Executive Summary

The mission of the California Department of Toxic Substances Control (DTSC), Office of Pollution Prevention is to reduce hazardous waste generation. Many State agencies, including the Department of General Services (DGS), operate vehicle fleets and are focused on reducing operating costs as well as protecting the environment.

In the transportation sector, extending oil drain intervals is one way to save money and reduce the generation of used oil, a hazardous waste in California. High efficiency (HE) oil filters, which clean motor oil better than standard filters, extend the useful life of engine oil. However, despite demonstrable savings from reduced motor oil purchases and waste oil generation, HE filter technology has not been widely adopted.

California State agencies operate a combined fleet of more than 70,000 vehicles which provided an excellent opportunity for demonstrating the cost savings and environmental benefits of this technology. With the source reduction goal in mind, the California Integrated Waste Management Board (CIWMB) contracted with DTSC to study the benefits and barriers to using HE oil filters.

Study Approach

The project had four goals: (1) discover why State agencies have not yet adopted this technology, (2) identify barriers to its adoption, (3) determine how the barriers could be overcome, and (4) demonstrate the technology's performance in actual fleet operations.

To accomplish these goals, DTSC employed a six step methodology:

1. DTSC conducted a literature search on HE filters and extended oil drain intervals.
2. Staff then prepared and administered a fleet managers' survey to learn why State agencies have not adopted this technology and what adoption barriers existed.
3. DTSC then held focus group meetings with fleet managers to identify ways to overcome the barriers.
4. Fleets representing a variety of engine types and sizes were then recruited for the demonstration phase. Operators recorded mileages and oil change events for each vehicle. They also collected oil samples and sent them to a private laboratory for analysis of the oil's physical and chemical parameters. This included viscosity, total base number (TBN), oxidation, and nitration along with oil contaminants such as water, soot, and wear metals. Original drain intervals were used to establish a baseline for comparison. Oil analysis results were used to predict oil degradation rates and propose new oil drain intervals.
5. Next, a cost-benefit analysis of proposed extended drain intervals was prepared from the projected costs and savings for each vehicle type.
6. DTSC staff completed the project with a survey of the operators of vehicles in the demonstration and with the development of an outreach mailer suitable for fleet operators.

Results

Literature Search on High Efficiency Oil Filters

Staff reviewed over 200 articles concerning HE oil filter technology and extended oil drain intervals. Most articles had descriptions of reduction in engine wear, operating costs, and waste generation with HE filter usage. Because most wear results from particles in the 5-20 micrometer (μm) size range (the oil film's thickness between moving parts), numerous studies documented a correlation between filtration efficiency and engine wear.

The HE filters used in this study claimed filtration of particles to 1-2 μm, much better than standard filters of 30-50 μm. Using standard filters is one reason that motor oil needs to be changed; it gets dirty with small particles which results in engine wear. In this regard, standard filters have not improved over the years compared to significant improvements in motor oil quality. The oil change interval set in warranties is a result of standard filters being the limiting factor, not the motor oil quality. Hence, higher quality filters will help to extend motor oil life to its full potential.

Fleet Manager Survey and Focus Groups

To investigate barriers to HE filter technology use, staff mailed surveys to 1,987 fleet managers. Two hundred and sixty-two surveys were returned (a 13 percent response rate) including responses from several State agencies, and other public and private fleet operators representing a broad spectrum of vehicle types and sizes. Concerns consistently reported across fleet size, vehicle type, and operator type included: purchase and installation costs; maintenance expenditures; HE filter performance; and engine warranty limitations.

Fleet operators in five focus groups met to validate the survey results and to identify ways to overcome the barriers. Focus group participants expressed skepticism about the technology's performance claims and identified additional institutional barriers such as service schedules and record-keeping requirements. Focus group recommendations included suggestions to eliminate many adoption barriers, such as encouraging manufacturers to include HE technology as standard equipment on new vehicles. The groups also helped to define the demonstration study goals and to identify what information should be collected.

Demonstration of Extended Oil Service Intervals

Four State agencies, two local school districts, and one local transit agency partnered with DTSC for the study's demonstration phase. Throughout the two-year study, a total of 119 vehicles completed the demonstration and accumulated nearly 2 million miles with no reported engine failures.

Table 1 shows the participating agencies, the number and types of vehicles involved, and summary of information gathered during the study. Projected drain intervals were derived for each vehicle type based on oil sample results, motor oil performance, and contamination limits, and then compared to baseline original drain intervals. In general these projected intervals are conservative and some vehicles of each type studied achieved distances beyond these values.

Drain interval extensions were achieved for DGS vehicles using standard filters and motor oil. CAL FIRE and Caltrans trucks and FAX compressed natural gas (CNG) fueled buses (all using OilGuard HE filters) achieved a three-fold extension to 18,000 miles. Both FUSD and LBUSD bus fleets used the Luberfiner ZGard HE filter and achieved equivalent results with extension to 36,000 miles. CDC buses used puraDYN filters and achieved drain intervals of 50,000 miles.

Table 1. Fleet Vehicle Results Summary

Participating Fleets	Number and Type of Vehicles	Filter Make and Model	Miles Accumulated During Study	Oil Samples Collected	Original Drain Intervals	Proposed Drain Intervals	Projected Payback Period (yrs)
Department of General Services (DGS)	40 passenger cars	Fram X2	798,000	212	6,000	10,000	0.2
California Department of Forestry and Fire Protection (CAL FIRE)	13 two- and three-axle trucks	OilGuard EPS 60	134,980	42	5,000	18,000	3.1
California Department of Transportation (Caltrans)	5 two- and three-axle trucks	OilGuard EPS 60	160,711	39	6,000	18,000	1.3
Fresno Area Express (FAX)	10 city transit buses	OilGuard EPS 60	179,099	56	6,000	18,000	3.7
Fresno Unified School District (FUSD)	14 school buses	Luberfiner ZGard LPF9750	116,618	34	9,000	36,000	2.5
Long Beach Unified School District (LBUSD)	26 school buses	Luberfiner ZGard LPF9750	505,115	57	10,000	36,000	6.8
California Department of Corrections (CDC)	11 coach buses	puraDYN TF 40	949,649	100	10,000	50,000	3.6

Fleet Manager Post-Survey

Participating fleet managers were surveyed at the demonstration's conclusion. Some managers reiterated concerns voiced in the initial survey and focus group meetings. Cost and warranty limitations were not the main issues, however. Now, operational problems such as logistics, maintenance schedules, and record-keeping became predominant. They expressed satisfaction with the HE filter technology's performance and reliability; however, only one fleet manager planned to continue using HE filters. Clearly, significant barriers to adoption of HE filter technology remain. There is resistance to changing the prescribed maintenance schedules that operators have followed over time.

One issue mentioned during the demonstration is the difficulty maintaining a separate maintenance schedule for relatively few vehicles. If all vehicles in a fleet were equipped with HE filters this should become a non-issue.

Operators also voiced concern about putting vehicles back into service while waiting for oil analysis results, and then needing to call the vehicle back in for an oil change if the analysis results deemed it necessary. This results in extra costs and disruption. Over time and with

experience, operators should become comfortable with a given extended mileage and be able to settle into consistent operation.

Cost-Benefit Assessment

Costs for filters and elements, oil analysis, and labor were balanced against those of lower motor oil purchases, reduced used oil generation and other savings. Proposed extended drain intervals were established from demonstration vehicle results based on oil quality criteria and fleet operator comfort with engine safety. Estimated economic payback periods were determined based on the cost-benefit analysis for each fleet studied.

Table 1 shows payback periods for HE filter-fitted fleets ranging from 1.3 years to 6.8 years. Periods were highly dependent on engine sizes and drain extensions achieved. Oil drain extensions on passenger vehicles had much shorter payback periods primarily because oil analysis test costs were offset by reduced motor oil purchases. Over time, the overall economics and payback periods should improve, primarily because as fleet managers became comfortable with drain extensions, they typically reduce the number of oil analyses they collect. While not included in this cost-benefit analysis, there will also be an added benefit of increased fleet operating time in the field for many vehicles. Hence, the calculated periods in Table 1 are conservative.

Principal Study Findings and Recommendations

The three key findings and three recommendations from the study are:

Finding 1: For any type of vehicle, oil drain intervals can be simply and safely extended beyond their current level to the maximum mileage recommended by the vehicle/engine manufacturer, or further.

The study confirmed that today's average oil change interval is considerably shorter than the maximum suggested by oil analysis results. The fleet managers' survey showed an average passenger vehicle oil change interval of 4,460 miles, which is well below some manufacturers' recommendations of 7,500 miles or even 10,000 miles. The oil analysis results showed that oil drain intervals can be safely extended for all vehicle types studied. Oil sampling results indicate that in many cases, oil drain intervals can be extended beyond warranty limits.

Finding 2: Fleet operators can further extend oil change intervals by using higher quality oil and by using oil analysis for determining optimum drain intervals.

The oil quality parameter that triggered an oil change was unique to each fleet, the motor oils used, and operating conditions. However, in most cases, the limiting factor was the oil's Total Base Number (TBN), which is a measure of the oil's ability to neutralize acids. Oils with higher initial TBN levels and longer-lasting additive packages are important factors in extending the useful life of engine oil. For engine safety, routine oil analysis is an important tool for ensuring oil functionality.

Finding 3: In larger engines, HE oil filters are an effective and economical technology for extending oil drain intervals.

Typically, diesel engine fleets achieved the greatest extensions when using motor oil with higher initial TBN levels or HE filters that addressed TBN consumption. The puraDYN filter design features a time-released additive package that replenishes the oil's buffering capacity. The Luberfiner ZGard filter has a zinc liner that mitigates acid buildup in the oil. Both address the

TBN consumption and provide high filtration, thereby extending oil drain intervals the furthest. Other HE filters with only high particulate filtration also produced lengthened drain intervals.

Recommendation 1: Develop outreach that convinces fleet operators to follow manufacturers' recommendations for oil change intervals and institute routine oil analysis programs for extended oil change intervals.

Targeted outreach is necessary to convince fleet managers of the advantages to extended drain intervals. Outreach should include training on oil sampling and interpretation of oil analysis results. Promotional information featuring this project's results could influence fleet managers and their behavior.

Recommendation 2: To overcome adoption barriers, promote HE filter usage by establishing education, training, and outreach programs for managers with large engine vehicle fleets.

Vehicles with larger engines (higher oil sump capacities) and that accumulate significant annual mileages appear to be the most appropriate HE filter candidates. Large-engine vehicle fleet managers need outreach programs to help overcome HE technology adoption barriers. Focus group participants recommended promoting testimonials from satisfied HE filter users. Informational fact sheets, training programs, and consultations could lessen vehicle maintenance tracking and operational concerns. A technical resource center for ongoing consultation services and oil condition recommendations would support fleet managers who implement extended drain interval programs. For new vehicles replacing aging fleet models, fleet managers could specify HE filters as original equipment and avoid manufacturers' engine warranty concerns.

Recommendation 3: Vehicle producers, engine manufacturers and oil formulators can endorse extended oil drain intervals.

Vehicle producers and engine manufacturers can include HE oil filters as original equipment, require the use of higher quality motor oils such as synthetics, and install monitoring systems for safely extending oil change intervals. Honda, General Motors, Mercedes-Benz, and BMW have installed oil change indicator systems on their vehicles. This needs to be expanded to all new vehicles sold by all auto makers. Oil formulators can market oil blends with additive packages and buffering agents designed specifically for extended drain intervals. Procurement specifications can include purchases of vehicles and oils that support extended drain intervals. CIWMB and DTSC should work together to contact vehicle manufacturers with these recommendations.