A Closer Look at Diesel

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The Division of Oil and Public Safety regulates those who own or operate amusement rides and devices, commercial boilers, conveyances (elevators and escalators) and retail fueling facilities and those who are permitted to use high explosives.
Diesel

- Rudolf Diesel invented the compression ignition engine in the 1890’s.

- Most notable specification changes in last decade have been reduction of sulfur and biodiesel blending.
Diesel Specifications

• ASTM D 975 – *Standard Specification for Diesel Fuel Oils*

• Covers seven grades of diesel fuel oil suitable for various types of diesel engines.

• Up to 5% biodiesel (B5) can be blended in diesel without disclosure.
EPA Highway Diesel Rule

- Intended to make heavy-duty trucks and buses run cleaner.

- Required a 97% reduction in the sulfur content of highway diesel fuel from 500 ppm (low sulfur diesel, or LSD) to 15 parts per million (ultra-low sulfur diesel, or ULSD).

- Refiners began producing the cleaner-burning diesel fuel, ULSD, for use in highway vehicles beginning June 1, 2006.
Phase-in of ULSD

• ULSD was phased in for Highway diesel fuel from 2006-2010.

• Low sulfur (500 ppm) and ULSD fuel was phased in for Nonroad, Locomotive, and Marine (NRLM) engines from 2007-2014.

• Since 2014, all diesel (Highway and NRLM) should be ULSD.
Ultra Low Sulfur Diesel is the primary highway diesel fuel produced.

The full transition to ULSD fuel is complex and involves coordination at many levels. Under the EPA standards:

- Effective June 1, 2006, refiners and importers nationwide are now required to ensure that at least 80 percent of the volume of the highway diesel fuel they produce or import is ULSD-compliant.
- Diesel fuel classified as ULSD is flowing to distribution and marketing points downstream from refineries (i.e., pipelines, distributors, terminals and transporters) and is now available at many retail locations.
- Diesel fuel classified as Low Sulfur Diesel fuel may still be sold at retail locations outside of California until December 1, 2010.
- The State of Alaska received an extension of the highway fuel 15 ppm requirement until 2010.
- Click here for Corrosion in Systems Storing and Dispensing ULSD. Hypotheses Investigation
- Click here for Guidance for Underground Storage Tank Management at ULSD Dispensing Facilities

### Effective Dates for Highway ULSD Fuel

<table>
<thead>
<tr>
<th>Who</th>
<th>What</th>
<th>U.S.</th>
<th>California</th>
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<tbody>
<tr>
<td>Refiners &amp; Importers</td>
<td>Import/produce at least 80% ULSD for on highway use</td>
<td>6/01/06</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Import/produce at least 100% ULSD for on highway use</td>
<td>6/01/10</td>
<td>6/01/06</td>
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<tr>
<td>Downstream from</td>
<td>Facilities that choose to carry ULSD must meet 15 ppm sulfur specification</td>
<td>9/01/06</td>
<td></td>
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<tr>
<td>Refineries through</td>
<td>All highway diesel must be ULSD</td>
<td>10/01/10</td>
<td>7/15/06</td>
</tr>
<tr>
<td>Fuel Terminals</td>
<td>Facilities that choose to carry ULSD must meet 15 ppm sulfur specification</td>
<td>10/15/06</td>
<td></td>
</tr>
<tr>
<td>Retail Outlets</td>
<td>All highway diesel must be ULSD</td>
<td>12/01/10</td>
<td>9/01/06</td>
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Although ULSD fuel is the dominant highway diesel fuel produced, EPA does not require service stations and truck stops to sell ULSD fuel. Therefore, ULSD fuel might not be available at every service station or truck stop. Diesel retailers may choose to sell Low Sulfur Diesel fuel instead of ULSD fuel until December 1, 2010, when only ULSD fuel will be available for highway use. The industries involved in the transition are doing all they can to minimize potential
Diesel Fuel Sulphur Levels: Global Status
October 2011

* Information in parts per million (ppm)

Sulphur levels are maximum allowable as of October 2011. For additional details and comments per country, visit www.unep.org/transport/pcfv.
Retail Gas Station
Typical UST System
Field Observations Since 2006

• Fuel seeps and leaks around certain gasket fittings in UST systems storing and dispensing ULSD

• Need to replace dispenser fuel filters more frequently due to clogging with particulates or biomass

• Erratic operation or failure of tank and line monitoring equipment due to rust buildup

• An increase in the number of ULSD systems showing internal corrosion

• Minimal external evidence of corrosion
Noteworthy Properties of ULSD

- Sulfur content
- Lubricity additives
- Oxidation stability
Sulfur Content

• The presence of sulfur in diesel can have an adverse effect on microbial growth.

• As the sulfur content in diesel dropped from 500 ppm to 15ppm, the fuel’s “antibiotic” properties diminish, possibly allowing for more microbial activity.
Detecting presence of microbes
Lubricity

• Lubricity of diesel fuel decreases as sulfur is removed during the refining process.

• To compensate for this loss, lubricity additives are blended into ULSD to minimize engine wear.

• The net effect is that ULSD fuel may not be compatible with certain non-metallic seals and gaskets.
ULSD Leak at Meter Gasket

Photo courtesy of CO OPS
Oxidation Stability

• The natural anti-oxidation properties of diesel fuel also decrease as sulfur is removed during the refining process.

• ULSD, without the natural oxidation inhibitors which are removed by hydrotreating, may form peroxides during long-term storage.

• Biodiesel is also more susceptible to oxidative degradation than petroleum diesel.

• Can result in the buildup of oxidation products, commonly seen as rust or sediment buildup.
Rusted Submersible Pump

Photo courtesy of CO OPS
Blending with Biodiesel

• Biodiesel fuels degrade more rapidly than conventional diesel fuel and may lead to increased biological growth during storage.

• Biodiesel is also more susceptible to oxidative degradation than petroleum diesel.

• Contrary to intuition, two fuels that, by themselves, have good stability may form a less stable blend when they are combined.
Notice of Corrosion Risks in Underground Storage Tanks Storing Diesel Fuel

EPA developed this notice recommending that UST owners check for corrosion on metal components inside their steel or fiberglass underground tank systems.

You will need Adobe Reader to view some of the files on this page. See EPA's About PDF page to learn more.

- Notice Of Corrosion Risks In Underground Storage Tanks Storing Diesel Fuel (PDF)  (2 pp, 498 K, July 2016)

Contact Us to ask a question, provide feedback, or report a problem.
Corrosion in ULSD Tanks
Key findings of EPA's Study

- 83% of UST systems evaluated in the study exhibited moderate to severe corrosion.

- Only 25% of the affected owner/operators were aware of the corrosion prior to the study.

- Severe corrosion is not limited to the tanks, but also prevalent in all the metal components of the fueling system. Found in steel as well as fiberglass tanks.

- The condition is widespread – affecting diesel fueling systems in multiple regions of the country.
Key findings of EPA's Study

• Ethanol was present in 90% of the 42 tanks sampled, “suggesting cross contamination of diesel fuel with ethanol is likely the norm.”

• Many UST systems may be storing fuel that is less “clean and dry” than those standards stipulate.

• The presence of particulates and water in the fuel were “closest to being statistically predictive factors for metal corrosion”.
Water in Diesel

- High throughput in the fuel distribution/delivery infrastructure allows less time for water to settle out of the product before it's delivered into the distribution system from the refinery or as it's moved along the shipping process.

- Water is the number one contaminant of diesel fuel and causes premature failure of fuel system components, promotes the growth of microbial slime, corrosion, and leads to iced fuel lines during cold weather.

- Detection and elimination of water in diesel fuel is critical to the performance of your fuel.
Limited Colorado Survey

- Checked for presence of water in ULSD tanks
- Inspected 109 diesel tanks in Oct 2016
- Measurable water present in 7 tanks (6.4%)
- Thickness of water ranged from $\frac{1}{4}$” to 2”
- 71.4% of those with water or 5 tanks had less than 1” water
- 28.6% of those with water or 2 tanks had more than 1” water
- Some correlation between presence of water and corrosion
Diesel tank riser corrosion.

Robert Schlegel - CDLE

to Jennifer, me

Here is a pic of the inside of a riser pipe. Diesel tank with 1/2" of water. No threaded adaptor on top. Just a vapor recovery cap covering this.
FID 14312 Loaf N Jug #83.
Best Management Practices

• Aggressive Water Management – monitor for the presence of water in tanks and remove water bottoms promptly.

• Periodic Inspection and Maintenance – monthly walk-through inspections of dispenser cabinets, spill buckets and sumps.

• Periodic Internal Tank Inspections – remove drop tubes and ATG probes.

• Minimize Stagnant Product in Tanks – aged product degrades.
Section 4. Retail Storage Tanks and Dispenser Filters

4.1. Water in Gasoline-Alcohol Blends, Biodiesel Blends, Ethanol Flex Fuel, Aviation Gasoline, and Aviation Turbine Fuel. – No water phase greater than 6 mm (¼ in) as determined by an appropriate detection paste or other acceptable means, is allowed to accumulate in any tank utilized in the storage of gasoline-alcohol blend, biodiesel, biodiesel blends, ethanol flex fuel, aviation gasoline, and aviation turbine fuel.

4.2. Water in Gasoline, Diesel, Gasoline-Ether, and Other Fuels. – Water shall not exceed 25 mm (1 in) in depth when measured with water indicating paste or other acceptable means in any tank utilized in the storage of diesel, gasoline, gasoline-ether blends, and kerosene sold at retail except as required in Section 4.1. Water in Gasoline-Alcohol Blends, Biodiesel Blends, Ethanol Flex Fuel, Aviation Gasoline, and Aviation Turbine Fuel.
Proposed Revision

• Harmonize water thickness allowance among all fuels, streamline and simplify HB 130.

• Best management practice - any measurable phase separated water in fuel is not desirable and if not managed promptly can have adverse effects on fuel quality, stability and in some cases cause drivability issues.

• Fuel formulation changes (especially with diesel) over the last decade make today's fuels more susceptible to water.

• No new technology required to measure 1/4 inch water in tanks. NIST HB 158 and EPA have a 1/8 inch requirement.
X6 | MICROBIAL CONTAMINATION

X6.1 Uncontrolled microbial contamination in fuel systems can cause or contribute to a variety of problems, including increased corrosivity and decreased stability, filterability, and caloric value. Microbial processes in fuel systems can also cause or contribute to system damage.

X6.2 Because the microbes contributing to the problems listed in X6.1 are not necessarily present in the fuel itself, no microbial quality criterion for fuels is recommended. However, it is important that personnel responsible for fuel quality understand how uncontrolled microbial contamination can affect fuel quality.

X6.3 Guide D6469 provides personnel with limited microbiological background an understanding of the symptoms, occurrences, and consequences of microbial contamination. Guide D6469 also suggests means for detecting and controlling microbial contamination in fuels and fuel systems. Good housekeeping, especially keeping fuel dry, is critical.
Publications on this Issue

• **Steel Tank Institute** - R111 Storage Tank Maintenance Standard

• **CRC Report No. 672** - Preventive Maintenance Guide for Diesel Storage and Dispensing Systems

• **CRC Report No. 667** - Diesel Fuel Storage and Handling Guide. September 2014

• **Clean Diesel Fuel Alliance** - Guidance for Underground Storage Tank Management at ULSD Dispensing Facilities
INTRODUCTION

Operations and maintenance procedures for water monitoring and removal in fuel storage tanks have been a recommended practice for over thirty years. However, a number of factors have changed over the past few years that have increased the risk for water entry and accumulation in the storage system, and subsequent potential for microbial growth, if water is not removed.

Today's distribution/delivery infrastructure is different from only a few years ago. Terminal capacity in the United States has been shrinking, yet fuel consumption has continued to grow. As a result, more fuel is moving through distribution at a faster rate, allowing less time for water to settle out before the product moves through each phase in the distribution process. Also, as the industry has moved from proprietary to shared delivery infrastructures, individual companies have less control over the process and product.

Gasoline chemistry has changed significantly as well, from the removal of lead and MTBE, to additives such as ethanol. Most of these changes were made to comply with standards set by EPA Fuels and Fuel Additive Regulations (40 CFR 79) that became effective in 1996.

These new fuels are more susceptible to moisture accumulation, separation, and potential biodegradation accelerated by water. For example, lead was a natural poison to the microbes that can grow in a moist environment, but in today's lead-free fuels, microbial growth can more readily occur. With alcohol-enhanced fuels, "phasing" can more easily occur, separating water, gasoline, and alcohols into three distinct layers.

Most of these conditions did not exist in the 1970s, 1980s, or even much of the 1990s—certainly not to the extent that they exist today. Furthermore, microbial activity is better understood today and has been found to be a much more common phenomenon than previously realized.

Owners and operators of storage systems need to be aware of these problems and immediately implement operations and maintenance practices to monitor for and remove any water from storage tanks.
Preventive Maintenance Guide for
Diesel Storage and Dispensing Systems

This guide provides practical tips for maintaining underground storage tanks (USTs), minimizing fuel contamination and maximizing fuel system cleanliness necessary for diesel equipment. Adopting these guidelines can help improve fuel quality, prolong equipment life, reduce corrosion and owner’s operating expenses. All suggestions below should be performed in a safe, legal and environmentally sensitive manner.

Good water management eliminates most fuel quality problems:

Keep water from entering tanks to minimize tank water bottoms:

- Remove standing water, ice and/or snow around tank fill covers.
- Make sure all tank opening bungs and caps are tight – Inspect and replace any broken gaskets.
- Keep fill and vapor recovery buckets clean – pump out any water, clean out excess fuel and dirt (don’t depress drain plungers allowing contamination into the tank).
- Verify tank vents are installed and caps are sealing properly – replace cap or repair as needed.
- Avoid prolonged periods of low tank volume to minimize tank water from condensation.

No detectable water is desirable and if found should be removed as soon as possible. Test removed water for microbes. If detected, take appropriate corrective action. If biocide is used, expect more frequent filter changes for a brief period.

Methods of detecting contaminants/water

Tank gauging—physically stick tank bottoms with water finding paste weekly and compare to automatic tank gauge electronic measurements (if available).

- The following will affect the water level measurements: Striker plate below gauging equipment, drop tube tank protection devices, sloping tank, and correct use of water finding paste.
Examples of microbial contaminated samples and corroded fuel system parts:

(F1 - ATG Floats w Corrosion Products
F2 - Diesel Tank Bottom Sample w Microbes
F3 - Corroded Dispenser Filter
(Courtesy Innospec Fuel Specialties and Biodeterioration Control Associates)

Evidence of contaminants and/or water:

<table>
<thead>
<tr>
<th>Dispenser filters</th>
<th>Other indicators</th>
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<tr>
<td>- Clogging/frequent replacements</td>
<td>- Meter failure</td>
</tr>
<tr>
<td>- Slow flow, especially after new receipts—indicates possible contamination (should be &gt;5 gallons per minute)</td>
<td>- Automatic Tank Gauge (ATG) water warnings/alarms</td>
</tr>
<tr>
<td>- Observed rust, microbial slime or other contamination</td>
<td>- Automatic nozzle shutoff failures</td>
</tr>
<tr>
<td></td>
<td>- Customer complaints</td>
</tr>
<tr>
<td></td>
<td>- Check valves not seating</td>
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EPA pump labeling and downgrading facts for ULSD supplier and fleet compliance.

With certain exceptions, the EPA's ULSD regulations require retailers and operators of fleet fueling facilities to label diesel fuel pumps with specific language identifying the type of fuel being dispensed.

Results of the consortium ULSD surveys, September 2006 through the Third Quarter 2011

It is recommended that facility owners/operators implement a simple and routine set of management and housekeeping practices to monitor and minimize fuel quality and fuel system issues.

Guidance for Underground Storage Tank Management at ULSD Dispensing Facilities 8-16-10

In addition, diesel fuel designated as ULSD must remain ULSD (15 ppm sulfur content) throughout the distribution system, with certain exceptions. The EPA Ultra Low Sulfur Diesel Fuel Labeling and Downgrading Fact Sheet provides information that describes the pump labeling requirements and how downgrading provisions affect tank truck carriers, retailers and fleet fuel facilities, as well as the potential consequences of failing to comply with the regulations.

Also, the Clean Diesel Fuel Alliance PowerPoint® presentation on ULSD Downgrading provides an overview of downgrading provisions, regulations, compliance dates, recordkeeping, examples, kerosene blending, and penalties.

EPA Winterization Standards Letter 11-30-07
Approved Alternative Product Transfer Wording 6-22-06
Approved Alternative Product Transfer Wording and Language Correction 7-20-07
Approval of Alternative Product Transfer Document Language for Heating Oil 10-10-07
Approved Product Transfer Document Language for Undyed 500 ppm NR Diesel and Undyed 500 ppm LM Diesel 5-4-10

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GUIDANCE FOR UNDERGROUND STORAGE TANK MANAGEMENT AT ULSD DISPENSING FACILITIES

INTRODUCTION
If a fuel storage facility is not properly maintained, bacteria and fungi can grow in the fuel-water interface, causing filter problems and deactivating the water monitoring system. With the exception of fuel with inadequate low-temperature fluidity (i.e., wax formation in diesel tanks at cold temperatures), most problems can normally be avoided by keeping the fuel storage system clean and as water-free as possible.

Water in the storage system can accelerate fuel degradation which should be avoided in order to assure vehicle performance and because it can increase sludge accumulation in the bottom of tanks. Contaminants such as salts in the water may cause the fuel chemical structure to degrade into components that may be detrimental to storage system components. These contaminants may also cause fuel additives necessary for maintaining the quality of the fuel distribution system to leave the fuel and enter the water.

Not only is water a problem in itself, but it is also the environment for biological growth within the fuel. Less than 0.25 inches of water is more than sufficient to promote microbial growth. Microorganisms live at the fuel-water interface and feed on the fuel. The presence of microorganisms can lead to filter-plugging, pump and injector problems, deactivation of the water monitor and buildup within the tank that is costly to remove.

IDENTIFICATION OF SYMPTOMS
When dispenser flow slows to about half its normal rate (at gas stations from 10-12 gpm to around 5 gpm or at truckstops from 30 or more gpm to about 15 gpm), it is an indication that the dispenser filter requires attention and needs to be replaced. However, reduced dispenser flows along with frequent filter replacement, constant system maintenance or customer complaints may indicate that a more systemic problem exists as opposed to routine maintenance. Signs of fuel or fuel system issues include
Solving Common Rail Diesel Problems

The Common Rail Diesel (CRD) injection system is the most recent development to achieve ever more stringent diesel exhaust emission standards, but it is currently associated with widespread problems, including engine rattles, expensive injector and fuel pump failures, injector sticking, stalling problems and rapid piston and liner wear. Problems have been documented across a wide range of engine suppliers, including Toyota, BMW, Volkswagen, Nissan and many more.
Collaboration Opportunities?

• Raising awareness about ULSD corrosion issues
• Changing acceptable water limits in fuel
• Engineered solutions – nitrogen blanketing, filming amines, biocides, etc.
• Research projects
• Partnerships - tank manufacturers, refiners, autos
‘Catastrophic’ Fire Ball incident at Ohio State Fair caused by corrosion, ridemaker says

By Lindsey Bever and Alex Horton  August 7

The ride manufacturer said excessive corrosion caused the 18-year-old ride to malfunction.

Authorities said one 18-year-old man died and seven others were injured after a ride malfunctioned at the Ohio State Fair on July 26. (Amber Ferguson/The Washington Post)
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