 e C 4BAR 4 i F 2100 2 e F 4150c 4 e H 2300 2 e H 4100 4 e F	ABD 2 e C 2100 2 e F 2300 2 e H 4100 4 e F	1920 1 e H 2100 2 e F 4100 4 e F	Triple 6 i H 2100 2 e F 4100 4 e F	Triple 6 i H 2100 2 e F 4100 4 e F	2100 2 e F 4150 4 e H 4100 4 e F	2100 2 e F 4100 4 e F	4300 4 e F 2100 2 e F 4100 4 e F	4300 4 e F 2100 2 e F 4100 4 e F	4300 4 e F 2100 2 e F 6200 2 e F 4100 4 e F	4300 4 e F 2100 2 e F 4100 4 e F
Comet/ Montego	NONE	NONE	NONE	NONE	NONE	NONE	1904 1 e H 1908 1 e H 1960 1 e H	1904 1 e H 1908 1 e H 1960 1 e H 1909 1 i H	1100 1 e F 1101 1 e F	1100 1 e F 1101 1 e F 2100 2 e F 4100 4 e F	1100 1 e F 1101 1 e F 2100 2 e F 4100 4 e F	1100 1 e F 1101 1 e F 2100 2 e F 4100 4 e F 4300 4 e F	1100 1 e F 1101 1 e F 4100 4 e F 4300 4 e F	1100 1 e F 2100 2 e F 4150 4 e H 4300 4 e F	1101 1 e F 2100 2 e F 4300 4 e F
Cougar	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE	4300 4 e F 4150 4 e H	2100 2 e F 4300 4 e F 4150 4 e H	2100 2 e F 4300 4 e F 4150 4 e H
Oldsmobile	WGD e C WCFB 4 e C 2GC 2 i R 4GC 4 i R	2GC 2 i R 4GC 4 i R	2G 2 i R 4GC 4 i R	2GC 2 i R 4GC 4 i R	2G 2 i R 2GC 2 i R 2GC 2 e R 4GC 4 i R	2GC 2 e R 4GC 4 e R	2GC 2 e R 4GC 4 e R	2GC 2 e R 4GC 4 e R	2GC 2 e R 4GC 4 e R	2GC 2 e R 4GC 4 e R	2GC 2 e R 4GC 4 e R	BV 1 e R Triple 6 e R 2GC 2 e R 4MV 4 e R	BV 1 e R 2GC 2 e R 4MV 4 e R	MV 1 e R 2GC 2 e R 4MV 4 e R	MV 1 e R 2GC 2 e R 4MV 4 e R
F-85/ Cutlass	NONE	NONE	NONE	NONE	NONE	NONE	2GC 2 e R	2GC 2 e R	2GC 2 e R 4GC 4 e R	2GC 2 e R BC 1 i R	2GC 2 e R BC 1 i R	2GC 2 e R BV 1 e R	2GC 2 e R BV 1 e R 4MV 4 e R YF 1 e C	2GC 2 e R BV 1 e R 4MV 4 e R	2GC 2 e R BV 1 e R 4MV 4 e R
Plymouth	BBS 1 e C BBD 2 e C WCFB 4 e C	BBS 1 e C BBD 2 e C WCFB 4 e C	BBS 1 e C BBD 2 e C WCFB 4 e C WW15 S	BBS 1 e C WW 2 e S AFB 4 i C	BBS 1 e C BBD 2 e C AFB 4 i C WW2 2 e S	BBS 1 e C BBD 2 e C AFB 4 i C WW2 2 e S	BBS 1 e C BBD 2 e C AFB 4 i C WW2 2 e S	BBS 1 e C BBD 2 e C AFB 4 i C WW2 2 e S 1920 1 e H	BBS 1 e C BBD 2 e C WA 1 e S WW2 2 e S 1920 1 e H 4150 4 e H	BBS 1 e C BBD 2 e C WW2 2 e S 1920 1 3 H 4150 4 e H	BBS 1 e C BBD 2 e C WWC 2 e S WW2 2 e S 1920 1 e H 4150 4 e H	BBD 2 e C WWC 2 e S WW2 2 e S 1920 1 e H 4150 4 e H	BBS 1 e C BBD 2 e C WW2 2 e S 1920 1 e H 4150 4 e H	BBD 2 e C AVS 4 e C 1920 1 e H	BBD 2 e C AVS 4 e C 1920 1 e H 4163 1 e H
Valiant	NONE	NONE	NONE	NONE	NONE	BBS 1 e C	BBS 1 e C	BBS 1 e C 1920 1 e H	BBS 1 e C 1920 1 e H	BBS 1 e C BBD 2 e C 1920 1 e H	BBS 1 e C 1920 1 e H	BBS 1 e C 1920 1 e H	BBS 1 e C 1920 1 e H	BBD 2 e C 1920 1 e H	BBS 1 e C BBD 2 e C 1920 1 e H
Pontiac	WGD e C 2GC 2 i R WCFB 4 e C	WCFB 4 e C 4GC 4 i R	AFB 4 i C 2GC 2 i R 2G 2 i R 4GC 4 i R	AFB 4 i C 2GC 2 e R 2G 2 i R 4GC 4 e R	AFB 4 e C 2GC 2 e R Triple 6 e R 4GC 4 e R	AFB 4 e C 2GC 2 e R Triple 6 e R 4GC 4 e R	AFB 4 e C 2GC 2 e R Triple 6 e R	AFB 4 e C 2GC 2 e R Triple 6 e R	AFB 4 e C 2GC 2 e R Triple 6 e R BC 1 e R	AFB 4 e C 2GC 2 u R Triple 6 e R	AFB 4 e C 2GC 2 e R Triple 6 e R	2GC 2 e R Triple 6 e R	2GC 2 e R 4MV 4 e R	MV 1 e R 2GV 2 e R 4MV 4 e R	MV 1 e R 2GV 2 e R 4MV 4 e R

APPENDIX E

CARBURETOR VENT SUMMARY FOR LIGHT- AND HEAVY-DUTY VEHICLES (Concl.)

CAR MAKE	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
Tempest/ LeMans	NONE	NONE	NONE	NONE	NONE	NONE	B 1 i R BC 1 i R 2GC 2 e R 4GC 4 e R	B 1 i R BC 1 i R	B 1 e R BC 1 e R AFB 4 e C	BC 1 e R BV 1 e R 2GC 2 e R AFB 4 e C Triple 6 e R	BV 1 e R AFB 4 e C Triple 6 e R	BV 1 e R 4MV 4 e R Triple 6 e R	BV 1 e R 4MV 4 e R	BV 1 e R 2GV 2 e R 4MV 4 e R MV 1 e R	2GV 2 e R 4MV 4 e R M 1 e R
Firebird	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE	4MV 4 e R 2GV 2 e R	4MV 4 e R 2GV 2 e R
American Motors	YF 1 e C 4GC 4 e R AS 1 i C	AS 1 i C YF 1 e C	WGD e C AS 1 i C WCD 2 e C	YF 1 e C AS 1 i C NGD 2 e C 4150c 4 e H	YF 1 e C WCD 2 e C 4150c 4 e H 4150 4 e H 1904 1 e H	YF 1 e C AS 1 i C 2040 H WCD 2 e C 4150 4 e H 1904 1 e H	YF 1 e C AS 1 i C 2040 H WCD 2 e C 4150 4 e H 1904 1 e H	YF 1 e C AS 1 i C WCD 2 e C 4150 4 e H 1904 1 e H	RBS 1 e C AS 1 i C 1909 1 e H WCD 2 e C 4150 4 e H	RBS 1 e C 1909 1 e H 1931 1 e H 4150 4 e H WCD 2 e C	RBS 1 e C 2209 1 e H 1909 1 e H 1931 1 e H	RBS 1 e C 2209 1 e H 1931 1 e H	RBS 1 e C 2209 1 e H 1931 1 e H	AFB 4 e C 6200 2 e F WCD 2 e C 1931 1 e H	AFB 4 e C 6200 2 e F WCD 2 e C 1931 1 e H
Other Domestics	WE e C YF 1 e C WW 2 i S WCFB 4 e C WGD e C	WE e C WW 2 i S WCFB 4 e C WGD e C	WE e C BBR1 e C WW 2 i S WCFB 4 e C	WE e C BBR1 e C WW 2 i S WCFB 4 e C	AS 1 i C WW 2 i S WCFB 4 e C	AS 1 i C WW 2 i S	AS 1 i C WW 2 i S	AS 1 i C WCFB 4 e C	AS 1 i C BV 1 e R RBS 1 e C AFB 4 e C WW6 2 e S	AS 1 i C RBS 1 e C AFB 4 e C WW6 2 e S	4GC 4 e R BV 1 e R	2GV 2 e R BV 1 e R	BV 1 e R	NONE	NONE
Import PC 6	Solex; S.U.; Weber; Zenith; Stromberg; (2/5s of which are externally vented)													26PCI 1 i Sr	NONE
Volkswagen	Solex Internally Vented Carburetors			NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE		
Import PC 7	Solex; S.U.; Weber; Zenith; Stromberg; (2/5s of which are externally vented)														
Class 3 Trucks *Also 1908 & 1960 Bolley **4150 and 4160	2G 2 i R 11ADX 1 i Z BB 1 i C 2B 1 i Z 29 1 i Z 63 1 i Z AA1G 1 i H 885JJS 1 i H 847FS 1 i H 228BV 1 i H 48AR 4 i F 2300 2 i H WCFB 4 e C	2G 2 i R BBS 1 i C 2B 1 i Z 29 1 i Z 63 1 i Z AA1G 1 i H 885JJS 1 i H 847FS 1 i H 228BV 1 i H 2300 2 i H 852FPG 1 i H	2G 2 i R 4G 4 e R BBS 1 i C 2B 1 i Z 29 1 i Z 63 1 i Z AA1G 1 i H 885JJS 1 i H 847FS 1 i H 228BV 1 i H 4000 i H 2300 2 i H 4150 4 i H 852FPG 1 i H 885JJG 1 i H	4G 4 e R 2B 1 i Z 29 1 i Z 63 1 i Z AA1G 1 i H 885JJS 1 i H 847FS 1 i H 228BV 1 i H 4000 i H 2300 2 i H 4150 4 i H 852FPG 1 i H	2G 2 i R 4G 4 e R 2B 1 i Z 29 1 i Z 63 1 i Z AA1G 1 i H 885JJS 1 i H 847FS 1 i H 228BV 1 i H 2300 2 i H 4150 4 i H 852FPG 1 i H AFB 4 i C	2G 2 i R 4G 4 e R 2B 1 i Z 29 1 i Z 63 1 i Z AA1G 1 i H 885JJS 1 i H 847FS 1 i H 228BV 1 i H 2300 2 i H 852FPG 1 i H AFB 4 i C	2G 2 i R 4G 4 e R 2B 1 i Z 29 1 i Z 63 1 i Z AA1G 1 i H 885JJS 1 i H 847FS 1 i H BBD 2 i C WW2 2 e S WWC 2 i S WCFB 4 e C 2300 2 i H WCFB 4 e C 852FPG 1 i H AFB 4 i C	4G 4 e R BBS 1 i C 28 1 i Z 29 1 i Z 63 1 i Z AA1G 1 i H 885JJS 1 i H 847FS 1 i H BBD 2 i C WW2 2 e S WWC 2 i S WCFB 4 e C AFB 4 i C	4G 4 e R BBS 1 i C 28 1 i Z 29 1 i Z 63 1 i Z 885JJS 1 i H 847FS 1 i H BBD 2 i C WW2 2 e S WWC 2 i S WCFB 4 e C AFB 4 i C	4G 4 e R BBS 1 i C 28 1 i Z 29 1 i Z 63 1 i Z 885JJS 1 i H 847FS 1 i H BBD 2 i C WW2 2 e S WWC 2 i S WCFB 4 e C AFB 4 i C	4G 4 e R BBS 1 i C 28 1 i Z 29 1 i Z 63 1 i Z 885JJS 1 i H 847FS 1 i H BBD 2 i C WW2 2 e S WWC 2 i S WCFB 4 e C AFB 4 i C	BBS 1 i C 2B 1 i Z 29 1 i Z 63 1 i Z 4MV 4 e R 885JJS 1 i H 847FS 1 i H BBD 2 i C WW2 2 e S WWC 2 i S WCFB 4 e C 4QJ e R AFB 4 i C 4150 4 i H 4150G 4 e H MV 1 e R	BBS 1 i C 2B 1 i Z 29 1 i Z 63 1 i Z 4MV 4 e R 885JJS 1 i H 847FS 1 i H BBD 2 i C WW2 2 e S WWC 2 i S WCFB 4 e C 4QJ 4 e R AFB 4 e C 4150 4 i H 4150G 4 e H MV 1 e R
Class 2 Heavy-Duty Vehicle	2G 2 i R B 1 i R 2B 1 i Z 29 1 i Z 63 1 i Z BB 1 i C 852FPG 1 i H WCFB 4 e C 228BV 1 i H 2300 2 i H 11ADX 1 i Z 2BAR 2 i F	2G 2 i R B 1 i R 2B 1 i Z 29 1 i Z 63 1 i Z BBS 1 i C 852FPG 1 i H WCFB 4 e C 228BV 1 i H 2300 2 i H 2BAR 2 i F	2G 2 i R 4G 4 e R 2B 1 i Z 29 1 i Z 63 1 i Z BBS 1 i C 852FPG 1 i H WCFB 4 e C 228BV 1 i H 4000 i H 4150 4 i H 2BAR 2 i F	2G 2 i R 28 1 i Z 29 1 i Z 63 1 i Z BBS 1 i C 852FPG 1 i H WCFB 4 e C 228BV 1 i H 2300 2 i H 4000 i H 4150 4 i H 2BAR 2 i F	2G 2 i R 28 1 i Z 29 1 i Z 63 1 i Z BBS 1 i C 852FPG 1 i H WCFB 4 e C 228BV 1 i H 2300 2 i H 4000 i H 4150 4 i H 2BAR 2 i F AFB 4 i C	2G 2 i R 4G 4 e R 2B 1 i Z 29 1 i Z 63 1 i Z BBS 1 i C 852FPG 1 i H WCFB 4 e C 228BV 1 i H 2300 2 i H AA1G 1 i H 885JJS 1 i H 2BAR 2 i F YF 1 e C BBD 2 i C	4G 4 e R 28 1 i Z 29 1 i Z 63 1 i Z BBS 1 i C 852FPG 1 i H WCFB 4 e C WW2 2 e S WWC 2 i S 847FS 1 i H 885JJS 1 i H 2BAR 2 i F YF 1 e C BBD 2 i C	28 1 i Z 29 1 i Z 63 1 i Z 852FPG 1 i H WCFB 4 e C WW2 2 e S WWC 2 i S 847FS 1 i H 885JJS 1 i H 2BAR 2 i F YF 1 e C BBD 2 i C	2E 1 i Z 29 1 i Z 63 1 i Z 852FPG 1 i H WCFB 4 e C WW2 2 e S WWC 2 i S 847FS 1 i H 885JJS 1 i H 2BAR 2 i F YF 1 e C BBD 2 i C	28 1 i Z 29 1 i Z 63 1 i Z 852FPG 1 i H WCFB 4 e C WW2 2 e S WWC 2 i S 847FS 1 i H 885JJS 1 i H 2BAR 2 i F YF 1 e C BBD 2 i C	28 1 i Z 29 1 i Z 63 1 i Z 852FPG 1 i H WCFB 4 e C WW2 2 e S WWC 2 i S 847FS 1 i H 885JJS 1 i H 2BAR 2 i F YF 1 e C BBD 2 i C	28 1 i Z 29 1 i Z 63 1 i Z BBS 1 i C 852FPG 1 i H WCFB 4 e C WW2 2 e S WWC 2 i S 847FS 1 i H 885JJS 1 i H 2BAR 2 i F YF 1 e C BBD 2 i C	28 1 i Z 29 1 i Z 63 1 i Z BBS 1 i C 852FPG 1 i H WCFB 4 e C WW2 2 e S WWC 2 i S 847FS 1 i H 885JJS 1 i H 2BAR 2 i F YF 1 e C MV 1 e R
Class 1 Light-Duty Vehicle	2BAR 2 i F B 1 i R 2G 2 i R 1904 1 i H BB 1 i C WW 2 e S WCFB 4 e C 1BAR 1 i F 11ADX 1 i Z	2BAR 2 i F B 1 i R 2G 2 i R 1904 1 i H BB 1 i C WW 2 e S WCFB 4 e C 1BAR 1 i F	2BAR 2 i F B 1 i R 2G 2 i R 1904 1 i H BBS 1 i C WW 2 e S WCFB 4 e C 1BAR 1 i F 4000 i H 4150 4 i H 4G 4 e R	2BAR 2 i F B 1 i R 2G 2 i R 1904 1 i H BBS 1 i C WW 2 e S WCFB 4 e C 1BAR 1 i F 4000 i H 4150 4 i H	2BAR 2 i F B 1 i R 2G 2 i R 1904 1 i H BBS 1 i C WW 2 e S WCFB 4 e C 1BAR 1 i F 4000 i H 4150 4 i H	2BAR 2 i F B 1 i R 2G 2 i R 1904 1 i H BBS 1 i C WW 2 e S WCFB 4 e C 1BAR 1 i F	2BAR 2 i F B 1 i R 2G 2 i R 1904 1 i H BBS 1 i C WW 2 e S WCFB 4 e C 1BAR 1 i F BBD 2 i C	2BAR 2 i F B 1 e R 2G 2 e R WWC 2 i S BBS 1 e C WW2 2 e S WCFB 4 e C YF 1 e C BBD 2 e C	2BAR 2 i F B 1 e R 2G 2 e R WWC 2 i S BBS 1 e C WW2 2 e S WCFB 4 e C YF 1 e C BBD 2 e C	2BAR 2 i F B 1 e R 2G 2 e R WWC 2 i S BBS 1 e C WW2 2 e S WCFB 4 e C YF 1 e C BBD 2 e C	2BAR 2 i F B 1 e R 2G 2 e R WWC 2 i S BBS 1 e C WW2 2 e S WCFB 4 e C YF 1 e C BBD 2 e C	2BAR 2 i F B 1 e R 2G 2 e R WWC 2 i S BBS 1 e C WW2 2 e S WCFB 4 e C YF 1 e C BBD 2 e C	2BAR 2 i F B 1 e R 2G 2 e R WWC 2 i S BBS 1 e C WW2 2 e S WCFB 4 e C YF 1 e C BBD 2 e C	2BAR 2 i F B 1 e R 2G 2 e R WWC 2 i S BBS 1 e C WW2 2 e S WCFB 4 e C YF 1 e C BBD 2 e C M 1 e R	2BAR 2 i F B 1 e R 2G 2 e R WWC 2 i S BBS 1 e C WW2 2 e S WCFB 4 e C YF 1 e C BBD 2 e C MV 1 e R

APPENDIX F

PRE-1970 LIGHT- AND HEAVY-DUTY VEHICLES CARBURETOR MAKES AND MODELS

APPENDIX F

PRE-1970 LIGHT- AND HEAVY-DUTY VEHICLES CARBURETOR MAKES AND MODELS

This appendix lists the domestic 1955-1969 vehicles and identifies the engine-carburetor combinations as a function of carburetor manufacturer. In the majority of cases, each engine-carburetion system combination has at least two carburetor models identified. Many of the vehicles, especially Ford Motor, had four or five carburetors identified.

APPENDIX F

PRE-1970 LIGHT- AND HEAVY-DUTY VEHICLES

CARBURETOR MAKES AND MODELS

VEHICLE	YEAR	ENGINE	DISPL.	HP	CARBURETOR BARRELS	CARBURETOR MODELS: CARTER	ROCHESTER	HOLLY	STROMBERG
BUICK	1955	V8	264	150	2	WCFB-2197S	4GC-7006200		WW7-104
	1955	V8	322	188	4	WCD-2197S	4GC-7009100		
	1955	V8	322	236	4				
	1956	V8	322	220	2	WCD-2378S	4GC-7009200		WW7-103
	1956	V8	322	255	4	WGD-2400S, WCFB-2347S			WW7-105B
	1957	V8	364	250	2	WGD-2529S, WGD-2536S	4GC-7010070		WW7-106C
	1957	V8	364	300	4	AFB-2507S	4GC-7011570		
	1958	V8	364	250	2	AFB-2800S, WGD-2674S	4GC-7011600		WW7-109B
	1958	V8	364	300	4	WGD-2675S, WGD-2845S	4GC-7013100		
	1959	V8	364	250	2	WGD-2837S, 2838S	4GC-7013044		WW7-112C
	1959	V8	401	325	4	AFB-3877S, 2840S			
	1960	V8	364	210	2	WGD-2979S, 2980S	4GC-7015040		WW7-113A
	1960	V8	364	250	2	AFB-2981S, 2982S			
	1960	V8	364	235	2				
	1960	V8	364	300	4				
	1960	V8	401	325	4				
	1961	V8	364	250	2	AFB-3088S, 3089S	4GC-7019040		WW7-114A
	1961	V8	364	235	2		2GC-7019042		
	1961	V8	401	325	4				
	1962	V6	198	135	2	AFB-3279S	2GC-7020140, 7020141		
	1962	V8	215	155	2		2GC-7020142, 7020143		
	1962	V8	215	185	4		2GC-7020146, 7020147		
	1962	V8	401	265	2		4GC-7020144, 7020145		
	1962	V8	401	280	2		2GC-7020046, 7020047		
	1962	V8	401	325	4		2GC-7020048, 7020049		
							4GC-7020040, 7020041		
	1963	V6	198	135	2	AFB-3503S	2GC-7023041, 7023042		
	1963	V8	215	155	2		2GC-7023043, 7023047		
	1963	V8	215	200	4		2GC-7023049, 7023046		
	1963	V8	401	265	2		2GC-7023048		
	1963	V8	401	280	2		4GC-7023040, 7023044		
	1963	V8	401	325	4		4GC-7023045		
	1963	V8	401	340	4				
	64-65	V6	225	155	1	AFB-3633S, 3635S	BC-7024148, 7024149		
	64-65	V8	300	210	2	AFB-3665S, 3645S	2GC-7024046, 7024047		
	64-65	V8	300	250	4	AFB-3646S, 3634S	4GC-702040, 702044		
	64-65	V8	401	325	4	AFB-3826S, 3827S	4GC-702045		
	64-65	V8	425	340	4	AFB-3921S, 3922S			
	64-65	V8	425	360	2-4	AFB-3923S, 3925S, SA			
						AFB-3924S, SA			
	1966	V6	225	160	2	AFB-4056S, 4055S,	2GC-7026145, 7026144		
	1966	V8	300	210	2	AFB-4061S, AFB-4179S	2GC-7036144, 7026047		
	1966	V8	340	220	2	AFB-4060S, 4180S	2GC-7026046, 7026048		
	1966	V8	340	260	4	AFB-4181S, 4054S	4GC-7025042, 7026040		
	1966	V8	401	325	4	AFB-4053S, 4059S	4MC-7026240, 7036240		
	1966	V8	425	340	4				
	1966	V8	425	360	2-4				
	1967	V6	225	160	2	AFB-4331S, 4332S	4MV-7027140, 7027141		
	1967	V8	300	210	2	AFB-4344S	4MV-7027146, 7027147		
	1967	V8	340	220	2		4MV-7027148, 7027149		
	1967	V8	340	260	4		4MV-7027240, 7027241		
	1967	V8	400	340	4		4MV-7027214, 7027246		
	1967	V8	430	360	4		4MV-7027248		
							2GC-7027040		
							2GC-7027041, 7027042		
							2GC-7027044, 7027045		
							2GC-7027046, 7027049		
	1968	6	240	155	1		(M, MV) 7028014		
	1968	V8	350	320	2		7028047		
	1968	V8	350	280	4		4MV-7028240, 7028242		
	1968	V8	400	340	4		4MV-7028243, 7028244		
	1968	V8	430	360	4		4MV-7028245, 7028248		
							2GV-7028140, 7028141		
	1969	6	250	155	1		(M, MV) 7029014		
	1969	V8	350	230	2		7029047		
	1969	V8	350	280	4		4MV-7029240, 7029241		
	1969	V8	400	340	4		4MV-7029242, 7029243		
	1969	V8	430	360	4		4MV-7029244, 7029245		
							2GV-7029140, 7029141		
CHEVROLET	1955	6	235	123	1		BC-7007180, 7007181		
	1955	6	235	136	1		2GC-7005810, 7006825		
	1955	V8	265	162	2	WCFB-2351S, 2218S	2GC-7008004, 7008005		
	1955	V8	265	180	4				
	1955	V8	265	195	2				
	1956	6	235	140	1		BC-7009254, 7009255		
	1956	V8	265	162	2		2GC-7008387, 7008388		
	1956	V8	265	170	2	WCFB-2362S, 2419S	4GC-7008737		
	1956	V8	265	205	4	WCFB-2366S-A,			
	1956	V8	265	225	2-4	WGD-2286S			
	1957	6	235	140	1		BC-7009656, 7009657		
	1957	V8	265	162	2		2GC-7010647, 7010648		
	1957	V8	283	185	2		2GC-7010719, 7011131		
	1957	V8	283	220	4	WCFB-2655S, 2626S	2GC-7011149, 7011224		
	1957	V8	283	245	2-4	WCFB-2627S	2GC-7012133		
	1957	V8	283	250	Fuel Inj.	WCFB-2055S-A, 2555S	4GC-7009846, 7012126		
	1957	V8	283	270	2-4				
	1957	V8	283	283	Fuel Inj.				
	1958	6	235	145	1		BC-7011102, 7012127		
	1958	V8	283	185	2		2GC-7011951, 7011952		
	1958	V8	283	230	4	AFB-2859S	2GC-7011953, 7012451		
	1958	V8	283	245	2-4		2GC-7012452, 7012503		
	1958	V8	283	250	Fuel Inj.		2GC-7012851, 7012853		
	1958	V8	348	250	4		4GC-7011108, 7012128		
	1958	V8	283	270	2-4				
	1958	V8	348	280	3-2				
	1958	V8	283	290	Fuel Inj.				

APPENDIX F

PRE-1970 LIGHT- AND HEAVY-DUTY VEHICLES

CARBURETOR MAKES AND MODELS (Cont.)

VEHICLE	YEAR	ENGINE	DISPL.	HP	CARBURETOR BARRELS	CARBURETOR MODELS: CARTER	ROCHESTER	HOLLY	STROMBERG
CHEVROLET (Cont)	1959	6	235	135	1		BC-7013000, 7013003		
	1959	V8	283	185	2		BC-7013955, 7013956		
	1959	V8	283	220	4	AFB-2897S	2GC-7013007, 7013008		
	1959	V8	283	245	2-4	WCFB-2816S, 2817S	2GC-7013015, 7013016		
	1959	V8	348	250	4	WCFB-2818S	2GC-7013017, 7013018		
	1959	V8	283	270	2-4		2GC-7013020, 7013026		
	1959	V8	348	280	3-2		4GC-7013004, 7013006		
	1959	V8	283	290	Fuel Inj.		4GC-7013010, 7013012		
	1959	V8	348	315	3-2				
	1959	V8	283	250	Fuel Inj.				
	1960	6	235	135	1		BC-7013000, 7013003		
	1960	V8	283	170	2		BC-7013955, 7013956		
	1960	V8	283	230	4	AFB-3012S	2GC-7013007, 7013008		
	1960	V8	348	250	4	WCFB-2816S, 2817S	2GC-7013015, 7013016		
	1960	V8	348	320	4	WCFB-2818S	2GC-7013017, 7013018		
	1960	V8	348	305	4		2GC-7013020, 7013026		
	1960	V8	348	280	3-2		4GC-7013004, 7013005		
	1960	V8	348	335	3-2		4GC-7013010, 7013012		
	1960	V8	283	315	Fuel Inj.		4GC-7015004, 7015006		
	1960	V8	283	245	2-4		4GC-7015010, 7015012		
	1960	V8	283	270	2-4				
	1961	6	235	135	1		BC-7019000		
	1961	V8	283	170	2		2GC-7019007, 7019008		
	1961	V8	283	230	4	AFB-3221S, 3012S	2GC-7019018		
	1961	V8	283	245	2-4		4GC-7015010, 7015012		
	1961	V8	348	250	4		4GC-7019004, 7019006		
	1961	V8	283	270	2-4		4GC-7019010, 7019014		
	1961	V8	348	280	3-2				
	1961	V8	283	290	Fuel Inj.				
	1961	V8	283	275	Fuel Inj.				
	1962	6	230	140	1		BC-7020103, 7020104		
	1962	V8	283	195	2		BC-7020105, 7020108		
	1962	V8	327	250	4	AFB-3269S, 3270S	BC-7020114, 7020115		
	1962	V8	327	300	4	WCFB-3190S, 3191S	BC-7020000, 7020003		
	1962	V8	327	340	4		BC-7020106, 7020107		
	1962	V8	327	360	Fuel Inj.		2GC-7020007, 7020008		
	1962	V8	409	380	4		2GC-7020018		
	1962	V8	409	409	2-4		4GC-7020006, 7020012		
							4GC-7020022		
	1963	6	230	140	1	YF-3379S, 3402S	BC-7023105, 7023108		
	1963	V8	283	195	2		BC-7023000, 7023003		
	1963	V8	327	250	4		2GC-7023007, 7023008		
	1963	V8	327	300	4		2GC-7023018		
	1963	V8	409	340	4	AFB-3361S, 3362S	4GC-7023006, 7023012		
	1963	V8	409	400	4	WCFB-3500S, 3501S			
	1963	V8	409	425	2-4				
	1963	V8	327	250	4				
	1963	V8	327	300	4				
	1963	V8	327	340	4				
	1963	V8	327	360	Fuel Inj.				
	1964	4	153	90	1		BV-7024000, 7024001		
	1964	6	194	120	1	YF-3379S, 3402S	2GV-7024100, 7024102		
	1964	6	230	140	1	AFB-3361S, 3362S	2GV-7024106, 7024108		
	1964	6	230	155	1	AFB-3499S	2GV-7024101, 7024110		
	1964	V8	283	195	2	AFB-3720, 3721	2GV-7024112	4150	
	1964	V8	283	220	4	AFB-3783S, 3804S	4GC-7024123, 7024124		
	1964	V8	327	250	4		4GC-7024127		
	1964	V8	327	300	4	WCFB-3696S, 3697S	4GC-7024128, 7024220		
	1964	V8	327	365	4		4GC-7024225, 7024226		
	1964	V8	327	375	Fuel Inj.				
	1964	V8	409	340	4				
	1964	V8	409	400	4				
	1964	V8	409	425	2-4				
	1965	4	153	90	1	YF-3379S, 3402S	BV-7025105, 7025108		
	1965	6	194	120	1		BV-7025003, 7025000		
	1965	6	230	140	1		BV-7025004, 7025005		
	1965	V8	283	195	2		2GV-7024101, 7024110		
	1965	V8	283	220	4		2GV-7024112		
	1965	V8	327	250	4	AFB-3963S	4GC-7025121, 7025122		
	1965	V8	327	300	4	AFB-3361S, 3720, 3721	4GC-7025127, 7024126		
	1965	V8	327	350	4	AFB-3783S, 3804S	4GC-7025128, 7025123		
	1965	V8	327	365	4	WCFB-3696S, 3697S	4GC-7025124		
	1965	V8	327	375	Fuel Inj.		4MV-7025100, 7025101		
	1965	V8	396	325	4		4MV-7025000, 7025201		
	1965	V8	396	425	4			4150	
	1965	V8	409	340	4			4160	
	1965	V8	409	400	4				
	1966	4	153	90	1	YF-4079S, 4080S	BV-7025000, 7025003		
	1966	6	194	120	2	YF-3379S, 3402S	BV-7025105, 7025108		
	1966	6	230	140	1	AVS-4027S-SA 4028S-SA	BV-7026027, 7026028		
	1966	6	250	155	2		4GC-7025126, 7025127		
	1966	V8	283	195	2		4GC-7025128, 7036118	4160	
	1966	V8	283	220	4		4GC-7036119, 7036120		
	1966	V8	327	275	4		4GC-7036121	4150	
	1966	V8	327	300	4				
	1966	V8	396	325	4				
	1966	V8	327	350	4				
	1966	V8	396	360	4				
	1966	V8	427	390	4				
	1966	V8	427	425	4				
	1967	4	153	90	1	YF-4367S, 4368S	BV-7022503, 7025000	R3659A	
	1967	6	194	120	1	YF-4373S, 4374S	BV-7025105, 7025108	R3660A	
	1967	6	230	140	1	YF-4377S, 4378S	BV-7026027, 7026028	R3888A	
	1967	6	250	155	1	YF-4387S	4MV-7027200, 7027201		
	1967	V8	283	195	2		4MV-7027202, 7027203		
	1967	V8	302	290	4		4MV-7027210, 7027211		
	1967	V8	327	210	2		4MV-7027212, 7027213		
	1967	V8	327	275	4		4MV-7027214, 7027218		
	1967	V8	350	295	4		4MV-7037200, 7037201		
	1967	V8	327	300	4		4MV-7037202, 7037210		
	1967	V8	327	325	4		4MV-7037211, 7037212		
	1967	V8	396	325	4		4MV-7037213, 7037216		
	1967	V8	327	350	4		4MV-7037218		

APPENDIX F

PRE-1970 LIGHT- AND HEAVY-DUTY VEHICLES

CARBURETOR MAKES AND MODELS (Cont.)

VEHICLE	YEAR	ENGINE	DISPL.	HP	CARBURETOR BARRELS	CARBURETOR MODELS: CARTER	ROCHESTER	HOLLY	STROMBERG
CHEVROLET (Cont)	1967	V8	396	350	4				
	1967	V8	396	375	4				
	1967	V8	427	385	4				
	1967	V8	427	390	4				
	1967	V8	427	400	3-2				
	1967	V8	427	425	4				
	1967	V8	427	435	3-2				
	1968	4	153	90	1		MV-7028008, 7028009		
	1968	6	230	140	1		MV-7028015, 7028017		
	1968	6	250	155	1		2GV-7028110, 7028101		
	1968	V8	302	290	4		2GV-7028112, 7028113		
	1968	V8	307	200	2		4MV-7028212, 7028213		
	1968	V8	327	210	2		4MV-7028229, 7028208		
	1968	V8	327	250	4		4MV-7028207, 7028219		
	1968	V8	327	275	4		4MV-7028217, 7028210		
	1968	V8	327	300	4		4MV-7028211, 7028216		
	1968	V8	327	325	4		4MV-7028209	4150	
	1968	V8	327	350	4		MV-7028014		
	1968	V8	350	295	4				
	1968	V8	396	325	4				
	1968	V8	396	350	4				
	1968	V8	396	375	4				
	1968	V8	427	385	4				
	1968	V8	427	390	4				
	1968	V8	427	400	3-2				
	1968	V8	427	425	4				
	1968	V8	427	430	4				
	1968	V8	427	435	3-2				
	1969	4	153	90	1		MV-7029008, 7029014	4150	
	1969	6	230	140	1		MV-7029015, 7029017		
	1969	6	250	155	1		2GV-7029101, 7029102		
	1969	V8	302	290	4		2GV-7029103, 7029104		
	1969	V8	307	200	2		2GV-7029110, 7029112		
	1969	V8	327	210	2		2GV-7029117, 7029118		
	1969	V8	327	235	2		2GV-7029119, 7029120		
	1969	V8	350	255	4		2GV-7029127, 7029129		
	1969	V8	350	300	4		4MV-7029202, 7029203		
	1969	V8	350	350	4		4MV-7029204, 7029207		
	1969	V8	350	370	4		4MV-7029215		
	1969	V8	396	265	2				
	1969	V8	396	325	4				
	1969	V8	396	350	4				
	1969	V8	396	375	4				
	1969	V8	427	335	4				
	1969	V8	427	390	4				
	1969	V8	427	400	4				
	1969	V8	427	425	4				
	1969	V8	427	430	4				
	1969	V8	427	435	3-2				
OLDSMOBILE	1955	V8	324	170	2		2GC-7006970		
	1955	V8	324	202	4		4GC-7006000, 7007000		
	1956	V8	324	230	2		2GC-7007223, 7008800		
	1956	V8	324	250	4		4GC-7007221, 7007222		
	1957	V8	371	277	4		2GC-7010958, 7010959		
							2GC-7010960		
							4GC-7010925, 7010926		
							4GC-7009470, 7009471		
	1958	V8	371	265	2		2GC-7011712, 7011713		
	1958	V8	371	305	4		2GC-7011714, 7012480		
	1958	V8	371	312	3-2		2GC-7012913		
							4GC-7012400, 7012401		
	1959	V8	371	270	2		2GC-7013052, 7013058		
	1959	V8	394	315	4		4GC-7013050, 7013150		
							4GC-7013950, 7013952		
	1960	V8	371	240	2		2GC-7015052, 7015058		
	1960	V8	394	315	4		4GC-7013950, 7013952		
	1961	V8	394	250	2		2GC-7019052, 7019058		
	1961	V8	394	325	4		4GC-7019050, 7019054		
	1961	V8	215	155	2				
	1961	V8	215	185	4				
	1962	V8	215	155	2		2GC-7020052, 7020058		
	1962	V8	215	185	4		2GC-7020051, 7020053		
	1962	V8	215	215	1		2GC-7020954, 7020956		
	1962	V8	394	260	2		2GC-7020959, 7020980		
	1962	V8	394	280	2		4GC-7020950, 7020955		
	1962	V8	394	330	4		4GC-7020957, 7020981		
	1962	V8	394	345	4				
	1963	V8	215	155	2		2GC-7016327, 7016336		
	1963	V8	215	185	4		2GC-7016335, 7023052		
	1963	V8	215	215	1		2GC-7023053, 7023056		
	1963	V8	394	260	2		2GC-7023058		
	1963	V8	394	280	2		4GC-7016332, 7016333		
	1963	V8	394	330	4		4GC-7016334, 7016331		
	1963	V8	394	345	4		4GC-7016228, 7023050		
	1963	V8	215	195	4		4GC-7023051, 7023054		
							4GC-7023055		
	1964	V6	225	155	1		2GC-7024052, 7024053		
	1964	V8	330	230	2		2GC-7024056, 7024057		
	1964	V8	330	290	4		2GC-7024058, 7024059		
	1964	V8	330	245	2		2GC-7024155, 7024156		
	1964	V8	330	290	4		4GC-7024050, 7024051		
	1964	V8	394	345	4		4GC-7024054, 7024055		
							4GC-7024153, 7024154		

APPENDIX F

PRE-1970 LIGHT- AND HEAVY-DUTY VEHICLES

CARBURETOR MAKES AND MODELS (Cont.)

VEHICLE	YEAR	ENGINE	DISPL.	HP	CARBURETOR BARRELS	CARBURETOR MODELS: CARTER	ROCHESTER	HOLLY	STROMBERG
OLDSMOBILE (Cont)	1965	V6	225	155	1		2GC-7025052, 7025053		
	1965	V8	330	250	2		2GC-7025056, 7025057		
	1965	V8	330	260	2		2GC-7025058, 7025152		
	1965	V8	425	300	2		2GC-7025156, 7025159		
	1965	V8	425	310	2		2GC-7025252, 7025253		
	1965	V8	330	315	4		2GC-7025254		
	1965	V8	400	345	4		4GC-7025050, 7025051		
	1965	V8	425	360	4		4GC-7025054, 7025055		
	1965	V8	425	370	4		4GC-7025150, 7025151		
							4GC-7025157, 7025158		
							4GC-7025255		
	1966	6	250	155	1	YF-4072SA, 4367S	2GC-7036159, 7036053		
	1966	V8	330	250	2		2GC-7025052, 7025053		
	1966	V8	330	260	2		2GC-7025056, 7025057		
	1966	V8	330	310	4		2GC-7025058, 7025152		
	1966	V8	330	320	4		2GC-7025156, 7025159		
	1966	V8	400	350	4		2GC-7025252, 7025253		
	1966	V8	425	300	2		2GC-7025254		
	1966	V8	425	310	2		4MV-7026250, 7026254		
	1966	V8	425	365	4		4MV-7026255, 7026256		
	1966	V8	425	375	4		4MV-7036250, 7036254		
	1966	V8	425	385	4				
	1967	6	250	155	1	YF-4072SA, 4367S	2GC-7027033, 7027035		
	1967	V8	330	250	2		2GC-7027133, 7027136		
	1967	V8	330	260	2		2GC-7027139, 7037051		
	1967	V8	400	300	2		2GC-7037052, 7037053		
	1967	V8	425	300	2		2GC-7037054, 7037055		
	1967	V8	330	310	4		2GC-7037056, 7037057		
	1967	V8	425	310	2		2GC-7037058		
	1967	V8	330	320	4		4MV-7027032, 7027036		
	1967	V8	400	350	4		4MV-7027130, 7027131		
	1967	V8	425	365	4		4MV-7027132, 7027135		
	1967	V8	425	375	4		4MV-7027153, 7027156		
	1967	V8	425	385	4		4MV-7027157		
	1968	6	250	155	1		MV-7028014, 7028057		
	1968	V8	350	250	2		2GC-7028154, 7028155		
	1968	V8	400	290	2		2GC-7028156, 7028157		
	1968	V8	350	300	4		2GC-7028158, 7028159		
	1968	V8	350	310	4		4MV-7028250, 7028251		
	1968	V8	455	310	2		4MV-7028252		
	1968	V8	455	320	2				
	1968	V8	400	350	4				
	1968	V8	400	360	4				
	1968	V8	455	365	4				
	1968	V8	455	375	4				
	1968	V8	455	400	4				
	1969	6	250	155	1		2GC-7029155, 7029156		
	1969	V8	350	250	2		2GC-7029158, 7029159		
	1969	V8	350	310	4		4MV-7029250, 7029251		
	1969	V8	455	310	2		4MV-7029252, 7029253		
	1969	V8	350	325	4		4MV-7029254, 7029255		
	1969	V8	400	325	4				
	1969	V8	400	350	4				
	1969	V8	400	360	4				
	1969	V8	455	365	4				
	1969	V8	455	375	4				
	1969	V8	455	390	4				
	1969	V8	455	400	4				
PONTIAC	1955	V8	287	180	2	WQD-2182S-A, 2207S-B WCFB-2268S, 2283S	2GC-7006100 4GC-7007800		
	1956	V8	316	192	2	WCFB-2364S-A	2GC-7008695, 7008696		
	1956	V8	316	216	4	WQD-2359S	4GC-7007900, 7008697		
	1956	V8	316	205	2				
	1956	V8	316	227	4				
	1956	V8	316	285	2-4				
	1957	V8	347	227	2	AFB-2506S	2GC-7011500, 7009831		
	1957	V8	347	252	2		2GC-7009832, 7011350		
	1957	V8	347	270	4		2GC-7011351, 7011352		
	1958	V8	370	240	2	AFB-2767S-A, 2768S-A	4GC-7011701		
	1958	V8	370	255	4	AFB-2740S, 2751S	2GC-7011702, 7011703		
	1958	V8	370	285	4		2GC-7011705, 7011706		
	1958	V8	370	270	2		2GC-7011707, 7011709		
	1958	V8	370	300	3-2		2GC-7012702, 7012703		
	1958	V8	370	310	Fuel Inj.				
	1959	V8	389	215	2	AFB-2819S, 2820S	2GC-7013060, 7013061		
	1959	V8	389	245	2		2GC-7013063, 7013064		
	1959	V8	389	260	4		2GC-7013065, 7013067		
	1959	V8	389	280	2		2GC-7013069, 7013075		
	1959	V8	389	300	4				
	1959	V8	389	315	3-2				
	1959	V8	389	330	4				
	1959	V8	389	345	3-2				
	1960	V8	389	215	2	AFB-2975S, 2976S	2GC-7013063, 7013065		
	1960	V8	389	281	4		2GC-7015062, 7015066		
	1960	V8	389	283	2		2GC-7015070, 7015072		
	1960	V8	389	303	4		2GC-7015073,		
	1960	V8	389	318	3-2				
	1960	V8	389	333	4				
	1960	V8	389	348	3-2				
	1961	4	195	110	1	AFB-3123S, 3124S	2GC-7013063, 7013065		
	1961	4	195	130	1	AFB-3125S	2GC-7019060, 7019064		
	1961	4	195	120	1		2GC-7019067, 7019069		
	1961	4	195	140	1		2GC-7019070, 7019071		
	1961	4	195	155	4		2GC-7019072, 7019073		
	1961	V8	215	155	2		2GC-7019074, 7019075		
	1961	V8	389	215	2		2GC-7019076, 7019077		
	1961	V8	389	230	2				
	1961	V8	389	235	4				
	1961	V8	389	267	2				

APPENDIX F

PRE-1970 LIGHT- AND HEAVY-DUTY VEHICLES

CARBURETOR MAKES AND MODELS (Cont.)

VEHICLE	YEAR	ENGINE	DISPL.	HP	CARBURETOR BARRELS	CARBURETOR MODELS: CARTER	ROCHESTER	HOLLY	STROMBERG
PONTIAC (Cont)	1961	V8	389	382	2				
	1961	V8	389	303	4				
	1961	V8	389	318	3-2				
	1961	V8	389	333	4				
	1961	V8	389	348	3-2				
	1962	4	195	110	1	AFB-3123S, 3320S	2GC-7013063, 7013065		
	1962	4	195	115	1	AFB-3300S	2GC-7020060, 7020064		
	1962	4	195	120	1		2GC-7020067, 7020069		
	1962	4	195	140	1		2GC-7020070, 7020071		
	1962	4	195	166	4		2GC-7020072, 7020073		
	1962	V8	215	185	4		2GC-7020074, 7020075		
	1962	V8	389	215	2		2GC-7020076, 7020077		
	1962	V8	389	230	2				
	1962	V8	389	235	4				
	1962	V8	389	267	2				
	1962	V8	389	283	2				
	1962	V8	389	303	4				
	1962	V8	389	318	4-2				
	1962	V8	389	333	4				
	1962	V8	389	348	3-2				
	1963	4	195	115	1	AFB-3474S, 3477S	BV-7023067, 7023068		
	1963	4	195	120	1	AFB-3479S, 3502S	2GC-7023060, 7023061		
	1963	4	195	140	1	AFB-3545 All	2GC-7023066, 7023075		
	1963	4	195	166	4		2GC-7023077, 7023073		
	1963	V8	326	260	2		2GC-7023063, 7023064		
	1963	V8	389	215	2		2GC-7023078, 7023079		
	1963	V8	389	230	2		2GC-7023161, 7023162		
	1963	V8	389	235	4		4GC-7023069, 7023070		
	1963	V8	389	267	2				
	1963	V8	389	283	2				
	1963	V8	389	303	4				
	1963	V8	389	313	3-2				
	1963	V8	421	353	4				
	1963	V8	421	370	3-2				
	1964	6	215	140	1	AFB-3647S, 3648S	BV-7024164, 7024166		
	1964	V8	326	250	2	AFB-3649S, 3650S	2GC-7024062, 7024074		
	1964	V8	326	280	4	AFB-3651S, 3666S	2GC-7024075, 7024078		
	1964	V8	389	325	4	AFB-3687S	2GC-7024079, 7024173		
	1964	V8	389	348	3-2		2GC-7024175, 7024178		
	1964	V8	389	230	2		2GC-7024179		
	1964	V8	389	235	2				
	1964	V8	389	267	2				
	1964	V8	389	283	2				
	1964	V8	389	303	4				
	1964	V8	389	306	4				
	1964	V8	421	320	4				
	1964	V8	389	330	3-2				
	1964	V8	421	350	3-2				
	1964	V8	421	370	3-2				
	1965	6	215	140	1	AFB-3895S, 3896S	BV-7025167, 7025168		
	1965	V8	326	250	2	AFB-3898S, 3899S	2GC-7024078, 7024079		
	1965	V8	326	285	4	AFB-3900S	2GC-7024178, 7024179		
	1965	V8	389	335	4		2GC-7036061, 7025060		
	1965	V8	389	360	3-2		2GC-7025061, 7025062		
	1965	V8	389	256	2		2GC-7025066, 7036062		
	1965	V8	389	290	2		2GC-7025070, 7025071		
	1965	V8	389	325	4		2GC-7025074, 7025075		
	1965	V8	389	333	4		2GC-7036071, 7025078		
	1965	V8	421	338	4		2GC-7025079, 7025173		
	1965	V8	421	356	3-2		2GC-7025175, 7025178		
	1965	V8	421	376	3-2		2GC-7025179, 7026060		
							2GC-7026061, 7026062		
							2GC-7026066, 7026071		
							2GC-7036060		
	1966	6	230	165	1	AFB-4030S, 4031S	BV-7026167, 7026168		
	1966	6	230	207	4	AFB-4033S, 4034S	BV-7026169, 7036167		
	1966	V8	326	250	2	AFB-4035S, 4036S	4MV-7026260, 7026261		
	1966	V8	389	256	2	AFB-4037S, 4041S	BV-7036167, 7026167		
	1966	V8	326	285	4		BV-7026168, 7026169		
	1966	V8	389	290	2		BV-7036168		
	1966	V8	389	325	4		2GC-7026074, 7026075		
	1966	V8	389	333	2		2GC-7036175		
	1966	V8	389	335	4				
	1966	V8	421	338	4				
	1966	V8	421	356	3-2				
	1966	V8	389	360	3-2				
	1966	V8	421	376	3-2				
	1967	6	230	165	1	AFB-4242S, 4243S	BV-7036168, 7037167		
	1967	6	230	215	4	AFB-4244S, 4245S	BV-7037168, 7027167		
	1967	V8	326	250	2	AFB-4246S, 4248S	BV-7027168		
	1967	V8	400	255	2		2GC-7027060, 7027061		
	1967	V8	400	265	2		2GC-7027062, 7027066		
	1967	V8	326	285	4		2GC-7037071, 7027071		
	1967	V8	400	290	2		2GC-7037061, 7037062		
	1967	V8	400	325	4		2GC-7037162, 7037066		
	1967	V8	400	333	4		4MV-7027260, 7027261		
	1967	V8	400	335	4		4MV-7027262, 7027263		
	1967	V8	400	350	4		4MV-7027268, 7027269		
	1967	V8	400	360	4		4MV-7027272, 7027273		
	1967	V8	428	360	4		4MV-7037260, 7037261		
	1967	V8	428	376	4		4MV-7037262, 7037263		
							4MV-7037268, 7037269		
							4MV-7037271, 7037272		
							4MV-7037273, 7037276		
	1968	6	250	175	1		BV-7028168		
	1968	6	250	215	4		MV-7028067, 7028075		
	1968	V8	350	265	2		MV-7028065		
	1968	V8	400	265	2		2GC-7028060, 7028062		
	1968	V8	400	290	2		2GC-7028066, 7028071		
	1968	V8	350	320	4		4MV-7028260, 7028261		
	1968	V8	400	330	4		4MV-7028262, 7028263		
	1968	V8	400	335	4		4MV-7028264, 7028265		
	1968	V8	400	340	4		4MV-7028266, 7028267		
	1968	V8	400	350	4		4MV-7028268, 7028269		

APPENDIX F

PRE-1970 LIGHT- AND HEAVY-DUTY VEHICLES

CARBURETOR MAKES AND MODELS (Cont.)

VEHICLE	YEAR	ENGINE	DISPL.	HP	CARBURETOR BARRELS	CARBURETOR MODELS: CARTER	ROCHESTER	HOLLY	STROMBERG
PONTIAC (Cont)	1968	V8	400	360	4		4MV-7028271, 7028274		
	1968	V8	428	375	4		4MV-7028275, 7028276		
	1968	V8	428	390	4		4MV-7028277		
	1969	6	250	175	1		2GV-7028066, 7028071		
	1969	6	250	215	4		2GV-7029060, 7029062		
	1969	6	250	230	4		MV-7029165, 7029166		
	1969	V8	350	265	2		MV-7029167, 7029168		
	1969	V8	350	325	4		4MV-7028270, 7028273		
	1969	V8	350	330	4		4MV-7029261, 7029262		
	1969	V8	400	265	2		4MV-7029263, 7029268		
	1969	V8	400	290	2		4MV-7029270, 7029273		
	1969	V8	400	330	4		4MV-7029260		
	1969	V8	400	335	4				
	1969	V8	400	345	4				
	1969	V8	400	350	4				
	1969	V8	400	366	4				
	1969	V8	400	370	4				
	1969	V8	428	360	4				
	1969	V8	428	370	4				
	1969	V8	428	390	4				
CADILAC	1955	V8	331	250	4		4GC-7007970		
	1955	V8	331	270	2-4		4GC-7009070		
	1956	V8	365	285	4		4GC-7008750		
	1956	V8	365	305	2-4		4GC-7009750		
	1957	V8	365	300	4		4GC-7010100, 7010101		
	1957	V8	365	325	2-4		4GC-7012000		
	1958	V8	365	310	4		4GC-7012010, 7012011		
	1958	V8	365	335	3-2		4GC-7012810, 7012811		
	1959	V8	390	325	4	AFB-2814S, 2815S	4GC-7013030, 7013031		
	1959	V8	390	345	3-2				
	1960	V8	390	325	4	AFB-2814S, 2951S	4GC-7013030, 7013031		
	1960	V8	390	345	3-2				
	1961	V8	390	325	4	AFB-3177S, 3178S	4GC-7019030, 7019031		
	1962	V8	390	325	4	AFB-3351S, 3352S	4GC-7019030, 7019031		
	1963	V8	390	325	4	AFB-3480S, 3481S	4GC-7016316, 7023030 4GC-7023031		
	1964	V8	429	340	4	AFB-3655S, 3656S	4GC-7024030, 7024031		
	1965	V8	429	340	4	AFB-3903S	4GC-7025030, 7025031		
	1966	V8	429	340	4	AFB-4168S, 4169S AFB-4171S	4GC-7026030, 7026031		
	1967	V8	429	340	4		4MV-7027230, 7027231 4MV-7027232, 7027234 4MV-7027235, 7037230 4MV-7037231, 7037234 4MV-7037235		
	1968	V8	472	375	4		4MV-7028230, 7028231 4MV-7028234, 7028235 4MV-7028236, 7028237 4MV-7028238, 7028239		
	1969	V8	472	375	4		4MV-7028230, 7028231 4MV-7028234, 7028235 4MV-7028236, 7028237 4MV-7028238, 7028239		
RAMBLER	1955	6	196	90	1	AS-2349S, YF-2014S			
	1956	6	196	120	1	AS-2349S, YF-2014S			
	1957	6	196	125	1	WGD-2352S, 2352SA			
	1957	6	196	135	2	WCD-2586S, 2350S			
	1957	V8	250	190	2	AS-2664S, 2665S			
	1957	V8	250	203	4	AS-2580S			
	1957	V8	327	255	4				
	1958	6	196	90	1	WGD-2586S, 2350S		4150	
	1958	6	196	127	1	YF-2757S			
	1958	6	196	138	2				
	1958	V8	250	215	4				
	1958	V8	327	270	4				
	1959	6	196	90	1	WCD-2887S, 2887SA		1904	
	1959	6	196	127	1	YF-2757S		4150	
	1959	6	196	138	2				
	1959	V8	250	215	4				
	1959	V8	327	270	4				
	60-61	6	196	90	1	WCD-2887S, 2887SA		1904, 1908	
	60-61	6	196	125	1	WCD-3170S			
	60-61	6	196	127	1	YF-2757S			
	60-61	6	196	138	2				
	60-61	V8	250	200	2				
	60-61	V8	250	215	4				
	60-61	V8	327	250	2				
	60-61	V8	327	270	4				
	62-63	6	196	90	1	AS-3536S		1908-1909	
	62-63	6	196	125	1	RBS-3487S, 3498S		2300	
	62-63	6	196	127	1	WCD-3434S, 3535S		4150	
	62-63	6	196	138	2				
	62-63	V8	327	250	2				
	62-63	V8	327	270	4				
	63-64	6	196	90	1	AS-3536S		1909	
	63-64	6	196	125	1	WCD-3434S, 3535S		2300	
	63-64	6	196	127	1	WCD-3707S		4150	

APPENDIX F

PRE-1970 LIGHT- AND HEAVY-DUTY VEHICLES

CARBURETOR MAKES AND MODELS (Cont.)

VEHICLE	YEAR	ENGINE	DISPL.	HP		CARBURETOR MODELS: CARTER	ROCHESTER	HOLLY	STROMBERG
RAMBLER (Cont)	63-64	6	196	138	2	RBS-3487S, 3498S			
	63-64	6	232	145	1	RBS-3488S			
	63-64	V8	287	198	2	RBS-3708S, 3709S			
	63-64	V8	327	250	2	RBS-3727S, 3728S			
	63-64	V8	327	270	4				
	65-66	6	196	90	1	WCD-3888S, 4191S		1909, 1931, 2209	
	65-66	6	196	125	1	RBS-2765S, 3766S			
	65-66	6	199	128	1	RBS-3882S			
	65-66	6	232	145	1				
	65-66	6	232	155	2				
	65-66	V8	287	198	2				
	65-66	V8	290	200	2				
	65-66	V8	290	225	4				
	65-66	V8	327	250	2				
	65-66	V8	327	270	4				
	1967	6	199	128	1	WCD-4365S, 3888S		1931, 2209	
	1967	6	232	145	1	RBS-3882			
	1967	6	232	155	2	AFB-4216S, 4258S			
	1967	V8	290	200	2	AFB-4352S, 4353S			
	1967	V8	290	225	4	AFB-4354S, 4358S			
	1967	V8	343	280	4				
	68-69	6	199	128	1	WCD-4410S, 4537S		1931	
	68-69	6	232	145	1	WCD-4667S, 4668S			
	68-69	6	232	155	2	RBS-4470S, 4626S			
	68-69	V8	290	200	2	RBS-4631S, 4633S			
	68-69	V8	290	225	4	RBS-4634S, 4666S			
	68-69	V8	343	235	2	AFB-4467S, 4468S			
	68-69	V8	343	280	4	AFB-4469S, 4583S			
	68-69	V8	390	315	4	AFB-4584S, 4585S			
						AFB-4622S, 4623S			
						AFB-4624S, 4660S			
						AFB-4661S, 4662S			
						AFB-4663S, 4664S			
						AFB-4665S			
FORD-MERCURY	1955	6	223	120	1			1904	
	1955	V8	272	162	2			2110	
	1955	V8	272	182	4			4000	
	1955	V8	292	188	4				
	1956	6	223	137	1			1904	
	1956	V8	272	162	2			2110	
	1956	V8	272	182	4			4000	
	1956	V8	312	210	4				
	1956	V8	312	215	4				
	1957	6	223	144	1	AFB-2441S		1904	
	1957	V8	272	190	2			2300	
	1957	V8	292	212	2			4150	
	1957	V8	312	245	4				
	1957	V8	312	255	4				
	1957	V8	368	290	4				
	1958	6	223	145	1	AFB-2640S-A-C		1904	
	1958	V8	292	205	2			2300	
	1958	V8	332	265	4			4160	
	1958	V8	383	312	4				
	1958	V8	383	330	4				
	1958	V8	430	360	4				
	1958	V8	312	235	2				
	1959	6	223	145	1	AFB-2853S		2300	
	1959	V8	292	210	2			4160	
	1959	V8	312	210	2			1904	
	1959	V8	332	225	2				
	1959	V8	383	280	2				
	1959	V8	352	300	4				
	1959	V8	383	322	4				
	1959	V8	430	345	4				
							FORD (Autolite)		
	1960	6	144	85	1	AFB-2292S	2100-2V	4160	
	1960	6	223	145	1		C0AE-M,-H,-R,-S,	1904	
	1960	V8	292	185	2		-J,-X	1908	
	1960	V8	312	205	2		4100-4V		
	1960	V8	352	220	2		C0AE-M,-R,-S,-J,-X		
	1960	V8	352	235	2				
	1960	V8	383	280	2				
	1960	V8	430	310	2				
	1960	V8	352	300	4				
	1960	V8	352	360	4				
	1961	6	144	85	1		2100-2V		
	1961	6	170	101	1		C1AE-S,-Z,-AC,-AD	1908	
	1961	6	223	135	1		-AG,-AH	1904	
	1961	V8	292	175	2		4100-4V		
	1961	V8	352	220	2		C1AE-Y,-Z,-AC,-AD		
	1961	V8	390	300	4		-AG,-AH		
	1961	V8	390	330	4				
	1961	V8	390	375	4				
	1961	V8	390	401	3-2				
	1962	6	144	85	1		1100-1V	1908	
	1962	6	144	101	1		C2OE-S,-T,-N,R	1909	
	1962	6	170	101	1		2100-2V		
	1962	V8	221	145	2		C2AE-Y,-Z,-AC		
	1962	V8	260	164	2		C2AE-AD,-AJ,-AG,-AK		
	1962	6	223	135	1		4100-4V		
	1962	6	223	138	1		C2AE-Y,-AD,-Z,-AJ,		
	1962	V8	292	175	2		-AC,-AG,-AK		
	1962	V8	292	220	2				
	1962	V8	390	330	4				
	1962	V8	390	375	4				
	1962	V8	406	385	4				
	1962	V8	390	401	3-2				
	1962	V8	406	405	2-4				
	1962	V8	390	300	4				

APPENDIX F

PRE-1970 LIGHT- AND HEAVY-DUTY VEHICLES

CARBURETOR MAKES AND MODELS (Cont.)

VEHICLE	YEAR	ENGINE DISPL.	HP	CARBURETOR BARRELS	CARBURETOR MODELS: CARTER	FORD (Autolite)	HOLLY	STROMBERG
FORD MERCURY (Cont)	1963 6	144	85	1	1100-1V	2100-2V	4100-4V	
	1963 6	170	101	1	C3AF-A,-B,-C,-D	C3AF-E,-F	C3AF-N,-R,-S,-T	
	1963 6	223	138	1	C3DF-A,-B	C3MF-A,-B	C3SF-A	
	1963 V8	260	145	2	C3GA-F,	C3OF-E,-F		
	1963 V8	260	164	2	C3GF-B			
	1963 V8	352	220	2	C3OF-A,-E			
	1963 V8	390	300	2	C3YF-A,-B,-H			
	1963 V8	390	330	4				
	1963 V8	406	385	4				
	1963 V8	406	405	3-2				
	1964 6	223	138	1	1100-1V	2100-2V	4100-4V	
	1964 V8	289	195	2	C3AF-BL,-BM,-BS,-BT	C4AF-DM,-DN,-DD,-DE	C4AF-DM,-DN,-DD,-DE	
	1964 V8	289	210	4	C3DF-R,-S	-B,-C,-N,-R,	-B,-C,-N,-R	
	1964 V8	352	250	2	C3GF-E	C3AF-BL,-BM,-BS,-BT	C3AF-BL,-BM,-BS,-BT	
	1964 V8	289	271	4	C3OF-AK,-AL,-AM	-BJ,-BV	-BJ,-BV	
	1964 V8	399	300	4	C3YF-F,-G,-H	C4OF-AL,-AT	C4MF-A,-D,-E	
	1964 V8	427	410	4	C4AF-DM,-DN	C4MF-A,-D,-E	C4OF-AL,-AT	
	1964 V8	427	425	2-4	C4OF-BA,-BB,-BE			
	1965 6	170	105	1	1100-1V	2100-2V	4100-4V	
	1965 6	200	120	1	C4ZF-A,-B,-J,-K	C5AF-T,-U,-A,-AH,-B	C5AF-T,-J,-A,-AH,-B	
	1965 V8	289	200	2	C5AF-T,-U,-V,-Y	-AJ,-Z,-AK,-AA,-AL	-Z,-AK,-AA,-AC,-AL	
	1965 V8	289	225	4	C5DF-E,-F,-G,-H	-AC,-AN	-AN,-AJ	
	1965 V8	390	250	2	C5OF-E,-F,-H,-N	C5MF-A,-D,-B,-E,-C	C5MF-A,-D,-B,-E,-C	
	1965 V8	390	266	4	-R,-S	-F	-F	
	1965 V8	289	271	4				
	1965 V8	390	300	4				
	1965 V8	427	425	2-4				
	1966 6	170	105	1	1100-1V	2100-2V	4100-4V	
	1966 6	200	120	1	C5DF-C,-L,-M	C6AF-R,-V,-M,-F,-Y	C6ZF-C,-D,-E,-A,-B	
	1966 V8	289	200	2	C5OF-AC,-Y,-Z	-N,-A,-Z,-B,-AA,-L	C6AF-AB,-AC,-AF,-AG	
	1966 V8	289	225	4	C6AF-M,-N,-R,-S,-V	-AH,-C,-AJ,-E,	-AJ,-E,-F,-K,-L	
	1966 V8	289	271	4	-Y	-AB,-AC,-AF,-J,-K	C6OF-D,-Z,-H,-J	
	1966 V8	390	265	2	C6DF-D,-G	-AG		
	1966 V8	390	275	2		C6MF-D,-A		
	1966 V8	390	315	4	4300-4V			
	1966 V8	410	330	4	C6AF-BU			
	1966 V8	390	335	4				
	1966 V8	428	345	4				
	1966 V8	429	425	2-4				
	1967 6	170	105	1	1100-1V	2100-2V	4300-4V	
	1967 6	200	120	1	C6AF-R,-AK,-BL,-BM	C7AF-N,-R,-S,-T,-V,-U	C7AF-F,-L,-M,-AC,-AD	
	1967 V8	289	200	2	C6DF-R,-S	-Y,-Z	-AE,-AF,-AG,-AH,-BH	
	1967 V8	289	225	4	C6OF-AB,-AC,-AD	C7DF-AJ,-AL,-E,-F,-G	-AV,-BJ,-AY	
	1967 V8	390	265	2	C6TF-F,-G	-J,-R,-S		
	1967 V8	289	271	4	C6UF-AF,-V	C7OF-J,-K,-L,-M		
	1967 V8	390	275	2	C7AF-AA,-AB	C7TF-C,-D		
	1967 V8	390	270	2	C7DF-J,-K			
	1967 V8	390	315	4	C7OF-N,-R			
	1967 V8	390	320	4	C7TF-K			
	1967 V8	410	330	4	C7UF-A,-B,-C,-D			
	1967 V8	390	335	4	C5UF-L,-M			
	1967 V8	428	345	4				
	1968 6	170	105	1	1100-1V	2100-2V	4300-4V	
	1968 6	200	120	1	C8AF-E	C8AF-AK,-L,-M,-AM,-N	C8AF-A,-B	
	1968 V8	289	200	2	C8OF-A,-B	C8OF-K,-U	C8VF-F,-H	
	1968 V8	302	210	2		C8ZF-G	C8ZF-C,-D	
	1968 V8	302	230	4				
	1968 V8	302	235	4				
	1968 V8	390	265	2				
	1968 V8	390	270	2				
	1968 V8	289	271	4				
	1968 V8	390	280	2				
	1968 V8	390	315	4				
	1968 V8	390	320	4				
	1968 V8	390	325	4				
	1968 V8	428	340	4				
	1968 V8	427	390	4				
	1969 6	170	105	1	1100-1V	2100-2V	4300-4V	
	1969 6	200	120	1	C9DF-B	C8AF-BD	C8SF-H,-J	
	1969 6	250	155	1	C9OF-A,-B,-J,-K	C9OF-C	C9AF-G,-R	
	1969 V8	302	210	2		C92F-A,-B,-G	C9OF-D,-E	
	1969 V8	351	250	2		C9MF-A	C9ZF-C,-D,-E,-F	
	1969 V8	390	270	2		C9AF-A,-B,-C		
	1969 V8	351	290	4				
	1969 V8	390	321	4				
	1969 V8	429	320	4				
	1969 V8	429	360	2				
	1969 V8	428	335	4				
						ROCHESTER		
CHRYSLER-DESOTO-IMPERIAL	1955 V8	291	185	4	WCFB-2317S,2126S,			
	1955 V8	301	188	2	WCFB-2210S			
	1955 V8	291	200	2	BBD-2162S-A-B			
	1955 V8	331	250	4	BBD-2180S-A-B			
	1955 V8	331	300	4	BBD-2176S,			
					BBD-2177S-A			
	1956 V8	331	225	2	BBD-2312S,2313S			
	1956 V8	330	230	2	BBD-2308S,2309S			
	1956 V8	331	250	4	BBD-2310S			
	1956 V8	330	255	4	WCFB-2367S-A, 2314S-A			
	1956 V8	354	280	4	WCFB-2444S			
	1956 V8	341	320	4	WCFB-2445S, 2476S			
	1956 V8	354	340	4	WCFB-2311S-A			
	1957 V8	325	245	2	AFB-2448S, 2686S			
	1957 V8	325	260	4	BBD-2527S, 2522S-A-B			
	1957 V8	341	270	2	WCFB-2590S, 2589S			
	1957 V8	350	280	2	WCFB-2532S, 2588S			
	1957 V8	354	285	2				
	1957 V8	341	295	4				
	1957 V8	354	295	4				

APPENDIX F

PRE-1970 LIGHT- AND HEAVY-DUTY VEHICLES

CARBURETOR MAKES AND MODELS (Cont.)

VEHICLE	YEAR	ENGINE	DISPL.	HP	CARBURETOR BARRELS	CARBURETOR MODELS: CARTER	ROCHESTER	HOLLY	STROMBERG
CHRYSLER-DESOTO-IMPERIAL (Cont)	1957	V8	392	325	4				
	1957	V8	392	375	2-4				
	1958	V8	350	280	2	AFB-2651S, 2650S			
	1958	V8	354	290	2	AFB-2806S, 2805S			
	1958	V8	361	295	2	AFB-2836S, 2772S			
	1958	V8	361	305	4	AFB-2642S, 2823S			
	1958	V8	354	310	4	BBD-2685S, 2733S			
	1958	V8	361	345	2-4	BBD-2637S, 2772S			
	1958	V8	392	345	4	BBD-2822S			
	1958	V8	392	380	2-4	WCFB-2741S, 2742S			
	1959	V8	361	290	2	AFB-2797S, 2794S			
	1959	V8	383	305	2	BBD-2795S, 2872S			
	1959	V8	383	325	4	BBD-2924S, 2793S			
	1959	V8	413	350	4	BBD-2870S, 2871S			
	1959	V8	383	350	2-4				
	1959	V8	413	380	2-4				
	1960	V8	361	295	2	AFB-2950S, 2927S			
	1960	V8	383	305	2	AFB-2968S, 2903S			
	1960	V8	413	350	4	BBD-2923S-SA			
	1960	V8	383	325	4				
	1960	V8	413	375	2-4				
	1961	V8	361	265	2	AFB-2927S, 2950S			WWC3-188
	1961	V8	383	305	2	AFB-2968S, 2903S			
	1961	V8	383	325	4	AFB-3108S, 3134S			
	1961	V8	413	350	4	BBD-2923S-SA			
	1961	V8	413	375	2-4				
	1962	V8	361	265	2	AFB-3251S, 3258S			WWC3-201
	1962	V8	383	305	2	AFB-3259S, 3256S			
	1962	V8	413	380	2-4	BBD-3244S, 3245S			
	1962	V8	413	340	4				
	1963	V8	361	265	2	AFB-3478S, 3256S			WWC3-201
	1963	V8	383	305	2	AFB-3505S			
	1963	V8	413	360	4	BBD-3438S			
	1963	V8	413	340	4				
	1963	V8	413	390	2-4				
CHRYSLER-IMPERIAL	1964	V8	361	265	2	BBD-3685S			
	1964	V8	383	305	2	AFB-3611S, 3612S			
	1964	V8	413	340	4	AFB-3613S, 3614S			
	1964	V8	413	360	4	AFB-3615S, 3644S			
	1964	V8	413	390	2-4	AFB-3705S			
	1965	V8	383	270	2	BBD-3843S, 3844S			
	1965	V8	383	315	4	BBD-3847S, 3848S			
	1965	V8	413	340	4	BBD-3849S, 3850S			
	1965	V8	413	360	4	AFB-3853S, 3854S AFB-3855S, 3856S AFB-3858S, AFB-3859S, 3860S AFB-3861S, 3871S			
	1966	V8	383	270	2	BBD-4125S, 4126S		1920	WW3-258, 259
	1966	V8	383	325	4	AFB-4130S, 4131S			WW3-260, 261
	1966	V8	440	350	4	AFB-4132S, 4133S AFB-4136S, 4137S			WWC3-262, 263
	1967	V8	383	270	2	BBD-4296S, 4297S		1920	WW3
	1967	V8	383	325	4	AFB-4298S, 4299S		4160	WWC3
	1967	V8	440	350	4	AFB-4309S, 4310S			
	1967	V8	440	375	4	AFB-4326S, 4327S AFB-4311S, 4312S AFB-4328S, 4329S			
	1968	V8	383	290	2	BBD-4422S, 4423S		1920	
	1968	V8	383	330	4	AVS-4426S, 4429S		4160	
	1968	V8	440	350	4				
	1968	V8	440	375	4				
	1969	V8	383	290	2	BBD-4613S, 4614S		1920	
	1969	V8	383	330	4	AVS-4616S, 4711S		4160	
	1969	V8	440	350	4	AVS-4638S, 4617S		2300-6V	
	1969	V8	440	375	4	AVS-4640S			
DODGE-PLYMOUTH	1955	6	230	117	1	WCFB-2253S, 2181S			WW3-120, 121, 122
	1955	6	230	123	1	BBD-2141S, 2154S,			WW3-131, 132, 133
	1955	V8	241	157	2	BBD-2155S, 2262S			WW3-124, 125, 126
	1955	V8	259	167	2	BBD-2203S, 2215S			
	1955	V8	270	175	2	BBD-2062S, 2063S			
	1955	V8	259	177	2	BBD-2116SA, 2049S			
	1956	6	230	125	1	BBD-2299S, 2409S			WW3-124, 125, 126
	1956	6	230	131	2	BBD-2408S, 2407S			WW3-135, 136, 137
	1956	V8	270	180	2	BBD-2424S, 2422S			WW3-138, 139, 140
	1956	V8	270	189	2	BBD-2423S, 2301S			WW15-23, 24, 25
	1956	V8	277	200	4	BBD-2300S			
	1956	V8	315	218	2	WCFB-2442S			
	1956	V8	315	230	4	BBS-2410S, 2293S			
	1956	V8	303	240	4	BBS-2294S, 2295S			
	1956	V8	315	260	4	BBS-2380S			
	1957	6	230	132	1	BBD-2512S,SA,SB,SC			WW3-149, 150
	1957	6	230	138	2	BBD-2513S,SA,SB,SC			WW3-159, 160
	1957	V8	277	197	2	BBD-2514S,SA,SB,SC			WW15-23, 24, 25
	1957	V8	301	215	2	BBD-2567S, 2568S			
	1957	V8	301	235	4	BBD-2569S, 2604S			
	1957	V8	325	245	2	WCFB-2622S, 2532S			
	1957	V8	325	260	4				
	1957	V8	325	285	4				
	1957	V8	318	290	4				
	1957	V8	325	310	2-4				
	1957	V8	354	340	2-4				

APPENDIX F

PRE-1970 LIGHT- AND HEAVY-DUTY VEHICLES

CARBURETOR MAKES AND MODELS (Cont.)

VEHICLE	YEAR	ENGINE DISPL.	HP	CARBURETOR BARRELS	CARBURETOR MODELS: CARTER	ROCHESTER	HOLLY	STROMBERG
DODGE-PLYMOUTH (Cont)	1958	6 230	132	1	AFB-2641S, 2642S			
	1958	6 230	138	2	AFB-2812S, 2813S			WW3-159, 160, 163
	1958	V8 318	225	2	AFB-2652S, 2653S			WW3-164,
	1958	V8 318	250	2	AFB-2641S, 2642S			WW15-23, 24, 25
	1958	V8 325	252	2	AFB-2744S			
	1958	V8 325	265	4	WCFB-2660S			
	1958	V8 350	295	4	BBD-2644S, 2645S			
	1958	V8 318	290	2-4	BBD-2646S			
	1958	V8 361	305	4				
	1958	V8 350	305	2-4				
	1958	V8 361	320	2-4				
	1958	V8 361	333	Fuel Inj.				
	1959	6 230	132	1	BBS-2567S, 2569S			
	1959	6 230	135	1	BBD-2822S, 2870S			WW3-164, 181, 182
	1959	V8 318	230	2	BBD-2775S, 2776S			WW3-183
	1959	V8 326	255	2	BBD-2777S, 2864S			WW15-40
	1959	V8 318	260	4	BBD-2865S, 2866S			
	1959	V8 361	295	4	BBD-2896S			
	1959	V8 361	305	4	AFB-2773S, 2787S			
	1959	V8 383	320	4				
	1959	V8 383	345	2-4				
	1960	6 170	101	1	BBS-2985S, 2986S		4160	
	1960	6 225	145	1	BBS-2900S, 2901S			WW15-41A, 42
	1960	6 170	148	4	BBS-3053S			WWC3-188
	1960	V8 318	230	2	AFB-2903S, 2948S			WW3-181, 182
	1960	V8 318	255	4	AFB-2925S, 2969S			WW3-183
	1960	V8 318	260	4	AFB-2991S, 2970S			WW15-40
	1960	V8 361	265	2	BBD-2921S, 2922S			
	1960	V8 361	305	4	BBD-2983S			
	1960	V8 361	310	2-4				
	1960	V8 383	325	4				
	1960	V8 383	330	2-4				
	1961	6 170	101	1	BBS-3093S, 3094S		4160	
	1961	6 170	145	1	BBS-3127S, 3128S			WW15-43, 44, 45
	1961	6 225	145	1	BBS-3098S, 3099S			WWC3-188A
	1961	6 170	148	4	BBS-3097S, 3129S			
	1961	6 225	196	4	BBD-2921S, 2922S			
	1961	V8 318	230	2	BBD-3132S			
	1961	V8 318	260	4	AFB-3103S, 3131S			
	1961	V8 361	265	2	AFB-3106S, 3105S			
	1961	V8 361	305	4	AFB-3140S, 2903S			
	1961	V8 383	325	4	AFB-2968S, 3133S			
	1961	V8 383	330	2-4	AFB-3152S			
	1962	6 170	101	1	BBS-3231S, 3232S		1920	
	1962	6 225	145	1	BBS-3135S, 3098S			WW3-198, 199, 200
	1962	V8 318	230	2	BBS-3099S, 3097S			WWC3-201
	1962	V8 318	260	4	BBS-3129S			
	1962	V8 361	265	2	BBD-3240S, 3241S			
	1962	V8 361	305	4	BBD-3245S, 2921S			
	1962	V8 318	310	2-4	BBD-2922S, 3132S			
	1962	V8 383	330	4	AFB-3247S, 3249S			
	1962	V8 383	335	2-4	AFB-3252S, 3253S			
	1962	V8 413	365	4	AFB-3957S, 3103S			
	1962	V8 413	385	2-4	AFB-3131S, 3106S			
	1962	V8 413	410	2-4	AFB-3105S, 3140S			
					AFB-2968S, 3133S			
					AFB-3152S, 2903S			
	1963	6 170	101	1	BBS-3462S, 3463S		1920	
	1963	6 225	145	1	BBS-3464S, 3465S			WA3-219
	1963	V8 318	320	2	BBS-3466S, 3468S			WW3-222, 223
	1963	V8 361	265	2	BBS-3472S, 3473S			
	1963	V8 383	330	4	BBS-3438S			
	1963	V8 413	385	2-4	BBD-3475S, 3472S			
	1963	V8 426	425	2-4	BBD-3473S,			
					AFB-3437S, 3447S			
	1964	6 170	101	1	BBD-3682S, 3683S		1920	
	1964	6 225	145	1	BBD-3684S, 3685S			3-239
	1964	V8 273	180	2	BBS-3675S, 3676S			3-240
	1964	V8 318	230	2	BBS-3677S, 3678S			3-242
	1964	V8 361	265	2	BBS-3679S, 3680S			3-244
	1964	V8 383	330	4	BBS-3681S			
	1964	V8 383	305	2	AFB-3447S, 3505S			
	1964	V8 413	340	4	AFB-3611S, 3612S			
	1964	V8 426	375	4	AFB-3613S, 3614S			
	1964	V8 426	425	2-4	AFB-3615S, 3644S			
					AFB-3705S			
	1965	6 170	101	1	BBD-3843S, 3844S		1920	
	1965	6 225	145	1	BBD-3847S, 3848S			3-248
	1965	V8 273	180	2	BBD-3849S, 3850S			3-249
	1965	V8 318	230	2	BBS-3833S, 34S, 35S, 36S			3-250
	1965	V8 273	235	4	BBS-3839S, 40S, 41S, 37S			3-251
	1965	V8 361	265	2	BBS-3838S			3-254
	1965	V8 383	270	2	AFB-3853S, 3854S			3-255
	1965	V8 383	315	4	AFB-3855S, 3856S			
	1965	V8 383	330	4	AFB-3858S, 3860S			
	1965	V8 413	340	4	AFB-3861S, 3871S			
	1965	V8 426	365	4	AFB-3859S			
	1966	6 170	101	1	BBD-4125S, 4127S		1920	
	1966	6 225	145	1	BBD-4113S, 4414S			WW3-258, 259
	1966	V8 273	180	2	BBD-4115S, 4116S			WW3-260, 261
	1966	V8 273	235	4	BBD-4126S, 4128S			WWC3-262, 263
	1966	V8 318	230	2	BBS-4099S, 4101S			
	1966	V8 361	265	2	BBS-4103S, 4105S			
	1966	V8 383	270	2	BBS-4100S, 4102S			
	1966	V8 383	320	4	BBS-4104S, 4106S			
	1966	V8 426	365	4	AFB-4132S, 4133S			
	1966	V8 440	365	4	AFB-4136S, 4137S			
	1966	V8 426	425	2-4	AFB-4120S, 4121S			
					AFB-4122S			

APPENDIX F
PRE-1970 LIGHT- AND HEAVY-DUTY VEHICLES
CARBURETOR MAKES AND MODELS (Concl.)

VEHICLE	YEAR	ENGINE DISPL.	HP	CARBURETOR BARRELS	CARBURETOR MODELS: CARTER	ROCHESTER	HOLLY	STROMBERG
DODGE-PLYMOUTH (Cont)	1967	6 170	115	1	BBS-4286S, 4287S		1920	WW3-272, 273 WW3-274, 275 WWC3-276
	1967	6 225	145	1	BBS-4302S			
	1967	V8 273	180	2	BBD-4113SA, 4114SA			
	1967	V8 273	235	4	BBD-4115SA, 4116SA			
	1967	V8 318	230	2	BBD-4296S, 4297S			
	1967	V8 383	270	2	BBD-4306S, 4307S			
	1967	V8 383	320	4	AFB-4298S, 4299S			
	1967	V8 440	350	4	AFB-4309S, 4310S			
	1967	V8 440	375	4	AFB-4326S, 4327S			
	1967	V8 426	425	2-4	AFB-4311S, 4312S			
	1968	6 170	115	1	BBS-4414S, 4415S		1920	
	1968	6 225	145	1	BBD-4420S, 4422S			
	1968	V8 273	190	2	BBD-4423S, 4416S			
	1968	V8 318	230	2	BBD-4417S			
	1968	V8 340	275	4	AFB-4430S, 4431S			
	1968	V8 383	290	2	AFB-4432S			
	1968	V8 383	300	4	AVS-4424S, 4425S			
	1968	V8 383	330	4	AVS-4426S, 4401S			
	1968	V8 440	350	4	AVS-4429			
	1968	V8 440	375	4				
	1968	V8 426	425	2-4				
	1969	6 170	115	1	BBD-4608S, 4607S		1920	
	1969	6 225	145	1	BBD-4606S, 4605S			
	1969	V8 273	190	2	BBD-4613S			
	1969	V8 318	230	2	BBS-4602S, 4601S			
	1969	V8 340	275	4	AFB-4619S, 4620S			
	1969	V8 383	290	2	AVS-4615S, 4616S			
	1969	V8 383	330	4	AVS-4638S, 4711S			
	1969	V8 383	335	4	AVS-4611S, 4612S			
	1969	V8 440	350	4	AVS-4639S, 4617S			
	1969	V8 440	375	4	AVS-4618S, 4640S			
	1969	V8 426	425	2-4				
LINCOLN-CONTINENTAL	1955	V8 341	225	4			4000	
	1956	V8 368	285	4			4000	
	1957	V8 368	300	4	WCFB-2404S-A			
	1958	V8 430	375	4			4160	
	1959	V8 430	375	4	AFB-2853S		4160	
	1960	V8 430	315	2	ABD-2965S			
	1961	V8 430	315	2	ABD-3149S			
	1962	V8 430	315	2	ABD-3327S, 3328S			
	1963	V8 430	315	2	AFB-3521S, 3522S			
	1964	V8 430	320	4	AFB-3521S, 3522S			
	1965	V8 430	320	4	AFB-3521S, 3522S AFB-3928S, 3929S AFB-3523S, 3524S AFB-3930S, 3931S			
	1966	V8 462	340	4	AFB-4147S, 4148S AFB-4204S, 4205S			
	1967	V8 462	340	4	AFB-C7VF-A,B,C,D			
						FORD (AUTOLITE)		
	1968	V8 460	365	4	AFB-C8VF-E	4300-C8VF		
	1968	V8 462	340	4	AFB-C7VF-A,B,C,D			
	1969	V8 460	365	4		4300-C8VF		

APPENDIX G

PRE-1970 LIGHT-DUTY VEHICLE RETROFIT COST ESTIMATES

APPENDIX G

PRE-1970 LIGHT-DUTY VEHICLE RETROFIT COST ESTIMATES

The items essential to a fuel evaporative emission control system for light-duty vehicles consists of a liquid-vapor separator, overfill limiting-check valve, carbon canister, vent lines, and associated hardware. The cost of these items approximates 70 percent of the installed cost of the evaporative emission control system.

November 1973 list prices of these items was obtained from new car dealers and local parts supply outlets, but does not include sales tax.

Labor for installation of a system was based on a posted labor flat rate of $10.00/hour.

The installed cost of an evaporative emission control system for light-duty vehicles is the sum of the Fuel System and Carburetor System installed costs as tabulated in Appendix G.

APPENDIX G

PRE-1970 LIGHT-DUTY VEHICLE

RETROFIT COST ESTIMATES

ALT. NO.	FUEL SYSTEM	BUICK	CHEVROLET	OLDSMOBILE	PONTIAC	CADILLAC	RAMBLER	FORD
1	New Fuel Tank w/Vents, etc.	$38.50 - 54.15	$34.00 - 47.50	$35.35 - 69.85	$39.75 - 55.30	$66.20	$50.12	$22.30 - 56.40
	Sending Unit	11.45 - 23.95	10.60 - 21.00	15.00 - 25.00	10.95 - 29.20	17.40	8.18	5.55 - 15.35
	Liquid Vapor Separator	21.48	8.95 - 14.30	15.00	10.25	15.00	-	1.65 - 3.15
	Overfill Limiting Valve	-	-	-	-	-	15.13	-
	Canister	20.40	24.50 - 28.20	20.00 - 25.00	24.20	20.40	28.02	21.45
	Tubing/Hardware	16.75 - 21.20	16.75 - 21.20	16.75 - 21.20	16.75 - 21.20	16.75 - 21.20	16.75 - 21.20	16.75 - 21.20
	Pressure/Vac Filler Cap	1.19	1.19	1.19	1.19	1.19	1.19	1.19
	Installation Labor	30.00	30.00	30.00	30.00	30.00	30.00	30.00
	Installed Cost	$139.77 - 172.37	$125.99 - 162.39	$133.29 - 187.24	$131.29 - 171.34	$166.94 - 171.39	$149.39 - 153.84	$108.89 - 148.74
2	Original Fuel Tank							
	Vented Sending Unit Assy.							
	Fuel Expansion Chamber-							
	or Liquid/Vapor Separator	$21.48	$8.95 - 14.30	$15.00	$10.25	$15.00	15.00	$1.65 - 3.15
	Overfill Limiting Valve	20.00 - 25.00	20.00 - 25.00	20.00 - 25.00	20.00 - 25.00	25.00	15.13	20.00 - 25.00
	Canister	20.40	24.50 - 28.20	20.00 - 25.00	24.20	20.40	28.02	21.45
	Tubing Hardware	18.25 - 22.70	18.25 - 22.70	18.25 - 22.70	18.25 - 22.70	18.25 - 22.70	18.25 - 22.70	18.25 - 22.70
	Pressure/Vac Filler Cap	1.19	1.19	1.19	1.19	1.19	1.19	1.19
	Installation Labor	27.50 - 29.00	27.50 - 29.00	27.50 - 29.00	27.50 - 29.00	27.50 - 29.00	27.50 - 29.00	27.50 - 29.00
	Installed Cost	$109.32 - 119.77	$100.39 - 120.39	$101.94 - 117.89	$101.39 - 112.34	$107.34 - 113.29	$105.09 - 111.04	$90.04 - 102.49
3	Original Fuel Tank							
	Vented Filler Tube Extension							
	Liquid/Vapor Separator	$21.48	$8.95 - 14.30	$15.00	$10.25	$15.00	$15.00	$1.65 - 3.15
	Overfill Limiting Valve	20.00 - 25.00	20.00 - 25.00	20.00 - 25.00	20.00 - 25.00	20.00 - 25.00	15.13	20.00 - 25.00
	Canister	20.40	24.50 - 28.20	20.00 - 25.00	24.20	20.40	28.02	21.45
	Tubing/Hardware	24.75 - 29.20	24.75 - 29.20	24.75 - 29.20	24.75 - 29.20	24.75 - 29.20	24.75 - 29.20	24.75 - 29.20
	Filler Cap	1.19	1.19	1.19	1.19	1.19	1.19	1.19
	Installation Labor	12.50	12.50	12.50	12.50	12.50	12.50	12.50
	Installed Cost	$100.32 - 109.77	$91.89 - 110.39	$93.44 - 107.89	$92.89 - 102.34	$93.84 - 103.29	$96.59 - 101.04	$81.54 - 92.49
3 Alt.	Original Fuel Tank							
	Side Vented Pressure/Vac							
	Filler Cap							
	Fuel Expansion Chamber or							
	Liquid/Vapor Separator	$21.48	$8.95 - 14.30	$15.00	$10.25	$15.00	$15.00	$1.65 - 3.15
	Overfill Limiting Valve	20.00 - 25.00	20.00 - 25.00	20.00 - 25.00	20.00 - 25.00	20.00 - 25.00	15.13	20.00 - 25.00
	Canister	20.40	24.50 - 28.20	20.00 - 25.00	24.20	20.40	28.02	21.45
	Tubing Hardware	21.94 - 26.39	21.94 - 26.39	21.94 - 26.39	21.94 - 26.39	21.94 - 26.39	21.94 - 26.39	21.94 - 26.39
	Installation Labor	15.00 - 16.50	15.00 - 16.50	15.00 - 16.50	15.00 - 16.50	15.00 - 16.50	15.00 - 16.50	15.00 - 16.50
	Installed Cost	$93.82 - 109.77	$90.39 - 110.39	$91.94 - 107.89	$91.39 - 102.34	$92.34 - 103.29	$95.09 - 100.04	$80.04 - 92.49

[a] List Prices as of November 1973
Sales Tax Not Included

APPENDIX G

PRE-1970 LIGHT-DUTY VEHICLE

RETROFIT COST ESTIMATES (Cont.)

ALT. NO.	FUEL SYSTEM	BUICK	CHEVROLET	OLDSMOBILE	PONTIAC	CADILLAC	RAMBLER	FORD
4	Original Fuel Tank							
	Nipple (Vent) Welded on Tank							
	Liquid Vapor Separator	$21.48	$8.95 - 14.30	$15.00	$10.25	$15.00	$15.00	$1.65 - 3.15
	Overfill Limiting Valve	20.00 - 25.00	20.00 - 25.00	20.00 - 25.00	20.00 - 25.00	20.00 - 25.00	15.13	20.00 - 25.00
	Canister	20.40	24.50 - 28.20	20.00 - 25.00	24.20	20.40	28.02	21.45
	Filler Cap	1.19	1.19	1.19	1.19	1.19	1.19	1.19
	Tubing/Hardware	18.25 - 22.70	18.25 - 22.70	18.25 - 22.70	18.25 - 22.70	18.25 - 22.70	18.25 - 22.70	18.25 - 22.70
	Installation Labor	30.00 - 31.66	30.00 - 31.66	30.00 - 31.66	30.00 - 31.66	30.00 - 31.66	30.00 - 31.66	30.00 - 31.66
	Installed Cost	$110.57 - 121.68	$102.14 - 122.30	$103.69 - 119.30	$103.14 - 114.25	$104.09 - 115.20	$106.84 - 112.95	$91.79 - 104.40
5	Original Vented Fuel Tank							
	Liquid Vapor Separator	$21.48	$8.95 - 14.30	$15.00	$10.25	$15.00	$15.00	$1.65 - 3.15
	Overfill Limiting Valve	20.00 - 25.00	20.00 - 25.00	20.00 - 25.00	20.00 - 25.00	20.00 - 25.00	15.13	20.00 - 25.00
	Canister	20.40	24.50 - 28.20	20.00 - 25.00	24.20	20.40	28.02	21.45
	Filler Cap	1.19	1.19	1.19	1.19	1.19	1.19	1.19
	Tubing/Hardware	18.25 - 22.70	18.25 - 22.70	18.25 - 22.70	18.25 - 22.70	18.25 - 22.70	18.25 - 22.70	18.25 - 22.70
	Installation Labor	15.00 - 16.66	15.00 - 16.66	15.00 - 16.66	15.00 - 16.66	15.00 - 16.66	15.00 - 16.66	15.00 - 16.66
	Installed Cost	$95.57 - 106.68	$87.39 - 108.05	$88.69 - 104.30	$88.14 - 99.25	$89.09 - 100.20	$91.84 - 97.95	$86.79 - 89.40
	CARBURETOR SYSTEMS							
6	Replace Original Carburetor with Internally Vented Unit (New)	$47.55 - 104.45	$54.80 - 90.75	$47.55 - 101.33	$47.55 - 97.88	$97.25	$57.81 - 95.85	$42.15 - 95.50
	Adapter Plate/Hardware	7.50 - 10.00	7.50 - 10.00	7.50 - 10.00	7.50 - 10.00	10.00	7.50 - 10.00	7.50 - 10.00
	Installation Labor	10.00 - 15.00	10.00 - 15.00	10.00 - 15.00	10.00 - 15.00	15.00	10.00 - 15.00	10.00 - 15.00
	Installed Cost	$65.05 - 129.45	$72.30 - 115.75	$65.05 - 126.33	$65.05 - 122.88	$122.25	$75.31 - 120.85	$59.65 - 120.50
7	Replace Original Carburetor with Internally Vented Rebuilt Unit	$26.40 - 58.08	$30.45 - 57.00	$26.40 - 56.30	$26.40 - 54.38	$54.05	$32.15 - 53.25	$23.40 - 53.05
	Adapter Plate	7.50 - 10.00	7.50 - 10.00	7.50 - 10.00	7.50 - 10.00	10.00	7.50 - 10.00	7.50 - 10.00
	Installation Labor	10.00 - 15.00	10.00 - 15.00	10.00 - 15.00	10.00 - 15.00	15.00	10.00 - 15.00	10.00 - 15.00
	Installed Cost	$43.90 - 83.05	$47.95 - 82.00	$43.90 - 81.30	$43.90 - 69.38	$79.05	$49.65 - 78.25	$40.90 - 78.05

[a] List Prices as of November 1973
Sales Tax Not Included

APPENDIX G

PRE-1970 LIGHT-DUTY VEHICLE

RETROFIT COST ESTIMATES (Cont.)

ALT. NO.	CARBURETOR SYSTEMS	BUICK	CHEVROLET	OLDSMOBILE	PONTIAC	CADILLAC	RAMBLER	FORD
8	Original Carburetor - Fuel Bowl Vented to Air Cleaner							
	Vent Tube/Hardware/Kit	$11.50 - 12.50	$11.50 - 12.50	$11.50 - 12.50	$11.50 - 12.50	$12.50	$11.50 - 12.50	$11.50 - 12.50
	Installation Labor	15.00 - 18.00	15.00 - 18.00	15.00 - 18.00	15.00 - 18.00	18.00	15.00 - 18.00	15.00 - 18.00
	Installed Cost	$26.50 - 30.50	$26.50 - 30.50	$26.50 - 30.50	$26.50 - 30.50	30.50	$26.50 - 30.50	$26.50 - 30.50
9	Original Carburetor - Fuel Bowl Vented to Canister							
	Vent Tube/Hose,Clamps/Kit	$12.20 - 14.50	$12.20 - 14.50	$12.20 - 14.50	$12.20 - 14.50	$14.50	$12.20 - 14.50	$12.20 - 14.50
	Installation Labor	15.00 - 18.00	15.00 - 18.00	15.00 - 18.00	15.00 - 18.00	18.00	15.00 - 18.00	15.00 - 18.00
	Installed Cost	$27.20 - 32.50	$27.20 - 32.50	$27.20 - 32.50	$27.20 - 32.50	$32.50	$27.20 - 32.50	$27.20 - 32.50
10	Original Carburetor Carburetor Enclosure (Shroud)							
	Hardware	$16.00 - 21.00	$16.00 - 21.00	$16.00 - 21.00	$16.00 - 21.00	$21.00	$16.00 - 21.00	$16.00 - 21.00
	Installation Labor	15.00 - 20.00	15.00 - 20.00	15.00 - 20.00	15.00 - 20.00	20.00	15.00 - 20.00	15.00 - 20.00
	Installed Cost	$31.00 - 41.00	$31.00 - 41.00	$31.00 - 41.00	$31.00 - 41.00	$41.00	$31.00 - 41.00	$31.00 - 41.00
11	Original Carburetor Replace Fuel Bowl - Air Horn with Internal Bowl Vent Assembly							
	Replace Part/Rebuilding Kit	$19.00 - 35.90	$19.00 - 35.90	$19.00 - 35.90	$19.00 - 35.90	$35.90	$19.00 - 35.90	$19.00 - 35.90
	Installation Labor	20.00 - 27.50	20.00 - 27.50	20.00 - 27.50	20.00 - 27.50	27.50	20.00 - 27.50	20.00 - 27.50
	Installed Cost	$39.00 - 63.40	$39.00 - 63.40	$39.00 - 63.40	$39.00 - 63.40	$63.40	$39.00 - 63.40	$39.00 - 63.40

[a] List Prices as of November 1973
Sales Tax Not Included

APPENDIX G

PRE-1970 LIGHT-DUTY VEHICLE

RETROFIT COST ESTIMATES (Cont.)

ALT. NO.	FUEL SYSTEM	MERCURY	LINCOLN CONTINENTAL	PLYMOUTH	DODGE	CHRYSLER IMPERIAL	VOLKSWAGEN
1	New Fuel Tank w/Vents, etc.	$43.80 - 54.40	$45.95	$38.97 - 63.48	$51.45	$63.48	$35.80
	Sending Unit	15.35	15.35	10.00	10.00	10.00	10.60
	Liquid Vapor Separator	3.15	3.15	14.50	14.50	14.50	11.70
	Overfill Limiting Valve	-	-	24.88	24.88	24.88	-
	Canister	12.05	16.55	20.82	20.82	20.82	19.00
	Tubing/Hardware	16.75 - 21.20	16.75 - 21.20	16.75 - 21.20	16.75 - 21.20	16.75 - 21.20	16.75 - 21.20
	Pressure/Vac Filler Cap	1.19	1.19	1.19	1.19	1.19	1.19
	Installation Labor	30.00	30.00	30.00	30.00	30.00	30.00
	Installed Cost	$122.29 - 137.34	$128.94 - 133.39	$157.11 - 186.07	$169.59 - 174.04	$181.62 - 186.07	$125.04 - 129.49
2	Original Fuel Tank Vented Sending Unit Assy. Fuel Expansion Chamber- or Liquid/Vapor Separator	$3.15	$3.15	$14.50	$14.50	$14.50	$11.70
	Overfill Limiting Valve	20.00 - 25.00	20.00 - 25.00	24.88	24.88	24.88	15.13
	Canister	12.05	16.55	20.82	20.82	20.82	19.00
	Tubing/Hardware	18.25 - 22.70	18.25 - 22.90	18.25 - 22.90	18.25 - 22.90	18.25 - 22.90	18.25 - 22.90
	Pressure/Vac Filler Cap	1.19	1.19	1.19	1.19	1.19	1.19
	Installation Labor	27.50 - 29.00	27.50 - 29.00	27.50 - 29.00	27.50 - 29.00	27.50 - 29.00	27.50 - 29.00
	Installed Cost	$82.14 - 93.09	$86.64 - 97.59	$107.14 - 113.09	$107.14 - 113.09	$107.14 - 113.09	$92.77 - 98.72
3	Original Fuel Tank Vented Filler Tube Extension Liquid/Vapor Separator	$3.15	$3.15	$14.50	$14.50	$14.50	$11.70
	Overfill Limiting Valve	20.00 - 25.00	20.00 - 25.00	24.88	24.88	24.88	15.13
	Canister	12.05	16.55	20.82	20.82	20.82	19.00
	Tubing/Hardware	24.75 - 29.20	24.75 - 29.20	24.75 - 29.20	24.75 - 29.20	24.75 - 29.20	24.75 - 29.20
	Filler Cap	1.19	1.19	1.19	1.19	1.19	1.19
	Installation Labor	12.50	12.50	12.50	12.50	12.50	12.50
	Installed Cost	$73.64 - 83.09	$78.14 - 87.59	$98.64 - 103.09	$98.64 - 103.09	$98.64 - 103.09	$84.27 - 88.72
3 Alt	Original Fuel Tank Side Vented Pressure/Vac Filler Cap Fuel Expansion Chamber or Liquid/Vapor Separator	$3.15	$3.15	$14.50	$14.50	$14.50	$11.70
	Overfill Limiting Valve	20.00 - 25.00	20.00 - 25.00	24.88	24.88	24.88	15.13
	Canister	12.05	16.55	20.82	20.82	20.82	19.00
	Tubing/Hardware	21.94 - 26.39	21.94 - 26.39	21.94 - 26.39	21.94 - 26.39	21.94 - 26.39	21.94 - 26.39
	Installation Labor	15.00 - 16.50	15.00 - 16.50	15.00 - 16.50	15.00 - 16.50	15.00 - 16.50	15.00 - 16.50
	Installed Cost	$72.14 - 83.09	$76.64 - 87.59	$97.14 - 103.09	$97.14 - 103.09	$97.14 - 103.09	$82.77 - 88.72

[a] List Prices as of November 1973
Sales Tax Not Included

APPENDIX G

PRE-1970 LIGHT-DUTY VEHICLE

RETROFIT COST ESTIMATES (Cont.)

ALT. NO.	FUEL SYSTEM	MERCURY	LINCOLN CONTINENTAL	PLYMOUTH	DODGE	CHRYSLER IMPERIAL	VOLKSWAGEN
4	Original Fuel Tank						
	Nipple (Vent) Welded on Tank						
	Liquid Vapor Separator	$3.15	$3.15	$14.50	$14.50	$14.50	$11.70
	Overfill Limiting Valve	20.00 - 25.00	20.00 - 25.00	24.88	24.88	24.88	15.13
	Canister	12.05	16.55	20.82	20.82	20.82	19.00
	Filler Cap	1.19	1.19	1.19	1.19	1.19	1.19
	Tubing/Hardware	18.25 - 22.70	18.25 - 22.70	18.25 - 22.70	18.25 - 22.70	18.25 - 22.70	18.25 - 22.70
	Installation Labor	30.00 - 31.60	30.00 - 31.66	30.00 - 31.66	30.00 - 31.66	30.00 - 31.66	30.00 - 31.66
	Installed Cost	$83.89 - 95.00	$88.39 - 99.50	$108.89 - 115.00	$108.89 - 115.00	$108.89 - 115.00	$94.52 - 100.63
5	Original Vented Fuel Tank						
	Liquid Vapor Separator	$3.15	$3.15	$14.50	$14.50	$14.50	$11.70
	Overfill Limiting Valve	20.00 - 25.00	20.00 - 25.00	24.88	24.88	24.88	15.13
	Canister	12.05	16.55	20.82	20.82	20.82	19.00
	Filler Cap	1.19	1.19	1.19	1.19	1.19	1.19
	Tubing/Hardware	18.25 - 22.70	18.25 - 22.70	18.25 - 22.70	18.25 - 22.70	18.25 - 22.70	18.25 - 22.70
	Installation Labor	15.00 - 16.66	15.00 - 16.66	15.00 - 16.66	15.00 - 16.66	15.00 - 16.66	15.00 - 16.66
	Installed Cost	$68.89 - 95.00	$73.39 - 84.50	$93.89 - 100.00	$93.89 - 100.00	$93.89 - 100.00	$79.52 - 85.63
	CARBURETOR SYSTEMS						
6	Replace Original Carburetor with Internally Vented Unit (New)	$51.05 - 95.50	$81.70	$42.87 - 121.45	$51.40 - 121.45	$121.45	INTERNALLY VENTED. NO CARBURETOR MODIFICATION REQUIRED.
	Adapter Plate/Hardware	7.50 - 10.00	10.00	7.50 - 10.00	7.50 - 10.00	10.00	
	Installation Labor	10.00 - 15.00	15.00	10.00 - 15.00	10.00 - 15.00	15.00	
	Installed Cost	$68.55 - 120.50	$106.70	$60.37 - 146.45	$68.90 - 146.45	$146.45	
7	Replace Original Carburetor with Internally Vented Rebuilt Unit	$28.35 - 53.05	$45.40	$23.60 - 67.45	$23.60 - 67.45	$67.45	
	Adapter Plate	7.50 - 10.00	10.00	7.50 - 10.00	7.50 - 10.00	10.00	
	Installation Labor	10.00 - 15.00	15.00	10.00 - 15.00	10.00 - 15.00	15.00	
	Installed Cost	$45.85 - 78.05	$70.40	$41.10 - 92.45	$41.10 - 92.45	$92.45	

[a] List Prices as of November 1973
Sales Tax Not Included

APPENDIX G

PRE-1970 LIGHT-DUTY VEHICLE

RETROFIT COST ESTIMATES (Concl.)

ALT. NO.	CARBURETOR SYSTEMS	MERCURY	LINCOLN CONTINENTAL	PLYMOUTH	DODGE	CHRYSLER IMPERIAL	VOLKSWAGEN
8	Original Carburetor Fuel Bowl Vented to Air Cleaner						INTERNALLY VENTED. NO CARBURETOR MODIFICATION REQUIRED
	Vent Tube/Hardware Kit	$11.50 - 12.50	$12.50	$11.50 - 12.50	$11.50 - 12.50	$12.50	
	Installation Labor	15.00 - 18.00	18.00	15.00 - 18.00	15.00 - 18.00	18.00	
	Installed Cost	$26.50 - 30.50	$30.50	$26.50 - 30.50	$26.50 - 30.50	$30.50	
9	Original Carburetor Fuel Bowl Vented to Canister						
	Vent Tube/Hose, Clamps/Kit	$12.20 - 14.50	$14.50	$12.20 - 14.50	$12.20 - 14.50	$14.50	
	Installation Labor	15.00 - 18.00	18.00	15.00 - 18.00	15.00 - 18.00	18.00	
	Installed Cost	$27.20 - 32.50	$32.50	$27.20 - 32.50	$27.20 - 32.50	$32.50	
10	Original Carburetor Carburetor Enclosure (Shroud)						
	Hardware	$16.00 - 21.00	$21.00	$16.00 - 21.00	$16.00 - 21.00	$21.00	
	Installation Labor	15.00 - 20.00	20.00	15.00 - 20.00	15.00 - 20.00	20.00	
	Installed Cost	$31.00 - 41.00	$41.00	$31.00 - 41.00	$31.00 - 41.00	$41.00	
11	Original Carburetor Replace Fuel Bowl - Air Horn with Internal Bowl Vent Assembly						
	Replace Part/Rebuilding Kit	$19.00 - 35.90	$35.90	$19.00 - 35.90	$19.00 - 35.90	$35.90	
	Installation Labor	20.00 - 27.50	27.50	20.00 - 27.50	20.00 - 27.50	27.50	
	Installed Cost	$39.00 - 63.40	$63.40	$39.00 - 63.40	$39.00 - 63.40	$63.40	

[a] List Prices as of November 1973
Sales Tax Not Included

APPENDIX H

PRE-1970 HEAVY-DUTY VEHICLE RETROFIT COST ESTIMATES

APPENDIX H

PRE-1970 HEAVY DUTY VEHICLE RETROFIT COST ESTIMATES

The items essential to a fuel evaporative emission control system for heavy-duty vehicles are equivalent to those of light-duty vehicles (Appendix G).

November 1973 list prices of required items were obtained from truck dealers and local parts supply outlets, but does not include sales tax.

Labor for installation of a system was based on a labor flat rate of $10.00/hour. The installed cost of a closed evaporative emission control system for heavy-duty vehicles is the sum of the Fuel System and Carburetor System installed costs as tabulated in Appendix H.

APPENDIX H

PRE-1970 HEAVY-DUTY VEHICLE

RETROFIT COST ESTIMATES

ALT. NO.	FUEL SYSTEM	CHEVROLET	FORD	DODGE	GMC
1	New Fuel Tank with Vents, etc.	$53.60	$47.15	$61.82	$53.60
	Sending Unit	10.60 - 21.00	15.35	10.60	10.60 - 21.00
	Liquid/Vapor Separator	14.30	3.15	14.30	14.30
	Overfill Limiting Valve	15.13	15.13	24.88	15.13
	Carbon Canister	28.20	21.45	20.82	28.20
	Hardware	22.39	22.39	22.39	22.39
	Installation Labor	30.00	30.00	30.00	30.00
	Installed Cost	$174.22 - $184.62	$154.62 -	$184.81 -	$174.22 - 184.62
2	Original Fuel Tank				
	Vented Sending Unit Assembly				
	Liquid/Vapor Separator	$14.30	$ 3.15	$14.30	$14.30
	Overfill Limiting Valve	15.13 - 24.88	15.13 - 24.88	15.13 - 24.88	15.13 - 24.88
	Carbon Canister	28.20	21.45	20.82	28.20
	Hardware/Cap	19.44	19.44	19.44	19.44
	Installation Labor	27.50 - 29.00	27.50 - 29.00	27.50 - 29.00	27.50 - 29.00
	Installed Cost	$104.57 - 115.82	$86.67 - 97.92	$97.19 - 108.44	$104.57 - 115.82
3	Original Fuel Tank				
	Vented Fill Tube Extension				
	Liquid/Vapor Separator	$14.30	$ 3.15	$14.30	$14.30
	Overfill Limiting Valve	15.13 - 24.88	15.13 - 24.88	15.13 - 24.88	15.13 - 24.88
	Carbon Canister	28.20	21.45	20.82	28.20
	Hardware/Cap	25.94	25.94	25.94	25.94
	Installation Labor	12.50	12.50	12.50	12.50
	Installed Cost	$96.07 - 105.80	$78.17 - 87.92	$88.69 - 98.44	$96.07 - 105.82
3 Alt.	Original Fuel Tank				
	Vented Filler Tube Cap				
	Liquid/Vapor Separator	$14.50	$ 3.15	$14.30	$14.30
	Overfill Limiting Valve	15.13 - 24.88	15.13 - 24.88	15.13 - 24.88	15.13 - 24.88
	Carbon Canister	28.20	21.45	20.82	28.20
	Hardware	23.13	23.13	23.13	23.13
	Installation Labor	15.00	15.00	15.00	15.00
	Installed Cost	$95.96 - 105.71	$77.86 - 87.61	$88.38 - 98.13	$95.76 - 105.51

[a] List Prices as of November 1973
Sales Tax Not Included

APPENDIX H
PRE-1970 LIGHT-DUTY VEHICLE
RETROFIT COST ESTIMATES (Cont.)

ALT. NO.	FUEL SYSTEM	CHEVROLET	FORD	DODGE	GMC
4	Original Fuel Tank				
	Nipple (Vent) Welded on Tank				
	Liquid/Vapor Separator	$14.30	$ 3.15	$14.30	$14.30
	Overfill Limiting Valve	15.13 - 24.88	15.13 - 24.88	15.13 - 24.88	15.13 - 24.88
	Carbon Canister	28.20	21.45	20.82	28.20
	Hardware/Cap	19.44	19.44	19.44	19.44
	Installation Labor	31.66	31.66	31.66	31.66
	Installed Cost	$108.73 - 118.48	$90.83 - 100.58	$101.35 - 111.10	$108.73 - 118.48
5	Original Vented Fuel Tank				
	Liquid/Vapor Separator	$14.30	$ 3.15	$14.30	$14.30
	Overfill Limiting Valve	15.13 - 24.88	15.13 - 24.88	15.13 - 24.88	15.13 - 24.88
	Carbon Canister	28.20	21.45	20.82	28.20
	Tubing/Hardware	19.44	19.44	19.44	19.44
	Installation Labor	16.66	16.66	16.66	16.66
	Installed Cost	$93.73 - 103.48	$75.83 - 85.58	$86.35 - 96.10	$93.73 - 103.48
6	CARBURETOR SYSTEM				
	Replace Original Carburetor with New-Vented Unit	$48.88 - 96.84	$48.70 - 56.85	$35.75 - 71.00	$51.80 - 101.60
	Adapter Plate Hardware	7.50 - 10.00	7.50 - 10.00	7.50 - 10.00	7.50 - 10.00
	Installation Labor	10.00 - 15.00	10.00 - 15.00	10.00 - 15.00	10.00 - 15.00
	Installed Cost	$66.38 - 121.84	$66.20 - 81.85	$53.25 - 96.00	$69.30 - 126.60
7	Replace Original Carburetor with Rebuilt-Vented Unit	$34.50 - 67.40	$34.50 - 40.35	$23.75 - 54.50	$36.57 - 71.72
	Adapter Plate Hardware	7.50 - 10.00	7.50 - 10.00	7.50 - 10.00	7.50 - 10.00
	Installation Labor	10.00 - 15.00	10.00 - 15.00	10.00 - 15.00	10.00 - 15.00
	Installed Cost	$52.00 - 92.40	$52.00 - 65.35	$41.25 - 79.40	$54.07 - 96.72
8	Original Carburetor Vented to Air Cleaner				
	Hardware/Kit	$11.50 - 12.50	$11.50 - 12.50	$11.50 - 12.50	$11.50 - 12.50
	Installation Labor	15.00 - 18.00	15.00 - 18.00	15.00 - 18.00	15.00 - 18.00
	Installed Cost	26.50 - 30.50	26.50 - 30.50	26.50 - 30.50	26.50 - 30.50

[a] List Prices as of November 1973
Sales Tax Not Included

APPENDIX H

PRE-1970 LIGHT-DUTY VEHICLE

RETROFIT COST ESTIMATES (Concl.)

ALT. NO.	CARBURETOR SYSTEM	CHEVROLET	FORD	DODGE	GMC
9	Original Carburetor Vented to Canister				
	Hardware/Kit	$12.20 - 14.50	$12.20 - 14.50	$12.20 - 14.50	$12.20 - 14.50
	Installation Labor	15.00 - 18.00	15.00 - 18.00	15.00 - 18.00	15.00 - 1800
	Installed Cost	$27.20 - 32.50	$27.20 - 32.50	$27.20 - 32.50	$27.20 - 32.50
10	Original Carburetor Carburetor Enclosure (Shroud)				
	Hardware	$16.00 - 21.00	$16.00 - 21.00	$16.00 - 21.00	$16.00 - 21.00
	Installation Labor	15.00 - 20.00	15.00 - 20.00	15.00 - 20.00	15.00 - 20.00
	Installed Cost	$31.00 - 41.00	$31.00 - 41.00	$31.00 - 41.00	$31.00 - 41.00
11	Original Carburetor Replace Fuel Bowl - Airhorn with Internal Bowl Vent Assembly				
	Replace Part/Rebuilding Kit	$19.00 - 35.90	$19.00 - 35.90	$19.00 - 35.90	$19.00 - 35.90
	Installation Labor	20.00 - 27.50	20.00 - 27.50	20.00 - 27.50	20.00 - 27.50
	Installed Cost	$39.00 - 63.40	$39.00 - 63.40	$39.00 - 63.40	$39.00 - 63.40

[a] List Prices as of November 1973
Sales Tax Not Included

APPENDIX I

LIGHT AND HEAVY DUTY VEHICLES
ANNUAL NUMBER OF TRIPS

APPENDIX I

LIGHT DUTY VEHICLE AGE VERSUS VEHICLE POPULATION AND ANNUAL NUMBER OF TRIPS

This appendix relates the number of annual trips per vehicle and fraction of total vehicle population as a function of vehicle age for both light-duty and heavy-duty vehicles.

LIGHT-DUTY VEHICLES

n Vehicle Age	VP_n Fraction of Total[a] Vehicle Population	T_n Annual Average[b] Number of Trips
1	0.081	1,650
2	0.105	1,500
3	0.100	1,370
4	0.095	1,200
5	0.091	1,170
6	0.087	1,090
7	0.082	1,080
8	0.077	1,010
9	0.065	910
10	0.059	880
11	0.042	710
12	0.034	610
13	0.027	540
14	0.018	540
15	0.009	540
16 and over	0.028	540

[a]Refer to Appendix A for the derivation of these values.

[b]These values are based on the average mileage per vehicle lifetime (Ref. **26**) and the normal mileage per trip of 7.5 miles from LA test cycle and reference 16.

HEAVY-DUTY VEHICLES

n Vehicle Age	VP_n Fraction of Total Vehicle Population[a]	T_n Annual Average Number of Trips[b]
1	0.093	2,600
2	0.090	2,600
3	0.097	2,600
4	0.091	2,600
5	0.070	2,600
6	0.063	2,600
7	0.067	2,600
8	0.068	2,600
9	0.066	2,600
10	0.052	2,600
11	0.043	2,600
12	0.031	2,600
13	0.032	2,600
14	0.026	2,600
15	0.016	2,600
16 and over	0.094	2,600

[a]Derived from truck mileage and lifetime data obtained from the American Trucking Association. (Ref. 22)

[b]These numbers are based on the above facts, a, and trip data found in the Wilbur Smith and Associates study (Ref. 17).

APPENDIX J

DAILY TRAFFIC DISTRIBUTIONS

APPENDIX J

DAILY TRAFFIC DISTRIBUTIONS

The day is divided into six intervals. Each interval has a corresponding percentage of total traffic associated with it. The following describes this traffic distribution as a function of time.

Interval j	Time	Proportion of Daily Traffic for Interval j	
		Light Duty Vehicles	Heavy Duty Vehicles
1	0600-0900	0.195 [1]	0.201 [2]
2	0900-1200	0.172	0.312
3	1200-1530	0.205	0.280
4	1530-1800	0.210	0.131
5	1800-2200	0.118	0.032
6	2200-0600	0.100	0.049

[1] Ref. 21.

[2] Ref. 17.

APPENDIX K

EFFECTIVENESS MODEL DERIVATION AND MEASURE OF EFFECTIVENESS (MOE) CALCULATION

APPENDIX K

EFFECTIVENESS MODEL DERIVATION AND MEASURE OF EFFECTIVENESS (MOE) CALCULATION

This appendix includes development of the model elements and discussion of how the various distributions are utilized.

Based on the three major categories, a top-level effectiveness model can be structured like Equation 3-2. In brief, the equation can be expressed as:

$$MOE = \sum_{n=1}^{y} \left[(R_{chs} + R_{trhs})(T_n) + (R_{dc}) \right]_n \qquad \text{(Eq. K-1)}$$

where:

MOE = Measure of effectiveness (i.e., the amount of hydrocarbon vapor contained) measured in units of mass

R_{chs} = Carburetor hot soak losses per vehicle per trip measured in units of mass

R_{trhs} = Fuel tank running and hot soak losses per vehicle per trip measured in mass units

T_n = Total number of trips completed by pre-1970 vehicles per air basin

R_{dc} = Total diurnal losses per air basin per season measured in mass units

n = Index describing the number of seasons over which the effectiveness is measured

y = Maximum number of seasons over which the effectiveness is measured[1]

Each of these major model elements is in turn comprised of several components.

$$R_{chs} = \sum_{j=1}^{6} \left(r_{chspt}\right)_j \left(T_{dis}\right)_j \qquad \text{(Eq. K-2)}$$

where:

r_{chspt} = Carburetor hot soak loss per trip (refer to Section 3 for the values as a function of time and air basin)

T_{dis} = Fraction of total vehicle population on the road during one of intervals, j.

j = Index of time intervals considered

Refer to Appendices I and J for the time intervals considered and their corresponding values of j and T_{dis}.

$$R_{trhs} = \sum_{j=1}^{6} \left(r_{trhspt}\right)_j \left(T_{dis}\right)_j \qquad \text{(Eq. K-3)}$$

---

[1]The effectiveness of alternatives is measured over a 13 year interval. Hence, the upper limit of n equals 52 (13 x 4) seasons.

where:

r_{trhspt} = Tank running and hot soak losses per trip (refer to Table 3-1 for the values as a function of time and air basin)

while T_{dis} and j were defined previously.

The expected values of carburetor hot soak and tank running and hot soak losses are thus completely defined. The value of diurnal cycle losses is directly given in Table 3-1.

T_n is defined as the total number of trips completed by pre-1970 vehicles. Further examination of this variable reveals that:

$$T_n = \sum_{k=x}^{16} (t_k)\,(VP_k)\,(VPOP_n) \qquad \text{(Eq. K-4)}$$

where:

t_k = Number of trips completed by a vehicle with age k, see Appendix I

VP_k = Fraction of total vehicle population with age k, see Appendix I

VPOP = Total air basin vehicle population. Note that as n increases by one, an approximate 3.5 and 2.5 percent annual population increase occurs for light and heavy-duty vehicles, respectively

k = Index relating the vehicle age under consideration

x = Age of latest model being considered. If for example, the number of trips is being considered for the year 1975, then x would equal six because only pre-1970 vehicles are involved.

The total diurnal cycle evaporative loss per air basin per season is given as R_{dc}. This quantity is comprised of several components.

$$R_{dc} = \sum_{k=x}^{16} \left[(r_{dc}) (VP_k) (VPOP_k) \right] (DPS) \qquad \text{(Eq. K-5)}$$

where:

r_{dc} = Diurnal cycle loss per vehicle per day

DPS = Number of days per season (i.e., 365/4)

and where VP, VPOP, k, and x were defined previously.

In view of the previous discussion, the effectiveness model can be given as follows:

$$MOE = \sum_{x=1}^{y} \left\{ \left[\sum_{j=1}^{6} \left(r_{chspt} \right)_j \left(T_{dis} \right)_j + \left(r_{trhspt} \right)_j \left(T_{dis} \right)_j \right] \cdot \left[\sum_{k=x}^{16} (t_k) (VP_k) (VPOP) \right] + \left[(DPS) \sum_{k=x}^{16} (r_{dc}) (VP_k) (VPOP) \right] \right\}_n \qquad \text{(Eq. K-6)}$$

This yields the total amount of evaporative emissions per season per air basin. Emission values are computed separately for light-duty and heavy-duty vehicles.

Because of the large amounts of data involved and the frequent use of summing methods, the effectiveness model solutions were obtained using an IBM 370/165 computer and related FORTRAN IV numerical method techniques. Also, note that the above MOE equation implies control of both carburetor and fuel tank losses. If other levels of effectiveness are investigated, deletion of the appropriate major elements is required, as described in Section 3.3.

APPENDIX L

ASSESSED AUTOMOBILE VALUES

APPENDIX L

ASSESSED AUTOMOBILE VALUES

In determining the feasibility of the retrofit approaches, it is appropriate to examine the worth of the vehicles on which the alternatives would be installed. The desirability of a retrofit would tend to decrease as its cost would approach the vehicle's assessed worth.

APPENDIX L

ASSESSED AUTOMOBILE VALUES ($) AS OF NOVEMBER 1973[1]

VEHICLE MODELS	PRE-1964	1964	1965	1966	1967	1968	1969
AMC							
American	2	150	250	400	600	775	975
Rebel		150	200	300	450	575	785
Ambassador		150	220	360	500	650	910
Javelin		----	----	----	----	900	1115
Buick							
Special Skylark		200	350	425	675	925	1300
Others		250	400	500	780	980	1400
Cadillac		300	500	650	1200	1750	2550
Chevrolet							
Corvair/Vega		150	150	150	170	250	325
Chevy II/Nova		200	250	400	545	720	970
Camaro		----	----	----	965	1160	1360
Chevelle		225	350	450	565	975	1040
Others		250	375	480	580	1040	1200
Chrysler		300	440	500	600	910	1385
Dodge							
Dart		300	425	500	610	855	1040
Others		300	375	475	560	750	1240
Ford							
Falcon		200	300	400	555	660	990
Mustang		----	550	700	875	1070	1300
Fairlane/Torino		250	300	450	550	740	945
Thunderbird		250	300	500	690	1040	1450
Others	2	200	250	375	480	650	980

ASSESSED AUTOMOBILE VALUES ($) AS OF NOVEMBER 1973[1]

VEHICLE MODELS	PRE-1964	1964	1965	1966	1967	1968	1969
Imperial	2	300	425	550	655	1150	1865
Lincoln		300	400	600	750	1275	2450
Mercury							
Comet/Montego		250	300	375	485	710	930
Cougar		----	----	----	1000	1240	1485
Others		300	375	450	580	865	1225
Oldsmobile							
F85/Cutlass		250	400	525	670	970	1205
Others		250	400	550	620	920	1305
Plymouth							
Valiant		250	375	450	560	765	1015
Others		250	375	450	530	620	895
Pontiac							
Tempest		250	400	480	625	865	1130
Firebird		----	----	----	950	1175	1450
Others		250	400	500	645	915	1480
Volkswagen		250	350	500	650	775	925
PC-6		150	275	400	500	650	850
PC-7	2	1000	1200	1500	1900	2800	3350

[1] These assessments are the "low" or wholesale values and are generally based on the values derived by Allstate Insurance Corporation.

[2] The average worth of pre-1964 automobiles is approximately $150 except for PC-7 models which is generally $500.

APPENDIX M

APPLICATION GUIDE FOR RETROFIT APPROACHES

APPENDIX M

APPLICATION GUIDE FOR RETROFIT APPROACHES

Alternatives No. 1, 6 and 7 are applicable to all 1955-1969 light duty and heavy duty vehicles.

Alternatives No. 2, 3 and 4 are applicable to the following vehicles. This comprises about 75 percent of the 1955-1969 vehicle population.

Rebel, Rogue, Ambassador 69-55
Austin-Austin Healy 1969-1958
Buick Sta. Wagon 1969-1966
Buick 1969-1957
Buick Spec.Sta.Wag. 1969-1964
Buick Special 1963-1961
Cadillac Eldorado 1967-1955
Checker 1969-1963
Chevrolet Sta. Wag. 1969-65
Chevrolet 1964-1955
Camaro 1969-1967
Chevrolet 1969-1964
Chevy II 1969-1968, 64-62
Corvair 1969-1960
Corvette 1962-1955
Chevrolet Trucks 1969-1955
Chevrolet El Camino 69-64
Chrysler Sta. Wag. 1969-1956
Chrysler 1965-1960
Chrysler Imperial 1969-1964
Desoto 1961-1957
Diamond T Trucks 1960-1955
Dodge Charger, Polara 69-55
Edsel Sta. Wag. 1960-1958
Federal Truck 1960-1955
Fiat 1967-1960
Ford 1969-1960
Ford Station Wagon 1963-1961
Ford Fairlane St.Wag. 69-63
Ford Falcon 1969-1965
Ford Maverick 1969-1965
Ford Torino 1969-1955
Ford: Bronco, Econoline 69-61
Ford English 1969-1955
GMC Trucks 1969-1955
IHC Trucks 1969-1961
Jaguar 1969-1957
Kaiser Jeep Wagoneer 69-64
Lincoln 1969-1961
Mercedes 1969-1964

Mercury 1969
Mercury Station Wagon 1969-1961
M G 1969
Oldsmobile Sta. Wagon 1969-1964
Oldsmobile 1963-1955
Plymouth Belvedere 1965-1960
Plymouth Fury Sta. Wag. 69-65
Pontiac Station Wagon 69-65
Pontiac 1965-1958
Pontiac Tempest St.Wag. 69-65
Pontiac Tempest 1965, 62-61
Renault 1969-1955
Reo Trucks 1961-1955
Studebaker 1966-1959
Toyota 1969
Volkswagon 1969-1960
White Truck 1961-1955

Alternate No. 5 is applicable to the following vehicles. This comprises about 20 percent of the 1955-1969 vehicle population.

Buick 1969-1965
Corvair 1969-1963
Dodge Sta. Wag. 1969-1962
Dart/Demon 1969-1962
Cadillac 1964-1956
Chrysler 1969-1966
Dodge Polara, Monaco 69-65
Dodge Barracuda 1966-1965
Edsel 1960-1958
Ford Fairlane 1969-1966
Ford 1963-1956
Ford Torino 1969
Mercury 1963-1961, 58-56
Oldsmobile 1969-1964
Opel 1969-1964
Ply. Belvedere 1969-1966
Ply. Fury, Satellite 69-67
Pontiac Tempest 1969-1965
IHC Trucks 1968-1967
American 1966-1964
AMX 1969
Dodge Coronet 1969-1968

Alternatives 8, 9, 10 and 11 are applicable to all 1, 2, and 4 barrel carburators manufactured by Rochester, Carter, Ford, Solex, and Stromberg for 1969-1959 domestic vehicles. Approximately 40 percent of single barrel carburetors manufactured by Holley, S.U., Zenith, Weber and Stromberg for 1969-1959 imported vehicles were vented externally.

APPENDIX N

COST MODEL DERIVATION

APPENDIX N

COST MODEL DERIVATION

This appendix includes development of the cost model elements and discusses the various elements used.

Based on the two major cost categories, a top-level cost model can be structured like Equation 4-1. This equation can be expressed as:

$$LCC = PWF\sum_{n=1}^{y}(C_{INV_n}+C_{AM_n})N_n \qquad \text{(Eq. 4-1)}$$

where:

LCC = Discounted life-cycle consumer cost of an evaporative control system alternative from time of purchase and installation and throughout the prescribed life cycle, measured in 1974 dollars.

n = Index of years over which costs are accumulated.

y = Number of years over which costs are accumulated.

PWF = Present worth factor applied from base year 1975 to all future costs.

C_{INV} = Initial investment cost per vehicle, measured in dollars.

C_{AM} = Annually recurring system operation costs per vehicle, measured in dollars

N = Number of vehicles under consideration during year n.

Each of these major model elements in turn is comprised of several components and/or unique data values.

The present worth factor will usually vary as a function of the time in the future. However, since the escalation factor approximates the expected consumer rate of return, the adjusted discount rate is, in essence, zero. Hence the present worth factor, PWF, is unity for all future points in time.

C_{AM} applies to all one through five alternatives. It is the cost for replacing a filter in the carbon canister. The value is $2.50 per year regardless of the vehicle make and age.

The variables C_{INV} and N, however, are a function of vehicle type. C_{INV} does not vary as a function of vehicle age but does vary with respect to vehicle make. As mentioned, the cost for each alternative as it applies to each make of vehicle is given in Appendices G and H.

The specific value of N which multiplies a given C_{INV} is a function of vehicle make, age, and percentage of vehicles to which the alternatives apply. Hence

$$N = N_{MAKE}\ N_{AGE}\ N_{PERC}\ VPOP \qquad \text{(Eq. N-1)}$$

where:

N_{MAKE} = Fraction of vehicles of a specific make.

N_{AGE} = Fraction of vehicles of a specific age.

N_{PERC} = Fraction of vehicles to which the alternatives apply.

VPOP = Vehicle population.

Some explanation of N_{PERC} may be in order. N_{PERC} is also actually a function of vehicle make and age. Often a given alternative will not apply to a specific vehicle. For example, a substantial percentage of pre-1960 vehicles have internally vented carburetors as given in Appendix E. Consequently, no carburetor modifications would apply to these vehicles. N_{PERC} takes such factors into account.

As a result of the varying nature of C_{INV} and N in addition to the previous discussion, their product total for all applicable vehicles under consideration can be given by:

$$C_{INV} \cdot N = \sum_{j=1}^{M} \left\{ C_{INV_j} N_{MAKE_j} \sum_{k=1}^{N} N_{AGE_k} N_{PERC_{jk}} VPOP \right\} \qquad \text{(Eq. N-2)}$$

where j is the model type index and k is the vehicle age index. Values of j and k refer to vehicle type and age, respectively, for all vehicles under consideration.

In view of the above and Equation 4-1, a detailed cost model is obtained:

$$LCC = PWF \sum_{M=1}^{y} \left[\sum_{j=1}^{m} \left\{ \left[C_{INV_j} \right] \left[N_{MAKE_j} \sum_{k=1}^{n} (N_{AGE_k} N_{PERC_{jk}} VPOP) \right] \right\} \right]_n \qquad \text{(Eq. N-3)}$$

Equation N-3 yields the total cost for a given area. The value of the vehicle population, VPOP, specifies the area being considered. The total costs are computed separately lfor light- and heavy-duty vehicles.

Because of the large amounts of data involved and the frequent use of summing methods, the cost model solutions were obtained using an IBM 370/165 computer and related FORTRAN IV numerical method techniques.

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