TM 810 760

DEPARTMENT OF EDUCATIONAL ACCOUNTABILITY

# Cost Effectiveness of Premium Versus Regular Gasoline in MCPS Buses



MONTGOMERY COUNTY PUBLIC SCHOOLS
ROCKVILLE, MARYLAND

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REGULAR GASOLINE IN MCPS BUSES

by

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Summary

The primary question posed in this study is whether premium or regular gasoline is more cost effective for the MCPS bus fleet, as a whole, when miles-per-gallon, cost-per-gallon, and repair costs associated with mileage are considered. On average, both miles-per-gallon and repair costs-per-mile favor premium gasoline by a slight margin. However, cost-per-gallon significantly favors the use of regular gasoline with the net result that total cost-per-mile is approximately one-half cent less for regular gasoline. Based on a bus fleet operation of 7,973,448 miles annually, the potential savings for MCPS by the use of regular gasoline are $39,070 or approximately 2.6 percent of the $1,475,200 budgeted in FY 1979 for bus operation and maintenance.

This study result confirms the decision a year ago to convert the school bus fleet to regular gasoline. If the difference in cost between regular and premium gasoline continues to increase, the projected savings from that decision will also increase.

Secondary study results show that (1) operational costs vary significantly depending on the types of routes to which buses are assigned; (2) operational costs were higher during the second phase of the study when colder weather was experienced; (3) medium engine Dodge buses and large engine International buses are the most cost effective using regular gasoline; and (4) operating costs tend to have increased with more recent model years, although the 1977 models show signs of reversing that trend. These secondary results suggest the need for continuing to monitor bus operations by make, model year, routes, and engine size in order to have available maximum information for management decisions regarding bus procurements and assignments to routes.

Interviews with drivers showed a majority favored the use of premium gasoline. However, not all of the drivers' reasons for this preference were substantiated by the study data. For example, (1) none of the engine noise differences for buses between regular and premium gasoline were as large as the two decibel allowance required to exceed the variability of the noise test measure itself; and (2) the numbers of shop referrals during the study were virtually identical between premium and regular uses.

Introduction

By Resolution Number 530-78 of July 24, 1978, the Board of Education requested the Department of Educational Accountability to conduct a study of the cost effectiveness of regular versus premium gasoline in MCPS school buses. Cost effectiveness for this study is based on gasoline mileage, gasoline cost, and the costs of parts and labor for repairs normally associated with type of gasoline.

Two transportation depots, Bethesda and Shady Grove, were selected as the study sites since they (1) permitted a comparison to avoid a unique factor at any one depot which might influence the study outcome, (2) appeared to have bus routes which were generally representative of the county as a whole, and (3) were convenient for the management of the study.

At each depot, 80 buses were randomly selected and divided into two groups of equal size and characteristics. Comparisons were made following the assignments to determine the comparability of each group to the fleet as a whole and to each other in terms of year of manufacture, make, seating capacity, transmission type, and performance history. The 160 buses assigned to the study were 25 percent of the entire fleet of 651 buses.

One group at each depot was assigned regular gasoline, and the second group at each depot assigned premium. The type of gasoline assigned was reversed at the midpoint of the study to equate for possible differences between bus groups and to evaluate the possible effects of sequence in gasoline use. The date for changing from one type of gasoline to the other was set to equalize projected differences in temperature during the two twelve-week periods established for the study. This date represented the average temperature midpoint for the previous five years as measured by degree days.[1] Therefore, the use of each type of gasoline would include approximately the same number of colder and warmer days. The time period for data collection extended from October 23, 1978, through April 20, 1979.

To determine possible side effects in using the different types of gasoline, data were also analyzed on the number of shop referrals; the number of early morning no-starts; engine noise; and the opinions of drivers, mechanics, and supervisors.

Methodology

To the extent possible, the study was designed so that data would be collected through procedures normally used by the Division of Transportation to minimize the impact of the study on daily operations. The study plan and methodology were reviewed with transportation and school services staff to ensure that the requirements were considered practical without disrupting bus operations.

The buses selected for the study were prepared by (1) adjusting point settings to correspond to the type of gasoline assigned, and (2) painting a letter "P" on the gas door and dashboard of those buses assigned premium to remind drivers and bus attendants of the appropriate gasoline.

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[1]A "degree day" is the difference between the mean outside temperature over a 24 hour period and a base temperature of 65 degrees. Degree day information is maintained on a monthly basis throughout the year by the Department of School Services.

Bus drivers were informed of the purposes and procedures of the study before it started and when the switch was made to another type of gasoline. Staff from the Department of Educational Accountability participated in the January driver in-service meetings to discuss the study and answer driver questions regarding it.

Gasoline pump tickets completed daily by drivers provided data on the bus number, odometer reading, type of gasoline used, and gallons of gasoline pumped. One copy of each ticket was turned over to the Department of Educational Accountability staff for tabulation. A part-time clerk performed the additional tasks of recording data, selecting daily gasoline tickets for the buses in the study, and identifying tickets that evidenced the use of incorrect gasoline.

Records on parts and labor costs on each bus were maintained on a daily basis as a part of the regular operation of the Division of Transportation. These records were reviewed by the supervisor of auto maintenance at scheduled data cut-off points to select and summarize those items and amounts agreed to be associated with type of gasoline used. In general, these items included condensers, spark plugs, exhaust systems, and tune up supplies. The repair records also documented the number of shop referrals and early morning no-starts for each bus.

Interviews were conducted one day during the final week of the study to inquire whether drivers, mechanics, and supervisors observed major differences in the operation and/or maintenance of the buses due to the type of gasoline used. All available drivers that day were included in the interviews as they refueled their buses; and approximately half of the drivers in each of the four groups were reached. Twelve mechanics and supervisors were interviewed that same day.

In response to informal comments made at various times by drivers, possible differences in engine noise levels with the two types of gasoline were measured by the Maryland Automotive Safety Enforcement Division of the State Motor Vehicle Administration. A sample of 28 study buses at one depot was tested using one type of gasoline in January and the other type in the same vehicles in February. Decibel ratings were recorded for each bus at 45 miles-per-hour and at engine governed speed in second and third gears. The results were analyzed by year of manufacture, make, size, and transmission type, according to standard practice for evaluating this kind of data.

To monitor the entire study, the project leader from the Department of Educational Accountability (1) visited early morning start-ups once each week during the coldest period of the study, (2) audited the data collection from the gasoline tickets, (3) talked periodically with drivers about the study and bus operations, and (4) discussed maintenance needs with transportation staff.

The methodology of the study plan was generally maintained, due in large part to the excellent cooperation of the 160 drivers whose buses were included in the study. Only the following variations or problems need to be noted:

1. Attrition. Transportation staff attempted to retain at the study depots the buses assigned to the study by minimizing trade-ins or routine reassignments to other depots. The study began with 40 buses in each group, and only 12 were lost to the study. Final group sizes were 37, 37, 35, and 39.

2. Type of Gasoline Errors. Project staff monitored the use of gasoline type assigned to each bus through the pump tickets. When incorrect gasoline was used, drivers were informed by transportation staff and requested to use the appropriate type in the future. As a result of cooperation among the project staff, transportation staff, and bus drivers, no bus had so many gasoline errors so as to warrant its exclusion from the study. Forty-five drivers had a perfect record on using the appropriate gasoline; 67 had one or two improper fill-ups; 23 had three or four; and 13 had five to 12. An estimated 4,896 of the 253,022 gallons of gasoline (1.9 percent) used by the study buses were not the type assigned.

3. Unleaded Gasoline Regular gasoine was not delivered to MCPS on schedule several times during the study. Drivers whose buses were assigned regular gasoline were instructed to use unleaded gasoline. These were not counted as improper fill-ups because of the similarity of the octane ratings. Unleaded is rated at 88.4, while regular is rated at 89.

4. Temperature Variations. The study design postulated a change from one type of gasoline to the other on the date which represented the average mid-point over five years in annual temperature readings. Actual readings for the 1978-79 winter showed a different distribution of degree days from the historical pattern; although in total the winter was no colder than average. The fact that the second gasoline period was colder than the first period is considered in the interpretation of the study findings.

5. Depot Switch Dates. When it was discovered that the first gasoline period was averaging slightly warmer than usual, the date for the switch from one type of gasoline to the other was delayed for one week to equalize the degree days to some extent. Due to a misunderstanding, one depot kept to the original schedule while the other depot moved to the new schedule. As a result, one depot finished the study with 11 weeks in phase one, followed by 12 weeks in phase two; while the other depot had the reverse number of weeks in each phase. (Snow days and school holidays are removed from the schedule in both phases.) The data analysis plan was adjusted for this difference; and it is not viewed as influencing the study results.

6. Gasoline Costs. Because the cost of gasoline continued to increase during the study period, average costs for premium and regular gasoline were used for the data analysis to avoid confounding the results for different time phases and type of gasoline.

Results

The primary question posed in this study is whether premium or regular gasoline is more cost effective for the MCPS bus fleet, as a whole, when miles-per-gallon, cost-per-gallon, and repair costs associated with mileage are considered. Table 1 presents the comparison of means for premium and regular gasoline for all buses in the study and shows the averge total cost-per-mile to operate with each type of gasoline. On average, both miles-per-gallon and repair-costs-per-mile favor premium gasoline by a slight margin. However, cost-per-gallon significantly favors the use of regular gasoline with the net result that total cost-per-mile is approximately one-half cent less for regular gasoline.

As table 2 shows, based on a bus fleet operation of 7,973,448 miles annually, the potential savings for MCPS by the use of regular gasoline are $39,070. This savings represents approximately 2.6 percent of the $1,475,200 budgeted in FY 1979 for bus operation and maintenance. This result confirms the decision a year ago to convert the school bus fleet to regular gasoline.

The estimated savings is projected for the entire fleet on the assumption that the study conditions would hold for the entire fleet and for future years. However, that assumption is not, in fact, a correct one since virtually all of the study factors are constantly changing. For example, the difference in cost between regular and premium gasoline continues to increase. The average difference for the study period was $0.0289, but the closing difference in April was $0.0389. At that greater cost difference, the projected savings for the entire fleet by using regular gasoline would increase to $54,219.

There may be other ways to increase fleet savings. The results presented in Tables 1 and 2 are based on means applied to the entire fleet of buses without regard to any other factors. However, other variables are represented in the study data; and some of the other variables appear to influence the cost-per-mile for bus operations by more than the type of gasoline does. Although the study did not focus on these additional variables and therefore the data is somewhat limited for some of them, the study information does permit some comparative analysis of cost-per-mile for each variable with each type of gasoline. Table 3 exhibits these comparisons for such variables as bus depot, study phase, make and engine size of the bus, and model year. Since each one-tenth of a cent difference in cost-per-mile represents $7,973 when projected to the annual fleet operation, even small variations can be significant. To simplify the presentation on this table, small capacity buses and repair costs have been eliminated. Following are brief discussions of possible interpretations for the variations:

1. Type of gasoline. The overall difference in cost-per-mile, based only on the type of gasoline, is shown as $0.004. Note that this is one-tenth of a cent less than the gasoline cost-per-mile difference shown on Table 1. The drop is a result of the elimination of the small capacity buses which have significantly better performance records. This $0.004 difference becomes the standard against which to judge the relative importance of other variables on operting costs.

## Table 1

Comparison of Means for Regular and Premium Gasoline for All Buses in Study on Miles-per-gallon and Selected Costs-per-mile *

| | Mean Miles-per-gallon | Mean Cost-per-gallon | Mean Gasoline Cost-per-mile | Mean Repair Cost-per-mile | Mean Total Cost-per-mile |
|---|---|---|---|---|---|
| Premium Gasoline | 4.5260 | $0.5299 | $0.1247 | $0.0051 | $0.1303 |
| Regular Gasoline | 4.4815 | 0.5010 | 0.1195 | 0.0056 | 0.1254 |
| Difference | 0.0445 | $0.0289 | $0.0052 | ($0.0005) | $0.0049 |

* Numbers will not necessarily add exactly due to averaging and rounding in preliminary calculations.

## Table 2

Estimated Annual Savings for Entire MCPS Bus Fleet with Regular Gasoline

| | Mean Total Cost-per-mile | Bus Fleet Miles-per-year* | Estimated Fleet Cost |
|---|---|---|---|
| Premium Gasoline | $0.1303 | 7,973,448 | $1,038,940 |
| Regular Gasoline | 0.1254 | 7,973,448 | 999,870 |
| Difference | $0.0049 | -- | $ 39,070 |

* Estimate of bus fleet miles-per-year provided by the Division of Transportation.

## Table 3

Comparison of Mean Cost-per-mile for Selected Variables[1]

| Variable | | Number of Cases | Premium Cost-per-mile | Regular Cost-per-mile | Difference |
|---|---|---|---|---|---|
| Gasoline | | 122 | $0.132 | $0.128 | $0.004 |
| Depot: | Bethesda | 65 | 0.137 | 0.133 | 0.004 |
| | Shady Grove | 57 | 0.127 | 0.123 | 0.004 |
| | Difference | | 0.010 | 0.010 | |
| Study Phase: | Two | 63[2] | 0.135 | 0.134 | 0.001 |
| | One | 59[2] | 0.130 | 0.122 | 0.008 |
| | Difference | | 0.005 | 0.012 | |
| Make & Engine Size: | | | | | |
| | Ford, large engine | 0 | | | |
| | Ford, medium " | 27 | 0.137 | 0.130 | 0.007 |
| | Dodge, large " | 12 | 0.148 | 0.137 | 0.011 |
| | Dodge, medium " | 12 | 0.126 | 0.121 | 0.005 |
| | Int'l., large " | 57 | 0.133 | 0.127 | 0.006 |
| | Int'l., medium " | 14 | 0.113 | 0.129 | (0.016) |
| | Range | | 0.035 | 0.016 | |
| Model Year: | 1969 | 14 | 0.113 | 0.129 | (0.016) |
| | 1970 | 12 | 0.126 | 0.121 | 0.005 |
| | 1971 | 8 | 0.125 | 0.119 | 0.006 |
| | 1972 | 14 | 0.128 | 0.124 | 0.004 |
| | 1973 | 13 | 0.131 | 0.127 | 0.004 |
| | 1974 | 14 | 0.143 | 0.133 | 0.010 |
| | 1975 | 15 | 0.139 | 0.131 | 0.008 |
| | 1976 | 12 | 0.148 | 0.137 | 0.011 |
| | 1977 | 20 | 0.137 | 0.130 | 0.007 |
| | Range | | 0.035 | 0.018 | |

[1] Excludes small capacity buses and all repair costs; 122 study buses included.

[2] The number of cases is for regular gasoline. For premium, the numbers are reversed: 63 in phase one and 59 in phase 2.

2. Depot. Although each depot showed the same $0.004 difference between types of gasoline, the difference between depots is significantly greater at $0.010. Probably this difference may be attributed almost entirely to the types of bus routes. Bethesda Depot buses generally experience shorter runs in heavier suburban traffic, with frequent stops and starts. Although this is a very significant variable, the alternatives available to the Board and transportation managers are limited. An increase in the walking distance would compensate for some of the route inequities because it would impact the more suburban areas to a greater extent. Assigning the most economical buses (See items 4 and 5 below.) to the suburban routes would also minimize their higher operating costs.

3. Study phase. The gasoline study was divided into two phases or periods - the first running from October to mid-January, and the second from mid-January to April. The second phase included most of the coldest days of the past winter. Gasoline cost-per-mile shows considerable

   differences between the two phases: $0.005 and $0.012 for premium and regular respectively. The cost-per-mile continued to favor regular gasoline during both phases; although the difference narrowed to only $0.001 in the second phase.

   Three possible explanations for the higher costs during the second phase are:

   a. In colder weather buses do not operate as efficiently, regardless of any other factors. To the extent this explanation is true, little can be done by transportation managers.

   b. The practice of having the mechanics start the buses on cold mornings contributes to higher operating costs. In order for a small number of mechanics to start all of the buses, the mechanics must begin the process 20 to 30 minutes ahead of scheduled runs. Therefore, many buses are burning gasoline without accumulating mileage. Since the study showed no cases of bus "no starts" during the past winter, this practice may need to be reevaluated. If the reason that all buses did start is because mechanics are better trained than drivers to start a cold engine, it may be more cost effective to provide in-service training to drivers than to continue the energy consuming process of using the mechanics.

   c. The buses are better tuned at the start of the school year. Each bus undergoes a full maintenance program prior to the start of annual operations. It may be that, as buses are driven throughout the year, time and/or the number of staff does not permit sufficient continuing preventive maintenance to provide the highest possible efficiency of engine operation. Although data is not available regarding total miles driven by study buses during the year (since no mileage data was collected from September to the start of the study in late October), study data does show that many of the buses had no shop visits during the entire study period for repairs normally associated with mileage performance. If appropriate, a reassessment of the routine maintenance program could be undertaken by transportation managers.

4. Make and engine size. Comparative costs by make and engine size show that the medium engine International buses are the only group of buses in the entire study to perform more cost effectively on premium than on regular gasoline. As the other differences in cost-per-mile for premium versus regular gasoline indicate, without the 14 medium engine Internationals, the overall projected savings for the entire fleet would have been greater, since the other differences range from $0.005 to $0.011 in favor of regular gasoline.

   Looking at group performance on regular gasoline, it is evident that medium engine Dodge buses and large engine International buses are the most cost-effective. Although the data is too limited here to draw firm conclusions, repeated monitoring of cost-per-mile for the buses could have significant implications for future bus procurements. The computerized gas pump system recently installed for MCPS should permit such monitoring.

5. Model year. With the exception of the 1969 buses, which by state law must soon be retired from the fleet, all model years performed better on regular gasoline, ranging from the studywide difference of $0.004 to a high of $0.011. The most significant trend among the years is the increasingly higher operating costs-per-mile in the more recent years, although the 1977 buses show evidence of reversing that trend. Unless cost-per-mile turns out to remain relatively lower in the next few model years, overall fleet costs will rise faster than would be predicted by gasoline prices alone because the older, more cost effective buses will be removed from the fleet.

   A combination analysis of make and engine size compared to model year was not performed because the number of buses in each subgroup at that combination level would be too small to have much significance, even as a trend indicator. However, close monitoring of such combination factors should be undertaken, as recommended above, in order to project better possible future operating costs for budget purposes.

Table 4 summarizes the results of the end-of-study interviews with drivers, mechanics, and supervisors. Of the 73 drivers interviewed, 52 (71 percent) believed there were major differences in the ways the buses operated with the two types of gasoline. All but one of these 52 drivers stated that the bus operated better with premium gasoline. The specific operational features which these drivers identified are included on Table 4. Several of these features merit discussion:

1. Better engine starting. This was the most frequently cited difference; although, as discussed earlier, there were no reported cases of "no starts" among the study buses, and during the coldest part of the winter, the mechanics started the buses.

Table 4

Features of Bus Operation Associated with Using Premium, as Reported by Drivers, Mechanics, and Supervisors Who Felt There Is a Difference

| Operational Feature | Drivers Number | Drivers Percent | Mechanics and Supervisors Number | Mechanics and Supervisors Percent |
|---|---|---|---|---|
| Better engine starting | 35 | 67% | 6 | 100% |
| Better mileage | 33 | 63 | 6 | 100 |
| Less smoke & exhaust fumes | 28 | 54 | 4 | 67 |
| Less hesitation | 25 | 48 | 6 | 100 |
| Less engine noise | 24 | 46 | 5 | 83 |
| More maneuverability | 18 | 35 | 5 | 83 |
| Less repairs | 9 | 17 | 5 | 83 |
| Less run-on with switch off | 2 | 4 | | |
| More power | 2 | 4 | | |
| Better idling | 1 | 2 | | |
| Less oil burning | 1 | 2 | | |
| Faster warm up | 1 | 2 | | |
| Better overall running | 1 | 2 | | |

## Table 5

Engine Noise Levels in Decibels at the Driver's Seat for a Sample of 28 Buses in the Study that Were on One Type Gasoline in January and Another Type Gasoline in February

| Type Bus | Number of Buses | Mean Decibel Ratings Regular | Premium |
|---|---|---|---|
| 1. 1969 International, 66 passenger, standard transmission | 6 | 82.3 | 82.9 |
| 2. 1977 International, 66 passenger, automatic transmission | 7 | 84.8 | 85.0 |
| 3. 1977 International, 66 passenger, lift gate, automatic transmission | 1 | 85.5 | 87.0 |
| 4. 1977 Chevrolet, 18 passenger, automatic transmission | 2 | 85.3 | 86.7 |
| 5. 1976 Dodge, 66 passenger, automatic transmission | 1 | 82.6 | 81.6 |
| 6. 1970 Dodge, 66 passenger, standard transmission | 2 | 85.6 | 85.1 |
| 7. 1971 International, 66 passenger, standard transmission | 2 | 84.8 | 84.1 |
| 8. 1972 International, 66 passenger, automatic transmission | 3 | 81.5 | 82.0 |
| 9. 1974 Ford, 66 passenger, automatic transmission | 1 | 86.6 | 86.8 |
| 10. 1975 International, 66 passenger, automatic transmission | 3 | 82.6 | 82.5 |
| Sample Means | 28 | 84.2 | 84.4 |

Note: According to specified procedure, buses were grouped and analyzed, separately by year, make, size, and transmission type. A sound level near the driver's seat was measured to determine whether it would be effected by the type of gasoline used. The SAE recommended practice for "Sound Level for Truck Interior" SAE J336a was used as a guide. All available buses in the study were tested that were parked at the Shady Grove Depot. The dB reading was recorded with the microphone mounted at the seated driver's ear level and 10 inches away toward the center of the bus. Records were made at 45 MPH and at engine governed speed in second and third gears. In setting standards for sound levels, the Society of Automotive Engineers recommends a "...2dB allowance over the sound level limit is recommended to provide for variations in test site, temperature gradients, test equipment, and inherent differences in nominally identical vehicles." See page 35.15, "Report of Vehicle Sound Level Committee approved June 1968, and last revised July, 1973. In view of the 2dB SAE allowance, type gasoline does not affect sound level near the driver's seat.

2. Better mileage. The study results confirm that the mileage was, on average, slightly better for buses using premium gasoline.

3. Less smoke and exhaust fumes. Smoke or exhaust fumes were considered to be less with premium gasoline by 28 drivers. The validity of these views is beyond the scope of this study. However, it should be noted that MCPS does receive continuing information on carbon monoxide levels in school buses through a testing program conducted by the Office of Safety. One percent of the buses each month are tested, resulting in 12 percent annually. Additionally, buses are tested for carbon monoxide levels whenever drivers question transportation staff about fumes on their buses. This testing service has only been provided for a few months so coorelation with study results was not possible.

4. Less hesitation, better maneuverability. These types of factors were not measured as part of the study.

5. Less engine noise. Although 24 drivers reported less engine noise with the use of premium gasoline, their opinions are not supported by the noise test results shown in Table 5. None of the differences for buses between regular and premium gasoline were as large as the two decibel allowance required to exceed the variability of the test measure itself.

6. Less repairs. Although nine drivers cited less repairs with premium gasoline, the study results show that the numbers of shop referrals were virtually identical between premium and regular gasoline uses.

The ratings of supervisors and mechanics were tallied separately from those of drivers, and are also included in Table 4. Of the 12 surveyed, six thought there was a significant difference between the use of premium and the use of regular, always in favor of premium. The operating features cited as evidence of the difference were similar to the more frequent driver reasons.

Recommendations

The results of the study suggest six recommendations for consideration by the transportation line managers. These recommendations were alluded to in the "Results" section and are summarized here.

1. Using whatever modification may be necessry in the computerized gas pump system, begin monitoring the cost-per-mile performance of the bus fleet on the basis of bus make, model year, engine size, and type of route.

2. Assign the most cost-efficient buses to the suburban routes.

3. Use the information gained from bus monitoring in the development of procurement specifications and the evaluation of bid proposals.

4. Reevaluate the practice of having the mechanics start the buses ahead of time on cold mornings.

5. Review the preventive bus maintenance program on a cost-benefit basis to determine what efficiency gains could be achieved in bus performance by investing some additional resources in the maintenacne operation.

6. Inform the drivers of the results of this study so as to allay some of the concerns expressed regarding the use of regular gasoline - especially the results for cost-per-mile, repairs, and noise levels.