

# Operation and Maintenance Manual

## Caterpillar Machine Fluids Recommendations

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## Distillate Diesel Fuel

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**Note:** For on-highway diesel engine fluids requirements, refer to specific engine Operation and Maintenance Manuals, and also refer to the most current revision level of Special Publication, SEBU6385, "Caterpillar On-Highway Diesel Engine Fluids Recommendations". Also consult your Cat dealer.

Caterpillar is not in the position to continuously evaluate and monitor all of the many worldwide distillate diesel fuel specifications and their on-going revisions that are published by governments and technological societies.

The "Caterpillar Specification for Distillate Fuel for Off-Highway Diesel Engines" provides a known, reliable baseline to judge the expected performance of distillate diesel fuels that are derived from conventional sources (crude oil, shale oil, oil sands, etc.) when used in Cat diesel engines.

Using the Cat distillate diesel fuel specification as the baseline, it is much easier to determine any potential economic and/or performance trade-offs, and overall acceptability when using fuels of varying characteristics and quality levels.

- When required, have the diesel fuel that either is being used or is planned to be used, tested per the Cat distillate diesel fuel specification.
- Use the Cat distillate diesel fuel specification as a fuel quality baseline for comparison of distillate diesel fuel analysis results, and/or a baseline for comparison of other distillate diesel fuel specifications.
- Typical fuel characteristics can be obtained from the fuel supplier.

Fuel parameters outside of the Cat fuel specification limits have explainable consequences.

- Some fuel parameters that are outside of the specification limits can be compensated for (e.g. fuel can be cooled to address low viscosity; etc.).
- Some fuel parameters that are outside of specification limits may be able to be improved with the use of appropriate amounts of well proven fuel additives. Refer to this Special Publication, "Distillate Diesel Fuel" article, "Aftermarket Fuel Additives" and "Cat Diesel Fuel Conditioner" topics for guidance.

To help 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 the "Caterpillar Specification for Distillate Fuel for Nonroad Diesel Engines", Table 1.

**Note:** The diesel fuel cannot have any visually apparent sediment, suspended matter, or undissolved water.

Diesel Fuels that meet the specifications in table 1 will help provide maximum engine service life and performance.

In North America, diesel fuels that are identified as meeting the latest version of "ASTM D975" Grades No. 1-D or No. 2-D (all listed sulfur levels) generally meet the table 1 requirements.

In Europe, diesel fuels that are identified as meeting the latest version of "European Standard EN590" generally meet the table 1 requirements.

Table 1 is for diesel fuels that are distilled from conventional sources (crude oil, shale oil, oil sands, etc.). Diesel fuels from other sources could exhibit detrimental properties that are not defined or controlled by this specification.

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### NOTICE

**Ultra Low Sulfur Diesel (ULSD) fuel 0.0015 percent ( $\leq 15$  ppm (mg/kg)) sulfur is required by regulation for use in engines certified to nonroad Tier 4 standards (U.S. EPA Tier 4 certified) and that are equipped with exhaust aftertreatment systems.**

**European ULSD 0.0010 percent ( $\leq 10$  ppm (mg/kg)) sulfur fuel is required by regulation for use in engines certified to European nonroad Stage IIIB and newer standards and are equipped with exhaust aftertreatment systems.**

**Certain governments/localities and/or applications MAY require the use of ULSD fuel. Consult federal, state, and local authorities for guidance on fuel requirements for your area.**

**Typical aftertreatment systems include Diesel Particulate Filters (DPF), Diesel Oxidation Catalysts (DOC), Selective Catalytic Reduction (SCR) and/or Lean NO<sub>x</sub> Traps (LNT). Other systems may apply.**

**Low sulfur diesel (LSD) fuel 0.05 percent ( $\leq 500$  ppm (mg/kg) sulfur) is strongly recommended for use in engines that are pre-Tier 4 models, while diesel fuel with  $> 0.05$  percent (500 ppm (mg/kg)) sulfur is acceptable for use in areas of the world where allowed by law. Pre-Tier 4 engines that are equipped with a Diesel Oxidation Catalyst (DOC) require the use of LSD fuel or ULSD fuel.**

**ULSD fuel or sulfur-free diesel fuel are applicable for use in all engines regardless of the engine Tier or Stage.**

**Use appropriate lubricating oils that are compatible with the engine certification and aftertreatment system and with the fuel sulfur levels. Refer to the "Diesel Fuel Sulfur Impacts" article of this "Fuels**

**Specifications" section and to the "Lubricants Specifications" section of this Special Publication.**

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Engine operating conditions play a key role in determining the effect that fuel sulfur will have on engine deposits and on engine wear.

**Note:** The removal of sulfur and other compounds in Ultra Low Sulfur Diesel (ULSD) fuel decreases the conductivity of ULSD and increases the ability of the fuel to store static charge. Refineries may have treated the fuel with a static dissipating additive. However, there are many factors that can reduce the effectiveness of the additive over time. Static charges can build up in ULSD fuel while the fuel is flowing through fuel delivery systems. Static electricity discharge when combustible vapors are present could result in a fire or explosion. Therefore, ensuring that the entire system used to refuel your machine (fuel supply tank, transfer pump, transfer hose, nozzle, and others) is properly grounded and bonded is important. Consult with your fuel or fuel system supplier to ensure that the delivery system is in compliance with fueling standards for proper grounding and bonding practices.

**Using fuels with higher than recommended fuel sulfur levels can or will:**

- Reduce engine efficiency and durability
- Increase wear
- Increase corrosion
- Increase deposits
- Shorten the time interval between aftertreatment device service intervals (cause the need for more frequent service intervals)
- Negatively impact the performance and life of aftertreatment devices (cause loss of performance)
- Reduce regeneration intervals of aftertreatment devices
- Lower fuel economy
- Shorten the time period between oil drain intervals (cause the need for more frequent oil drain intervals)
- Increase overall operating costs

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**NOTICE**

**Do not add new engine oil, waste engine oil or any oil product to the fuel unless the engine is designed and certified to burn diesel engine oil (for example Caterpillar ORS designed for large engines). Caterpillar experience has shown that adding oil products to Tier 4 engine fuels (U.S. EPA Tier 4 certified), to EURO Stage IIB and IV certified engine fuels, or to the fuels of engines equipped with exhaust aftertreatment devices, will generally cause the need for more frequent ash service intervals and/or cause loss of performance.**

**Adding oil products to the fuel may raise the sulfur level of the fuel and may cause fouling of the fuel system and loss of performance.**

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Caterpillar does not require the use of ULSD in non-road and machine applications that are not Tier 4/Stage IIB/ Stage IV certified engines and are not equipped with aftertreatment

devices. For Tier 4/Stage IIIB/Stage IV certified engines, always follow operating instructions and fuel tank inlet labels to insure the correct fuels are used.

ULSD and any other fuel used in Cat engines have to be properly formulated and additized by the fuel supplier and have to meet Special Publication, "Caterpillar Specification for Distillate Diesel Fuel for Off-Highway Diesel Engines". Fuels that are defined as "ASTM D975" Grade No. 1-D S15 or "ASTM D975" Grade No. 2-D S15 generally meet Cat requirements for ULSD.

Refer to this Special Publication, "Characteristics of Diesel Fuel" article for additional pertinent information concerning fuel lubricity, fuel oxidative stability, fuel sulfur, and aftertreatment devices. Also refer to "ASTM D975-08a", to the specific engine Operation and Maintenance Manual, and to aftertreatment device documentation for guidance.

**Note:** Caterpillar strongly recommends the filtration of distillate fuel and/or biodiesel/biodiesel blends through a fuel filter with a rating of four microns(c) absolute or less. This filtration should be located on the device that dispenses the fuel to the fuel tank for the engine, and also on the device that dispenses fuel from the bulk storage tank. Series filtration is recommended. Caterpillar recommends that the fuel dispensed into the machine tank meets "ISO 18/16/13" cleanliness level.

**Note:** The owner and the operator of the engine has the responsibility of using the correct fuel that is recommended by the manufacturer and allowed by the U.S. EPA and, as appropriate, other regulatory agencies.

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### NOTICE

**Operating with fuels that do not meet Cat recommendations can cause the following effects: starting difficulty, reduced fuel filter service life, 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.**

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### NOTICE

**The footnotes are a key part of the "Caterpillar Specification for Distillate Diesel Fuel" Table. Read ALL of the footnotes.**

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**For additional guidance related to many of the fuel characteristics that are listed, refer to "Cat Specification for Distillate Fuel for Off-Highway Diesel Engines", table 1.**

The values of the fuel viscosity given in table 1 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 lower 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.

The lubricity of a fuel is a concern with low sulfur and ultra low sulfur fuel. To determine the lubricity of the fuel, use the "ASTM D6079 High Frequency Reciprocating Rig (HFRR)" test. There are many aftermarket additives that are available to treat fuel. If the lubricity of a fuel does not meet the minimum requirements, consult your fuel supplier for proper recommendations regarding fuel additives. Also, refer to this Special Publication, "Characteristics of Diesel Fuel" article, "Aftermarket Fuel Additives" and "Cat Diesel Fuel Conditioner" topics. Do not treat the fuel without consulting the fuel supplier. Some additives are not compatible. These additives can cause problems in the fuel system.

Table 1

<b>Cat Specification for Distillate Fuel for Nonroad Diesel Engines</b>			
<b>Specifications</b>	<b>Requirements</b>	<b>ASTM Test</b>	<b>ISO Test</b>
Aromatics	35% maximum	"D1319"	"ISO 3837"
Ash	0.01% maximum (weight)	"D482"	"ISO 6245"
Carbon Residue on 10% Bottoms	0.35% maximum (weight)	"D524"	"ISO 4262"
Cetane Number <sup>(1)</sup>	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 <sup>(2)</sup>		
	90% at 350° C (662° F) maximum <sup>(2)</sup>		
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
Density at	800 kg/m <sup>3</sup> minimum	"D287"	No

15° C (59° F) <sup>(3)</sup>	860 kg/m <sup>3</sup> maximum		equivalent test
Pour Point	6°C (10°F) minimum below ambient temperature	"D97"	"ISO 3016"
Sulfur	<sup>(4)</sup>	"D5453" or "D2622"	"ISO 20884"
Kinematic Viscosity	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	0.05% maximum	"D1796"	"ISO 3734"
Water	0.05% maximum	"D1744"	No equivalent test
Sediment	0.05% maximum (weight)	"D473"	"ISO 3735"
Gums and Resins <sup>(5)</sup>	10 mg per 100mL maximum	"D381"	"ISO 6246"
Lubricity	0.52 mm (0.0205 inch) maximum at 60° C (140° F)	"D6079"	No equivalent test
Cleanliness	<sup>(6)</sup>	"D7619"	"ISO 4406"

<sup>(1)</sup> 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 44.2 (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.

<sup>(2)</sup> Distillation of 90% at 350° C (662° F) maximum is recommended for Tier 4 engines and preferred for all engines. Distillation of 90% at 350° C (662° F) is equivalent to 95% at 360° C (680° F). Distillation of 90% at 360° C (680° F) maximum is 360° C (680° F). Distillation of 90% at 360° C (680° F) maximum is acceptable for Pre-Tier 4 engines.

<sup>(3)</sup> The density range allowed includes #1 and #2 diesel fuel grades. Fuel density varies depending on the sulfur level, where high sulfur fuels have higher densities. Some unblended (neat) alternative fuels have lower densities, which are acceptable if the other properties fall within this spec.

<sup>(4)</sup> Follow the federal, state, local, and other governing authorities for guidance concerning the fuel requirements in your area. Follow the engine Operation and Maintenance Manual and the details provided in this Fuel section. ULSD 0.0015% (<15 ppm S) is required by law for Tier 4 engines and engines with aftertreatment devices. ULSD and LSD 0.05% (≤500 ppm S) are strongly recommended for pre-Tier 4 engines. Diesel fuel with >0.05% (>500 ppm) sulfur is acceptable for use where allowed by law. Consult your Cat dealer for guidance when sulfur levels are above 0.1% (1000 ppm). Certain Cat fuel systems and engine components can operate on fuel with a maximum sulfur content of 3%. Refer to the specific engine Operation and

Maintenance Manual and consult your Cat dealer

- (5) Follow the test conditions and procedures for gasoline (motor).
- (6) Recommended cleanliness level for fuel as dispensed into machine or engine fuel tank is "ISO 18/16/13" or cleaner per "ISO 4406" or "ASTM D7619". Refer to the "Recommendations for Cleanliness of Fuels" in this chapter

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 the "Caterpillar Specification for Distillate Fuel for Off-Highway Diesel Engines", Table 1. To help 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 the "Cat Specification for Distillate Fuel for Off-Highway Diesel Engines", Table 1.

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### NOTICE

**In order to meet expected fuel system component life, 4 micron(c) absolute or less secondary fuel filtration is required for all Cat diesel engines that are equipped with common-rail fuel systems. Also, 4 micron(c) absolute or less secondary fuel filtration is required for all Cat diesel engines that are equipped with unit injected fuel systems. For all other Cat diesel engines (mostly older engines with pump, line and nozzle type fuel systems), the use of 4 micron(c) absolute or less secondary fuel filtration is strongly recommended. Note that all current Cat diesel engines are factory equipped with Cat Advanced Efficiency 4 micron(c) absolute fuel filters.**

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In order to obtain additional information on Cat designed and produced filtration products, refer to this Special Publication, "Reference Material" article, "Filters" and "Miscellaneous" topics, and then contact your Cat dealer for assistance with filtration recommendations for your Cat machine.

**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.**

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## Contamination Control Recommendations for Fuels

Fuels of "ISO 18/16/13" cleanliness level or cleaner as dispensed into the engine or machine fuel tank should be used in order to reduce power loss, failures and related down time of engines. This cleanliness level is particularly important for new fuel system designs such as Common Rail injection systems and unit injection systems. These new injection system designs utilize higher fuel pressures and are designed with tight clearances between moving parts in order to meet required stringent emissions regulations. Peak injection pressures in

current fuel injection systems may exceed 30,000 psi. Clearances in these systems are less than 5  $\mu\text{m}$ . As a result, particle contaminants as small as 4  $\mu\text{m}$  can cause scoring and scratching of internal pump and injector surfaces and of injector nozzles.

Water in the fuel causes cavitation, corrosion of fuel system parts, and provides an environment where microbial growth in the fuel can flourish. Other sources of fuel contamination are soaps, gels or other compounds that may result from undesirable chemical interactions in the fuels, particularly in Ultra Low Sulfur Diesel (ULSD). Gels and other compounds can also form in biodiesel fuel at low temperatures or if biodiesel is stored for extended periods. The best indication of microbial contamination, fuel additives or cold temperature gel is very rapid filter plugging of bulk fuel filters or machine fuel filters.

In order to reduce downtime due to contamination, follow these fuel maintenance guidelines in addition to the "General Contamination Control Recommendations or Practices" given above in this Chapter:

- Use high quality fuels per recommended and required specifications (refer to the "Fuel" chapter in this Special Publication).
- Fill machine fuel tanks with fuels of "ISO 18/16/13" cleanliness level or cleaner, in particular for engines with common rail and unit injection systems. When you refuel the machine, filter the fuel through a 4  $\mu\text{m}$  absolute filter (Beta 4 = 75 up to 200) in order to reach the recommended cleanliness level. This filtration should be located at the device that dispenses the fuel to the engine or machine fuel tank. In addition, filtration at the dispensing point should have the ability to remove water to ensure fuel is dispensed at 500 ppm water or less.
- Caterpillar recommends the use of bulk fuel filter / coalescer units which remove both particulate contamination and water in a single pass. These units have the ability to clean fuel to "ISO 16/13/11" or cleaner and remove free water to 500 ppm (mg/kg) or less. Cat offers heavy duty filter / coalescer units to accommodate fueling rates from 50 to 300 gpm (gallons per minute). Cat custom designs filter / coalescer units specifically for the conditions of fuel at the worksite if needed.
- Ensure that you use Cat Advanced Efficiency Fuel Filters. Change your fuel filters per recommended service requirements or as needed.
- Drain your water separators daily per the Operation and Maintenance Manual of your machine.
- Drain your fuel tanks of sediment every 500 hours or 3 months per the Operation and Maintenance Manual of your machine.
- Install and maintain a properly designed bulk filter / coalescer filtration system. Continuous bulk filtration systems may be required to ensure dispensed fuel meets the cleanliness target. Refer to your Cat dealer for availability of bulk filtration products.
- Centrifugal filters may need to be used as a pre-filter with fuel that is severely contaminated with gross amounts of water or large particulate contaminants. Centrifugal filters can effectively remove large contaminants, but may not be able to remove the very small abrasive particles required to achieve the recommended "ISO" cleanliness level. Bulk filter / coalescers are necessary as a final filter in order to achieve the recommended cleanliness level.
- Install desiccant type breathers of 4  $\mu\text{m}$  or less absolute efficiency with the ability to remove water on bulk storage tanks.
- Follow proper practices of fuel transport and filtration from storage tank to the machine in order to allow the delivery of clean fuel to machine tank. Fuel filtration can be installed at each transport stage in order to keep the fuel clean.

- Cover, protect and ensure cleanliness of all connection hoses, fittings and dispensing nozzles.

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### NOTICE

**In order to meet expected fuel system component life, 4 micron(c) absolute or less secondary fuel filtration is required for all Cat diesel engines that are equipped with common-rail fuel systems. Also, 4 micron(c) absolute or less secondary fuel filtration is required for all Cat diesel engines that are equipped with unit injected fuel systems. For all other Cat diesel engines (mostly older engines with pump, line and nozzle type fuel systems), the use of 4 micron(c) absolute or less secondary fuel filtration is strongly recommended. Note that all current Cat diesel engines are factory equipped with Cat Advanced Efficiency 4 micron(c) absolute fuel filters.**

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Consult your local Cat dealer for additional information on Cat designed and produced filtration products.

Refer to the "Contamination Control" chapter in this Special Publication for more details.

## Heavy Fuel Oil, Residual Fuel, Blended Fuel

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### 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.**

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## Alternative Fuels - Cold Weather Applications

In extreme cold ambient conditions, you may choose to use the distillate fuels that are specified in table 2. However, the fuel that is selected must meet the requirements that are specified in the "Cat Specification for Distillate Diesel Fuel for Off-Highway Diesel Engines", Table 1. These fuels are intended to be used in operating temperatures that are down to -54 °C (-65 °F).

**Note:** The fuels that are listed in table 2 typically have much higher sulfur levels than the 15 ppm maximum sulfur allowed for ULSD. The sulfur levels for these fuels typically far exceed 15 ppm. These fuels typically will not be acceptable for use in areas that restrict maximum fuel sulfur levels to 15 ppm or less.

**Note:** The fuels that are listed in table 2 typically have much higher sulfur levels than the 50 ppm maximum sulfur allowed in the European Standard "EN 590:2004". The sulfur content

of these fuels typically far exceeds 50 ppm. These fuels typically will not be acceptable for use in areas that restrict maximum fuel sulfur levels to 50 ppm or less.

The fuel that is selected must meet the requirements that are specified in "Cat Specification for Distillate Diesel Fuel for Off-Highway Diesel Engines", table 1. Cooling of the fuel may be required to maintain 1.4 cSt or greater viscosity at the fuel injection pump. Consult the supplier for the recommended additives in order to maintain the proper fuel lubricity.

The fuel specifications listed in this table allow and/or recommend the use of fuel additives that have not been tested by Cat for use in Cat fuel systems. The use of these specifications allowed and/or recommended fuel additives are at the risk of the user.

Jet A is the standard fuel used by U.S. commercial airlines when operating within the U.S. Jet A-1 is the standard fuel used by commercial airlines worldwide. Per "ASTM D1655-08a, Table 1 (Detailed Requirements of Aviation Turbine Fuels)", Jet A and Jet A-1 have identical requirements except for freezing point. Jet A has a freeze point requirement of -40 °C (-40 °F) versus the Jet A-1 has a freeze point requirement of -47 °C (-52.6 °F), but the fuel purchaser and the fuel supplier may agree on other freezing points.

Table 2	
Alternative Distillate Fuels - Cold Weather Applications	
Specification	Grade
"MIL-DTL-5624U"	JP-5
"MIL-DTL-83133F"	JP-8
"ASTM D1655-08a"	Jet A, Jet A-1

These fuels are lighter than the No. 2 grades of fuel. The cetane number of the fuels in table 2 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.

**Note:** These fuels may not prove acceptable for all applications.

## Renewable and Alternative Fuels

Renewable fuels are derived from renewable resources such as planted crops and crop residues (referred to as biomass), waste, algae, cellulosic material, yard and food waste, etc. Renewable fuels reduce the carbon footprint of the fuels compared to fossil fuels on a Life Cycle Analysis basis. Caterpillar, through its sustainability initiatives, supports the development and use of renewable fuels.

Renewable fuels (other than biodiesel) and alternative fuels (such as but not limited to Gas-to-Liquid fuel) are typically hydrocarbons (composed of carbon and hydrogen). An exception is

biodiesel, which is an oxygenated renewable fuel. Biodiesel is discussed in a separate article in this Fuel section. Significant research is on going to develop renewable fuels and produce them economically.

Caterpillar is not in a position to test all varieties of renewable and alternative fuels that are advertised in the market place. If a renewable or alternative fuel fulfills the performance requirements described in Cat Fuel Specification, the latest version of "ASTM D975", the latest version of "EN 590", or the latest version of the paraffinic fuel specification "CEN TS 15940" (which defines quality requirements for Gas to Liquids (GTL), Biomass to Liquids (BTL) and hydrotreated vegetable oil (HVO)), then this fuel or a blend of this fuel (blended with appropriate diesel fuel) can be used as a direct replacement of petroleum diesel in Cat engines. Consult with the fuel supplier and with your Cat dealer to ensure that the cold-weather performance of the fuel is appropriate to the expected ambient temperatures at the operation sites and to ensure elastomer compatibility. Certain elastomers used in older engines (such as engines manufactured up to the early 1990s) may not be compatible with the new alternative fuels.

Caterpillar is following the development of renewable and alternative fuels and the respective fuel specifications in order to ensure successful application of these fuels in the engines. Information and guidelines will be published as the production of these fuels becomes established.

## 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 plug fuel filters. Some additives may be corrosive, and some additives may be harmful to the elastomers in the fuel system. Some additives may damage emission control systems. Some additives may raise fuel sulfur levels above the maximum allowed by the United States (U.S.) Environmental Protection Agency (EPA) and/or, as appropriate, other regulatory agencies. Consult 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:** Metallic fuel additives can cause fuel system/injector fouling and after treatment device fouling. Caterpillar discourages the use of metallic fuel additives in most applications. Metallic fuel additives should only be used in applications where their use is specifically recommended by Caterpillar.

**Note:** Diesel fuel additives/conditioners may not improve markedly poor diesel fuel properties enough to make them acceptable for use.

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

## Cat Diesel Fuel Conditioner

**Note:** Cat Diesel Fuel Conditioner, part number 256-4968, is the only fuel conditioner/additive available to the end user that is tested and approved by Caterpillar for use in Cat diesel engines.

Cat Diesel Fuel Conditioner is a proprietary metal and ash free formulation that has been extensively tested for use with distillate diesel fuels for use in Cat diesel engines. Cat Diesel Fuel Conditioner helps address many of the challenges that various fuels worldwide present in regards to fuel life/stability, engine startability, injector deposits, fuel system life, and long term engine performance.

**Note:** Diesel fuel additives/conditioners may not improve markedly poor diesel fuel properties enough to make them acceptable for use.

**Note:** For maximum overall benefits, ask your fuel supplier to add Cat Diesel Fuel Conditioner at the recommended treat rate before fuel delivery, or you may add Cat Diesel Fuel Conditioner at the recommended treat rate during the early weeks of fuel storage. Follow all applicable national, regional, and local laws, mandates, and regulations concerning the use of diesel fuel conditioners/additives.

Cat Diesel Fuel Conditioner is a proven high performance, multipurpose diesel fuel conditioner that is designed to improve:

- Fuel economy (through fuel system cleanup)
- Lubricity
- Oxidative stability
- Detergency/dispersancy
- Moisture dispersancy
- Corrosion protection
- Cetane (typically 2-3 cetane numbers)

Cat Diesel Fuel Conditioner has been validated through lab and field tests to improve/reduce diesel fuel consumption and emissions for typical fleets through fuel system/injector cleanup, and to help maintain new engine performance by keeping fuel systems clean. Note that while fuel system/injector cleanup takes place over time, maintaining fuel system/injector cleanliness is an ongoing process.

Data indicates that average fuel economy improvements across typical fleets may be in the 2-3+ percentage range. Note that improvements may vary based on factors such as engine model, age and condition of the engine, and application.

Cat Diesel Fuel Conditioner also reduces the formation of gums, resins, and sludge, and disperses insoluble gums. This can dramatically improve fuel storage life, reduce fuel related engine deposits and corrosion, and extend fuel filter life.

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## **NOTICE**

**Use of Cat Diesel Fuel System Cleaner or Cat Diesel Fuel System Conditioner does not lessen the responsibility of the engine owner and/or responsibility of the fuel supplier to follow all industry standard maintenance practices for fuel storage and for fuel handling. Refer to the "General Fuel Information" article in this Special Publication for**

**additional information. Additionally, use of Cat Diesel Fuel System Cleaner or Cat Diesel Fuel System Conditioner does NOT lessen the responsibility of the owner of the engine to use appropriate diesel fuel. Refer to the "Fuel Specifications" section in this Special Publication (Maintenance Section) for guidance.**

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Caterpillar strongly recommends that Cat Diesel Fuel Conditioner be used with biodiesel and biodiesel blends. Cat Diesel Fuel Conditioner is suitable for use with biodiesel/biodiesel blends that meet Cat biodiesel recommendations and requirements. **Note that not all fuel additives are suitable for use with biodiesel/biodiesel blends.** Read and follow all applicable label usage instructions. Also, refer to this Special Publication, "Distillate Diesel Fuel" article and also refer to the "Biodiesel" article, which includes Cat biodiesel recommendations and requirements.

When used as directed, Cat Diesel Fuel Conditioner has proven to be compatible with non-road Tier 4 U.S. EPA certified engines that are equipped with aftertreatment devices.

**Note:** When used as directed, Cat Diesel Fuel Conditioner will not raise fuel sulfur levels measurably in the final fuel/additive blend. In the U.S. the current formulation of Cat Diesel Fuel Conditioner must be blended in at the recommended treat-rate at the fuel supplier/distributor level for use in on-highway or other applications where use of ULSD fuel is mandated (15 ppm or less fuel sulfur). Follow all applicable national, regional, and local laws, mandates, and regulations concerning the use of diesel fuel conditioners/additives.

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## NOTICE

**When used as directed Cat Diesel Fuel Conditioner will not raise fuel sulfur levels measurably in the final fuel/additive blend. Follow all applicable national, regional, and local laws, mandates, and regulations concerning the use of diesel fuel conditioners/additives.**

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## Cat Diesel Fuel System Cleaner

**Note:** Cat Diesel Fuel System Cleaner, part number 343-6210, is the only fuel system cleaner available to the end user that is tested and approved by Caterpillar for use in Cat diesel engines.

Cat Diesel Fuel System Cleaner is a proven high performance detergent product specifically designed for cleaning deposits that form in the fuel system. Deposits in the fuel system reduce system performance and can increase fuel consumption. Cat Diesel Fuel System Cleaner addresses the deposits formed due to the use of degraded diesel fuel, poor quality diesel fuel, and diesel fuel containing high quantities of high molecular weight compounds. Cat Diesel Fuel System Cleaner addresses deposits formed due to the use of biodiesel, biodiesel blends, and biodiesel that does not meet the appropriate quality specifications. Continued use of Cat Diesel Fuel System Cleaner is proven to inhibit the growth of new deposits.

Cat Diesel Fuel System Cleaner can be added directly to diesel fuel, biodiesel, or biodiesel blends. Cat Diesel Fuel System Cleaner is a United States Environmental Protection Agency registered fuel additive that can be used with Ultra Low Sulfur Diesel Fuel. In addition this

cleaner is appropriate for use with other ultra low, low, and higher sulfur diesel fuels around the world.

Cat Diesel Fuel System Cleaner is a proven high performance cleaner that is designed to perform the following:

- Clean performance-robbing fuel system deposits
- Restore fuel economy losses resulting from injector deposits
- Restore power losses resulting from injector deposits
- Eliminate visible black exhaust smoke resulting from injector deposits
- Prevent the formation of new fuel-related deposits

For engines experiencing problems such as power loss, increased fuel consumption, or black smoke due to the presence of fuel-related deposits in fuel injectors, a high-strength cleaning cycle is recommended. Add one 0.946L (32 oz.) bottle of Cat Diesel Fuel System Cleaner per 250 L (65 gal) of fuel, which corresponds to a treat rate of 0.4% by volume. Prior to re-fueling, pour Cat Diesel Fuel System Cleaner directly into the fuel tank, then refill with fuel. The refilling process should give satisfactory mixing of the cleaner. The cleaner will begin to be effective immediately. Testing has shown most deposits are cleaned and related issues are resolved after 30 hours of operating the engine on fuel with the cleaner. For maximum results, continue to use at this treat rate for up to 80 hours.

To prevent the return of fuel-related deposits, Cat Diesel Fuel System Cleaner, add the cleaner to the fuel as previously described, but at a 0.2% treat rate. In this case, one 0.946L (32 oz.) bottle will treat 500 L (130 gallons) of fuel. Cat Diesel Fuel System Cleaner can be used on an on-going basis with no adverse impact on engine or fuel system durability.

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## NOTICE

**Use of Cat Diesel Fuel System Cleaner or Cat Diesel Fuel System Conditioner does not lessen the responsibility of the engine owner and/or responsibility of the fuel supplier to follow all industry standard maintenance practices for fuel storage and for fuel handling. Refer to the "General Fuel Information" article in this Special Publication for additional information. Additionally, use of Cat Diesel Fuel System Cleaner or Cat Diesel Fuel System Conditioner does NOT lessen the responsibility of the owner of the engine to use appropriate diesel fuel. Refer to the "Fuel Specifications" section in this Special Publication (Maintenance Section) for guidance.**

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Caterpillar strongly recommends that Cat Diesel Fuel System Cleaner be used with biodiesel and biodiesel blends. Cat Diesel Fuel System Cleaner is suitable for use with biodiesel/biodiesel blends that meet Cat biodiesel recommendations and requirements. Note that not all fuel cleaners are suitable for use with biodiesel/biodiesel blends. Read and follow all applicable label usage instructions. Also, refer to this Special Publication, "Distillate Diesel Fuel", article and also refer to the "Biodiesel" article, which includes Cat biodiesel recommendations and requirements.

When used as directed, Cat Diesel Fuel System Cleaner has proven to be compatible with non-road Tier 4 U.S. EPA certified engines that are equipped with aftertreatment devices.

**Note:** When used as directed, Cat Diesel Fuel System Cleaner will not raise fuel sulfur levels measurably in the final fuel/additive blend. Follow all applicable national, regional, and local laws, mandates, and regulations concerning the use of diesel fuel conditioners/additives.

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## NOTICE

**When used as directed Cat Diesel Fuel System Cleaner will not raise fuel sulfur levels measurably in the final fuel/additive blend. But, in the U.S., aftermarket fuel additives (retail consumer level versus bulk fuel additives used at the fuel supplier/distributor level) with more than 15 ppm sulfur are NOT allowed to be used in applications where ULSD usage is mandated (15 ppm or less fuel sulfur). Note that Cat Diesel Fuel System Cleaner contains less than 15 ppm of sulfur and is acceptable for use with ULSD fuel.**

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