ENERGY CONSERVATION AND MONEY SAVINGS THROUGH THE USE OF DIESEL-POWERED TRUCKS

by

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(The opinions, findings, and conclusions expressed in this report are those of the author and not necessarily those of the sponsoring agencies.)

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SUMMARY

This report presents an analysis of the potential energy and money savings to be achieved from the increased use of class 7, diesel-powered, 4-yard dump trucks by the Department.

The technical differences between diesel and gasoline power plants are reviewed. The findings of a literature search are presented along with the results of a survey conducted to examine diesel truck use by various types of highway maintenance facilities. A data base of the average estimated mileage use and gasoline consumption of the Department's gasoline-powered, 4-yard dump trucks was generated for this analysis. The possible energy and money savings are calculated using the data base and a computer simulation for the diesel truck fuel consumption. These calculations use five alternative future fuel costs and economic analyses of payback and present worth. The study conclusions indicate that considerable energy and money can be saved by the increased use of diesel-powered trucks.

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INTRODUCTION

During the years from 1974 through 1977, the sale of class 6* and class 7** trucks powered by diesel engines increased by approximately 8% and 20%, respectively.(1) An increase in diesel-powered trucks to 50% of the class 6 fleet and 75% of the class 7 fleet before 1990 has been projected by both industry and the federal government.(2,3,4) These increases reflect the rise in costs of vehicle fuel and maintenance since the oil embargo of 1973. The commercial trucking industry no longer considers it a risk to purchase class 6 and 7 diesel trucks; on the contrary, it is now considered an economic necessity.

A number of studies have indicated that in addition to providing an overall economic advantage, dieselization of the class 6 and class 7 truck fleets is one of the most significant actions that could be taken to decrease the fuel use of commercial type highway vehicles. Former Secretary of Transportation Brock Adams last year stated that "As far as the optional features that one could choose for a truck, the diesel engine replacing a gasoline engine shows the biggest gain".(5) Adams also stated that the voluntary fuel conservation measures undertaken by the owners and operators of large highway vehicles saved 1.7 billion gallons of fuel from 1973 through 1978.

Highway maintenance departments at the state and local levels use a large number of class 6 and class 7 trucks in their daily operations.(6) It is reasonable to assume that if the purchase and operation of diesel-powered trucks result in fuel conservation and decreased maintenance costs in the private sector, they provide similar savings in the public sector.

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*Class 6 trucks are those of 19,500 to 26,000 lb. gross vehicle weight (GVW).

**Class 7 trucks are those of 26,001 to 33,000 lb. GVW.

The state of Virginia uses approximately 1,900 4-yard dump trucks of the clsss 6 and class 7 GVW range (all newer trucks are class 7). They are generally equipped with a V-8 engine; a single rear axle equipped with a two-speed differential; and a five-speed manual transmission (see Appendix A for detailed specifications). These type trucks are used for all facets of highway maintenance work such as removing snow, spreading chemicals, and hauling materials. Since these trucks represent the majority of the fleet now in use, they were the subject of the research leading to this report.

COMPARISON OF DIESEL AND GASOLINE ENGINES

There has been a general increase in the use of diesel engines in truck classes 6 and 7 in the United States since 1973. This trend is responsible for the relatively large number of manufacturers currently marketing diesel-powered class 6 and class 7 trucks in this country. In 1977 four manufacturers were actively engaged in the United States market, and that number has now grown to ten; three are domestic and seven are foreign firms. At Hampton, Virginia, one of the foreign firms, Mercedes Benz, is constructing an assembly plant which will be completed by early 1980.

The increase in the use of diesel engines in class 6 and class 7 trucks is due mainly to the cost savings that can be realized by operating diesel instead of gasoline-powered trucks. These savings are due to the differences between a diesel engine and a gasoline engine, which include compression ratios, ignition sources, fuel delivery systems, and the types of fuel used. The diesel engine has a higher compression ratio than the gasoline engine, and this gives it a greater expansion of the combustion gasses in the cylinder that increases the efficiency of energy conversion within the engine. Gasoline engines also can be manufactured with higher compression ratios; however, such engines require a premium grade of high octane fuel to prevent abnormal combustion. High octane gasoline is at present the most expensive fuel commercially available and its use would significantly increase the cost of operating a vehicle.

Diesel engines use compression heat to ignite the air-fuel charge within the combustion chamber, while a gasoline engine uses an electrical ignition system. Since there is no external ignition system in the diesel engine to adjust and maintain, there are no problems from a faulty ignition system as might be the case with a gasoline engine.

Fuel is supplied to a diesel engine at the cylinder; it is not premixed with air outside of the combustion chamber as it is in a gasoline engine equipped with a carburetor. The gasoline engine carburetor has a butterfly valve to control, or throttle, the air and fuel flow into the engine intake manifold. At idle and less than full load, this throttling process results in a decrease of engine efficiency. The diesel engine has no carburetor and thus is not subject to this decrease in efficiency.

The fuel used in a diesel truck engine is usually the number two type. The average heat content of this fuel is approximately 137,000 Btu's per gallon, while that of gasoline is 125,000 Btu's a gallon. As previously explained, the diesel engine is more efficient than a gasoline engine so the diesel can convert a larger portion of the energy in the fuel into useful mechanical work. This diesel engine efficiency, plus the use of a fuel with a higher Btu content, explains why a diesel engine can do the same work that a gasoline engine does while using less fuel on a volume basis. The actual decrease in the amount of fuel needed to operate a diesel-powered truck as compared to that needed for a gasoline-powered truck depends on the power output of the engine, the size of the truck and its load, and the particular application of the truck. There are, however, some general empirical factors that have been used and proven to be fairly accurate in judging fuel use. The diesel engine will, for example, use 40% less fuel at full load, 50% less fuel at half load, and up to 200% less fuel at idle.[7,8,9,10] A realistic range for the overall decrease in fuel use by a diesel engine over a gasoline engine in the same application is from 40% to 80%. This range has been documented by many fleets operating both diesel- and gasoline-powered trucks in the class 6 and class 7 GVW categories.[3,4,11,12,13,14,15,16,17]

PURPOSE AND SCOPE

The purpose of the study reported here was twofold. First, it investigated the current trends toward the increased use of diesel trucks for highway maintenance. Second, it investigated the energy conservation and monetary savings that might be realized by the Virginia Department of Highways and Transportation if it increased the number of diesel-powered trucks in its maintenance fleet.

The study consisted of four tasks.

1. A literature search of the available material concerning the use of diesel and gasoline trucks in the class 6 and class 7 weight ranges.

2. A survey of state and local government highway departments to gather current data concerning the trends in diesel truck use for highway maintenance operations.

3. An estimation of the average yearly mileage and fuel consumption for both the gasoline-powered trucks currently in use by the Department and for the diesel-powered trucks that could be used as replacements.

4. An economic analysis to determine if the purchase and operation of diesel-powered trucks in lieu of gasoline-powered trucks would be cost-effective.

METHODOLOGY

The available literature dealing with comparisons of operations employing diesel- and gasoline-powered trucks was reviewed. The publications reviewed included research reports, trade journals, reports and brochures provided by engine and vehicle manufacturers, documents supplied by various federal government agencies, and the proceedings and journals of professional societies.

The survey of trends in the use of diesel trucks in highway maintenance operations was conducted by using a return-mail questionnaire. The questionnaire was sent to maintenance and equipment engineers in state, city, and county highway departments, five Canadian Provinces, and ten United States Toll Road Commissions. One hundred and twenty-five of the 167 organizations who were sent the questionnaires returned them. The 22 questions asked dealt with diesel truck use according to GVW range, type of operation, type of climate, topographic region, cost of maintenance as compared to that of gasoline-powered trucks, and the advantages and disadvantages of using diesel-powered trucks as opposed to gasoline-powered trucks.

The estimates of average yearly mileage use and the miles per gallon of fuel used by the Department's gasoline-powered trucks were developed by using figures for a sample of the vehicles currently in service throughout the Staunton District. This district was chosen because of its varying topographical regions. The average yearly mileage use of the gasoline-powered trucks was also used for the diesel trucks, the assumption being that the mileage would be the same regardless of the type of power plant. The estimated average miles per gallon fuel use for the diesel trucks was obtained from a computer simulation that is explained in the section dealing with yearly mileage and fuel consumption.

The economic analysis was based on computations of the payback period for the initial cost difference between gasoline and diesel trucks along with a present worth analysis of each truck for 6 years of operation.

LITERATURE REVIEW

In reviewing the available literature it became clear that the majority of the information dealt with the positive and negative aspects of using both gasoline- and diesel-powered trucks. The general question discussed in the literature is not whether the use of diesel trucks can lead to savings in fuel and decreased total operating cost, but rather at what mileage use per year the diesel truck becomes cost-effective. The pertinent information in the literature can be classified into one of four major areas: initial cost, fuel use, maintenance cost, and overall reliability.

Initial Cost

Currently, a diesel-powered truck with a 4-yard dump body costs from $4,000 to $8,000 more than a comparable gasoline-powered truck.

Fuel Use

The use of diesel engines in mid-range trucks does save fuel on both a miles-per-gallon and miles-per-Btu basis. This fact has been overwhelmingly proven in both public and private vehicle fleets. The basic reasons for these savings were explained earlier. Of course, the actual savings will vary from application to application and from truck to truck. The Regulated Common Carrier Council (RCCC) fuel use data indicate that the average consumption for gasoline applications is 3.37 miles per gallon (mpg), while the average consumption of diesel fuel for the same application is 5.98 mpg.[4,18] These data show a 77% increase in fuel mileage of the diesel as compared to the gasoline application. In a recent study of class 6 trucks used for highway maintenance by the state of Maine,[11] it was found that the fuel economy of the diesel-powered trucks was 33% better than that of the trucks powered by gasoline engines. According to reports by the U.S. DOT and the Motor Vehicles Manufacturing Association, the increased use of mid-range diesel engines in class 6 and class 7 trucks since 1973 has saved 33 million gallons of fuel and has the capability of saving even more fuel in the

future.[19,20] The results of a recent survey concerning class 6 trucks indicated that the diesel trucks averaged 48% better fuel mileage than the gasoline trucks.[12]

The examples of fuel savings cited above are only a small number of those available in the current literature; other cases may be found in other references.[21,22,23,24]

The change from gasoline to diesel power for class 6 and class 7 trucks should not pose a problem for diesel fuel suppliers. They estimate that they could provide enough diesel fuel to meet the demand created by a total vehicle population* mix of 25% diesels.[3,25] As class 6 and class 7 trucks are at present estimated to be only 1% of the total vehicle population, it seems apparent that even if they all become diesel-powered, the fuel supply could be increased to meet the demand. This observation, of course, assumes that gasoline consumption would drop and make available the crude oil necessary for producing diesel fuel. However, if the demand for gasoline increases and the gasoline not used by class 6 and class 7 trucks is still produced and sold to other consumers, problems could very well be encountered in providing adequate supplies of diesel fuel.

Maintenance Cost

All the pertinent literature reviewed indicates that the maintenance cost of diesel-powered trucks is less than that of gasoline-powered trucks. Here again the question does not seem to be whether diesels save money but how much they can save. The recent survey by the Diesel Equipment Superintendent indicates that the average maintenance cost of gasoline-powered trucks is 38% higher than that of diesel-powered trucks.[12,26] The RCCC data on maintenance cost indicate that the average gasoline truck maintenance cost is 160% higher than that of the diesel truck.[27] The Burlington Fleet Service, with data supplied by some of its customers operating class 6 trucks, places the cost of gasoline truck maintenance 130% higher than diesel truck maintenance.[28] In addition, the manufacturers that are presently marketing both gasoline-and diesel-powered trucks advertise that the diesel units will save considerable maintenance cost based on actual user operations.[4,27]

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*NOTE: The total vehicle population includes all types of highway vehicles being operated in the United States.

Overall Reliability

It was generally agreed in the literature that diesel trucks were more reliable than the gasoline models. This reliability is usually expressed as a function of total days out of service due to maintenance and/or necessary repairs. However, another aspect often cited is the ability of the diesel engine to operate with high reliability in wet weather due to the lack of an external electrical ignition system. The Maine study indicates that the diesel trucks were out of service 50% less than the gasoline trucks.(11) General industry data show that diesel trucks have an average annual downtime of 5 days less than gasoline trucks.

The literature review also uncovered several other possible attributes for each of the truck types. These areas, however, are not sufficient in size or impact to consider them alone as any basis for a choice between diesel- and gasoline-powered trucks. They should, however, be included in the overall picture when comparing diesel and gasoline trucks. These additional aspects are shown in Table 1.

Table 1

ADDITIONAL ATTRIBUTES OF DIESEL AND GASOLINE ENGINES

Diesel	Gasoline
1. Less theft of fuel	1. Less engine weight
2. Less theft of parts	2. Mechanic familiarity
3. Higher resale value	3. Driver familiarity
4. Increased engine life	4. Less costly overhaul

DIESEL USE SURVEY

A direct mail survey was conducted to document the current trends in diesel truck use by highway maintenance departments. It was not intended that the survey provide specific numbers of trucks used or the manufacturers of the vehicles used. The survey was concerned with present diesel truck usage and the expected increase in the use of class 6 and class 7 trucks.

The survey questionnaire consisted of 22 questions covering five general areas (see Appendix B). The data requested included purchase information, future replacement of gasoline trucks by diesel trucks, the advantages and disadvantages of using diesel trucks, maintenance and repair, and operational information. The questionnaires were mailed to five types of highway maintenance organizations to include the 50 states, and Washington, D. C. and Puerto Rico; 50 cities; 50 counties; 10 toll roads; and 5 Canadian Provinces. As previously stated, 167 questionnaires were mailed and 125 were returned for a return rate of 75%. The return figures were as follows: states 45, cities 34, counties 32, toll roads 9, and Canadian Provinces 5.

The data collected represent the actual present use of diesel trucks by those agencies responding to the survey. At this time there do not appear to be any other data of this type available for comparison or correlation. It is believed, therefore, that the collected data are the best available and as such are an accurate representation of the present and expected use of diesel trucks in highway maintenance.

Survey Results

States

As previously stated, 45 responses were received from the states; however, only the responses from 43 were used in the compilations. Wisconsin was omitted because no highway maintenance equipment is operated on the state level there, and the responses from the Virginia Department of Highways and Transportation were used only for comparative purposes. For easy reference, the results of each section of the survey are presented in table form along with the discussion of the section. Complete tabulations of state responses are shown in Appendix C.

Reasons for Purchase

Table 2 summarizes the purchase information described in this section. Two states specify diesel engines for trucks purchased in the under 10,000 lb. GVW range, while 17 states specify diesels for trucks of 10,000-28,000 lb. GVW. By far the largest group, 42 states, specify diesel power in trucks above 28,000 lb. GVW.

Table 2

DIESEL TRUCK PURCHASE INFORMATION

	Yes		No	
	No. of Responses	% of Total	No. of Responses	% of Total
Specify Diesel by Weight:				
Under 10,000 lb. GVW	2	5	41	95
10,000 to 28,000 lb. GVW	17	40	26	60
Over 28,000 lb. GVW	42	98	1	2
Specify Diesel For:				
Snowplowing	18	43	24	57
Truck Tractors	14	33	28	67
High Mileage	4	10	33	90
Long Hauls	9	21	33	79
Heavy Loads	21	50	21	50
Trailer Pulling	1	2	41	98
Tank Trucks	2	5	40	95
Paving	2	5	40	95
Increased Auxiliary Equipment	2	5	40	95
Other Uses	15	36	27	64
Specify Diesel by Terrain:				
Mountain Land	2	5	41	95
Other Type Land	1	2	42	98
Specify Diesel by Climate:				
Low Temperature	2	5	41	95
High Temperature	2	5	41	95
Maintenance Training a Deterrent to Purchase:	5	12	38	88
Operator Training a Deterrent to Purchase:	6	14	37	86

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In the responses relating to purchase for a specific use, 21 states indicated that diesel trucks are purchased for hauling heavy loads. Snow and ice removal was indicated by 18 states, and truck-tractors by 15 states. The purchase of diesel trucks for long hauls by 9 states and for high-mileage units by 4 states complete the main categories of use for which diesel trucks are purchased. Other truck uses that were indicated by a total of 22 states included paving work, high auxiliary equipment use, tank trucks, fire equipment, drilling rigs, stripers, trailer pulling, and concrete mixers. One response, given by 11 states under the "Other" category, was the purchase of diesel trucks for overall use with no specific application but for all phases of highway maintenance. Only 3 states indicated that their diesel trucks were purchased for use in a specific topographical or climatic region.

Additional operator and maintenance training was viewed by some states as a deterrent to purchasing diesel trucks. Six states felt that operator training was a cause for concern and 5 states felt that maintenance training was a deterrent. Among these 11 states, 4 felt that each of these areas of training was a deterrent.

Future Replacement of Gasoline Trucks with Diesels

Table 3 summarizes replies to the question on the future replacement of trucks. Future replacement of the under 10,000 lb. GVW gasoline-powered trucks with diesel units was indicated by 12 states. For this weight truck, the percentage of the fleet size to be replaced by diesel ranged from unknown to 100%. The responses concerning the 10,000-28,000 lb. GVW trucks show that 21 states plan to purchase diesel replacements in numbers ranging from 20% to 100% of the fleet size. Four other states indicated that this replacement is being planned, but were unable to provide a probable percentage of the fleet size.

Table 3

FUTURE REPLACEMENT OF GASOLINE TRUCKS BY DIESEL TRUCKS IN THE UNDER 10,000 LB. GVW AND 10,000-28,000 LB. GVW RANGES

Under 10,000 lb. GVW

Future Replacement in Percent of Fleet Size	Number of Responses	Percent of Total Responses
None	30	71.4
0-5	1	2.4
16-20	1	2.4
21-25	2	4.8
36-40	1	2.4
46-50	2	4.8
96-100	1	2.4
Unknown	4	9.5

10,000-28,000 lb. GVW

Future Replacement in Percent of Fleet Size	Number of Responses	Percent of Total Responses
None	17	40.5
21-25	2	4.8
26-30	1	2.4
46-50	3	7.1
71-75	3	7.1
76-80	1	2.4
86-90	1	2.4
96-100	10	23.8
Unknown	4	9.5

Advantages and Disadvantages of Diesel Truck Use

Table 4 contains the responses indicating the advantages and the disadvantages of diesel truck use. Thirty-nine states listed increased fuel economy as an advantage of diesels. Decreased maintenance cost was listed as an advantage by 35 states, longer engine life by 25 states, wet weather reliability by 11 states, and better operating characteristics by 5 states. Other advantages listed included decreased air pollution, decrease in fuel theft, better cold weather performance, better overall reliability, and higher resale value. One or more of these responses came from 11 states.

Table 4

ADVANTAGES AND DISADVANTAGES OF DIESELS

	No. of Responses	% of Total
Advantages:		
Fuel Economy	39	93
Decreased Maintenance	35	83
Better Engine Torque	5	12
Longer Engine Life	25	60
Wet Weather Reliability	11	26
Decrease in Fuel Theft	1	2
Less Air Pollution	1	2
Other Aspects	9	21
Disadvantages:		
High Initial Cost	28	70
Driver Training	4	10
Maintenance Training Cost	4	10
Availability of Fuel	1	3
Cold Weather Starting	9	23
Cold Weather Fuel Problems	2	5
Engine and Exhaust Noise	1	3
Exhaust Fumes and Odor	1	3
Other Aspects	8	21

Twenty-eight states indicated that the disadvantage of diesel trucks was their high initial cost. Poorer cold weather starting was listed as a disadvantage by 9 states, and the need for operator and maintenance training by four states. Other disadvantages included increased engine and exhaust noise, fuel problems in cold weather, exhaust odor, shortage of mechanics, and higher overhaul costs. These responses came from 13 states. Three states indicated that, in their opinion, the diesel had no disadvantages.

Maintenance and Repair Information

Table 5 contains the maintenance and repair information explained in this section. There were no responses on this set of questions for the under 10,000 lb. GVW range diesel-powered trucks. Those states using this type of truck stated that the length of time these units had been in operation was not long enough to allow sufficient data collection for a comparison with gasoline-powered trucks.

10,000-28,000 lb. GVW - Eight states responded that routine maintenance for diesel trucks required less time than for gasoline trucks and 9 states said that the same amount of time was required for both. Nine states considered routine maintenance costs to be less for diesel trucks, 4 considered the costs as the same, and two considered the cost for the diesels to be more. Fourteen states considered the amount of necessary repair to be less for diesel trucks and 1 state considered the amount the same. In the last category, the cost of necessary repair, 10 states considered the cost for the diesel to be less, 2 states said the costs were the same, and 8 states said the diesel cost more.

Above 28,000 lb. GVW - Twenty-four states indicated that the time required for routine maintenance of diesel trucks was less than that for gasoline trucks, 10 states considered the times to be the same, and 5 states said the diesel trucks required more time. The routine maintenance cost of diesel trucks was considered to be less by 24 states, the same by 7 states, and more by 8 states. Thirty-two states considered the amount of necessary repairs for diesel trucks to be less, 5 states considered them to be the same, and 2 states indicated they were more. The cost of necessary repairs for diesel trucks was considered to be less by 22 states, the same by 6 states, and more by 9 states.

Table 5

DIESEL MAINTENANCE AND REPAIR COMPARED TO THAT FOR GASOLINE-POWERED TRUCKS

	More		Less		Same	
Routine Maintenance Time:	No. of Responses	% of Total	No. of Responses	% of Total	No. of Responses	% of Total
Under 10,000 lb. GVW	0	0	0	0	0	0
10,000-28,000 lb. GVW	0	0	8	53	7	47
Over 28,000 lb. GVW	5	13	24	61	10	26
Routine Maintenance Cost:						
Under 10,000 lb. GVW	0	0	0	0	0	0
10,000-28,000 lb. GVW	2	13	9	60	4	27
Over 28,000 lb. GVW	8	20	24	62	7	18
Amount of Repairs Needed:						
Under 10,000 lb. GVW	0	0	0	0	0	0
10,000-28,000 lb. GVW	0	0	14	93	1	7
Over 28,000 lb. GVW	2	5	32	82	5	13
Cost of Necessary Repairs:						
Under 10,000 lb. GVW	0	0	0	0	0	0
10,000-28,000 lb. GVW	2	14	10	72	2	14
Over 28,000 lb. GVW	9	24	22	60	6	16

Overall Evaluation

Table 6 contains the results of the overall evaluations described in this section. The question was, Are you pleased in general with the maintenance and operational characteristics of your diesel trucks? There were, again, no responses for trucks in the under 10,000 lb. GVW range. For trucks in the 10,000-28,000 lb. GVW range, 14 states said yes; and for vehicles in the above 28,000 lb. GVW range, 37 states responded affirmatively. It should be noted that not 1 negative response was received.

Table 6

OVERALL EVALUATION

	Yes		No	
	No. of Responses	% of Total	No. of Responses	% of Total
Pleased with Operation and Maintenance:				
Under 10,000 lb. GVW	0	0	0	0
10,000-28,000 lb. GVW	14	100	0	0
Over 28,000 lb. GVW	38	100	0	0
Recommendation of Purchase:				
Under 10,000 lb. GVW	1	50	1	50
10,000-28,000 lb. GVW	16	100	0	0
Over 28,000 lb. GVW	38	100	0	0

The questions concerning the recommendation to buy diesel trucks were not answered by all the respondents. In some cases, this was because of the short length of time that the respondents had been using the equipment. Here again the responses for the under 10,000 lb. GVW category did not produce sufficient data to report on. In the remaining two categories, 10,000-28,000 lb. GVW and above 28,000 lb. GVW, all the responses were positive.

Sixteen states recommended purchase of the 10,000-28,000 lb. GVW diesel trucks, while 38 states recommended purchase of diesel-powered trucks above 28,000 lb. GVW.

Composite Response

While the above responses were by no means unanimous, there does seem to be a majority response to each question. These responses can be used to form a composite trend of diesel truck use by state highway agencies. The composite response would indicate a state that is now specifying diesel engines for trucks above 28,000 lb. GVW and is planning to use diesel power for trucks in the 10,000-28,000 lb. GVW range. The future fleet mix of the 10,000-28,000 lb. GVW range trucks will be 80% diesel and 20% gasoline. In addition, the composite state response indicates no plans to purchase diesel trucks in the under 10,000 lb. GVW range.

The composite state would generally purchase the diesel-powered truck for heavy hauling, snow and ice removal, truck tractors, and for general maintenance uses. Increased fuel mileage, decreased maintenance, and longer engine life would be the perceived advantages of the diesel. Its disadvantage would be its higher initial cost. The time required for maintenance and the maintenance costs for the diesels would be the same or less than those for the gasoline trucks used. The cost and amount of necessary repair would also be considered less than those required for a gasoline-powered truck.

The response on the overall ratings would be positive for both the 10,000-28,000 lb. GVW and above 28,000 lb. GVW ranges. This finding would correspond, then, to a recommendation that diesel trucks of 10,000-28,000 lb. GVW and above 28,000 lb. GVW should be purchased by other highway maintenance agencies.

Virginia Response

In order that the current use of diesel trucks in Virginia could be compared to the results of the survey of other states, the questionnaire was also completed by the Department's Equipment Division. The Equipment Division does not at present specify diesel engines in trucks under 28,000 lb. GVW. Diesel trucks are purchased for snow removal, for use as truck tractors, and for use in mountainous terrain. The Division is testing 50 class 7, 4-yard dump trucks that are diesel-powered and 10 diesel-powered pickup trucks in the under 10,000 lb. GVW range. These diesel-powered trucks are of the same size and weight range as the

currently purchased gasoline-powered trucks. A comparison of the specifications for each type of 4-yard dump truck (see Appendix A) clearly shows that the only difference in the equipment is the type of engine (diesel or gasoline).

The Equipment Division does not consider the additional operator or maintenance training a deterrent to the purchase of diesel-powered trucks. The Division would recommend that other states purchase diesel trucks in the 10,000-28,000 lb. and the above 28,000 lb. GVW ranges. The major advantages of diesel truck use are considered to be increased fuel mileage and better operation during snow removal. The disadvantages are seen as higher cost, low mileage use, and loss of fuel efficiency by continuous idling.

The maintenance and repair information supplied by the Equipment Division indicates that the time and cost of maintenance of diesel trucks in the 10,000-28,000 lb. and above 28,000 lb. GVW ranges are the same as those for gasoline trucks. The cost of repair for diesel trucks in the 10,000-28,000 lb. and above 28,000 lb. GVW ranges is also the same as for gasoline units; however, the number of repairs for diesel trucks in these GVW ranges is less than for gasoline trucks of the same size.

As the purchase recommendation would indicate, the maintenance and performance characteristics of diesels in the 10,000-28,000 lb. and above 28,000 lb. GVW ranges were judged to be satisfactory.

The present use of diesel trucks for highway maintenance by the Department was compared to the composite response explained earlier. The Virginia response was very close to the composite, with the exception of the present use or planned use of diesel-powered trucks in the 10,000-28,000 lb. GVW range. As previously mentioned, Virginia is testing diesel trucks of this type, but has made no commitment to purchases for the purpose of replacing gasoline-powered trucks.

As a further comparison of diesel truck use trends, the results of the survey response from the cities, counties, toll roads, and Canadian Provinces are shown in Appendixes D through G and the total results are shown in Appendix H.

The city and county responses indicate that the use of diesel trucks in the 10,000-28,000 lb. and above 28,000 lb. GVW ranges is slightly lower than the present state use. In addition, the cities and counties responding purchase a large number of diesel-powered trucks for refuse hauling. This category of use did not appear on any of the state responses.

The responses dealing with the future replacement of gasoline trucks by diesel trucks for both the cities and counties were very similar to the state responses on a percentage basis. Approximately 60% indicated replacements of trucks in the 10,000-28,000 lb. GVW range and 25% for trucks in the under 10,000 lb. GVW range.

The advantages and disadvantages of diesel truck use cited by the cities and counties were comparable to the state responses with one exception, the response of high initial cost as a disadvantage was considerably lower on a percentage basis. The state responses indicated 70% while the city and county responses indicated 40% or less.

The maintenance and repair information obtained from the city and county responses matched that from the state responses with only slight differences in the percentages of responses.

The results of the city and county overall evaluation of diesel trucks were identical on a percentage basis to those of the state. All of the city and county respondents to this section were pleased with the operating and maintenance characteristics of their diesel trucks in both the 10,000-28,000 lb. and the above 28,000 lb. GVW ranges. The recommendations to purchase diesel trucks in the 10,000-28,000 lb. and above 28,000 lb. GVW ranges were also identical for the city, county, and state on a percentage basis with one exception. One county respondent did not recommend the purchase of diesel trucks in the 10,000-28,000 lb. GVW range.

YEARLY MILEAGE AND FUEL CONSUMPTION FOR VIRGINIA

Gasoline Trucks

It was recognized that estimates of the average yearly mileage use and fuel consumption for a typical gasoline-powered, 4-yard dump truck were needed for a comparison with those for a diesel truck. Initially, it was thought that the information about mileage and fuel use could be easily obtained from the data recording section of the Department. However, because of the method used to record this information, it could not be obtained from this source. The Maintenance Division leases its trucks from the Equipment Division on an hourly basis and the cost of the rental includes all fuel and maintenance of the vehicles. Accordingly, the Equipment Division has been interested only in the total annual cost of operating a particular class of equipment on an hourly basis. This average hourly cost does not reflect

the mileage or the fuel used as separate components and thus this information is not available under the presently used record-keeping system. The mileage data needed are recorded on the equipment rental sheet (see Appendix Figure I-1) but these data are not used in the present data processing system and can be obtained only by inspecting the equipment rental sheets for each truck. A copy of the rental sheet is retained by the district equipment engineer and one is sent to the Equipment Division in Richmond.

A similar problem makes it difficult to estimate fuel consumption. Each time a truck is fueled a credit card is used and a fuel ticket is issued for that use. The district equipment engineer retains a copy of the fuel ticket (see Appendix Figure I-2). The gallon figure on the fuel ticket is used in the current data processing system to determine the total fuel used in a month for all equipment of a certain type. However, the information contained on the individual fuel ticket is not recorded in the system and is lost after the total fuel cost is calculated.

Because the detailed information could not be obtained from records, 100 trucks used in the five residencies making up the Staunton District were chosen as a representative sample to determine the average fuel consumption and yearly mileage. Fourteen trucks were excluded from the calculated yearly mileage because of odometer or reporting failures, and 5 were excluded from the fuel consumption calculation because of errors in fuel tickets. This sample was purposely chosen to include trucks manufactured by each of the firms that had sold trucks to the Equipment Division during the years 1972-1978. These manufacturers were Chevrolet, Dodge, Ford, GMC, and International Harvester. No attempt was made to compute yearly use or fuel consumption on the basis of vehicle manufacturer, as the intent was to arrive at average yearly use and fuel consumption figures that would be representative of the entire fleet of 4-yard dump trucks in use by the Department. Each truck has an Equipment Division number (ED number). The number appears on the equipment rental sheet and the equipment fuel ticket and thus provided a means of obtaining the necessary information from the records retained at the district offices.

With the ED number available, data collection consisted of manually searching the equipment rental sheets and fuel tickets at the Staunton District Office for the appropriate information and recording it. The mileage was recorded from the equipment rental sheets covering the 12-month period from June 1978 through May 1979. The fuel use data were recorded only for the month of April because of the large number of fuel tickets that had to be reviewed. Even this limited collection of data required 80 hours.

The results of the calculations of gallons of fuel used and miles traveled in April 1979, miles per gallon, and the total yearly mileage are shown in Appendix J. Using these data, the average mileage use of a 4-yard dump truck was estimated to be 17,800 miles per year. The estimated average miles traveled per gallon of fuel was 5.17. It is believed that this estimate is the best that could be obtained under the present data collection and reporting procedures.

Diesel Trucks

A yearly mileage estimate of 17,800 miles will be used for the diesel trucks, as it is expected that the diesel trucks will be used at least as much as the present gasoline models.

The fuel use of the diesel trucks however, cannot be computed from operating records since the use of the trucks is rather recent and the available data are too limited to provide a representative sample. It was, therefore, decided to use one of the several available computer simulation programs of vehicle operation taking into account the GVW, engine type, transmission and drive axle ratios and driving cycles to estimate the average fuel use in miles per gallon for the diesel trucks. The TCAPE Program currently used by the International Harvester Company was selected because that company manufactured the fifty 4-yard diesel dump trucks being tested by the Department. It is hoped that at a later date the results of the simulation can be compared with the actual operating records to determine their accuracy. A copy of a TCAPE simulation printout is shown in Appendix K. The results of the simulation indicate that an average of 8.35 miles per gallon should be realized for the diesel trucks.

Fuel Savings

The estimated amount of fuel to be saved by replacing gasoline-powered trucks with diesel-powered units was calculated using the data obtained from the Staunton District operating records and the computer simulation for diesel fuel consumption.

Three fleet replacement plans were considered in calculating the amount of possible fuel savings: (1) total replacement, (2) 75% replacement, and (3) 50% replacement.

The present fleet of 1,900 gasoline-powered, 4-yard dump trucks is replaced at a rate of approximately 300 new trucks a year. In a 6-year time span the entire fleet will be replaced. This same time span would be used for the diesel replacement plan.

For example, in the total replacement plan, for a fleet of 1,900 trucks, approximately 300 diesel trucks would be purchased each year. After 6 years, the entire fleet would have become diesel-powered and all future replacements would also be diesel-powered.

The 50% replacement plan for a fleet of 1,900 trucks would entail the purchase of approximately 150 diesel, and 150 gasoline replacement trucks each year. After 6 years, 50% of the fleet will be diesel-powered and all future replacements would include 50% each of diesel and gasoline trucks. In addition to the volume of fuel saved, the Btu's saved were also calculated. The results of the calculations for each percentage replacement and the present fleet are shown in Appendix L.

The total replacement plan makes possible a reduction in gasoline use of 6.5 million gallons each year with a corresponding increased use of 4 million gallons of diesel fuel a year. Accordingly, the volume saving in fuel use would be approximately 2.5 million gallons a year. The total energy saved by complete replacement would amount to 258.5 billion Btu's per year (equivalent to 2.07 million gallons of gasoline per year).

The 75% replacement rate would reduce gasoline consumption by 4.8 million gallons a year. This rate would still require 1.7 million gallons of gasoline along with 3 million gallons of diesel fuel, and would save 1.8 million gallons of fuel a year. The total energy saved would amount to 190.5 billion Btu's per year (equivalent to 1.5 million gallons of gasoline).

The 50% replacement would reduce gasoline consumption by 3.25 million gallons a year. This option would require gasoline use of 3.25 million gallons a year along with 2 million gallons of diesel fuel. The fuel saved would be 1.2 million gallons a year and the total energy saved would be about 129 billion Btu's (equivalent to 1.03 million gallons of gasoline).

From the description of the fuel and energy savings for the three proposed replacement schemes it is easily seen that even the 50% replacement plan would save a considerable amount of fuel and total energy.

ECONOMIC ANALYSIS

The economic analysis consisted of a comparison between a gasoline-powered, 4-yard dump truck and a comparable type of truck powered by a diesel engine, both having a 27,000 lb. GVW (class 7). For the gasoline truck the yearly use and mpg figures

obtained from the Staunton District operating records were used. For the diesel truck, figures for one of those types recently purchased for evaluation by the Department were used. The average mileage use for the diesel truck was assumed to be the same as that for the gasoline-powered truck and the miles per gallon were estimated by the TCAPE computer simulation.

Two types of economic analyses are presented. The first analysis deals with the payback time period necessary to recoup the initial cost differential between a gasoline-powered and a diesel-powered truck. The second is a standard present worth calculation that gives the costs of purchasing and operating a unit for its lifetime in terms of present dollars.

To facilitate the analysis, several assumptions were made. These assumptions tended to favor the gasoline-powered truck, so the results of the analysis can be viewed as being somewhat conservative. The common assumptions were as follows:

1. The vehicles are retired from service at the same mileage and/or age, regardless of the type of engine.

2. The average overall fuel use of each truck type remains constant (5.17 mpg for gasoline and 8.35 mpg for diesel).

3. The vehicles are fueled on the same basis, regardless of engine type or size of fuel tank.

4. The costs of maintenance and repair are the same for the truck types over the entire life of the vehicles.

5. The average yearly mileage use for each truck type is constant at 17,800.

6. The initial cost differential between gasoline and diesel trucks of the same GVW is constant on a percentage basis, not on the actual dollar amount.

7. The salvage value of a diesel truck is higher than that of a gasoline truck by an amount equal to 50% of the initial cost differential.

8. The size of the 4-yard dump truck fleet is constant at approximately 1,900 vehicles.

Several areas that could possibly increase the cost factors of operating the diesel trucks were not included in the economic analysis. These include installing additional tanks for the storage of diesel fuel, training maintenance personnel, training truck operators, stocking additional parts for the diesel trucks, possible cold weather starting problems, and increased noise and exhaust odors. While these factors could increase costs, it is

believed that the conservative assumptions used as a basis for the economic analysis outweigh any increase these factors might cause. It is, however, necessary to be aware of these possible extra costs when considering the purchase of diesel trucks to replace gasoline trucks.

Also common to both types of economic analyses were the following five alternative futures relating to fuel costs:

1. The price of gasoline and diesel fuel charged to users by the Equipment Division remains constant at the current level; 70¢/gal. for gasoline and 64¢/gal. for diesel fuel.

2. The price per gallon of both gasoline and diesel fuel increases 20 cents a year during the time period of the analysis and gasoline remains 6 cents higher than diesel fuel.

3. The price per gallon of gasoline and diesel fuel increases 20 cents a year with no difference in these prices; i.e., the price of gasoline is equal that of diesel fuel.

4. The price per gallon of gasoline and diesel fuel increases 10 cents a year and gasoline remains 6 cents higher than diesel fuel.

5. The price per gallon of gasoline and diesel fuel increases 10 cents a year with no difference in their prices.

Payback Analysis

The payback analysis was performed to determine the time necessary to make up (payback) the initial difference between the costs of the gasoline and diesel trucks. The 4-yard dump truck used in this analysis is usually retired after 6 years of service and approximately 100,000 miles. It is necessary that the payback be accomplished before the end of the vehicle's expected service life. Any payback period of less than 6 years would indicate that the decrease of fuel use would balance off the higher initial purchase price of a diesel truck. The future fuel costs outlined earlier were used in the analysis. Two examples of the calculations for the complete analysis are given in Appendix M. The results of the analysis for the five futures concerning fuel costs are presented in Table 7.

Table 7

PAYBACK ANALYSIS

Futures	Payback in Years
1 (least probable)	3.9
2	3.1
3	3.3
4 (most probable)	3.4
5	3.7

It can be seen that even the longest payback period of 3.9 years is quite adequate in terms of the expected service life of the truck. It also should be pointed out that this payback period is the least probable, since the future fuel cost used is the least probable of those cited. Under future 4, which is the most probable, the payback period would be reduced to 3.4 years. Based on the payback analysis, it would appear that the purchase of diesel trucks is economically sound.

An additional calculation was made to determine what increase in diesel fuel price would be necessary to negate the fuel savings and increase the payback to 6 years. Using the current price of gasoline, it was found that a 25% increase in the price of diesel fuel, while the price of gasoline remained constant, would be necessary for such an increase in payback time. This is highly unlikely.

Present Worth Analysis of Total Cost

A present worth analysis was conducted using the purchase prices of a diesel and a gasoline truck, the annual fuel use, the five futures on fuel costs cited earlier, and the salvage value of each truck at the normal retirement age of 6 years. It was determined from a telephone survey of motor truck dealers that the difference in salvage value between a gasoline-powered truck and a diesel-powered truck at the end of 6 years and 100,000 miles is approximately 50% of the initial cost differential. In this analysis, therefore, the salvage value of the gasoline truck was put at $4,000 and that of the diesel truck at $6,000. Also,

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the analysis used discount rates of 10% and 12%. These two discount rates were chosen on the basis of information obtained from T. B. Omohundro, fiscal manager, that the Department's unused funds can generate a return of approximately 11% at this time. A summary of the results is presented here and two examples of the complete calculations at the 10% discount rate are given in Appendix N. The cost based on the present worth of each type of truck over 6 years for the five future fuel costs are given in Table 8.

Table 8

PRESENT WORTH ANALYSIS

Present Worth Costs at 10% Discount Rate:

Future	Gas	Diesel	Difference	Should Purchase
1	$19,412	$17,250	$2,162	Diesel
2	$26,733	$21,783	$4,950	Diesel
3	$26,733	$22,395	$4,338	Diesel
4	$23,068	$19,513	$3,555	Diesel
5	$23,068	$20,126	$2,942	Diesel

Present Worth Costs at 12% Discount Rate:

1	$19,277	$17,310	$1,867	Diesel
2	$26,051	$21,573	$4,478	Diesel
3	$26,051	$22,163	$3,888	Diesel
4	$22,611	$19,443	$3,168	Diesel
5	$22,611	$20,032	$2,579	Diesel

It is evident from the results shown in Table 8 that for all futures regarding fuel costs and both discount rates the present worth costs of the diesel truck are less than those of the gasoline truck. When this difference is multiplied by the number of trucks purchased yearly for each replacement plan, it becomes substantial.

For example, the total replacement plan using the results of the analysis for future 2 at 12% would yield a difference in present worth costs of $1.3 million in favor of the diesel trucks for the first year's purchase and operation alone. It follows, then, that the present worth analysis indicates that the purchase of diesel trucks is economically sound and would result in considerable savings to the Department. Considering the payback and present worth analyses together serves to strengthen the results and provides a highly defensible position for the purchase of the higher initial cost diesel trucks to replace the retired gasoline trucks.

Additional Factors

There are two additional factors which must be considered from the standpoint of their possible impact on any action taken by the Department to purchase and operate an increasing number of diesel-powered trucks. These factors are restrictions on the availability and allocation of future diesel fuel, and possible future rulings by the Environmental Protection Agency (EPA). The latter factor might involve restricting the use of diesels or, more importantly, decreasing the allowable emissions and thus probably decreasing the basic efficiency of the diesel power plant. At present these two possibilities are completely open to speculation.

The availability and allocation of diesel fuel are presently controlled by the federal government, and it is unlikely that any new large allocation of diesel fuel will be made. However, the Commonwealth of Virginia has an allocation for gasoline and diesel fuel. Were the entire 4-yard dump truck fleet to be equipped with diesel engines under the current allocation, this would produce a surplus of 6.5 million gallons of gasoline and a shortage of 4 million gallons of diesel fuel. The Department's suppliers of diesel fuel and gasoline have indicated that an allocation trade-off of 6.5 million gallons of gasoline for 4 million gallons of diesel fuel could probably be accommodated. The trade-off would of necessity have to take place over a period of several years. Such increased use of diesel fuel and decreased use of gasoline associated with the 6-year total replacement plan, while acceptable to the current suppliers, would require permission from the federal government. This shift in allocations is dependent on approval from the Department of Energy (DOE) and must be requested on DOE Form ERA 99. If the DOE grants the modification, the supplier can legally process the shift in fuel allocation and deliveries. Either of the other two replacement plans could be handled easily by the same kind of shift in allocations, since those two plans each require a smaller increase in the amount of diesel fuel needed than does the total replacement plan.

The possibility of future EPA action regarding the increased use of diesel power plants in class 6 and class 7 trucks also creates uncertainty. There is at present concern by the EPA that a significant increase in diesel engine use could possibly pose a health hazard to the general public. This concern is being expressed mainly in regard to an increase in diesel-powered automobiles and light trucks. As mentioned previously, the entire population of class 6 and class 7 trucks accounts for only about 1% of the total United States vehicle fleet. Even if the entire population of class 6 and class 7 trucks were to be powered by diesel engines, the effect on overall air quality would seem to be insignificant. However, regulatory action by the EPA could affect the economy of diesel operation.

The present position of the EPA on the subject of whether diesel engine emissions are a significant health hazard is best described by the following quote: "We plan to collect a broad variety of health effects data on diesel exhaust products. Although the results from any one study may not be sufficient to address the possible health effects from diesel exhaust products, it is hoped that the results from several related experiments will suggest whether EPA needs to take any action concerning diesel exhaust products. In the Clean Air Act Amendments of 1977, Congress provided EPA with many possible alternatives. The health effects data that EPA obtains by November 1979 will help us identify the most reasonable position to take concerning industry's desire to introduce large numbers of diesel powered vehicles on the American road. Hopefully, a large portion of the research described here will be completed by November 1979, so we will have a large health effects data base from which to draw conclusions."(29)

The two possibilities discussed above have the potential to significantly decrease the desirability of purchasing diesel-powered trucks. At the present time, however, there does not appear to be reason for any great concern since the purchase of diesel trucks would most likely be in no larger number than the current replacement rate. This rate would provide ample time to alter purchase decisions should fuel availability or EPA actions cause a change in present conditions.

CONCLUSIONS

The conclusions to be drawn from the several phases of this research study are given under the succeeding subheadings.

Literature Review

1. A diesel-powered truck uses considerably less fuel than a gasoline truck of the same type and weight class.

2. A diesel-powered truck is less expensive to maintain, on the average, than a gasoline-powered truck.

3. Diesel use in class 7 trucks is increasing rapidly and industry is gearing up to meet the demand.

4. Diesel trucks are more reliable than gasoline trucks.

Diesel Use Survey

1. At present mid-range and heavy-duty trucks are more likely to be diesel than are light-duty trucks.

2. Diesel trucks have found favorable uses in all areas of highway maintenance.

3. The use of mid-range diesel trucks is increasing in the public sector.

4. The positive aspects of diesels as compared to gasoline-powered trucks include better fuel mileage, more engine power, increased engine life, decreased maintenance costs, higher salvage value, and better overall reliability.

5. The negative aspects of diesel use include high initial cost, cold start problems, operator training, and maintenance training.

6. Diesel users believe the diesel trucks can be maintained for the same expenditure or less than that required for gasoline trucks.

7. Diesel users are pleased with the operating and maintenance characteristics of their medium- and heavy-duty trucks.

8. Diesel users have not been operating light-duty diesel trucks long enough to form opinions concerning their overall desirability and economy.

Mileage and Fuel Use of 4-Yard Dump Trucks Used by the Department

1. Current operational records do not reflect fuel use and mileage of individual vehicles.

2. The period of diesel truck use was too short to provide any useable data. Average fuel usage was obtained by a computer simulation.

Possible Fuel Savings by Using Diesel Trucks

1. The purchase of 4-yard, diesel-powered dump trucks will decrease the total gallons of fuel used annually by the Department.

2. The complete replacement of the present gasoline-powered, 4-yard dump truck fleet with diesel-powered trucks could yield an estimated annual savings of 2.5 million gallons of fuel.

Economic Analysis

1. For the purchase and operation of diesel trucks having a life span of 6 years, the payback period for the initial cost differential is under 4 years.

2. The present worth analysis of diesel trucks as compared to gasoline trucks favored the diesel trucks in all cases reviewed.

3. It is highly unlikely that the superior economic position of the diesel truck will be altered in the foreseeable future.

General

Diesel trucks are fuel efficient, cost less than gasoline trucks to maintain, and are more reliable than gasoline trucks. There is rapid growth in the use of the mid-range classes and highway maintenance agencies are included on the growing list of purchasers. Class 6 and class 7 diesel trucks are highly regarded for their operating and maintenance characteristics by those maintenance agencies now using them. The purchase of mid-range diesels is economically sound and can be easily defended, in spite of their higher initial cost.

RECOMMENDATIONS

1. In the interest of fuel conservation and operating economy, it is recommended that action be initiated to totally replace the present fleet of gasoline-powered, 4-yard dump trucks at their normal retirement age with diesel-powered units. Although the effects of total dependence on diesel trucks in this category must be considered in the event of a severe

shortage of diesel fuel, the current purchasing practice of replacing approximately three hundred 4-yard dump trucks each year will allow enough time to alter the total replacement plan, should such fuel supply problems arise. Once the total replacement is completed, the use of diesel trucks and the process of obtaining the necessary fuel should be well established.

2. A program should be developed and implemented that will provide diesel truck operator and maintenance training for those employees needing it. This program should be provided on a continuing basis that will keep pace with the incremental purchase of the diesel replacement trucks.

3. The operating and maintenance characteristics of the 50 diesel, 4-yard dump trucks already owned by the Department should be closely monitored and data collected in an attempt to determine their actual fuel usage and maintenance cost.

4. To obtain valid information for guidance, several changes should be made in the method of maintaining vehicle operating records. While the present system provides the data necessary to adequately determine an hourly charge for the rental of the vehicles to the Maintenance Division by the Equipment Division, the system does not provide any information about the operating characteristics of the individual trucks. Knowledge of these operating characteristics is useful in determining fuel use trends, needed repairs and possible early equipment failures. Information about fuel use, mileage, maintenance cost, and downtime can be of extreme value in producing an operating profile for each truck. The profile can, in turn, be used for a decision on retiring that vehicle in an attempt to minimize operating and maintenance costs. The specific changes recommended for the computerized system for recording information on vehicle operations are as follows:

   A. Catalog all data by ED number and district.

   B. Include data for mileage, fuel use, parts, labor, and downtime, all on a monthly basis.

   C. Retain this information by ED number and district for the entire life of the vehicle.

   D. Provide quarterly and cumulative printouts of the operating profiles of each vehicle to the district equipment engineer.

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APPENDIX A

EQUIPMENT DIVISION

SPECIFICATIONS FOR DIESEL TRUCKS

27,000 GVW Truck Chassis and Cab
(Diesel)

Truck GVW rating substantiated by published literature shall be not less than 27,000 regardless of the various components as listed herein.

Frame to be of "L" shaped reinforcing or fishplated with front bumper in line with main frame for heavy duty snow plow operation.

Wheelbase to be approximately 137", CA or cab to axle dimension not less than 72".

Front Axle: Capacity at ground of not less than 9,000 lbs., to be "I" beam construction with heavy duty springs, 4,500 lbs. at ground each side. To be furnished with power steering and front shock absorbers.

Rear Axle: To be equipped with one piece housing having two speed rear axle, gear ratio to be approximately 4.88/6.65 with road speed of approximately 58 MPH in high range and 42 MPH in low range at rated RPM. Capacity at ground of not less than 18,500 lbs. Rear springs to be heavy duty, main and auxiliary combined not less than 10,400 capacity at ground each side.

Transmission: To be five speed direct in fifth speed, heavy duty, opening on both sides for separate power take-off units.

Brakes: To be hydraulic with brake booster, lining area at least 199.0 sq. in. on front brakes and 400.0 sq. in. on rear brakes. To be equipped with vacuum gauge, reserve tank with 1,000 cu. in. capacity. Reserve vacuum tank mounting location must be approved by the Department.

Clutch: To be heavy duty not less than (2) 12" or 14" ceramic.

Engine: To be diesel engine, heavy duty, not less than 160 SAE net horsepower at rated RPM and SAE net torque of not less than 345 lbs. ft. at rated RPM. Engine supplied to be equipped with oil filter and oil bath or dry air cleaner. Engine to be equipped with governor set to manufacturer's RPM. Single exhaust only. Tilt type hood not acceptable.

Wheels: Cast steel spoke wheels with 7" rims.

Tires: To be equipped with single 900 x 20, 10 ply, tires on front and dual 900 x 20, 12 ply, tires on rear. All tires are to be furnished with tubes. The four rear tires to be Firestone Super-All-Traction; Goodyear Custom XTRA Grip; General Super-All-Grip; Goodrich Extra Traction; Uniroyal Fleetmaster Deep Lug; or mud and snow tires comparable in quality and tread design.

Inside rear tires on truck to have space between tire and spring assembly to allow for use of dual tire chains. Trucks to be furnished under these specifications will allow use of dual chains without modifications.

Cab: To be furnished with running board located below door. To be furnished with dual West Coast mirrors, size 6" x 15".

Convex mirrors to be furnished and mounted under the west coast mirrors, round in shape, diameter at least 5".

Electrical System: Electrical system to be 12 volt with 60 amp. alternator, heavy duty batteries at least 70 amp. each.

Fuel System: To be equipped with at least 50 gallon step tank - left side.

Miscellaneous: Signal lights - double face, amber and red, installed on front fenders and single red 4" round on rear frame, cab clearance lamps, (fresh air type) heavy duty defroster and heater, dual electric two speed windshield wipers to be furnished. Blade assembly to be detachable from arm. Windshield wiper and blade assembly fastened as a unit will not be acceptable. Windshield washers, sun visors, arm rests, tinted windshield, and seat belts also to be furnished. Odometer must record tenths. To be equipped with ICC traffic hazard switch and lug wrench. Twenty (20) current shop service manuals to be furnished.

Paint: To be painted orange in accordance with the color now used by the Virginia Department of Highways & Transportation. Du Pont color #93-74279 or equivalent.

Vehicle to be furnished to conform to the (National Traffic & Motor Safety Act of 1966) Federal Motor Vehicle Safety Standards with amendments as of date of delivery, and the Motor Vehicle Code of Virginia.

Award will be made to the best interest of the State.

EQUIPMENT DIVISION

SPECIFICATIONS

27,000 GVW Truck Chassis and Cab
(gasoline)

Truck GVW rating substantiated by published literature shall be not less than 27,000 regardless of the various components as listed herein.

Frame to be of "L" shaped reinforcing or fishplated with front bumper in line with main frame for heavy duty snow plow operation.

Wheelbase to be approximately 137", CA or cab to axle dimension not less than 72".

Front Axle: Capacity at ground of not less than 9,000 lbs., to be "I" beam construction with heavy duty springs, 4,500 lbs. at ground each side. To be furnished with power steering and front shock absorbers.

Rear Axle: To be equipped with one piece housing having two speed rear axle, gear ratio to be approximately 6.5/9.0. Capacity at ground of not less than 18,500 lbs. Rear springs to be heavy duty, main and auxiliary combined not less than 10,400 capacity at ground each side.

Transmission: To be five speed direct in fifth speed, heavy duty, opening on both sides for separate power take-off units.

Brakes: To be hydraulic with brake booster, lining area at least 200.0 sq. in. on front brakes and 400.0 sq. in. on rear brakes. To be equipped with vacuum gauge, reserve tank with 1,000 cu. in. capacity. Reserve vacuum tank mounting location must be approved by the Department.

Clutch: To be heavy duty type (14" minimum diameter), or 13" ceramic type with facings, or ceramic type with at least 9 buttons.

Engine: To be 360 cu. in. V8 engine, heavy duty, not less than 170 SAE net horsepower at rated RPM and SAE net torque of not less than 280 lbs. ft. at rated RPM. Engine supplied to be equipped with oil filter and oil bath or dry air cleaner. Engine to be equipped with governor set to manufacturer's RPM. To be furnished with positive crankcase ventilation system. Single exhaust only.

Wheels: Cast steel spoke wheels with 7" rims.

SPECIFICATIONS
27,000 GVW Truck Chassis and Cab

Tires: To be equipped with single 900 x 20, 10 ply, tires on front and dual 900 x 20, 12 ply, tires on rear. All tires are to be furnished with tubes. The four rear tires to be Firestone Super-All-Traction; Goodyear Custom XTRA Grip; General Super-All-Grip; Goodrich Extra Traction; Uniroyal Fleetmaster Deep Lug; or mud and snow tires comparable in quality and tread design.

Inside rear tires on truck to have space between tire and spring assembly to allow for use of dual tire chains. Trucks to be furnished under these specifications will allow use of dual chains without modifications.

Cab: To be furnished with running board located below door. To be furnished with dual West Coast Convex type mirrors, size 6" x 15".

Electrical System: Electrical system to be 12 volt with 60 amp. alternator, heavy duty battery 70 amp.

Fuel System: To be equipped with at least 50 gallon step tank - left side.

Miscellaneous: Signal lights - double face, amber and red, installed on front fenders and single red 4" round on rear frame, cab clearance lamps, (fresh air type) heavy duty defroster and heater, dual electric two speed windshield wipers to be furnished. Blade assembly to be detachable from arm. Windshield wiper and blade assembly fastened as a unit will not be acceptable. Windshield washers, sun visors, arm rests, tinted windshield, and seat belts also to be furnished. Odometer must record tenths. To be equipped with ICC traffic hazard switch and lug wrench. Eighty (80) current shop service manuals to be furnished.

Paint: To be painted orange in accordance with the color now used by the Virginia Department of Highways and Transportation. Du Pont Color #93-74279 or equivalent.

Vehicle to be furnished to conform to the (National Traffic & Motor Safety Act of 1966) Federal Motor Vehicle Safety Standards with amendments as of date of delivery, and the Motor Vehicle Code of Virginia.

Award will be made to the best interest of the State.

A SURVEY OF DIESEL VEHICLE USE TRENDS

CITY _____ STATE _____ DATE _____

PLEASE ANSWER ALL THE QUESTIONS THAT APPLY TO YOUR OPERATION AND RETURN BY MAIL. NO POSTAGE REQUIRED

1) Do you specify diesel engines in any trucks you now purchase? Yes___ No___
If yes, in what range? 0-10,000 GVW___ 10,000-28,000 GVW___ Above 28,000 GVW___

2) Do you purchase diesel trucks for a specific task(s)? Yes___ No___
If yes, please give the task(s):

_____

_____

3) Do you purchase diesel trucks for use in a specific topographical and/or climatic area?
Yes___ No___ If yes, please list the specific kind of topographical and climatic characteristics you consider.

_____

_____

4) Have you considered replacing your (0-10,000 GVW) and (10,000-28,000 GVW) range trucks at retirement with diesel powered units?
0-10,000 GVW Yes___ No___ 10,000-28,000 GVW Yes___ No___
If yes, what is the maximum percentage of replacement diesels you would consider?
0-10,000 GVW____% 10,000-28,000 GVW____%

5) Have you purchased any diesel powered automobiles, pickups, and light duty vans as a replacement for gasoline powered units in your fleet?
Yes___ No___; If yes, vehicle type(s) purchased?_____
If no, have you considered such purchases? type(s)_____

6) Is the additional operator instruction necessary for diesel throttle operation and shifting a deterrent to your purchasing diesel trucks? Yes___ No___

7) Have you purchased any diesel powered trucks equipped with automatic transmissions?
Yes___ No___ If yes, in what range? 0-10,000 GVW____; 10,000-28,000 GVW____;
Above 28,000 GVW____

8) Would you consider the purchase of diesel trucks with automatic transmissions in order to eliminate possible throttle and shifting errors by the operator? Yes___ No___

9) Is the additional training necessary for diesel maintenance personnel a deterrent to your purchasing diesel trucks? Yes___ No___

10) Please list what you consider to be advantages of using diesel trucks in your operation.

_____

_____

11) What are the disadvantages?_____

_____

12) Would you like to receive the results of this survey? Yes___ No___

IF YOUR OPERATION DOES NOT USE DIESEL TRUCKS, PROCEED TO QUESTION 22.

IF YOUR OPERATION DOES USE DIESEL TRUCKS, PLEASE CONTINUE.

13) Is the time required for routine maintenance of your diesel trucks more, less, or the same as for your gasoline trucks?

0-10,000 GVW	10,000-28,000 GVW	above 28,000 GVW
more____	more____	more____
less____	less____	less____
same____	same____	same____

14) Is the cost of routine maintenance for your diesel trucks more, less, or the same as for your gasoline trucks?

0-10,000 GVW	10,000-28,000 GVW	above 28,000 GVW
more____	more____	more____
less____	less____	less____
same____	same____	same____

15) Do your diesel trucks require more, less, or the same amount of repair as your gasoline trucks?

0-10,000 GVW	10,000-28,000 GVW	above 28,000 GVW
more____	more____	more____
less____	less____	less____
same____	same____	same____

PLEASE COMPLETE REVERSE SIDE ALSO

1702

16) Is the cost of repair for your diesel trucks more, less, or the same as that for your gasoline trucks?

0-10,000 GVW	10,000-28,000 GVW	above 28,000 GVW
more____	more____	more____
less____	less____	less____
same____	same____	same____

17) In your opinion are diesel truck and/or engine manufacturers willing to offer training assistance for your maintenance personnel? Yes___ No___

18) Do your operators show a preference for diesel or gasoline trucks?
Diesel____ Gasoline____ No Preference____

19) Please list the most common problems you have experienced in the use of diesel trucks.

_____

_____

20) Are you pleased with the operation and maintenance characteristics of your diesel trucks?

0-10,000 GVW	10,000-28,000 GVW	above 28,000 GVW
Yes____	Yes____	Yes____
No ____	No ____	No ____

21) Would you recommend the purchase of diesel trucks to other state highway departments?

0-10,000 GVW	10,000-28,000 GVW	above 28,000 GVW
Yes____	Yes____	Yes____
No ____	No ____	No ____

22) Questionnaire answered by: Name & Title_____

Address_____

Telephone Number ( )_____

PLEASE FOLD, STAPLE AND MAIL. THANK YOU.

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ATTENTION: MR. G. L. ROBERTS

APPENDIX C

STATE RESPONSES TO SURVEY QUESTIONNAIRE

Table C-1

ADVANTAGES AND DISADVANTAGES OF DIESELS

	No. of Responses	% of Total
Advantages:		
Fuel Economy	39	93
Decreased Maintenance	35	83
Better Engine Torque	5	12
Longer Engine Life	25	60
Wet Weather Reliability	11	26
Decrease in Fuel Theft	1	2
Less Air Pollution	1	2
Other Aspects	9	21
Disadvantages:		
High Initial Cost	28	70
Driver Training	4	10
Maintenance Training Cost	4	10
Availability of Fuel	1	3
Cold Weather Starting	9	23
Cold Weather Fuel Problems	2	5
Engine and Exhaust Noise	1	3
Exhaust Fumes and Odor	1	3
Other Aspects	8	21

	Yes		No	
	No. of Responses	% of Total	No. of Responses	% of Total
Engine and/or truck manufacturers willing to train purchasers' maintenance personnel:	40	98	1	2

Table C-2

DIESEL MAINTENANCE AND REPAIR COMPARED TO GASOLINE-POWERED TRUCKS

	More		Less		Same	
	No. of Responses	% of Total	No. of Responses	% of Total	No. of Responses	% of Total
Routine Maintenance Time:						
Under 10,000 lb. GVW	0	0	0	0	0	0
10,000-28,000 lb. GVW	0	0	8	53	7	47
Over 28,000 lb. GVW	5	13	24	61	10	26
Routine Maintenance Cost:						
Under 10,000 lb. GVW	0	0	0	0	0	0
10,000-28,000 lb. GVW	2	13	9	60	4	27
Over 28,000 lb. GVW	8	20	24	62	7	18
Amount of Repairs Needed:						
Under 10,000 lb. GVW	0	0	0	0	0	0
10,000-28,000 lb. GVW	0	0	14	93	1	7
Over 28,000 lb. GVW	2	5	32	82	5	13
Cost of Necessary Repairs:						
Under 10,000 lb. GVW	0	0	0	0	0	0
10,000-28,000 lb. GVW	2	14	10	72	2	14
Over 28,000 lb. GVW	9	24	22	60	6	16

Table C-3

DIESEL TRUCK PURCHASE INFORMATION

1795

	Yes		No	
	No. of Responses	% of Total	No. of Responses	% of Total
Specify Diesel by Weight:				
Under 10,000 lb. GVW	2	5	41	95
10,000-28,000 lb. GVW	17	40	26	60
Over 28,000 lb. GVW	42	98	1	2
Specify Diesel For:				
Snowplowing	18	43	24	57
Truck Tractors	14	33	28	67
High Mileage	4	10	38	90
Long Hauls	9	21	33	79
Heavy Loads	21	50	21	50
Trailer Pulling	1	2	41	98
Tank Trucks	2	5	40	95
Paving	2	5	40	95
Increased Auxiliary Equipment	2	5	40	95
Other Uses	15	36	27	64
Specify Diesel by Terrain:				
Mountain Land	2	5	41	95
Other Type Land	1	2	42	98
Specify Diesel by Climate:				
Low Temperature	2	5	41	95
High Temperature	2	5	41	95
Maintenance Training a Deterrent to Purchase:	5	12	38	88
Operator Training a Deterrent to Purchase:	6	14	37	86
Purchased Diesel Trucks with Automatic Transmission:				
Under 10,000 lb. GVW	3	7	40	93
10,000-28,000 lb. GVW	14	33	29	67
Over 28,000 lb. GVW	25	58	18	42
Would purchase diesel truck with automatic transmission to eliminate shifting errors:	25	61	16	39
Purchased diesel to replace gasoline:				
Automobile	5	12	38	88
Pickup truck	7	16	36	84
Light Duty Van	0	0	0	0

Table C-4

COMMON PROBLEMS OF DIESEL TRUCK OPERATION

	No. of Responses	% of Total
Problems:		
Hard Starting in Cold Weather	9	30
Driver Abuse	14	47
Improper Maintenance	5	17
Contaminated Fuel	4	13
Noise and Fumes	2	7
Other Common Problems	10	33

Table C-5

OVERALL EVALUATION

	Yes		No	
	No. of Responses	% of Total	No. of Responses	% of Total
Pleased with Operation and Maintenance:				
Under 10,000 lb. GVW	0	0	0	0
10,000-28,000 lb. GVW	14	100	0	0
Over 28,000 lb. GVW	38	100	0	0
Recommendation of Purchase:				
Under 10,000 lb. GVW	1	50	1	50
10,000-28,000 lb. GVW	16	100	0	0
Over 28,000 lb. GVW	38	100	0	0

	Diesel		Gas		None	
	No. of Responses	% of Total	No. of Responses	% of Total	No. of Responses	% of Total
Operator Prefers Diesel or Gasoline	30	77	1	3	8	20

Table C-6

FUTURE REPLACEMENT OF GASOLINE TRUCKS BY DIESEL TRUCKS IN THE UNDER 10,000 LB. GVW AND 10,000-28,000 LB. GVW RANGES

Under 10,000 lb. GVW

Future Replacement in Percent of Fleet Size	Number of Responses	Percent of Total Responses
None	30	71
0-5	1	2
16-20	1	2
21-25	2	5
36-40	1	2
46-50	2	5
96-100	1	2
Unknown	4	10

10,000-28,000 lb. GVW

Future Replacement in Percent of Fleet Size	Number of Responses	Percent of Total Responses
None	17	41
21-25	2	5
26-30	1	2
46-50	3	7
71-75	3	7
76-80	1	2
86-90	1	2
96-100	10	24
Unknown	4	10

1708

APPENDIX D

CITY RESPONSES TO SURVEY QUESTIONNAIRE

Table D-1

ADVANTAGES AND DISADVANTAGES OF DIESELS

	No. of Responses	% of Total
Advantages:		
Fuel Economy	24	75
Decreased Maintenance	20	63
Better Engine Torque	7	22
Longer Engine Life	14	44
Wet Weather Reliability	2	6
Decrease in Fuel Theft	0	0
Less Air Pollution	0	0
Other Aspects	5	16
Disadvantages:		
High Initial Cost	12	40
Driver Training	0	0
Maintenance Training Cost	3	10
Availability of Fuel	1	3
Cold Weather Starting	4	13
Cold Weather Fuel Problems	0	0
Engine and Exhaust Noise	1	3
Exhaust Fumes and Odor	2	7
Other Aspects	10	33

	Yes		No	
	No. of Responses	% of Total	No. of Responses	% of Total
Engine and/or Truck Manufacturers willing to train purchasers' maintenance personnel:	24	86	4	14

Table D-2

DIESEL MAINTENANCE AND REPAIR COMPARED TO GASOLINE-POWERED TRUCKS

	More		Less		Same	
	No. of Responses	% of Total	No. of Responses	% of Total	No. of Responses	% of Total
Routine Maintenance Time:						
Under 10,000 lb. GVW	0	0	1	100	0	0
10,000-28,000 lb. GVW	0	0	9	82	2	18
Over 28,000 lb. GVW	3	11	16	57	9	32
Routine Maintenance Cost:						
Under 10,000 lb. GVW	0	0	1	100	0	0
10,000-28,000 lb. GVW	1	9	9	82	1	9
Over 28,000 lb. GVW	5	18	16	57	7	25
Amount of Repairs Needed:						
Under 10,000 lb. GVW	0	0	1	100	0	0
10,000-28,000 lb. GVW	0	0	9	82	2	18
Over 28,000 lb. GVW	1	3	24	86	3	11
Cost of Necessary Repairs:						
Under 10,000 lb. GVW	0	0	1	100	0	0
10,000-28,000 lb. GVW	2	20	6	60	2	20
Over 28,000 lb. GVW	7	25	17	61	4	14

Table D-3

DIESEL TRUCK PURCHASE INFORMATION

1711

	Yes		No	
	No. of Responses	% of Total	No. of Responses	% of Total
Specify Diesel by Weight:				
Under 10,000 lb. GVW	1	3	3	97
10,000-28,000 lb. GVW	11	32	23	68
Over 28,000 lb. GVW	28	82	6	18
Specify Diesel For:				
Snowplowing	8	24	26	76
Truck Tractors	3	9	31	91
High Mileage	1	3	33	97
Long Hauls	1	3	33	97
Heavy Loads	4	12	30	88
Trailer Pulling	1	3	33	97
Tank Trucks	0	0	34	100
Paving	2	6	32	94
Increased Auxiliary Equipment	3	9	31	91
Other Uses	20	59	14	41
Specify Diesel by Terrain:				
Mountain Land	0	0	33	100
Other Type Land	3	9	30	91
Specify Diesel by Climate:				
Low Temperature	2	6	31	94
High Temperature	0	0	33	100
Maintenance Training a Deterrent to Purchase:	6	18	28	82
Operator Training a Deterrent to Purchase:	2	6	31	94
Purchased Diesel Trucks with Automatic Transmission:				
Under 10,000 lb. GVW	2	6	32	94
10,000-28,000 lb. GVW	11	32	23	68
Over 28,000 lb. GVW	22	65	12	35
Would purchase diesel truck with automatic transmission to eliminate shifting errors:	31	91	3	9
Purchased Diesel to replace gasoline:				
Automobile	0	0	34	100
Pickup truck	2	6	32	94
Light Duty Van	0	0	34	100

Table D-4

COMMON PROBLEMS OF DIESEL TRUCK OPERATION

	No. of Responses	% of Total
Problems:		
Hard Starting in Cold Weather	4	16
Driver Abuse	5	20
Improper Maintenance	4	16
Contaminated Fuel	0	0
Noise and Fumes	3	12
Other Common Problems	9	36

Table D-5

OVERALL EVALUATION

	Yes		No	
	No. of Responses	% of Total	No. of Responses	% of Total
Pleased with Operation and Maintenance:				
Under 10,000 lb. GVW	1	100	0	0
10,000-28,000 lb. GVW	10	91	1	9
Over 28,000 lb. GVW	28	100	0	0
Recommendation of Purchase:				
Under 10,000 lb. GVW	2	67	1	33
10,000-28,000 lb. GVW	15	94	1	6
Over 28,000 lb. GVW	28	100	0	0

	Diesel		Gas		None	
	No. of Responses	% of Total	No. of Responses	% of Total	No. of Responses	% of Total
Operator Prefers Diesel or Gasoline	24	83	0	0	5	17

Table D-6

FUTURE REPLACEMENT OF GASOLINE TRUCKS BY DIESEL TRUCKS IN THE UNDER 10,000 LB. GVW AND 10,000-28,000 LB. GVW RANGES

Under 10,000 lb. GVW

Future Replacement in Percent of Fleet Size	Number of Responses	Percent of Total Responses
None	24	80
16-20	1	3
31-35	1	3
46-50	1	3
71-75	1	3
86-90	1	3
Unknown	1	3

10,000-28,000 lb. GVW

Future Replacement in Percent of Fleet Size	Number of Responses	Percent of Total Responses
None	11	34
0-5	1	3
6-10	2	6
11-15	1	3
21-25	1	3
36-40	1	3
46-50	2	6
56-60	1	3
71-75	1	3
86-90	2	6
96-100	9	28

APPENDIX E

COUNTY RESPONSES TO SURVEY QUESTIONNAIRE

Table E-1

ADVANTAGES AND DISADVANTAGES OF DIESELS

	No. of Responses	% of Total
Advantages:		
Fuel Economy	21	84
Decreased Maintenance	15	60
Better Engine Torque	1	4
Longer Engine Life	11	44
Wet Weather Reliability	2	8
Decrease in Fuel Theft	0	0
Less Air Pollution	1	4
Other Aspects	8	32
Disadvantages:		
High Initial Cost	6	29
Driver Training	1	5
Maintenance Training Cost	2	10
Availability of Fuel	1	5
Cold Weather Starting	5	24
Cold Weather Fuel Problems	2	10
Engine and Exhaust Noise	0	0
Exhaust Fumes and Odor	1	5
Other Aspects	4	18

	Yes		No	
	No. of Responses	% of Total	No. of Responses	% of Total
Engine and/or Truck Manufacturers willing to train purchasers' maintenance personnel:	20	87	3	13

Table E-2

DIESEL MAINTENANCE AND REPAIR COMPARED TO GASOLINE-POWERED TRUCKS

	More		Less		Same	
	No. of Responses	% of Total	No. of Responses	% of Total	No. of Responses	% of Total
Routine Maintenance Time:						
Under 10,000 lb. GVW	0	0	1	20	4	80
10,000-28,000 lb. GVW	0	0	6	50	6	50
Over 28,000 lb. GVW	0	0	14	64	8	36
Routine Maintenance Cost:						
Under 10,000 lb. GVW	0	0	3	60	2	40
10,000-28,000 lb. GVW	1	8	9	75	2	17
Over 28,000 lb. GVW	2	9	15	68	5	23
Amount of Repairs Needed:						
Under 10,000 lb. GVW	0	0	4	80	1	20
10,000-28,000 lb. GVW	0	0	11	92	1	8
Over 28,000 lb. GVW	0	0	19	86	3	14
Cost of Necessary Repairs:						
Under 10,000 lb. GVW	1	20	3	60	1	20
10,000-28,000 lb. GVW	4	36	4	36	3	27
Over 28,000 lb. GVW	8	40	9	45	3	15

Table E-3

DIESEL TRUCK PURCHASE INFORMATION

1717

	Yes		No	
	No. of Responses	% of Total	No. of Responses	% of Total
Specify Diesel by Weight:				
Under 10,000 lb. GVW	4	13	28	87
10,000-28,000 lb. GVW	11	34	21	66
Over 28,000 lb. GVW	23	72	9	28
Specify Diesel For:				
Snowplowing	2	7	29	93
Truck Tractors	4	13	27	87
High Mileage	0	0	31	100
Long Hauls	3	10	28	90
Heavy Loads	3	10	28	90
Trailer Pulling	1	3	30	97
Tank Trucks	1	3	30	97
Paving	1	3	30	97
Increased Auxiliary Equipment	0	0	31	100
Other Uses	11	36	20	64
Specify Diesel by Terrain:				
Mountain Land	0	0	30	100
Other Type Land	0	0	30	100
Specify Diesel by Climate:				
Low Temperature	0	0	30	100
High Temperature	0	0	30	100
Maintenance Training a Deterrent to Purchase:	2	7	28	93
Operator Training a Deterrent to Purchase:	1	3	30	97
Purchased Diesel Trucks with Automatic Transmission:				
Under 10,000 lb. GVW	4	13	27	87
10,000-28,000 lb. GVW	4	13	27	87
Over 28,000 lb. GVW	11	36	20	64
Would purchase diesel truck with automatic transmission to eliminate shifting errors:	23	74	8	26
Purchased Diesel to replace gasoline:				
Automobile	0	0	31	100
Pickup truck	4	13	27	87
Light Duty Van	0	0	31	100

Table E-4

COMMON PROBLEMS OF DIESEL TRUCK OPERATION

	No. of Responses	% of Total
Problems:		
Hard Starting in Cold Weather	4	24
Driver Abuse	4	24
Improper Maintenance	5	29
Contaminated Fuel	4	24
Noise and Fumes	2	12
Other Common Problems	6	35

Table E-5

OVERALL EVALUATION

	Yes		No	
	No. of Responses	% of Total	No. of Responses	% of Total
Pleased with Operation and Maintenance:				
Under 10,000 lb. GVW	5	83	1	17
10,000-28,000 lb. GVW	12	100	0	0
Over 28,000 lb. GVW	23	100	0	0
Recommendation of Purchase:				
Under 10,000 lb. GVW	5	83	1	17
10,000-28,000 lb. GVW	13	93	1	7
Over 28,000 lb. GVW	23	100	0	0

	Diesel		Gas		None	
	No. of Responses	% of Total	No. of Responses	% of Total	No. of Responses	% of Total
Operator Prefers Diesel or Gasoline	14	67	0	0	7	33

Table E-6

FUTURE REPLACEMENT OF GASOLINE TRUCKS BY DIESEL TRUCKS IN THE UNDER 10,000 LB. GVW AND 10,000-28,000 LB. GVW RANGES

Under 10,000 lb. GVW

Future Replacement in Percent of Fleet Size	Number of Responses	Percent of Total Responses
None	21	72
0-5	2	7
6-10	1	3
31-35	1	3
46-50	1	3
96-100	2	7
Unknown	1	3

10,000-28,000 lb. GVW

Future Replacement in Percent of Fleet Size	Number of Responses	Percent of Total Responses
None	12	41
11-15	1	3
16-20	1	3
46-50	3	10
61-65	1	3
96-100	10	15
Unknown	1	3

1720

APPENDIX F

TOLL ROAD AUTHORITY RESPONSES TO SURVEY QUESTIONNAIRE

Table F-1

ADVANTAGES AND DISADVANTAGES OF DIESELS

	No. of Responses	% of Total
Advantages:		
Fuel Economy	6	86
Decreased Maintenance	6	86
Better Engine Torque	2	29
Longer Engine Life	2	29
Wet Weather Reliability	1	14
Decrease in Fuel Theft	0	0
Less Air Pollution	0	0
Other Aspects	0	0
Disadvantages:		
High Initial Cost	3	43
Driver Training	0	0
Maintenance Training Cost	0	0
Availability of Fuel	0	0
Cold Weather Starting	3	43
Cold Weather Fuel Problems	0	0
Engine and Exhaust Noise	0	0
Exhaust Fumes and Odor	0	0
Other Aspects	2	29

	Yes		No	
	No. of Responses	% of Total	No. of Responses	% of Total
Engine and/or Truck Manufacturers willing to train purchasers' maintenance personnel:	5	100	0	0

Table F-2

DIESEL MAINTENANCE AND REPAIR COMPARED TO GASOLINE-POWERED TRUCKS

	More		Less		Same	
	No. of Responses	% of Total	No. of Responses	% of Total	No. of Responses	% of Total
Routine Maintenance Time:						
Under 10,000 lb. GVW	0	0	0	0	0	0
10,000-28,000 lb. GVW	0	0	1	50	1	50
Over 28,000 lb. GVW	0	0	2	50	2	50
Routine Maintenance Cost:						
Under 10,000 lb. GVW	0	0	0	0	0	0
10,000-28,000 lb. GVW	0	0	2	100	0	0
Over 28,000 lb. GVW	0	0	4	100	0	0
Amount of Repairs Needed:						
Under 10,000 lb. GVW	0	0	0	0	0	0
10,000-28,000 lb. GVW	0	0	3	100	0	0
Over 28,000 lb. GVW	0	0	4	100	0	0
Cost of Necessary Repairs:						
Under 10,000 lb. GVW	0	0	0	0	0	0
10,000-28,000 lb. GVW	1	50	1	50	0	0
Over 28,000 lb. GVW	1	33	2	67	0	0

Table F-3

DIESEL TRUCK PURCHASE INFORMATION

1723

	Yes		No	
	No. of Responses	% of Total	No. of Responses	% of Total
Specify Diesel by Weight:				
Under 10,000 lb. GVW	0	0	8	100
10,000-28,000 lb. GVW	3	37	5	63
Over 28,000 lb. GVW	5	63	3	37
Specify Diesel For:				
Snowplowing	3	37	5	63
Truck Tractors	0	0	8	100
High Mileage	0	0	8	100
Long Hauls	0	0	8	100
Heavy Loads	1	12	7	88
Trailer Pulling	0	0	8	100
Tank Trucks	0	0	8	100
Paving	0	0	8	100
Increased Auxiliary Equipment	0	0	8	100
Other Uses	2	25	6	75
Specify Diesel by Terrain:				
Mountain Land	0	0	8	100
Other Type Land	0	0	8	100
Specify Diesel by Climate:				
Low Temperature	0	0	8	100
High Temperature	0	0	8	100
Maintenance Training a Deterrent to Purchase:	2	25	6	75
Operator Training a Deterrent to Purchase:	0	0	8	100
Purchased Diesel Trucks with Automatic Transmission:				
Under 10,000 lb. GVW	1	12	7	88
10,000-28,000 lb. GVW	2	25	6	75
Over 28,000 lb. GVW	2	25	6	75
Would purchase diesel truck with automatic transmission to eliminate shifting errors:	5	63	3	37
Purchased Diesel to replace gasoline:				
Automobile	1	12	7	88
Pickup truck	2	25	6	75
Light Duty Van	0	0	8	100

1724

Table F-4

COMMON PROBLEMS OF DIESEL TRUCK OPERATION

	No. of Responses	% of Total
Problems:		
Hard Starting in Cold Weather	1	33
Driver Abuse	1	33
Improper Maintenance	0	0
Contaminated Fuel	1	33
Noise and Fumes	0	0
Other Common Problems	2	67

Table F-5

OVERALL EVALUATION

	Yes		No	
	No. of Responses	% of Total	No. of Responses	% of Total
Pleased with Operation and Maintenance:				
Under 10,000 lb. GVW	0	0	0	0
10,000-28,000 lb. GVW	2	100	0	0
Over 28,000 lb. GVW	4	100	0	0
Recommendation of Purchase:				
Under 10,000 lb. GVW	0	0	0	0
10,000-28,000 lb. GVW	2	100		
Over 28,000 lb. GVW	4	100		

	Diesel		Gas		None	
	No. of Responses	% of Total	No. of Responses	% of Total	No. of Responses	% of Total
Operator Prefers Diesel or Gasoline	3	60	0	0	2	40

Table F-6

FUTURE REPLACEMENT OF GASOLINE TRUCKS BY DIESEL TRUCKS IN THE UNDER 10,000 LB. GVW AND 10,000-28,000 LB. GVW RANGES

Under 10,000 lb. GVW

Future Replacement in Percent of Fleet Size	Number of Responses	Percent of Total Responses
None	7	88
16-20	1	13

10,000-28,000 lb. GVW

Future Replacement in Percent of Fleet Size	Number of Responses	Percent of Total Responses
None	7	88
36-40	1	13

1726

APPENDIX G

CANADIAN PROVINCE RESPONSES TO SURVEY QUESTIONNAIRE

Table G-1

ADVANTAGES AND DISADVANTAGES OF DIESELS

	No. of Responses	% of Total
Advantages:		
Fuel Economy	3	60
Decreased Maintenance	1	20
Better Engine Torque	1	20
Longer Engine Life	4	80
Wet Weather Reliability	2	40
Decrease in Fuel Theft	0	0
Less Air Pollution	0	0
Other Aspects	2	40
Disadvantages:		
High Initial Cost	3	60
Driver Training	1	20
Maintenance Training Cost	0	0
Availability of Fuel	0	0
Cold Weather Starting	1	20
Cold Weather Fuel Problems	0	0
Engine and Exhaust Noise	0	0
Exhaust Fumes and Odor	0	0
Other Aspects	2	40

	Yes		No	
	No. of Responses	% of Total	No. of Responses	% of Total
Engine and/or Truck Manufacturers willing to train purchasers' maintenance personnel:	5	100	0	0

Table G-2

DIESEL MAINTENANCE AND REPAIR COMPARED TO GASOLINE-POWERED TRUCKS

	More		Less		Same	
	No. of Responses	% of Total	No. of Responses	% of Total	No. of Responses	% of Total
Routine Maintenance Time:						
Under 10,000 lb. GVW	0	0	0	0	1	100
10,000-28,000 lb. GVW	0	0	1	100	0	0
Over 28,000 lb. GVW	1	25	1	25	2	50
Routine Maintenance Cost:						
Under 10,000 lb. GVW	0	0	0	0	1	100
10,000-28,000 lb. GVW	0	0	1	100	0	0
Over 28,000 lb. GVW	1	25	2	50	1	25
Amount of Repairs Needed:						
Under 10,000 lb. GVW	0	0	1	100	0	0
10,000-28,000 lb. GVW	0	0	1	100	0	0
Over 28,000 lb. GVW	0	0	4	100	0	0
Cost of Necessary Repairs:						
Under 10,000 lb. GVW	0	0	1	100	0	0
10,000-28,000 lb. GVW	0	0	1	100	0	0
Over 28,000 lb. GVW	1	25	2	50	1	25

Table G-3

DIESEL TRUCK PURCHASE INFORMATION

1729

	Yes		No	
	No. of Responses	% of Total	No. of Responses	% of Total
Specify Diesel by Weight:				
Under 10,000 lb. GVW	1	20	4	80
10,000-28,000 lb. GVW	2	40	3	60
Over 28,000 lb. GVW	5	100	0	0
Specify Diesel For:				
Snowplowing	3	60	2	40
Truck Tractors	1	20	4	80
High Mileage	0	0	5	100
Long Hauls	0	0	5	100
Heavy Loads	0	0	5	100
Trailer Pulling	0	0	5	100
Tank Trucks	0	0	5	100
Paving	1	20	4	80
Increased Auxiliary Equipment	0	0	5	100
Other Uses	1	20	4	80
Specify Diesel by Terrain:				
Mountain Land	1	25	3	75
Other Type Land	0	0	4	100
Specify Diesel by Climate:				
Low Temperature	1	25	3	75
High Temperature	0	0	4	100
Maintenance Training a Deterrent to Purchase:	0	0	5	100
Operator Training a Deterrent to Purchase:	0	0	5	100
Purchased Diesel Trucks with Automatic Transmission:				
Under 10,000 lb. GVW	1	20	4	80
10,000-28,000 lb. GVW	0	0	5	100
Over 28,000 lb. GVW	4	80	1	20
Would purchase diesel truck with automatic transmission to eliminate shifting errors:	2	40	3	60
Purchased Diesel to replace gasoline:				
Automobile	0	0	5	100
Pickup truck	3	60	2	40
Light Duty Van	0	0	5	100

1739

Table G-4

COMMON PROBLEMS OF DIESEL TRUCK OPERATION

	No. of Responses	% of Total
Problems:		
Hard Starting in Cold Weather	0	0
Driver Abuse	2	40
Improper Maintenance	0	0
Contaminated Fuel	0	0
Noise and Fumes	0	0
Other Common Problems	2	40

Table G-5

OVERALL EVALUATION

	Yes		No	
	No. of Responses	% of Total	No. of Responses	% of Total
Pleased with Operation and Maintenance:				
Under 10,000 lb. GVW	0	0	0	0
10,000-28,000 lb. GVW	1	100	0	0
Over 28,000 lb. GVW	5	100	0	0
Recommendation of Purchase:				
Under 10,000 lb. GVW	0	0	0	0
10,000-28,000 lb. GVW	1	100	0	0
Over 28,000 lb. GVW	5	100	0	0

	Diesel		Gas		None	
	No. of Responses	% of Total	No. of Responses	% of Total	No. of Responses	% of Total
Operator Prefers Diesel or Gasoline	4	100	0	0	0	0

Table G-6

FUTURE REPLACEMENT OF GASOLINE TRUCKS BY DIESEL TRUCKS IN THE UNDER 10,000 LB. GVW AND 10,000-28,000 LB. GVW RANGES

Under 10,000 lb. GVW

Future Replacement in Percent of Fleet Size	Number of Responses	Percent of Total Responses
None	4	80
20-25	1	20

10,000-28,000 lb. GVW

Future Replacement in Percent of Fleet Size	Number of Responses	Percent of Total Responses
None	2	40
86-90	1	20
96-100	2	40

1734

APPENDIX H

TOTAL RESPONSES TO SURVEY QUESTIONNAIRE

Table H-1

ADVANTAGES AND DISADVANTAGES OF DIESELS

	No. of Responses	% of Total
Advantages:		
Fuel Economy	93	84
Decreased Maintenance	77	69
Better Engine Torque	16	14
Longer Engine Life	56	51
Wet Weather Reliability	18	16
Decrease in Fuel Theft	1	1
Less Air Pollution	2	2
Other Aspects	24	22
Disadvantages:		
High Initial Cost	52	51
Driver Training	6	6
Maintenance Training Cost	10	10
Availability of Fuel	3	3
Cold Weather Starting	22	22
Cold Weather Fuel Problems	4	4
Engine and Exhaust Noise	2	2
Exhaust Fumes and Odor	4	4
Other Aspects	26	26

	Yes		No	
	No. of Responses	% of Total	No. of Responses	% of Total
Engine and/or Truck Manufacturers willing to train purchasers' maintenance personnel:	94	92	8	8

Table H-2

DIESEL MAINTENANCE AND REPAIR COMPARED TO GASOLINE-POWERED TRUCKS

	More		Less		Same	
	No. of Responses	% of Total	No. of Responses	% of Total	No. of Responses	% of Total
Routine Maintenance Time:						
Under 10,000 lb. GVW	0	0	2	29	5	71
10,000-28,000 lb. GVW	0	0	25	60	17	40
Over 28,000 lb. GVW	9	9	57	59	31	32
Routine Maintenance Cost:						
Under 10,000 lb. GVW	0	0	4	57	3	43
10,000-28,000 lb. GVW	4	9	31	74	7	17
Over 28,000 lb. GVW						
Amount of Repairs Needed:						
Under 10,000 lb. GVW	0	0	6	86	1	14
10,000-28,000 lb. GVW	0	0	38	91	4	9
Over 28,000 lb. GVW	3	3	83	86	11	11
Cost of Necessary Repairs:						
Under 10,000 lb. GVW	1	14	5	72	1	14
10,000-28,000 lb. GVW	9	24	22	58	7	18
Over 28,000 lb. GVW	26	28	52	57	14	15

Table H-3

DIESEL TRUCK PURCHASE INFORMATION

1735

	Yes		No	
	No. of Responses	% of Total	No. of Responses	% of Total
Specify Diesel by Weight:				
Under 10,000 lb. GVW	8	7	114	93
10,000-28,000 lb. GVW	44	36	78	64
Over 28,000 lb. GVW	103	84	19	16
Specify Diesel For:				
Snowplowing	34	28	86	72
Truck Tractors	22	18	98	82
High Mileage	5	4	115	96
Long Hauls	13	11	107	89
Heavy Loads	29	24	91	76
Trailer Pulling	3	3	117	97
Tank Trucks	3	3	117	97
Paving	6	5	114	95
Increased Auxiliary Equipment	5	4	115	96
Other Uses	49	41	71	59
Specify Diesel by Terrain:				
Mountain Land	3	3	115	97
Other Type Land	4	4	114	96
Specify Diesel by Climate:				
Low Temperature	5	4	113	96
High Temperature	2	2	116	98
Maintenance Training a Deterrent to Purchase:	15	13	105	87
Operator Training a Deterrent to Purchase:	9	8	110	92
Purchased Diesel Trucks with Automatic Transmission:				
Under 10,000 lb. GVW	11	9	110	91
10,000-28,000 lb. GVW	31	26	90	74
Over 28,000 lb. GVW	64	53	57	47
Would purchase diesel truck with automatic transmission to eliminate shifting errors:	86	73	32	27
Purchased Diesel to replace gasoline:				
Automobile	6	5	115	95
Pickup truck	18	15	103	85
Light Duty Van	0	0	121	100

Table H-4

COMMON PROBLEMS OF DIESEL TRUCK OPERATION

	No. of Responses	% of Total
Problems:		
Hard Starting in Cold Weather	18	23
Driver Abuse	26	33
Improper Maintenance	14	18
Contaminated Fuel	9	11
Noise and Fumes	7	9
Other Common Problems	29	36

Table H-5

OVERALL EVALUATION

	Yes		No	
	No. of Responses	% of Total	No. of Responses	% of Total
Pleased with Operation and Maintenance:				
Under 10,000 lb. GVW	5	71	2	29
10,000-28,000 lb. GVW	39	98	1	2
Over 28,000 lb. GVW	97	100	0	0
Recommendation of Purchase:				
Under 10,000 lb. GVW	8	73	3	27
10,000-28,000 lb. GVW	47	96	2	41
Over 28,000 lb. GVW	98	100	0	0

	Diesel		Gas		None	
	No. of Responses	% of Total	No. of Responses	% of Total	No. of Responses	% of Total
Operator Prefers Diesel or Gasoline	75	77	1	1	22	22

Table H-6

FUTURE REPLACEMENT OF GASOLINE TRUCKS BY DIESEL TRUCKS IN THE UNDER 10,000 LB. GVW AND 10,000-28,000 LB. GVW RANGES

Under 10,000 lb. GVW

Future Replacement in Percent of Fleet Size	Number of Responses	Percent of Total Responses
None	86	75
0-5	3	2
6-10	1	1
16-20	3	3
21-25	3	3
31-35	2	2
36-40	1	1
46-50	4	4
71-75	1	1
86-90	1	1
96-100	3	3
Unknown	6	5

10,000-28,000 lb. GVW

Future Replacement in Percent of Fleet Size	Number of Responses	Percent of Total Responses
None	47	42
0-5	1	1
6-10	2	2
11-15	2	2
16-20	1	1
21-25	3	3
26-30	1	1
36-40	2	2
46-50	8	7
56-60	1	1
61-65	1	1
71-75	4	4
76-80	1	1
86-90	4	4
96-100	30	27
Unknown	5	4

1738

APPENDIX I-1

EQUIPMENT RENTAL FUEL FORMS

VIRGINIA DEPARTMENT OF HIGHWAYS AND TRANSPORTATION
EQUIPMENT RENTAL TIMESHEET

COUNTY	ROUTE	CITY OR COUNTY SECTION	PROJECT: SECTION	PROJECT: LET DES.	PROJECT: JOB NO.	LAND OWNER	ACTIVITY	DAILY HOURS 1	2	3	4	5	6	7	8	9	10	E.O. NO. 11	12	13	14	15	RATE	TOTAL HOURS	TOTAL TENTHS
								16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31		
TOTAL -PRODUCTIVE TIME																									

SHOW TOTAL PRODUCTIVE HOURS ONLY ON FORM DP-93 →

NON-PRODUCTIVE TIME																									
BROKEN DOWN	302																								

	TYPE EQUIPMENT	SPEEDOMETER-START	END	MILES

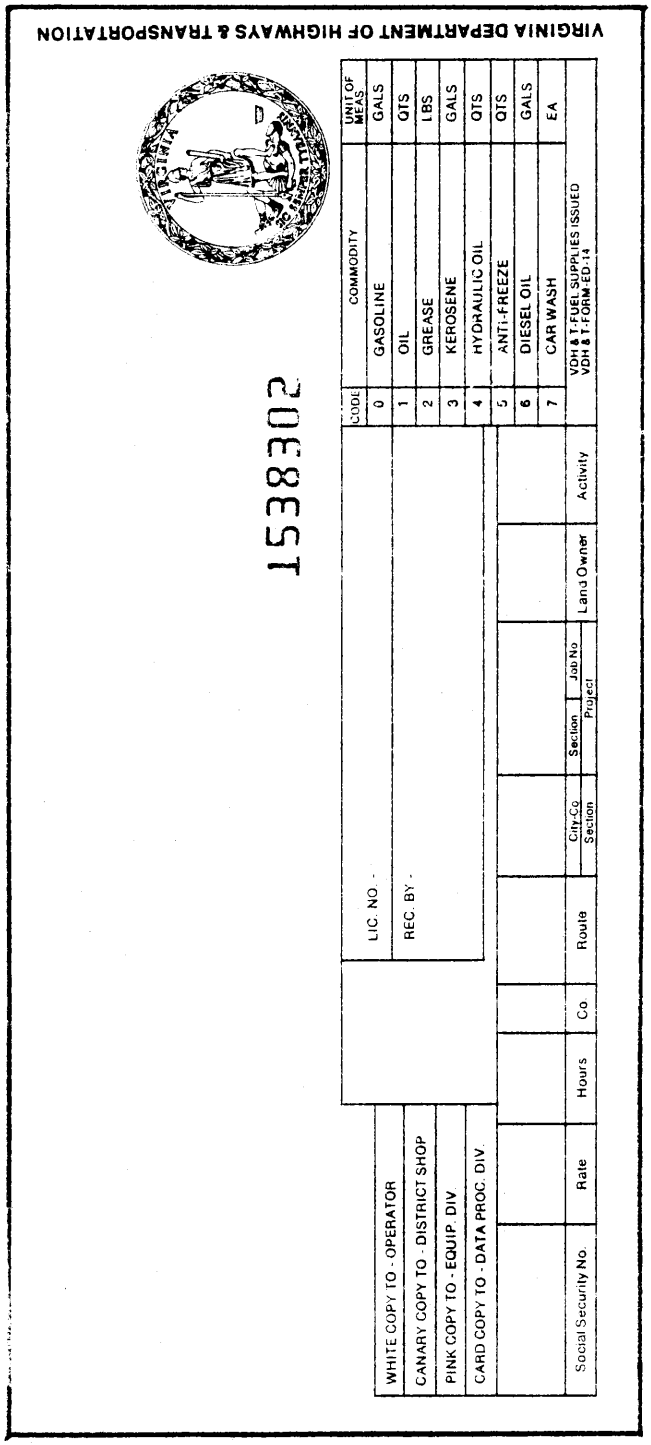
PERIOD ENDING	HEADQUARTERS	OPERATOR

FORM ED-7 (REV. 11/77)

FISCAL AND ACCOUNTING COPY

APPENDIX I-2

FUEL TICKET



APPENDIX J

NOTE: Figures in gallons and miles columns are for April 1979.

Table J-1

SAMPLE TRUCKS IN LEXINGTON RESIDENCY

ED No.	Gallons	Miles	MPG	Yearly Mileage
30469	258	1030	3.99	15150
30492	282	1126	3.99	16817
34964	323	1870	5.79	20199
34718	251	1342	5.35	19262
30378	135	875	6.48	14520
37432	257	1148	4.47	*
34080	243	1737	7.15	22684
30425	261	1487	5.70	19767
30405	405	1917	4.73	21744
30346	258	1602	6.21	21754
28803	329	1417	4.30	*
34793	168	810	4.82	21164
34957	187	789	4.22	20511
30474	249	1030	4.14	13911
30489	376	1599	4.25	18249
30330	615	2882	4.69	24825
33951	300	1458	4.86	15392
34011	262	1383	5.28	20198
33983	444	1750	3.94	24532
35657	174	629	3.61	19403

* Mileage figure was not used in total due to odometer malfunction for a portion of the time period.

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Table J-2

SAMPLE TRUCKS IN VERONA RESIDENCY

ED No.	Gallons	Miles	MPG	Yearly Mileage
33966	256	1011	3.95	12458
35693	182	1008	5.54	18743
37278	195	583	2.99	*
34720	179	1175	6.56	15480
34712	201	1031	5.13	13394
34960	208	1258	6.05	16316
27992	200	935	4.68	14442
30488	241	1202	4.99	18446
28876	230	1748	7.60	16658
30394	353	1466	4.15	18850
34015	303	1684	5.55	23172
34795	273	1437	5.26	20745
34797	234	1046	4.47	17263
36055	292	1803	6.17	16979
34790	153	646	4.22	14365
37262	280	1243	4.40	15052
34958	312	1572	5.04	19551
27995	169	869	5.14	16647
27951	262	1292	4.93	14125
37026	222	1162	5.23	19478
32761	161	666	4.14	13416
37263	113	504	4.46	*
34700	245	1422	5.8	13770
27967	235	1454	6.18	*
33989	219	1540	7.03	20747

Table J-3

SAMPLE TRUCKS IN HARRISONBURG RESIDENCY

ED No.	Gallons	Miles	MPG	Yearly Mileage
37042	156	827	5.30	*
27976	125	824	6.59	12211
34959	125	806	6.45	17024
30490	219	909	4.15	15510
37272	313	1376	4.40	*
34737	228	1254	5.50	16386
34956	184	935	5.08	16994
37463	187	1154	6.17	*
34746	296	1535	5.18	14237
35664	212	1444	6.81	16759
34721	288	2709	9.40	21864
34756	318	2778	8.73	19453
34785	240	1083	4.51	*
34961	354	1645	4.64	19007
27956	234	1401	5.98	17098
37022	140	673	4.80	15025
37201	142	868	6.11	*
37204	176	1028	5.84	*

Table J-4

SAMPLE TRUCKS IN EDINBURG RESIDENCY

ED No.	Gallons	Miles	MPG	Yearly Mileage
27915	307	1589	5.17	18279
28811	237	1537	6.48	14787
27962	303	923	3.04	14605
37461	318	1193	3.75	*
36048	385	1794	4.66	*
34051	424	2285	5.39	22757
34076	381	1967	5.16	21461
34962	299	1360	4.55	22393
34788	385	1880	4.88	21053
37357	403	1703	4.23	*
34963	306	1820	5.95	19045
34739	242	1195	4.94	17109
27969	311	1815	5.84	17122
27993	271	1602	5.91	16658
34953	429	1622	3.78	21213
35611	429	1564	3.65	23049
35603	488	1906	3.91	19831
35691	231	1399	6.06	18302
28911	187	1235	6.60	19763

Table J-5

SAMPLE TRUCKS IN LURAY RESIDENCY

ED No.	Gallons	Miles	MPG	Yearly Mileage
27943	196	703	3.59	14972
37023	139	493	3.55	*
35687	150	743	4.95	14821
34778	205	1289	6.29	20542
33998	328	1266	3.86	15817
34085	261	1151	4.41	17618
28858	186	1077	5.79	15740
28915	254	1289	5.07	17217
28944	190	1037	5.46	15227
33980	258	1235	4.79	23302
37021	207	1276	6.16	20752
30464	103	508	4.93	12030
34955	54	272	5.04	12221

APPENDIX K

1745

COMPUTER SIMULATION PRINTOUT

*** INTERNATIONAL HARVESTER TAPE *** 01-AUG-79

1984 COMP OF VA

ENGINE 18203
TRANSMISSION 13674
AUXILIARY TRANSMISSION ..... NONE
DRIVING AXLE 14136
DRIVING AXLE RATIO 4.88/6.65
GVW/GCW, LBS 27000
WEIGHT ON DRIVING AXLE 18500
ENGINE ACCESSORY LOAD ..... STANDARD W/MODULATED FAN
TIRE SIZE, REV/MI 515
TIRE TYPE ..... BIAS PLY
NUMBER OF TIRES 6
FRONTAL AREA, FT2 ..... 70.0
DRAG COEFFICIENT 0.90
DRIVE-LINE EFFICIENCY 0.90
ROAD-SURFACE COEFFICIENT ... 1.2

TAPE HAS BEEN DESIGNED TO GIVE ECONOMY PREDICTIONS WHICH HAVE BEEN SHOWN TO BE TYPICAL FOR MOST OPERATIONS. HOWEVER, DUE TO OPERATING CONDITIONS, DRIVER INFLUENCES, AND OTHER FACTORS, YOUR ACTUAL MILEAGE MAY VARY FROM THAT PREDICTED.

CYCLE:	CITY	SUBURBAN	HIGHWAY
MILES PER GALLON	7.12	8.72	8.18
AVERAGE MPH	19.4	40.1	54.0
MISSION MINUTES	29.2	51.7	175.4
MINUTES LOST/HOUR	2.7	1.5	1.2

GEAR	TRANSMISSION RATIO	AXLE RATIO	VEHICLE SPEED (MPH)	ENGINE SPEED (RPM)	WHEEL POWER (HP)	GRADE-ABILITY (%)
1-1	6.50	6.65	2.2	800	33.7	21.2
			3.2	1200	71.5	31.1
			7.5	2800	141.6	25.9
1-2	6.50	4.88	2.9	800	33.7	15.2
			4.4	1200	71.5	22.1
			7.3	2000	113.1	20.8
			10.3	2800	141.6	18.4
2-1	3.52	6.65	4.0	800	34.5	11.2
			6.0	1200	73.3	16.3
			10.1	2024	117.6	15.2
			13.9	2800	145.3	13.5
2-2	3.52	4.88	13.7	2022	117.1	10.3
			19.0	2800	145.3	9.5
3-1	1.93	6.65	18.7	2065	120.3	7.8
			25.4	2800	147.2	6.7
3-2	1.93	4.88	25.1	2032	119.2	5.3
			34.6	2800	147.2	4.3
4-1	LOCKED					
		T	34.3	2309	132.6	3.7
			41.6	2800	148.2	3.0
5-1	1.00	6.65	41.1	2348	134.5	2.6
			49.1	2800	148.4	1.8
4-2	1.18	4.88	48.5	2399	136.3	1.6
			54.6	2700	145.3	1.0
			56.7	2800	148.2	0.8
5-2	1.00	4.88	50.1	2100	123.4	1.0
			56.0	2347	134.4	0.5
			62.1	2600	143.5	-0.0
			66.8	2800	148.4	-0.5

APPENDIX L

FUEL AND ENERGY USE
(All gallon and Btu figures are x 10^6)

Table L-1

PRESENT FLEET
(NOTE: Fifty diesel trucks being evaluated by the Department not included.)

Number Gas Trucks	1,900
Gal. Gas	6.536
Number Diesel Trucks	0
Gal. Diesel Fuel	0
Total Gal.	6.536
Gal. Gas saved over base	0
Actual Gal. Fuel saved over base	0
Btu Gas	817,000
Btu Diesel	0
Btu Total	817,000
Btu Saved over base	0

Table L-2

100% REPLACEMENT PLAN

	YEAR					
	1	2	3	4	5	6
Number of Gas trucks	1,600	1,300	1,000	700	400	0
Gal. gas	5.504	4.472	3.440	2.408	1.376	0
Number Diesel trucks	300	600	900	1,200	1,500	1,900
Gal. Diesel Fuel	.639	1.287	1.917	2.556	3.195	4.047
Total Gal.	6.143	5.759	5.357	4.964	4.571	4.047
Gal. Gas saved over base	1.032	2.064	3.096	4.128	5.160	6.536
Actual Gal. fuel saved over base	.393	.777	1.179	1.572	1.965	2.489
Btu Gas	688,000	559,000	430,000	301,000	172,000	0
Btu Diesel	88,182	177,606	264,546	352,728	440,910	558,486
Btu Total	776,182	736,606	694,546	653,728	612,910	558,486
Btu saved over base	40,818	80,394	122,454	163,272	204,090	258,514

Table L-3

75% REPLACEMENT PLAN

	YEAR					
	1	2	3	4	5	6
Number Gas Trucks	1,670	1,440	1,210	980	750	500
Gal. Gas	5.7448	4.9536	4.1624	3.3712	2.580	1.720
Number Diesel Trucks	230	460	690	920	1,150	1,400
Gal. Diesel Fuel	.4899	.9798	1.4697	1.9596	2.4495	2.982
Total Gal.	6.2347	5.9334	5.6321	5.3308	5.0295	4.702
Gal. Gas saved over base	.7912	1.5824	2.3736	3.1648	3.956	4.816
Actual Gal. fuel saved over base	.3013	.6026	.9039	1.2052	1.5065	1.834
Btu Gas	718,000	619,200	520,300	421,400	322,500	215,000
Btu Diesel	67,606	135,212	202,818	270,425	338,031	411,516
Btu Total	785,606	754,412	723,118	691,825	660,531	626,516
Btu saved over base	31,394	62,588	93,882	125,175	156,469	190,484

Table L-4

50% REPLACEMENT PLAN

	YEAR					
	1	2	3	4	5	6
Number Gas Trucks	1,740	1,580	1,420	1,260	1,100	950
Gal. Gas	5.9856	5.4352	4.8848	4.3344	3.784	3.268
Number Diesel Trucks	160	320	480	640	800	950
Gal. Diesel Fuel	.3408	.6816	1.0224	1.3632	1.704	2.0235
Total Gal.	6.3264	6.1168	5.9072	5.6976	5.4880	5.2915
Gal. Gas saved over base	.5504	1.1008	1.6512	2.2016	2.7520	3.2680
Actual Gal. fuel saved over base	.2096	.4192	.6288	.8384	1.048	1.2445
Btu Gas	748,200	679,400	610,600	541,800	473,000	408,500
Btu Diesel	47,030	94,061	141,091	188,122	235,152	279,243
Btu Total	795,230	773,461	751,691	729,922	708,152	687,743
Btu saved over base	21,770	43,539	65,309	87,078	108,848	129,257

APPENDIX M

PAYBACK ANALYSIS

Table M-1

CONSTANT FUEL PRICES
70¢/gal. gasoline, 64¢/gal. diesel fuel

	Gasoline	Diesel
Yearly Mileage	17,800	17,800
MPG	5.17	8.35
Cost of Fuel	$.70	$.64
Purchase Cost	$10,350	$14,440 Diff. - $4,090

$\frac{17,800 \text{ miles}}{5.17 \text{ mi./gal.}} = 3442.9 \text{ gal.}$ $\frac{17,800}{8.35} = 2131.7 \text{ gal.}$

All further calculations will use 3,440 gal. gas/yr./truck
2,130 gal. diesel/yr./truck

Fueling time and maintenance cost are assumed equal, so payback can be computed as a matter of fuel cost only.

3,440 gal. x $.70/gal. = $2,408.00

2,130 gal. x $.64/gal. = $1,363.20

If gasoline and diesel fuel costs were constant, then payback would be

$2,408.00 - $1,363.20 = $1,044.80

$\frac{\$4,090.00 \text{ cost differential}}{\$1,044.80 \text{ cost savings/yr.}} = 3.9 \text{ yr.}$

Payback would take 3.9 years.

Table M-2

FULL PRICES INCREASE 20¢/gal./yr. —
GASOLINE 6¢ HIGHER THAN DIESEL FUEL

Fuel	Year 1	Year 2	Year 3	Year 4
Gasoline	$.70/gal.	$.90/gal.	$1.10/gal.	$1.30/gal.
Diesel	$.64/gal.	$.84/gal.	$1.04/gal.	$1.24/gal.

Cost differtial between trucks = $4,090.00

Fuel Cost Differtial (savings from diesel use)

Year 1 $3,440 x $.70 = $2,408 $2,130 x $.64 = $1,363.20
$2,408 - $1,363.20 = $1,044.80

Year 2 $3,440 x $.90 = $3,096 $2,130 x $.84 = $1,789.20
$3,096 - $1,789.20 = $1,306.80

Year 3 $3,440 x $1.10 = $3,784 $2,130 x $1.04 = $2,215.20
$3,784 - $2,215.20 = $1,568.80

Year 4 $3,440 x $1.30 = $4,472 $2,130 x $1.24 = $2,641.20
$4,472 - $2,641.20 = $1,830.80

Savings

Year 1	$1,044.80	$4,090.00 - $3,920.40 = $169.60
Year 2	$1,306.80	
Year 3	$1,568.80	$ 169.60
	$3,920.40	$1,830.80/yr. = .093 yr.

Payback = 3 yr. + .093 yr. or approximately 3.1 years

APPENDIX N

SINGLE TRUCK PRESENT WORTH COST ANALYSIS (6 YEARS)

Discount rate: 10%

Future Fuel Costs:

Gasoline constant @ $2,410 per year
Diesel fuel constant @ $1,364 per year

Truck Costs:

Gasoline truck - initial cost $10,350
- salvage value 4,000

$10,350 + $2,410 + $2,410 (3.791) - $4,000 (.6209) = $19,412

Diesel truck - initial cost $14,400
- salvage value 6,000

$14,400 + $1,364 + $1,364 (3.791) - $6,000 (.6209) = $17,250

Present Worth Costs:

Gasoline truck = $19,412
Diesel truck = $17,250

Discount Rate: 10%

Future Fuel Costs:

Gasoline and diesel fuel costs increase 20¢/gal/yr.

Truck Costs:

Gasoline truck - initial cost $10,350
- salvage value 4,000

$10,350 + $2,410 + $3,096 (.9091) + $3,784 (.8264) + $4,472 (.7513) + $5,160 (.6830) + $5,848 (.6209) - $4,000 (.6209) = $26,733

Diesel truck - initial cost $14,400
- salvage value 6,000

$14,400 + $1,364 + $1,789 (.9091) + $2,215 (.8264) + $2,641 (.7513) + $3,067 (.6830) + $3,493 (.6209) - $6,000 (.6209) = $21,743

Present Worth Costs:

Gasoline truck = $26,733
Diesel truck = $21,743

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