Science Applications, Inc.
One Continental Plaza, Suite 310
101 Continental Boulevard
El Segundo, California 90245

SURVEY OF HEAVY-DUTY DIESEL MAINTENANCE PRACTICES

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PREPARED BY:

D. F. HAUSKNECHT
I. B. OSOFSKY

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STATE OF CALIFORNIA
AIR RESOURCES BOARD
SACRAMENTO, CALIFORNIA 95812

ABSTRACT

The California Air Resources Board is evaluating the potential benefits in air quality of an inspection/maintenance (I/M) program for heavy-duty diesel vehicles. The present study was conducted to develop information needed for this evaluation including ownership, use and maintenance practices, and alternatives for an I/M program for heavy-duty diesels.

Information on heavy-duty vehicles with diesel engines was obtained from responses to questionnaires which were mailed to a stratified sample of owners obtained from the files of the California Department of Motor Vehicles. The questionnaires addressed the areas of number, type, age, usage, and maintenance practices for diesel vehicles. Maintenance costs for parts and labor for emissions related work were also obtained.

A review of existing I/M programs in other states was conducted for the purpose of obtaining information, which could be useful in developing alternatives for a heavy-duty diesel program. Emission testing of diesels must be conducted with the engine under load to be effective. Capital costs are higher than the more common idle tests used on gasoline powered vehicles. Less costly and less adequate alternatives are also identified. A pilot program with testing of urban buses under transient or steady loading could provide the basic data necessary for a comprehensive evaluation of the benefits and costs of a larger I/M program for heavy-duty diesels.

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1.0 SUMMARY

1.1 Objectives and Information Sources

The Clean Air Act Amendments of 1977 require states having air quality control regions in which National Ambient Air Quality Standards will not be attained by 1982 to submit state implementation plans which include a mandatory emission inspection and maintenance (I/M) program for motor vehicles. California's current I/M programs exempts heavy-duty diesel vehicles (over 6000 pounds gross vehicle weight GVWR) from inspection. As diesel engines are known to emit appreciable quantities of oxides of nitrogen and particulates, there is concern over whether continued exemption of heavy-duty diesel-powered vehicles will jeopardize attainment of the ambient standards, despite implementation of an expanded I/M program for gasoline- and light-duty diesel-powered vehicles. The California State Air Resources Board (ARB) is planning to estimate the potential emission reduction benefits of an I/M program for heavy-duty diesel vehicles. To estimate the costs as well as the benefits, it is necessary to have information on the size and characteristics of the heavy-duty diesel truck population operating in California; the type of maintenance which these vehicles normally receive; the form which an appropriate I/M program might take; and the cost of such a program.

The objectives of this study are to characterize the diesel fleet operations in California and classify them by size and ownership; to estimate the average annual vehicle miles traveled by each class of vehicle; to determine what constitutes routine and major maintenance practice; to estimate costs of maintenance; and to define and evaluate alternative realistic I/M programs. This information was obtained from several sources including files of the California Department of Motor Vehicles, questionnaires sent to registered owners, discussions with the staff of repair facilities and review of existing I/M programs in other states.

1.2 Findings

There are nearly 210,000 heavy-duty diesel powered vehicles base-plated in California and about 34,000 base-plated in other states, but registered to operate part of the time in California. Of the 210,000 based in California 93,400 are also pro-rated, meaning that they operate in other states, as well as in California.

There are a wide variety of types and sizes of registered vehicles, but the three most prevalent are tractors at 73%, buses at 6.5% and dump trucks at 6%. Each of the other types are 3% or less. For California based tractors, 62% are pro-rated while only 42% of the buses are. Virtually none of the other types of vehicles base-plated in California are pro-rated. Most of the heavy-duty diesels had gross vehicle weight ratings (GVWR) over 19,500 pounds.

Smaller fleets (consisting of 50 or fewer vehicles) were an order of magnitude more numerous than all the larger ones. In contrast a few large fleets have thousands of diesel powered vehicles. Identifiable owner-operators of heavy-duty diesels numbered almost 3800, but the actual number is many times higher. A large number of individual owner-operators act as agents for large van lines or otherwise under an umbrella organization for business purposes. Registration may occur under a common company name, but the vehicle maintenance or other aspects of their usage may not be similar.

Over 50% of the California-based diesels were four years old or less and 12% were ten years old or more. Bus fleets owned by school or transit districts typically had at least some older units ranging up to 20 years old or more.

Annual mileage for school and transit district buses ranged from roughly 10,000 to over 50,000 miles annually with the school buses reporting the lower mileage and transit district buses the higher. Cross-country bus fleets reported 12,000 to 140,000 miles per year with the high value being the annual mileage of a large fleet of about 2000 buses. The annual mileage reported for tractors and vans shows a wide range of values depending on use. However, for the numerically prevalent large vehicles (over 19,500 pounds) the annual mileage commonly reported was in the 50,000 to 100,000 miles range.

Lube and oil service, air and fuel filter changes, and servicing of the injectors and turbochargers were the maintenance areas addressed in the questionnaire. Responses to cost of servicing were widely dispersed. Costs were divided about equally between parts and labor for most services and generally were higher for larger vehicles. Injector service was in general the most expensive ranging up to $830 for parts and labor. However, turbocharger service was comparable for vehicles with GVWR over 33,000 pounds. Both fuel and filter changes generally cost less than $50 for parts and labor, but were reported near $100 for large tractors in two fleets. Several respondents indicated mileage of 50,000 to 100,000 miles or more between air filter services on large tractors and vans. This could contribute to higher emissions, if the air flow becomes partially blocked between changes.

Review of existing I/M programs in other states provided an indication of costs of operating programs, but heavy-duty diesel inspection activity, was rare and consisted of opacity tests only. In order to realistically test a diesel vehicle for the emissions of primary interest, oxides of nitrogen, hydrocarbons and particulates, the engine must be loaded, which usually requires a significant capital investment and more time per test than is customary for passenger vehicles. The large variety of heavy-duty diesel vehicle configurations further exacerbates the testing difficulty. A model I/M program for transit district and school buses is recommended as the next step in assessing the cost-benefit tradeoff of a heavy-duty diesel inspection program. Since they typically operate in highly populated air basins, have a duty cycle of many stops and starts, and constitute a readily identifiable group, evaluation of a model program would be very informative. Preliminary estimates of the cost of an inspection are given in Section 5.

1.3 Conclusions

Loaded mode testing on a vehicle dynamometer is the approach of choice for a thorough I/M program for heavy-duty diesels. The capital and operational costs would be higher than for autos and therefore a pilot program for transit and school district buses is recommended, as a means of validating costs and benefits in an urban area, such as the South Coast Basin. The cost per vehicle for inspection could be expected to be in the 12 to 15 dollar range, but the cost of needed repairs might be high and difficult for owners to accept, especially for older vehicles.

Alternatively, visual inspection of components is not generally revealing and opacity tests at idle or higher rpm without loading could be expected to identify only the very worst emitters of particulates. An opacity test with the vehicle loaded is somewhat better, but will miss many vehicles emitting excessive oxides of nitrogen or carbon monoxide.

While not as numerous as diesel tractors, urban buses may produce an important contribution of pollutants for several reasons:

(1) The operate daily within densely populated ares, which have high pollution levels.

(2) Their duty cycle of many stops and starts is likely to produce higher emission rates than other diesel vehicles.

(3) Many school and transit district buses are old and in some instances major engine maintenance may be postponed until absolutely necessary, or the vehicle is sold.

This group of vehicles is easily identified (small number of large fleets) and therefore may be easier to study.

Although not specifically addressed by this study, fuel quality including the presence of water at the time of injection into the engine could be a very important factor in reducing emissions statewide. This reduction comes about through reduced release of contaminants at the time of combustion and, in the longer run, through reduced wear of the injector nozzles. The hygroscopic nature of diesel fuel makes water content an important parameter of fuel quality. The quality of fuel supplies is generally expected to deteriorate in the coming years. Requirements on fuel quality at distribution points and/or fuel filtering systems on vehicles could alleviate this problem.

2.0 BACKGROUND, OBJECTIVES AND APPROACH

In California, as in most of the U.S., heavy-duty, diesel-powered vehicles constitute an important and very active segment of the transportation industry. For California this is indicated by the large quantities of diesel fuel sold in the State. These are summarized in Table 2-1 for the past ten years together with gasoline sales for the same period. In addition to the magnitude of diesel fuel sales being large, it is also increasing faster than gasoline sales. The ratio of diesel to gasoline volumes was less than 0.07 in 1971 and last year it was over 0.10. Combustion of over a billion gallons of diesel fuel can lead to emissions of hundreds of thousands of tons of hydrocarbons, oxides of nitrogen and carbon monoxide. Although an exact figure is not available, it is commonly accepted that well over 90% of the diesel fuel sold in the State for on-road vehicles is used in heavy-duty vehicles.

California certifies diesel engines to assure compliance with emission standards. The current standards are 1.0 gram per brake horsepower-hour (g/bhp-hr) hydrocarbons (HC), 25 g/bph-hr carbon monoxide (CO) and 6.0g/bhp-hr HC plus oxides of nitrogen (NO_x). The 1980 results for California Certification of diesels were obtained from 13-mode dynamometer testing. For 16 engine families, the HC, CO and NO_x emissions were 0.5, 2.2 and 4.76 g/bhp-hr, respectively. These emission rates are presently acceptable, but more stringent standards of 0.5 g/bhp-hr for HC, and 4.5 g/bhp-hr for HC plus NO_x are set for 1984. However, there is presently no means for assuring the engine certification values are at or near the emissions actually emitted by vehicles after they have been in use for some time.

2.1 Objectives

Heavy-duty diesel powered vehicles 6001 pounds (gross vehicle weight rating, GVWR) and over are presently exempt from the Mandatory Vehicle Inspection Program in California. As the emissions from light-duty vehicles are more stringently controlled, the emissions, especially oxides of nitrogen and particulates, from heavy-duty diesels may become a more significant component of the air pollution problem. It is the purpose of

Table 2-1. Gasoline and Diesel Fuel Sales in California (Cole, 1981)

Year	Gasoline (Gal x 10^6)	Diesel (Gal x 10^6)
1971	9,401	647
1972	10,040	701
1973	10,356	776
1974	9,906	761
1975	10,237	779
1976	10,756	867
1977	11,328	910
1978	11,878	1073
1979	11,540	1163
1980	11,228	1155

this study to develop information and data to enable the California Air Resources Board (ARB) to effectively assess the potential benefits of an inspection program for heavy-duty diesel vehicles (HDDV) and to define some alternatives for a program of this type. Specifically the objectives of this study are to:

- Determine the number of fleet operations in California.
- Estimate the annual average vehicle miles by each class of vehicle.
- Determine what constitutes routine and major maintenance practices and their costs.
- Define and evaluate realistic alternative I/M programs.

2.2 Approach

Early in the planning of this study, it was recognized that the files of the California Department of Motor Vehicles (DMV) could provide a great deal of information on vehicle types, fleet sizes, ownership and other parameters of interest, and also provide the basis for sampling by questionnaire in order to obtain more specific data. Working together with the staff of the DMV, computer tapes containing data edited from the current (August 30-31, 1980) DMV master file were obtained. Data tapes containing the commercial, exempt and personalized (enviornmental) registrations of diesel-powered vehicles with a GVWR over 6000 pounds were received and constituted the available data base for analysis by computer. There were nearly 209,000 California based heavy-duty diesels with commercial and exempt registrations and 1045 with custom environmental plates. The environmental plated vehicles were eliminated from further analysis because the cost and complexity they could add to the computer manipulation was large by comparison to the importance of the information to be gained.

The computerized data files were sorted after considerable computational effort, and the fleets for sampling were selected. There were approximately 13,000 oversized records, which were not amenable to efficient computer analysis. These were countable to the extent that they could be included in the fleet size results, but were not otherwise analysed. The sorting was then accomplished on the remaining records only after eliminating irrelevant data in each file, reformatting the entries and separating the registrations into two groups: one, which had been assigned fleet numbers by the DMV and a second, which had not. The DMV fleet numbers are the result of an in-process effort by the DMV to streamline registration of fleets. Approximately half of the computerized registrations had been asigned DMV fleet numbers, while the other half had not. Large and small fleets appeared in both of the groupings and there were no distinguishing characteristics for registrations to appear in the DMV fleet numbered set or in the set without fleet numbers. A sample of one of these groups, printed from the microfische output, is shown as Exhibit 1.

The DMV also maintains a hard-copy (non-computerized) file of prorated registrations which are for vehicles base-plated in other states, but making regular, albeit partial, use of California roads. Exact figures for this registered group are not available, but DMV estimated that there were almost 200,000 units of which 100,000 were powered (others are trailers) and a large fraction of these are diesels (Lyday, 1980). Our own estimate was only about 34,000 units were diesel powered. These files were examined and sampled by requesting the files of fleets which were large, medium and small from cognizant DMV staff. Approximately fifty fleets ranging from a single powered vehicle up to several thousand vehicles were identified in this manner and made part of the sample for further study.

A questionnaire was prepared by SAI and reviewed by ARB. It addressed the areas of the number of vehicles owned, type, age, GVWR classiffication, usage, and maintenance practices and costs. A copy of the questionnaire and the cover letter, which was from the ARB, are contained in the Appendix. Over 150 of the questionnaires were mailed to a sample of registered owners selected from those based in California (approximately 100) and those based in other states (approximately 50). Follow-up telephone contacts were used, whenever a response was not received or was incomplete or confusing. A total of about 60 questionnaires with varying degrees of completeness were finally collected. Supplemental information

Exhibit 1

Sample of DMV File Reformatted and Printed on Microfiche

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ALPHA BETA ACME MKTS 777 S HARBOR BL 6891     LA HACRA 90631 TFH92AV596087  30 GMC  731101 3 14260 G TRAC
ALPHA BETA ACME MKTS 777 S HARBOR BL 6684     LA HABRA 90631 TFH92AV599040  30 GMC  730000 3 14900 G TRAC
ALPHA BETA ACME MARKETS INC 999 MONTAGUE EXPWY     MILPITAS 95035 TFH92AV592858  43 GMC  730000 2 12060 G TRAC
ALPHA BETA ACME MARKETS INC 777 S HARBOR BL    6750     LA HABRA 90631 FH92AA178857  30 GMC  710000 3 14400 G TRAC
ALPHA BETA ACME MARKETS 777 S HARBOR BL 6690     LA HABRA 90631 TFH92AV600462  30 GMC  740000 2 14820 G TRAC
ALPHA BETA CO 777 S HARBOR BL 6902     LA HABRA 90631 TFH92AV521542  30 GMC  000000 2 12520 G TRAC
ALPHA BETA CO 777 S HARBOR BL 6901     LA HABRA 90631 TFH92AV521534  30 GMC  000000 2 12420 G TRAC
ALPHA BETA CO 777 S HARBOR BL 6562     LA HABRA 90631 TDH92AV533993  30 GMC  000000 3 14640 G TRAC
ALPHA BETA CO 777 S HARBOR BL 6564     LA HABRA 90631 TDH92AV534005  30 GMC  000000 3 14560 P TRAC
ALPHA BETA CO 777 S HARBOR BL 6565     LA HABRA .0631 TDH92AV534015  30 GMC  000000 3 14680 G TRAC
ALPHA BETA CO 777 S HARBOR BL 6566     LA HABRA 90631 TDHS   533990  30 GMC  000000 3 14520 G TRAC
ALPHA BETA COMPANY 777 S HARBOR BL 6571     LA HABRA 90631 TDH92AV533286  30 GMC  000000 3 14620 G TRAC
ALPHA BETA COMPANY 777 S HARBOR BL 6563     LA HABRA 90631 TDH92AV533997  30 GMC  000000 3 14320 G TRAC
ALPHA BETA CO 777 S HARBOR BL 6568     LA HABRA 90631 TDH92AV533980  30 GMC  000000 3 14900 G TRAC
ALPHA BETA CO 777 S HARBOR BL 6569     LA HABRA 90631 TDH92AV533928  30 GMC  000000 3 14980 G TRAC
ALPHA BETA CO 777 S HARBOR BL 6900     LA HABRA 90631 THD92AV534004  30 GMC  000000 3 14780 G TRAC
ALPHA BETA CO 777 S HARBOR BL 6899     LA HABRA 90631 TDH92AV534026  30 GMC  000000 3 14700 G TRAC
ALPHA BETA CO 777 S HARBOR BL 6570     LA HABRA 90631 TDH92AV533979  30 GMC  000000 3 14520 G TRAC
ALPHA BETA CO 777 S HARBOR BL 6567     LA HABRA 90631 TDH92AV533971  30 GMC  000000 3 14920 G TRAC
ALPHA BETA CO 777 S HARBOR BL 6907     LA HABRA 90631 TFH92AV521537  30 GMC  000000 2 12460 G TRAC
ALPHA BETA CO 777 S HARBOR BL 6908     LA HABRA 90631 TFH92AV521556  30 GMC  000000 2 12560 G TRAC
ALPHA BETA CO 777 S HARBOR BL 6906     LA HABRA 90631 TFH92AV521573  30 GMC  000000 2 12640 G TRAC
ALPHEUS RICHARD H OR DONNA LEE PO BX 824     RED BLUFF 96080 139832  52 KENWO  740712 3 17620 L LGBK
ALPHA BETA ACME MARKETS INC 777 S HARBOR BL 6723     LA HABRA 90631 FH92AA165734  30 GMC  700000 2 12240 G TRAC
ALPHA BETA ACME MARKETS INC 777 S HARBOR BL 6716     LA HABRA 90631 FH92AA162552  30 GMC  700000 2 12560 G TRAC
ALPHA BETA ACME MARKETS INC 777 S HARBOR BL 6724     LA HABRA 90631 FH92AA171657  30 GMC  700000 2 12660 G TRAC
ALPHA BETA ACME MARKETS INC 777 S HARBOR BL 6737     LA HABRA 90631 FH92AA178867  30 GMC  710000 2 12540 G TRAC
ALPHA BETA AMCE MARKETS INC 777 S HARBOR BL    6633     LA HABRA 90631 FH92AA142185  30 GMC  700319 2 11820 G TRACFH9642A
ALPHA BETA ACME MARKETS INC 777 S HARBOR BL    6634     LA HABRA 90631 FH92AA142215  30 GMC  700319 2 11760 G TRACFH9642A
ALPHA RECYCLING INC 13316 SATICOY ST     N HOLLYWOOD 91605 75025M  19 PETRB  740909 3 20580 D REFUSE
ALPHA BETA ACME MKTS INC 777 S HARBOR BL    6698     LA HABRA 90631 FW964CAD2005J  30 GMC  670000 3 12900 G ZC67TRAC
ALPHA BETA ACME MARKETS 777 S HARBOR    6746     LA HABRA 90631 FH92AA200999  30 GMC  710000 3 14540 G TRAC
ALPINE PRODUCE CO PO BX 909     GONZALES 93926 CA112HL040887  27 WFTLN  690423 2 11720 G TRAC
ALPINE TRUCKING CO 350 W WAKEFIELD RD     STOCKTON 95.  CA214HL057391  39 WFTLN  710828 3 13800 G TRAC
ALPINE MEADOWS OF TAHOE INC PO BX AM     TAHOE CITY 95730 PD41061408  31 GMC  000000 2 21420 B BUS
ALPINE HAY MARKET 2500 PETALUMA BL N     PETALUMA 94952 19591  49 PETRB  650000 2 11650 G ZC65TRAC
ALPINE PACKING CO 350 W WAKEFIELD RD     STOCKTON 95210 D70VUF92544  39 FORD  691023 3 15800 R REFC7000
ALPINE HAY MARKET 2500 PETALUMA BL     PETALUMA 94952 AP14621  49 WFTLN  650000 2 10960 G ZC65TRAC
ALPINE PACKING CO 350 W WAKEFIELD RD     STOCKTON 95210 D7C9VX29740  39 FORD  750902 3 17700 R REF
ALPINE PRODUCE CO PO BX 909     GONZALES 93926 22947CYB15279  27 INTL  730518 2 12600 G TRACTOR
ALPINE DRAINAGE SYSTEMS INC PO BX 847     ALPINE 92001 43747FYB11435  37 INTL  751126 3 19730 D DMP
ALPINE TRUCKING CO 350 W WAKEFIELD RD     STOCKTON 95210 CA513HL126329  39 WFTLN  761122 3 18570 Y VARIED
ALPINE TRUCKING INC 350 W WAKEFIELD RD     STOCKTON 95210 CA213HL161846  39 FRGHT  790102 3 15340 G TRACTOR
ALPINE DRAINAGE SYSTEMS INC PO BX 847     ALPINE 92001 21944  37 INTL  711020 3 18000 D DMP
ALPINE TRUCKING CO 350 W WAKEFIELD RD     STOCKTON 95210 CA213HL165287  39 FRGHT  800000 3 15420 G TRACTOR
ALPINE LUMBER/NURSERY PO BX 309     ALPINE 92001 T17DDAV569126  37 GMC  800000 2 12700 F FB
ALPINE MEADOWS TAHOE INC PO BX AM     TAHOE CITY 95730 21620  31 PETRB  000000 3 20600 D DMP
ALPINE CO RD RT 1 BX 37     MARKLEEVILLE 96120 113077  02 KENWO  000000 3 17810 D DMP
ALPINE CO PUB WKS DEPT ROUTE 1 BX 37     MARKLEEVILLE 96120 RM6864X1150  02 MACK  800000 2 40040 Y VARIED
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ALPS PRODUCE INC PO BX 428     WEAVERVILLE 96093 K121218302  53 KENWO  750000 2 12760 G TRAC
ALPS PRODUCE INC PO BX 428     WEAVERVILLE 96093 121154P  53 PETRB  800000 3 15220 G TRACTOR
ALS TOWING SERVICE 12301 E WARDMAN ST 9     WHITTIER 90602 AP12853  19 RECON  640000 3 15000 Y TOWCAR
ALS GARDEN ARTS INC 2110 TYLER     EL MONTE 91733 CG5388125444  19 CHEV  680000 2 08960 F STK52003
ALS TOWING SERVICE 12301 E WARDMAN ST 5     WHITTIER 90602 HN90A4098316  19 GMC  690000 2 11320 G TRACTOR
ALS SEPTIC TANK SERVICE PO BX 806     ANDERSON 96007 CA513HP073740  45 WFTLN  000000 3 20500 F FB
ALSCO INC PO BX 1330     RED BLUFF 96080 45744P  52 PETRB  720418 2 11220 G TRAC
ALSCO INC PO BX 1330     RED BLUFF 96080 118794  52 KENWO  000000 2 11350 G TRACTOR
ALSCO INC PO BX 1330     RED BLUFF 96080 24977  52 PETRB  670000 2 10800 G TRAC
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ALSCO INC PO BX 1330     RED BLUFF 96080 HB60061  52 KENWO  470000 3 30120 G TRACTOR
ALSCO INC PO BX 1330     RED BLUFF 96080 K70BVY69962  52 FORD  000000 2 08230 Z CRANE
ALSPAW DARREL 1230 ARTHUR AVE     BAKERSFIELD 93308 AP25034  15 WFTLN  670000 2 10780 G TRAC
ALSPAW TRANSPORTATION 1230 ARTHUR AVE     BAKERSFIELD 93308 L3590  15 PETRB  560000 3 16670 F ZD56FB
ALSTON KATHLEEN LOUISE 853 W REACH     INGLEWOOD 90302 E36424H  19 INTL  650000 3 18410 F FB
ALT DAVID LYNN 1062 ELLEN LN     EL CAJON 92021 Y00XU451252  37 FORD  630000 2 13410 G ZC63TRAC
ALT DAVID L OR EVELYN Y 1062 ELLEN LN     EL CAJON 92021 28610  37 PETRB  000000 2 13140 G TRACTOR
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ALTA BUILDING MATERIALS CO 2857 HANNAH ST 202     OAKLAND 94608 RL763LT6085  01 MACK  700217 2 11180 G TRACRL763LT
ALTA CONCRETE PIPE CO 42591 ROAD 80     DINUBA 93618 CC413HM010157  54 WHITE  690626 3 12220 N MIXRWFH6264
ALTA CONCRETE PIPE CO 42591 ROAD 80     DINUBA 93618 CC413HM010152  54 WFTLN  690821 3 12280 N MIXRWFH6264
ALTA BUILDING MATERIAL CO 2857 HANNAH ST 31     OAKLAND 94608 757951G3525089  01 INTL  690710 3 17480 D DMPF2050A
ALTA BUILDING MATERIAL CO 2857 HANNAH ST 130     OAKLAND .608 37710TG3780190  01 INTL  691118 3 12660 N TRMXM623
ALTA EQUIPMENT/LAND LEASE CO INC PO BX 730     VACAVILLE 95688 227951C067571  48 INTL  710505 2 10960 D SPRB
ALTA BUILDING MATERIAL PO BX 3200     ANAHEIM 92803 RL685LS119C  30 MACK  720000 3 12880 N TRMX
ALTA RUBBISH HAULING SERVICE 528 N TAYLOR AVE APT 201     MONTEBELLO 90640 DLW7013N4001L  19 GMC  630000 3 18520 D TRBY
ALTA DENA DAIRY 367 S HAMBLEDON AVE     CITY INDUSTRY 91744 CA113HL078023  19 WFTLN  730313 3 13150 G TRAC
ALTA BUILDING MATERIAL 2857 HANNAH ST     OAKLAND 94608 853S1541  01 MACK  640000 3 16540 F FB
ALTA DENA CERTIFIED DAIRY 637 S HAMBLEDON AVE     CITY INDUSTRY 91744 CDH930V190973  19 CHEV  730000 3 15050 G TRAC
ALTA DENA DAIRY 17637 E VALLEY BL     CITY INDUSTRY 91744 CB113HP098540  19 WFTLN  751022 3 17530 G TRACTOR
ALTA DENA DAIRY 637 S HAMBLEDON AVE W103     CITY INDUSTRY 91744 TDH925V557089  19 GMC  760312 3 14720 G TRAC
ALTA DENA DAIRY 637 S HAMBLEDON AVE W104     CITY INDUSTRY 91744 TFH925V582379  19 GMC  750330 2 12170 G TRAC
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ALTADENA DAIRY 637 S HAMBLEDON     CITY INDUSTRY 91744 TDC925V596740  19 GMC  770506 3 15760 G TRAC
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ALTA DENA DAIRY 637 S HAMBLEDON AVE     CITY INDUSTRY 91744 CA113HL172698  19 FRGHT  790502 3 14050 G TRACTOR
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ALTA DENA DAIRY 637 HAMBLEDON     CITY INDUSTRY 91744 R70BVB82443  19 FORD  790000 2 18130 V VAN
ALTA DENA DAIRY 637 HAMBLEDON     CITY INDUSTRY 91744 R70BVB82441  19 FORD  790000 2 18110 V VAN
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ALTA DENA DAIRY 637 HAMBLEDON AVE     CITY INDUSTRY 91744 TDC928V609107  19 GMC  790000 3 15360 G TRACTOR
ALTA DENA CERTIFIED DAIRY *N1703069 17637 VALLEY BL     CITY INDUSTRY 91744 T49KCAV596096  19 GMC  800000 3 15070 G TRACTOR
ALTA DENA CERTIFIED DAIRY *N1703070 17637 VALLEY BL     CITY INDUSTRY 91744 T49KCAV596097  19 GMC  800000 3 15030 G TRACTOR
ALTA DENA DAIRY 367 S HAMBLEDON AVE     CITY INDUSTRY 91744 CA113HL078023  19 WFTLN  730313 3 13150 G TRAC
ALTA BUILDING MATERIAL 2857 HANNAH ST     OAKLAND 94608 853S1541  01 MACK  640000 3 16540 F FB
ALTA DENA DAIRY 17637 E VALLEY BL     CITY INDUSTRY 91744 CA513HL090783  19 WFTLN  740102 3 19890 D DMP
ALTA DENA DAIRY 637 S HAMBLEDON     CITY INDUSTRY 91744 CA113HL099341  19 WFTLN  740604 3 13240 G TRAC
ALTADENA DAIRY 637 S HAMBLEDON AVE     CITY INDUSTRY 91744 Y035649  19 INTL  730000 3 14760 G TRAC
ALTERMATT DARREL DEE PO BX 2193     SAN RAFAEL 94902 29866  21 PETLT  000000 3 18920 Y MULTI
ALTFILLISCH GLADDEN INC 15536 E GALE     HACIENDA HTS 91745 R685AS14101  19 MACK  000000 3 24890 G TRACTOR
ALTFILLISCH/GLADDEN INC 15536 E GALE AVE     HACIENDA HTS 91745 W81CVR76314  19 FORD  730000 3 13230 G TRACTOR
ALTHOFF WALTER E 12635 FRANKLIN CT 3B     CHINO 91710 329471G284354  33 INTL  680000 2 12460 G TRACTOR
ALTO BROS TRUCKING CO RT 1 BX 2660     EUREKA 95501 24185  12 PETRB  670000 3 14420 G TRACTOR
ALTO BROS TRUCKING RT 1 BX 2660     EUREKA 95501 103347  12 KENWO  640000 3 14360 G TRACTOR
ALTO BROS TRUCKING RT 1 BX 2660     EUREKA 95501 102111  12 KENWO  640000 3 14120 L TRAC
ALTO BROS TRUCKING RT 1 BX 2660     EUREKA 95501 AP13193  12 WFTLN  640000 3 14980 G TRACTOR
ALTO BROS TRUCKING RT 1 BX 2660     EUREKA 95501 103467  12 KENWO  640000 3 15490 D TRACTOR
ALTON L DOCKERY DBA ABLE CHARTER BUS CO 5986 JURUPA AVE     RIVERSIDE 92504 6421  33 MCI  000000 2 20760 B BUS
ALTON FRED D 3239 1/2 W 112TH ST     INGLEWOOD 90303 229471G470139  19 INTL  710000 2 11870 G TRACTOR
ALTO/SONS TRUCKING RT 1 BX 2660     EUREKA 95501 KON5PHJ543601  12 WWSTN  740000 3 14880 G TRACTOR
ALTO BROTHERS RT 1 BX 2660     EUREKA 95501 K5261  12 PETRB  640000 3 14720 G TRAC
ALTON DOCKERY DBA ABLE CHARTER BUS CO 5986 JURUPA AVE BX 4336     RIVERSIDE 92500 7114  33 SILVE  661220 3 28800 B BUS
ALTO BROS TRUCKING RT 1 BX 2660     EUREKA 95501 D2327EGA10920  12 INTL  750000 3 15610 G TRACTOR
ALTON ORLO WHITESIDE 27850 SOLEMINT RD     CYN COUNTRY 91350 22962  19 PETRB  660000 3 17250 D ZQ66DMP
ALTON DOCKERY DBA ABLE CHARTER BUS CO 5986 JURUPA AVE PO BX 4336     RIVERSIDE 92504 7074  33 SILVE  670000 3 28280 B BUS
ALTURAS CITY FR DEPT 218 W NORTH ST     ALTURAS 96101 D1225GG812432  25 INTL  760000 2 27690 Y FIRE
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on usage and maintenance was gathered through visits and discussions with maintenance personnel, the California State Board of Equalization, the Public Utilities Commission, DMV and others. The basis for stratification of the sample and the information obtained from these questionnaires are presented in Sections 3 and 4.

Existing inspection/maintenance (I/M) programs were reviewed from the literature and through contacts with congnizant state and contractor personnel. Cost information, alternative methods of conducting the programs and especially experience with heavy-duty diesels was sought. From this information some alternatives for California are defined and evaluated in Section 5.

3.0 CHARACTERIZATION OF THE HDDV POPULATION

Heavy-duty diesel vehicles (HDDV) constitute a very diverse group in terms of use and functional characteristics. The majority of HDDV are trucks used for commercial purposes, but school and transit districts have significant numbers of diesel buses.

The HDDV of interest in this study have GVWR over 6,000 pounds. In reporting production and sales data, the industry uses the following weight classification scheme.

Class	Weight (Pounds - GVWR)		
I	0	-	6,000
II	6,001	-	10,000
III	10,001	-	14,000
IV	14,001	-	16,000
V	16,001	-	19,500
VI	19,501	-	26,000
VII	26,001	-	33,000
VIII	33,001	and	over

This classification scheme was used in the design of the questionnaire (see Appendix). Class I was included for completeness, but is numerically insignificant. From data published by the Motor Vehicle Manufacturer's Association, most (over 90%) of the HDDV sold are in Class VI and higher. For many years the largest single category by a factor of five to ten has been Class VIII (MVFF, 1978).

Data presented in this section were obtained primarily from analysis of DMV files. Annual mileage, age of vehicles, new or used purchase and location of purchase information were taken from the responses to the questionnaires. (Most of the data from the questionnaires relate to maintenance practices and costs and are therefore presented in Section 4.) Other insights on the HDDV population in California were obtained from contacts in the industry.

3.1 Fleet Size and Types of Vehicles

As indicated in Section 2, the HDDV in use on California roads and streets are either base-plated in California or in other states. Many commercial carriers, which are regulated by the Interstate Commerce Commission, fall into this latter group. While the HDDV base-plated in California include many commercial carriers, other types of activities are well represented. The distribution of vehicle types base-plated in California is given in Figure 3.1. Tractors constitute the overwhelming majority (73%) and together with buses (6.5%) and dump trucks (5.8%) represent 85% of the total. The tabulation of the absolute numbers of vehicles in each category appears in Table 3-1. The total number shown in Table 3-1 does not include a number of vehicles in categories which are not very numerous, i.e., less than 1% of the total.

Of the 138,225 tractors base-plated in California 85,351 or 63% are pro-rated (operate in other state(s) in addition to California). Buses are considerably different with 7,803 or 63% of the 12,359 being in the exempt category, which means that they belong to school or transit districts. Virtually all of the remaining vehicle types are operated exclusively within the State, and are primarily non-exempt, which means they are used for commercial purposes. The dominance of the California HDDV fleet by tractors used in interstate commerce (not necessarily common carriers) is substantial and further enhanced by the non-California based fleets which are pro-rated to operate in the State. There are almost 190,000 vehicles in this group (Lyday, 1980). Of these many are trailers and some powered-units are gasoline. The registrations for these vehicles are not computerized, but are maintained by the DMV as conventional paper files. No precise estimates were possible for the vehicles in this group, but cognizant DMV staff believed about 100,000 of the registrations were for diesel-powered units. An independent estimate was made by assuming all of the vehicles in the out-of-state file were either diesel tractors or non-powered trailers, and that the ratio of trailers to tractors was the same as it is for California-based vehicles. This ratio was found to be 4.47 which gives a diesel population of almost 34,000 diesel tractors based out-of-state.

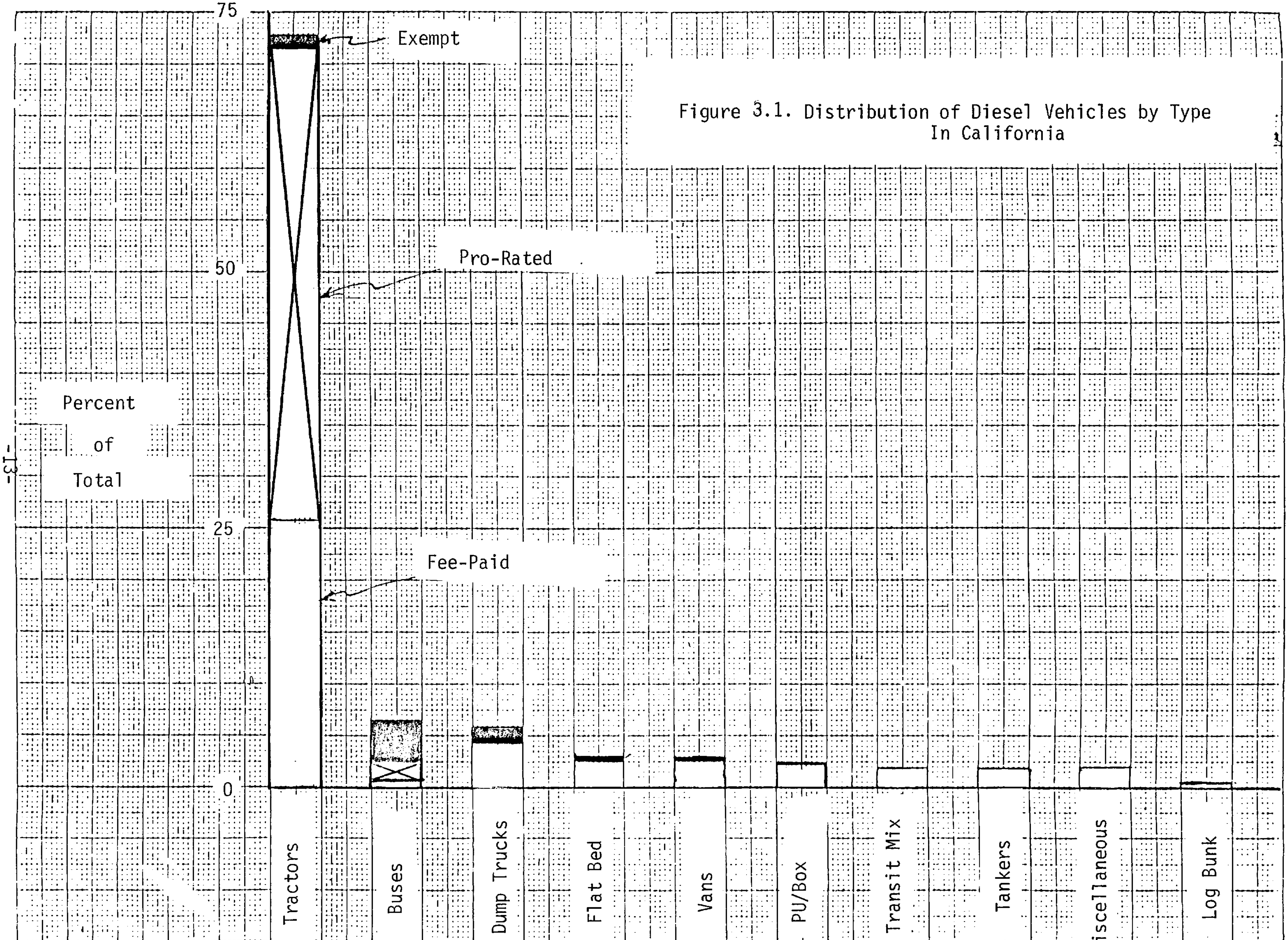


Figure 3.1. Distribution of Diesel Vehicles by Type In California

Table 3-1. Distribution of Diesel Vehicles by Type

Vehicle Type	Number
Tractors	138,225
Buses	12,359
Dump Trucks	11,063
Flat Bed	5,712
Vans	5,366
Pick Up/Box	4,405
Transit Mix	4,240
Tankers	4,106
Miscellaneous	4,046
Long Bunk	1,080
Total [1]	190,602

[1] Several DMV categories of vehicle types, such as panel delivery, refrigerated, special equipment, etc., are not included, but constitute an additional 5000 vehicles.

Overall fleet size information is presented in Figure 3.2 and in Table 3-2. Several caveats are important in understanding and using these data:

(1) Large fleets are not always what they seem to be, but sometimes are collectives of individual owner-operators flying a common banner for business purposes, but not having similar maintenance or usage. For example, some large van lines and others lease the vehicles from their agents (vehicle owners).

(2) Some large fleets are involved in long-distance hauling and consequently are serviced at a variety of service centers just as if they were individually owned and operated.

(3) Diesel vehicles may be part of larger fleets of non-diesel vehicles. Some bus fleets are examples of this situation.

For these reasons the spectrum of fleet sizes obtained is not precise, but should be considered as an estimate of the HDDV population operating in California.

In sampling from the population for the questionnaire survey, one of the goals was to have representation from each of the different sized fleets. Individual owner-operators in particular were sought and over 30 of the questionnaires were addressed to apparent candidates. The smallest fleet responding had three diesel vehicles. A histogram of the responses received versus fleet size is shown in Figure 3.3. As will be seen in Section 4, maintenance practices and costs are not correlated with fleet size.

3.2 Annual Mileage and Age of Vehicles

From Table 3-3, the annual mileage reported for school and transit district ranges from 10,000 up to 50,000 miles. Several of the respondents reported the same annual mileage for buses in all weight classifications in their fleet. In general the mileage does not correlate with the weight classification for buses. Most of the school buses fell into the lower end of the range (10,000 to 20,000 miles) and all of the transit district buses received more usage and were in the 20,000 to 50,000 mile range.

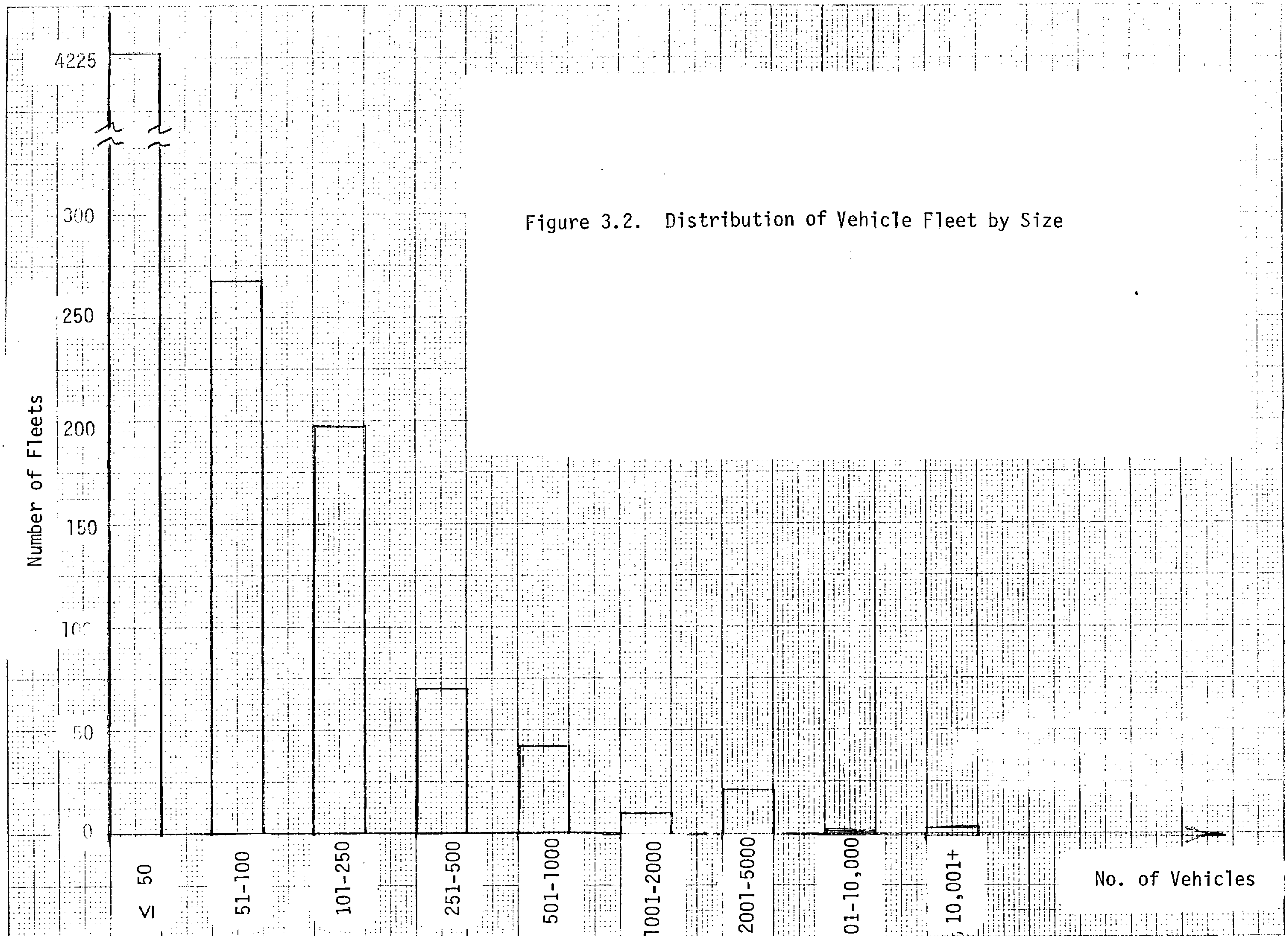


Figure 3.2. Distribution of Vehicle Fleet by Size

Table 3-2. Number of HDDV by Fleet Size

Fleet Size	No. of Vehicles [1]
Identifiable Owner-Operators (Single HDDV)	3,762
2 - 50	14,816
51 - 100	15,839
101 - 250	29,048
251 - 500	23,727
501 - 1,000	29,271
1,001 - 2,000	12,113
2,001 - 5,000	59,279
5,001 - 10,000	7,155
10,001 +	13,634
Total	208,644

[1] About 13,000 vehicle records, which were oversize, were countable for inclusion in fleets, and are presented here, but were not amenable to computer analysis for other groupings, such as vehicle type.

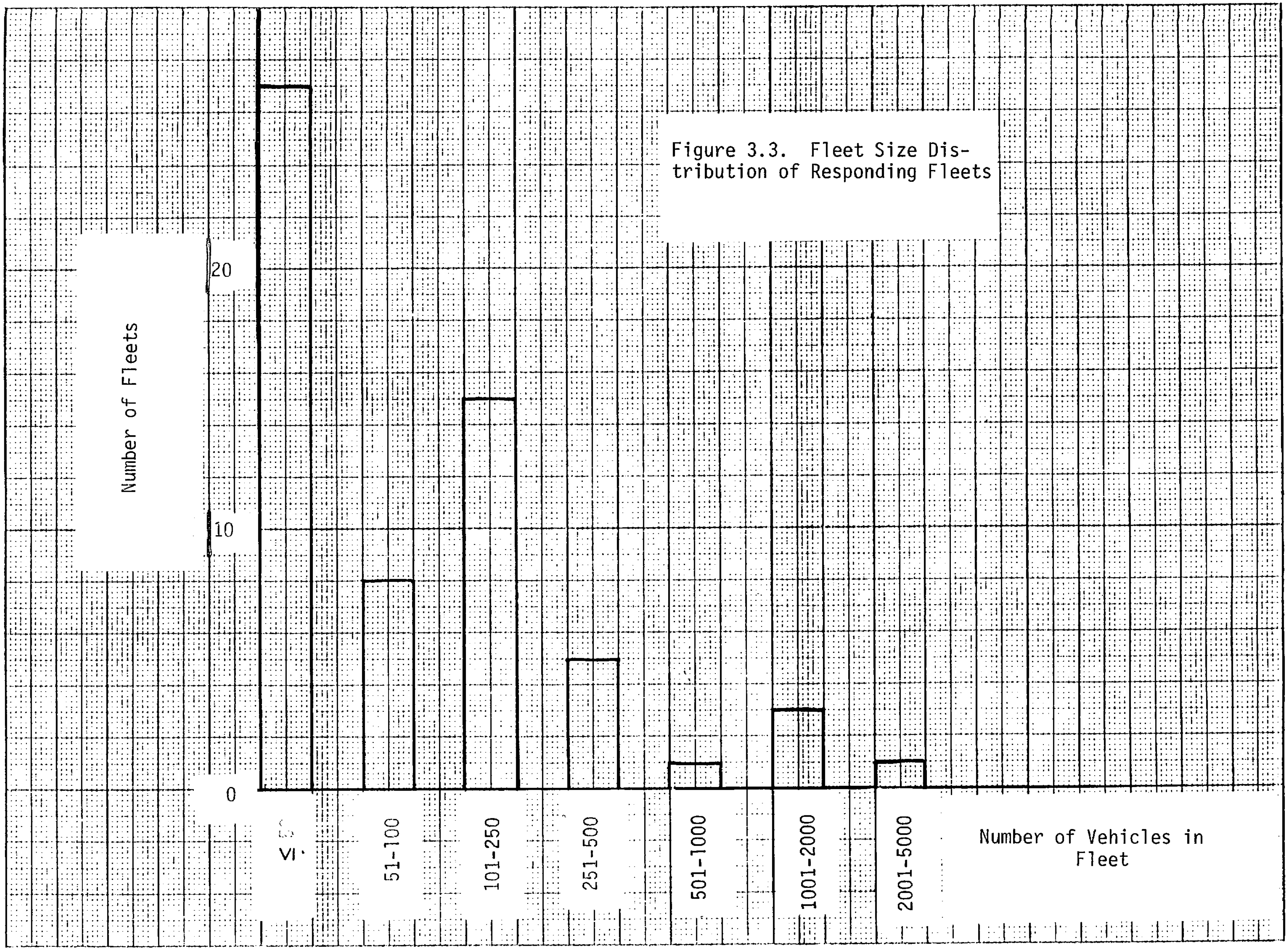


Figure 3.3. Fleet Size Distribution of Responding Fleets

Table 3-3 Annual Mileage and Average Age for School, Transit District and Other Buses

WEIGHT CLASS	SCHOOL AND TRANSIT DISTRICT BUSES				INTRA-STATE AND INTERSTATE BUSES			
	NUMBER OF VEHICLES	AVERAGE ANNUAL MILEAGE	AVERAGE AGE (Yrs)	PERCENT DRIVEN IN STATE/OUT OF STATE	NUMBER OF VEHICLES	AVERAGE ANNUAL MILEAGE	AVERAGE AGE (Yrs)	PERCENT DRIVEN IN STATE/OUT OF STATE
II	--	30,000	6	100/0				
III	8	38,539	16	100/0				
	3	30,000	20	100/0				
IV	6	38,539	11	100/0				
V	606	38,539	20	100/0				
	1	10,000	--	100/0				
	34	20,000	1	100/0				
	15	20,000	7	100/0				
VI	1905	38,539	13	100/0	32	65,000	7	85/15
	16	11,513	8	100/0	2	11,837	19	100/0
	124	30,156	--	100/0				
	82	12,000	--	100/0				
	286	12,000	--	100/0				
	--	50,000	--	100/0				
	22	14,450	14	100/0				
VII	200	38,539	3	100/0	60	15,000	20	100/0
	13	20,000	--	100/0	248	42,766	9	100/0
	17	11,513	26	100/0				
	8	67,090	8	100/0				
	--	50,000	--	100/0				
VIII	32	38,539	4	100/0	1976	142,596	6	25/75
	8	20,000	--	100/0	10	31,720	2	100/0
	5	11,513	10	100/0				
	497	--	3	100/0				
	3	28,233	8	100/0				
	107	--	--	100/0				
	625	12,000	--	100/0				
	8	20,000	--	100/0				

Intra-state and inter-state buses were identified as those fleets which logged 80% or more of their mileage in these modes. From Table 3-3, the total annual mileage is seen to be large, especially for one fleet of inter-state buses which averaged over 140,000 miles on its 2,000 buses. Seventy-five percent of these miles were accumulated in inter-state travel.

The variability of annual mileage represented for tractors and vans was large and was not readily correlated with size of fleet, but was generally greater for vehicles in the heavier GVWR classifications (see Table 3-4). Virtually none of the tractors or vans were reported to operate 80% or more as intra-city vehicles, but many did operate exclusively within the state.

The pro-rated vehicles are evident from the mileage split in-state and out-of-state. The fleets based in other states are flagged by asterisks. In either case these vehicles are almost exclusively in GVWR classification VIII. A systematic difference in the mileage driven in California by the vehicles based in California or in other states is not evident from the responding sample.

The age of all commercial diesels registered in California is presented as a histogram in Figure 3.4, and tabulated in Tables 3-3 and 3-4 for the respondents to the questionnaire. Overall 50% of the California-based vehicles are four years old or less and 12% are ten years old or more. From the survey results, it was found that many school and transit district buses are older, ranging up to 20 years or more in some cases. One of the reasons for this, besides economics, is that the load usually moved by a bus is relatively light by comparison with a tractor or other types of heavy-duty diesels. This results in less wear and leads to longer vehicle life.

Table 3-4 Annual Mileage and Average Age for Tractors and Vans

WEIGHT CLASS	TRACTORS: NUMBER OF VEHICLES	TRACTORS: AVERAGE ANNUAL MILEAGE	TRACTORS: AVERAGE AGE (Yrs)	TRACTORS: PERCENT DRIVEN IN STATE/OUT OF STATE	VANS: NUMBER OF VEHICLES	VANS: AVERAGE ANNUAL MILEAGE	VANS: AVERAGE AGE (Yrs)	VANS: PERCENT DRIVEN IN STATE/OUT OF STATE
I	3	4,000	2	100/0				
	2	--	--	100/0				
	1	8,000	5	100/0				
II	10	15,000	2	100/0				
	4	25,000	11	100/0				
	7	7,000	1	100/0				
	12	75,678	--	100/0				
III	6	7,000	1	100/0	20	36,000	1	100/0
	34	45,000	--	100/0				
	186	43,000	7	100/0				
	15	45,000	6	100/0				
	23	100,000	--	10/90				
	738	--	5	--				
IV	6	125,000	--	0/100	60	--	2	100/0
	10	16,000	2	100/0				
	11	45,000	7	--				
	35	30,000	--	100/0				
	1	960	--	--				
	21	150,000	--	1/99				
	21	--	4	--				
V	5	132,000	--	0/100	7	--	--	--
	45	12,000	--	--				
VI	124	15,000	--	--	14	13,462	1.5	12/88*
	1	--	--	100/0	7	--	--	--
	17	60,000	3	--	1	1,000	--	--
	75	12,000	5	100/0	119	20,000	--	--
	3	60,000	--	--	30	--	--	--
	220	60,000	--	--				
	314	--	--	--				
	1	26,000	--	100/0				
	8	125,000	--	--				
	195	18,000	1	--				

Cont. Page 2

Table 3-4 Annual Mileage and Average Age for Tractors and Vans

WEIGHT CLASS	TRACTORS NUMBER OF VEHICLES	TRACTORS AVERAGE ANNUAL MILEAGE	TRACTORS AVERAGE AGE (Yrs)	TRACTORS PERCENT DRIVEN IN STATE/OUT OF STATE	VANS NUMBER OF VEHICLES	VANS AVERAGE ANNUAL MILEAGE	VANS AVERAGE AGE (Yrs)	VANS PERCENT DRIVEN IN STATE/OUT OF STATE
VII	16	52,000	--	96/4	7	--	--	--
	20	36,000	12	--	200	60,000	--	--
	624	15,000	3	--	6	6,000	--	--
	2	8,000	--	--				
	75	12,000	--	13/87*				
	1	32,000	3	--				
	8	15,000	4	83/17*				
	25	--	--	--				
VIII	447	100,000	7	60/40	384	34,110	--	--
	23	40,000	--	--	15	90,000	4	55/45
	14	100,000	6	80/20	112	140,000	3	10/90
	11	--	--	--	475	144,000	--	5/95*
	23	95,000	--	5/95*	13	22,400	--	--
	450	100,000	3	20/80	888	140,000	1.5	5/95*
	50	120,000	2	50/50	16	22,000	7	--
	184	68,311	7	18/82*	102	127,428	4	--
	12	125,000	4	--	892	150,000	--	6/94*
					12	300,000	--	--
					163	17,209	2.9	34/66*
					149	96,000	8	15/85
					20	16,000	5	--
					64	--	--	--
					29	--	--	85/15
					16	--	5	--
					61	60,000	8	--
					139	13,000	4	--
					21	6,000	--	15/85*
					602	140,000	--	--

*Pro-Rated Vehicles, Based Out-of-State

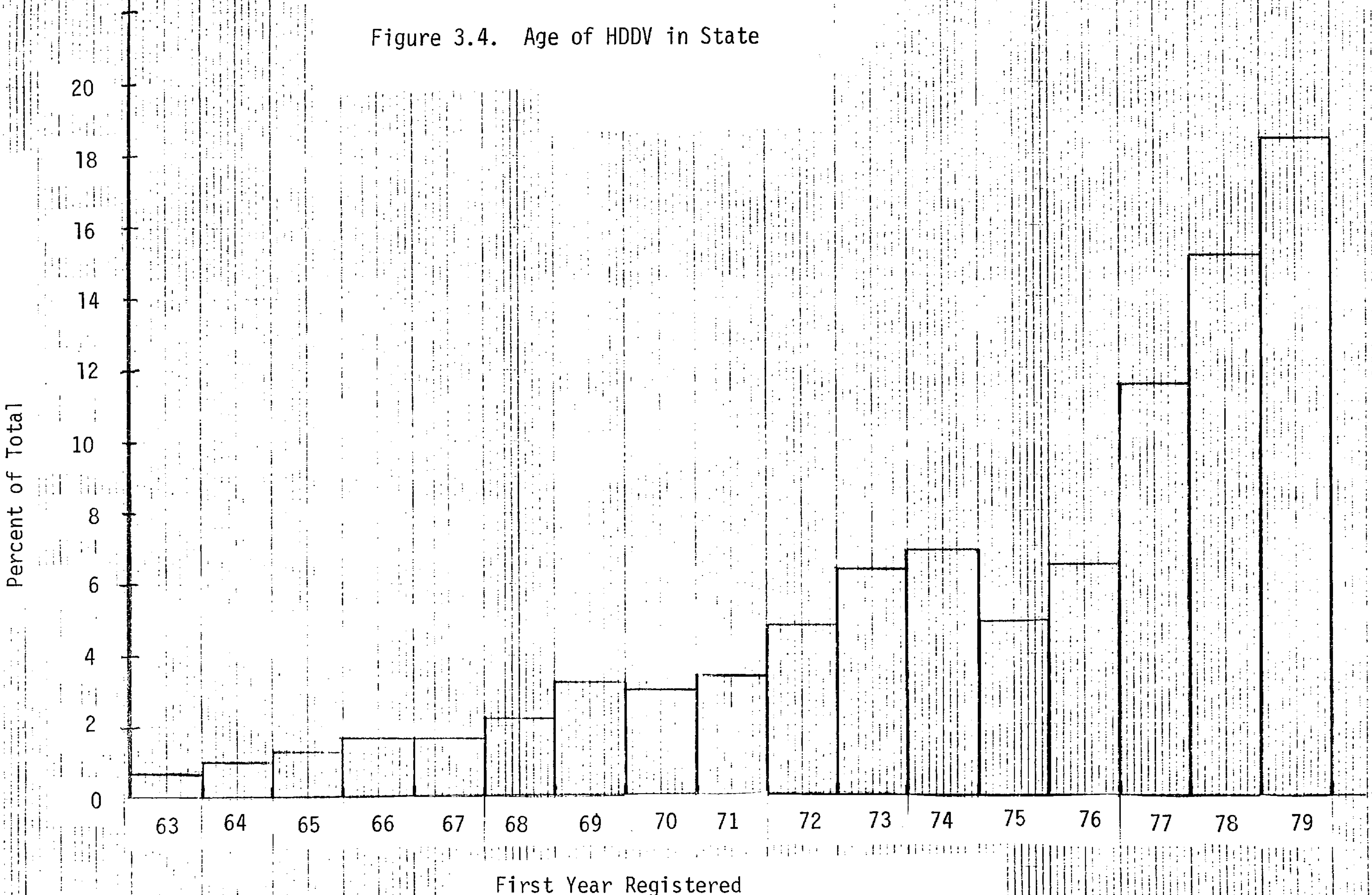


Figure 3.4. Age of HDDV in State

4.0 MAINTENANCE PRACTICES AND COSTS

Before summarizing the maintenance data obtained through the responses to the questionnaires a discussion of the general characteristics of diesel engines is helpful in understanding the survey design. It will serve to explain the basis for the type of information requested in the questionnaires, and to point up differences in maintenance and I/M programs for HDDV in contrast to those usually associated with passenger vehicles.

4.1 Some Characteristics of Diesel Engines

The diesel engine is an internal combustion compression ignition reciprocating piston engine which operates at full throttle at all times. The air entering the engine is never throttled and many of the engines are supercharged so as to augment the actual compression ratio and power delivered by a given engine displacement. Diesel engine power and speed are regulated by controlling the quantity of fuel that is burned during each power stroke. At idle, only sufficient fuel is supplied to each cylinder to overcome frictional losses whereas at maximum power condition, sufficient fuel is supplied so that all of the oxygen in the cylinder is "burned" by the fuel. In actual practice, the mixture ratio for maximum power may be greater than stoichiometric for various reasons.

Some of the diesel engines are "two stroke cycle" machines in which every cylinder produces a power stroke at every revolution of the crankshaft but most of the engines are "four stroke cycle" machines in which the cylinders produce a power stroke every other revolution of the crankshaft.

Figure 4.1 illustrates the operation of a typical four stroke diesel engine. Rotation of the crankshaft is clockwise. On the intake stroke, as illustrated in Figure 4.1a, the inlet valve opens and air is sucked into the cylinder as the piston moves down. The exhaust valve is closed. When the piston reaches the bottom of the stroke, the inlet valve closes and the compression stroke starts as shown in Figure 4.1b. The air is compressed by the piston to a small volume. Compression ratio (the total volume divided by the residual volume) is generally greater than

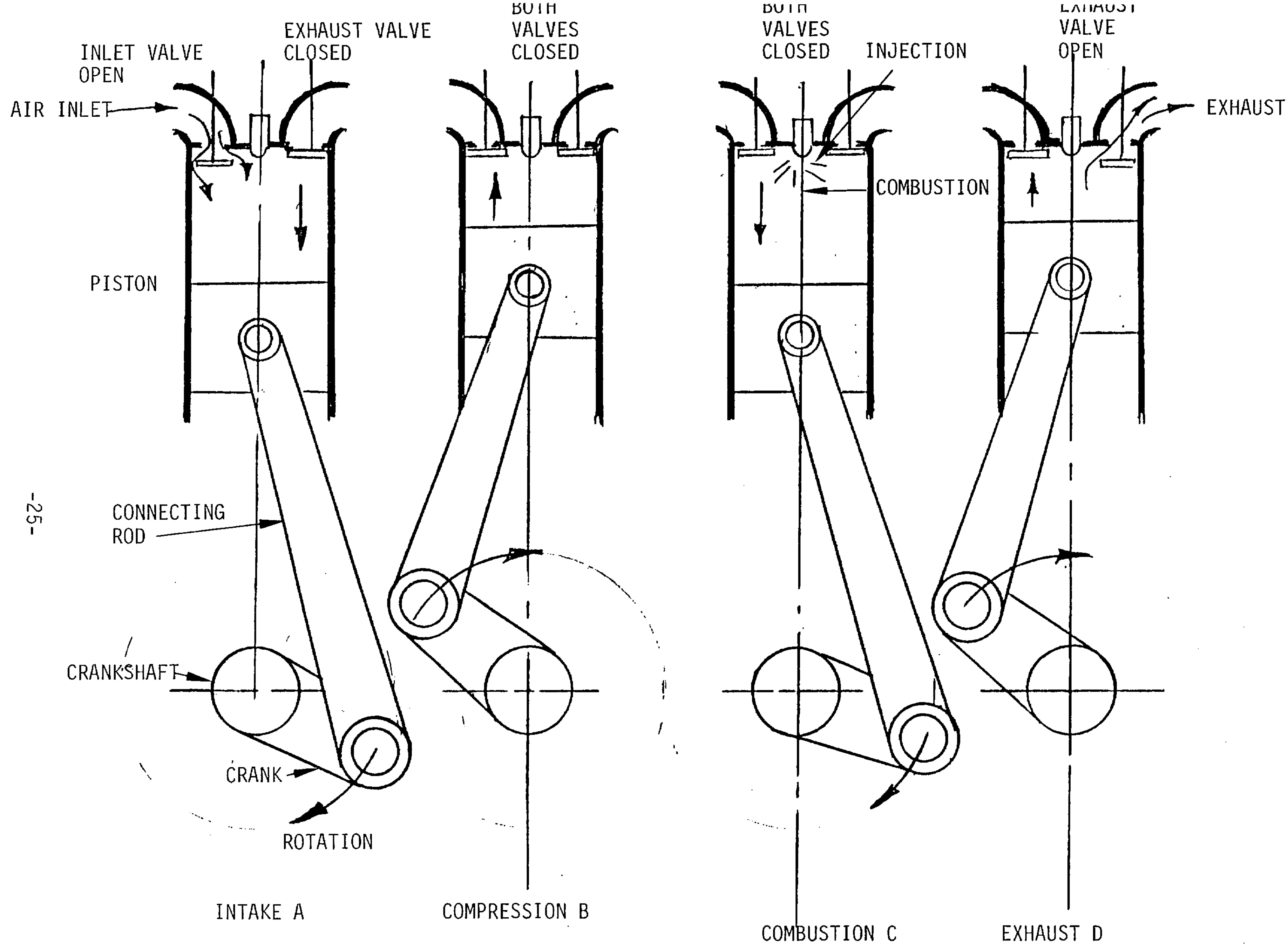


Figure 4-1: Typical 4 Stroke Diesel

20 to one compared with 6 or 8 to one for a spark ignition engine. The compression raises the pressure and the temperature of the air so that fuel injected into the cylinder after the compression stroke as in Figure 4.1c auto-ignites and burns to further heat and compress the air and produce power. Timing of the fuel injection and control of the fuel injection spray pattern is critical to the proper operation of the diesel engine. At the end of the power stroke, the exhaust valve opens and the upward traveling piston forces the products of combustion out of the cylinder. The exhaust valve closes at the end of the exhaust stroke and the cycle repeats with the intake stroke. In the operational engine, the valve operation and fuel injection timing actually overlap to a small degree to account for inertia and combustion delays.

The diesel fuel, usually number 2 diesel oil in California, is usually injected by a piston pump in combination with a poppet valve injector unit mounted on the cylinder head. The system is schematically illustrated in Figure 4.2. A small piston fits very closely into a pump cylinder. It is actually lapped individually to the cylinder and may have a clearance $\leq$ 0.0001 inches. This piston is actuated by a cam which in turn is driven by a shaft which is connected to the engine crankshaft or camshaft by a gear train. The piston is forced to follow the cam by a suitable return spring. Fuel oil is supplied to the cylinder barrel by a low pressure fuel pump through a check valve or port in the side of the cylinder which may use the piston as a valve. The action of the cam forces a predetermined amount of fuel oil through the fuel line to the injector body where the differential pressure lifts the poppet against spring pressure to admit the charge of fuel to the cylinder. Variations in fuel quantity per charge are obtained by rotating helical hydraulic ports on the piston pump to change the effective stroke or by physically altering the piston stroke by using a variable lift cam. In most injector systems, there is a separate piston pump for each cylinder but in an effort to reduce cost, some engines use a single pump but they hydraulically or mechanically commutate the flow to individual nozzles by

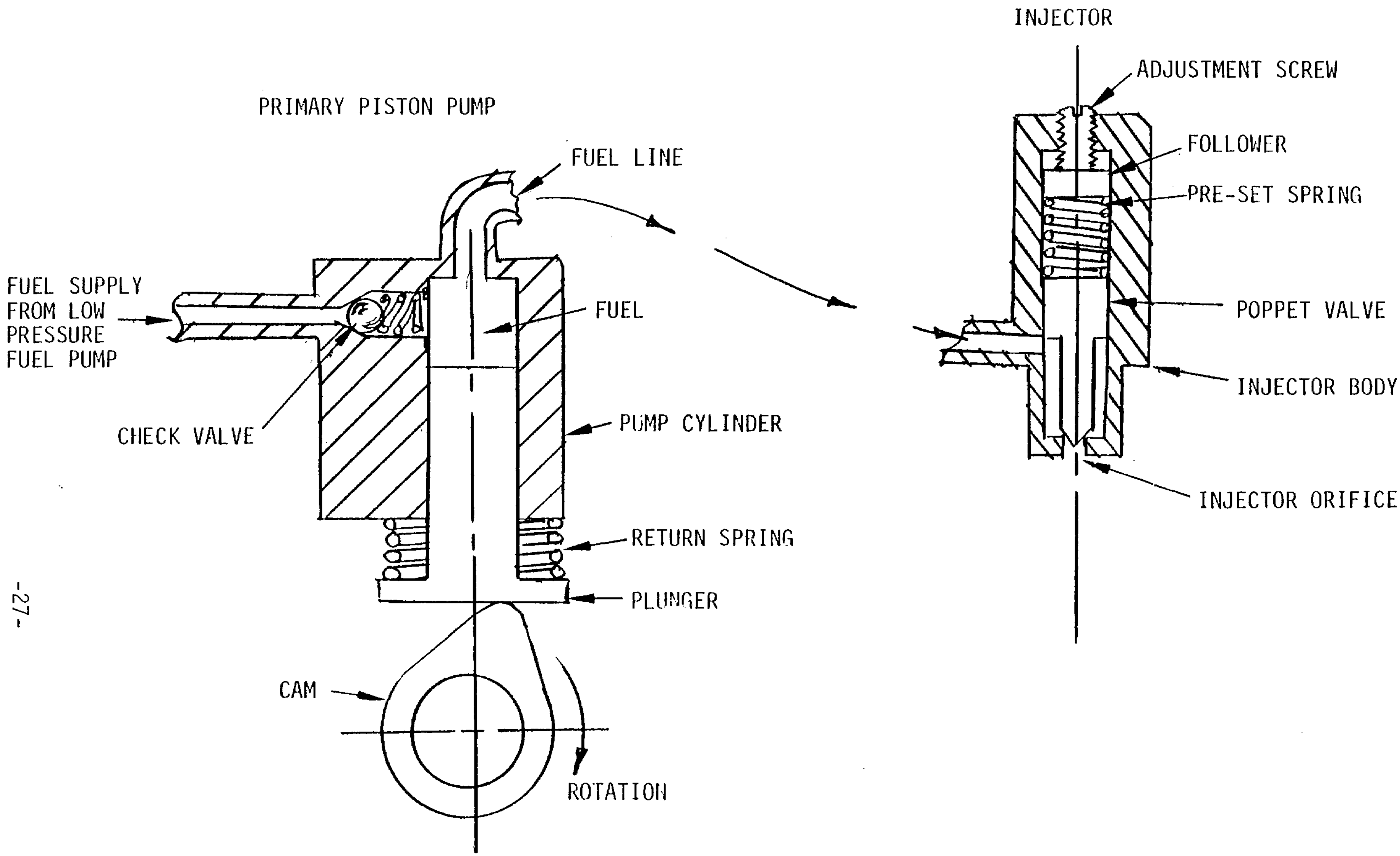


Figure 4-2: Typical Injection Pump

means of a rotary valve. Such an injector system is called a distributor system. Pressures in the injection systems vary from a low of approximately 1300 psi to 15,000 psi depending on the design.

The pump piston and cylinders as well as distributor valves are affected by condensate in combination with acids and impurities in the fuel. Corrosion and galling cause internal leakage and slow return of the pistons. This changes injection pressure and fuel quantity per stroke. Also the distributor valve may wear and leak, causing additional reduction in flow. Some cylinders may be more affected than others and the engine fuel mixture may be forced away from stoichiometric by power demands.

Unlike a spark ignition gasoline engine, the timing errors on a diesel engine are not adjusted during a tuneup. The injector repair shop usually just works on the pump and injector nozzles and resets them to factory specifications. Wear and slop in the engine timing gears and injector drive are not measured or accounted for. Thus, as an engine gear train wears, the timing of the fuel injection relative to engine piston position becomes more retarded which detrimentally affects combustion and emissions.

Both fuel and air filters are important to diesel engine operation. Fuel filters must adequately remove solid matter to prevent early erosion or wearing of the high tolerance fuel injectors. Some diesel engines are equipped with a system to remove water from the fuel which may accumulate because of condensate in tanks and supply contamination. Air filters are important for removing any foreign matter from the stream, and can have a strong effect on emissions, if they are not adequately maintained.

Turbocharging, which is becoming increasingly prevelent on HDDV, increases emission of NO_x. When engine speed is changed quickly, the turbocharger can lag behind the engine and not provide the necessary intake charge pressurization. This reduces the air charge in the cylinder and consequently allows transient overfueling which results in greately increased partial-oxidation product concentrations.

4.2 Questionnaire Design for Maintenance Information

Maintenance questions addressed primarily the servicing of fuel and air filters, injection system and turbocharger (see Appendix). Lubrication and oil changes, while not directly relatable to emissions, were included to provide an indication of the owner's general attitude on maintenance. Information on adjustment or other servicing was requested to elicit responses from owners on emissions related problems, which might be obvious to them, but were not specifically addressed elsewhere in the questionnaire. By separating costs into parts and labor, it was hoped that respondents would report costs more precisely. The last three questions addressed the areas of engine modifications, where injectors were serviced and average lifetime of engines.

4.3 Maintenance Data

Data on maintenance obtained from the responses to the questionnaires are summarized in Table 4-1 for urban buses in Table 4-2 for intra-state and inter-state buses, Table 4-3 for tractors and in 4-4 for vans.

The range of total costs (parts and labor) reported for air and fuel filter changes, and injector and turbocharger servicing are summarized in Figure 4.3 for all buses, in Figure 4.4 for tractors, and Figure 4.5 for vans. Some correlation of maintenance costs with vehicle weight classification is apparent from these figures. The clearest one is for air filter service costs, which increase with the GVWR of the vehicle, particularly for tractors and vans in Class VIII. The highest costs reported were $100 for tractors (Figure 4.4) and $175 for vans (Figure 4.5) in the heaviest class. Fuel filter service was the least expensive maintenance and showed only a slight correlation with size. One fleet, which reported a high of $150 for Class VIII vans, was considerably higher than any other response received (See Figure 4.5).

Injector and turbocharger servicing are major maintenance operations as indicated by the costs reported. These operations do not occur often and many respondents reported no information because their vehicles had not yet

Table 4-1: Maintenance Data for School and Transit District Buses

NUMBER OF VEHICLES		AVERAGE ANNUAL MILES	LUBE & OIL MILES BETWEEN SERVICING	LUBE & OIL PARTS/LABOR COSTS ($)		AIR FILTER CHANGE MILES BETWEEN SERVICING	AIR FILTER CHANGE PARTS/LABOR COSTS ($)		FUEL FILTER CHANGE MILES BETWEEN SERVICING	FUEL FILTER CHANGE PARTS/LABOR COSTS ($)		INJECTOR SERVICING (incl. gov. adj.) MILES BETWEEN SERVICING	INJECTOR SERVICING PARTS/LABOR COSTS ($)		TURBOCHARGER SERVICING MILES BETWEEN SERVICING	TURBOCHARGER SERVICING PARTS/LABOR	
Class I: 0 to 6,000 pounds GVWR																	
-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Class II: 6,001 to 10,000 pounds GVWR																	
-	T	30,000	4,000	7.44	15.	4,000	1.80	5.	4,000	3.50	5.50	50,000	-	50.00	-	-	-
Class III: 10,001 to 14,000 pounds GVWR																	
8	T	38,539	6,000	-	-	6,000	-	-	18,000	-	-	18,000	-	-	18,000	-	-
3	T	30,000	4,000	35.	25.50	4,000	-	8.50	4,000	15.	8.50	-	-	-	-	-	-
Class IV: 14,001 to 16,000 pounds GVWR																	
6	T	38,539	6,000	-	-	6,000	-	-	18,000	-	-	18,000	-	-	18,000	-	-
Class V: 16,000 to 19,500 pounds GVWR																	
606	T	38,539	6,000	-	-	6,000	-	-	18,000	-	-	18,000	-	-	18,000	-	-
1	S	10,000	6,000	25.	25.	12,000	15.	10.	24,000	25.	15.	-	-	-	-	-	-
34	S	20,000	2,000	-	-	8,000	-	-	8,000	-	-	30,000	350.	200.	-	-	-
15	S	20,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Class VI: 19,501 to 26,000 pounds GVWR																	
1905	T	38,539	6,000	-	-	6,000	-	-	18,000	-	-	18,000	-	-	18,000	-	-
16	S	11,513	3,500	9.	20.	10,000	10.77	3.	3,500	1.65	82.	30,000	80.	70.	-	-	-
124	S	30,156	6,000	29.59	125.44	24,000	44.06	35.85	12,000	8.60	35.85	-	-	89.60	-	180.	107.52
82	S	12,000	3,000	-	-	yrly.	15.	-	12,000	-	-	50,000	-	-	-	-	-
286	S	12,000	3,000	30.	45.	yrly.	-	-	5,000	3.50	-	-	100.	200.	-	-	-
-	T	50,000	5,000	18.60	30.	-	40.	6.	5,000	3.50	-	50,000	-	-	-	-	-
22	S	14,450	4,500	36.	160.	5,000	40.	10.	10,000	5.	5.	25,000	100.	200.	-	-	-
Class VII: 26,001 to 33,000 pounds GVWR																	
200	T	38,539	6,000	-	-	6,000	-	-	18,000	-	-	18,000	-	-	18,000	-	-
13	S	20,000	6,000	25.	25.	12,000	15.	10.	24,000	25.	15.	30,000	350.	200.	-	-	-

Table 4-1: Maintenance Data for School and Transit District Buses

NUMBER OF VEHICLES		AVERAGE ANNUAL MILES	LUBE & OIL MILES BETWEEN SERVICING	LUBE & OIL PARTS/LABOR COSTS ($)		AIR FILTER CHANGE MILES BETWEEN SERVICING	AIR FILTER CHANGE PARTS/LABOR COSTS ($)		FUEL FILTER CHANGE MILES BETWEEN SERVICING	FUEL FILTER CHANGE PARTS/LABOR COSTS ($)		INJECTOR SERVICING (incl. gov. adj.) MILES BETWEEN SERVICING	INJECTOR SERVICING PARTS/LABOR COSTS ($)		TURBOCHARGER SERVICING MILES BETWEEN SERVICING	TURBOCHARGER SERVICING PARTS/LABOR	
Class I: 0 to 6,000 pounds GVWR																	
-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Class II: 6,001 to 10,000 pounds GVWR																	
-	T	30,000	4,000	7.44	15.	4,000	1.80	5.	4,000	3.50	5.50	50,000	-	50.00	-	-	-
Class III: 10,001 to 14,000 pounds GVWR																	
8	T	38,539	6,000	-	-	6,000	-	-	18,000	-	-	18,000	-	-	18,000	-	-
3	T	30,000	4,000	35.	25.50	4,000	-	8.50	4,000	15.	8.50	-	-	-	-	-	-
Class IV: 14,001 to 16,000 pounds GVWR																	
6	T	38,539	6,000	-	-	6,000	-	-	18,000	-	-	18,000	-	-	18,000	-	-
Class V: 16,000 to 19,500 pounds GVWR																	
606	T	38,539	6,000	-	-	6,000	-	-	18,000	-	-	18,000	-	-	18,000	-	-
1	S	10,000	6,000	25.	25.	12,000	15.	10.	24,000	25.	15.	-	-	-	-	-	-
34	S	20,000	2,000	-	-	8,000	-	-	8,000	-	-	30,000	350.	200.	-	-	-
15	S	20,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Class VI: 19,501 to 26,000 pounds GVWR																	
1905	T	38,539	6,000	-	-	6,000	-	-	18,000	-	-	18,000	-	-	18,000	-	-
16	S	11,513	3,500	9.	20.	10,000	10.77	3.	3,500	1.65	82.	30,000	80.	70.	-	-	-
124	S	30,156	6,000	29.59	125.44	24,000	44.06	35.85	12,000	8.60	35.85	-	-	89.60	-	180.	107.52
82	S	12,000	3,000	-	-	yrly.	15.	-	12,000	-	-	50,000	-	-	-	-	-
286	S	12,000	3,000	30.	45.	yrly.	-	-	5,000	3.50	-	-	100.	200.	-	-	-
-	T	50,000	5,000	18.60	30.	-	40.	6.	5,000	3.50	-	50,000	-	-	-	-	-
22	S	14,450	4,500	36.	160.	5,000	40.	10.	10,000	5.	5.	25,000	100.	200.	-	-	-
Class VII: 26,001 to 33,000 pounds GVWR																	
200	T	38,539	6,000	-	-	6,000	-	-	18,000	-	-	18,000	-	-	18,000	-	-
13	S	20,000	6,000	25.	25.	12,000	15.	10.	24,000	25.	15.	30,000	350.	200.	-	-	-

Table 4-1: Maintenance Data for School and Transit District Buses

NUMBER		AVERAGE ANNUAL MILES	LUBE & OIL MILES BETWEEN SERVICING	LUBE & OIL PARTS/LABOR COSTS ($)		AIR FILTER CHANGE MILES BETWEEN SERVICING	AIR FILTER CHANGE PARTS/LABOR COSTS ($)		FUEL FILTER CHANGE MILES BETWEEN SERVICING	FUEL FILTER CHANGE PARTS/LABOR COSTS ($)		INJECTOR SERVICING (incl. gov. adj.) MILES BETWEEN SERVICING	INJECTOR SERVICING PARTS/LABOR COSTS ($)		TURBOCHARGER SERVICING MILES BETWEEN SERVICING	TURBOCHARGER SERVICING PARTS/LABOR	
Class VII: 26,001 to 33,000 pounds GVWR																	
17	S	11,513	3,500	13.50	20.	12,000	59.	5.	5,000	3.50	-	50,000	-	50.	-	-	-
8	S	67,090	5,000	95.	75.	12,000	59.	5.	12,000	3.37	5.	12,000	3.63	90.	-	-	-
-	T	50,000	5,000	22.32	30.	-	40.	6.	5,000	3.50	-	50,000	-	50.	-	-	-
Class VIII: 33,000 pounds and over GVWR																	
32	T	38,539	6,000	-	-	6,000	-	-	18,000	-	-	18,000	-	-	18,000	-	-
8	S	20,000	6,000	100.	75.	12,000	50.	40.	24,000	25.	15.	30,000	300.	200.	-	-	-
5	S	11,513	3,500	30.47	30.	10,000	31.77	10.	3,500	2.13	2.	100,000	200.	180.	150,000	-	-
497	T	-	25,000	-	9.60	10,000	31.77	9.60	20,000	2.88	9.60	50,000	24.92	20.	10,000	-	9.60
3	S	28,233	5,000	95.	75.	12,000	59.	5.	12,000	3.37	5.	12,000	-	-	-	-	5.
107	S	-	3,000	-	-	yrly	-	-	12,000	-	-	50,000	-	-	50,000	-	-
625	S	-	3,000	30.	45.	-	20.	15.	-	15.	15.	-	150.	120.	-	-	-
8	S	20,000	6,000	100.	75.	12,000	50.	40.	24,000	25.	15.	30,000	300.	200.	-	-	-

T = transit district or commuter buses

S = school buses

Table 4-2: Maintenance Data for Intra-State and Inter-State Buses

NUMBER	AVERAGE ANNUAL MILES	LUBE & OIL MILES BETWEEN SERVICING	LUBE & OIL PARTS/LABOR COSTS ($)		AIR FILTER CHANGE MILES BETWEEN SERVICING	AIR FILTER CHANGE PARTS/LABOR COSTS ($)		FUEL FILTER CHANGE MILES BETWEEN SERVICING	FUEL FILTER CHANGE PARTS/LABOR COSTS ($)		INJECTOR SERVICING (incl. gov. adj.) MILES BETWEEN SERVICING	INJECTOR SERVICING PARTS/LABOR COSTS ($)		TURBOCHARGER SERVICING MILES BETWEEN SERVICING	TURBOCHARGER SERVICING PARTS/LABOR	
Class VI: 19,501 - 26,000 pounds GVWR																
32	65,000	4,000 lube 12,000 oil	50. 150.	50. to 250.	4,000 to 10,000	20.	5. to 20.	20,000	16. to 20.	5. to 60.	200,000	300. to 450.	180. to 360.	-	-	-
2	11,827	12,000	22.62	17.28	12,000	15.77	8.64	12,000	3.05	8.64	100,000	138.60	155.52	-	-	-
Class VII: 26,001 - 33,000 pounds GVWR																
60	15,000	4,000	-	-	4,000	-	-	4,000	-	-	as req'd	-	-	N/A	-	-
248	42,766	12,000	22.62	17.28	12,000	15.77	8.64	12,000	3.05	8.64	100,000	184.80	207.36	-	-	-
Class VIII: 33,000 pounds and over GVWR																
1,976	142,596	4,000 lube 16,000 oil	34.13	20.35	16,000	10.35	20.35	16,000	3.99	20.35	50,000	-	80.40	50,000	-	-
10	31,720	6,000	23.32	17.28	6,000	101.46	8.64	6,000	15.56	8.64	6,000	-	17.28	60,000	-	-

N/A = No answer

Table 4-3: Maintenance Data for Tractors

NUMBER	AVERAGE ANNUAL MILES	LUBE & OIL MILES BETWEEN SERVICING	LUBE & OIL PARTS/LABOR COSTS ($)		AIR FILTER CHANGE MILES BETWEEN SERVICING	AIR FILTER CHANGE PARTS/LABOR COSTS ($)		FUEL FILTER CHANGE MILES BETWEEN SERVICING	FUEL FILTER CHANGE PARTS/LABOR COSTS ($)		INJECTOR SERVICING (incl. gov. adj.) MILES BETWEEN SERVICING	INJECTOR SERVICING PARTS/LABOR COSTS ($)		TURBOCHARGER SERVICING MILES BETWEEN SERVICING	TURBOCHARGER SERVICING PARTS/LABOR	
Class I: 0 - 6,000 pounds GVWR																
3	4,000	4,000	4.61	3.78	4,000	.83	3.28	4,000	.55	3.28	yrly	36.	60.	-	-	-
2	-	10,000	50.	39.	10,000	20.	6.	10,000	-	6	30,000	-	39.	-	-	-
1	8,000	3,000	25.	25.	12,000	12.	6.	24,000	35.	15.	30,000	150.	100.	-	-	-
Class II: 6,001 - 10,000 pounds GVWR																
10	15,000	4,000	5.54	2.	4,000	.96	2.	4,000	.43	2.	yrly	36.	60.	-	-	-
4	25,000	4,000	45.	13.50	16,000	20.	4.50	4,000	4.50	2.25	40,000	200.	32.	-	-	-
7	7,000	3,000	75.	70.	Guage	-	-	Guage	-	-	New	-	-	None	-	-
12	75,678	10,000	-	-	10,000	-	-	10,000	-	-	10,000	-	-	10,000	-	-
Class III: 10,001 - 14,000 pounds GVWR																
6	7,000	3,000	75.	70.	Guage	-	-	Guage	-	-	New	-	-	None	-	-
34	45,000	8,000	63.	13.50	40,000	20.	4.50	8,000	4.50	2.25	80,000	225.	32.	200,000	350.	32.
186	43,000	15,000	42.	36.	15,000	3.	9.	15,000	3.	5.	60,000	2.	18.	-	-	-
15	40-50,000	15,000	65.	35.	45,000	30.	12.50	45,000	7.50	12.	15,000	75. to 300.		only when turbo fails		
23	100,000	5,000	-	-	5,000	-	-	10,000	-	-	25,000	-	-	-	-	-
738	-	10,000	65.	39.	10,000	30.	6.	10,000	-	6.	30,000	-	39.	as need.	100.	50.
Class IV: 14,001 - 16,000 pounds GVWR																
6	125,000	6,000	-	-	6,000	-	-	12,000	-	-	25,000	-	-	-	-	-
10	16,000	4,000	16.51	2.75	4,000	.75	2.75	4,000	1.20	2.75	yrly	40.	60.	None	-	-
11	40-50,000	15,000	65.	35.	45,000	30.	12.50	45,000	7.50	12.	150,000	75. to 300.		only when turbo fails		
35	30,000	8,000	63.	13.50	40,000	20.	4.50	14,000	4.50	2.25	80,000	225.	32.	100,000	350.	32.
1	960	yrly	-	-	yrly	-	-	yrly	-	-	25,000	-	-	-	-	-
21	150,000	18,000	100.	10.	75,000	45.	15.	15,000	6.	7.50	100,000	130.	45.	300,000	-	-
21	-	10,000	65.	39.	10,0-0	30.	6.	10,000	10.	6.	30,000	-	39.	as need.	100.	50.
Class V: 16,001 - 19,500 pounds GVWR																
5	132,000	6,000	-	-	6,000	-	-	12,000	-	-	25,000	-	-	-	-	-
45	12,000	6,000	10.	30.	6,000	10.	10.	6,000	7.50	10.	25,000	-	50.	-	-	-

Maintenance Data for Tractors

NUMBER	AVERAGE ANNUAL MILES	LUBE & OIL MILES BETWEEN SERVICING	PARTS/LABOR COSTS ($)		AIR FILTER CHANGE MILES BETWEEN SERVICING	PARTS/LABOR COSTS ($)		FUEL FILTER CHANGE MILES BETWEEN SERVICING	PARTS/LABOR COSTS ($)		INJECTOR SERVICING (incl. gov. adj.) MILES BETWEEN SERVICING	PARTS/LABOR COSTS ($)		TURBOCHARGER SERVICING MILES BETWEEN SERVICING	PARTS/LABOR	
Class VI: 19,501 - 26,000 pounds GVWR																
124	15,000	6,000	10.	30.	6,000	27	10.	6,000	7.50	10.	25,000	-	60.	-	-	-
1	-	5,010	40.	20.	yrly	45.	10.	10,000	4.75	5.	50,000	450.	75.	when needed	-	-
17	60,000	4,000	17.24	6.86	4,000	3.09	6.86	4,000	2.16	6.86	yrly	46.	60.	none	-	-
75	12,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3	60,000	10-15,000	105.	66.	10-15,000	32.	11.	10-15,000	5	11.	As required	-	-	As required	-	-
220	60,000	4,000	42.	20	24,000	3.	10.	24,000	12.	10.	48,000	10	45.	96,000	150.	50.
314	-	10,000	65.	70.	10,000	30.	6.	10,000	10.	6.	30,000	-	39.	as need.	100.	50.
1	26,000	2,000	5.	10.	2,000	60.	10.	2,000	8.	5.	50,000	75.	25.	200,000	80.	30.
8	125,000	16,000	45.	-	100,000	15.	-	16,000	7.50	-	As needed	-	-	As needed		
195	18,000	5,000	50.	125.	yrly	15.	5.	5,000	-	2.	50,000	-	-	100,000	-	-
Class VII: 26,001 - 33,000 pounds GVWR																
16	52,000	4-8,000	36.	88.	semi-yrly	50.	incl in Lube	4-8,000	6.	incl in Lube	yrly	230.	220.	at overhaul	445.	-
20	36,000	6,000	2.02	16.	24,000	36.	6.	6,000	2.18	4.	36,000	38.70	72.	-	-	-
624	15,000	3,000	15.	50.	as needed	65.	-	3,000	12.	-	as needed	-	-	-	-	-
2	8,000	1,000	20.	10.	1,000	60.	10.	2,000	8.	5.	100,000	160.	100.	-	-	-
75	12,000	2,000	25.	10.	4,000	30.	5.	2,000	5.	5.	as needed	50.	50.	6,000	20.	20.
1	32,000	4,000	36.37	6.86	4,000	12.81	6.86	4,000	21.86	6.86	yrly	46.	60.	none	-	-
8	15,000	6,000	22.	23.	24,000	12.	15.	24,000	4.50	15.	when needed	-	-	when needed	-	-
25	-	7,500	75.	50.	50,000	35.	10.	7,500	20.	-	100,000	200.	200.	100,000	350.	175.
Class VIII: 33,000 pounds and over GVWR																
447	100,000	lube 9,000 o/c 18,000	22.	50.	70,000	80.	20.	9,000	3.25	10.	70,000	15.	60.	150,000	446.	50.
23	40,000	20,000	17.	54.	100,000	73.	27.	10,000	14.	18.	300,000	320.	108.	300,000	cond. determines-cost of repair	
14	100,000	5,000	40.	20.	yrly	68.	10.	10,000	4.75	5.	-	550.	100.	when needed	450.	25.
11	-	2,000	37.73	17.	4,000	28.09	16.	4,000	7.88	16.	50,000	295.-P & L		25,000	as needed	
23	95,000	15,000	60.	20.	80,000	35.	10.	5,000	2.67	2.	100,000	140.	80.	150,000	100.	100.
450	100,000	15,000	50.	50.	50,000	30.	5.	15,000	10.	5.	100,000	200.	100.	200,000	300.	50.
50	120,000	20,000	20.	66.	100,000	20.	11.	20,000	4.	11.	100,000	150.	130.	as required	-	-
184	68,311	26,000	4.32	32.	156,000	74.92	12.	26,000	16.32	12.	156,000	80.	160.	-	-	-
12	125,000	16,000	-	-	100,000	-	-	16,000	-	-	-	-	-	200,000	-	-

Table 4-4: Maintenance Data for Vans

NUMBER	AVERAGE ANNUAL MILES	LUBE & OIL MILES BETWEEN SERVICING	PARTS/LABOR COSTS ($)		AIR FILTER CHANGE MILES BETWEEN SERVICING	PARTS/LABOR COSTS ($)		FUEL FILTER CHANGE MILES BETWEEN SERVICING	PARTS/LABOR COSTS ($)		INJECTOR SERVICING (incl. gov. adj.) MILES BETWEEN SERVICING	PARTS/LABOR COSTS ($)		TURBOCHARGER SERVICING MILES BETWEEN SERVICING	PARTS/LABOR	
Class I: 0 - 6,000 pounds GVWR																
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Class II: 6,001 10,000 Pounds GVWR																
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Class III: 10,001 - 14,000 pounds GVWR																
20	36,000	6,000	3.14	315.	30,000	63.81	7.50	6,000	3.23	3.	3,000	18.75	84.	-	-	-
Class IV: 14,001 - 16,000 pounds GVWR																
60	-	1,600	-	-	40 days	10.	8.	60 days	5.	5.	-	-	-	-	-	-
Class V: 16,001 - 19,500 pounds GVWR																
7	-	10 weeks	$229/unit per period (13 periods) per year													
Class VI: 19,501 - 26,000 pounds GVWR																
14	13,462	2,000	11.50	30.	30,000	29.	4.	6,000	2.50	4.	100,000	varies with		engine model	-	-
7	-	10 weeks	$229/unit per period (13 periods) per year						-	-	-	-	-	-	-	-
1	1,000	200hrs.	11.34	22.	600hrs.	10.	5.	200hrs.	7.92	10.	-	-	-	-	-	-
119	15-25,000	6,000	15.	15.	as req.	20.	5.	6,000	2.	2.	as req.	-	-	192,000	400.	10.
30	-	7,500	75.	50.	50,000	35.	10.	7,500	20.	-	100,000	200.	200.	100,000	350.	175.
Class VII: 26,001 - 33,000 pounds GVWR																
7	-	10 weekds	$229/unit per period (13 period) per year						-	-	-	-	-	-	-	-
200	40-80,000	6,000	30.	15.	as req.	40.	5.	6,000	2.	2.	192,000	220.	25.	192,000	370.	10.
6	6,000	200hrs.	11.34	44.	600hrs	43.06	5.	200hrs.	7.82	10.	-	-	-	-	-	-

Maintenance Data for Vans

NUMBER	AVERAGE ANNUAL MILES	LUBE & OIL MILES BETWEEN SERVICING	PARTS/LABOR COSTS ($)		AIR FILTER CHANGE MILES BETWEEN SERVICING	PARTS/LABOR COSTS ($)		FUEL FILTER CHANGE MILES BETWEEN SERVICING	PARTS/LABOR COSTS ($)		INJECTOR SERVICING (incl. gov. adj.) MILES BETWEEN SERVICING	PARTS/LABOR COSTS ($)		TURBOCHARGER SERVICING MILES BETWEEN SERVICING	PARTS/LABOR	
Class VIII: 33,000 pounds and over GVWR																
384	34,110	10,000	50.32	48.	20,000	32.83	24.	10,000	17.16	48.	50,000	250.	72.	100,000	350.	96.
15	90,000	10,000	48.	20.40	50,000	58.05	6.80	10,000	9.08	3.40	100,000	335.	81.60	200,000	400.	27.20
112	140,000	25,000	100.	100.	90,000	75.	100.	25,000	75.	75.	250,000	500.	300.	250,000	200.	150.
475	144,000	15,000	75.	35.	10,000	21.23	3.25	5,000	6.23	3.25	50,000	180.	23.	145,000	434.	20.
13	22,400	6,000	44.	70.	6,000	60.	22.	100,000	13.	17.	100,000	380.	450.	200,000	750.	105.
888	140,000	11,000	34.	50.	50,000	40.	-	11,000	12.	-	as needed	-	-	300,000	400.	72.
16	22,000	8,000	55.	36.	8,000	28.	6.	1,000	6.50	6.	20,000	15.	48.	40,000	50.	26.
102	127,428	7,000	52.98	50.50	60,000	37.	25.25	7,000	6.47	incl in Lube	50,000	120.	101.	-	-	-
892	150,000	25,000	52.	110.	when needed	44.	30.	2,500	1.10	10.	100,000	-	180.	250,000	300.	100.
12	300,000	3,000	50.	25.	as req'd	25.	15.	as req'd	15.	10.	as req'd	150.	101.	none	-	-
163	17,209	2,000	14.50	30.	30,000	29.	4.	6,000	5.50	4.	100,000	varies with		engine model	-	-
149	96,000	25,000	6.70	31.50	50,000	59.44	7.50	25,000	6.45	3.	100,000	165.36	84.	200,000	451.	126.
20	16,000	6,000	22.	23.	24,000	12.	15.	24,000	4.50	15.	when Needed	-	-	when needed	-	-
64	-	12-24,000	36.	88.	50,000	50. inc in L.		12,000	6. inc in L.		2,000	230.	220.	at overhaul	445.	-
29	-	25,000	55.	35.	25,000	24.	3.	25,000	12.	3.	as needed	-	-	as needed	-	-
16	-	5,000	-	-	5,000	-	-	-	-	-	-	-	-	-	-	-
61	60,000	10,000	40.	45.	100	45.	10.	10,000	-	5.	100	8.	81.	at time of overhaul	450.	20.
139	13,000	1,000	40.	6.07	1,000	33.42	6.07	1,000	9.47	6.07	yrly	46.	60.	when needed	-	-
21	6,000	200hrs	11.34	44.	600hrs	43.06	5.	200hrs	7.82	10.	-	-	-	-	-	-
602	100-180,000	16,000	32.	25	as req.	40.	5.	16,000	2.	2.50	192,000	220.	25.	192,000	370.	10.

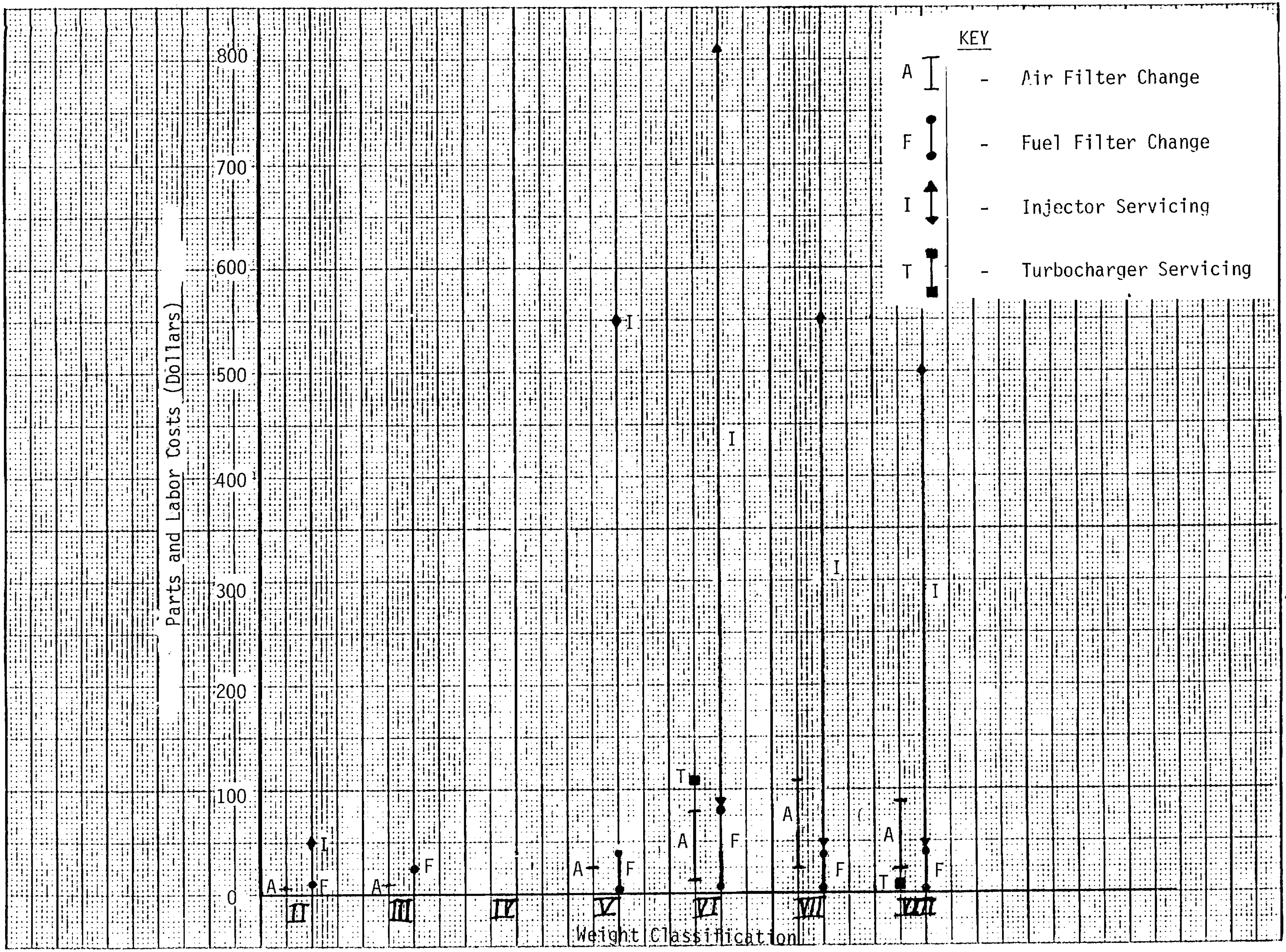


Figure 4.3. Reported Maintenance Cost for All Buses

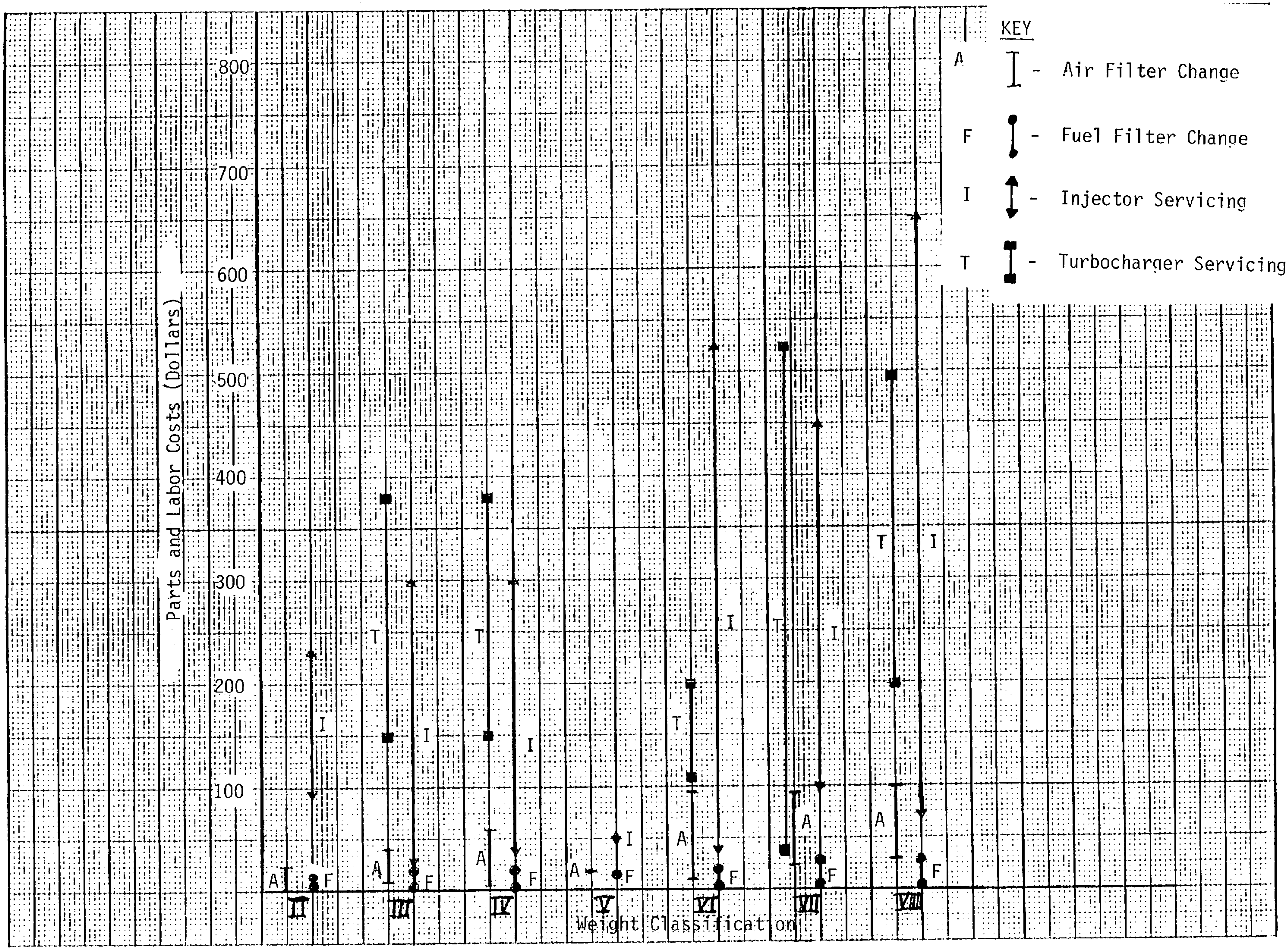


Figure 4.4. Reported Maintenance Costs for Tractors

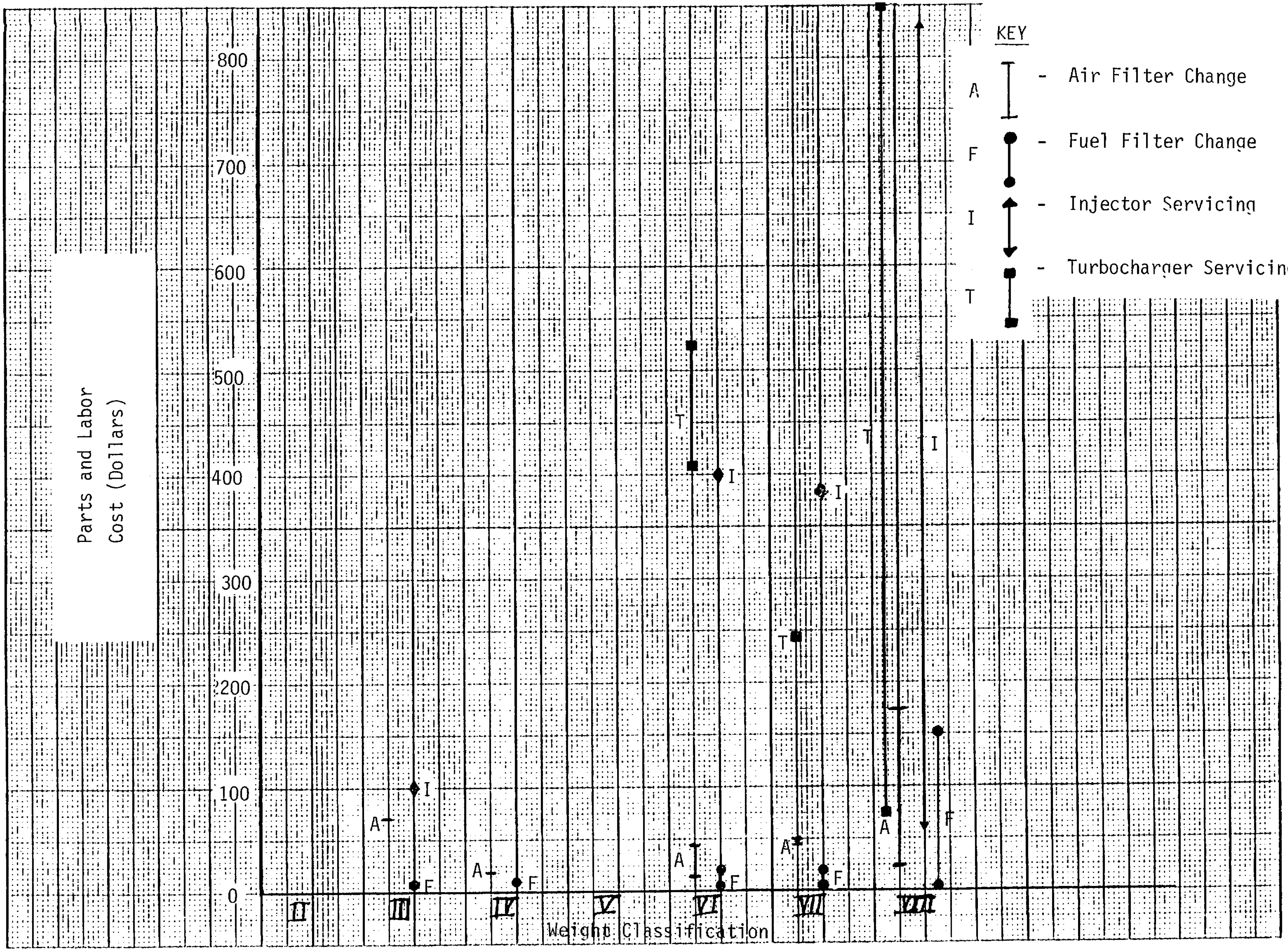


Figure 4.5. Reported Maintenance Costs for Vans

required these services. Some HDDV do not have turbocharging and would not require this service. The range of costs reported for each of these services is wide, frequently varying by a factor of 10 for the same type and class of vehicle (see Figures 4.3 through 4.5). This is in accordance with the range of services which may be required on the component. Usually injectors or turbochargers will require the most service up to complete replacement.

The overwhelming number of HDDV reported by the responses were in classes VI, VII and VIII with the most numerous group being the heaviest category. For urban buses (Table 4-1) the sample also shows a sizable number of vehicles in Class V, mainly due to one large fleet which has many heavier buses as well. For vans, which were used as a catch-all category, there were 4173 Class VIII vehicles reported by 20 fleets (Table 4-4). The prevalence of Class VIII tractors is less pronounced in the data (see Table 4-3).

No correlation of fleet size and costs of maintenance are apparent from the responses. For vans, where the largest number of responses were available for a single weight classification (VIII), the highest filter service costs were generally reported by a fleet of 112 vehicles and the lowest by several fleets in the same range. Generally, fleets that are high for one type of service are high for all types.

Mileage between services likewise is not correlated with fleet size. For example, the highest mileage (90,000 miles) and the lowest mileage (1,000 miles) between air filter changes were reported for fleets of 112 and 139 vehicles, respectively.

4.3.1 Tampering

There are no emission control devices per se on diesel engines, so that tampering of the type observed on gasoline-powered automobiles is not observed on diesels. However, the governor for the injection system can be adjusted differently than prescribed by the factory with a resultant increase in vehicle speed and also emissions. Tampering of this type does occur on the part of some drivers. Normally, governors are sealed by the service facility and the seal must be broken for the governor to be readjusted. Frequency cannot be ascertained, but it is not thought to be high (Masi, 1980). A concomitant loss of power usually occurs when the governor is not adjusted on spec and the driver is not satisfied with its performance under load, such as on long climbing roads. This sometimes will cause the driver to seek service at an authorized facility which will calibrate and reseal the unit.

4.3.2 Major Engine Overhaul and Other Data

Engine overhaul was typically reported to be performed only when needed. This was indicated by loss of compression, excessive smoke, increase in oil consumption or noise increase. For school buses those responders that provided a mileage estimate for engine overhaul indicated 90,000 to 200,000 miles with 100,000 being the most frequent response. Transit and cross country buses recorded between 200,000 and 300,000 miles. Tractors and vans had their engines overhauled between 125,000 miles and 400,000 for vans and 500,000 for tractors. From subjective comments on the questionnaires, few vehicles achieved 500,000 miles before engine overhaul and about 300,000 miles was most often reported for both vans and tractors.

Mileage between overhauls did not appear to be correlated with vehicle size, but there was some indication that short haul vehicles, both buses and vans, required overhauling after fewer miles than long haul vehicles.

All respondents except for four transit and school bus fleets indicated that number 2 diesel fuel was used. The four bus fleets indicated they used number 1 diesel fuel, chiefly to maintain good public relations by reducing smoke from their vehicles.

The engine components reported to have been changed from the original design were:

(1) Replacement of gasoline engines by diesel - three respondents, all buses

(2) Changes (unspecified) recommended by the manufacturer for recently purchased vehicles - two respondents

(3) Addition of superchargers to older diesel trucks - two respondents.

Most responders indicated they purchased their vehicles new or used in California and that servicing of injectors was performed by authorized factory shops or if they were large enough, in their own shop according to manufacturer's specifications. For California qualified engines, this would imply injectors, which would meet California specifications for the engine. No indication was found that anything else was done.

5.0 EXISTING I/M PROGRAMS AND ALTERNATIVES FOR HEAVY-DUTY DIESELS

Characteristics of the existing I/M programs, including the advantages and disadvantages, are summarized in this section. The limited experience with I/M for HDDV in other states and other relevant information are then applied to the task of defining alternatives for California. Cost information is also given.

5.1 Existing Inspection/Maintenance (I/M) Programs

The inspection and maintenance components of an I/M program can be separated, and ideally, each of these functions is performed independently to ensure integrity in a program. There are several alternative approaches for each of these components including centralized, versus decentralized for inspection, and a variety of possible technologies for maintenance programs. To judge the cost effectiveness of an I/M program it is necessary to estimate the cost of each program component, as well as the anticipated emissions reduction of the overall program. Only the costs are addressed in this study. In states where a safety inspection program is in place, the initial costs of emissions testing is minimized, if it is appended to the safety inspection.

The basic advantages and disadvantage of combinations of public, private, centralized and decentralized were summarized by Bentz, et al., 1977 and are shown here in Table 5-1. I/M for autos was the focus of this analysis. Application to heavy-duty diesels amplifies some of the advantages of the centalized approach. By strategic placement of the inspection facilities, many owners could be serviced efficiently and a minimum number inconvenienced. This will be discussed further in this section.

EPA's policy for the 1982 State Implementation Plans (SIP) will require states with I/M to respond to nine specific program elements (Cachette, 1980). The technological elements include: (1) inspection test procedures, (2) emissions standards and (3) analyzer specifications and maintenance requirements. The enforcement elements are: (4) station and inspection licensing requirements, (5) record keeping and submittal requirements, (6) quality control and auditing procedures, and (7)

Table [illegible]-1

ADVANTAGES AND DISADVANTAGES OF ALTERNATIVE I/M ORGANIZATIONAL STRUCTURES

Type of Structure	Advantages	Disadvantages
Public, Centralized	1. Inspection separate from repair; no conflict of interest 2. Easier quality control on instruments and personnel 3. Lower labor costs 4. Easier data collection 5. Loaded mode testing possible	1. Fewer facilities; less convenient to vehicle owners 2. Large initial public capital outlay 3. All costs borne by public sector
Private, Centralized	1. Same as above, except: 2. Most costs borne by private sector 3. Permits use of corporate tax structure to reduce burden of initial start-up capital expenditures	1. Same as above, except: 2. Possible adverse public reaction to corporation earning profits from a "captive market."
Private, Decentralized	1. Greater number of facilities, hence convenience to vehicle owners 2. Possibility for one-stop I/M 3. Lower startup costs 4. Most cost borne by private sector	1. If one stop I/M, possibility for conflict of interest 2. Quality control for instruments and personnel more difficult 3. Higher administrative costs to oversee a large number of garages 4. Less efficient use of equipment 5. Inspector training more costly 6. Uniform, detailed data collection more difficult 7. Loaded mode testing "improbable if not impossible"

Source: Adapted from Bentz et al., 1977.

enforcement procedures for noncompliance. The education elements are: (8) public awareness planning and, (9) mechanic training. The division of these elements into the three categories is shown in detail in Figure 5.1 for inspection and in Figure 5.2 for maintenance.

Thirty different areas of the U.S. have some degree of activity in I/M programs ranging from planning to operating stages. These programs are tabulated in Table 5-2. Only four states (Arizona, New Jersey, Oregon and Rhode Island) have mandatory programs in place which conform or conditionally conform with EPA's 1979 general program requirements. These requirements include legal authority, resources and implementation by the state. Although cost estimates are available for other programs, the four states which have ones that have been operative for several inspection cycles would seem to represent the best available cost information. Table 5-3 is a comparison of these costs. California's program in the South Coast Air Basin has not been included because it is not operated on the same basis as the others. Here the cost of the inspection program was assumed to be equal to the revenues (Column 1 x Column 2 = Column 5). The total maintenance costs were obtained by multiplying the vehicle volume by the stringency factor (failure rate) and the average repair cost. Other cost factors such as motorist inconvenience, would have to be included in total costs of each of the programs, but were assumed to not influence greatly the relative cost comparison. The cost per vehicle comparison suggests that state-operated I/M programs are less costly than contractor-operated ones. The maintenance to inspection cost ratio is an indicator of the cost shared by all the motorists in contrast to just those with high polluting vehicles. The Oregon program, therefore, imposes the greater share of the cost burden on those who have not maintained their vehicles adequately.

Two of the states, New Jersey and Rhode Island, have combined emissions and safety inspections while Arizona and Oregon have not piggy-backed their inspection programs. Only Rhode Island has a decentralized program. In general, centralized state operated programs are less costly than centralized contractor operated ones. Benefits resulting from various programs are highly dependent on enforcement and less on other characteristics.

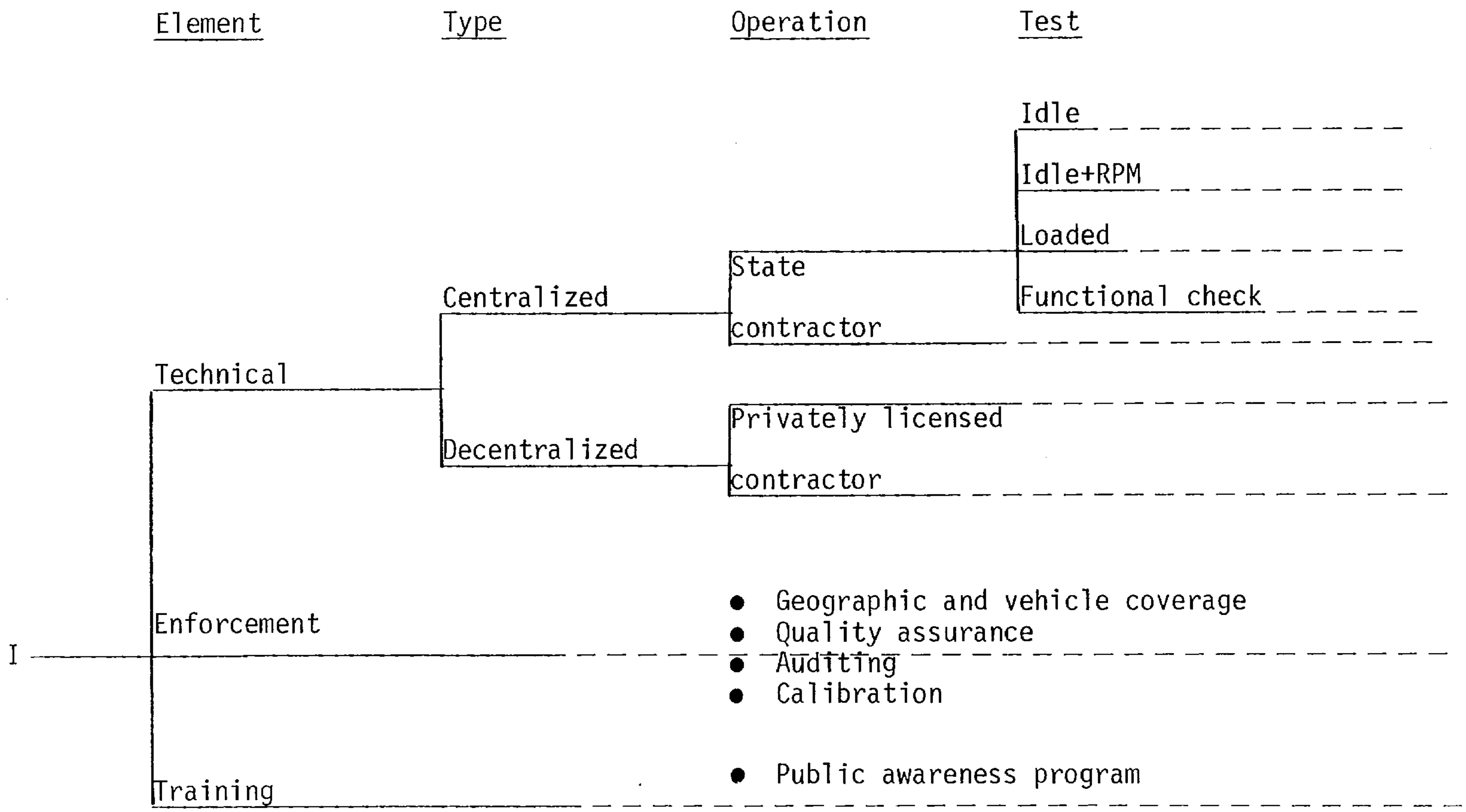
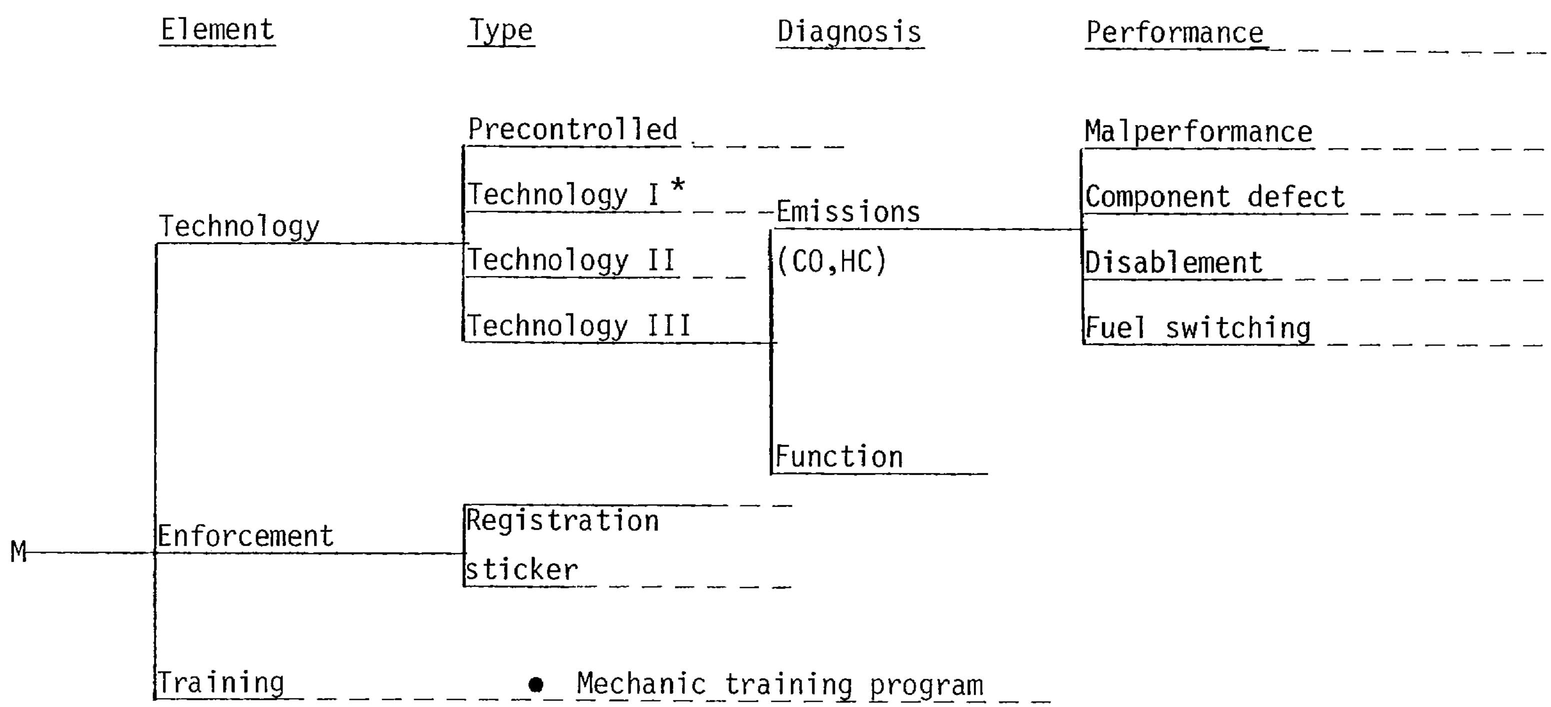


Figure 5.1. Major Program Elements for Defining the Inspection Function (After Elston, 1981)



*Three technologies of passenger vehicle emissions control are defined: Technology I includes the exhaust emission controls designed to achieve federal standards between 1968 and 1974. Technology II is for the period 1975 through 1980; and Technology III is for 1981 and later.

Figure 5.2. Major Program Elements for Defining the Maintenance Function (After Elston, 1981)

Table 5-2 Status of I/M program design as of November 1980. (After Elston, 1981)

Region and State	Area	Inspection	Type	Test	Cost	Stringency factor	Vehicle Types	Vehicle Classes/age	Repair waiver limits	Enforcement method	Mechanic training	Public awareness	Comments
I													
CT	Statewide	Emission	Centralized-contractor	Idle	10.00	0.20	LDV + LDT[a]	Tech I, II, III[b]	$70	Sticker	Yes	No	Only one contractor bid
MA	Statewide	Emission	Decentralized-state	Idle	10.00	0.20	LDV + L&MDT[a]	15 yr	$100 or 10% value	Sticker	Yes	No	
RI	Statewide	Emission & safety	Decentralized-state	Idle	4.00	0.20	LDV + L&MDT[a]	Tech I, II, III[b]	—	Sticker	Yes	No	Quality control problem
II													
NJ	Statewide	Emission & safety	Hybrid-state	Idle	2.50	0.20	LDV + LDT[a]	All	None	Sticker	Yes	Yes	RACT model
NY	NYC & Metro	Emission & safety	Decentralized-contractor	Idle	6.00	0.20	LDV + L&MDT[a]	All	Yes	Registration & sticker	Yes	Yes	Mechanic certificate program
III													
PA	Philadelphia Pittsburgh	Emission & safety	Decentralized-state	Idle		0.25	LDV + L&MDT[a]	25 yr	$150–250	Sticker	Yes	No	Consent decree
VA	DC Suburbs Richmond	Emission & safety	Decentralized-state	Idle	3.50		LDV[a]	8 yr	$75	Registration	Yes	No	Richmond uncertain
DC	Citywide	Emission & safety	Centralized-district	Idle		0.20	LDV[a]	25 yr	None	Sticker	Yes	Yes	Contingent-on surrounding areas
DE	Wilmington	Emission & safety	Centralized-state	Idle			LDV + LDT[a]	All		Sticker	Yes	No	Schedule difficulties
MD	Baltimore DC Suburbs	Emission	Centralized-contractor	Idle	9.00		LDV + L&MDT[a]	12 yr	$75	Registration	Yes	Yes	Bid received
IV													
GA	Atlanta	Emission & safety	Decentralized-state	Idle	3.00		LDV[a]	10 yr	$50	Sticker	Yes	No	
KY	Louisville	Emission	Centralized-county	Idle			All	All	$50	Sticker	Yes	No	Kenton & Campbell Co. sanctioned
NC	Charlotte	Emission	Decentralized-state	Idle	8.00		All	12 yr		Sticker	Yes	No	Schedule difficulties
TN	Nashville Memphis	Emission	County	Idle						Sticker	Yes	No	Memphis schedule deficiency
V													
IL	Chicago	Emission	Centralized-contractor	Idle	6.50	0.30	All	13 yr		Registration	Yes		Legislation uncertainties
IN	Chicago subs E. St. Louis	Emission	Centralized-contractor	Idle	10.00	0.20		13 yr	$100 or 2.5% of value		Yes		Enforcement uncertainties
MI	Detroit	Emission	Decentralized-state	Idle	10.00	0.20	LDV + L&MDT[a]	Tech I, II, III[b]	$50	Registration	Yes		Reluctant to commit resources
OH	Cleveland	Emission & safety	Centralized-state								Yes	Yes	State commitment uncertain
WI	Milwaukee	Emission	Centralized-contractor	Loaded		0.20	LDV + L&MDT[a]	15 yr	$55	Registration	Yes	Yes	Loaded diagnostic test
VI													
NM	Albuquerque	Emission	Centralized-contractor	Idle	10.00				$75 or 15% of value		Yes	Yes	Enforcement and design uncertain
TX	Houston	Emission		Parameter study									Legislation and program uncertain
VII													
MO	St. Louis	Emission & safety	Decentralized-state	Idle		0.30				Registration	Yes		Legislation and program uncertain
VIII													
CO	Denver	Emission & safety	Decentralized-state	Idle	8.00	0.30/ 0.40	LDV + L&MDT[a]	Tech I, II, III[b]	$15 (low cost repair)	Sticker	Yes		Sanctions applied then lifted
UT	Salt Lake C.	Emission	Centralized-contractor	Idle				Tech II, III[b]		Sticker	Yes		Enforcement uncertain
IX													
AZ	Phoenix/ Tucson	Emission	Centralized-contractor	Idle	5.75	0.25	All	14 yr	$75	Registration	Yes	Yes	5 yr contract renewed
NV	Las Vegas	Emission & safety	Decentralized-state	Idle + Parameter	12.00–17.00	0.30	LDV[a]	14 yr	$25 + parts	Registration	Yes	Yes	Change of ownership
CA	South Coast	Emission	Centralized-contractor	Idle (Loaded)	11.00		All	1955 and later			Yes	Yes	Change of ownership
X													
OR	Portland	Emission	Centralized-state	Idle + rpm	5.00	0.37	LDV + L&MDT[a]	Tech I, II, III[b]	None	Registration	Yes	Yes	Model program
WA	Seattle/ Vancouver	Emission	Centralized-contractor	Idle	10.00	0.30		Tech I, II, III[b]	$50	Registration	Yes	Yes	Contractor scheduled

[a] LDV = Light-duty vehicle (<6000 lb); LDT = Light-duty truck (<6000 lb); L&MDT = Light and Medium-duty truck (<8500 lb)
[b] Tech I, II, III = Technology I (1968–74 model year vehicle), Technology II (1975–80 model year vehicle), Technology III (1981 and later model year vehicle)

Table 5-3. Comparison of Total Annual Costs for I/M Programs (After Elston, 1981)

Type	(1) Vehicle volume (10^6)	(2) Inspection fee ($)	(3) Stringency	(4) Repair cost ($)	(5) Inspection cost(x10^6$)	(6) Maintenance cost(x10^6$)	(7) Total cost(x10^6$)	(8) M/I Cost Ratio (6/5)	(9) Cost/Veh. ($) (7/1)
Centralized Contractor									
Arizona	1.1	5.4	0.2	29	5.9	6.4	12.3	1.1	11.2
State operated									
New Jersey	4.2[a]	3[b]	0.2	19	12.6	13.7	26.3	1.1	7.3
Oregon	0.5	5	0.37	29	1.2[c]	5.4[c]	6.6[c]	4.3	13.2[c]
Oregon (Adjusted)			(0.2)			(1.45)[c]	(2.7)[c]	(1.2)	(5.4)[c]
Decentralized Privately licensed									
Rhode Island	0.5	4			2.0				

[a] Inspection fee distributed over total NJ State (HDV etc.) 4.2 X 10^6 vehicle; maintenance cost based on inspected vehicle (3.6 X 10^6)

[b] Inspection fee subsidized by general fund (assume \$0.50 thus \$2.50 + 0.50 = \$3.00).

[c] I/M operated biennially; annual cost assumed to be 1/2 biennial cost.

Heavy-Duty Vehicle Programs

Application of I/M to HDDV in other states has been minimal and does not appear to be under active development for the future. In Tucson, Arizona a HDDV program was operated from 1976 through 1980 and then discontinued. The primary reason was because of a low failure rate (three percent). Five to ten minutes per truck was required to perform an opacity (smoke) test while lugging down the engine from 90% of full power on a variable load dynamometer. An idle test was also performed (Watson, 1981). A $5 fee was charged, as for autos, but it was probably not adequate to cover costs for the trucks. Between 3500 and 4000 trucks were tested in a peak month (Sandheger, 1981).

In Portland, Oregon heavy-duty gasoline engine trucks are tested, but no diesels. They inspect between 800 and 2800 trucks per month at idle and at 2500 rpm. The average time is three to four minutes and the $5 charge has recently been raised to $7 for all vehicles. This charge covers the cost to the state. The failure rate is the highest of any program in the country, at about 40%, and is virtually the same for autos by design (Sumich, 1981).

In New Jersey, transit buses are emissions tested concurrently with a mandated safety inspection on a biannual basis. The buses are accelerated from 0 to 30 mph with a portable opacity meter attached. No failure rate data is available, and the cost is covered by the safety inspection fee (Elston, 1981A).

Other states have been less active in addressing heavy-duty diesel emissions, but in Denver, the brown haze problem has motivated the state to study possible control alternatives for light-duty diesels (Gallagher, 1981).

5.2 Inspection Alternatives for Heavy-Duty Diesels

Existing inspection programs were not designed for heavy-duty vehicles and particularly not diesels. Several important considerations have driven our selection of alternative approaches for heavy-duty diesel inspection.

(1) Testing should be adequate to realistically determine emissions of particulates and NO_x. For heavy-duty diesels, this requires testing the vehicle under load.

(2) Costs of equipment will be significantly higher than for auto testing.

(3) Loss of productivity (outage time) of high-cost vehicles should be minimized.

(4) Large metropolitan fleets (e.g., transit buses) with central service facilities could be inspected efficiented by on-site or nearby testing facilities, while most cross-country operations might be better served at existing weigh stations.

(5) The smaller number of vehicles (than autos) and scheduling for large fleets would permit a small number of strategically located stations to service all vehicles.

In developing alternatives a hierarchy of decisions must be faced to reduce the choices in a systematic manner to an analyzable set. Some of these choices are policy decisions, which must be made by the State and only the technological components are within the scope of this study. Two of the most important considerations are which of the HDDV are to be tested and the thoroughness or standards to which they are to be tested.

Testing of all of the 210,000 HDDV base-plated in the State is an option. Including the approximately 40,000 HDDV base-plased in other states may present legal difficulties. In its emissions testing programs, the State of Oregon opted for not testing out-of-state vehicles, because they believed that it might be considered to be interference with interstate commerce. This possibility would have to be thoroughly investigated, before this segment of the HDDV population is brought into an I/M program. Other choices are to apply an I/M program to all of the HDDV registered at addresses within areas such as SCAB. Selecting only specific subgroups which operate a high percentage of the time in an air basin is another possibility. Easily identified subgroups are transit and school district buses, supermarket fleets, and fleets of regional distributors. Fleets, such as these could be inspected by operators with random inspections conducted by the State to insure compliance. Choices between the alternative groups to be subjected to an I/M program are a policy decision to be made finally by the State. Another is stringency factor.

As shown in the previous section, centralized facilities are cost effective for autos and this can be enhanced for HDDV. Several factors can be identified:

(1) The need for emissions reduction is greatest in urban areas, such as the SCAB.

(2) There are readily identifiable centers of HDDV activity near which inspection stations can be conveniently located such as fleet terminals. This will reduce industry resistance.

(3) Higher equipment costs (for loaded testing) favor centralization to minimize costs.

(4) The numbers of HDDV to be tested is small compared with autos (over 900,000 tested yearly in SCAB).

Presently, there are 17 inspection stations for autos in the SCAB of California. There are a total of 45 testing lanes, which process approximately 900,000 autos yearly during 2,240 hours of operation (Canup, 1981). This implies an average testing time of 6.7 minutes per vehicle and an annual average lane capacity of 20-thousand vehicles. If all of the California base-plated HDDV were tested annually, eleven test lanes would be required provided the average testing time could be kept to 7 minutes or less. This amount of time is consistent with heavy-duty testing experience in Arizona and Oregon.

The most effective inspection alternative identified is then a single- or double-lane facility centrally located in a polluted air-basin for testing all HDDV operating in the basin most of the time. Deterioration of emissions performance for HDDV is not documented, but since annual mileage is generally high, an annual inspection is reasonable until definitive data are collected.

Cost information from other studies (e.g., Gunderson, 1979A) suggest that contractor operated programs are somewhat more expensive overall (about 8%) but eliminate the need for the state to make large capital outlays at the beginning of a program. This is a distinct advantage under prevailing economic conditions. Additionally it allows the state to act in strictly a quality control role by separating this function.

An inspection program for all HDDV base-plated in the State would require a minimum of 11 test lanes scattered throughout the State. Co-location with weigh stations would be efficient for many cross-country vehicles. Licensing of private garages is a possibility, but because of the capital investment it is believed that existing facilities with HDDV dynamometers are already fully utilized.

Training of mechanics to operate the inspection facility will be very similar to the training of mechanics for existing diesel-engine diagnostics facilities. Their training is usually obtained on-the-job and only a small number will be required to operate even the maximum number of lanes anticipated throughout the State.

5.3 Inspection Costs

In performing the cost estimation for the inspection program, available data of existing state programs were reviewed. Several important differences need to be taken into account to extrapolate to heavy-duty inspection from the cost experience with autos. Primarily these differences are:

- Increased capital costs due to a larger dynamometer and more sophisticated emissions measurement equipment.
- Increased set-up time per test because of the need to inspect vehicles with a wide variety of designs and weight.
- Increased training for the inspection technicians.

The method used to develop the cost estimate is based on extrapolation from existing I/M programs. Based on cost information for dynamometers and emissions instrumentation obtained from Clayton Manufacturing (Robinson, 1981), the capital cost for a HDDV testing lane would be approximately $100,000 more (see Table 5-4). Assuming an anticipated return on investment of 20% this would add $1 per vehicle to the inspection cost for a lane that could handle 20,000 vehicles per year.

Additionally, the average time per inspection may be higher than the 7 minutes achieved for autos. Cost per minute of operation for an

Table 5-4. Capital Cost Differences

Capital Costs which would be Different	Auto Inspection Lane	HDDV Inspection Lane
Dynamometer	9,650	45,000
Emissions Instrumentation	3,000	10,000
Structure	150,000 ($3,000\ ft^2$)	200,000 ($4,000\ ft^2$)

existing I/M lane in the SCAB is $1.64 per minute based on the data given in the previous section. Hence, the cost of inspection for a HDDV can be expected to be $12 as a minimum and may range up to $15 if as much as 2 minutes of additional time for set-up is justified. For comparison purposes, time on a heavy-duty dynamometer can presently be rented for an engine horsepower analysis at a few garages in California. Typically this cost is $35 to $40, but more time is required to obtain the complete power curve than for an emissions inspection.

Requiring fleets, such as school or transit district buses, to perform their own emissions inspection was previously mentioned as an alternative. Since many large fleet operators already have heavy-duty dynamometers for maintenance purposes, they might be used for annual emissions testing as well. Random inspection by the State could then provide a simple cost effective means for assuring compliance.

Another inexpensive alternative for the State would be to inspect for broken seals on governors at weigh stations. For a negligible cost (primarily just a small amount of training for inspectors), the most significant tampering activity could be discouraged.

APPENDIX

- QUESTIONNAIRE

E OF CALIFORNIA
EDMUND G. BROWN JR., Governor

RESOURCES BOARD
Q STREET
BOX 2815
AMENTO, CA 95812

November 18, 1980

Subject: Diesel Maintenance

Dear Vehicle Maintenance Supervisor:

The California Air Resources Board (ARB) has contracted with Science Applications, Inc. (SAI), of Los Angeles, California to examine current heavy-duty (over 6000 pounds, gross vehicle weight) vehicle maintenance in the state.

Your cooperation in providing the information described in the attached questionnaire would be appreciated. The data you provide will be evaluated along with information being gathered from other heavy-duty diesel operators throughout California and other states. Please be aware of the fact that the more complete and accurate the response to the questionnaire, the more valid the conclusions of the study will be.

This request for data is a formal one made by the ARB pursuant to Sections 39601, 43100 and 43101 of the California Health and Safety Code. The questionnaire has been designed to make your response as easy as possible. Completion of the 2 charts and 2 questions should take no more than a few minutes of your time.

Be advised that the information provided in the questionnaire can be released to the public upon request unless you request trade secret classification in writing, (in accordance with the California Public Records Act, Government Code Section 6250 et seq.). All such requests must be accompanied by an adequate justification for the trade secret designation, which should be as detailed as possible without disclosing the trade secret. Actual air pollution emission data cannot be classified as trade secrets, but other data such as privileged processes, costs, formulas, etc., may be eligible for such treatment. Information supplied to ARB which is designated as a trade secret will be kept confidential, although such information may be forwarded to the U.S. Environmental Protection Agency, which protects trade secrets in accordance with Federal law. Please note that the contractor, SAI, has formally agreed with the ARB to protect the disclosures of trade secrets to others.

Further information regarding ARB procedures for protecting trade secrets may be found in Section 91010, Title 17 of the California Administrative Code or by contacting ARB's Legal Affairs and Enforcement Division.

In order to expedite the completion of this study, please return the completed questionnaire within ten (10) working days after receipt of this correspondence to:

Science Applications, Inc.
Attention: Don Hausknecht
1801 Avenue of the Stars, Suite 1205
Los Angeles, CA 90067

For your convenience, a self-addressed envelope has been enclosed.

Should you require assistance in completion of this questionnaire, please contact Dr. Donald Hausknecht, Project Manager at SAI. He may be reached at the above address or at (213) 553-2705. In addition, he will be happy to answer any questions you may have concerning this project.

Your prompt response to this matter will be greatly appreciated.

Sincerely,

CALIFORNIA AIR RESOURCES BOARD

John R. Holmes

Dr. John R. Holmes
Chief, Research Division

Enclosure

Gross Vehicle Weight Classification	Number of Diesel Powered Vehicles By Type:			Are they usually purchased New or Used in California or Out-of-State?		Typical annual mileage for one vehicle and percent of miles driven intra-city, intra-state and inter-state:	Typical Age of Vehicle (years)	Fuel Type Used-Diesel Fuel No. 1, 2, or 3:
	Tractors	Vans	Buses	California	Out-of-State			
I: 0 to 6,000 pounds				New____ Used____	New____ Used____	____ miles annually Percent Intra-City ____% Intra-State ____% Inter-State ____%		No. 1 ____ No. 2 ____ No. 3 ____
II: 6,001 to 10,000 pounds				New____ Used____	New____ Used____	____ miles annually Percent Intra-City ____% Intra-State ____% Inter-State ____%		No. 1 ____ No. 2 ____ No. 3 ____
III: 10,001 to 14,000 pounds				New____ Used____	New____ Used____	____ miles annually Percent Intra-City ____% Intra-State ____% Inter-State ____%		No. 1 ____ No. 2 ____ No. 3 ____
IV: 14,001 to 16,000 pounds				New____ Used____	New____ Used____	____ miles annually Percent Intra-City ____% Intra-State ____% Inter-State ____%		No. 1 ____ No. 2 ____ No. 3 ____
V: 16,001 to 19,500 pounds				New____ Used____	New____ Used____	____ miles annually Percent Intra-City ____% Intra-State ____% Inter-State ____%		No. 1 ____ No. 2 ____ No. 3 ____
VI: 19,501 to 26,000 pounds				New____ Used____	New____ Used____	____ miles annually Percent Intra-City ____% Intra-State ____% Inter-State ____%		No. 1 ____ No. 2 ____ No. 3 ____
VII: 26,001 to 33,000 pounds				New____ Used____	New____ Used____	____ miles annually Percent Intra-City ____% Intra-State ____% Inter-State ____%		No. 1 ____ No. 2 ____ No. 3 ____
VIII: 33,000 pounds and over				New____ Used____	New____ Used____	____ miles annually Percent Intra-City ____% Intra-State ____% Inter-State ____%		No. 1 ____ No. 2 ____ No. 3 ____

Page 1 Of 3 Fleet No.____________

Please fill in the information requested for the diesel powered vehicles you maintain or are responsible for.

Gross Vehicle Weight Classification	Lube & Oil Change			Air Filter Change			Fuel Filter Change			Injector Servicing (Including Governor Adjustments)			Turbocharger Servicing			Adjustments or Other Servicing*		
	Miles Between Servicing	Cost Per Service		Miles Between Servicing	Cost Per Service		Miles Between Servicing	Cost Per Service		Miles Between Servicing	Cost Per Service		Miles Between Servicing	Cost Per Service		Miles Between Servicing	Cost Per Service	
		Parts $	Labor $		Parts $	Labor $		Parts $	Labor $		Parts $	Labor $		Parts $	Labor $		Parts $	Labor $
I: 0 to 6,000 pounds																		
II: 6,001 to 10,000 pounds																		
III: 10,001 to 14,000 pounds																		
IV: 14,001 to 16,000 pounds																		
V: 16,001 to 19,500 pounds																		
VI: 19,501 to 26,000 pounds																		
VII: 26,001 to 33,000 pounds																		
VIII: 33,000 pounds and over																		

Fleet No. ____________

*Exhaust Gas Recirculation System, if present, and/or Cooling System Maintenance including thermostats, pump, etc.

ave any engine components been changed from their original design? (If so, lease specify.)

☐ Yes Type of Change ______________________________

☐ No

s fuel injector servicing performed in your own shop? If not, where is it one?

☐ Yes

☐ No Where ______________________________

ow often do you overhaul or rebuild engines?

.fter ______________ miles on engine.

f there are any questions regarding this information, who may we contact?

ame ______________________________

irm ______________________________

none No. ______________________________

  Fleet No. ______________________

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