i02162487

Fuel Information for LP Gas Engines

SMCS Code: 1250; 1280

Use grade HD5 LPB. LP Gas is a highly volatile fuel. LP Gas has an octane rating of 100 to 140. Follow local ordinances regarding the storage of tanks of LP Gas. Follow local ordinances regarding the filling of tanks for LP Gas.

i02169732

Diesel Fuel Recommendations

SMCS Code: 1250; 1280

NOTICE
These recommendations are subject to change without prior notice. Contact your local Caterpillar dealer for the most up to date recommendations.

Diesel engines have the ability to burn a wide variety of fuels. These fuels are divided into two general groups. The two groups are called the preferred fuels and the permissible fuels.

The preferred fuels provide maximum engine service life and performance. The preferred fuels are distillate fuels. These fuels are commonly called diesel fuel, furnace oil, gas oil, or kerosene.

The permissible fuels are some crude oils and some blends of crude oil with distillate fuel. These fuels are not suitable for use in all engine applications. The acceptability of these fuels for use is determined on a case by case basis. A complete fuel analysis is required. Consult your Caterpillar dealer for further information.

NOTICE
Use of permissable fuels can result in higher maintenance costs and reduced engine service life.

Diesel fuels that meet the specifications in Table 13 will help to provide maximum engine service life and performance. In North America, diesel fuel that is identified as No. 1-D or No. 2-D in “ASTM D975” generally meet the specifications. Table 13 is for diesel fuels that are distilled from crude oil. Diesel fuels from other sources could exhibit detrimental properties that are not defined or controlled by this specification.

NOTICE
The footnotes are a key part of the “Caterpillar Specifications for Distillate Diesel Fuel” Table. Read ALL of the footnotes.

Table 13

Caterpillar Specifications for Distillate Diesel Fuel (1)			
Specifications	**Requirements**	**ASTM Test**	**ISO Test**
Aromatics	35% maximum	“D1319”	“ISO 3837”
Ash	0.02% maximum (weight)	“D482”	“ISO 6245”
Carbon Residue on 10% Bottoms	0.35% maximum (weight)	“D524”	“ISO 4262”
Cetane Number (2)	40 minimum (DI engines)	“D613” or “D6890”	“ISO 5165”
	35 minimum (PC engines)		
Cloud Point	The cloud point must not exceed the lowest expected ambient temperature.	D2500	ISO 3015
Copper Strip Corrosion	No. 3 maximum	“D130”	“ISO 2160”
Distillation	10% at 282 °C (540 °F) maximum	“D86”	“ISO 3405”
	90% at 360 °C (680 °F) maximum		
Flash Point	legal limit	“D93”	“ISO 2719”
Thermal Stability	Minimum of 80% reflectance after aging for 180 minutes at 150 °C (302 °F)	“D6468”	No equivalent test
API Gravity (3)	30 minimum	“D287”	No equivalent test
	45 maximum		
Pour Point	6 °C (10 °F) minimum below ambient temperature	“D97”	“ISO 3016”

(continued)

(Table 13, contd)

Caterpillar Specifications for Distillate Diesel Fuel (1)			
Specifications	**Requirements**	**ASTM Test**	**ISO Test**
Sulfur (4)	1% maximum	“D5453” or “D2622”	“DIN 51400”
Kinematic Viscosity (5)	1.4 cSt minimum and 20.0 cSt maximum as delivered to the fuel injection pumps	-	-
	1.4 cSt minimum and 4.5 cSt maximum as delivered to the rotary fuel injection pumps	-	-
Water and Sediment	0.1% maximum	“D1796”	“ISO 3734”
Water	0.1% maximum	“D1744”	No equivalent test
Sediment	0.05% maximum (weight)	“D473”	“ISO 3735”

(continued)

(Table 13, contd)

Caterpillar Specifications for Distillate Diesel Fuel (1)			
Specifications	**Requirements**	**ASTM Test**	**ISO Test**
Gums and Resins (6)	10 mg per 100 mL maximum	“D381”	“ISO 6246”
Lubricity (7)	0.52 mm (0.0205 inch) maximum at 60 °C (140 °F)	“D6079”	No equivalent test

(1) This specification includes the requirements for Ultra Low Sulfur Diesel (ULSD). ULSD fuel will have ≤ 15 ppm (0.0015%) sulfur using the ASTM D5453, ASTM D2622, or DIN 51400 test methods.

(2) Alternatively, to ensure a minimum cetane number of 35 (PC engines), and 40 (DI engines), distillate diesel fuel should have a minimum cetane index of 37.5 (PC engines), and 42.5 (DI engines) when the ASTM D4737-96a test method is used. A fuel with a higher cetane number may be required for operation at a higher altitude or in cold weather.

(3) Via standards tables, the equivalent kg/m^3 (kilograms per cubic meter) using the “ASTM D287” test method temperature of 15.56 °C (60 °F) for the minimum API gravity of 30 is 875.7 kg/m^3, and for the maximum API gravity of 45 is 801.3 kg/m^3.

(4) Caterpillar fuel systems and engine components can operate on fuels with a maximum sulfur content of 3%. Fuel sulfur levels affect exhaust emissions. High sulfur fuels also increase the potential for corrosion of internal components. Fuel sulfur levels above 1.0 percent may significantly shorten the oil change interval. For additional information, see this publication, “Engine Oil” topic (Maintenance Section). ULSD fuel will have ≤ 15 ppm (0.0015%) sulfur using the ASTM D5453, ASTM D2622, or DIN 51400 test methods.

(5) The values of the fuel viscosity are the values as the fuel is delivered to the fuel injection pumps. For ease of comparison, fuels should also meet the minimum and maximum viscosity requirements at 40 °C (104 °F) that are stated, by the use of either the “ASTM D445” test method or the “ISO 3104” test method. If a fuel with a low viscosity is used, cooling of the fuel may be required to maintain 1.4 cSt or greater viscosity at the fuel injection pump. Fuels with a high viscosity might require fuel heaters in order to bring down the viscosity to either 4.5 cSt or less for rotary fuel injection pumps or 20 cSt viscosity or less for all other fuel injection pumps.

(6) Follow the test conditions and procedures for gasoline (motor).

(7) The lubricity of a fuel is a concern with low sulfur fuel. To determine the lubricity of the fuel, use the “ASTM D6079 High Frequency Reciprocating Rig (HFRR)” test. If the lubricity of a fuel does not meet the minimum requirements, consult your fuel supplier. Do not treat the fuel without consulting the fuel supplier. Some additives are not compatible. These additives can cause problems in the fuel system.

Ultra Low Sulfur Diesel (ULSD)

Caterpillar recommends that all distillate diesel fuel, including ULSD fuel (fuel ≤ 15 ppm sulfur using ASTM D5453, ASTM D2622, or DIN 51400) meet the requirements of the Caterpillar Specifications for Distillate Diesel Fuel.

Note: Caterpillar recommends the filtration of fuel through a fuel filter with a rating of five microns(c) absolute or less. This filter should be located on the device that dispenses the fuel to the fuel tank for the engine.

NOTICE
Operating with fuels that do not meet Caterpillar's recommendations can cause the following effects: starting difficulty, poor combustion, deposits in the fuel injectors, reduced service life of the fuel system, deposits in the combustion chamber, and reduced service life of the engine.

In the USA, 0.05 percent diesel fuels have been used in all on-highway truck engines since 1 January 1994. This low sulfur diesel fuel was mandated as a means of directly reducing particulate emissions from diesel truck engines. This low sulfur fuel will also be used in Caterpillar commercial diesel engines and in Caterpillar machine engines. This diesel fuel will be used when low emissions are required. This fuel will be used when the fuel supplier can provide this type of fuel. Caterpillar has not seen any detrimental effects with 0.05 percent sulfur fuel in Caterpillar diesel engines.

NOTICE
Heavy Fuel Oil (HFO), Residual fuel, or Blended fuel must **NOT** be used in Caterpillar diesel engines (except in 3600 Series HFO engines). Blended fuel is residual fuel that has been diluted with a lighter fuel (cutter stock) so that they will flow. Blended fuels are also referred to as heavy fuel oils. Severe component wear and component failures will result if HFO type fuels are used in engines that are configured to use distillate fuel.

In extreme cold ambient conditions, you may use the distillate fuels that are specified in Table 14. However, the fuel that is selected must meet the requirements that are specified in Table 13. These fuels are intended to be used in operating temperatures that are down to −54 °C (−65 °F).

Table 14

Distillate Fuels (1)	
Specification	**Grade**
"MIL-DTL-5624U"	JP-5
"ASTM D1655-04"	Jet-A-1
"MIL-DTL-83133E"	JP-8

(1) The fuels that are listed in this table may not meet all of the requirements that are specified in table 13. Consult the supplier for the recommended additives in order to maintain the proper fuel lubricity.

These fuels are lighter than the No. 2 grades of fuel. The cetane number of the fuels in Table 13 must be at least 40. If the viscosity is below 1.4 cSt at 40 °C (104 °F), use the fuel only in temperatures below 0 °C (32 °F). Do not use any fuels with a viscosity of less than 1.2 cSt at 40 °C (104 °F).

Note: Fuel cooling may be required in order to maintain the minimum viscosity of 1.4 cSt at the fuel injection pump.

There are many other diesel fuel specifications that are published by governments and by technological societies. Usually, those specifications do not review all the requirements that are addressed in this specification. To ensure optimum engine performance, a complete fuel analysis should be obtained before engine operation. The fuel analysis should include all of the properties that are listed in Table 13.

⚠ WARNING

Mixing alcohol or gasoline with diesel fuel can produce an explosive mixture in the engine crankcase or fuel tank.

Personal injury and damage to the engine may result. Caterpillar recommends against this practice.

Aftermarket Fuel Additives

There are many different types of fuel additives that are available to use. Caterpillar does not generally recommend the use of fuel additives.

In special circumstances, Caterpillar recognizes the need for fuel additives. Fuel additives need to be used with caution. The additive may not be compatible with the fuel. Some additives may precipitate. This action causes deposits in the fuel system. The deposits may cause seizure. Some additives may be corrosive, and some additives may be harmful to the elastomers in the fuel system. Contact your fuel supplier for those circumstances when fuel additives are required. Your fuel supplier can make recommendations for additives to use and for the proper level of treatment.

Note: For best results, your fuel supplier should treat the fuel when additives are needed.

Biodiesel

Biodiesel is a fuel that can be made from a variety of sources. Soybean oil or rapeseed oil are the primary sources. Without esterification, these oils gel in the crankcase and the fuel tank. These fuels may not be compatible with many of the elastomers that are used in engines that are manufactured today. In original forms, these oils are not suitable for use as a fuel in compression engines. To use these oils as fuel, the oil must be esterified. Alternate base stocks for biodiesel may include animal tallow, waste cooking oils, or a variety of other feedstocks.

Engines that are manufactured by Caterpillar are certified by use of the prescribed EPA and European Certification fuels. Caterpillar does not certify engines on any other fuel.

Note: The user of the engine has the responsibility of using the correct fuel that is recommended by the manufacturer and allowed by the EPA or other local regulatory agencies. The user also has the responsibility of obtaining the proper local exemptions, regional exemptions, and/or national exemptions that are required for the use of biodiesel in any Caterpillar engine that is regulated by emissions standards.

Warranty and the Use of Biodiesel in Caterpillar Engines

Caterpillar neither approves nor prohibits the use of biodiesel fuels. Caterpillar is not in a position to evaluate the many variations of biodiesel and the long term effects on performance, durability, or compliance to emissions standards for Caterpillar products. The use of biodiesel does not affect the Caterpillar warranty for materials and the warranty for workmanship. **Failures that result from the use of any fuel are not Caterpillar factory defects. Therefore, the cost of repair would NOT be covered by a Caterpillar warranty.**

Recommendation for the Use of Biodiesel in Caterpillar Engines

For Caterpillar ACERT model numbers C7, C9, C11, C13, C15, C18, and also for Caterpillar 3046, 3064, 3066, 3114, 3116, 3126, 3176, 3196, 3208, 3306, C-9, C-10, C-12, 3406, C-15, C-16, C-18, 3456, 3408, 3412, 3500 series, 3600 series, CM20, CM25 and CM32 engines, biodiesel that meets the requirements that are listed in the Caterpillar specification for biodiesel, ASTM D6751, or EN 14214 are acceptable. Biodiesel may be blended in amounts up to a maximum of 30 percent with an acceptable diesel fuel. This blend is acceptable provided that the biodiesel constituent meets the requirements that are outlined in Table 15 prior to blending. In addition, the final blend must meet the requirements for distillate diesel fuel that are listed in Table 13.

Note: A complete Caterpillar S·O·S Oil Analysis program is recommended when using biodiesel blends of up to 30 percent.

Note: For blends of biodiesel above 30 percent, contact your Caterpillar dealer for guidance. A complete Caterpillar S·O·S Oil Analysis program is required when biodiesel/biodiesel blends above 30 percent are used. Biodiesel/biodiesel blends as used in the engine must meet the requirements that are stated in the “Caterpillar Specification for Distillate Diesel Fuel” in Table 13.

For Caterpillar 3003 through 3034, 3054 and 3056 engines, biodiesel that meets the requirements that are listed in Caterpillar’s biodiesel specification, ASTM D6751, or EN 14214 may be blended with an acceptable diesel fuel. This blend should be a maximum ratio of 5% biodiesel to 95% of an acceptable diesel fuel. The biodiesel must meet the requirements that are listed in Table 15 prior to blending. Use of more than a 5% biodiesel can cause premature failures. The repair for these failures would not be covered under the Caterpillar warranty.

Note: When biodiesel, or any blend of biodiesel is used, the user has the responsibility for obtaining the proper local exemptions, regional exemptions, and/or national exemptions that are required for the use of biodiesel in any Caterpillar engine that is regulated by emissions standards. Biodiesel that meets the requirements that are listed in Caterpillar’s specification for biodiesel, ASTM D6751, or EN 14214 should pose no problems when blended with an acceptable distillate diesel fuel at the maximum stated percentages, however, the following recommendations must be followed:

Recommendations

- The oil change interval can be affected by the use of biodiesel. Use S·O·S Oil Analysis in order to monitor the condition of the engine oil. Use S·O·S Oil Analysis also in order to determine the oil change interval that is optimum.
- In a comparison of distillate fuels to biodiesel, biodiesel provides less energy per gallon by 5% to 7%. Do NOT change the engine rating in order to compensate for the power loss. This will help avoid engine problems when the engine is converted back to 100 percent distillate diesel fuel.
- Compatibility of the elastomers with biodiesel is currently being monitored. The condition of seals and hoses should be monitored regularly.

- Biodiesel may pose low ambient temperature problems for both storage and operation. At low ambient temperatures, fuel may need to be stored in a heated building or a heated storage tank. The fuel system may require heated fuel lines, filters, and tanks. Filters may plug and fuel in the tank may solidify at low ambient temperatures if precautions are not taken. Consult your biodiesel supplier for assistance in the blending and attainment of the proper cloud point for the fuel.

- Biodiesel has poor oxidation stability, which can result in long term storage problems. The poor oxidation stability may accelerate fuel oxidation in the fuel system. This is especially true in engines with electronic fuel systems because these engines operate at higher temperatures. Consult the fuel supplier for oxidation stability additives.

- Biodiesel is an excellent medium for microbial contamination and growth. Microbial contamination and growth can cause corrosion in the fuel system and premature plugging of the fuel filter. The effectiveness of conventional anti-microbial additives when used in biodiesel is not known. Consult your supplier of fuel and additive for assistance.

- Care must be taken in order to remove water from fuel tanks. Water accelerates microbial contamination and growth. When biodiesel is compared to distillate fuels, water is naturally more likely to exist in the biodiesel.

Caterpillar Biodiesel

Note: The final blend of biodiesel as used in the engine must meet the requirements that are stated in the “Caterpillar Specification for Distillate Diesel Fuel” in Table 13.

NOTICE

The footnotes are a key part of the “Caterpillar Specification for Biodiesel Fuel” Table. Read ALL of the footnotes.

Table 15

Caterpillar Specification for Biodiesel Fuel[1]				
Property	**Test Method**	**Test Method**	**Units**	**Limits**
	United States	**International**	**Specific Properties of Fuel**	
Density at 15°C	“ASTM D1298”	“ISO 3675”	g/cm^3	0.86-0.90
Viscosity at 40°C	“ASTM D445”	“ISO 3104”	mm^2/s	4.0-6.0
Flash Point	“ASTM D93”	“ISO 2719”	°C	130 minimum
Cold Filter Plugging - Summer - Winter	“ASTM D4539”	“DIN EN 116”	°C	0 6 below ambient
Pour Point - Summer - Winter	“ASTM D97”	“ISO 3016”	°C	-9 maximum -20 maximum
Sulfur Content	“ASTM D2622”	“DIN 51400”	% weight	0.0015 maximum
Distillation - 10% Evaporation - 90% Evaporation	“ASTM D1160”	“ISO 6616”	°C	To Be Determined 345
Carbon Residue, Conradson (CCR)	“ASTM D189”	“ISO 6615”	% weight	0.05 maximum
Cetane Number	“ASTM D613”	“ISO 5165”		45 minimum
Sulfated Ash	“ASTM D874”	“DIN 51575” “ISO 3987”	mg/kg	0.02 maximum
Water/Sediment Content	“ASTM D1796”	“ISO 3734”	g/m^3	500 maximum
Particulate Matter	“DIN 51419”	“DIN 51419”		15
Copper Corrosion	“ASTM D130”	“ISO 2160”		No. 1
Oxidation Stability	“ASTM D2274”	“ISO 12205”	mg/100mL	15 maximum
Esterification			% volume	98.0 minimum
Acid Value	“ASTM D664”	“ISO 6619”	mg NaOH/g	0.5 maximum
Methanol Content	GC Method	“DIN 51608”	% weight	0.2 maximum
Monoglycerides	“ASTM D6584”	“DIN 51609”	% weight	0.8 maximum
Diglycerides	“ASTM D6584”	“DIN 51609”	% weight	0.2 maximum
Triglycerides	“ASTM D6584”	“DIN 51609”	% weight	0.2 maximum
Free Glycerine	“ASTM D6584”	“DIN 51609”	% weight	0.02 maximum
Total Glycerine	“ASTM D6584”	“DIN 51609”	% weight	0.240 maximum
Iodine Number	“DIN 53241 or IP 84/81”	“DIN 53241 or IP 84/81”	cg I_2/g	110 maximum
Phosphorus Content	“DGF C-VI4”	“DIN 51440-1”	mg/kg	0.2

(1) The final blend of biodiesel as used in the engine must meet the requirements that are stated in the “Caterpillar Specification for Distillate Diesel Fuel” in Table 13.

Note: Fuels that meet “ASTM D6751” or “EN14214” may be used for blending with distillate fuel. The conditions, recommendations, and limits noted in this biodiesel section apply.