SEBU6250-19
February 2013

Caterpillar Machine Fluids Recommendations

Special Publication

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.

⚠ WARNING

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.

⚠ WARNING

When replacement parts are required for this product Caterpillar recommends using Cat replacement parts or parts with equivalent specifications including, but not limited to, physical dimensions, type, strength and material.

Failure to heed this warning can lead to premature failures, product damage, personal injury or death.

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.

Table of Contents

Foreword

Literature Information

This manual should be stored in the operator's compartment in the literature holder or seat back literature storage area.

The information contained in this document is the most current information available for coolant, fuels, and lubricants. Special lubricants are required for some machine compartments. Refer to the Operation and Maintenance Manual for your machine for any special lubrication requirements.

Whenever a question arises regarding the machine, 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 machine 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 warning signs used on the machine.

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

Maintenance

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

Maintenance Interval Schedule

Use the Maintenance Interval Schedule in the Operation and Maintenance Manual for your machine to determine servicing intervals. Calendar intervals shown (daily, weekly, monthly, etc.) can be used instead of service hour meter intervals if they provide more convenient servicing schedules and approximate the indicated service hour meter reading. Recommended service should always be performed at the interval that occurs first.

Under extremely severe, dusty or wet operating conditions, more frequent lubrication than is specified in the Maintenance Interval Schedule might 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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Lubricant Information

SMCS Code: 1000; 1300; 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 Cat diesel engines that are covered by this Special Publication. This information supersedes all previous recommendations which have been published for Cat diesel engines that are covered by this Special Publication. Special fluids are required for some engines. These fluids will still be necessary in those engines. 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.

Failure to follow the recommendations found in this Special Publication can cause engine failures, shortened engine service life, and reduced engine performance.

In order to avoid potential damage to your Cat 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. 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.

Many of the guidelines, recommendations, and requirements that are provided in this Special Publication are interrelated. Before using the provided information, The user is responsible to read this Special Publication and understand the information provided.

The user is responsible to follow all safety guidelines found in this Special Publication and in the engine 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 Cat dealer.

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

Use of fluids that do not meet at least the minimum performance recommendations and/or requirements may lead to lower compartment performance and/or compartment failure.

Problems/failures that are caused by using fluids that do not meet the minimum recommended and/or required performance level for the compartment are not warrantable by Caterpillar Inc. . The fluid manufacturer and customer are responsible.

When fluids made by other manufacturers are used on Cat products, the Cat warranty is not affected simply because of such use. Failures that result from the installation or usage of other manufacturer fluids, however, are not Cat factory defects and therefore are NOT covered by the Cat warranty. Cat is not in a position to evaluate the many fluids promoted by other manufacturers and the effect on Cat 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.

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.

The overall performance of engine and machine compartments is dependent on the choice of the lubricants and on the maintenance and cleanliness practices. The choices include filtration products, contamination control, tank management, and general handling practices. Cat designed and produced filtration products offer optimal performance and system protection.

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 or consult your Cat dealer for assistance with filtration recommendations for your Cat machine.

Note: In order to help ensure the maximum expected compartment performance and life, use a fluid that meets Cat highest level of fluid performance as described in this Special Publication for the compartment. Using a fluid that is considered an acceptable, but lower performing option for typical applications, will provide lower performance. (ex: Where fluids meeting either Cat ECF-1-a, Cat ECF-2 or Cat ECF-3 are offered as an option in typical applications, in order to help ensure the maximum expected engine compartment performance and life, oil meeting the Cat ECF-3 specification must be used.)

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.

Cat Fluids

Cat fluids have been developed and tested by Cat in order to increase the performance 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 in order 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 Cat dealers for service fills and as aftermarket products. Consult with your Cat dealer for more information on these Cat fluids.

Cat recommends the use of the following Cat fluids:

Table 1

Cat Lubricants		Viscosity Grade
Diesel Engine Oil-Ultra Low Sulfur (API CJ-4)	Cat DEO-ULS	SAE 15W-40
		SAE 10W-30

(continued)

(Table 1, contd)

Cat Lubricants		Viscosity Grade
	Cat DEO-ULS SYN	SAE 5W-40
	Cat DEO Cold Weather	SAE 0W-40
Diesel Engine Oil (API CI-4/API CI-4PLUS)	Cat DEO	SAE 15W-40
		SAE 10W-30
Multi Application Engine Oil	Cat MAEO Plus (Non-Cat mixed fleets)	SAE 10W-40
Special Application Engine Oil (API CF)	Cat SAEO (Specific applications only)	SAE 30
		SAE 40
Diesel Engine Oil (API CF)	Cat DEO (3600 engines only)	SAE 40
Pre Combustion Oil	Cat PCO	SAE 40
Transmission/Drive Train Oil	Cat TDTO	SAE 10W
		SAE 30
		SAE 50
	Cat TDTO-TMS	Multigrade
	Cat TDTO Cold Weather	SAE 0W-20
Automatic Transmission Fluid	Cat ATF-HD	Multigrade Synthetic
Final Drive and Axles Oil	Cat FDAO	SAE 60
	Cat FDAO SYN	Multigrade
Gear Oil	Cat GO	SAE 80W-90
		SAE 85W-140
	Cat Synthetic GO	SAE 75W-140
Hydraulic Oil	Cat HYDO Advanced	SAE 10W
		SAE 20W
		SAE 30
	Cat Bio HYDO Advanced (HEES)	ISO 46 Multigrade
Multipurpose Tractor Oil	Cat MTO	SAE 10W-30

Note: Additional Cat fluids may be available.

Table 2

Cat Grease products	
Grease	Cat Multipurpose Grease
	Cat Advanced 3Moly Grease
	Cat Ultra 5Moly Grease
	Cat Desert Gold Grease
	Cat Cold Weather Platinum Grease
	Cat High Speed Ball Bearing Grease
	Cat White Assembly Grease
	Cat Hammer Paste

Note: Cat fluids availability will vary by region.

This information applies to Cat machines. For more lubricant recommendations see the following Special Publications:

- Special Publication, SEBU6251, “Caterpillar Commercial Diesel Engine Fluid Recommendations”
- Special Publication, SEBU6385, “Caterpillar On-Highway Diesel Engine Fluids Recommendations”
- Special Publication, SEBU6400, “Caterpillar Gas Engine Fluids Recommendations”
- Special Publication, SEBU7003, “Caterpillar 3600 Series and C280 Series Diesel Engine Fluids Recommendations”

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

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

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Engine Oil
(Cat Machine Diesel Engines)

SMCS Code: 1348; 7581

Engine lubricants play multiple roles in engines. Appropriate lubricants offer the following:

- Provide lubrication to the moving components of the engine under a wide range of temperatures
- Keep the engine components clean and remove wear debris
- Remove heat from the lubricated components
- Neutralize acidic products due to combustion process
- Protect the engine from cavitation and foaming
- Protect the engine from corrosion and rust
- Control Oil Consumption
- Disperse/Solubilize Contaminants (Soot)
- Support the regulated engine emissions limits

Current lubricant formulations are more advanced and complex than previous formulations. Current lubricants are developed to support advanced engine technologies that have lower emissions while supporting the performance and durability of these engines.

High performance oils are produced and validated using industry standard tests, proprietary tests, field tests, and often prior experience with similar formulation. Cat high quality and high performance lubricants are validated based on these factors.

In order to provide optimal engine performance and life and comply with regulated emission reduction, use the recommended engine oil as provided in this special publication. Due to the significant variations in the quality and performance of commercially available oils, Cat recommends the use of Cat oils as detailed in this article.

Cat Diesel Engine Oils

Cat fluids have been developed and tested by Cat in order to provide the full performance and service life that has been designed and built into Cat engines. 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 in order 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 Cat dealers for service fills and as aftermarket products. Consult your Cat dealer for more information on these Cat fluids.

Cat recommends the use of the following lubricants in commercial engines covered by this Special Publication:

Table 3

Cat Lubricants		Viscosity Grade
Diesel Engine Oil-Ultra Low Sulfur (API CJ-4)	Cat DEO-ULS	SAE 15W-40
		SAE 10W-30
	Cat DEO-ULS SYN	SAE 5W-40
	Cat DEO Cold Weather	SAE 0W-40
Diesel Engine Oil (API CI-4/CI-4 PLUS and API CH-4)	Cat DEO	SAE 15W-40
		SAE 10W-30
Multi Application Engine Oil	Cat MAEO Plus (Non-Cat mixed fleets)	SAE 10W-40
Special Application Engine Oil	Cat SAEO (Specific applications only)	SAE 30
		SAE 40
Diesel Engine Oil	Cat DEO (3600 engines only)	SAE 40
Precombustion Chamber Oil	Cat PCO (Specific applications only)	SAE 40

Note: Additional Cat fluids may be available.

Note: Cat engine oils exceed the performance requirements of the respective API categories.

This information applies to Cat commercial engines. For more lubricant recommendations see the following Special Publications:

- Special Publication, SEBU6250, Caterpillar Machine Fluids Recommendations
- Special Publication, SEBU6385, Caterpillar On-Highway Diesel Engine Fluids Recommendations
- Special Publication, SEBU6400, Caterpillar Gas Engine Fluids Recommendations
- Special Publication, SEBU7003, Caterpillar 3600 Series and C280 Series Diesel Engine Fluids Recommendations

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

Note: The optimal application of the lubricants is dependent on the oil quality and the maintenance practices. Such practices include contamination control, tank management, and general handling practices.

Cat Diesel Engine Oils Recommendations

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.

Table 4

Cat Engine Lubricants Recommendations/Requirements		
	Non-Road Tier 4 Certified	Non-Road Pre Tier 4 Certified
Preferred	Cat DEO-ULS (API CJ-4)	Cat DEO-ULS (API CJ-4)
		Cat DEO (API CI-4/API CI-4 PLUS)
Commercial Lubricants	Cat ECF-3/API CJ-4	Cat ECF-3/API CJ-4, Cat ECF-2, Cat ECF-1-a

Note: API engine oil categories are backwards compatible. Cat DEO-ULS (API CJ-4) oil can be used in all engines with some restrictions related to fuel sulfur level, refer to Table 6 for more details. Cat DEO (API CI-4/API CI-4 PLUS) can be used in engines that are Tier 3 emissions certified and prior, and in engines that do not use aftertreatment devices.

Note: Each of the Cat ECF specifications 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. Refer to table 5 for details.

For nonroad Tier 4 United States Environmental Protection Agency (U.S. EPA) certified engines that are equipped with aftertreatment devices refer to the specific section of this chapter.

Table 5

Cat Engine Crankcase Fluids (ECF) Definitions	
Cat Minimum Performance Requirements for Commercial Oils	**Cat 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 Passing standard Cat C13 engine test per API requirements and Oils of sulfated ash > 1.50 percent are not allowed
Cat ECF-1-a	API CH-4 Oil Category performance requirements and For oils that are between 1.30 percent and 1.50 percent sulfated ash, passing one additional Cat 1P SCOTE test (ASTM D6681) is required and Oils of sulfated ash > 1.50 percent are not allowed

Cat DEO-ULS exceeds the limits of API CJ-4 standard tests. Cat DEO exceeds the limits of API CI-4/CI-4PLUS and API CH-4. Cat DEO-ULS and Cat DEO are rigorously tested with full-scale proprietary Cat engine tests to ensure optimal protection of Cat diesel engines. The tests include the following: sticking of the piston rings, piston deposits, oil control tests, wear tests and soot tests. Proprietary tests help ensure that Cat oils provide superior performance in Cat diesel engines.

There are significant variations in the quality and performance of commercially available oils.

For this reason, Cat recommends the Cat oils listed in Table 4 and the guidelines in Table 5 .

NOTICE

Do not use single grade API CF oils or multigrade API CF oils in Cat Series 3500, Series C175 and smaller Direct Injection (DI) diesel engines. Single grade API CF oils (or oils that meet all the performance requirements of API CF category) may only be used in Cat Series 3600 and Series C280 diesel engines, and older Cat engines that have precombustion chamber (PC) fuel systems. Oils that are used in Cat Series 3600 and Series C280 diesel engines must also pass a 7000 field performance evaluation. Consult your Cat dealer for details.

Cat DEO-ULS multigrade and Cat DEO multigrade oils are formulated with the correct amounts and chemistry of various additives including detergents, dispersants, antioxidants, alkalinity, antifoam, viscosity modifiers, and others in order to provide superior performance in Cat diesel engines where recommended for use.

Use appropriate lubricating oils that are compatible with the engine certification and aftertreatment system and with the fuel sulfur levels. Refer to the oil recommendations for Tier 4 engines in this chapter and to “Diesel Fuel Sulfur Impacts” article of this “Fuels Specifications” section and to the “Lubricants Specifications” section of this Special Publication.

Cat DEO-ULS and Cat DEO are multigrade oils. The viscosity grades of these Cat oils are SAE 10W-30, SAE 15W-40, and SAE 0W-40 as detailed in table 3 in this article. Multigrade oils provide the correct viscosity for a broad range of operating temperatures. Multigrade oils provide the appropriate oil film thickness for moving engine components.

Cat DEO-ULS multigrade and Cat DEO multigrade oils can be used in other manufacturer diesel engines and in gasoline engines. Refer to the engine manufacturer 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. Also refer to the datasheets for the product.

Consult your Cat 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 API oil categories: API CJ-4, API CI-4, API CI-4 PLUS, API CH-4, and API CF (or oils that claim the performance requirements of API CF category). Cat DEO-ULS multigrade is compatible for use in engines equipped with aftertreatment devices.

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 (or oils that claim the performance requirements of API CF category). The availability of Cat DEO multigrade exceeding the noted requirements will vary by region.

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. Refer to your engine manufacturer literature and requirements.

Note: API oil categories CG-4 and CF-4 are obsolete. The API (American Petroleum Institute) does not license these categories effective August 2009. Oils that claim API CG-4 and CF-4 are not recommended for Cat engines.

API oil category CF is obsolete. The API (American Petroleum Institute) does not license this category effective end of 2010. API does not validate the quality of API CF oils and does not allow the display of API symbol (also called API doughnut) with CF as highest claim on the oil container. Oils that claim the requirements of API CF can be used ONLY in Cat 3112 and Cat 3126 Marine Engines. Refer to the details given in the Marine engine section in this Special Publication.

Recommendation for Tier 4 Engines

Cat DEO-ULS or oils that meet the Cat ECF-3 specification and the API CJ-4 oil category are required for use in nonroad Tier 4 United States Environmental Protection Agency (U.S. EPA) certified engines that are equipped with aftertreatment devices.

Cat DEO-ULS or oils that meet the Cat ECF-3 specification and the API CJ-4 are required for use in the applications listed below. If oils meeting the Cat ECF-3 specification and the API CJ-4 specifications are not available, oils meeting ACEA E9 may be used. ACEA E9 oils meet the chemical limits designed to maintain aftertreatment device life. ACEA E9 oils are validated using some but not all ECF-3 and API CJ-4 standard engine performance tests. Consult your oil supplier when considering use of an oil that is not Cat ECF-3 or API CJ-4 qualified.

- Nonroad EU Stage IIIB and IV type-approved engines that are equipped with aftertreatment devices
- Nonroad Japan Step 4 approved engines that are equipped with aftertreatment devices

Refer to Table 4 for the order of preference of engine oils. Cat DEO-ULS and oils meeting the Cat ECF-3 specification and the API CJ-4 and ACEA E9 oil categories have the following chemical limits:

- 1 percent maximum sulfated ash
- 0.12 percent maximum phosphorous
- 0.4 percent maximum sulfur

The chemical limits were developed in order to maintain the expected aftertreatment devices life, performance, and service intervals. Use of oils other than Cat DEO-ULS or oils that do not meet the Cat ECF-3 specification and the API CJ-4 oil category (and/or ACEA E9 category for EU and Japan-specific applications listed above) in aftertreatment-equipped engines can negatively impact performance of the aftertreatment devices, can contribute to Diesel Particulate Filter (DPF) plugging and/or can cause the need for more frequent DPF ash service intervals. Refer to your engine-specific Operation and Maintenance Manual, and refer to your aftertreatment device documentation, if available, for additional guidance.

Typical aftertreatment systems include the following:

- Diesel Particulate Filters (DPF)
- Diesel Oxidation Catalysts (DOC)
- Selective Catalytic Reduction (SCR)
- Lean NOx Traps (LNT)

Other systems may apply.

Cat DEO-ULS and Cat DEO are recommended for all pre-Tier 4 engines that use Ultra Low Sulfur Diesel (ULSD) or Low Sulfur Diesel (LSD) fuels.

Cat DEO is recommended for engines using fuels of sulfur levels that exceed 0.1 0.2 percent (2000 ppm). Cat DEO-ULS may be used in these applications if an oil analysis program is followed. The oil change interval may be affected by the fuel sulfur level. Refer to Table 6 in this section of this Special Publication.

Note: For on-Highway engines fluids recommendations, refer to the Operation and Maintenance Manual of your engine and also refer to the most current revision level of Special Publication, SEBU6385, Caterpillar On-Highway Diesel Engine Fluids Recommendations or consult your Cat dealer.

Ultra Low Sulfur Diesel (ULSD) fuel 0.0015 percent (≤15 ppm (mg/kg)) sulfur is required by regulation for use in engines certified to nonroad Tier 4 standards (U.S. EPA Tier 4 certified). ULSD must also be used in engines equipped with exhaust aftertreatment systems.

European ULSD 0.0010 percent (≤10ppm (mg/kg)) sulfur fuel is required by regulation for use in engines certified to European nonroad Stage IIIB and newer standards. European ULSD must also be used in engines equipped with exhaust aftertreatment systems.

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

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

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 IV/ Stage 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.

Commercial Oils

Commercial Crankcase Fluid Recommendations for all Current and Noncurrent Cat Diesel Engines that are covered by this Special Publication

Note: Non-Cat 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.

Cat developed the Engine Crankcase Fluid (ECF) specifications to ensure the availability of high performance commercial diesel engine oils.

There are three current Cat ECF specifications: Cat ECF-1-a, Cat ECF-2 and Cat ECF-3. 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. Refer to table 5 for details.

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

Note: The Cat ECF-3 specification was released in October 2006.

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

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

Note: Cat DEO and DEO-ULS are required to pass proprietary full-scale diesel engine testing. The testing is above and beyond the testing required by the various Cat ECF specifications and by the various API oil categories that are also met. 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 multigrade or DEO-ULS multigrade oils are not used, use only commercial oils that meet the recommendations and requirements stated below:

When the recommended Cat DEO-ULS and Cat DEO diesel engine oils are not used, commercial oils that meet the requirements of the Cat ECF-1-a, Cat ECF-2, and/or the Cat ECF-3 specification are acceptable, but second choice, for use in Cat diesel engines that are covered by this Special Publication.

Cat DEO-ULS or oils that meet the Cat ECF-3 specification and the API CJ-4 oil category are required for use in nonroad Tier 4 United States Environmental Protection Agency (U.S. EPA) certified engines that are equipped with aftertreatment devices.

Note: For engines that are Tier 4 EPA certified, refer to the Recommendations for Tier 4 Engines article in this Engine Oil section.

For engines using fuels of sulfur levels that exceed 0.2 percent (2000 ppm), Cat recommends Cat DEO. However, commercial oils that meet Cat ECF-2 or Cat ECF-1-a specifications are acceptable. Commercial oils that meet Cat ECF-3 specifications may be used in these applications if an oil analysis program is followed. The oil change interval is affected by the fuel sulfur level. Refer to Table 6 in this section of this Special Publication.

Note: For on-Highway engines fluids recommendations, refer to the Operation and Maintenance Manual of your engine and also refer to the most current revision level of Special Publication, SEBU6385, Caterpillar On-Highway Diesel Engine Fluids Recommendations or consult your Cat dealer.

Note: 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 “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.

NOTICE
Do not use single grade API CF oils or multigrade API CF oils in Cat Series 3500, Series C175 and smaller Direct Injection (DI) diesel engines. Single grade API CF oils (or oils that meet all the performance requirements of API CF category) may only be used in Cat Series 3600 and Series C280 diesel engines, and older Cat engines that have precombustion chamber (PC) fuel systems. Oils that are used in Cat Series 3600 and Series C280 diesel engines must also pass a 7000 field performance evaluation. Consult your Cat dealer for details.

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 IV/ Stage 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.

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

The use of Cat S·O·S Services oil analysis is recommended for determining oil life.

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

The minimum required Total Base Number (TBN) for oil depends on the fuel sulfur level. For direct injection engines that use distillate fuel, the following guidelines apply:

Table 6

TBN recommendations for applications in Cat engines		
Fuel Sulfur Level percent (ppm)	Cat Engine Oils (1)	TBN of Commercial Engine Oils
0.05 percent (500ppm)	Cat DEO-ULS Cat DEO	Min 7
>0.05-0.2 percent (>500- 2000 ppm) (2)	Cat DEO Cat DEO-ULS	Min 10
Above 0.2 percent (above 2000ppm) (3) (4)	Cat DEO (5)	Min 10

(1) Cat DEO-ULS applies to Cat DEO-ULS SAE 15W-40, SAE10W-30, Cat DEO-ULS SYN SAE 5W-40 and Cat DEO Cold Weather SAE 0W-40. Cat DEO applies to Cat DEO SAE 15W-40 and SAE 10W-30.
(2) Use of an oil analysis program to determine oil drain intervals is recommended if fuel sulfur is between 0.05% (500 ppm) and 0.5% (5000 ppm).
(3) Use of an oil analysis program to determine oil drain intervals is required if fuel sulfur is above 0.5% (5000 ppm).
(4) For fuels of sulfur levels that exceed 1.0 percent (10,000 ppm), refer to TBN and engine oil guidelines given in this section.
(5) Cat DEO-ULS may be used if an oil analysis program is followed. High fuel sulfur levels may reduce the oil drain intervals.

Note: For regions in the world where fuels of high sulfur that exceed 1.0 percent (10,000 ppm (mg/kg)) are available and allowed for use by law, use the following guidelines:

- Choose multigrade oil with the highest TBN that meets one of these specifications: Cat ECF-1-a, Cat ECF-2, or Cat ECF-3.
- Reduce the oil change interval. Base the oil change interval on the oil analysis. Ensure that the oil analysis includes the condition of the oil and a wear metal analysis. Cat S·O·S Services oil analysis is required.

TBN testing is an optional part of the S·O·S Services oil analysis program. TBN testing may be done in addition to the standard S·O·S Services tests for oil deterioration. In most applications, the S·O·S Services tests for oxidation, sulfation, viscosity, and wear will identify oil deterioration.

TBN of the oil is typically measured using ASTM D2896 and/or ASTM D4739 test methods. Both methods can be used to measure the TBN of used oils. However, ASTM D4739 is the preferred method for used oils.

- Consider changing the oil if the ASTM D2896 test result reaches 4 TBN. Look for other signs of oil deterioration, or abnormal wear to verify the need to change oil.
- Consider changing the oil if the ASTM D4739 test result reaches 3 TBN. Look for other signs of oil deterioration, or abnormal wear to verify the need to change oil.
- Be aware that both of these test methods have variability of approximately ±1 TBN. Care should be taken when analyzing the results of the TBN test. Consult a trained S·O·S Services analyst when making oil drain decisions based on oil sample results.

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

In order to help protect your engine, and in order to help optimize oil drain intervals for engine applications and duty cycles, use Cat S·O·S Services oil analysis as follows:

- Recommended normally
- Very strongly recommended in order to determine oil drain intervals when operating on fuel with sulfur levels between 0.05% (500 ppm) and 0.5% (5000 ppm)
- Required in order to determine oil drain intervals when operating on fuel with sulfur levels that are above 0.5% (5000 ppm)

Note: Engine operating conditions play a key role in determining the effect that fuel sulfur will have on engine deposits and on engine wear. Consult your Cat dealer for guidance when fuel sulfur levels are above 0.1% (1000 ppm).

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.

There are many factors that contribute to rapid TBN depletion, a not all inclusive list follows:

- High sulfur fuel (The more fuel sulfur, the more rapid the TBN depletion.)
- Faulty engine coolant regulators
- Light loads
- Short operation cycles
- Excessive idling
- Operating in applications where normal operating temperature is seldom reached
- High humidity (allowing excessive condensation)

Note bullets 2 through 7 directly above can contribute to excessive water in the crankcase oil. The water combines with available sulfur to form sulfuric acid, neutralizing this and other acids that are formed contribute to rapid TBN depletion.

NOTICE
Depending on application severity and localized environmental conditions, and also depending on maintenance practices, operating Direct Injection (DI) diesel engines and operating PC (Precombustion Chamber) diesel engines on fuel with sulfur levels over 0.1 percent (1000 ppm) may require significantly shortened oil change intervals in order to help maintain adequate wear protection. Refer to this Special Publication, “Fuel Specifications” section, “Diesel Fuel Sulfur” topic for additional information.

Note: For PC (Precombustion Chamber) diesel engines, which are mainly 1990 and older engines, the minimum new oil TBN must be 20 times the fuel sulfur level. The diesel engine oil types, specifications, and viscosity grades recommendations provided for DI diesel engines in this Special Publication are also applicable to PC diesel engines. For additional fluids information related to PC diesel engines, refer to the most current revision level of Caterpillar Commercial Diesel Engine Fluids Recommendations, SEBU6251.

Note: DO NOT USE ONLY THIS SPECIAL PUBLICATION AS A BASIS FOR DETERMINING OIL DRAIN INTERVALS.

This Special Publication does not address recommended oil drain intervals, but rather provides guidance that should be used with your specific engine/machine Operation and Maintenance Manuals in determining acceptable oil drain intervals. Consult your engine/machine Operation and Maintenance Manuals, and consult your Cat dealer for additional guidance, including but not limited to guidance on establishing optimized and/or acceptable oil drain intervals.

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Hydraulic Oil

SMCS Code: 5095; 7581

Applications

- Hydraulic Systems
- Hydrostatic Transmissions

Caterpillar has developed a new class of hydraulic oils, the HYDO Advanced fluids. These new advanced fluids are designed for optimal performance in new advanced hydraulic systems that are designed with close tolerances for precise operation and that operate under demanding conditions of temperatures and pressures. These fluids ensure optimal performance in current and previous hydraulic systems. Four new products have been introduced:

- HYDO Advanced 10 , SAE 10W
- HYDO Advanced 20 , SAE 20W
- HYDO Advanced 30 , SAE 30
- Bio HYDO Advanced , Multigrade

Cat HYDO Advanced Hydraulic Oils, SAE 10W, SAE 20W, and SAE 30

Cat HYDO Advanced hydraulic oils are designed to provide extended oil drain intervals and to provide extra protection to Cat hydraulic system components and hydrostatic transmissions.

Cat HYDO Advanced hydraulic oils are formulated of premium additives and premium base stocks that pass severe qualification testing requirements, in the field and in the laboratory, in order to provide superior protection for Cat hydraulic systems.

Cat HYDO Advanced hydraulic oils are preferred in most hydraulic systems and in most hydrostatic systems for the following ambient operating temperature ranges:

- Cat HYDO Advanced 10 range: −20° C (−4° F) min to 40° C (104° F) max
- Cat HYDO Advanced 20 range: −5° C (23° F) min to 45° C (113° F) max
- Cat HYDO Advanced 30 range: 10° C (50° F) min to 50° C (122° F) max

Cat HYDO Advanced oils have a 50% increase in the standard oil drain interval for machine hydraulic systems (3000 hours versus 2000 hours) over second and third choice oils - when following the maintenance interval schedule for oil filter changes and for oil sampling that is stated in the Operation and Maintenance Manual for your particular machine. 6000 hour oil drain intervals are possible with Cat HYDO Advanced oils when using S·O·S Services oil analysis. Consult your Caterpillar dealer for details.

Cat HYDO Advanced hydraulic oils offer the following benefits:

- Enhanced anti wear protection: protect wear surfaces and reduce component wear in various hydraulic pumps.
- Protection against rusting and corrosive wear.
- Dispersion of water prevents pump damage due to water ingestion and prevents system damage due to freezing of water.
- 250% increase in oxidation stability per ASTM D943.
- Rapid air release protects against cavitation.
- Improved filtration properties helps support component cleanliness.

Cat HYDO Advanced hydraulic oils should be used to achieve maximum life and maximum performance from hydraulic system components and from hydrostatic transmissions. In order to gain the most benefit from the improved performance designed into Cat HYDO Advanced oils, when switching to Cat HYDO Advanced oils, cross contamination with the previous hydraulic oil should be kept to less than 10%.

If a different viscosity is required due to ambient temperatures, the following Caterpillar oils can be used:

- Cat DEO-ULS and Cat DEO
- Cat DEO-ULS SYN and Cat DEO SYN
- Cat DEO Cold Weather
- Cat TDTO
- Cat TDTO Cold Weather
- Cat TDTO-TMS
- Cat MTO

Note: Caterpillar oil availability will vary by region.

For applications requiring the use of fire resistant hydraulic fluids, Caterpillar recommends the use of EcoSafe FR-46 . This product is a fully synthetic, non-aqueous hydraulic fluid. Water based and glycol based hydraulic products are not recommended for use in Cat machine hydraulic systems. EcoSafe FR-46 is an ISO 46 multi-grade product. For more information refer to the product information provided by the manufacturer of EcoSafe hydraulic oil. Refer to your Cat dealer for availability.

Cat Bio HYDO Advanced (Hydraulic Oil)

Cat Bio HYDO Advanced is biodegradable non-toxic hydraulic oil that is recommended for use in hydraulic systems when environmental compliance is required or desired. Cat Bio HYDO Advanced has a renewable content that exceeds 90% and complies with the European Eco-Label . Consult Federal, state, or local authorities for guidance on hydraulic oils environmental requirements in your area.

Cat Bio HYDO Advanced is formulated with premium additives and synthetic biodegradable base oil that pass severe qualification testing requirements in order to provide superior protection for Cat hydraulic systems and hydrostatic transmissions.

Cat Bio HYDO Advanced increases the standard oil drain interval for machine hydraulic systems (3000 hours versus 2000 hours) over second and third choice oils. Follow the maintenance interval schedule for oil filter changes and for oil sampling that is stated in the Operation and Maintenance Manual for your particular machine.

Cat Bio HYDO Advanced performs similar to Cat HYDO Advanced 10 and offers the following benefits: superior protection against mechanical wear, foaming and corrosion in hydraulic systems and in hydrostatic transmissions. This oil should be used to achieve maximum life and maximum performance from hydraulic system components and from hydrostatic transmissions. Cat Bio HYDO Advanced is preferred in most hydraulic systems and in most hydrostatic systems when ambient temperature is between −30° C (−22° F) and 45° C (113° F). Consult your Caterpillar dealer for details.

In order to gain the most benefit from the improved performance designed into Cat Bio HYDO Advanced oils, when switching to Cat Bio HYDO Advanced oils, cross contamination with the previous hydraulic oil should be kept to less than 3%. Flushing of the hydraulic system is recommended in order to reduce the cross contamination.

Cat Bio HYDO Advanced can be used in hydraulic systems of other Original Equipment Manufacturers (OEM). Refer to your manufacturer requirements for application details.

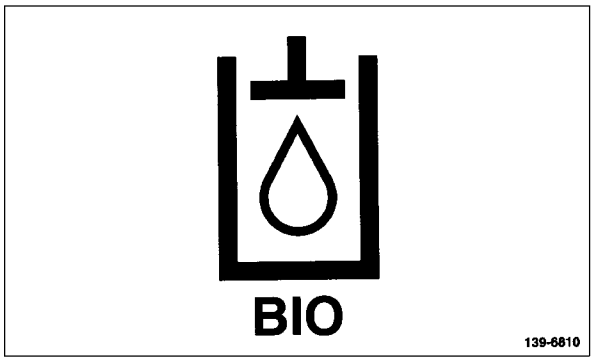

Illustration 1 g00103844

Machines with this symbol are filled with biodegradable hydraulic oil. This symbol is located on the hydraulic tank.

Commercial Oils

Note: Non-Caterpillar commercial oils that are acceptable for use in most Cat hydraulic and hydrostatic transmission systems are as a group third choice oils. Within this grouping of third choice oils there are tiered levels of performance.

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

The minimum viscosity for commercial alternative oils used in most Caterpillar machine hydraulic systems and in most Cat hydrostatic transmission systems is 6.6 cSt at 100 °C (212 °F)ASTM D445.

If Caterpillar oils cannot be used, oils meeting the following commercial specifications can be used in most Cat hydraulic systems and in most Cat hydrostatic transmission systems:

- Engine oils that meet the Cat ECF-1-a , Cat ECF-2 , or Cat ECF-3 specifications and have a minimum zinc additive of 0.09 percent (900 ppm)
- Biodegradable oils that meet the Cat BF-2 specification
- TO-4 specification oils that have a minimum zinc additive of 0.09 percent (900 ppm)

Note: Industrial hydraulic oils are not recommended for service fill in Caterpillar hydraulic systems.

Commercial Biodegradable Hydraulic Oil

Note: Non-Cat commercial oils that are acceptable for use in most Cat hydraulic and hydrostatic transmission systems are as a group third choice oils. Within this grouping of third choice oils there are tiered levels of performance.

Commercial oils that meet the Cat BF-2 specification should be used.

Note: Oil meeting the Cat BF-2 specification should only be used in hydraulic systems where specifically recommended.

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

If Cat oils cannot be used, commercial biodegradable hydraulic oils that meet the Cat BF-2 Performance Requirements should be used. Cat BF-2 replaces Cat BF-1 Performance Requirements. Cat BF-1 Performance Requirements is obsolete.

NOTICE
Do not use commercial oils that meet the BF-2 specification in compartments containing friction material except Hydraulic Excavators. Refer to the machine Operation and Maintenance Manual or consult your local Cat dealer for guidance before using commercial oils that meet the BF-2 specification in Hydraulic Excavators.

Biodegradable hydraulic oils are formulated with the following components: a saturated HEES (Hydraulic Environmental Ester Synthetic), synthetic base stock and selected additives. Consult Federal, state, or local authorities for guidance on hydraulic oil environmental requirements in your area.

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Transmission/Drive Train Oil

SMCS Code: 3080; 4000-OC; 4070; 7581

Transmission/drive train oils are classified by the Cat TO-4 and the Cat TO-4M Performance Requirements. These Performance Requirements were developed by Caterpillar for use in Cat Powershift transmissions and in most Cat final drives. Refer to the “Maintenance Section”, “Caterpillar Fluids” article for more information on Caterpillar fluids and to the Tables in the Lubricants Viscosity section for the application of these fluids in various Cat machines.

NOTICE
The Cat CD/TO-2 transmission/drive train oil specification has been obsolete since 1990. The obsolete CD/TO-2 specification is tied ONLY to the also obsolete API CD oil category. The “TO-2” oil specification existed only as CD/TO-2. Specification claims of CF/TO-2, ATF/TO-2, Cat TO-2 and other similar “TO-2” claims are not accurate. Caterpillar does not monitor or support the obsolete Cat CD/TO-2 specification. Use of CD/TO-2 oils, or the use of oils claiming to meet “TO-2” in machine compartments where Cat TO-4 specification oils are required is NOT recommended and their use is at the user's risk.

Applications

Transmission/Drive Train oils are recommended for use in Powershift Transmissions, certain Direct Drive Transmissions, certain Final Drives, Differentials and Final Drives, Drive Axles, Transfer Drives, and hydrostatic drive/hydraulic systems of various machines.

The details of the applications of Transmission/Drive Train oils are given in the “Lubricant Viscosity” section of this Special Publication.

Cat TDTO (Transmission/Drive Train Oil)

Cat TDTO exceeds the requirements of the Cat TO-4 transmission/drive train oil specification by passing five additional Cat tests.

Cat TDTO is balanced in order to give maximum frictional material life in powershift transmissions. Cat TDTO also helps eliminate brake chatter in wet brake applications in Cat machines. This oil passes the requirements for the TO-4 oil specification which includes the frictional requirements and gear wear requirements. This oil is offered in several lubricant viscosity grades.

Cat TDTO-TMS (Transmission/Drive Train Oil-Transmission Multi Season)

Cat TDTO-TMS exceeds the requirements of the Cat TO-4M transmission/drive train oil Performance Requirements by passing additional Cat tests.

Cat TDTO-TMS is synthetic multigrade oil that is developed to provide optimal performance in transmissions, wet brakes, final drives and hydraulic compartments that must operate in wide range of temperatures. Cat TDTO-TMS can be used in Cat machine compartments where Cat TO-4 and TO-4M oils are recommended. This oil can be used in other manufacturer machines that recommend TO-4 or TO-4M Performance Requirements oils.

TDTO-TMS is specifically formulated of reduce transmission gears wear, improve the performance and efficiency of transmissions in cold weather, especially for machines with electronic controls, and to ensure long life and excellent performance for gears, bearings, and friction disc materials.

NOTICE
Cat Transmission oils are formulated for transmissions and drive trains only, and should not be used in engines. Shortened engine life will result.

NOTICE
Do not use the Cat GO (Gear Oil) or commercial gear oil in the machine compartments unless specifically recommended by Caterpillar . The gear oil can cause seals to fail. The seals can also leak. The gear oil may not be compatible with friction materials. The oil can reduce the efficiency of the transmission and the brake performance.

Commercial Transmission/Drive Train Oils

Note: Non-Caterpillar commercial oils are as a group typically second or third choice oils. Within this grouping of second and/or third choice oils there are typically tiered levels of performance.

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

Commercial oils that are substituted for the Cat TDTO must comply with the requirements of the Cat TO-4 or the Cat TO-4M transmission/drive train oil Performance Requirements.

Note: Commercial multigrade oils must meet the requirements of the Cat TO-4M specification in order to be used in transmissions. Multigrade oils that use high molecular weight polymers as viscosity index improvers may lose the viscosity effectiveness. This effectiveness may be lost by the temporary shear of the polymer viscosity index improver. Permanent shear of the polymer viscosity index improver may also occur. These types of multigrade oils are not recommended for Caterpillar drive train compartments. The Cat TO-4M Performance Requirements includes a test for the shear stability of multigrade oil.

Final Drive and Axle Oil

Final Drive and Axle Oils are classified by the Cat FD-1 (Final Drive - 1) oil Performance Requirements. The Cat FD-1 Performance Requirements was developed by Caterpillar for use in certain highly loaded Cat final drives and axles that do **not** contain friction material.

Cat FDAO (Final Drive and Axle Oil), Cat FDAO SYN, or commercial FD-1 are the preferred oil types to maximize gear and bearing life in machine compartments where recommended for use.

Applications

Final Drive and Axle oils are recommended for use in certain Final Drives, Axles and Differentials. The details of the applications of these oils are given in the “Lubricant Viscosity” section of this Special Publication.

Cat FDAO (Final Drive and Axle Oil)

Cat FDAO is blended specifically for applications with high load and high temperature conditions. In these conditions,the protection of gears and bearings is a primary concern. This is the preferred lubricant for Cat final drives and axles that formerly specified Cat TO-4 oils and that do not contain friction materials. This oil should not be used in compartments that contain friction material unless Cat FDAO or oil meeting Cat FD-1 (Final Drive oil Performance Requirements - 1) has been specified because these oils do not develop a sufficient friction coefficient in order to satisfy the requirements of most clutches and brakes.

The performance of the Cat FDAO equaled or exceeded the performance of Cat TDTO in 18 of 18 tests for the following characteristics.

- Gear and bearing protection
- Physical properties and chemical properties

Cat FDAO also has the following qualities:

- Compatible with the Cat TDTO oils and the seals for the related compartments
- Excellent protection against rust
- Excellent protection against copper corrosion
- Minimizes foaming
- Extended life of the oil due to low rate of oxidation
- Reduced downtime due to extended oil change intervals

Cat FDAO SYN

Cat FDAO SYN is a full synthetic, natural multigrade (non-viscosity improved) final drive and axle oil that is designed for operation in a wide temperature range. Cat FDAO SYN exceeds the requirements of Cat FD-1 specification.

Cat FDAO SYN is the preferred lubricant for Cat Off-Highway Truck differentials, front wheels, and final drives that operate under high load factors and/ or that are operated continuously (multiple shifts per day).

Commercial Final Drive and Axle Oil

Commercial oils that are substituted for Cat FDAO must comply with the Cat FD-1 final drive oil Performance Requirements.

Note: Non-Caterpillar commercial oils that meet the Cat FD-1 Performance Requirements are second choice oils.

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Gear Oil

SMCS Code: 7000; 7551; 7581

NOTICE
Do not use the Cat GO (Gear Oil) or commercial gear oil in the machine compartments unless specifically recommended by Caterpillar . The gear oil can cause seals to fail. The seals can also leak. The gear oil may not be compatible with friction materials. The oil can reduce the efficiency of the transmission and the brake performance.

Applications

Gear oils are recommended for use in certain Direct Drive Transmissions, Differentials, Final Drives, Transfer drives, Circle Drives (excavators), and other applications. The details of the applications of these oils are given in the “Lubricant Viscosity” section of this Special Publication.

Cat GO (Gear Oil)

Cat GO offers maximum protection against the following damage: scoring of the gear teeth, pitting of the gear teeth and pitting of the parts in roller bearings. Cat GO provides excellent stability under high temperature conditions. Cat GO also has superior low temperature performance. This oil also gives protection against rust and corrosion. Some applications require additives for the extreme pressures that can occur at the surfaces/edges of the components. For these applications, Cat GO provides the extra protection.

When the use of gear oil is specified, use Cat GO or Cat Synthetic GO in order to maximize the component life.

NOTICE
Cat GO is not the same as Cat TDTO, and does not meet Cat TO-4 or TO-4M oil Performance Requirements. Cat GO or commercial gear oils should not be used in compartments that specify Cat TO-4 or TO-4M oil.

NOTICE
Cat GO is not the same as Cat FDAO, and does not meet the Cat FD-1 oil Performance Requirements. Cat GO or commercial gear oil should not be used in compartments that specify Cat FD-1 oil.

Commercial Gear Oils

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

Gear lubricants are classified by the API service category and by the SAE viscosity grade that is defined in SAE J306.

If the Cat GO or Cat Synthetic GO cannot be used, select a commercial oil that meets the API GL-5specification.

Note: Non-Caterpillar commercial API GL-5 gear oils are as a group second choice oils.

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Multipurpose Tractor Oil

SMCS Code: 7000; 7581

Application

Multipurpose Tractor Oils are recommended for use in certain Axles, Final Drives, Implement Steering, Rear Drive Axles, and other applications. The details of the applications of these oils are given in the “Lubricant Viscosity” section of this Special Publication.

Cat MTO is multigrade oil that can be used in cold weather operations. Refer to the “Viscosity Tables” in the “Lubricant Viscosities” section of this Special Publication for details.

Cat MTO (Multipurpose Tractor Oil)

NOTICE
Cat MTO is not the same as Cat TDTO, and does not meet Cat TO-4 or TO-4M transmission/drive train oil specifications. Cat MTO should not be used in compartments that specify Cat TO-4 or TO-4M oil.

NOTICE
Cat MTO is not the same as Cat FDAO, and does not meet the Cat FD-1 oil specification. Cat MTO should not be used in compartments that specify Cat FD-1 oil.

Cat MTO is multigrade oil that is developed, tested and approved by Caterpillar to provide optimal protection for components where approved for use. Cat MTO offers the following service qualties: improved braking and clutching, enhanced control and extended life in clutches and wet brakes, superior anti-wear properties, thermal stability, and oxidation resistance for long service life in severe applications.

Commercial Multipurpose Tractor Oils

Note: Non-Caterpillar commercial multipurpose tractor oils are as a group second choice oils.

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

If Cat MTO is not available, use an oil that meets the Ford/New Holland M2C134-D specification. The oil must also satisfy the requirements of the following commercial machine systems:

- Multipurpose tractor transmission
- Hydraulic drives on agricultural tractors and on industrial tractors
- Final drives on agricultural tractors and on industrial tractors

Automatic Transmission Oil

Automatic Transmission Oils are classified by the Cat AT-1 (Automatic Transmission - 1) oil Performance Requirements. Caterpillar developed AT-1 for use in automatic transmissions of on-highway trucks and in Caterpillar CX Series on-highway transmissions.

Cat ATF-HD automatic transmission fluid is the preferred oil to maximize the life and performance of automatic transmissions where recommended for use.

Application

Automatic Transmission oils are recommended for use in automatic transmissions of on-highway trucks and in Caterpillar CX Series on-highway transmissions. Refer to the Operation and Maintenance Manual for information for details.

NOTICE
Do not use Cat TDTO fluids in CX Series on-highway automatic transmissions.

Cat ATF-HD

Cat ATF-HD fluid is synthetic automatic transmission fluid developed to provide optimal performance in Caterpillar CX Series on-highway transmissions. Cat ATF fluid can be used in automatic transmissions that are designed to operate with fluids meeting Cat AT-1 or Dexron-III(H) Performance Requirements. Consult your Caterpillar dealer for Cat ATF-HD availability.

Cat ATF-HD increases the standard oil drain interval for CX Series on-highway automatic transmission (4 to 6 times) over second choice oils when following the maintenance interval schedule for oil filter changes and for oil sampling that is stated in the Operation and Maintenance Manual for your particular transmission.

Note: Proper warm up procedures should be followed when the temperature is less than −23° C (−10° F). In order to maintain optimum operating conditions of the bearing components, allow the engine to warm up for about 20 minutes. As an alternative, properly sized transmission heater can be installed. Follow all instructions and consult your Caterpillar dealer for cold weather operation of Cat CX Series on-highway automatic transmissions.

Commercial Fluids

For use in Cat CX Series on-highway automatic transmissions, commercial fluids must comply with the requirements of Cat AT-1 specification or the requirements of Dexron-III(H) .

Note: Non-Caterpillar commercial oils that meet the Cat AT-1 Performance Requirements are second choice oils.

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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 machine. The temperature may differ due to the machine 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 machine 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 machine. Refer to the “Lubricant Viscosities for Ambient Temperatures” tables for guidance. In cold-weather applications, the preferred method is to use properly sized machine compartment 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 temperature (the air in the immediate vicinity of the machine). Ambient temperature is the temperature when the machine is started and while the machine 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 machine and for operating a cold machine. Refer to the “Max” column in the table in order to select the oil viscosity grade for operating the machine at the highest temperature that is anticipated. Unless specified otherwise in the “Lubricant Viscosities for Ambient Temperatures” tables, use the highest oil viscosity that is allowed for the ambient temperature when you start the machine.

Machines that are operated continuously should use oils that have the higher oil viscosity in the final drives and in the differentials. The oils that have the higher oil viscosity will maintain the highest possible oil film thickness. Refer to this Special Publication, General Information for Lubricants article, Lubricant Viscosities tables, and any associated footnotes. Consult your Cat dealer if additional information is needed.

Note: SAE 0W and SAE 5W oils, where allowed for use in non-hydraulic system compartments, are not recommended for use in machines that are operated continuously and/or are heavily loaded. Refer to the “Lubricant Viscosities for Ambient Temperatures” tables for guidance. The oils that have the higher oil viscosity will maintain the highest possible oil film thickness. Consult your Cat dealer if additional information is needed.

Note: Oil viscosity grade selection is also machine compartment specific. Some machine models and/or machine compartments do not allow the use of all available viscosity grades. For guidance on selecting oil viscosity, refer to the “Lubricant Viscosities for Ambient Temperatures” tables.

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

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

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.

General Information for Lubricants

The information provided in this “Lubricant Viscosities for Ambient Temperatures” article and Tables should be used with the information provided in the “Lubricant Specifications” section (Maintenance Section) of this Special Publication.

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

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: Some machine models and/or machine compartments do NOT allow the use of all available oil viscosity grades.

Note: Only use the oil type and the specification that is recommended for the various machine compartments.

Note: Some machine compartments allow the use of more than one oil type. For the best results, do not mix oil types.

Note: Different brand oils may use different additive packages to meet the various machine compartment performance specification recommendations. For the best results, do not mix oil brands.

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

Note: SAE 10W viscosity grade oil used in most Cat machine compartments must have a minimum viscosity of 5.8 cSt at 100 °C (212 °F) (ASTM D445).

Note: The minimum acceptable viscosity for commercial alternative oils in most Cat machine hydraulic and hydrostatic transmission systems is 6.6 cSt at 100 °C (212 °F) (ASTM D445).

Note: Cat oils are the preferred oils. All other oil types and specifications that are listed in the applicable section are acceptable oils.

The minimum requirements for commercial oils for machine components are provided in Table 7 of this Special Publication. These requirements apply to all the fluids recommendations given in this Special Publication. Commercial oils are, as a group, second choice oils.

The factory fill oils for standard configuration machines are indicated in the lubricant recommendations tables, where pertinent. Factory fill information is general and exceptions may exist. For example, machines that are shipped to cold climates may have other factory fill oils.

When you are operating the machine in temperatures below −20°C (−4°F), refer to Special Publication, SEBU5898, Cold Weather Recommendations. This publication is available from your Cat dealer.

For cold-weather applications where transmission oil SAE 0W-20 is recommended, Cat TDTO Cold Weather is the first choice oil. Second choice oils for cold-weather transmission applications are commercial oils of full synthetic basestock that do not have viscosity index improvers. These oils do meet the Cat TO-4 performance requirements. Typical lubricant viscosity grades are SAE 0W-20, SAE 0W-30, and SAE 5W-30. Oils of lubricant viscosity grade SAE 0W-20, SAE 0W-30, or SAE 5W-30 that contain a Cat TO-4 additive package are a last choice.

The footnotes are a key part of the tables. Read ALL footnotes that pertain to the machine compartment in question.

Table 7

Recommendations for power train, transmissions, and hydraulics Fluids and Cat Performance Requirements		
Preferred	**Minimum Acceptable Performance Requirements for Commercial Oils**	**Application**
Cat HYDO Advanced	Per Product Data Sheet requirements	Hydraulic systems and Hydrostatic Transmissions
Cat Bio HYDO Advanced	Cat BF-2	Hydraulic systems and Hydrostatic transmissions requiring biodegradable fluids
Cat TDTO	Cat TO-4	Power shift transmissions, some direct drive transmissions, final drives, differentials, and transfer drives of many machines
Cat TDTO-TMS	Cat TO-4M	
Cat ATF	Cat AT-1	On-Highway truck Automatic transmissions
Cat FDAO, Cat FDAO SYN	Cat FD-1	Highly loaded final drives and axles that do not have friction materials
Cat GO	API GL-5	Gears and roller bearings where extreme pressure additives are required.

Organization of the Tables

Table 8 is for all Cat machine engines. This table applies to all oils that are recommended for the engine crankcase.

Table 9 is for all Cat machine hydraulic systems and machine hydrostatic transmissions. This table applies to all oils that are recommended for the machine hydraulic systems, pumps, and valves. This table applies to all oils that are recommended for the machine hydrostatic transmissions.

All other tables are listed in the product line categories. These tables contain information about other machine compartments and the lubrication recommendations for each compartment. Some machine compartments allow the use of more than one oil type. Some machine compartments restrict the use of some oil types. These tables contain any exceptions to the first two tables. Consult your Cat dealer if additional information is needed about any of the exceptions.

Special applications are included at the end of this section. Special applications include starting engine and variable pitch fan. If you do not find a compartment in the product category, check this table. Consult your Cat dealer if additional information is needed about special applications.

Note: Exceptions to any information in the common tables are listed in the tables in the product line sections.

All Cat Machine Engines

Refer to the “General Information for Lubricants” article for important lubricant information.

Supplemental heat is recommended for cold-soaked starts below the minimum ambient temperature. The parasitic load and other factors will determine if supplemental heat is required for cold-soaked starts that are above the minimum temperature that is stated. Cold-soaked starts occur when the engine has not been operated for a time. The oil becomes more viscous due to cooler ambient temperatures.

For oil recommendations for Tier 4 EPA certified engines, EU stage IIIB and IV type approved engines, and Japan Step IV approved engines refer to the “Cat Lubricants” table in Special Publication, SEBU6250, “Engine Oil”.

Refer to the “Lubricant Information” section in this Special Publication for a list of all Cat engine oils.

Cat ECF refers to Engine Crankcase Fluid specifications. Refer to the “Maintenance” section of this Special Publication, “Lubricant Information” for details. Commercial alternative diesel engine oils must meet one or more of these Cat ECF specifications. Refer to the “Cat Engine Lubricants Recommendations/Requirements” table in Special Publication, SEBU6250, “Engine Oil”.

The minimum requirements for commercial diesel engine oils are provided in Special Publication, SEBU6250, “Engine Oil (Cat Machine Diesel Engines)”. These requirements apply to all the fluids recommendations given in this Special Publication. Commercial alternative diesel engine oils are, as a group, second choice oils.

Note: SAE 10W-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: C175 Series diesel engines require the use of **multigrade** SAE 40 oil. For example: SAE 0W-40, SAE 5W-40, SAE 10W-40, or SAE 15W-40. In ambient temperatures of −9.5° C (15° F) or above, SAE 15W-40 is the preferred oil viscosity grade

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

Table 8

Cat Diesel Engines Lubricant Viscosities for Ambient Temperatures(1)

Compartment or System	Oil Type and Performance Requirements	Oil Viscosities	°C		°F	
			Min	Max	Min	Max
Engine Crankcase for all Direct Injection (DI) Engines	Cat DEO Cold Weather (API CJ-4)	SAE 0W-40	−40	40	−40	104
	Cat DEO-ULS SYN (API CJ-4)	SAE 5W-40	−30	50	−22	122
	Cat DEO-ULS (API CJ-4) Cat DEO (API CI-4/CI-4 PLUS)	SAE 10W-30	−18	50	0	122
		SAE 15W-40	−10	50	14	122
	Cat ECF-1a, Cat ECF-2, Cat ECF-3	SAE 0W-30	−40	30	−40	86
		SAE 5W-30	−30	30	−22	86
		SAE 10W-40	−18	30	0	86

(1) Refer to Special Publication, SEBU6250, “Engine Oil” for information on the recommended and required engine oils for Tier 4 emissions certified engines.

All Cat Machine Hydraulic Systems and Machine Hydrostatic Transmissions

Refer to the “General Information for Lubricants” article for important lubricant information.

Cat HYDO Advanced 10 SAE 10W, Cat HYDO Advanced 20 SAE 20W, Cat HYDO Advanced 30 SAE 30W, or Cat BIO HYDO Advanced are the preferred oils for use in most Cat machine hydraulic and hydrostatic transmission systems. **Cat HYDO Advanced fluids have at least a 50% increase in the standard oil drain interval** for machine hydraulic systems (3000 hours versus 2000 hours) over second and third choice oils - when following the maintenance interval schedule for oil filter changes and for oil sampling that is stated in the Operation and Maintenance Manual for your particular machine. 6000 hour oil drain intervals are possible when using S·O·S Services oil analysis. Consult your Cat dealer for details. In order to gain the most benefit from the improved performance designed into Cat HYDO Advanced fluids, when switching to Cat HYDO Advanced fluids, cross contamination with the previous oil should be kept to less than 10%.

Second choice oils are Cat MTO, Cat DEO, Cat DEO-ULS, Cat TDTO, Cat Cold Weather TDTO, Cat TDTO-TMS, Cat Cold Weather DEO-ULS. **Third choice** oils are commercial oils that meet Cat ECF-1-a, Cat ECF-2, Cat ECF-3, Cat TO-4, or the Cat TO-4M performance requirements, and that have a minimum zinc additive level of 0.09 percent (900 ppm). Commercial biodegradable hydraulic oil must meet the Cat BF-2 specification. Refer to the machine Operation and Maintenance Manual and/or consult your local Cat dealer before using commercial oils that meet Cat BF-2 in Cat Hydraulic Excavators .

The minimum viscosity for commercial alternative oils used in most Cat machine hydraulic and hydrostatic transmission systems is 6.6 cSt at 100 °C (212 °F) (ASTM D445).

Note: For machines equipped with hydraulic hammers, do not use viscosity grades SAE 0W or SAE 5W oils. Refer to the “Special Applications” section in this article.

If noise is a problem in the hydraulic system, 1U-9891 oil additive may be used in the hydraulic system. This additive is a friction modifier that helps reduce the noise level.

For applications requiring the use of fire resistant hydraulic fluids, Caterpillar recommends the use of EcoSafe FR-46 . This product is a fully synthetic, non-aqueous hydraulic fluid. Water based and glycol based hydraulic products are not recommended for use in Cat machine hydraulic systems. EcoSafe FR-46 is an ISO 46 multi-grade product. For more information refer to the product information provided by the manufacturer of EcoSafe hydraulic oil. Refer to your Cat dealer for availability.

Table 9 describes the hydraulic system recommendations for all Cat machines. Some machines require different temperature ranges or specific hydraulic fluids. The recommendations for those machines are given in the respective machine Lubricant Viscosity Table.

Table 9

Hydraulic Systems Lubricant Viscosities for Ambient Temperatures[1]						
Compartment or System	Oil Type and Performance Requirements	Oil Viscosities	°C		°F	
			Min	Max	Min	Max
Hydraulic System and **Hydrostatic Transmissions**	**Cat HYDO Advanced 10** [2] Cat TDTO	SAE 10W	−20	40	−4	104
	Cat HYDO Advanced 20 Cat TDTO	SAE 20W	−5	45	23	113
	Cat HYDO Advanced 30 Cat TDTO	SAE 30	0	50	32	122
	Cat BIO HYDO Advanced [3]	ISO 46 Multi-Grade	−30	45	−22	113
	Cat MTO Cat DEO-ULS Cat DEO	SAE 10W-30	−20	40	−4	104
	Cat DEO-ULS Cat DEO	SAE 15W-40	−10	50	5	122
	Cat TDTO-TMS	Multi-Grade	−15	50	5	122
	Cat DEO-ULS SYN	SAE 5W-40	-20	50	-22	122
	Cat DEO Cold Weather	SAE 0W-40	−40	40	−40	104
	Cat TDTO Cold Weather	SAE 0W-20	−40	40	−40	104
	Cat ECF-1a, Cat ECF-2, Cat ECF-3	SAE 10W-40	-18	50	0	122
		SAE 5W-30	-30	40	-22	104
		SAE 0W-30	-40	40	-40	104

(1) For fire resistant hydraulic oil recommendations, refer to Special Publication, SEBU6250, “Hydraulic Oil”.
(2) Typical factory fill oil for standard configuration machines.
(3) Factory fill oil for applications that require biodegradable oils.

Articulated Trucks

Refer to the “General Information for Lubricants” article for important lubricant information.

This section includes, but not limited to the following models:

- 725 through 740

For the Underground Mining articulated trucks, refer to the Underground Mining section is this article.

For Differentials and Final Drives of Series E II and Series 700 , Cat TDTO SAE 50 or commercial oil that meets Cat TO-4 SAE 50 performance requirements is preferred in most applications, particularly continuous operation. If the ambient temperature is below −15° C (5° F), warm up the oil prior to operation. The oil must be maintained to a temperature above −15° C (5° F) during operation. If the ambient temperature is below −15° C (5° F), perform the procedures in the Operation and Maintenance Manual, “Differential Warm-up and Break-in”, prior to operation. If the ambient temperature is below −25° C (−13° F), consult your Cat dealer for instructions. Failure to warm up the oil prior to operation will damage the machine.

For Differentials and Final Drives of Series E II and Series 700 , do NOT use SAE 0W-20 oils when the typical daily maximum ambient temperature is above −10° C (14° F).

For hydraulic systems that are not given in Table 10 , refer to the hydraulic system recommendations given in Table 9 .

Table 10

Articulated Trucks Lubricant Viscosities for Ambient Temperatures						
Compartment or System	Oil Type and Performance Requirements	Oil Viscosities	°C		°F	
			Min	Max	Min	Max
Power shift transmissions	Cat TDTO Cold Weather	SAE 0W-20	−40	10	−40	50
	Cat TDTO	SAE 10W	−20	10	−4	50
		SAE 30(1)	0	50	32	122
	Cat TDTO-TMS	Multi-Grade	−10	50	14	122
Hoist (Ejector), Steering and Brake System, Brake Control Valve Damper, and Suspension Hydraulic System for E Series II and 700 Series	Cat TDTO Cold Weather	SAE 0W-20	−40	40	−40	104
	Cat TDTO	SAE 10W(1) (2)	−20	50	−4	122
Differentials and Final Drives (except for E Series II Articulated Trucks, and 700 Series Articulated Trucks)	Cat Synthetic GO	SAE 75W-140	−30	45	−22	113
	Cat GO (Gear Oil)	SAE 80W-90(1)	−20	40	−4	104
		SAE 85W-140	−10	50	14	122
	API GL-5 gear oil	SAE 75W-90	−30	40	−22	104
		SAE 90	0	40	32	104
Differentials and Final Drives for E Series II Articulated Trucks and 700 Series Articulated Trucks	Cat TDTO Cold Weather	SAE 0W-20	−40	−10	−40	14
	Cat TDTO	SAE 50(1)	−15	40	5	104
	Cat TDTO-TMS	Multi-Grade	−25	22	−13	72
Output Transfer Gear for E Series II Articulated Trucks 700 Series Articulated Trucks	Cat TDTO Cold Weather	SAE 0W-20	−40	−10	−40	14
	Cat TDTO	SAE 30(1)	−20	50	−4	122

(1) Factory fill oil for standard configuration machines.
(2) The maximum allowable oil viscosity at 100° C (212° F)100C is 6.6 cSt (ASTM D445).

Backhoe Loaders

Refer to the “General Information for Lubricants” article for important lubricant information.

This section includes, but not limited to the following models:

- 414 through 450

For hydraulic systems that are not given in Table 11 , refer to the hydraulic system recommendations given in Table 9 .

Table 11

Backhoe Loaders Lubricant Viscosities for Ambient Temperatures						
Compartment or System	Oil Type and Specification	Oil Viscosity Grade	°C		°F	
			Min	Max	Min	Max
Direct drive transmissions Power shift transmissions	Cat TDTO Cold Weather	SAE 0W-20	−40	35	−40	95
	Cat TDTO	SAE 10W(1)	−20	35	−4	95
		SAE 30	25	50	77	122
	Cat TDTO-TMS	Multi-Grade	10	50	50	122

(continued)

(Table 11, contd)

Backhoe Loaders Lubricant Viscosities for Ambient Temperatures						
Front Axle Differentials Final Drives for A, B, C, D (Only D with ZF Front axle Series)	**Cat GO (Gear Oil)[2]**	SAE 80W-90[1]	−20	40	−4	104
		SAE 85W-140	−10	50	14	122
	Cat Synthetic GO[2] API GL-5 gear oil	SAE 75W-90	−30	40	−22	104
		SAE 75W-140	−30	45	−22	113
Front All Wheel Drive Axle Final Drives for D Series (with Cat front axle) E Series F Series	**Cat TDTO Cold Weather**	SAE 0W-20	−40	10	−40	50
	Cat TDTO	SAE 10W	−20	10	−4	50
		SAE 30[1]	-10	50	14	122
		SAE 50	10	50	50	122
	Cat TDTO-TMS	Cat TDTO-TMS	−20	43	−4	110
Hydraulic Systems for Side Shift Backhoe Loaders	**Cat HYDO Advanced 10**	SAE 10W[1]	−20	50	−4	122
	Cat HYDO Advanced 30 Cat TDTO	SAE 30	0	50	32	122
	Cat Bio HYDO Advanced	ISO 46 Multi-Grade	−20	40	−4	104
	Cat DEO-ULS Cat DEO	SAE 15W-40	-15	50	5	122
	Cat TDTO Cold Weather	SAE 0W-20	−40	40	−40	104
	Cat ECF-1a, Cat ECF-2, Cat ECF-3	SAE 0W-30	-40	20	−40	68
Brake Reservoir	**Cat HYDO Advanced 10**	SAE 10W	−20	50	−4	122

(1) Factory fill oil for standard configuration machines.
(2) Cat FDAO Syn can be used at a −15° C (5° F) and 50° C (122° F) temperature range

Backhoe Loader Rear Axles

Additional 197-0017 may be used in order to reduce brake noise.

Do not use Cat MTO or commercial M2C134-D specification oil with the 230-4017 brake disks. Do not use Cat MTO or commercial M2C134-D specification oil in any E Series Backhoe Loader rear axle.

Table 12

Backhoe Loader Rear Axles Lubricant Viscosities for Ambient Temperatures								
Backhoe Loaders	**Brake Disk Part Number**	**197-0017 Additive Volume**	**Oil Type and Performance Requirements for Rear Axle**	**Oil Viscosity Grade**	**°C**		**°F**	
					Min	**Max**	**Min**	**Max**
B, C, D Series	133-7234[1]	1L (1.1qt)[2]	Cat TDTO 30	SAE 30	−25	40	−13	104
	230-4017	150mL (5.1oz)[3]	Cat TDTO 30					
416E 420E 422E 428E 430E 432E 434E 442E 444E	238-5291	500 mL (17.0 oz)[4]	Cat TDTO 30					
450E	288-7303	200mL (6.8oz)[5]	Cat TDTO 30					

(1) Cat MTO or M2C134-D can be used with 133-7234 brake disks.
(2) The maximum amount of 197-0017 for this brake is 2 L (2.1 qt).
(3) The maximum amount of 197-0017 for this brake is 300 mL (10.2 oz).
(4) The maximum amount of 197-0017 for this brake is 550 mL (18.7 oz).
(5) The maximum amount of 197-0017 for this brake is 250 mL (8.5 oz).

Excavators, Front Shovels, Mass Excavators, Demolition Excavators, and Track Material Handlers

Refer to the “General Information for Lubricants” article for important lubricant information.

This section includes, but not limited to the following model Excavators:

- 301 through 390

This section includes, but not limited to the following model Front Shovels:

- 5090 through 5230 and 385

This section includes, but not limited to the following model Mass Excavators:

- 365 through 385, and 5110 through 5230

This section includes, but not limited to the following model Demolition Excavators:

- 330 through 385

This section includes, but not limited to the following model Track Material Handlers:

- 320 through 385

For Final Drive applications that use SAE 0W-30 or 5W-30 oils, full synthetic base stock without viscosity index improvers that meet the Cat TO-4 SAE 30 performance requirements are acceptable. Typical lubricant viscosity grades are SAE 0W-20, SAE 0W-30, and SAE 5W-30. **Second Choice:** Oils that contain a Cat TO-4 additive package and a lubricant viscosity grade of SAE 0W-20, SAE 0W-30, or SAE 5W-30.

For hydraulic systems that are not given in Table 13 , refer to the hydraulic system recommendations given in Table 9 .

Table 13

Excavators, Front Shovels, Mass Excavators, Demolition Excavators, and Track Material Handlers Lubricant Viscosities for Ambient Temperatures

Compartment or System	Oil Type and Performance Requirements	Oil Viscosity Grade	°C		°F	
			Min	Max	Min	Max
Final Drives and Swing Drives	Cat TDTO Cold Weather	SAE 0W-20	-40	0	-40	32
	Cat TDTO	SAE 10W	−30	0	-22	32
		SAE 30(1)	−30	35	−22	95
		SAE 50	-15	50	5	122
	Cat TDTO-TMS	Multi-Grade	−25	25	−13	77
Track Roller Frame Recoil Spring and Pivot Shaft Bearings	Cat TDTO Cold Weather	SAE 0W-20	−40	0	−40	32
	Cat TDTO	SAE 10W	−30	0	−22	32

(continued)

(Table 13, contd)

Excavators, Front Shovels, Mass Excavators, Demolition Excavators, and Track Material Handlers Lubricant Viscosities for Ambient Temperatures						
Compartment or System	**Oil Type and Performance Requirements**	**Oil Viscosity Grade**	**°C**		**°F**	
			Min	**Max**	**Min**	**Max**
		SAE 30(1)	−20	25	−4	77
		SAE 50	0	50	32	122
	Cat TDTO-TMS	Multi-Grade	−25	25	−13	77
Track Idlers and Track Rollers	**Cat DEO-ULS Cat DEO**	SAE 15W-40(1)	-10	50	14	122
	Cat DEO Cold Weather	SAE 0W-40	−40	40	−40	104
	Cat DEO-ULS SYN	SAE 5W-40	−35	40	−31	104
	Cat FDAO SYN	Multi-Grade	-30	50	-22	122

(1) Factory fill oil for standard configuration machines.

Mini-hex

Table 14

Mini-hex Lubricant Viscosities for Ambient Temperatures						
Compartment or System	Oil Type and Performance Requirements	Oil Viscosities	°C		°F	
			Min	Max	Min	Max
Differentials and Final Drives	Cat Synthetic GO	SAE 75W-140	-30	45	-22	113
	Cat GO (Gear Oil)	SAE 80W-90[1]	−20	40	−4	104
		SAE 85W-140	−10	50	14	122
	API GL-5 gear oil	SAE 75W-90	−30	40	−22	104
		SAE 90	0	40	32	104
Track Roller Frame Recoil Spring and Pivot Shaft Bearings	Cat TDTO Cold Weather	SAE 0W-20	−40	0	−40	32
	Cat TDTO	SAE 10W	−30	0	−22	32
		SAE 30[1]	−20	25	−4	77
		SAE 50	0	50	32	122
	Cat TDTO-TMS	Multi-Grade	−25	25	−13	77

(1) Factory fill oil for standard configuration machines.

Forestry

Refer to the “General Information for Lubricants” article for important lubricant information.

This section includes, but not limited to the following model Log Loaders:

- 320 through 345, and 568

This section includes, but not limited to the following model Wheel Feller Bunchers:

- 533 through 573

This section includes, but not limited to the following model Track Feller Bunchers:

- TK711 through TK722
- TK1051 through TK1162
- 511 through 552

This section includes, but not limited to the following model Track Harvester:

- 320 and 501

This section includes, but not limited to the following model Track Skidders:

- 517 through 527

This section includes, but not limited to the following model Wheel Skidders:

- 515 through 545

This section includes, but not limited to the following model Knuckleboom Loaders:

- 519 and 579

This section includes, but not limited to the following model Forwarders:

- 534 through 584

Commercial biodegradable hydraulic oil (HEES) must meet the Cat BF-2 specification.

Cat MTO SAE 15W-40 is the preferred viscosity grade for the hydraulic hood tilt system when the ambient temperature is below −15 °C (+5 °F) and does not go above 40 °C (104 °F).

For hydraulic systems that are not given in Table 15 , refer to the hydraulic system recommendations given in Table 9 .

Table 15

Forestry Lubricant Viscosities for Ambient Temperatures						
Compartment or System	**Oil Type and Performance Requirements**	**Oil Viscosities**	**°C**		**°F**	
			Min	**Max**	**Min**	**Max**
Power shift transmissions	**Cat TDTO Cold Weather**	SAE 0W-20	−40	10	−40	50
	Cat TDTO	SAE 10W	−20	10	−4	50
		SAE 30(1)	0	50	32	122
		SAE 50W	10	50	50	122
	Cat TDTO-TMS	Multi-Grade	−10	50	14	122
Final Drive and Swing Drive	**Cat TDTO Cold Weather**	SAE 0W-20	−40	0	−40	32
	Cat TDTO	SAE 10W	−30	0	−22	32
		SAE 30(1) (2)	−25	25	−13	77
		SAE 50(3)	−15	50	5	122
	Cat TDTO-TMS	Multi-Grade	−30	25	−22	72
Final Drive, Swing Drive and Pump Drive for Knuckelboom Loaders **Final Drive and Swing Drive** for Model 501 Track Harvester **Two Speed Transmission and Drive Axles** for Model 584 Forwarders	**Cat Synthetic GO**	SAE 75W-140	-30	45	-22	113
	Cat GO (Gear Oil)	SAE 80W-90(1)	−20	40	−4	104
		SAE 85W-140	−10	50	14	122
	API GL-5 gear oil	SAE 75W-90	−30	40	−22	104
		SAE 90	0	40	32	104
Track Idlers and Track Rollers	**Cat DEO-ULS Cat DEO**	SAE 15W-40(1)	-10	50	14	122
	Cat DEO Cold Weather	SAE 0W-40	−40	40	−40	104
	Cat DEO-ULS SYN	SAE 5W-40	−35	40	−31	104
	Cat FDAO SYN	Multi-Grade	-30	50	-22	122
Variable Pitch Fan	**Cat DEO Cold Weather**	SAE 0W-40	−40	40	−40	104
	Cat DEO-ULS SYN	SAE 5W-40	−40	50	−40	122
Drive Axles for Wheel Log Skidders (525-545) and Wheel Feller Bunchers (533, 573)	**Cat TDTO Cold Weather**	SAE 0W-20	−40	0	−40	32
	Cat TDTO	SAE 10W	−25	15	−13	59
		SAE 30(1)	−20	43	−4	110
		SAE 50	10	50	50	122
	Cat TDTO-TMS	Multi-Grade	−30	43	−22	110
Final Drives for Large Track Skidders (Steel Tracked Machines with Elevated Final Drives except the 561M and 561N)	**Cat FDAO**	SAE 60(1)	−7	50	19	122
	Cat TDTO	SAE 50	−15	32	5	90
		SAE 30	−25	15	−13	59
	Cat FDAO SYN	Multi-Grade	−15	50	5	122
	Cat TDTO-TMS	Multi-Grade	−35	15	−31	59

(1) Factory fill oil for standard configuration machines.
(2) Factory fill oils for swing drives of standard configuration Log Loaders, Model 320 Track Harvester, and Track Feller Bunchers
(3) Factory fill oils for final drives of standard configuration Log Loaders, Model 320 Track Harvester, and Track Feller Bunchers

Motor Graders

Refer to the “General Information for Lubricants” article for important lubricant information.

This section includes, but not limited to the following models:

- 12 through 24
- 120 through 163

For the Tandem Drive on the Series M , add 0.015 L (0.015 qt) of 1U-9891 oil additive per 1 L (1 qt) of oil. Do not add oil additive to the 24M Motor Grader or Motor Graders prior to the M series.

For hydraulic systems that are not given in Table 16 , refer to the hydraulic system recommendations given in Table 9 .

Table 16

Motor Graders Lubricant Viscosities for Ambient Temperatures						
Compartment or System	Oil Type and Performance Requirements	Oil Viscosity Grade	°C		°F	
			Min	Max	Min	Max
Transmission, Differential, and Final Drive	Cat TDTO Cold Weather	SAE 0W-20	−40	10	−40	50
	Cat TDTO	SAE 10W	−20	10	−4	50
		SAE 30(1)	0	35	32	95
		SAE 50	10	50	50	122
	Cat TDTO-TMS	Multi-Grade	−15	43	−5	110
Tandem Drive and Wheel Spindle Bearings	Cat TDTO Cold Weather	SAE 0W-20	−40	10	−40	50
	Cat TDTO	SAE 10W	−20	20	−4	68
		SAE 30(1)	−10	40	14	104
		SAE 50	10	50	50	122
	Cat TDTO-TMS	Multi-Grade	−15	43	−5	109
All Wheel Drive Gearbox	Cat TDTO	SAE 50	−15	50	5	122
Circle Drive except 16H, 24H, 16M, and 24M Series	Cat Synthetic GO	SAE 75W-140	−30	45	−22	113
	Cat GO (Gear Oil)	SAE 80W-90(1)	−20	40	−4	104
		SAE 85W-140	−10	50	14	122
	API GL-5 gear oil	SAE 75W-90	−30	40	−22	104
		SAE 90	0	40	32	104
Circle Drive for 16H, 24H, 16M, and 24M Series	Cat FDAO Syn	Multi-Grade	−15	50	5	122
Hydraulic Systems for M Series Motor Graders	Cat HYDO Advanced 10	SAE 10W(1)	−15	40	5	104
	Cat HYDO Advanced 30	SAE 30	20	50	68	122
	Cat BIO HYDO Advanced	ISO 46 Multi-Grade	−25	45	−13	113
	Cat TDTO Cold Weather	SAE 0W-20	−40	40	−40	104
	Cat DEO Cold Weather	SAE 0W-40	−25	40	−13	104
	Cat ECF-1a Cat ECF-2 Cat ECF-3	SAE 0W-30	−35	40	−31	104

(1) Factory fill oil for standard configuration machines.

Off Highway Trucks

Refer to the “General Information for Lubricants” article for important lubricant information.

This section includes, but not limited to the following models:

- 769 through 797

Some Off-Highway Truck torque converters have a common sump with the transmission. These torque converters will use the same fluid recommendations as the transmission. The affected Off-Highway Truck models include 769D, 770, 771D, 772, 773D, 773E, 773F, 775D, 775E, 775F, 793C-F, and all 797 models.

Cat FDAO SYN, Cat FDAO SAE 60 or commercial oil that meets Cat FD-1 SAE 60 is preferred in most Differential, Front Wheels, and Final Drives, particularly continuous operation. If the ambient temperature is below −10°C (14°F), warm up the oil prior to operation. The oil must be maintained to a temperature above −10°C (14°F) during operation. If the ambient temperature is below −10°C (14°F), perform the procedures in the Operation and Maintenance Manual, “Differential Warm-up and Break-in” prior to operation. If the ambient temperature is below −25°C (−13°F) (below −35°C (−31°F) for Cat FDAO SYN), consult your Cat dealer for instructions. Failure to warm up the oil prior to operation will damage the machine.

For hydraulic systems that are not given in Table 17 , refer to the hydraulic system recommendations given in Table 9 .

Table 17

Off Highway Trucks Lubricant Viscosities for Ambient Temperatures						
Compartment or System	**Oil Type and Performance Requirements**	**Oil Viscosities**	**°C**		**°F**	
			Min	**Max**	**Min**	**Max**
Power shift transmissions Except for models listed below	**Cat TDTO Cold Weather**	SAE 0W-20	−40	10	−40	50
	Cat TDTO	SAE 10W	−20	10	−4	50
		SAE 30(1)	0	50	32	122
	Cat TDTO-TMS	Multi-Grade	−10	50	14	122
Power shift transmission in 797 (all models)	**Cat TDTO**	SAE 30(1)	−6	50	−6	122
Power shift transmission for 768C, 768D, 769C, 769D, 770, 771C, 771D, and 772	**Cat TDTO Cold Weather**	SAE 0W-20	−40	22	−40	72
	Cat TDTO	SAE 10W(1)	−20	22	−4	72
		SAE 30	10	50	50	122
	Cat TDTO-TMS	Multi-Grade	10	50	50	122
Steering Systems except for 785D, 793D, 793F, 795F, 797(all models)	**Cat HYDO Advanced 10** Cat TDTO	SAE 10W(1)	−20	40	−4	104
	Cat HYDO Advanced 30 Cat TDTO	SAE 30	10	50	50	122
	Cat BIO HYDO Advanced	ISO 46 Multi-Grade	−20	40	−4	104
	Cat DEO-ULS SYN	SAE 5W-40	−30	40	−22	104
	Cat TDTO Cold Weather	SAE 0W-20	-40	40	-22	104
	Cat DEO Cold Weather	SAE 0W-40	−40	40	−40	104
	Cat ECF-1-a, Cat ECF-2, Cat ECF-3,	SAE 0W-30	−40	40	−40	104
		SAE 5W-30	−30	40	−22	104

(continued)

(Table 17, contd)

Off Highway Trucks Lubricant Viscosities for Ambient Temperatures						
Compartment or System	**Oil Type and Performance Requirements**	**Oil Viscosities**	**°C**		**°F**	
			Min	**Max**	**Min**	**Max**
	Cat DEO-ULS Cat DEO	SAE 10W-30	−20	40	−4	104
		SAE 15W-40	−15	50	5	122
	Cat MTO	Cat MTO	−20	40	−4	104
	Cat TDTO-TMS	Multi-Grade	−15	50	5	122
Steering system for 785D, 793D, 793F, 795F, 797B, and 797F	**Cat HYDO Advanced 30** Cat TDTO	SAE 30(1)	−5	50	23	122
	BIO HYDO Advanced	ISO 46 Multi-Grade	−25	35	−13	95
	Cat DEO-ULS SYN	SAE 5W-40	−30	40	−22	104
	Cat DEO-ULS Cat DEO	SAE 15W-40	−15	50	5	122
	Cat TDTO-TMS	Multi-Grade	−15	50	5	122
	Cat ECF-1-a, Cat ECF-2, Cat ECF-3	SAE 0W-30	−40	27	−40	77
Hoist, Torque Converter, and Brake System	**Cat TDTO Cold Weather**	SAE 0W-20	−40	40	−40	104
	Cat TDTO	SAE 10W(1)	−20	50	−4	122
Differential, Front Wheels, and Final Drives(2)	**Cat FD-1**	SAE 50	−10	32	14	90
	Cat FDAO	SAE 60(1)	−10	50	14	122
	Cat FDAO SYN	Multi-Grade	−10	50	14	122

(1) Factory fill oil for standard configuration machines.
(2) Cat TDTO or a commercial TO-4 oil may be used as a third choice in place of the recommended Cat FDAO, Cat FDAO Syn, and commercial Cat FD-1 oil.

Special Applications for Off Highway Trucks

Table 18

795F ACOff-Highway Truck Lubricant Viscosities for Ambient Temperatures						
Compartment or System	Oil Type and Performance Requirements	Oil Viscosities	°C		°F	
			Min	Max	Min	Max
Powered Stairway	Cat TDTO	SAE 10W(1)	0	50	32	122
	Cat TDTO Cold Weather	SAE 0W-20	0	50	32	122
	MIL-H-5606A	MIL-H-5606A	-40	40	-40	104

(1) Factory fill oil for standard configuration machines.

Paving

This section includes, but not limited to the following models:

- CS-323 through CS-683
- CP-323 through CP-663
- CB-14 through CB-34
- CB-114 through CB-634
- CC-24 through CC-34
- CS-44 through CS-76
- CP-44 through CP-76
- AS-2251 through AS-4251
- PS-150 through PS-360
- PF-300
- PM-102 through PM-565
- RM-250 through RM-500
- AP-500 through AP-1055
- BG-225 through BG-2455

Do not use SAE 50 viscosity grade oil in ICM controlled transmissions. Do not use SAE 50 viscosity grade oil for the hydraulic drive winch case.

Where recommended for use, Cat TDTO SAE 50 or Cat TO-4 SAE 50 is preferred in most applications, particularly continuous operation. If the ambient temperature is below −15 °C (5 °F), warm up the oil prior to operation. The oil must be maintained to a temperature above −15 °C (5 °F) during operation. If the ambient temperature is below −15 °C (5 °F), perform the procedures in the Operation and Maintenance Manual, “Engine and Machine Warm-Up” prior to operation. If the ambient temperature is below −25 °C (−13 °F), consult your Cat dealer for instructions. Failure to warm up the oil prior to operation will damage the machine.

Do not use API GL-5 or API GL-4 Gear Oils for the Vibratory Compactor Eccentric Weight Housing, Final Drive Planetary Drum, or Vibratory Support. Cat Synthetic Compactor Oil is a premium PAO (Polyalpaolefin) gear and bearing lubricant with no viscosity improvers.

For hydraulic systems that are not given in Table 19 , refer to the hydraulic system recommendations given in Table 9 .

Table 19

Paving Lubricant Viscosities for Ambient Temperatures						
Compartment or System	**Oil Type and Performance Requirements**	**Oil Viscosities**	**°C**		**°F**	
			Min	**Max**	**Min**	**Max**
Powershift, Manual Transmissions	**Cat TDTO Cold Weather**	SAE 0W-20	−40	10	−40	50
	Cat TDTO	SAE 10W(1)	−20	10	−4	50
		SAE 30	0	35	32	95
		SAE 50	10	50	50	122
	Cat TDTO-TMS	Multi-Grade	−15	43	5	110
Hydraulic Systems and Hydrostatic Transmissions for Asphalt Compactors Except for Pneumatic Compactors PS-150B s/n:3XR00621-Up, PS-200B s/n:5JR00393-Up, PS-360B s/n:9LS00259-Up, PS-150C, and PS360C	**Cat HYDO Advanced 10** Cat TDTO	SAE 10W(1)	−20	40	−4	104
	Cat HYDO Advanced 30 Cat TDTO	SAE 30	10	50	50	122
	Cat BIO HYDO Advanced	ISO 46 Multi-Grade	−40	40	−40	104
	Cat TDTO Cold Weather	SAE 0W-20	−40	40	−40	104
	Cat DEO Cold Weather	SAE 0W-40	−40	40	−40	104
	Cat DEO-ULS SYN	SAE 5W-40	-30	40	-22	104
	Cat ECF-1-a, Cat ECF-2, Cat ECF-3,	SAE 0W-30	−40	40	−40	104
	Cat DEO Cat DEO-ULS	SAE 10W-30	−20	40	−4	104
		SAE 15W-40	−15	50	5	122
	Cat MTO	SAE 10W-40	−20	40	−4	104
	Cat TDTO-TMS	Multi-Grade	−15	50	5	122
Hydraulic Systems and Hydrostatic Transmissions for Pneumatic Compactors PS-150B s/n:3XR00621-Up, PS-200B s/n:5JR00393-Up, PS-360B s/n:9LS00259-Up, PS-150C, and PS360C	**Cat TDTO-TMS**	Multi-Grade	−15	50	5	122
Drive Axles for Medium Compactors (815-826), Vibratory Soil Compactor model numbers with the E or higher suffix	**Cat TDTO Cold Weather**	SAE 0W-20	−40	0	−40	32
	Cat TDTO	SAE 10W	−30	0	−22	32
		SAE 30	−25	25	−13	77
		SAE 50(1)	−15	50	5	122
	Cat TDTO-TMS	Multi-Grade	−30	43	−22	110
Drive Axles for Large Compactors	**Cat TDTO Cold Weather**	SAE 0W-20	−40	0	−40	32
	Cat TDTO	SAE 10W	−30	0	−22	32
		SAE 30	−25	25	−13	77
		SAE 50(1)	−15	50	5	122
	Cat TDTO-TMS	Multi-Grade	−25	22	−13	72
Axle for the Series 500 Vibratory Soil Compactor models with the D suffix or lower	**Cat MTO** commercial M2C 134-D	SAE 10W-30	−25	40	−13	104

(continued)

(Table 19, contd)

Paving Lubricant Viscosities for Ambient Temperatures						
Compartment or System	Oil Type and Performance Requirements	Oil Viscosities	°C		°F	
			Min	Max	Min	Max
Vibratory Compactor Eccentric Weight Housing, Final Drive Planetary Drum, and Vibratory Support	Cat Synthetic Compactor Oil Commercial Synthetic Oil	Synthetic ISO 220 (2)	−20	50	−4	122
		Synthetic ISO 68 (3)	−47	21	−53	70

(1) Factory fill oil for standard configuration machines.
(2) This Cat lubricant is a premium PAO (polyalphaolefin) synthetic gear oil with no viscosity improver. This lubricant has an ISO viscosity grade to 220, and a minimum viscosity index of 152. Commercial oil for this application should have a full synthetic base stock with no viscosity improvers and an ISO viscosity grade to 220, and a minimum viscosity index of 150.
(3) Select a synthetic lubricant with no viscosity improvers and ISO 68 viscosity grade. This lubricant should have a minimum viscosity index of 145 and a minimum pour point of −47° C (−53° F).

Table 20

Special Paving Lubricant Viscosities for Ambient Temperatures						
Compartment or System	Oil Type and Performance Requirements	Oil Viscosities	°C		°F	
			Min	Max	Min	Max
Propel Final Drive	Cat TDTO	SAE 50	10	50	50	122
	Cat TDTO-TMS	Multi-Grade	−20	43	−4	110
Auger, Conveyor, and Pump Drive Reducers	Cat GO (Gear Oil)	SAE 80W-90(1)	−20	40	−4	104
		SAE 85W-140	−10	50	14	122
	Cat Synthetic GO	SAE 75W-140	−30	45	−22	113
	API GL-5 gear oil	SAE 75W-90	−30	40	−22	104
		SAE 90	0	40	32	104
Track Idlers and Track Rollers	Cat DEO-ULS Cat DEO	SAE 15W-40(1)	−10	50	−14	122
	Cat DEO Cold Weather	SAE 0W-40	−40	40	−40	104
	Cat DEO-ULS SYN	SAE 5W-40	-35	40	-31	104
	Cat FDAO SYN	Multi-grade	-30	50	-22	122

(1) Factory fill oil for standard configuration machines.

Pipe Layers

Refer to the “General Information for Lubricants” article for important lubricant information.

This section includes, but not limited to the following models:

- 561 through 589
- PL61

When you operate the machine at temperatures below −18 °C (0 °F), refer to Special Publication, SEBU5898, “Cold Weather Recommendations For All Caterpillar Equipment”. This publication is available from your Cat dealer.

Except for the winch hydraulic system, use SAE 30 viscosity grade for 0°C (32°F) to 43°C (110°F) or Cat TDTO-TMS for −20°C (−4°F) to 50°C (122°F).

Do not use SAE 50 oil viscosity grade in transmissions with “ICM” transmission control. Do not use SAE 50 oil viscosity grade for the winch cases with hydraulic drive.

Where recommended for use, Cat FDAO or commercial oil that meets Cat FD-1 are the preferred oil types in order to maximize gear life and bearing life. Do not use Cat FDAO or Cat FD-1 in compartments that contain clutches and/or brakes. Cat TDTO, Cat TDTO-TMS, or commercial oil that meets Cat TO-4 must be used in any compartment that contains friction material unless you are otherwise specified by Cat .

For the Final Drives in severe usage or in continuous operations, WARM-UP is required. Exercise the final drives for several minutes with the engine at a partial throttle in order to warm up the oil prior to production operation.

For hydraulic systems that are not given in Table 21 , refer to the hydraulic system recommendations given in Table 9 .

Table 21

Pipe Layers Lubricant Viscosities for Ambient Temperatures						
Compartment or System	**Oil Type and Performance Requirements**	**Oil Viscosities**	**°C**		**°F**	
			Min	**Max**	**Min**	**Max**
Power Shift Transmission and Winch	**Cat TDTO Cold Weather**	SAE 0W-20	−40	0	−40	32
	Cat TDTO	SAE 10W	−30	0	−22	32
		SAE 30(1)	−25	25	−13	77
		SAE 50	−15	50	5	122
	Cat TDTO-TMS	Multi-Grade	−15	50	5	122
PACCAR Winches	**Cat TDTO Cold Weather**	SAE 0W-20	-40	10	-40	50
Track Pins	**Cat Synthetic GO**	SAE 75W-140	−30	45	−22	113
	Cat GO (Gear Oil)	SAE 80W-90(1)	−20	40	−4	104
		SAE 85W-140	−10	50	14	122
	API GL-5 gear oil	SAE 75W-90	−30	40	−22	104
		SAE 90	0	40	32	104
The Recoil Spring for the Track Roller Frame and the Pivot Shaft Bearings	**Cat TDTO Cold Weather**	SAE 0W-20	−40	0	−40	32
	Cat TDTO	SAE 10W	−30	0	−22	32
		SAE 30(1)	−20	25	−4	77
		SAE 50	0	50	32	122
	Cat TDTO-TMS	Multi-Grade	−25	25	−13	77
Track Idlers and Track Rollers	**Cat DEO-ULS Cat DEO**	SAE 15W-40(1)	−10	50	14	122
	Cat DEO Cold Weather	SAE 0W-40	−40	40	−40	104
	Cat DEO-ULS SYN	SAE 5W-40	−35	40	-31	104
	Cat FDAO SYN	Multi-Grade	-30	50	-22	122
Final Drive(2)	**Cat FDAO**	SAE 60(1)	−7	50	19	122
	Cat TDTO	SAE 50(3)	−15	32	5	90
		SAE 30	−25	15	−13	59
	Cat TDTO-TMS	Multi-Grade	−35	15	−31	59
	Cat FDAO SYN	Multi-Grade	-15	50	5	122

(1) Factory fill oil for standard configuration machines.
(2) These recommendations apply to moderate use or intermittent operation. For severe usage or continuos operation (multiple shifts), follow the severe application recommendations for Track Type Tractors final drives located in Table 25 .
(3) Factory fill for PL61 standard configuration machine.

Skid Steer Loaders

Refer to the “General Information for Lubricants” article for important lubricant information.

This section includes, but not limited to the following models:

- 216 through 299

For hydraulic systems that are not given in Table 22 , refer to the hydraulic system recommendations given in Table 9 .

Table 22

Skid Steer Lubricant Viscosities for Ambient Temperatures						
Compartment or System	**Oil Type and Performance Requirements**	**Oil Viscosities**	**°C**		**°F**	
			Min	**Max**	**Min**	**Max**
Track Idlers and Track Rollers for Compact Track Loaders	**Cat DEO-ULS Cat DEO**	**SAE 15W-40(1)**	**−10**	**50**	**14**	**122**
	Cat DEO Cold Weather	**SAE 0W-40**	**−40**	**40**	**−40**	**104**
	Cat DEO-ULS SYN	**SAE 5W-40**	**−35**	**40**	**-31**	**104**
	Cat FDAO SYN	**Multi-Grade**	**-30**	**50**	**-22**	**122**
Final Drive for Multi Terrain Loaders and Compact Track Loaders	**Cat Synthetic GO**	SAE 75W-140	−30	45	−22	113

(1) Factory fill oil for standard configuration machines.

Telehandler

Refer to the “General Information for Lubricants” article for important lubricant information.

This section includes, but not limited to the following models of Telehandlers:

- TH255 through TH514
- TL642 through TL1255

Table 23

Telehandlers Lubricant Viscosities for Ambient Temperatures						
Compartment or System	**Oil Type and Performance Requirements**	**Oil Viscosities**	**°C**		**°F**	
			Min	**Max**	**Min**	**Max**
Hydraulic System, Service Brake System, Transmission, Differentials, and Front Drives for TH220, TH225, TH330, TH360 . and Hydraulic systems for TH336, TH337, TH406, TH407, TH414, TH417, TH514, TL642, TL943, TL1055, and TL1255 .	**Cat TDTO Cold Weather**	SAE 0W-20	−40	40	−40	104
	Cat TDTO	SAE 10W(1)	−20	40	−4	104
		SAE 30	10	50	50	122
	Cat TDTO-TMS	Multi-Grade	−20	50	−4	122
	Cat DEO-ULS Cat DEO	SAE 15W-40	−15	50	5	122
		SAE 10W-30	-20	40	-4	104
	Cat DEO-ULS SYN	SAE 5W-40	−30	40	-22	104
	Cat ECF-1-a Cat ECF-2 Cat ECF-3	SAE 5W-30	-30	40	-22	104
Axles differentials and Wheel Ends for TH336 through TH514, TL642C, and TL943C .	**Cat TDTO**	SAE 30	-20	40	-4	104
Axles differentials and Wheel Ends for TL642, TL943, TL1055, and TL1255 . (Except for the C Series)	**Cat Synthetic GO**	SAE 75W-140	−30	45	−22	113
	Cat GO (Gear Oil)	SAE 80W-90(1)	-23	49	−10	120
		SAE 85W-140	−12	59	10	120
	Cat TDTO-TMS	Multi-Grade	−20	50	−4	122

(continued)

(Table 23, contd)

Telehandlers Lubricant Viscosities for Ambient Temperatures						
Compartment or System	Oil Type and Performance Requirements	Oil Viscosities	°C		°F	
			Min	Max	Min	Max
Transmission and Transfer Case for TL642, TL943, TL1055, and TL1255	Cat MTO	SAE 10W-30[2]	-23	40	-10	104
	Cat TDTO Cold Weather	SAE 0W-20	-40	35	-40	95
	Cat TDTO	SAE 10W[3]	-20	35	-4	95
		SAE 30	25	50	77	122
		SAE 50	10	50	50	122
	Cat TDTO-TMS	Multi-Grade	10	50	50	122
	Cat ATF Dexron or Mercon ATF	Multi-Grade Synthetic	-42	-1	-40	14
Transmission and Transfer Case for TH406, TH407, TH514/417, TH336, and TH337	Cat TDTO Cold Weather	SAE 0W-20	−40	35	−40	95
	Cat TDTO	SAE 10W[1]	−20	35	−4	95
		SAE 30	25	50	77	122
		SAE 50	10	50	50	122
	Cat TDTO-TMS	Multi-Grade	10	50	50	122

(1) Factory fill oil for standard configuration machines and dealer service.
(2) Factory fill oil for standard configuration machines.
(3) Dealer service fill.

Track Loaders

Refer to the “General Information for Lubricants” article for important lubricant information.

This section includes, but not limited to the following models:

- 933 through 973

For hydraulic systems that are not given in Table 24 , refer to the hydraulic system recommendations given in Table 9 .

Table 24

Track Loaders Lubricant Viscosities for Ambient Temperatures						
Compartment or System	Oil Type and Performance Requirements	Oil Viscosities	°C		°F	
			Min	Max	Min	Max
Final Drive	Cat TDTO Cold Weather	SAE 0W-20	−40	0	−40	32
	Cat TDTO	SAE 10W	−30	0	−22	32
		SAE 30[1]	−25	25	−13	77
		SAE 50	−15	50	5	122
	Cat TDTO-TMS	Multi-Grade	−30	25	−22	77
Equalizer Bar End and Pin Joint	Cat Synthetic GO	SAE 75W-140	−30	45	−22	113
	Cat GO (Gear Oil)	SAE 80W-90[1]	−20	40	−4	104
		SAE 85W-140	−10	50	14	122

(continued)

(Table 24, contd)

Track Loaders Lubricant Viscosities for Ambient Temperatures						
Compartment or System	Oil Type and Performance Requirements	Oil Viscosities	°C		°F	
			Min	Max	Min	Max
	API GL-5 gear oil	SAE 75W-90	−30	40	−22	104
		SAE 90	0	40	32	104
Track Roller Frame Recoil Spring and the Pivot Shaft Bearings	**Cat TDTO Cold Weather**	SAE 0W-20	−40	0	−40	32
	Cat TDTO	SAE 10W	−30	0	−22	32
		SAE 30(1)	−20	25	−4	77
		SAE 50	0	50	32	122
	Cat TDTO-TMS	Multi-Grade	−25	25	−13	77
Track Idlers and Track Rollers	**Cat DEO-ULS Cat DEO**	SAE 15W-40(1)	−10	50	14	122
	Cat DEO Cold Weather	SAE 0W-40	−40	40	−40	104
	Cat DEO-ULS SYN	SAE 5W-40	−35	40	-31	104
	Cat FDAO SYN	Multi-Grade	-30	50	-22	122

(1) Factory fill oil for standard configuration machines.

Track Type Tractors

Refer to the “General Information for Lubricants” article for important lubricant information.

This section includes, but not limited to the following models:

- D3 through D11

Where recommended for use, Cat FDAO SYN Cat FDAO or commercial oil that meets Cat FD-1 are the preferred oil types to maximize gear life and bearing life. Do not use Cat FDAO, Cat FDAO SYN, or Cat FD-1 in compartments containing clutches and/or brakes. Cat TDTO, Cat TDTO-TMS, or commercial oil that meets Cat TO-4 oil types must be used in any compartment containing friction material unless specified otherwise by Cat .

For the Final Drives in severe usage or in continuous operations, WARM-UP is required. Exercise the final drives for several minutes with the engine at a partial throttle in order to warm up the oil prior to production operation.

For hydraulic systems that are not given in Table 25 , refer to the hydraulic system recommendations given in Table 9 .

Table 25

Track Type Tractors Lubricant Viscosities for Ambient Temperatures							
Compartment or System	**Application**	**Oil Type and Performance Requirements**	**Oil Viscosities**	**°C**		**°F**	
				Min	**Max**	**Min**	**Max**
Power Shift Transmissions	Normal	Cat TDTO Cold Weather	SAE 0W-20	−40	10	−40	50
		Cat TDTO	SAE 10W	−20	10	−4	50
			SAE 30(1)	0	35	32	95
			SAE 50	10	50	50	122
		Cat TDTO-TMS	Multi-grade	−15	43	−5	110
Final Drive for D7E and Elevated Track Type Tractors (Except the D5M, D5N, D6M, and D6N)	Moderate Usage or Intermittent Operation	Cat FDAO	SAE 60(1)	−7	50	19	122
		Cat TDTO	SAE 50	−15	32	5	90
			SAE 30	−25	15	−13	59
		Cat TDTO-TMS	Multi-grade	−35	15	−31	59
		Cat FDAO SYN	Multi-grade	−15	50	5	122
	Severe Usage or Continuous Operation (Multiple Shifts)	Cat FDAO	SAE 60(1)	−25	50	−13	122
		Cat TDTO	SAE 50	−33	14	−27	58
			SAE 30	−40	0	−40	32
		Cat TDTO-TMS	Multi-Grade	−40	0	−40	32
		Cat FDAO SYN	Multi-Grade	−33	50	−27	122
Final Drive (Differential Gear Boxes) Oval Track Type Tractors (Including the D5M, D5N, D6M, and D6N)(Except the D7E)	Normal	Cat TDTO Cold Weather	SAE 0W-20	-40	0	-40	32
		Cat TDTO	SAE 10W	-30	0	-22	32
			SAE 30	-25	25	-13	77
			SAE 50(1)	-15	50	5	122

(1) Factory fill oil for standard configuration machines.

Track Type Tractors Special Applications

Table 26

Special Track Type Tractors Lubricant Viscosities for Ambient Temperatures							
Compartment or System	**Application**	**Oil Type and Performance Requirements**	**Oil Viscosities**	**°C**		**°F**	
				Min	**Max**	**Min**	**Max**
End Pin Joints for the Equalizer Bar, Bogie Cartridge Pins, and Track Pins	Normal	Cat Synthetic GO	SAE 75W-140	−30	45	−22	113
		Cat GO	SAE 80W-90(1)	−20	40	−4	104
			SAE 85W-140	−10	50	14	122
		API GL-5 Gear Oil	SAE 75W-90	-30	40	-22	104
Winches (hydraulic drive)	Normal	Cat TDTO Cold Weather	SAE 0W-20	−40	0	−40	32
		Cat TDTO	SAE 10W	−20	10	−4	50
			SAE 30(1)	0	43	32	110
		Cat TDTO-TMS	Multi-Grade	−10	35	14	95
Track Roller Frame Recoil Spring Pivot Shaft Bearings	Normal	Cat TDTO Cold Weather	SAE 0W-20	−40	0	−40	32
		Cat TDTO	SAE 10W	−30	0	−22	32
			SAE 30(1)	−20	25	−4	77
			SAE 50	0	50	32	122
		Cat TDTO-TMS	Multi-Grade	−25	25	−13	77
Track Idlers and Track Rollers	Normal	Cat DEO-ULS Cat DEO	SAE 15W-40(1)	-10	50	58	122
		Cat DEO Cold Weather	SAE 0W-40	−40	40	−40	104
		Cat DEO-ULS SYN	SAE 5W-40	−35	40	−31	104
		Cat FDAO SYN (2)	Multi-Grade	-30	50	-22	122
Variable Pitch Fan	Normal	Cat DEO Cold Weather	SAE 0W-40	−40	40	−40	104
		Cat DEO-ULS SYN	SAE 5W-40	−40	50	−40	122

(1) Factory fill oil for standard configuration machines.
(2) Cat FDAO SYN is required for D11 track idlers.

Underground Mining Equipment

Refer to the “General Information for Lubricants” article for important lubricant information.

This section includes, but not limited to the following models:

- AD30 through AD55
- AE40
- R1300 through R3000

For hydraulic systems that are not given in Table 27 , refer to the hydraulic system recommendations given in Table 9 .

Table 27

Underground Mining Equipment Lubricant Viscosities for Ambient Temperatures						
Compartment or System	**Oil Type and Performance Requirements**	**Oil Viscosities**	**°C**		**°F**	
			Min	**Max**	**Min**	**Max**
Power Shift Transmission	**Cat TDTO Cold Weather**	SAE 0W-20	−40	10	−40	50
	Cat TDTO	SAE 10W	−20	10	−4	50
		SAE 30(1)	0	35	32	95
		SAE 50	10	50	50	122
	Cat TDTO-TMS	Multi-Grade	−15	43	−5	110
Hoist, Torque Converter and Brake System AD45 and AE40	**Cat TDTO Cold Weather**	SAE 0W-20	−40	40	−40	104
	Cat TDTO	SAE 10W	−20	50	−4	122
		SAE 30(1)	-15	50	5	122
Drive Axles AD30 - AD60, and AE40	Cat FD-1	SAE 50	−10	32	14	90
	Cat FDAO	SAE 60(1)	-10	50	14	122
	Cat FDAO SYN	Multi-Grade	-10	50	14	122
Drive Axles Load Haul Dumps R1300 - R3000(2)	**Cat TDTO**	SAE 30	−20	20	−4	68
		SAE 50(1)	−10	43	14	110
	Cat TDTO-TMS	Multi-Grade	−15	22	−5	72

(1) Factory fill oil for standard configuration machines.
(2) R2900 uses SAE 50 fluid if equipped with axle oil cooling.

Wheel Excavators and Wheel Material Handlers

Refer to the “General Information for Lubricants” article for important lubricant information.

This section includes, but not limited to the following models of Wheel Excavators and Wheel Material Handlers:

- M312 through M325

With exception to the hydraulic drive winch gear case, use SAE 30 viscosity grade for 0°C (32°F) to 43°C (110°F) or Cat TDTO-TMS for −20°C (-4°F) to 50°C (122°F).

Do not use SAE 50 viscosity grade oil in ICM controlled transmissions. Do not use SAE 50 viscosity grade oil for the hydraulic drive winch case.

For hydraulic systems that are not given in Table 28 , refer to the hydraulic system recommendations given in Table 9 .

Table 28

Wheel Excavators and Wheel Material Handler Lubricant Viscosities for Ambient Temperatures						
Compartment or System	**Oil Type and Performance Requirements**	**Oil Viscosities**	**°C**		**°F**	
			Min	**Max**	**Min**	**Max**

(continued)

(Table 28, contd)

Swing Drives for M325C MH, M325C L MH, M325D MH and M325D L MH	**Cat TDTO Cold Weather**	SAE 0W-20	−40	0	−40	32
	Cat TDTO	SAE 10W	−30	0	−22	32
		SAE 30[1]	-25	25	-13	77
		SAE 50	-15	50	5	122
	Cat TDTO-TMS	Multi-Grade	−25	25	−13	77
Final Drive and Axle for M300A Series, M300C Series with Serial numbers 1 through 2000, M325C MH, M325C L MH, M325D MH and M325D L MH [2]	**Cat Synthetic GO**	SAE 75W-140	−30	45	−22	113
	Cat GO (Gear Oil)	SAE 80W-90[1]	−20	40	−4	104
		SAE 85W-140	−10	50	14	122
	API GL-5 gear oil	SAE 75W-90	−30	40	−22	104
		SAE 90	0	40	32	104
Final Drive and Axle for M300A Series, M300C Series, M300D Series, M325C MH, M325C L MH, M325D MH, and M325D L MH	**Cat MTO commercial M2C 134-D**	SAE 10W-30	−25	40	−13	104
Transmission	**Cat TDTO Cold Weather**	SAE 0W-20	−40	0	−40	32
	Cat TDTO	SAE 10W	−20	10	−4	50
		SAE 30	0	35	32	95
		SAE 50	10	50	50	122
	Cat TDTO-TMS	Multi-Grade	−15	43	5	110

[1] Factory fill oil for standard configuration machines.
[2] All models require the use of limited slip additive, Cat 197-0017, Refer to the machine Operation and Maintenance Manual.

Wheel Loaders, Integrated Toolcarriers, Wheeled Dozers, and Compactors

Refer to the “General Information for Lubricants” article for important lubricant information.

This section includes Wheel Loaders and Integrated Toolcarriers, but not limited to the following models:

- 902 through 994
- IT14 through IT62

This section includes Wheeled Dozers and Compactors, but not limited to the following models:

- 814 through 854
- 816 through 836
- 815 through 825

Except for machines that are equipped with a hydraulic drive winch gear case. Use SAE 30 viscosity grade for 0°C (32°F) to 43°C (110°F) or Cat TDTO-TMS for −20°C (-4°F) to 50°C (122°F).

When you are operating the machine in temperatures below −20°C (−4°F), refer to Special Publication, SEBU5898, Cold Weather Recommendations. This publication is available from your Cat dealer.

Except for machines that are equipped with ICM controlled transmissions. Do not use SAE 50 viscosity grade oil in ICM controlled transmissions.

Wheel Loaders, Integrated Toolcarriers, Wheeled Dozers, and Compactors require the use of oil additives 1U-9891 and 185-4771 for axles that have a wet disc and axle shaft speed brakes. Refer to Special Lubricants for more information.

For hydraulic systems that are not given in Table 29 , refer to the hydraulic system recommendations given in Table 9 .

Table 29

Wheel Loaders, Integrated Toolcarriers, Wheeled Dozers, and Compactors Lubricant Viscosities for Ambient Temperatures						
Compartment or System	**Oil Type and Performance Requirements**	**Oil Viscosities**	**°C**		**°F**	
			Min	**Max**	**Min**	**Max**
Power Shift Transmission	**Cat TDTO Cold Weather**	SAE 0W-20	−40	0	−40	32
	Cat TDTO	SAE 10W	−20	10	−4	50
		SAE 30(1)	0	35	32	95
		SAE 50	10	50	50	122
	Cat TDTO-TMS	Multi-Grade	−15	43	5	110
Final Drive, Differential, and Transfer Drive for 902, 906 and 908 Compact Wheel Loaders	**Cat TDTO**	SAE 30(1)	−20	43	−4	110
Final Drive, Differential, and Transfer Drive for 904 Compact Wheel Loaders	**Cat Synthetic GO**	SAE 75W-140	−30	45	−22	113
	Cat GO (Gear Oil)	SAE 80W-90(1)	−20	40	−4	104
		SAE 85W-140	−10	50	14	122
	Commercial API GL-5	SAE 75W-90	−30	40	−22	104
		SAE 90	0	40	32	104
Final Drive, Differential, and Transfer Drive for Compact Wheel loaders, 910-914 (Except for 914G2)	**Cat TDTO Cold Weather**	SAE 0W-20	−40	0	−40	32
	Cat TDTO	SAE 10W	−25	15	−13	59
		SAE 30(1)	-20	43	-4	110
		SAE 50	10	50	50	122
	Cat TDTO-TMS	Multi-Grade	−30	43	-22	110
Drive Axles for 914 G2 Compact Wheel Loaders	**Cat MTO API GL-4**	SAE 10W-30	-40	40	-40	104
Drive Axles for Small Wheel Loaders (924-938, except for 938K) Medium Wheel Loaders (950-980) IT12-IT62 Machines Small and Medium Wheel Dozers (814, 824) Medium Compactors (815-826)	**Cat TDTO Cold Weather**	SAE 0W-20	−40	-0	−40	32
	Cat TDTO	SAE 10W	−25	15	−4	59
		SAE 30(1) (2)	−20	43	−4	95
		SAE 50(1) (3)	10	50	50	122
	Cat TDTO-TMS	Multi-Grade	−25	43	−13	110
Drive Axles for 938K	**Cat MTO**	SAE 10W-30	-25	40	-13	104
Drive Axles for Large Wheel Loaders (988-993), Large Wheel Dozers (834-854), and Large Compactors (836)	**Cat TDTO Cold Weather**	SAE 0W-20	−40	-10	−40	14
	Cat TDTO	SAE 10W	−25	0	−4	32
		SAE 30	-20	20	-4	68
		SAE 50(1)	-10	50	14	122
	Cat TDTO-TMS	Multi-Grade	−25	22	−13	72
Drive Axles for 994 Wheel Loader	**Cat TDTO**	SAE 10W	−25	0	−13	32
		SAE 30	−20	20	−4	68
		SAE 50(4)	−10	43	14	110
	Cat TDTO-TMS	Multi-Grade	−25	22	−13	72

(continued)

(Table 29, contd)

(1) Factory fill oil for standard configuration machines.
(2) Cat TDTO SAE 30 is factory fill for standard configuration Medium Wheel Loaders (950-980) and Medium Wheel Dozer (824).
(3) Cat TDTO SAE 50 is factory fill for standard configuration Small Wheel Dozer (814) and Medium Compactors (815-826).
(4) Dealer service fill for standard configuration machines.

Special Applications for 906, 907, 908

Table 30

Compact Wheel Loaders Lubricant Viscosities for Ambient Temperatures						
Compartment or System	Oil Type and Performance Requirements	Oil Viscosities	°C		°F	
			Min	Max	Min	Max
Brakes on Standard Drive	Cat HYDO Advanced 10	SAE 10W	−20	40	−4	104

Table 31

Special Additive Requirement for Axles on Wheel Loaders, IT machines, Wheel Dozers, and Compactors	
Required Volume of 1U-9891 Oil Additive or 185-4771 Oil Additive for axles that have Wet Disc, Axle Shaft Speed Brakes (1)	
Machine Model	Number of bottles per axle
All Compact and Small (910-930) Wheel Loaders IT28-IT62 Integrated Tool Carriers 938-962Wheel Loaders	0.5
966F, 970F, 966G, and 972GWheel Loaders 815 and 816Compactors 814Wheel Dozers	1.0
980F, 980G, and 980HWheel Loaders 824G and 824HWheel Dozers 825G, 825H, 826G, and 826HCompactors	1.5
988FII, 988G, and 988HWheel Loaders 834B, 834G, and 834HWheel Dozers 836, 836G, and 836HCompactors	3
990Series IIWheel Loaders 844Wheel Dozers	4
992GWheel Loaders 854GWheel Dozers 854KWheel Dozers	5
993KWheel Loaders	7

(1) Do not use 1U-9891Oil Additive in brake compartments when the service brake is also used as the parking brake unless specifically recommended by Caterpillar .

Wheel Tractor-Scrapers

Refer to the “General Information for Lubricants” article for important lubricant information.

This section includes, but not limited to the following models:

- 611 through 657
- TS180 through TS225

Except for the hydraulic drive winch gear case. Use SAE 30 viscosity grade for 0 °C (32 °F) to 43 °C (110 °F) or Cat TDTO-TMS for −20 °C (−4 °F) to 50 °C (122 °F).

Do not use SAE 50 viscosity grade oil in ICM controlled transmissions. Do not use SAE 50 viscosity grade oil for the hydraulic drive winch case.

Where recommended for use, Cat TDTO SAE 50 or commercial oil that meets Cat TO-4 SAE 50 is preferred in most applications, particularly continuous operation. If the ambient temperature is below −15 °C (5 °F), warm up the oil prior to operation. The oil must be maintained to a temperature above −15 °C (5 °F) during operation. If the ambient temperature is below −15 °C (5 °F), perform the procedures in the Operation and Maintenance Manual, “Engine and Machine Warm-Up” prior to operation. If the ambient temperature is below −25 °C (−13 °F), consult your Cat dealer for instructions. Failure to warm up the oil prior to operation will damage the machine.

For hydraulic systems that are not given in Table 32 , refer to the hydraulic system recommendations given in Table 9 .

Table 32

Wheel Tractor-Scrapers Lubricant Viscosities for Ambient Temperatures						
Compartment or System	Oil Type and Performance Requirements	Oil Viscosities	°C		°F	
			Min	Max	Min	Max
Transmission	Cat TDTO Cold Weather	SAE 0W-20	−40	0	−40	32
	Cat TDTO	SAE 10W	−20	10	−4	50
		SAE 30(1)	0	35	32	95
		SAE 50	10	50	50	122
	Cat TDTO-TMS	Multi-Grade	−20	50	−4	122
Nondriven Scraper Wheels except for 613G (2)	Cat FDAO	SAE 60(1)	−7	50	19	122
	Cat FD-1	SAE 50	−15	32	5	90
	Cat TDTO	SAE 30	−25	15	−13	59
	Cat FDAO SYN	Multi-Grade	−15	50	5	122
	Cat TDTO-TMS	Multi-Grade	−35	15	−31	122
Nondriven Scraper Wheels for 613G	Cat Multipurpose Grease	NLGI 2	−30	40	−22	104
Nondriven Scraper Wheels (Towed Scrapers)	Cat Synthetic GO	SAE 75W-140	−30	45	−22	113
	Cat GO (Gear Oil)	SAE 80W-90(1)	−20	40	−4	104
		SAE 85W-140	−10	50	14	122
	API GL-5 gear oil	SAE 75W-90	−30	40	−22	104
		SAE 90	0	40	32	104
Differentials and Final Drives, Auger Lower Bearings, Auger, and Elevator Speed Reducers	Cat Synthetic GO	SAE 75W-140	−30	45	−22	113
	Cat GO (Gear Oil)	SAE 80W-90(1)	−20	40	−4	104
		SAE 85W-140	−10	50	14	122
	API GL-5 gear oil	SAE 75W-90	−30	40	−22	104
		SAE 90	0	40	32	104
Brake Circulation for 620H Series	Cat TDTO Cold Weather	SAE 0W-20	-40	40	-40	104
	Cat TDTO	SAE 10W(1)	-20	50	-4	122
Elevator Lower Rollers	Cat DEO Cold Weather	SAE 0W-40	−40	40	−40	104
	Cat DEO-ULS Cat DEO	SAE 15W-40	−10	50	14	122

(1) Factory fill oil for standard configuration machines.
(2) Non Driven scraper wheels (except for 613G) can also use the gear oils listed under Differentials and Final Drives in this table.

Petroleum Transmissions

Refer to the “General Information for Lubricants” article for important lubricant information.

This section includes, but not limited to the following models:

- TH31-E61 through TH55-E90
- CX31-P600
- CX35-P800

For hydraulic systems that are not given in Table 33 , refer to the hydraulic system recommendations given in Table 9 .

Table 33

Petroleum Transmissions Lubricant Viscosities for Ambient Temperatures						
Compartment or System	Oil Type and Performance Requirements	Oil Viscosities	°C		°F	
			Min	Max	Min	Max
Petroleum Transmissions TH48-E70, TH48-E80, TH55-E70, and TH55-E90	Cat TDTO Cold Weather	SAE 0W-20	−40	10	−40	50
	Cat TDTO	SAE 10W	−20	10	−4	50
		SAE 30(1)	0	50	32	122
	Cat TDTO-TMS	Multi-Grade	−10	50	14	122
Petroleum Transmissions TH31-E61and TH35-E81	Cat TDTO Cold Weather	SAE 0W-20	−40	22	−40	72
	Cat TDTO	SAE 10W	−20	22	−4	72
		SAE 30(1)	10	50	50	122
	Cat TDTO-TMS	Multi-Grade	−15	50	5	122

(1) Factory fill oil for standard configuration machines.

On-Highway Transmissions

Refer to the “General Information for Lubricants” article for important lubricant information.

This section includes the following models:

- CX28, CX31 and CX35

Cat CX Series transmissions are used in both on and off-highway.

Typical on-highway applications include: line haul, pickup and delivery, beverage delivery, public service dump, emergency vehicles, and recreational vehicles with living accommodations.

Typical off-highway applications include: dump trucks, transit mixers, refuse trucks, all wheel drive public utility trucks, yard spotters, concrete pumpers, heavy equipment transport, and specialty PTO applications.

Fluid change intervals for Standard Cat CX Series transmissions and Standard and Retarder Cat CX Series transmissions are different. Refer to the Operation and Maintenance Manual for your transmission or consult your Cat dealer for details.

Fluid change intervals for severe applications are shorter than fluid change intervals for general applications. Refer to the Operation and Maintenance Manual for your transmission or consult your Cat dealer for details.

Table 34

On-Highway Transmissions Lubricant Viscosities for Ambient Temperatures						
Compartment or System	Oil Type and Performance Requirements	Oil Viscosities	°C		°F	
			Min	Max	Min	Max
On-Highway Transmissions CX28, CX31 and CX35	Cat ATF-HD (1) (2)	Multi-Grade Synthetic	−23	45	−10	113

(1) For temperatures lower than −23° C (−10° F), warm up the engine for 20 minutes or use an appropriate transmission oil heater.
(2) Cat AT-1, Dexron III, Dexron IV, and Dexron VI specifications define the minimum requirements for alternative commercial oils for use in Cat CX series transmissions.

Special Applications

Refer to the “General Information for Lubricants” article for important lubricant information.

This section includes, but not limited to the special applications as they apply to Cat equipment.

Table 35

Special Applications Lubricant Viscosities for Ambient Temperatures						
Compartment or System	Oil Type and Performance Requirements	Oil Viscosities	°C		°F	
			Min	Max	Min	Max
Starting Engine	SH SJ SL	SAE 0W-20	−40	40	−40	104
		SAE 0W-30	−40	40	−40	104
		SAE 5W-20	−30	10	−22	50
		SAE10W	−20	50	−4	122
Starting Engine Transmission	Cat TDTO Cold Weather	SAE 0W-20	−40	10	−40	50
	Cat DEO Cold Weather	SAE 0W-40	−40	40	−40	104
	Cat DEO-ULS SYN	SAE 5W-40	−40	50	−40	122
	Cat TO-4	SAE 5W-20	−30	10	−22	50
	Cat TDTO	SAE 10W	−30	20	−22	68
		SAE 30	−10	25	14	77
Variable Pitch Fan	Cat DEO Cold Weather	SAE 0W-40	−40	40	−40	104
	Cat DEO-ULS SYN	SAE 5W-40	−40	50	−40	122
Hydraulic Hammer	Cat HYDO Advanced 10	SAE 10W	−20	50	−4	122
	Cat HYDO Advanced 30	SAE 30	10	50	50	122
	Cat BIO HYDO Advanced	ISO 46 Multi-Grade	−40	40	−4	104
	Cat ECF-1-a, Cat ECF-2, Cat ECF-3, Cat TO-4	SAE 0W-30	−40	10	−40	50
	Cat DEO-ULS Cat DEO	SAE 15W-40	−15	50	5	122
	Cat MTO	SAE10W-30	−20	40	−4	104
	Cat TDTO-TMS	Multi-grade	−15	50	5	122
Bar and Chain Oil	Cat DEO Cold Weather	SAE 0W-40	−40	40	−40	104
	Cat DEO-ULS Cat DEO	SAE 10W-30	−18	40	0	104
		SAE 15W-40	−10	50	14	122

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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 in order 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 forward of this special publication.

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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.

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Aftermarket Oil Additives

SMCS Code: 1300; 1348; 7581

Caterpillar does not recommend the use of aftermarket additives in oil. It is not necessary to use aftermarket additives in order to achieve the machine's maximum service life or rated performance. 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 finished oils with 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's additive package, which could lower the performance of the finished oil. The aftermarket additive could fail to mix with the finished oil. This could produce sludge. Caterpillar discourages the use of aftermarket additives in finished oils.

To achieve the best performance from Caterpillar machines, conform to the following guidelines:

- Select the proper Caterpillar oil or select commercial oil that meets the specifications designated by Caterpillar for the compartment.
- See the appropriate “Lubricant Viscosities for Ambient Temperatures” table in this publication in order to find the correct oil viscosity grade for the machine compartment.
- At the specified interval, service the engine or service the other machine compartments. 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”.

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Specialty Lubricants

SMCS Code: 7000; 7581

Table 36

Special-Purpose Caterpillar Lubricants	
Item	**Size**
6V-4876 Lubricant(1)	500 g (17.6 oz)
5P-3931 Thread Compound(2)	150 g (5.3 oz)

(1) Recommended for use on typical components such as head bolt threads and washers.
(2) Recommended for mating connectors such as exhaust manifold studs and exhaust manifold nuts.

Table 37

UV Visible Dyes for Leak Detection[1]			
Part Number	**Description**	**Size**	**Dosage**
To detect oil leaks in engines, transmissions, hydraulic systems, etc.			
1U-5572	Oil Glo 22 Additive	28.4 gram (1 ounce) bottle	28.4 gram (1 ounce) per 7.58 L (2 US gal) of oil
1U-5573	Oil Glo 22 Additive	0.47 L (1 pint) bottle	28.4 gram (1 ounce) per 7.58 L (2 US gal) of oil
To detect fuel leaks or suspected fuel dilution			
1U-5574	Gas Glo 32 Additive	28.4 gram (1 ounce) bottle	28.4 gram (1 ounce) per 37.9 L (10 US gal) of gasoline or diesel fuel
1U-5575	Gas Glo 32 Additive	0.47 L (1 pint) bottle	28.4 gram (1 ounce) per 37.9 L (10 US gal) of gasoline or diesel fuel
To detect cooling system leaks			
1U-5576	Water Glo 23 Additive	28.4 gram (1 ounce) bottle	28.4 gram (1 ounce) per 151.5 L (40 US gal) of water
1U-5577	Water Glo 23 Additive	0.47 L (1 pint) bottle	28.4 gram (1 ounce) per 151.5 L (40 US gal) of water

(1) UV visible dyes must be used with a special glo gun in order to detect leaks. Consult your Cat dealer for availability.

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Dry Brake Shoe Applications

SMCS Code: 4250-OC; 7579; 7581

This publication is a supplement to the machine Operation and Maintenance Manuals. This publication does not replace the Operation and Maintenance Manuals that are specific to the machine.

Note: In machine applications where U.S. Department Of Transportation (DOT) specification brake circuit actuation fluids are required, refer to the machine specific Operation and Maintenance Manual for fluid type and usage recommendations.

Note: DOT-3, DOT-4, and DOT-5.1 fluids are glycol based. DOT-5 fluids are silicone based.

NOTICE

DOT-3, DOT-4, DOT-5.1, or DOT-5 fluids are not compatible with petroleum based products.

Do not mix DOT-3, DOT-4, and DOT-5.1 with DOT-5 fluids.

Do not use DOT-3, DOT-4, DOT-5.1, or DOT-5 brake circuit actuation fluids in compartments that contain friction material or wet brake systems.

Do not use DOT-3, DOT-4, DOT-5.1, or DOT-5 brake circuit actuation fluids in compartments where hydraulic oil or TO-4 fluids are recommended.

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Dry Film Lubricant

SMCS Code: 7581

222-3116 Dry Film Lubricant has the following characteristics: superior lubricity, excellent adhesion to most surfaces, fast dry times and easy application.

The dry lubricant can be used for the following applications: backhoe extendable stick, blade circles for motor graders, shift mechanisms, masts for lift trucks, slides that require frequent lubrication, locks that have tumblers and applications that require a press fit. This lubricant is recommended for use on the Compact Wheel Loaders . Use the dry film lubricant for the following applications: all moving door latches, hinges, door locks, lock for the hood, hinges for the hood and throttle pedal linkage.

Use this lubricant in a well ventilated area.

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Cold Weather Lubricants

SMCS Code: 1300; 1348; 7581

Engine

NOTICE
Recommended compartment warm-up procedure must be followed. Refer to the machine Operation and Maintenance Manual. Also refer to the relevant "Lubricant Viscosities for Ambient Temperatures" tables footnotes in this Special Publication and to the "Warm-up Procedures for Machines that are used in Cold Weather - (Generic)" topic 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 type and/or specification, refer to this Special Publication, "Engine Oil" section. Also, refer to the relevant "Lubricant Viscosities for Ambient Temperatures" tables in this Special Publication.

For the proper selection of oil viscosity grade, refer to the relevant "Lubricant Viscosities for Ambient Temperatures" table in this Special Publication. Also, refer to this Special Publication, "Lubricant Viscosities" article.

NOTICE
Not following the recommendations found in the "Lubricant Viscosities for Ambient Temperatures" tables 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 need to be the proper size 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" (Maintenance 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. Evaporation will 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 oil performance, and reduce the engine protection that the additives provide. If your machine is equipped with a gasoline starting engine (earlier machine), make sure that the oil is fluid enough to flow.

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 a synthetic basestock multigrade oil. The oil should have a lubricant viscosity grade of SAE 0W or SAE 5W. Use an 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 "Lubricant Viscosities for Ambient Temperatures", use the viscosity grade that is specified in the table. **In arctic applications, a properly sized engine compartment heater is recommended and use 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 becomes 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 when you start the engine **BUT,** under **Continuous Usage (Multiple Shifts/Day),** and/or when using **fluid or pan heaters**, etc., use a higher viscosity oil, **NOT** the oil with 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 Caterpillar diesel engines for cold-soaked starts at −40 °C (−40 °F) is multigrade oil of the SAE 0W viscosity grade (SAE 0W-30, etc.). 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.

Non-Engine Machine Compartments

NOTICE

Recommended compartment warm-up procedure must be followed. Refer to the machine Operation and Maintenance Manual. Also refer to the relevant “Lubricant Viscosities for Ambient Temperatures” tables footnotes in this Special Publication and to the “Warm-up Procedures for Machines that are used in Cold Weather - (Generic)” topic in this Special Publication.

For the proper selection of oil type and/or specification, refer to this Special Publication, “Lubricant Specifications” section. Also, refer to the relevant “Lubricant Viscosities for Ambient Temperatures” tables (Oil Type and Specification column) and table footnotes in this Special Publication.

For the proper selection of oil viscosity grade, refer to this Special Publication, “Lubricant Viscosities for Ambient Temperatures” tables. Also, refer to this Special Publication, “Lubricant Viscosities” article.

NOTICE

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

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.

Note: Use the highest oil viscosity grade that is allowed for the ambient temperature when you start the machine. If a different oil viscosity grade is specified in the “Lubricant Viscosities for Ambient Temperatures” table, use the viscosity grade that is specified in the table. **In arctic applications, a properly sized engine compartment heater is recommended and use 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 machine has not been operated for a time. The oil becomes more viscous due to cooler ambient temperatures.

NOTICE

Machines 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 when you start the machine **BUT,** under **Continuous Usage (Multiple Shifts/Day),** and/or when using **fluid or pan heaters**, etc., use a higher viscosity oil, **NOT** the oil with 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.

NOTICE
Some machine compartments do not allow the use of SAE 0W, SAE 5W or certain other viscosity grade oils. Refer to the tables for “Lubricant Viscosities for Ambient Temperatures” that are in this Special Publication.

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

NOTICE
Recommended compartment warm-up procedure must be followed. Refer to the machine Operation and Maintenance Manual. Also refer to the relevant “Lubricant Viscosities for Ambient Temperatures” tables footnotes in this Special Publication and to the “Warm-up Procedures for Machines that are used in Cold Weather - (Generic)” topic in this Special Publication.

Warm-Up Procedures for Machines that are used in Cold Weather (Generic)

Note: For recommendations that are specific to your machine, refer to the Operation and Maintenance Manual for your machine.

After the engine is warm, warm up the other systems. Start with the hydraulic system. Run the engine at less than one-third throttle and slowly move the control lever in order to lift the attachment. Initially, lift the control lever for a few centimeters (inches). Lower the attachment slowly. Continue the following sequence: raising, lowering, extending and retracting. Extend the travel during each cycle. Perform this operation for all hydraulic circuits. Alternate between all of the attachments.

Exercise the transmission and the power train. If you cannot move the control for the transmission, perform the following steps:

- Engage the parking brake or apply the parking brake.
- Run the engine slightly above LOW IDLE.
- Shift the transmission several times from FIRST GEAR FORWARD to FIRST REVERSE.

Release the brake. Move the equipment forward and backward for several meters (yards). Exercise the machine for several minutes.

In order to reduce the total warm-up time, start exercising the entire machine before you complete the hydraulic warm-up time.

Operate under a light load until the systems reach normal operating temperatures.

If the engine temperature is not high enough, enclose the engine and block the radiator. A thermostat that opens at a higher temperature will not increase the engine temperature if the engine is not under load.

In order to prevent seal damage and gasket damage, keep the pipe for the engine crankcase breather clear of blockage.

In extreme conditions, use a canvas over the engine compartment. Heat the engine area with a space heater. Heating will aid in starting the engine. Extending the canvas over the hydraulic components will provide initial warming of the components. **Follow all applicable safety guidelines.**

Running the engine at low idle will not keep the hydraulic systems warm.

cold-weather operations require more time for completion than other operations. The extra time that is spent in properly caring for the equipment can prolong the life of the equipment. Extra care is especially helpful in extreme conditions. Longer equipment life will decrease overall cost.

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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 Cat 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 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 analyst uses established guidelines or trend analysis to determine if the oil is no longer useable.

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 level of contamination that is allowed in the various compartments of a Cat machine.

Oil Identification is another important part of the S·O·S Oil Analysis program. The wrong oil in a compartment can severely damage major components. The S·O·S 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 Cat dealership should make the final analysis.

Oil analysis is one of the diagnostic tools to determine engine health. Oils that are within the limits given by the guidelines may not indicate all engine health issues. Under certain conditions, including, but not limited to severe operating conditions, oils that are within the limits given by the guidelines may require changing early.

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

Refer to the “Conamination Control” article in this Special Publication for recommended fluid cleanliness targets.

Table 38

S·O·S Oil Analysis Guidelines	
Test Parameter	**Guideline**
Oxidation	(1)
Soot	(1)
Sulfation	(1)
Wear Metals	Trend Analysis and Cat Wear Table norms (1)
Water	0.5% maximum
Glycol	0%
Fuel Dilution	based on viscosity (1) and GC(2) fuel dilution in excess of 4%
Viscosity - engines: ASTM D445 measured at 100° C (212° F)	+/-3 centistoke (cSt) change from new oil viscosity.
Viscosity - hydraulics & power train: ASTM D445 measured at 100° C (212° F)	+/-2 cSt change from new oil viscosity
Particle Count/ISO Code	Trend Analysis

(1) Acceptable values for this guideline parameter are proprietary to the S·O·S Oil Analysis program.
(2) Gas Chromatograph

Note: Most oil analysis programs do not detect larger particles in the oil sample. Some failure modes only produce larger particles. Oil analysis alone will not always detect an impending failure. Oil filters should be sectioned and inspected for the presence of visible particles.

The engine oil consumption must be measured and recorded. A significant increase in oil consumption can indicate a problem with cylinder pack deposits or components. Additionally, oil additions dilute wear metals and other contaminants. Oil analysis results may become inaccurate.

Consult your Cat 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 machine 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.

NOTICE
Always use a designated pump for oil sampling, and use a separate designated pump for coolant sampling. Using the same pump for both types of samples may contaminate the samples that are being drawn. This contaminate may cause a false analysis and an incorrect interpretation that could lead to concerns by both dealers and customers.

There are two 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 for pressurized oil systems.
- Use a sampling gun 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. Whenever you obtain the samples, obtain the samples from the same point. The samples will be more representative of the oil that is in the system.

Normally, the oil sample is taken at low idle. If the flow rate is too low, increase engine speed to obtain the oil sample.

In-line sampling valves cannot be used on nonpressurized oil systems such as differentials and final drives. Use of the sampling gun is the preferred method for nonpressurized oil systems.

Refer to the Operation and Maintenance Manual, “Maintenance Interval Schedule” for the proper interval.

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Oil Sampling Interval

SMCS Code: 1000; 3000; 4000; 4050; 4250; 4300; 5050; 7000; 7542

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 , establish a consistent trend of data. In order to establish a pertinent history of data, perform consistent oil samplings that are evenly spaced.

Refer to the Operation and Maintenance Manual that came with your machine for the recommended oil sampling intervals for each compartment. Severe applications may require a more frequent oil sampling interval.

For other acceptable oil types and specifications, refer to the “Lubricant Viscosities for Ambient Temperatures” Tables in this Special Publication.

For best results, engine oil samples should be taken at 250 hour intervals. A 250 hour sampling interval can provide a timely indication of oil contamination and oil degradation. Under certain conditions, the Caterpillar dealer or the Operation and Maintenance Manual may allow a longer interval between oil samplings.

Refer to the Operation and Maintenance Manual that came with your machine for the recommended oil change intervals for each compartment.

Table 39

Compartment	Recommended Sampling Interval	Sampling Valve	Oil Type
Engine	250 Hours	Yes	Cat DEO Cat DEO-ULS
Transmission	500 Hours	Yes	Cat TDTO Cat TDTO-TMS
Hydraulics	500 Hours	Yes	Cat HYDO Advanced
Differential and Final Drive	500 Hours	No	Cat TDTO Cat FDAO

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

Traditionally, S·O·S sampling intervals have been at 250 hours for engines and at 500 hours for all other compartments. However in severe service 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 125 hour intervals and sample the other compartments at 250 hour intervals. These additional samples will increase the chance of detecting a potential failure.

Determining Optimum Oil Change Intervals

Sampling the oils per the recommendations given in Table 39 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 by a trained analyst also allows you to obtain the maximum use of the oil. For detailed information on optimizing oil change intervals, consult your Cat dealer.

This Special Publication does not address recommended oil drain intervals, but rather provides guidance that should be used with your specific engine/machine Operation and Maintenance Manuals in determining acceptable oil drain intervals. Consult your engine/machine Operation and Maintenance Manuals, and consult your Caterpillar dealer for additional guidance, including but not limited to guidance on establishing optimized and/or acceptable oil drain intervals.

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

Standard oil drain intervals as published in the engine Operation and Maintenance Manuals are for typical applications:

- Using recommended oils
- Using good fuel
- Using recommended filters
- Using industry standard good maintenance practices
- Following maintenance intervals as published in the engine Operation and Maintenance Manuals

More severe applications may require shortened oil drain intervals, while less severe applications may allow for longer than standard oil drain intervals. High load factors (above 75%), particularly with high sulfur fuels, can contribute significantly to reducing oil drain intervals below standard oil drain intervals.

Consult your Caterpillar dealer regarding the testing that is required in establishing oil drain intervals that are optimized for your application.

In order to help protect your engine, and in order to help optimize oil drain intervals for engine applications and duty cycles, use Cat S·O·S Services oil analysis as follows:

- Recommended normally
- Very strongly recommended in order to determine oil drain intervals when operating on fuel with sulfur levels between 0.05% (500 ppm) and 0.5% (5000 ppm)
- Required in order to determine oil drain intervals when operating on fuel with sulfur levels that are above 0.5% (5000 ppm)

Note: Engine operating conditions play a key role in determining the effect that fuel sulfur will have on engine deposits and on engine wear. Consult your Caterpillar dealer for guidance when fuel sulfur levels are above 0.1% (1000 ppm).

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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 various greases that vary in performance from a moderate performance 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.

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 the products which barely meet the minimum performance requirements can be expected to produce the minimum parts life. False economy is being used if a grease is purchased with 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 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 special ultra fine technical grade. The maximum particle size of the Moly used in Cat greases is 5 microns. The typical median size of the Moly is 3 microns. 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.

Moderate Applications

Cat greases that are developed for moderate applications are made with a lithium complex thickener. This type of grease is applicable for moderate applications of medium loads and speeds. These greases are formulated to provide optimal performance for these applications.

Cat Multipurpose Grease

Cat Multipurpose 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 Multipurpose Grease is formulated for use in applications that have a low severity to a medium severity and moderate temperatures.

Cat Multipurpose Grease meets the NLGI certification of GC-LB.

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

Cat White Assembly Grease

Cat White Assembly Grease is an NLGI grade 2 grease. This grease is made with a petroleum base oil and a lithium complex thickener. 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 Advanced 3Moly Grease

Cat Advanced 3Moly Grease is an NLGI grade 2 grease. This grease is made with petroleum base oil and a lithium complex thickener. This grease also has 3% Molybdenum diSulfide (MoS_2 or “Moly”). Cat Advanced 3Moly Grease is formulated for use in applications with low severity to high severity at moderate temperatures. Cat Advanced 3Moly Grease is recommended for heavily loaded pin joints and high impact applications in machines such as track-type tractors, backhoe loaders and skid steer loaders .

Cat Advanced 3Moly Grease meets the NLGI certification of GC-LB.

Note: If the application calls for a multipurpose grease with molybdenum and Cat Advanced 3Moly Grease is not available, consult the data sheets for the greases. Use a substitute that meets or exceeds the performance characteristics of Cat Advanced 3Moly Grease.

Severe Applications

Caterpillar has greases which are made with a Calcium Sulfonate Complex thickener. This type of grease is necessary for more severe applications. These greases provide more load carrying (galling resistance), lower wear, longer working life, exceptional water washout, and resistance to corrosion.

Hammer Grease

Note: Refer to the Operation and Maintenance Manual for a particular hammer for recommendations that relate to greases for Cat Hammers.

Cat Ultra 5Moly Grease

Cat Ultra 5Moly Greases are available in NLGI grades 0, 1, and 2. Cat Ultra 5Moly Greases are made with special blends of petroleum base oils and a Calcium Sulfonate Complex thickener. These greases also have 5% Molybdenum diSulfide (MoS_2 or “Moly”) and added tackifier. Cat Ultra 5Moly Greases are specially formulated in order to protect all of the most heavily loaded joints in any Cat machine against galling, wear, and corrosion. This protection is sustained while work is being done in moderate temperatures and with wet working conditions or dry working conditions.

Cat Ultra 5Moly Greases are formulated with special blends of naphthenic petroleum base oils that have low pour points. Cat Ultra 5Moly Greases will pump at lower temperatures. The ability to pump Cat Ultra 5Moly Greases at lower temperatures means added insurance that all of the grease joints in the machine will be adequately lubricated even if the ambient temperature drops unexpectedly. The machine critical lubrication points rely on an automatic lubrication system for adequate lubrication.

A significant challenge exists in order to get grease to pump into the joints at low temperatures. Once the grease gets to the joint, the grease must have extremely high resistance to galling, wear, fretting, water washout, and corrosion in order to protect highly loaded joints adequately.

Even under severely loaded conditions, the grease should preferably have a long working life. In order to make greases that meet these greater demands, a Calcium Sulfonate Complex thickener with a properly blended naphthenic oil and/or a synthetic base oil is required. Caterpillar uses these ingredients in Cat Ultra 5Moly Greases.

Cat Ultra 5Moly Greases also have 5% Moly, instead of the 0% to 3% that is found in most other greases. This additional Moly greatly improves the ability of the grease to protect parts from damage in applications with severe impact (slamming).

Cat Ultra 5Moly Greases are also made to be extra tacky. In some applications, the film of grease must adhere to the vertical surfaces. An example of this application is swing gears for excavators. Many conventional greases do not have enough of the tacky characteristic in order to allow the grease to stay in place resulting in incomplete lubrication and premature wear or failure of components.

Cat Ultra 5Moly Grease exceeds the NLGI certification of GC-LB.

Note: If the application calls for Cat Ultra 5Moly Grease and Cat Ultra 5Moly Grease is not available, consult the data sheets for the grease. From these data sheets, use a substitute that meets the performance characteristics of Cat Ultra 5Moly Grease.

Cat Ultra 5Moly Grease is formulated not to contain lead, antimony, barium, zinc, phosphorous, or chlorine additives. Thus, when Cat Ultra 5Moly Greases are compared to many other types of grease, the Cat Ultra 5Moly Greases have low environmental impact.

Cat Desert Gold Grease

Cat Desert Gold Grease is formulated in order to protect the most severely loaded joints in Cat machines against galling, wear, and corrosion. This protection is sustained while work is being done at moderate temperatures to hot temperatures with wet conditions or dry conditions.

Cat Desert Gold Grease is an NLGI grade 2 grease. This grease is made with a synthetic base oil that has a high viscosity and a Calcium Sulfonate Complex thickener. This grease also has 5% Molybdenum diSulfide (MoS_2 or “Moly”) and tackifier.

As the temperature changes, Cat Desert Gold Grease will experience a minimal change in viscosity because the base is a synthetic oil. Because Cat Desert Gold Grease has a synthetic base oil with a high viscosity, Cat Desert Gold Grease maintains a thick lubricant film even at hot temperatures.

Cat Desert Gold Grease is made with a Calcium Sulfonate Complex thickener. Cat Desert Gold Grease provides the necessary protection against galling, wear, fretting, water washout, and corrosion. Cat Desert Gold Grease also has a long life. This grease will resist breakdown even when the application is under extremely heavy loads and with frequent oscillations. This protection is sustained while work is being done at moderate temperatures to hot temperatures with wet conditions or dry conditions.

Cat Desert Gold Grease has 5% molybdenum instead of the 0% to 3% that is found in most other greases. This additional molybdenum greatly improves the ability of the grease to protect parts from damage in applications with severe impact (slamming). In addition, the molybdenum in Cat Desert Gold Grease is a special grade.

Cat Desert Gold Grease is made to be extra tacky. In some applications, the film of grease must adhere to the vertical surfaces. An example of this application is swing gears for excavators. Many conventional greases do not have enough of the tackifier to allow the grease to stay in place resulting in incomplete lubrication and premature wear or failure of components. In addition, many of these conventional greases do not have the performance, particularly at high ambient temperatures, to protect the gear teeth in these applications adequately.

Cat Desert Gold Grease prevents galling and wear at hot temperatures under extremely severe loads and conditions. In moderate temperatures, Cat Desert Gold Grease can be used in those extremely severe applications if an improvement over Cat Ultra 5Moly Grease is desired.

Cat Desert Gold Grease can be used in applications that require the lubricant to last for long periods of time because this grease has an extremely high performance and long life.

Cat Desert Gold Grease exceeds the NLGI certification of GC-LB.

Note: If the application calls for Cat Desert Gold Grease and Cat Desert Gold Grease is not available, consult the data sheets for the grease. From these data sheets, use a substitute that meets the performance characteristics of Cat Desert Gold Grease. With consideration given to the application, Cat Ultra 5Moly Grease, or Cat Arctic Platinum Grease may perform adequately. However, the use of these greases may require a different schedule for lubrication.

Cat Desert Gold Grease is formulated not to contain lead, antimony, barium, zinc, phosphorous, or chlorine additives. Thus, when Cat Desert Gold Grease is compared to many other types of grease, the Cat Desert Gold Grease has low environmental impact.

Cat Arctic Platinum

Cat Arctic Platinum Grease is formulated to protect the most heavily loaded joints in Caterpillar machines against galling, wear, and corrosion. With dependence on the consistency of the grease, this protection is sustained, while work is being done in moderate temperatures and in temperatures that may reach a temperature of −50 °C (−58 °F). In addition, the conditions may be wet or dry. Cat Arctic Platinum Grease is available in NLGI grade 0.

Cat Arctic Platinum Grease is made with a synthetic base oil that has a low viscosity and a Calcium Sulfonate Complex thickener. The performance is enhanced with 5% Molybdenum diSulfide (MoS_2 or “Moly”) and tackifier.

Because the base oil is synthetic, Cat Arctic Platinum Grease has a minimal change in viscosity as the temperatures drop. Because the synthetic base oil has a low viscosity, the Cat Arctic Platinum Grease that is made with this base oil has a minimal change in viscosity and flows easily as the temperature drops. Cat Arctic Platinum Grease pumps easily at extremely low temperatures. In fact, Cat Arctic Platinum Grease NLGI grade 0 can be pumped through standard automatic lubrication systems that are machine mounted and at temperatures down to −50 °C (−58 °F). This means that the grease can be pumped through those long unheated lines and into the required joints.

Cat Arctic Platinum Grease is made with Calcium Sulfonate Complex thickener in order to provide the necessary protection against galling, wear, fretting, water washout, and corrosion.

Cat Arctic Platinum Grease performs well for long periods of time. This grease resists breakdown even with extremely heavy loads in applications with frequent oscillations. This grease provides protection that will be sustained in conditions that are wet or dry. Also, this grease will provide protection in moderate temperatures as well as extremely cold temperatures.

Cat Arctic Platinum Grease has 5% of molybdenum instead of 0% or 3% that is found in most of the other greases. This additional molybdenum greatly improves the ability of the grease in order to protect parts from damage in applications with severe impact (slamming).

Cat Arctic Platinum Grease is made to be extra tacky. In some applications, the film of grease must adhere to the vertical surfaces. An example of this application is swing gears for excavators. Many conventional greases do not have enough tackifier to adhere well to the vertical surfaces. This ability is necessary in order to protect the gear teeth in these applications adequately.

Cat Arctic Platinum Grease prevents galling and wear at cold temperatures under extremely severe loads and conditions. In moderate temperatures, Cat Arctic Platinum Grease can be used in the application if the compartment is sealed tightly in order to contain the grease.

Cat Arctic Platinum Grease is sometimes used in applications that require the lubricant to last for long periods of time. This grease has an extremely high performance and also has a long life.

Note: If the application calls for Cat Arctic Platinum Grease and no Cat Arctic Platinum Grease is available, consult the data sheets for the grease. Use a substitute that most closely meets the performance characteristics.

Cat Arctic Platinum Grease is formulated not to contain lead, antimony, barium, zinc, phosphorous, or chlorine additives. Thus, when Cat Arctic Platinum Grease is compared to many other types of grease, the Cat Arctic Platinum Grease has low environmental impact.

Cat High Speed Ball Bearing Grease

Cat High Speed Ball Bearing Grease is an NLGI grade 2 grease. This grease is made with a petroleum base oil and a polyurea thickener. 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 High Speed Ball Bearing Grease is formulated not to contain lead, antimony, barium, zinc, phosphorous, or chlorine additives. Thus, when Cat High Speed Ball Bearing Grease is compared to many other types of grease, the Cat High Speed Ball Bearing Grease has low environmental impact.

Cat Multipurpose Marine Grease

Cat Multipurpose Marine Grease is a National Lubricating Grease Institute (NLGI) grade 2 grease. This grease is made with petroleum base oil and a calcium sulfonate complex thickener. Cat Multipurpose Marine Grease is formulated for use in low to high severity and moderate temperatures. Cat Multipurpose Marine Grease is recommended for use in many types of equipment operating in corrosive and water-related environments. It adheres to surfaces strongly and it offers high corrosion resistance. The corrosion resistance of this product has been proven by passing over 4000 hours of standard salt spray testing.

Note: If the application calls for a multipurpose marine grease and Cat Multipurpose Marine Grease is not available, consult the grease data sheets. Use an alternative grease that meets or exceeds the performance characteristics of Cat Multipurpose Marine Grease.

Grease Application Charts

Type of Grease

Severe Applications are heavy loads, frequent oscillations, and heavy shock loads.

Extreme pressure (EP) refers to 4-Ball Weld point in the technical data sheet (ASTM D 2596).

N/R = Not Recommended

Table 40

Type of Cat Grease							
Cat Grease Name	**NLGI Grade**	**Severe Applications**	**Severe Applications**	**Severe Applications**	**Severe Applications with Extremely Heavy Loads**	**Severe Applications**	**Extreme Pressure (EP)**
Operating Conditions		Extremely Low to Low Temps	Low to Moderate Temps	Moderate to High Temps	Moderate to High Temps	High to Extremely High Temps	(Anti-Wear Protection)
Optimum Temperature Range		−50° C (−58° F) to −18° C (0° F)	−23° C (−10° F) to 29° C (85° F)	18° C (65° F) to 60° C (140° F)	18° C (65° F) to 41° C (105° F)	38° C (100° F) to 232° C (450° F)	
Desert Gold	2	N/R	Excellent	Excellent	Excellent	Very Good	Excellent
Ultra 5Moly	2	N/R	Excellent	Excellent	Very Good	Good	Excellent
Ultra 5Moly	1	Good	Excellent	Good	Good	Fair	Excellent
Ultra 5Moly	0	Good	Excellent	Good	Good	Fair	Excellent
Arctic Platinum 0	0	Excellent	Very Good	N/R	N/R	N/R	Excellent
Advanced 3Moly	2	N/R	Fair	Good	Good	N/R	Very Good
Multipurpose Grease	2	N/R	N/R	N/R	N/R	N/R	Fair
High Speed Ball Bearing Grease	2	N/R	N/R	N/R	N/R	N/R	N/R
Marine Multipurpose	2	Good	Excellent	Excellent	Excellent	Good	Excellent
Hammer Paste	2	N/R	Good	Excellent	Excellent	Excellent	Excellent

Type of Grease (continued)

Pumpability is based on USS Mobility and Lincoln Ventmeter Tests. Performance may vary depending on lubrication equipment and the length of the lines.

Service Life refers to the percent of change after 100,000 strokes in technical data sheet (ASTM D 217).

Low Environmental Impact means that the grease is not formulated to contain Lead, Antimony, Barium, Zinc, Phosphorous, or Chlorine additives.

Corrosion protection is the resistance to salt water and salt spray (ASTM B 117).

Water washout resistance refers to roll stability with water and the percent of change (ASTM D 1264).

For additional performance data on these greases refer to this Special Publication, “Reference Material” article.

Table 41

Type of Cat Grease						
Cat Grease Name	**NLGI Grade**	**Low Temp. Pumpability**	**Service Life**	**Low Environmental Impact**	**Corrosion Protection**	**Water Washout Resistance**
Operating Conditions		[In Centralized (Auto-Lube) Systems]	(Shear Stability)			
Optimum Temperature Range						
Desert Gold	2	above 2° C (35° F)	Excellent	Yes	Excellent	Excellent
Ultra 5Moly	2	above −7° C (20° F)	Excellent	Yes	Excellent	Excellent
Ultra 5Moly	1	above −18° C (0° F)	Excellent	Yes	Excellent	Excellent
Ultra 5Moly	0		Excellent	Yes	Excellent	Excellent
Arctic Platinum 0	0	above −43° C (−45° F)	Excellent	Yes	Excellent	Excellent
Advanced 3Moly	2	above −18° C (0° F)	Good	No	Fair	Fair
Multipurpose Grease	2	above −23° C (−10° F)	Good	No	Fair	Fair
High Speed Ball Bearing Grease	2	above −18° C (0° F)	Very Good	No	Good	Good
Marine Multipurpose	2	above −7° C (20° F)	Excellent	Yes	Excellent	Excellent
Hammer Paste	2	N/R	Good	No	Fair	Fair

Type of Cat Grease by Machine Category

Drive shaft universal joints should NOT be serviced with any lubricant that contains Molybdenum disulfide (Ultra 5Moly or Advanced 3Moly).

Table 42

Type of Cat Grease by Machine Category									
Vehicle	**Application Point**	**Typical Load and Speed**	**Load Factor**	**Ambient Temperature Range**				**NLGI Grade**	**Grease Type**
				° C		**° F**			
				Min	**Max**	**Min**	**Max**		
Agricultural Products	Front Axle, Drive Shaft Slip Spline	High	Agricultural drawbar work at full throttle, engine lugged to max. power most of the time, little or no idling or travel in reverse.	−35	40	−31	104	1	Ultra 5Moly Grease
				−30	50	−22	122	2	

(continued)

(Table 42, contd)

Type of Cat Grease by Machine Category									
Vehicle	Application Point	Typical Load and Speed	Load Factor	Ambient Temperature Range				NLGI Grade	Grease Type
				° C		° F			
				Min	Max	Min	Max		
		Medium	Agricultural drawbar work at full throttle but not always lugging engine. Some idling and some travel with no load.	−20	40	−4	104	2	Advanced 3Moly Grease
		Low	Considerable idling or travel with no load.	−30	40	−22	104	2	Multipurpose Grease
Asphalt Pavers	Track Takeup Linkage, Takeup Idler Bearings	High	Wide width, deep lift paving.	−35	40	−31	104	1	Ultra 5Moly Grease
				−30	50	−22	122	2	
		Medium	3-4 m (10'-12') width, 50-75 mm (2-3) lift.	−20	40	−4	104	2	Advanced 3Moly Grease
		Low	Narrow width paving - low production.	−30	40	−22	104	2	Multipurpose Grease
Backhoe Loaders	Drive Shaft Slip Spline, Kingpin Bearing, Wheel Bearing	High	Production work with long cycles and/or constant flow implements.	−35	40	−31	104	1	Ultra 5Moly Grease
				−30	50	−22	122	2	
		Medium	General work with regular cycles in medium applications.	−20	40	−4	104	2	Advanced 3Moly Grease
		Low	Utility work with intermittent cycles in light to medium applications.	−30	40	−22	104	2	Multipurpose Grease
Vibratory Soil and Asphalt Compactors	Articulation Bearing, Control Cables, Drum Bearings, Leveling Blade, Operator Platform, Oscillating Bearings, Oscillating Pins, Steering Cylinder Ends, Steering Pins, Weight Bearings	High	Vibration 80-100%, heavy cohesive soil, 350 mm (12) lifts or more.	−35	40	−31	104	1	Ultra 5Moly Grease
				−30	50	−22	122	2	
		Medium	Vibration 50-80%, granular soil, 100mm-305 mm (4-12) lifts.	−20	40	−4	104	2	Advanced 3Moly Grease
		Low	Vibration 30-50%, asphalt mix, 51mm - 100 mm (2-4) lifts.	−30	40	−22	104	2	Multipurpose Grease

(continued)

(Table 42, contd)

Type of Cat Grease by Machine Category									
Vehicle	Application Point	Typical Load and Speed	Load Factor	Ambient Temperature Range				NLGI Grade	Grease Type
				° C		° F			
				Min	Max	Min	Max		
Wheeled and Track-type Excavators	Axle Bearings, Belt Tensioner, Blade Linkage, Boom, and Stick Linkage, Boom Cylinder Bearing, Boom Cylinder Head, Cab Riser, Drive Shaft Slip Spline, Drive Shaft Support Bearing, Fan Drive Bearing, Steering Linkage, Stick Linkage, Swing Bearings, Swing Drive Gear, Swing Frame	High	Most pipeline applications in hard rocky material. Digging 90-95% of the daily work schedule.	−35	40	−31	104	1	Ultra 5Moly Grease
				−30	50	−22	122	2	
		Medium	Most residential sewer applications in natural bed clay. Digging 60-85% of the daily work schedule. Most log loading applications.	−20	40	−4	104	2	Advanced 3Moly Grease
		Low	Most utility, urban applications in sandy loam. Digging less than 50% of the daily work schedule. Scrap handling applications.	−30	40	−22	104	2	Multipurpose Grease
Forest Products	Articulation Bearings, Bogie Bearings, Drive Shaft Support Bearing, Drive Shaft Slip Spline, Gate Cylinder, Grapple Head Rotator, Swing Drive Bearing, Swing Drive Gear, Winch Drive Shaft Bearing, Winch Drive Shaft Support Bearing, Winch Drum Bearing	High	517- Skidding over 4536 kg (10,000 lb) in steep terrain (over 30%) with high resistance. 525B - Skidding over 6800 kg (15,000 lb) in steep terrain (over 10%) with high resistance. 527 - Skidding over 6360 kg (14,000 lb) in steep terrain (over 30%) with high resistance.	−35	40	−31	104	1	Ultra 5Moly Grease
				−30	50	−22	122	2	
		Medium	517- Skidding up to 4536 kg (10,000 lb) in moderate terrain (8-30%) with medium resistance. 525B - Skidding up to 6800 kg (15,000 lb) in moderate terrain (5-10%) with average resistance. 527 - Skidding up to 6360 kg (14,000 lb) in moderate terrain (8-30%) with medium resistance.	−20	40	−4	104	2	Advanced 3Moly Grease

(continued)

(Table 42, contd)

Type of Cat Grease by Machine Category									
Vehicle	Application Point	Typical Load and Speed	Load Factor	Ambient Temperature Range				NLGI Grade	Grease Type
				° C		° F			
				Min	Max	Min	Max		
		Low	517 - Skidding less than 4536 kg (10,000 lb) in flat terrain (0-8%) with low resistance. 525B - Skidding less than 4500 kg (10,000 lb) in flat terrain (0-5%) with low resistance. 527 - Skidding less than 6360 kg (14,000 lb) in flat terrain (0-8%) with low resistance.	−30	40	−22	104	2	Multipurpose Grease
	Fan Drive Bearings			−20	40	−4	104	2	High Speed Ball Bearing Grease
Motor Graders	Articulation Bearings, Articulation Pins, Blade Lift Cylinder Socket, Centershift Cylinder Socket, Fan Drive Belt Tightener, Pump Drive Shaft Slip Spline	High	Ditching, fill spreading, spreading base material, ripping, heavy road maintenance, snow plowing.	−35	40	−31	104	1	Ultra 5Moly Grease
				−30	50	−22	122	2	
		Medium	Average road maintenance, road mix work, scarifying, snow plowing.	−20	40	−4	104	2	Advanced 3Moly Grease
		Low	Finish grading, light maintenance, road travel.	−30	40	−22	104	2	Multipurpose Grease
	Fan Drive Bearings			−20	40	−4	104	2	High Speed Ball Bearing Grease
Off-Highway Trucks and Tractors	Belt Tightener, Drive Shaft Slip Spline, Fan Drive Pulley, Hoist Control Bellcrank, Hoist Cylinder Bearing, Front and Rear Axle A-Frame Bearing, Steering Cylinder End, Steering Linkage, Steering Tie Rod and Pin Bearings, Swaybar, Tachometer Drive	High	40-50% load factor.	−35	40	−31	104	1	Ultra 5Moly Grease
				−30	50	−22	122	2	
		Medium	30-40% load factor.	−20	40	−4	104	2	Advanced 3Moly Grease
		Low	20-30% load factor.	−30	40	−22	104	2	Multipurpose Grease
	Autolube System			−35	40	−31	104	1	Ultra 5Moly Grease
				−30	50	−22	122	2	
	Fan Drive Bearings Traction Motor Bearings			−20	40	−4	104	2	High Speed Ball Bearing Grease

(continued)

(Table 42, contd)

Type of Cat Grease by Machine Category									
Vehicle	Application Point	Typical Load and Speed	Load Factor	Ambient Temperature Range				NLGI Grade	Grease Type
				° C		° F			
				Min	Max	Min	Max		
Articulated Trucks	Belt Tightener, Drive Shaft Slip Spline, Fan Drive Pulley, Hoist Control Bellcrank, Hoist Cylinder Bearing, Rear Axle A-Frame Bearing, Steering Cylinder End, Steering Linkage, Steering Tie Rod and Pin Bearings, Tachometer Drive, Tailgate Bearings	High	Long haul time with frequent adverse grades. Continuous use on poorly maintained haul roads with high rolling resistance.	−35	40	−31	104	1	Ultra 5Moly Grease
				−30	50	−22	122	2	
		Medium	Normal load and haul time. Varying load and haul road conditions. Some adverse grades. Some high rolling resistance	−20	40	−4	104	2	Advanced 3Moly Grease
		Low	Large amount of idling. Short to medium hauls on well maintained level haul roads. Minimum total resistance.	−30	40	−22	104	2	Multipurpose Grease
	Fan Drive Bearings			−20	40	−4	104	2	High Speed Ball Bearing Grease
Pavement Profilers/Road Reclaimers	Chain Tensioner, Fan Drive Bearings, Propel Transmission Control Cable, Pump Drive Shaft Slip Spline, Rotor Transmission Shift Linkage, Wheel Hub Bearings	High	457 mm (18) soil/305 mm (12) asphalt.	−35	40	−31	104	1	Ultra 5Moly Grease
				−30	50	−22	122	2	
		Medium	305 mm (12) soil/150 mm (6) asphalt.	−20	40	−4	104	2	Advanced 3Moly Grease
		Low	150 mm (6) soil/100 mm (4) asphalt.	−30	40	−22	104	2	Multipurpose Grease
Telehandlers	Boom Chain, Boom Cylinder Pin, Boom Extension and Retraction Chain Pulley, Boom Head Section, Boom Pivot Shaft, Compensating Cylinder Bearing, Drive Shaft Slip Spline, Fork Leveling Cylinder Pin, Frame Leveling Cylinder Pin, Stabilizer, and Cylinder Bearings	High	Heavy loading, continuous loading with steady cycling.	−35	40	−31	104	1	Ultra 5Moly Grease
				−30	50	−22	122	2	
		Medium	Normal load and work conditions.	−20	40	−4	104	2	Advanced 3Moly Grease
		Low	Considerable idling or travel with no load.	−30	40	−22	104	2	Multipurpose Grease
Track Loaders	Equalizer Bar Pin, Recoil Piston, Track Adjustment	High	Continuous excavating and loading from bank. Land clearing.	−35	40	−31	104	1	Ultra 5Moly Grease
				−30	50	−22	122	2	
		Medium	Bank or stockpile loading with idling periods. Load and carry.	−20	40	−4	104	2	Advanced 3Moly Grease

(continued)

(Table 42, contd)

Type of Cat Grease by Machine Category									
Vehicle	Application Point	Typical Load and Speed	Load Factor	Ambient Temperature Range				NLGI Grade	Grease Type
				° C		° F			
				Min	Max	Min	Max		
		Low	Large amounts of idling in any application.	−30	40	−22	104	2	Multipurpose Grease
Track-Type Tractors	Adjust Track, Angle Blade Tilt Brace, Equalizer Bar Pins, Fan Drive Belt Tightener, Lift Cylinder Yoke Bearing, Winch Drum Bearing, Winch Fairlead Rollers	High	Ditching, fill spreading, spreading base material, ripping, heavy road maintenance, snow plowing.	−35	40	−31	104	1	Ultra 5Moly Grease
				−30	50	−22	122	2	
		Medium	Average road maintenance, road mix work, scarifying, snow plowing.	−20	40	−4	104	2	Advanced 3Moly Grease
		Low	Finish grading, light maintenance, road travel.	−30	40	−22	104	2	Multipurpose Grease
	Fan Drive Bearings			−20	40	−4	104	2	High Speed Ball Bearing Grease
Wheel Dozers and Compactors	Articulation Bearings, Drive Shaft Support Bearing, Drive Shaft Slip Spline, Lift Cylinder Yoke Bearing, Steering Shaft, Tilt Cylinder Bearing	High	Heavy dozing, compacting heavy material. Heavy landfill work.	−35	40	−31	104	1	Ultra 5Moly Grease
				−30	50	−22	122	2	
		Medium	Production dozing, most push-loading, shovel cleanup, normal compaction.	−20	40	−4	104	2	Advanced 3Moly Grease
		Low	Considerable idling or travel with no load.	−30	40	−22	104	2	Multipurpose Grease
	Fan Drive Bearings			−20	40	−4	104	2	High Speed Ball Bearing Grease
Wheel Loaders	Articulation Bearings, Axle Oscillation Bearings, Bucket Pivot Bearings, Drive Shaft Support Bearing, Drive Shaft Slip Spline, Frame Pivot Bearings, Steering Cylinder Bearings, Steering Shaft, Wheel Brake Camshafts	High	Continuous and aggressive tight truck loading, hard bank excavation, and shot rock loading from a face.	−35	40	−31	104	1	Ultra 5Moly Grease
				−30	50	−22	122	2	
		Medium	Maximum productivity in aggregate truck loading and hopper charging. Assumes the normal slamming and load and carry associated with the high productivity stockpile load-out and batch plant applications.	−20	40	−4	104	2	Advanced 3Moly Grease

(continued)

(Table 42, contd)

Type of Cat Grease by Machine Category									
Vehicle	Application Point	Typical Load and Speed	Load Factor	Ambient Temperature Range				NLGI Grade	Grease Type
				° C		° F			
				Min	Max	Min	Max		
		Low	Light utility, construction, low production aggregate truck loading, and most logging applications where there is considerable idling, empty traveling, and load and carry.	−30	40	−22	104	2	Multipurpose Grease
	Fan Drive Bearings			−20	40	−4	104	2	High Speed Ball Bearing Grease
Integrated Toolcarriers	Articulation Bearings, Axle Oscillation Bearings, Bucket Pivot Bearings, Drive Shaft Support Bearing, Drive Shaft Slip Spline, Frame Pivot Bearings, Steering Cylinder Bearings, Steering Shaft, Wheel Brake Camshafts	High	Continuous and aggressive tight truck loading, hard bank excavation, and shot rock loading from a face.	−35	40	−31	104	1	Ultra 5Moly Grease
				−30	50	−22	122	2	
		Medium	Maximum productivity in aggregate truck loading and hopper charging. Assumes the normal slamming and load and carry associated with the high productivity stockpile load-out and batch plant applications.	−20	40	−4	104	2	Advanced 3Moly Grease
		Low	Light utility, construction, low production aggregate truck loading, and most logging applications where there is considerable idling, empty traveling, and load and carry.	−30	40	−22	104	2	Multipurpose Grease
	Fan Drive Bearings			−20	40	−4	104	2	High Speed Ball Bearing Grease
Wheel Tractor-Scrapers	Brake Camshaft Bearings, Drive Shaft Slip Spline, Ejector Carrier, and Support Rollers, Sprocket Shaft Support Bearings	High	Continuous high total resistance conditions with steady cycling.	−35	40	−31	104	1	Ultra 5Moly Grease
				−30	50	−22	122	2	
		Medium	Typical road building use.	−20	40	−4	104	2	Advanced 3Moly Grease
		Low	Average use but with considerable idling, favorable grades, low rolling resistance, and easy loading material.	−30	40	−22	104	2	Multipurpose Grease
	Fan Drive Bearings			−20	40	−4	104	2	High Speed Ball Bearing Grease

(continued)

(Table 42, contd)

Type of Cat Grease by Machine Category									
Vehicle	**Application Point**	**Typical Load and Speed**	**Load Factor**	**Ambient Temperature Range**				**NLGI Grade**	**Grease Type**
				° C		**° F**			
				Min	**Max**	**Min**	**Max**		
Hammers	Hammer Lubrication							2	Hammer Paste
Extreme Temperature Conditions - All Applications Except Hammers	All except Autolubrication Systems, Fan Drive Bearings, and Universal Joints	High, Medium, and Low		−50	20	−58	68	0	Arctic Platinum
				−20	60	−4	140	2	Desert Gold

Fuel Specifications

i04663449

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 Caterpillar diesel engines that are covered by this Special Publication. This information supersedes all previous recommendations which have been published for the 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
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
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 Cat dealer.

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

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
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's responsibility to follow all industry standard practices for fuel storage and for fuel handling.

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: Caterpillar 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 Caterpillar requirements for distillate diesel fuel. Refer to the "Caterpillar Specification for Distillate Diesel Fuel for Off-Highway Diesel Engines" table in this Special Publication, "Distillate Diesel Fuel" article.
- Use a properly designed and maintained bulk storage fuel tank.
- Confirm with the filter manufacturer that the fuel filter/filters to be used are compatible with the fuel type that will be filtered.
- Filter the fuel coming into the bulk storage fuel tank and at every subsequent transfer into and out of any container and prior to adding to the engine fuel tank preferably through filters with a rating of 20 microns (c) absolute or less. Filter the fuel at the last dispensing stage into the engine fuel tank through a filter with a rating of four microns (c) absolute or less. This filtration should be located at the device that dispenses the fuel to the engine fuel tank downstream from any equipment such as transfer pumps that could potentially shed debris into the fluid stream. Series filtration is recommended. The use of wire mesh media (strainer-type filters) are NOT recommended except for when filters with standard media (cellulose or synthetic) are downstream of the wire mesh media filters. Wire mesh filters typically have poor filtration efficiency and can corrode with time, allowing the passing of large particles.
- The use of water separators or water coalesces is also recommended at points of fuel filtration.
- Install and maintain a properly designed and grounded filtration system on bulk storage fuel tanks for continuous filtration of stored fuel. The filter element/elements should be rated at a maximum of 5 microns(c) absolute. Change fuel filters based on manufacturers recommendations.
- Caterpillar offers multiple sizes of bulk fuel filtration and water coalescing units that are recommended for ensuring the availability of clean dry fuel. Refer to Special Publication, PEHJ0156, "Cat Bulk Fuel Filtration Systems" and consult your Caterpillar dealer for more information.
- 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 “Caterpillar Specification for Distillate Diesel Fuel for Off-Highway Diesel Engines” table in this Special Publication, “Distillate Diesel Fuel” article. Take corrective action if necessary. Corrective actions may include, but are not limited to, 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 ten minutes. This will allow the water and sediment to 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.
- Caterpillar 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, and 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 six 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 in order to reduce tank breathing and in order to reduce 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: Caterpillar 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 Caterpillar dealer for information on the coalescer filters available through Cat .

Note: It is strongly recommended that fuel storage tanks be thoroughly cleaned 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 may need to be shortened for an extended period of time in order to allow for this cleaning effect.

Note: Caterpillar 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, and also on the device that dispenses fuel from the bulk storage tank. Series filtration is recommended.

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

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Fuel Information for Diesel Engines

SMCS Code: 1250; 1280

NOTICE

Ultra Low Sulfur Diesel (ULSD) fuel (≤ 15 ppm (mg/kg) sulfur) is required by regulation for use in engines certified to nonroad Tier 4 standards (U.S. EPA Tier 4 certified) and that are equipped with exhaust after-treatment systems.

European ULSD (≤ 10ppm (mg/kg) sulfur) fuel is required by regulation for use in engines certified to EU nonroad Stage IIIB and newer standards and that are equipped with exhaust aftertreatment systems.

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

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

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

ULSD fuel or sulfur-free diesel fuel are acceptable in all engines regardless of the engine U.S. EPA Tier or EU Stage requirements.

Use appropriate lubricating oils that are compatible with the engine certification and aftertreatment system and with the fuel sulfur levels. Refer to the “Diesel Fuel Sulfur Impacts” article of this “Fuels Specifications” section and to the “Lubricants Specifications” section of this Special Publication.

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 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 properly sized 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.

Note: 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 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.

NOTICE
When you use fuel heaters, do not allow the fuel to get above 52°C (125°F). Never exceed 75°C (165°F) with straight distillate fuel. The high fuel temperatures 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 and/or 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, consult 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

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 test engines. However, the fuel characteristics of additives used to improved fuel cetane number are different than those of the naturally occurring 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 a 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”.

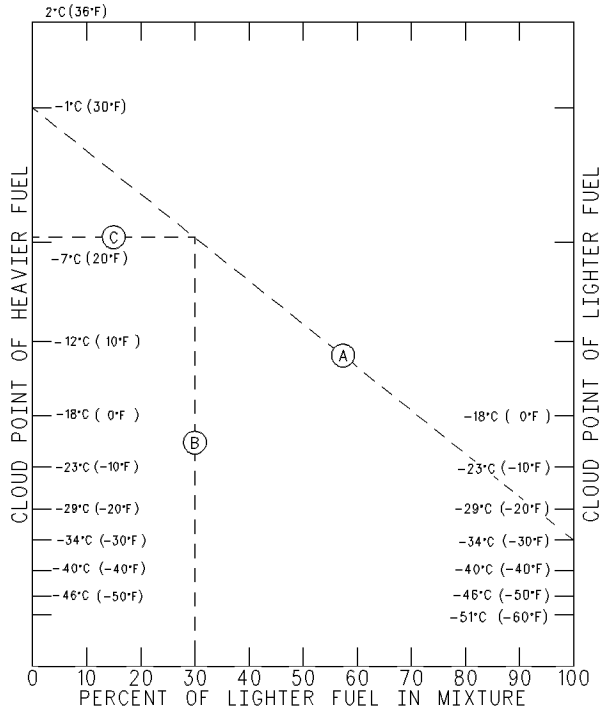

Illustration 2 g00592741

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 inside of the 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 a 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.

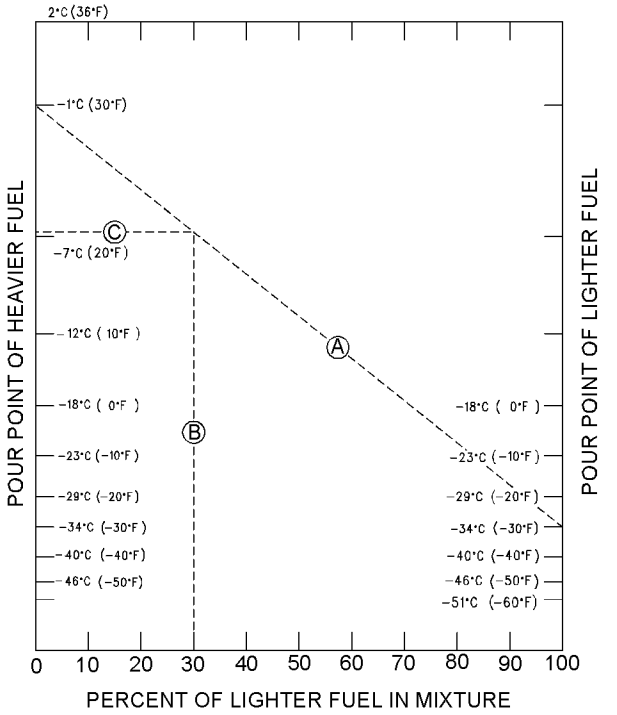

Illustration 3 g01180699

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 the proper 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 contacted in order to blend the fuel with the additives. The blended fuel can be delivered to your fuel tanks.

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

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 the "Fuel Specifications" section and this Special Publication, "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 this Special Publication, "Biodiesel" topic for guidance when biodiesel will be used.

Note: The fuel lubricity is important. You should consider the fuel's lubricity whenever you operate the equipment in temperature extremes, whether extremely hot or extremely cold. Also, you should consider the fuel 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" 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.

In order to determine the lubricity of the fuel, use the ASTM D6079 High Frequency Reciprocating Rig (HFRR) test. The maximum allowable wear scar is 0.52 mm (0.0205 inch) at 60° C (140° F). 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.

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 preferred distillate diesel fuel (refer to the “Fuel Recommendations” article in this Special Publication), 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. Contact 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 fuel and the sulfur levels for these fuels typically far exceed 50 ppm, the EU 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” article, “Aftermarket Fuel Additives”, “Cat Diesel Fuel Conditioner”, and “Alternative Fuels - Arctic Applications” topics for guidance.

Diesel Fuel Sulfur

Sulfur is a natural component of diesel fuels. High sulfur in the fuel can be reduced through refining technologies.

Sulfur levels in the fuel affect the durability of engine components and also affect engine exhaust emissions. Modern Cat diesel engines are designed to meet mandated gaseous emissions requirements. To meet these emissions requirements, the engines are tested and developed with specific sulfur levels in the diesel fuel.

The maximum allowable fuel sulfur level is controlled by various emissions laws, regulations, and mandates. Consult federal, state, and local authorities for guidance on fuel requirements for your area.

The list below provides a quick reference for acceptable sulfur levels for diesel fuel that will be used in Cat machine diesel engines but the controlling documents are the engine Operation and Maintenance Manuals, the specific aftertreatment device documentation, and the applicable emissions laws, regulations, and mandates.

- U.S. EPA regulations require the use of Ultra Low Sulfur Diesel fuel (ULSD) , ≤ 0.0015 percent (≤ 15 ppm (mg/kg)) sulfur, for nonroad and stationary Tier 4 EPA certified engines using fuel sensitive technologies such as SCR systems and particulate filters. Fuels other than ULSD can cause damage in those engines and should not be used. Consult the U.S. EPA for fuel sulfur regulations and for the ULSD point of sales required dates for various nonroad applications.
- European sulfur free fuel, 0.0010 percent (= 10 mg/kg) sulfur, fuel is required by regulation for use in engines certified to EU nonroad Stage IIIB and newer standards and that are equipped with exhaust aftertreatment systems.
- Certain governments/localities and/or applications MAY require the use of ULSD fuel. Consult federal, state, and local authorities for guidance on fuel requirements for your area.
- The maximum allowable fuel sulfur level for most pre-Tier 4 engines that are equipped with DOC (Diesel Oxidation Catalyst) is 0.05 percent (500 ppm (mg/kg)). Some DOC equipped engines require the use of fuel with a maximum of 0.005% (50 ppm (mg/kg)) fuel sulfur. Refer to the engine/ machine Operation and Maintenance Manual and refer to the aftertreatment device specific documentation for guidance.
- For machine diesel engines that are retrofitted with an aftertreatment device, refer to the aftertreatment device specific documentation.

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

In addition to the emission regulations, factors that affect maximum allowed and/or acceptable fuel sulfur level include:

- Engine model/design
- Engine application
- Overall fuel quality
- Using recommended fluids, including but not limited to engine oil quality
- Exhaust aftertreatment device type
- Environmental factors and other site specific operating conditions
- Fuel costs versus risk of shortened engine/engine component life
- Fuel costs versus shortened oil drain intervals
- Maintenance intervals and other maintenance practices

Ultra-Low Sulfur Diesel (ULSD)

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(mg/kg)) or 0.0015 percent by weight.

ULSD was introduced for the U.S. on-highway diesel engine market in October 2006. ULSD is available sinceDecember 2010 for nonroad diesel engines and machines. Refer to the U.S. EPA for the required ULSD point of sales dates for various nonroad applications.

Engines certified to nonroad Tier 4 standards (Stage IV in Europe) and are equipped with fuel sulfur sensitive exhaust aftertreatment systems are designed to run on ULSD only. Use of LSD or fuels higher than 15 ppm (mg/kg) sulfur in these engines will reduce engine efficiency and engine durability and will damage emissions control systems and/or shorten their service interval. Failures that result form the use of fuels are not Cat factory defects. Therefore the cost of repairs would not be overed by a Cat warranty.

ULSD fuel can be used in any engine designed to run on diesel fuel. Cat does not require the use of ULSD in nonroad and machine applications that are not Tier 4/Stage IIIB/Stage IV certified engines and are not equipped with aftertreatment devices. For Tier 4/ Stage IIIB/Stage IV certified engines, always follow operating instructions and fuel tank inlet labels, if available, to insure the correct fuels are used.

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

Sulfur-free Diesel Fuel

In Europe , ultra low sulfur diesel fuel will have a maximum of 0.0010 percent (10 ppm(mg/kg)) sulfur and is typically referred to as “sulfur-free”. This sulfur level is defined in European Standard EN 590:2004.

Low Sulfur Diesel (LSD)

Low Sulfur Diesel (LSD - S500) is defined by the U.S. EPA as a U.S. diesel fuel with sulfur content not to exceed 500 ppm or 0.05 percent by weight.

Note: Both ULSD and LSD must meet the fuel requirements outlined in the most current revision level of ASTM D975.

Diesel Fuel Sulfur Impacts

Sulfur in the fuel results in the formation of sulfur dioxide (SO2) and sulfur trioxide (SO3) gases during the combustion process. When combined with water in the exhaust gas SO2 and SO3 can form acids. The acids can impact engine components and engine lubricants.

Sulfur in the exhaust gas can interfere with the operation of aftertreatment devices causing loss of passive regeneration performance, reduced gaseous emission conversion efficiency, and increased particulate matter emissions.

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

Use of fuels with higher than recommended and/or maximum allowed fuel sulfur levels can and/or will:

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

Depending on operating conditions, and depending on maintenance practices, the potential issues stated above may and/or will take place with fuel sulfur levels that are at or below the recommended fuel sulfur levels, and/or that are at or below the maximum allowable fuel sulfur levels.

Fuel sulfur levels above 0.1% (1000 ppm (mg/kg)) may significantly shorten the oil change interval.

When other factors do no preclude, and understanding that there may be trade-offs such as shortened oil drain intervals, certain commercial and machine diesel engines that are covered by this Special Publication MAY be able to operate satisfactorily on fuels with up to 1 percent (10, 000 ppm(mg/kg)) sulfur if the following conditions are met:

- All emissions laws, regulations and mandates are followed
- The engine/engines are not equipped with aftertreatment device/devices
- All appropriate guidelines and maintenance practices as stated in the engine Operation and Maintenance Manual are followed
- All appropriate guidelines and maintenance practices as stated in this Special Publication are followed
- Operating in otherwise low to moderate severity applications
- Your Cat dealer is consulted and approves
- You refer to this Special Publication, and you refer to your specific Cat commercial engine and/or refer to your specific Cat machine Operation and Maintenance Manual for additional guidance and exceptions

Oil Drain Intervals

Note: DO NOT USE ONLY THIS SPECIAL PUBLICATION AS A BASIS FOR DETERMINING OIL DRAIN INTERVALS.

Fuel sulfur level impacts the oil drain interval. For detailed information, refer to the “S·O·S Services Oil Analysis” section in the “Lubricants Specification” article in this Special Publication.

- Cat S·O·S Services oil analysis is recommended.
- Cat S·O·S Services oil analysis is very strongly recommended to determine oil drain intervals when using fuel with sulfur levels between 0.05% (500 ppm) and 0.5% (5000 ppm).
- Cat S·O·S Services oil analysis is required to determine oil drain intervals when using fuel with sulfur levels above 0.5% (5000 ppm).
- Consult your Cat dealer for guidance when fuel sulfur levels are above 0.1% (1000 ppm).

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(100 mg/kg or 0.010 percent) of water in solution at 18°C (65°F). This same fuel can possibly hold only 30 ppm(30 ppm or 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(mg/kg) 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. Refer to the "Lubricity and Low Sulfur Fuel Diesel (LSD) and Ultra Low Sulfur Diesel (ULSD) Fuel" topic in this Special Publication, "Characteristics of Diesel Fuel" article.

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 to 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 biodiesel blends that are greater than B20 may be much shorter than six months.

The Thermal Stability and Oxidation Stability of Fuel

Diesel fuels can deteriorate rapidly for a variety of reasons. When the fuel is stressed and stored for long intervals, degradation and oxidation can occur. Degradation and oxidation are complex chemical changes. These changes lead to deposits or sediment from certain hydrocarbons and traces of naturally occurring nitrogen and sulfur containing compounds in the fuel. Fuel composition and environmental factors influence the process.

Diesel fuel is being used as a coolant for high pressure fuel injection systems with high temperature fuel wetted walls. This can stress the fuel in the fuel system. The thermal stress and an increase in recirculation fuel temperature is often responsible for fuel degradation and the formation of gums, resins, sediment, and deposits, which can cause fuel flow restriction through fuel filters and fuel injection systems.

Certain products are often left with the fuel in the fuel system for long periods. This exposes the fuel to oxygen. Complex reactions between the oxygen and the fuel components can generate fuel particulates. The particulates in the fuel system can turn into the sludge that is found in fuel tanks, fuel lines and the fuel filters. This will deteriorate the performance of the fuel system. Degradation also leads to a plugged fuel filter, a restriction to the fuel line and deposit formation in the fuel injection nozzle.

Biodiesel and blends of biodiesel have poor thermal stability and oxidation stability compared to petroleum distillate diesel fuels. The use of these biodiesels and blends of biodiesel can accelerate the problems that are addressed in this Special Publication. Using biodiesel blends above the maximum level approved for the engine is not recommended.

Thermal and oxidative degradation of diesel fuel can result in a darkening of fuel color. Fuel color is not necessarily an indication of excessive degradation that will lead to the problems outlined in this Special Publication. But darkened fuel color can be an indicator of degradation leading to concerns about the stability of darkened fuel. Thermal oxidation and oxidative stability tests should be run to confirm actual fuel degradation.

Thermal Stability

Caterpillar recommends the use of the Accelerated Fuel Oil Stability Test (ASTM D6468). This is a test method that determines the instability of a fuel subjected to a thermal degradation process. This test exposes the fuel to conditions that are similar to actual operating conditions when the fuel cools the injectors during the engine operation.

The test is performed by using a spectrophotometer. The percentage reflectance of fuel should not be less than eighty percent after aging for three hours at a temperature of 150° C (302° F).

Oxidative Stability Test

Caterpillar recommends the use of the Oxidative Stability Test. This is a test method that determines long term storage of distillate fuels such as home heating oils, kerosene and diesel oils. The test method is not suitable for highly volatile fuels with flash points under 38° C (100° F). This test method is used for storage stability, with the use of stabilizing additives and without the use of stabilizing additives.

As per the specification EN590:2004 Automotive Fuels - Diesel, a test for a direct measurement of oxidation stability is the test method ISO 12205 Petroleum products - Determination of the oxidation stability of middle distillate diesel fuels. The fuel sample is heated at 95° C (203° F) for 16 hours while bubbles of oxygen travel through the sample. The resulting amount of solid oxidation by products are then measured. This test simulates the oxidation of fuel during long-term storage. For diesel fuel the maximum amount of insolubles that are formed should not exceed 25 g per cubic meter.

Caterpillar recommends that for diesel, biodiesel, or biodiesel blends that are going to be used several months after purchase, artificially aging the fuel to predict the storage stability, followed by an analysis of the fuel. For most distillate fuels that age the fuel for 7 days at 80° C (176° F) can simulate storage for 4 to 8 months at typical ambient storage temperatures. Analysis of this matured fuel per the methods discussed in this document can then be used to aid in predicting the stability of the fuel after numerous months of storage. Analysis of Diesel fuel should include Thermal Stability - ASTM D6468, Fuel Gums - ASTM D381 and Fuel Sediments - ASTM D473. Analysis of biodiesel fuel and biodiesel fuel blends should include Oxidation - EN14112, Acid Value - ASTM D664, Viscosity - ASTM D445 and Sediments - ASTM D2709.

A test that can be used to help determine the degradation of biodiesel fuel and biodiesel fuel blends is the measurement of the Acid Value - ASTM D664 or EN 14104. This value represents the amount of acid present in the biodiesel fuel or biodiesel blend fuel as a result of degradation. The required limit for B100 biodiesel is given in “Caterpillar Biodiesel specification” in this Special Publication or in B100 specification - ASTM D6751. The required limit for B6-B20 biodiesel fuel blend is given in ASTM D7467 specification.

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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 may 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 “Cat Specification for Distillate Diesel Fuel for Off-Highway Diesel Engines” found in this Special Publication, “Distillate Diesel Fuel” 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 Cat dealer for further information. For information concerning biodiesel/biodiesel blends, refer to this Special Publication, “Biodiesel” article.

Note: Except for 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.

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Distillate Diesel Fuel

SMCS Code: 1280

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

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

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

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

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

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

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

To help ensure optimum engine performance, a complete fuel analysis should be obtained before engine operation. The fuel analysis should include all of the properties that are listed in the “Caterpillar Specification for Distillate Fuel for Nonroad Diesel Engines”, Table 43 .

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

Diesel Fuels that meet the specifications in table 43 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 43 requirements.

In Europe , diesel fuels that are identified as meeting the latest version of European Standard EN590 generally meet the table 43 requirements.

Table 43 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

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

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

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

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

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

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

Use appropriate lubricating oils that are compatible with the engine certification and aftertreatment system and with the fuel sulfur levels. Refer to the “Diesel Fuel Sulfur Impacts” article of this “Fuels Specifications” section and to the “Lubricants Specifications” section of this Special Publication.

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

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

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

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.

Caterpillar does not require the use of ULSD in nonroad and machine applications that are not Tier 4/ Stage IIIB/ Stage IV certified engines and are not equipped with aftertreatment devices. For Tier 4/ Stage IIIB/Stage IV certified engines, always follow operating instructions and fuel tank inlet labels to insure the correct fuels are used.

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

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

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

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

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

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

For additional guidance related to many of the fuel characteristics that are listed, refer to “Cat Specification for Distillate Fuel for Off-Highway Diesel Engines”, table 43 .

The values of the fuel viscosity given in table 43 are the values as the fuel is delivered to the fuel injection pumps. For ease of comparison, fuels should also meet the minimum and maximum viscosity requirements at 40° C (104° F) that are stated by the use of either the ASTM D445 test method or the ISO 3104 test method. If a fuel with a low viscosity is used, cooling of the fuel may be required to maintain 1.4 cSt or greater viscosity at the fuel injection pump. Fuels with a high viscosity might require fuel heaters in order to lower the viscosity to either 4.5 cSt or less for rotary fuel injection pumps or 20 cSt viscosity or less for all other fuel injection pumps.

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

Table 43

Cat Specification for Distillate Fuel for Nonroad Diesel Engines			
Specifications	**Requirements**	**ASTM Test**	**ISO Test**
Aromatics	35% maximum	D1319	ISO 3837
Ash	0.01% maximum (weight)	D482	ISO 6245
Carbon Residue on 10% Bottoms	0.35% maximum (weight)	D524	ISO 4262
Cetane Number (1)	40 minimum (DI engines)	D613 or D6890	ISO 5165
	35 minimum (PC engines)		
Cloud Point	The cloud point must not exceed the lowest expected ambient temperature.	D2500	ISO 3015
Copper Strip Corrosion	No. 3 maximum	D130	ISO 2160
Distillation	10% at 282° C (540° F) maximum	D86	ISO 3405
	90% at 360° C (680° F) maximum (2)		
	90% at 350° C (662° F) maximum (2)		
Flash Point	legal limit	D93	ISO 2719
Thermal Stability	Minimum of 80% reflectance after aging for 180 minutes at 150° C (302° F)	D6468	No equivalent test
API Gravity (3)	30 minimum	D287	No equivalent test
	45 maximum		
Pour Point	6°C (10°F) minimum below ambient temperature	D97	ISO 3016
Sulfur	(4)	D5453 or D2622	ISO 20884
Kinematic Viscosity	1.4 cSt minimum and 20.0 cSt maximum as delivered to the fuel injection pumps	–	–
	1.4 cSt minimum and 4.5 cSt maximum as delivered to the rotary fuel injection pumps		
Water and Sediment	0.05% maximum	D1796	ISO 3734
Water	0.05% maximum	D1744	No equivalent test
Sediment	0.05% maximum (weight)	D473	ISO 3735
Gums and Resins (5)	10 mg per 100mL maximum	D381	ISO 6246
Lubricity	0.52 mm (0.0205 inch) maximum at 60° C (140° F)	D6070	No equivalent test
Cleanliness	(6)	D7619	ISO 4406

(1) 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.

(continued)

(Table 43, contd)

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

(3) Via standards tables, the equivalent kg/m3 (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/m3, and for the maximum API gravity of 45 is 801.3 kg/m3.

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

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

(6) Recommended cleanliness level for fuel as dispensed into machine or engine fuel tank is ISO 18/16/13 or cleaner per ISO 4406 or ASTM D7619. Refer to the “Recommendations for Cleanliness of Fuels” in this chapter

There are many other diesel fuel specifications that are published by governments and by technological societies. Usually, those specifications do not review all the requirements that are addressed in the “Caterpillar Specification for Distillate Fuel for Off-Highway Diesel Engines”, Table 43 . To help ensure optimum engine performance, a complete fuel analysis should be obtained before engine operation. The fuel analysis should include all of the properties that are listed in the “Cat Specification for Distillate Fuel for Off-Highway Diesel Engines”, Table 43 .

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 this Special Publication, “Reference Material” article, “Filters” and “Miscellaneous” topics, and then contact your Cat dealer for assistance with filtration recommendations for your Cat machine.

⚠ 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.

Contamination Control Recommendations for Fuels

Fuels of ISO 18/16/13 cleanliness level or cleaner as dispensed into the engine or machine fuel tank should be used in order to reduce power loss, failures and related down time of engines. This cleanliness level is particularly important for new fuel system designs such as Common Rail injection systems and unit injection systems. These new injection system designs utilize higher fuel pressures and are designed with tight clearances between moving parts in order to meet required stringent emissions regulations. Peak injection pressures in current fuel injection systems may exceed 30,000 psi. Clearances in these systems are less than 5 µm. As a result, particle contaminants as small as 4 µm can cause scoring and scratching of internal pump and injector surfaces and of injector nozzles.

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

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

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

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.

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

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

Heavy Fuel Oil, Residual Fuel, Blended Fuel

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.

Alternative Fuels - Cold Weather Applications

In extreme cold ambient conditions, you may choose to use the distillate fuels that are specified in table 44 . However, the fuel that is selected must meet the requirements that are specified in the “Cat Specification for Distillate Diesel Fuel for Off-Highway Diesel Engines”, Table 43 . 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 44 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 44 typically have much higher sulfur levels than the 50 ppm maximum sulfur allowed in the European Standard EN 590:2004. The sulfur content of these fuels typically far exceeds 50 ppm. These fuels typically will not be acceptable for use in areas that restrict maximum fuel sulfur levels to 50 ppm or less.

The fuel that is selected must meet the requirements that are specified in “Cat Specification for Distillate Diesel Fuel for Off-Highway Diesel Engines”, table 43 . Cooling of the fuel may be required to maintain 1.4 cSt or greater viscosity at the fuel injection pump. Consult the supplier for the recommended additives in order to maintain the proper fuel lubricity.

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

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

Table 44

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

These fuels are lighter than the No. 2 grades of fuel. The cetane number of the fuels in table 44 must be at least 40. If the viscosity is below 1.4 cSt at 40 °C (104 °F), use the fuel only in temperatures below 0 °C (32 °F). Do not use any fuels with a viscosity of less than 1.2 cSt at 40 °C (104 °F).

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

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

Renewable and Alternative Fuels

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

Renewable fuels (other than biodiesel) and alternative fuels (such as but not limited to Gas-to-Liquid fuel) are typically hydrocarbons (composed of carbon and hydrogen). An exception is biodiesel, which is an oxygenated renewable fuel. Biodiesel is discussed in a separate article in this Fuel section. Significant research is on going to develop renewable fuels and produce them economically.

Caterpillar is not in a position to test all varieties of renewable and alternative fuels that are advertised in the market place. Before operating on any fuels other than diesel fuel or biodiesel (as discussed in this Fuels section), consult with the fuel supplier and with your Cat dealer. Due to the nature of the of the hydrocarbons that make up some alternative fuels in the marketplace, the fuel may inherently have poor lubricity, poor cold weather performance, and potentially have compatibility issues with fuel system elastomers.

If a renewable or alternative fuel fulfills the performance requirements described in Cat Fuel Specification, the latest version of ASTM D975 or the latest version of EN 590, then this fuel or a blend of this fuel (blended with appropriate distillate diesel fuel) can be used as a direct replacement of petroleum diesel in Cat engines.

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

Aftermarket Fuel Additives

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

In special circumstances, Caterpillar recognizes the need for fuel additives. Fuel additives need to be used with caution. The additive may not be compatible with the fuel. Some additives may precipitate. This action causes deposits in the fuel system. The deposits may cause seizure. Some additives may plug fuel filters. Some additives may be corrosive, and some additives may be harmful to the elastomers in the fuel system. Some additives may damage emission control systems. Some additives may raise fuel sulfur levels above the maximum allowed by the United States (U.S.) Environmental Protection Agency (EPA) and/or, as appropriate, other regulatory agencies. Consult your fuel supplier for those circumstances when fuel additives are required. Your fuel supplier can make recommendations for additives to use and for the proper level of treatment.

Note: Metallic fuel additives can cause fuel system/injector fouling and after treatment device fouling. Caterpillar discourages the use of metallic fuel additives in most applications. Metallic fuel additives should only be used in applications where their use is specifically recommended by Caterpillar .

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

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

Cat Diesel Fuel Conditioner

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

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

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

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

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

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

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

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

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

NOTICE

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

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

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

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

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 Cat diesel engines.

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

Cat Diesel Fuel System Cleaner can be added directly to diesel fuel, biodiesel, or biodiesel blends. Cat Diesel Fuel System Cleaner is a United States Environmental Protection Agency registered fuel additive that can be used with Ultra Low Sulfur Diesel Fuel. In addition this cleaner is appropriate for use with other ultra low, low, and higher sulfur diesel fuels around the world.

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

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

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

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

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

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

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

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

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

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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 various 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. The oil or fat must be esterified and the water and contaminants removed.

Fuel made of 100 percent FAME is 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. 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.

Note: The user of the engine has the responsibility of using the correct fuel that is recommended by the manufacturer. The fuel must be 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 Cat products.

Note: Cat follows the latest revision of ASTM D7467 specification for B6-B20 blends. Biodiesel fuel must meet defined quality standards. Cat 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.

Recommendations for the Use of Biodiesel in Caterpillar Off-Highway Engines

Refer to table 45 and 46 to the details provided in this section for biodiesel fuel requirements.

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.

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.

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.

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.

For Tier 4 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 Stage IIIB and later 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 EN 590. The final blend must have 15 ppm sulfur.

Table 45

Recommendations for biodiesel fuel application in Cat Off-Highway engines		
Production year/Tier/Stage	**Engine model**	**Biodiesel acceptable blend levels**
Tier 2 / Stage II or earlier Emissions Regulations	3003-3034, 3044, 3046, 3054, 3056, 3064, and 3066, 3054C (mechanical), 3054E (electronic) and 3056E (electronic). C0.5, C0.7, C1.1, C1.5, C1.6, C2.2, C3.4, C2.6, C3.3B. Certain C4.4 (S/N 44400001-04303), Certain C6.6 (S/N CE600001-14623 (Machines) and S/N 66600001-09015 (Industrial))	Up to B5 (1)
Tier 4 Interim / Stage IIIa (without aftertreatment)	C1.8, C2.4, C3.3B, C3.4	
Tier 4 Interim / Stage IIIb (with aftertreatment devices)	C3.8	
Tier 4 Interim / Stage IIIb and beyond (with aftertreatment devices)	ACERT engines: C3.4B, C4.4, C6.6, C7.1, C9.3, C13, C15, C18, C27, and C32	Up to B20
All years, except for the engine models listed above	C0.5 through C2.2 (2) Certain C4.4 ACERT (S/N C4E05524-Up (Machines) and 44404304 -Up (Industrial)), C4.4 (Mechanical), C6.4, and certain C6.6 ACERT (S/N CE614624-Up (Machines) and 66609016-Up (Industrial))	Up to B20 (For use of higher blend levels up to B100, consult your Cat dealer)

(continued)

(Table 45, contd)

Recommendations for biodiesel fuel application in Cat Off-Highway engines		
Production year/Tier/Stage	**Engine model**	**Biodiesel acceptable blend levels**
All years	3114, 3116, 3126, 3176, 3196, 3208, 3306 3406, 3408, 3412, 3456, 3406E, 3408E, 3412E, 3500 Series, and 3600 Series C-9, C10, C-12, C-15, C-16, C-18, C280 Series, CM20, CM25, and CM32 ACERT engines [1] sure C7, C9, C9.3, C11, C13, C15, C18, C27, C32, and C175	

(1) Up to B7 can be used in these engines. B7 has to be per Cat distillate diesel fuel specification, ASTM D975 or EN590.
(2) Models without aftertreatment only

Table 46

Fuel Recommendations for Cat Nonroad Engines		
Biodiesel Blend Stock	Final Blend	Distillate Diesel Fuel used for blending
Cat biodiesel specification, [1] ASTM D6751 or EN14214	B5: Cat distillate diesel fuel specification, [2] ASTM D975 or EN590	Cat distillate diesel fuel specification, ASTM D975 or EN590
	B20: ASTM D7467 and API gravity 30-45	

(1) Refer to Table 48 in the Biodiesel section of this Special Publication.
(2) Refer to “Cat Specification for Distillate Diesel Fuel for On-Highway Engines” in the Fuel section of this Special Publication.

Note: For Tier 4 certified/ Stage IIIB and newer engine models that are equipped with aftertreatment devices, use only the biodiesel blend levels that are recommended in “Recommendations for biodiesel fuel application in Caterpillar Off-Highway Engines” in this Special Publication, table 45 . Use of biodiesel blend levels higher than the recommendations provided in table 45 can adversely affect engine and aftertreatment components. There may be contaminants present in biodiesel. The repair of any engine or aftertreatment components due to such contamination or due to other biodiesel impacts would not be covered under the Cat 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 47 in this Special Publication for the guidelines and impacts of using high biodiesel blends. Consult your Caterpillar dealer for guidance. Cat S·O·S Services oil analysis program is required when biodiesel or blends that are B20 (20 percent) or above are used.

Two methods can be used for determining the volume percent biodiesel in a biodiesel blend:

- 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)”
- EN 14078“- Liquid Petroleum Products - Determination of fatty acid methyl esters (FAME) in middle distillates -Infrared spectroscopy method”

For applications running biodiesel or biodiesel blends, Cat recommends either of the following treatments:

- Cat Diesel Fuel System Cleaner (Part number 343-6210)
- 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. Chemical composition and characteristics of biodiesel fuel, such as density and volatility. Chemical contaminants 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-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, and so on)).
- 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 affect the life and performance of aftertreatment emissions control devices and can accumulate in Diesel Particulate Filters (DPF). The ash accumulation may cause the need for more frequent ash service intervals and/or cause loss of performance.

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 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 .

Guidelines

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 these recommendations, the cautions, guidelines, and recommendations applicable to biodiesel (B100) are also applicable to biodiesel blends (B2, B5, B20, and so on). 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 47 of this Biodiesel section for more details.

Note: Fuel storage tanks need to be cleaned thoroughly 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 should be shortened for an extended period in order to allow for this cleaning effect.

In North America , obtain biodiesel from BQ-9000 accredited producers and BQ-9000 certified marketers. 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.

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.

Table 47

Risks and Guidelines associated with the use of biodiesel and biodiesel blends[1]				
Paragraph reference	Risk/Recommendation	B5	B6-B20	B21-B100
1	Risk of reduction of oil change interval	Negligible	Low	High
2	Risk of fuel filters compatibility	Negligible	Low	Medium
3	Risk of reduction of fuel filter change interval	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	Risk of low ambient temperature problems for both storage and operation.	Medium	Medium-High	High
8	Feedstock impact	Medium	Medium	High
9	Risk of oxidation stability and Injector deposits	Low	Medium	High
10	Oxidation stability-Duration of storage	Similar to Diesel fuel	8 months[2]	4 months[3]
11	Use in engines with limited operational time	Maximum allowed	Unacceptable	Unacceptable
12	Risk of microbial contamination and growth	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) Refer to the paragraph reference number for details of each listed Risk/Recommendation.
(2) Testing of B20 blends is recommended at 4 months of storage and on a monthly basis thereafter. Tests should include oxidation, acid number, viscosity, and sediments.
(3) B100 stored for over 2 months should be tested every 2 weeks to ensure that the fuel is not degraded. Tests should include oxidation, acid number, viscosity, and sediments. The use of appropriate additives is required if B100 is stored more than 4 months. Consult your fuel supplier for more information. 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.

The following are the paragraph reference numbers:

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 should be shortened for an extended period in order to allow for this cleaning effect when converting used engines to biodiesel. Filter change interval of 50 hours or less is recommended following the initial conversion to B20 biodiesel blend.

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. Engine problems may occur when the engine is converted back to 100 percent distillate diesel fuel. Any adjustments to the engine in service 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 biodiesel blend has a 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. Cold flow affects filter plugging and oxidation stability affects deposit formation and biodiesel fuel storage duration and life. 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, which may accelerate fuel oxidation. Oxidized fuel can form deposits in fuel injection systems and in fuel systems in general. 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 recommended. Tests should include oxidation, acid number, viscosity, and sediments. Tests should be conducted periodically to ensure that 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 8 months. Testing of B20 blends is recommended at 4 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 4 months. Testing of B100 is recommended at 2 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 4 months. Consult your fuel supplier for more information.

c. 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.

11. Due to poor oxidation stability and other potential issues, engines with limited operational time (such as seasonal use or standby power generation) 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. For more information, refer to the “Seaconal Operation” section.

a. Addition of Cat Diesel Fuel Conditioner , part number 256-4968, is 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 not in specification (provided in Table 48 in this "Biodiesel" section), drain the tank, flush the engine by running with high-quality fuel. Repeat the process until the system is clean. Refill with high-quality fuel following the recommendations provided in this "Fuel" section

c. For standby generator sets and emergency vehicles that use biodiesel, use fuel with oxidation stability 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 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.

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

Seasonally operated engines should have the fuel systems, including fuel tanks, flushed with conventional diesel fuel before prolonged shutdown periods. Applications that should seasonally flush the fuel system include school buses (U.S.) and farm machinery.

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

1. Operate the engine until the fuel level in the tank is 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, is recommended prior to engine shutdown 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, 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.

The final blend of biodiesel as used in the engine must meet the requirements that are stated in table 48 this "Biodiesel" article.

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 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).

Table 48

Cat Specification for Biodiesel Fuel				
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
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 KOH/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

(continued)

(Table 48, contd)

Cat Specification for Biodiesel Fuel				
Property	**Test Method**	**Test Method**	**Units**	**Limits**
	United States	**International**	**Specific Properties of Fuel**	
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	ASTM D7501	–	seconds	360 maximum
Cleanliness	ASTM D7619	ISO 4406	–	(1)

(1) Recommended cleanliness level for fuel as dispensed into machine or engine fuel tank is ISO 18/16/13 or cleaner per ISO 4406 or ASTM D7619. Refer to the “Contamination Control” section in this Special Publication.

Note: Fuels that meet the most current revision level of ASTM D6751 or EN 14214 may be used for blending with an acceptable distillate fuel. The conditions, recommendations, and limits that are noted in this Biodiesel section apply.

Referenced Documents

Refer to the “Reference Material - Fuel” section of this Special Publication for the reference material for the information in this section.

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.

Table 49

Special Requirements[1]	
Cat diesel engines equipped with air-to-air aftercooling (ATAAC)	Minimum of 30% glycol is required. 50% Glycol is recommended. Water alone or water with SCA or with ELI is NOT allowed.
Cat 3618 engine model	Water-ELI is recommended. Water-SCA is acceptable. Glycol-based coolants are NOT allowed.
Cat 3500C engine model	Maximum of 20% glycol is allowed in the aftercooler circuit.[2] (not applicable to the jacket water circuit, which is capable of 50% glycol)

(1) Recommendations for commercial engines, including marine engines, are provided in Special Publication, SEBU6251, Cat Commercial Diesel Engine Fluids Recommendations.
(2) For freezing protection of −5° C (23° F) temperatures and lower, consult your Cat dealer for guidance.

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 50 .

Table 50

Cat Minimum Acceptable Water Requirements		
Property	**Maximum Limit**	**ASTM Test**
Chloride (Cl)	40 mg/L (2.4 grains/US gal)	D512, D4327
Sulfate (SO_4)	100 mg/L (5.9 grains/US gal)	D516 D4327
Total Hardness	170 mg/L (10 grains/US gal)	D1126
Total Solids	340 mg/L (20 grains/US gal)	D1888 Federal Method 2504B[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 51 and 52 .

Table 51

Ethylene Glycol Concentration		
Concentration	**Freeze Protection**	**Boil Protection** (1)
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 52

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.

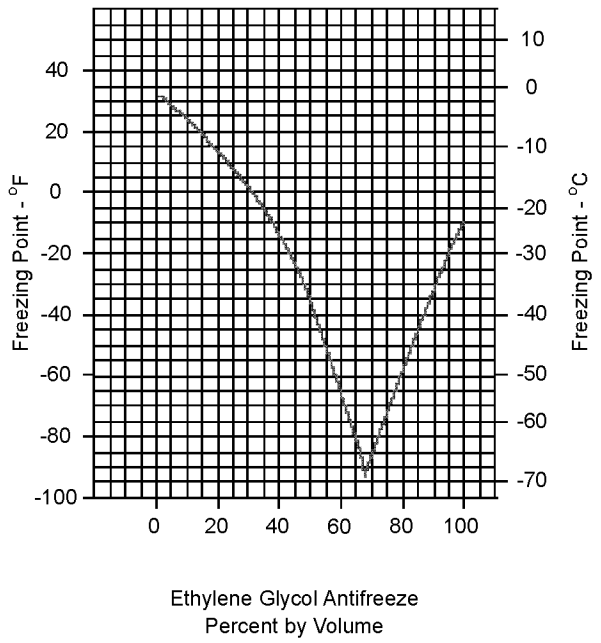

Illustration 4 g01189253

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

Table 53

Freeze Protection for Antifreeze Concentrations(1)	
Protection to:	**Concentration**
−15 °C (5 °F)	30% glycol 70% water

(continued)

(Table 53, contd)

−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 D4985-05 or 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 D4985-05 or 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

The finished coolants that are recommended or acceptable for use in Cat diesel engines are given in Table 54 below:

Table 54

Recommendations for Finished Coolants for use in Cat engines				
Coolant Type	**Recommendations**	**Product**	**Service hours (1) (2)**	**Required Maintenance(3)**
Cat ELC, Cat ELI, or commercial coolant that meets Cat EC-1	Preferred	Cat ELC	12000 hours or 6 years	Add Cat ELC Extender at 6000 service hours or one half of service life
		Cat ELI (water based) (4)	12000 hours or 6 years	Add Cat ELC Extender at 6000 service hours or one half of service life
	Min requirements	Cat EC-1 specification and ASTM D6210 and Organic Additive Technology (OAT) based on a combination of a monocarboxylic acid and a dicarboxylic acid Phosphate, borate, and silicate free Tolyltriazole: minimum typical concentration of 900 ppm Nitrite: minimum typical concentration of 500 ppm in new coolants	6000 hours or 6 years	Add Extender at 3000 service hours or one half of service life
Cat DEAC, Cat SCA, conventional coolants and commercial extended life coolants that do not meet EC-1	Acceptable	Cat DEAC	3000 hours or 3 years	SCA at maintenance intervals
		Cat SCA (water based) (4)	3000 hours or 2 years	SCA at maintenance intervals
	Min requirements for fully formulated Heavy Duty Commercial coolants	ASTM D6210 and Nitrite (as NO2) concentration: Minimum of 1200 ppm (70 grains/US gal) and maximum of 2400 ppm (140 grains/US gal) Silicon concentration: minimum of 100 ppm and maximum of 275 ppm	3000 hours or 2 years	SCA at maintenance intervals
	Min requirements for Commercial coolants requiring SCA precharge	ASTM D4985 and (4) Nitrite (as NO2) concentration: Minimum of 1200 ppm (70 grains/US gal) and maximum of 2400 ppm (140 grains/US gal) Silicon concentration: minimum of 100 ppm and maximum of 275 ppm	3000 hours or 1 year	SCA at initial fill and SCA at maintenance intervals
	Min requirements for SCA and water(5)	Commercial supplemental coolant additive and water having Nitrite (as NO2) concentration: Minimum of 1200 ppm (70 grains/US gal) and maximum of 2400 ppm (140 grains/US gal) Silicon concentration: minimum of 100 ppm and maximum of 275 ppm	3000 hours or 1 year	Per manufacturer recommendations

(continued)

(Table 54, contd)

(1) New Coolants at 50 volume percent diluted. Coolants that are prediluted at the coolant manufacturer must be diluted with water that meets Reagent 4 ASTM D1193 requirements.
(2) Maintain the in-service coolant at the given limits.
(3) For appropriate maintenance procedures, refer to the details given in this Chapter. For applications that allow the use of Cat ELI in water, a minimum of 7.5 percent of Cat ELI is recommended. For applications that allow the use of SCA and water, a minimum of 6 percent to a maximum of 8 percent concentration of Cat SCA are recommended.
(4) Water-based coolants are not allowed for use in machines that has NOx reduction aftertreatment devices, in engines that has AATAC and in Marine engines that have SWAC
(5) There are currently no industry standards to define the quality of water-based conventional coolants. In order to control the quality of SCA and water coolants, the commercial SCA additive package should pass ASTM D6210 and/or ASTM D4985 when this package is used in a glycol based coolant. Do not use a commercial SCA additive package that only meets the ASTM D3306 or equivalent specification when used in a glycol based coolant.

Table 55

Special Requirements(1)	
Cat diesel engines equipped with air-to-air aftercooling (ATAAC)	Minimum of 30% glycol is required. 50% Glycol is recommended. Water alone or water with SCA or with ELI is NOT allowed.
Cat 3618 engine model	Water-ELI is recommended. Water-SCA is acceptable. Glycol-based coolants are NOT allowed.
Cat C7-C32 SCAC and Cat 3500C engine model Marine EPA Tier 3 capable engines (heat exchanger cooled and keel cooled configurations)	Maximum of 20% glycol is allowed in the aftercooler circuit.(2) (not applicable to the jacket water circuit, which is capable of 50% glycol)

(1) Recommendations for commercial engines, including marine engines, are provided in Special Publication, SEBU6251, Cat Commercial Diesel Engine Fluids Recommendations.
(2) For freezing protection of −5° C (23° F) temperatures and lower, consult your Cat dealer for guidance.

When referring to the Service Life in table 54 , use the interval that occurs first. These coolant change intervals are only achievable with annual S·O·S Services Level 2 coolant sampling analysis.

Refer to the engine Operation and Maintenance Manual for the correct interval for replacement of the cooling system water temperature regulator.

Extended life coolants require the one time maintenance addition of an extender at coolant service mid-life. For commercial coolants, do NOT use an extender with a coolant unless the extender has been approved by the coolant manufacturer for use with the coolant. The coolant manufacturer is responsible to ensure compatibility and acceptable performance. Failure to follow these recommendations can result in shortened cooling system component life.

Conventional coolants require the maintenance addition of SCA throughout the expected life. For commercial coolants, do NOT use an SCA unless approved by the coolant supplier for use with the coolant. The coolant manufacturer is responsible to ensure compatibility and acceptable performance.

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 maximum of 1 year (ASTM D4985) and 2 years (ASTM D6210). **The suitability for use requirement is the direct responsibility of the coolant manufacturer and SCA manufacturer.** Consult with the coolant and/or SCA manufacturer concerning the suitability of the products for use in a given application.

Cat DEAC does not require a treatment with an SCA at the initial fill.

A commercial heavy-duty coolant/antifreeze that meets the ASTM D6210specification does not require a treatment with an SCA at the initial fill.

A commercial heavy-duty coolant/antifreeze that only meets ASTM D4985, WILL require a treatment with an SCA at the initial fill and has to fulfill all the requirements listed in the “Technical Requirements for Commercial Extended Life Coolants” table. The user and the coolant manufacturer are responsible to ensure the SCA is compatible. Compatibility is based on the recommendations provided by the coolant manufacturer and SCA manufacturer. For example, an extended life coolant that meets the ASTM D4985 specification may not be compatible with an SCA designed for use with conventional coolants. The coolant manufacturer is responsible to provide sources of compatible SCAs. The coolant manufacturer and SCA manufacturer are responsible to demonstrate a positive influence on reducing cavitation corrosion in an operating diesel engine.

Read the label or the instructions that are provided by the manufacturer of the commercial heavy-duty coolant/antifreeze.

When adding SCA at initial fill to a coolant/antifreeze that only meets ASTM D4985, the user and the coolant manufacturer must ensure the SCA is compatible with the antifreeze/coolant. The addition must be 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. Follow the test procedure using the antifreeze/coolant of interest to compare the SCA of interest with the reference SCA. The ratio of insoluble for SCA to reference SCA must be < 1. Total insoluble should not exceed 4.0 mL for a 6% SCA mixture. 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 is found in ASTM D6210, Table X1.1.

The coolant manufacturer and the SCA manufacturer are responsible to ensure that the products will not cause cooling system harm.

Cat ELC can be recycled into conventional coolants.

Cat ELC, Cat ELI, Cat DEAC, Cat Extender, and Cat SCA are available in several container sizes. The availability of part numbers will vary by the region. Consult your Cat dealer.

In stationary and marine engine applications that do not require protection from boiling or freezing, except as noted in Table 55 , Cat ELI in water or SCA and water are acceptable. **Caterpillar recommends a minimum of 7.5 percent concentration of Cat ELI in those cooling systems using Cat ELI. Caterpillar recommends a minimum of 6 percent to a maximum of 8 percent concentration of Cat SCA in those cooling systems using Cat SCA.** Distilled water or deionized water is preferred in those systems. If distilled or deionized water is not available, use water that meets or exceeds the minimum acceptable water requirements that are listed in this Special Publication, “General Coolant Information” article.

After the addition of water and proper mixing, the concentration of Cat ELI can be determined using the 360-0744 digital Brix refractometer. Refer to the tool operating manual for that refractometer for more information. The concentration of a sample of in-use Cat ELI taken from the cooling system can also be determined using this refractometer

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.

NOTICE

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

Use only the coolant/antifreeze that is recommended.

Caterpillar recommends a 50 volume percent glycol and water of proper quality. This mixture will provide optimum heavy-duty performance as a coolant/ antifreeze.

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
- 298-5311 nitrite level titration kit, subject to regional availability, use only with mixtures of water and SCA. Not for use with glycol-based coolants.

Frequently check the concentration of glycol in glycol-based coolant. Use a coolant/battery tester. Two products are available from Cat dealers. 245-5829 is an analogue refractometer that shows the freeze protection level of the coolant in both degrees Celsius and degrees Fahrenheit. 360-0774 is a digital Brix refractometer.

Maintain the proper concentrations of glycol and additives in the coolant. Lowering the concentration of glycol or additives will lower the ability of the coolant to protect the system from pitting, from cavitation, from erosion, and from deposits.

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.

Clean the cooling system for the following reasons:

- Contamination of the cooling system
- Overheating of the engine
- Foaming of the coolant
- Changing from conventional heavy-duty coolant/ antifreeze to Cat ELC or ELC-1 coolant

Note: Air pockets can form in the cooling system if the cooling system is filled at a rate that is greater than 20 L (5 US gal) per minute. The maximum recommended cooling system fill rate for some smaller engine models will be less. Refer to the engine Operation and Maintenance Manual for exceptions.

After you drain the cooling system and after you refill the cooling system, operate the engine. Operate the engine without the filler cap until the coolant level stabilizes. Ensure that the coolant is maintained to the proper level.

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Extended Life Coolant

SMCS Code: 1350; 1352; 1395

Cat ELC

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 coolants, the Cat ELC anti-corrosion package is based on a different additive system. Cat ELC has been formulated with the correct amounts of additives. Superior corrosion protection is provided for all metals that are in engine cooling systems.

Cat ELC extends the service life of the coolant to 12000 service hours or 6 years. Cat ELC does not require the frequent addition of the Cat ELC Extender additive. An Extender is the only additional maintenance that is needed at 6000 service hours 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 diesel and gasoline OEM engines. Cat ELC meets the performance requirements of ASTM D4985 and ASTM D6210 for heavy-duty low silicate antifreeze/coolants. Cat ELC also meets the performance requirements of ASTM D3306 for automotive applications.

Commercial Extended Life Coolant

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

In order to be used in Cat diesel engine cooling systems at the published service intervals, select a commercial extended life coolant that meets all the requirements given in Table 56 in this Special Publication.

Table 56

Technical Requirements for Commercial Extended Life Coolants	
Specifications	Cat EC-1 and ASTM D6210
Additional Requirements	Organic Additive Technology (OAT) based on a combination of a mono-carboxylic 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"
Maintenance	One time addition of an extender at the mid-life of the coolant in order to maintain the coolant nitrite level between 300 - 600 ppm

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

Use an extender that is recommended by the EC-1 coolant supplier at mid-life of the coolant.

Commercial coolants that do not meet the minimum requirements defined in this Special Publication are not allowed for use in Cat engines.

Commercial extended life coolant used in Cat engines must meet all requirements given in Table 56 . If the ELC does meet the requirements, the service interval listed in this Special Publication may not be used. Follow the maintenance guidelines for the coolant from the supplier of the commercial extended life coolant. Follow the Cat guidelines for the quality of water and the specified coolant change interval.

Note: Coolants must be tested against the Cat EC-1 specification requirements. Coolants that only claim to meet the performance requirements of the Cat EC-1 specification may not meet all the minimum requirements.

In order to be marketed as a product that meets Cat EC-1, all Cat EC-1 specification requirements must be met. Requirements include, but are not limited to the following:

- Physical and Chemical Properties
- Compatibility Characteristics
- Bench Testing
- Field Testing

The field test includes the use of the following requirements:

- Radiator types
- Minimum field test duration
- Minimum number of diesel engines
- Cat diesel engine models of the required minimum power rating

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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 Cat 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.

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, maintain the recommended concentration of Cat ELC . Lowering the proportion of antifreeze lowers the proportion of additive. The coolant will not be able to protect the system from pitting, cavitation, erosion, and deposits.

During daily maintenance, use the premixed Cat ELC as a cooling system top-off. 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. Add the concentrate 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 .

Cat ELC Extender

Cat ELC Extender is added to the cooling system halfway through the Cat ELC service life. Treat the cooling system with Cat ELC Extender at 6000 hours or one half of the coolant service life. Refer to your machine Operation and Maintenance Manual for exceptions. Refer to the “Part Number of Coolant” table in this Special Publication, “Coolant Recommendations” article for available quantities and part numbers.

Use the formula in Table 58 to determine the proper amount of Cat ELC Extender for your cooling system. Refer to Operation and Maintenance Manual, “Refill Capacities and Recommendations” in order to determine the capacity of the cooling system.

Table 57

Formula For Adding Cat ELC Extender To Cat ELC
V × 0.02 = X
V is the total capacity of the cooling system.
X is the amount of Cat ELC Extender that is required.

Table 58 is an example for using the formula that is in Table 57 . This example is based on the typical capacity of a D8RTrack-Type Tractor .

Table 58

Example Of The Equation For Adding Cat ELC Extender To Cat ELC		
Total Volume of the Cooling System (V)	**Multiplication Factor**	**Amount of Cat ELC Extender that is Required (X)**
94.6 L (25.0 US gal)	× 0.02	1.9 L (0.5 US gal)

NOTICE
When using Cat ELC, do not use conventional SCAs, or, if equipped, SCA maintenance elements. In order to avoid SCA contamination of an 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 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 a properly maintained 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.

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 classified as either Cat ELC or Cat DEAC . Consult your Cat dealer for more information. Recycled coolants should meet the most current revision level of ASTM D6210.

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 Cat 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 by-pass the coolant lines.

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

5. Use Cat Quick Flush Cooling System Cleaner for cooling systems in order to clean the system. Cat Quick Flush Cooling System Cleaner is available in various sizes. Part numbers are 4C-4609 (0.5 L (0.125 US gal)) through 4C-4613 (208.2 L (55 US gal)). Follow the instructions on the label using a 6-10% concentration of cleaner in water.

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, 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.

Note: Replace hoses that are cracked, soft, or that have other signs of damage. Tighten all hose clamps and fittings.

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 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 a properly maintained cooling system.

Cat ELC Cooling System Contamination

NOTICE
Mixing Cat ELC with other products 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 Cat EC-1 specification for premixed or concentrate coolants. Use only Cat ELC Extender with Cat ELC . Do NOT mix brands or types of coolants. Failure to follow these recommendations can result in shortened cooling system component life.

Cat ELC cooling systems can withstand contamination to a maximum of 10 percent of conventional heavy-duty coolant/antifreeze and/or SCA. The advantages of Cat ELC are reduced above 10 percent. If the contamination exceeds 10 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 10 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 10 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. Submit a coolant sample for Level 2 S·O·S Coolant Analysis to determine the coolant condition. Maintain a 3 to 6 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.

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Extended Life Inhibitor (ELI)

SMCS Code: 1350; 1352; 1395

Cat Extended Life Inhibitor (ELI) is water-based coolant that does not contain glycol. Cat ELI is for applications that do not require freeze protection. Exceptions are listed in this. Failure to follow these recommendations can or will result in failures.

Cat ELI is a corrosion inhibitor concentrate that is mixed to approximately 7.5 % by volume with water. Cat ELI has the following characteristics:

- Based on the same organic additive technology that is used in Cat Extended Life Coolant (ELC)
- Does not contain glycol. Designed for use in applications that do not require freeze protection.
- Provides superior corrosion and cavitation protection compared to SCA mixed with water.
- Provides an extended drain interval of up to 6 years or 12,000 hours. The drain interval may be longer as determined by using Cat S·O·S coolant analysis.
- Requires little maintenance compared to conventional SCA mixed with water.

Cat ELI can replace SCA/Water coolant in engine applications that do not require freeze protection.

Exceptions for use of water-based ELI or SCA coolants are listed in this Special Publication, “Coolant Recommendations - Special Requirements Table”.

Additional information is available from your Cat Dealer. Refer to Information Release Memo, PELJ1212, “Cat ELI – PERFORMANCE LIKE Cat ELC FOR APPLICATIONS NOT REQUIRING FREEZE PROTECTION”. Refer to Table 59 for information about Cat ELI.

Table 59

Part Number	Container Size	Volume of Finished Coolant Produced
351-9431	3.8 L (1 US gal)	50.5 L (13.3 US gal)
351-9432	20 L (5.3 US gal)	267 L (70.5 US gal)
351-9433	208 L (55 US gal)	2773 L (733 US gal)
366-2753 (1)	1000 L (264 US gal)	13333 L (3523 US gal)

(1) NACD and LACD only

Mixing Cat ELI

The recommended water for mixing with Cat ELI concentrate is distilled or deionized water. Water must meet requirements of ASTM 1193, Type IV Reagent Water Specification. If distilled or deionized water is not available, water should meet the "Caterpillar Minimum Acceptable Water Requirements" provided in this Special Publication.

To ensure a proper concentration, the preferred method is to mix Cat ELI concentrate with water. Then, add the mixed coolant to the engine cooling system. Add the proper amounts of water and Cat ELI into a clean container and mix thoroughly by manual stirring or mechanical agitation.

If the preferred method cannot be performed, a Cat ELI mixture can be made by adding Cat ELI concentrate directly into engine cooling system. Add good quality water until the dilution level is approximately 7.5%. Adequate mixing is attained by operating the engine for at least 30 minutes.

Appropriate mixing rates for available ELI container sizes are provided in Table 59 .

After the addition of water and proper mixing, the concentration of Cat ELI can be determined using the 360-0744 digital Brix refractometer.

Changing to Cat ELI

For cooling systems previously running Cat ELC or an extended life coolant that meets Cat EC-1 requirements, drain the cooling system and flush with water. Then refill the cooling system with a mixture of 7.5% Cat ELI in water that meets the "Caterpillar Minimum Acceptable Water Requirements".

For cooling systems previously running a conventional heavy-duty coolant or a water/SCA mixture, follow the steps listed in this Special Publication, "Changing to Cat ELC". Then refill the cooling system with a mixture of 7.5% Cat ELI in water that meets the "Caterpillar Minimum Acceptable Water Requirements".

Cat ELI Maintenance

Maintenance of Cat ELI is similar to Cat ELC. A coolant sample should be submitted for S·O·S Level 2 Coolant Analysis after the first 500 hours of operation and then annually thereafter.

Cat ELC Extender should be added at the midpoint of service life (typically 6,000 hours), or as recommended by S·O·S Coolant Analysis results.

Analysis and interpretation of Cat ELI S·O·S results is similar to the analysis and interpretation of Cat ELC. There will be no glycol and glycol oxidation products, which do not apply to Cat ELI.

The concentration of a sample of in-use Cat ELI taken from the cooling system can also be determined using the 360-0744 digital Brix Refractometer.

The concentration of Cat ELI can be determined using a refractometer such as Cat part number 360-0774.

Note: Clean water is the only flushing agent that is required when Cat ELI is drained from a properly maintained cooling system.

Mixing Cat ELI and Cat ELC

Since Cat ELI and Cat ELC are based on the same corrosion inhibitor technology, Cat ELI can be mixed with Cat ELC. Mixing may be desired when only low level of freeze protection is required. Consult your local Cat dealer to ensure proper mixing of the products to provide adequate freeze protection and corrosion protection.

i04331825

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

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.

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, the test the concentration on a scheduled basis. Refer to the Operation and Maintenance Manual, “Maintenance Interval Schedule”, of the 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.

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, the test the concentration on a scheduled basis. 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.

Note: Do not exceed a 6 percent maximum concentration of SCA. Maintain a 3 to 6 percent SCA concentration 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
- 298-5311 nitrite level titration kit, subject to regional availability, use only with mixtures of water and SCA. Not for use with glycol-based coolants

i04331875

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
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.

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.

NOTICE
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.

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

If non-Cat conventional coolants that meet Cat minimum published requirements are used, confirm with the coolant manufacturer before using Cat SCA that Cat SCA is acceptable for use with the coolant. Do not exceed the 6 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.

Cat engine cooling systems should be tested at 250 hour intervals or at the PM Level 1 intervals for the concentration of SCA (Supplemental Coolant Additive).

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

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

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

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

Do not exceed the 6 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.

Do not use the maintenance spin-on element for the SCA and the liquid for the SCA at the same time. Spin-on elements may not be available for all applications.

Table 60

Cat SCA Requirements for Heavy-Duty Coolant/Antifreeze				
Cooling System Capacity	**Initial Fill**	**250 hours or Intervals for PM Level 1**	**Spin-on Element at 250 hours or at Intervals for PM Level 1**	**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
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

Cooling systems of larger capacities than provided in Table 60 should follow the equation given in Table 39 for appropriate amount of SCA required at initial fill. The equation given in Table 41 is the appropriate amount of SCA and water at maintenance intervals.

Adding the SCA to Conventional Coolant/Antifreeze at Initial Fill

Table 61

Equation For Adding The Cat SCA To Water At The Initial Fill (1)
V × 0.07 = X
V is the total volume of the cooling system.
X is the amount of Cat SCA that is required.

(1) For fluids that only meet the ASTM D4985 specification

Table 62 is an example for using the equation that is in Table 61 .

Table 62

Example Of The Equation For Adding The Cat SCA To Water At The Initial Fill		
Total Volume of the Cooling System (V)	**Multiplication Factor**	**Amount of Cat SCA that is Required (X)**
946 L (250 US gal)	× 0.07	66 L (18 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 Cat dealer. Test the concentration of SCA or submit a coolant sample to your Cat dealer. Refer to 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.

Table 63

Equation for the Addition of Cat SCA To Water For Maintenance
V × 0.023 = X
V is the total volume of the cooling system.
X is the amount of Cat SCA that is required.

Table 64 is an example for using the equation that is in Table 63 .

Table 64

Example of the Equation for the Addition of Cat SCA To Water For Maintenance		
Total Volume of the Cooling System (V)	**Multiplication Factor**	**Amount of Cat SCA that is Required (X)**
946 L (250 US gal)	× 0.023	22 L (6 US gal)

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

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 scales, corrosion products, light oil contaminations, and sludges
- 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 Cleaners clean the cooling system while still in service.
- Reduces downtime and cleaning costs
- Helps 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 Cleaners are 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 Cat 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.

Prior to performing a cleaning of the cooling system, take a 1-liter (1-quart) sample of coolant from the engine while in operation into a clear container. Take the sample shortly after start-up while the coolant is not yet hot. The coolant should be adequately mixed by the water pump. Allow the sample to sit for 2 hours. If a visible oil layer is present, neither the Standard cleaners nor Quick Flush cleaner will be fully effective. First, drain the coolant and then perform the procedure given below (using non-foaming dish detergent), followed by the procedure for the Quick Flush cleaner.

Procedure for Cleaning an Oil Contaminated Cooling System

1. Drain the cooling system.
2. Fill the cooling system with acceptable quality water.

Note: Refer to the “Caterpillar Minimum Acceptable Water Quality Requirements” in this Special Publication.

3. Start the engine and run the engine until the thermostat opens.
4. Add 0.473 L (0.5 qt) of 269-1948 non-foaming detergent. If the cooling system capacity exceeds 113.6 L (30 US gal), add enough detergent to equal approximately 2-3% cooling system capacity.

Note: Pre-dissolve the detergent in approximately 19 L (5 US gallons) of acceptable quality water. Add this mixture directly to the cooling system and top off the cooling system with water.

5. Run the engine for at least 30 minutes. Drain the cooling system.
6. Remove a small sample of the detergent solution from the cooling system. Allow the solution to sit for at least 30 minutes and check for signs of a visible oil layer on top. If oil is still present, repeat the procedure.

Note: Corrosion of the metal can occur if the detergent solution is left in the cooling system for longer than 1 hour.

7. Flush the cooling system, if there is no visible oil layer in the solution. Fill the cooling system with acceptable quality water. Run the engine for 20 minutes and then drain the water.
8. Perform the cleaning procedure found in this Special Publication for “Cat Cooling System Cleaner - Quick Flush”, if additional removal of scale, rust, and inhibitor deposits from the previous coolant is needed.
9. If additional cleaning is not needed, refill the cooling system with new coolant.

Table 65

Cat Cooling System Cleaner for use with Quick Flush Method	
Cleaner part number	Size of Container
4C-4609	0.5 L (0.125 US gal)
4C-4610	1 L (0.25 US gal)
4C-4611	3.8 L (1 US gal)
4C-4612	19 L (5 US gal)
4C-4613	208 L (55 US gal)

Procedure for using Cat Cooling System Cleaner - Quick Flush

1. Drain the cooling system.

2. Refill the cooling system to 90-94% capacity with acceptable quality water.

Note: Refer to the “Caterpillar Minimum Acceptable Water Quality Requirements” as found in this Special Publication.

3. Top off the cooling system with Cat Cooling System Cleaner - Quick Flush cleaner so that the solution is 6-10% cleaner.

4. Run the engine for 1.5 hours.

5. After allowing adequate time for the system to cool, drain the cooling system.

Note: Corrosion of the metals can occur if the Quick Flush cleaning solution is in the cooling system for longer than 2 hours.

6. Flush the cooling system.

a. Fill the cooling system with acceptable quality water.

b. Run the engine for 20 minutes.

c. Drain the water.

7. Refill the cooling system with new coolant.

Table 66

Cat Cooling System Cleaner - Standard		
Part Number	Volume	Availability
6V-4511	1.89 L (0.5 US gal)	North and South America
185-5121	1.89 L (0.5 US gal)	Europe , Africa , Middle East

Procedure for using Cat Cooling System Cleaner - Standard

1. If necessary, drain off coolant from the cooling system for the amount of the cleaner.

2. Add 1 bottle (1.89 L (0.5 US gal)) of Cat Cooling System Cleaner - Standard for each 30 L of cooling system capacity. Add the cleaner directly to the coolant.

3. Run the engine as usual.

4. After 30 days, drain the cooling system.

5. Flush the cooling system.

a. Fill the cooling system with acceptable quality water.

b. Run the engine for 20 minutes.

c. Drain the water.

6. Refill the cooling system with new coolant.

Recycling Cat DEAC

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

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

Recycled coolants should meet the latest revision of ASTM D6210.

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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 67 . 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 67

Technical Requirements for Commercial Diesel Engine Antifreeze Coolants	
Specifications	ASTM D6210-08 or ASTM D4985-05
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 D4985-05: Add compatible SCA at initial fill ASTM D6210-08 and ASTM D4985-05: Add compatible SCA at maintenance intervals Clean and flush the cooling system at drain intervals

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Water/SCA (Supplemental Coolant Additive)

SMCS Code: 1350; 1352; 1395

Cat SCA can be added to water of the recommended quality to form a Water/SCA finished coolant. SCA/Water finished coolant is glycol free. SCA/Water finished coolant is for engine applications that do not require freeze protection.

Exceptions are listed in this Special Publication, “Coolant Recommendations - Special Requirements”. Failure to follow these recommendations can or will result in failures.

NOTICE
Never use water alone without Supplemental Coolant Additives (SCA) or without inhibited coolant. Water alone is corrosive at engine operating temperatures. In addition, water alone does not provide adequate protection against boiling or freezing.

In engine cooling systems that use water alone, Caterpillar recommends the use of Cat SCA. Cat SCA helps to prevent the following conditions from occurring:

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

If Cat SCA is not used, select a fully formulated commercial SCA. The commercial SCA must provide a minimum of 2400 mg/L or 2400 ppm (140 grains/US gal) of nitrites in the final coolant mixture.

The quality of the water is an important factor in this type of cooling system. Distilled water or deionized water is recommended for use in cooling systems. If distilled water or deionized water is not available, use water that meets or exceeds the minimum requirements that are listed in the table for recommended water properties in this Special Publication, “General Coolant Information” topic.

A cooling system that uses a mixture of SCA and water only needs more SCA. The SCA concentration in a cooling system that uses SCA and water should be 6 to 8 percent by volume.

Note: Do not exceed the 8 percent maximum concentration. Check the concentration of Cat SCA with a 298-5311 Coolant Nitrite Test Kit for SCA or perform an S·O·S coolant analysis . The test kit includes: testing tool, 30 nitrite test ampoules, instruction and hardcase. 294-7420 contains refill ampoules for the 298-5311 Coolant Nitrite Test Kit.

Note: The 298-5311 Coolant Nitrite Test Kit is NOT calibrated to test the nitrite levels of conventional coolants or extended life coolants.

Maintain the Cat SCA in the same way as you would maintain a cooling system that uses heavy-duty coolant/antifreeze. Adjust the maintenance for the amount of Cat SCA additions.

Adding the Cat SCA to Water at the Initial Fill

Use the equation that is in this Special Publication, “Conventional Coolant/Antifreeze Cooling System Maintenance” to determine the amount of Cat SCA that is required at the initial fill. This equation is for a mixture of only Cat SCA and water.

Adding the Cat SCA to Water for Maintenance

For the recommended service interval, refer to the Operation and Maintenance Manual, “Maintenance Interval Schedule” for your engine.

Submit a coolant sample to your Cat dealer. See this Special Publication, “S·O·S Services Coolant Analysis” topic.

Additions of Cat SCA are based on the results of the coolant analysis. The size of the cooling system determines the amount of Cat SCA that is required.

Use the equation that is in this Special Publication, "Conventional Coolant/Antifreeze Cooling System Maintenance" to determine the amount of Cat SCA that is required for maintenance, if necessary:

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

SCA and part numbers are available from your Cat dealer.

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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. Caterpillar 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

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.

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

The following table contains the recommended sampling interval for all coolants that meet Cat EC-1 (Engine Coolant specification - 1) . This is also the recommended sampling interval for all conventional heavy-duty coolant/antifreeze.

The Level 2 Coolant Analysis should be performed if a problem is suspected or identified.

Table 68

Recommended Interval		
Type of Coolant	**Level 1**	**Level 2**
Cat DEAC and Conventional Heavy-Duty Coolants	Every 250 hours	Yearly
Cat ELC and Commercial EC-1 coolants	Optional	Yearly

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
- Ability to protect from erosion and corrosion
- pH
- Conductivity
- Visual analysis
- 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)
- 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.

Exhaust Aftertreatment Fluids Specifications

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Diesel Exhaust Fluid (DEF) (For Use in SCR-equipped engines)

SMCS Code: 108K

General Information

Diesel Exhaust Fluid (DEF) is a liquid that is injected into the exhaust system of engines equipped with Selective Catalytic Reduction (SCR) systems. SCR reduces emissions of nitrogen oxides (NOx) in diesel engine exhaust.

Diesel Exhaust Fluid (DEF) is available in many brands, including those brands that carry the AdBlue or API certification. DEF is also generically referred to as urea.

In engines equipped with SCR emissions reduction system, DEF is injected in controlled amounts into the engine exhaust stream. At the elevated exhaust temperature, urea in DEF is converted to ammonia. The ammonia chemically reacts with NOx in diesel exhaust in the presence of the SCR catalyst. The reaction converts NOx into harmless nitrogen (N_2) and water (H_2O).

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

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

DEF Recommendations for Diesel Engines

For use in Cat engines, DEF must meet all the requirements defined by the ISO 22241-1 standard.

The caps of DEF tanks are blue, as required by emissions regulations. Fill DEF only in clearly marked DEF tanks that have the blue cap.

Caterpillar recommends the use of DEF available through the Cat parts ordering system for use in Cat engines equipped with SCR systems. Refer to Table 69 for part number information:

Table 69

Cat Part Number (32.5% Urea)	Container Size
350-8733	2.5 gal bottle
350-8734	1000-L tote

In North America , commercial DEF that is API approved and meets all the requirements defined in ISO 22241-1 may be used in Cat engines that are equipped with SCR systems.

Outside of North America , commercial DEF that meets all requirements defined in ISO 22241-1 may be used in Cat engines that are equipped with SCR systems.

The supplier should provide documentation to prove the DEF is compliant with the requirements of ISO 22241-1.

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

NOTICE
Do not use agriculture grade urea solutions. Do not use any fluids that do not meet ISO 22241-1 Requirements in SCR emissions reduction systems. Use of these fluids can result in numerous problems including damage to SCR equipment and a reduction in NOx conversion efficiency.

DEF is a solution of solid urea that is dissolved in demineralized water to produce a final concentration of 32.5% urea. Most SCR systems are designed to operate only on DEF concentration of 32.5 percent. DEF solution of 32.5% urea has the lowest attainable freeze point of −11.5° C (11.3° F). DEF concentrations that are higher or lower than 32.5% have higher freeze points. DEF dosing systems and ISO 22241-1 specifications are designed for a solution that is approximately 32.5%.

Cat offers refractometers that can be used to measure DEF concentration. Refer to Table 70 for the part numbers. Follow the instructions provided with the instruments.

Table 70

Cat DEF Refractometers		
Refractometer Part Numbers	360-0774	Digital display, easy to use, and multifunctional (DEF, coolant, battery fluid, and more)
	431-7087	Analog, specific to DEF, and requires a multi-step test procedure

DEF Guidelines

DEF solution is typically colorless and clear. Changes to color or clarity are indicators of quality issues. Quality of DEF can degrade when stored and handled inappropriately or if DEF is not protected from contamination. Details are provided below.

If quality issues are suspected, testing of DEF should focus on urea percentage, alkalinity as NH3 and biuret content. DEF that does not pass all these tests or that is no longer clear should not be used.

Note: Caterpillar strongly recommends that customers purchase the pre-mixed DEF urea solution from a reputable supplier. The DEF must satisfy all the specifications of quality given in this chapter of this Special Publication. Urea solutions that are not made of urea and water of the appropriate quality and cleanliness may damage the SCR system. Poor or questionable quality DEF can lead to additional repair and maintenance costs to the customer. Cat warranties do not cover failures caused by or related to use of out of specification urea solutions in Tier 4 Stage IIIB MLIT Step 4 products equipped with SCR systems.

Materials compatibility

DEF is corrosive. Due to the corrosion caused, DEF must be stored in tanks constructed of approved materials. Recommended storage materials:

Stainless Steels:

- 304 (S30400)
- 304L (S30403)
- 316 (S31600)
- 316L (S31603)

Alloys and metals:

- Chromium Nickel (CrNi)
- Chromium Nickel Molybdenum (CrNiMo)
- Titanium

Non-metallic materials:

- Polyethylene
- Polypropylene
- Polyisobutylene
- Teflon (PFA)
- Polyfluoroethylene (PFE)
- Polyvinylidene fluoride (PVDF)
- Polytetrafluoroethylene (PTFE)

Materials NOT compatible with DEF solutions include aluminum, copper, copper alloys, magnesium, zinc, nickel coatings, silver and carbon steel and solders containing any of the above. Unexpected reactions may occur if DEF solutions come in contact with any non-compatible material or unknown materials.

Bulk storage

Follow all local regulations covering bulk storage tanks. Follow proper tank construction guidelines. Tank volume typically should be 110% of planned capacity. Appropriately vent indoor tanks. Plan for control of overflow of the tank. Heat tanks that dispense DEF in cold climates.

Bulk tank breathers should be fitted with filtration to keep airborne debris from entering the tank. Desiccant breathers should not be used because water will be absorbed, which potentially can alter DEF concentration.

Handling

Follow all local regulations covering transport and handling. DEF transport temperature is recommended to be −5° C (23° F) to 25° C (77° F). All transfer equipment and intermediate containers should be used exclusively for DEF. Containers should not be reused for any other fluids. Ensure that transfer equipment is made from DEF-compatible materials. Recommended material for hoses and other non-metallic transfer equipment include:

- Nitrile Rubber (NBR)
- Fluoroelastomer (FKM)
- Ethylene Propylene Diane Ionomer (EPDM)

The condition of hoses and other nonmetallic items that are used with DEF should be monitored for signs of degradation. DEF leaks are easily recognizable by white urea crystals that accumulate at the site of the leak. Solid urea can be corrosive to galvanized or unalloyed steel, aluminum, copper, and brass. Leaks should be repaired immediately to avoid damage to surrounding hardware.

Cleanliness

Contaminants can degrade the quality and life of DEF. Filtering DEF is recommended when dispensed into the DEF tank. Filters should be compatible with DEF and should be used exclusively with DEF. Check with the filter supplier to confirm compatibility with DEF before using. Mesh-type filters using compatible metals, such as stainless steel, are recommended. Paper (cellulose) media and some synthetic filter media are not recommended because of degradation during use.

Care should be taken when dispensing DEF. Spills should be cleaned immediately. Machine or engine surfaces should be wiped clean and rinsed with water. Caution should be used when dispensing DEF near an engine that has recently been running.

Note: Spilling DEF onto hot components may cause the release of ammonia vapors. Do not breathe ammonia vapors. Do not clean up any spills with bleach.

Stability

DEF fluid is stable when stored and handled properly. The quality of DEF rapidly degrades when stored at high temperatures. The ideal storage temperature for DEF is between −9° C (15.8° F) and 25° C (77° F). DEF that is stored above 35° C (95° F) for longer than 1 month must be tested before use. Testing should evaluate Urea Percentage, Alkalinity as NH_3 and Biuret content.

The length of storage of DEF is listed in the following table:

Table 71

Storage Temperature	Expected DEF Life
Below 25° C (77° F)	18 months
25° C (77° F) to 30° C (86° F)	12 months
30° C (86° F) to 35° C (95° F)	6 months
Above 35° C (95° F)	test quality before use

Refer to ISO 22241 document series for more information about DEF quality control.

Note: Dispose of all fluids according to applicable regulations and mandates.

General Characteristics of DEF

For detailed information on the requirements and characteristics of DEF, refer ISO 22241. For a quick reference, typical characteristics of DEF are given in Table 72 .

Table 72

Characteristics for Urea Solutions		
Property	Unit	DEF 32.5 percent
Urea content		32.5 percent (1)
Alkalinity as NH_3	Percent	0.2
Density at 20° C (68° F)	g/L	1.087 - 1.093 (2)
Refractive Index at 25° C (77° F)		1.381 - 1.384 (3)
Biuret	Percent	0.3 max
Aldehydes	mg/kg	5 max
Insoluble Matter	mg/kg	20 max
Aluminum	mg/kg	0.5 max
Calcium	mg/kg	0.5 max
Chromium	mg/kg	0.2 max
Copper	mg/kg	0.2 max
Iron	mg/kg	0.5 max
Magnesium	mg/kg	0.5 max
Nickel	mg/kg	0.2 max
Phosphate (PO_4)	mg/kg	0.5 max
Potassium	mg/kg	0.5 max
Sodium	mg/kg	0.5 max
Zinc	mg/kg	0.2 max

(1) Acceptable range is 31.8 - 33.2 percent
(2) Target value is 1.090 g/L
(3) Target value is 1.382

Contamination Control

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Contamination Control

SMCS Code: 1280; 1348; 3080; 5095; 7581

Defining Contamination

Contamination is defined as the presence of unwanted foreign substances in fluid systems or fluid wetted parts. Contamination alters the properties of fluids, causes damage of fluid systems, and prevents systems and components from attaining the desired reliability and durability. Contamination is the primary cause of fluid system failures.

Contaminants include a wide variety of unwanted substances including but not limited to the following:

- Foreign and abrasive substances such as wear particles, fibers, dirt, and dust
- Chemical substances such as products of combustion that are suspended in the fluids
- Cross contamination of water, coolant, oil, and fuel
- Biological micro-organisms such as algae or fungi
- Physical/chemical contaminants such as products of oxidation and heat

Some contaminants are generated within the fluid system due to the normal operation of the system. Contaminants may be drawn into the system from the outside environment or contaminated fill fluids or improper maintenance and repair practices.

Particle contaminants are visible to the naked eye if the particles are approximately 40 µm (microns) and larger while smaller particles are not visible. Particle contaminants can cause damage even if the particles are not visible to the naked eye. The critical particle size for wear particles in a modern diesel engine fuel system is 4 µm.

Contaminants of all types can be controlled by following contamination control practices and using appropriate filtration. Refer to your Operation and Maintenance Manual and to your local Cat dealer for recommendations.

Controlling contamination is especially important for current machine systems. Current machine systems such as hydraulic systems and fuel injection systems are designed with close tolerances and operate at high pressures for enhanced performance. These design improvements emphasize the importance of higher performing fluids, enhanced fluid filtration, and greatly improved fluid cleanliness levels.

Measuring Cleanliness

Fluid cleanliness can be measured by taking fluid samples from various machine compartments. Your Cat dealer can analyze the samples. Particle contaminants are typically measured by particle counters. Chemical contaminants can be measured by specific analysis techniques such as oxidation, water, or soot tests. Some chemical contaminants, such as water in fuel, can interfere with the particle counters and can be counted as particles. Refer to your Cat S·O·S lab or to your Cat dealer for more information.

The number of particles in fluids is expressed in ISO (International Organization for Standardization) ratings. ISO 4406 Standard classifies fluid cleanliness by the number and size of particles in 1 milliliter of fluid. ISO 4406 Standard measures particle size in µm (microns) and reports the resulting count in three code ranges X, Y & Z. The three code range defines the size and distribution of particles in 1 milliliter of fluid:

- The first code range, X represents the number of particles equal to or larger than 4 µm per milliliter of fluid.
- The second code range, Y represents the number of particles equal to or larger than 6 µm per milliliter of fluid.
- The third code range, Z represents the number of particles equal to or larger than 14 µm per milliliter of fluid.

An example of an ISO 4406 particle count is 18/16/13. Cat ISO cleanliness recommendations are expressed as two or three codes, depending on the machine system. The three code range follows ISO 4406 definitions and is used for liquid fuels such as diesel and gasoline. The two code system, example ISO -/16/13, is used for certain lubricant systems. In the two code system, the first number is the number of particles equal to or larger than 4 µm per milliliter of fluid. This number is not required and may be represented by a dash (-). The second number (Y) and the third number (Z) follow ISO 4406 definitions. Cat reports the Y and Z codes for lubricating oils to keep consistency with older data and reports.

An example of the particle size and distribution of the ISO 4406 codes is given in Table 73 .

Table 73

ISO 4406 Code	Number of particles in 1 milliliter of fluid		
	4µm and up	6µm and up	14µm and up
ISO 18/16/13	1300 - 2500	320 - 640	40 - 80
ISO 21/19/17	10000 - 20000	2500 - 5000	80 - 160

Note: Several factors affect the results of particle counts. The factors include the cleanliness of the equipment used to obtain the sample, sample techniques, the cleanliness, and type of sample container, particle counter accuracy (calibration, maintenance, and process), and the environment where the sample is procured. Samples should be taken at representative locations in the fluid circulation system or the fluid distribution system when possible. The sample should be protected adequately from contamination during transport to the lab for analysis.

In addition, particle counters may count water droplets and air bubbles as particulate contamination.

Note: American Society for Testing and Measurement has developed ASTM D7619“Standard Test Method for Sizing and Counting Particles in Light and Middle Distillate Fuels, by Automatic Particle Counter”. This test procedure was developed in 2010 to count and measure the size of dispersed dirt particles, water droplets, and other particles in 1-D and 2-D diesel fuels when the specified particle counter is used. ASTM D7619 is also applicable to biodiesel fuels.

Cleanliness Standards for Machine Systems

Cat recommends that machine systems be maintained at the factory defined fluid cleanliness targets.

Cat has established minimum fluid cleanliness targets for fuels and fill oils and for machine roll-off. Fluids filled into the machine or engine fill tanks are recommended to be at the target levels provided in Table 74 or cleaner. Cleanliness targets for applicable machine component systems are referred to as “Roll-off”. Roll-off is defined as the cleanliness specification of the fluid that is to be obtained before the machine returns to work after maintenance and or system invasion repair. When system fill fluids and Roll-off are maintained at or cleaner than the ISO cleanliness targets, contamination-related effects will be reduced.

Table 74

Cat Recommended Fluid Cleanliness Targets[1]		
Cat Recommended Cleanliness Targets for Fluids Dispensed into Machine or Engine Fill tanks[2]	Fill oils	ISO -/16/13
	Dispensed fuels	ISO 18/16/13
Cat Recommended Machine Roll-off Cleanliness Targets	Hydraulic systems (Implement & Steering)	ISO -/18/15
	Electronic Transmissions	ISO -/18/15
	Mechanical Transmissions	ISO -/21/17
	Differentials, Wheels, and Axles [3]	ISO -/18/15

(1) The fluids should meet or exceed the cleanliness requirements of the listed ISO levels.
(2) For engine oils, when filtering the oil prior to dispensing into the engine tank, use engine oil filters of 12 micron absolute efficiency and ensure that the oil temperature is 20° C (68° F) or higher. Refer to the details given in this article.
(3) This cleanliness standard applies only to the Series 700 family of rigid frame trucks, 777 size and larger.

The “fill” fluids cleanliness target is not a fluid “delivery” target. The level of cleanliness for delivered fluids is not specified by Cat . Customers can work with the distributors or carriers to determine the cleanliness level of delivered fluids. However, a more effective and economic means to achieve the fill cleanliness targets is to filter the fluids prior to filling into machine tanks as compared with specifying delivery fluid cleanliness level. Follow the guidelines provided in this Contamination Control article.

Although older technology machines may not be able to maintain the recommended cleanliness targets of advanced models, the same contamination control intervention measures such as filtration and subsequent service procedures should be used on all Cat products.

Note: When particle counting new multi-viscosity engine oils, there may be difficulties achieving cleanliness targets. Optical particle counters cannot distinguish between particulate contaminants and additives. Do not use optical particle count for the evaluation of used engine oils because soot levels render oil too dark for optical particle counters. Soot levels in used engine oils should be evaluated by using S·O·S Services Oil Analysis.

When filtering engine oil before dispensing into the engine tank or when engine oil kidney looping filtration is done, follow these recommendations:

- Use engine oil filters of 12 microns absolute efficiency. Cat Ultra High Efficiency Lube filter is recommended. Consult your Cat dealer for the most current part number.
- Ensure that the temperature of engine oil is 20° C (68° F) or higher.

Consult your Cat dealer for information and solutions to your oil and fuel analysis needs.

General Contamination Control Recommendations or Practices

Maintaining a low contamination level can reduce down time and can control the maintenance cost of the machine. The productive life as well as the reliability of components and fluid systems is often increased as a result of proper contamination control practices.

The following are general guidelines for controlling contaminants.

- Refer to the Recommendations for Fuel Systems in this chapter for recommended fuel cleanliness levels and guidelines.
- Refer to the machine Operation and Maintenance Manual for the required maintenance for all machine compartments.
- When you add oil to a machine, use adequate filtration in order to clean the oil to meet the targets provided in Table 74 .
- Perform scheduled S·O·S Services Oil Analysis for contamination in order to maintain the recommended ISO cleanliness level of fill and machine fluids. Refer to the S·O·S Oil Analysis section in this Special Publication. The particle count analysis can be performed by your Cat dealer. Particle count can be conducted during the scheduled S·O·S Services Oil Analysis for the compartment. Extra oil samples are not required for the particle count sampling.
- Use only coolants that are recommended by Cat for your machine. Follow the recommended maintenance procedure for the cooling system in the Operation and Maintenance Manual for your machine.
- Maintain the engine air filters and air intake system to avoid unwanted contaminant ingression.
- Follow contamination control practices for the shop area, component/machine disassembly areas, parts, shop tools, test setups, test areas, storage areas and waste collection areas, Keep components clean during inspection, assembly, testing, and filling machines with clean fluids. Good practices will enhance component life and reduce downtime associated with contaminants. Your Cat dealer can provide details on proper contamination processes and practices.
- Follow contamination control practices for the workplace and for the worksite. Maintaining clean oil fill fluids saves time and effort and ensures that fill fluids are at the proper cleanliness levels.
- Use properly designed and maintained bulk storage fluids tanks.
- Protect the fluids storage tanks from dirt and water entry by using 4 µm or less absolute efficiency breathers with the ability to remove water.
- Keep the areas around the tanks filler necks clean of debris and water.
- Drain the storage tanks from water and sediments frequently. The draining schedule depends on use of proper inlet and outlet filters, the use of 4 µm breathers with the ability to remove water, and following recommended contamination control practices. Based on the contamination control program followed, and/or on the fuel supplier recommendations, the storage tank draining schedule may be as frequent as daily until no water is present, and then can be extended to longer periods.
- Install and maintain a properly designed and grounded filtration system. Filtration should include at the entry and at the dispensing point. Continuous bulk filtration may be required to ensure that dispensed oils meet the cleanliness target.
- Cover, protect, and ensure cleanliness of all connection hoses, fittings, and dispensing nozzles.

Note: Bulk fuel filtration units are available through your Cat dealer. Proper maintenance practices of the bulk filtration systems are available through your Cat dealer.

Contamination Control Recommendations for Fuels

Fuels of ISO 18/16/13 cleanliness level or cleaner as dispensed into the engine or machine fuel tank should be used. Reduce power loss, failures, and related down time of engines will result. This cleanliness level is important for new fuel system designs such as Common Rail injection systems and unit injection systems. Injection system designs utilize higher fuel pressures and tight clearances between moving parts in order to meet required stringent emissions regulations. Peak injection pressures in current fuel injection systems may exceed 30,000 psi. Clearances in these systems are less than 5 µm. As a result, particle contaminants as small as 4 µm can cause scoring and scratching of internal pump and injector surfaces and of injector nozzles.

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

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

- Use high-quality fuels per recommended and required specifications (refer to the Fuel Chapter in this Special Publication)
- Fill machine fuel tanks with fuels of ISO 18/16/13 cleanliness level or cleaner, in particular for engines with common rail and unit injection systems. When you refuel the machine, filter the fuel through a 4 µm absolute filter (Beta 4 = 75 up to 200) in order to reach the recommended cleanliness level. This filtration should be located at the device that dispenses the fuel to the engine or machine fuel tank. In addition, filtration at the dispensing point should remove water to ensure that fuel is dispensed at 500 ppm water or less.
- Cat recommends the use of bulk fuel filter / coalescer units which clean the fuel of both particulate contamination and water in a single pass. Cat offers heavy-duty filter / coalescer units to accommodate fueling rates from 50 to 300 gpm (gallons per minute).
- Ensure that you use Cat Advanced Efficiency Fuel Filters . Change your fuel filters per recommended service requirements or as needed.
- Drain your water separators daily per the Operation and Maintenance Manual of your machine.
- Drain your fuel tanks of sediment and water per the Operation and Maintenance Manual of your machine or sooner as fuel condition indicates.
- Install and maintain a properly designed bulk filter / coalescer filtration system. Continuous bulk filtration systems may be required to ensure that dispensed fuel meets the cleanliness target. Consult your Cat dealer for availability of bulk filtration products.
- Centrifugal filters may need to be used as a pre-filter with fuel that is severely contaminated with gross amounts of water and/or large particulate contaminants. Centrifugal filters can effectively remove large contaminants, but may not be able to remove the small abrasive particles required to achieve the recommended “ISO” cleanliness level. Bulk filter / coalescers are necessary as a final filter in order to achieve the recommended cleanliness level.
- Install desiccant type breathers of 4 µm or less absolute efficiency with the ability to remove water on bulk storage tanks.
- Follow proper practices of fuel transportation. Filtration from the storage tank to the machine promotes the delivery of clean fuel to machine tank. Fuel filtration can be installed at each transport stage in order to keep the fuel clean.
- Cover, protect, and ensure cleanliness of all connection hoses, fittings, and dispensing nozzles.

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.

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

Reference Information Section

Reference Materials

i05257867

Reference Material

SMCS Code: 1000; 7000

The following publications are available for order through your Caterpillar dealer.

Note: The information that is contained in the listed publications is subject to change without notice. Consult your local Caterpillar dealer for the most current recommendations.

Note: Refer to this Special Publication, the respective product data sheet, and to the appropriate Operation and Maintenance Manual for product application recommendations.

Lubricants, Coolants, and Greases

- Data sheets, specifications, and recommendations for Cat lubricants, coolants, and greases are available through your Cat dealer and at the following website:

  http://parts.cat.com/parts/machine-fluids

- Special Publication, PEWJ0074, “Filters and Fluids Application Guide”
- Special Publication, PEHJ0149, “Cat Filters and Fluids Toolbox Update - Datasheet Set”
- Special Publication, REHS1063, “Know Your Track-Type Tractor Cooling System”
- Special Publication, SEBD0518, “Know Your Cooling System”
- Special Publication, SEBD0970, “Coolant and Your Engine”
- Special Publication, PEGJ0035, “Grease Selection Guide”

Fuel

- Special Publication, PEHP7046, Fuel Contamination Control Data Sheet
- Special Publication, SENR9620, Improving Fuel System Durability
- Special Publication, SEBD0717, Diesel Fuels and Your Engine
- 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 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
- Facts You Should Know About Renewable Fuels, EMA (Engine Manufacturer Association)
- EMA Technical Position on Use of Biodiesel Position Statement, EMA (Engine Manufacturer Association)

  http://www.truckandenginemanufacturers.org/articles

Filters

- For general Cat filtration products, refer to the following website:

  https://commerce.cat.com/en/catcorp/filters

- Special Publication, PEWJ0074, “Filters and Fluids Application Guide”
- Special Publication, PEHP7046, “Fuel Contamination Control”

S·O·S Services

- Special Publication, PEHJ0191, “S·O·S Services Data Sheet”
- Special Publication, PEHP7052, “Making the Most of S·O·S Services”
- Special Publication, PEGJ0046, “Understanding S·O·S Reports”
- Special Publication, PEGJ0047, “How to Take a Good S·O·S Sample”
- Special Publication, PEGJ0045, “Reporting Particle Count by ISO Code”
- Special Publication, PEDJ0129, “Fuel Sampling Guide”
- Special Publication, PEDP7036, “S·O·S Fluids Analysis Cornerstone”
- Special Publication, PEHP7076, “Understanding S·O·S Service Tests”

Miscellaneous

- Special Publication, PEBJ0002, Caterpillar Dealer Contamination Control Compliance Guide
- Special Publication, PEBJ0007, Caterpillar Customer Contamination Control Compliance Guide
- Special Publication, SEBU5898, Cold Weather Recommendations
- Special Publication, PEDP9131, “Fluid Contamination - The Silent Thief”
- Special Publication, AECQ1043, “Caterpillar Product Line Brochure”
- Special Publication, PEWJ0074, “Cat Filter and Fluid Application Guide”
- Special Publication, PECP9067, “One Safe Source”
- Special Publication, NENG2500, “Caterpillar Dealer Service Tool Catalog”
- Special Publication, PECJ0003, “Cat Shop Supplies and Tools” catalog
- Special Publication, SENR3130, “Torque Specifications”
- Special Publication, SENR9620, “Improving Component Durability - Fuel Systems” (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)
- Special Publication, SEBF1015, “Improving Component Durability - Final Drives and Differentials” (Package of 10)
- Special Publication, SEBF1016, “Improving Component Durability - Powershift Transmissions” (Package of 10)
- Special Publication, SEBF1017, “Improving Component Durability - Component Removal and Installation” (Package of 10)
- Special Publication, SEBF1019, “Improving Component Durability - Hydraulics” (Package of 10)
- Special Publication, SEBF1021, “Improving Component Durability” Boxed set (Includes one each of the 7 “Improving Component Durability” series.)

- Special Publication, SEBD0348, “Caterpillar Performance Handbook”
- ASTM D6469, Standard Guide for Microbial Contamination in Fuels and Fuel Systems

Additional Reference Material

SAE J183, Classification This document can normally be found in the SAE handbook.

SAE J313, Diesel Fuels This document can be found in the SAE handbook. Also, this publication can be obtained from your local technological society, from your local library, or from your local college.

SAE J754, Nomenclature This document can normally be found in the SAE handbook.

Engine Manufacturers Association, Engine Fluids Data Book

Engine Manufacturers Association
Two North LaSalle Street, Suite 2200
Chicago, Illinois USA 60602
http://www.truckandenginemanufacturers.org/articles

For information on the American Petroleum Institute (API) engine oil categories, contact the API at:

1220 L Street, NW
Washington, DC USA 20005-4070
http://www.api.org

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Product and Dealer Information

Note: For
product identification plate locations, see the section “Product Identification Information” in the Operation and Maintenance Manual.

Delivery Date: _____

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:	_____	_____	_____