SEBU6385-09 (en-us)
February 2024

Operation and Maintenance Manual

Caterpillar On-Highway Diesel Engine Fluids Recommendations

Special Publication

Scan to find and purchase genuine Cat® parts and related service information.

Important Safety Information

Most accidents that involve product operation, maintenance and repair are caused by failure to observe basic safety rules or precautions. An accident can often be avoided by recognizing potentially hazardous situations before an accident occurs. A person must be alert to potential hazards, including human factors that can affect safety. This person should also have the necessary training, skills and tools to perform these functions properly.

Improper operation, lubrication, maintenance or repair of this product can be dangerous and could result in injury or death.

Do not operate or perform any lubrication, maintenance or repair on this product, until you verify that you are authorized to perform this work, and have read and understood the operation, lubrication, maintenance and repair information.

Safety precautions and warnings are provided in this manual and on the product. If these hazard warnings are not heeded, bodily injury or death could occur to you or to other persons.

The hazards are identified by the “Safety Alert Symbol” and followed by a “Signal Word” such as “DANGER”, “WARNING” or “CAUTION”. The Safety Alert “WARNING” label is shown below.



The meaning of this safety alert symbol is as follows:

Attention! Become Alert! Your Safety is Involved.

The message that appears under the warning explains the hazard and can be either written or pictorially presented.

A non-exhaustive list of operations that may cause product damage are identified by “NOTICE” labels on the product and in this publication.

Caterpillar cannot anticipate every possible circumstance that might involve a potential hazard. The warnings in this publication and on the product are, therefore, not all inclusive. You must not use this product in any manner different from that considered by this manual without first satisfying yourself that you have considered all safety rules and precautions applicable to the operation of the product in the location of use, including site-specific rules and precautions applicable to the worksite. If a tool, procedure, work method or operating technique that is not specifically recommended by Caterpillar is used, you must satisfy yourself that it is safe for you and for others. You should also ensure that you are authorized to perform this work, and that the product will not be damaged or become unsafe by the operation, lubrication, maintenance or repair procedures that you intend to use.

The information, specifications, and illustrations in this publication are on the basis of information that was available at the time that the publication was written. The specifications, torques, pressures, measurements, adjustments, illustrations, and other items can change at any time. These changes can affect the service that is given to the product. Obtain the complete and most current information before you start any job. Cat dealers have the most current information available.

NOTICE

When replacement parts are required for this product Caterpillar recommends using original Caterpillar® replacement parts.

Other parts may not meet certain original equipment specifications.

When replacement parts are installed, the machine owner/user should ensure that the machine remains in compliance with all applicable requirements.

In the United States, the maintenance, replacement, or repair of the emission control devices and systems may be performed by any repair establishment or individual of the owner's choosing.

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Foreword

Literature Information

This manual should be stored in the literature storage area.

The information contained in this document is the most current information available for coolants, fuels, and lubricants. Refer to the Operation and Maintenance Manual for any special lubrication requirements for your engine.

Whenever a question arises regarding the engine, this publication, or the Operation and Maintenance Manual, please consult any Cat dealer for the latest available information.

Safety

Refer to the Operation and Maintenance Manual for your engine for all safety information. Read and understand the basic safety precautions listed in the Safety Section. In addition to safety precautions, this section identifies the text and locations of safety signs used on the engine.

Read and understand the basic precautions listed in the Safety Section before operating or performing lubrication, maintenance and repair on this engine.

Maintenance

Refer to the Operation and Maintenance Manual for your engine to determine all maintenance requirements.

Maintenance Intervals

Use the Maintenance Interval Schedule in the Operation and Maintenance Manual for your engine to determine servicing intervals. The actual operating environment of the engine also governs the maintenance interval schedule. Therefore, under extremely severe, dusty, wet or freezing cold operating conditions, more frequent lubrication and maintenance than is specified in the Maintenance Interval Schedule may be necessary.

Extended Engine Oil Drains and Warranty

Failures that result from extended oil drain periods are not Caterpillar factory defects and therefore are not covered by Caterpillar's warranty. In addition, failures that result from not using the recommended oil type are not Caterpillar factory defects and therefore are not covered by Caterpillar's warranty.

Refer to the applicable Operation and Maintenance Manual for standard oil drain periods and to the Maintenance Section, “Lubricant Specifications” of this publication for engine oil type and viscosity grade recommendations.

To reduce the potential risk of failures associated with extended oil drain periods; it is recommended that oil drain intervals only be extended based on oil analysis, and subsequent engine inspections. Oil analysis alone does not provide an indication of the rate of formation of lacquer, varnish and/or carbon on pistons and other engine surfaces. The only accurate way to evaluate specific oil performance in a specific engine and application that utilizes extended oil drain periods is to observe the effects on the engine components. This involves tear-down inspections of engines that have run to their normal overhaul period with extended oil drain intervals. Following this recommendation will help ensure that excessive component wear does not take place in a given application.

NOTICE
Light loads, low hour accumulation, and excessive idling time can contribute to excessive water in the crankcase oil. Corrosive damage, piston deposits and increased oil consumption can also result. If oil analysis is not done or the results are ignored, the potential for corrosive damage and piston deposits increases. Refer to the appropriate Operation and Maintenance Manual for guidance.

Note: Failures that result from extended oil drain periods are not warrantable failures, regardless of use of this recommended procedure. Failures that result from extended engine oil drain periods are considered improper use under the warranty.

Aftermarket Products and Warranty

NOTICE
When auxiliary devices, accessories or consumables (filters, oil, additives, catalysts, fuel, etc.) made by other manufacturers are used on Caterpillar products, the Caterpillar warranty is not affected simply because of such use. Failures that result from the installation or usage of other manufacturers auxiliary devices, accessories or consumables, however, are not Caterpillar factory defects and therefore are NOT covered by Caterpillar's warranty.

Caterpillar is not in a position to evaluate the many auxiliary devices, accessories or consumables promoted by other manufacturers and their effect on Caterpillar products. Installation or use of such items is at the discretion of the customer who assumes ALL risks for the effects that result from this usage.

Furthermore, Caterpillar does not authorize the use of its trade name, trademark, or logo in a manner which implies our endorsement of these aftermarket products.

Maintenance Section

Lubricant Specifications

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General Lubricant Information

SMCS Code: 0645; 1000; 1300; 1348; 7581

NOTICE
Every attempt is made to provide accurate, up-to-date information. By the use of this document, you agree that Caterpillar Inc. is not responsible for errors or omissions.

The information that is provided is the latest recommendations for Caterpillar diesel engines that are covered by this Special Publication. This information supersedes all previous recommendations which have been published for Caterpillar diesel engines that are covered by this Special Publication. Special fluids are required for some engines and it will be necessary to continue to use these special products. Refer to the applicable Operation and Maintenance Manual.

This publication is a supplement to the Operation and Maintenance Manual. This publication does not replace the engine specific Operation and Maintenance Manuals.

NOTICE
These recommendations are subject to change without notice. Consult your local Cat dealer for the most up to date recommendations.

NOTICE
Many of the guidelines, recommendations, and requirements that are provided in this Special Publication are interrelated. Before using the provided information, it is the responsibility of the user of this Special Publication to read and understand the information provided in its entirety.

It is the responsibility of the user of this Special Publication to follow all safety guidelines found in this Special Publication and in engine and/or machine specific Operation and Maintenance Manual when performing all recommended and/or required engine, engine systems, and/or machine maintenance.

For questions concerning the information presented in this Special Publication and/or in your product Operation and Maintenance Manual, and/or for additional guidelines and recommendations (including maintenance interval recommendations/requirements) consult your Caterpillar dealer.

NOTICE
Commercial products that make generic claims of meeting “Cat” requirements without listing the specific Cat recommendations and requirements that are met may not provide acceptable performance. Commercial products may cause reduced engine and/or machine fluid compartment life. Refer to this Special Publication and refer to product specific Operation and Maintenance Manual for Cat fluids recommendations and requirements.

Note: Instructions for the installation of the filter are printed on the side of each Caterpillar spin-on filter. For non-Caterpillar filters, refer to the installation instructions that are provided by the supplier of the filter.

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.

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

NOTICE
Faulty engine coolant temperature regulators, or operating with light loads, short operation cycles, excessive idling, or operating in applications where normal operating temperature is seldom reached can contribute to excessive water in the crankcase oil. Corrosive damage, piston deposits, increased oil consumption, and other damage can result. If a complete oil analysis program is not followed or if the results are ignored, the potential for damage increases. Follow engine warmup recommendations provided in this Special Publication and/or given in your engine Operation and Maintenance Manual.

NOTICE
Not following the recommendations found in this Special Publication can lead to reduced performance and compartment failure.

Cat Fluids

Cat fluids have been developed and tested by Caterpillar in order to increase the performance of Cat components and the life of Cat components. The quality of finished oil is dependent on the quality of the base stock, the quality of the additives and the compatibility of the base stock and additives. Cat fluids are formulated of high quality refined oil base stocks and additives of optimal chemistry and quantity to provide high performance in engines and machine components. Cat fluids are used for factory fill of Cat engines and components and are offered by Caterpillar dealers for service fills and as aftermarket products. Consult your Caterpillar dealer for more information on these Cat fluids.

Table 1

Cat lubricants for on-highway applications						
Compartment or System	Oil Type	Oil Viscosity Grade	Typical Application Temp C (1)		Typical Application Temp F (1)	
			Min	Max	Min	Max
Engine Oils	Cat DEO-ULS	SAE 15W-40	−9.5	50	15	122
		SAE 10W-30	−18	40	0	104
	Cat DEO-ULS SYN	SAE 5W-40	−30	50	−22	122
	Cat DEO	SAE 15W-40	−9.5	50	15	122
		SAE 10W-30	−18	40	0	104
	Cat DEO SYN	SAE 5W-40	−30	50	−22	122
	Cat Arctic DEO SYN	SAE 0W-30	−40	30	−40	86
Transmission and Drive Train Oils (On-Highway applications)	Cat ATF-HD	Multi-Grade Synthetic	(2)		(2)	
Hydraulic Oils	Cat HYDO Advanced	SAE 10W	−20	40	−4	104
		SAE 30	10	50	50	122
	Cat Bio HYDO (HEES)	ISO 46 Multi-grade	−25	45	−13	113

(1) The application temperatures will vary per machine application. Follow the recommendations provided in the “Lubricant Viscosity” section of this Special Publication and your Operation and Maintenance Manual for fluid temperature recommendations of the specific application and machine compartment.

(2) If the temperature is less than −23° C (−10° F), warm up the engine for 20 minutes. As an alternative to the warm up, you may install an appropriate transmission oil heater.

Table 2

Caterpillar Grease and Coolant products	
Grease	Cat Multipurpose Grease
	Cat Advanced 3Moly Grease
	Cat Ultra 5Moly Grease
	Cat Desert Gold Grease
	Cat Arctic Platinum Grease

(continued)

(Table 2, contd)

Caterpillar Grease and Coolant products	
	Cat High Speed Ball Bearing Grease
	Cat White Assembly Grease
Coolants	Cat ELC (Extended Life Coolant)
	Cat ELC Extender (for use with Cat ELC)
	Cat DEAC (Diesel Engine Antifreeze/Coolant)
	Cat SCA (Supplemental Coolant Additive, for use with Cat DEAC)

This information is only for Caterpillar on-highway diesel engines. For more lubricant recommendations see the following Special Publications:

- Special Publication, SEBU6251, “Caterpillar Commercial Diesel Engine Fluid Recommendations”
- Special Publication, SEBU6250, “Caterpillar Machine Fluids Recommendations”
- Special Publication, SEBU6400, “Caterpillar Gas Engine Lubricant, Fuel, and Coolant Recommendations”
- Special Publication, SEBU7003, “Caterpillar 3600 Series and C280 Series Diesel Engine Fluids Recommendations”

Always consult your Caterpillar dealer in order to ensure that you have the current revision level of the publication.

Note: The optimal application of the lubricants is dependant on the oil quality and the maintenance practices such as contamination control, tank management, and general handling practices.

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Engine Oil
(Engine Crankcase Fluid Recommendations for all Cat On-Highway Diesel Engines)

SMCS Code: 1348; 7581

Summary of Typical Cat Lubricant Recommendations

Table 3

Cat Engine Lubricants Recommendations (1)		
	Model Year 2007	Pre-Model year 2007
Preferred	Cat DEO-ULS	Cat DEO-ULS
		Cat DEO
Commercial Lubricants	Cat ECF-3/“API CJ-4” (2)	Cat ECF-3/“API CJ-4”
		Cat ECF-2
		Cat ECF-1-a

(1) The oils are listed in order of preference.
(2) Cat ECF-2 oils of ≤1 percent ash content are also acceptable.

Table 4

Cat Engine Crankcase Fluids (ECF) performance requirements	
Cat Performance Requirement	Caterpillar ECF Specifications Requirements
Cat ECF-3	“API CJ-4” Oil Category performance requirements
Cat ECF-2	“API CI-4/CI-4 PLUS” Oil Category performance requirements **and** 1 - passing the Standard Cat C13 engine test per “API” requirements **and** 2- Oils of sulfated ash >1.50 percent are not allowed
Cat ECF-1-a	“API CH-4” Oil Category performance requirements **and** 1- for oils that are between 1.30 percent and 1.50 percent sulfated ash level, passing 1 additional Cat 1P SCOTE (1) test (“ASTM D6681”) is required **and** 2- Oils of sulfated ash >1.50 percent are not allowed

(1) SCOTE Single Cylinder Oil Test Engine

Cat Diesel Engine Oil

Cat oils have been developed and tested in order to provide the full performance and service life that has been designed and built into Cat engines. Cat oils are currently used to fill diesel engines at the factory. These oils are offered by Caterpillar dealers for continued use when the engine oil is changed. Consult your Caterpillar dealer for more information about these oils.

Due to the additional full scale proprietary engine testing required of Cat DEO-ULS and Cat DEO, and due to significant variations in the quality and in the performance of commercially available oils, Caterpillar makes the following recommendations:

- **Cat DEO-ULS (Diesel Engine Oil - Ultra Low Sulfur) (15W-40)**
- **Cat DEO-ULS (Diesel Engine Oil - Ultra Low Sulfur) (10W-30)**

- **Cat DEO (Diesel Engine Oil) (15W-40)**
- **Cat DEO (Diesel Engine Oil) (10W-30)**

Cat DEO-ULS multigrade and Cat DEO multigrade oils are formulated with the correct amounts of detergents, dispersants, and alkalinity in order to provide superior performance in Cat diesel engines where recommended for use.

Cat DEO-ULS and Cat DEO multigrade oils are the preferred oils for use in **ALL** Cat diesel engines that are covered by this Special Publication. Commercial alternative diesel engine oils are, as a group, second choice oils. Refer to table 4 in this Special Publication.

It is strongly recommended that Cat DEO-ULS be used in model year 2007 and newer (United States Environmental Protection Agency (U.S. EPA) 2007 certified) Cat on-highway, and other aftertreatment-equipped Cat diesel engines, and in Cat EURO IV diesel engines. Cat DEO-ULS limits the sulfated ash in the oil to 1 percent or less, which helps maintain the expected aftertreatment performance. Use of oils other than Cat DEO-ULS in aftertreatment-equipped engines may negatively impact performance of the aftertreatment devices, may cause the need for more frequent Diesel Particulate Filter (DPF) cleaning cycles and may contribute to DPF plugging.

Typical aftertreatment systems include Diesel Particulate Filter (DPF), Diesel Oxidation Catalysts (DOC), Selective Catalytic Reduction (SCR), and/or Lean NOx Traps (LNT). Other systems may apply.

Note: Acceptable commercial oils information is given in the “Commercial Oils” section of the “Engine Oil” article of this Special Publication. Other systems may apply.

NOTICE
Oils that have more than 1% total sulfated ash should not be used in aftertreatment device equipped engines.

In order to achieve expected ash service intervals, performance, and life, aftertreatment device equipped diesel engines require the use of Cat DEO-ULS or oils meeting the Cat ECF-3 specification and the API CJ-4 oil category. Use of oils with more than 1% total sulfated ash in aftertreatment device equipped engines will cause the need for more frequent ash service intervals, and/or cause loss of performance. Refer to your engine specific Operation and Maintenance Manual, and refer to your aftertreatment device documentation for additional guidance.

NOTICE
Model year 2007 and newer (U.S. EPA 2007 certified) on-highway diesel engines REQUIRE the use of Ultra Low Sulfur Diesel (ULSD) fuel (≤ 15 ppm sulfur).

“Sulfur-free” diesel fuel (≤ 10 ppm sulfur) is strongly recommended for use in “EURO IV” certified on-highway diesel engines, while diesel fuel with ≤ 50 ppm sulfur is acceptable.

Low Sulfur Diesel (LSD) fuel (≤ 500 ppm sulfur) is strongly recommended (required in the U.S.) for use in model year 2006 and older on-highway diesel engines, while diesel fuel with ≤ 5000 ppm sulfur is acceptable for use in areas of the world where allowed by law. Diesel Oxidation Catalyst (DOC) equipped engines require the use of LSD fuel or ULSD fuel.

ULSD fuel is applicable in pre 2007 engines. Refer to this Special Publication, “Distillate Diesel Fuel (Fuel Recommendations for On-Highway Diesel Engines)”, article.

Note: In the U.S., burning fuel with greater than 15 ppm sulfur in model year 2007 and newer on-highway diesel engines is illegal and punishable with civil penalties.

Cat DEO-ULS and Cat DEO multigrade oils are available in various viscosity grades that include SAE 10W-30, SAE 15W-40, and SAE 5W-40. Refer to Table 3 for details. Multigrade oils provide the correct viscosity for a broad range of operating temperatures.

Multigrade oils are effective in maintaining low oil consumption and low levels of piston deposits.

Cat DEO-ULS multigrade and Cat DEO multigrade oils can be used in other manufacturer's diesel engines and in gasoline engines. See the engine manufacturer's literature for the recommended categories/specifications. Compare the categories/specifications to the specifications of Cat DEO-ULS multigrade and Cat DEO multigrade oils. The current industry standards for Cat DEO-ULS multigrade and Cat DEO multigrade oils are listed on the product labels and on the datasheets for the product.

Consult your Caterpillar dealer for part numbers and for available sizes of containers.

Cat DEO-ULS multigrade exceeds the requirements of the following Cat Engine Crankcase Fluid (ECF) specifications: Cat ECF-1-a, Cat ECF-2 and Cat ECF-3. Cat DEO-ULS multigrade exceeds the performance requirements for the following American Petroleum Institute (API) oil categories: “API CJ-4”, “API CI-4”, “API CI-4 PLUS”, “API CH-4” and “API CF”. Cat DEO-ULS multigrade also passes additional proprietary tests that include the following: sticking of the piston ring, oil control tests, wear tests, and soot tests. Proprietary tests help ensure that Cat multigrade oil provides superior performance in Cat diesel engines. Cat DEO-ULS multigrade is compatible for use in aftertreatment device-equipped engines.

Cat DEO multigrade exceeds the requirements of the following Cat Engine Crankcase Fluid (ECF) Specifications: Cat ECF-1-a and Cat ECF-2. Cat DEO multigrade exceeds the performance requirements for the following American Petroleum Institute (API) oil categories: “API CI-4”, “API CI-4 PLUS”, “API CH-4” and “API CF”. The availability of Cat DEO multigrade exceeding the noted requirements will vary by region. Cat DEO SAE 15W-40 also passes additional proprietary tests that include the following: sticking of the piston ring, piston deposits, oil control tests, wear tests and soot tests. Proprietary tests help ensure that Cat multigrade oil provides superior performance in Cat diesel engines.

Cat multigrade oils exceed many of the performance requirements of other manufacturers of diesel engines. Therefore these oils are excellent choices for many mixed fleets. True high performance oil is produced by using a combination of the following factors: industry standard tests, proprietary tests, field tests and prior experience with similar formulations. The design and the development of Cat lubricants that are both high performance and high quality are based on these factors.

Note: Cat DEO-ULS and Cat DEO are excellent choices for many mixed fleets. Refer to your engine manufacturer literature and requirements.

Note: API CG-4 oil category is obsolete. The American Petroleum Institute (API) does not license this category effective August 2009. API CG-4 oils are not recommended in Cat engines.

Commercial Oils

Commercial Crankcase Fluid Recommendations for all Current and Noncurrent Caterpillar On-highway Diesel Engines

Note: Non-Caterpillar commercial oils are, as a group, second choice oils. Within this grouping of second choice oils there are tiered levels of performance.

NOTICE
Cat does not warrant the quality or performance of non-Cat fluids.

Caterpillar developed the Engine Crankcase Fluid (ECF) specifications to ensure the availability of high performance commercial diesel engine oils in order to provide satisfactory life and performance in Cat diesel engines where recommended for use.

There are three current Cat ECF specifications: Cat ECF-1-a, Cat ECF-2 and Cat ECF-3. Refer to table 4 in this Special Publication. Each higher Cat ECF specification provides increased performance over lower Cat ECF specifications. For example, Cat ECF-3 provides higher performance than Cat ECF-2 and Cat ECF-3 provides much higher performance than Cat ECF-1-a.

Cat ECF-3 is related to “API CJ-4” oil category. Oils that meet “API CJ-4” oil category requirements are Cat ECF-3 specification compliant. Cat ECF-2 is related to “API CI-4/CI4 PLUS” oil category but with additional requirements (refer to Table 4 for details). Cat ECF-1-a is related to “API CH-4” oil category but with additional requirements (refer to Table 4 for details).

Note: The Cat ECF-1-a and Cat ECF-2 specifications replaced the Cat ECF-1 specification as of March 1, 2007. The Cat ECF-3 specification was released October 2006.

Note: Cat DEO-ULS and DEO are required to pass additional proprietary full scale diesel engine testing that is above and beyond the testing required by the various Caterpillar ECF specifications and by the various API oil categories that they also meet. This additional proprietary testing helps ensure that Cat multigrade diesel engine oils, when used as recommended, provide superior performance in Cat diesel engines. If Cat DEO-ULS multigrade or DEO multigrade oils are not used, as a second choice, use only commercial oils that meet the following specifications:

- When the recommended and preferred Cat diesel engine oils are not used, commercial oils that meet the requirements of the Caterpillar ECF-1-a, Caterpillar ECF-2, and/or the Caterpillar ECF-3 specification are acceptable for use in Cat diesel engines that are covered by this Special Publication. API category oils that have not met the requirements of at least one Cat ECF specification may cause reduced engine life. Refer to table 3 .

- When the recommended and preferred Cat diesel engine oils are not used, commercial oils that meet the requirements of the Caterpillar ECF-3 specification are acceptable for use in Cat diesel engines that are covered by this Special Publication. **After** Cat DEO-ULS and Caterpillar DEO, commercial oils that meet the Caterpillar ECF-3 specification are preferred oils - when compared to commercial diesel engine oils that do not meet the Caterpillar ECF-3 specification - for use in Cat diesel engines that are covered by this Special Publication. Refer to table 3 .

API category oils that have not met the requirements of at least one Cat ECF specification may cause reduced engine life. Oils that meet the “API CJ-4” oil category requirements are Cat ECF-3 specification compliant.

It is strongly recommended that Cat DEO-ULS or oils that meet the Caterpillar ECF-3 specification and “API CJ-4” oil category be used in model year 2007 and newer (United States Environmental Protection Agency (U.S. EPA) 2007 certified) Cat on-highway, and other aftertreatment-equipped Cat diesel engines, and in Cat EURO IV diesel engines. Cat DEO-ULS and Caterpillar ECF-3 specification and “API CJ-4” oil category limit the sulfated ash in the oil to 1 percent or less, which helps maintain the expected aftertreatment performance. Use of oils other than Cat DEO-ULS or oils that meet the Caterpillar ECF-3 specification and “API CJ-4” oil category in aftertreatment-equipped engines may negatively impact performance of the aftertreatment devices, may cause the need for more frequent Diesel Particulate Filter (DPF) cleaning cycles and may contribute to DPF plugging.

Typical aftertreatment systems include Diesel Particulate Filter (DPF), Diesel Oxidation Catalysts (DOC), Selective Catalytic Reduction (SCR), and/or Lean NOx Traps (LNT). Other systems may apply.

NOTICE
Oils that have more than 1% total sulfated ash should not be used in aftertreatment device equipped engines.

In order to achieve expected ash service intervals, performance, and life, aftertreatment device equipped diesel engines require the use of Cat DEO-ULS or oils meeting the Cat ECF-3 specification and the API CJ-4 oil category. Use of oils with more than 1% total sulfated ash in aftertreatment device equipped engines will cause the need for more frequent ash service intervals, and/or cause loss of performance. Refer to your engine specific Operation and Maintenance Manual, and refer to your aftertreatment device documentation for additional guidance.

NOTICE
API category oils that have not met the requirements of at least one Cat ECF specification may cause reduced engine life.

NOTICE
In selecting oil for any engine application, both the oil viscosity and oil performance category/specification as specified by the engine manufacturer must be defined and satisfied. Using only one of these parameters will not sufficiently define oil for an engine application.

In order to make the proper diesel engine oil viscosity grade choice, refer to the applicable “Lubricant Viscosities for Ambient Temperatures” table in this Special Publication.

NOTICE
Failure to follow these oil recommendations can cause shortened engine service life due to deposits and/or excessive wear.

Total Base Number (TBN) and Fuel Sulfur Levels for Direct Injection (DI) Diesel Engines

The minimum required Total Base Number (TBN) for oil depends on the fuel sulfur level. The TBN for new oil is typically determined by the “ASTM D2896” procedure. For direct injection engines that use distillate fuel, the following guidelines apply.

Table 5

TBN recommendations for applications in Cat engines		
Fuel Sulfur Level percent (ppm)	**Cat Engine Oils**	**TBN of Commercial Engine Oils**
≤0.05 percent (≤500 ppm)	Cat DEO-ULS, Cat DEO	Min 7
0. 1 - 0.05 percent (1000-500 ppm)	Cat DEO-ULS, Cat DEO	Min 7
Above 0.1 percent (above 1000 ppm)	Cat DEO	Min 10

Reaching one half of new oil TBN is one of the condemning factors for diesel engine oil. In order to help provide the best protection for your engine, Cat S·O·S Services oil analysis is the preferred method for determining oil life. TBN of the oil is typically measured using “ASTM D2896” and/or the “ASTM D4739” test methods. It is recommended to change the oil when one half of new oil TBN with either method is reached.

For example, new oil with a TBN of 10 by “ASTM D2896” should be changed when, during use, the TBN deteriorates to 5 as determined by the “ASTM D2896” test method. New oil with a TBN of 10 by “ASTM D4739” should be changed when, during use, the TBN deteriorates to 5 as determined by the “ASTM D4739” test method.

Note: TBN is also commonly referred to as Base Number (BN).

Excessive piston deposits can be produced by oil with a high TBN and/or high ash. These deposits can lead to a loss of control of the oil consumption and to the polishing of the cylinder bore.

The use of Cat S·O·S Services oil analysis helps the environmental sustainability as it is the best way to optimize oil life, and will help engines reach their expected life. Consult your Caterpillar dealer regarding testing required to establish a safe, optimized oil drain interval.

Note: For the noncurrent on-highway PC (Precombustion Chamber) engines, the minimum new oil TBN must be 20 times the fuel sulfur level. The TBN for new oil is typically determined by the “ASTM D2896” procedure. The minimum TBN of the new oil is 7, regardless of the fuel sulfur level.

Caterpillar strongly recommends that Cat S·O·S Services fluids analysis be used in order to optimize oil, coolant, and engine life.

NOTICE

Model year 2007 and newer (U.S. EPA 2007 certified) on-highway diesel engines REQUIRE the use of Ultra Low Sulfur Diesel (ULSD) fuel (≤ 15 ppm sulfur).

“Sulfur-free” diesel fuel (≤ 10 ppm sulfur) is strongly recommended for use in “EURO IV” certified on-highway diesel engines, while diesel fuel with ≤ 50 ppm sulfur is acceptable.

Low Sulfur Diesel (LSD) fuel (≤ 500 ppm sulfur) is strongly recommended (required in the U.S.) for use in model year 2006 and older on-highway diesel engines, while diesel fuel with ≤ 5000 ppm sulfur is acceptable for use in areas of the world where allowed by law. Diesel Oxidation Catalyst (DOC) equipped engines require the use of LSD fuel or ULSD fuel.

ULSD fuel is applicable in pre 2007 engines.

Refer to this Special Publication, “Distillate Diesel Fuel (Fuel Recommendations for On-Highway Diesel Engines)” article.

Note: In the U.S., burning fuel with greater than 15 ppm sulfur in model year 2007 and newer on-highway diesel engines is illegal and punishable with civil penalties.

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Lubricant Viscosities

SMCS Code: 1000; 7000; 7581

Selecting the Viscosity

Ambient temperature is the temperature of the air in the immediate vicinity of the engine. This may differ due to the engine application from the generic ambient temperature for a geographic region. When selecting the proper oil viscosity for use, review **both** the regional ambient temperature and the potential ambient temperature for a given engine application. Generally, use the higher temperature as the criterion for the selection of the oil viscosity. Generally, use the highest oil viscosity that is allowed for the ambient temperature when you start the engine. Refer to the “Lubricant Viscosities for Ambient Temperatures” tables and the associated footnotes for guidance. In arctic applications, the preferred methods are to use a heated enclosure, or properly sized engine heaters and a higher viscosity grade oil. Thermostatically controlled heaters that circulate the oil are preferred.

The proper oil viscosity grade is determined by the minimum ambient air temperature (the air in the immediate vicinity of the engine). This is the temperature when the engine is started and while the engine is operated. In order to determine the proper oil viscosity grade, refer to the “Min” column in the table. This information reflects the coldest ambient temperature condition for starting a cold engine and for operating a cold engine. Refer to the “Max” column in the table in order to select the oil viscosity grade for operating the engine at the highest temperature that is anticipated. Unless specified otherwise in the “Lubricant Viscosities for Ambient Temperatures” Table, use the highest oil viscosity that is allowed for the ambient temperature when you start the engine.

Engines that are operated continuously and/or are heavily loaded should use oils that have the higher oil viscosity. The oils that have the higher oil viscosity will maintain the highest possible oil film thickness. Refer to this Special Publication, “Lubricant Viscosities for Ambient Temperatures” Tables and associated footnotes for any exceptions. Consult your dealer if additional information is needed.

Note: SAE 0W and SAE 5W oils are generally not recommended for use in engines that are operated continuously and/or are heavily loaded. Refer to the “Lubricant Viscosities for Ambient Temperatures” tables and the associated footnotes for guidance. The oils that have the higher oil viscosity will maintain the highest possible oil film thickness. Consult your Caterpillar dealer if additional information is needed.

NOTICE
Proper oil viscosity **AND** oil type/specification are required to maximize machine compartment performance and life. Do **NOT** use only oil viscosity, or only oil type to determine the machine compartment oil selection. Using only the oil viscosity or only the oil type to determine a machine compartment oil selection can lead to reduced performance and compartment failure. Refer to the “Lubricant Viscosities for Ambient Temperatures” tables and to ALL of the associated footnotes.

NOTICE
In colder ambient conditions a machine warm-up procedure and/or supplemental machine fluid compartment heat may be required. Machine specific warm-up procedures can typically be found in the Operation and Maintenance Manual for the machine. In addition, generic machine warm-up procedures can be found in this Special Publication, “Procedures for Machines that are Used in Cold Weather - (Generic)” topic. Some of the “Lubricant Viscosities for Ambient Temperatures” tables in this Special Publication include footnotes that address compartment warm-up.

NOTICE
Not following the recommendations found in this Special Publication can lead to reduced performance and compartment failure.

NOTICE
Do NOT use only the oil viscosities when determining the recommended oil for an engine compartment. The oil type (performance requirements) MUST also be used.

Note: Different brand oils may use different additive packages to meet the various engine performance category/specification requirements. For the best results, do not mix oil brands.

Note: The availability of the various Cat oils will vary by region.

The proper SAE viscosity grade of oil is determined by the minimum ambient temperature during cold engine start-up, and the maximum ambient temperature during engine operation.

Refer to Table 6 (minimum temperature) in order to determine the required oil viscosity for starting a cold engine.

Refer to Table 6 (maximum temperature) in order to select the oil viscosity for engine operation at the highest ambient temperature that is anticipated.

Note: Generally, use the highest oil viscosity that is available to meet the requirement for the temperature at start-up.

If ambient temperature conditions at engine start-up require the use of multigrade SAE 0W oil, SAE 0W-40 viscosity grade is generally preferred over SAE 0W-30.

Note: SAE 10W-30 is the preferred viscosity grade for the following diesel engines when the ambient temperature is above −18 °C (0 °F), and below 40 °C (104 °F).

- C7
- C-9
- C9
- 3116
- 3126

Table 6

Lubricant Viscosities for Ambient Temperatures[1][2]		
	Ambient Temperature	
Viscosity Grade	Minimum	Maximum
SAE 0W-30	−40 °C (−40 °F)	30 °C (86 °F)
SAE 0W-40	−40 °C (−40 °F)	40 °C (104 °F)
SAE 5W-30	−30 °C (−22 °F)	30 °C (86 °F)
SAE 5W-40	−30 °C (−22 °F)	50 °C (122 °F)
SAE 10W-30[3].	−18 °C (0 °F)	40 °C (104 °F)
SAE 10W-40	−18 °C (0 °F)	50 °C (122 °F)
SAE 15W-40	−9.5 °C (15 °F)	50 °C (122 °F)

(1) Refer to this Special Publication, “Engine Oil” article for recommendations of diesel engine oil type.
(2) Supplemental heat is recommended for cold-soaked starts below the minimum ambient temperature. Supplemental heat may be required for cold-soaked starts that are above the minimum temperature that is stated, depending on the parasitic load and other factors. Cold-soaked starts occur when the engine has not been operated for a period of time, allowing the oil to become more viscous due to cooler ambient temperatures.
(3) SAE10W-30 is the preferred viscosity grade for the 3116, 3126, C7, C-9 and C9 diesel engines when the ambient temperature is between −18 °C (0 °F) and 40 °C (104 °F).

Note: Supplemental heat is recommended for cold-soaked starts below the minimum ambient temperature. Supplemental heat may be required for cold-soaked starts that are above the minimum temperature that is stated, depending on the parasitic load and other factors. Cold-soaked starts occur when the engine has not been operated for a period of time, allowing the oil to become more viscous due to cooler ambient temperatures.

i04058277

Cold Weather Lubricants

SMCS Code: 1300; 1348; 7581

NOTICE
Recommended engine warm-up procedure must be followed. Refer to the engine Operation and Maintenance Manual. Also refer to the relevant “Lubricant Viscosities for Ambient Temperatures” table footnote in this Special Publication.

NOTICE
Excessive engine idling time can contribute to excessive water in the crankcase oil, causing corrosion, sludge, and other problems. Excessive engine idling time can also lead to injector fouling, piston and combustion chamber deposits, corrosive damage, and increased oil consumption.

For proper selection of oil viscosity grade and oil type and/or specification, refer to this Special Publication, “Lubricant Specifications” section.

Also, refer to this Special Publication, “Lubricant Viscosities” article.

NOTICE
Not following the recommendations found in the “Lubricant Viscosities for Ambient Temperatures” table and associated footnotes can lead to reduced performance and engine failure.

NOTICE
Do NOT use only the oil viscosities when determining the recommended oil for an engine compartment. The oil type (performance requirements) MUST also be used.

For easier cold weather starting, make sure that all of the components of the engine electrical system are properly maintained. All electrical wiring and connections should be free of the following: fraying, damaged insulation and corrosion. Batteries should be kept fully charged and warm. The batteries and the battery cables must be sized properly for the application.

Various starting aids are available in order to assist with cold engine starts in low temperature conditions. Follow the recommendations that are provided by the manufacturer of the starting aid. Refer to the foreword section of this Special Publication, “Aftermarket Products and Warranty”.

For additional information concerning cold-weather operation, refer to this Special Publication, “Fuel Specifications” section. Also refer to this Special Publication, “Cooling System Specifications” section.

Before attempting to start the engine, make sure that the oil in the engine is fluid enough to flow. Check the oil by removing the dipstick. If the oil will drip from the dipstick, then the oil should be fluid enough to allow the engine to start. Do not use oil that has been diluted with kerosene. Kerosene will evaporate in the engine. and cause the oil to thicken. Kerosene will cause swelling and softening of the silicone seals. Kerosene will dilute the oil additives. Dilution of the oil additives will reduce the performance, and reduce the engine protection that the additives provide.

If the viscosity of the oil is changed for colder weather, also change the filter element. If the filter is not changed, the filter element and the filter housing can become a solid mass. After you change the oil, operate the engine in order to circulate the thinner oil.

When you start a cold-soaked engine or when you operate an engine in ambient temperatures that are below −18°C (0°F), use base oils that can flow in low temperatures. These multigrade oils have lubricant viscosity grade of SAE 0W or of SAE 5W. An example of viscosity grade is SAE 5W-40.

When you start a cold-soaked engine or when you operate an engine in ambient temperatures that are below −30°C (−22°F), use synthetic basestock multigrade oil. The oil should have a lubricant viscosity grade of SAE 0W or SAE 5W. Use oil with a pour point that is lower than −40°C (−40°F).

Note: Use the highest oil viscosity grade that is allowed for the ambient temperature when you start the engine. If a different oil viscosity grade is specified in the table, use the viscosity grade that is specified in the table. **In arctic applications, the preferred method of lubrication is to use a properly sized engine compartment heater and a higher viscosity grade oil.** Refer to the “Lubricant Viscosities” article in this Special Publication for further details.

Note: Cold-soaked starts occur when the engine has not been operated for a time. The oil will become more viscous due to cooler ambient temperatures. Supplemental heat is recommended for cold-soaked starts that are below the minimum ambient temperatures listed in the “Lubricant Viscosities for Ambient Temperatures” tables. Supplemental heat may be required for cold-soaked starts that are above the minimum temperature that is stated, depending on the parasitic load and other factors.

NOTICE
Engines that use fluid or pan heaters, or heated enclosures, or are kept running under load, etc. can, and generally should use higher viscosity oil. The “Lubricant Viscosities for Ambient Temperatures” tables (Maintenance Section) **Minimum** viscosity for ambient temperature recommendations are for cold-soaked conditions. Use the highest viscosity oil that is allowed for the ambient temperature at startup. **BUT, under continuous usage (multiple shifts per day),** and/or when using **fluid or pan heaters**, use a higher viscosity oil than the minumum recommended viscosity for cold-soaked starting conditions. The higher viscosity oil will maintain the highest possible oil film thickness. Refer to the “Lubricant Viscosities for Ambient Temperatures” tables and the table footnotes for exceptions.

Example: The oil viscosity recommended for use in Cat diesel engines for cold-soaked starts at −40 °C (−40 °F) is multigrade oil of the SAE 0W viscosity grade (SAE 0W-30). If the diesel engine is run continuously, SAE 15W-40 viscosity grade diesel engine oil can be used and is generally the preferred oil viscosity in this situation.

NOTICE
If ambient conditions warrant, a higher viscosity oil of the recommended specification for a given compartment may need to be installed in order to provide adequate film thickness.

i06523041

Synthetic Basestock Oils

SMCS Code: 1300; 1348; 7581

Synthetic base oils are acceptable for use in Caterpillar engines and in Caterpillar machines **IF these oils meet the performance requirements that are specified by Caterpillar for a particular compartment**. Each compartment has specific lubrication specifications to ensure proper lubrication and life of the system.

Synthetic base oils generally perform better than conventional oils in the following two areas:

- Synthetic base oils have improved flow at low temperatures especially in arctic conditions.

- Synthetic base oils have improved oxidation stability especially at high operating temperatures.

Some synthetic base oils have performance characteristics that enhance the service life of the oil. However, Caterpillar does not recommend automatically extending the oil drain interval for any machine compartment for any type of oil, whether synthetic or non-synthetic.

Oil drain intervals for Caterpillar diesel engines can only be adjusted after an oil analysis program that contains the following data:

- Oil condition, oil contamination, and wear metal analysis (Caterpillar S·O·S Services Oil Analysis)
- Trend analysis
- Fuel consumption
- Oil consumption

Refer to the “Extended Engine Oil Drains and Warranty” article in the “ Warranty Information” section of this special publication.

i07999506

Synthetic Basestock Oils

SMCS Code: 1300; 1348; 7581

S/N: KCA1–Up

S/N: KCB1–Up

S/N: MTB1–Up

S/N: BKD1–Up

S/N: CPD1–Up

S/N: 7SF1–Up

S/N: DPF1–Up

S/N: LEF1–Up

S/N: 6ZG1–Up

S/N: 9DG1–Up

S/N: BFH1–Up

S/N: 1AJ1–Up

S/N: 9CJ1–Up

S/N: MBJ1–Up

S/N: 2BK1–Up

S/N: 9GK1–Up

S/N: BEK1–Up

S/N: 5GL1–Up

S/N: 8YL1–Up

S/N: KAL1–Up

S/N: MBL1–Up

S/N: 1MM1–Up

S/N: 9SM1–Up

S/N: CKM1–Up

S/N: CSM1–Up

S/N: 9LN1–Up

S/N: 9YN1–Up

S/N: MBN1–Up

S/N: CRP1–Up

S/N: HEP1–Up

S/N: MDP1–Up

S/N: MEP1–Up

S/N: 2FR1–Up

S/N: 6NR1–Up

S/N: 2KS1–Up

S/N: 2WS1–Up

S/N: 3CS1–Up

S/N: 5DS1–Up

S/N: 7AS1–Up

S/N: 7HS1–Up

S/N: 8YS1–Up

S/N: 9NS1–Up

S/N: BXS1–Up

S/N: 1BW1–Up

S/N: 1LW1–Up

S/N: BEW1–Up

S/N: BFY1–Up

S/N: 5JZ1–Up

S/N: 6NZ1–Up

S/N: 6PZ1–Up

S/N: 7CZ1–Up

S/N: 7JZ1–Up

S/N: 8SZ1–Up

S/N: 9SZ1–Up

Synthetic base oils are acceptable for use in Caterpillar engines and in Caterpillar machines **IF these oils meet the performance requirements that are specified by Caterpillar for a particular compartment**. Each compartment has specific lubrication specifications to ensure proper lubrication and life of the system.

Synthetic base oils generally perform better than conventional oils in the following two areas:

- Synthetic base oils have improved flow at low temperatures especially in arctic conditions.
- Synthetic base oils have improved oxidation stability especially at high operating temperatures.

Some synthetic base oils have performance characteristics that enhance the service life of the oil. However, Caterpillar does not recommend automatically extending the oil drain interval for any machine compartment for any type of oil, whether synthetic or non-synthetic.

Oil drain intervals for Caterpillar diesel engines can only be adjusted after an oil analysis program that contains the following data:

- Oil condition, oil contamination, and wear metal analysis (Caterpillar S·O·S Services Oil Analysis)
- Trend analysis
- Fuel consumption
- Oil consumption

Refer to the “Extended Engine Oil Drains and Warranty” article in the “ Warranty Information” section of this special publication.

i04058332

Re-refined Basestock Oils

SMCS Code: 1300; 1348; 7581

Rerefined basestock oils are acceptable for use in Cat engines **IF these oils meet the performance requirements that are specified by Cat.**

Rerefined basestock oils can be used exclusively in finished oil or in a combination with new basestock oils. The US military specifications and the specifications of other heavy equipment manufacturers also allow the use of rerefined basestock oils that meet the same criteria.

The process that is used to make rerefined basestock oil should adequately remove all wear metals and all additives that are in the used oil. Vacuum distillation and the hydrotreating of the used oil are acceptable processes that are used for producing rerefined base oil.

Note: Filtering is inadequate for the production of high quality rerefined basestock oils from used oil.

i04066049

Aftermarket Oil Additives

SMCS Code: 1300; 1348; 7581

Cat does not recommend the use of aftermarket additives in oil. Aftermarket additives are not necessary in order to achieve the maximum service life of the engine or rated performance of the engine. Fully formulated, finished oils consist of base oils and of commercial additive packages. These additive packages are blended into the base oils at precise percentages in order to help provide performance characteristics that meet industry standards.

There are no industry standard tests that evaluate the performance or the compatibility of aftermarket additives in finished oil. Aftermarket additives may not be compatible with the finished oil additive package, which could lower the performance of the finished oil. The aftermarket additive could fail to mix with the finished oil and produce sludge in the crankcase. Cat discourages the use of aftermarket additives in finished oils.

To achieve the best performance from a Cat engine, conform to the following guidelines:

- Select the proper Cat oil or commercial oil. Refer to the “Lubricant Specifications” section of this Special Publication.
- Refer to the “Lubricant Viscosities for Ambient Temperatures” table in this Special Publication in order to find the correct oil viscosity grade for your engine.
- At the specified interval, service the engine compartment. Use appropriate new oil and install an appropriate new oil filter.
- Perform maintenance at the intervals that are specified in the Operation and Maintenance Manual, “Maintenance Interval Schedule”.

i07139162

Lubricating Grease

SMCS Code: 0645; 1000; 7000; 7581

NOTICE
These recommendations are subject to change without notice. Consult your local Cat dealer for the most up to date recommendations.

Note: Non-Cat commercial greases are as a group second choice greases. Within this grouping of second choice greases there are tiered levels of performance.

NOTICE
Cat does not warrant the quality or performance of non-Cat fluids and greases.

Caterpillar provides a family of grease products that vary in performance from moderate to high performance. These greases service the entire line of Cat products in the wide variety of climates throughout the world. From this variety of Cat grease products, you can find a Cat grease that will meet or exceed the performance requirements for almost every machine that is produced by any Original Equipment Manufacturer (OEM), and for almost every machine application or equipment application.

Before selecting a grease product, the performance requirements must be determined. Consult the grease recommendations in your Operation and Maintenance Manual. Also, consult your Cat dealer for a list of greases that have the performance specifications and the available container sizes.

This grease chapter refers to NLGI of the grease products offered by Caterpillar. The National Lubricating Grease Institute (NLGI) classifies the greases per their consistency or hardness according to “ASTM D4950” and “SAE J310”. The higher the NLGI value the more firm the grease. NLGI is an important classification for greases and it should be used along with other properties such as stability, corrosion resistance, viscosity, etc.

Note: Always choose grease that meets or exceeds the recommendations that are specified by the equipment manufacturer for the application.

Some work sites require the use of a single grease to fulfill the needs of all the equipment. Always choose a grease that meets or exceeds the requirements of the most demanding application. Remember that commercial products which barely meet the minimum performance requirements can be expected to produce the minimum life for the parts. It is not recommended to purchase grease products based on the lowest cost as the only consideration. Instead, use the grease that yields the lowest **total** operating cost. This cost should be based on an analysis that includes the improved product life, costs of parts, labor, downtime, and the cost of the amount of grease that is required.

Note: Certain Cat grease products are formulated with Molybdenum disulfide (MoS_2 or “Moly”). The Moly used in Cat greases is of a technical fine grade. This size meets the special requirements of some rolling element bearings, joints, and other moving components of tight clearances.

Note: When the grease in a joint is changed from one type of grease to another or a grease from a different supplier is to be used, the general recommendation is to purge all of the old grease from the joint. Some greases are not chemically compatible. Consult your supplier in order to determine if the greases are compatible.

If in doubt, Purge!

Note: All Cat greases are “chemically” compatible with each other. Mixing of Cat greases will not result in an adverse chemical reaction. However, mixing of Cat greases might result in reduced performance.

Cat Utility Grease

Cat Utility Grease is formulated for use in applications that have a low severity to a medium severity and moderate temperatures. Cat Utility Grease is a National Lubricating Grease Institute (NLGI) grade 2 grease. This grease is made with petroleum base oil and a lithium complex thickener.

Cat Utility Grease is formulated to offer a good service life in engine applications. Service Life refers to the percent of change after 100,000 strokes per “ASTM D217”.

For more information on Cat Utility Grease, refer to the product information on the package or to the data sheet of this product.

Note: If the application calls for a utility grease and Cat Utility Grease is not available, consult the grease data sheets. Use a substitute that meets or exceeds the performance characteristics of Cat Utility Grease.

Cat Ball Bearing Grease

This grease is recommended for applications that utilize roller bearings and ball bearings at low loads to moderate loads at high speed. Typical applications for this grease are electric motors, alternators, and constant velocity (CV) joints for automotive products. Cat Ball Bearing Grease is an NLGI grade 2 grease. This grease is made with petroleum base oil and polyurea thickener.

Cat Ball Bearing Grease is formulated to offer very good service life in engine applications. Service Life refers to the percent of change after 100,000 strokes per “ASTM D217”.

Cat Ball Bearing Grease offers good corrosion protection and good water washout resistance. Corrosion protection is the resistance to salt water per “ASTM B1743”. Water washout resistance refers to roll stability with water and the percent of change “ASTM D1264”.

For more information on Cat Ball Bearing Grease, refer to the product information on the package or to the data sheet of this product.

Cat White Assembly Grease

Cat White Assembly Grease is formulated for use in applications that have low to medium severity and moderate temperatures. This grease has been made extra tacky in order to hold gaskets, O-rings, and needle bearings to aid in the assembly of engines, transmissions, and other components. Cat White Assembly Grease is an NLGI grade 2 grease. This grease is made with a petroleum base oil and a lithium complex thickener.

Note: Cat grease products given above are applicable to marine engines. Refer to Special Publication, SEBU6250, “Caterpillar Machine Fluids Recommendations” for other Cat grease products that include extreme applications and can also be used in marine engines. Consult your Cat dealer for information and for availability.

i03002117

S·O·S Services Oil Analysis

SMCS Code: 1000; 1348; 3080; 4070; 4250; 4300; 5095; 7000; 7542; 7581

NOTICE
These recommendations are subject to change without notice. Consult your local Cat dealer for the most up to date recommendations.

Caterpillar has developed a maintenance management tool that evaluates oil degradation and detects the early signs of wear on internal components. The Caterpillar tool for oil analysis is called S·O·S oil analysis and the tool is part of the S·O·S Services program. S·O·S oil analysis divides oil analysis into four categories:

- Component wear rate
- Oil condition
- Oil contamination
- Oil identification

Component Wear Rate analysis evaluates the wear that is taking place inside the lubricated compartment. The S·O·S Services analyst uses the results of elemental analysis and particle count tests to evaluate the wear. Trend analysis and proprietary wear tables are then used to determine if wear rates are normal or abnormal.

Oil Condition analysis is used to determine if the oil has degraded. Tests are done to look at the oxidation, sulfation, and viscosity of the oil. The S·O·S Services analyst uses established guidelines or trend analysis to determine if the oil has reached the end of its useful life.

Oil Contamination tests are performed to determine if anything harmful has entered the oil. This analysis relies on the results from the following tests: elemental analysis, soot, particle count, fuel dilution, water, and glycol. The S·O·S Services program has guidelines for the levels of contamination that are allowed in Cat engines.

Oil Identification is another very important part of the S·O·S oil analysis program. The wrong oil in an engine can severely damage major components. The S·O·S Services analyst uses elemental analysis and viscosity results to identify key characteristics of the oils.

These four types of analysis are used to monitor the condition of your equipment, and to help you identify potential problems. A properly administered S·O·S Services oil analysis program will reduce repair costs and the program will lessen the impact of downtime.

The S·O·S oil analysis program uses a wide range of tests to determine the condition of the oil and the condition of the lubricated compartment.

Guidelines that are based on experience and a correlation to failures have been established for these tests. See the following chart for the guidelines. Exceeding one or more of these guidelines could indicate serious fluid degradation or a pending component failure. A trained person at your Caterpillar dealership should make the final analysis.

Note: Cooling system problems will also reduce the life of engines. S·O·S coolant analysis together with S·O·S oil analysis provide a complete and accurate method for monitoring the health of all engine systems. Refer to the S·O·S Services coolant analysis information in this publication. A properly administered S·O·S Services program will reduce repair costs and lessen the impact of downtime.

Table 7

S·O·S Oil Analysis Guidelines	
Test Parameter	**Guideline**
Oxidation	(1)
Soot	(1)
Sulfation	(1)
Wear Metals	Trend Analysis and Cat Wear Table(1) norms
Water	0.5% maximum

(continued)

(Table 7, contd)

S·O·S Oil Analysis Guidelines	
Glycol	0%
Fuel Dilution	Based on viscosity(1) and GC(2) fuel dilution in excess of 4%
Viscosity “ASTM D445” measured at 100° C (212° F)	+/-3 centistokes (cSt) change from new oil viscosity.

(1) Acceptable values for these parameters are proprietary to the S·O·S oil analysis program.
(2) Gas Chromatograph

Consult your Caterpillar dealer for complete information and assistance about the S·O·S oil analysis program.

Obtaining S·O·S Oil Samples

Before you obtain an S·O·S oil sample, operate the engine until the oil is warm and the oil is well circulated. Then obtain the S·O·S oil sample.

In order to obtain a good oil sample, do not take the oil sample from the drain stream. The drain stream method can allow a stream of dirty oil from the bottom of the compartment to contaminate the sample. Likewise, never dip an oil sample from an oil container or pour a sample from a used filter.

There are two acceptable ways to obtain S·O·S oil samples. **The following methods are listed in the order that is preferred:**

- Use an in-line sampling valve on the pressurized oil manifold.
- Use a sampling gun (vacuum pump) that is inserted into the sump.

Use of the in-line sampling valve is the preferred method. This method provides samples that are less likely to be contaminated.

In order to obtain an oil sample from the engine, it may be necessary to increase the engine's speed. Normally, the oil sample is taken at low idle. If the flow rate is too low, increase engine speed to HIGH IDLE in order to obtain the oil sample.

NOTICE
Do not use the same vacuum sampling pump for extracting oil samples that is used for extracting coolant samples.

A small residue of either type sample may remain in the pump and may cause a false positive analysis for the sample being taken.

Always use a separate pump for oil sampling and a separate pump for coolant sampling.

Failure to do so may cause a false analysis which could lead to customer and dealer concerns.

Oil Sampling Interval

Take the oil samples as close as possible to the standard intervals. In order to receive the full value from S·O·S oil analysis, you must establish a consistent trend of data. In order to establish pertinent history of data, perform consistent oil samplings that are evenly spaced.

Table 8

Compartment	Engine
Recommended Sampling Interval	24140 kilometers (15000 miles) (1)(2)
Sampling Valve	Yes
Oil Type	DEO, DEO-ULS
Recommended Oil Change Interval	(3)

(1) Under certain conditions, the Caterpillar dealer or the Operation and Maintenance Manual may allow a longer interval between oil samplings.
(2) Severe applications may require a more frequent sampling interval.
(3) Consult the Operation and Maintenance Manual that came with your engine for the recommended oil change intervals.

Consult your Caterpillar dealer for complete information and assistance in establishing an S·O·S Services program for your equipment.

More Frequent S·O·S Sampling Improves Life Cycle Management

Studies have revealed that obtaining oil samples at every 24140 kilometers (15000 miles) is too long a time interval in some applications in order to predict potential failure modes. In severe applications, more frequent oil sampling is recommended. Severe service for lubricated compartments occurs at high loads, in high temperatures, and in dusty conditions. If any of these conditions exist, sample the engine oil at 16093 kilometer (10000 mile) intervals. These additional samples will increase the chance of detecting a potential failure.

Determining Optimum Oil Change Intervals

Sampling the compartments at every 16093 kilometers (10000 miles) provides information for oil condition and for oil performance. This information is used to determine the optimum usable life of a particular oil. Also, more points of data will allow closer monitoring of component wear rates. Close monitoring also allows you to obtain the maximum use of the oil. For detailed information on optimizing oil change intervals, please consult your Caterpillar dealer.

Optimizing the Component Life Cycle

An increase in the number of oil samples provides a better definition of the trends in data between oil change intervals. More oil samples will allow you to closely monitor wear patterns of components. This action will ensure that the full lives of the components are achieved.

Fuel Specifications

i04660851

General Fuel Information

SMCS Code: 1250; 1280

NOTICE
Every attempt is made to provide accurate, up-to-date information. By the use of this document, you agree that Caterpillar Inc. is not responsible for errors or omissions.

The information provided are the latest recommendations for the Cat diesel engines that are covered by this Special Publication. This information supersedes all previous recommendations which have been published for the Cat diesel engines that are covered by this Special Publication. Special fluids are required for some engines and continued will be necessary. Refer to the applicable Operation and Maintenance Manual.

This publication is a supplement to the Operation and Maintenance Manual. This publication does not replace the engine Operation and Maintenance Manuals.

NOTICE
These recommendations are subject to change without notice. Consult your local Cat dealer for the most up to date recommendations.

NOTICE
In order to avoid potential damage to your Cat machine and/or Cat engine, only purchase Cat fluids and Cat filters through your Cat dealer or Cat authorized outlets. For a list of authorized Cat parts outlets in your area, consult your Cat dealer.

If you purchase what appear to be Cat fluids and/or Cat filters through other outlets/sources, you are at a very high risk of purchasing counterfeit ("look-alike") products.

Counterfeit or "look-alike" products may visually appear the same as the original Cat product, but the product performance and internal quality will typically be very low.

Counterfeit or "look-alike" products have a very high likelihood of causing and/or allowing engine and/or machine compartment damage.

Follow all industry standard safety practices when operating engines and/or machines and when performing all recommended and/or required maintenance.

Note: Instructions for the installation of the filter are printed on the side of each Cat spin-on filter. For non-Cat filters, refer to the installation instructions that are provided by the supplier of the filter.

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.

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

NOTICE
Caterpillar does not warrant the quality or performance of non-Caterpillar fluids and filters.

General Recommendations and Guidelines

Follow all applicable industry standards and all applicable governmental, environmental, and safety guidelines, practices, regulations, and mandates.

Note: These general recommendations and guidelines concerning maintenance and care of fuel and fuel storage systems are not intended to be all inclusive. **Discuss proper fuel safety and health, handling, and maintenance practices with your fuel supplier.** Use of these general recommendations and guidelines does not lessen the engine owners and/or fuel supplier responsibility. All industry standard practices for fuel storage and for fuel handling must be followed.

Note: Where recommendations for draining water and/or sediment and/or debris are stated, dispose of this waste according to all applicable regulations and mandates.

Note: Cat filters are designed and built to provide optimal performance and protection of the fuel system components.

- Discuss application-specific fuel concerns, needs, and requirements with a reputable fuel supplier.

- Purchase fuel from a reputable supplier.
- Use fuel that meets or exceeds Cat requirements for distillate diesel fuel. Refer to the “Cat Specification for Distillate Diesel Fuel for Nonroad Diesel Engines” table in this Special Publication, “Distillate Diesel Fuel” article.
- Confirm with the filter manufacturer that the fuel filter/filters to be used are compatible with the fuel type that will be filtered.
- Follow all the “Contamination Control Recommendations for Fuels” that are provided in this chapter. Dispense fuels of “ISO 18/16/13” cleanliness level or cleaner into the machine or engine fuel tank as detailed in the “Contamination Control Recommendations” section.
- Follow all industry standard grounding and other safety practices.
- Test for microbial contamination on a regular basis and take proper corrective action if contamination is present. Properly dispose of cleanup waste according to all applicable regulations and mandates.
- Every 3 months, or sooner if problems are suspected, have a complete analysis of the bulk storage fuel per the “Cat Specification for Distillate Diesel Fuel for Nonroad Diesel Engines” table in this Special Publication, “Distillate Diesel Fuel” article. Take corrective action if necessary. Corrective actions may include treating the fuel, cleaning of the fuel storage tank/system, and replacing the problematic fuel with fresh fuel.
- Keep the fuel storage tank clean of water, debris, and sediment.
- Drain water and sediment from the fuel storage tank weekly. Drain water and sediment before the tank is refilled.
- Keep the area around the fuel tank filler neck clean of debris in order to prevent contamination of the fuel tank.
- As required, clean the inside of the engine fuel tank and the inside of the bulk storage fuel tank.
- Drain water and sediment from the engine fuel tank daily. Drain water and sediment from the tank at the start of each shift. After the fuel tank has been filled, allow the fuel to settle for 10 minutes. The water and sediment will separate from the fuel. Then, drain the water and sediment from the tank.
- Install fuel/water separators at the bulk storage fuel tank dispensing point and install fuel/water separators on the engine. Wire mesh media is NOT recommended.
- Drain the water from the fuel/water separators daily.
- Cat Advanced Efficiency fuel filters are required for distillate fueled diesel engines in order to provide maximum life to the fuel system.
- Change fuel filters at the scheduled interval. Never fill the new secondary fuel filter with fuel before installation. Use the fuel priming pump to remove air from the system.
- Install and properly maintain four micron(c) absolute breather filters on the engine fuel tank vent. Install and properly maintain four micron(c) absolute breather filters on the bulk storage fuel tank vent. Desiccant type breather vent filters are also recommended in order to remove moisture from air entering the fuel tank. Breather filters are typically changed every 6 months, and desiccant type breather filters are typically changed on saturation. Refer to the literature that was included with the filter. Discuss the availability of desiccant breather vent filters for your application with your filter supplier.
- Top off fixed roof fuel tanks as often as practical. Keeping the tank full reduces the amount of condensation generated water.
- Protect fuel tanks from dirt and water entry.

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.

Note: Cat has four different size coalescer type fuel filters available for bulk storage fuel tank applications that filter both dirt and water. The filter elements are rated at four microns(c) absolute. Consult your Cat dealer for information on the coalescer filters available through Cat.

Note: The fuel storage tanks must be cleaned thoroughly before converting to Ultra Low Sulfur Diesel (ULSD) (15 ppm or less sulfur) and/or biodiesel/biodiesel blends. Conversion to ULSD and/or biodiesel/biodiesel blends can loosen fuel system and fuel storage tank deposits. Bulk tank continuous filtration unit and dispensing point filters, and onboard engine filters change intervals should be shortened to allow for this cleaning effect.

Note: Cat strongly recommends the filtration of distillate diesel fuel and/or biodiesel/biodiesel blends through a 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. Also, filter the fuel from the bulk storage tank. Series filtration is recommended.

Note: Follow all fuel storage maintenance practices that are relevant to your application. Cat recommends a maximum of 1 year from production for distillate fuel storage. A maximum of 6 months from production for biodiesel and blended biodiesel storage is recommended. Storage life for biodiesel and biodiesel blends that are greater than B20 may be much shorter than 6 months.

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Fuel Information for Diesel Engines

SMCS Code: 1250; 1280

NOTICE
Model year 2007 and newer (U.S. EPA 2007 certified) on-highway diesel engines REQUIRE the use of Ultra Low Sulfur Diesel (ULSD) fuel (≤ 15 ppm sulfur).

“Sulfur-free” diesel fuel (≤ 10 ppm sulfur) is strongly recommended for use in “EURO IV” certified on-highway diesel engines, while diesel fuel with ≤ 50 ppm sulfur is acceptable.

Low Sulfur Diesel (LSD) fuel (≤ 500 ppm sulfur) is strongly recommended (required in the U.S.) for use in model year 2006 and older on-highway diesel engines, while diesel fuel with ≤ 5000 ppm sulfur is acceptable for use in areas of the world where allowed by law. Diesel Oxidation Catalyst (DOC) equipped engines require the use of LSD fuel or ULSD fuel.

Note: In the U.S., burning fuel with greater than 15 ppm sulfur in model year 2007 and newer on-highway diesel engines is illegal and punishable with civil penalties.

The two basic types of distillate diesel fuel are No. 2 diesel fuel and No. 1 diesel fuel. No. 2 diesel fuel is the most commonly available summer grade diesel fuel. No. 1 diesel fuel is a winter grade diesel fuel. During the winter months fuel suppliers will typically blend No. 1 and No. 2 diesel fuel in various percentages in order to meet the historical low ambient temperature cold-flow needs for a given area or region. No. 2 diesel fuel is a heavier diesel fuel than No. 1 diesel fuel. In cold weather, heavier fuels can cause problems with fuel filters, fuel lines, fuel tanks, and fuel storage. Heavier diesel fuels such as No. 2 diesel fuel can be used in diesel engines that operate in cold temperatures with an appropriate amount of a well proven pour point depressant additive. For more information on fuels which include blends of No. 1 and No. 2 diesel fuel, consult your fuel supplier.

When you use No. 2 diesel fuel or other heavier fuels, some of the fuel's characteristics may interfere with successful cold weather operation. Additional information about the characteristics of diesel fuel is available. This information contains a discussion on the modification to the characteristics of diesel fuel. There are several possible methods that can be used to compensate for the fuel qualities that may interfere with cold weather operation. These methods include the use of starting aids, engine coolant heaters, fuel heaters, and de-icers. In addition, the manufacturer of the fuel can add cold flow improvers and/or blend No. 1 and No.2 diesel in various percentages.

Not all areas of the world classify diesel fuel using the No. 1 and No. 2 nomenclature described above. But, the basic principles of using additives and/or blending fuels of different densities in order to help compensate for the fuel qualities that may interfere with cold weather operation are the same.

Starting Aids

The use of a starting aid is a conventional method of assistance for cold starts in low temperature conditions. A variety of starting aids are available for Caterpillar engines. Follow the recommendations that are provided by the manufacturer of the starting aid. Refer to the foreword section in this Special Publication, “Aftermarket Products and Warranty” article.

Engine Coolant Heaters

These heaters heat the engine coolant. The heated coolant flows through the cylinder block. The flow of heated coolant keeps the engine warm. A warm engine is easier to start in cold weather. Most coolant heaters use electrical power. A source of electricity is necessary for this type of heater. Other heaters that burn fuel are available as a source of heat. These heaters may be used in place of the electrical heaters.

With either type of heater, starting aids and/or fuels with higher cetane numbers are less important because the engine is warm. Problems with fuel cloud point can cause the plugging of fuel filters. Problems with fuel cloud point cannot be corrected by engine coolant heaters. This is especially true for fuel filters that are cooled by air flow during operation.

Fuel Heaters

The fuel cloud point is related to problems with fuel filters. The fuel heater heats the fuel above the cloud point before the fuel enters the fuel filter. This prevents wax from blocking the filter. Fuel can flow through pumps and lines at temperatures below the cloud point. The cloud point is often above the pour point of a fuel. While the fuel can flow through these lines, the wax in the fuel can still plug the fuel filter.

In some engine installations, small modifications can prevent problems that are caused by the cloud point. One of the following changes can prevent problems in many conditions: a change in the location of fuel filters and/or supply lines and the addition of insulation. In extreme temperatures, heating of the fuel may be required to prevent the filters from plugging. There are several types of fuel heaters that are available. The heaters typically use either engine coolant or exhaust gas as a heat source. These systems may prevent filter waxing problems without the use of de-icers or cold flow improvers. These systems may be ineffective when the fuel contains a large amount of dirt or of water. Use of a fuel heater can help eliminate some cold weather problems. A fuel heater should be installed so that the fuel is heated before flowing into the fuel filter.

Note: A fuel heater is not effective for cold-soaked starts unless the fuel heater can be powered from an external power source. External fuel lines may require the use of heaters that circulate the fuel.

Note: Only use fuel heaters that are controlled by thermostats or use fuel heaters that are self-regulated. Thermostatically controlled fuel heaters generally heat fuel to 15.5 °C (60 °F). Do not use fuel heaters in warm temperatures.

For distillate fuel configured engines, Caterpillar recommends a fuel viscosity as delivered to rotary fuel injection pumps of between 1.4 cSt and 4.5 cSt, and between 1.4 cSt and 20 cSt for all other fuel injection pumps.

If a fuel with a low viscosity is used, cooling of the fuel may be required in order to maintain 1.4 cSt or greater viscosity at the fuel injection pump. Fuels with a high viscosity might require heaters in order to lower the viscosity to either 4.5 cSt or less for rotary fuel injection pumps or 20 cSt or less for all other fuel injection pumps.

NOTICE
Do not allow the fuel to get too warm, because fuel above 52°C (125°F) will affect the power output of the engine. Never exceed 75°C (165°F) with straight distillate fuel. The high fuel temperatures also affect the fuel viscosity. When the fuel viscosity falls below 1.4 cSt, pump damage may occur.

⚠ WARNING

Overheating the fuel or the fuel filter can result in personal injury and/or damage to the engine. Use extreme care and caution for heating of the fuel filter.

Select a fuel heater that is mechanically simple, yet adequate for the application. The fuel heater should also prevent overheating of the fuel. Disconnect the fuel heater or deactivate the fuel heater in warm weather. An unacceptable loss of fuel viscosity and engine power will occur if the fuel supply temperature is allowed to become too hot.

For additional information on fuel heaters, see your Caterpillar dealer.

De-Icers

De-icers lower the freezing point of the moisture in the fuel. De-icers are not generally needed when fuel heaters are used. If you experience trouble, consult your fuel supplier for recommendations of a compatible commercial de-icer.

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Characteristics of Diesel Fuel

SMCS Code: 1250; 1280

Lubricity and Low Sulfur Diesel (LSD) and Ultra Low Sulfur Diesel (ULSD) Fuel

NOTICE
Model year 2007 and newer (U.S. EPA 2007 certified) on-highway diesel engines REQUIRE the use of Ultra Low Sulfur Diesel (ULSD) fuel (≤ 15 ppm sulfur).

"Sulfur-free" diesel fuel (≤ 10 ppm sulfur) is strongly recommended for use in "EURO IV" certified on-highway diesel engines, while diesel fuel with ≤ 50 ppm sulfur is acceptable.

Low Sulfur Diesel (LSD) fuel (≤ 500 ppm sulfur) is strongly recommended (required in the U.S.) for use in model year 2006 and older on-highway diesel engines, while diesel fuel with ≤ 5000 ppm sulfur is acceptable for use in areas of the world where allowed by law. Diesel Oxidation Catalyst (DOC) equipped engines require the use of LSD fuel or ULSD fuel.

Note: In the U.S., burning fuel with greater than 15 ppm sulfur in model year 2007 and newer on-highway diesel engines is illegal and punishable with civil penalties.

In the United States (U.S.), LSD will have 0.05 percent (500 ppm) maximum sulfur. ULSD will have 0.0015 percent (15 ppm) maximum sulfur. Refer to this Special Publication, "Distillate Diesel Fuel" article for additional information. Also, refer to the most current revision level of "ASTM D975 (Standard Specification for Diesel Fuel Oils)" for additional information.

Note: "ASTM D975" currently allows up to 5 percent biodiesel blends. Refer to this Special Publication, "Fuel Specifications" and the "Biodiesel" topic for guidance when biodiesel will be used.

In Europe, the commonly available diesel fuel will have 0.005 percent (50 ppm) maximum sulfur. In Europe, ULSD fuel will have 0.0010 percent (10 ppm) maximum sulfur, and is typically referred to as "sulfur-free". Refer to the most current revision level of "European Standard EN 590 (Automotive Fuels - Diesel - Requirements and Test Methods)" for additional information.

Note: "EN 590" currently allows up to 5 percent biodiesel blends. Refer to the "Fuel Specifications" section and the "Biodiesel" topic in this Special Publication for guidance when biodiesel will be used.

In the United States (U.S.), a new 0.0015 percent (15 ppm) limit on fuel sulfur was introduced for the on-highway diesel engine market in October of 2006. Owners of model year 2007 and newer (U.S. EPA 2007 certified) on-highway diesel engines must refuel only with ULSD. Owners of 2006 and older model year on-highway diesel engines may use ULSD or LSD fuel during the transition period. In the U.S., starting December of 2010, only ULSD will be available for on-highway use. The 2007 and newer on-highway diesel engines are designed to operate on ULSD. Use of LSD or other fuels with more than 15 ppm sulfur in these engines will reduce engine efficiency and engine durability, and may damage emission control systems. Failures that result from the use of fuels are not Caterpillar factory defects. Therefore, the cost of repair would not be covered by a Caterpillar warranty.

Note: The fuel lubricity is important. You should consider the fuel's lubricity whenever you operate the equipment in arctic weather. Also, you should consider the fuel's lubricity whenever you use fuels that are lower in viscosity or that have been hydro-treated. There are many aftermarket additives that are available to treat fuel. If the fuel's lubricity is an issue, consult your fuel supplier for proper recommendations regarding fuel additives. Also, refer to this Special Publication, "Distillate Diesel Fuel (Fuel Recommendations for On-Highway Diesel Engines)" article, "Aftermarket Fuel Additives" and "Cat Diesel Fuel Conditioner" topics.

The fluid's lubricity describes the ability of the fluid to reduce the friction between surfaces that are under load. This ability reduces the damage that is caused by friction. Fuel injection systems rely on the lubricating properties of the fuel. Until fuel sulfur limits were mandated, the fuel's lubricity was generally believed to be a function of fuel viscosity.

The process that is most commonly used to remove sulfur from fuel is called hydro-treatment. This process is also the most economical process. Each source of crude oil contains different amounts of sulfur. Crude oils typically require hydro-treatment to obtain the 0.0015 percent maximum sulfur limit. Crude oils with high sulfur require a more severe treatment.

The hydro-treatment removes the fuel's sulfur as well as other components. The treatment removes nitrogen compounds, polar materials, bicyclic aromatics, polycyclic aromatics, and oxygen compounds. While the removal of sulfur has shown no detrimental effects to the engine, the removal of other compounds have lowered the lubricity of the fuel. As a result of the lowered lubricity, the fuel is less tolerant of contamination by water and dirt. The lower fuel lubricity can be seen as abrasive wear of fuel system components. Fuels that have a low lubricity may not provide adequate lubrication to plungers, to barrels, and to injectors. This problem may be compounded in areas that require winter blends of fuel. The lighter winter fuel blend has the following characteristics: lower viscosity, lower cloud point and lower pour point.

When required, the fuel's lubricity may be enhanced with additives. Many fuel suppliers treat the fuel with these additives. Do not use a fuel lubricity additive before you consult the fuel's supplier. Some aftermarket additives may not be compatible with the additives that are already in the fuel, and some may damage emission control systems. Some additive packages that are supplied by the aftermarket manufacturer may not be compatible with the seals that are used in fuel systems of some diesel engines. Other additive packages that are supplied by aftermarket manufacturers cannot provide proper performance in high temperature conditions. These additives may leave deposits because of the high temperatures that exist in the fuel systems of diesel engines.

Maximum life of the fuel system can be achieved by performing the following tasks: using a reliable fuel supplier and performing proper maintenance of the fuel system. Caterpillar Advanced Efficiency fuel filters are required for diesel engines that run on diesel fuel in order to provide maximum life to the fuel system.

Note: Lighter fuels are frequently used in arctic temperatures. Lighter fuels may include the following fuels: Jet A, Jet A-1, JP-8, JP-5 and kerosene. The specifications that apply to these fuels do not include a minimum lubricity requirement. Do not assume that a fuel meets the minimum Caterpillar specification. Consult the fuel supplier for proper recommendations on fuel lubricity additives.

Note: The sulfur levels for Jet A, Jet A-1, JP-8, JP-5 and kerosene fuels typically far exceed 15 ppm, the U.S. ULSD, and the sulfur levels for these fuels typically far exceed 50 ppm, the European low sulfur fuel.

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

Refer to this Special Publication, “Distillate Diesel Fuel (Fuel Recommendations for On-Highway Diesel Engines)” article, “Aftermarket Fuel Additives”, “Cat Diesel Fuel Conditioner”, and “Alternative Fuels - Arctic Applications” topics for guidance.

Viscosity

The viscosity of the fuel is significant because the fuel serves as a lubricant for fuel system components. Fuels need to have sufficient viscosity. The fuel must lubricate the fuel system in both extremely cold and in extremely hot temperatures. If the kinematic viscosity of the fuel is lower than 1.4 cSt as supplied to the fuel injection pump or to the unit injectors, excessive scuffing and seizure can occur.

For distillate fuel configured engines, Caterpillar recommends a fuel viscosity as delivered to rotary fuel injection pumps of between 1.4 cSt and 4.5 cSt, and between 1.4 cSt and 20 cSt for all other fuel injection pumps.

If a fuel with a low viscosity is used, cooling of the fuel may be required in order to maintain 1.4 cSt or greater viscosity at the fuel injection pump. Fuels with a high viscosity might require heaters in order to lower the viscosity to either 4.5 cSt or less for rotary fuel injection pumps or 20 cSt or less for all other fuel injection pumps.

Cetane Number

The cetane number of the fuel has an effect on the ability of the engine to start. Also, the cetane number has an effect on the interval of time before the engine runs smoothly. Generally, an increase of ten in the cetane number will allow the engine to be started at a lower temperature. The starting temperature can be improved approximately 7 to 8°C (12 to 15°F) for every increase of ten in the cetane number. After the engine reaches the normal operating temperature, a change in the cetane from 40 to 50 will have a minimal effect on engine performance.

Most fuels that have a cetane number above 40 will permit acceptable engine starts in warmer outside temperatures. The engine will start satisfactorily with this fuel when the engine is kept warm. The engine can be kept warm by using either a heated enclosure or a properly sized coolant heater.

During average starting conditions, direct injection diesel engines require a minimum cetane number of 40. A higher cetane value may be required for operation in high altitudes or for cold weather operation. The minimum fuel cetane number that is required for the precombustion chamber (PC) diesel engine is 35.

Modifying the Cetane Number

The cetane number of a fuel can be changed if the fuel is mixed with a fuel that has a different cetane number. Generally, the cetane number of the mixture will be in direct relation to the ratio of the fuels that were mixed. Your fuel supplier can provide the information about the cetane number of a particular fuel.

Additives can also be used to improve the cetane number of a fuel. Additives are evaluated through testing in special engine tests. However, the fuel characteristics of additives used to improve fuel cetane number are different than the naturally occuring proper cetane fuel. While both fuels may be rated as having the same cetane number, starting may be different.

Cloud Point

It is important to understand that the cloud point of a fuel is different from the pour point. There is no relationship between cloud point and the pour point. The cloud point is the temperature that allows some of the heavier components in the wax to solidify in the fuel. This wax is not a contaminant in the fuel. The wax is an important element of No. 2 diesel fuel. The wax has high fuel energy content and the wax has a very high cetane value. Removal of the heavier wax lowers the cloud point of the fuel. Removal of the wax also increases the cost because less fuel can be made from the same amount of crude oil. Basically, a No. 1 diesel fuel is formulated by removing the wax from a No. 2 diesel fuel.

The cloud point of the fuel is important because the cloud point can limit the performance of the fuel filter. The wax can alter the fuel characteristics in cold weather. Solid wax can fill the fuel filters. The solidified wax will stop the flow of fuel. Fuel filters are necessary in order to remove dirt from the fuel. The filters block foreign material, and the filters protect the parts for the fuel injection system. Since fuel must flow through the filters, installing a fuel heater is the most practical way to prevent the problem. A fuel heater will keep the fuel above the cloud point as the fuel flows through the fuel system. The fuel heater will permit the wax to flow through the filters with the fuel.

Modifying the Cloud Point

You can lower the cloud point of a diesel fuel by mixing the diesel fuel with a different fuel that has a lower cloud point. No. 1 diesel fuel or kerosene may be used to lower the cloud point of a diesel fuel. The efficiency of this method is not good, because the ratio of the mixture does not have a direct relation to the improvement in cloud point. The amount of fuel with low cloud point that is required makes the process less preferable to use.

The following illustration contains a table that can be used to find the necessary mixture for two fuels with different cloud points. In order to use the table, you must know the exact fuel cloud point of each fuel. This specification can change from one purchase of fuel to the next purchase of fuel. This specification is normally available from personnel at the source of the fuel supply. When fuels that have a lower cloud point are not available, this method cannot be used.

The manufacturer of the fuel can add cold flow improvers to the fuel. Cold flow improvers modify the wax crystals in the fuels. The cold flow improvers do not change the fuel's cloud point. However, the cold flow improvers keep the wax crystals small enough to pass through standard fuel filters. For mixing precautions, see the section “Pour Point”.

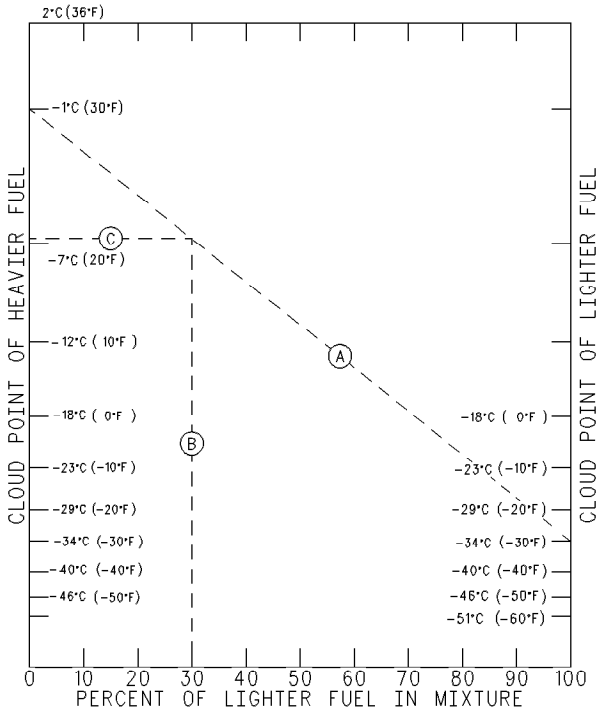

Illustration 1 g00592741

Cloud point of fuel mixtures

Generally, the most practical method that is used to prevent problems that are caused by fuel cloud point at low temperatures is the use of fuel heaters. In most applications, fuel heaters can be used at a lower cost than fuel mixtures.

Pour Point

The fuel's pour point is a temperature below the fuel's cloud point. Fuel stops flowing below the pour point. The pour point is the temperature which limits movement of the fuel with pumps.

To measure the pour point, the fuel temperature is lowered below the cloud point in steps of 3°C (5°F) at a time. The temperature is lowered until the fuel does not flow. The pour point is the last temperature that is shown before the flow stops. At the pour point, the wax has solidified out of the fuel. This makes the fuel more solid than liquid. The pour point of the fuel can be improved. This does not require the removal of important elements. This process is the same process that is used to improve the cloud point of fuel.

A fuel's pour point should be at least 6°C (10°F) below the lowest ambient temperature that is required for engine start-up and for engine operation. To operate the engine in extremely cold weather, No. 1 fuel or No. 1-D fuel may be necessary because of these fuels' lower pour points.

Modifying the Pour Point

You can lower the fuel's pour point by using additives. You can also lower the pour point of a diesel fuel by mixing the diesel fuel with a different fuel that has a lower pour point. No. 1 diesel fuel or kerosene may be used to lower the pour point of a diesel fuel. The amount of fuel with low pour point that is required makes the process less preferable to use.

The following illustration contains a table that can be used to find the necessary mixture for two fuels with different pour points. This is true only if the fuels do not have additives which change the pour point. In order to use the table, you must know the exact pour point of each fuel. This specification can change from one purchase of fuel to the next purchase of fuel. This specification is normally available from personnel at the source of the fuel supply. When fuels that have a lower pour point are not available, this method cannot be used.

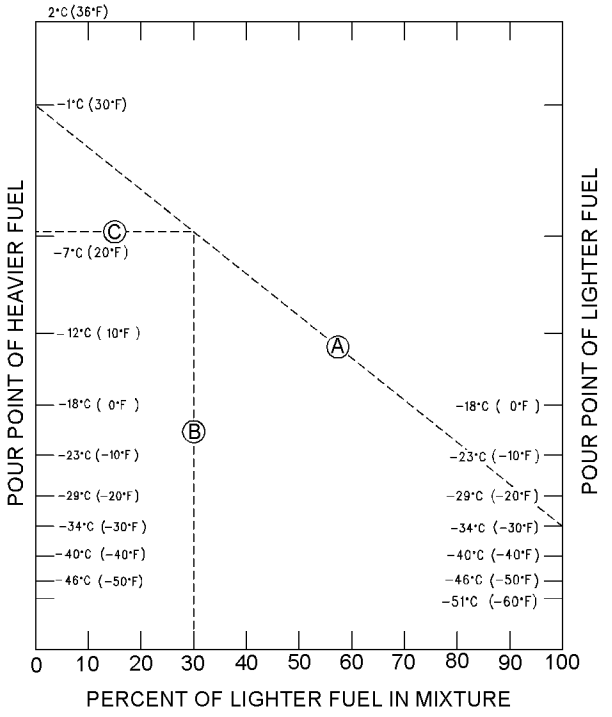

Illustration 2 g01180699
Pour point of fuel mixtures

In order to calculate the amount of lighter fuel that is required to be blended with the heavier fuel, perform the following steps:

1. Obtain the specification for the cloud point or the pour point of both fuels from your fuel supplier.
2. Locate the cloud point or the pour point of the heavier fuel on the left side of the table. Mark the point on the table.
3. Locate the cloud point or the pour point of the lighter fuel on the right side of the table. Mark the point on the table.
4. Draw a line between the two points that were established. Label this line “A” .
5. Determine the lowest outside temperature for machine operation. Find this point on the left side of the table. Mark this point. Draw a horizontal line from this point. Stop the line at the intersection of line “A” . Label this new line “C” .
6. Line “C” and line “A” intersect. Mark this point. Draw a vertical line from this point. Stop the line at the bottom of the table. Label this line “B” . The point at the bottom of line “B” reveals the percentage of lighter fuel that is required to modify the cloud point or the pour point.

The above example shows that the blending will require a thirty percent mixture of lighter fuel.

Additives are a good method to use in order to lower the pour point of a fuel. These additives are known by the following names: pour point depressants, cold flow improvers and wax modifiers. When the additives are used in a low concentration, the fuel will flow through pumps, lines, and hoses.

Note: These additives must be thoroughly mixed into the fuel at temperatures that are above the cloud point. The fuel supplier should be consulted in order to blend the fuel with the additives. The blended fuel can be delivered to your fuel tanks.

Moisture Content

Problems with fuel filters can occur at any time. The cause of the problem can be water in the fuel or moisture in the fuel. At low temperatures, moisture causes special problems. There are three types of moisture in fuel: dissolved moisture (moisture in solution), free and dispersed moisture in the fuel and free and settled at the bottom of the tank.

Most diesel fuels have some dissolved moisture. Just as the moisture in air, the fuel can only contain a specific maximum amount of moisture at any one temperature. The amount of moisture decreases as the temperature is lowered. For example, a fuel could contain 100 ppm (0.010 percent) of water in solution at 18°C (65°F). This same fuel can possibly hold only 30 ppm (0.003 percent) at 4°C (40°F).

After the fuel has absorbed the maximum possible amount of water, the additional water will be free and dispersed. Free and dispersed moisture is fine droplets of water that is suspended in the fuel. Since the water is heavier than the fuel, the water will slowly become free and settled at the bottom of the tank. In the above example, when the fuel temperature was lowered from 18°C (65°F) to 4°C (40°F), 70 ppm of water became free and dispersed in the fuel.

The small drops of water cause a cloudy appearance in the fuel. If the change in temperature is slow, the small drops of water can settle to the bottom of the tank. When the fuel temperature is lowered rapidly to freezing temperature, the moisture that comes out-of-solution changes to very fine particles of ice instead of small drops of water.

The particles of ice are lighter than the fuel, and the particles of ice will not settle to the bottom of the tank. When this type of moisture is mixed in the fuel, this moisture will fill the fuel filters. The ice crystals will plug the fuel filters in the same way as wax plugs the fuel filters.

If a filter is plugged and fuel flow is stopped, perform the following procedure to determine the cause:

1. Remove the fuel filters.

2. Cut the fuel filters open.

3. Inspect the fuel filter before the filter warms. This inspection will show that the filter is filled with particles of either ice or wax.

The moisture which is free and settled at the bottom of the tank can become mixed with the fuel. The force of any pumping action will mix the moisture with the fuel whenever fuel is transferred. This moisture then becomes free and dispersed water. This moisture can cause ice in the filters. This moisture can cause other problems with filters at any temperature. Generally, the same force that mixes the water into the fuel will also mix dirt and rust from the bottom of the tank with the water. The result is a dirty mixture of fuel and water which can also fill the filters and stop fuel flow.

Specific Gravity / API Gravity

The specific gravity of diesel fuel is the weight of a fixed volume of fuel in comparison to the weight of the same volume of water at the same temperature. A higher specific gravity correlates into a heavier fuel. Heavier fuels have more energy or power per volume for the engine to use.

Note: The settings for the fuel mixture should not be adjusted in order to compensate for a loss of power with fuels that are lighter. The life of fuel system components can be decreased with fuels that are very light because lubrication will be less effective as a result of the lower viscosity. This is compounded if the fuel does not have sufficient lubricity. See this publication, “Lubricity and Low Sulfur Fuel” under the “Characteristics of Diesel Fuel” section.

The API gravity of a fuel is also a measure of the density of the fuel or the relationship of the weight to the volume. The scale for API gravity is inverse to the scale for specific gravity. The API gravity will become higher as the fuel becomes lighter.

Lighter fuels will not produce the rated power. Lighter fuels may also be a blend of ethanol or methanol with diesel fuel. Blending alcohol or gasoline with diesel fuel will create an explosive atmosphere in the fuel tank. In addition, water condensation in the tank can cause the alcohol to separate in the tank.

⚠ 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.

NOTICE
Mixing alcohol or gasoline with diesel fuel may cause damage to the engine. Caterpillar recommends against this practice. Water condensation in the fuel tank can cause the alcohol to separate which could cause damage to the engine.

Heavier fuels tend to create more deposits from combustion. Deposits from combustion can cause abnormal cylinder liner and ring wear. This is most noticeable in smaller diesel engines that operate at higher speeds.

Gums and Resins

The gums and resins that occur in diesel fuel are the result of dissolved oxidation products in the fuel that do not evaporate easily. The products that are dissolved in the fuel also do not burn cleanly. Excessive gum in the fuel will coat the inside of fuel lines, pumps, and injectors. Excessive gum will also interfere with the close tolerances of the moving parts of the fuel systems. Gum and resin in the fuel will also cause the filter to plug rapidly. Oxidation of the fuel will occur and the formation of additional gums and resins will occur during fuel storage. The storage time for fuel needs to be minimized in order to help reduce the formation of gums and resins.

Note: Even when all fuel storage maintenance practices that are relevant for your application are followed, Caterpillar recommends a maximum of one year from production for distillate diesel fuel storage, and a maximum of six months from production for biodiesel and blended biodiesel storage. Storage life for biodiesel and for biodiesel blends that are greater than B20 may be much shorter than six months.

i03004299

Fuel Recommendations

SMCS Code: 1250; 1280

NOTICE
These recommendations are subject to change without notice. Consult your local Cat 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. These fuels must meet the “Caterpillar Specification for Distillate Diesel Fuel for On-Highway Diesel Engines” found in this Special Publication, “Distillate Diesel Fuel (Fuel Recommendations for On-Highway Diesel Engines)” article.

Note: The permissible fuels are some crude oils, some blends of crude oil with distillate fuel, some biodiesel, and some marine diesel 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. For information concerning biodiesel/biodiesel blends, refer to this Special Publication, “Biodiesel” article.

Note: With the exception of some biodiesel, permissible fuels are not acceptable for use in on-highway applications.

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

i03002692

Distillate Diesel Fuel
(Fuel Recommendations for On-Highway Diesel Engines)

SMCS Code: 1280

NOTICE
These recommendations are subject to change without notice. Consult your local Cat dealer for the most up to date recommendations.

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

The “Caterpillar Specification for Distillate Fuel for On-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 Caterpillar diesel engines.

Using the Caterpillar 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 Caterpillar distillate diesel fuel specification.
- Use the Caterpillar distillate diesel fuel specification as a fuel quality baseline for comparison of distillate diesel fuel analysis results to, and/or a baseline for comparison of other distillate diesel fuel specifications to.
- Typical fuel characteristics can be obtained from the fuel supplier.

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

- Compensate for some fuel parameters that are outside of the specification limits (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 (Fuel Recommendations for On-Highway Diesel Engines)” 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 On-Highway Diesel Engines”, table 9 .

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

Diesel Fuels that meet the specifications in table 9 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 9 requirements.

In Europe, diesel fuels that are identified as meeting the latest version of “European Standard EN590” generally meet the table 9 requirements.

Table 9 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.

NOTICE

Model year 2007 and newer (U.S. EPA 2007 certified) on-highway diesel engines REQUIRE the use of Ultra Low Sulfur Diesel (ULSD) fuel (≤ 15 ppm sulfur).

“Sulfur-free” diesel fuel (≤ 10 ppm sulfur) is strongly recommended for use in “EURO IV” certified on-highway diesel engines, while diesel fuel with ≤ 50 ppm sulfur is acceptable.

Low Sulfur Diesel (LSD) fuel (≤ 500 ppm sulfur) is strongly recommended (required in the U.S.) for use in model year 2006 and older on-highway diesel engines, while diesel fuel with ≤ 5000 ppm sulfur is acceptable for use in areas of the world where allowed by law. Diesel Oxidation Catalyst (DOC) equipped engines require the use of LSD fuel or ULSD fuel.

Note: In the U.S., burning fuel with greater than 15 ppm sulfur in model year 2007 and newer on-highway diesel engines is illegal and punishable with civil penalties.

Engines that are manufactured by Caterpillar are certified by use of the prescribed U.S. Environmental Protection Agency (EPA) and European Certifications fuels. Caterpillar does not certify diesel engines on any other fuel.

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.

NOTICE
Ultra Low Sulfur Diesel (ULSD) fuel will have ≤15 ppm (0.0015%) sulfur using the “ASTM D5453”, “ASTM D2622”, or “ISO 20846, ISO 20884” test methods. Model year 2007 and newer Caterpillar on-highway diesel engines REQUIRE the use of ULSD fuel in order to meet the U. S. EPA 2007 emissions regulations for on-highway diesel engines. In the U. S., failure to use ULSD in these engines is illegal and punishable with civil penalties. Model year 2007 and newer Caterpillar on-highway diesel engines are designed to operate on ULSD. Failure to use ULSD in these engines will reduce engine efficiency and durability. Failure to use ULSD may also damage emission control systems and reduce fuel economy. Refer to the Frequently Asked Questions article in the “Reference Information” section of this Special Publication for additional ULSD fuel information. In addition, certain other governments/localities MAY require the use of ULSD fuel. Diesel engines equipped with a Diesel Particulate Filter (DPF) require the use of ULSD. Other emission controlled diesel engines and/or diesel engines equipped with exhaust aftertreatment devices MAY also require the use of ULSD fuel. Consult federal, state, and local authorities for guidance on fuel requirements for your area. Also, consult the specific engine Operation and Maintenance Manual for guidance.

When ULSD is used, there are concerns with fuel viscosity, lubricity, and thermal stability. The fuel viscosity, lubricity, and thermal stability limits stated in this Special Publication, “Caterpillar Specification for Distillate Diesel Fuel for On-highway Diesel Engines” address these concerns. In North America, diesel fuels that meet the latest version of “ASTM D975 Grade No. 1-D S15” or “ASTM D975 Grade No. 2-D S15” and meet the “ASTM D975 Thermal Stability Guideline”, generally meet the Caterpillar requirements for ULSD fuel.

In Europe, diesel fuels that meet the latest version of “European Standard EN590” requirements for ≤ 10 ppm sulfur fuel (typically referred to as “sulfur-free”) generally meet Caterpillar requirements for ULSD fuel.

“Sulfur-free” diesel fuels (≤ 10 ppm sulfur) as defined in the latest version of “European Standard EN590” are strongly recommended for use in “EURO IV” certified on-highway diesel engines, while diesel fuel with ≤ 50 ppm sulfur is acceptable. Use of diesel fuel with greater than 50 ppm in Caterpillar “EURO IV” engines will reduce the engine efficiency and durability, and may reduce fuel economy.

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.

Note: Caterpillar strongly recommends the filtration of distillate fuel and/or biodiesel and biodiesel blends through a fuel filter with a rating of four microns(c) absolute or less. This filter should be located on the device that dispenses the fuel to the fuel tank for the engine. Series filtration is recommended. Refer to the “General Recommendations and Guidelines” for more details.

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.

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

Table 9

Caterpillar Specification for Distillate Diesel Fuel for On-Highway Diesel Engines(1)			
Specifications	**Requirements**	**ASTM Test**	**ISO Test**
Aromatics	35 percent maximum	“D1319”	“ISO 3837”
Ash	0.01 percent maximum (weight)	“D482”	“ISO 6245”
Carbon Residue on 10 percent Bottoms	0.35 percent maximum (weight)	“D524”	“ISO 4262”
Cetane Number (2)	40 minimum (DI engines)	“D613” or “D6890”	“ISO 5165”

(continued)

(Table 9, contd)

Caterpillar Specification for Distillate Diesel Fuel for On-Highway Diesel Engines[1]			
Specifications	**Requirements**	**ASTM Test**	**ISO Test**
	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 percent at 282 °C (540 °F) maximum	“D86”	“ISO 3405”
	90 percent at 360 °C (680 °F) maximum		
Flash Point	legal limit	“D93”	“ISO 2719”
Thermal Stability	Minimum of 80 percent reflectance after aging for 180 minutes at 150 °C (302 °F)	“D6468”	No equivalent test
API Gravity [3]	30 minimum (875.7 kg/m^3)	“D287”	No equivalent test
	45 maximum (801.3 kg/m^3)		
Pour Point	6 °C (10 °F) minimum below ambient temperature	“D97”	“ISO 3016”
Sulfur [1]	0.05 percent (500 ppm) maximum (Pre-2007 engines)[4]	“D5453” or “D2622”	“ISO 20846” or “ISO 20884”
	0.0015 percent (15 ppm) maximum (2007 and newer engines)		
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		

(continued)

(Table 9, contd)

Caterpillar Specification for Distillate Diesel Fuel for On-Highway Diesel Engines[1]			
Specifications	**Requirements**	**ASTM Test**	**ISO Test**
Water and Sediment	0.1 percent maximum	“D1796”	“ISO 3734”
Water	0.1 percent maximum	“D6304”	No equivalent test
Sediment	0.05 percent maximum (weight)	“D473”	“ISO 3735”
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 percent) sulfur using the “ASTM D5453”, “ASTM D2622”, or “ISO 20846, ISO 20884” test methods. This specification includes the requirements for Low Sulfur Diesel (LSD). LSD fuel will have ≤500 ppm (0.05 percent) sulfur using the “ASTM 5453, ASTM D2622” or the “ISO 20846”, “ISO 20884”test methods. Aftertreatment devices can be permanently damaged by the use of high sulfur fuels. Diesel engines that are equipped with a Diesel Particulate Filter (DPF) require the use of ULSD. Diesel Oxidation Catalyst (DOC) equipped engines require the use of LSD fuel or ULSD fuel. Refer to the NOTICE that immediately follows the footnotes to this Table.

(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 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.

(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) Fuel sulfur levels affect exhaust emissions. High sulfur fuels also increase the potential for corrosion of internal components. Fuel sulfur levels above 0.5 percent may significantly shorten the oil change interval. Caterpillar strongly recommends that S·O·S Services oil analysis be used to determine oil change intervals when fuel sulfur levels are above 0.5 percent. Consult your Caterpillar dealer for guidance when fuel sulfur levels are above 0.5 percent. For additional information, see this Special Publication, “Engine Oil” article. Model year 2007 and newer (U.S. EPA 2007 certified) on-highway diesel engines are required to use fuel with 15 ppm or less sulfur. ULSD fuel will have ≤ 15 ppm (0.0015 percent) sulfur using “ASTM D5453”, “ASTM D2622”, or “ISO 20846, ISO 20884” test methods. It is strongly recommended that “EURO IV” certified on-highway diesel engines use ULSD. Aftertreatment devices can be permanently damaged by the use of high sulfur fuels. Diesel engines that are equipped with a Diesel Particulate Filter (DPF) require the use of ULSD. Diesel Oxidation Catalyst (DOC) equipped engines require the use of LSD fuel or ULSD fuel. Refer to the NOTICE that immediately follows the footnotes to this Table.

(continued)

(Table 9, contd)

(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 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.

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

(7) 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. 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.

NOTICE

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. In the U.S., burning fuel with greater than 15 ppm sulfur in model year 2007 and newer (U.S. EPA 2007 certified) on-highway diesel engines is illegal and punishable with civil penalties. In addition, model year 2007 and newer Caterpillar on-highway diesel engines are designed to operate on ULSD fuel. The use of fuel with greater than 15 ppm sulfur will reduce the engine efficiency and durability, and may damage emission control systems and reduce fuel economy. In the U.S., burning fuel with greater than 500 ppm sulfur in model year 2006 and older on-highway diesel powered vehicles is illegal and punishable with civil penalties.

In Europe, diesel fuel that meets the latest version of “European Standard EN590” requirements for ≤ 10 ppm sulfur fuel (typically referred to as “sulfur-free”) generally meet Caterpillar requirements for ULSD fuel.

“Sulfur-free” diesel fuels (≤ 10 ppm sulfur) as defined in the latest version of “European Standard EN590” are strongly recommended for use in “EURO IV” certified on-highway diesel engines, while diesel fuel with ≤ 50 ppm sulfur is acceptable. Use of diesel fuel with greater than 50 ppm in Caterpillar “EURO IV” engines will reduce the engine efficiency and durability, and may reduce fuel economy.

Ultra Low Sulfur Diesel (ULSD)

ULSD is a number 1 distillate diesel fuel or a number 2 distillate diesel fuel that contains a maximum of 0.0015 percent (15 ppm or 15 mg/kg) sulfur by weight.

Caterpillar recommends that all distillate diesel fuel, including ULSD fuel (fuel ≤ 15 ppm sulfur using “ASTM D2622, ASTM D5453” or “ISO 20846, ISO20884”) meet the requirements of the Caterpillar Specifications for Distillate Diesel Fuel for On-Highway Diesel Engines that are specified in table 9 .

Note: ULSD has less electrical conductivity than LSD. Follow all industry standard grounding and safety practices.

NOTICE
Ultra Low Sulfur Diesel (ULSD) fuel will have ≤15 ppm (0.0015%) sulfur using the “ASTM D5453”, “ASTM D2622”, or “ISO 20846, ISO 20884” test methods. Model year 2007 and newer Caterpillar on-highway diesel engines REQUIRE the use of ULSD fuel in order to meet the U. S. EPA 2007 emissions regulations for on-highway diesel engines. In the U. S., failure to use ULSD in these engines is illegal and punishable with civil penalties. Model year 2007 and newer Caterpillar on-highway diesel engines are designed to operate on ULSD. Failure to use ULSD in these engines will reduce engine efficiency and durability. Failure to use ULSD may also damage emission control systems and reduce fuel economy. Refer to the Frequently Asked Questions article in the “Reference Information” section of this Special Publication for additional ULSD fuel information. In addition, certain other governments/localities MAY require the use of ULSD fuel. Diesel engines equipped with a Diesel Particulate Filter (DPF) require the use of ULSD. Other emission controlled diesel engines and/or diesel engines equipped with exhaust aftertreatment devices MAY also require the use of ULSD fuel. Consult federal, state, and local authorities for guidance on fuel requirements for your area. Also, consult the specific engine Operation and Maintenance Manual for guidance.

When ULSD is used, there are concerns with fuel viscosity, lubricity, and thermal stability. The fuel viscosity, lubricity, and thermal stability limits stated in this Special Publication, “Caterpillar Specification for Distillate Diesel Fuel for On-highway Diesel Engines” address these concerns. In North America, diesel fuels that meet the latest version of “ASTM D975 Grade No. 1-D S15” or “ASTM D975 Grade No. 2-D S15” and meet the “ASTM D975 Thermal Stability Guideline”, generally meet the Caterpillar requirements for ULSD fuel.

In Europe, diesel fuels that meet the latest version of “European Standard EN590” requirements for ≤ 10 ppm sulfur fuel (typically referred to as “sulfur-free”) generally meet Caterpillar requirements for ULSD fuel.

“Sulfur-free” diesel fuels (≤ 10 ppm sulfur) as defined in the latest version of “European Standard EN590” are strongly recommended for use in “EURO IV” certified on-highway diesel engines, while diesel fuel with ≤ 50 ppm sulfur is acceptable. Use of diesel fuel with greater than 50 ppm in Caterpillar “EURO IV” engines will reduce the engine efficiency and durability, and may reduce fuel economy.

Note: In Europe, ultra low sulfur diesel fuel will have a maximum of 0.0010 percent (10 ppm) sulfur, and is typically referred to as “sulfur-free”.

Note: Caterpillar recommends the filtration of distillate fuel and/or biodiesel and biodiesel blends through a fuel filter with a rating of four 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.

⚠ 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.

Heavy Fuel Oil, Residual Fuel, Blended Fuel

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. **DO NOT USE THESE FUELS IN CATERPILLAR ON-HIGHWAY DIESEL ENGINES.**

Alternative Fuels Arctic Applications

In extreme cold ambient conditions, you may choose to use the distillate fuels that are specified in table 10 . However, the fuel that is selected must meet the requirements that are specified in the “Caterpillar Specification for Distillate Diesel Fuel for On-Highway Diesel Engines”, Table 9 . 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 10 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 of less.

Note: The fuels that are listed in table 10 typically have much higher sulfur levels than the 50 ppm maximum sulfur allowed in the the latest version of European Standard “EN 590”. 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.

Table 10

Alternative Distillate Fuels - Arctic Applications (1) (2)	
Specification	**Grade**
“MIL-DTL-5624U”	JP-5
“MIL-DTL-83133F”	JP-8
“ASTM D1655-08a”	Jet A(3), Jet A-1(3)

(1) The fuel that is selected must meet the requirements that are specified in the “Caterpillar Specification for Distillate Diesel Fuel for On-Highway Diesel Engines” table, table 9 . 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.

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

(3) 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 other freezing points may be agreed on by the fuel purchaser and the fuel supplier.

These fuels are lighter than the No. 2 grades of fuel. The cetane number of the fuels in table 9 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.

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 Caterpillar 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 Caterpillar 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.

Note: Use of Cat Diesel Fuel Conditioner does not lessen the engine owner and/or fuel supplier responsibility 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 Conditioner does NOT lessen the engine owner responsibility to use appropriate diesel fuel. Refer to the “Fuel Specifications” section in this Special Publication (Maintenance Section) for guidance.

Cat Diesel Fuel Conditioner is suitable for use with biodiesel/biodiesel blends that meet Caterpillar 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, which includes Caterpillar biodiesel recommendations and requirements. Caterpillar strongly recommends the use of Cat Diesel Fuel Conditioner with biodiesel and biodiesel blends.

When used as directed, Cat Diesel Fuel Conditioner has proven to be compatible with existing and U.S. EPA 2007 on-highway certified diesel engine emission control catalysts and particulate filters.

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.

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 Caterpillar 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 Cat Diesel Fuel System Cleaner is appropriate for use with other ultra low, low, and higher sulfur diesel fuels around the world.

Cat Diesel Fuel System Cleaner is designed to perform the following:

- Clean performance-reducing 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 percent 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.

In order to prevent the return of fuel-related deposits, add the Cat Diesel Fuel System Cleaner to the fuel as previously described, but at a 0.2 percent 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 performance or fuel system durability.

Note: Use of Cat Diesel Fuel System Cleaner does not lessen 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 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.

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 Caterpillar 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 Caterpillar biodiesel recommendations and requirements.

When used as directed, Cat Diesel Fuel System Cleaner has proven to be compatible with existing and U.S. EPA 2007 on-highway certified diesel engine emission control catalysts and particulate filters.

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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Biodiesel

SMCS Code: 1280

NOTICE
These recommendations are subject to change without notice. Consult your local Cat dealer for the most up to date recommendations.

Biodiesel is a fuel that can be made from a variety of renewable resources that include vegetable oils, animal fat, and waste cooking oil. Soybean oil and rapeseed oil are the primary vegetable oil sources. The raw oils or animal fats are chemically processed (esterified) to form a fatty acid methyl ester (referred to as FAME). The esterified product (FAME) is biodiesel fuel that can be used in compression ignition engines. Without the chemical processing referred to as esterification, the oils or fats are not suitable for use as fuel in compression ignition engines. In order to use any of the oils or fats listed above as fuel, the oil or fat must be esterified and the water and contaminants removed.

Fuel made of 100 percent FAME is generally referred to as B100 biodiesel or neat biodiesel.

Biodiesel can be blended with distillate diesel fuel. The blends can be used as fuel. The most commonly available biodiesel blends are B5, which is 5 percent biodiesel and 95 percent distillate diesel fuel, and B20, which is 20 percent biodiesel and 80 percent distillate diesel fuel. Note that the percentages are volume based.

U.S. distillate diesel fuel specification “ASTM D975-09a” includes up to B5 (5 percent) biodiesel. Currently, any diesel fuel in the U.S. may contain up to B5 biodiesel fuel.

European distillate diesel fuel specification “EN 590” includes up to B5 (5 percent) and in some regions up to B7 (7 percent) biodiesel. Any diesel fuel in Europe may contain up to B5 or in some regions up to B7 biodiesel fuel.

Engines that are manufactured by Caterpillar are certified by use of the prescribed U.S. EPA and European Certification fuels. Caterpillar does not certify diesel engines to meet emissions standards 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 U.S. EPA and other appropriate regulatory agencies.

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.

Note: In order to align Caterpillar recommendations with the latest revision of “ASTM D7467” specification for B6-B20 blends and to ensure that biodiesel fuel meets defined quality standards, Caterpillar recommendations for acceptable biodiesel blend for most engines have been changed to B20. Details on the use of higher blends are given in this “Biodiesel” section of this Special Publication.

NOTICE
In North America, the use of biodiesel from “BQ-9000” accredited producers and “BQ-9000” certified marketers is required. Refer to the “Recommendations” section for details.

NOTICE
Failures that result from the use of any fuel are not Caterpillar factory defects. Therefore, the cost of repair would NOT be covered by the Caterpillar warranty for materials and/or the warranty for workmanship.

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

Table 11

Recommendations for biodiesel fuel application in On-Highway Cat engines		
Production year	Engine model	Biodiesel acceptable blend levels (1)
2007 and newer	C13 and C15 EPA certified and/or C15 Euro IV certified	Up to B20 (2)
	C7 and C9 EPA certified	Up to B5 (2) (3)
2006 and older	All models	Up to B20 (4)

(1) Refer to Tables 12 and 14 and to the details provided in this section for biodiesel fuel requirements.
(2) For applications in the U.S, the diesel fuel portion of the final blend must meet the requirements of S15 fuels (≤15 ppm sulfur) designations in the latest edition of “ASTM D975” specification. For applications in EU, the diesel fuel portion of the final blend must meet the requirements for sulfur free (≤10 ppm sulfur) designation in the latest edition of “EN590”. The final blend must have ≤15 ppm sulfur.
(3) The acceptable biodiesel blend level can be increased up to B10±1 for C7 and C9 EPA 2007 model year certified engines and newer if Cat Diesel Fuel System Cleaner (part number 343-6210) is used at every oil drain interval for at least one fuel tank (follow the recommendations provided in the Cat “Fuel Additives” section in this Special Publication) and the Cat Nozzle Cleaner (part number 304-7755) is used as needed to clean the ARD nozzle.
(4) For 2006 and older engine models, for use of blends of biodiesel above B20 (20 percent), refer to Table 13 in this Special Publication for the guidelines and impacts of using high biodiesel blends and consult your Caterpillar dealer for guidance. A complete Caterpillar S·O·S Services oil analysis program is required when biodiesel or blends of biodiesel that is B20 (20 percent) or above is used.

Table 12

Fuel Recommendations for On-Highway Caterpillar engines		
Biodiesel Blend Stock	Final Blend	Distillate Diesel Fuel used for blending
Caterpillar biodiesel specification, (1) “ASTM D6751” or “EN14214”	B5: Caterpillar distillate diesel fuel specification, (2) “ASTM D975” or “EN590”	Caterpillar distillate diesel fuel specification, “ASTM D975” or “EN590”
	B20: “ASTM D7467” and “API” gravity 30-45	

(1) Refer to Table 14 in the Biodiesel section of this Special Publication.
(2) Refer to “Caterpillar Specification for Distillate Diesel Fuel for On-Highway Engines” in the Fuel section of this Special Publication.

In order to be acceptable for blending, the biodiesel constituent must meet the requirements that are listed in “Caterpillar Specification for Biodiesel Fuel” in this Special Publication, the latest edition of “ASTM D6751”, and/or the latest edition of “EN14214”.

Distillate diesel fuels that meet the requirements of “Caterpillar Specification for Distillate Diesel Fuel for On-Highway Engines” in this Special Publication, the “National Conference on Weights and Measures ”(NCWM) Premium Diesel definition, the latest edition of “ASTM D975 S15” designation; and/or the latest edition of “EN 590”, sulfur free designation. No.1-D and No.2-D are examples of fuels that are acceptable for creating biodiesel blends.

Biodiesel blends of B6 to B20 must meet the requirements listed in the latest edition of “ASTM D7467” (B6 to B20) **and** must be of an API gravity of 30-45.

Biodiesel blends of up to B5 must meet the requirements for the distillate diesel fuel that are listed in the “Caterpillar Specification for Distillate Diesel Fuel for On-Highway Engines” in this Special Publication, the latest edition of “ASTM D975”, and/or the latest edition of “EN 590”.

Note: The acceptable biodiesel blend level can be increased up to B10±1 for C7 and C9 EPA 2007 model year certified engines and newer, **if** Cat Diesel Fuel System Cleaner (part Number 343-6210) is used in the first fuel tank fill **and** at every oil drain interval thereafter. Follow the recommendations provided in the “Fuel Additives” topic in this Special Publication, “Characteristics of Diesel Fuel” article. Also, the Cat Nozzle Cleaner (part number 304-7755) may be used as needed in order to clean the Aftertreatment Regeneration Device (ARD) nozzle.

Note: For 2007 and newer engine models, use of biodiesel blends higher than the recommendations provided in “Caterpillar Specification for Biodiesel Fuel” in this Special Publication may adversely affect engine and aftertreatment components, mainly due to contaminants present in biodiesel. The repair of any engine or aftrereatment components due to such contamination or due to other biodiesel impacts would not be covered under the Caterpillar warranty for materials and/or the warranty for workmanship. Refer to “Additional Maintenance Requirements” topic in this Special Publication, “Biodiesel” article.

Note: For 2006 and older engine models, for use of blends of biodiesel above B20 (20 percent), refer to “Guidelines and potential impacts associated with the use of biodiesel and biodiesel blends” table 13 in this Special Publication for the guidelines and impacts of using high biodiesel blends. Consult your Caterpillar dealer for guidance. A complete Caterpillar S·O·S Services oil analysis program is required when biodiesel or blends of biodiesel that are B20 (20 percent) or above are used.

Either “ASTM D7371” - “Test Method for Determination of Biodiesel (Fatty Acid Methyl Esters) Content in Diesel Fuel Oil Using Mid Infrared Spectroscopy (FTIR-ATR-PLS Method)” or “EN 14078” “- Liquid Petroleum Products - Determination of fatty acid methyl esters (FAME) in middle distillates -Infrared spectroscopy method” can be used for determining the volume percent biodiesel in a biodiesel blend.

For applications running biodiesel or biodiesel blends, it is recommended to use either Cat Diesel Fuel System Cleaner (Part number 343-6210) or Cat Diesel Fuel Conditioner (Part number 256-4968). Cat Diesel Fuel System Cleaner, used as needed or on an on-going basis, is most effective at cleaning and preventing the formation of fuel-related deposits. Cat Diesel Fuel Conditioner can be used to improve fuel stability and can help prevent the formation of fuel related deposits.

Additional maintenance requirements

When biodiesel fuel is used, crank case oil and aftertreatment systems may be influenced. This influence is due to the chemical composition and characteristics of biodiesel fuel, such as density and volatility, and to chemical contaminants that can be present in this fuel, such as phosphorous, alkali, and alkaline metals (sodium, potassium, calcium, and magnesium).

- Crankcase oil fuel dilution can be higher when biodiesel and/or biodiesel blends are used. This increased level of fuel dilution when using biodiesel and/or biodiesel blends is related to the typically lower volatility of biodiesel. In addition, in-cylinder emissions control strategies utilized in many of the latest engine designs may lead to a higher level of biodiesel concentration in the sump. The long-term effect of biodiesel concentration in crankcase oil is currently unknown. **The use of Cat S·O·S Services oil analysis is strongly recommended when up to B20 (20 percent) and lower biodiesel blends are used, and required when using biodiesel/ biodiesel blends that are B20 or above** (when requesting oil analysis, be sure to note the level of biodiesel being used (B5, B20, etc.)).
- Biodiesel fuel contains metal contaminants (phosphorous, sodium, potassium, calcium, and/or magnesium) that form ash products upon combustion in the diesel engine. The ash can accumulate in Diesel Particulate Filters (DPF) that are used in EPA and/or EU 2007 model year certified and newer engines. When B6 to B20 biodiesel fuel is used, ash accumulation in the DPF may be higher than with lower blends. The ash accumulation may cause the need for more frequent ash service intervals and/or cause loss of performance.
- For Cat EPA 2007 model year certified and newer C7, C9 on-highway diesel engines that use the appropriate blend of biodiesel, as set forth above, Caterpillar recommends cleaning the nozzle of the Cat Regeneration System Aftertreatment Regeneration Device (ARD) (also known as the Cat Regeneration System (CRS)) at the regularly scheduled oil change maintenance interval. Refer to the applicable Operation and Maintenance Manual for the procedure for cleaning the ARD nozzle. Failure to perform this additional maintenance will not negatively impact the Caterpillar emissions warranty.

Note: Use of blends higher than B20 is not recommended in engines equipped with DPF devices.

Note: Cat Nozzle Cleaner, part number 304-7755, is recommended for use to clean the ARD nozzle. Refer to the applicable Operation and Maintenance Manual for the procedure for cleaning the nozzle.

Fuel System Deposits

Biodiesel and biodiesel blends are known to cause an increase in fuel system deposits, most significant of which are deposits within the fuel injector. These deposits can cause a loss in power due to restricted or modified fuel injection or cause other functional issues associated with these deposits. Cat Diesel Fuel System Cleaner (part number 343-6210), used as needed or on an on-going basis, is most effective in cleaning and preventing the formation of deposits. Cat Diesel Fuel Conditioner (part number 256-4968) helps to limit deposit issues by improving the stability of biodiesel and biodiesel blends while also hindering the production of new deposits. **Therefore, the use of Cat Diesel Fuel System Cleaner and/or Cat Diesel Fuel Conditioner is strongly recommended when running biodiesel and biodiesel blends, especially when using B20 or higher blend levels.** Refer to this Special Publication, “Distillate Diesel Fuel”, article, “Cat Diesel Fuel Conditioner” and “Cat Diesel Fuel System Cleaner” topics in this Special Publication, “Distillate Diesel Fuel” for additional information.

Consult your Caterpillar dealer for availability of Cat Diesel Fuel System Cleaner and Cat Diesel Fuel Conditioner.

Recommendations

Biodiesel that meets the requirements that are listed in the “Caterpillar Specification for Biodiesel Fuel”, the latest edition of “ASTM D6751”, or the latest edition of “EN 14214” is not expected to pose major problems when blended with an acceptable distillate diesel fuel at the maximum stated percentages. However, the following recommendations should be followed:

Note: For the purpose of these recommendations, the cautions, guidelines and recommendations applicable to biodiesel (B100) are also applicable to biodiesel blends (B2, B5, B20, etc.). The impacts of biodiesel blends higher than B20 are, in general, more severe than the impacts of biodiesel blends of B20 or lower. Refer to Table 13 of this Biodiesel section for more details.

Note: Fuel storage tanks should be thoroughly cleaned before converting to biodiesel/biodiesel blends. Conversion to biodiesel/biodiesel blends can loosen fuel system and fuel storage tank deposits. Bulk tank continuous filtration unit and dispensing point filters, and onboard engine filters change intervals may need to be shortened for an extended period of time in order to allow for this cleaning effect.

In North America, the use of biodiesel from “BQ-9000” accredited producers and “BQ-9000” certified marketers is required. Look for the “BQ-9000” biodiesel quality accreditation program certification logo that is available to distributors that meet the requirements of “BQ-9000”. For more information on the “BQ-9000” program, go to “www.BQ-9000.org”.

In other areas of the world, the use of biodiesel that is “BQ-9000” accredited and certified, or that is accredited and certified by a comparable biodiesel quality body to meet similar biodiesel quality control standards, is required.

When using biodiesel fuel, the following recommendations and guidelines should be observed:

1. The oil change interval can be negatively affected by the use of biodiesel. Use S·O·S Services oil analysis in order to monitor the condition of the engine oil. S·O·S Services oil analysis will also help determine the oil change interval that is optimum.

2. Confirm with the filter manufacturer that the fuel filter/filters to be used are compatible with biodiesel. Fuel water separators are preferred when biodiesel is used.

Note: Cat fuel filters and Cat fuel water separators are compatible with biodiesel fuel.

3. Conversion to biodiesel can loosen fuel system deposits. Fuel filter change intervals may need to be shortened for an extended period of time in order to allow for this cleaning effect when converting used engines to biodiesel.

4. Filter biodiesel and biodiesel blends through a fuel filter with a rating of four microns(c) absolute or less. Filters should be located on the device that dispenses the fuel to the fuel tank for the engine. Filters should be located on the device that dispenses fuel from the bulk storage tank. Series filtration is recommended.

5. In a comparison of distillate fuels to biodiesel, neat biodiesel (B100) typically provides less energy per gallon by 5 percent to 8 percent. Do NOT attempt to 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. Furthermore, any adjustments to the engine in service to compensate for the power loss may result in violation of emissions regulations such as the U.S. EPA anti-tampering provisions.

6. Compatibility of the elastomers with biodiesel is currently being monitored. The condition of seals and hoses should be monitored regularly. Biodiesel may soften, degrade, or leak from some types of elastomers used in seals and hoses. The higher the biodiesel blend the greater the risk of elastomer related issues.

a. In general, Cat engines built early to mid 90s use Viton seals and Viton O-rings in the fuel system. Viton is compatible with biodiesel.

b. Nitrile hoses typically used in some fuel transfer lines are not compatible with biodiesel. Monitor the condition of the hoses and confirm with the hose manufacturer that the hoses are compatible with the biodiesel blend used. If necessary, replace with hoses of compatible materials.

7. Biodiesel may pose low ambient temperature problems for both storage and operation. At low ambient temperatures, biodiesel 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 attaining of the proper cloud point for the fuel.

Note: The performance of cold flow improvers can be reduced in the presence of biodiesel fuel. Consult the fuel supplier for appropriate cold flow improvers if needed.

8. Biodiesel can be produced using various renewable sources. The source used can affect product performance. Two of the fuel characteristics affected are cold flow and oxidation stability. Consult your fuel supplier for guidance.

9. Biodiesel has poor oxidation stability, which may accelerate fuel oxidation in the fuel system. Engines with an electronic fuel system operate at higher temperatures. Refer to this Special Publication, “Distillate Diesel Fuel” article, “Aftermarket Fuel Additives”, “Cat Diesel Fuel Conditioner”, and “Cat Diesel Fuel System Cleaner” topics for information concerning oxidation stability and other fuel additives.

10. Poor oxidation stability of biodiesel can result in long-term storage problems. Biodiesel should be used within a limited time from production. In order to ensure appropriate storage duration, testing of the stored biodiesel is strongly recommended. Tests should include oxidation, acid number, viscosity, and sediments. Tests should be conducted periodically to ensure biodiesel is per specification. Antioxidants are recommended to improve stability of biodiesel. Cat Diesel Fuel Conditioner, part number 256-4968, or appropriate commercial additives are recommended. Consult your fuel supplier for more information.

a. B20 biodiesel blend can generally be stored up to eight months. Testing of B20 blends is strongly recommended at four months of storage and on a monthly basis thereafter to ensure that the fuel has not degraded.

b. B100 biodiesel can generally be stored up to four months. Testing of B100 is strongly recommended at two months of storage and every two weeks thereafter to ensure that the fuel has not degraded. The use of appropriate additives is required if B100 is stored more than four months. Consult your fuel supplier for more information.

c. B100 biodiesel should be stored at temperatures of 30° C (50° F) to 60° C (100° F) above the cloud point.

11. Due to poor oxidation stability and other potential issues, it is strongly recommended that engines with limited operational time either not use biodiesel/biodiesel blends or, while accepting some risk, limit biodiesel to a maximum of B5. Examples of applications that should limit the use of biodiesel are the following: Standby Generator sets and certain emergency vehicles.

a. Addition of Cat Diesel Fuel Conditioner, part number 256-4968, or an appropriate commercial additive containing antioxidants/ oxidation stability improvers, is strongly recommended for standby generator sets and emergency vehicles using biodiesel/biodiesel blends. The conditioner should be added when the engine is fueled or as early as possible when the fuel is delivered and stored. Preferably, the conditioner or additive should be added as soon as possible after the fuel is produced.

b. For standby generator sets and emergency vehicles that use biodiesel, sample the fuel in the engine tank monthly. Test the fuel for acid number and oxidation stability. If the test results show that the fuel is degraded and that the fuel is not per the appropriate specifications (provided in Table 14 in this “Biodiesel” section), drain the tank, flush with high quality fuel and then refill with high quality fuel following the recommendations provided in this “Fuel” section

c. For standby generator sets and emergency vehicles that use biodiesel, it is strongly recommended that the fuel oxidation stability is 10 hours or more per “EN 14112” test method.

12. 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. Consult your supplier of fuel and additive for assistance in selecting appropriate anti-microbial additives.

13. 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.

14. Biodiesel dilution of engine oil may result in oil side leaks due to incompatibility of the seals that are typically used on the oil side. Liner seals and oil cooler seals may be affected by biodiesel dilution. Monitor the condition of the oil side seals and consult your Caterpillar dealer for appropriate replacement if needed.

15. Biodiesel is not compatible with some metals. Biodiesel, in particular B100 and blends higher than B20, will oxidize and form sediments upon long term contact with lead, zinc, tin, copper, and copper alloys such as brass and bronze. Consult your Dealer for more information.

NOTICE
The footnotes are an integral part of the “Potential Risk Associated with Biodiesel Blends” table. Read ALL footnotes.

Table 13

Guidelines and potential impacts associated with the use of biodiesel and biodiesel blends [1]				
	Recommendation/impacts	B5	B6-B20	B21-B100
1	Risk of reduction of oil change interval	Negligible	Low	High
2	Fuel filters compatibility risk	Negligible	Low	Medium
3	Loosening of fuel system deposits upon conversion to biodiesel.	Negligible	Medium	High
4	Bulk filtration of biodiesel	≤4 microns absolute	≤4 microns absolute	≤4 microns absolute
5	Energy content of biodiesel	Similar to Diesel	Minor loss of 1-2 percent	Detectable loss of 5-8 percent
6	Compatibility with elastomers	Low	Low-Medium	High
7	Low ambient temperature problems for both storage and operation.	Medium	Medium-High	High
8	Feedstock impact	Medium	High	High
9	Oxidation stability-Injector deposits risk	Low	Medium	High
10	Oxidation stability-Duration of storage [2]	Similar to Diesel fuel	Eight months [3]	Four months [4]
11	Use in engines with limited operational time	Maximum allowed	Unacceptable	Unacceptable
12	Microbial contamination and growth-Risk.	Medium	High	High
13	Need for water removal	Medium	High	High
14	Oil-side seal incompatibility	Negligible	Medium	High
15	Metal incompatibility	Negligible	Low	High

(1) Information provided in this table refers to biodiesel and biodiesel blends that fully comply with the appropriate specifications as described in the “Biodiesel” section of this Special Publication and to handling and maintenance procedures that follow recommended guidelines.
(2) Testing of biodiesel or biodiesel blend during storage is strongly recommended. Tests should include oxidation, acid number, viscosity and sediments. Tests should be conducted periodically to ensure biodiesel is per specification. Antioxidants are recommended to improve stability of biodiesel. Cat Diesel Fuel Conditioner, part number 256-4968, or commercial appropriate additives are recommended. Consult your fuel supplier for more information.
(3) Testing of B20 blends is recommended at four months of storage and on a monthly basis thereafter.
(4) B100 stored for over two months should be tested every two weeks to ensure that the fuel is not degraded. The use of appropriate additives is required if B100 is stored more than four months. Consult your fuel supplier for more information. In addition, B100 should be stored at temperatures of 3 degrees C to 6 degrees C (5 degrees F to 10 degrees F) above the cloud point.

Note: The use of biodiesel at a B2 level improves the lubricity of the final blend by an estimated 66 percent. Increasing the blend level higher than B2 does not improve the lubricity any further.

Seasonal Operation

It is strongly recommended that seasonally operated engines have the fuel systems, including fuel tanks, flushed with conventional diesel fuel before prolonged shutdown periods. An example of an application that should seasonally flush the fuel system is school buses (U.S.).

Perform the following process before shutting down the engine for prolonged periods:

1. Operate the engine until the fuel level in the tank is very low.
2. Refill the fuel tank with high quality conventional distillate diesel fuel.
3. Repeat steps 1 and 2 a minimum of two times before the engine is shut down for prolonged periods.

If distillate fuel is not available to operate the engine as described above, while accepting some risk, limit biodiesel to a maximum of B5. Follow the recommendations provided in this section and the guidelines given below to reduce the risk:

- Addition of Caterpillar Diesel Fuel Conditioner, part number 256-4968, or an appropriate commercial additive containing antioxidants/ oxidation stability inprovers, is strongly recommended prior to engine shut down for prolonged periods. The conditioner should be added when the engine is fueled. Preferably, the conditioner is added to the fuel as soon as possible after the fuel production.
- Addition of Caterpillar Diesel Fuel System Cleaner, part number 343-6210, or an appropriate commercial cleaner is recommended when the engine is first operated after the prolonged shutdown period and preferably for a total of two tanks of fuel. Follow the recommendations provided in the Caterpillar Diesel Fuel System Cleaner section in the “Fuel” article in this Special Publication.

Consult your Caterpillar dealer for the availability of Caterpillar Diesel Fuel Conditioner and Caterpillar Diesel Fuel System Cleaner.

Biodiesel Specification

Biodiesel fuel used that is used for blending must meet the requirements in the following table.

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

Table 14

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 (cSt)	1.9-6.0
Flash Point	“ASTM D93”	“ISO 3679”	°C	93 minimum
Pour Point - Summer - Winter	“ASTM D97”	“ISO 3016”	°C	6 °C (10 °F) minimum below ambient temperature
Cloud Point	“ASTM D2500”		°C	Report
Sulfur Content	“ASTM D5453”	“ISO 20846” “ISO 20884”	percent weight	0.0015 maximum
Distillation - 10 percent Evaporation - 90 percent Evaporation	“ASTM D1160”		°C	To Be Determined 360
Carbon Residue, Conradson (CCR)	“ASTM D4530”	“ISO 10370”	percent weight	0.05 maximum

(continued)

(Table 14, contd)

Caterpillar Specification for Biodiesel Fuel[1]				
Property	**Test Method**	**Test Method**	**Units**	**Limits**
	United States	**International**	**Specific Properties of Fuel**	
Cetane Number	“ASTM D613”	“ISO 5165”		45 minimum
Sulfated Ash	“ASTM D874”	“ISO 3987”	percent weight	0.02 maximum
Water/Sediment Content	“ASTM D2709”	“ISO 12937”	percent volume	0.05 maximum
Copper Corrosion	“ASTM D130”	“ISO 2160”		No. 1
Oxidation Stability	“EN 14112”	“EN 14112”	hours	3 minimum
Esterification	“EN 14103”	“EN 14103”	percent volume	97.5 minimum
Acid Value	“ASTM D664”	“EN 14104”	mg NaOH/g	0.5 maximum
Methanol Content	“EN 14110”	“EN 14110”	percent weight	0.2 maximum
Monoglycerides	“ASTM D6584”	“EN 14105”	percent weight	0.8 maximum
Diglycerides	“ASTM D6584”	“EN 14105”	percent weight	0.2 maximum
Triglycerides	“ASTM D6584”	“EN 14105”	percent weight	0.2 maximum
Free Glycerin	“ASTM D6584”	“EN 14105”	percent weight	0.02 maximum
Total Glycerin	“ASTM D6584”	“EN 14105”	percent weight	0.240 maximum
Phosphorus Content	“ASTM D4951”	“EN 14107”	percent weight	0.001
Calcium and Magnesium combined	“EN 14538”	“EN 14538”	ppm	5 maximum
Sodium and Potassium combined	“EN 14538”	“EN 14538”	ppm	5 maximum
Cold Soak Filterability	Annex A1 in “ASTM D6751”		seconds	360 maximum[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 for On-Highway Diesel Engines” table in this Special Publication, “Distillate Diesel Fuel” article.

(2) B100 intended for blending into diesel fuel that is expected to give satisfactory vehicle performance at fuel temperatures at or below −12° C (10.4° F) shall comply with a cold soak filterability limit of 200 seconds maximum. Passing this “ASTM D6751” 200 seconds Cold Soak Filterability test limit does not guarantee cold performance for all biodiesel blends at all possible fuel temperatures, but biodiesel that fails this Cold Soak Filterability test requirement will produce biodiesel blends that will likely plug fuel filters when fuel temperatures are below −12° C (10.4° F).

Referenced Documents

- “ASTM D6751 Standard Specification for Biodiesel Fuel Blend Stock (B100) for Middle Distillate Fuels”
- “EN 14214 Automotive fuels - Fatty acid methyl esters (FAME) for diesel engines - Requirements and test methods”
- “ASTM D7467 Standard Specification for Diesel Fuel Oil, Biodiesel Blend (B6 to B20)”
- “ASTM D975-08a Standard Specification for Diesel Fuel Oils” (includes requirements for B5 and lower biodiesel blends)
- “EN 590 Automotive fuels - Diesel - Requirements and test methods” (includes requirements for B5 and lower biodiesel blends)
- “EN 14078 Liquid petroleum products - Determination of fatty acid methyl esters (FAME) in middle distillates - Infrared spectroscopy method”
- “EN 14104 Fat and oil derivatives - Fatty Acid Methyl Esters (FAME) - Determination of Acid Value”
- “ASTM D664 Standard Test Method for Acid Number of Petroleum Products by Potentiometric Titration”
- “ASTM D6469 Standard Guide for Microbial Contamination in Fuels and Fuel Systems”

Cooling System Specifications

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General Coolant Information

SMCS Code: 1350; 1395

⚠ WARNING

The cooling system operates under pressure which is controlled by the radiator pressure cap. Removing the cap while the system is hot may allow the escape of hot coolant and steam, causing serious burns.

Before you remove the radiator cap, allow the system to cool. Use a thick cloth and turn the radiator cap slowly to the first stop to allow pressure to escape before fully removing the cap.

Avoid contact with coolant.

NOTICE
Every attempt is made to provide accurate, up-to-date information. By the use of this document, you agree that Caterpillar Inc. is not responsible for errors or omissions.

The information that is provided is the latest recommendations for the Cat diesel engines that are covered by this Special Publication. This information supersedes all previous recommendations which have been published for the Cat diesel engines that are covered by this Special Publication. Special fluids may be required for some engines. Continue to use these special products. Refer to the applicable Operation and Maintenance Manual.

This publication is a supplement to the Operation and Maintenance Manual. This publication does not replace the engine Operation and Maintenance Manual.

NOTICE
These recommendations are subject to change without notice. Consult your local Cat dealer for the most up to date recommendations.

NOTICE
In order to avoid potential damage to your Cat machine and/or Cat engine, only purchase Cat fluids and Cat filters through your Cat dealer or Cat authorized outlets. For a list of authorized Cat parts outlets in your area, consult your Cat dealer.

If you purchase what appear to be Cat fluids and/or Cat filters through other outlets/sources, you are at a very high risk of purchasing counterfeit ("look-alike") products.

Counterfeit or "look-alike" products may visually appear the same as the original Cat product, but the product performance and internal quality will typically be very low.

Counterfeit or "look-alike" products have a very high likelihood of causing and/or allowing engine and/or machine compartment damage.

NOTICE
Commercial products that make generic claims of meeting "Cat" requirements without listing the specific Cat recommendations and requirements that are met may not provide acceptable performance. Commercial products may cause reduced engine and/or machine fluid compartment life. Refer to this Special Publication and refer to product specific Operation and Maintenance Manual for Cat fluids recommendations and requirements.

NOTICE
Never add coolant to an overheated engine. Engine damage could result. Allow the engine to cool first.

NOTICE
If the engine is to be stored in, or shipped to an area with below freezing temperatures, the cooling system must be either protected to the lowest outside temperature or drained completely in order to prevent damage caused by freezing coolant.

NOTICE
Never operate an engine without water temperature regulators in the cooling system. Water temperature regulators help to maintain the engine coolant at the proper operating temperature. Cooling system problems can develop without water temperature regulators.

If you operate the engine without the regulator, some coolant bypasses the radiator. This may cause overheating.

Note: Refer to the specific engine Operation and Maintenance Manual, "Maintenance Interval Schedule" for the correct interval for the replacement of the thermostat.

Refer to Special Instruction, SEBD0518, “Know Your Cooling System” for more detailed information.

Many engine failures are related to the cooling system. The following problems are related to cooling system failures:

- Overheating
- Leakage of the water pump
- Plugged radiators or heat exchangers
- Pitting of the cylinder liners

These failures can be avoided with proper cooling system maintenance. Cooling system maintenance is as important as maintenance of the fuel system and the lubrication system. Quality of the coolant is as important as the quality of the fuel and the lubricating oil.

A coolant that is ready to use in the engine can also be referred to as “finished coolant”. A finished coolant is a coolant that has been diluted with appropriate amount of acceptable quality water.

Coolant is normally composed of the following elements:

- water
- additives
- glycol
- Embitterment: in coolants containing ethylene glycol to make the coolant taste bad.

Technical information for each of the coolant elements is provided in this Special Publication.

Water

NOTICE
Never use water alone as a coolant. Water alone is corrosive at engine operating temperatures. In addition, water alone does not provide adequate protection against boiling or freezing.

Note: In glycol-based coolants, Cat strongly recommends a minimum of 30 percent glycol in diesel engine cooling systems, with a minimum of 50 percent glycol recommended. Use only glycol-based coolants that meet one or more of the coolant specifications that are defined as preferred or acceptable in this Special Publication and that also comply with any additional requirements that are stated in this Special Publication (that is, chemical composition, the use of SCA, the use of Extender). Refer to the Operation and Maintenance Manual for your engine for any exceptions.

NOTICE
All Cat engines that are equipped with a Cat NOx Reduction System require a minimum of 50 percent glycol to help prevent cavitation damage and boiling of the engine coolant. These engines include Tier 4 engines.

Water in the water/glycol coolants is more effective than glycol alone in transferring heat.

Distilled water or deionized water is recommended to add to glycol or to water based coolants in engine cooling systems.

DO NOT use the following types of water in cooling systems: hard water, softened water that has been conditioned with salt and sea water.

If distilled water or deionized water is not available, use water that meets or exceeds the minimum acceptable water requirements that are listed in Table 15 .

Table 15

Cat Minimum Acceptable Water Requirements		
Property	**Maximum Limit**	**ASTM Test**
Chloride (Cl)	40 mg/L (2.4 grains/US gal)	“D4327”
Sulfate (SO_4)	100 mg/L (5.9 grains/US gal)	“D4327”
Total Hardness	170 mg/L (10 grains/US gal)	“D1126”
Total Solids	340 mg/L (20 grains/US gal)	“Federal Method 2540B”(1)
Acidity	pH of 5.5 to 9.0	“D1293”

(1) Total dissolved solids dried at 103° C (217° F) - 105° C (221° F), “Standard Method for the Examination of Water and Wastewater”, “American Public Health Association”, “www.apha.org”, “www.aphabookstore.org”, (888) 320-APHA.

For a water analysis, consult one of the following sources:

- Cat dealer
- Local water utility company
- Agricultural agent
- Independent laboratory

Periodic analysis of water that is used to add to the coolant is recommended. Water quality can be affected by various factors including malfunctioning purification equipment, earthquakes, and droughts.

Additives

Additives help to protect the metal surfaces of the cooling system and can improve coolant performance. A lack of coolant additives, insufficient amounts of additives, or improper additives for the application can cause the following conditions to occur:

- Corrosion
- Formation of mineral deposits
- Rust
- Scale
- Pitting and erosion from cavitation of the cylinder liner
- Foaming of the coolant

Many additives are depleted during engine operation. These additives must be replaced periodically. Additives that can be added:

- ELC Extender to Cat ELC (Extended Life Coolant)
- ELC Extender to Cat ELI (Extended Life Inhibitor)
- Cat SCA (Supplemental Coolant Additive) to Cat DEAC (Diesel Engine Antifreeze/Coolant)
- · Cat SCA to Cat SCA in water finished coolant

Additives must be added at the proper concentration. Overconcentration of additives can cause the inhibitors to drop out-of-solution. The deposits can enable the following problems to occur:

- Formation of gel compounds
- Reduction of heat transfer
- Leakage of the water pump seal
- Plugging of radiators, coolers, and small passages

Glycol

Glycol in the coolant helps to provide protection against the following conditions:

- Boiling
- Freezing
- Water pump cavitation (ATAAC equipped engines)

For optimum performance, Cat recommends a 50 percent by volume of glycol in the finished coolant (also referred to as 1:1 mixture).

Note: Use a mixture that will provide protection against the lowest ambient temperature.

Most conventional heavy-duty coolant/antifreezes use ethylene glycol. Propylene glycol may also be used. In a 50 percent by volume of glycol in the finished coolant, ethylene and propylene glycol provide similar protection against freezing and boiling. Refer to tables 16 and 17 .

Table 16

Ethylene Glycol Concentration		
Concentration	**Freeze Protection**	**Boil Protection** (1)
20 Percent	−8° C (18° F)	102° C (216° F)
50 Percent	−37 °C (−34 °F)	106 °C (223 °F)
60 Percent	−52 °C (−62 °F)	111 °C (232 °F)

(1) Boiling protection is increased with the use of a pressurized radiator.

Do not use propylene glycol in concentrations that exceed 50 percent glycol because of the reduced heat transfer capability. Use ethylene glycol in conditions that require additional protection against boiling or freezing. Do not use ethylene glycol in concentrations that exceed 60 percent glycol.

Table 17

Propylene Glycol Concentration		
Concentration	**Freeze Protection**	**Boil Protection** (1)
50 Percent	−32 °C (−26 °F)	106 °C (223 °F)

(1) Boiling protection is increased with the use of a pressurized radiator.

Propylene glycol coolant that is used in the cooling systems for Cat diesel engines must meet ASTM D6210-06, “Fully-Formulated Glycol-Based Engine Coolant for Heavy-Duty Engines”. When propylene glycol coolant is used in heavy-duty diesel engines, a regular addition of SCA is required for protection against liner cavitation. Consult your Cat dealer for additional information.

Ethylene or propylene glycols used in cooling systems for Cat diesel engines must meet ASTM E1177-06, “Standard Specification for Engine Coolant Grade Glycol”.

Testing the Concentration of Glycol

To check the concentration of glycol, use the 245 - 5829 Coolant/Battery Tester/Refractometer or 360-0774 refractometer. The tester can be used with ethylene or propylene glycol.

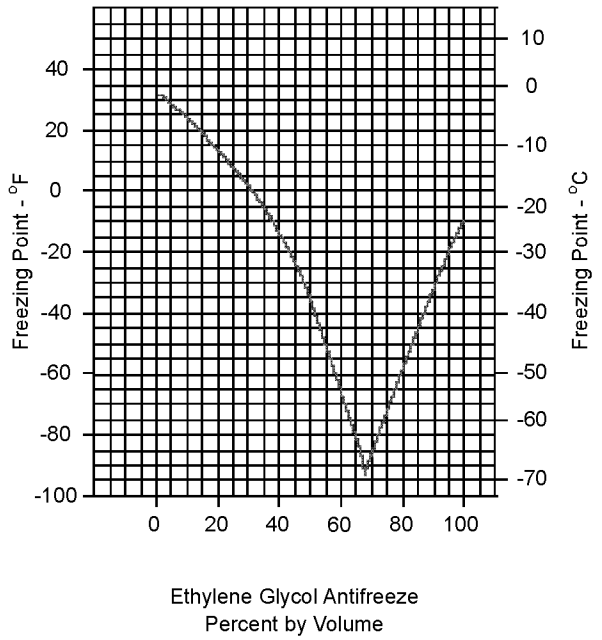

Illustration 3 g01189253

Approximate curve of the freezing point for a typical ethylene glycol solution.

Table 18

Freeze Protection for Antifreeze Concentrations[1]	
Protection to:	**Concentration**
−8° C (18° F)	20% glycol 80% water
−15 °C (5 °F)	30% glycol 70% water
−24 °C (−12 °F)	40% glycol 60% water
−37 °C (−34 °F)	50% glycol 50% water
−52 °C (−62 °F)	60% glycol 40% water

(1) Ethylene glycol-based antifreeze.

Alternative products that are used to protect from boiling or freezing of the engine coolant include:

- “1,3 propandiol” (PDO)
- glycerin
- mixtures of these alternative products with glycol

At the time of publication of this document, there currently exists no ASTM, “specifications” for coolants using these chemicals. **Until specifications are published and then evaluated by Cat, use of PDO and glycerin or glycerin/glycol coolants are not recommended in Cat cooling systems.**

Embitterment

Ethylene glycol is a toxic chemical with a naturally sweet taste. In order to avoid accidental excessive ingestion by humans or animals, coolants may contain embittering agents that make the coolant taste bad. **All Cat glycol containing coolants (Cat ELC, Cat DEAC, and Cat NGEC) are embittered.** Embittering agents have no beneficial or detrimental effect on coolant performance or characteristics.

Coolant Terminology

Extended Life Coolant (ELC) – A coolant that relies largely on organic inhibitors for corrosion and cavitation protection. Carboxylate is an example of organic corrosion and cavitation inhibitors. Cat ELC and Cat ELI in water are extended life coolants that also include nitrites and molybdates for increased cavitation protection.

- Commercial extended life coolants containing silicate do not meet the additional requirements set in this Special Publication for coolants claiming to meet Cat EC-1 specification.
- Do not use commercial extended life coolants with more than 125 ppm silicon (present in the coolant in the form of silicate)
- Extended life coolants that meet “ASTM D6210-06” may be used at the recommended maximum coolant service life intervals stated in this Special Publication for coolants that meet the ASTM specifications.

Conventional coolant – A coolant that relies largely on inorganic inhibitors for corrosion and cavitation protection. Silicates and nitrites are examples of inorganic inhibitors. Conventional coolants are also referred to as heavy-duty coolants, heavy-duty fully formulated coolants, or traditional coolants. In order to be used in most Cat cooling systems, conventional coolants must meet “ASTM D6210-06”. Cat DEAC and Cat SCA in water (also referred to as SCA/Water coolant) are conventional coolants

Supplemental Coolant Additive (SCA) – SCA is a general term for a concentrated inorganic inhibitor package. SCA is used for three different purposes:

- to precharge a new conventional coolant that is not fully Formulated. Cat DEAC is fully formulated and does not require SCA

- to provide corrosion protection in water/SCA cooling systems
- to recharge an in service conventional coolant on a maintenance basis to maintain proper inhibitor levels

Extender – An inhibitor package that is added to extended life coolants, to recharge an in-service coolant. Extenders, typically, only should be added at one half the service life of the coolant.

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Coolant Recommendations

SMCS Code: 1350; 1352; 1395

NOTICE
Do Not Mix Brands and/or Types of Products.

Mixing other products with Cat ELC reduces the effectiveness of the Cat ELC and shortens the Cat ELC service life. Use only Cat products or commercial products that have passed the Caterpillar EC-1 specification for premixed or concentrate coolants, and that have also passed the additional requirements for EC-1 as found in the coolant section of this Special Publication. Use only Cat ELC Extender with Cat ELC. Do NOT mix brands or types of coolants. Do NOT mix brands or types of SCA. Do NOT mix brands or types of extenders. Do NOT mix SCAs and extenders.

Failure to follow these recommendations can result in shortened cooling system component life.

NOTICE
Use Only Approved SCAs and Extenders.

Conventional coolants require the maintenance addition of SCA throughout their expected life. Do NOT use an SCA with a coolant unless specifically approved by the coolant supplier for use with their coolant. It is the responsibility of the coolant manufacturer to ensure compatibility and acceptable performance.

In order to ensure expected performance, EC-1 coolants require the one time maintenance addition of an extender at coolant service mid-life. Do NOT use an extender with a coolant unless the extender has been specifically approved for use by the coolant manufacturer for use with the coolant. It is the responsibility of the coolant manufacturer to ensure compatibility and acceptable performance.

Failure to follow these recommendations can result in shortened cooling system component life.

The following two types of coolants may be used in Cat diesel engines:

Preferred – Cat ELC (Extended Life Coolant) or a commercial extended life coolant that meets the Caterpillar EC-1 (Engine Coolant -1) specification.

Acceptable – Cat DEAC (Diesel Engine Antifreeze/ Coolant) or a commercial heavy-duty antifreeze/ coolant that meets “ASTM D4985-05” or “ASTM D6210-06” specifications

Chemical Requirements for New Coolant (50 volume % diluted)

Preferred Coolants – Cat ELC or EC-1

- Organic Additive Technology (OAT) based on a combination of a monocarboxylic acid and a dicarboxylic acid
- Phosphate, borate, and silicate free
- Minimum typical tolyltriazole level of 900 ppm
- Minimum typical nitrite level of 500 ppm
- Coolants that are prediluted at the coolant manufacturer must be diluted with water that meets Reagent 4 (“ASTM D1193”) requirements

Acceptable Coolants – Cat DEAC, “ASTM D6210-06”, or “ASTM D4985-05” (after the addition of the specification required SCA precharge)

- A minimum concentration of nitrite (as NO2-) of 1200 ppm
- A minimum silicon concentration of 100 ppm
- A maximum silicon concentration of 275 ppm
- Coolants that are prediluted at the coolant manufacturer must be diluted with water that meets Reagent 4 (“ASTM D1193”) requirements

Note: “ASTM D4985” and “ASTM D6210” require coolants that are properly dosed with SCA and that are in a properly maintained cooling system in normal service to be suitable for use for a minimum of one year (“ASTM D4985”) and 2 years (“ASTM D6210”). **The suitability for use requirement is the direct responsibility of the coolant manufacturer and SCA manufacturer.**

NOTICE
Do not use a commercial coolant/antifreeze that only meets the ASTM “D3306” specification. This type of coolant/antifreeze is made for light duty automotive applications.

Use only the coolant/antifreeze that is recommended.

Caterpillar recommends a 1:1 mixture of properly inhibited distilled or deionized water and glycol. This mixture will provide optimum heavy-duty performance as a coolant/antifreeze.

Note: Cat DEAC does not require a treatment with an SCA at the initial fill. However, a commercial heavy-duty coolant/antifreeze that only meets “ASTM D4985”, by specification, WILL require a treatment with an SCA at the initial fill. A commercial heavy-duty coolant/antifreeze that meets the “ASTM D6210” specification WILL NOT require a treatment with an SCA at the initial fill. Read the label or the instructions that are provided by the manufacturer of the commercial heavy-duty coolant/antifreeze.

Note: When adding SCA at initial fill to a coolant/antifreeze that only meets the “ASTM D4985”, ensure the SCA is compatible with the antifreeze/coolant. For example, a HOAT coolant that meets the “ASTM D4985” specification may not be compatible with an SCA designed for use with conventional coolants. It is the responsibility of the coolant manufacturer to provide sources of compatible SCAs. It is the responsibility of the coolant manufacturer and SCA manufacturer to demonstrate a positive influence on reducing cavitation corrosion in an operating diesel engine.

Note: These coolants WILL require a treatment with a supplemental coolant additive on a maintenance basis.

Note: When adding SCA at initial fill to a coolant/antifreeze that only meets the “ASTM D4985”, it is a collective responsibility of the user, coolant manufacturer, and SCA manufacturer to ensure the SCA is compatible with the antifreeze/coolant based on the recommendations provided by the coolant manufacturer and SCA manufacturer. One of the test methods required to be used to help ensure SCA compatibility with the antifreeze/coolant concentrate is “ASTM D5828-97”. 6% SCA in the solution that is 60 parts antifreeze/coolant of interest, 34 parts water, and 6 parts SCA must have no more than 0.1 mL of formed insolubles. 12% SCA in a solution that is 60 parts antifreeze/coolant of interest, 28 parts water, and 12 parts SCA must have no more than 2 mL of formed insolubles. The SCA manufacturer is responsible for ensuring their SCA is compatible with water meeting the “Caterpillar Minimum Acceptable Water Quality Requirements” as found in this Special Publication and as found in “ASTM D6210-06”, Table X1.1.

NOTICE
All Cat diesel engines equipped with air-to-air aftercooling (ATAAC) require a minimum of 30 percent glycol in order to help prevent water pump cavitation.

Note: Refer to the engine Operation and Maintenance Manual for exceptions.

Table 19

Service Life Before Flushing and Before Refilling	
Coolant	**Service Life(1)(2)(3)**
Cat ELC	965,606 kilometers (600,000 miles) 12000 hours 6 years(4)
Commercial coolant that meets the Caterpillar EC-1 specification	482,803 kilometers (300,000 miles) 6000 hours 6 years(5)
Cat DEAC	321,869 kilometers (200,000 miles) 3000 hours 3 years
Commercial Heavy-Duty Coolant/Antifreeze that meets “ASTM D4985” or “ASTM D6210”	241,402 kilometers (150,000 miles) 3000 hours 1 year

(1) Whichever comes first.
(2) Refer to the specific engine Operation and Maintenance Manual, “Maintenance Interval Schedule” for the service interval for the cooling system water temperature regulator.
(3) Cat truck engines with excessive idle time must reduce coolant drain intervals to one-half of the stated kilometers/miles recommendations, or base the coolant service life on the stated hours. Engine hours of operation are reported in the ECM (Electronic Control Module). Two examples in which engines may experience excessive idle time are engines that are normally operated in city pickup and delivery applications, and over the road truck applications in which the engines are kept running in order to provide heat and/or air conditioning while the driver sleeps. Refer to the Operation and Maintenance Manual for the specific engine for additional information.
(4) Cat ELC Extender must be added at 6000 service hours or one half of the service life of the Cat ELC.
(5) An extender must be added at 3000 service hours or one half of the service life of the coolant.

Note: These coolant change intervals are only achievable with annual S·O·S Services Level 2 coolant sampling and analysis.

Cat ELC, Cat DEAC, Cat Extender, and Cat SCA are available in several container sizes.

Table 20

Part Numbers of Coolant		
Description	**Size**	**Part Number(1)**
Cat DEAC (Concentrate)	Bulk	2P-9868 or 156-2649
	208.2 L (55 US gal)	8C-3686 238-8653(2)

(continued)

(Table 20, contd)

	3.8 L (1 US gal)	8C-3684 238-8651(2)
Cat ELC (50/50 Premix)	Bulk	156-2653
	208.2 L (55 US gal)	101-2845 238-8650(2)
	18.9 L (5 US gal)	129-2151 238-8649(2)
	3.8 L (1 US gal)	101-2844 238-8648(2)
Cat ELC (Concentrate)	3.8 L (1 US gal)	119-5150 238-8647(2)
Cat ELC Extender	0.946 L (1 qt) 3.8 L (1 US gal)	119-5152 210-0786

(1) The availability of part numbers will vary by the region. Consult your Caterpillar dealer.
(2) With embitterment. Embitterment makes the coolant taste bad. This is done in order to deter accidental human or animal ingestion of the coolant/antifreeze.

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Extended Life Coolant

SMCS Code: 1350; 1352; 1395

Caterpillar provides Cat ELC (Extended Life Coolant) for use in the following applications:

- Heavy-duty diesel engines
- Automotive applications

When Cat ELC is compared to conventional automotive and heavy-duty coolants, the Cat ELC anti-corrosion package is based on a totally different additive system. Cat ELC has been formulated with the correct amounts of additives in order to provide superior corrosion protection for all metals that are in engine cooling systems.

Cat ELC extends the service life of the coolant to 965,606 kilometers (600,000 miles), 12,000 service hours or six years. Cat ELC does not require the frequent addition of a SCA (Supplemental Coolant Additive). An Extender is the only additional maintenance that is needed at 482,803 kilometers (300,000 miles) or one half of the Cat ELC service life.

Cat ELC is available in a 1:1 premixed cooling solution with distilled water. The Premixed Cat ELC provides freeze protection to −37 °C (−34 °F). The Premixed Cat ELC is recommended for the initial fill of the cooling system. The Premixed Cat ELC is also recommended for topping off the cooling system.

Cat ELC Concentrate is also available. Cat ELC Concentrate can be used to lower the freezing point to −52 °C (−62 °F) for arctic conditions.

Containers of several sizes are available. Refer to this Special Publication, “Coolant Recommendations” article for available quantities and part numbers.

Note: Cat ELC can be used in most OEM engines of the following types: diesel and gasoline. Cat ELC meets the performance requirements of “ASTM D4985” and “ASTM D6210” for heavy-duty low silicate antifreeze/coolants. Cat ELC does not require treatment with a conventional SCA. Cat ELC also meets the performance requirements of “ASTM D3306” for automotive applications.

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Extended Life Coolant Cooling System Maintenance

SMCS Code: 1350; 1352; 1395

Proper Additions to the Cat ELC (Extended Life Coolant)

NOTICE
Use only Cat products or commercial products that have passed the Caterpillar EC-1 specification for pre-mixed or concentrated coolants.

Use only Cat ELC Extender with Cat ELC.

Do NOT use conventional SCA with Cat ELC. Mixing Cat ELC with conventional coolants and/or conventional SCA reduces the Cat ELC service life.

Do NOT mix brands or types of coolant. Do NOT mix brands or types of SCA and/or brands or types of extenders. Different brands or types may use different additive packages to meet the cooling system requirements. Different brands or types may not be compatible.

Do not mix brands or types of coolants with different brands or types of SCA or extender. Cat Extender is compatible with Cat ELC. If using non Cat EC-1 coolant, refer to the coolant manufacturer for information on a compatible extender.

Failure to follow the recommendations can reduce cooling system component life unless appropriate corrective action is performed.

In order to maintain the correct balance between the antifreeze and the additives, you must maintain the recommended concentration of ELC. Lowering the proportion of antifreeze lowers the proportion of additive. This will lower the ability of the coolant to protect the system from pitting, from cavitation, from erosion, and from deposits.

During daily maintenance, use the premixed Cat ELC as a cooling system top-off. This will bring the coolant up to the proper level. Check the specific gravity of the coolant system with the 245 - 5829 Coolant/ Battery Tester/Refractometer. This tester gives readings that are immediate and accurate in both degrees Celsius and degrees Fahrenheit. Use Cat ELC Concentrate to restore the proper glycol concentration in the coolant system. This should be done before the engine is exposed to freezing temperatures.

NOTICE
Do not use a conventional coolant to top-off a cooling system that is filled with Cat ELC.

Do not use conventional SCA. Only use Cat ELC Extender in cooling systems that are filled with Cat ELC.

Do not top-off the cooling system with water unless there is a specific need to adjust the water/glycol ratio. Compatible 50/50 (water/glycol) coolant is typically used and recommended when cooling system top-off is required.

Cat ELC Extender

Cat ELC Extender is added to the cooling system halfway through the ELC service life. Treat the cooling system with ELC Extender at 483 000 km (300,000 miles) or 3 years. Use Table 21 in order to determine the proper amount of ELC Extender that is required.

Containers of several sizes are available. Consult your Caterpillar dealer for the part numbers.

Table 21

Cat ELC Extender Additions by Cooling System Capacity	
Cooling System Capacity	**Addition of ELC Extender**
22 to 30 L (6 to 8 US gal)	0.57 L (20 fl oz)
31 to 38 L (9 to 10 US gal)	0.71 L (24 fl oz)
39 to 49 L (11 to 13 US gal)	0.95 L (32 fl oz)
50 to 64 L (14 to 17 US gal)	1.18 L (40 fl oz)
65 to 83 L (18 to 22 US gal)	1.60 L (54 fl oz)
84 to 114 L (23 to 30 US gal)	2.15 L (72 fl oz)
115 to 163 L (31 to 43 US gal)	3.00 L (100 fl oz)
164 to 242 L (44 to 64 US gal)	4.40 L (148 fl oz)

NOTICE
When using Cat ELC, do not use conventional SCAs, or, if equipped, SCA maintenance elements. In order to avoid SCA contamination of a Cat ELC system, remove the SCA element base and plug off or bypass the coolant lines.

Cat ELC Cooling System Cleaning

Note: If the cooling system is already using Cat ELC, cleaning agents are not required to be used at the specified coolant change interval. Cleaning agents are only required if the system has been contaminated by the addition of some other type of coolant or by cooling system damage.

Clean water is the only cleaning agent that is required when Cat ELC is drained from the cooling system.

After the cooling system is drained and after the cooling system is refilled, operate the engine while the cooling system filler cap is removed. Operate the engine until the coolant level reaches the normal operating temperature and until the coolant level stabilizes. As needed, add the coolant mixture in order to fill the system to the proper level.

A Level II coolant analysis by S·O·S Services is recommended after cooling system cleaning and refill in order to ensure proper additive levels are present and in order to ensure there are no excessive levels of physical contaminants and chemical contaminants.

Recycling Cat ELC

Cat ELC can be recycled into conventional coolants. The drained coolant mixture can be distilled in order to remove the ethylene glycol and the water. The ethylene glycol and the water can be reused. The distilled material does not contain the additives that are required to be classified as either Cat ELC or Cat DEAC. Consult your Caterpillar dealer for more information. Recycled coolants should meet “ASTM D6210-06”

Changing to Cat ELC

To change from heavy-duty coolant/antifreeze to the Cat ELC, perform the following steps:

NOTICE
Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the product. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids.

Refer to Special Publication, NENG2500, “Caterpillar Dealer Service Tool Catalog” and to Special Publication, PECJ0003, “Cat Shop Supplies and Tools” for tools and supplies suitable to collect and contain fluids on Caterpillar products.

Dispose of all fluids according to applicable regulations and mandates.

1. Drain the coolant into a suitable container.

2. Dispose of the coolant according to local regulations.

3. If equipped, remove the empty SCA maintenance element and remove the element base. Plug the coolant lines or bypass the coolant lines.

NOTICE
Do not leave an empty SCA maintenance element on a system that is filled with Cat ELC.

The element housing may corrode and leak causing an engine failure.

Remove the SCA element base and plug off or bypass the coolant lines.

4. Flush the system with clean water in order to remove any debris.

5. Use Cat cleaner for cooling systems in order to clean the system. Follow the instructions on the label. Consult your Caterpillar dealer to determine the appropriate cleaner type and to obtain the corresponding part number.

6. Drain the cleaner into a suitable container. Flush the cooling system with clean water.

Note: Deposits that remain in the system may be loosened and removed by the Cat ELC.

7. In systems with heavy deposits, it may be necessary to disconnect the hoses. Clean the deposits and debris from the hoses and the fittings. Install the hoses and tighten the hose fittings. Refer to Specifications, SENR3130, “Torque Specifications” for the proper torques. Pipe threads may also need to be cleaned and sealed. Seal the threads with 5P-3413 Pipe Sealant.

8. Fill the cooling system with clean water and operate the engine until the engine is warmed to 49 °C to 66 °C (120 °F to 151 °F).

NOTICE
Improper or incomplete rinsing of the cooling system can result in damage to copper and other metal components.

To avoid damage to the cooling system, make sure to completely flush the cooling system with clear water. Continue to flush the system until all signs of the cleaning agent are gone.

9. Drain the cooling system into a suitable container and flush the cooling system with clean water.

NOTICE
The cooling system cleaner must be thoroughly flushed from the cooling system. Cooling system cleaner that is left in the system will contaminate the coolant. The cleaner may also corrode the cooling system.

10. Repeat Steps 8 and 9 until the system is completely clean.

11. Fill the cooling system with the Cat ELC.

12. Operate the engine until the engine is warmed. While the engine is running, inspect the engine for leaks. Tighten hose clamps and connections in order to stop any leaks.

13. Attach the Special Publication, PMEP5027, “Label” to the cooling system filler for the engine in order to indicate the use of Cat ELC.

Note: Clean water is the only flushing agent that is required when Cat ELC is drained from the cooling system.

14. A Level II coolant analysis by S·O·S Services is recommended after changing over to Cat ELC in order to ensure proper additive levels are present and in order to ensure there are no excessive levels of physical and chemical contaminants

Cat ELC Cooling System Contamination

NOTICE
Mixing other products with Cat ELC reduces the effectiveness of the Cat ELC and shortens the Cat ELC service life. Use only Cat ELC Extender with Cat ELC. Failure to follow these recommendations can result in shortened cooling system component life.

Cat ELC cooling systems can withstand contamination to a maximum of ten percent of conventional heavy-duty coolant/antifreeze and/or SCA before the advantages of Cat ELC are reduced. If the contamination exceeds ten percent of the total system capacity; perform ONE of the following procedures:

- If the cooling system contamination is caused by cooling system damage, follow the procedures under the “Changing to Cat ELC” heading. Also follow the procedures under the “Changing to Cat ELC” heading if the engine has been operated since being contaminated with more than ten percent conventional heavy-duty coolant/ antifreeze and/or SCA. Certain types of cooling system contamination may require disassembly of the cooling system and manual cleaning of system components.
- If the cooling system is contaminated with more than ten percent conventional heavy-duty coolant/ antifreeze and/or SCA, but the engine has not been operated, drain the cooling system into a suitable container. Dispose of the coolant according to local regulations. Thoroughly flush the system with clean water. Fill the system with the Cat ELC.
- Maintain the system as a conventional DEAC (Diesel Engine Antifreeze/Coolant) or other conventional coolant. If the SCA concentration is less than three percent, treat the system with an SCA. Maintain a three to six percent SCA concentration in the coolant. Change the coolant at the interval that is recommended for Cat DEAC or at the interval that is recommended for the conventional commercial coolants.

NOTICE
Do Not Mix Brands and/or Types of Products.

Mixing other products with Cat ELC reduces the effectiveness of the Cat ELC and shortens the Cat ELC service life. Use only Cat products or commercial products that have passed the Caterpillar EC-1 specification for premixed or concentrate coolants, and that have also passed the additional requirements for EC-1 as found in the coolant section of this Special Publication. Use only Cat ELC Extender with Cat ELC. Do NOT mix brands or types of coolants. Do NOT mix brands or types of SCA. Do NOT mix brands or types of extenders. Do NOT mix SCAs and extenders.

Failure to follow these recommendations can result in shortened cooling system component life.

NOTICE
Use Only Approved SCAs and Extenders.

Conventional coolants require the maintenance addition of SCA throughout their expected life. Do NOT use an SCA with a coolant unless specifically approved by the coolant supplier for use with their coolant. It is the responsibility of the coolant manufacturer to ensure compatibility and acceptable performance.

In order to ensure expected performance, EC-1 coolants require the one time maintenance addition of an extender at coolant service mid-life. Do NOT use an extender with a coolant unless the extender has been specifically approved for use by the coolant manufacturer for use with the coolant. It is the responsibility of the coolant manufacturer to ensure compatibility and acceptable performance.

Failure to follow these recommendations can result in shortened cooling system component life.

Commercial Extended Life Coolant

NOTICE
Cat does not warrant the quality or performance of non-Cat fluids.

In order to be used in most Cat diesel engines cooling systems according to the service interval listed in this Special Publication for Commercial coolant that meets the Caterpillar EC-1 specification, the commercial extended life coolants must meet the following requirements:

- Caterpillar EC-1 specification
- The minimum performance requirements of the “ASTM D6210” specification
- The additional requirements that are stated in this Special Publication for EC-1 coolants

In Cat diesel engines, extended life coolant that does not meet both the Caterpillar EC-1 specification and the additional requirements that are stated in this Special Publication for EC-1 coolants cannot be used according to the service interval listed in this Special Publication for commercial coolant that meets the Caterpillar EC-1 specification. Follow the maintenance guide for the coolant from the supplier of the commercial extended life coolant. Use an extender that is recommended by the EC-1 coolant supplier at coolant in-service mid-life. Follow the Caterpillar guidelines for the quality of water and the specified coolant change interval

Coolants that pass all of the Caterpillar EC-1 specification requirements, and that complete the additional requirements stated in this Special Publication, have a recommended service life of 482,803 kilometers (300,000 miles), 6000 hours, or 6 years, which ever comes first.

Note: Coolants that meet the Caterpillar EC-1 specification requirements only meet the minimum Caterpillar requirements for extended life coolants.

Note: As they have not been tested against the Caterpillar EC-1 specification requirements, coolants that only claim to meet the performance requirements of the Caterpillar EC-1 specification may not meet all the minimum EC-1 specification requirements.

Note: The Caterpillar EC-1 specification describes the minimum requirements for extended life coolants.

NOTICE
Because of the ongoing commitment to improve engine performance and life, Caterpillar places the following additional requirements on EC-1 coolants that will be used in most Cat diesel engine cooling systems in order to ensure optimal protection:

- Organic Additive Technology (OAT) based on a combination of a monocarboxylic acid and a dicarboxylic acid

- Phosphate, borate and silicate free

- Minimum typical tolyltriazole level of 900 ppm for new coolants

- Minimum typical nitrite level of 500 ppm in new coolants

- The one time addition of an extender at in-service coolant mid-life in order to maintain the coolant nitrite level between 300 – 600 ppm

NOTICE
In order to be marketed as a product that meets Caterpillar EC-1, **all** Caterpillar EC-1 specification requirements must be met, including, but not limited to the following:

- Physical and Chemical Properties

- Compatibility Characteristics

- Bench Testing

- Field Testing (Including using the required radiator types, using the required minimum field test duration, using the required minimum number of diesel engines, and using the required Cat diesel engine models of the required minimum power rating.)

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Diesel Engine Antifreeze/ Coolant
(DEAC)

SMCS Code: 1350; 1352; 1395

Follow the maintenance information provided in this Special Publication, “Coolant and General Maintenance Recommendations”section.

Cat recommends using Cat DEAC (Diesel Engine Antifreeze/Coolant) for cooling systems that require a high performance conventional heavy-duty coolant/ antifreeze. Cat DEAC is alkaline single-phase ethylene glycol type antifreeze that contains corrosion inhibitors and antifoam agents.

Cat DEAC is formulated with the correct amount of Cat SCA (Supplemental Coolant Additive). Do not use Cat SCA at the initial fill when Cat DEAC is used at the recommended 50 percent by volume glycol or higher concentration with recommended water.

Containers of several sizes are available. Consult your Cat dealer for the part numbers.

If concentrated Cat DEAC is used, Caterpillar recommends mixing the concentrate with distilled water or with deionized water. If distilled water or deionized water is not available, use water which has the required properties. For the water properties, see this publication, “General Coolant Information”.

Note: Mix the concentrated Cat DEAC and water thoroughly prior to filling the cooling system.

SCA is added to cooling systems that use conventional coolants for one of three reasons:

- to precharge a new conventional coolant that is not fully Formulated. Cat DEAC is fully formulated and does not require SCA

- to provide corrosion protection in water/SCA cooling systems
- to recharge an in service conventional coolant on a maintenance basis to maintain proper inhibitor levels

Conventional coolants typically require SCA additions at approximately 250-300 service hours. The use of SCA helps to prevent the following conditions from occurring:

- Corrosion
- Formation of mineral deposits
- Cavitation erosion of the cylinder liners
- Foaming of the coolant

Containers of Cat SCA are available in several sizes. Refer to this Special Publication, “Conventional Coolant/Antifreeze Cooling System Maintenance” article for available quantities and part numbers.

Note: Do not exceed a 6 percent maximum concentration of SCA. Maintain a 3 to 6 percent SCA concentration in the coolant.

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Supplemental Coolant Additive

SMCS Code: 1350; 1352; 1395

Supplemental Coolant Additive (SCA) – SCA is a general term for an inhibitor package that is added to a cooling system. SCA is added for one of three reasons:

- to precharge a new coolant that is not fully formulated
- to provide corrosion protection in water/SCA cooling systems
- to recharge an in service conventional coolant on a maintenance basis to maintain proper inhibitor levels

Conventional coolants typically require SCA additions at approximately 250-300 service hours.

The use of SCA (supplemental coolant additive) helps to prevent the following conditions from occurring:

- Corrosion
- Formation of mineral deposits
- Cavitation erosion of the cylinder liners
- Foaming of the coolant

Cat DEAC (Diesel Engine Antifreeze/Coolant) is formulated with the correct level of Cat SCA. When the cooling system is initially filled with Cat DEAC, adding more Cat SCA is not necessary. To ensure that the correct amount of Cat SCA is in the cooling system, test the concentration on a scheduled basis. Testing the concentration of nitrites and silicates through the S·O·S analysis is the best indicator of the amount of SCA in the coolant.

Maintain a concentration level of nitrites in the cooling system that is between 1200 ppm (70grains/US gal) and 2400 ppm (140 grains/US gal). S·O·S coolant analysis is the preferred method to check SCA concentration. Alternatively, nitrite levels can be tested with the following tools:

- 4C-9301 nitrite level test strips, English instructions only, use with glycol-based coolants such as Cat DEAC
- 286-2578 nitrite level test strips, English, French, and Spanish instructions, use with glycol-based coolants such as Cat DEAC

For the maintenance schedule, refer to the Operation and Maintenance Manual, “Maintenance Interval Schedule” (Maintenance Section) of the specific engine.

Containers of Cat SCA are available in several sizes. Refer to this Special Publication, “Conventional Coolant/Antifreeze Cooling System Maintenance” article for available quantities and part numbers.

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Conventional Coolant/ Antifreeze Cooling System Maintenance

SMCS Code: 1350; 1352; 1395

NOTICE
Cat does not warrant the quality or performance of non-Cat fluids.

NOTICE
Do NOT mix brands or types of SCA. Do NOT mix SCAs and extenders.

Failure to follow the recommendations can result in shortened cooling system component life.

NOTICE
Use Only Approved SCAs. Conventional coolants require the maintenance addition of SCA throughout their expected life. Do NOT use an SCA with a coolant unless specifically approved by the coolant supplier for use with their coolant. It is the responsibility of the coolant manufacturer to ensure compatibility and acceptable performance.

Failure to follow the recommendations can result in shortened cooling system component life.

Note: Cat SCA is compatible with Cat DEAC. If you use non Cat-brand conventional coolants, consult with the coolant manufacturer for information on a compatible SCA.

Note: Do not top-off the cooling system with water unless there is a specific need to adjust the water/glycol ratio. Compatible 50/50 (water/glycol) coolant is typically used and recommended when cooling system top-off is required.

NOTICE
Never operate an engine without water temperature regulators in the cooling system. Water temperature regulators help to maintain the engine coolant at the proper operating temperature. Cooling system problems can develop without water temperature regulators.

Note: Refer to the specific engine Operation and Maintenance Manual, “Maintenance Interval Schedule” for the service interval for the cooling system water temperature regulator.

Check the coolant/antifreeze (glycol concentration) in order to ensure adequate protection against boiling or freezing. Caterpillar recommends the use of a refractometer for checking the glycol concentration. Use the 245-5829 Coolant/Battery Tester/Refractometer. The tester gives readings in both degrees Celsius and degrees Fahrenheit that are immediate and accurate. The tester can be used with ethylene or with propylene glycol.

Cat engine cooling systems should be tested at 20120 kilometers (12500 miles) to 24140 kilometers (15000 miles) intervals or at the PM Level 1 intervals for the concentration of Supplemental Coolant Additive (SCA). SCA test kits are available from your Caterpillar dealer. Test the concentration of SCA or submit a coolant sample to your Caterpillar dealer at 20120 kilometers (12500 miles) to 24140 kilometers (15000 miles) intervals or at the intervals for PM Level 1. Refer to this publication, “S·O·S Services Coolant Analysis” for more information on this topic.

Additions of SCA are based on the results of the test or based on the results of the coolant analysis. An SCA that is liquid or a maintenance element for an SCA (if equipped) may be needed at 20120 kilometers (12500 miles) to 24140 kilometers (15000 miles) intervals or at the intervals for PM Level 1.

Table 22 lists the amount of Cat SCA that is needed at the initial fill in order to treat coolant/antifreeze. These amounts of Cat SCA are for systems that use heavy-duty coolant/antifreeze.

Table 22 also lists additions of supplemental coolant additive for liquid and for maintenance elements at 20120 kilometer (12500 mile) intervals or at the intervals for PM Level 1. The additions are required for Cat DEAC (Diesel Engine Antifreeze/Coolant) and for commercial heavy-duty coolant/antifreeze.

Note: Acceptable conventional heavy-duty coolant/antifreeze of all types REQUIRE periodic additions of SCA.

Table 22

Caterpillar SCA Requirements for Heavy-Duty Coolant/Antifreeze				
Cooling System Capacity	**Initial Fill(1)**	**20120 kilometers (12500 miles) or Intervals for PM Level 1 (2)(3)**	**Spin-on Element at 20120 kilometers (12500 miles) or at Intervals for PM Level 1(2) (3)**	**Quantity of Elements**
22 to 30 L (6 to 8 US gal)	0.95 L (32 fl oz)	0.24 L (8 fl oz)	111-2370	1
31 to 38 L (9 to 10 US gal)	1.18 L (40 fl oz)	0.36 L (12 fl oz)	111-2369	1
39 to 49 L (11 to 13 US gal)	1.42 L (48 fl oz)	0.36 L (12 fl oz)	111-2369	1
50 to 64 L (14 to 17 US gal)	1.90 L (64 fl oz)	0.47 L (16 fl oz)	9N-3368	1
65 to 83 L (18 to 22 US gal)	2.37 L (80 fl oz)	0.60 L (20 fl oz)	111-2371	1
84 to 114 L (23 to 30 US gal)	3.32 L (112 fl oz)	0.95 L (32 fl oz)	9N-3718	1

(continued)

(Table 22, contd)

Caterpillar SCA Requirements for Heavy-Duty Coolant/Antifreeze				
Cooling System Capacity	**Initial Fill(1)**	**20120 kilometers (12500 miles) or Intervals for PM Level 1 (2)(3)**	**Spin-on Element at 20120 kilometers (12500 miles) or at Intervals for PM Level 1(2) (3)**	**Quantity of Elements**
115 to 163 L (31 to 43 US gal)	4.75 L (160 fl oz)	1.18 L (40 fl oz)	111-2371	2
164 to 242 L (44 to 64 US gal)	7.60 L (256 fl oz)	1.90 L (64 fl oz)	9N-3718	2

(1) When the coolant system is first filled, the SCA is not required to be used with Cat DEAC or with fully formulated coolants that meet the “ASTM D6210” specification.
(2) Do not exceed the six percent maximum concentration. Check the concentration of SCA with a SCA test kit, or check the concentration of SCA with Cat S·O·S coolant analysis.
(3) Do not use the maintenance element for the SCA and the liquid for the SCA at the same time.

Note: Specific engine applications may require maintenance practices to be periodically evaluated in order to properly maintain the engine's cooling system.

Refer to Table 22 and Table 23 for part numbers and for quantities of SCA maintenance elements and/or liquid SCA.

Table 23

Cat Liquid SCA(1)	
Part Number	**Size of Container**
6V-3542	0.24 L (8 oz)
8T-1589	0.47 L (16 oz)
3P-2044	0.94 L (32 oz)
217-0616	1 L (34 oz)
8C-3680	19 L (5.0 US gal)
217-0617	20 L (5.3 US gal)
5P-2907	208 L (55 US gal)
217-0618	208 L (55 US gal)

(1) The availability of part numbers will vary from one region to another region.

Cooling Systems with Larger Capacities

Adding the SCA to Conventional Coolant/Antifreeze at the Initial Fill

Note: When the coolant system is first filled, the SCA is not required to be used with Cat DEAC or with fully formulated coolants that meet the “ASTM D6210” specification.

Note: Do not exceed the six percent maximum concentration. Check the concentration of SCA with a SCA test kit, or check the concentration of SCA with Cat S·O·S coolant analysis.

Commercial heavy-duty coolant/antifreeze that meets only the “ASTM D4985” specification WILL require adding supplemental coolant additive at the initial fill. Read the label or the instructions that are provided by the manufacturer of the commercial heavy-duty coolant/antifreeze.

Use the equation that is in Table 24 as a guideline in order to aid in determining the amount of SCA that is required when the cooling system is initially filled with fluids that only meet the “ASTM D4985” specification.

Note: When adding SCA at initial fill to a coolant/antifreeze that only meets the “ASTM D4985”, ensure the SCA is compatible with the antifreeze/coolant. For example, a HOAT coolant that meets the “ASTM D4985” specification may not be compatible with an SCA designed for use with conventional coolants. It is the responsibility of the coolant manufacturer to provide sources of compatible SCAs. It is the responsibility of the coolant manufacturer and SCA manufacturer to demonstrate a positive influence on reducing cavitation corrosion in an operating diesel engine

Note: When adding SCA at initial fill to a coolant/antifreeze that only meets the “ASTM D4985”, it is a collective responsibility of the user, coolant manufacturer, and SCA manufacturer to ensure the SCA is compatible with the antifreeze/coolant based on the recommendations provided by the coolant manufacturer and SCA manufacturer. One of the test methods required to be used to help ensure SCA compatibility with the antifreeze/coolant concentrate is “ASTM D5828-97”. 6% SCA in the solution that is 60 parts antifreeze/coolant of interest, 34 parts water, and 6 parts SCA must have no more than 0.1 mL of formed insolubles. 12% SCA in a solution that is 60 parts antifreeze/coolant of interest, 28 parts water, and 12 parts SCA must have no more than 2 mL of formed insolubles. The SCA manufacturer is responsible for ensuring their SCA is compatible with water meeting the “Caterpillar Minimum Acceptable Water Quality Requirements” as found in this "Special Publication, and as found in “ASTM D6210-06”, Table X1.1.

Table 24

Equation for Adding the Cat SCA to Conventional Coolant/ Antifreeze at the Initial Fill
V × 0.045 = X
V is the total volume of the cooling system.
X is the amount of Cat SCA that is required.

Table 25 is an example for using the equation that is in Table 24 .

Table 25

Example of the Equation for Adding the Cat SCA to Conventional Coolant/Antifreeze at the Initial Fill		
Total Volume of the Cooling System (V)	**Multiplication Factor**	**Amount of Cat SCA that is Required (X)**
190 L (50 US gal)	× 0.045	8.5 L (2.3 US gal)

Adding the SCA to Conventional Coolant/Antifreeze for Maintenance

Conventional heavy-duty coolant/antifreeze of all types REQUIRE periodic additions of a supplemental coolant additive.

Test the coolant/antifreeze periodically for the concentration of SCA. For the interval, see the Operation and Maintenance Manual, “Maintenance Interval Schedule” for your engine. SCA test kits are available from your Caterpillar dealer. Test the concentration of SCA or submit a coolant sample to your Caterpillar dealer. See this Special Publication, “S·O·S Services Coolant Analysis” article.

Additions of SCA are based on the results of the test or based on the results of the coolant analysis. The size of the cooling system determines the amount of SCA that is needed.

Use the equation that is in Table 26 as a guideline in order to aid in determining the amount of SCA that is required, if necessary.

Table 26

Equation For Adding The Cat SCA To Conventional Coolant/ Antifreeze For Maintenance
V × 0.014 = X
V is the total volume of the cooling system.
X is the amount of Cat SCA that is required.

Table 27 is an example for using the equation that is in Table 26 .

Note: Specific engine applications may require maintenance practices to be periodically evaluated in order to properly maintain the engine's cooling system.

Table 27

Example Of The Equation For Adding The Cat SCA To Conventional Coolant/Antifreeze For Maintenance		
Total Volume of the Cooling System (V)	**Multiplication Factor**	**Amount of Cat SCA that is Required (X)**
190 L (50 US gal)	× 0.014	2.7 L (0.7 US gal)

Table 23 lists part numbers and the sizes of containers for Cat SCA that is available from your Caterpillar dealer.

Cleaning the System of Heavy-Duty Coolant/Antifreeze

Before Cat SCA can be effective, the cooling system must be free from rust, scale, and other deposits. Preventive cleaning helps avoid downtime caused by expensive out-of-service cleaning required for extremely dirty and neglected cooling systems.

Cat Cooling System Cleaners:

- Dissolves or depresses mineral scale, corrosion products, light oil contamination, and sludge.
- Cleans the cooling system after used coolant is drained or before the cooling system is filled with new coolant.
- Cleans the cooling system whenever the coolant is contaminated or whenever the coolant is foaming.

- The “Standard” version of the Cat Cooling System Cleaner cleans the cooling system while still in service
- Reduces downtime and cleaning costs.
- Avoid costly repairs from pitting and other internal problems caused by improper cooling system maintenance.
- Can be used with glycol-based antifreeze.
- For the recommended service interval, refer to the Operation and Maintenance Manual, “Maintenance Interval Schedule” for your engine.

Cat Standard Cooling System Cleaner is designed to clean the cooling system of harmful scale and corrosion without removing the engine from service. The cleaners, both “Standard” and “Quick Flush” can be used in all Cat engine cooling systems. Consult your Caterpillar dealer for part numbers.

Note: These cleaners must not be used in systems that have been neglected or that have heavy scale buildup. These systems require a stronger commercial solvent that is available from local distributors.

Follow label directions for proper usage.

Recycling Cat DEAC

Cat DEAC can be recycled. The drained coolant mixture can be distilled in order to remove the ethylene glycol and water. The ethylene glycol and the water can be reused. The distilled material does not contain the additives that are required to be classified as either Cat ELC or Cat DEAC. Consult your Caterpillar dealer for more information.

When recycled coolants are used, use only coolants that have been recycled from extended life, heavy-duty or automotive coolants that were originally manufactured from virgin ethylene or propylene glycol.

Recycled coolants should meet “ASTM D6210-06”.

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Commercial Heavy-Duty Coolant/Antifreeze and SCA (Supplemental Coolant Additive)

SMCS Code: 1350; 1352; 1395

NOTICE
Cat does not warrant the quality or performance of non-Cat fluids.

NOTICE
Do NOT mix brands or types of SCA. Do NOT mix SCAs and extenders.

Failure to follow the recommendations can result in shortened cooling system component life.

NOTICE
Use Only Approved SCAs. Conventional coolants require the maintenance addition of SCA throughout their expected life. Do NOT use an SCA with a coolant unless specifically approved by the coolant supplier for use with their coolant. It is the responsibility of the coolant manufacturer to ensure compatibility and acceptable performance.

Failure to follow the recommendations can result in shortened cooling system component life.

Follow the maintenance information provided in the “Coolant and General Maintenance Recommendations” section in this Special Publication.

Select a commercial diesel engine antifreeze coolant that meets all the requirements given in Table 28 . The table contains the requirements for coolant to meet the published service intervals.

The provided requirements are applicable to finished coolants and not for the concentrates. When concentrated coolant/antifreeze is mixed, Cat recommends mixing the concentrate with distilled water or with deionized water. If distilled water or deionized water is not available, water which has the required properties may be used. For the water properties, refer to this Special Publication, “General Coolant Information” article.

Coolant/antifreezes for heavy-duty applications that meet “ASTM D6210” do not require treatment with SCA at the initial fill. Use the recommended 1:1 or higher concentration with recommended water. Treatment with SCA is required on a maintenance basis.

The SCA manufacturer is responsible for ensuring the SCA is compatible with water meeting the “Caterpillar Minimum Acceptable Water Quality Requirements” as found in this Special Publication, and “ASTM D6210-08, Table X1.1”. The coolant manufacturer and the SCA manufacturer are responsible to ensure that the products will not cause cooling system harm.

Do not mix brands or types of coolants with different brands or types of SCA or extender.

If using non Cat coolants, refer to the coolant manufacturer for information on a compatible SCA.

Treat the compatible commercial coolant with 3 to 6 percent Cat SCA by volume. Maintain a 3 to 6 percent concentration level of SCA in the cooling system. For more information, refer to this Special Publication, “Conventional Coolant/Antifreeze Cooling System Maintenance” article.

Table 28

Technical Requirements for Commercial Diesel Engine Antifreeze Coolants	
Specifications	ASTM D6210-08
Additional Requirements	Silicon: 100 ppm minimum to 275 ppm maximum Nitrites: maintained at 1200ppm (70 grains/US gal) minimum to 2400 ppm (140 grains/US gal) maximum Cat SCA at 3 to 6 percent (if Cat SCA is added)
Maintenance	ASTM D6210-08 Add compatible SCA at maintenance intervals Clean and flush the cooling system at drain intervals

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S·O·S Services Coolant Analysis

SMCS Code: 1350; 1395; 7542

Testing the engine coolant is important to ensure that the engine is protected from internal cavitation and corrosion. The analysis also tests the ability of the coolant to protect the engine from boiling and freezing. S·O·S coolant analysis can be done at your Caterpillar dealer. Cat S·O·S coolant analysis is the best way to monitor the condition of your coolant and your cooling system. S·O·S coolant analysis is a program that is based on periodic samples.

NOTICE
The preferred method for obtaining a representative coolant sample is to draw a sample from a coolant sampling valve that is located at a point where coolant is flowing freely. Do not take samples from any cooling system drain valves.

If no suitable coolant sampling valve is available and the use of a vacuum sampling pump is required, do not use the same vacuum sampling pump for extracting oil samples that is used for extracting coolant samples. Do not draw a sample from the coolant overflow tank as it will not be representative of the coolant in the system.

A small residue of either type sample may remain in the pump and may cause a false positive analysis for the sample being taken.

Always use a separate pump for oil sampling and a separate pump for coolant sampling.

Failure to do so may cause a false analysis which could lead to customer and dealer concerns.

New Systems, Refilled Systems, and Converted Systems

Perform an S·O·S coolant analysis (Level 2) at the following maintenance intervals.

- Every Year
- Initial 500 service hours

Perform this analysis at the interval that occurs first for new systems, for refilled systems, or for converted systems that use Cat ELC (Extended Life Coolant) or use Cat DEAC (Diesel Engine Antifreeze/Coolant). This 500 hour check will also check for any residual cleaner that may have contaminated the system.

Recommended Interval for S·O·S Services Coolant Sample

Table 29

Recommended Interval		
Type of Coolant	**Level 1**	**Level 2**
Cat DEAC	Every 24140 kilometers (15000 miles)(1)(2)	Yearly(2) (3)
Cat ELC	Optional(3)	Yearly(3)

(1) This is also the recommended sampling interval for all commercial coolants that meet Cat EC-1 (Engine Coolant specification - 1)
(2) The recommended sampling interval for all other conventional heavy-duty coolant/antifreeze is 20120 kilometers (12500 miles).
(3) The Level 2 Coolant Analysis should be performed sooner if a problem is suspected or identified.

Note: Check the SCA (Supplemental Coolant Additive) of the conventional coolant at every oil change or at every 250 hours. Perform this check at the interval that occurs first.

S·O·S Services Coolant Analysis (Level 1)

A coolant analysis (Level 1) is a test of the properties of the coolant.

The following properties of the coolant are tested:

- Glycol concentration for freeze protection and boil protection
- Nitrite concentration
- pH
- Conductivity
- Visual analysis of color, appearance, foaming tendency, and observation of any visible contaminants such as precipitates, oil, or fuel
- Odor analysis

The results are reported, and appropriate recommendations are made.

S·O·S Services Coolant Analysis (Level 2)

A coolant analysis (Level 2) is a comprehensive chemical evaluation of the coolant. This analysis is also a check of the overall condition of the cooling system.

The S·O·S coolant analysis (Level 2) has the following features:

- Full coolant analysis (Level 1)
- Measurement of concentrations of all coolant corrosion and cavitation inhibitors
- Identification of metal corrosion and of contaminants
- Identification of buildup of the impurities that cause corrosion
- Identification of buildup of the impurities that cause scaling
- Determination of the possibility of electrolysis within the cooling system of the engine

The results are reported, and appropriate recommendations are made.

For more information on S·O·S coolant analysis, consult your Caterpillar dealer.

Reference Information Section

Reference Materials

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Frequently Asked Questions (Ultra Low Sulfur Diesel (ULSD) Fuel)

SMCS Code: 1000; 7000

NOTICE
Every attempt is made to provide accurate, up-to-date information. By the use of this document, you agree that Caterpillar Inc. is not responsible for errors or omissions.

1. What is ULSD and how is it different from Low Sulfur Diesel (LSD)?

The United States (U.S.) Environmental Protection Agency (EPA) defines Ultra-Low Sulfur Diesel (ULSD - S15) as a U.S. diesel fuel with a sulfur content not to exceed 15 parts per million (ppm) or 0.0015% by weight. Low Sulfur Diesel (LSD - S500) is defined as a U.S. diesel fuel with a sulfur content not to exceed 500 ppm or 0.05% by weight. The LSD fuel commonly available in North America normally does not exceed 350 ppm sulfur. Both ULSD and LSD should meet the fuel requirements outlined in “ASTM D975-07b”.

2. Why is the sulfur content of diesel fuel in the U.S. reduced to 15 ppm?

ULSD is required by U.S. EPA regulations for highway vehicles to ensure that these vehicles will meet emissions standards to improve air quality. In California, other properties of vehicular diesel fuel are also controlled to help reduce smog.

3. Can I use LSD fuel in model year (MY) 2007 or newer on-highway engines?

On-highway diesel engines built in 2007 and later model years (U.S. EPA 2007 certified) must operate with ULSD fuel to comply with U.S. EPA regulations. Using LSD fuel in MY2007 and newer diesel engines powering on-highway vehicles is illegal and punishable with civil penalties. Fuel sulfur above 15 ppm can reduce the efficiency and durability of the engine. The potential impact may include permanent damage to the emissions control systems, reduced fuel economy and more frequent regeneration events. Engine failures that result from improper fuel usage are not Caterpillar factory defects and the cost of repair is not covered by a Caterpillar warranty.

4. How do I know if I have a MY2007 on-highway engine?

Cat MY2007 Low Emission Engines can be identified with the following serial number prefixes:

- C15: SDP1–UP
- C13: LEE1–UP
- C9: C9S1–UP
- C7: C7S1–UP

Note: The truck chassis model year may or may not correspond to the engine emissions model year. In some cases, a MY2006 emissions engine may power a MY2007 chassis model.

The MY2007 engine is identified with specific labels that show the following:

- Serial Number
- 2007 Engine Emissions Label

Fuel labels incorporating the words “Ultra-Low Sulfur Diesel fuel” are attached by the truck manufacturer to the on-highway vehicle chassis at the following places:

- Near the fuel tank(s) filler neck
- Instrument panel (dashboard)

5. When will ULSD be available in the U.S. for MY2007 on-highway engines?

The timeline proposed by the U.S. EPA states that ULSD fuel is expected to be available at most retail locations by October 15, 2006.

Note: In the U.S., diesel fuel classified as LSD fuel may still be sold at some retail locations outside of California during the October 15, 2006 and December 1, 2006 time period.

a. State of Alaska

Fuel distributors in urban Alaska will follow the same transition schedule as the distributors in the rest of the U.S. for on-highway diesel fuel.

Alaska has received an extension of the on-highway fuel 15 ppm maximum fuel sulfur requirement for rural areas (those areas not served by the Federal Aid Highway System). The 15 ppm maximum sulfur content diesel fuel must be in retail facilities in the rural areas by December 1, 2010 for all of the following applications: highway, non-road, locomotive and marine diesel engines.

All diesel fuel in Alaska remains exempt from the dyeing requirements in the U.S. EPA highway and non-road final rules.

Source: U.S. EPA website: www.epa.gov

6. What are the Fuel Sulfur Regulations for Canada and Mexico?

a. Canada

Canada follows the same timeline and regulations as the U.S. where 15 ppm maximum sulfur fuel is available beginning October 15, 2006.

b. Mexico

The Mexican government has drafted a regulation requiring ULSD fuel in Mexico beginning in September 2008, but the regulation has not been finalized. This could change when the new low-emitting vehicles begin to travel between Mexico and its northern neighbors. If there is no change in the situation, MY2007 U.S. vehicles (U.S. EPA 2007 certified) that enter Mexico will need to fuel up in the U. S., and it is possible that some fuel supplied by U.S. refineries could be stored in Mexico near major metropolitan areas for use under private, contractual arrangements.

7. Can ULSD be used in engines that were built before 2007?

On-highway vehicles powered by MY2007 and newer low-emissions diesel engines (U.S. EPA 2007 certified) must use only ULSD fuel. Owners of MY2006 and older diesel engines may use ULSD or LSD fuel. In the U.S., only ULSD fuel will be available for on-highway use starting on December 1, 2010.

8. Should I be concerned with the lubricity of ULSD?

Diesel fuel lubricity is necessary to minimize wear on fuel pumps and injectors. ULSD fuel requires good lubricity and corrosion inhibitors in order to prevent unacceptable engine wear. In the U.S., as necessary, additives to increase lubricity and to inhibit corrosion will be added to ULSD fuel prior to its retail sale. With these additives, ULSD fuel is expected to perform as well as LSD fuel. All Cat electronic engines produced since MY2000 are qualified to run on ULSD fuel.

Note: Have the fuel supplier confirm that the ULSD fuel available meets all “ASTM D975-07b S15” requirements.

In North America, diesel fuel that is identified as “ASTM D975” Grade No. 2-D S15 or “ASTM D975” Grade No. 1-D S15 and meeting the “ASTM D975-07b” Thermal Stability Guideline X3.10.2.2 generally meet the “Caterpillar Specification for Distillate Diesel Fuel” requirements for ULSD fuel.



Illustration 4 g01367847

9. In the U.S., how do I know if I am purchasing ULSD or LSD fuel?

The U.S. EPA regulation concerning ULSD fuel requires that new labels be placed on every diesel dispenser in the U.S., excluding California, where LSD fuel is no longer available. The label should be located near the metering display showing how many gallons have been pumped into the diesel vehicle fuel tank. When the diesel fuel contains 15 ppm sulfur or less, the label will be titled “Ultra Low Sulfur Highway Diesel Fuel”. With LSD fuel, the label will be titled “Low Sulfur Highway Diesel Fuel”. Using LSD fuel in MY2007 and newer on-highway diesel engines (U.S. EPA 2007 certified) is illegal and punishable with civil penalties. In California, the state has mandated that ULSD be the only fuel available. Therefore, the U.S. EPA has exempted California from labeling fuel dispenser pumps.

In the U.S., beginning June 1, 2006, trucking companies that store and dispense their own diesel fuel must label their dispensers in accordance with the regulations. There are two labels required, depending on the sulfur content of the diesel fuel being dispensed. Refer to illustration 4 .

A dispensing facility may have 15 ppm or less sulfur fuel in the storage tank and the ULSD fuel label is not being displayed. When the inspector verifies that the diesel fuel meets the 15 ppm maximum fuel sulfur requirement, the label is usually attached to the pump.

The U.S. EPA is warning diesel retailers they face fines of over $32,000 a day if they fail to update the pump labels, and has recently begun sending out notices of violation to individual gas stations, as well as a January 9, 2007 general warning letter to fuel retailers and distributors.

Currently, a litmus paper or other testing devices are not available to inexpensively field test for fuel sulfur content less than 70 ppm.

Note: October 15, 2006 is the Federal Government mandated deadline for customer availability of ULSD.

Note: Purchase diesel fuel through a reputable source.

10. Will a special color or dye identify the ULSD fuel?

Due to the processing required to produce ULSD fuel, ULSD fuel color can vary widely from the traditional colorless to amber, to anything from a light toned green, yellow, orange, or pink. Under certain light conditions, the color may appear to be slightly fluorescent.

In the U.S., diesel fuel destined for off-highway use is required by law to be dyed red. Use of this red dyed fuel in on-highway applications is illegal. There are currently no regulations that require diesel fuel destined for on-highway use to be dyed.

There is no relationship between the 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, algae, bacteria, or other sources that can cause operational problems.

11. Is there a cost difference between ULSD and LSD?

ULSD fuel costs more to refine and distribute than LSD fuel. No one can predict with certainty the price of ULSD fuel at the pump. Many factors affect the consumer price of fuels, including the price of crude oil on the global market, geopolitical, weather, transportation and economic events, as well as supply and demand. Visit the U. S. Energy Information Administration web site at http://tonto.eia.doe.gov/oog/info/gdu/gasdiesel.asp for more information on fuel prices.

12. Does ULSD affect the fuel system seals?

Caterpillar has completed the review of the engine fuel system technology and the system compatibility with ULSD fuel for on and off-highway products. Electronically controlled (ECM) engines, manufactured after 2000 and that have been properly maintained, are compatible with fuel with less than 50 ppm sulfur content and comply with “ASTM D975” Grade No. 2-D S15 or “ASTM D975” Grade No. 1-D S15. Refer to this Special Publication, “Fuel Specifications” section for more information.

Earlier engines including those with mechanical fuel systems should be watched for external leaks. The belief is that only a small number of fuel system seals may be affected. Leaks that do develop are expected to typically be experienced as minor seepage, slobber, or drips. If a leak should develop, a possible correction is to tighten the joint and/or connection to the proper torque. If a leak is detected, please consult your Caterpillar dealer or authorized service center as soon as possible and schedule a repair. Whenever possible, use Viton seal material and hoses that are compatible with diesel fuel as your best protection against fuel system leaks.

Note: Fuel additives will not stop or will not prevent seal leaks, seepage, slobber, or drips that result from transitioning to ULSD fuel.

13. Can I use the current Cat fuel filters?

Yes, ULSD fuel is fully compatible with current fuel filter technology. ULSD fuel has a tendency to clean fuel tanks and other fuel system parts efficiently, which may cause fuel filter plugging during the initial transition period. More frequent fuel filter changes may be required during the transition period from LSD to ULSD fuel.

ULSD fuel typically has slightly higher wax content than LSD fuel. Have your fuel supplier confirm that the fuel is blended to flow at the ambient temperatures being experienced in your region. In the U.S., diesel fuels are typically blended to provide cold performance per the guidelines that are provided in “ASTM D975-07b”.

Caterpillar recommends a 10 micron(c) absolute primary fuel filter with a water separator and a 4 micron(c) absolute high-efficiency secondary fuel filter for all MY2006 and older on-highway diesel engines. Caterpillar requires the use of a 10 micron(c) absolute primary fuel filter with a water separator and a 4 micron(c) absolute high-efficiency secondary fuel filter for MY2007 and newer on-highway diesel engines.

14. Are aftermarket fuel additives recommended with ULSD?

There are many different types of fuel additives. 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 and cause 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 U.S. 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. For best results, your fuel supplier should treat the fuel when additives are needed. Refer to the answer to question 8 for more information. Also refer to this Special Publication, “Fuel Specifications” section, “Aftermarket Fuel Additives” and “Cat Diesel Fuel Conditioner” topics.

15. Can I use ULSD in the non-highway engines?

Yes, in the U.S., ULSD fuel meets the same specifications for lubricity and corrosion inhibitors as LSD fuel.

U.S. EPA fuel standards for locomotive, marine, and non-road diesel fuel engines and equipment, such as farm or construction equipment, will become effective at later dates than those for highway vehicles:

- Diesel fuel intended for locomotive, marine and non-road engines and equipment must meet the LSD fuel specification with maximum sulfur of 500 ppm in 2007.
- By December 1, 2010, the ULSD fuel sulfur standard of 15 ppm or less will apply to non-road diesel engines.
- Beginning in 2012, locomotive and marine diesel fuel must meet the ULSD fuel sulfur standard of 15 ppm or less.

16. Can biodiesel fuel be blended as ULSD?

Biodiesel can be blended as either LSD or as ULSD.

Note: The use of biodiesel fuels with MY2007 on-highway, low-emissions engines is currently under review.

For additional information, refer to the “Fuel Specifications” section, and to the “Biodiesel” article in this Special Publication.

The engine user has the responsibility of using the correct fuel that is recommended by the manufacturer and is allowed by the U.S. EPA and other appropriate regulatory agencies.

17. Is Cat ECF-3 (Engine Crankcase Fluid - 3) or API (American Petroleum Institute) CJ-4 diesel engine oil required for MY2007 on-highway diesel engines using ULSD fuel?

It is strongly recommended that Cat MY2007 and newer on-highway diesel engines use diesel engine oil that meets either the Cat ECF-3 specification or API CJ-4 oil category requirements. The Cat ECF-3 specification and the API CJ-4 oil category were developed in order to protect MY2007 and newer on-highway diesel engines that are designed to use fuels with 15 ppm or less sulfur. Oils that meet the Cat ECF-3 specification or API CJ-4 oil category are designed to protect emissions control systems, help comply with the emissions standards, reduce engine wear, and control piston deposits and oil consumption.

The Cat ECF-3 specification and the API CJ-4 oil category limits the sulfated ash to 1.0% or less, which helps maintain the expected Diesel Particulate Filter (DPF) performance. Use of oil that does not meet either Cat ECF-3 specification or API CJ-4 oil category may require more frequent DPF cleaning cycles and may contribute to DPF plugging.

Note: Oils that meet the API CJ-4 oil category requirements are Cat ECF-3 specification compliant.

Note: The combination of ULSD fuel and Cat ECF-3/ API CJ-4 compliant diesel engine oil is strongly recommended for optimum engine system performance.

Note: Oil change intervals are unaffected by the use of ULSD fuel and Cat ECF-3 or API CJ-4 oil. S·O·S Services oil analysis is always a recommended component of a sound engine maintenance program.

Note: Oil control is necessary to prevent the DPF from plugging. DO NOT overfill the engine crankcase or mix engine oil with diesel fuel.

Cat ECF-3 and API CJ-4 compliant oils are backward compatible and therefore can be used in MY2006 and older engines. Owners of MY2006 and older on-highway engines and MY2008 and older off-highway engines may continue to use oils that meet the Cat ECF-1-a and Cat ECF-2 specifications.

Note: The Cat ECF-1-a and Cat ECF-2 specifications replaced the Cat ECF-1 specification as of March 1, 2007. Consult your Caterpillar dealer for guidance.

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

In general, 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 U.S. EPA, state, and other appropriate regulatory agencies requirements.

Note: Blending lubricating oil with ULSD fuel may raise the sulfur level above 15 ppm.

Do **not** use diesel fuel that has been blended with lubricating oil in the following applications:

- MY2007 and newer on-highway diesel engines. Use of oil/fuel blends in MY2007 and newer on-highway diesel engines may cause engine damage
- Engines that are equipped with a DPF. Use of oil/fuel blends in DPF equipped diesel engines may cause the need for more frequent cleaning cycles, contribute to DPF plugging and may cause DPF damage.

The user 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 other appropriate 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 crankcase oil/fuel blends in any Cat engine that is regulated by emissions standards.

19. What about special fuels (JP-5, JP-8, Kerosene, Jet A)?

These fuels typically do not meet the U.S. EPA regulations for sulfur content of ULSD. The sulfur content for these fuels typically exceeds 15 ppm.

20. Does ULSD affect engine performance and fuel economy?

There is no measurable difference in performance and fuel economy for MY2007 heavy-duty engines. The slightly lower energy content of ULSD fuel is compensated by a slight increase in engine efficiency. The MY2007 midrange engines will show between 0% to 4% improvements in fuel economy.

Diesel fuel suppliers advise that the new ULSD fuel contains more wax, but will deliver 0% to 2% lower fuel economy (approximately 1% lower on average). How can this be?

Diesel engine operators/truckers often consider the waxes found in diesel fuel as delivering most of the fuel's energy. This is assumed because lighter fuels such as No. 1D and kerosene do not typically have winter wax problems and because No. 1D and kerosene give lower fuel economy.

During desulfurization, a percentage of the fuels aromatic and naphthenic components are converted to less dense paraffinic waxes. There is now more wax, but the density of the fuel is lower. The lower fuel density of ULSD results in less energy per gallon.

Refer to Special Publication, LEGT6380, “Understanding Tractor-Trailer Performance” for more information.

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

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

Note: ULSD has less electrical conductivity than LSD. Follow all industry standard grounding and safety practices.

Note: For applications where ULSD is required, have the fuel supplier confirm that the ULSD fuel available meets all “Caterpillar Specification for Distillate Diesel Fuel for On-Highway Diesel Engines” and/or the “ASTM D975-07b S15” requirements.

In North America, diesel fuel that is identified as “ASTM D975-07b” Grade No. 2-D S15 or Grade No. 1-D S15 and meeting the “ASTM D975-07b” Thermal Stability Guideline X3.10.2.2 generally meet the Caterpillar requirements for ULSD fuel. Refer to this Special Publication, “Fuel Specifications” section.

22. Does ULSD fuel require a different storage procedure?

No. When properly treated by the fuel supplier with a fuel stability additive, both LSD and ULSD fuel can typically be stored for up to one year. The same commonly used and approved storage tank maintenance practices used for LSD fuel should also be used with ULSD fuel. The storage tanks and containers commonly used with LSD fuel are suitable for ULSD fuel.

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Reference Material

SMCS Code: 1000; 7000

The following literature can be obtained through any Caterpillar dealer.

Note: The information that is contained in the listed publications is subject to changes without notice.

Note: Refer to this publication, the respective product data sheet and special publication, and the appropriate Operation and Maintenance Manual for product application recommendations.

Coolants

- Special Publication, PMEP5027, “Label - Cat ELC Radiator Label”
- Datasheet, PEHJ0067, “Cat ELC (Extended Life Coolant)” (Worldwide)
- Datasheet, PEHP9554, “Cat DEAC (Diesel Engine Antifreeze/Coolant) (Concentrate)”

Lubricants

- Datasheet, PEHJ0159, “Cat DEO-ULS (SAE15W-40)” (North America, Canada, Mexico, and United States)
- Datasheet, PEHJ0059, “Cat DEO (SAE 10W-30 and SAE 15W-40)” (North America, Canada, Mexico, and United States)
- Datasheet, PEHJ0021, “Cat DEO (SAE 10W-30 and SAE 15W-40)” (Worldwide except North America, Egypt, Saudi Arabia, and Brazil)
- Datasheet, PEHJ0072, “Cat DEO (SAE 10W-30 and SAE 15W-40)” (Brazil)
- Datasheet, PEHJ0091, “Cat DEO (SAE 10W-30 and SAE 15W-40)” (Egypt and Saudi Arabia)
- Datasheet, PEHP7062, “Cat DEO SYN (SAE 5W-40)”
- Datasheet, PEHJ0008, “Cat Arctic DEO (SAE 0W-30)” (Canada and United States)

Grease

- Special Publication, PEGJ0035, “Grease Selection Guide”
- Datasheet, PEHP0002, “Cat Advanced 3Moly Grease” (NLGI grade 2)
- Datasheet, NEHP6010, “Cat Ultra 5Moly Grease” (NLGI grades 1 and 2)
- Datasheet, NEHP6011, “Cat Arctic Platinum Grease” (NLGI grade 0)
- Datasheet, NEHP6012, “Cat Desert Gold Grease” (NLGI grade 2)
- Datasheet, NEHP6015, “Cat High Speed Ball Bearing Grease” (NLGI grade 2)
- Datasheet, PEHJ0088, “Cat Multipurpose Grease” (NLGI grade 2)

S·O·S Services

- Special Publication, PEHJ0191, “S·O·S Coolant Analysis”
- Special Publication, PEGJ0047, “How To Take A Good Oil Sample”
- Special Publications, PEDP7036, “S·O·S Fluids Analysis Cornerstone”
- Special Publications, PEHP7076, “Understanding S·O·S Services Tests”
- Special Publication, PEHP7052, “Making the Most of S·O·S Services”
- Special Publication, PEGJ0046, “Understanding Your S·O·S Services Results”

Filters

- Datasheet, PEHP7046, “Fuel Contamination Control”
- Datasheet, PEHJ0068, “Cat Advanced Efficiency Engine Oil Filter”
- Datasheet, PEHJ0165, “Open Crankcase Ventilation Filter”

Miscellaneous

- Special Publication, PECP9067, “One Safe Source”
- Special Publication, AECQ1042, “Caterpillar Product Line Brochure”
- Special Publication, PEWJ0074, “Cat Filter and Fluid Application Guide”
- Datasheet, PEHJ0030, “Cat Synthetic GO (SAE 75W-140)”
- Datasheet, PEHP7508, “Cat GO (SAE 80W-90 and SAE 85W-140)”
- Special Publication, NENG2500, “Caterpillar Dealer Service Tool Catalog”
- Special Publication, PECJ0003, “Cat Shop Supplies and Tools” catalog
- Special Publication, LEGT6380, “Understanding Tractor-Trailer Performance”
- Special Publication, SENR9620, “Improving Fuel System Durability” (Package of 10)

- Special Publication, SEBF1018, “Improving Component Durability - Engines” (Package of 10)
- Special Publication, SEBF1020, “Improving Component Durability - Managing Fluid Cleanliness” (Package of 10)
- “ASTM D6469 Standard Guide for Microbial Contamination in Fuels and Fuel Systems”

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Product Information

Model: _____

Product Identification Number: _____

Engine Serial Number: _____

Transmission Serial Number: _____

Generator Serial Number: _____

Attachment Serial Numbers: _____

Attachment Information: _____

Customer Equipment Number: _____

Dealer Equipment Number: _____

Dealer Information

Name: _____ Branch: _____

Address: _____

_____

_____

	Dealer Contact	Phone Number	Hours
Sales:	_____	_____	_____
Parts:	_____	_____	_____
Service:	_____	_____	_____

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