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Project Summary

Waste Oil Reduction for Diesel Engines

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This project reduced waste oil from diesel engines at remote sites in Alaska by extending oil change intervals using bypass filters and a closed-loop reblending process in connection with portable field monitors and laboratory analysis. Incidents of normal and abnormal oil degradation were recorded and correlated between field and laboratory tests. A quality assurance program evaluated data precision and accuracy.

Waste oil from diesel engines represents the greatest environmental health problem in Alaska, especially in remote areas where disposal/recycling options are nonexistent. Results of this project showed that small, isolated communities can reduce the amount of waste oil generated at the source with techniques that are easy to implement and inexpensive. However, they depend primarily on operator interest in closely monitoring the engine because degradation levels need to be determined individually for each engine and oil type by establishing baseline data.

This Project Summary was developed by EPA's National Risk Management Research Laboratory, Cincinnati, OH, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

This study was a cooperative effort between EPA's National Risk Management Research Laboratory (NRMRL) and the Alaska Health Project (AHP), the central site of the project. The AHP, located in Anchorage, is a nonprofit organization offering technical assistance on pollution prevention and waste reduction. The goal of this project was to test different technologies to reduce waste oil at remote sites in Alaska.

The generation of energy is critical to remote villages, marine vessels and military bases throughout Alaska. The use of diesel generators to provide that energy results in large quantities of used oil, part of the more than one billion gallons of waste oil generated annually in the U.S. The U.S. Environmental Protection Agency (EPA) is concerned about the quantity of waste oil improperly disposed of each year because of its threat to the environment and its cost to remediate. Carefully managed, used oil retains its economic value, but many small communities have neither the experience nor the knowledge to evaluate the condition of used oil or to determine a reasonable means of recycling. Consequently, much of the accumulated used oil is transported many miles at substantial cost, and indiscriminate dumping is common. Current filtration technology may be able to process used oil on site, providing a recycled oil that meets specifications for burning. Objectives for this project were to determine (1) whether engine manufacturer's recommendations for oil change intervals (OCIs) could be increased with field and laboratory measurements of oil degradation; (2) whether bypass filters are effective in extending oil drain intervals; (3) whether the closed-loop process is efficient and affordable in eliminating waste oil; and (4) whether these technologies can be easily implemented by small, isolated communities. The project also evaluated whether technologies for extending oil life would concentrate polynuclear aromatic hydrocarbons (PAHs) at levels hazardous to the health of oil handlers.

Procedure

The sites selected for this project were stationary electric generating plants located in rural areas ranging from the Arctic north, through the Aleutian Islands, to the temperate rain forests of Southeastern Alaska. Other participants were a marine vessel and a federal hydroelectric facility. Phase I—extension of oil change intervals using analysis alone—was conducted over an 11-month period at 13 Alaskan sites on 20 diesel engines ranging from 23 to 3,000 hp. Participants were asked to gradually extend OCI based on field monitoring and laboratory analysis alone.

In Phase II—extension of OCIs through the use of bypass filters—data was compiled from nine diesel engines at four sites. Filtration is defined for this project as the physical separation of liquids and solids by means of centrifuges and media filters, the two technologies commonly used in bypass filters. Oil is commonly filtered between oil pump and engine by diverting 100% of the oil through a "full flow" filter able to remove large particles (greater than 20 microns). Full flow filters are inefficient at removing liquids (such as water, unburned fuel or acids) and small metal contaminants below 20 µm. Bypass filters remove particles in the below-20-micron range by intercepting about 10% of the main flow of oil. The following filter systems were selected for this project based on product quality and information, experience and cost: Gulf Coast, Spinner, Purifiner, Harvard and Power Plus. Used oil samples were taken from the engines as often as every two days and tested by the engine operator onsite and by the project manager at the AHP office. To monitor oil quality in the field a portable battery-powered comparative dielectric analyzer (CDA) was used. This equipment determines the deterioration in motor oil from continued use. By measuring any deviation of the dielectric constant between fresh and used oil, it indicates the overall condition of the oil and helps determine the optimal oil change interval. For this project, the LubriSensor Model NI-2B was selected based on its cost, usability and documentation ability. After each sample was tested in the field it was sent to Analysts Laboratory in Oakland, CA, for analysis of the physical and chemical properties of the oil. This lab was chosen after a national search on the basis of its quality manuals, experience and commercial availability. For this project, Analysts tested each sample for 21 metals and the total base number (TBN). TBN is an indicator of oil buffering quality, i.e., the quantity of hydrochloric acid, expressed in terms of the equivalent number of milligrams of potassium hydroxide required to neutralize all the basic constituents present in a one-gram sample of oil. The TBN indicates relative change in oil regardless of color or other properties. This project chose to analyze TBN and CDA as the best indicators of oil quality. Lab results were sent to AHP and then to the engine operator. With every fifth used oil sample, a quality control sample was sent to the lab.

In Phase III—the elimination of waste oil through reblending and recycling—a closed-loop process was used on a stationary engine and a marine engine at two different sites. The closed-loop process is one in which the oil is removed from the engine at a set rate and blended in the fuel tank at a varied ratio of oil to fuel. In addition to eliminating the need to dispose of waste oil, the quality of the fuel is increased. For this project, the Power Plus Smart Tank Model ED3500S was selected for the stationary engine; the Volvo MD11C marine engine used its own blending system constructed onsite. Oil was removed at the rate of 1.3 oz/engine hr and blended in the fuel tank at 2% oil : fuel. This removal rate uses the same amount of oil as changing the oil once every 150 hr. Upon good analysis, the removal rate was reduced by 50% to .65 oz/hr, and the blend to 1% oil : fuel, a removal rate equal to changing the oil once every 300 hr.

During the project, the methods or independent variables were oil analysis and filtration systems. Dependent variables were oil change intervals and cost. Results from samples collected at each site were compiled on data sheets and entered into a database. To ensure accuracy, the data were entered twice by two separate individuals. Each data set was cross checked for discrepancies. All measurements, data gathering equipment and data generation activities were routinely assessed for precision, accuracy, completeness and detection limits.

Results and Discussion

Results of the data were plotted on graphs; several examples are shown here. Figure 1 shows the CDA readings against engine hours on oil for each of the bypass filters on engine No. 5. A higher CDA rating can be an indication of possible oil contamination. The control plot is an extension of oil drain interval without a bypass filter. On this engine the control samples had lower CDA readings than samples from the Spinner filter. The samples from the Purifiner filter had a lower CDA reading than the Spinner or control samples. All samples on this engine were able to extend their OCI to over 800 hr without any CDA readings indicating oil contamination. Figure 2 shows CDA readings against engine hours for the control used-oil samples and the Gulf Coast used-oil samples on engine No. 8. A higher CDA reading can be an indication of possible oil contamination. The control plot is an extension of oil drain interval without a bypass filter. This figure shows that on this engine the control samples had lower CDA readings than the Gulf Coast samples, but that both sets of used-oil samples were able to be extended to over 1200 hr without any CDA readings indicating oil contamination. Figure 3 shows the CDA readings against engine hours for the control used oil samples and the 1.5% oil : fuel blend samples on the Volvo MD11C engine within a 95% confidence level. A higher CDA reading can be an indication of possible oil contamination. The control plot is an extension of oil drain interval without a by-pass filter. The blend is a closed-loop process where used oil is blended with incoming fuel. This figure shows lower CDA ratings than the control samples on this engine. The blend samples were extended to over 200 hr without CDA readings indicating any oil contamination. (Manufacturer's recommendation is 50 hr.) The control samples were able to extend the oil to over 350 hr but had CDA readings indicating possible oil contamination. Figure 4 plots the complete range of data points and extends the data to the point where TBN level would reach zero on the Volvo MD11C engine. The figure shows a direct relationship between CDA and TBN readings with a 95% confidence level extended to over 1000 hr. This ability to predict the TBN level aids the engine operator because lab analyses take time and are costly.

Conclusions

This study focused on answering the objectives stated in the Introduction. The study finds that:

1. Oil change intervals can be extended beyond engine manufacturers' warranty recommendations without oil degradation. To ensure protection of the engine while extending the OCI, field monitoring of oil condition is recommended. CDA data collection is easy, inexpen-

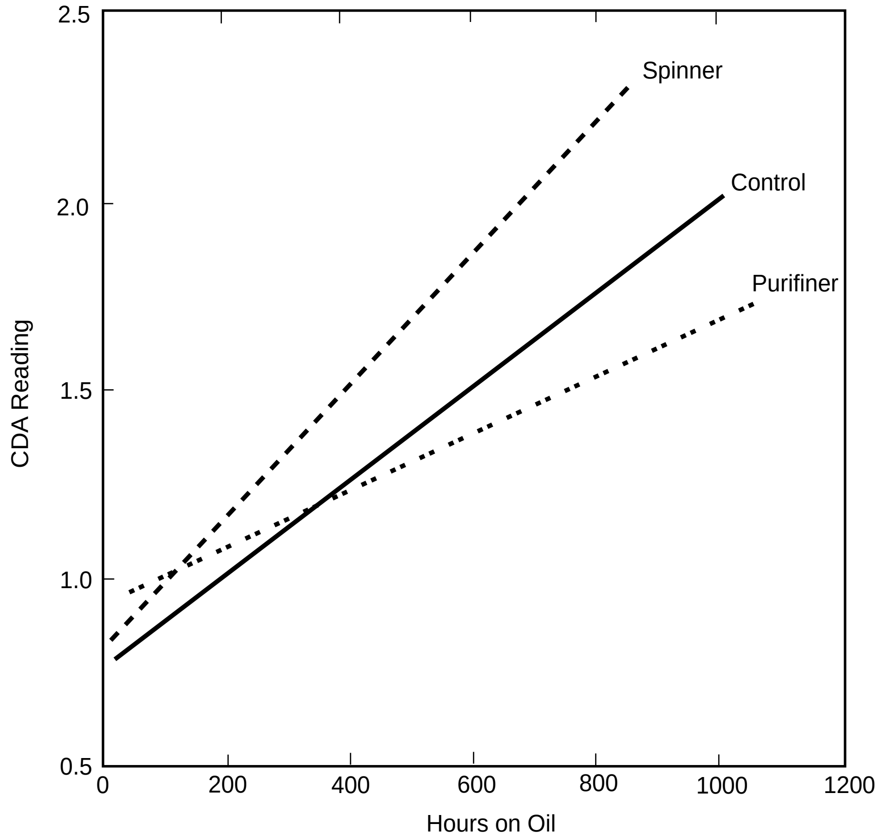

***Figure 1**. Bypass filter vs. control samples CAT 3512, engine No. 5.*

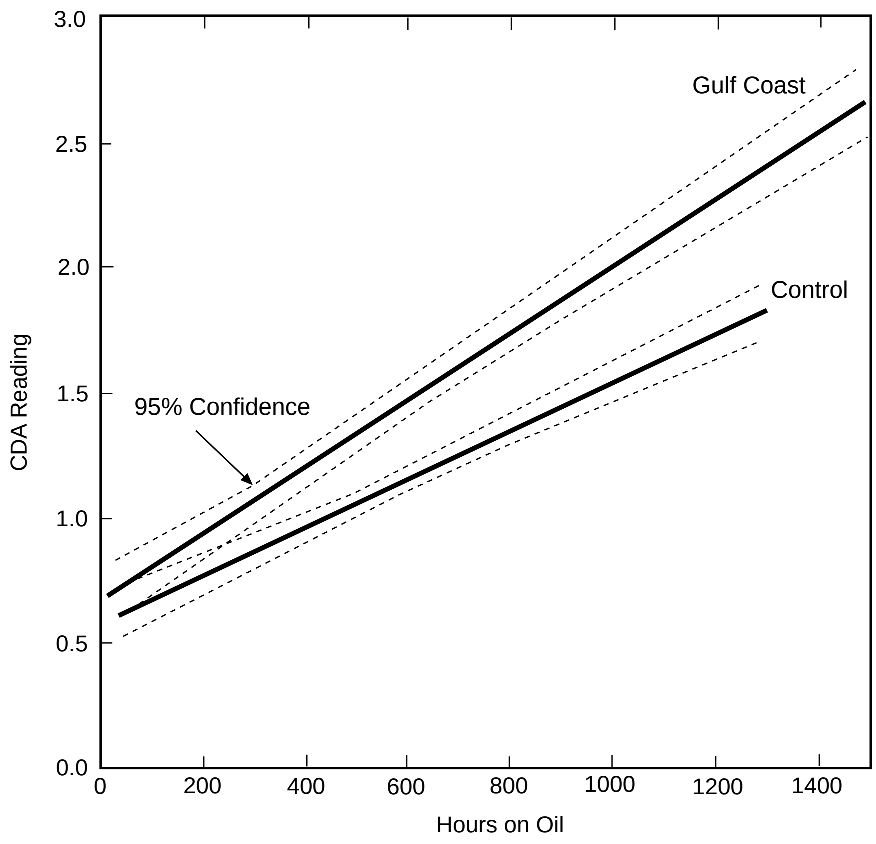

***Figure 2.** Bypass filter vs. control samples CAT 3516, engine No. 8.*

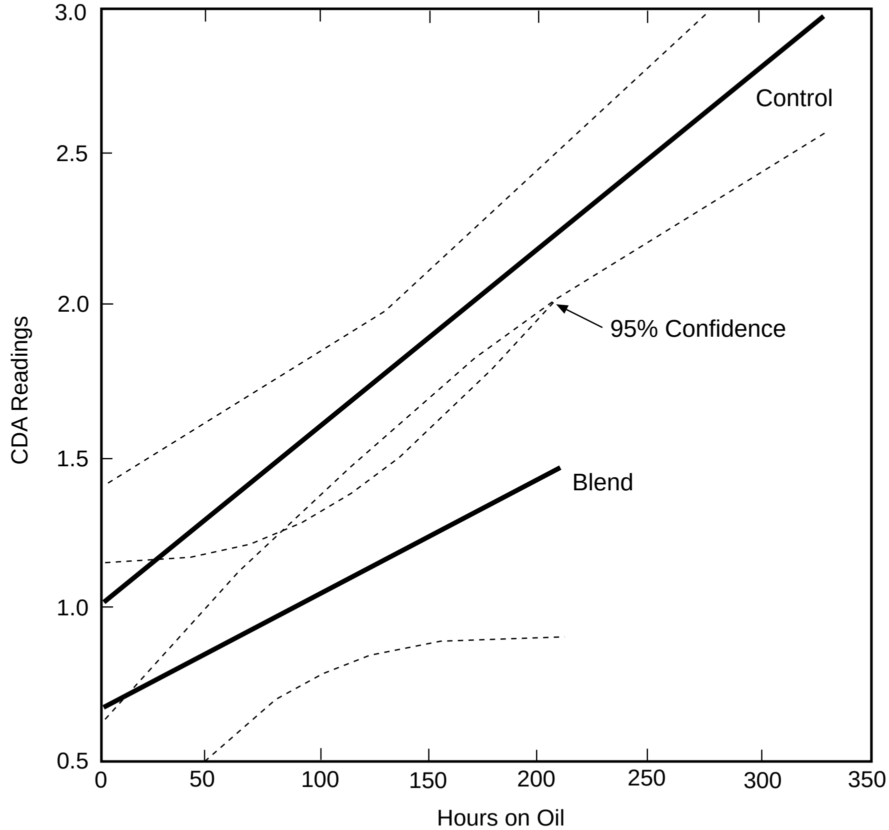

***Figure 3**. 1.5% oil : fuel blend engine, Volvo MD11C.*

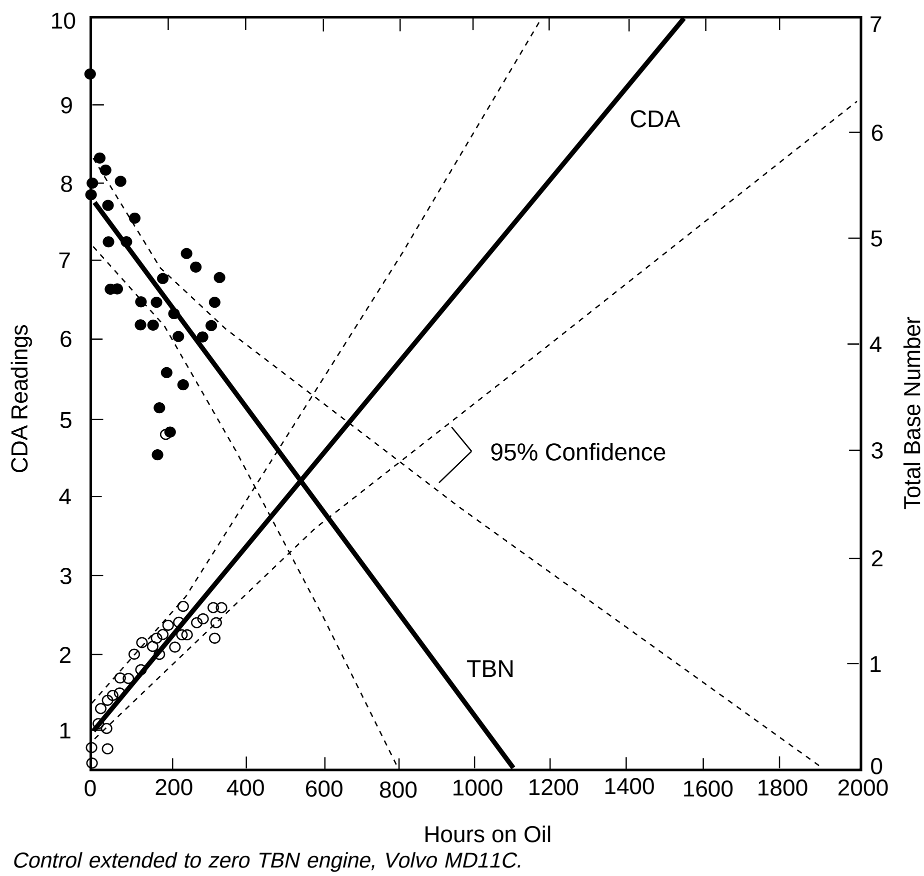

***Figure 4**. Control extended to zero TBN engine, Volvo MD11C.*

sive and a good indicator of oil degradation. There is a consistent relation between CDA readings and TBN levels in measuring oil degradation. However, each engine and situation is unique. Therefore, OCI extensions based on CDA response should be correlated with laboratory analysis for each engine, lubricating oil and fuel type. The probability of oil decreasing TBN increases between 800-2000 hr and at a CDA reading of 3.0-6.0 for the engines tested in this study.

2. Oil samples from stationary diesel engines that used bypass filters showed no less oil contamination than control samples. Other studies have revealed that oil change intervals can be extended when using bypass filters, but they had no control data. The Power Plus used-oil blend unit limits oil degradation and eliminates waste oil for stationary diesel engines. The Power Plus unit is efficient, effective and affordable. Based on a 5,000 hr/yr operational period, engines at one site (Unalaska) saved over 2,000 gal/yr. One engine at Unalaska, and the engine at Seward, eliminated waste oil while using the Power Plus re-blend technology. Based on a 5,000 hr/yr operational period, engines at one site (Unalaska) saved over 2,000 gal/yr of lubricating oil.

3. Small isolated communities can reduce the amount of waste oil they generate. However, the ability to do so is based primarily on operator interest and desire to closely monitor the engine. This increased attention is needed because degradation levels need to be determined individually for each engine and oil by establishing baseline data.

The study further found no significant health hazard from PAHs in the used oil sampled resulting from oil exchange intervals or burning used oil.

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The complete report, entitled "Waste Oil Reduction for Diesel Engines," (Order No. PB96-196779; Cost: $28.00, subject to change) will be available only from:
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