

Diesel Fuel 101

What is diesel fuel?

Diesel fuel is principally a blend of petroleum-derived compounds called middle distillates (heavier than gasoline but lighter than lube oil) and may or may not contain additional additives. Other middle distillates include kerosene and No. 2 Heating Oil. Diesel fuel is designed to operate in a diesel engine where it is injected into the compressed, high-temperature air in the combustion chamber and ignites spontaneously. This differs from gasoline, which is ignited in a gasoline engine by the spark plugs.

What specification requirements of diesel fuel should concern me and why?

Sulfur content, Cetane number (ignition quality), cleanliness, lubricity, low-temperature operability and stability are the diesel fuel requirements of principal concern to you.

With the introduction of the 2007 model year, diesel powered vehicles have to meet stringent emissions limits. The equipment used by vehicles to meet those standards depend upon a fuel with very low sulfur content, 15 parts per million (ppm) or less, referred to as Ultra Low Sulfur Diesel (ULSD). Use of LSD, with sulfur content that can be as high as 500 ppm, can, in a single tank full, permanently damage the emission control equipment of the new vehicles. We should note that ULSD is suitable for all diesel engines including those manufactured before 2007. All diesel dispensers have a decal on them indicated the type of diesel fuel being dispensed. Look for the ULSD decal for 2007 model vehicles and newer.

The cetane number is a measure of the ease with which the fuel is ignited in your engine. It is most significant in relation to low-temperature startability, warm-up and smooth, even combustion. The cetane number of the fuel should meet your engine manufacturer's minimum recommendation for the type of service. A cetane number higher than required does not materially improve engine efficiency or operation. Most engine manufacturers recommend diesel fuels with a cetane number of at least 40. Diesel fuels sold by reputable marketers meet or exceed this requirement.

Cleanliness refers to the absence of water and particulate contamination. This characteristic is important because dirt and water can plug fuel filters in your engine and cause severe damage to your fuel injection system because of the close tolerances within fuel pumps and injectors. All diesel engine manufacturers equip their engines with fuel filters to protect the fuel delivery system. You should replace these filters according to the manufacturer's recommendations. Some manufacturers also provide filters with drain valves and recommend periodic draining of any water that may accumulate from condensation and careless handling in storage or vehicle tanks.

Lubricity is the characteristic that ensures protection against fuel pump and injector wear. Since 2005 the use of lubricity additives has become common and all Exxon diesel fuels intended for over the road use contain them.

Low-temperature operability is the ability of the fuel to flow and to be pumped through diesel fuel system filters without plugging at low temperatures. Filter plugging due to the presence of

wax crystals in the fuel can be estimated by measuring the cloud point temperature or other low temperature fluidity and filterability tests.

Stability is the term used to describe a fuel's resistance to the formation of gums and insoluble oxidation products. Fuels with poor oxidation stability contain insoluble particles that can plug fuel filters. This may lead to decreased engine performance or engine stalling from fuel starvation.

Is all diesel fuel sold at gas stations and truck stops in the U.s. now ULSD?

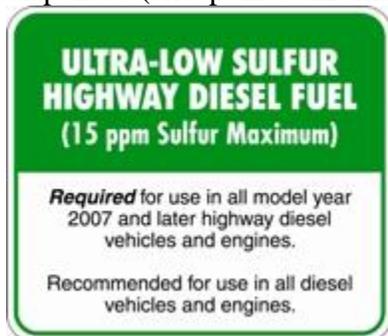
No. At present the EPA requires only 80% of the highway diesel fuel manufactured in the U.S. to be ULSD. Consumers may still find some LSD at services stations and truck stops until December 1, 2010 when EPA regulations will require all highway diesel fuel to be ULSD.

Does Exxon have ULSD available at all of its service stations?

No. At most Exxon retail locations where diesel fuel is sold, the product will be ULSD. However, some Exxon locations will still be selling LSD, particularly over the next several months as we make the transition from LSD to ULSD.

How will I know whether a pump is dispensing ULSD or the higher sulfur LSD fuel?

Federal regulations require all diesel fuel pumps to have labels specifying the type of fuel dispensed (except in California where all diesel fuel must be ULSD). Look for this decal.



What vehicles require ULSD?

Vehicles with diesel engines manufactured in the 2007 model year or later require the use of ULSD for proper operation. Using LSD or other improper fuel may reduce the efficiency and durability of engines, permanently damage advanced emissions control systems, reduce fuel economy and possibly prevent the vehicles from running at all. Additionally, manufacturer warranties are likely to be voided by improper fuel use.

How can I determine if my vehicle requires ULSD?

Instrument panel and fuel inlet/fill cap labeling is being mandated for 2007 and newer model year engines and vehicles that require ULSD fuel. Also, you can check your owner's manual for vehicle fuel requirements.

Can I use ULSD in diesel engines manufactured before the 2007 model year?

Yes. ULSD is acceptable for use in all diesel engines.

I have heard that removing the sulfur from diesel can cause problems in older engines. Is ULSD going to harm the engine in my pre-2007 diesel vehicle?

Some of the sulfur compounds naturally occurring in diesel fuel provide some wear protection or lubricity. To compensate for the sulfur removal in ULSD Exxon branded diesel fuel is treated with additives to improve lubricity. Customers can be confident in choosing Exxon because our branded ULSD fuel meets ASTM D 975 diesel fuel specifications, which provide standards for lubricity, cetane number and other performance characteristics.

How will ULSD fuel affect air quality?

ULSD fuel enables the use of cleaner technology diesel engines and vehicles with advanced emissions control devices. Even when used in older diesel engines ULSD is believed to result in lower vehicle emissions.

May I continue to blend No. 1 diesel with my diesel fuel to improve cold weather performance?

Only ultra low sulfur No. 1 diesel (No. 1 diesel with no more than 15 ppm sulfur) may be blended with ULSD fuel to improve cold weather performance. Kerosene should never be used to improve the low temperature operability of ULSD; its sulfur level is too high. In cold weather climates Exxon branded diesel fuels are blended with additives in winter months to improve low temperature performance. This should eliminate the need for supplemental ULSD No. 1 blending in most circumstances.

Will ULSD affect the fuel economy of existing diesel cars, trucks and non-road engines and equipment?

Theoretically, fuel economy may be reduced slightly (about 1%) because the refining process that removes sulfur also can reduce the energy content of the fuel.

Is there a place I can go to get additional industry information on ULSD?

Yes. For additional industry information on ULSD you can go to the Clean Diesel Fuel Alliance's web site (www.clean-diesel.org).

How do I know which grade to use?

Most engines are designed to operate on ASTM No. 2-D grade, but some diesel engines in stop-and-go service require No. 1-D diesel fuels in order to perform satisfactorily. Follow the recommendations of the engine manufacturer and a reputable fuel supplier who recognize that some fuels may have special or additive-derived quality features. Be sure to use ULSD in 2007 model vehicles and newer.

What are some fuel-handling causes of poor diesel engine performance?

Contamination of fuel by water and dirt entering the fuel as a result of careless fuel handling may cause poor diesel engine performance. Extreme care must be exercised. Fuel-tank caps, dispensing nozzles and hoses should be kept clean to eliminate potential sources of contamination. Regularly removing water from storage tanks, vehicle fuel tanks, and filter bowls is important. Dry storage systems will reduce fuel emulsion problems, injection system corrosion and microbial growth.

Why do diesel engines smoke?

Diesel engine smoke is caused by incomplete combustion. White smoke is caused by tiny droplets of unburned fuel resulting from engine misfiring at low temperature. This smoke should disappear as the engine warms up. Black smoke could be caused by a faulty injector, insufficient air and overloading and/or over-fueling the engine. Blue-gray smoke is the result of burning lubricating oil and is an indication the engine is in poor mechanical condition.

Why was the sulfur content of diesel fuel reduced?

Ultra Low sulfur diesel fuels (less than 15 ppm) are required by federal regulations for 2007 model year highway vehicles to ensure that these vehicles will meet emissions standards to improve the quality of the air we breathe. In California, other properties of vehicular diesel fuel are also controlled to help reduce smog.

Do Ultra Low Sulfur Diesel Fuels cause fuel system leaks?

When low sulfur diesel fuels were first introduced in some markets back in the 1990s, there was a rash of fuel injector O-ring failures causing fuel system leaks. The failures were limited to older vehicles and the problems have not recurred. The recent introduction of ULSD has not proven problematic.

How can I avoid having filter plugging problems?

Fuel filters can plug from a variety of causes. In the winter, small amounts of water or using fuel with inadequate low-temperature fluidity can cause filter plugging. At other times, common dirt and fuel distribution debris can cause filter plugging. And, if a fuel storage facility is not properly maintained, bacteria and algae can grow in the fuel and cause filter problems. With the exception of the fuel with inadequate low-temperature fluidity, all of these problems can normally be avoided by keeping the fuel storage system clean and dry. You should be sure to drain water accumulation frequently. That will obviously avoid icing problems in the Winter but will also minimize bacterial growth. Be sure to use dispenser filters when filling the vehicle tank.

How does water get into diesel fuel and what problems can it cause?

Water gets into diesel fuel storage and vehicle tanks in several ways – by condensation of humid air, during transportation from refineries to service stations, by leakage through faulty fill pipes or vents and by careless handling. Water can cause injector nozzle and pump corrosion, microorganism growth and fuel filter plugging with materials resulting from the corrosion or microbial growth. Both vehicle and storage tanks should be checked frequently for water and drained or pumped out as necessary. In extreme cases, biocides may be required to control microorganism growth. In cold northern winters, ice formation in fuels containing water creates severe fuel line and filter plugging problems. Regularly removing the water is the most effective means of preventing this problem.

What does the heat energy or BTU content of a diesel fuel mean?

The energy content of diesel fuel is defined by the amount of energy stored in one gallon. The higher the fuel's heat of combustion, the more power will be derived from each gallon of fuel consumed. Energy content is measured in British Thermal Units (BTU) per gallon and is related to the fuel's specific gravity and the temperature range at which it vaporizes. The BTU content per unit volume increases as the specific gravity increases. The BTU content of a unit volume

(gallon or liter) of diesel fuel is higher than that of gasoline, and the BTU content of No. 2-D diesel fuel is generally higher than that of No.1-D diesel fuel. The BTU content of No. 2-D diesel fuel is typically about 130,000 BTU/Gal.

What factors affect power/fuel economy?

Engine design is the most important factor leading to power and fuel economy. However, fuels with a higher density like our Ultra Low Sulfur Diesel No. 2 will provide improved power and fuel economy compared to fuels with Diesel Fuel No. 1 blended into them.

What is low-temperature operability?

Low-temperature operability is a diesel fuel's ability to perform at low temperatures. All petroleum distillate products contain waxy materials, which, at low temperatures, can crystallize and plug fuel filters. The cloud point of the fuel measures the first appearance of the waxes, although filter plugging will not typically occur until the ambient temperature is 5° to 10°F below the cloud point. There are several approaches, both operational and fuel-related, to ensure proper operability in cold weather.

Vehicle-related approaches include the use of fuel heaters, keeping the engine running, parking the vehicle in heated areas, etc. Each of these is designed to keep the fuel warm, above the point where waxing occurs. But each of these approaches has obvious drawbacks, as well.

The low-temperature operability of the fuel can be adjusted in several ways, as well. Blending a No. 2 fuel with No. 1 can lower its cloud point; this has traditionally been the most common approach to dealing with winter operability. But, the use of Diesel Fuel No. 1 reduces power and fuel economy, and often is more expensive, so minimizing the amount of No. 1 Fuel in the blend is an important consideration. Another approach to reduce the filter plugging incidence is to use wax-modifying additives. These additives can give operability benefits equivalent to No. 1 Fuel blending without the power and fuel economy losses. Use of wax-modifying additives is generally the approach for ULSD No. 2.

Note that, especially early in the winter season, water buildup in vehicle tanks, when it freezes, can also plug fuel filters or fuel lines. If you experience filter plugging problems when the ambient temperatures are between 10° and 30°F, the most likely cause is water, not the fuel itself.

What should I do in the winter to adjust for the cold temperatures?

We recommend that you purchase a diesel fuel that has been winterized for your area by mixing it with Diesel Fuel No. 1 or low-temperature fluidity improver additives. Non-winterized diesel fuel will not generally cause problems as long as temperatures are at or above 10°F. The addition of about 15% to 20% Diesel Fuel No. 1 to Diesel Fuel No. 2 will reduce the cloud point of the fuel by about 5°F.

We offer winterized product in a majority of markets that experience severe weather conditions. If temperatures fall well below norms for the local area or you will be driving much farther north, additional Diesel Fuel No. 1 blending is recommended.

Why shouldn't I just use Diesel Fuel No. 1?

While Diesel Fuel No. 1 has an advantage in low temperature operability, there are some disadvantages, as well. The energy content of Diesel Fuel No. 1 is about 95% that of Diesel Fuel No. 2 and will provide a correspondingly lower fuel economy. Diesel Fuel No. 1 is also lower in viscosity and provides less lubrication for the fuel pump and fuel distributor.

What are the differences among diesel fuels, heating oils and kerosenes?

Diesel fuels, heating oils and kerosenes are all products distilled from crude oil. While they are similar, there are some critical specification and legal differences among the products that normally prohibits using them interchangeably. These differences come about because their respective applications differ; diesel fuels are used in internal combustion engines, heating oils in oil burners and kerosenes are used in lamps and non-vented heaters. In addition to these differences, the products are subject to different tax laws. A few of the differences are highlighted below.

Diesel fuels have cetane specifications to assess combustion properties in diesel engines. They are also exposed to outdoor temperatures and relatively fine filtration. The most common measure for low-temperature fluidity is the cloud point. Neither heating oils nor kerosines require cetane number or cloud point specs. In the United States, heating oils and kerosenes are not taxed as are over-the-road diesel fuels. To distinguish them, with a few exceptions, the IRS requires that they be dyed dark red.

How long can I store diesel fuel?

If you keep it clean, cool and dry, diesel fuel can be stored 6 months to 1 year without significant quality degradation. Storage for longer periods can be accomplished through use of periodic filtrations and addition of fuel stabilizers and biocides.

What effect does blending used lubricating oil into diesel fuel have on engine performance and fuel quality?

This practice is not recommended. It may adversely affect fuel quality features and could lead to fuel system and piston deposits, increased exhaust emissions and fuel-filter plugging. This practice may also result in the diesel fuel being out of compliance with state or federal regulations or other specifications.

Does diesel fuel color affect performance?

No. There is no relationship between natural diesel fuel color and such desirable diesel fuel qualities as heat content, viscosity, cloud point, cetane number or distillation range. Diesel fuel color varies with the crude source, refinery methods and the use of dyes. However, if the fuel color darkens appreciably during storage, this could indicate oxidation and/or contamination from dirt, water, or other sources, which can cause operational problems.

What is flash point?

The flash point of a fuel is the temperature at which vapors formed above the surface of the liquid fuel will ignite when exposed to an open flame under prescribed laboratory test conditions. Flash point has a negligible effect on engine performance but can be a significant fire hazard in

the handling and storage of fuel. A low flash point temperature may indicate contamination of the diesel fuel with gasoline or other volatile materials such as alcohols.

What is diesel fuel lubricity?

Diesel fuel lubricity is a measure of diesel fuel's ability to reduce wear on contacting metal surfaces found in fuel pumps and injectors. In the case of diesel engines, fuel pumps and fuel injectors are lubricated by the fuel, so lubricity is a measure of a diesel fuel's ability to prevent wear in these parts.