# Synthetic Oil Study

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ABSTRACT

A comparison is made of fuel and engine oil consumption of diesel highway maintenance trucks with 27,000 lb gross vehicle weight using standard 15W-40 engine oil and synthetic engine oil. A control group and a test group, of eight trucks each, made up the test fleet, which was monitored for a period of 18 months under normal operating conditions. The trucks were geographically distributed throughout the state of Maine, so that one truck from the control group and one from the test group were located in each of eight geographic regions. For the entire 18-month test period, the data indicated that the trucks using synthetic oil had a 5 percent overall improvement in fuel consumption rate (fuel used in gallons per hour of operation) over the trucks with 15W-40 oil. Fuel consumption data were also compiled separately for the summer and the winter. The fuel consumption in gallons per hour for the test units during the summer was approximately 4 percent less than that for the control units. For the winter period the test units exhibited a fuel consumption advantage of approximately 7 percent over the control units. The wear analysis of the engine oil indicated there may be more wear when the synthetic oil is used.

The objective of this study was to conduct a field evaluation to compare the effects on fuel consumption and wear rate in diesel truck engines of using synthetic oil as opposed to using SAE 15W-40 oil. The Maine Department of Transportation (Maine DOT) selected 16 diesel trucks of the same gross vehicle weight (GVW) and engine type (27,000 lb GVW, International 1854-5) for participation in the study. These were new, or nearly new, trucks that were acquired in 1979 and 1980. Eight units were used for control vehicles and eight were designated as test vehicles.

For the initial 200 to 400 hr of operation, the test vehicles used 15W-40 engine oil to break in the engines; then the test trucks were changed to the use of synthetic oil for the subsequent 18-month test period. The control vehicles used only 15W-40 oil for the duration of the study.

Samples of the engine oil were taken after every 200 hr of operation, the normal drain interval, unless the analysis of the oil showed extremely high wear or contamination, after which the drain interval was reduced to 100 hr. The engine oil analysis was conducted by an independent laboratory.

The fuel consumption and other information were derived from weekly equipment reports that contained the odometer reading for miles traveled, engine operating hours, gallons of fuel added, and engine oil replaced.

During the test period, the trucks were subjected to weather conditions that ranged from extremely cold (-40°F) to hot (95°F). The winter cold-start problems that the synthetic oils were designed to alleviate were also evaluated.

## METHODOLOGY

At least one pair of trucks, consisting of a test truck and a control truck, was selected from each Maine DOT division in order to have units geographically distributed throughout the state. The pairing of test and control vehicles within a division should have minimized biases resulting from operational differences such as climatic conditions, work load, and terrain.

The fuel and engine oil used by the units were tabulated from weekly equipment reports sent directly to the Maine DOT's Motor Transport Division in Augusta. From the tabulations of fuel and oil used, of engine operating hours, and of miles driven for the test and control vehicles, the fuel efficiency was calculated.

In an effort to determine whether the lubricating qualities of synthetic oil were the same as those of the 15W-40 oils, the engine wear rate was derived from an analysis of engine oil samples taken at appropriate drain intervals. An independent laboratory performed the oil analysis under contract.

## ANALYSIS OF DATA

Two major parameters for potential difference between the test and control units were analyzed: fuel consumption and engine wear.

### Fuel Consumption Analysis

The measures used to determine fuel efficiency differences between the trucks using synthetic oil and those using 15W-40 oil were miles per gallon (mpg) and gallons per hour (gph). These two parameters were computed for the entire 18-month test period, for the summer, and for the winter. The summer period consisted of June, July, and August and the winter consisted of December, January, and February.

Because the operation of these trucks included a significant amount of idling time, the rate of fuel consumption in gallons per hour is a more meaningful indicator of fuel efficiency than miles per gallon.

The fuel consumption results for the 18-month test period are summarized in Table 1. The average fuel consumption rate for the test units (synthetic oil) was 5 percent less than that for the control units. The fuel efficiency difference in miles per gallon between the test units and the control units (15W-40) was less than 1 percent during the 18-month period.

#### Summer

For the summer months only, the fuel consumption rate for the test units was approximately 4.5 percent less than that for the control units (Table 2). The summer fuel efficiency (based on mpg) for the test units was approximately 5 percent better than that for the control units (Table 2).

TABLE 1 Fuel Consumption for 18-Month Test Period

Synthetic Fuel (Test Units)

| Unit No. | Miles | Hours | Fuel in Gal | Ave. Speed | MPG | GPH |
|---|---|---|---|---|---|---|
| 11-774 | 20,648 | 1,529 | 3,847 | 13.5 | 5.37 | 2.52 |
| 11-775 | 16,633 | 899 | 2,304 | 18.5 | 7.22 | 2.56 |
| 11-778[a] | 9,927 | | 1,332[a] | (Est | 7.45[a] | |
| | | 1,194 | 1,773 | 11.1) | | 1.48 |
| 11-780 | 28,253 | 1,752 | 4,353 | 16.1 | 6.49 | 2.48 |
| 11-781[a] | 20,525 | | 2,541[a] | (Est | 8.08[a] | |
| | | 1,244 | 2,901 | 18.8) | | 2.33 |
| 11-785 | 19,090 | 1,091 | 2,434 | 17.5 | 7.84 | 2.23 |
| 11-795 | 18,133 | 1,332 | 2,540 | 13.6 | 7.14 | 1.91 |
| 11-800 | 15,150 | 897 | 1,782 | 14.7 | 8.50 | 1.99 |
| Totals | 148,359 | | 21,133[a] | 15.7[b] | 7.02 | |
| | | 9,938 | 21,934 | | | 2.21 |

Non - Synthetic Oil (15W-40) (Control Units)

| Unit No. | Miles | Hours | Fuel in Gal | Ave. Speed | MPG | GPH |
|---|---|---|---|---|---|---|
| 11-748 | 23,910 | 1,231 | 2,959 | 19.4 | 8.08 | 2.40 |
| 11-773 | 28,370 | 1,719 | 4,336 | 16.5 | 6.54 | 2.52 |
| 11-776 | 27,900 | 1,784 | 3,766 | 15.6 | 7.41 | 2.11 |
| 11-777[c] | 25,592 | | 4,433[c] | | 5.77 | |
| | | 1,914 | 5,422 | | | 2.83 |
| 11-791 | 22,897 | 1,657 | 2,935 | 13.8 | 7.80 | 1.77 |
| 11-798 | 27,395 | 1,617 | 3,613 | 16.9 | 7.58 | 2.23 |
| 11-802 | 17,718 | 1,322 | 2,502 | 13.4 | 7.08 | 1.89 |
| 11-805 | 27,535 | 1,550 | 4,184 | 17.8 | 6.58 | 2.70 |
| Totals | 201,317[c] | | 28,728[c] | 16.2[b] | 7.01 | |
| | | 12,794 | 29,717 | | | 2.32 |

[a] Odometers broken for 3 to 4 weeks; fuel quantities used in computation of MPG correspond to measured miles.

[b] Does not include values for trucks 11-778, 11-781, or 11-777, as appropriate.

[c] Odometer broken for 9 weeks; fuel quantity used in computation of MPG corresponds to measured miles.

TABLE 2 Fuel Consumption for Summer Months

Synthetic Fuel (Test Units)

| Unit No. | Miles | Hours | Fuel in Gal | Ave. Speed | MPG | GPH |
|---|---|---|---|---|---|---|
| 11-774 | 6,481 | 391 | 909 | 16.5 | 7.13 | 2.32 |
| 11-775 | 3,826 | 256 | 608 | 14.9 | 6.29 | 2.38 |
| 11-778 | 3,537 | 344 | 493 | 10.3 | 7.17 | 1.43 |
| 11-780 | 12,290 | 543 | 1,500 | 22.6 | 8.19 | 2.76 |
| 11-781 | 5,175[a] | | 942 | (Est | 8.89[a] | 2.14 |
| | | 440 | 582[a] | 19.0) | | 2.14 |
| 11-785 | 6,040 | 317 | 694 | 19.1 | 8.70 | 2.19 |
| 11-795 | 4,455 | 319 | 494 | 14.0 | 9.01 | 1.55 |
| 11-800 | 4,555 | 232 | 459 | 19.6 | 9.92 | 1.98 |
| Totals | 46,359[a] | | 5,739[a] | 17.4[b] | 8.08 | |
| | | 2,842 | 6,099 | | | 2.15 |

Non - Synthetic Oil (15W-40) (Control Units)

| Unit No. | Miles | Hours | Fuel in Gal | Ave. Speed | MPG | GPH |
|---|---|---|---|---|---|---|
| 11-748 | 7,760 | 349 | 881 | 22.2 | 8.81 | 2.52 |
| 11-773 | 8,025 | 528 | 1,075 | 15.2 | 7.47 | 2.04 |
| 11-776 | 9,729 | 534 | 1,171 | 18.2 | 8.31[c] | 2.19 |
| 11-777 | 5,651[c] | | 847[c] | (Est. | 6.67 | |
| | | 671 | 1,814 | 18.0) | | 2.70 |
| 11-791 | 8,269 | 558 | 883 | 14.8 | 9.36 | 1.58 |
| 11-798 | 8,523 | 502 | 1,329 | 17.0 | 6.41 | 2.64 |
| 11-802 | 4.594 | 368 | 577 | 12.5 | 7.96 | 1.57 |
| 11-805 | 10,746 | 579 | 1,457 | 18.6 | 7.38 | 2.52 |
| Totals | 63,297 | | 8,220[c] | 16.9[b] | 7.70 | |
| | | 4,089 | 9,187 | | | 2.25 |

[a] Odometers broken for 3 to 4 weeks; fuel quantities used in computation of MPG correspond to measured miles.

[b] Does not include values for trucks 11-781 or 11-777, as appropriate

[c] Odometer broken for 3 weeks; fuel quantity used in computation of MPG corresponds to measured miles.

Winter

For the winter months, the test units consumed fuel at a rate (gph) approximately 7 percent less than that for the control units (Table 3). During the winter months when the vehicles spend a significant amount of time idling, the miles per gallon for the test trucks was approximately 3 percent more than that for the control units (Table 3).

TABLE 3 Fuel Consumption for Winter Months

Synthetic Fuel (Test Units)

| Unit No. | Miles | Hours | Fuel in Gal | Ave. Speed | MPG | GPH |
|---|---|---|---|---|---|---|
| 11-774 | 6,093 | 409 | 1,331 | 14.9 | 4.58 | 3.25 |
| 11-775 | 4,490 | 251 | 711 | 17.9 | 6.32[a] | 2.83 |
| 11-778 | 1,324[a] | 390 | 200[a] | (Est | 6.62[a] | 1.64 |
| | | | 641 | 10.9) | | |
| 11-780 | 5,663 | 453 | 1,242 | 12.5 | 4.56 | 2.74 |
| 11-781 | 6,181 | 341 | 855 | 18.1 | 7.23 | 2.51 |
| 11-785 | 4,087 | 292 | 615 | 14.0 | 6.65 | 2.11 |
| 11-795 | 4,954 | 438 | 907 | 11.3 | 5.46 | 2.07 |
| 11-800 | 3,365 | 215 | 439 | 15.7 | 7.67 | 2.04 |
| Totals | 36,157[a] | | 6,300[a] | 15.1[b] | 5.74 | |
| | | 2,789 | 6,741 | | | 2.42 |

Non - Synthetic Oil (15W-40) (Control Units)

| Unit No. | Miles | Hours | Fuel in Gal | Ave. Speed | MPG | GPH |
|---|---|---|---|---|---|---|
| 11-748 | 3,758 | 235 | 588 | 16.0 | 6.39 | 2.50 |
| 11-773 | 5,131 | 321 | 1,011 | 16.0 | 5.08 | 3.15 |
| 11-776 | 4,092 | 283 | 688 | 14.5 | 5.95 | 2.43 |
| 11-777 | 4,428 | 286 | 834 | 15.4 | 5.31 | 2.92 |
| 11-791 | 4,273 | 403 | 781 | 10.6 | 5.47 | 1.94 |
| 11-798 | 5,831 | 386 | 1,035 | 15.4 | 5.63 | 2.68 |
| 11-802 | 3,411 | 235 | 555 | 14.5 | 6.15 | 2.36 |
| 11-805 | 4,519 | 309 | 910 | 14.6 | 4.97 | 2.94 |
| Totals | 35,443 | 2,458 | 6,402 | 14.4 | 5.54 | 2.60 |

[a] Odometer broken for 3 to 4 weeks; fuel quantity used in computation of MPG corresponds to measured miles.

[b] Does not include value for truck 11-778

## Engine Oil Use Analysis

Both the control and the test groups had five units that required oil drains at 100 hr or half the normal drain period; thus the oil use value should be fairly accurate. The test units used approximately 7 percent less oil than the control units for the 18-month test period.

## Wear Analysis

Two wear analyses were conducted using the laboratory results of engine oil tests. The first analysis, using all the units, was an evaluation for the 18-month test period. The second analysis was a one-time analysis of only the test units, which initially used the 15W-40 engine oil and then changed to the synthetic oil.

The laboratory results indicated that more of every element analyzed appeared in the engine oil from the test trucks and significantly more for the elements iron (Fe) and lead (Pb). The wear was less significant for the elements chromium (Cr) and silver (Ag) and was almost insignificant for copper (Cu) and tin (Sn). The wear differences for the two elements aluminum (Al) and nickel (Ni) were not significant. Figures 1 and 2 show the statistical significance of the wear difference for the elements.

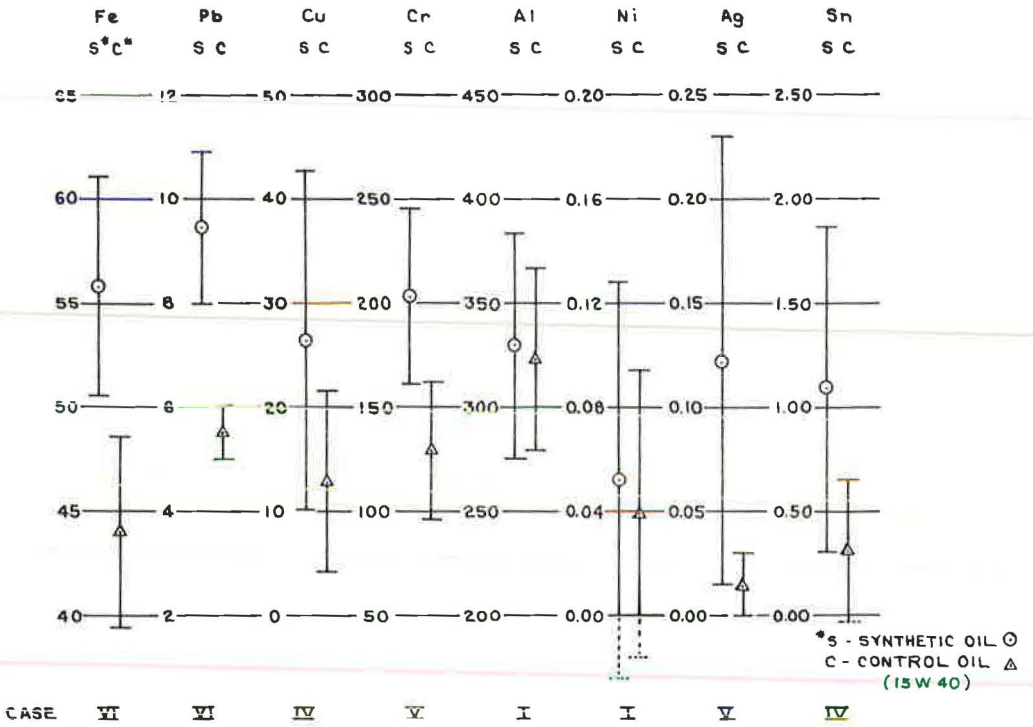


FIGURE 1 Wear analysis error bars $\bar{X} \pm 25\bar{x}$ (95 percent probability).

The results from the one-time analysis of only the test units showed that 50 percent of the elements indicated higher wear values when synthetic oil was used than when 15W-40 oil was used.

The results of these two analyses should be viewed cautiously, because the synthetic oil appears to have a higher detergent action than the 15W-40 oil. Thus, the wear particles may have been more readily suspended in the synthetic oil, which when analyzed in the laboratory would contain more parts per million of the wear elements than the 15W-40 oil.

## Driver Comments

The drivers who operated in the northern portion of Maine, where severely cold temperatures are common in winter, had the most favorable comments about the

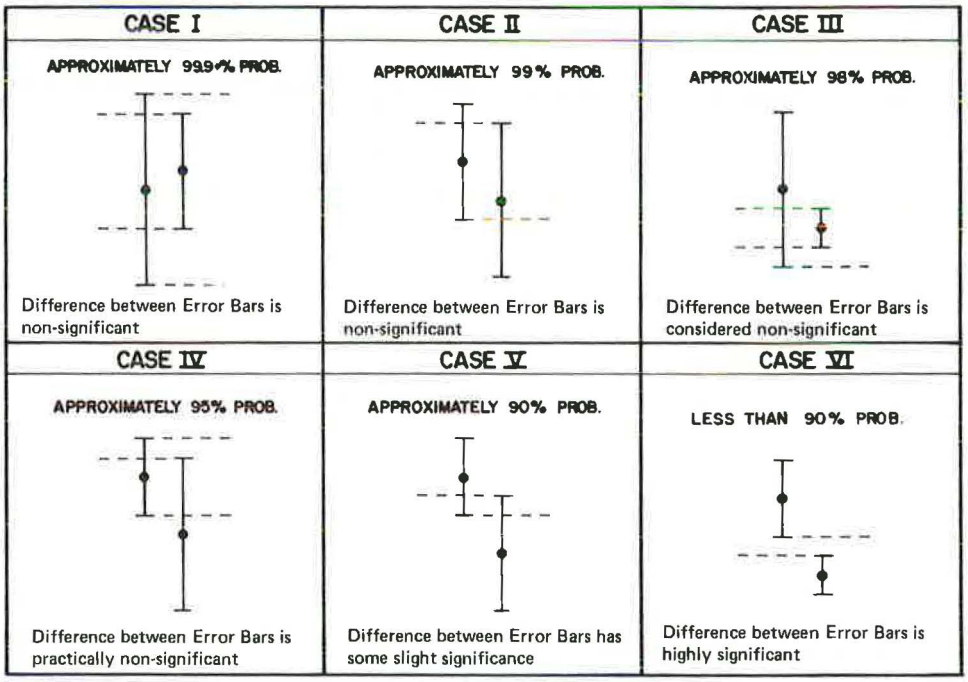


FIGURE 2 Error bar interpretation: examples.

synthetic oil. During winter weather in Aroostook County, the synthetic oil enabled much easier starting of the trucks. The easier starting was the quality most appreciated by the drivers.

The drivers from the central and southern portions of the state, who were also aware that the units started more easily in cold weather, noted that the engines remained cleaner.

## DISCUSSION OF RESULTS

The fuel consumption improvement when the synthetic oil was used was observed to be as much as 7 percent. Because highway maintenance, in many instances, requires more idling time than would normally be expected for other types of operations, the measure that is more indicative of the true fuel efficiency for the operating profile of these trucks is the fuel consumption rate in gallons per hour rather than in miles per gallon. The average fuel rate for the test trucks over the 18-month test period was approximately 5 percent less than that for 15W-40 oil.

The engine oil use appeared to be slightly less for those units using the synthetic product than for those using the 15W-40.

The drivers believed that the greatest asset of the synthetic oil was the ease of starting when the trucks were outdoors in cold weather.

## CONCLUSIONS

The following conclusions were derived from this study.

1. For the 18-month evaluation the test units (synthetic oil) used fuel at a rate that was 5 percent less in terms of gallons per hour than that of the control units.
2. For the summer period, the fuel consumption rate for the test units was 4 to 5 percent less than that for the control units.
3. For the winter months the fuel consumption rate of the test units was 7 percent less than that for the control units.
4. The engine oil use was approximately 7 percent less for the test units than for the control units.
5. The engine oil analysis for wear indicated significantly more recovered parts per million of the elements Fe, Pb, and Cr for the test units than for the control units.

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