

Product: EXCAVATOR

Model: 320C EXCAVATOR BCB

Configuration: 320C & 320C L EXCAVATORS BCB00001-UP (MACHINE) POWERED BY 3066 ENGINE

Operation and Maintenance Manual Caterpillar Machine Fluids Recommendations

Media Number -SEBU6250-26

Publication Date -01/11/2018

Date Updated -05/10/2017

Foreword

SMCS - 1000; 7000

Fluids/Filters Recommendation

Literature Information

This manual should be stored in the literature holder or in the literature storage area on the machine. Immediately replace this manual if lost, damaged, or unreadable.

The information contained in this document is the most current information available for fluid maintenance and service products. Special maintenance and service products may be required for some machine compartments. Refer to the Operation and Maintenance Manual for your machine for the maintenance and service requirements. Read, study, and keep this manual with the product. This manual should be read carefully before using this product for the first time and before performing maintenance.

Whenever a question arises regarding your product, or this publication, consult your dealer for the latest available information.

Safety

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

Read and understand the applicable precautions listed in the Maintenance and Operation Sections before operating or performing lubrication, maintenance, and repair on this machine.

Maintenance

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

Proper maintenance and repair are essential to keep the equipment and systems operating correctly. As the owner, you are responsible for the performance of the required maintenance listed in the Owner Manual, Operation and Maintenance Manual, and Service Manual.

Maintenance Interval Schedule

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

Under extremely severe, dusty, or wet operating conditions, more frequent lubrication and/or filter changes than is specified in the maintenance intervals chart might be necessary.

Following the recommended maintenance intervals reduces the risk of excessive wear and potential failures of components.

Aftermarket Products and Warranty

NOTICE

When auxiliary devices, accessories or consumables (filters, oil, additives, catalysts, fuel, etc.) made by other manufacturers are used on Cat 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 Cat products. Installation or use of such items is at the discretion of the customer who assumes ALL risks for the effects that result from this usage.

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.

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Lubricant Information

SMCS - 1000; 1300; 7581

NOTICE

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

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

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

NOTICE

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

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

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

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

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

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

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

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

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

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

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

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

When fluids made by other manufacturers are used on Cat products, the Cat warranty is not affected simply because of such use. Failures that result from the installation or usage of other manufacturer fluids, however, are not Cat factory defects and therefore are NOT covered by the Cat warranty. Cat is not in a position to evaluate the many fluids promoted by other manufacturers and the effect on Cat products. Installation or use of such items is at the discretion of the customer who assumes ALL risks for the effects that result from this usage.

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

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

In order to obtain additional information on Cat designed and produced filtration products, refer to Special Publication, SEBU9208, "Caterpillar Filters Recommendations". Also refer to the “Reference Material” article, “Filters” and “Miscellaneous” topics in this Special Publication. Consult your Cat dealer for assistance with filtration recommendations for your Cat machine.

Note: In order to help ensure the maximum expected compartment performance and life, use a fluid that meets Cat highest level of fluid performance as described in this Special Publication for the compartment. Using a fluid that is considered an acceptable, but lower performing option for typical applications, will provide lower performance.

NOTICE

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

Cat Fluids

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

Cat recommends the use of the following Cat fluids:

Table 1

Cat Lubricants	Viscosity Grade	
Diesel Engine Oil-Ultra Low Sulfur (API CK-4)	Cat DEO-ULS	SAE 15W-40
	Cat DEO-ULS SYN	SAE 10W-30
	Cat DEO-ULS SYN	SAE 5W-40
	Cat DEO Cold Weather	SAE 0W-40
Diesel Engine Oil (API CI-4/API CI-4PLUS)	Cat DEO	SAE 15W-40
	Cat DEO	SAE 10W-30
Multi-Application Engine Oil	Cat MAEO Plus (Non-Cat mixed fleets)	SAE 10W-40
Diesel Engine Oil (API CF)	Cat DEO (3600 engines only)	SAE 40
Pre Combustion Oil	Cat PCO	SAE 40

		SAE 10W
	Cat TDTO	SAE 30
Transmission/Drive Train Oil		SAE 50
	Cat TDTO-TMS	Multigrade
	Cat TDTO Cold Weather	SAE 0W-20
Special Application Transmission Oil	Cat SATO	Multigrade
Automatic Transmission Fluid	Cat ATF-HD2	Multigrade Synthetic
	Cat FDAO	SAE 60
Final Drive and Axles Oil	Cat FDAO SYN	Multigrade
	Cat GO	SAE 80W-90
Gear Oil		SAE 85W-140
	Cat Synthetic GO	SAE 75W-140
		SAE 10W
	Cat HYDO Advanced	SAE 20W
Hydraulic Oil		SAE 30
	Cat Bio HYDO Advanced (HEES)	ISO 46 Multigrade
Multipurpose Tractor Oil	Cat MTO	SAE 10W-30

Note: Additional Cat fluids may be available.

Note: Cat offers Special Application Engine Oil (SAEO), API CF oil of SAE 30 and SAE 40 viscosity grades. These oils are recommended for use in 3116 and 3126 marine engines.

Table 2

Cat Grease products	
Grease	Cat Utility Grease
	Cat Prime Application Grease
	Cat Extreme Application Grease
	Cat Extreme Application Grease - Desert
	Cat Extreme Application Grease - Arctic (Semi-Synthetic)
	Cat Ball Bearing Grease
	Cat White Assembly Grease
	Cat Hammer Paste

Note: Cat fluids availability will vary by region.

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

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

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

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

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Engine Oil - Cat Machine Diesel Engines

SMCS - 1348; 7581

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

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

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

High-performance oils are produced and validated using industry standard tests, proprietary tests, field tests, and often prior experience with similar formulation. The American Petroleum Institute (API) categories describe the key industry standards that set the minimum acceptable performance for engine oils. Other global standard setting organizations may also develop common standards, for example the European ACEA oil specs. Cat high quality and high-performance lubricants are validated based on these factors.

In order to provide optimal engine performance and life and comply with regulated emission reduction, use the recommended engine oil as provided in this special publication. Due to the

significant variations in the quality and performance of commercially available oils on a global basis, Cat recommends the use of Cat oils as detailed in this article.

Cat Diesel Engine Oils

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

Cat recommends the use of the following lubricants in commercial engines covered by this Special Publication are in Table 1 below:

Table 1

Cat Lubricants ⁽¹⁾			Viscosity Grade
Recommendations for all Cat diesel engines	Cat Diesel Engine Oil-Ultra Low Sulfur (API CK-4) ⁽²⁾	Cat DEO-ULS	SAE 15W-40
			SAE 10W-30
		Cat DEO-ULS SYN	SAE 5W-40
		Cat DEO Cold Weather	SAE 0W-40
	Cat Diesel Engine Oil (API CI-4/CI-4 PLUS and API CH-4)	Cat MAEO Plus (Non-Cat mixed fleets)	SAE 15W-40
			SAE 10W-30
Specialty oils for specific Cat diesel engines	Cat Multi-Application Engine Oil	Cat MAEO Plus (Non-Cat mixed fleets)	SAE 10W-40
	Cat Diesel Engine Oil	Cat DEO (3600 engines only)	SAE 40
	Cat Precombustion Chamber Oil	Cat PCO (Specific applications only)	SAE 30

⁽¹⁾ Cat engine oils exceed the performance requirements of the respective API categories

⁽²⁾ These oils have changed from API CJ-4 to API CK-4 early in 2017

Note: Cat offers Special Application Engine Oil (SAEO), API CF oil of SAE 30 and SAE 40 viscosity grades. These oils are recommended for use in 3116 and 3126 marine engines.

Note: Additional Cat fluids may be available.

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

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

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

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

Cat Diesel Engine Oils Recommendations

Cat DEO-ULS and Cat DEO multigrade oils are the preferred oils for use in ALL Cat diesel engines that are covered by this Special Publication. Commercial alternative diesel engine oils are, as a group, second choice oils. Refer to Table 2 below for information.

Table 2

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

Note: API engine oil categories are backwards compatible. Cat DEO-ULS (API CK-4) oil can be used in all engines with some restrictions related to fuel sulfur level, refer to Table 2 for more details. Cat DEO (API CI-4/API CI-4 PLUS) can be used in engines that are Tier 3 emissions certified and prior, and in engines that do not use aftertreatment devices.

Note: When the recommended Cat diesel engine oils are not used, commercial oils that are API CK-4 licensed and/or meet the requirements of the Cat ECF-1-a, Cat ECF-2, and/or the Cat ECF-3 specification are acceptable, but second choice, for use in Cat diesel engine.

Refer to "The Current American Petroleum Institute (API) Oil Categories" and "Commercial Engine Oil Recommendations" sections of this chapter for information on the API categories and corresponding Cat engine oils.

API CK-4 exceeds the performance requirements of prior oil categories.

Caterpillar has released a new Cat diesel engine oil, Cat DEO-ULS that is per the new API CK-4 heavy duty engine oil category. The new Cat DEO-ULS replaces the prior Cat oil that was per API CJ-4 category, but it is of the same brand name. The new Cat DEO-ULS preserved the same level of phosphorous, 1000 ppm (parts per million) (mg/kg), to ensure achieving long hour engine durability goals.

Note: The new API FA-4 Heavy Duty Engine Oil Category is NOT allowed in Cat engines. API FA-4 is a special low High Temperature High Shear (HTHS) viscosity oil that is designed for certain 2017 On-Highway engine models.

Note: Each of the Cat ECF specifications provides increased performance over lower Cat ECF specifications. For example, Cat ECF-3 provides higher performance than Cat ECF-2 and Cat ECF-3 provides much higher performance than Cat ECF-1-a. Refer to Table 3 for details.

The engine oils recommended/required for Tier 4 certified engines are formulated with limited ash and chemical limits:

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

These chemical limits were developed in order to maintain the expected aftertreatment devices life, performance, and service intervals. Use of oils other than those listed in this section of this special publication in aftertreatment equipped engines can negatively impact performance of the aftertreatment devices, can contribute to Diesel Particulate Filter (DPF) plugging and/or can cause the need for more frequent DPF ash service intervals.

Cat DEO-ULS and Cat DEO are recommended for all pre-Tier 4 engines that use Ultra Low Sulfur Diesel (ULSD) or Low Sulfur Diesel (LSD) fuels. Cat DEO is recommended for engines using fuels of sulfur levels that exceed 0.2 percent (2000 ppm). Cat DEO-ULS may be used in these applications if an oil analysis program is followed. The oil change interval may be affected by the fuel sulfur level. Refer to Table 4 in this section of this Special Publication.

Table 3 below provides details of Cat ECF specifications.

Table 3

Cat Engine Crankcase Fluids (ECF) Definitions	
Cat Minimum Performance Requirements for Commercial Oils	Cat ECF Specifications Requirements
(1)	API CK-4 Oil Category performance requirements
Cat ECF-3	API CJ-4 Oil Category performance requirements

Cat ECF-2	API CI-4 / CI-4 PLUS Oil Category performance requirements and Passing standard Cat C13 engine test per API requirements and Oils of sulfated ash > 1.50 percent are not allowed
Cat ECF-1-a	API CH-4 Oil Category performance requirements and For oils that are between 1.30 percent and 1.50 percent sulfated ash, passing one additional Cat 1P SCOTE test ("ASTM D6681") is required and Oils of sulfated ash > 1.50 percent are not allowed

⁽¹⁾ Caterpillar did not develop an ECF external specification for API CK-4. Cat DEO-ULS API CK-4 oil is specifically developed and validated for Cat engines. The API categories define the minimum common OEM requirements for engine oils

Refer to "Commercial Engine Oil Recommendations" and "The Current American Petroleum Institute (API) Oil Categories" sections of this chapter for information on the API categories and corresponding Cat engine oils.

Cat DEO-ULS exceeds many of the performance requirements of API CK-4 standard tests and Cat ECF specifications. Cat DEO-ULS is formulated with 1000 ppm (parts per million) (mg/kg) phosphorous level to ensure achieving long hour engine durability goals.

Cat DEO exceeds the limits of API CI-4/CI-4PLUS and API CH-4.

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

There are significant variations in the quality and performance of commercially available oils. For this reason, Cat recommends the Cat oils listed in Table 2 and the guidelines in Table 2.

NOTICE

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

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

Use appropriate lubricating oils that are compatible with the engine certification and aftertreatment system and with the fuel sulfur levels. Refer to the oil recommendations for Tier 4

certified engines in this Chapter, to “Diesel Fuel Sulfur Impacts” article of the “Fuels Specifications” section and to “Lubricants Specifications” section of this Special Publication.

Cat DEO-ULS (API CK-4) is compatible for use in engines with aftertreatment devices. Refer to the appropriate section in this article for details.

Cat DEO-ULS and Cat DEO are multigrade oils. Refer to Table 1 in this article for details. Multigrade oils provide the correct viscosity for a broad range of operating temperatures. Multigrade oils provide the appropriate oil film thickness for moving engine components such as piston, ring and liners, bearings, valve train and others.

Cat diesel engine oils exceed many of the performance requirements of the corresponding API categories and of other manufacturers of diesel engines. Therefore these oils are excellent choices for many mixed fleets. Refer to the engine manufacturer literature for the recommended categories/specifications. Compare the categories/specifications to the specifications of Cat diesel engine oils. The current industry standards for Cat diesel engine oils are listed on the product labels.

Also, refer to the datasheets for the product for technical details.

Cat DEO-ULS and Cat DEO are recommended for all pre-Tier 4 engines that use Ultra Low Sulfur Diesel (ULSD) or Low Sulfur Diesel (LSD) fuels. Cat DEO is recommended for engines using fuels of sulfur levels that exceed 0.2 percent (2000 ppm). Cat DEO-ULS may be used in these applications if an oil analysis program is followed. The oil change interval may be affected by the fuel sulfur level. Refer to Table 4 in this section of this Special Publication.

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

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

Recommendation for US EPA Tier 4 Certified Nonroad Engines

All diesel engines with aftertreatment devices are **REQUIRED** to use specially formulated engine oils and specific diesel fuels. The engine categories that are certified per the emissions regulations listed below commonly have aftertreatment devices:

- United States Environmental Protection Agency (EPA) Tier 4 Nonroad
- European Union Stage IIIB, IV, and V, Nonroad
- Japan 2014 (Tier 4) Nonroad
- Korea Tier 4 Nonroad
- India Bharat Stage IV for Construction Equipment Vehicles
- China Nonroad Stage IV

Engine Oils

The REQUIRED engine oils are listed below. These oils are developed with restricted ash level and chemical limits that are suitable for use in engines with aftertreatment.

- Cat DEO-ULS (preferred)
- API CK-4 engine oil category
- Oils meeting the Cat ECF-3 specification
- API CJ-4 engine oil category
- ACEA E9

Note: Note that ACEA E9 oils are validated using some but not all ECF-3 and API CJ-4 standard engine performance tests. Consult your oil supplier when considering use of an oil that is not API CK-4, CatECF-3 or API CJ-4 qualified.

The chemical limits are detailed in the Section titled "Cat Diesel Engine Oils Recommendations" of this chapter

Diesel Fuels

The diesel fuels REQUIRED by regulations for use in engines that are certified to nonroad emissions standards listed above and in engines equipped with exhaust aftertreatment systems are.

- United States Ultra Low Sulfur Diesel (ULSD) fuel ≤ 15 ppm (mg/kg) (0.0015 percent) sulfur
- European ULSD ≤ 10 ppm (mg/kg) (0.0010 percent) sulfur fuel. This fuel is also called "sulfur free"
- Other fuels available around the world that are ≤ 15 ppm (mg/kg) (0.0015 percent) sulfur

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

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

The fuels listed above have to meet the performance levels detailed in the Fuel Information for Diesel Engines chapter in this Publication. The Fuel Information for Diesel Engines Chapter also includes the pertinent recommendations for biodiesel fuels in the engines certified to non-road emissions standards listed above.

Diesel Exhaust Fluid (DEF)

This fluid MUST be used in engines that are equipped with Selective Catalytic Reduction (SCR) systems. DEF must meet all the requirements detailed in the Exhaust Aftertreatment Fluids Specification chapter in this Special Publication.

Aftertreatment systems may include the following:

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

Other systems may apply.

Regulations may vary around the world. Follow all the local regulations and fluids requirements in your area. Refer to your engine-specific Operation and Maintenance Manual, and refer to your aftertreatment device documentation, if available, for additional guidance.

NOTICE

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

Recommendation for Europe Stage V Certified Nonroad Engines

All the recommendations and requirements given in "Recommendation for US EPA Tier 4 Certified Nonroad Engines" section are applicable to the Europe Stage V type-approved Nonroad Engines

Additionally, for the correct operation of the engine in order to maintain the gaseous and particulate pollutant emissions of the engine within the limits of the type-approval, unless specified otherwise in the engine-specific Operation and Maintenance Manual, **EU Stage V** regulations REQUIRE the diesel fuels (also called non-road gas oil) used in engines operated within the European Union (EU) to have the characteristics below

- The sulfur content should not be greater than 10 mg/kg (20 mg/kg) at point of final distribution
- The Cetane number should not be less than 45
- The biodiesel (also called Fatty Acid Methyl Ester (FAME)) content should not be greater than 8 % volume/volume

Note: Certain Cat engines that are certified per EU Stage V can use up to B20 biodiesel blends. Refer to your engine specific Operation and Maintenance Manual.

Follow all the local regulations and fluids requirements in your area. Refer to your engine-specific Operation and Maintenance Manual, and refer to your aftertreatment device documentation, if available, for additional guidance.

Commercial Engine Oil Recommendations

Note: The engine oil recommendations given in "Commercial Engine Oil Recommendations" are applicable to all current and noncurrent Cat Diesel Engines that are covered by this Special Publication.

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

NOTICE

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

Refer to "The Current American Petroleum Institute (API) Oil Categories" section of this chapter for information on the API categories and corresponding Cat engine oils.

When the recommended Cat diesel engine oils are not used, commercial oils that are API CK-4 licensed and/or meet the requirements of the Cat ECF-1-a, Cat ECF-2, and/or the Cat ECF-3 specification are acceptable, but second choice, for use in Cat diesel engine.

Oils that are API CJ-4, API CI-4/CI-4 PLUS and API CH-4, and do not meet any Cat ECF specification are, as a group, third choice.

Note: API FA-4 oils are NOT allowed for use in Cat engines. These oils are designed for use in certain 2017 On-Highway engine models.

API CK-4 oils exceed the performance requirements of prior API categories. Cat developed the Engine Crankcase Fluid (ECF) specifications to ensure the availability of acceptable performance commercial diesel engine oils. The three Cat ECF specifications: Cat ECF-1-a, Cat ECF-2 and Cat ECF-3 are described in Table 2. These specifications require more engine tests than the corresponding API categories. As a result, oils that are API CK-4 and/or per these specifications can offer acceptable engine performance.

Each higher Cat ECF specification provides increased performance over lower Cat ECF specifications. For example, Cat ECF-3 provides higher performance than Cat ECF-2 and Cat ECF-3 provides much higher performance than Cat ECF-1-a. Refer to Table 3 for details

Oils that meet only API CI-4/CI-4 PLUS and/or API CH-4 categories and that have not met the requirements of at least one Cat ECF specification may cause reduced engine life.

Note: Cat diesel engine oils are required to pass proprietary full-scale diesel engine testing. The testing is above and beyond the testing required by the various Cat ECF specifications and by the various API oil categories that are also met. This additional proprietary testing helps ensure that Cat multigrade diesel engine oils, when used as recommended, provide superior performance in Cat diesel engines. If Cat diesel engine oils are not used, use only commercial oils that meet the recommendations and requirements stated in this section of this Special Publication.

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

For engines using fuels of sulfur levels that exceed 0.2 percent (2000 ppm), Caterpillar recommends Cat DEO engine oils. However, commercial oils that meet Cat ECF- 2 or Cat ECF-1-a specifications are acceptable but second choice. Commercial oils that meet Cat ECF- 3 specifications may be used in these applications if an oil analysis program is followed. The oil change interval is affected by the fuel sulfur level. Refer to Table 4 in this section of this Special Publication.

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

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

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

NOTICE

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

NOTICE

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

The Current American Petroleum Institute (API) Oil Categories

The American Petroleum Institute, working closely with Original Engine Manufacturers (OEMs) including Caterpillar, has been developing engine oil categories since the 1950s. These categories define the minimum common OEM and industry requirements for engine oils. Cat oils exceed the

requirements of API categories and the corresponding Cat ECF specifications (Refer to Table 3 in this Chapter).

The American Petroleum Institute (API), has developed two new Heavy Duty Diesel Engine Oil categories. The two new categories, described below, are planned for release in December of 2016.

1. API CK-4: backwards compatible oil that is based on API CJ-4 technology with additional performance improvements:
 - a. Improved oxidation stability (per ASTM D8048).
 - b. Improved air release (Per ASTM D8047).
 - c. Improved used oil shear stability per tighter specification limits.
 - d. Same chemical limits as API CJ-4 oil category, designed for use in engines with aftertreatment devices.

2. API FA-4: low High Temperature High Shear (HTHS) viscosity oil developed for certain 2017 On-Highway engine models that have to meet certain on-road emissions regulations. This category is not backwards compatible. API FA-4 is not recommended for Caterpillar engines.

Caterpillar is **NOT** recommending API FA-4 for Cat engines. These oils are designed with low HTHS viscosity for application in certain 2017 On-Highway truck engines. The level of HTHS viscosity for API FA-4 is lower than the traditional levels of HTHS for heavy duty engine oils. API FA-4 oils are not backwards compatible.

Caterpillar new diesel oil, Cat DEO-ULS, released in Dec 2016, is per API CK-4 oil category. This oil changed from API CJ-4 formulation, but is of the same brand name. Cat DEO-ULS exceeds the performance requirements of API CK-4 and has been extensively validated in Caterpillar engine tests.

Cat DEO-ULS is formulated with 1000 ppm (parts per million) (mg/kg) phosphorous level to ensure achieving long hour engine durability goals.

The API oil categories and the corresponding Caterpillar engine oils are described in Table 4 below. Refer to API 1509 document and/or ASTM D4485 for details of the API tests requirements and limits.

Table 4

API Category to Cat Oil Reference		
API Category	Corresponding Cat Oil ⁽¹⁾	Date of Release
API CK-4 ⁽²⁾	Cat DEO-ULS	December, 2016
API FA-4	Not recommended for Cat engines	December, 2016
API CJ-4 ⁽²⁾	None Replaced by DEO-ULS, CK-4	2006

API CI4/CI-4 PLUS	Cat DEO ⁽¹⁾	2002
API CH-4	Cat DEO ⁽¹⁾⁽³⁾ Available only in certain geographical regions	1998
API CF (Obsolete)	Cat DEO Restricted applications in Cat engines	1994
API CG-4, CF-4, CE, CD, and prior. (Obsolete)	No Cat oils Not allowed in Cat engines	1955 - 1990

⁽¹⁾ Cat oils exceed the requirements of API categories and the corresponding Cat ECF specifications (Refer to Table 3 in this Chapter).

⁽²⁾ Oils with Chemical limits. Compatible with emissions-reducing aftertreatment devices.

⁽³⁾ Cat DEO API CH-4 and Cat ECF-1-are available only in China, India, and Thailand. These oils are used in Tier 2 emissions certified engines.

Note: Each API category is more technically advanced than the prior categories.

Oils that meet only API CI-4/CI-4 PLUS and/or API CH-4 categories and that have not met the requirements of at least one Cat ECF specification may cause reduced engine life.

Note: Obsolete API oil categories are not licensed by the API and hence are of uncontrolled quality. These oils are technically inferior to current oils and can result in reduced engine performance and life.

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

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

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

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

Table 5

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

⁽¹⁾ Use of an oil analysis program to determine oil drain intervals is recommended if fuel sulfur is between 0.05% (500 ppm) and 0.5% (5000 ppm).

⁽²⁾ Use of an oil analysis program to determine oil drain intervals is required if fuel sulfur is above 0.5% (5000 ppm).

⁽³⁾ For fuels of sulfur levels that exceed 1.0 percent (10,000 ppm), refer to TBN and engine oil guidelines given in this section.

⁽⁴⁾ Cat DEO-ULS may be used if an oil analysis program is followed. High fuel sulfur levels may reduce the oil drain intervals.

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

- Choose multigrade oil with the highest TBN that meets one of these specifications: Cat ECF-1-a, Cat ECF-2, Cat ECF-3, and Cat API CK-4. Commercial oils are second choice oils.
- Reduce the oil change interval. Base the oil change interval on the oil analysis. Ensure that the oil analysis includes the condition of the oil and a wear metal analysis. Cat S·O·S Services oil analysis is required.

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

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

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

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

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

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

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

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

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

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

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

NOTICE

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

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

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

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

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