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Oil Bypass Filter Technology Evaluation Seventh Quarterly Report April-June 2004

TECHNICAL REPORT

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August 2004

Idaho National Engineering and Environmental Laboratory
Bechtel BWXT Idaho, LLC

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ABSTRACT

This Oil Bypass Filter Technology Evaluation quarterly report (April–June 2004) details the ongoing fleet evaluation of an oil bypass filter technology being conducted by the Idaho National Engineering and Environmental Laboratory (INEEL) for the U.S. Department of Energy's (DOE) FreedomCAR & Vehicle Technologies Program. Eight INEEL four-cycle diesel engine buses used to transport INEEL employees on various routes and six INEEL Chevrolet Tahoes with gasoline engines are equipped with oil bypass filter systems from the puraDYN Corporation. The bypass filters are reported to have engine oil filtering capability of <1 micron and a built-in additive package to facilitate extended oil-drain intervals.

This quarter, the eight diesel engine buses traveled 85,632 miles. As of the end of June 2004, they had accumulated 498,814 miles since the beginning of the test and 473,192 miles without an oil change. This represents an avoidance of 39 oil changes, which equates to 1,374 quarts (343 gallons) of new oil not consumed and, furthermore, 1,374 quarts of waste oil not generated. One bus had its oil changed this quarter due to the degraded quality of the engine oil.

This quarter, the six Tahoe test vehicles traveled 48,193 miles. As of the end of June 2004, the six Tahoes have accumulated 109,708 total test miles. The oil for all six Tahoes was changed this quarter due to low total base numbers. The recycled oil used initially in the Tahoe testing was replaced with virgin Castrol oil, and the testing was restarted. However, the six Tahoe's did travel a total of 98,266 miles on the initial engine oils. This represents an avoidance of 26 oil changes, which equates to 130 quarts (32.5 gallons) of new oil not consumed and, consequently, 130 quarts of waste oil not generated.

Based on the number of oil changes averted at the INEEL by the test buses and Tahoes to date, the estimated annual amount of engine oil saved if the entire INEEL, DOE complex and all Federal on-road vehicle fleets were to use an oil bypass filter system would be:

- INEEL fleet – 3,400 gallons
- All DOE fleets – 32,000 gallons
- All Federal fleets – 1.7 million gallons.

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Oil Bypass Filter Technology Evaluation
Seventh Quarterly Report

INTRODUCTION AND BACKGROUND

This Oil Bypass Filter Technology Evaluation quarterly report covers the evaluation period April through June 2004. PuraDYN oil bypass filter systems (Figure 1) are being tested on eight diesel buses and six Chevrolet Tahoes (eight cylinder gasoline engines) in the Idaho National Engineering and Environmental Laboratory (INEEL) fleet. Typically, the INEEL buses travel established routes, carrying workers during their morning and evening trips to and from the INEEL test site (100+ miles per round-trip). The Tahoes are used within the 900 square mile INEEL site or between the INEEL site facilities and Idaho Falls, Idaho, a distance of 50 miles each way. This work is being performed for the U.S. Department of Energy's (DOE's) FreedomCAR and Vehicle Technologies Program.

The eight buses are equipped with the following types of four-cycle diesel engines:

- Three buses with Series 50 Detroit diesel engines
- Four buses with Series 60 Detroit diesel engines
- One bus with a Model 310 Caterpillar engine.

This quarterly report covers the following:

- Status of bus mileage and performance
- Analysis and reporting of bus engine oil
- Status of light-duty vehicle mileage and performance
- Lessons learned
- Amount of engine oil that could potentially be saved in INEEL, DOE-complex, and Federal fleets.

Table 1 lists all prior quarterly reports and the major topics presented.

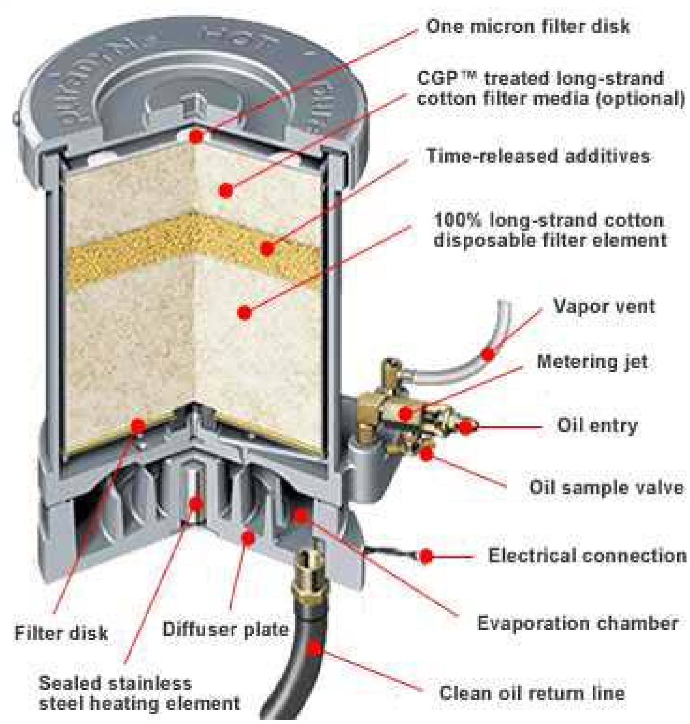

Figure 1. Cutaway of a puraDYN oil bypass filter.

Table 1. Major topics of previous quarterly reports. All reports are available online at http://avt.inel.gov/obp.html.

Reporting Quarter	Report Number	Major Topics
Oct 2–Dec 2 2002	INEEL/EXT-03-00129	• Background on fleet operations, vehicles, filters, and oil selection • Performance evaluation status • Economic analysis • Photographs of installed systems • Bypass Filtration System Evaluation Test Plan
Jan 3–Mar 3 2003	INEEL/EXT-03-00620	• Background on reports • Bus mileage and performance status • Revised filter replacement schedule • Oil-analysis sampling • Light-duty vehicle test status
Apr 3–Jun 3 2003	INEEL/EXT-03-00974	• Background on reports • Bus mileage and performance status • Preliminary trends in oil analysis reports • Revised economic analysis • Ancillary data • Light-duty vehicle test status
Jul 3–Sep 3 2003	INEEL/EXT-03-01314	• Background on prior quarterly reports • Bus mileage and performance status • Used engine-oil disposal costs • Unscheduled oil change • Light-duty vehicle test status
Oct 3–Dec 3 2003	INEEL/EXT-04-01618	• Bus mileage and performance status • Bus oil analysis testing and reporting • Light-duty vehicle filter installations • Light-duty vehicle filter installations lessons learned • Light-duty vehicle filter evaluation status
Jan 4–Mar 4 2004	INEEL/EXT-04-02004	• Bus mileage and performance status • Bus oil analysis testing and reporting • Bus engine oil particulate count analysis • Light-duty vehicle mileage and performance status • Light-duty vehicle filter evaluation lessons learned

HEAVY-VEHICLE TESTING

Status of Bus Mileage and Performance

During this reporting quarter (April—June 2004), the eight diesel-powered buses traveled 85,632 miles. Figure 2 shows the quarterly and cumulative evaluation miles. Table 2 details the mileage status of the eight test buses. Figure 3 shows the total evaluation miles per bus, by evaluation quarter.

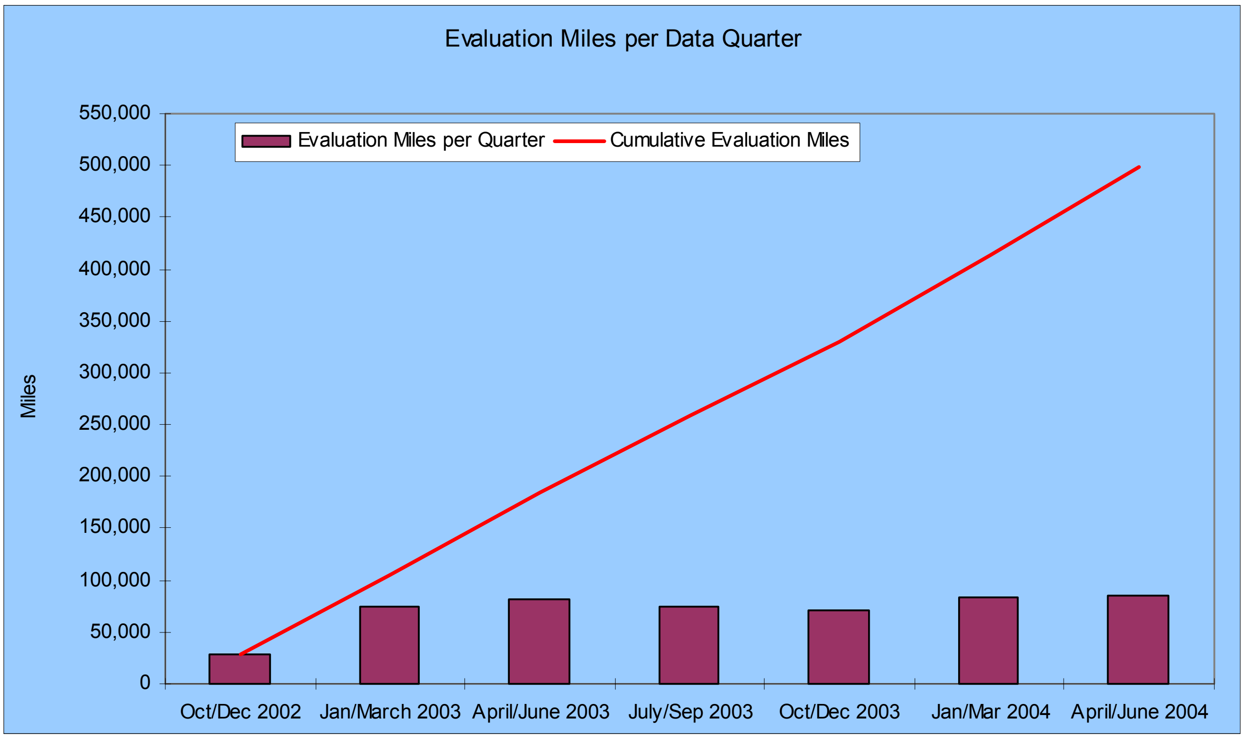

Figure 2. Quarterly and cumulative miles traveled.

Table 2. Test buses and test mileage on the bus engine oil as of June 30, 2004.

Bus Number	Test Start Date	Bus Mileage at Start Date	Current Bus Mileage (June 30)	Total Miles over the Oil Evaluation Test
73425	Dec 18, 2002	41,969	85,780	43,811
73432	Feb 11, 2003	47,612	109,089	61,477
73433	Dec 4, 2002	198,582	265,953	67,371
73446[1]	Oct 23, 2002	117,668	173,598	55,930
73447	Nov 14, 2002	98,069	150,623	52,554
73448[2]	Nov 14/2002	150,600	200,409	49,809
73449	Nov 13, 2002	110,572	157,561	46,989
73450	Nov 20, 2002	113,502	234,375	120,873
Total (June 30, 2004)				498,814[3]

[1] The oil on bus 73446 was intentionally changed on June 2, 2004. The total includes the mileage before and after that date.

[2] The oil on bus 73448 was inadvertently changed on September 16, 2003. The total includes the mileage before and after that date.

[3] The total bus test miles are 498,814 miles; the total miles without an oil change are 473,192 miles.

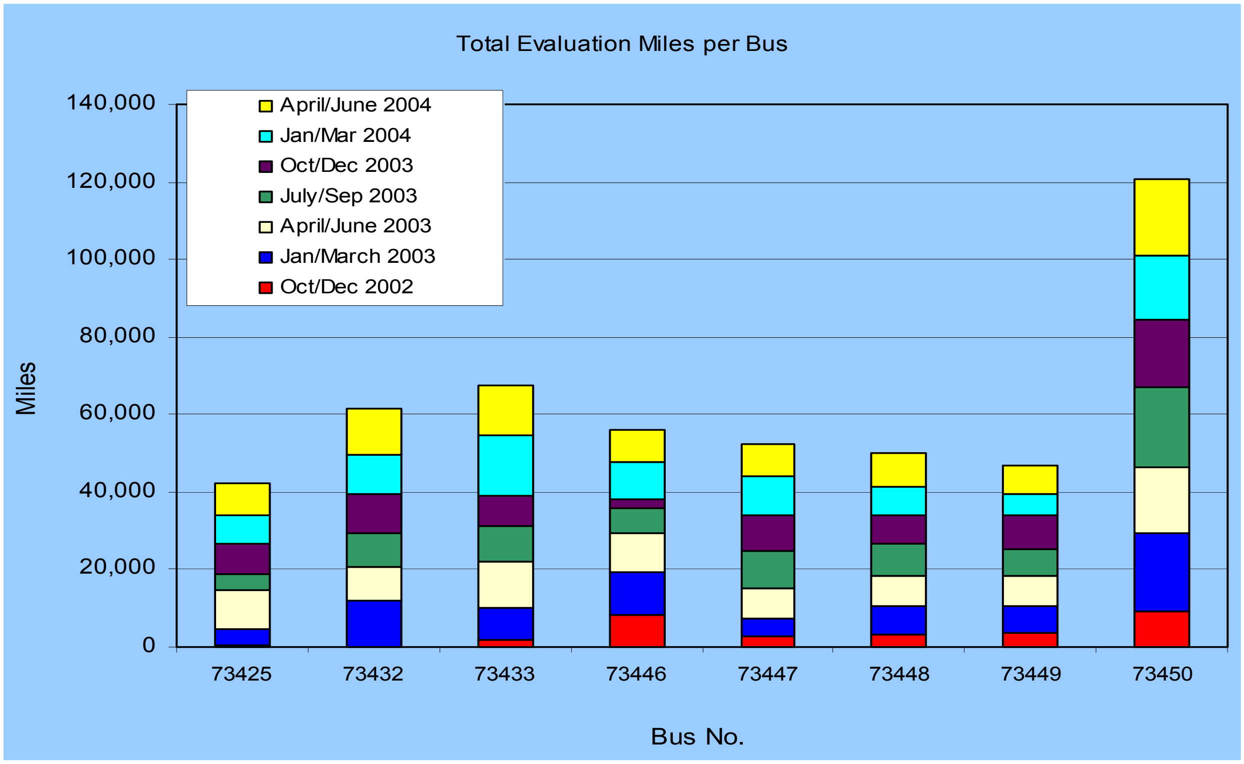

Figure 3. Total evaluation miles by bus for the April–June quarter.

Analysis and Reporting of Bus Engine Oil

The research plan calls for all engine oil samples to be sent to two different laboratories for redundancy testing. The used-engine-oil analysis reports provide the empirical data for this research; the virgin oil analysis reports provide baseline data on the oils used in the evaluation. The data from the oil analysis reports rolls into the quarterly reports. Figure 4 is a flow diagram showing the evaluation process.

As of the end of June 2004, the INEEL had obtained a total of ~150 oil analysis reports for the used engine oil in the eight buses and for the virgin Rotello oil. Fourteen reports for used oil were generated this quarter (seven service events, with an analysis report generated by both laboratories for each service event). The analysis reports for the oil in the engines are generated as a result of oil analysis samples being taken during vehicle-servicing events (when bypass and full-flow filters are changed).

Oil Quality and Physical Properties

One section of the oil analysis report focuses on the oil quality (also known as the physical properties of the oil), which is determined by (the acceptable limits are listed in the parenthesizes):

- Measuring the presence of fuel (≤3%), water (<0.25%), and glycol (≤0.25%)
- Determining oxidation and nitration numbers (≤30 Abs/cm)
- Calculating total base number (≥3.0 mgKOH/mL)
- Measuring the soot content (≤3%)
- Determining the viscosity (12.50 to 16.39 centistokes).

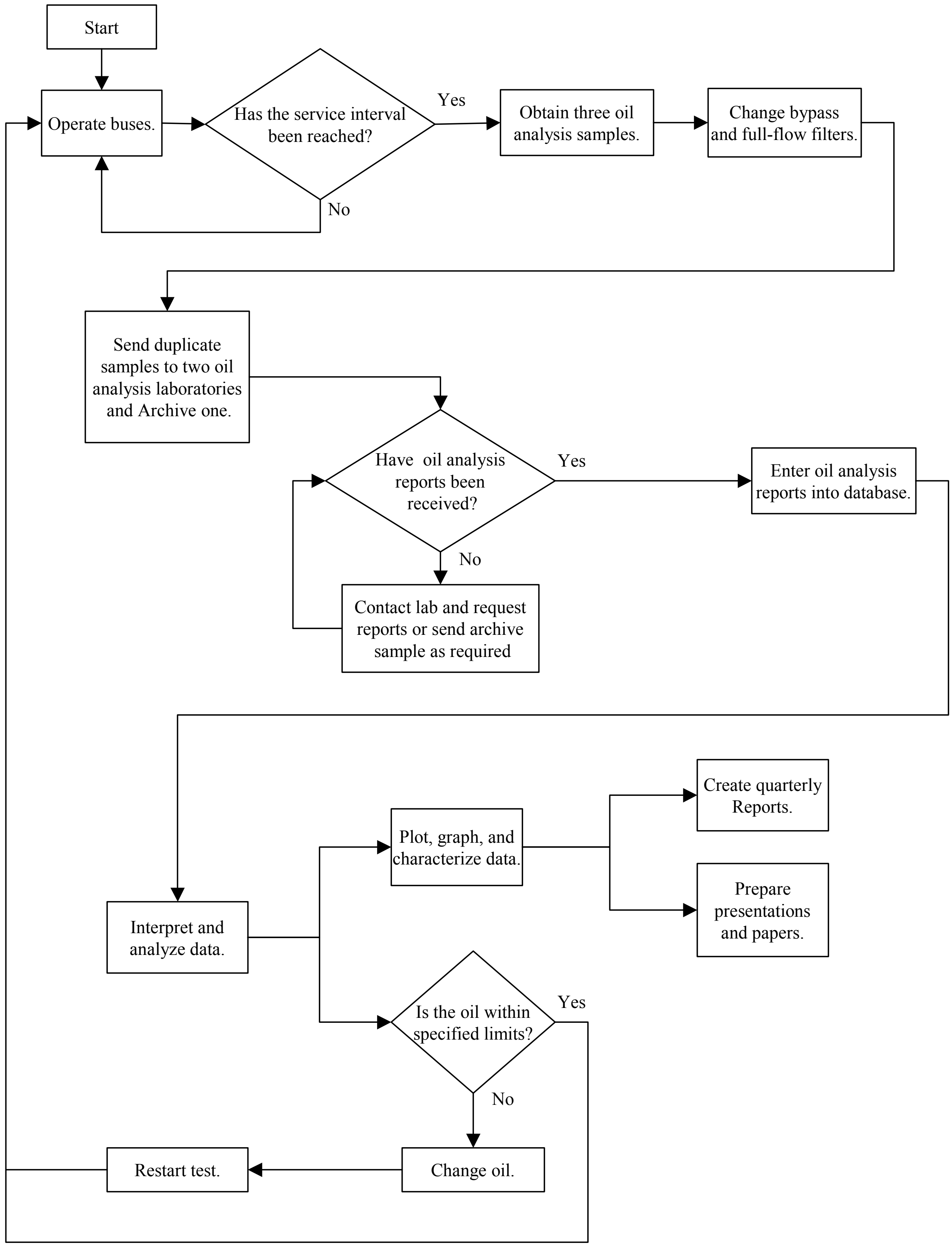

Figure 4. Flowchart of oil bypass filter evaluation activities.

The above oil quality variables are the metrics for definitively evaluating the oil quality in the eight test buses. (A detailed discussion of these metrics is found in the appendix of the First Quarterly Report, INEEL/EXT-03-00620). The specific numerical value for each variable should remain within the limits listed for the oil to be considered acceptable and fit for continued use.

The test results for the fuel, water, and glycol contaminates in the bus engine oils have never reached the minimal reporting values and have been acceptable since testing began.

Figures 5, 6, and 7, graph some of the analysis report data. The bottom scale (x axis) indicates the report numbers (1 through 6, or 1 through 12) for the buses graphed. Generally, the first and second test results for each bus were conducted at 6,000 and 12,000 miles of oil use, and succeeding tests at 12,000-mile intervals. The oxidation and nitration tests were added after the testing began and therefore, fewer of these tests have been conducted. The TBN (total base number) tests started at the inception of the evaluation. Therefore, more TBN tests have been conducted then oxidation or nitration tests.

Oxidation and nitration values are determined by spectrometric analysis. These values reflect the organic contaminants and oil degradation level or products in used oil. The bus oxidation and nitration data from the two laboratories are shown in Figures 5 and 6. The data show a negative trend (increasing levels) for most bus oils. This expected trend reflects the oil deterioration and accumulation of oxidation products. Tests for oxidation and nitration are not typical for most oil analysis reports, but for these long-term extended oil changes it is a valuable measure in ensuring oil quality. In most cases showing higher oxidation and nitration levels, the oil becomes slightly acidic. As the acid levels increase, the TBN levels decline. This relationship is most evident when comparing the oxidation/nitration and the TBN numbers for Buses 73446 and 73447, which have about the highest oxidation and nitration results and the lowest TBN results. Oxidation and nitration values for new Shell Rotello-T engine oil are both 0.1 absolute per cubic centimeter (Abs/cm).

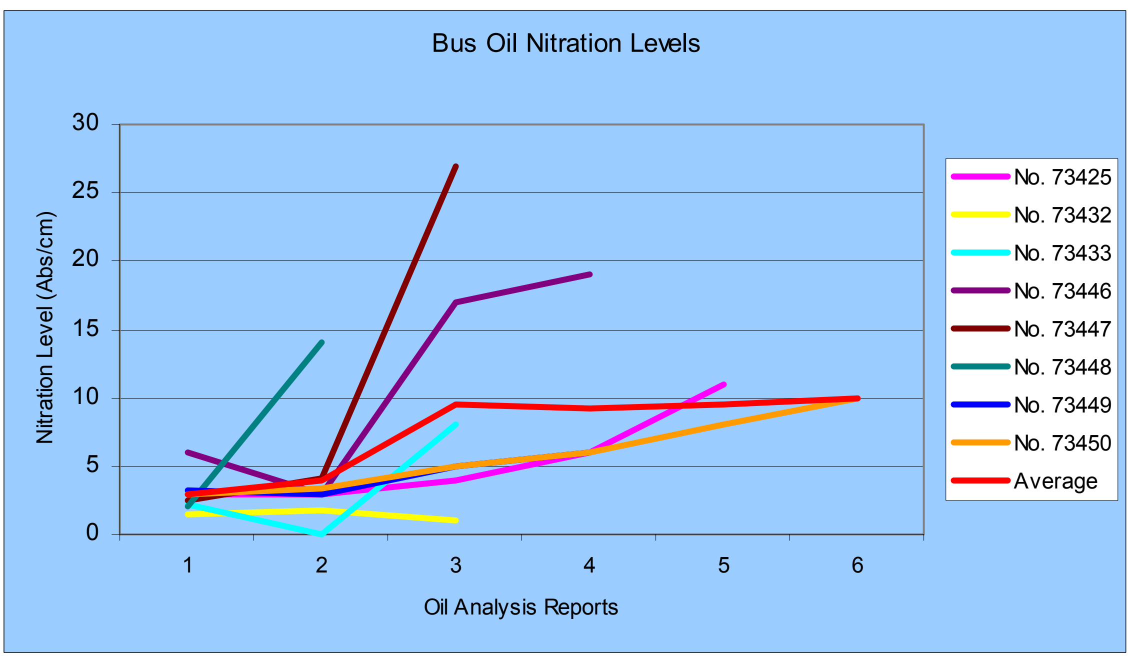

Figure 5. Results from bus-engine-oil nitration tests and overall average result. The oil in Bus 73448 was inadvertently changed. The nitration results are for the changed oil.

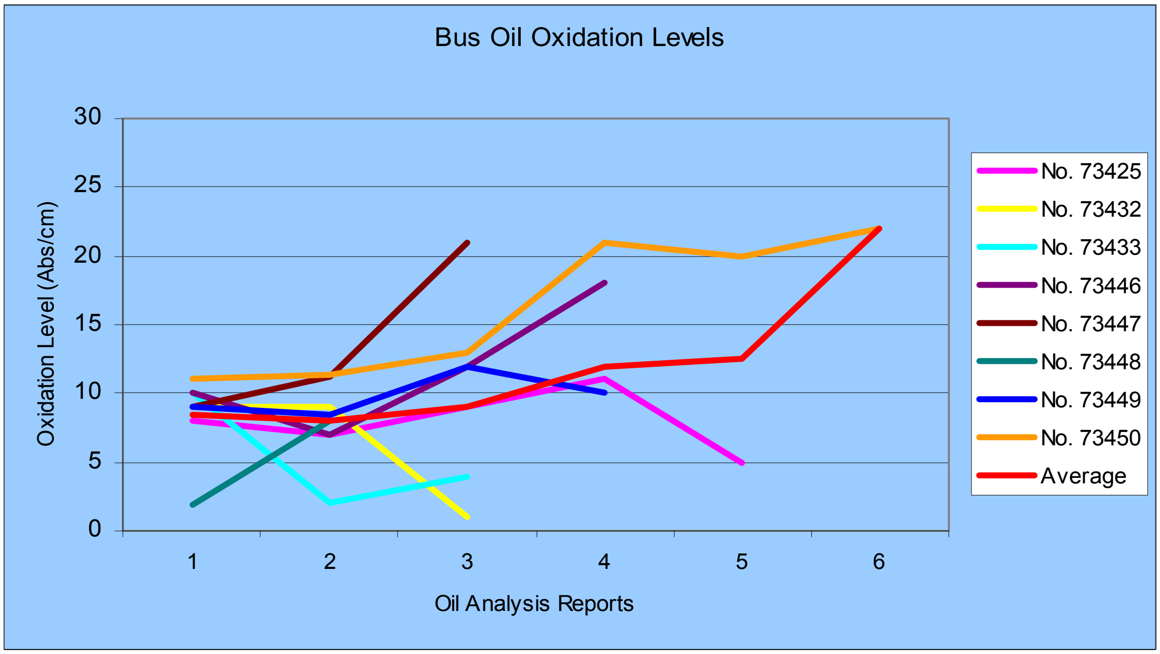

Figure 6. Results from bus-engine-oil oxidation tests and overall average result. The oil in Bus 73448 was inadvertently changed. The oxidation results are for the changed oil.

The TBN values (TBN relates to the acid reducing ability of oil) from the bus engine oils are sporadic but show an overall downward trend (see Figure 7). However, all values except those from Bus 73447 are still acceptable (the oil in Bus 73446 was changed).

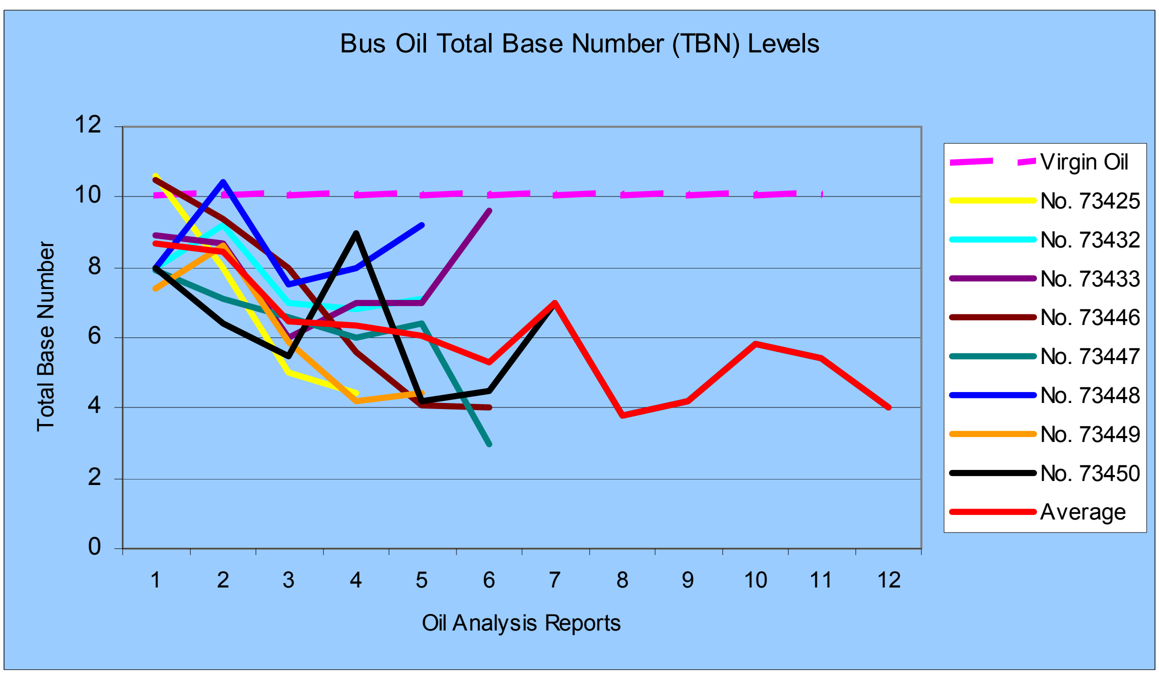

Figure 7. Results for the total base number (TBN) tests. The oil in Bus 73448 was inadvertently changed; the TBN results are for the changed oil. "Virgin Oil" indicates the Shell Rotello oil, which is included for comparison only. (Bus 73450 data beyond report number 7 becomes the average).

In May 2004, INEEL Fleet Operations started transitioning from petroleum-based diesel fuel to B20 (a blend of 20% biodiesel and 80% petroleum diesel) in winter months and to B50 in summer months, as part of the INEEL petroleum reduction effort. Since this changeover is to occur in stages, eight fleet buses (two of which are part of the oil bypass filter evaluation) were selected to initially run B20 for a few months before converting the entire fleet over. INEEL Fleet Operations also decided to intensely monitor the oil quality on the initial B20 test fleet to ascertain any deleterious affects on the bus engines. Therefore, weekly oil analysis samples from the eight test vehicles were taken. Bus 73446 was selected as one of the B20 test vehicles; TBN results were below 3 mgKOH/mL on two consecutive oil analysis samples sent to the NTS Laboratory. Consequently, on June 2, 2004, the oil on Bus 73446 was changed. Oil samples from Bus 73447 were taken on June 30, 2004; subsequent TBN test results from the two laboratories were 2 and 3 mgKOH/mL. These results were not received, however, until after the reporting period. The engine oil in Bus 73447 will be changed during the July–September reporting period.

Synergism of Spectrochemical and Particulate Analysis

Typically, oil analysis measures three conditions:

1. Lubricating quality of the oil (viscosity and total base number)
2. Engine wear metals, oil additives, and metal contaminates (iron, calcium, potassium, etc.)
3. Oil contaminates (fuel, water, soot, etc.).

Spectrochemical or spectrometric analysis is used to detect and quantify the parts per million (ppm) of engine wear metals, oil additives, and metal contaminates in oil. This analysis is the essence of most oil analysis reports. These reports also reveal other data helpful to understanding the condition of the engine and to solving potential problems. For instance, a report showing very high silicon would indicate the air filter could be faulty, or high potassium could indicate a coolant leak. With every oil analysis report, the analysis laboratory offers observations, and sometimes recommendations, concerning the condition of the oil. Given the experimental nature of this oil bypass filter evaluation, duplicate oil analysis samples are always taken and always sent to two independent oil analysis laboratories. It is essential to have a second opinion to ensure that correct analysis is received and to ensure nothing is overlooked.

During review of the last oil analysis test performed this quarter for Bus 73447, one of the test laboratories warned of possible bearing wear due to higher levels of lead and copper. Table 3 lists the lead and copper for the last two oil analysis reports from one of the laboratories. One must remember the spectrochemical analysis apparatus measures particles that are less that 4 microns (μm). This small size is typically not harmful to engine wear, since the distance between the main bearings and the crankshaft of an engine can be as small as 0.001 inch, or 25 μm.

Table 3. Lead and copper spectrometric analysis results for bus 73447.

Wear Metals	February 4, 2004 Sample (ppm)	June 30, 2004 Sample (ppm)
Lead	46	49
Copper	33	37

If a bearing were actually failing in bus 73447, the particle sizes would generally be larger than 4 μm, and since both lead and copper are soft metals, the particles would be flattened or extruded. If the particles were larger than 4 μm, however, standard spectrochemical analysis apparatus would not discern them. Therefore, the particulate evaluations also use rotrode filter spectroscopy (RFS) to detect the larger particles. An 8-μm filter is used in RFS, and the process forces the oil through a filter to catch the larger particles. The RFS analysis apparatus is calibrated to process particle sizes between 4 and 20 μm. These larger particles can be the first indicators of abnormal wear. If there was abnormal wear, the RFS analysis would show it. Table 4 shows the RFS analysis results for the duplicate samples (Table 3) for Bus 73447.

Table 4. Rotrode filter spectrometric analysis results for Bus 73447.

Wear Metals	February 4, 2004 Sample (ppm)	June 30, 2004 Sample (ppm)
Lead	0	0
Copper	0	1

Oil-analysis engineers at one of the laboratories suggested that 50 ppm of particle sizes between 4 and 20 μm be the upper limit trigger point that would alert of a serious wear-metal condition. The data, therefore, do not show bearing wear. In discussions with a laboratory engineers regarding the lead content, they suggested that the lead might be a fuel contaminate instead of bearing wear. A higher lead content (92 to 46 ppm) appeared in the last oil analysis reports for three buses. Analysis next quarter into the sources of the lead may reveal additional information.

Lessons Learned from the Evaluation of Heavy-Vehicle Filters

Oil Analysis Reports

For this evaluation, sending duplicate samples to independent laboratories proved valuable. Duplicate samples help in comparing data and in showing trends. Sometimes, when the data do not follow the trend of previous testing, there can be a temptation to consider the data anomalous, and if the data are not considered essential or critical, data points can be overlooked especially if the other data values are consistent. However, data for TBN levels or another metric of oil quality need to be reliable. On two recent occasions, TBN values (for Buses 73446 and 73447) significantly increased. In both cases, INEEL personnel anticipated that the TBN results would not be within acceptance levels, yet the results indicated that the TBN values were *greatly* improved—too much improved. The oil analysis laboratories were contacted in both cases; the samples were retested; and more consistent data were obtained. And in both cases, the degraded values prompted changing the oil.

LIGHT-VEHICLE TESTING

Status of Light-Vehicle Mileage and Performance

During the April-June quarter, the six light-duty Tahoe test vehicles traveled 48,193 miles, accumulating 109,708 total test miles. The oil analyses reported degrading TBN levels on all six vehicles (Figure 8). As a result, the engine oil for all six was changed. However, the Tahoe vehicles did travel a total of 98,266 miles on the initial oil. This is an avoidance of 26 oil changes. This equates to 130 quarts (33 gallons) of new oil not consumed and, consequently, 130 quarts of waste oil not generated.

The engine oil used initially in the Tahoe test vehicles was recycled Americas Choice 10W-30. The recycled oil was replaced with virgin Castrol 10W-30 oil, and the testing of the six Tahoes was restarted.

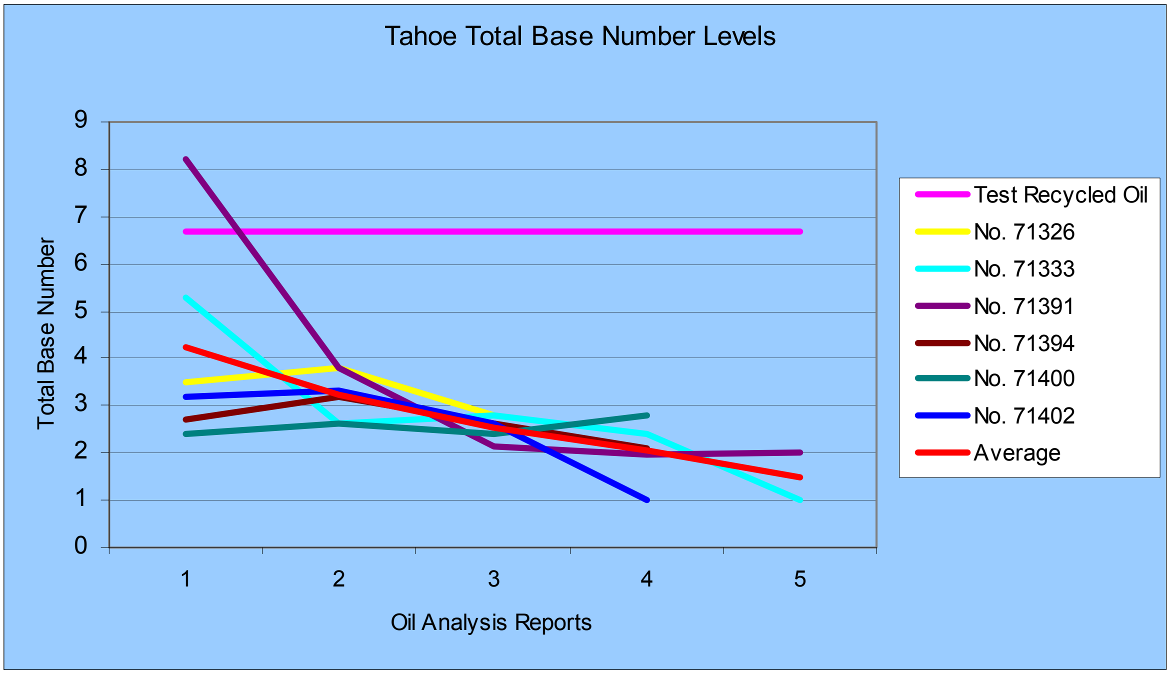

Figure 8. Results from Tahoe engine oil total-base-number tests. "Test Recycled Oil" is the Americas Choice oil initially used in the Tahoes. It is 25% recycled oil and is graphed for comparison only.

Lessons Learned from the Evaluation of Light-Vehicle Filters

Oil Pan Plug

Diesel engine oil pans often have multiple ports or plugs, but light duty vehicles typically have only one oil pan port—that to drain the oil. To facilitate an oil bypass filter system required oil return line on a vehicle with only one oil pan port, the oil pan plug has to be replaced or exchanged with a longer plug to allow oil to return to the oil pan after filtering. A colloquial name for the end fitting on the return line is *banjo fitting,* due to its shape. Because the banjo fitting fits between the oil pan and the oil pan plug, it requires a longer oil pan plug. When one of the Tahoe oil pan plugs was removed to drain the oil, the longer plug (bolt) broke. Since the Tahoe's are security vehicles, it could not be kept in the service bay waiting for a replacement plug to arrive. Therefore, the bypass filter system was disabled until the plug arrived. It would be prudent to have a few spare parts on hand to meet such problems.

Engine Flushing before Testing

When this evaluation began in 2002, it was not considered essential to flush the engine oils before installing the bypass filter systems. Since then, it was learned that when an engine oil brand or type (such as 30W to 10W-30) is changed in an engine, the new oil, with its different additives and detergents, potentially cleans the engine of accumulated "gunk", thus contaminating the engine oil. Testing of the Tahoe engines is scheduled to restart with Castrol oil only after engine flushing, because the oil was changed from recycled oil to virgin oil. The Tahoe engines will operate one service interval (3,000 miles) on the new Castrol oil to flush the engine. After the one flushing, another batch of new Castrol oil will be added to all of the engines, and the test will restart. It is anticipated that this flushing to add to the life of the engine oil.

POTENTIAL ENGINE OIL SAVINGS IN INEEL, DOE COMPLEX, AND FEDERAL FLEETS

This section discusses potential engine oil use and waste disposal savings if all on-road vehicles in the INEEL, DOE-complex, and Federal Government fleets were equipped with oil bypass filter systems. The assumptions, types and numbers of vehicles, and miles driven for all of the fleet vehicles are discussed. The results presented are based on the INEEL oil bypass filter evaluation results to date.

Basis for Oil Savings

Extended Bus Oil Change Intervals

As of the end of June 2004, the eight buses in the INEEL oil bypass filter technology evaluation had accumulated 447,620 miles without an intentional oil change. The oil in bus 73448 was previously changed by mistake, so the miles on the initial engine oil are not included in Table 5. The engine oil in Bus 73446 was changed on June 2, 2004. The average miles per bus on the unchanged engine oil was 63,946 miles, which is an average of 5.3 extended oil drain intervals (63,946 average miles divided by the 12,000-miles-per-service interval per bus). If the oil on all buses were to be changed immediately, the average oil changes avoided for each bus would be four. A percentage rate of oil savings of 80% is determined by dividing the number of oil changes avoided (4) by the number of extended oil drain intervals (5). It is assumed that bus engine oil changes can be avoided at least 80% of the time (4 out of 5 oil changes will be avoided). It should be noted that as this evaluation continues, this percentage might change.

Extended Tahoe Oil Change Intervals

The six Tahoes in the INEEL Oil Bypass Evaluation accumulated a total of 98,266 miles on the engine oil before it was changed in all of the Tahoes (Table 6). The average number of engine oil miles per Tahoe on unchanged oil was 16,378 miles, which averages 5.5 avoided oil changes per Tahoe (16,378 average miles driven per 3,000-mile service interval). Table 6 shows at least an 80% oil saving value. It should be noted that as this evaluation continues, this percentage might increase because virgin Castrol oil, which is perceived to be premium quality oil, is replacing the recycled oil in the test.

Percentage of Oil Saved

Preliminary data from the INEEL buses (heavy vehicles) and the Tahoe's (light vehicles) show a consistent 80% saving in oil use with bypass oil filters. Until additional data are gathered, this 80% value will be used as a basis for estimating the engine oil saving potential for vehicle fleets.

Table 5. Oil bypass filter evaluation test miles on the INEEL buses and the average number of oil changes avoided per bus, based on the average miles per bus divided by a 12,000-mile service interval.

Bus[1] No.	Months on Test Oil	Miles on Test Oil	Number of Oil Change Intervals[2]	Number of Oil Changes Avoided[3]	Percent of Oil Changes Avoided[6]
73425	18.7	43,811	3	3	100
73432	16.8	61,477	5	5	100
73433	19.1	67,282	5	5	100
73446	20.1	54,634	4	3	75
73447	19.8	52,554	4	4	100
73449	19.8	46,989	3	3	100
73450	19.6	120,873	10	10	100

[1] Bus 73448 is not included in this list because the oil was inadvertently changed in September 2003

[2] The number of oil change intervals extended or missed. 12,000 miles is the established service interval for changing the oil on buses. The total miles on the test oil was divided by 12,000 miles to get the number of service intervals that represent the number of extended oil change intervals.

[3] Number of oil changes avoided is the number of oil changes performed during the quarter subtracted from the total number of oil change intervals extended.

Table 6. Oil bypass filter evaluation test miles on the INEEL Tahoe's and the average oil changes avoided per Tahoe, based on the average miles per Tahoe divided by 3,000 miles.

Tahoe	Months on Test Oil	Miles on Test Oil	Number of Oil Changes Extended[1]	Number of Oil Changes Avoided[2]	Percent of Oil Changes Avoided
1326	4.4	16,236	5	4	80
71333	7.7	16,768	6	5	83
71391	5.4	19,155	6	5	83
71394	4.6	15,261	5	4	80
71400	6.1	16,180	5	4	80
71402	5.5	14,666	5	4	80

[1] 3,000 miles is the established service interval for changing the oil on Tahoes. These Tahoes are considered severe-duty vehicles and receive service on 3,000-mile intervals. Total miles on the test oil was divided by 3,000 miles to get the number of service intervals that represents the number of extended oil change intervals.

[2] Oil changes avoided is the number of oil changes performed during the quarter subtracted from the total number of oil change intervals extended.

Vehicle Categories

Federal Vehicles

Table 7 lists the vehicle categories that all Federal department and agency fleets must use to annually report the number and type of on-road vehicles in their fleets to both DOE and the General Services Administration (GSA). The Federal fleets report these data on a Web-based data acquisition system designed and maintained by INEEL for DOE and GSA, called the Federal Acquisition Statistical Tool (FAST). The FAST data presented here are for Fiscal Year 2003, as of March 2004.

Table 7 also lists the estimated engine oil capacity for each class or type of vehicle as defined by DOE and GSA in the FAST system. Also listed is the estimated service interval in miles that each vehicle is driven between oil changes. The oil capacities and miles per oil change for the first four types of vehicles are based on INEEL fleet practices and manufacturer-recommended practices. The estimated oil capacities and oil changes for the *medium-duty truck from 8,501 to 16,000 pounds* class are based on average manufacturer recommendations for Ford trucks, such as the F350 and F450 models with gasoline engines.

The *heavy-duty truck over 16,001 pounds* class (Table 7) is an extremely broad class of vehicles. Vehicles in this class can range from Ford F550 and F650 trucks, with gasoline engines and 6-quart engine oil capacities, to Class 6, 7, or 8 trucks, including truck tractors with diesel engine oil capacities of nearly 40 quarts. Base values of 15 quarts of oil and a service interval of 6,000 miles for the *heavy-duty truck over 16,001 pounds* class of vehicles was selected for these potential oil saving calculations. The oil capacity and service interval values for the *bus* class of vehicles are based on the INEEL buses.

Table 7. Estimated oil capacity and miles per service interval for Federal Acquisition Statistical Tool (FAST) vehicle types. (LD = light duty, MD = medium duty, HD = heavy duty).

FAST Vehicle Type	Estimated Oil Capacity (qt)	Estimated Miles per Service Interval
Ambulance	5	3,000
Sedan or station wagon	5	3,000
LD truck 4 × 2	5	3,000
LD truck 4 × 4	5	3,000
MD truck 8,501–16,000 lb	6	4,000
HD truck over 16,001 lb	15	6,000
Bus	35	12,000

Potential Annual Savings: INEEL Fleet

For fiscal year 2003, INEEL reported driving 871 on-road vehicles 8.3 million miles (Table 8). An estimated 2,007 oil changes occurred, and 4,286 gallons of engine oil were used without oil bypass filter systems. Based on the previously derived 80% estimated number of average oil changes that could be avoided (Tables 5 and 6), and oil capacities and oil serving intervals or change frequencies (Table 7), if oil bypass filter systems were installed on INEEL's 871 on-road vehicles, both the consumption and disposal of 3,428 gallons of engine oil could be avoided annually.

Table 8. Potential estimated annual engine oil savings for the INEEL fleet. The results are based on the types and number of vehicles, and miles driven as reported in FAST for Fiscal Year 2003. (LD = light duty, MD = medium duty, HD = heavy duty).

INEEL Vehicle Type	Number of Units	Total Miles Driven Annually	Est. Annual Oil Changes	Est. Total Gals Oil Used Annually	Est. Total Gals Oil Potential (80%) Annual Savings
Ambulance	5	18,200	6	8	6
Sedans and station wagon	87	1,007,888	336	420	336
LD truck 4 × 2	288	1,835,255	612	765	612
LD truck 4 × 4	233	2,576,506	859	1,074	859
MD truck 8,501–16,000 lb	14	27,910	7	11	9
HD truck, >16,001 lb	124	287,048	48	179	143
Bus	120	2,512,583	209	1,829	1,463
Totals	871	8,265,390	2,077	4,286	3,428

Potential Annual Savings: DOE Complex Fleet

The same estimating method used for the INEEL fleet is also used to estimate the potential engine oil savings to the entire DOE complex of 15,464 vehicles.

For Fiscal Year 2003, the entire DOE complex of 92 fleets (see Table 9) reported driving 15,464 on-road vehicles 91.7 million miles during fiscal year 2003. It is estimated that 26,433 oil changes occurred and 39,635 gallons of oil was used annually without oil bypass filter systems. Based on the estimated number of average oil changes that could be avoided (Tables 5 and 6) and oil capacities and oil change frequencies (Table 7), it is estimated that if oil bypass filter systems were installed on the DOE complex's

15,464 on-road vehicles, the use and disposal of 31,707 gallons of engine oil could be avoided annually (Table 10).

Table 9. All U.S. Department of Energy sites with vehicles listed in the Federal Acquisition Statistical Tool (FAST) database for Fiscal Year 2003.

AL Site Office NM	Office of Secure Transportation Non-MSA Operation
Albany Research Center	Other Offices (Non-MSA)
Ames Laboratory	Pacific Northwest National Laboratory
Argonne East	Pantex Plant, TX
Argonne West	Princeton Plasma Physics Lab
Ashtabula	Puget Sound
Bechtel Hanford, Inc.	Remote Sensoring Lab Andrews AFB - MD
Bechtel Jacobs Company	Rocky Flats
Bechtel National, Inc.	Ross Aviation, NM
Bettis Atomic Power Laboratory	Savannah River
Brookhaven National Laboratory	SNL California, Livermore
BWXT - Y-12	SNL Hawaii and Alaska
Carlsbad Field Office	SNL Nevada, Tonopah Test Range
CH2MHill	SNL New Mexico
DOE - GSA Fuel	SNR Kennith Kesselring Site
DOE Headquarters	SNR Knolls Atomic Power Laboratory
DOE Office of Security - NNSI	Southeastern Power Administration
East Tennessee Mechanical Contractors	Spokane
Environmental Measurement Laboratory	SPR Bayou Choctaw
Eugene/Springfield	SPR Big Hill
FERMILAB	SPR Bryan Mound
Fernald	SPR Project Office LA
Fluor Hanford	SPR West Hackberry
Gore Maintenance	Springfield O&M Office
Grand Junction Office	Stanford Linear Accelerator
Honeywell KC Plant, MO	Thomas Jefferson National Lab.
Honeywell, NM	Tulsa
Idaho National Engineering and Environmental Laboratory	UT-Battelle
Jonesboro Maintenance	Wackenhut Services, Inc. (DOE)
Lawrence Berkeley	Wackenhut Services, Inc. (NNSA)
Lawrence Livermore	WAPA Billings
Los Alamos National Laboratory	WAPA CSO
Los Alamos Site Office	WAPA Desert Southwest
Miamisburg	WAPA Montana Maintenance
Mound	WAPA North Dakota Maintenance
National Energy Technology Laboratory-OK	WAPA Rocky Mountain Office - Colorado
National Energy Technology Laboratory-PA	WAPA Rocky Mountain Office - non-MSA
National Energy Technology Laboratory-WV	WAPA SD Maintenance
National Renewable Energy Laboratory	WAPA Sierra Nevada - California
Naval Petroleum and Oil Shale Reserves CO, UT, WY	WAPA Sierra Nevada - non-MSA
Nevada Site Office	WAPA Watertown Operations Office
Nevada Test Site	West Valley
Oak Ridge Institute for Science and Education	Western Environmental Technology Office
Oak Ridge Operations (Fed)	Williamette Valley
Office of Scientific and Technical Information	Yucca Las Vegas
Office of Secure Transportation MSA/CMSA Operation	Yucca NTS

Table 10. Potential estimated annual engine oil savings for the DOE complex fleet. (HD = heavy duty, LD = light duty, MD = medium duty).

DOE Complex Vehicle Type	Number of Units	Total Miles Driven Annually	Est. Annual Oil Changes	Est. Total Gals Oil Used Annually	Est. Total Gals Oil Potential (80%) Annual Savings
Ambulance	52	184,033	61	76	61
Sedan or station wagon	1,422	11,103,935	3,701	4,626	3,701
LD truck 4 × 2	4,980	23,226,774	7,742	9,678	7,742
LD truck 4 × 4	2,520	20,874,455	6,958	8,698	6,958
MD truck 8,501–16,000 lb	4,237	25,890,372	6,473	9,710	7,768
HD truck > 16,001 lb	2,071	7,510,302	1,252	4,694	3,755
Buses	182	2,946,971	246	2,153	1,722
Totals	15,464	91,736,842	26,433	39,635	31,707

Potential Annual Savings: U.S. Federal Fleet

The same estimating method used for the INEEL fleet is also used to estimate the potential engine oil savings to the entire Federal fleet of 607,630 vehicles if oil bypass filter systems were used.

For fiscal year 2003, the entire United States Federal fleet of 61 administrations, agencies, authorities, boards, branches, corps, commissions, corporations, departments, institutions, offices, and other government entities (Table 11) reported driving 607,630 on-road vehicles 4.8 billion miles during fiscal year 2003 (Table 12). It is estimated that 1.5 million oil changes occurred and 2.1 million gallons of engine oil was consumed without oil bypass filter systems. Based on the estimated number of average oil changes that could be avoided (Tables 5 and 6), and oil capacities and oil change frequencies (Table 7) it is estimated that if oil bypass filter systems were installed on the Federal fleet's 607,630 on-road vehicles, the use and disposal of 1.7 million gallons of engine oil could be avoided annually (Table 12).

Table 11. All Federal fleets with vehicles listed in the Federal Acquisition Statistical Tool (FAST) database for Fiscal Year 2003.

American Battle Monuments Commission	Federal Communications Commission
Architect of the Capitol	Federal Deposit Insurance Corporation
Armed Forces Retirement Home- Washington	Federal Election Commission
Broadcasting Board of Governors	Federal Emergency Management Agency
Commodity Future Trading Commission	Federal Labor Relations Board
Consumer Product Safety Commission	Federal Trade Commission
Corps of Engineers, Civil Works	General Accounting Office
Defense Agencies	General Services Administration
Defense Contract Management Agency	Government Printing Office
Defense Intelligence Agency	Library of Congress
Defense Logistics Agency	National Aeronautics and Space Administration
Department of Agriculture	National Archives & Records Administration
Department of Air Force	National Foundation on Arts and Humanities

Department of Army	National Gallery of Art
Department of Commerce	National Labor Relations Board
Department of Education	National Science Foundation
Department of Energy	Nuclear Regulatory Commission
Department of Health and Human Services	Office of Personnel Management
Department of Housing and Urban Development	Overseas Private Investment Corporation
Department of Justice	Peace Corps
Department of Labor	Railroad Retirement Board
Department of Navy	Securities and Exchange Commission
Department of State	Selective Service System
Department of the Interior	Small Business Administration
Department of Transportation	Smithsonian Institution
Department of Treasury	Social Security Administration
Department of Veterans Affairs	Tennessee Valley Authority
Environmental Protection Agency	United States Postal Service
Equal Employment Opportunity Commission	United States Marine Corps
Executive Office of the President	United States Agency for International Development
Export-Import Bank of the United States	

Table 12. Potential annual savings for the U.S. Federal fleet. (HD = heavy duty, MD = medium-duty, LD = light-duty).

Federal Fleets Vehicle Types	No. of Units	Total Miles Driven Annually	Est. Annual Oil Changes	Est. Total Gallons of Oil Used Annually	Est. Potential Total Gals Oil Saved Annually (80%)
Ambulance	1,607	6,792,631	2,264	2,831	2,265
Sedan or station wagon	107,374	1,272,609,971	424,203	530,254	424,203
LD truck, 4 × 2	291,082	1,684,343,052	561,448	701,810	561,448
LD truck, 4 × 4	67,462	876,559,154	292,186	365,233	292,186
MD truck, 8,501– 16,000 lb	99,907	632,302,885	158,076	237,114	189,691
HD truck, >16,001 lb	32,882	291,086,951	48,514	181,929	145,543
Bus	7,316	74,447,848	6,204	54,285	43,428
Totals	607,630	4,838,142,492	1,492,895	2,073,456	1,658,764

SUMMARY

PuraDYN PFT-40 (40-quart capacity) oil bypass filter systems are being tested on eight INEEL buses. To date, the eight buses have accumulated 498,814 miles since testing began, and 473,192 miles without an oil change. With a 12,000-mile servicing schedule, this represents an avoidance of 39 oil changes, which equates to 1,374 quarts (343 gallons) of new oil conserved and 1,374 quarts of waste-oil not generated. Oxidation and nitration values are increasing (oil degradation), and some buses are showing negative total base number trends (decreasing values). The oil from Bus 73446 was changed this quarter, and the oil in Bus 73447 will be changed next quarter due to a degraded total base number—below 3 mgKOH/g.

Six puraDYN PFT-8 (8-quart capacity) oil bypass filter systems are being tested on six Chevrolet Tahoe vehicles. This quarter, these light-duty Tahoe test vehicles traveled 48,193 miles, accumulating 109,708 total test miles. The six Tahoe's traveled 98,266 miles on their initial engine oils. With a 3,000-mile service schedule, this represents an avoidance of 26 oil changes, which equates to 130 quarts (32.5 gallons) of new oil not consumed and, consequently, 130 quarts of waste oil not generated. The engine oils in all six Tahoes were changed this quarter due to degraded total base numbers—below 3 mgKOH/g.

Oil quality data are being recorded on diesel-powered buses using B20. Not enough data are currently available to show any change in oil quality.

Testing results to date for the buses and Tahoes show 80% savings in oil use with bypass oil filters. The 80% value was used as the basis for estimating the potential engine oil savings (use and disposal) on a fleet basis for the on-road vehicles in the INEEL, DOE complex, and entire Federal fleet if oil bypass filter systems were installed:

- INEEL (871 vehicles)—3,428 gallons of engine oil saved annually
- DOE complex (15,464 vehicles)—31,707 gallons of engine oil saved annually
- Federal Fleet (607,630 vehicles)—1.7 million gallons of engine oil saved annually.