Research Briefing

Diesel Fuel Additives: Use and Efficacy for Alaska’s Diesel Generators

This research was prepared by the Alaska Center for Energy and Power for the Alaska Energy Authority.

To date, the authors of this report have found no credible information to support the claim that any product can improve the operating efficiency above that of a well-maintained diesel engine. We recommend bona fide testing of additives where controlled conditions can be ensured. Use of test facilities and rigorous protocols will increase the understanding of the efficacy of — and improve the credibility of — representations of additives. At this time, no additive for improving fuel efficiency has been identified as a candidate for such extensive laboratory testing. However, augmenting testing of additives or add-on devices at utility sites by use of unbiased, third-party analysts could bring more understanding to the testing and help identify promising additives.

Overview

Rural Alaska communities remain dependent on diesel generators to provide electricity, which costs significantly more than in grid-connected communities. Reducing the cost by improving engine efficiency and/or reducing engine maintenance is a high priority for those responsible for rural electric utilities. In this report, we assess the current use of diesel fuel additives in the Alaska electric utility industry, focusing on evaluating fuel additives — chemical mixtures that are added to a diesel fuel in order to change the fuel’s properties — with the intention of improving the performance of a diesel engine and improve fuel economy.

Significant improvements in diesel engines over the past few decades, especially the introduction of electronically controlled injection systems and higher compression turbo chargers, have led to much more efficient diesel operation, and some have suggested that additional efficiency can be realized through the use of diesel fuel additives.

For this research, information was gathered about fuel sources and distribution networks, additives used by fuel suppliers, experiences of electric utility operators with additives, the performance of additives anticipated by additive suppliers, recommendations of diesel engine manufacturers, peer-reviewed journal articles and other public sources including the Environmental Protection Agency.
Background

Many vendors actively market diesel fuel additives purported to decrease fuel consumption, reduce emissions and extend maintenance periods and mean time to failure for stationary diesel engines. Evaluating these claims is difficult, as fuel properties, diesel engine types, operating parameters and other factors may affect the observed performance. Often there is little or no credible information documenting claims of beneficial effects, but profuse anecdotal information and testimonials that can seem compelling are routinely proffered. Although there is a possibility that some of these fuel additives may positively affect engine performance, the uncertain value of using additives warrants a more systematic, comprehensive approach to addressing these products. An unbiased review and assessment of known products by an organization able to assess new products as they are marketed to Alaskans should well serve communities that rely on diesel fuel.

There are over 200 communities throughout Alaska that use diesel generators to produce electricity. In addition, there are a number of industrial users of diesel generator sets (gensets) for primary and secondary electrical power generation. Typically, vendors of fuel additives claim increases in diesel efficiency of 10 to 15 percent, which would mean that savings could be substantial. In the fiscal year 2009, utilities participating in Power Cost Equalization (PCE) consumed in excess of 29 million gallons of diesel fuel for electrical power generation. With a vendor-proposed savings of 10 percent, that would represent an annual savings of almost 3 million gallons with a cost savings of greater than $10,000,000 (assuming a conservative fuel cost of $3.50 per gallon). The net savings could be between $7 million and $8.5 million given the nominal cost associated with these fuel additives. On the other hand, if the products are not effective and/or damage engines, the net result is more expensive energy.

Quantifying the potential benefit of additives that claim to extend maintenance periods and mean time to failure is more difficult but nonetheless extremely valuable to utilities in the state. Utilities routinely seek new ways to improve the performance of their plants in cold temperatures, avoid unnecessary engine wear and prevent fuel contamination. Additives can play an important role in all these enterprises, yet it remains unclear to many utilities when these products should be used, which products can provide legitimate benefits and how the products can be blended with the fuel most effectively. Compiling an overview of the different types of additives and their appropriate applications in Alaska will provide a useful guide for utilities.

Diesel Fuels and Additives

Diesel fuel is defined as any fuel intended for sustained operation in a diesel engine. That definition means diesel fuel can contain a mixture of an enormous variety of chemicals from various sources; as long as the collection of chemicals can power a compression ignition engine, it is considered diesel fuel. Diesel fuels are most commonly distilled from crude oils, resulting in a mixture that may vary considerably in composition, and the product is sometimes adjusted at the refinery to bring the fuel into specification. This may be done either through a refining process (such as the removal of sulfur in the production of Ultra Low Sulfur Diesel (ULSD) or by use of additives. ASTM D975 — the most commonly referenced standard for properties and classification of diesel fuels — permit, and sometimes require, the use of additives to bring fuels into proper specifications. Examples are the use of conductivity and lubricity additives for ULSD fuels and the use of pour point depressants to adjust for local geographic conditions, such as those found in Alaska during the winter.

The point in the fuel delivery stream where additives are mixed with the fuel varies depending on the properties of the additive and transport constraints. No guidance for mixing is specified by ASTM D975. Pour point depressants are most effectively added at the refinery, because a less expensive addi-
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Common Diesel Additives in Alaska

<table>
<thead>
<tr>
<th>Additive Type</th>
<th>Function</th>
<th>ASTM D975</th>
<th>Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biocide</td>
<td>Kill or prevent biological growth in fuel tanks</td>
<td>Permitted</td>
<td>Used</td>
</tr>
<tr>
<td>Cetane Boost</td>
<td>Increase the cetane number of a fuel</td>
<td>Permitted</td>
<td>Rarely used</td>
</tr>
<tr>
<td>Conductivity</td>
<td>Increase the conductivity of fuel to reduce the risk of static charge buildup</td>
<td>Required for ULSD</td>
<td>Used by refiners</td>
</tr>
<tr>
<td>Cloud Point Depressant</td>
<td>Decrease cloud point</td>
<td>Permitted</td>
<td>(1)</td>
</tr>
<tr>
<td>Efficiency Boost</td>
<td>Increase the efficiency of an engine</td>
<td>Not addressed</td>
<td>Rarely used</td>
</tr>
<tr>
<td>Emissions</td>
<td>Reduce pollutant emissions</td>
<td>Not addressed</td>
<td>Rarely used</td>
</tr>
<tr>
<td>Injector Cleaner</td>
<td>Clean fuel injectors</td>
<td>Not addressed</td>
<td>(2)</td>
</tr>
<tr>
<td>Lubricity</td>
<td>Increase fuel lubricity</td>
<td>Required for ULSD</td>
<td>Used</td>
</tr>
<tr>
<td>Pour Point Depressant</td>
<td>Decrease the pour point</td>
<td>Permitted</td>
<td>Used</td>
</tr>
<tr>
<td>Stabilizer</td>
<td>Improve the storage stability of fuel</td>
<td>Permitted</td>
<td>Used</td>
</tr>
<tr>
<td>Water Disperser</td>
<td>Disperse water in fuel. Intended to allow the water to be evaporated during combustion while the fuel burns.</td>
<td>Not recommended</td>
<td>Not recommended</td>
</tr>
</tbody>
</table>

(1) Alaska utilities use warm fuel to eliminate wax particles and do not generally specify cloud point
(2) Injector cleaner use may be warranted if injector fouling is suspected.

tive can be used to give better results if the additive is mixed with hot fuel. On the other hand, lubricity additives for treating Ultra Low Sulfur Diesel (ULSD) fuels are often added when transferring fuel from the barge to the bulk fuel storage tanks because the lubricity additives are hygroscopic (attract water from the atmosphere.) If the additive were in the fuel during barge transport, there would be increased potential for water contaminating the fuel. Other additives, such as injector cleaners or biocides might be added anywhere in the delivery stream to treat specific issues that develop in utility operation.

In addition to the additives discussed above, many other products are available for treating diesel fuel, some of which claim to improve the efficiency of diesel engines by 10 to 20 percent. However, these claims are often supported by testimonials based on very short-term experience and reports that appear to have been edited or altered after their creation and/or lack signatures or certifications by the testing organizations. Often, links to patents or studies are missing, or no information is given at all. Complicating these claims is the fact that under normal operation, fuel consumption and power generation efficiencies vary because of factors not always accounted for, including temperature, load variation, changes in fuel properties and maintenance history. In addition, marketing efforts tend to use only those studies that show a positive effect; studies that show either no effect or negative effects are simply not presented.

Product Testing

Attempting to test products with sufficient rigor to establish the veracity of their claims is a significant and costly undertaking, especially if long-term costs or benefits are to be experimentally evaluated. There is one testing program in the U.S. dedicated to evaluating efficiency additives and retrofit devices. The program was founded in 1971 and is run by the EPA. A quote from its website addresses the results of their studies:

“If a marketed device [claims to have] significant benefits, the manufacturer may submit data to the EPA and apply for EPA testing through the Voluntary Aftermarket Retrofit Device Evaluation Program. Very few manufacturers have applied for this program in the past 10 years. Most devices tested in earlier years had a neutral or negative effect on fuel economy and/or exhaust emissions.”
No similar program has been identified for additives specifically designed for diesel engine fuels, but many additives and devices claim to provide benefits in both gasoline and diesel engines. None of the products currently marketed in Alaska have been identified as participating in the EPA testing program. The testing program is distinct from the EPA registration program. EPA registration verifies that a diesel additive does not violate emission regulations but does not provide any analysis of its efficacy.

Some fuel additives, such as those identified for pour point depression and lubricity additives for ULSD fuels, are necessary for bringing fuels into ASTM D975 compliance. Other additives, such as biocides, might be useful for long-term storage of diesel fuels in damp climates. Some engines not operating at optimal performance may benefit from an injector or fuel system-cleaning additive. But in general, engine manufacturers recommend that no additives be used in diesel fuels; this appears to be sound advice.

**Findings**

Our survey of utilities in Alaska indicated that most operators understand the need for pour point management and ULSD lubricity additives and are purchasing fuel adequately treated for these properties. Some utilities routinely and appropriately use biocides. Other utilities blend lubricity additives into their fuel on site, which may add an unnecessary cost to their operation given that fuel distribution companies only deliver ULSD fuel that has already been treated and meets the ASTM lubricity specification. Some utilities do use multipurpose additives that include lubricity and injector cleaning detergent agents, although they are branded as efficiency boosters.

Proper use requires good mixing of additives into the fuels, with increased attention the closer the point of introduction of the additive is to the utility. Adding additives to fuel tanks adjacent to the power plant requires attention to the physical mixing, temperatures of the fuel and the additive, and the mixing ratio. These conditions are often better controlled during delivery of the fuel to the region and are best controlled by the fuel producer or bulk distributor.

A handful of Alaska utilities have also experimented with additives or aftermarket devices intended to improve efficiency. While two out of seven users reported some positive results, neither could, with certainty, provide an economic analysis of the benefits of such devices, and neither appeared willing to recommend their widespread use to other utilities.

Modern, well-maintained diesel engines operate at very high thermodynamic efficiency levels. Fuel efficiencies achieved in large diesel engines are at, or are very close to, the maximum achievable efficiency. Fuel efficiencies associated with electrical power production from smaller engines generally cannot match those of larger engines because of physical design considerations combined with theoretical maximum combustion cycle efficiency constraints. Theoretical and experimental reports support the assertion that additives cannot, and therefore have not, been documented to improve fuel efficiency in well-maintained engines.

While not replacing the need for regular maintenance, additives may clean engine components that show degraded performance because of the buildup of deposits. This may well be more valuable for older engines as well as engines long into their prescribed maintenance cycle as a means for restoring original performance. Therefore, we recommend continuing to assess the need for cleaning agents in fuels and the appropriate use of those kinds of additives in engines of all ages to help ensure long engine life and new-engine performance.