Ultra Low Sulfur Diesel

Presented By: Eric Fegley
ULSD & Lubricity

- Natural lubricating property in fuels
  - Sulfur is a natural lubricant
  - ULSD regulations a major concern with diesel engine performance

- ASTM Lubricity requirement effective Jan 1, 2005 for **diesel fuels**
  - High Frequency Reciprocating Rig (HFRR)
  - 520 micron max scar
2007 Model Year Engines

- EPA regulations require reduced sulfur in diesel fuel for 2007 model year engines
- 80% of highway diesel fuel must be ULSD (≤ 15 ppm sulfur) beginning June 1, 2006
ULSD Timeline

<table>
<thead>
<tr>
<th>Year</th>
<th>Highway Diesel Fuel</th>
<th>Non-Road (NR)</th>
<th>Locomotive &amp; Marine (LM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006</td>
<td>≤ 500 ppm</td>
<td>≤ 5000 ppm</td>
<td>≤ 5000 ppm</td>
</tr>
<tr>
<td>2007</td>
<td>80% of pool ≤ 15 ppm</td>
<td>≤ 500 ppm</td>
<td>≤ 500 ppm</td>
</tr>
<tr>
<td>2008</td>
<td>≤ 15 ppm</td>
<td>≤ 15 ppm</td>
<td>≤ 15 ppm</td>
</tr>
<tr>
<td>2009</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2010</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2011</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2013</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2014</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

≤ 15 ppm = ULSD
≤ 500 ppm = LSD
≤ 5000 ppm = HSD
U.S. Supply & Demand

- “Real” demand for ULSD
  - Government Fleets
  - Special applications
  - Mandated retrofits
  - New 2007 + engines

- Little “real” demand for ULSD in 2006

- EPA mandated 80% of on-road diesel supply be ULSD by June 2006

- “Real” demand projected to be ~25% of all on-road diesel by 2010 and ~50% by 2015

*Results of Turner, Mason & Company industry survey*
Expected ULSD Demand vs. ULSD Supply

*Results of Turner, Mason & Company industry survey
Refiners Have Few Alternatives

- Heating oil is a viable alternative in PADD I
- Off-road diesel, which EPA will lower to 500 ppm in 2007 and 15 ppm in 2010, is the dominate HS distillate outside PADD I
- Nature of supply chain dictates that some off-road markets will be supplied “on-road quality”
- Loss of fungibility between heating oil and off-road diesel will limit or eliminate HS diesel supply in certain regions

*Results of Turner, Mason & Company industry survey*
Current Status of Industry
ULSD Preparations

- U.S. Refineries are well along with plans/implementation to produce ULSD by 2006

- Supply capabilities will be greater than forecasted demand in 2006-2010

- Major pipeline systems have been working with shippers and terminal operators to define distribution system over last two years – but are not as advanced in their preparedness as the refineries
U.S. Refining Industry Plans

- Planned ULSD capacity by June 2006 of >2.5 million BPD*

- 90% of refineries surveyed have designed units to produce ULSD with 7-10 ppm sulfur*

*Results of Turner, Mason & Company industry survey

* As measured at distillate HDS unit outlet.
### 2006 EPA Transitional Flexibility

<table>
<thead>
<tr>
<th>Category</th>
<th>Current</th>
<th>Proposed</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Refineries</strong></td>
<td>15 ppm</td>
<td>22 ppm</td>
</tr>
<tr>
<td></td>
<td>June 1</td>
<td>June 1</td>
</tr>
<tr>
<td><strong>Pipelines &amp; Terminals</strong></td>
<td>15 ppm</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>July 15</td>
<td>July 15</td>
</tr>
<tr>
<td><strong>Retail</strong></td>
<td>Sept 1</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Oct 15</td>
</tr>
</tbody>
</table>
2004 ULSD Transportation Tests
MAP 2004 ULSD Testing

- Sulfur in ULSD increases as it moves through each part of the transportation system

- To meet the 15-ppm spec when the fuel reaches the customer, pipeline and terminal operators will not allow ULSD that contains sulfur above a specified amount

- Receipt specs may be different at different facilities
  - Pipelines 7 to 9 ppm
  - Terminals 12 to 13 ppm
  - Refineries will need to produce in 5 to 7 ppm range.
# Contamination Concerns

<table>
<thead>
<tr>
<th>7,500 Gallons 15ppm ULSD contaminated with:</th>
<th>&lt;500 ppm Diesel Fuel</th>
<th>&lt;3000 ppm Jet/Diesel Fuel</th>
<th>&lt;5000 ppm Heating Oil</th>
</tr>
</thead>
<tbody>
<tr>
<td>7 Gallons or .1%</td>
<td>+ 0.5 ppm</td>
<td>+ 3 ppm</td>
<td>+ 5 ppm</td>
</tr>
<tr>
<td>37 Gallons or .5%</td>
<td>+ 2.5 ppm</td>
<td>+ 15 ppm</td>
<td>+ 25 ppm</td>
</tr>
<tr>
<td>75 Gallons or 1%</td>
<td>+ 5 ppm</td>
<td>+ 30 ppm</td>
<td>+ 50 ppm</td>
</tr>
</tbody>
</table>
Terminals and Bulk Plants

- Sulfur increased as it moved through dead leg piping that contained higher sulfur products
- Product layering occurred when ULSD was put into above ground storage tanks
- A single tank sample did not represent the overall product sulfur level of the tank
- Due to product layering, heel mixing may not be effective for converting tanks to on-spec ULSD
- Tanks should be completely emptied, two or more times.
Converting Above Ground Storage Tanks

- Take several samples at different liquid heights to obtain an accurate sulfur reading
- Completely empty tanks at least two times before accepting ULSD into a tank
- Check each facility thoroughly for possible dead leg piping contamination
Transports

- Sloped-bottom transports
  - should contribute little, if any, sulfur contamination to ULSD

- Flat-bottom transports
  - can cause significant sulfur contamination to ULSD
  - Sulfur contamination can be reduced by draining compartments prior to loading ULSD

- All transports need to be completely drained when switching from higher sulfur products to ULSD

- Flushing compartments with ULSD prior to loading helps remove sulfur left from other products
Retail Marketing / Jobbers

- During 2004 test program, USTs showed signs of product layering.
- Mixing ULSD among several manifold tanks can alleviate product layering
- Making multiple deliveries into different tanks promotes better mixing
- Product layering can occur if the volume of ULSD delivered is less than 60 percent of the final inventory in the UST
**Station Drop Volume Correlation**

\[
\% \text{ Drop Volume} = \frac{\text{Volume of Load Delivered}}{\text{Total Inventory After Delivery}}
\]

<table>
<thead>
<tr>
<th>Location</th>
<th>% Drop Volume</th>
<th>Layering?</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>LOUISVILLE</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Truck Stop A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tank 1 *</td>
<td>70%</td>
<td>No</td>
</tr>
<tr>
<td>Tank 2</td>
<td>66%</td>
<td>No</td>
</tr>
<tr>
<td>Tank 3</td>
<td>70%</td>
<td>No</td>
</tr>
<tr>
<td>Truck Stop B</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tank 1</td>
<td>86%</td>
<td>No</td>
</tr>
<tr>
<td>Tank 2 *</td>
<td>77%</td>
<td>No</td>
</tr>
<tr>
<td>Gas Station</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tank 1*</td>
<td>25%</td>
<td>Yes</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Location</th>
<th>% Drop Volume</th>
<th>Layering?</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MACON</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Truck Stop C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tank 1 *</td>
<td>58%</td>
<td>Slight</td>
</tr>
<tr>
<td>Tank 2</td>
<td>49%</td>
<td>Yes</td>
</tr>
<tr>
<td>Truck Stop D</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tank 1</td>
<td>63%</td>
<td>No</td>
</tr>
<tr>
<td>Tank 2</td>
<td>62%</td>
<td>No</td>
</tr>
</tbody>
</table>

* drop tank
Converting USTs

When planning ULSD deliveries

- Minimize product inventories in all USTs prior to receiving ULSD.
- Schedule several ULSD deliveries into different tanks.
Regulations
ULSD – Designate & Track Rules

What is Designate and Track?

- From the time a distillate product leaves a refinery till it arrives at a retail location, the product transfer document into and out of each “facility” will need to specify:
  - The intended use of the distillate
    - highway use or
    - non-road use and
  - The sulfur content of the product
    - Ultralow sulfur diesel <15 ppm sulfur,
    - Low Sulfur Diesel <500 ppm sulfur,
    - High Sulfur Diesel <5000 ppm sulfur, or
    - Jet <3000 ppm sulfur.
Designate and Track

- A “facility” can be:
  - Pipelines (or pipeline segments)
  - Pipeline breakout tankage
  - Marine transportation facilities
  - Rail transportation facilities
  - Terminal facilities
  - Bulk Plant facilities
  - Any combination of these

- A retail station is not a “facility”

- Facilities must be register with the EPA by December 31, 2005. Visit the EPA website for facility registration forms and instructions
20% Downgrade Limit

- A “downgrade” occurs when one product is sold as a product of lesser quality or value
  - premium gasoline to regular gasoline
  - low sulfur diesel to high sulfur diesel

- The only restricted downgrade placed by the EPA is highway ultra low sulfur diesel to highway low sulfur diesel

- No more than 20% of highway ULSD can be downgraded to highway LSD within a “facility”
## ULSD Product Distribution & Downgrades

### ULSD Distribution – Refinery to Market - Downgrade Flow Chart

<table>
<thead>
<tr>
<th>Refining</th>
<th>Transportation Pipeline / Marine</th>
<th>Terminal</th>
<th>Retail</th>
</tr>
</thead>
<tbody>
<tr>
<td>ULSD</td>
<td>ULSD Only</td>
<td>ULSD Only</td>
<td></td>
</tr>
<tr>
<td>LSD</td>
<td>LSD Only</td>
<td>LSD Only</td>
<td></td>
</tr>
</tbody>
</table>

#### Scenario #1 – ULSD Only
- ULSD Only
- ULSD Downgrade Limit: 20% of Receipt Volume
- Downgrade Limit: 10 ppm Highway

#### Scenario #2 – ULSD & LSD
- ULSD Only
- LSD Only
- ULSD Downgrade Limit: 20% of Receipt Volume
- Downgrade Limit: 10 ppm Highway

#### Scenario #3 – ULSD & Non-Road
- ULSD Only
- LSD Only
- ULSD Downgrade Limit: 20% of Receipt Volume
- Downgrade Limit: 10 ppm Highway

#### Scenario #1 – Stations Selling ULSD and LSD
- ULSD Only
- LSD Only
- ULSD Downgrade Limit: 10 ppm Highway
- LSD Downgrade Limit: 500 ppm Highway

#### Scenario #2 – Stations Selling Only ULSD
- ULSD Only
- LSD Only
- ULSD Downgrade Limit: 10 ppm Highway
- LSD Downgrade Limit: 500 ppm Highway

#### Scenario #3 – Stations Selling Only LSD
- ULSD Only
- LSD Only
- ULSD Downgrade Limit: 10 ppm Highway
- LSD Downgrade Limit: 500 ppm Highway

### Separate Facilities
1. Refining
2. Transportation
3. Terminals
4. Retail

The EPA allows various Downgrade compliance options, this graphic depicts the one that should provide the most flexibility.

[ULSD Downgrade Composite 08252004.vsd]
Unlimited Downgrading - Station Selling ULSD and LSD

Scenario #1 – Stations Selling ULSD and LSD

ULSD <15 ppm

ULSD <15

<15 ppm Highway Fuel

LSD <500 ppm

LSD <500

<500 ppm Highway Fuel
No Downgrades - Stations Only Selling ULSD
20% Downgrade Limit - Stations Only Selling LSD

Scenario #3 – Stations Selling Only LSD

ULSD < 15 ppm

LSD < 500 ppm

LSD < 500

< 500 ppm Highway Fuel
ULSD Compliance

- Compliance with applicable standards
- Designate and track requirements and limitations (through terminal level)
- Anti-downgrading rule
- Additive standards and use
- Product transfer documents
- Fuel pump stand labeling
- Report and record keeping
Misdeliveries

- Liability can occur if a “misdelivery” is allowed
- Check product transfer documents and reject improper fuel deliveries
- Ensure the fuel is dropped into the proper tank
- If an improper fuel delivery occurs, promptly stop sales of the contaminated product and correct the sulfur level
Misfueling

Liability can occur if “misfueling” is allowed

- For putting >15-ppm fuel into an engine that requires 15-ppm fuel.
- For allowing anyone else to put >15-ppm fuel into an engine that requires 15-ppm fuel.
- If retail pumps are not labeled properly.
Basics of Ethanol Blending
Ethanol Blending

What is Ethanol?

- Renewable biodegradable alcohol produced from grain or corn
- High Octane – 113 (R+M/2)
- Blends currently used in 15-20% of total US gasoline sales (Typically 90% gasoline 10% Ethanol)
- Mixable with all amounts of water
Ethanol Blended Gasoline
Phase Separation

- Ethanol can absorb small amounts of water
- If water exceeds 0.5% (5 gal per 1000 gal) Phase Separation will occur
- Water/ethanol phase will drop out of the fuel solution

Original ethanol blended fuel sample
A small amount of blue colored water is added
Water is added until initial Phase Separation occurs
Within an hour, phases are completely separate
Ethanol Blending

- Converting Station to Ethanol Blending
  - Station inspection
    - Review Tank History – What is in your tanks now?
    - Inspect Spill buckets, seals, gaskets, etc
  - Order special water/phase separation detecting paste
  - Order and Install 10 Micron Phase Detecting Alert filters.
Ethanol Blending

- Converting Station to Ethanol Blending
  - Reduce Tank Inventory as low as possible
  - Remove all water and or sediment bottoms
    - If “Rag” layer – treat with Biocide prior to removing water bottoms
    - May require tank cleaning
  - Deliver Blended Fuel
    - Fill Tank
  - Purge all Dispenser Lines
  - Check for water/Phase within 24 Hours of delivery
Questions?