



Cat Commercial Diesel Engine Fluids Recommendations

Special Publication For All 3500 Series, C175 Series and Smaller Commercial Diesel Engines

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. 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 have read and understood the operation, lubrication, maintenance and repair information.

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

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



The meaning of this safety alert symbol is as follows:

Attention! Become Alert! Your Safety is Involved.

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

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

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



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.

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Foreword

Literature Information

This manual should be stored in the literature storage area.

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

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

Safety

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

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

Maintenance

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

Maintenance Intervals

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

Extended Engine Oil Drains and Warranty

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

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

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

NOTICE

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

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

Aftermarket Products and Warranty

NOTICE

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

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

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

Maintenance Section

Lubricant Specifications

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General Lubricant Information

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

NOTICE

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

The information that is provided is the latest recommendations for 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 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	Cat DEO-ULS	SAE 15W-40
		SAE 10W-30
	Cat DEO-ULS SYN	SAE 5W-40
	Cat DEO-ULS Cold Weather	SAE 0W-40
Diesel Engine Oil	Cat DEO	SAE 15W-40
		SAE 10W-30
	Cat DEO SYN	SAE 5W-40
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
Transmission/Drive Train Oil	Cat TDTO	SAE 10W
		SAE 30
		SAE 50

Note: Additional Cat fluids may be available.

Table 2

Cat fluids	
Grease	Cat Multipurpose Grease
	Cat Marine Multipurpose Grease
	Cat Advanced 3Moly Grease
	Cat Ultra 5Moly Grease (multiple NLGI Grades)
	Cat Desert Gold Grease
	Cat Arctic Platinum Grease
	Cat High Speed Ball Bearing Grease
Coolants	Cat ELC (Extended Life Coolant)
	Cat ELC Extender (for use with Cat ELC)
	Cat ELI (Extended Life Inhibitor - non-glycol based coolant)
	Cat DEAC (Diesel Engine Antifreeze/Coolant)
	Cat SCA (Supplemental Coolant Additive, for use with water or with Cat DEAC)

Note: Cat fluids availability will vary by region.

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.

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Engine Oil

SMCS Code: 1348; 7581

This article contains engine crankcase fluid recommendations for all Cat 3500 Series, C175 Series, and Smaller Direct Injection (DI) Engines and Precombustion Chamber (PC) Engines. Some exceptions may be noted.

Most Cat medium and heavy-duty PC diesel engines were produced before 1991.

Exceptions to these recommendations are 3116 and 3126 Marine Engines with Mechanical Unit Injection (MUI). Refer to the section pertaining to these engines in this Special Publication.

Cat Diesel Engine Oils

Table 3

Summary of Cat engine lubricants Recommendations/Requirements		
	Non-Road Tier 4 Certified	Non-Road Pre Tier 4 Certified
Preferred	Cat DEO-ULS	Cat DEO-ULS
		Cat DEO
Commercial Lubricants	Cat ECF-3/API CJ-4	Cat ECF-3/API CJ-4, Cat ECF-2, Cat ECF-1-a

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 4 for details.

Table 4

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

Cat DEO and Cat DEO-ULS are rigorously tested with full-scale proprietary engine testing. There are significant variations in the quality and performance of commercially available oils.

Cat makes the following recommendations:

- Cat DEO-ULS (Diesel Engine Oil - Ultra Low Sulfur) (15W-40 and 10W-30)
- Cat DEO-ULS SYN (Diesel Engine Oil - Ultra Low Sulfur Synthetic) (5W-40)
- Cat Cold Weather DEO-ULS (Cold Weather Diesel Engine Oil - Ultra Low Sulfur) (0W-40)
- Cat DEO (Diesel Engine Oil) (15W-40 and 10W-30)
- Cat DEO SYN (Diesel Engine Oil Synthetic) (5W-40)

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 of detergents, dispersants, and alkalinity in order to provide superior performance in Cat diesel engines where recommended for use.

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

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 3 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 NO_x 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 percent (1000 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 5 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 (≤ 10 ppm (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.

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.

Cat DEO-ULS and Cat DEO multigrade oils are available in various viscosity grades that include SAE 10W-30, SAE 15W-40, SAE 5W-40, and SAE 0W-40. Refer to the Cat Lubricants Table in the "Lubricant Information" article for details. Multigrade oils provide the correct viscosity for a broad range of operating temperatures.

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

Cat DEO-ULS multigrade and Cat DEO multigrade oils can be used in other manufacturer 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 aftertreatment device equipped engines.

Cat DEO multigrade exceeds the requirements of the following Cat Engine Crankcase Fluid (ECF) Specifications: Cat ECF-1-a and Cat ECF-2. Cat DEO multigrade exceeds the performance requirements for the following American Petroleum Institute (API) oil categories: API CI-4, API CI-4 PLUS, API CH-4, and API CF (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 also pass additional proprietary tests that include the following: sticking of the piston rings, piston deposits, oil control tests, wear tests, and soot tests. Proprietary tests help ensure that Cat multigrade oil provides superior performance in Cat diesel engines.

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

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

Note: API 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.

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. This oil provides satisfactory life and performance in Cat diesel engines where recommended for use.

There are three current Cat ECF specifications: Cat ECF-1-a, Cat ECF-2, and Cat ECF-3. 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 4 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 1 March 2007.

Note: Cat DEO and DEO-ULS are required to pass additional 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.

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 ACAE E9 may be used. ACAE E9 oils meet the chemical limits designed to maintain aftertreatment device life. ACAE 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 3 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 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.

For pre-Tier 4 engines that use ULSD and LSD fuels, Cat recommends Cat DEO-ULS and Cat DEO. However, commercial oils that meet Cat ECF-3, Cat ECF-2 or Cat ECF-1-a are acceptable.

For engines using fuels of sulfur levels that exceed 0.1 percent (1000 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 5 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.

Severe Applications Require the Use of Higher Performing Diesel Engine Oils. Examples of severe duty applications include, but not limited to the following:

- operating at greater than 75% load factor
- operating in high humidity
- operating with fuel sulfur levels that are above 0.1% (1000 ppm)

In order to help ensure the maximum expected compartment performance and life, higher performing fluids as described in this Special Publication may be required. Fluids that meet only the minimum performance levels may be allowed for typical applications, but maintenance intervals must be reduced. For the maximum expected engine compartment performance and life and where LSD or ULSD fuels are available, oils meeting the Cat ECF-3 specification must be used.

Note: There are additional oil considerations that are related to fuel sulfur levels. Refer to the various “Total Base Number (TBN) and Fuel Sulfur Levels...” topics in this Special Publication. Also refer to the “Diesel Fuel Sulfur” topic in this Special Publication.

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

This article provides information for Direct Injection (DI) Diesel Engines, Precombustion Chamber (PC) Engines and Direct Injection (DI) 3116 and 3126 Marine 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. The TBN for new oil is typically determined by the “ASTM D2896” procedure. For commercial diesel engines that use distillate fuel, the following guidelines apply:

Table 5

TBN recommendations for applications in Cat engines		
Fuel Sulfur Level percent (ppm)	Cat Engine Oils	TBN of Commercial Engine Oils
≤ 0.05 percent (≤500 ppm)	Cat DEO-ULS	Min 7
	Cat DEO	
0.1 - 0.05 percent (1000-500 ppm)	Cat DEO-ULS	Min 7
	Cat DEO	
Above 0.1 percent (above 1000 ppm) ⁽¹⁾	Cat DEO ⁽²⁾	Min 10

⁽¹⁾ For fuels of sulfur levels that exceed 1.0 percent (10,000 ppm), refer to TBN and engine guidelines given in this section.

⁽²⁾ Cat DEO-ULS may be used if an oil analysis program is followed. Base the oil change interval on the analysis.

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.

Use the following guidelines for fuel sulfur levels that exceed 1.0 percent (10,000 ppm):

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.

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

For example:

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

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)

Bullets 2 through 7 directly above all can contribute to excessive water in the crankcase oil. The water combines with available sulfur to form sulfuric acid. Neutralizing 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: 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.

Note: The use of Cat S·O·S Services oil analysis helps environmental sustainability as the best way to optimize oil life. The service will help engines reach the 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 optimize oil drain intervals for engine applications and duty cycles, use Cat S·O·S Services oil analysis as follows:

- Recommended as a matter of course
- 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).

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Engine Oil (3116 and 3126 Marine Engines)

SMCS Code: 1348; 7581

Recommendations

Cat does not recommend the use of multigrade oils in the 3116 and 3126 Marine Diesel Engines that use mechanical unit injection (MUI).

Multigrade oils use high molecular weight polymers as viscosity index improvers. When the crankcase blowby flows through the turbocharger and the aftercooler, the viscosity index improvers can adhere to the turbocharger compressor and aftercooler core.

The fouling of the turbocharger and aftercooler can cause reduced air flow, loss of power, and increased black smoke. The emission of black smoke results in buildup of soot on the transom of the boat.

Note: Cat recommends the use of single grade oils that pass all API CF-4 category requirements unless crankcase blowby has been routed away from the air cleaner inlet.

Cat SAEO (Special Application Engine Oil)

Note: Cat SAEO is recommended for use in Cat 3116 and 3126 Marine Diesel Engines with mechanical unit injection. 3116 and 3126 Marine Diesel Engines that begin with the following serial number prefixes are included: (S/N: 6SR), (S/N: 8NM), (S/N: 4KG), (S/N: 1SK), (S/N: 1ZJ), (S/N: 6MK), and (S/N: 4EZ).

The factory-fill for 3116 and 3126 Marine Engines is Cat SAEO with the following properties:

- Meets all requirements of API CF-4 category
- Viscosity grade of SAE 30

For maximum performance in 3116 and 3126 Marine Diesel Engines with mechanical unit injection, Cat recommends the following engine oil:

- Cat SAEO (SAE 30)
- Cat SAEO (SAE 40)

Commercial Oils (3116 and 3126 Marine Engines)

NOTICE

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

When Cat SAEO is not used, use the following commercial oils:

- Single grade oil with a viscosity of SAE 30 or SAE 40 that meets all API CF category requirements is preferred.
- Single grade oil with a viscosity of SAE 30 or SAE 40 with an API CF additive package and no viscosity improvers is acceptable oil.

The American Petroleum Institute (API) is planning to obsolete the API CF oil category by the end of 2010. When API CF is obsolete, API will not validate the quality of API CF oils and will not allow the display of API symbol (also referred to as API doughnut) with CF as highest claim on the oil containers.

Oil products that used to be licensed as API CF oil performance category and have not changed their formulation are acceptable for use in Cat 3116 and 3126 marine engines.

For an acceptable commercial single grade oil, consult your Cat dealer.

Some commercial oils that meet the requirements API CF-4 category may require reduced oil change intervals. To determine the oil change interval, closely monitor the condition of the oil and perform a wear metal analysis. Cat S-O-S Services oil analysis program is the preferred method.

NOTICE

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

Total Base Number (TBN) and Fuel Sulfur Levels for Direct Injection (DI) Diesel Engines (3116 and 3126 Marine Engines)

The information given in the "Total Base Number (TBN)" and "Fuel Sulfur Levels" article in the "DI and PC Engines" section apply also to Direct Injection (DI) 3116 and 3126 Marine Diesel Engines.

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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. This 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). This 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 tables, use the highest oil viscosity that is allowed for the ambient temperature when you start the machine.

Engines 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, are generally not recommended for use in engines that are operated continuously and/or are heavily loaded. Refer to the “Lubricant Viscosities for Ambient Temperatures” tables 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: Generally, use the highest oil viscosity that is available to meet the requirement for the temperature at start-up.

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

Follow the recommendations found in the “Lubricant Viscosities for Ambient Temperatures” tables and associated footnotes in order to enhance performance and reduce risk of engine failure.

In colder ambient conditions an engine warm-up procedure and/or supplemental engine fluid compartment heat may be required. Engine specific warm-up procedures can typically be found in the Operation and Maintenance Manual for the engine. The “Lubricant Viscosities for Ambient Temperatures” tables in this Special Publication include footnotes that address engine warm-up.

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

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

Lubricant Viscosity Recommendations for Direct Injection (DI) and Precombustion Chamber (PC) engines

Refer to the minimum temperature in table 6 in order to determine the required oil viscosity for starting a cold engine. Refer to the maximum temperature in order to select the oil viscosity for engine operation at the highest ambient temperature that is anticipated.

Refer to this Special Publication, “General Information for Lubricants” article for important lubricant information.

Supplemental heat is recommended for cold-soaked starts below the minimum ambient temperature. Supplemental heat may be required for cold-soaked starts that are above the minimum temperature that is stated, depending on the parasitic load and other factors. Cold-soaked starts occur when the engine has not been operated for a time, allowing the oil to become more viscous in 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 Special Publication, "Engine Oil" section. Refer to this Special Publication, "Lubricant Information" section for a list of all Cat engine oils.

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

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

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

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

Note: C175 Series diesel engines require the use of multigrade SAE 40 oil: 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. Refer to table 6 and associated footnotes for guidance on selecting the proper oil viscosity grade for various ambient temperatures.

Table 6

Lubricant Viscosities for Ambient Temperatures for Cat Diesel Engines						
Engine Type	Oil Type and Performance Requirements	Viscosity Grade	°C		°F	
			Min	Max	Min	Max
Direct Injection (DI) and Pre Combustion (PC)	Cat ECF-1-a, Cat ECF-2, Cat ECF-3	SAE 0W-30	-40	30	-40	86
	Cat Cold Weather DEO-ULS Cat ECF-1-a, Cat ECF-2, Cat ECF-3	SAE 0W-40	-40	40	-40	104
	Cat DEO-ULS Cat ECF-1-a, Cat ECF-2, Cat ECF-3	SAE 5W-30	-30	30	-22	86
	Cat DEO-ULS SYN Cat DEO Cat ECF-1-a, Cat ECF-2, Cat ECF-3	SAE 5W-40	-30	50	-22	122
	Cat ECF-1-a, Cat ECF-2, Cat ECF-3	SAE 10W-30	-18	40	0	104
	Cat DEO-ULS Cat DEO	SAE 10W-40 SAE 15W-40	-18 -9.5	50 50	0 15	122 122
Pre Combustion (PC) only	Cat SAEO API CF or equivalent	SAE 30	0	40	32	104
		SAE 40	5	50	41	122

Refer to this Special Publication, "Lubricant Viscosities" and "Cold Weather Lubricants" for additional information.

Lubricant Viscosity Recommendations (3116 and 3126 Marine Engines)

The information provided in the "Lubricant Viscosities, Selecting the Viscosity" article in the "DI and PC Engines" section is applicable to 3116 and 3126 Marine Engines.

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

Refer to Table 7, minimum temperature, in order to determine the required oil viscosity for starting a cold engine. Refer to maximum temperature in order to select the oil viscosity for engine operation at the highest ambient temperature that is anticipated.

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. Supplemental heat may be required for cold-soaked starts that are above the minimum temperature. Use of supplemental heat may depend on the parasitic load and other factors. Cold-soaked starts occur when the engine has not been operated for a time, allowing the oil to become more viscous in cooler ambient temperatures.

Use the highest oil viscosity that is allowed for the ambient temperature at start-up.

Table 7

Lubricant Viscosities for Ambient Temperatures for Cat 3116 and 3126 Marine Engines						
Engine Model	Oil Type and Performance Requirements	Viscosity Grade	°C		°F	
			Min	Max	Min	Max
3116 and 3126 Marine Diesel Engines	Cat SAEO API CF or equivalent	SAE 30	0	40	32	104
		SAE 40	5	50	41	122

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Marine Transmission Oil

SMCS Code: 3080; 3300; 7581

Cat Transmission/Drive Train Oils

Cat TDTO (Transmission/Drive Train Oil) is balanced in order to give maximum frictional material service life and performance in Cat transmissions. Cat TDTO exceeds the requirements for the Cat TO-4 oil specification which includes the frictional requirements and gear wear requirements. Cat TDTO is offered in different lubricant viscosity grades for maximum service life of components at high ambient temperatures and heavy-duty cycles.

For optimum transmission service life and performance, Cat TDTO is recommended.

Table 8

Lubricant Viscosities for Ambient Temperatures for Cat Marine Transmissions						
Cooling of transmission	Oil Type and Performance Requirements	Viscosity Grade	°C		°F	
			Min	Max	Min	Max
Raw/Sea Water	Cat TDTO Cat TO-4	SAE 30	-15	80	5	176
		SAE 50	-5	95	23	203
Jacket Water		SAE 50	-5	95	23	203

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

Cat TDTO oil is formulated for transmissions and drive trains only, and should not be used in engines. Shortened engine life will result.

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.

Commercial Transmission Oils

If Cat TDTO (Transmission/Drive Train Oil) is not used, commercial oils meeting the Cat TO-4 specification must be used in Cat marine transmissions. Use TO-4 specification oils that are single grade only.

Commercial Marine Transmissions

For marine transmissions which are not manufactured by Cat, refer to the lubrication recommendation of the Original Equipment Manufacturer (OEM).

i04058329

Synthetic Basestock Oils

SMCS Code: 1300; 1348; 7581

Synthetic base oils are acceptable for use in Cat engines. **These oils must meet the performance requirements that are specified by Cat for the engine compartment.**

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, Cat does not recommend the automatic extension of oil drain intervals for any type of oil, whether synthetic or non-synthetic.

Oil drain intervals for Cat engines can only be adjusted higher (longer interval) after an oil analysis program that contains the following data:

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

Refer to the “Extended Engine Oil Drains and Warranty” article in the Foreword 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.

i04069617

Aftermarket Oil Additives

SMCS Code: 1300; 1348; 7581

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

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

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

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

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Specialty Lubricants

SMCS Code: 7000; 7581

Table 9

Special-Purpose Cat 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 10

UV Visible Dyes for Leak Detection			
Part Number	Description	Size	Dosage
To detect oil leaks in engines, transmissions, hydraulic systems			
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

The dyes must be used with a special Glo Gun to detect the leaks. Consult with your local Cat dealer for availability.

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Cold Weather Lubricants

SMCS Code: 1300; 1348; 7581

NOTICE

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

NOTICE

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

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

Also, refer to this Special Publication, "Lubricant Viscosities" article.

NOTICE

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

NOTICE

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

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

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

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

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

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

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

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

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

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

NOTICE

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

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

NOTICE

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

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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.

Cat 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 Services analyst uses the results of elemental analysis and particle count tests to evaluate the wear. Trend analysis and proprietary wear tables are then used to determine if wear rates are normal or abnormal.

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

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 are allowed in Cat engines.

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

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

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

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

Table 11

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

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

(2) Gas Chromatograph

Consult your 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 engine until the oil is warm and the oil is circulated. Then obtain the S·O·S oil sample.

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

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

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

Use of the in-line sampling valve is the preferred method. This method provides samples that are less likely to be contaminated. Whenever you obtain the samples, obtain the samples from the same point. This makes the samples 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 high idle in order to obtain the oil sample.

NOTICE

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

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

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

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

Oil Sampling Interval

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

Table 12

S·O·S Oil Sampling Interval	
Compartment	Interval ⁽¹⁾⁽²⁾
Engine crankcase	Every 250 Service Hours

(1) Severe applications may require a more frequent oil sampling interval.

(2) Under certain conditions, the Cat dealer or the Operation and Maintenance Manual may allow a longer interval between oil samplings.

Note: Refer to the Operation and Maintenance Manual for your specific engine for recommended oil drain intervals.

Consult your Cat dealer for complete information and assistance in order to establish an S·O·S Services program for your engine.

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

Traditionally, the suggested S·O·S sampling intervals for diesel engines have been at 250 hours. However in severe applications, more frequent oil sampling is recommended. Severe service for lubricated compartments occurs at high loads, in high temperatures, and in dusty conditions. If any of these conditions or other severe service indicators exist, sample the engine oil at 125 hour intervals. These additional samples will increase the chance of detecting a potential failure.

Determining Optimum Oil Change Intervals

Sampling the engine oil at every 125 hours provides information for oil condition and for oil performance. This information is used to determine the optimum usable life of a particular oil. Also, more points of data will allow closer monitoring of component wear rates. Close monitoring also allows you to obtain the maximum use of the oil. For detailed information on optimizing oil change intervals, consult your Cat dealer.

This Special Publication does not address recommended oil drain intervals. Guidance is provided that should be used in conjunction with your specific engine Operation and Maintenance Manual in determining acceptable oil drain intervals. Consult your engine Operation and Maintenance Manual, and consult your Cat 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 it is the best way to optimize oil life, and will help engines reach their 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 engine specific Operation and Maintenance Manual 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 engine specific 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 in conjunction with high sulfur fuels, can contribute significantly to reducing oil drain intervals below standard oil drain intervals.

Consult your Cat 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 help optimize oil drain intervals for engine specific applications and duty cycles, use Cat S·O·S Services oil analysis as follows:

- Recommended as a matter of course
- 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).

Optimizing the Component Life Cycle

An increase in the number of oil samples provides a better definition of the trends in data between oil change intervals. More oil samples will allow you to monitor wear patterns of components. This action will ensure the maximum component life.

i04057816

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.

Cat 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 required.

Before selecting a grease product, the performance requirements must be determined. Consult the grease recommendations that are made by the OEM for the equipment. Then, 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.

If necessary, choose a single grease to use for all of the equipment at one site. 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 of the costs of parts, labor, downtime, and the amount of grease that is required.

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, Cat recommends purging all of the old grease from the joint. Some greases are not chemically compatible. Consult your supplier in order to determine if the greases are compatible.

If in doubt, Purge!

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

Cat 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". (This certification relates to extended service intervals in automotive chassis points and in wheel bearings with disc brakes in automobiles, vans, and light trucks.)

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 Multipurpose Grease is also available in an extra tacky version, known as Cat White Assembly Grease. Cat White Assembly Grease has the same formula and the same performance as regular Cat Multipurpose Grease. One difference between Cat Multipurpose Grease and Cat White Assembly Grease is the white color. In addition, this grease has been made extra tacky in order to hold gaskets, O-rings, and needle bearings better in the assembly process.

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. In addition, the molybdenum in Cat Advanced 3Moly Grease is a special grade that has a median particle size of 3 microns. This size meets the special requirements of some rolling element bearings. Cat Advanced 3Moly Grease is recommended for heavily loaded pin joints, and high impact applications in machines. Examples include track-type tractors, backhoe loaders, and skid steer loaders.

Cat Advanced 3Moly Grease meets the NLGI certification of "GC-LB". (This certification relates to extended service intervals in automotive chassis points and in wheel bearings with disc brakes in automobiles, vans, and light trucks.)

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

Cat 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.

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 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. This formulation allows the Cat Ultra 5Moly Greases to 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. Pumpability is important when critical lubrication points rely on an automatic lubrication system.

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 high resistance to galling, wear, fretting, water washout, and corrosion.

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. Cat 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). The Moly in Cat Ultra 5Moly Grease is a special grade that has a median particle size of 3 microns. This size meets the special requirements of some rolling element bearings.

Cat Ultra 5Moly Grease is 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. In addition, many of these greases do not have the performance in order to protect the gear teeth adequately in these applications.

Cat Ultra 5Moly Grease exceeds the NLGI certification of "GC-LB". (This certification relates to extended service intervals in automotive chassis points and in wheel bearings with disc brakes in automobiles, vans, and light trucks.)

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 are more environmentally friendly.

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 (MoS₂ 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. 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. Desert Gold 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 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. This grade has a median particle size of 3 microns in order to meet the special requirements of some rolling element bearings.

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. In addition, many of these greases do not have the performance, particularly at high ambient temperatures, to protect the gear teeth adequately in these applications.

Cat Desert Gold Grease prevents galling and wear at hot temperatures under severe loads and conditions. In moderate temperatures, Cat Desert Gold Grease can be used in those 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. This grease has an high performance and long life.

Cat Desert Gold Grease exceeds the NLGI certification of "GC-LB". (This certification relates to extended service intervals in automotive chassis points and in wheel bearings with disc brakes in automobiles, vans, and light trucks.)

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 is more environmentally friendly.

Cat Arctic Platinum

Cat Arctic Platinum Grease is formulated to protect the most heavily loaded joints in Cat 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. Cat Arctic Platinum Grease flows easily as the temperature drops. Cat Arctic Platinum Grease pumps easily at low temperatures. In fact, Cat Arctic Platinum Grease NLGI grade 0 can be pumped through standard automatic lubrication systems that are machine mounted. Pumpability is good 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. This thickener provides 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 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 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). In addition, the molybdenum in Cat Arctic Platinum Grease is a special grade. This molybdenum has a median particle size of 3 microns in order to meet the special requirements of some rolling element bearings.

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 adequately in these applications.

Cat Arctic Platinum Grease prevents galling and wear at cold temperatures under 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 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 is more environmentally friendly.

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. When compared to many other types of grease, the Cat High Speed Ball Bearing Grease is more environmentally friendly.

Grease Application Charts

Type of Grease

Severe Applications are with 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 13

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

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”).

Green (Environmentally) Friendly 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 14

Type of Cat Grease						
Cat Grease Name	NLGI Grade	Low Temp. Pumpability	Service Life	Green Friendly	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

Fuel Specifications

i04058280

General Fuel Information

SMCS Code: 1250; 1280

NOTICE

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

The information provided are the latest recommendations for the Cat diesel engines that are covered by this Special Publication. This information supersedes all previous recommendations which have been published for the Cat diesel engines that are covered by this Special Publication. Special fluids are required for some engines and 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 Caterpillar dealer or Caterpillar authorized outlets. For a list of authorized Caterpillar parts outlets in your area, consult your Caterpillar 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 Cat spin-on filter. For non Cat filters, refer to the installation instructions that are provided by the supplier of the filter.

NOTICE

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

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

NOTICE

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

General Recommendations and Guidelines

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

Note: These general recommendations and guidelines concerning maintenance and care of fuel and fuel storage systems are not intended to be all inclusive. **Discuss proper fuel safety and health, handling, and maintenance practices with your fuel supplier.** Use of these general recommendations and guidelines does not lessen the engine owners and/or fuel supplier'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: Cat filters are designed and built to provide optimal performance and protection of the fuel system components.

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

- Use fuel that meets or exceeds Cat requirements for distillate diesel fuel. Refer to the "Cat Specification for Distillate Diesel Fuel for Nonroad Diesel Engines" table in this Special Publication, "Distillate Diesel Fuel" article.
- 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.
- Cat 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 Cat 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.

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- Every 3 months, or sooner if problems are suspected, have a complete analysis of the bulk storage fuel per the “Cat Specification for Distillate Diesel Fuel for Nonroad Diesel Engines” table in this Special Publication, “Distillate Diesel Fuel” article. Take corrective action if necessary. Corrective actions may include, 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.
 - Cat Advanced Efficiency fuel filters are required for distillate fueled diesel engines in order to provide maximum life to the fuel system.
 - Change fuel filters at the scheduled interval. Never fill the new secondary fuel filter with fuel before installation. Use the fuel priming pump to remove air from the system.
 - Install and properly maintain four micron(c) absolute breather filters on the engine fuel tank vent, 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.
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- NOTICE**
- Do not add new engine oil, waste engine oil or any oil product to the fuel unless the engine is designed and certified to burn diesel engine oil (for example Caterpillar ORS designed for large engines). Caterpillar experience has shown that adding oil products to Tier 4 engine fuels (U.S. EPA Tier 4 certified), to EURO Stage IIB and IV certified engine fuels, or to the fuels of engines equipped with exhaust aftertreatment devices, will generally cause the need for more frequent ash service intervals and/or cause loss of performance.
- Adding oil products to the fuel may raise the sulfur level of the fuel and may cause fouling of the fuel system and loss of performance.
-
- Note:** Cat has four different size coalescer type fuel filters available for bulk storage fuel tank applications that filter both dirt and water. The filter elements are rated at four microns(c) absolute. Consult your Cat dealer for information on the coalescer filters available through Cat.
- Note:** 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: Cat strongly recommends the filtration of distillate diesel fuel and/or biodiesel/biodiesel blends through a filter with a rating of four microns(c) absolute or less. This filtration should be located on the device that dispenses the fuel to the fuel tank for the engine, 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, Cat 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.

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 aftertreatment systems.

European ULSD (≤ 10 ppm (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 Cat 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, Cat 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 Cat 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, Cat 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".

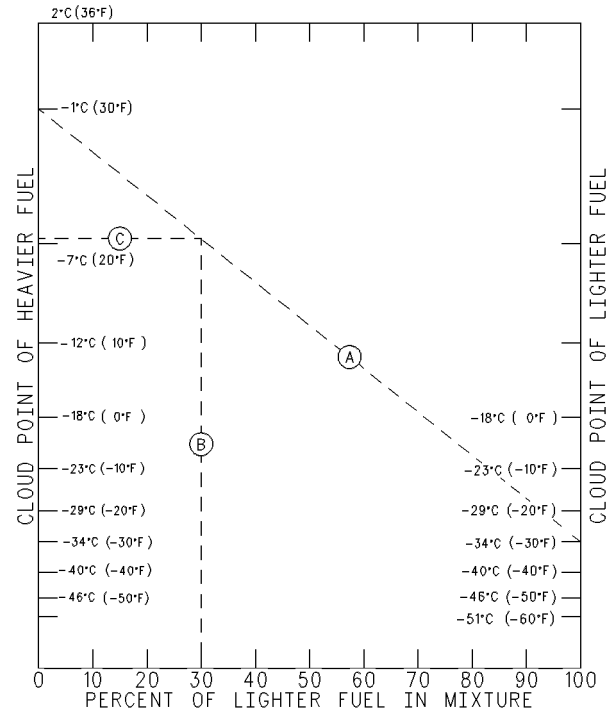


Illustration 1

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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.

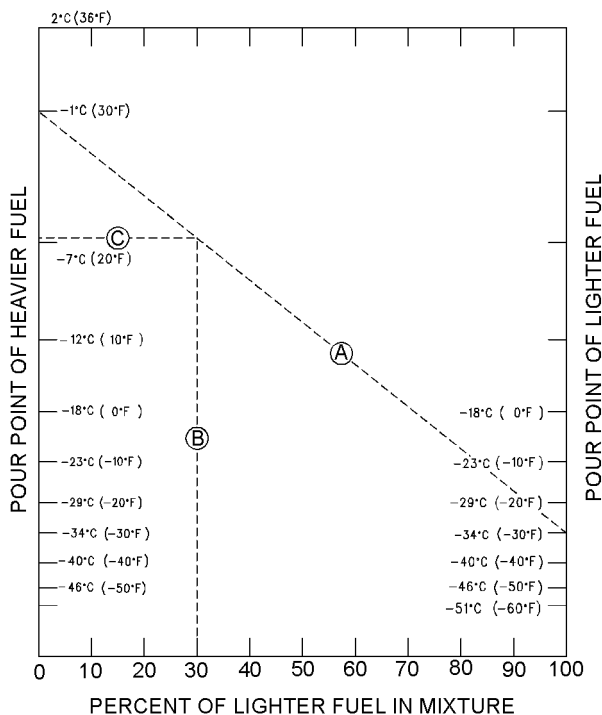


Illustration 2

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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. Cat 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 Cat 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

NOTICE

Refer to your engine/machine specific Operation and Maintenance Manual, and refer to your aftertreatment device documentation for the recommended and/or maximum allowable fuel sulfur levels.

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

- 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

Depending on operating conditions, and depending on maintenance practices, the potential issues stated in this NOTICE 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.

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.

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 will be available in December 2010 for nonroad diesel engines and machines and for the on-highway diesel engine markets. Engines certified to nonroad Tier 4 standards (Stage IV in Europe) and are equipped with 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 from the use of fuels are not Cat factory defects. Therefore the cost of repairs would not be covered by a Cat warranty.

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 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”.

Note: Another available diesel fuel in Europe has a maximum sulfur content of 0.005 percent (50 ppm). 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

Fuel sulfur levels affect exhaust emissions. Sulfur in the fuel results in the formation of sulfur dioxide (SO₂) and sulfur trioxide (SO₃) gases in the exhaust gas. 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 Particulate Filters (DPF), Diesel Oxidation Catalysts (DOC), Selective Catalytic Reduction (SCR) and/or Lean NO_x Traps (LNT). Other systems may apply.

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 specific engine Operation and Maintenance Manuals, the specific aftertreatment device documentation, and the applicable emissions laws, regulations and mandates.

- 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 maximum allowable fuel sulfur level for Tier 4 engines that are equipped with aftertreatment devices is 0.0015 percent (15 ppm (mg/kg)). Refer to the engine/machine specific Operation and Maintenance Manual and refer to the aftertreatment device specific documentation, if available, for guidance
- 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 specific Operation and Maintenance Manual and refer to the aftertreatment device specific documentation for guidance.
- For machine diesel engines that are equipped with an aftertreatment device that is not listed in this section, refer to the engine specific 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.

Note: “non DOC and non DPF equipped” refers to engines that were not originally designed to require DOC and/or DPF aftertreatment, and did not come from the factory with a DOC and/or a DPF installed and/or required.

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

High sulfur in the fuels can increase corrosion, wear and deposits of internal components. During the combustion process, sulfur in the fuel can form acidic products that increase corrosion and wear as well as negatively impact engine oil. Sulfur in the fuel may also increase the soot formation in the engine oil, which can reduce the oil life and can cause the formation of deposits in the engine.

Fuel sulfur levels above 0.5% (5000 ppm (mg/kg)) may significantly shorten the oil change interval.

There are many factors that affect maximum allowed and/or acceptable fuel sulfur levels, including but not limited to the following:

- Engine Certification
- Laws, regulations, and other legal mandates
- Exhaust aftertreatment device type
- Maintenance intervals and other maintenance practices
- Engine model/design
- Engine application
- Overall fuel quality
- Using recommended fluids
- Oil TBN (Total Base Number)
- 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

Note: Consult federal, state, local, and other governing authorities for guidance concerning fuel requirements for your area.

Note: Consult specific engine Operation and Maintenance Manuals for additional guidance, including but not limited to guidance on acceptable oil drain intervals and guidance on maximum acceptable fuel sulfur level.

When other factors do not 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 engine specific Operation and Maintenance Manuals 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.

- Cat S·O·S Services oil analysis is recommended as a matter of course.
- Cat S·O·S Services oil analysis is 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).
- Cat S·O·S Services oil analysis is required in order to determine oil drain intervals when operating on fuel with sulfur levels that are above 0.5% (5000 ppm).
- Consult your Cat dealer for guidance when fuel sulfur levels are above 0.1% (1000 ppm).

Note: For guidance related to on-highway diesel engines refer to specific engine Operation and Maintenance Manuals, and to the most current revision level of Caterpillar On-Highway Diesel Engine Fluids Recommendations, SEBU6385.

Refer to the “Oil Sampling Interval” article in this Special Publication for guidance in determining the oil change intervals.

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, Cat 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

Cat 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

Cat 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.

Cat 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 "Cat 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.

Cat 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 “Cat Specification for Distillate Fuel for Nonroad 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 “Cat Specification for Distillate Fuel for Nonroad Diesel Engines”, Table 15.

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

Diesel Fuels that meet the specifications in table 15 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 15 requirements.

In Europe, diesel fuels that are identified as meeting the latest version of “European Standard EN590” generally meet the table 15 requirements.

Table 15 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 (≤ 10 ppm (mg/kg)) sulfur fuel is required by regulation for use in engines certified to European nonroad Stage IIIB and newer standards and are equipped with exhaust aftertreatment systems.

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

Typical aftertreatment systems include Diesel Particulate Filters (DPF), Diesel Oxidation Catalysts (DOC), Selective Catalytic Reduction (SCR) and/or Lean 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.

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 to insure the correct fuels are used.

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

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

Note: Cat 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.

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 Caterpillar's 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 Nonroad Diesel Engines", table 15.

The values of the fuel viscosity given in table 15 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 15

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"

(continued)

(Table 15, contd)

Cat Specification for Distillate Fuel for Nonroad Diesel Engines			
Specifications	Requirements	ASTM Test	ISO Test
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 20846 or 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" or "D2709"	"ISO 3734"
Water	0.05% maximum	"D6304"	No equivalent test

(continued)

(Table 15, contd)

Cat Specification for Distillate Fuel for Nonroad Diesel Engines			
Specifications	Requirements	ASTM Test	ISO Test
Sediment	0.05% maximum (weight)	"D473"	"ISO 3735"
Gums and Resins ⁽⁵⁾	10 mg per 100 mL maximum	"D381"	"ISO 6246"
Lubricity	0.52 mm (0.0205 inch) maximum at 60 °C (140 °F)	"D6079"	No equivalent test

- (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.
- (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 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).

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 "Cat Specification for Distillate Fuel for Nonroad Diesel Engines", Table 15. 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 Nonroad Diesel Engines", Table 15.

NOTICE

In order to meet expected fuel system component life, 4 micron(c) absolute or less secondary fuel filtration is required for all Caterpillar diesel engines that are equipped with common-rail fuel systems, and for all Caterpillar diesel engines that are equipped with unit injected fuel systems. For all other Caterpillar 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 Caterpillar diesel engines are factory equipped with Caterpillar 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.

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 16. However, the fuel that is selected must meet the requirements that are specified in the "Cat Specification for Distillate Diesel Fuel for Nonroad Diesel Engines", Table 15. 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 16 typically have much higher sulfur levels than the 15 ppm maximum sulfur allowed for ULSD. The sulfur levels for these fuels typically far exceed 15 ppm. These fuels typically will not be acceptable for use in areas that restrict maximum fuel sulfur levels to 15 ppm or less.

Note: The fuels that are listed in table 16 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 Nonroad Diesel Engines", table 15. 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 16

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 16 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. Cat, through its sustainability initiatives, supports the development and use of renewable fuels.

Renewable fuels (other than biodiesel) and alternative (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.

Cat 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.

Cat 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. Cat does not generally recommend the use of fuel additives.

In special circumstances, Cat 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. Cat 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 Cat.

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 Cat 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.

Cat 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 existing and U.S. EPA 2007 on-highway certified diesel engine emission control catalysts and particulate filters.

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 Cat 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.

Cat 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 existing and U.S. EPA Tier 4 nonroad certified diesel engine emission control catalysts and particulate filters.

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 Caterpillar 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. In order to use any of the oils or fats listed above as fuel, the oil or fat must be esterified and the water and contaminants removed.

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

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

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

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

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

Cat 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: In order to align Cat recommendations with the latest revision of "ASTM D7467" specification for B6-B20 blends and to ensure that biodiesel fuel meets 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 Cat Nonroad Engines

Refer to table 18 and table 19 and 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 "Cat 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 "Cat 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 "Cat 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 17

Recommendations for biodiesel fuel application in Cat Nonroad 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, Certain C4.4 (S/N 44400001-04303), Certain C6.6 (S/N C6E00001-14623 (Machines) and S/N 66600001-09015 (Industrial))	Up to B5
Tier 4 Interim / Stage IIIb and beyond (with aftertreatment devices)	ACERT engines: C4.4, C6.6, C7.1, C9.3, C13, C15, C18, C27, and C32	Up to B20
All years post Tier 2/Stage II	C0.5 through C2.2 ⁽¹⁾ 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 C6E14624-Up (Machines) and 66609016-Up (Industrial))	Up to B20 (For use of higher blend levels, consult with your Cat dealer)
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⁾ : C7, C9, C9.3, C11, C13, C15, C18, C27, C32, and C175	

(1) Models without aftertreatment only

Table 18

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 20 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 Cat Nonroad Engines” in this Special Publication, table 17. Use of biodiesel blend levels higher than the recommendations provided in table 17 can adversely affect engine and aftertreatment components, mainly due to 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 19 in this Special Publication for the guidelines and impacts of using high biodiesel blends. Consult your Cat dealer for guidance. A complete Cat S·O·S Services oil analysis program is required when biodiesel or blends of biodiesel that are B20 (20 percent) or above are used.

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

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

Additional maintenance requirements

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

- Crankcase oil fuel dilution can be higher when biodiesel and/or biodiesel blends are used. This increased level of fuel dilution when using biodiesel and/or biodiesel blends is related to the typically lower volatility of biodiesel. In addition, in-cylinder emissions control strategies utilized in many of the latest engine designs may lead to a higher level of biodiesel concentration in the sump. The long-term effect of biodiesel concentration in crankcase oil is currently unknown. **The use of Cat S·O·S Services oil analysis is strongly recommended when up to B20 (20 percent) and lower biodiesel blends are used, and required when using biodiesel/biodiesel blends that are B20 or above** (when requesting oil analysis, be sure to note the level of biodiesel being used (B5, B20, 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 and biodiesel blends while also hindering the production of new deposits. **Therefore, the use of Cat Diesel Fuel System Cleaner and/or Cat Diesel Fuel Conditioner is strongly recommended when running biodiesel and biodiesel blends, especially when using B20 or higher blend levels.** Refer to this Special Publication, “Distillate Diesel Fuel”, article, “Cat Diesel Fuel Conditioner” and “Cat Diesel Fuel System Cleaner” topics in this Special Publication, “Distillate Diesel Fuel” for additional information.

Consult your Cat 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 “Cat 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 19 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 may should be shortened for an extended period of time in order to allow for this cleaning effect.

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

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

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 19

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 two 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. In addition, B100 should be stored at temperatures of 3 degrees C to 6 degrees C (5 degrees F to 10 degrees F) above the cloud point.

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 may should be shortened for an extended period of time 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. This will help avoid engine problems when the engine is converted back to 100 percent distillate diesel fuel. Furthermore, any adjustments to the engine in service to compensate for the power loss may result in violation of emissions regulations such as the U.S. EPA anti-tampering provisions.
6. Compatibility of the elastomers with biodiesel is currently being monitored. The condition of seals and hoses should be monitored regularly. Biodiesel may soften, degrade, or leak from some types of elastomers used in seals and hoses. The higher 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 strongly 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 strongly 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 strongly 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, it is strongly recommended that 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 "Seasonal Operation" section.

- a. Addition of Cat Diesel Fuel Conditioner, part number 256-4968, or an appropriate commercial additive containing antioxidants/oxidation stability improvers, is strongly recommended for standby generator sets and emergency vehicles using biodiesel/biodiesel blends. The conditioner should be added when the engine is fueled or as early as possible when the fuel is delivered and stored. Preferably, the conditioner or additive should be added as soon as possible after the fuel is produced.
 - b. For standby generator sets and emergency vehicles that use biodiesel, sample the fuel in the engine tank monthly. Test the fuel for acid number and oxidation stability. If the test results show that the fuel is degraded and that the fuel is not per the appropriate specifications (provided in Table 20 in this “Biodiesel” section), drain the tank, flush the engine by running it using 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, it is strongly recommended that the fuel oxidation stability is 10 hours or more per “EN 14112” test method.
- 12.** Biodiesel is an excellent medium for microbial contamination and growth. Microbial contamination and growth can cause corrosion in the fuel system and premature plugging of the fuel filter. Consult your supplier of fuel and additive for assistance in selecting appropriate anti-microbial additives.
- 13.** Care must be taken in order to remove water from fuel tanks. Water accelerates microbial contamination and growth. When biodiesel is compared to distillate fuels, water is naturally more likely to exist in the biodiesel.
- 14.** Biodiesel dilution of engine oil may result in oil side leaks due to incompatibility of the seals that are typically used on the oil side. Liner seals and oil cooler seals may be affected by biodiesel dilution. Monitor the condition of the oil side seals and consult your Cat dealer for appropriate replacement if needed.
- 15.** Biodiesel is not compatible with some metals. Biodiesel, in particular B100 and blends higher than B20, will oxidize and form sediments upon long-term contact with lead, zinc, tin, copper, and copper alloys such as brass and bronze. Consult your Dealer for more information.

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

Seasonal Operation

It is strongly recommended that seasonally operated engines have the fuel systems, including fuel tanks, flushed with conventional diesel fuel before prolonged shutdown periods. 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 very low.
2. Refill the fuel tank with high quality conventional distillate diesel fuel.
3. Repeat steps 1 and 2 a minimum of two times before the engine is shut down for prolonged periods.

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

- Addition of Cat Diesel Fuel Conditioner, part number 256-4968, or an appropriate commercial additive containing antioxidants/oxidation stability improvers, is strongly 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 Cat Diesel Fuel System Cleaner, part number 343-6210, or an appropriate commercial cleaner is recommended when the engine is first operated after the prolonged shutdown period and preferably for a total of two tanks of fuel. Follow the recommendations provided in the Cat Diesel Fuel System Cleaner section in the “Fuel” article in this Special Publication.

Consult your Cat dealer for the availability of Cat Diesel Fuel Conditioner and Cat 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 18 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 this "ASTM D6751" 200 seconds Cold Soak Filterability test limit does not guarantee cold performance for all biodiesel blends at all possible fuel temperatures, but biodiesel that fails this Cold Soak Filterability test requirement will produce biodiesel blends that will likely plug fuel filters when fuel temperatures are below -12°C (10.4°F).

Table 20

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 NaOH/g	0.5 maximum
Methanol Content	"EN 14110"	"EN 14110"	percent weight	0.2 maximum

(continued)

(Table 20, contd)

Cat Specification for Biodiesel Fuel				
Property	Test Method	Test Method	Units	Limits
	United States	International	Specific Properties of Fuel	
Monoglycerides	"ASTM D6584"	"EN 14105"	percent weight	0.8 maximum
Diglycerides	"ASTM D6584"	"EN 14105"	percent weight	0.2 maximum
Triglycerides	"ASTM D6584"	"EN 14105"	percent weight	0.2 maximum
Free Glycerin	"ASTM D6584"	"EN 14105"	percent weight	0.02 maximum
Total Glycerin	"ASTM D6584"	"EN 14105"	percent weight	0.240 maximum
Phosphorus Content	"ASTM D4951"	"EN 14107"	percent weight	0.001
Calcium and Magnesium combined	"EN 14538"	"EN 14538"	ppm	5 maximum
Sodium and Potassium combined	"EN 14538"	"EN 14538"	ppm	5 maximum
Cold Soak Filterability	Annex A1 in "ASTM D6751"		seconds	360 maximum

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.

Exhaust Aftertreatment Fluids Specifications

Diesel Exhaust Fluid (DEF) (For Use in SCR-equipped engines)

i04144290

SMCS Code: 1091; 7579

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 also known under other names including Aqueous Urea Solution (AUS) 32, AdBlue, or 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 (N₂) and water (H₂O).

DEF Recommendations

For use in Cat engines, DEF must meet all the requirements defined by "ISO 22241-1" Requirements.

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 21 for part number information:

Table 21

Cat Part Number	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. DEF concentration of 32.5% is optimal for use in SCR systems. 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%.

Caterpillar offers a refractometer, Cat part number 360-0774, that can be used to measure DEF concentration. Follow the instructions provided with the instrument. Appropriate commercial portable refractometers can be used to determine urea concentration. Follow the instructions from the manufacturer.

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.

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, 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 Diene Monomer (EPDM)

The condition of hoses and other nonmetallics 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. Spilling DEF onto hot components will cause harmful vapors.

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 22

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 23.

Table 23

Typical Characteristics ⁽¹⁾	
pH	9.5
Alkalinity as NH3	0.20%
Density at 20°C	1.09 kg/L
Refractive Index at 25°C	1.4
Dynamic Viscosity at 25°C	1.40 cP
Kinetic Viscosity at 25°C	1.28 cat
Thermal Conductivity at 25°C	0.570 W/m.K
Specific Heat at 25°C	3.40 kJ/kg.K
Surface Tension at 20°C	65 mN/m, min
Heat Capacity	0.82 BTU/lb (°F)
Vapor Pressure Factor (relative to water)	0.88
Biuret	0.30%
Aldehydes	5 mg/kg
Insoluble Matter	<20 mg/kg
Aluminum	<0.5 mg/Kg
Calcium	<0.5 mg/Kg
Chromium	<0.2 mg/Kg
Copper	<0.2 mg/Kg
Iron	<0.5 mg/Kg
Magnesium	<0.5 mg/Kg
Nickel	<0.2 mg/Kg
Phosphate (PO4)	<0.5 mg/Kg
Potassium	<0.5 mg/Kg
Sodium	<0.5 mg/Kg
Zinc	<0.2 mg/Kg

⁽¹⁾ The values provided are typical values for DEF with a 32.5% urea concentration. The values should not be used as quality control parameters to either accept or reject product.

Cooling System Specifications

i04058489

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 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 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.

Frequently check the specific gravity of the coolant for proper freeze protection or for anti-boil protection. 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 Celcius and degrees Fahrenheit. 360-0774 is a digital Brix refractometer.

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's 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.

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.

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 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.

Note: Cat strongly recommends a minimum of 30 percent glycol in diesel engine cooling systems, with a minimum of 50 percent glycol very strongly 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 (i.e. chemical composition, the use of SCA, the use of Extender, etc.). 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.

NOTICE

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

Water alone and/or water mixed with SCA are not approved coolants for use with C7-C32 Heat Exchanger cooled marine engines. C7-C32 heat exchanger cooled marine engines require a minimum of 30 percent glycol to prevent cavitation of cooling system components, with a minimum of 50 percent glycol very strongly recommended.

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

Distilled water or deionized water is recommended for use 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 24.

Table 24

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 in the coolant is recommended. Water quality can be affected by a variety of 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. This can be done by adding Cat SCA (Supplemental Coolant Additive) to Cat DEAC (Diesel Engine Antifreeze/Coolant) or by adding ELC Extender to Cat ELC (Extended Life 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 1:1 mixture of properly inhibited distilled or deionized water and glycol.

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

Note: 100 percent pure ethylene glycol will freeze at a temperature of -23 °C (-9 °F).

Most conventional heavy-duty coolant/antifreezes use ethylene glycol. Propylene glycol may also be used. In a 1:1 mixture with water, ethylene and propylene glycol provide similar protection against freezing and boiling. Refer to tables 25 and 26.

Table 25

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 propylene glycol's 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 26

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

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

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

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

Testing the Concentration of Glycol

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

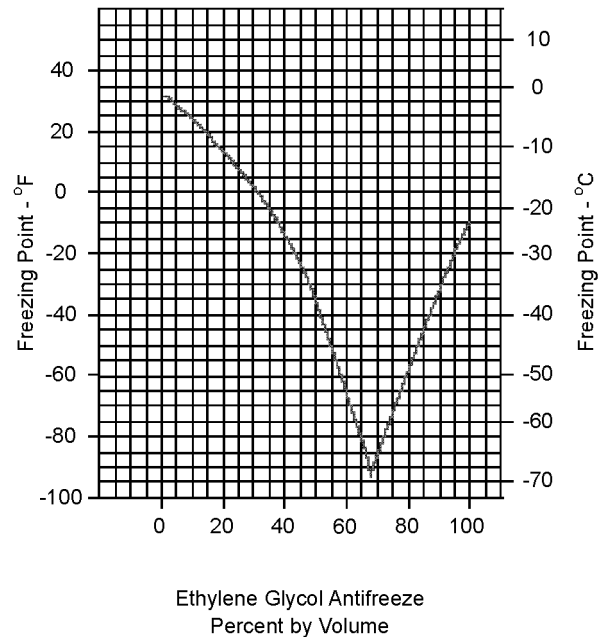


Illustration 3

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

Table 27

Freeze Protection for Antifreeze Concentrations ⁽¹⁾	
Protection to:	Concentration
-15 °C (5 °F)	30% glycol 70% water
-24 °C (-12 °F)	40% glycol 60% water
-37 °C (-34 °F)	50% glycol 50% water
-52 °C (-62 °F)	60% glycol 40% water

⁽¹⁾ Ethylene glycol based antifreeze.

Note: Alternative products that are used to protect from boiling or freezing of the engine coolant include "1,3 propandiol" (PDO), glycerin, and 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, SCA, and Extender Terminology

Conventional coolant – A coolant that relies largely on inhibitors for corrosion and cavitation protection that are inorganic in nature, such as silicate and nitrite. Conventional coolants are also referred to as a 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 is a conventional coolant.

Organic Additive Technology (OAT) coolant – A coolant that includes carboxylate inhibitors that provide corrosion and cavitation protection. Cat ELC is an OAT-type coolant that also includes nitrites and molybdates for increased cavitation protection.

- Do not use OAT-type coolants with more than 125 ppm silicon (present in the coolant in the form of silicate)
- OAT-Type coolants containing silicate do not meet the additional requirements set in this Special Publication for coolants claiming to meet EC-1

Hybrid Organic Additive Technology coolant (HOAT) – Similar to an OAT coolant, but also includes additional inhibitors, such as silicate, that are typically found in conventional heavy-duty coolants but are not present in non-hybrid OAT coolants.

- HOAT-type coolants containing silicate do not meet the additional requirements set in this Special Publication for coolants claiming to meet EC-1.
- Do not use HOAT-type coolants with more than 125 ppm silicon (present in the coolant in the form of silicate)
- HOAT-type 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 these “ASTM” specifications

Supplemental Coolant Additive (SCA) – SCA is a general term for an inhibitor package that is added to a cooling system. In glycol based coolant applications, SCA is added in order to pre-charge a new coolant that is not fully formulated and/or in order 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. Always be sure to add SCA based on coolant testing. This will ensure that the system does not contain too much SCA or too little SCA.

Extender – An inhibitor package that is added to a coolant, typically an OAT or HOAT coolant, to re-charge an in-service coolant. Extenders, such as Cat Extender being added to Cat ELC, typically only need to be added at one half the service life of the coolant.

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Coolant Recommendations

SMCS Code: 1350; 1352; 1395

The coolants that are recommended or acceptable for use in Cat diesel engines are given in Table 28 below:

Table 28

Recommendations for Coolants for use in Cat engines				
Coolant Type	Reccommendations	Product	Service hours ⁽¹⁾⁽²⁾	Required Maintenance
OAT and HOAT	Preferred	Cat ELC	12000 hours or six years	Add Cat ELC Extender at 6000 service hours or one half of service life
		Cat ELI	12000 hours or six 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 concntration of 900 ppm Nitrite: minimum typical concentration of 500 ppm in new coolants	6000 hours or Six years	Add Extender at 3000 service hours or one half of service life
Conventional	Acceptable	Cat DEAC	3000 hours or three years	SCA at maintenance intervals
		Cat SCA in water	3000 hours or two years	SCA at maintenance intervals
	Min requirements for fully formulated Heavy Duty Commercial coolants	"ASTM D6210" and Nitrite (as NO ₂) 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 two years	SCA at maintenance intervals
	Min requirements for Commercial coolants requiring SCA precharge	"ASTM D4985" and(1) Nitrite (as NO ₂) 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 one year	SCA at initial fill and SCA at maintenance intervals
	Min requirements for SCA and water	Commercial supplemental coolant additive and water	3000 hours or one year	Per manufacturer recommendations

(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.

When referring to the Service Life in the table, 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.

In order to ensure expected performance, EC-1 coolants require the one time maintenance addition of an extender at coolant service mid-life. Do NOT use an extender with a coolant unless the extender has been approved for use 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. Do NOT use an SCA with a coolant 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 minimum 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 only meets “ASTM D4985”, WILL require a treatment with an SCA at the initial fill. Ensure the SCA is compatible with the antifreeze/coolant. For example, a HOAT coolant that meets the “ASTM D4985” specification may not be compatible with an SCA designed for use with conventional coolants. 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.

When adding SCA at initial fill to a coolant/antifreeze that only meets the “ASTM D4985”, the user and the coolant manufacturer must ensure the SCA is compatible with the antifreeze/coolant based on the recommendations provided by the coolant manufacturer and SCA manufacturer. One of the test methods required to be used to help ensure SCA compatibility with the antifreeze/coolant concentrate is “ASTM D5828-97”. 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.

A commercial heavy-duty coolant/antifreeze that meets the “ASTM D6210” specification does not require a treatment with an SCA at the initial fill.

Cat ELC can be recycled into conventional coolants.

Cat ELC, 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 engine applications and marine engine applications that do not require protection from boiling or freezing, Cat ELI or a mixture of SCA and water is 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. 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.

Water alone and/or water mixed with SCA are not approved coolants for use with C7-C32 Heat Exchanger cooled marine engines. These engines require a minimum of 30 percent glycol to prevent cavitation of cooling system components. A minimum of 50 percent glycol is recommended strongly. 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. The coolant must also comply with any additional requirements that are stated in this Special Publication.

NOTICE

All Cat engines that are equipped with a Cat NO_x 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.

All Cat diesel engines equipped with air-to-air aftercooling (ATAAC) require a minimum of 30 percent glycol to prevent water pump cavitation. A minimum of 50 percent glycol is recommended strongly. 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. The coolant must also comply with any additional requirements that are stated in this Special Publication.

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

Cat ELC can be recycled into conventional coolants.

Cat ELC, 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.

For ELI part numbers, refer to ELI section in this Special Publication.

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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 a SCA (Supplemental Coolant 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 OEM engines of the following types: diesel and gasoline. Cat ELC meets the performance requirements of "ASTM D4985" and "ASTM D6210" for heavy-duty low silicate antifreeze/coolants. Cat ELC does not require treatment with a conventional SCA. Cat ELC also meets the performance requirements of "ASTM D3306" for automotive applications.

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 29 in this Special Publication.

Table 29

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 monocarboxylic acid and a dicarboxylic acid
	Phosphate, borate, and silicate free
	Minimum typical tolyltriazole level of 900 ppm for new coolants
	Minimum typical nitrite level of 500 ppm in new coolants"
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.

Extended life coolant used in Cat engines must meet all requirements given in Table 29. 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. This proportion will lower the ability of the coolant to protect the system from pitting, from cavitation, from erosion, and from deposits.

During daily maintenance, use the premixed Cat ELC as a cooling system top-off. This top-off will bring the coolant up to the proper level. Check the specific gravity of the coolant system with the 245-5829 Coolant/Battery Tester/Refractometer or 360-0774 refractometer. Use Cat ELC Concentrate to restore the proper glycol concentration in the coolant system. This addition should be done before the engine is exposed to freezing temperatures.

Do not use a conventional coolant to top-off a cooling system that is 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 30 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 30

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

Table 31 is an example for using the formula that is in Table 30. This example is based on the capacity of a D8R Track-Type Tractor with a cooling system capacity of 92 L (24.3 US gal).

Table 31

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)
946 L (250 US gal)	× 0.02	19 L (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 required 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, disconnecting the hoses may be necessary. 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. 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 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.

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.

In engine applications that do not require freeze protection, Cat ELI replaces Cat Supplemental Coolant Additive (SCA). SCA can provide adequate engine corrosion protection. SCA requires regular checks and maintenance to ensure proper additive levels. The recommended drain interval for SCA is relatively short compared to extended life coolant products. Improper SCA maintenance can result in corrosion and cavitation.

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 32 for information about Cat ELI.

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Extended Life Inhibitor (ELI)

SMCS Code: 1350; 1352; 1395

Cat Extended Life Inhibitor (ELI) is for applications that do not require freeze protection. ELI is water-based coolant that does not contain glycol.

Table 32

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

Note: Water alone and/or water mixed with SCA or ELI are not approved coolants for use with C7 through C32 Marine Engines cooled by heat exchangers. C7 through C32 Marine Engines cooled by heat exchangers require a minimum of 30 percent glycol to prevent cavitation of cooling system components. But, a minimum of 50 percent glycol is recommended. Refer to this Special Publication, "Coolant Section" for additional details.

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 before adding the 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 and then adding 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 32.

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 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 with Cat ELC may be mixed together. 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.

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Diesel Engine Antifreeze/ Coolant (DEAC)

SMCS Code: 1350; 1352; 1395

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 1:1 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.

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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

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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.

Select a commercial diesel engine antifreeze coolant that meets all the requirements given in Table 33. 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.

Table 33

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

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.

Note: Add SCA at initial fill to a coolant/antifreeze that meets the “ASTM D4985”. 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. 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 to compare the SCA 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 “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.

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Conventional Coolant/ Antifreeze Cooling System Maintenance

SMCS Code: 1350; 1352; 1395

NOTICE

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

NOTICE

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

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

NOTICE

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

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

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.

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

NOTICE

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

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

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.

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

Cat engine cooling systems should be tested at 250 hour intervals or at the PM Level 1 intervals for the concentration of SCA (Supplemental Coolant Additive). Nitrite test kits are available from your Cat dealer. Test the concentration of nitrite or submit a coolant sample to your Cat dealer at 250 hour intervals or at the intervals for PM Level 1. 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 Services 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.

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

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 34

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 with Larger Capacities

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

When the coolant system is first filled, the SCA is not required with Cat DEAC or with fully formulated coolants that meet the “ASTM D6210” specification when used at the recommended 1:1 or higher concentration with a recommended water.

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.

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

Use the equation that is in Table 35 as a guideline in order to aid in determining the amount of Cat SCA that is required when the cooling system is initially filled with fluids that only meet the “ASTM D4985” specification.

Note: Add SCA at initial fill to a coolant/antifreeze that meets the “ASTM D4985”. 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, a HOAT 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.**

Note: Add SCA at initial fill to a coolant/antifreeze that meets the “ASTM D4985” at a minimum. The user and the coolant manufacturer are responsible to ensure the SCA is compatible. 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 insolubles for SCA to reference SCA must be < 1. Total insolubles 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 as found in “ASTM D6210-06, Table X1.1”.

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

Table 35

Equation For Adding The Cat SCA To Conventional Coolant/Antifreeze At The Initial Fill
$V \times 0.045 = X$
V is the total volume of the cooling system.
X is the amount of Cat SCA that is required.

Table 36 is an example for using the equation that is in Table 35.

Table 36

Example Of The Equation For Adding The Cat SCA To Conventional Coolant/Antifreeze At The Initial Fill		
Total Volume of the Cooling System (V)	Multiplication Factor	Amount of Cat SCA that is Required (X)
946 L (250 US gal)	× 0.045	43 L (11 US gal)

Adding the SCA to Conventional Coolant/Antifreeze For Maintenance

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

Test the coolant/antifreeze periodically for the concentration of SCA. For the interval, see the Operation and Maintenance Manual, "Maintenance Interval Schedule" for your engine. SCA test kits are available from your Caterpillar dealer. Test the concentration of SCA or submit a coolant sample to your 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.

Use the equation that is in Table 37 to determine the amount of Cat SCA that is required, if necessary.

Table 37

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

Table 38 is an example for using the equation that is in Table 37.

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

Table 38

Example Of The Equation For Adding The Cat SCA To Conventional Coolant/Antifreeze For Maintenance		
Total Volume of the Cooling System (V)	Multiplication Factor	Amount of Cat SCA that is Required (X)
946 L (250 US gal)	× 0.014	9 L (4 US gal)

Table 34 lists part numbers and the sizes of containers for Cat SCA that is available from your Cat dealer.

Cleaning the System of Heavy-Duty Coolant/Antifreeze

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

Cat Cooling System Cleaners

- Dissolves or depresses mineral 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 Caterpillar 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.

Caterpillar 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 Caterpillar engine cooling systems. Contact your Caterpillar dealer for part numbers.

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

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 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 39

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.

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- b. Run the engine for 20 minutes.
 - c. Drain the water.
7. Refill the cooling system with new coolant.

Table 40

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 Caterpillar dealer for more information.

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

Recycled coolants should meet the latest revision of "ASTM D6210".

Water/SCA (Supplemental Coolant Additive)

SMCS Code: 1350; 1352; 1395

Note: Caterpillar 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, and so on). Refer to the Operation and Maintenance Manual for your engine for any exceptions.

Water alone and/or water mixed with SCA are not approved coolants for use with C7-C32 Heat Exchanger cooled marine engines. C7-C32 heat exchanger cooled marine engines require a minimum of 30 percent glycol to prevent cavitation of cooling system components, 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, and so on).

NOTICE

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

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 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 a 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 Table 41 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.

Table 41

Equation For Adding The Cat SCA To Water At The Initial Fill
$V \times 0.07 = X$
V is the total volume of the cooling system.
X is the amount of Cat SCA that is required.

Table 42 is an example for using the equation that is in Table 41.

Table 42

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 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 Table 41 to determine the amount of Cat SCA that is required for maintenance, if necessary:

Table 43

Equation for the Addition of Cat SCA To Water For Maintenance
$V \times 0.023 = X$
V is the total volume of the cooling system.
X is the amount of Cat SCA that is required.

Table 44 is an example for using the equation that is in Table 41.

Table 44

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 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 Cat dealer. Cat S-O-S coolant analysis is the best way to monitor the condition of your coolant and your cooling system. S-O-S coolant analysis is a program that is based on periodic samples.

NOTICE

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 Cat DEAC (Diesel Engine Antifreeze/Coolant). This 500 hour check will also check for any residual cleaner that may have contaminated the system.

Recommended Interval for S-O-S Services Coolant Sample

Table 45

Recommended Interval		
Type of Coolant	Level 1	Level 2
Cat DEAC	Every 250 hours ⁽¹⁾⁽²⁾	Yearly ⁽¹⁾⁽²⁾⁽³⁾
Cat ELC	Optional ⁽³⁾	Yearly ⁽³⁾

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

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

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

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

The following properties of the coolant are tested:

- Glycol concentration for freeze protection and boil protection
- 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 Cat dealer.

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 is the primary cause of fluid system failures.

All of the following may alter the properties of the fluids. Efficiency losses and/or fluid systems breakdowns may occur.

1. Foreign substances (such as wear particles, fibers, dirt, dust, or products of combustion that are suspended in the fluids).
2. Chemical substances (such as water or fuel)
3. Biological micro-organisms (such as algae or fungi)
4. Physical/chemical properties (such as heat)

Particle contamination can be classified in two broad categories:

- Particles visible to the naked eye (40 microns and larger)
- Particles that cannot be seen with the naked eye (smaller than 40 microns)

Both size ranges must be controlled within Cat recommended cleanliness specifications.

Current machine 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

The fluid cleanliness can be measured by taking fluid samples from the various machine compartments and analyzing these fluids by your Cat dealer. The number of particles in fluids is expressed in "ISO (International Organization for Standardization)" units. "ISO 4406 Hydraulic (Fluid Power – Methods for Coding the Level of Contamination by Solid Particles)". "ISO 4406" reports in three code ranges (for example: 18/16/13). Cat "ISO" cleanliness results are expressed as two codes. An example of a standard for cleanliness is "ISO" 16/13. The first number (16) refers to the number of particles that are 6 microns and larger in size. The second number (13) refers to the number of particles that are 14 microns and larger in size. There are 28 codes on the "ISO" scale. Each code represents a given range of particles per milliliter of fluid. The smaller the code, the lower number of harmful particles per milliliter of fluid.

Note: Do not use the particle count for the evaluation of the engine oils. Additives in new engine oils may interfere with particle counting methods. Soot in used engine oils should be evaluated by using S·O·S Services Oil Analysis. Consult your local Cat dealer for guidance.

Recommendations or Practices

Some guidelines to use for controlling contaminants are listed in this Special Publication. By maintaining a low contamination level, the maintenance cost of the machine can be controlled. The productive life of the component/fluid systems may also be increased.

Follow the general guidelines for controlling contaminants.

1. Use fuels that meet Cat diesel fuel Performance Requirements. Filter all diesel fuel through a 4 micron(c) or less absolute filter (Beta 4 = 75) when you refuel the machine. This filtration should be located at the device that dispenses the fuel to the engine fuel tank. Ensure that you use Caterpillar Advanced Efficiency Fuel Filters for all engines that have a high-pressure fuel injection system.

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.

2. Use only coolants that are recommended by Cat for your equipment. Follow the recommended maintenance procedure for the cooling system in the Operation and Maintenance Manual for your equipment.
3. When you add engine oil, the recommendation is to filter the oil at the fill point in order to ensure cleanliness of the oil. Oil stored in bulk tanks should be filtered.
4. When you add oil to the marine transmissions, use adequate filtration to clean the oil. The oil must meet the target fill point cleanliness of 16/13 or better.
5. Maintain the engine air filters in order to minimize contamination at the engine air intake system.
6. Follow contamination control practices for all the following areas. Keep components clean during inspection, assembly, testing, and filling engines with clean fluids. Enhanced component life and reduced downtime associated with contaminants will result.
 - the shop
 - component and machine disassembly
 - parts
 - shop tools
 - test setups
 - test areas

- storage
 - waste collection
7. Follow contamination control practices for the workplace. Use properly designed and maintained bulk storage fluids tanks. Protect the fluids storage tanks from dirt and water entry. Keep the areas around the tanks filler necks clean of debris and water. Drain the storage tanks from water and sediments on an annual basis. Install and maintain a properly designed and grounded filtration system, continuous filtration, desiccant type breathers (4 micron(c) or less absolute) on the bulk storage tanks. Maintaining clean fill fluids saves time and effort and ensures that fill fluids are at the proper cleanliness levels.

Reference Information Section

Reference Materials

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Reference Material

SMCS Code: 1000; 7000

The following literature can be obtained through any Cat dealer.

Note: The information that is contained in the listed publications is subject to changes without notice.

Note: Refer to this Special Publication, the respective product datasheet and other special publications, and the appropriate Operation and Maintenance Manual for product application 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.

Coolants

- Special Publication, P MEP5027, “Label - Cat ELC Radiator Label”
- Datasheet, PEHJ0067, “Cat ELC (Extended Life Coolant)” (Worldwide)
- Datasheet, PEHP9554, “Cat DEAC (Diesel Engine Antifreeze/Coolant) (Concentrate)”

Diesel Engine Oil

- Datasheet, PEHJ0159, “Cat DEO-ULS (SAE 15W-40)” (North America - Canada, Mexico, and United States)
- Datasheet, PEHJ0059, “Cat DEO (SAE 10W-30 and SAE 15W-40)” (North America - Canada, Mexico, and United States)
- Datasheet, PEHJ0021, “Cat DEO (SAE 10W-30 and SAE 15W-40)” (Worldwide - except North America, Egypt, Saudi Arabia, and Brazil)
- Datasheet, PEHJ0072, “Cat DEO (SAE 10W-30 and SAE 15W-40)” (Brazil)
- Datasheet, PEHJ0091, “Cat DEO (SAE 10W-30 and SAE 15W-40)” (Egypt and Saudi Arabia)
- Datasheet, PEHP7062, “Cat DEO SYN (SAE 5W-40)”
- Datasheet, PEHJ0093, “Cat DEO (SAE 30 and SAE 40)” (For use in 3600 Series diesel engines, C280 Series diesel engines and in older precombustion chamber diesel engines. Do NOT use in 3500 Series, C175 Series and smaller direct injected diesel engines.)
- Datasheet, PEHP9516, “Cat SAEO (SAE30 and SAE40)” (For use in certain Cat 3116 and 3126 Marine Diesel Engines with mechanical fuel injection. Refer to this Special Publication, “Engine Oil (3116 and 3126 Marine Engines)” article. Do NOT use in other engine applications.)
- Datasheet, PEHJ0008, “Cat Arctic DEO (SAE 0W-30)” (Canada and United States)

Grease

- Special Publication, PEGJ0035, “Grease Selection Guide”
- Datasheet, PEHP0002, “Cat Advanced 3Moly Grease” (NLGI grade 2)
- Datasheet, NEHP6010, “Cat Ultra 5Moly Grease” (NLGI grades 1 and 2)
- Datasheet, NEHP6011, “Cat Arctic Platinum Grease” (NLGI grade 0)
- Datasheet, NEHP6012, “Cat Desert Gold Grease” (NLGI grade 2)
- Datasheet, NEHP6015, “Cat High Speed Ball Bearing Grease” (NLGI grade 2)

- Datasheet, PEHJ0088, “Cat Multipurpose Grease” (NLGI grade 2)

S·O·S Services

- Special Publication, PEHJ0191, “S·O·S Coolant Analysis”
- Special Publication, PEGJ0047, “How To Take A Good Oil Sample”
- Special Publications, PEDP7036, “S·O·S Fluids Analysis Cornerstone”
- Special Publications, PEHP7076, “Understanding S·O·S Services Tests”
- Special Publication, PEHP7052, “Making the Most of S·O·S Services”
- Special Publication, PEGJ0045, “Reporting Particle Count by ISO Code”
- Special Publication, PEGJ0046, “Understanding Your S·O·S Services Results”

Filters

- Datasheet, PEHP6028, “Cat Ultra High Efficiency Air Filters”
- Datasheet, PEHP7032, “Radial Seal Air Filters”
- Datasheet, PEHP7077, “Cat Turbine Pre-Cleaners”
- Datasheet, PEHP9013, “Air Filter Service Indicator”
- Datasheet, PEHJ0082, “Cat Fuel/Water Separators and Prime Time Priming Pumps”
- Datasheet, PEHP7046, “Fuel Contamination Control”
- Datasheet, PEHJ0068, “Cat Advanced Efficiency Engine Oil Filter”
- Datasheet, PEHJ0165, “Open Crankcase Ventilation Filter”

Miscellaneous

- Special Publication, PECP9067, “One Safe Source”
- Special Publication, AECQ1042, “Caterpillar Product Line Brochure”
- Special Publication, PEWJ0074, “Cat Filter and Fluid Application Guide”

- Datasheet, PEHJ0030, “Cat Synthetic GO (SAE 75W-140)”
- Datasheet, PEHP7058, “Cat GO (SAE 80W-90 and SAE 85W-140)”
- Special Publication, NENG2500, “Caterpillar Dealer Service Tool Catalog”
- Special Publication, GECJ0003, “Cat Shop Supplies and Tools” catalog
- Special Publication, SENR3130, “Torque Specifications”
- Special Publication, SENR9620, “Improving Fuel System Durability” (Package of 10)
- Special Publication, SEBF1018, “Improving Component Durability - Engines” (Package of 10)
- Special Publication, SEBF1020, “Improving Component Durability - Managing Fluid Cleanliness” (Package of 10)
- Special Publication, SEBD0349, “Caterpillar Performance Handbook”
- “ASTM D6469 Standard Guide for Microbial Contamination in Fuels and Fuel Systems”

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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: _____

