Emissions, Engines & Ultra Low Sulfur Diesel Fuel Management Update for 2006
Beginning Sept 2006 **On-Road** Diesel Engines must be fitted with exhaust after-treatment technology:

- Oxidation & NOx catalytic converters
- Particulate traps

June 1, 2006 The Petroleum Industry must reduce sulfur in diesel fuel by 97% from 500 ppm to a maximum 15 ppm

Ultra Low Sulfur Diesel must be in retail locations nationwide by October 15, 2006
Clean Air Act
Non-Road Diesel Rule

Non-Road Diesel Engines must begin using Low Sulfur Fuel (max 500 ppm) in June 2007 and use Ultra Low Sulfur Diesel by June 2010.

Non-Road includes:
- Agriculture, Construction, Mining, etc.
- Locomotives
- Marine
Diesel Sulfur Phase-out Timeline

- **ASTM D975 HFRR**
  - June 1: Refineries
  - Sept 1: Terminals
  - Oct 15: Retail

- **On Hwy 80% S15**
  - Off Hwy S500

- **On Hwy 100% S15**
  - Off Hwy S15
  - excluding locomotive & marine

- **Off Hwy S15**
  - all NRLM diesel fuel

On Highway Rule: 40 CFR Parts 69, 80, 86
Off Highway Rule: 40 CFR Parts 9, 69, etc.
## What Are the Regulated Emissions

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Abbrev.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen Oxides</td>
<td>NOx</td>
<td>Is generated when combustion overheats the air. The natural oxygen and nitrogen combine, creating nitrogen oxides. NO and NO$_2$ are regulated, other oxides of nitrogen are not.</td>
</tr>
<tr>
<td>Hydrocarbons</td>
<td>HC</td>
<td>Caused by poor combustion - unburned fuel. Regulated as either total hydrocarbon (THC) or non methane hydrocarbon (NMHC)</td>
</tr>
</tbody>
</table>
### What Are the Regulated Emissions

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<tr>
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<tbody>
<tr>
<td>Carbon Monoxide</td>
<td>CO</td>
<td>Caused by poor combustion – lack of oxygen. Direct measurement</td>
</tr>
<tr>
<td>Particulate Matter</td>
<td>PM</td>
<td>Comprised of – carbon soot from unburned fuel, sulfur compounds to be largely eliminated with ULSF, and particulate ash from engine oil consumption</td>
</tr>
<tr>
<td>Smoke</td>
<td></td>
<td>Caused by poor combustion, excessive engine oil consumption and low Cetane. Opacity measured by optical methods</td>
</tr>
</tbody>
</table>
Attainment and Nonattainment Areas in the U.S. 8-hour Ozone Standard

- Attainment (or Unclassifiable) Areas (2668 counties)
- Nonattainment Areas (432 entire counties)
- Nonattainment Areas (42 partial counties)
Directly-Emitted Diesel Fine Particle Concentrations by County
Diesel Particulates

Are carbon at their core with toxic and carcinogenic substances attached to their surfaces
36 Toxic Air Contaminants in Diesel Exhaust

- Acetaldehyde
- Acrolein
- Aniline
- Antimony Compounds
- Arsenic
- Benzene
- Beryllium Compounds
- Biphenyl
- Bis(2-ethylhexyl) phthalate
- 1.3-butadiene
- Cadmium
- Chlorobenzene
- Chromium Compounds
- Cobalt Compounds
- Cresol Isomers
- Cyanide Compounds
- Dioxins & Dibenzofurans
- Dibutylphthalate
36 Toxic Air Contaminants in Diesel Exhaust

- Ethyl Benzene
- Formaldehyde
- Hexane
- Inorganic Lead
- Manganese Compounds
- Mercury Compounds
- Methanol
- Methyl Ethyl Ketone
- Naphthalene
- Nickel
- 4-Nitrobiphenyl
- Phosphorus
- Poly-cyclic Aromatic Hydrocarbons (PAH)
- Propionaldehyde
- Selenium Compounds
- Styrene
- Toluene
- Xylene isomers & mixtures
On-Road Heavy Duty Emission Requirements
Where Have We Been – Where Are We Going?

Beginning 2006

Emission Requirements for 2006

NO\textsubscript{x}: 0.2 g/bhp-hr

Particulates: 0.01 g/bhp-hr
Emission Levels in Perspective
g/bhp-hr (454 grams = 1 pound)

1998 Model 455hp Diesel Engine
HC 1.30 x 455 = 1.3 pounds per hour
NOx 4.00 x 455 = 4.0 pounds per hour
PM 0.07 x 455 = 0.1 pounds per hour
Emission Total = 5.4 pounds per hour

2007 Model 455hp Diesel Engine
HC 0.14 x 455 = 0.14 pounds per hour
NOx 0.20 x 455 = 0.20 pounds per hour
PM 0.01 x 455 = 0.01 pounds per hour
Emission Total = 0.35 pounds per hour

Equals a 93% Reduction in Emissions
EPA Estimated Reduction of Emissions

There are over 13 million Highway and Non-Road Diesel powered vehicles in the USA. When new diesel and fuel technologies are fully implemented:

- Cut harmful pollution by 90%
  - 3.3 million tons of smog-causing nitrogen oxide emissions per year
  - 250,000 tons of particulate matter per year
EPA’s Estimated Health Benefits of Clean Fuel & Vehicle Programs

- Premature deaths: 20,000
- Chronic bronchitis: 12,000
- Hospital admissions: 18,000
- Lost work days: over 3 million

# prevented annually (in 2030)
2007 Model Year Diesel Engines Are Re-Designed to Reduce Emissions

Ultra Low Sulfur Fuel Is Required for These New Engines & Devices to Work
Cummins, Detroit Diesel, International, Mack, Mercedes Benz, Volvo and Other’s 2007 Engines

Next Generation

**Heavy** EGR and VG Turbo Charging

**PLUS**

1. Oxidation Catalyst
2. Diesel Particulate Trap
Next Generation Cooled HEGR

The Volume of Exhaust Gas Recirculation in 2007 model engines will probably **DOUBLE** over the 2004 engine models. Another reason for ULSD to reduce the amount of sulfuric acid returning to the engine via EGR

Source: Cummins
Variable Geometry Turbocharger (VGT)
Caterpillar 2007 Engines

Next Generation Advanced Combustion Emission Reduction Technology

ACERT® with Clean Gas Induction & VGT

PLUS

1. Oxidation Catalyst
2. Particulate Trap
3. “Clean” EGR?
Oxidation Catalysts

- Reduces Hydrocarbons (HC) and Particulate Emissions (PM) and some NOx Emissions
- WILL REQUIRE ULTRA LOW SULFUR FUEL TO WORK
- Expected cost of “add-on” catalysts systems is about $2,000 to $5,000
  - Honey comb rare earth ceramic with active surface coated with either **Platinum**, **Rhodium**, or **Palladium**
Oxidation Catalysts

Dirty Exhaust with Carbon Monoxide & Unburned Hydrocarbons

O₂ → CO₂, H₂O

Carbon Dioxide Gas & Water Vapor
Diesel Particulate Filters or Traps

- Requires less than 50 PPM sulfur fuel
- Requires cleaning to remove ash
- Requires backpressure monitor
- Requires engines to be maintained for low oil consumption <1 Qt/1000 miles
Diesel Particulate Filters

- Designed to replace existing muffler (can be retro-fitted to older engines)
- Some traps are designed to be taken apart for cleaning
- Per EPA, particulate filters must go 150,000 miles between cleanings
Catalyzed Diesel Particulate Filter

- Some Particulate Filters have built-in Oxidation Catalyst and are designed to be manually cleaned.
Catalyzed Particulate Filter with Active Regeneration Using Fuel Injection

- Constructed of aluminized stainless steel surrounding a ceramic substrate, this system actively monitors the filter status and regenerates the filter when necessary.
- Small Diesel Fuel Injector
Diesel engine undergoing physical and catalytic durability testing at Southwest Research Institute

Additional cost of new exhaust devices will be $5,000 to $10,000 depending upon engine size for new 2007 diesel trucks and buses

Photo Courtesy of Southwest Research Institute
2007 Requirements for New School Buses

- Improved Injection Precision & Combustion Control (CAT – ACERT)
- Improved On-board Diagnostic Capability
- Engine Oil to Control Oil Consumption & Be Compatible with After Treatment
- Improved Fuel Lubricity, Stability & Detergency Additive
- Ultra Low Sulfur Diesel Fuel
- Active Particulate Filters
- Oxidation Catalysts
- Exhaust Gas Recirculation VG Turbo-Charger
- Increased Maintenance?
What Do I Need to Know About ULSD?
Total highway diesel Demand was 2.4 million bbl/day in 2004

Planned ULSD refinery Capacity by September 2006 is >2.5 million bbl/day

90% of the refineries surveyed have designed hydrogen desulfurization units to produce ULSD with 7 – 10 ppm sulfur

Source: US Dept of Energy/American Petroleum Institute
U.S. Distillate Inventory
Actual/Projected End of Year

* Does not include Northeast Home Heating Oil Reserve
Source: DOE/EIA
Ultra Low Sulfur Diesel
Removing Sulfur Chemically Changes the Fuel

- Poor lubricity
- Reduced oxidative stability
- Lower conductivity
- Changes cold flow behavior
- Less solvency – watch for injector deposits
- Lower density – lower Btu energy content per gallon
FTIR Analysis of ULSD (Green) “Regular LS Diesel” (Black)

Beneficial Nitrogen Compounds Removed

20% Aromatics in LS Diesel compared to 1% in ULSD

Sulfur Compounds
# Diesel Fuel Today & October 2006

## Properties

<table>
<thead>
<tr>
<th></th>
<th>ULSD Requirements</th>
<th>May 2006 California</th>
<th>May 2006 Rest of USA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cetane Number</td>
<td>55 min</td>
<td>48</td>
<td>43</td>
</tr>
<tr>
<td>Cetane Index</td>
<td>52 min</td>
<td>45</td>
<td>40</td>
</tr>
<tr>
<td>Density, kg/m³</td>
<td>820 min 840 max</td>
<td>844</td>
<td>847</td>
</tr>
<tr>
<td>Sulfur, ppm</td>
<td>&lt;15</td>
<td>300 max</td>
<td>500 max</td>
</tr>
<tr>
<td>Total Aromatics, %</td>
<td>1</td>
<td>&lt;10</td>
<td>15 to 25</td>
</tr>
<tr>
<td>Lubricity, ASTM D975-04c SBOCLE minimum load, gram or HFRR Maximum scar diameter, microns</td>
<td>3100 520</td>
<td>NR</td>
<td>NR</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Ultra Low Sulfur Diesel
Off-Road Fuel Is Changing Too

- In advance of June 2007 requirement for Low Sulfur Diesel – Max 500 ppm Sulfur
- From September 2006 to June 2007 - Off-Road Diesel could have a sulfur range of 18 ppm to 3400 ppm Sulfur
- Off-highway equipment will see “off-spec” ULSD (>18 ppm S) that is downgraded
Ultra Low Sulfur Diesel

Lubricity

- 100% of ULSD needs Lubricity Additives
- Diesel Fuel serves as the Only Lubricant for pumps and injectors
- Fuels with insufficient lubricity will cause severe wear of fuel pumps and fuel injectors
Ultra Low Sulfur Diesel Lubricity

Highlighted States Have Delayed Implementation of Diesel Fuel ASTM D975-04c Lubricity Standard

Source: OPIS ULSD & Biodiesel Supply Conference March 8-10, 2006
ULSD Lubricity Improvement
Using Biodiesel or Additives

Source: Lubrizol Corporation

**Preferred Level of Lubricity**
2% or B2

**Biodiesel vs. Lubricity Improver in ULSD**

- **Treat Rate Comparison**
- **75 ppm LAC**
- **ASTM D975-04b**
- **Preferred Level of Lubricity**
- **EN 590**
- **100 to 150 ppm Lubricity Additive**

**Source:** Lubrizol Corporation
<table>
<thead>
<tr>
<th>Lubricity Additives vs. Biodiesel</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Conventional Additives</strong></td>
</tr>
<tr>
<td>✧ Treat 75 (LAC) – 150 ppm</td>
</tr>
<tr>
<td>✧ Attractive handling characteristics</td>
</tr>
<tr>
<td>✧ Low Additive Concentration</td>
</tr>
<tr>
<td>✧ Lower storage requirements</td>
</tr>
<tr>
<td>✧ Use of existing handling systems</td>
</tr>
<tr>
<td>✧ Ratable economics</td>
</tr>
<tr>
<td><strong>Biodiesel</strong></td>
</tr>
<tr>
<td>✧ Treat 20,000 ppm or 2%</td>
</tr>
<tr>
<td>✧ Feedstock dependent handling temperatures</td>
</tr>
<tr>
<td>✧ Larger capacity storage, heat requirements</td>
</tr>
<tr>
<td>✧ Overall infrastructure requirements</td>
</tr>
<tr>
<td>✧ Economic volatility – soy bean supply, weather</td>
</tr>
<tr>
<td>✧ Supply considerations to treat national diesel fuel pool</td>
</tr>
</tbody>
</table>
Ultra Low Sulfur Diesel Injector Deposit Problems

Analysis of injectors from problematic buses
- Injector tips heavily fouled
- Deposits also observed on the needle seat
- Rapid growth of deposits - 6,000 to 10,000 miles

Common Factors
- City Buses
- Electronically controlled in-line pump
- Serial injectors
- ULSD with passing lubricity

Source: Lubrizol Corporation
Magnification

Injector Deposit Problems

Significant deposits on injector tip with ULSF

350 ppm Sulfur
Clogged Injector Spray Pattern
Caused by Poor Fuel Quality

Results: Poor Combustion, Higher Emissions, Reduced Fuel Economy & Higher Maintenance Expenses
Improved fuel atomization allows more complete combustion for reduced emissions, more power and better fuel economy.
ULSD Delivery Concerns June 1 to October 15, 2006
Transporting ULSD from Refinery to Market

- **U.S. Highway Diesel Demand**
  2004 was 2.4 Million Bbl/day

- **Regional breakdown:**

<table>
<thead>
<tr>
<th>PADD</th>
<th>Demand, mbpd</th>
<th>Production, mbpd</th>
</tr>
</thead>
<tbody>
<tr>
<td>I East Coast</td>
<td>763</td>
<td>248</td>
</tr>
<tr>
<td>II Midwest</td>
<td>768</td>
<td>693</td>
</tr>
<tr>
<td>III South</td>
<td>428</td>
<td>1,248</td>
</tr>
<tr>
<td>IV Rocky Mtns</td>
<td>109</td>
<td>142</td>
</tr>
<tr>
<td>V West Coast</td>
<td>348</td>
<td>416</td>
</tr>
<tr>
<td><strong>Total:</strong></td>
<td><strong>2,416</strong></td>
<td><strong>2,847</strong></td>
</tr>
</tbody>
</table>

Source: DOE
Pipeline Issues

- Some pipelines will no longer handle distillate in excess of 500 ppm (with the exception of jet fuel).
- The ULSD sulfur spec required by pipelines ranges from 7 – 10 ppm with most pipelines’ limit being 8 ppm.
- Initially, Colonial Pipeline will NOT deliver ULSD beyond Fairfax, VA and will expand deliveries north as their experience increases.
- Pipeline expenses will probably increase dependent on the additional investment required to transport ULSD.
- Some OFF-ROAD High Sulfur Diesel demand will be supplied with “on-road quality” ULSD.
Pipeline Issues
What Is Transmix? How Will It Affect You?

- Transmix is the interface of two dissimilar products – in today’s pipeline operation the dissimilar products are Diesels and Gasoline.
- Transmix taken back to refineries or Transmix facilities for reprocessing.
- Today’s typical pipeline cycling pattern.

![Diagram showing pipeline cycling pattern with sulfur level at 1500 to 3000 ppm and 500 ppm].
A Little Sulfur Goes A Long Way
ULSD Is Dissimilar to All Other Diesel

<table>
<thead>
<tr>
<th>10,000 bbls ULSD 15 ppm contaminated with</th>
<th>500 ppm Diesel</th>
<th>3000 ppm Jet</th>
<th>Pipeline Rate = 8,500 BPH = 142 BPM = 2.4 BPS</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 bbls or 0.1%</td>
<td>+ 0.5 ppm</td>
<td>+ 3 ppm</td>
<td>4 Seconds</td>
</tr>
<tr>
<td>50 bbls or 0.5%</td>
<td>+ 2.5 ppm</td>
<td>+ 15 ppm</td>
<td>21 Seconds</td>
</tr>
<tr>
<td>100 bbls or 1%</td>
<td>+ 5 ppm</td>
<td>+ 30 ppm</td>
<td>42 Seconds</td>
</tr>
</tbody>
</table>

👉 ULSD exceeding 18 ppm sulfur must be down graded
Pipeline Issues
ULSD Will Increase the Volume of Transmix That Must be Reprocessed

- Terminals will need more tankage to handle higher volume of Transmix to separate “dissimilar” ULSD from Jet Fuel, Home Heating Fuel, Off-Road Diesel and Gasoline

- Higher Demand for tank trucks or pipelines to return Transmix for reprocessing

![Diagram showing the flow of fuels and Transmix with sulfur levels](image)
Other Distribution Systems
Will Cost More

How your fuel gets from the refinery to the regional terminal will determine the transportation charge:

<table>
<thead>
<tr>
<th>Mode</th>
<th>Cents/Gallon</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pipeline</td>
<td>1.5 – 2.5</td>
</tr>
<tr>
<td>Barge</td>
<td>4 – 5</td>
</tr>
<tr>
<td>Truck</td>
<td>30 – 40</td>
</tr>
</tbody>
</table>
Ultra Low Sulfur Diesel
There Will Be Distribution Issues During 2006

- Retail availability delayed until mid-October – when kerosene winter blends and heating oil demand increases
- Sulfur pickup in moving ULSD through pipeline, barge and truck distribution
- Severe EPA penalties for off-spec fuel ($32,500)
Delivery Disruptions & Price Spikes

- Areas at the most risk for high demand price spikes and disruptions are:
  - At the end of long pipelines – New England, Chicago
  - High heating oil inventory/demand – New England
  - Limited inventory diversity – PADD IV Rocky Mountains
  - Limited alternate supply sources – e.g., Florida

- Hopefully disruption to be short lived and corrected by January 2007

Source: Turner, Mason & Company Consulting Engineers
Ultra Low Sulfur Diesel Will Cost More

- 4 to 6¢ per gallon to recover capital expense for refinery modifications
  - $8 Billion Total Investment for hydrotreating to remove sulfur
- Another 1 to 2¢ to cover added refinery operating expenses
  - Process hydrogen and refinery energy
- 5 to 8¢ per gallon Cost Increase at the refinery spigot
- Supply & Demand will determine real Price
What Should You Do?

- Contact your fuel supplier to find out when ULSD will arrive in your area – You need to label your pumps
- Establish a RELATIONSHIP with your fuel supplier
- Do not be a “Spot Purchase Customer”
- Become a Preferred Customer so you will have a fuel allocation if there is a supply disruption
What Should You Do?

ULSD Testing

✧ Ask your supplier how will they ensure 15 ppm sulfur level?
✧ Laboratories are required to Qualify their Sulfur measurements with EPA per 40 CFR 80.580
✧ As of March 21, 2006 there were 170 Qualified Laboratories
  ✧ Will laboratory “turn-around” delay releasing ULSD from terminals to retail outlets?
What Should You Do?

Label your diesel fuel dispensing pumps

- From June 1, 2006 through May 31, 2010, any "wholesale purchaser-consumer," (like farmers, school bus & truck fleets, mines, quarries, etc.), who dispenses motor vehicle diesel fuel subject to the 15 ppm ULSD sulfur standard must affix the to the pump following conspicuous and legible label, in block letters of no less than 24-point bold type, and printed in a color contrasting with the background:

ULTRA-LOW SULFUR HIGHWAY DIESEL FUEL
(15 ppm Sulfur Maximum)
Required for use in all model year 2007 and later high
way highway vehicles and engines.

Recommended for use in all diesel vehicles and engines.
What Should You Do?

Label your diesel fuel dispensing pumps

- From June 1, 2006 through September 30, 2010, any wholesale purchaser-consumer, who dispenses motor vehicle diesel fuel subject to the 500 ppm sulfur standard must prominently and conspicuously display in the immediate area of each pump the following legible label, in block letters of no less than 24-point bold type, printed in a color contrasting with the background:

```
LOW SULFUR HIGHWAY DIESEL FUEL
(500 ppm Sulfur Maximum)

WARNING
Federal law prohibits use in model year 2007 and later highway vehicles and engines.

Its use may damage these vehicles and engines.
```
What Should You Do?

- Establish a fuel specification with your supplier
- Obtain Certificates of Analysis (C of As) for all your bulk fuel deliveries
  
  “C of As” should include:
  - Statement that your diesel fuel Meets ASTM D975 specification
  - Sulfur ppm
  - Cloud Point
  - Lubricity meets ASTM D975-04c performance
  - API Gravity – this is the density of your fuel. No. 2 Diesel has an API range of 30 to 42
What Should You Do?

API Gravity Effects Fuel Economy

- API gravity of diesel fuel has a profound effect on engine power.
- As a general rule, there is a 3-5% decrease in the thermal energy content of fuel for every 10 degree increase in API gravity.
- This decrease in energy content will result in roughly the same percentage decrease in engine power. Use of fuels with higher API gravity will also result in higher fuel consumption (lower mpg).

<table>
<thead>
<tr>
<th>API Gravity</th>
<th>Btu Per Gal</th>
</tr>
</thead>
<tbody>
<tr>
<td>30.0</td>
<td>141,800</td>
</tr>
<tr>
<td>31.0</td>
<td>141,200</td>
</tr>
<tr>
<td>32.0</td>
<td>140,600</td>
</tr>
<tr>
<td>33.0</td>
<td>140,000</td>
</tr>
<tr>
<td>34.0</td>
<td>139,400</td>
</tr>
<tr>
<td>35.0</td>
<td>138,800</td>
</tr>
<tr>
<td>36.0</td>
<td>138,200</td>
</tr>
<tr>
<td>37.0</td>
<td>137,600</td>
</tr>
<tr>
<td>38.0</td>
<td>137,000</td>
</tr>
<tr>
<td>39.0</td>
<td>136,400</td>
</tr>
<tr>
<td>40.0</td>
<td>135,800</td>
</tr>
<tr>
<td>41.0</td>
<td>135,200</td>
</tr>
<tr>
<td>42.0</td>
<td>134,700</td>
</tr>
</tbody>
</table>
What Should You Do?
Have Your Fuel Tested

- Take **Bottom Samples** from your storage tanks check for water and have tested for bacteria and fungus
What Should You Do?

- Ask how will your fuel supplier ensure proper lubricity of the fuel delivered to you
  - Lubricity additives will NOT be added at the refinery
    - Lubricity additives are NOT allowed in pipelines because they affect hydrolytic properties of commercial and military jet fuel
  - If you fuel supplier just uses the Lowest Additive Concentration (LAC) then ALL ULSD deliveries may NOT have adequate lubricity per ASTM D975-04C
What Should You Do?

- Clean your storage tanks
  - Remove water, rust, scale, and high sulfur bottoms
  - Especially important if you use Biodiesel for lubricity
- Have extra fuel filters available for your fueling station pump AND your vehicles
- Consider using a rust and corrosion inhibitor additive

Source: National Assoc. of Corrosion Engineers
What Should You Do?
Have Your Fuel Tested

- Take **Nozzle Samples** and have your fuel checked for oxidation stability:
- **Octel F21-61 Millipore** filters after filtering 50 ml of diesel fuel after 300°F Accelerated Stability Test
What Should You Do?

- Consider using a stability additive
- 55 Cetane ULSD promotes quicker combustion but is less oxidatively stable and prone to deposit formation during storage
- Many of the sulfur compounds removed from ULSD were also antioxidants that provided some fuel stability

78% Less Filter Blockage with Stability Additive

Untreated Fuel  Treated Fuel
What Should You Do?

- Check your vehicles fuel system for leaks and correct them now – the aromatics and sulfur compounds that are removed for ULSD provided some seal protection.
What Should You Do?

* Make sure injectors are clean & operating properly
* ULSD will have about 3% less Btus – like burning winter fuel (Diesel blended with kerosene)
* Dirty and malfunctioning injectors will only make fuel economy worse
Bottom-line

Every time we have changed our fungible fuels:

- 1993 High Sulfur to Low Sulfur Diesel
- Introduction of CARB Diesel in California
- Summer and Winter Grade Reid Vapor Pressure Gasolines
- Removal of MTBE from gasoline and replacing with ethanol
- Boutique Gasolines for special non-attainment areas
- AND NOW ULTRA LOW SULFUR DIESEL

There have been supply disruptions and unintended consequences

GET READY NOW!
Questions ?