

## **X. ULTRA LOW SULFUR DIESEL (ULSD)**

### **A. Product Overview and Description**

The EPA's diesel fuel regulation limits the sulfur content in highway diesel fuel to 15 ppm (by weight), down from the previous 500 ppm. Refiners will be required to start producing the 15 ppm sulfur fuel beginning June 1, 2006. At the terminal level, highway diesel fuel sold as low sulfur diesel fuel must meet the 15 ppm sulfur standard as of July 15, 2006. For retail stations and wholesale purchasers, highway diesel fuel was originally required to meet the 15 ppm sulfur standard by September 1, 2006, however the implementation date was extended to October 15, 2006 because of refinery production and distribution disruptions caused by the hurricanes of 2005. Refiners can also take advantage of a temporary compliance option that will allow them to continue producing diesel fuel with up to 500 ppm sulfur content in 20% of the volume of diesel fuel they produce until December 31, 2009. In addition, refiners can participate in an averaging, banking and trading program with other refiners in their geographic area. ULSDS will be required for use in offroad equipment beginning in 2010.

### **B. Emission Reduction**

Without the use of any other emission-reducing technology, the lower sulfur content of ULSD allows engine-out PM reductions of several percent (about 0.8% per 100 ppm reduction in sulfur content) compared to conventional highway low sulfur diesel fuel.

### **C. Status & Availability**

The U.S. Department of Energy, Energy Information Administration (DOE-EIA) has estimated that in 2004, 137 million gallons of ULSD were produced (prior to EPA's mandate) and made available in several areas of the country (primarily the West Coast, Mid-Atlantic, upper Mid-West, and the metro Houston areas) as a "technology enabler" to pave the way for advanced, sulfur-intolerant exhaust emission control technologies, such as DPFs and LNCs which will be needed to meet the 2007 emission standards.

### **D. Selection & Use Criteria**

ULSD enables catalyst-based retrofit technologies such as DPFs and DOCs to operate at maximum emission control efficiencies and effectiveness.

The lower sulfur content of ULSD has the benefit of reducing the acidic compounds that can promote fuel system corrosion, however, fuel-bound sulfur can help to promote fuel lubricity. The significant reduction of sulfur in ULSD, compared to conventional low sulfur diesel fuel can lead to increased wear in fuel injectors, particularly in older vehicles. Elastomer materials used in O-rings, seals and gaskets contained in fuel system components can also be degraded and fail. The diesel fuel industry is aware of this and is incorporating lubricity additives in ULSD to maintain lubricity.

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The significant majority of operators currently using ULSD have reported no problems with ULSD usage or delivery. Typical start-up problems involved failure of fuel pump seals on older model vehicles, plugged fuel filters, and leaking fuel system O-rings. Once the filters and O-rings were replaced, no further problems were experienced. Another problem identified was the need for periodic replacement of fuel dispensing equipment filters to achieve proper sediment and water control. This is a typical equipment maintenance practice and not considered unusual.

Most ULSD users have not reported any impact on fuel economy when switching from regular low sulfur diesel fuel to ULSD. One user reported that test data taken at various intervals throughout the project indicated that the ULSD it used contained about 4% less energy content than regular low sulfur diesel fuel, but that the impact on fuel economy was minimal (approximately 0.15%). Another user operating line-haul delivery trucks reported a 3.54% fuel economy penalty attributable to the ULSD fuel it used. In both cases, the grade of fuel was not specified. Furthermore, rigorous and extensive data collection procedures and involved statistical analysis would need to be performed to be able to segregate the fuel economy effect of ULSD from that caused by other factors, including any other retrofit technology products.

### **E. Costs**

The high differential cost between regular diesel and ULSD in some areas is due to special handling and delivery requirements. This high cost is another impediment to initiating programs with DPF, LNC/DPF and low-pressure EGR/DPF technologies. Public fleets that have installed DPFs on fleet vehicles and initially had the cost differential funded by a government grant, face a dilemma once that funding stops. A ULSD cost differential as high as \$0.20 per gallon or more adds significantly to a fleet's operating expenses and creates additional problems for continuing the program. Programs that have been successful in promoting the widespread use of ULSD to multiple public fleets (school bus, transit and city fleets) in a close geographic area have been successful in obtaining a supply of ULSD with a lower price differential (\$0.03 to \$0.05 per gallon).

### **F. Product Quality, Delivery, Storage and Fueling**

ASTM International has developed a fuel specification specific to ULSD. The Engine Manufacturers Association (EMA) recommends that anyone using ULSD do so with ULSD fuels meeting ASTM fuel specification D 975, and further, that the fuel have a minimum cetane number of 40, a minimum lubricity level of 3100 grams, and a minimum thermal stability value of 70% reflectance after aging for 180 minutes at a temperature of 150°C. Overall, the use of ULSD is expected to be transparent to vehicle users.

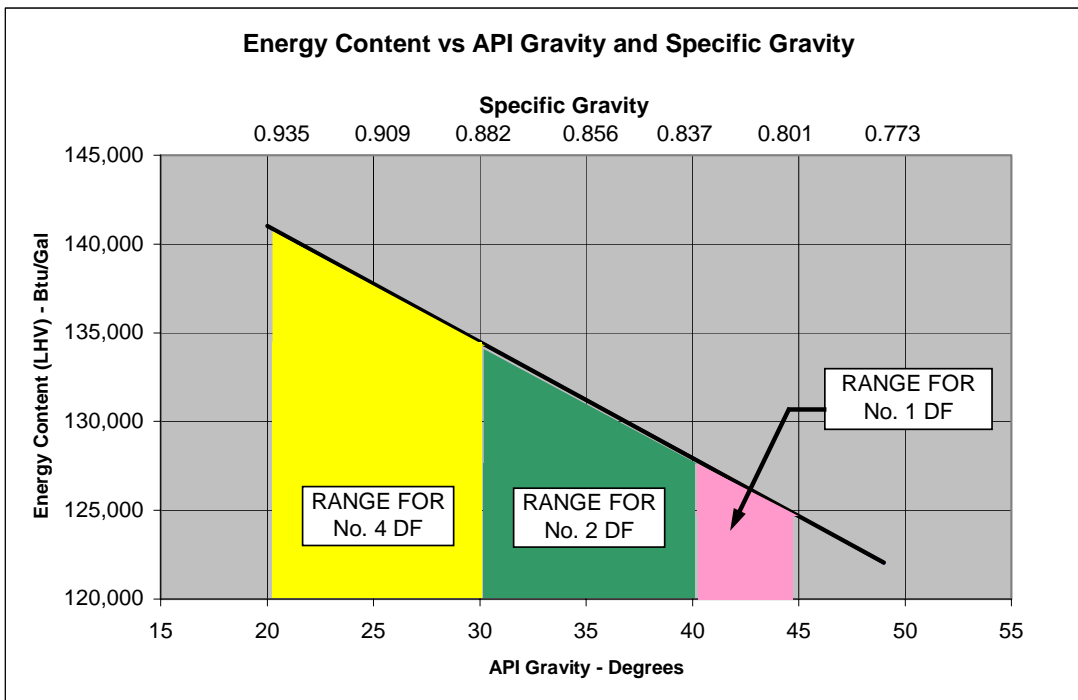
It is important to note that the energy content of ULSD is not inherently lower than that of diesel fuel of higher sulfur content. As shown in Figure 10-1, the energy content of the most widely used diesel fuel grades (No. 1, No. 2, and No. 4) vary by nearly 15% across all of the grades. The energy content can vary by up to 5% for No.2 diesel fuel, and by up to 2.5% for No. 1 diesel fuel. Note from Figure 10-1 that the energy content of No. 1 diesel fuel (which is often used as a blending component to winterize the No. 2 grade in areas with abnormally cold temperatures) is lower than that of No.2 diesel fuel, which is lower than that of No.4 diesel fuel

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(which is typically used in large diesel engines, particularly for marine applications). Also note that for these fuels, the relationship of energy density to specific gravity and API gravity is essentially linear. More dense (or “heavier”) fuels have a higher energy content than fuels of lower density. Since fuel economy is directly related to the energy content of a fuel, if all other things are equal, use of a fuel with a higher energy content would improve fuel economy, and vice versa.

*Figure 10-1, Energy Content of Diesel Fuels*



The ASTM International specification for diesel fuels (currently D 975-04c) contains no specification for diesel fuel energy content or API gravity. However, the National Conference on Weights and Measures (NCWM) and the EMA proposed definitions for so called “Premium Diesel” to ensure that consumers receive a functional benefit. To be sold as Premium Diesel fuel, the fuel must meet the minimum values for at least two of five criteria: 1) heating value (energy content), 2) cetane number, 3) low temperature operability, 4) thermal stability, and 5) fuel injector cleanliness. Thus, those that purchase Premium Diesel (of any grade) may also not be assured of getting fuel with a minimum energy content.

Diesel fuel users that are concerned about fuel quality can use a fuels hydrometer to determine the API gravity (and thus the energy content, as shown from the relationship in Figure 2-6). Fuels hydrometers are available for less than \$50 to allow the API gravity of fuels to be checked at the point of delivery to the fleet, thus providing an inexpensive means of checking the energy content (and first ordered quality check) of the fuel being delivered to the fleet. Checking the API gravity of fuel deliveries is a routine practice carried out in the aviation industry and is used as a one means for identifying fuel quality problems.

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In general, while the sulfur content of a fuel is not directly related to its energy content, some refinery processing methods used to remove sulfur from petroleum to the lower levels now required can alter the properties of the finished fuel in a way that results in a less dense fuel, for the same grade. Overall, as production of ULSD becomes widespread, the DOE-EIA estimates that an overall slight decline of 0.5% to 1.8% in energy content of ULSD might be possible.

To maintain the sulfur content integrity of ULSD, pipelines and the equipment used for fuel transport and storage must be well maintained and kept free from contaminants. This includes excess sulfur residue that may have accumulated from prior handling of diesel fuels with higher sulfur content. Measures should also be taken to prevent vehicle misfueling with higher level sulfur content fuels and the resultant problems that can occur with sulfur-sensitive retrofit products such as DPFs. To minimize the chances of misfueling a vehicle with regular diesel fuel, signage warning of the need to refuel with ULSD can be developed and displayed in prominent places on vehicles and equipment refueling. Vehicle filler caps can also be equipped with locks, the keys to which are available to only authorized personnel.

