Diesel Fuel

Questions & Answers

For Highway and Off-Highway Use

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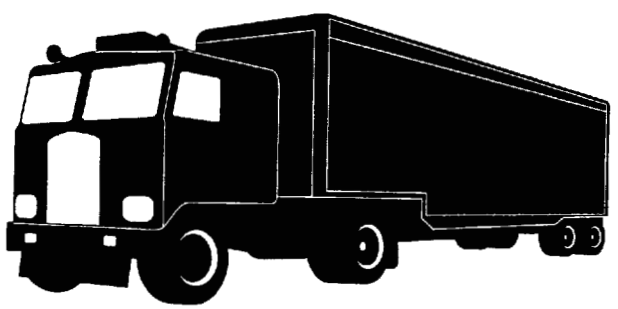

Diesel Fuel for Highway and Off-Highway Use

Table of Contents

Grades of Diesel Fuel

1.

Q. What is diesel fuel?

A. 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. During the operation of a diesel engine, diesel fuel is injected into the compressed, high-temperature air in the combustion chamber where it ignites spontaneously.

2.

Q. How many grades of diesel fuel are there?

A. The American Society for Testing and Materials (ASTM) in ASTM Standard Specification D 975 defines two grades of low-sulfur diesel fuel for highway use—No. 1-D and No. 2-D. Three high-sulfur grades of diesel fuel are specified for off-highway use—No. 1-D, No. 2-D, and No. 4-D. Federal regulations prohibit the use of high-sulfur diesel fuel for highway use. Federal regulations also require fuel suppliers to add red dye to high-sulfur diesel fuel and to low-sulfur, tax-exempt fuel. California regulations prohibit the use of high-sulfur diesel fuel in all motor vehicles.

ASTM describes diesel fuel grades by their intended primary application. This is usually associated with the tendency for the fuel to vaporize as follows:

Grade No. 1-D—includes the most volatile diesel fuels from kerosene to intermediate distillates. These fuels are usually the lowest cloud and pour point

fuels available. Fuels in this classification are suitable for use in high-speed diesel engines in services involving frequent and relatively wide variations in loads and speeds, such as in stop-and-go bus and door-to-door operations. These fuels are also for use when abnormally low ambient temperatures may be encountered.

Grade No. 2-D—includes the distillates of higher and wider boiling range than the No. 1-D fuels. These fuels normally have higher specific gravity (more dense) and higher cloud and pour points than No. 1-D fuels. These fuels are for use in diesel engines carrying relatively heavy loads at uniform speeds. They are generally used in equipment that operate in climates where cold starting and cold fuel handling are not severe problems but can be winterized to operate at lower temperatures. The No. 2-D grade is the most common and is widely used to satisfy the majority of automotive-type and heavy-duty-type diesel applications. Examples are automobiles, long-haul trucks, construction equipment, total energy units, farm tractors, and railroad diesels.

Grade No. 4-D—includes fuel oil containing distillates that are harder to vaporize and more viscous, as well as some blends with residual fuel oils. These fuels are for use in low- and medium-speed diesel engines in services involving sustained loads at substantially constant speeds and are used mostly in large, high output diesels for stationary power plants and ships.

3.

Q. Why was the sulfur content of diesel fuel lowered?

A. Low-sulfur diesel fuels (less than 0.05 mass percent) are required by federal regulations for highway vehicles to ensure that these vehicles will meet particulate emissions standards to improve the quality of the air we breathe. In California, properties of vehicular diesel fuel are also controlled to help reduce smog.

4.

Q. Is diesel fuel sulfur content important to engine life?

A. Diesel fuel sulfur content may be important to engine life if it is above the current ASTM limit of 0.50 mass percent for high-sulfur fuels. Fuel sulfur content above that level can increase piston ring and cylinder wear unless the type of lubricating oil or the oil drain interval is changed to accommodate higher sulfur levels. Suppliers will recommend specific lubricants for use with higher sulfur fuels.

5.

Q. Why can't all diesel fuel in the U.S. be made to one uniform standard?

A. The properties of diesel fuels vary with the crude oil from which they are made and the processing they undergo, as well as the additives used (if any). In addition, engine fuel requirements change with geographic area and climates. Winter operation in colder, northern states imposes more severe requirements than for the warmer parts of the coun-

try. In cold areas, winterized diesel fuels are marketed by many manufacturers to offer a fuel that will perform better in cold weather. To make all diesel fuel meet the most severe standard would increase the cost of fuel to all customers and would not be energy efficient. Most suppliers provide diesel fuel meeting the requirements of ASTM D 975.

6.

Q. How do I know which grade to use?

A. 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 recognizes that some fuels may have special or additive-derived quality features.

Properties and Specifications

7.

Q. What specification requirements of diesel fuel should concern me?

A. Cetane number (ignition quality), cleanliness, low-temperature operability, and stability are the diesel fuel requirements of principal concern.

8.

Q. What is the significance of each of these requirements?

A. Cetane number is a measure of the ease with which the fuel is ignited in an engine and is most significant in relation to low-

temperature startability, warm-up, and smooth, even combustion. The cetane number of the fuel should meet the 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 and cause severe damage to the fuel injection system because of the close tolerances of fuel pumps and injectors. All diesel engine manufacturers equip their engines with fuel filters to protect the fuel delivery system. These filters should be replaced 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.

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 and by various fluidity and filterability tests. (See API Publication 1577, "Winter Diesel—Questions and Answers," for additional information.)

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.

9.

Q. How is the cetane number of a diesel fuel measured?

A. The cetane number of a diesel fuel is determined by comparing its ignition characteristics under prescribed operating conditions using standard reference fuels in a single-cylinder laboratory engine.

10.

Q. What does the heat energy or Btu content of a diesel fuel mean?

A. The higher the fuel's heat of combustion, the more power will be derived from each gallon of fuel consumed. The energy content of diesel fuel is defined by the amount of energy stored in one gallon. 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.

11.

Q. What is diesel fuel lubricity?

A. Diesel fuel lubricity is a measure of diesel fuel's ability to reduce wear on contacting solid surfaces found in some fuel pumps

and injectors. In the case of diesel engines, some 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.

12.

Q. What is the significance of diesel fuel viscosity?

A. Diesel fuel viscosity affects fuel delivery rate and the ability of the fuel to atomize. Also, the viscosity of diesel fuel can protect against wear in fuel pumps designed to be lubricated by the fuel. Follow the recommendations of your engine's manufacturer for the grades of diesel fuel providing an acceptable viscosity range for your type of use.

13.

Q. What is flash point?

A. 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 open flames 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.

Low Temperature Operability

14.

Q. What is winter diesel fuel?

A. A winter diesel fuel is a No. 1-D or a No. 2-D fuel that has been modified to permit its use at lower ambient tempera-

tures. Typically this improvement is accomplished by blending No. 1-D with No. 2-D. The final blend has a lower cloud point than No. 2-D; therefore, wax crystals or gelling occurs at a lower temperature than for No. 2-D. Additives also can improve the low-temperature performance of No. 2-D. Additional information on winter diesel fuel is found in API Publication 1577, "Winter Diesel—Questions and Answers."

CAUTION: Gasoline should not be used to dilute diesel fuel because the mixture has much greater flammability and explosive potential than either gasoline or diesel fuel alone.

15.

Q. What factors affect low temperature performance?

A. Many factors, such as battery condition, cetane number, and injector settings, can affect low temperature starting and performance. However, the most important fuel characteristic is the cloud point temperature.

16.

Q. Why are the cloud point and pour point temperatures important?

A. Cloud point is the temperature at which wax crystals first appear in the fuel. As the temperature drops below the cloud point, the wax crystals continue to grow and can result in filter plugging and engine stalling or non-starting. Generally, No. 1-D and winterized No. 2-D grades have lower cloud points than Grade No. 2-D fuel. The pour point, generally lower than

the cloud point, is 3°C (5°F) higher than the temperature at which the fuel will no longer flow under prescribed laboratory test conditions. Petroleum manufacturers, on the basis of area temperature studies, manufacture and distribute fuels with cloud points and pour points that have been adjusted so that the fuel should operate satisfactorily in the various localities concerned.

17.

Q. How can I improve low temperature operability by equipment modification?

A. Low temperature operability can be improved by properly installing tank heaters, fuel-line heaters, and heated fuel filters. Many equipment manufacturers offer these as options and, in some cases, as standard equipment.

Low temperature operability of vehicles not equipped with fuel heating devices must rely on a fuel's cold-flow characteristics for satisfactory operation. If vehicles are equipped with fuel-heating devices, good operability may be obtained at fuel tank temperatures below the cloud point.

18.

Q. Are diesel cold-starting fluids effective?

A. When properly used, diesel cold-starting fluids can be a valuable aid to cold starting. These fluids are usually composed of a mixture of ethyl ether and a blend of solvent materials pressurized with carbon dioxide (CO_2). For effective response, the secondary component combined with the ether should have high volatility and

high-cetane qualities. Care should be exercised, however, to avoid overdosing an engine with starting fluids, as severe mechanical damage can result.

CAUTION: The engine manufacturer's recommendations must be referred to before using any starting aids.

Performance Issues

19.

Q. Why do diesel engines smoke?

A. 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 overfueling the engine. Blue-gray smoke is the result of burning lubricating oil and is an indication the engine is in poor mechanical condition.

20.

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

A. Water gets into diesel fuel storage and vehicle tanks in several ways—by condensation, during transportation, by leakage through faulty fill pipes or vents, and by careless handling. Water can cause injector nozzle and pump corrosion, bacteria and fungi growth, and fuel filter plugging with materials resulting from corrosion or microbial growth. Both vehicle and storage tanks should be checked frequently for water and drained or pumped as necessary. In extreme

cases, biocides may be required to control bacterial 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; however, small quantities of alcohol may be used on an emergency basis to prevent fuel line and filter freeze-ups. (See Question 24, Item 5.)

21.

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

A. 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.

22.

Q. Does diesel fuel color affect performance?

A. 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 operating problems.

23.

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

A. You should consult your engine manufacturer regarding the blending of used lubricating oils into diesel fuel. This practice 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.

Additives

24.

Q. What additives are normally used in diesel fuels and for what purposes?

A. If required, fuel suppliers generally blend the necessary additives into the fuel before distribution. It should be noted that most engine manufacturers recommend against the use of additives other than those added by fuel suppliers. The following types of additives may be used to enhance particular fuel properties. Not all fuel will contain any or all of these additives.

1. Oxidation inhibitors are used to reduce the formation of gums and insoluble residues that can clog fuel filters.

2. Ignition quality (cetane number) improvers are used to increase the cetane number when the base fuel cetane does not meet requirements.

3. Detergent-dispersant additives help keep fuel-insoluble materials in suspension and are helpful in maintaining a clean engine and fuel delivery system.

4. Rust preventives and metal deactivators are used when storage, handling, or shipping conditions warrant.

5. Anti-icing additives, such as alcohols, may be used in very cold areas in winter to help prevent ice from plugging fuel lines and filters.

CAUTION: Do not use excessive amounts of alcohol since alcohol lowers the cetane number and flash point and can increase corrosive wear on the fuel pump and injectors. In all cases, follow the manufacturer's recommended maximum dosage. Never use more than one pint (473 milliliters) of alcohol per 100 gallons (379 liters) of fuel. Many engine manufacturers specifically warn against using alcohols because of the adverse effects on pumps, pump seals, and flash point.

6. Cold-flow improvers, when used selectively, may permit operation at temperatures below the cloud point temperature of the fuel in certain diesel equipment. Effectiveness varies with crude oil source and refining techniques.

7. Biocides may be added to diesel fuel to prevent microbial growth. Microbial growth in stored fuel creates insoluble particles that can cause fuel-filter clogging.

8. Red dye is required to be added to high-sulfur and low-sulfur tax-exempt diesel fuel by federal regulations.

9. Lubricity additives may be used in certain applications to improve the lubricating ability of the fuel.

Fuel suppliers carefully weigh the benefits and possible adverse effects of all of these various additives in the fuel they market.

25.

Q. Can diesel fuel additives, such as those offered by automotive chemical manufacturers, improve diesel fuel and/or engine performance?

A. Many of the over-the-counter automotive chemicals may provide some improvements, such as low-temperature flow and cetane performance. However, engine manufacturers usually recommend against using additives other than those added by fuel suppliers.

Additional Information

26.

Q. Where can I get more information about diesel fuel?

A. Most petroleum companies are happy to answer inquiries about their products. You can also write or telephone the following organizations:

American Petroleum Institute
1220 L Street, NW
Washington, DC 20005
202-682-8000

Society of Automotive Engineers
400 Commonwealth Drive
Warrendale, Pennsylvania 15096
412-776-4841

American Society for Testing and Materials
100 Barr Harbor Drive
West Conshohocken, PA 19428
610-832-9500

PG-01400—1/96—10M (1E

American Petroleum Institute
1220 L Street, Northwest
Washington, D.C. 20005
202-682-8000

Order No. F157104