CATERPILLAR®

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Caterpillar Commercial Diesel Engine Fluids Recommendations

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

SAFETY.CAT.COM

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.

⚠ WARNING

The meaning of this safety alert symbol is as follows:

Attention! Become Alert! Your Safety is Involved.

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

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. 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 be made unsafe by the operation, lubrication, maintenance or repair procedures that you choose.

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. Caterpillar dealers have the most current information available.

⚠ WARNING

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

Table of Contents

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 use of this document you agree that Caterpillar Inc. is not responsible for errors or omissions.

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

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

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

NOTICE
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.

For questions concerning the information provided in this Special Publication, consult with your Caterpillar dealer.

For additional guidelines, recommendations, and requirements (including maintenance interval recommendations/requirements) refer to your product specific Operation and Maintenance Manual.

NOTICE
Commercial products that make generic claims of meeting "Cat" and/or "Caterpillar" requirements without listing the specific Cat recommendations and/or requirements that are met may not provide acceptable performance and 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 Caterpillar fluids recommendations and/or requirements.

NOTICE
It is the responsibility of the user of this Special Publication to read, understand, and 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 provided in this Special Publication and/or in your product Operation and Maintenance Manual, consult with your Caterpillar dealer.

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

NOTICE
In order to meet expected fuel system component life, 4 micron(c) absolute or less secondary fuel filtration is required for all 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 Caterpillar designed and produced filtration products, refer to the “Reference Material” article, “Filters” and “Miscellaneous” topics in this Special Publication, and then consult your Caterpillar dealer for assistance with filtration recommendations for your Caterpillar machine.

NOTICE
Faulty engine coolant temperature regulators, or operating with light loads, short operation cycles, excessive idling, or operating in applications where normal operating temperature is seldom reached can contribute to excessive water in the crankcase oil. Corrosive damage, piston deposits and increased oil consumption can result. If a complete oil analysis program is not followed or if the results are ignored, the potential for corrosive damage and piston deposits increases.

NOTICE
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., and are the fluid manufacturer and customer responsibility.

In order to help ensure the maximum expected compartment performance and life, severe duty applications require the use of higher performing fluids as described in this Special Publication, versus using fluids that meet the minimum performance levels that may be allowed for typical applications.

When fluids 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 manufacturer fluids, however, are not Caterpillar factory defects and therefore are NOT covered by the Caterpillar warranty. Caterpillar is not in a position to evaluate the many fluids 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.

Note: In order to help ensure the maximum expected compartment performance and life, it is required to use a fluid that meets Caterpillar highest level of fluid performance as described in this Special Publication for the compartment, rather than using a fluid that is considered an acceptable, but lower performing option for typical applications. (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
Not following the recommendations found in this Special Publication can lead to reduced performance and compartment failure.

Caterpillar Fluids

Caterpillar fluids have been approved by Caterpillar in order to increase the performance of Caterpillar components and the life of Caterpillar components. Caterpillar fluids that are currently used for engines and for machines are offered by Caterpillar dealers. Caterpillar fluids are also offered for service refills. Consult your Caterpillar dealer for more information on these Caterpillar fluids.

Caterpillar recommends the use of the following Caterpillar fluids:

- Cat DEO (Multigrade Diesel Engine Oil)
- Cat DEO-ULS (Multigrade Diesel Engine Oil - Ultra Low Sulfur)
- Cat DEO SYN (Synthetic Diesel Engine Oil SAE 5W-40)
- Cat Arctic DEO SYN (Synthetic Diesel Engine Oil SAE 0W-30)
- Cat Multipurpose Grease
- Cat Advanced 3Moly Grease
- Cat Ultra 5Moly Grease
- Cat Desert Gold Grease
- Cat Arctic Platinum Grease
- Cat High Speed Ball Bearing Grease
- Cat White Assembly Grease
- Cat ELC (Extended Life Coolant)
- Cat DEAC (Diesel Engine Antifreeze/Coolant)

Note: Caterpillar fluids availability will vary by region.

Note: Additional Caterpillar fluids are available for Cat machine applications.

This information is for Caterpillar commercial diesel engines. For more lubricant recommendations, see Special Publication, SEBU6250, “Caterpillar Machine Fluids Recommendations”, Special Publication, SEBU6400, “Caterpillar Gas Engine Fluids Recommendations”, Special Publication, SEBU6385, “Caterpillar On-Highway Diesel Engine Fluids Recommendations”, and Special Publication, SEBU7003, “Caterpillar 3600 Series and C280 Series Diesel Engine Fluids Recommendations”. Always check with your Caterpillar dealer in order to ensure that you have the current revision level of the publication.

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Engine Oil (Engine Crankcase Fluid Recommendations for all Caterpillar 3500 Series, C175 Series, and Smaller Direct Injection (DI) Engines)

SMCS Code: 1348; 7581

Exceptions to these recommendations are 3116 and 3126 Marine Engines with Mechanical Unit Injection (MUI).

Cat DEO (Diesel Engine Oil)

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

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

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

Note: 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 multigrade and Cat DEO-ULS 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 available in various viscosity grades that include SAE 10W-30 and SAE 15W-40. 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.

Note: Do not use single grade oils in Caterpillar 3500 Series, C175 Series, and smaller Direct Injection (DI) diesel engines.

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

In order to achieve expected ash service intervals, performance, and life, aftertreatment device equipped diesel engines require the use of Cat DEO-ULS or oils meeting the Cat ECF-3 specification and the API CJ-4 oil category. Oils that meet the Cat ECF-2 specification and that have a maximum sulfated ash level of 1% are also acceptable for use in most aftertreatment equipped engines. Use of oils with more than 1% total sulfated ash in aftertreatment device equipped engines will cause the need for more frequent ash service intervals, and/or cause loss of performance. Refer to your engine specific Operation and Maintenance Manual, and refer to your aftertreatment device documentation for additional guidance.

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

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

Note: 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, API CG-4, and API CF. The availability of Cat DEO multigrade exceeding the noted requirements will vary by region. Cat DEO SAE 15W-40 also passes additional proprietary tests that include the following tests: sticking of the piston ring, oil control tests, wear tests, and soot tests. Proprietary tests help ensure that Cat multigrade oil provides superior performance in Cat diesel engines. In addition, Cat multigrade oil exceeds many of the performance requirements of other manufacturers of diesel engines. Therefore, this oil is an excellent choice for many mixed fleets. **True high performance oil is produced by using a combination of the following factors: industry standard tests, proprietary tests, field tests, and prior experience with similar formulations. The design and the development of Caterpillar lubricants that are both high performance and high quality are based on these factors.**

Note: Cat DEO-ULS multigrade exceeds the requirements of the Cat ECF-1-a, Cat ECF-2, and Cat ECF-3 specifications. 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, API CG-4, and API CF. Cat DEO-ULS multigrade also passes additional proprietary tests that include the following tests: sticking of the piston ring, oil control tests, wear tests, and soot tests. Proprietary tests help ensure that Cat multigrade oil provides superior performance in Cat diesel engines. In addition, Cat multigrade oil exceeds many of the performance requirements of other manufacturers of diesel engines. Therefore this oil is an excellent choice for many mixed fleets. **True high performance oil is produced by using a combination of the following factors: industry standard tests, proprietary tests, field tests, and prior experience with similar formulations. The design and the development of Caterpillar lubricants that are both high performance and high quality are based on these factors.**

Commercial Oils

Engine Crankcase Fluid Recommendations for all Current and Noncurrent Caterpillar Diesel Engines that are Covered by this Special Publication

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

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

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

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

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

- When the recommended and preferred Cat diesel engine oils are not used, commercial oils that meet the requirements of the Cat ECF-1-a, Cat ECF-2, and/or the Cat ECF-3 specification are acceptable for use in Cat diesel engines that are covered by this Special Publication. API category oils that have not met the requirements of at least one Cat ECF specification may cause reduced engine life. Note that in order to achieve the maximum expected engine performance and life, some engines/engine applications will require the use of higher performance oils such as those meeting Cat ECF-3 versus meeting Cat ECF-2 or Cat ECF-1-a.
- When the recommended and preferred Cat diesel engine oils are not used, commercial oils that meet the requirements of the Cat ECF-3 specification are acceptable for use in Cat diesel engines that are covered by this Special Publication. After Cat DEO-ULS and Cat DEO, commercial oils that meet the Cat ECF-3 specification are preferred oils, when compared to commercial diesel engine oils that do not meet the Cat ECF-3 specification for use in Cat diesel engines that are covered by this Special Publication. Note that in order to achieve the maximum expected engine performance and life, some engines/engine applications will require the use of higher performance oils such as those meeting Cat ECF-3 versus meeting Cat ECF-2 or Cat ECF-1-a.

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

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

In order to achieve expected ash service intervals, performance, and life, aftertreatment device equipped diesel engines require the use of Cat DEO-ULS or oils meeting the Cat ECF-3 specification and the API CJ-4 oil category. Oils that meet the Cat ECF-2 specification and that have a maximum sulfated ash level of 1% are also acceptable for use in most aftertreatment equipped engines. Use of oils with more than 1% total sulfated ash in aftertreatment device equipped engines will cause the need for more frequent ash service intervals, and/or cause loss of performance. Refer to your engine specific Operation and Maintenance Manual, and refer to your aftertreatment device documentation for additional guidance.

Severe Applications Require the Use of Higher Performing Diesel Engine Oils

In order to help ensure the maximum expected compartment performance and life, severe duty applications such as those operating at greater than 75% load factor, operating in high humidity, operating with fuel sulfur levels that are above 0.1% (1000 ppm), etc., require the use of higher performing fluids as described in this Special Publication, versus using fluids that meet the minimum performance levels that may be allowed for typical applications. (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.)

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.

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

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

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

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

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

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

Note: The following information concerning oil life relative to used oil TBN level is provided for general information only, and is not the recommended method for determining oil life. **If the one half of new oil TBN guideline that is stated below is used for determining oil life it must only be used in conjunction with a complete S·O·S Services oil analysis program.**

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

The minimum required Total Base Number (TBN) for oil depends on the fuel sulfur level. For direct injection engines that use distillate fuel, the minimum new oil TBN must be 10 times the fuel sulfur level. The TBN for new oil is typically determined by the “ASTM D2896”procedure.

Note: The minimum TBN of the new oil is 7 regardless of the fuel sulfur level. Reaching one half of new oil TBN is one of the condemning factors for diesel engine oil, but, 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. For best results when determining oil life using the one half new oil TBN method, determine the new and used oil TBN using both the “ASTM D2896” and the “ASTM D4739” test methods. Change the oil when reaching one half of new oil TBN with either respective TBN test method using the results from which ever respective test method shows reaching one half of new oil TBN first.

For example, new oil with a TBN of 10 by “ASTM D2896” should be changed when, during use, the TBN deteriorates to 5 as determined by the “ASTM D2896” test method, and new oil with a TBN of 10 by “ASTM D4739” should be changed when, during use, the TBN deteriorates to 5 as determined by the “ASTM D4739” test method. Use the results from which ever respective test method reaches one half of new oil TBN first.

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 were normal operating temperature is seldom reached
- High humidity (allowing excessive condensation)

Note that 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 this and other acids that are formed contribute to rapid TBN depletion.

NOTICE

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

Note: For PC (Precombustion Chamber) diesel engines, which are mainly 1990 and older engines, the minimum new oil TBN must be 20 times the fuel sulfur level. The diesel engine oil types, specifications, and viscosity grades recommendations provided for DI diesel engines in this Special Publication are also applicable to PC diesel engines. For additional fluids information related to PC diesel engines, refer to this Special Publication, “Engine Oil for Precombustion Chamber (PC) Diesel Engines (Engine Crankcase Fluid Recommendations for All Series 3500 Series and Smaller PC Diesel Engines)” article.

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 in conjunction 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 Caterpillar dealers 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 with your Caterpillar 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 Manuals are for typical applications:

- Using recommended oils
- Using good fuel
- 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 with your Caterpillar dealer regarding the testing that is required in establishing oil drain intervals that are optimized for your application.

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

- 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 Caterpillar dealer for guidance when fuel sulfur levels are above 0.1% (1000 ppm).

Lubricant Viscosity Recommendations for Direct Injection (DI) Diesel Engines

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

Refer to Table 1 (minimum temperature) in order to determine the required oil viscosity for starting a cold engine.

Refer to Table 1 (maximum temperature) in order to select the oil viscosity for engine operation at the highest ambient temperature that is anticipated.

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

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

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

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

Refer to table 1 and associated footnotes for guidance on selecting the proper oil viscosity grade for various ambient temperatures.

Note: C175 Series diesel engines require the use of **multigrade** SAE 40 oil. IE: 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 1 and associated footnotes for guidance on selecting the proper oil viscosity grade for various ambient temperatures.

Table 1

Lubricant Viscosities for Ambient Temperatures for DI Diesel Engines[1][2][3][4]		
	Ambient Temperature	
Viscosity Grade	Minimum	Maximum
SAE 0W-30	−40 °C (−40 °F)	30 °C (86 °F)
SAE 0W-40	−40 °C (−40 °F)	40 °C (104 °F)
SAE 5W-30	−30 °C (−22 °F)	30 °C (86 °F)
SAE 5W-40	−30 °C (−22 °F)	50 °C (122 °F)
SAE 10W-30	−18 °C (0 °F)	40 °C (104 °F)
SAE 10W-40	−18 °C (0 °F)	50 °C (122 °F)
SAE 15W-40	−9.5 °C (15 °F)	50 °C (122 °F)

(1) Refer to this Special Publication, “Engine Oil” article in this section for recommendations of diesel engine oil type.

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

(3) SAE10W-30 is the preferred viscosity grade for the 3116, 3126, C7, C-9 and C9 diesel engines when the ambient temperature is between −18 °C (0 °F) and 40 °C (104 °F).

(4) C175 Series diesel engines require the use of **multigrade** SAE 40 oil. IE: 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.

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

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

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Lubricant Viscosities

SMCS Code: 1000; 7000; 7581

Selecting the Viscosity

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

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

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

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

NOTICE
Proper oil viscosity **AND** oil type (category/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, and to the "Lubricant Specifications" in this publication.

NOTICE
The footnotes are an integral part of the "Lubricant Viscosities for Ambient Temperatures" tables - read ALL footnotes!

NOTICE
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 publication include footnotes that address compartment warm-up.

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

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

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

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

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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 type, refer to the applicable “Engine Oil” article in this Special Publication.

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

NOTICE
Not following the recommendations found in the “Lubricant Viscosities for Ambient Temperatures” 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 (specification) 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 should be properly sized for the application.

A variety of 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 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. This will cause the oil to thicken. Kerosene will cause swelling and softening of the silicone seals. Kerosene will dilute the oil's additives. Dilution of the oil's additives will reduce the oil's 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 a synthetic base stock multigrade oil. The oil should have a lubricant viscosity grade of SAE 0W or SAE 5W. Use an oil with a pour point that is lower than −40°C (−40°F).

Note: Use the highest oil viscosity grade that is allowed for the ambient temperature when you start the engine. If a different oil viscosity grade is specified in the table for “Lubricant Viscosities for Ambient Temperatures”, use the viscosity grade that is specified in the table. **In arctic applications, the preferred method of lubrication is to use an engine compartment heater that is properly sized and to use oil that is a higher viscosity grade.** 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 period of time, allowing the oil to 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 when you start the engine - **BUT,** under **Continuous Usage (Multiple Shifts/Day),** and/or when using **fluid or pan heaters**, etc., use a higher viscosity oil, **NOT** the oil with the 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 Caterpillar diesel engines for cold-soaked starts at −40 °C (−40 °F) is multigrade oil of the SAE 0W viscosity grade (SAE 0W-30, etc.). If the diesel engine is run continuously, SAE 15W-40 viscosity grade diesel engine oil can be used - and is generally the preferred oil viscosity in this situation.

NOTICE

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

NOTICE

Recommended engine warm-up procedure must be followed. Refer to the Operation and Maintenance Manual.

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Engine Oil (3116 and 3126 Marine Engines)

SMCS Code: 1348; 7581

Recommendations

Caterpillar 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 in the oil vapor 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: Caterpillar recommends the use of single grade oils that pass all API CF-4 category requirements for all 3116 and 3126 MUI Marine Engines unless crankcase blowby has been routed completely away from the air cleaner inlet.

Cat SAEO (Special Application Engine Oil)

Note: Cat SAEO is for use in Caterpillar 3116 and 3126 Marine Diesel Engines with mechanical unit injection. This includes all 3116 and 3126 Marine Diesel Engines that begin with the following serial number prefixes: (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 in 3116 and 3126 Marine Engines is Cat SAEO. The oil that is used for the factory fill has the following properties:

- API CF-4 category
- Viscosity grade of SAE 30

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

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

Commercial Oils (3116 and 3126 Marine Engines)

NOTICE

Caterpillar does not warrant the quality or performance of non-Caterpillar 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 pass all API CF-4 category requirements is preferred.

- Single grade oil with a viscosity of SAE 30 or SAE 40 with an API CF-4 or API CG-4 additive package that does NOT contain viscosity improvers is acceptable oil.

For an acceptable commercial single grade oil, contact your oil supplier or Caterpillar Customer Service:

1-800-447-4986

The following explanation of the API CF-4 category can be used to make the proper choice when commercial single grade oil with API CF-4 category is chosen.

API CF-4 – API CF-4 oils provide more stable oil control and reduced piston deposits in comparison to API CF and the obsolete CE and CD categories of oil. API CF-4 oils provide improved soot dispersancy in comparison to API CF and obsolete CD oils. The API CF-4 category was developed with a 0.40 percent sulfur diesel fuel.

Some commercial oils that meet the API CF-4 categories 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. Caterpillar's 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 use of Cat S·O·S Services oil analysis is strongly recommended for determining oil life.

Note: The following information concerning oil life relative to used oil TBN level is provided for general information only, and is not the recommended method for determining oil life. **If the one half of new oil TBN guideline that is stated below is used for determining oil life it must only be used in conjunction with a complete S·O·S Services oil analysis program.**

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

The minimum required Total Base Number (TBN) for oil depends on the fuel sulfur level. For direct injection engines that use distillate fuel, the minimum new oil TBN must be 10 times the fuel sulfur level. The TBN for new oil is typically determined by the “ASTM D2896” procedure.

Note: The minimum TBN of the new oil is 6.5 regardless of the fuel sulfur level. Reaching one half of new oil TBN is one of the condemning factors for diesel engine oil but, 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. For best results when determining oil life using the one half new oil TBN method, determine the new and used oil TBN using both the “ASTM D2896” and the “ASTM D4739” test methods. Change the oil when reaching one half of new oil TBN with either respective TBN test method using the results from which ever respective test method shows reaching one half of new oil TBN first.

For example, new oil with a TBN of 10 by “ASTM D2896” should be changed when, during use, the TBN deteriorates to 5 as determined by the “ASTM D2896” test method, and new oil with a TBN of 10 by “ASTM D4739” should be changed when, during use, the TBN deteriorates to 5 as determined by the “ASTM D4739” test method. Use the results from which ever respective test method reaches one half of new oil TBN first.

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.

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.

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

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

- 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 Caterpillar dealer for guidance when fuel sulfur levels are above 0.1% (1000 ppm).

Lubricant Viscosity Recommendations (3116 and 3126 Marine Engines)

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

Refer to Table 2 (minimum temperature) in order to determine the required oil viscosity for starting a cold engine.

Refer to Table 2 (maximum temperature) in order to select the oil viscosity for engine operation at the highest ambient temperature that is anticipated.

Generally, use the highest oil viscosity that is allowed for the ambient temperature at start-up.

Table 2

Lubricant Viscosities for Ambient Temperatures[1]		
Cat SAEO Viscosity Grade	Ambient Temperature	
	Minimum	Maximum
SAE 30	0 °C (32 °F)	40 °C (104 °F)
SAE 40	5 °C (41 °F)	50 °C (122 °F)

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

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Engine Oil for Precombustion Chamber (PC) Diesel Engines (Engine Crankcase Fluid Recommendations for All 3500 Series and Smaller PC Diesel Engines)

SMCS Code: 1348; 7581

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

Cat DEO (Diesel Engine Oil)

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

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

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

NOTICE
Do not use single grade API CF oils or multigrade API CF oils in Caterpillar 3500 Series, C175 Series and smaller Direct Injection (DI) diesel engines.

API CF oils are only recommended for Caterpillar 3600 Series and C280 Series diesel engines, and Caterpillar engines that have precombustion chamber (PC) fuel systems. Oils that are used in Caterpillar 3600 Series and C280 Series diesel engines must also pass a 7000 hour field performance evaluation. Contact your Caterpillar dealer for details.

Note: 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.

Note: Do not use single grade oils in Caterpillar Series 3500 series, Series C175 series, and smaller Direct Injection (DI) diesel engines.

Cat DEO multigrade and Cat DEO-ULS 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 available in various viscosity grades that include SAE 10W-30 and SAE 15W-40. 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.

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

In order to achieve expected ash service intervals, performance, and life, aftertreatment device equipped diesel engines require the use of Cat DEO-ULS or oils meeting the Cat ECF-3 specification and the API CJ-4 oil category. Oils that meet the Cat ECF-2 specification and that have a maximum sulfated ash level of 1% are also acceptable for use in most aftertreatment equipped engines. Use of oils with more than 1% total sulfated ash in aftertreatment device equipped engines will cause the need for more frequent ash service intervals, and/or cause loss of performance. Refer to your engine specific Operation and Maintenance Manual, and refer to your aftertreatment device documentation for additional guidance.

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

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

Note: 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, API CG-4, and API CF. The availability of Cat DEO multigrade exceeding the noted requirements will vary by region. Cat DEO SAE 15W-40 also passes additional proprietary tests that include the following tests: sticking of the piston ring, oil control tests, wear tests, and soot tests. Proprietary tests help ensure that Cat multigrade oil provides superior performance in Cat diesel engines. In addition, Cat multigrade oil exceeds many of the performance requirements of other manufacturers of diesel engines. Therefore, this oil is an excellent choice for many mixed fleets. **True high performance oil is produced by using a combination of the following factors: industry standard tests, proprietary tests, field tests, and prior experience with similar formulations. The design and the development of Caterpillar lubricants that are both high performance and high quality are based on these factors.**

Note: Cat DEO-ULS multigrade exceeds the requirements of the Cat ECF-1-a, Cat ECF-2, and Cat ECF-3 specifications. 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, API CG-4, and API CF. Cat DEO-ULS multigrade also passes additional proprietary tests that include the following tests: sticking of the piston ring, oil control tests, wear tests, and soot tests. Proprietary tests help ensure that Cat multigrade oil provides superior performance in Cat diesel engines. In addition, Cat multigrade oil exceeds many of the performance requirements of other manufacturers of diesel engines. Therefore this oil is an excellent choice for many mixed fleets. **True high performance oil is produced by using a combination of the following factors: industry standard tests, proprietary tests, field tests, and prior experience with similar formulations. The design and the development of Caterpillar lubricants that are both high performance and high quality are based on these factors.**

Commercial Oils

Engine Crankcase Fluid Recommendations for all Current and Noncurrent Caterpillar Diesel Engines that are Covered by this Special Publication

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

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

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

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

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

- When the recommended and preferred Cat diesel engine oils are not used, commercial oils that meet the requirements of the Cat ECF-1-a, Cat ECF-2, and/or the Cat ECF-3 specification are acceptable for use in Cat diesel engines that are covered by this Special Publication. API category oils that have not met the requirements of at least one Cat ECF specification may cause reduced engine life. Note that in order to achieve the maximum expected engine performance and life, some engines/engine applications will require the use of higher performance oils such as those meeting Cat ECF-3 versus meeting Cat ECF-2 or Cat ECF-1-a.
- When the recommended and preferred Cat diesel engine oils are not used, commercial oils that meet the requirements of the Cat ECF-3 specification are acceptable for use in Cat diesel engines that are covered by this Special Publication. After Cat DEO-ULS and Cat DEO, commercial oils that meet the Cat ECF-3 specification are preferred oils when compared to commercial diesel engine oils that do not meet the Cat ECF-3 specification for use in Cat diesel engines that are covered by this Special Publication. Note that in order to achieve the maximum expected engine performance and life, some engines/engine applications will require the use of higher performance oils such as those meeting Cat ECF-3 versus meeting Cat ECF-2 or Cat ECF-1-a.

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

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

In order to achieve expected ash service intervals, performance, and life, aftertreatment device equipped diesel engines require the use of Cat DEO-ULS or oils meeting the Cat ECF-3 specification and the API CJ-4 oil category. Oils that meet the Cat ECF-2 specification and that have a maximum sulfated ash level of 1% are also acceptable for use in most aftertreatment equipped engines. Use of oils with more than 1% total sulfated ash in aftertreatment device equipped engines will cause the need for more frequent ash service intervals, and/or cause loss of performance. Refer to your engine specific Operation and Maintenance Manual, and refer to your aftertreatment device documentation for additional guidance.

Severe Applications Require the Use of Higher Performing Diesel Engine Oils

In order to help ensure the maximum expected compartment performance and life, severe duty applications such as those operating at greater than 75% load factor, operating in high humidity, operating with fuel sulfur levels that are above 0.1% (1000 ppm), etc., require the use of higher performing fluids as described in this Special Publication, versus using fluids that meet the minimum performance levels that may be allowed for typical applications. (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.)

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.

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

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

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

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 Precombustion Chamber (PC) Diesel Engines

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

Note: The following information concerning oil life relative to used oil TBN level is provided for general information only, and is not the recommended method for determining oil life. **If the one half of new oil TBN guideline that is stated below is used for determining oil life it must only be used in conjunction with a complete S·O·S Services oil analysis program.**

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

Note: Oils that have not met the requirements of at least one Cat ECF specification may cause reduced engine life.

Note: While API CF category single grade and multigrade oils may be acceptable for use in PC diesel engines, API CF oils and single grade oils are not acceptable for use in Caterpillar DI engines. Excessive piston deposits will occur when oils that meet only the API CF oil category are used in Caterpillar 3500 Series, C175 Series and smaller DI diesel engines.

The minimum required Total Base Number (TBN) for oil depends on the fuel sulfur level. For direct injection engines that use distillate fuel, the minimum new oil TBN must be 20 times the fuel sulfur level. The TBN for new oil is typically determined by the “ASTM D2896” procedure.

Note: The minimum TBN of the new oil is 7 regardless of the fuel sulfur level. Reaching one half of new oil TBN is one of the condemning factors for diesel engine oil but, 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. For best results when determining oil life using the one half new oil TBN method, determine the new and used oil TBN using both the “ASTM D2896” and the “ASTM D4739” test methods. Change the oil when reaching one half of new oil TBN with either respective TBN test method using the results from which ever respective test method shows reaching one half of new oil TBN first.

For example, new oil with a TBN of 10 by “ASTM D2896” should be changed when, during use, the TBN deteriorates to 5 as determined by the “ASTM D2896” test method, and new oil with a TBN of 10 by “ASTM D4739” should be changed when, during use, the TBN deteriorates to 5 as determined by the “ASTM D4739” test method. Use the results from which ever respective test method reaches one half of new oil TBN first.

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.

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

Note: For PC (Precombustion Chamber) diesel engines, which are mainly 1990 and older engines, the minimum new oil TBN must be 20 times the fuel sulfur level. The diesel engine oil types, specifications, and viscosity grades recommendations provided for DI diesel engines in this Special Publication are also applicable to PC diesel engines.

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

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

- 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 Caterpillar dealer for guidance when fuel sulfur levels are above 0.1% (1000 ppm).

Lubricant Viscosity Recommendations for Precombustion Chamber (PC) Diesel Engines

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

Refer to Table 3 (minimum temperature) in order to determine the required oil viscosity for starting a cold engine.

Refer to Table 3 (maximum temperature) in order to select the oil viscosity for engine operation at the highest ambient temperature that is anticipated.

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

Note: Table 3 is only for PC diesel engines.

Table 3

Lubricant Viscosities for Ambient Temperatures for PC Diesel Engines[1][2]

	Ambient Temperature	
Viscosity Grade	Minimum	Maximum
SAE 0W-30	−40 °C (−40 °F)	30 °C (86 °F)
SAE 0W-40	−40 °C (−40 °F)	40 °C (104 °F)
SAE 5W-30	−30 °C (−22 °F)	30 °C (86 °F)
SAE 5W-40	−30 °C (−22 °F)	50 °C (122 °F)
SAE 10W-30	−18 °C (0 °F)	40 °C (104 °F)
SAE 10W-40	−18 °C (0 °F)	50 °C (122 °F)
SAE 15W-40	−9.5 °C (15 °F)	50 °C (122 °F)
SAE 30[4]	0 °C (32 °F)	40 °C (104 °F)
SAE 40[4]	5 °C (41 °F)	50 °C (122 °F)

(1) Refer to this publication, “Engine Oil for Precombustion Chamber (PC) Diesel Engines” article for recommendations of diesel engine oil type.
(2) Supplemental heat is recommended for cold-soaked starts below the minimum ambient temperature. Supplemental heat may be required for cold-soaked starts that are above the minimum temperature that is stated, depending on the parasitic load and other factors. Cold-soaked starts occur when the engine has not been operated for a period of time, allowing the oil to become more viscous due to cooler ambient temperatures.
(4) PC engines only

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

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

i02434366

Marine Transmission Oil

SMCS Code: 3080; 3300; 7581

Cat TDTO (Transmission/Drive Train Oil) is balanced in order to give maximum frictional material service life and performance in Caterpillar transmissions. Cat TDTO exceeds the requirements for the Caterpillar 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 maximum transmission service life and performance, Caterpillar recommends Cat TDTO.

Table 4

Cat TDTO Lubricant Viscosities For Operating Temperatures			
Cooling of Transmission	**Oil Viscosities**	**Minimum Temperature**	**Maximum Temperature**
Raw/Sea water	SAE 30	−15 °C (5 °F)	80 °C (176 °F)
	SAE 50	−5 °C (23 °F)	95 °C (203 °F)
Jacket Water	SAE 50	−5 °C (23 °F)	95 °C (203 °F)

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

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

NOTICE
Cat GO (Gear Oil) is not the same as Cat TDTO, and does not meet Caterpillar's specifications for TO-4 oil. Cat GO or commercial gear oils should not be used in compartments which specify TO-4 oil.

Caterpillar Transmission/Drive Train Oils

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

Commercial Marine Transmissions

For marine transmissions which are not manufactured by Caterpillar, refer to the lubrication recommendation of the Original Equipment Manufacturer (OEM) for the marine transmission or the vessel.

i03002053

Synthetic Base Stock Oils

SMCS Code: 1300; 1348; 7581

Synthetic base oils are acceptable for use in Caterpillar engines **if these oils meet the performance requirements that are specified by Caterpillar 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, Caterpillar does not recommend the automatic extension of oil drain intervals for any type of oil, whether synthetic or non-synthetic.

Oil drain intervals for Caterpillar 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 (Caterpillar S·O·S Services oil analysis)
- Trend analysis
- Fuel consumption
- Oil consumption

Refer to the “Extended Engine Oil Drains and Warranty” article in the Foreword of this Special Publication.

i03304768

Re-refined Basestock Oils

SMCS Code: 1300; 1348; 7581

Re-refined basestock oils are acceptable for use in Caterpillar engines **IF these oils meet the performance requirements that are specified by Caterpillar.**

Re-refined 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 re-refined basestock oils that meet the same criteria.

The process that is used to make re-refined basestock oil should adequately remove all wear metals that are in the used oil 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 re-refined base oil.

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

i03451083

Aftermarket Oil Additives

SMCS Code: 1300; 1348; 7581

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

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

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

- Select the proper Caterpillar 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”.

i03002059

Lubricating Grease

SMCS Code: 0645; 1000; 7000; 7581

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

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

Before selecting a grease product, the performance requirements must be determined. Consult the grease recommendations that are made by the OEM for the equipment. Then, consult with your Caterpillar 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 it is necessary to choose a single grease to use for all of the equipment at one site, always choose 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 barely produce the minimum parts life. False economy is being used if grease is purchased with the lowest cost as the only consideration. Instead, use the grease that yields the lowest total operating cost. This cost should be based on an analysis that includes the costs of parts, labor, downtime, and the cost of the amount of grease that is required.

NOTICE
Do NOT mix brands and/or types of grease.

Different brands and/or types of grease may not be chemically compatible.

When switching grease brands and/or grease types, it is strongly recommended that the old grease be purged. If in doubt, Purge!

Even when grease brands and/or types are chemically compatible, mixing greases can affect characteristics such as penetration, water washout resistance, etc., with a potential negative affect on grease performance.

To help ensure expected grease performance, it is strongly recommended that grease brands and/or types NOT be mixed.

When switching brands and/or types of grease, it is strongly recommended to purge as much of the old grease as possible from the compartment or system, and to reduce the greasing interval for a short period thereafter.

Note: While all Cat brand greases (except Cat "High Speed Ball Bearing Grease") are chemically compatible, they are formulated with different levels of performance and mixing them can affect the expected grease performance.

Cat Multipurpose Grease

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

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

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

Cat White Assembly Grease

Cat 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 of engines and other components.

Cat Advanced 3Moly Grease

Cat Advanced 3Moly Grease is NLGI grade 2 grease. This grease is made with petroleum base oil and a lithium complex thickener. This grease also has three percent 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 in order to meet the special requirements of some rolling element bearings.

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

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

Severe Applications

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

Cat Ultra 5Moly Grease

Cat Ultra 5Moly Greases are available in NLGI grades 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 five percent Molybdenum disulfide (MoS_2 or "Moly") and an added tackifier. Cat Ultra 5Moly Greases are specially formulated in order to protect all of the most heavily loaded points in any Caterpillar application where grease is required 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 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 will be adequately lubricated even if the ambient temperature drops unexpectedly.

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

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

Cat Ultra 5Moly Greases also have five percent Moly, instead of the zero to three percent 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). In addition, the Moly in Cat Ultra 5Moly Grease is a special grade that has a median particle size of 3 microns in order to meet the special requirements of some rolling element bearings.

Cat Ultra 5Moly Greases are also made to be extra tacky. In some applications, the film of grease must adhere to the vertical surfaces. Many conventional types of grease 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 adequately protect the gear teeth in these applications.

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

Note: If the application calls for Cat Ultra 5Moly Grease and Cat Ultra 5Moly Grease is not available, consult the datasheets for the grease. From these datasheets, 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 Caterpillar machines against galling, wear, and corrosion. This protection is sustained while work is being done at moderate temperatures to very hot temperatures with wet conditions or dry conditions.

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

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

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

Cat Desert Gold Grease has five percent molybdenum instead of the zero to three percent 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 in order to be extra tacky. In some applications, the film of grease must adhere to the vertical surfaces. Many conventional type of grease do not have enough of the tackifier in order 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 adequately protect the gear teeth in these applications.

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

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

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

Note: If the application calls for Cat Desert Gold Grease and Cat Desert Gold Grease is not available, consult the datasheets for the grease. From these datasheets, 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 Grease

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

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

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

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

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

Cat Arctic Platinum Grease has five percent of molybdenum instead of zero to three percent 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 in order to be extra tacky. In some applications, the film of grease must adhere to the vertical surfaces. Many conventional greases do not have enough tackifier in order to adhere well to the vertical surfaces. This ability is necessary in order to adequately protect the gear teeth in these applications.

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

Cat Arctic Platinum Grease is sometimes used in applications that require the lubricant to last for very long periods of time. This is due to the fact that this grease has an extremely high performance and this grease 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 NLGI grade 2 grease. This grease is made with 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.

Cat High Speed Ball Bearing Grease is formulated not to contain lead, antimony, barium, zinc, phosphorous or chlorine additives. Thus, when Cat High Speed Ball Bearing Grease is compared to many other types of grease, the Cat High Speed Ball Bearing Grease is more environmentally friendly.

Illustration 1

Grease Application Chart

Caterpillar Grease Name	NLGI Grade	[1]Low Temp. Pumpability	[2]Severe Applications	[2]Severe Applications	[2]Severe Applications	[2]Severe Applications with Extremely Heavy Loads	[2]Severe Applications	[3]Extreme Pressure (EP)	[4]Service Life	[5]Environnmentally Friendly	[6]Corrosion Protection	[7]Water Washout Resistance
Recommended Operating Conditions		[In Centralized (Auto-Lube) Systems]	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)	(Shear Stability)			
Optimum Temperature Range			-50ºC (-58°F) to -18ºC (0°F)	-23ºC (-10°F) to +29ºC (+85°F)	+18ºC (+65°F) to +60ºC (+140°F)	+18ºC (+65°F) to +41ºC (+105°F)	+38ºC (+100°F) to +232ºC (+450°F)					
Desert Gold	2	above +35°F	N/R	Excellent	Excellent	Excellent	Very Good	Excellent	Excellent	Yes	Excellent	Excellent
Ultra 5Moly	2	above +20°F	N/R	Excellent	Excellent	Very Good	Good	Excellent	Excellent	Yes	Excellent	Excellent
Ultra 5Moly	1	above 0°F	Good	Excellent	Good	Good	Fair	Excellent	Excellent	Yes	Excellent	Excellent
Arctic Platinum 0	0	above -45°F	Excellent	Very Good	N/R	N/R	N/R	Excellent	Excellent	Yes	Excellent	Excellent
Advanced 3Moly	2	above 0°F	N/R	Fair	Good	Good	N/R	Very Good	Good	No	Fair	Fair
Multipurpose Grease	2	above -10°F	N/R	N/R	N/R	N/R	N/R	Fair	Good	No	Fair	Fair
High Speed Ball Bearing Grease	2	above 0ºF	N/R	N/R	N/R	N/R	N/R	N/R	Very Good	No	Good	Good

[1] Based on USS Mobility and Lincoln Ventmeter Tests, Performance may vary depending on lubrication equipment and length of lines

[2] Severe Applications are those with: very heavy loads, frequent oscillations,and heavy shock loads.

[3] Extreme pressure (EP), refer to 4-Ball Weld point in technical data sheet (ASTM D 2596)

[4] Service Life, refer to % change after 100,000 strokes in technical data sheet (ASTM D 217)

[5] Is not formulated to contain: Lead, Antimony, Barium, Zinc, Phosphorous, or Chlorine additives.

[6] Resistance to Salt water and Salt Spray (ASTM B 117)

[7] Water Washout Resistance, refer to Roll Stability with Water, % Change (ASTM D 1264)

[8] depending on the application

N/R = Not Recommended

Note: For additional performance data on these greases refer to this Special Publication, "Reference Material" article.

Note: Cat Ultra 5Moly grease is also available in NLGI grade 0 for use in autolube systems that are used in moderate to cold ambient temperatures.

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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 prior notice. Consult your local Caterpillar dealer for the most up to date recommendations.

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

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

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

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

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

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

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

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

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

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

Table 5

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

Obtaining S·O·S Oil Samples

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

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

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

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

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

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

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

Oil Sampling Interval

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

Table 6

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 Caterpillar 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 Caterpillar 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, please consult your Caterpillar dealer.

Optimizing the Component Life Cycle

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

Fuel Specifications

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General Fuel Information

SMCS Code: 1250; 1280

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

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

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

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

NOTICE
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.

For questions concerning the information provided in this Special Publication, consult with your Caterpillar dealer.

For additional guidelines, recommendations, and requirements (including maintenance interval recommendations/requirements) refer to your product specific Operation and Maintenance Manual.

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

For questions concerning the information provided in this Special Publication and/or in your product Operation and Maintenance Manual, consult with your Caterpillar 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 and/or Caterpillar requirements without listing the specific Cat recommendations and/or requirements that are met may not provide acceptable performance and may cause reduced engine and/or machine fluid compartment life. Refer to this Special Publication and refer to product specific Operation and Maintenance Manuals for Caterpillar fluids recommendations and/or requirements.

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

NOTICE
In order to meet expected fuel system component life, 4 micron(c) absolute or less secondary fuel filtration is required for all 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 Caterpillar designed and produced filtration products, refer to the "Reference Material" article, "Filters" and "Miscellaneous" topics in this Special Publication, and then consult your Caterpillar dealer for assistance with filtration recommendations for your Caterpillar diesel engine.

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.

- Discuss application specific fuel concerns, needs, and requirements with a reputable fuel supplier.
- Purchase fuel from a reputable supplier.
- Use fuel that meets or exceeds Caterpillar requirements for distillate diesel fuel. Refer to the "Caterpillar Specification for Distillate Diesel Fuel for Off-Highway Diesel Engines" table in this Special Publication, "Distillate Diesel Fuel" article.
- Use a properly designed and maintained bulk storage fuel tank.
- Confirm with the filter manufacturer that the fuel filter/filters to be used are compatible with the fuel type that will be filtered.
- Filter the fuel coming into the bulk storage fuel tank to 20 microns(c) absolute or less.
- 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.
- Install and properly 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.
- Every 3 months, or sooner if problems are suspected, have a complete analysis of the bulk storage fuel per the "Caterpillar Specification for Distillate Diesel Fuel for Off-Highway Diesel Engines" table in this Special Publication, "Distillate Diesel Fuel" article. Take corrective action if necessary. Corrective actions may include, but are not limited to, treating the fuel, cleaning of the fuel storage tank/system, and replacing the problematic fuel with fresh fuel.
- Keep the fuel storage tank clean of water, debris and sediment.
- Drain water and sediment from the fuel storage tank weekly. Drain water and sediment before the tank is refilled.
- Keep the area around the fuel tank filler neck clean of debris in order to prevent contamination of the fuel tank.
- As required, clean the inside of the engine fuel tank and the inside of the bulk storage fuel tank.

- Drain water and sediment from the engine fuel tank daily. Drain water and sediment from the tank at the start of each shift. After the fuel tank has been filled, allow the fuel to settle for ten minutes. This will allow the water and sediment to separate from the fuel. Then, drain the water and sediment from the tank.
- Install fuel/water separators at the bulk storage fuel tank dispensing point and install fuel/water separators on the engine. Wire mesh media is NOT recommended.
- Drain the water from the fuel/water separators daily.
- Caterpillar Advanced Efficiency fuel filters are required for distillate fueled diesel engines in order to provide maximum life to the fuel system.
- Change fuel filters at the scheduled interval. Never fill the new secondary fuel filter with fuel before installation. Use the fuel priming pump to remove air from the system.
- Install and properly maintain four micron(c) absolute breather filters on the engine fuel tank vent, and install and properly maintain four micron(c) absolute breather filters on the bulk storage fuel tank vent. Desiccant type breather vent filters are also recommended in order to remove moisture from air entering the fuel tank. Breather filters are typically changed every six months, and desiccant type breather filters are typically changed on saturation. Refer to the literature that was included with the filter. Discuss the availability of desiccant breather vent filters for your application with your filter supplier.
- Top off fixed roof fuel tanks as often as practical in order to reduce tank breathing and in order to reduce the amount of condensation generated water.
- Protect fuel tanks from dirt and water entry.

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

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

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

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

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Fuel Information for Diesel Engines

SMCS Code: 1250; 1280

NOTICE

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 with your Caterpillar dealer.

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

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

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

Starting Aids

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

Engine Coolant Heaters

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

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

Fuel Heaters

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

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

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

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

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

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

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

⚠ WARNING

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

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

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

De-Icers

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

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Characteristics of Diesel Fuel

SMCS Code: 1250; 1280

NOTICE
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 with your Caterpillar dealer.

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, and also refer to the “Characteristics of Diesel Fuel” article, “Diesel Fuel Sulfur” and other related topics 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 the “Biodiesel” topic in this Special Publication for guidance when biodiesel will be used.

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

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

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. 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 fuel lubricity is important. You should consider the fuel 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. Consult with your fuel supplier to make sure that the supplied fuel meets Caterpillar minimum requirements.

There are many aftermarket additives that are available to treat fuel. If the fuel 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.

Fluid 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 lubricity was generally believed to be a function of fuel viscosity.

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

The hydro-treatment removes the 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 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 supplier. Some aftermarket additives may not be compatible with the additives that are already in the fuel, and some may damage emission control systems. Some additive packages that are supplied by the aftermarket manufacturer may not be compatible with the seals that are used in fuel systems of some diesel engines. Other additive packages that are supplied by aftermarket manufacturers cannot provide proper performance in high temperature conditions. These additives may leave deposits because of the high temperatures that exist in the fuel systems of diesel engines.

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

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

Note: The sulfur levels for Jet A, Jet A-1, JP-8, JP-5, and kerosene fuels typically exceed 15 ppm and the fuel sulfur levels for these fuels typically far exceed 50 ppm. Refer to this Special Publication, “Distillate Diesel Fuel” article, “Alternative Fuels - Arctic Applications” topic for additional information on these fuels.

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” and “Cat Diesel Fuel Conditioner” topics for guidance.

Viscosity

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

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

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 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 room 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 engines. However, the fuel characteristics of additives are not identical to a natural product. 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 cloud point. However, the cold flow improvers keep the wax crystals small enough to pass through standard fuel filters. For mixing precautions, see the section “Pour Point”.

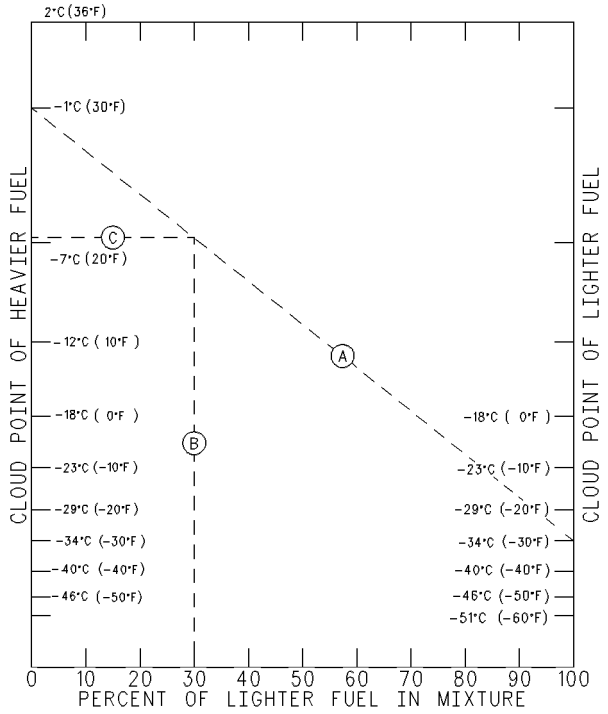

Illustration 2 g00592741

Cloud point of fuel mixtures

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

Pour Point

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

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

A fuel 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 lower pour points.

Modifying the Pour Point

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

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

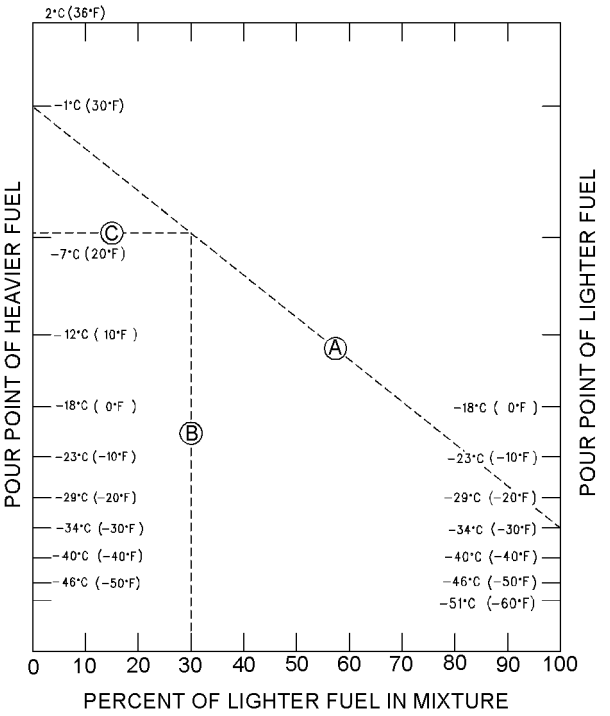

Illustration 3 g01180699

Pour point of fuel mixtures

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

1. Obtain the specification for the cloud point or the pour point of both fuels from your fuel supplier.

2. Locate the cloud point or the pour point of the heavier fuel on the left side of the table. Mark the point on the table.

3. Locate the cloud point or the pour point of the lighter fuel on the right side of the table. Mark the point on the table.

4. Draw a line between the two points that were established. Label this line “A”.

5. Determine the lowest outside temperature for machine operation. Find this point on the left side of the table. Mark this point. Draw a horizontal line from this point. Stop the line at the intersection of line “A”. Label this new line “C”.

6. Line “C” and line “A” intersect. Mark this point. Draw a vertical line from this point. Stop the line at the bottom of the table. Label this line “B”. The point at the bottom of line “B” reveals the percentage of lighter fuel that is required to modify the cloud point or the pour point.

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

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

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

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)

- 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 Caterpillar 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) or 0.0015% by weight.

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% by weight. The LSD fuel commonly available in North America normally does not exceed 350 ppm sulfur.

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

Sulfur-free Diesel Fuel

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

Note: The most commonly 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”.

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 in conjunction 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 Caterpillar dealers 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 with your Caterpillar dealer regarding the testing required to establish a safe, optimized oil drain interval.

Fuel sulfur levels affect exhaust emissions. High sulfur fuels also increase the potential for corrosion of internal components. Fuel sulfur levels above 0.5% (5000 ppm) may significantly shorten the oil change interval.

Note: Oil drain intervals are affected by many factors that are in addition to fuel sulfur levels, so that even when using fuel with lower sulfur levels, significantly shortened oil change intervals may be required.

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

- Using recommended oils
- Using good fuel
- 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 with your Caterpillar dealer regarding the testing that is required in establishing oil drain intervals that are optimized for your application.

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

- 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 Caterpillar dealer for guidance when fuel sulfur levels are above 0.1% (1000 ppm).

Fuel sulfur levels may affect the oil life in a diesel engine. Diesel fuels with higher levels of sulfur may shorten oil life, and may shorten engine life. The oil drain recommendations in the Caterpillar Operation and Maintenance Manuals are partially dependent on the level of sulfur in diesel fuel.

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

- 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
- Exhaust aftertreatment device type
- Maintenance intervals and other maintenance practices
- Engine Certification
- Laws, regulations, and other legal mandates

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.

The list below provides a quick reference for acceptable sulfur levels for diesel fuel that will be used in Cat commercial and 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 also controlled by various emissions laws, regulations and mandates. Consult federal, state, and local authorities for guidance on fuel requirements for your area.
- The maximum fuel sulfur level allowed for a DPF (Diesel Particulate Filter) equipped commercial and machine diesel engines is 0.0015% (15 ppm).
- The preferred maximum fuel sulfur level for DOC (Diesel Oxidation Catalyst) equipped commercial and machine diesel engines is 0.005% (50 ppm). Some DOC equipped engines REQUIRE the use of fuel with a maximum of 0.005% (50 ppm) fuel sulfur. Refer to the engine/machine specific Operation and Maintenance Manual and refer to the aftertreatment device specific documentation for guidance.
- The maximum fuel sulfur level allowed for most DOC (Diesel Oxidation Catalyst) equipped commercial and machine diesel engines is 0.05% (500 ppm). Some DOC equipped engines REQUIRE the use of fuel with a maximum of 0.005% (50 ppm) fuel sulfur. Refer to the engine/machine specific Operation and Maintenance Manual and refer to the aftertreatment device specific documentation for guidance.
- For commercial and machine diesel engines that are equipped with an aftertreatment device that is not listed in this section, refer to the engine/machine specific Operation and Maintenance Manual and refer to the aftertreatment device specific documentation for guidance.
- For commercial and machine diesel engines that are retrofitted with an aftertreatment device, refer to the aftertreatment device specific documentation.
- The preferred fuel sulfur level for non aftertreatment device equipped commercial and machine diesel engines is 0.05% (500 ppm) or less.

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.

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% (10, 000 ppm) 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

In order to help protect your engine:

- 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 Caterpillar 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.

Moisture Content

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

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

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

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

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

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

1. Remove the fuel filters.
2. Cut the fuel filters open.
3. Inspect the fuel filter before the filter warms. This inspection will show that the filter is filled with particles of either ice or wax.

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

Note: Among other potential problems, such as breaking down of the fuel protective film strength, excessive water in the fuel can lead to sulfuric acid creation from the sulfur present in the diesel fuel, increasing the potential for corrosion of internal components. Refer to this Special Publication, the “Characteristics of Diesel Fuel” article, “Diesel Fuel Sulfur” and other related topics for additional information. Also, refer to the most current revision level of “ASTM D975 (Standard Specification for Diesel Fuel Oils)” for additional information.

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

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 and sediment, 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 Oxidation Stability

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

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

Oxidative Stability Test

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

As per the specification “EN590:2004 Automotive Fuels - Diesel”, a test for a direct measurement of oxidation stability is the test method “ISO 12205 Petroleum products - Determination of the oxidation stability of middle distillate diesel fuels”. The fuel sample is heated at 95° C (203° F) for 16 hours while bubbles of oxygen travel through the sample. The resulting amount of solid oxidation by products are then measured. The process of cavitating oxygen into the fuel can simulate an impact over a long term of contact with fuel with oxygen that results in degradation. With diesel fuel the maximum amount of soluble that are formed should not exceed 25 g per cubic meter.

Caterpillar recommends that for diesel, biodiesel, or biodiesel blends that are going to be used several months after purchase, artificially aging the fuel to predict the storage stability, followed by an analysis of the fuel. For most distillate fuels that age the fuel for 7 days at 80° C (176° F) is equivalent to 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.

A test that can be used to help determine the degradation of biodiesel and biodiesel blends is the measurement of the Total Acid Number (TAN). This number represents the amount of acid present in the biodiesel or biodiesel blend as a result of degradation. The following test methods may be used: “EN 14104 Fat and oil derivatives - Fatty Acid Methyl Esters (FAME) - Determination of Acid Value” or “ASTM D664 Standard Test Method for Acid Number of Petroleum Products by Potentiometric Titration”. For neat (B100) biodiesel, this value should not exceed 0.5 mg KOH/g. For biodiesel blends such as 20% biodiesel and 80% diesel (B20), this value should not exceed 0.3 mg KOH/g. Biodiesel and biodiesel blends that exceed these values should be considered degraded beyond acceptable limits and further testing would not be required. Biodiesel and biodiesel blends that exceed 0.16 mg KOH/g may result in the formation of undesired degradation by-products that can cause the problems discussed in this document. Samples that exceed 0.16 mg KOH/g but do not exceed 0.3 mg KOH/g should be tested with the other methods in order to determine the thermal and oxidative stability of the fuel.

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Fuel Recommendations

SMCS Code: 1250; 1280

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

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

The preferred fuels provide maximum engine service life and performance. The preferred fuels are distillate fuels. These fuels are commonly called diesel fuel, furnace oil, gas oil, or kerosene. These fuels must meet the “Caterpillar 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 Caterpillar dealer for further information. For information concerning biodiesel/biodiesel blends, refer to this Special Publication, “Biodiesel” article.

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

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

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Distillate Diesel Fuel

SMCS Code: 1280

NOTICE
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 with your Caterpillar dealer.

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

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

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

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

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

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

To help ensure optimum engine performance, a complete fuel analysis should be obtained before engine operation. The fuel analysis should include all of the properties that are listed in the “Caterpillar Specification for Distillate Fuel for Off-Highway Diesel Engines”, Table 7.

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

Diesel Fuels that meet the specifications in table 7 will help provide maximum engine service life and performance.

In North America, diesel fuels that are identified as “ASTM D975-08a” Grades No. 1-D or No. 2-D (all listed sulfur levels) generally meet the table 7 requirements.

In Europe, diesel fuels that are identified as meeting “European Standard EN590:2004” generally meet the table 7 requirements.

Table 7 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 will have ≤15 ppm (0.0015%) sulfur using the “ASTM D5453”, “ASTM D2622”, “ISO 20846”, or “ISO 20884” test methods. Certain applications and/or governments/localities MAY require the use of ULSD fuel. Emission controlled diesel engines and/or diesel engines equipped with exhaust aftertreatment devices MAY require the use of ULSD fuel. Diesel engines equipped with a Diesel Particulate Filter (DPF) require the use of ULSD. Consult federal, state, and local authorities for guidance on fuel requirements for your area. Also, refer to this Special Publication, “Characteristics of Diesel Fuel”, article, refer to the specific engine Operation and Maintenance Manual, and refer to the aftertreatment device documentation for guidance.

When ULSD is used, there are concerns with fuel viscosity, lubricity, and thermal stability. The fuel lubricity and thermal stability limits stated in the “Caterpillar Specification for Distillate Fuel for Off-Highway Diesel Engines” address these concerns. In North America, diesel fuels that are identified as meeting “ASTM D975 Grade No. 1-D S15” or “ASTM D975 Grade No. 2-D S15” and meet the “ASTM D975-08a Thermal Stability Guideline X3.10.2.2”, generally meet the Caterpillar requirements for ULSD fuel.

In Europe, diesel fuels that are identified as meeting “European Standard EN590:2004” requirements for ≤ 10 ppm sulfur fuel (typically referred to as “sulfur-free”) generally meet Caterpillar requirements for ULSD fuel.

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

- Reduce engine efficiency and durability
- Cause more frequent aftertreatment ash cleaning intervals
- Damage emission control systems
- Cause the need for more frequent oil drain intervals
- Reduce fuel economy

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.

NOTICE
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 with your Caterpillar dealer.

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

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

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

NOTICE
Operating with fuels that do not meet Caterpillar 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 for Off-Highway Diesel Engines” Table. Read ALL of the footnotes.

Table 7

Caterpillar Specification for Distillate Fuel for Off-Highway Diesel Engines(1)			
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 (2)	40 minimum (DI engines)	“D613” or “D6890”	“ISO 5165”
	35 minimum (PC engines)		
Cloud Point	The cloud point must not exceed the lowest expected ambient temperature.	“D2500”	“ISO 3015”
Copper Strip Corrosion	No. 3 maximum	“D130”	“ISO 2160”

(continued)

(Table 7, contd)

Caterpillar Specification for Distillate Fuel for Off-Highway Diesel Engines[1]			
Specifications	**Requirements**	**ASTM Test**	**ISO Test**
Distillation	10% at 282 °C (540 °F) maximum 90% at 360 °C (680 °F) maximum	“D86”	“ISO 3405”
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 45 maximum	“D287”	No equivalent test
Pour Point	6 °C (10 °F) minimum below ambient temperature	“D97”	“ISO 3016”
Sulfur	[1][4]	“D5453” or “D2622”	ISO 20846 or ISO 20884
Kinematic Viscosity [5]	1.4 cSt minimum and 20.0 cSt maximum as delivered to the fuel injection pumps 1.4 cSt minimum and 4.5 cSt maximum as delivered to the rotary fuel injection pumps	-	-
Water and Sediment	0.05% maximum	“D1796”	“ISO 3734”
Water	0.05% maximum	“D1744”	No equivalent test
Sediment	0.05% maximum (weight)	“D473”	“ISO 3735”

(continued)

(Table 7, contd)

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

(1) **For additional guidance related to many of the fuel characteristics that are listed in this table, refer to this Special Publication, “Characteristics of Diesel Fuel”, article.** This specification includes the requirements for Ultra Low Sulfur Diesel (ULSD). ULSD fuel will have ≤ 15 ppm (0.0015%) sulfur using the “ASTM D5453”, “ASTM D2622”, or “ISO 20846”, “ISO 20884” test methods. This specification includes the requirements for Low Sulfur Diesel (LSD). LSD fuel will have ≤500 ppm (0.05%) sulfur using the “ASTM D5453”, “ASTM D2622” or the “ISO 20846”, “ISO 20884” test methods. Aftertreatment devices can be permanently damaged by the use of high sulfur fuels. Refer to this Special Publication, “Characteristics of Diesel Fuel” article, refer to the specific engine Operation and Maintenance Manual, and refer to the aftertreatment device documentation for guidance.

(2) Alternatively, to ensure a minimum cetane number of 35 (PC engines), and 40 (DI engines), distillate diesel fuel should have a minimum cetane index of 37.5 (PC engines), and 44.2 (DI engines) when the “ASTM D4737-96a” test method is used. A fuel with a higher cetane number may be required for operation at a higher altitude or in cold weather.

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

(4) **Engine operating conditions play a key role in determining the effect that fuel sulfur will have on engine deposits and on engine wear. Consult your Caterpillar dealer for guidance when fuel sulfur levels are above 0.1% (1000 ppm).** There are many factors that affect maximum allowed and/or acceptable fuel sulfur levels. Fuel sulfur levels affect exhaust emissions. High sulfur fuels increase the potential for corrosion of internal components, and can shorten expected oil life, and can shorten expected aftertreatment device life. Aftertreatment devices can be permanently damaged by the use of high sulfur fuels. For additional information related to fuel sulfur, including fuel sulfur limits, refer to this Special Publication, “Characteristics of Diesel Fuel” article, refer to this Special Publication, “Engine Oil” article, refer to the specific engine Operation and Maintenance Manual, and refer to the aftertreatment device documentation.

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

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

(7) The lubricity of a fuel is a concern with low sulfur and ultra low sulfur fuel. To determine the lubricity of the fuel, use the “ASTM D6079 High Frequency Reciprocating Rig (HFRR)” test. There are many aftermarket additives that are available to treat fuel. If the lubricity of a fuel does not meet the

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(Table 7, contd)

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.

There are many other diesel fuel specifications that are published by governments and by technological societies. Usually, those specifications do not review all the requirements that are addressed in the “Caterpillar Specification for Distillate Fuel for Off-Highway Diesel Engines”, Table 7. To help ensure optimum engine performance, a complete fuel analysis should be obtained before engine operation. The fuel analysis should include all of the properties that are listed in the “Caterpillar Specification for Distillate Fuel for Off-Highway Diesel Engines”, Table 7.

Ultra Low Sulfur Diesel (ULSD)

Caterpillar recommends that all distillate diesel fuel, including ULSD fuel (fuel ≤ 15 ppm sulfur using “ASTM D5453”, “ASTM D2622”, or “ISO 20846”, “ISO 20884”) meet the requirements of the “Caterpillar Specification for Distillate Fuel for Off-Highway Diesel Engines”, that are specified in Table 7.

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

NOTICE

Ultra Low Sulfur Diesel (ULSD) fuel will have ≤15 ppm (0.0015%) sulfur using the “ASTM D5453”, “ASTM D2622”, or “ISO 20846”, “ISO 20884” test methods. Certain applications and/or governments/localities MAY require the use of ULSD fuel. Emission controlled diesel engines and/or diesel engines equipped with exhaust aftertreatment devices MAY require the use of ULSD fuel. Diesel engines equipped with a Diesel Particulate Filter (DPF) require the use of ULSD. Consult federal, state, and local authorities for guidance on fuel requirements for your area. Also, refer to this Special Publication, “Characteristics of Diesel Fuel” article, refer to the specific engine Operation and Maintenance Manual, and refer to the aftertreatment device documentation for guidance.

When ULSD is used, there are concerns with fuel viscosity, lubricity, and thermal stability. The fuel lubricity and thermal stability limits stated in the “Caterpillar Specification for Distillate Fuel for Off-Highway Diesel Engines” address these concerns. In North America, diesel fuels that are identified as meeting “ASTM D975 Grade No. 1-D S15” or “ASTM D975 Grade No. 2-D S15” and meet the “ASTM D975-08a Thermal Stability Guideline X3.10.2.2”, generally meet the Caterpillar requirements for ULSD fuel.

In Europe, diesel fuels that are identified as meeting “European Standard EN590:2004” requirements for ≤ 10 ppm sulfur fuel (typically referred to as “sulfur-free”) generally meet Caterpillar requirements for ULSD fuel.

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

- Reduce engine efficiency and durability
- Cause more frequent aftertreatment ash cleaning intervals
- Damage emission control systems
- Cause the need for more frequent oil drain intervals
- Reduce fuel economy

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.

NOTICE
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 with your Caterpillar dealer.

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

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

NOTICE
Operating with fuels that do not meet Caterpillar 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
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.

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

In order to obtain additional information on Caterpillar designed and produced filtration products, refer to this Special Publication, “Reference Material” article, “Filters” and “Miscellaneous” topics, and then contact your Caterpillar dealer for assistance with filtration recommendations for your Caterpillar 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 - Arctic Applications

In extreme cold ambient conditions, you may choose to use the distillate fuels that are specified in table 8. However, the fuel that is selected must meet the requirements that are specified in the “Caterpillar Specification for Distillate Diesel Fuel for Off-Highway Diesel Engines”, Table 7. 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 8 typically have much higher sulfur levels than the 15 ppm maximum sulfur allowed for ULSD. The sulfur levels for these fuels typically far exceed 15 ppm. These fuels typically will not be acceptable for use in areas that restrict maximum fuel sulfur levels to 15 ppm of less.

Note: The fuels that are listed in table 8 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.

Table 8

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

(1) The fuel that is selected must meet the requirements that are specified in the “Caterpillar Specification for Distillate Diesel Fuel for Off-Highway Diesel Engines” table, table 7. Cooling of the fuel may be required to maintain 1.4 cSt or greater viscosity at the fuel injection pump. Consult the supplier for the recommended additives in order to maintain the proper fuel lubricity.

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

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

These fuels are lighter than the No. 2 grades of fuel. The cetane number of the fuels in table 8 must be at least 40. If the viscosity is below 1.4 cSt at 40 °C (104 °F), use the fuel only in temperatures below 0 °C (32 °F). Do not use any fuels with a viscosity of less than 1.2 cSt at 40 °C (104 °F).

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

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

Aftermarket Fuel Additives

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

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

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

Note: The U.S. EPA bans the use of metallic fuel additives in on-highway applications.

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

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

Cat Diesel Fuel Conditioner

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

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

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

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

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

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

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

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

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

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

Caterpillar strongly recommends that Cat Diesel Fuel Conditioner be used with biodiesel and biodiesel blends. Cat Diesel Fuel Conditioner is suitable for use with biodiesel/biodiesel blends that meet Caterpillar biodiesel recommendations and requirements. **Note that not all fuel additives are suitable for use with biodiesel/biodiesel blends.** Read and follow all applicable label usage instructions. Also, refer to this Special Publication, “Distillate Diesel Fuel” article and also refer to the “Biodiesel” article, which includes Caterpillar 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. 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). The current formulation of Cat Diesel Fuel Conditioner has more than 15 ppm sulfur. Follow all applicable national, regional, and local laws, mandates and regulations concerning the use of diesel fuel conditioners/additives.

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Biodiesel

SMCS Code: 1280

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

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 Special Publication, SEBU6385, “Caterpillar On-Highway Diesel Engine Fluids Recommendations”.

Referenced Documents:

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

Note: For the purpose of these recommendations, the cautions, guidelines and recommendations applicable to biodiesel (B100) are also applicable to biodiesel blends (B2, B5, B20, etc.).

Note: A complete Caterpillar S·O·S Services oil analysis program is strongly recommended when using biodiesel blends B1 (1 percent) through B19 (19 percent), and a complete Caterpillar S·O·S Services oil analysis program is required when using biodiesel/biodiesel blends that are B20 or above (when requesting oil analysis, be sure to note the level of biodiesel being used (B5, B20, etc.)).

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 in conjunction 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 Caterpillar dealers for additional guidance, including but not limited to guidance on establishing optimized and/or acceptable oil drain intervals.

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

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

Biodiesel and biodiesel blends are known to cause an increase in fuel system deposits, most significant of which is 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. Caterpillar Diesel Fuel Conditioner helps to limit these issues by improving the stability of biodiesel and biodiesel blends while also cleaning formed deposits and hindering the production of new deposits. **Therefore, the use of Caterpillar 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, “Caterpillar Diesel Fuel Conditioner” topic for additional information.

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

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

Caterpillar is not in a position to evaluate the many variations of biodiesel and the long-term effects on performance, durability, or compliance to emissions standards for Caterpillar products.

Note: Visually apparent phase separation, sediment, suspended matter, or undissolved water should not be present in biodiesel and biodiesel blends.

Biodiesel and biodiesel blends should not contain any constituent, additive or other substance that makes them unacceptable for use in diesel engines.

"EN 14078" is the recommended test method for determining the volume percent biodiesel in a biodiesel blend.

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.

Recommendation for the Use of Biodiesel in Caterpillar Commercial and Machine Diesel Engines

For Caterpillar Series C175 Series diesel engines, consult the Caterpillar Application & Installation Group or consult your Caterpillar dealer before using biodiesel or biodiesel blends.

For Caterpillar off-highway ACERT Technology diesel engine model numbers C7, C9, C11, C13, C15, C18, C27, and C32 and also for Caterpillar 3114, 3116, 3126, 3176, 3196, 3208, 3306, C-9, C-10, C-12, 3406, C-15, C-16, C-18, 3456, 3408, 3412, Series 3500 Series, Series 3600 Series, Series C280 Series, CM20, CM25, and CM32 engines, biodiesel that meets the requirements that are listed in the "Caterpillar Specification for Biodiesel Fuel", "ASTM D6751", or "EN 14214" are acceptable blendstock. Biodiesel may be blended in amounts up to a maximum of 20 percent (B20) with an acceptable diesel fuel. This blend is acceptable provided that the biodiesel constituent meets the requirements that are outlined in Table 9 prior to blending. In addition, the final blend must meet the requirements for distillate diesel fuel that are listed in the "Caterpillar Specification for Distillate Diesel Fuel for Off-Highway Diesel Engines", Table in this Special Publication, "Distillate Diesel Fuel" article. Biodiesel that meets "ASTM D7467" (B6 to B20), or biodiesel that meets "ASTM D975-08a" or "EN 590" requirements for B5 and lower biodiesel blends are also acceptable for use in the listed engines.

C0.5-C2.2, C4.4, and C4.4 ACERT Technology diesel engines and C6.6 ACERT Technology diesel engines compatible with up to B20 biodiesel as described above have been released as follows:

- C0.5-C2.2 Tier 4 Interim/Stage IIIB, at model introduction, starting April 2007
- C4.4 (Mechanical) Tier 3/Stage IIIA, at model introduction, starting Nov 2007
- C4.4 ACERT Technology Tier 3/Stage IIIA electronic diesel engines manufactured after 1 July 2008, Serial numbers:

- Cat Machine Group - C4E05524-UP

- Cat Industrial - 44404304-UP

- C6.6 ACERT Technology electronic diesel engines built after 1 July 2008, Serial numbers:

- Cat Machine Group - CE614624-UP

- Cat Industrial - 66609016-UP

Note: Diesel fuels that meet the requirements of the most current versions of the "Caterpillar Specification for Distillate Diesel Fuel for Off-Highway Diesel Engines", the "Caterpillar Specification for Distillate Diesel Fuel for On-Highway Diesel Engines", the National Conference on Weights and Measures (NCWM) Premium Diesel definition, "EN 590" and/or "ASTM 975 (No.1-D, No.2-D)", are examples of fuels that are acceptable for creating biodiesel blends. These biodiesel blends must meet the Caterpillar recommendations and requirements for biodiesel blends.

Note: Crankcase oil fuel dilution may be much higher when biodiesel and/or biodiesel blends are used. This increased level of fuel dilution when using biodiesel and/or biodiesel blends is related to the typically lower volatility of biodiesel. In-cylinder emissions control strategies utilized in many of the industries 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, but some potential issues are:

- A higher risk of corrosion
- A higher risk of wear
- A higher risk of piston deposits
- Either increased or deceased oil viscosity
- Shortened aftertreatment device ash service intervals (more frequent) and/or shortened aftertreatment device life
- Shortened oil life (more frequent oil drain intervals)

The use of a complete Caterpillar S·O·S Services oil analysis program is strongly recommended when B19 and lower biodiesel blends are used, and the use of a complete Caterpillar S·O·S Services oil analysis program is required when using biodiesel/biodiesel blends that are B20 or above (when requesting oil analysis, be sure to note the level of biodiesel being used (B5, B20, etc.)).

For blends of biodiesel B20 or above, consult your Caterpillar dealer for guidance. A complete Caterpillar S·O·S Services oil analysis program is required when biodiesel or blends of biodiesel that are B20 or above are used. Biodiesel or blends of biodiesel as used in the engine must meet the requirements that are stated in the “Caterpillar Specification for Distillate Diesel Fuel for Off-Highway Diesel Engines” Table in this Special Publication, “Distillate Diesel Fuel” article.

For Caterpillar C0.5 through C2.2 and for C4.4 mechanical engines that meet Tier2/Stage2 or earlier emissions regulations, for C4.4 (machine engine serial numbers C4E05523 and lower, and industrial engine serial numbers 44404303 and lower) and C6.6 (machine engine serial numbers CE614623 and lower, and industrial engine serial numbers 66609015 and lower) ACERT Technology diesel engines, and for C3.4, 3003 through 3034, 3044, 3046, 3054, 3056, 3064, and 3066 engines, biodiesel that meets the requirements that are listed in the “Caterpillar Specification for Biodiesel Fuel”, “ASTM D6751”, or “EN 14214” may be blended with an acceptable diesel fuel. This blend should be a maximum ratio of 5% biodiesel to 95% of an acceptable diesel fuel. The biodiesel must meet the requirements that are listed in Table 9 prior to blending. Biodiesel that meets “ASTM D975-08a” or “EN 590” requirements for B5 and lower biodiesel blends are also acceptable for use in the listed engines. Use of more than a 5% biodiesel can cause premature failures. The repair for these failures would not be covered under the Caterpillar warranty.

Note: When biodiesel, or any blend of biodiesel is used, the user has the responsibility for obtaining the proper local exemptions, regional exemptions, and/or national exemptions, if required, for the use of biodiesel in any Caterpillar engine that is regulated by emissions standards. Biodiesel that meets the requirements that are listed in the “Caterpillar Specification for Biodiesel Fuel”, “ASTM D6751”, or “EN 14214” is not expected to pose major problems when blended with an acceptable distillate diesel fuel and when used as recommended at the maximum stated percentages. In addition, biodiesel that meets “ASTM D7467” (B6 to B20), or biodiesel that meets “ASTM D975-08a” or “EN 590” requirements for B5 and lower biodiesel blends are not expected to pose major problems and when used as recommended. However, the following additional recommendations must be followed.

Recommendations

For the purpose of these recommendations, the cautions, guidelines and recommendations applicable to biodiesel (B100) are also applicable to biodiesel blends (B2, B5, B20, etc.).

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

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

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

- The oil change interval can be negatively affected by the use of biodiesel. Use Caterpillar S·O·S Services oil analysis in order to monitor the condition of the engine oil. Use Caterpillar S·O·S Services oil analysis also in order to determine the oil change interval that is optimum. A complete Caterpillar S·O·S Services oil analysis program is strongly recommended when using biodiesel blends B1 through B19, and a complete Caterpillar S·O·S Services oil analysis program is required when using biodiesel/biodiesel blends that are B20 or above (when requesting oil analysis, be sure to note the level of biodiesel being used (B5, B20, etc.)).

- Confirm with the filter manufacturer that the fuel filter/filters to be used are compatible with biodiesel. Caterpillar fuel filters are compatible with biodiesel that meets the quality requirements given in this Special Publication.

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

- Filter biodiesel and 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.

- In a comparison of distillate fuels to biodiesel, biodiesel typically provides less energy per gallon by 5% to 8%. Do NOT change the engine rating in order to compensate for the power loss. This will help avoid engine problems when the engine is converted back to 100 percent distillate diesel fuel.

- Compatibility of the elastomers with biodiesel is currently being monitored. The condition of seals and hoses should be monitored regularly by the end user.

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

- Biodiesel has poor oxidation stability, which can result in long term storage problems. Biodiesel should be used within six months of production. Storage life for biodiesel and biodiesel blends that are greater than B20 may be much shorter than six months. The poor oxidation stability may accelerate fuel oxidation in the fuel system. This is especially true in engines with electronic fuel systems because these engines operate at higher temperatures. In addition to this “Biodiesel” article, also refer to this Special Publication, “Distillate Diesel Fuel” article, “Aftermarket Fuel Additives” and “Cat Diesel Fuel Conditioner” topics for information concerning oxidation stability and fuel additives.

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

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

- 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. Refer to “ASTM D6469”, and consult your supplier of fuel and fuel additive for assistance in selecting appropriate anti-microbial additives.

- 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.

- Refer to this Special Publication, “General Fuel Information” article for additional recommendations.

Seasonal Operation

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

Perform the following items in the listed order 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 the previous steps a minimum of two times before the engine is shut down for prolonged periods.

Biodiesel Degradation

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.

A test that can be used to help determine the degradation of biodiesel and biodiesel blends is the measurement of the Total Acid Number (TAN). This number represents the amount of acid present in the biodiesel or biodiesel blend as a result of degradation. The following test methods may be used: “EN 14104” or “ASTM D664”. For neat (B100) biodiesel, this value should not exceed 0.5 mg KOH/g. For biodiesel blends such as 20% biodiesel and 80% diesel (B20), this value should not exceed 0.3 mg KOH/g. **Biodiesel and biodiesel blends that exceed these values should be considered degraded beyond acceptable limits and further testing would not be required.** Biodiesel and biodiesel blends that exceed 0.16 mg KOH/g may result in the formation of undesired degradation by-products that can cause the problems discussed in this document. Samples that exceed 0.16 mg KOH/g but do not exceed 0.3 mg KOH/g should be tested with the other methods in order to determine the thermal and oxidative stability of the fuel.

With the following considerations, commercial and machine diesel engines that are covered by this Special Publication should be able to operate satisfactorily on fuels with the stated maximum biodiesel levels:

- The biodiesel/biodiesel blends meet all of the requirements that are stated in this Special Publication.

- All appropriate guidelines and maintenance practices as stated in engine specific Operation and Maintenance Manuals and in this Special Publication are followed.

- The engines are operating in applications with low to moderate severity.

- When other factors do not preclude.

Refer to this Special Publication, and refer to your specific Cat commercial engine Operation and Maintenance Manual and/or refer to your specific Cat machine Operation and Maintenance Manual for additional guidance.

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 Caterpillar designed and produced filtration products, refer to this Special Publication, “Reference Material” article, “Filters” and “Miscellaneous” topics, and then contact your Caterpillar dealer for assistance with filtration recommendations for your Caterpillar machine.

Fuel System Deposits

Biodiesel and biodiesel blends are known to cause an increase in fuel system deposits, most significant of which is 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. Caterpillar Diesel Fuel Conditioner helps to limit these issues by improving the stability of biodiesel and biodiesel blends while also cleaning formed deposits and hindering the production of new deposits. **Therefore, the use of Caterpillar 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, “Caterpillar Diesel Fuel Conditioner” topic for additional information.

Biodiesel Specification

The final blend of biodiesel as used in the engine must meet the requirements that are stated in the “Caterpillar Specification for Distillate Diesel Fuel for Off-Highway Diesel Engines” Table in this Special Publication, “Distillate Diesel Fuel” article.

NOTICE
The footnotes are a key part of the “Caterpillar Specification for Biodiesel Fuel” Table 9. Read ALL footnotes.

Table 9

Caterpillar Specification for Biodiesel Fuel[1]				
Property	**Test Method**	**Test Method**	**Units**	**Limits**
	United States	**International**	**Specific Properties of Fuel**	
Density at 15°C	“ASTM D1298”	“ISO 3675”	g/cm^3	0.86-0.90
Viscosity at 40°C	“ASTM D445”	“ISO 3104”	mm^2/s (cSt)	1.9-6.0
Flash Point	“ASTM D93”	“ISO 3679”	°C	93 minimum
Pour Point - Summer - Winter	“ASTM D97”	“ISO 3016”	°C	6 °C (10 °F) minimum below ambient temperature
Cloud Point	“ASTM D2500”		°C	Report
Sulfur Content	“ASTM D5453”	“ISO 20846” “ISO 20884”	% weight	0.0015 maximum
Distillation - 10% Evaporation - 90% Evaporation	“ASTM D1160”		°C	To Be Determined 360
Carbon Residue, Conradson (CCR)	“ASTM D4530”	“ISO 10370”	% weight	0.05 maximum
Cetane Number	“ASTM D613”	“ISO 5165”		45 minimum
Sulfated Ash	“ASTM D874”	“ISO 3987”	% weight	0.02 maximum
Water/Sediment Content	“ASTM D2709”	“ISO 12937”	% 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”	% volume	97.5 minimum
Acid Value	“ASTM D664”	“EN 14104”	mg NaOH/g	0.5 maximum
Methanol Content	“EN 14110”	“EN 14110”	% weight	0.2 maximum
Monoglycerides	“ASTM D6584”	“EN 14105”	% weight	0.8 maximum
Diglycerides	“ASTM D6584”	“EN 14105”	% weight	0.2 maximum
Triglycerides	“ASTM D6584”	“EN 14105”	% weight	0.2 maximum
Free Glycerin	“ASTM D6584”	“EN 14105”	% weight	0.02 maximum
Total Glycerin	“ASTM D6584”	“EN 14105”	% weight	0.240 maximum
Phosphorus Content	“ASTM D4951”	“EN 14107”	% weight	0.001
Calcium and Magnesium combined	“EN 14538”	“EN 14538”	ppm	5 maximum
Sodium and Potassium combined	“EN 14538”	“EN 14538”	ppm	5 maximum
Cold Soak Filterability	Annex A1 in “ASTM D6751”		seconds	360 maximum[2]

(1) The final blend of biodiesel as used in the engine must meet the requirements that are stated in the “Caterpillar Specification for Distillate Diesel Fuel for Off-Highway Diesel Engines” Table in this Special Publication, “Distillate Diesel Fuel” article.

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

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 article apply.

Cooling System Specifications

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General Coolant Information

SMCS Code: 1350; 1395

NOTICE
Every attempt is made to provide accurate, up to date information. By 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 Caterpillar diesel engines that are covered by this Special Publication. This information supersedes all previous recommendations which have been published for the Caterpillar diesel engines that are covered by this Special Publication. Special fluids 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 Caterpillar dealer for the most up to date recommendations.

NOTICE
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.

For questions concerning the information provided in this Special Publication, consult with your Caterpillar dealer.

For additional guidelines, recommendations, and requirements (including maintenance interval recommendations/requirements) refer to your product specific Operation and Maintenance Manual.

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

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

For questions concerning the information provided in this Special Publication and/or in your product Operation and Maintenance Manual, consult with your Caterpillar dealer.

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

Note: For the purpose of this Special Publication, the term "coolant" is interchangeable with the terms "antifreeze", "coolant/antifreeze", and/or "antifreeze/coolant".

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 to prevent damage caused by freezing coolant.

NOTICE
Frequently check the specific gravity of the coolant for proper freeze protection or for anti-boil protection.

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. Removing the regulators allows some coolant to bypass the radiator, potentially causing overheating.

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

Refer to Special Instruction, SEBD0518, “Know Your Cooling System” and Special Instruction, SEBD0970, “Coolant and Your Engine” 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, and 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 three elements: water, additives, and glycol.

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: Caterpillar 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
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. 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.).

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

Water is used in the cooling system in order to transfer heat.

Note: Caterpillar recommends a minimum of 30 percent glycol in diesel engine cooling systems. Refer to the Operation and Maintenance Manual for your engine for exceptions.

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 10.

Table 10

Caterpillar 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:

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

Note: Periodic analysis of water used in the cooling system 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. A lack of coolant additives or insufficient amounts of additives enable 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, Caterpillar 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. See Tables 11 and 12.

Table 11

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.

NOTICE
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 12

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.

Note: Propylene glycol coolant that is used in the cooling systems for Caterpillar 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 Caterpillar dealer for additional information.

Note: Ethylene or propylene glycols used in cooling systems for Caterpillar 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. The tester gives readings that are immediate and accurate in both degrees Celsius and degrees Fahrenheit. The tester can be used with ethylene or propylene glycol.

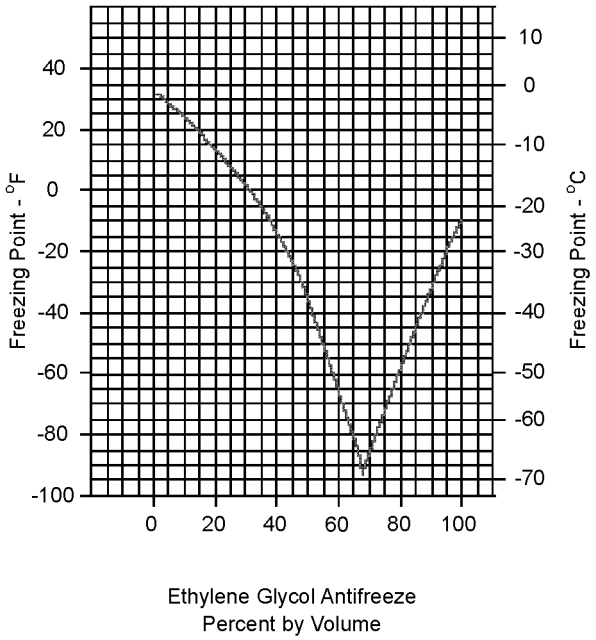

Illustration 4 g01189253

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

Table 13

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 Caterpillar, use of PDO and glycerin or glycerin/glycol coolants are not recommended in Caterpillar cooling systems.**

Coolant, SCA, and Extender Terminology

Conventional coolant – A coolant (often also referred to as a heavy-duty coolant, heavy-duty fully formulated coolant, or traditional coolant) that relies largely on inhibitors for corrosion and cavitation protection that are inorganic in nature, such as silicate and nitrite. To be used in most Caterpillar 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. SCA is added for one of three reasons: to pre-charge a new coolant that is not fully formulated, to provide corrosion protection in water/SCA cooling systems, or 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.

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

NOTICE
Do Not Mix Brands and/or Types of Products

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

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

NOTICE
Use Only Approved SCAs and Extenders

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

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

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

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

Preferred – Cat ELC (Extended Life Coolant) or a commercial extended life coolant that meets the Caterpillar EC-1 (Engine Coolant -1) specification. In order to be used in Caterpillar diesel engines in accordance with the service interval for EC-1 coolants that is listed in this Special Publication, commercial EC-1 coolants must also pass/conform to the additional requirements for EC-1 specification coolants as stated in the coolant section of this Special Publication.

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

Chemical Requirements for New Coolant (50 volume % diluted)

Preferred Coolants – Cat ELC or EC-1

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

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

- A minimum concentration of nitrite (as NO_2) of 1200 ppm
- A minimum silicon concentration of 100 ppm
- A maximum silicon concentration of 275 ppm
- Coolants that are prediluted at the coolant manufacturer must be diluted with water that meets Reagent 4 (“ASTM D1193”) requirements

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

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

Use only the coolant/antifreeze that is recommended.

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

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

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

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

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

In stationary engine applications and marine engine applications that do not require protection from boiling or freezing, a mixture of SCA and water is acceptable. **Caterpillar recommends a minimum of six percent to a maximum of eight percent concentration of Cat SCA in those cooling systems.** 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 (Maintenance Section).

Note: Caterpillar 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

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. 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.).

NOTICE

All Caterpillar diesel engines equipped with air-to-air aftercooling (ATAAC) require a minimum of 30 percent glycol to prevent water pump cavitation, 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.).

Table 14

Coolant Service Life	
Coolant Type	**Service Life** (1)(2)
Cat ELC	12000 Service Hours or Six Years(3)
Commercial coolant that meets the Caterpillar EC-1 Specification	6000 Service Hours or Six Years(4)(5)
Cat DEAC	3000 Service Hours or Three Years
Commercial Heavy-Duty Coolant/Antifreeze that meets “ASTM D6210”	3000 Service Hours or Two Years
Commercial Heavy-Duty Coolant/Antifreeze that meets “ASTM D4985”	3000 Service Hours or One Year
Cat SCA(6) and water(7)	3000 Service Hours or Two Years
Commercial supplemental coolant additive(8) and water(6)(7)(8)	3000 Service Hours or One Year

(1) Use the interval that occurs first.
(2) Refer to the engine's Operation and Maintenance Manuals, “Maintenance Interval Schedule” for the correct interval for replacement of the cooling system water temperature regulator.
(3) Cat ELC Extender must be added at 6000 service hours or one half of the service life of the Cat ELC.
(4) An extender must be added at 3000 service hours or one half of the service life of the coolant.
(5) In order to be used in Caterpillar diesel engines in accordance with the service interval for EC-1 coolants that is listed in this Special Publication, commercial EC-1 coolants **must** also pass/conform to the additional requirements for EC-1 specification coolants as stated in the coolant section of this Special Publication.
(6) The concentration of Cat SCA in a cooling system that uses Cat SCA and water should be from 6 to 8 percent by volume.
(7) Refer to this Special Publication, “General Coolant Information” under the section that discusses the requirements for water.
(8) Consult the supplier for the commercial SCA for instructions on usage. Also, refer to this Special Publication, “Water/Supplemental Coolant Additive” topic for additional information.

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

Cat ELC can be recycled into conventional coolants.

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

Table 15

Part Numbers of Coolant		
Description	**Size**	**Part Number**(1)
Cat DEAC (Concentrate)	Bulk	2P-9868 or 156-2649
	208.2 L (55 US gal)	8C-3686 238-8653(2)
	3.8 L (1 US gal)	8C-3684 238-8651(2)
Cat ELC (50/50 Premix)	Bulk	156-2653
	208.2 L (55 US gal)	101-2845 238-8650(2)
	18.9 L (5 US gal)	129-2151 238-8649(2)
	3.8 L (1 US gal)	101-2844 238-8648(2)
Cat ELC (Concentrate)	3.8 L (1 US gal)	119-5150 238-8647(2)
Cat ELC Extender	0.946 L (1 qt) 3.8 L (1 US gal)	119-5152 210-0786

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

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Extended Life Coolant

SMCS Code: 1350; 1352; 1395

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 totally different additive system. Cat ELC has been formulated with the correct amounts of additives in order to provide superior corrosion protection for all metals that are in engine cooling systems.

Cat ELC extends the service life of the coolant to 12000 service hours or six years. Cat ELC does not require the frequent addition of a SCA (Supplemental Coolant Additive). An Extender is the only additional maintenance that is needed at 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.

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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 Caterpillar products or commercial products that have passed Caterpillar's EC-1 specification for pre-mixed or concentrated coolants. In order to be used in Caterpillar diesel engines in accordance with the service interval for EC-1 coolants that is listed in this Special Publication, commercial EC-1 coolants **must** also pass/conform to the additional requirements for EC-1 specification coolants as stated in the coolant section of this Special Publication.

Use only Cat ELC Extender with Cat ELC.

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

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

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

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

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

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

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

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

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

Cat ELC Extender

Cat ELC Extender is added to the cooling system halfway through the 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 the “Part Number of Coolant” table in this Special Publication, “Coolant Recommendations” article for available quantities and part numbers.

Use the formula in Table 16 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 16

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

Table 17 is an example for using the formula that is in Table 16.

Table 17

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. 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 to be used at the specified coolant change interval. Cleaning agents are only required if the system has been contaminated by the addition of some other type of coolant or by cooling system damage.

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

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

Recycling Cat ELC

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

Changing to Cat ELC

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

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

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

Dispose of all fluids according to applicable regulations and mandates.

1. Drain the coolant into a suitable container.

2. Dispose of the coolant according to local regulations.

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

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

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

Remove the SCA element base and plug off or by-pass the coolant lines.

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

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

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

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

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

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

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

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

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

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

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

11. Fill the cooling system with the Cat ELC.

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

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

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

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

Cat ELC Cooling System Contamination

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

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

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

NOTICE
Do Not Mix Brands and/or Types of Products

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

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

NOTICE
Use Only Approved SCAs and Extenders

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

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

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

Commercial Extended Life Coolant

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

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

- Cat EC-1 specification
- The minimum performance requirements of the “ASTM D6210” specification

- The additional requirements that are stated in this Special Publication for EC-1 coolants

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

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

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

Note: As they have not been 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 EC-1 specification requirements.

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

NOTICE

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

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

- Phosphate, borate and silicate free

- Minimum typical tolyltriazole level of 900 ppm for new coolants

- Minimum typical nitrite level of 500 ppm in new coolants

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

NOTICE

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

- Physical and Chemical Properties

- Compatibility Characteristics

- Bench Testing

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

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Diesel Engine Antifreeze/ Coolant

SMCS Code: 1350; 1352; 1395

Caterpillar 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. Refer to this Special Publication, “Coolant Recommendations” for available container sizes and part numbers, or consult your Caterpillar 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: The concentrated Cat DEAC and the recommended water must be thoroughly mixed prior to filling the cooling system.

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Supplemental Coolant Additive

SMCS Code: 1350; 1352; 1395

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

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

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, or 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 until the concentration of Cat SCA has been reduced to an unacceptable level. To ensure that the correct amount of Cat SCA is in the cooling system, the concentration of Cat SCA must be tested 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 six percent maximum concentration of SCA. Maintain a three to six percent SCA concentration in the coolant.

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Conventional Coolant/ Antifreeze Cooling System Maintenance

SMCS Code: 1350; 1352; 1395

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

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

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

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

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

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

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

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

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

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.

Caterpillar 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). SCA test kits are available from your Caterpillar dealer. Test the concentration of SCA or submit a coolant sample to your Caterpillar dealer at 250 hour intervals or at the intervals for PM Level 1. Refer to this Special Publication, “S·O·S Services Coolant Analysis” for more information on this topic.

Additions of SCA are based on the results of the test or based on the results of the coolant analysis. An SCA may be needed at 250 hour intervals or at the intervals for PM Level 1.

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 properly maintain the engine's cooling system.

Refer to Table 18 and refer to table 19 for part numbers and for the quantities of SCA maintenance elements and/or liquid SCA.

Table 18

Caterpillar Liquid SCA(1)	
Part Number	**Size of Container**
6V-3542	0.24 L (8 oz)
8T-1589	0.47 L (16 oz)
3P-2044	0.94 L (32 oz)
217-0616	1 L (34 oz)
237-7673	5 L (1.3 US gal)
8C-3680	19 L (5.0 US gal)
217-0617	20 L (5.3 US gal)
5P-2907	208 L (55 US gal)
217-0618	208 L (55 US gal)

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

Table 19

Caterpillar SCA Requirements for Heavy-Duty Coolant/Antifreeze				
Cooling System Capacity	**Initial Fill**(1)	**250 hours or Intervals for PM Level 1** (2)(3)	**Spin-on Element at 250 hours or at Intervals for PM Level 1**(2)(3)(4)	**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

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

Cooling Systems with Larger Capacities

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

Note: When 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 their coolant.

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

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

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

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

It is also the responsibility of the coolant manufacturer and the SCA manufacturer to ensure that when used according to their recommendations that their products will not cause cooling system harm.

Table 20

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

Table 21 is an example for using the equation that is in Table 20.

Table 21

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 Caterpillar 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 22 to determine the amount of Cat SCA that is required, if necessary.

Table 22

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

Table 23 is an example for using the equation that is in Table 22.

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

Table 23

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

Cleaning the System of Heavy-Duty Coolant/Antifreeze

Before Caterpillar's 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.

Caterpillar Cooling System Cleaner:

- Dissolves or depresses mineral scale, corrosion products, light oil contamination, and sludge.
- Cleans the cooling system after used coolant is drained or before the cooling system is filled with new coolant.
- Cleans the cooling system whenever the coolant is contaminated or whenever the coolant is foaming.
- The “Standard” version of the Caterpillar Cooling System Cleaner cleans 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 Cleaner is designed to clean the cooling system of harmful scale and corrosion without removing the engine from service. The cleaners, both “Standard” and “Quick Flush” can be used in all 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.

Follow label directions for proper usage.

Recycling Cat DEAC

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

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

Recycled coolants should meet “ASTM D6210-06”.

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

SMCS Code: 1350; 1352; 1395

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

If Cat DEAC (Diesel Engine Antifreeze/Coolant) is not used, select a coolant/antifreeze with low silicate content for heavy-duty applications that meets “ASTM D6210-06” or “ASTM D4985-05” specifications.

Note: When NOT using Cat DEAC (or coolant that does not meet the Cat EC-1 specification) the cooling system must be drained one time every year. The cooling system must be flushed out at this time as well.

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

It is also the responsibility of the coolant manufacturer and the SCA manufacturer to ensure that when used according to their recommendations that their products will not cause cooling system harm.

Note: Do not mix brands or types of coolants with different brands or types of SCA or extender. Cat SCA is compatible with Cat DEAC. If using non Cat-branded coolants, refer to the coolant manufacturer for information on a compatible SCA

When a heavy-duty coolant/antifreeze is used and compatibility with Cat SCA is confirmed as previously described, treat the cooling system with three to six percent Cat SCA by volume. Maintain a concentration level of SCA in the cooling system that is between three percent and six percent. For more information, see this Special Publication, “Conventional Coolant/Antifreeze Cooling System Maintenance” article.

If Cat SCA is not used, select a commercial SCA. The commercial SCA must provide a minimum of 1400 mg/L or 1400 ppm (82 grains/US gal) of nitrites in the final coolant mixture.

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).

By specification, coolant/antifreeze for heavy-duty applications that only meets the “ASTM D4985” specification WILL require treatment with SCA at the initial fill. These coolants WILL require treatment with SCA on a maintenance basis.

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

When concentrated coolant/antifreeze is mixed, Caterpillar 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, see this Special Publication, “General Coolant Information” article.

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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 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

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. 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.).

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

NOTICE
Never use water alone without SCA (Supplemental Coolant Additives). 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 very 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 than a cooling system that uses a mixture of glycol and water. The SCA concentration in a cooling system that uses SCA and water should be six to eight percent by volume.

Note: Do not exceed the eight 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.

Refer to Table 24 for part numbers and for the sizes of containers of SCA.

Table 24

Caterpillar Liquid SCA[1]	
Part Number	**Size of Container**
6V-3542	0.24 L (8 oz)
8T-1589	0.47 L (16 oz)
3P-2044	0.94 L (32 oz)
217-0616	1 L (34 oz)
237-7673	5 L (1.3 US gal)
8C-3680	19 L (5.0 US gal)
217-0617	20 L (5.3 US gal)
5P-2907	208 L (55 US gal)
217-0618	208 L (55 US gal)

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

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 25 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 25

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

Table 26 is an example for using the equation that is in Table 25.

Table 26

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 Caterpillar 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 25 to determine the amount of Cat SCA that is required for maintenance, if necessary:

Table 27

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

Table 28 is an example for using the equation that is in Table 25.

Table 28

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 properly maintain the engine's cooling system.

Table 24 lists part numbers and the sizes of containers for Cat SCA that are available from your Caterpillar dealer.

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S·O·S Services Coolant Analysis

SMCS Code: 1350; 1395; 7542

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

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

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

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

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

New Systems, Refilled Systems, and Converted Systems

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

- Every Year
- Initial 500 service hours

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

Recommended Interval for S·O·S Services Coolant Sample

Table 29

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) This is also the recommended sampling interval for all commercial coolants that meet Cat EC-1 (Engine Coolant specification - 1)
(2) This is also 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 Caterpillar dealer.

Reference Information Section

Reference Materials

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

SMCS Code: 1000; 7000

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

NOTICE
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 with your Caterpillar dealer.

Note: For additional information on ULSD, refer to this Special Publication, “Fuel Specifications” section.

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

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

Note: In Europe, ultra low sulfur diesel fuel will have a maximum of 0.0010 percent (10 ppm) sulfur and is typically referred to as “sulfur-free”. Also, the most commonly available diesel fuel in Europe has a maximum sulfur content of 0.005 percent (50 ppm). These sulfur levels are defined in European Standard “EN 590:2004”.

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

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

For additional on-highway diesel engine fluids requirements, refer to the most current revision level of Special Publication, SEBU6385, “Caterpillar On-Highway Diesel Engine Fluids Recommendations”.

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

Yes. Refer to these “Frequently Asked Questions” and to the “Fuel Specifications” section in this Special Publication for guidance when ULSD will be used.

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

Diesel fuel lubricity is necessary to minimize wear on fuel pumps and injectors. ULSD fuel requires good lubricity and corrosion inhibitors in order to prevent unacceptable engine wear. In the U.S., as necessary, additives to increase lubricity and to inhibit corrosion will be added to ULSD fuel prior to its retail sale. With these additives, ULSD fuel is expected to perform as well as LSD fuel. **All Caterpillar electronic engines produced since model year (MY) 2000 are qualified to run on ULSD fuel.**

Note: Have the fuel supplier confirm that the ULSD fuel available meets the most current revision level of “ASTM D975” and/or “EN 590” lubricity requirements.

In North America, diesel fuel that is identified as “ASTM D975” Grade No. 2-D S15 or “ASTM D975” Grade No. 1-D S15 and meeting the “ASTM D975-08a” Thermal Stability Guideline X3.10.2.2 generally meet the “Caterpillar Specification for Distillate Diesel Fuel for Off-Highway Diesel Engines” requirements for ULSD fuel.

Diesel fuels that are identified as meeting “EN 590:2004” 10 ppm or less sulfur requirements (“sulfur-free”), and diesel fuels that are identified as meeting “ASTM D975-08a” 15 ppm or less sulfur requirements (“S15”), generally meet the Caterpillar requirements for ULSD fuel.

Note: The current revision level of both “EN 590” and of “ASTM D975” allows up to 5 percent (B5) biodiesel. Refer to the “Fuel Specifications” section and to the “Biodiesel” article in this Special Publication for guidance when biodiesel will be used.

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

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

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

There is no relationship between the natural diesel fuel color and such desirable diesel fuel qualities as heat content, viscosity, cloud point, cetane number or distillation range. Diesel fuel color varies with the crude source, refinery methods and the use of dyes. However, if the fuel color darkens appreciably during storage, this could indicate oxidation and/or contamination from dirt, water, algae, bacteria, or other sources that can cause operational problems.

6. Does ULSD affect the fuel system seals?

Caterpillar has completed the review of the engine fuel system technology and the system compatibility with ULSD fuel for on and off-highway products. Electronically controlled (ECM) engines, manufactured after 2000 and that have been properly maintained, are compatible with fuel with less than 50 ppm sulfur content and comply with “ASTM D975” Grade No. 2-D S15 or “ASTM D975” Grade No. 1-D S15 or “EN 590” “sulfur-free” (10 ppm or less sulfur). Refer to this Special Publication, “Fuel Specifications” section for more information.

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

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

7. Can I use the current Caterpillar fuel filters?

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

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

8. Are aftermarket fuel additives recommended with ULSD?

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

In special circumstances, Caterpillar recognizes the need for fuel additives. Fuel additives need to be used with caution. The additive may not be compatible with the fuel. Some additives may precipitate and cause deposits in the fuel system. The deposits may cause seizure. Some additives may plug fuel filters. Some additives may be corrosive, and some additives may be harmful to the elastomers in the fuel system. Some additives may damage emission control systems. Some additives may raise fuel sulfur levels above the maximum allowed by the U.S. EPA and/or, as appropriate, other regulatory agencies. Consult your fuel supplier for those circumstances when fuel additives are required. Your fuel supplier can make recommendations for additives to use and for the proper level of treatment. For best results, your fuel supplier should treat the fuel when additives are needed. Refer to the answer to question 4 for more information. Also, refer to this Special Publication “Fuel Specifications” section, “Aftermarket Fuel Additives”, and “Cat Diesel Fuel Conditioner” topics.

9. Can biodiesel fuel be blended as ULSD?

Biodiesel can be blended as either LSD or as ULSD.

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

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

10. What effect does blending used lubricating oil into diesel fuel have on engine performance and fuel quality?

In general, **this practice is not recommended**. It may adversely affect fuel quality features and could lead to fuel system and piston deposits, increased exhaust emissions and fuel filter plugging. This practice may also result in the diesel fuel being out of compliance with U.S. EPA, state, and other appropriate regulatory agencies requirements.

Note: Blending lubricating oil with ULSD fuel may raise the sulfur level above 15 ppm.

Do **not** use diesel fuel that has been blended with lubricating oil in the following applications:

- MY2007 and newer on-highway diesel engines. Use of oil/fuel blends in MY2007 and newer (U.S. EPA 2007 certified) on-highway diesel engines and/or EURO IV certified on-highway diesel engines may cause engine damage.
- Engines that are equipped with an aftertreatment device. Use of oil/fuel blends in aftertreatment device equipped diesel engines may cause the need for more frequent cleaning cycles, contribute to aftertreatment device plugging and may cause aftertreatment device damage.

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

11. What about special fuels (JP-5, JP-8, Kerosene, Jet A, Jet A-1)?

These fuels typically have a much higher sulfur content than is allowed by the U.S. EPA regulations for maximum sulfur content of ULSD. The sulfur content for these fuels typically far exceeds 15 ppm.

These fuels typically have a much higher sulfur content than the maximum fuel sulfur content allowed by the European Standard “590:2004”. The sulfur content of these fuels typically far exceeds 50 ppm.

12. Does ULSD affect engine performance and fuel economy?

Diesel fuel suppliers advise that the new ULSD fuel contains more wax, but will deliver 0% to 2% lower fuel economy (approximately 1% lower on average). How can this be?

Diesel engine operators often consider the waxes found in diesel fuel as delivering most of the fuel's energy. This is assumed because lighter fuels such as No. 1D and kerosene do not typically have winter wax problems and because No. 1D and kerosene give lower fuel economy.

During desulfurization, a percentage of the fuels aromatic and naphthenic components are converted to less dense paraffinic waxes. There is now more wax, but the density of the fuel is lower. The lower fuel density of ULSD results in less energy per gallon.

13. What specification requirements of diesel fuel should concern me?

Cetane number (ignition quality), cleanliness, low-temperature operability, stability, and lubricity are the diesel fuel requirements of principal concern to the end user.

Refer to this Special Publication, “Fuel Specifications” section for more information.

Note: For applications where ULSD is required, have the fuel supplier confirm that the ULSD fuel available meets all Caterpillar requirements for distillate diesel fuel and/or the most current revision level of “ASTM D975 S15” and/or the “EN 590” (“sulfur-free”) requirements.

Note: “ASTM D975-08a” and “EN 590” currently allow up to 5 percent (B5) biodiesel. Refer to the “Fuel Specifications” section, and to the “Biodiesel” article in this Special Publication for guidance when biodiesel will be used.

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

14. Does ULSD fuel require a different storage procedure?

No. When properly treated by the fuel supplier with a fuel stability additive, both LSD and ULSD fuel can typically be stored for up to one year. The same commonly used and approved storage tank maintenance practices used for LSD fuel should also be used with ULSD fuel. The storage tanks and containers commonly used with LSD fuel are typically suitable for ULSD fuel.

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Reference Material

SMCS Code: 1000; 7000

The following literature can be obtained through any Caterpillar dealer.

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

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

NOTICE
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.

Coolants

- Special Publication, PMEP5027, "Label - Cat ELC Radiator Label"
- Datasheet, PEHJ0067, "Cat ELC (Extended Life Coolant)" (Worldwide)
- Datasheet, PEHP9554, "Cat DEAC (Diesel Engine Antifreeze/Coolant) (Concentrate)"

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” (Edition 39)
- “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:	_____	_____	_____

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