



---

# **Cat Gas Engine Lubricant, Fuel, and Coolant Recommendations**

---

## Important Safety Information

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

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

**Do not operate or perform any lubrication, maintenance or repair on this product, until you have read and understood the operation, lubrication, maintenance and repair information.**

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

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



The meaning of this safety alert symbol is as follows:

**Attention! Become Alert! Your Safety is Involved.**

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

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

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

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



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

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

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

---

## Table of Contents

Foreword ..... 4

### **Maintenance Section**

Lubricant Specifications ..... 6

Fuel Specifications ..... 28

Cooling System Specifications ..... 35

### **Reference Information Section**

Reference Materials ..... 43

### **Index Section**

Index ..... 45

---

## 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

i03115441

## 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 are the latest recommendations for Cat gas engines. This information supersedes all previous recommendations which have been published for Cat gas engines. 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 Special Publication does not replace the machine 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.

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

### NOTICE

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

### NOTICE

**Refer to the engine Operation and Maintenance Manual for any lubricant information that may be specific to that application.**

### NOTICE

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

## Engine Oil

Engine oil performs several functions:

- Keeping the engine clean
- Preventing rust and corrosion
- Acting as a coolant
- Reducing friction and wear

Engines that use gaseous fuel require oils that are formulated with additives that are specific to these engines. There are no industry standards that define the performance specifications of oils for these engines. Field evaluations must be used in order to determine oils that are acceptable. To aid in oil selection, guidelines are provided in this Special Publication.

## Hydraulic Oil

For information on hydraulic oil, see this Special Publication, "Hydraulic Oil" topic.

## Lubricating Grease

For information on grease, see this Special Publication, "Lubricating Grease" topic.

i03115460

## Engine Oil

**SMCS Code:** 1348

The following costs are associated with maintenance of the engine lubrication system:

- Initial fill
- Consumption
- Analysis of the engine oil
- Replacement of the engine oil and engine oil filter
- Disposal of the used engine oil

Maintaining the engine lubrication system is usually between 10 and 20 percent of the total cost of the engine maintenance. This percentage can be affected by the type of fuel, the engine duty cycle, and the maintenance practices.

The temperature of the cooling system, extended operation at light loads, and the condition of the engine (wear) have an effect on the rate of consumption and on the engine oil service life.

Maintenance costs can be greatly increased by the wrong engine oil. Inadequate lubrication that destroys moving parts causes expensive unscheduled down time. The following problems can result from the use of incorrect engine oil:

- Buildup of varnish (glazing) in the cylinder liners
- Damage to bearings
- Deposits on the valves that can lead to guttering of the valves
- Oil coking in the turbocharger
- Piston rings and valves that stick

In order to achieve the lowest maintenance costs for the lubrication system, use the recommended and preferred Cat natural gas engine oils.

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

Due to the significant variations in the quality and in the performance of commercially available oils, Caterpillar makes the following recommendations, in order of oil performance:

- **Cat Natural Gas Engine Oil (NGEO) EL350**
- **Cat Natural Gas Engine Oil (NGEO) EL250**
- **Cat Natural Gas Engine Oil (NGEO)**

Cat natural gas engine oils are the preferred oils for use in ALL Cat natural gas fueled engines that are covered by this Special Publication. Commercial alternative natural gas engine oils are, as a group, second choice oils.

Cat natural gas engine oils are formulated with the correct amounts of additives in order to provide superior performance in Cat natural gas engines.

Cat NGEO products have been tested throughout the world in demanding environments and have been tested in engines that use all types of gaseous fuel. Cat NGEO products are formulated and blended with special additives and high quality basestocks in order to provide protection against oxidation and nitration and to provide very good thermal stability. The formulations of these oils have been proven to be superior to many brands of available oil.

Cat NGEO products also provide the following benefits:

- Reduction of the formation of carbon and sludge
- Resistance to foaming
- Protection against cylinder liner wear
- Protection of valves and of valve seats
- Improved cleanliness of pistons
- Protection against scoring of the pistons and scuffing of the pistons

Table 1 lists the oil properties of Cat gas engine oils. The properties are based on ASTM test specifications.

Table 1

Cat NGE0 SAE 40 Viscosity Grade Properties				
Characteristic	ASTM Test	Cat NGE0	Cat EL250	Cat EL350
API Gravity at 16.0 ° C (60.8 ° F)	"D0287"	28	27.5	29.3
Flash Point 0 ° C (32 ° F)	"D0092"	252	262	247
Pour Point 0 ° C (32 ° F)	"D0097"	-15	-12	-21
Viscosity (cSt) at 100 ° C (212 ° F)	"D0445"	13.2	13.5	13.5
Viscosity Index	"D2270"	98	99	97
Weight (Percent) of Sulfated Ash	"D0874"	0.52	0.57	0.54
Total Base Number	"D2896"	5.6	6.5	6.2

## Engine Oil and Sour Gas Fuels

Many gaseous fuels contain sulfur compounds. These compounds are primarily composed of hydrogen sulfide (H<sub>2</sub>S). Gaseous fuels with less than 0.43 mg H<sub>2</sub>S/MJ (.45 µg H<sub>2</sub>S/Btu) are considered to be sweet gas.

Gaseous fuels with more than 0.43 mg H<sub>2</sub>S/MJ (.45 µg H<sub>2</sub>S/Btu) are considered to be sour gas. Sour gas can reduce the service life of an engine and of the engine oil. When the sulfur compounds are combined with water, acids are produced in the engine oil. These acids attack the metals in the engine crankcase and in other components. This causes corrosive wear. To reduce the effects of these sulfur compounds, Caterpillar recommends the use of devices that treat the fuel. For further information, see this Special Publication, "Hydrogen Sulfide Effects on Engine Maintenance Costs" in the Fuel Specifications section.

**Note:** Caterpillar does NOT recommend the use of engine oils with a high concentration of sulfated ash (greater than 0.6 percent) in order to reduce the harmful effects of sour gas. High levels of sulfated ash (greater than 0.6 percent) may produce excessive deposits on the valves and on the turbine wheel of the turbocharger. These deposits will reduce the service life of the engine. These deposits will also increase the cost of maintenance.

## Engine Oil and Bio-Gas Fuels

Bio-gas fuels that are generated from landfill or digester gas power plants can include contaminants that react with the engine lube oil. This can create varied combustion deposits. Excessive deposits on the piston, the liner, and the cylinder head can occur if the oil is not properly matched for the application. Laquering of the liner may also occur.

Lube oils that are specifically designed for applications that use bio-gas are recommended. These oils should have a concentration of sulfated ash that is not greater than 0.6 percent. When possible, these oils should also be formulated with Group II base stock. Group II base stocks have been shown to provide reduced engine deposit buildup. The use of a lube oil with a high concentration of sulfated ash will result in excessive deposits in the combustion chamber. Because of the inconsistent, variable composition of most bio-gas fuels, the lube oil may react differently to the composition of a particular fuel. Use the S-O-S oil analysis program to determine the proper oil change interval.

For new installations, sample the oil frequently in order to establish a consistent program for oil changes. Initially, sample the oil on a daily basis. The properties of landfill gas can change rapidly. Therefore, it is necessary to continue to monitor the oil on a weekly basis or two times per month in order to ensure adequate protection.

Consult your local Caterpillar dealer for a recommendation for lube oil for your bio-gas application.

## S-O-S Services Oil Analysis

Caterpillar recommends the S-O-S oil analysis program in order to monitor the condition of the oil. The analysis can help determine the maintenance requirements for the engine. The S-O-S program is part of the preventive maintenance program. For further information about the S-O-S program, see this Special Publication, "S-O-S Services Oil Analysis" topic.



i03115825

i03115827

## Commercial Oils

**SMCS Code:** 1318; 1348

Commercial oil specifications do not exist for Cat engines that operate on gaseous fuels. The performance of lubrication oil for gas engines is determined by a field evaluation. Successful field operation has been achieved with oils that meet the following guidelines:

- Caterpillar recommends the use of oils that are formulated specifically for heavy-duty gas engines. Do not use oils that are specially formulated for gasoline engines or for diesel engines.
- Caterpillar does not recommend multigrade oils for use in gas engines.
- Caterpillar recommends the use of oils that have a sulfated ash content between 0.40 and 0.60 percent.
- The oil must demonstrate adequate protection for a minimum of 7000 hours in a field evaluation under controlled conditions.

## 7000 Hour Field Performance Evaluation

Caterpillar recommends oils for gas engines that meet the requirements of the 7000 hour field evaluation. The 7000 hours of field service must be documented. Standard and/or Low Emission engine configurations may be used for the evaluation. The field evaluation must be performed in an engine configuration that is similar to the engine that will use the oil that is proposed. The field evaluation must be performed at a power level that is at least equal to the power that is required by the engine that will use the oil that is proposed.

Field evaluations may identify commercial brands of oil with successful results. Caterpillar will not endorse a commercial brand of oil because of the results. The oil company can use the results of the field evaluation as a proof of the oil performance. The oil company is responsible for the performance and the quality of the oil, and for any changes in the formulation of the oil. Before purchasing a lubrication oil for a gas engine, discuss the claims of performance for the oil with the oil supplier.

For additional details on the 7000 hour Field Performance Evaluation, refer to this Special Publication, "Field Evaluation of Commercial Oil" topic.

## Field Evaluation of Commercial Oil

**SMCS Code:** 1348

Due to the significant variations in the quality and in the performance of commercially available oils, Caterpillar makes the following recommendations, in order of oil performance:

- **Cat NGEO (Natural Gas Engine Oil) EL350 (SAE 40)**
- **Cat NGEO (Natural Gas Engine Oil) EL250 (SAE 40)**
- **Cat NGEO (Natural Gas Engine Oil) (SAE 40)**

Cat natural gas engine oils are the preferred oils for use in ALL Cat natural gas fueled engines that are covered by this Special Publication. Commercial alternative natural gas engine oils are, as a group, second choice oils.

Cat natural gas engine oils are formulated with the correct amounts of additives and high quality basestock in order to provide superior performance in Cat natural gas engines.

Caterpillar Inc. is frequently approached by engine owners and/or oil companies that wish to qualify an oil for use in gas engines. Caterpillar does not recommend the names of other commercial brands of lube oils. However, Caterpillar will evaluate the results of the Field Performance Evaluation for commercial brands of lube oils. The evaluation can verify that the oil meets the minimum lubrication requirements that are recommended by Caterpillar. Caterpillar has established the following guidelines for the Field Performance Evaluation of lube oil in gas engines. These guidelines are applicable to the engines that use the following fuels: dry natural gas, sour gas, and bio-gas.

## Operating Conditions for the Field Performance Evaluation

**Duration** – The minimum number of operating hours for a G3300, G3400, G3500, and G3600 is 7000 hours.

**Load Factor** – The load factor must be representative of the normal engine application at the site. High load factors are preferred.

**Lube Oil** – The oil must meet the requirements for the oil properties that are described in this Special Publication, “Engine Oil” topic. The oil must also meet the requirement for the formulation for gaseous fuel and the requirement for 0.40 to 0.60% sulfated ash that are described in the “Commercial Oils” topic.

**Oil Analysis** – Caterpillar recommends the S-O-S Services oil analysis program. Alternate oil analysis programs must measure oil condition and wear metals. Used oil samples must be obtained for analysis at 250 hour intervals. A baseline analysis of the new oil should also be obtained.

**Oil Change Interval** – The oil change interval is determined by condemning limits that are established by Caterpillar. The limits are based on analysis of the used oil and the trend lines that are established. For typical oil change intervals, see this Special Publication, “Oil Change Interval” topic.

**Fuel Analysis** – An analysis of the fuel must be provided by an independent laboratory at the beginning of the Field Performance Evaluation. The results from the gas analysis must meet the guidelines of the engine models. For the guidelines, see this Special Publication, “Fuel Specifications” section.

## Criteria for the Evaluation

**Oil Consumption** – The oil consumption must not exceed two times the initial oil consumption during the Field Performance Evaluation. The initial oil consumption is established during the first 1000 hours of operation with the oil that is being evaluated.

**Valve Recession** – The valves and the valve seats wear over time. This causes the valves to recede into the cylinder head. This condition is called “valve recession”. Measure the valve recession at the engine commissioning. This measurement is the baseline. The baseline is a reference for subsequent measurements. Measure the valve recession according to the engine Operation and Maintenance Manual, “Maintenance Interval Schedule”. The valve recession must not exceed the limits that are established for the engine by Caterpillar. Refer to the engine Operation and Maintenance Manual, “Valve Stem Projection - Measure/Record” topic for the limits for the valve recession.

**Parts Requirements** – If a new engine is used for the Field Performance Evaluation, all of the engine cylinders must be inspected with a borescope during the final inspection. The cylinder that shows the worst deposits or wear and the cylinder that shows average deposits or wear must be used for the visual inspection. If a used engine is used to evaluate the oil, two new sets of these components must be installed before the Field Performance Evaluation: pistons, piston rings, cylinder liners, and cylinder heads. These new components will be examined during the final inspection.

**Final Inspection** – At the end of the Field Performance Evaluation, these components from two cylinders must be removed and inspected:

- Pistons
- Piston rings
- Cylinder liners
- Cylinder heads

None of the following conditions are acceptable:

- Sticking of the piston rings
- Scuffing of the piston rings and/or cylinder liners
- Excessive wear of the piston rings
- Polishing of the cylinder liner bore must be confined to the area that is affected by the uppermost position of the top piston ring.
- The entire circumferences of the inlet valves and the exhaust valves must seal.
- Guttering of the valves is not acceptable.

Close up photographs that show the wear and deposits must be taken in order to document the appearance of these components: pistons, piston rings, cylinder liners, crankcase, top deck of the cylinder head, bottom deck of the cylinder head, inlet valves, and exhaust valves (bottom, face, and stem). In addition, two exhaust valve guides must be removed from two cylinders and sectioned lengthwise. Photographs that show the entire component must also be provided.

**Summary** – This procedure for a field evaluation provides the oil company and the engine owner with a method of evaluating a lubricating oil for gas engines. If the oil meets these guidelines for the field evaluation, the oil has fulfilled the Caterpillar requirements. Caterpillar will not endorse any oil for use in Cat gas engines as a result of field evaluation. The oil company can use the evaluation as proof of performance.

## Responsibilities

**Care must be taken in order to define the responsibilities of each person that is involved in the Field Performance Evaluation.** The oil company and the engine owner must recognize the responsibilities if the performance of the oil reduces the service life of the engine. Caterpillar recommends specific definitions of the responsibilities for the oil company and the engine owner in a field evaluation. An agreement should be made before the field evaluation is initiated. Both the oil company and the engine owner must understand that the Field Performance Evaluation is not monitored by Caterpillar. The field evaluation is not sponsored by Caterpillar.

## Field Performance Evaluation Agreement

The Field Performance Evaluation agreement is between the engine owner and the oil company. The agreement is a very important part of the field evaluation. The completion and signing of the agreement should occur before the initiation of the field evaluation. The agreement must fully define the field evaluation and the responsibilities of each party. This publication contains the information and guidelines that are necessary to write a detailed agreement. The initial field evaluation involves some risk. Use of the guidelines will minimize the risk. If the guidelines are followed, the probability of a successful field evaluation will be enhanced.

### Responsibilities of the Oil Company

**Performance** – The performance of the oil is the responsibility of the oil company. The oil must maintain stable oil control and the oil must control deposits in the combustion chamber and in the crankcase. Engine service life must be maintained at the predicted stage for the particular engine application.

**Supply** – The supply of the oil is the responsibility of the oil company. If special storage and/or shipping is required, the oil company should cover the cost of those items.

**Oil and Fuel Analysis** – During the evaluation, the oil company should pay for the cost of the oil and fuel analyses. The oil samples should be analyzed by a Cat S·O·S Services regional lab or by the local Caterpillar dealer in the S·O·S Services program. The data that is obtained from the oil analyses must be plotted in order to establish trends. The fuel should be analyzed by an independent laboratory. Results of the oil and fuel analyses must be sent to the engine owner. The owner should review the data. Also, the owner should keep records of the data.

**Hardware** – If the oil is evaluated in a used engine, two new sets of these components must be installed before the Field Performance Evaluation:

- pistons
- piston rings
- connecting rod bearings
- cylinder liners
- cylinder heads

The cost should be covered by the oil company. These new components will be examined as part of the final inspection.

**Final Inspection** – The cost of the final inspection should be paid by the oil company. If the final inspection reveals severe deposits and/or damage to the hardware, the oil company must make the repairs that are necessary for restoring the engine to an acceptable condition.

**End of the Evaluation** – After completion of the Field Performance Evaluation, the oil company should work with the engine owner in order to restore the engine to normal operation. If the Field Performance Evaluation is not completed, the same conditions should be applicable. The oil company should bear the cost of the restoration. This could include the cost for the removal of storage tanks, special piping, flow meters, and instrumentation.

**Final Report** – The oil company must prepare a final report that documents the following items:

- The data on oil consumption must be recorded on a minimum schedule of every two weeks. A chart of the data must be included in the final report.
- Results of the oil analysis must be plotted.
- Oil changes
- Replacement of the oil filters
- Results of fuel analysis

- A histogram for fuel consumption or a histogram for power output
- A histogram for average engine speed
- The typical duty cycle
- Valve recession
- Side clearance for the piston ring
- Valve guide to valve stem clearances
- Close up photographs of the following components from two cylinders must also be included: pistons, piston rings before removal and after removal, piston ring grooves after removal, cylinder liners, crankcase, top deck of the cylinder head, bottom deck of the cylinder head, inlet valves (top and bottom), and exhaust valves (top and bottom).

The final report should be confidential. The final report must be made available to the engine owner and to Caterpillar, Inc..

### Responsibilities of the Engine Owner

**Engine for the Evaluation** – The owner must provide access to the engine for the duration of the Field Performance Evaluation. Special piping and instrumentation may be attached to the engine for the duration of the field evaluation.

**Operation and Maintenance** – Daily operation and maintenance of the engine is the responsibility of the owner. Operation and maintenance of the engine must follow the guidelines that are published by Caterpillar in the engine Operation and Maintenance Manual. The daily records of this activity should be made available to the oil company.

**Oil Samples and Fuel Samples** – Oil samples and fuel samples will be collected by the owner. The samples will be sent to the appropriate laboratory for analysis.

### Caterpillar Responsibilities

**Advisory** – Caterpillar will not assume an active function in the field evaluation. However, Caterpillar will provide technical advice and guidance to the parties that are involved. Caterpillar understands that this function does not satisfy all of the situations that may arise in a field evaluation. Therefore, technical judgments may be required for the initiation of some evaluations.

To provide assistance with the Field Performance Evaluation, your Caterpillar dealer or district representative can consult the appropriate technical support personnel at Caterpillar Inc.

**Final Inspection** – Under some circumstances, Caterpillar is asked to assist with the inspection. This is evaluated on an individual basis. The decision depends on the availability of personnel and on the amount of technical interest.

**Note:** All associated travel, meals, and lodging are at the expense of the oil company.

## Guidelines for the Use of A Proven Lubricant In Other Engines (Interchanging)

**Interchanging** – The information that is obtained from most field evaluations will be applicable to other gas engines at other sites. However, guidelines must be established in order to limit the application of a lubricant that has been evaluated. This is for the protection of the engine and the engine owner. The limit on the application of the lubricant is defined as interchanging.

The interchanging of the lubricant is limited by these factors:

- The oil viscosity grade
- The base stock of the oil
- The engine configuration
- The engine rating
- The engine application
- The engine load factor
- The fuel type

### Oil Viscosity Grade

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. To determine the oil viscosity that is required for starting a cold soaked engine, refer to the minimum temperature in Table 2. To select the oil viscosity for operation at the highest anticipated ambient temperature, refer to the maximum temperature in Table 2. Use the highest oil viscosity that is available in order to meet the required temperature during start up. The oils that have the higher oil viscosity will maintain the highest possible oil film thickness.

Table 2

Engine Oil Viscosity		
Oil 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)

**Note: Cat NGEN oils are available in SAE 40 grade only. Multigrade oils are NOT recommended for use in Cat Gas Engines. If other grades of viscosity are selected, ensure that the oil meets the requirements for Cat Gas Engines. Consult the supplier of the oil.**

**Note:** In G3600 engines, only SAE 40 is recommended. Also, when the ambient temperature is 10 °C (50 °F) or less, an oil heater is recommended.

## Base Stock of the Oil

Finished lubricants are made of base stocks and additives. Properly blended lubricants will have base stocks and additives that work together in order to consistently provide the following qualities: adequate control of deposits, adequate control of wear, adequate service life of the oil, stability to oxidation and nitration, and resistance to corrosion.

The quality and performance of a base stock depends on the source of the crude oil and the process that is used to produce the base stock. The performance of the base stock can have a significant effect on the performance of the finished lubricant. A responsible oil company closely controls the quality of the base stock by testing the oil in laboratories and in engines. Through careful testing, the oil company can identify base stocks that provide similar performance levels.

Because of the complex chemistry that is involved with the evaluation of base stocks, Caterpillar cannot establish stringent guidelines for the interchanging of base stocks. However, the following characteristics can be used for identifying differences in the performance of base stocks.

**Viscosity index** – The viscosity index of single grade oil is an estimate of the base oil composition. Oil that has a viscosity index that is less than 95 could contain a significant amount of naphthenic base stocks. Otherwise, the base stock could have a low level of processing. Naphthenic base stocks do not provide the same performance as paraffinic base stocks. A finished lubricant must be specially blended in order to use naphthenic base stocks.

Oil that has viscosity index of 95 or more contains paraffinic base stock. If the viscosity index of different shipments of a particular oil increases or decreases by more than 5, the base stock could have been significantly changed. If this occurs, the oil company should be questioned regarding the source and quality of the base stock.

**API base oil classification** – The API has divided base stocks into five groups. The groups are identified by the viscosity index and by chemical composition. The different groups provide different performance in the finished lubricants. The interchanging of base stocks between those groups is NOT recommended. The API base stock group cannot be easily detected in the finished lubricant. Therefore, the oil company must inform the customer about the type of base stock in the finished lubricant. The oil company must also inform the customer if the base stock is changed to a different API base stock group.

The oil company must accept the responsibility for the performance of the finished oil. This responsibility includes the additives and the base stocks. Any significant changes to the composition of the finished oil must be reported to the customer in order for the risk to be evaluated.

## Engine Configuration

Lube oil cannot be interchanged between engines that use different types of fuel.

Lube oil that is evaluated in G3500 Series Low Emissions Engines may also be used in G3300, G3400, and G3500 engines.

Lube oil for G3600 Series Engines must be evaluated in a G3600 Series Engine.

Lube oil that is evaluated in G3400 Series or G3300 Series Engines may ONLY be used in G3400 Series or G3300 Series Engines.

## Engine Rating

The average power output that is produced by the engine during the field evaluation is used to establish the power rating of the field evaluation. The power output must be expressed as Brake Mean Effective Pressure (BMEP). The power output is derived from one of the following sources:

- Output of the generator set
- Torque meter
- Output of the gas compressor
- Displayed load for the engine

In order to calculate the BMEP, the average engine power output must be expressed in kilowatts. Use the equation in Table 3 to calculate the BMEP.

Table 3

Equation for Calculating the Brake Mean Effective Pressure (BMEP)			
$\frac{120\,000}{L}$	×	$\frac{\text{kW}}{\text{rpm}}$	= BMEP (kg/meter <sup>2</sup> )
kW is the average engine power output during the evaluation.			
L is the total displacement of the engine in liters.			

Lube oil can be interchanged between engines at different sites that operate with a similar duty cycle. However, the interchanging is limited by a maximum of a ten percent increase in BMEP.

Duty cycles can vary greatly between different sites and between different engine configurations. Therefore, it is difficult to determine an accurate degree of severity for oil in all the various duty cycles. For best results, only use the proven oil in applications with a similar duty cycle. When different duty cycles are introduced, the risk is increased.

**Note:** For cases with different duty cycles, the oil company and the engine owner will assess the risk in order to determine if another Field Performance Evaluation is required. In most cases, an oil with proven performance in a particular duty cycle will be preferred over an oil that has not been proven for that duty cycle.

i03116067

## Synthetic Base Stock Oils

**SMCS Code:** 1300; 1348; 7581

Synthetic base oils are acceptable for use in Cat engines if these oils meet the performance requirements that are specified for the engine.

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.

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

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

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

i03116076

## Re-refined Base Stock Oils

**SMCS Code:** 1300; 1348; 7581

Re-refined basestock oils are acceptable for use in Cat 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 a re-refined base oil.

**Note:** Just filtering is inadequate for the production of re-refined basestock oils from used oil.

i03116125

## 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 maximum service life of the engine 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 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.

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

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

i03116161

## Oil Change Interval (and Oil Sampling)

**SMCS Code:** 1348

The standard oil change interval for a Cat gas engine is available in the Operation and Maintenance Manual. Consult the Operation and Maintenance Manual for the specific engine model under consideration.

In some applications, the oil drain may need to be reduced. Some factors that can reduce an oil drain are fuel type, fuel contamination, operating conditions, and environment. In other applications there could be additional life available in the oil. In both cases, the oil drain can be adjusted through the use of S·O·S Services oil analysis.

In an oil drain optimization program, it is strongly suggested that oil drain extensions be limited to 250 hour intervals. For example, if the standard oil drain is 1000 hours, and the oil appears to have additional life, the first extension should not exceed 1250 hours. The 1250 hour oil drain interval should be evaluated for three service periods, before another extension is considered.

Consult with your Caterpillar S·O·S Services laboratory regarding the adjustment or optimization of oil change intervals. Your S·O·S consultant will work with you to develop a plan that provides optimum oil life without compromising engine life of durability.

One of the basic characteristics of an oil evaluation program is consistent oil sampling and frequent oil sampling. For Cat gas engines, oil samples should be taken every 250 hours. This consistent rate of sampling is especially important if an engine is operating on an inconsistent gas supply.

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

**The maximum increment for increasing the oil change interval is 250 service hours.** This is particularly important if a long amount of time is required to obtain results of oil analysis.

Illustration 1 is a graphic representation of adjusting the oil change interval.

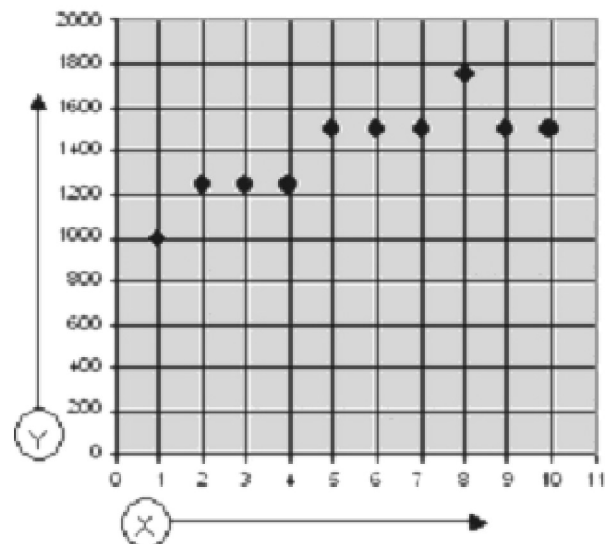


Illustration 1

g01933230

Adjustment of oil change intervals

(X) Numbers of oil changes  
(Y) Service hours

In Illustration 1, the initial oil change was performed after 1000 service hours. The interval was increased in 250 hour increments. At oil change number 8, the oil had reached the condemning limit after 1750 service hours. Therefore, the interval was reduced to 1500 service hours. The results of the oil analysis were acceptable when the oil was used for 1500 service hours.

i04127249

## S·O·S Services Oil Analysis

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

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

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

**Component wear rate** analysis evaluates the wear that is taking place inside the engine. The S·O·S analyst uses the results of elemental analysis 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 in order to determine if the oil has degraded. Tests are performed in order to look at the oxidation, nitration, and viscosity of the oil. The S·O·S analyst uses trend analysis and proprietary guidelines to determine if the oil has reached the end of useful life.

**Note:** The standard oil analysis should include: Oxidation, Nitration, Viscosity, and wear metals at a minimum.

**Oil contamination** tests are performed in order to determine if anything harmful has entered the oil. This analysis relies on the results from the following tests: elemental analysis, water, and glycol. The S·O·S Services program has guidelines that are used in order to evaluate the level of contamination in the engine oil.

**Oil identification** is another important part of the S·O·S Oil Analysis program. The wrong oil in an engine can severely damage internal components. The wrong oil can also produce excessive deposits in the combustion chamber. Deposits in the combustion chamber may lead to valve failures, piston ring scuffing, and a loss of oil control. The S·O·S analyst uses elemental analysis and viscosity results to identify key characteristics of the oils.

These four types of analysis are used to monitor the condition of your engine, and to help you identify potential problems. A properly administered S·O·S Services Oil Analysis program helps prevent costly damage, reduces repair costs, and reduces downtime.

**Note:** Obtain each oil sample when the oil is warm and mixed. The sample is ensured to be representative of the oil in the engine crankcase.

## Corrosive Gaseous Fuels

Corrosive gases may contain high levels of sulfur compounds, halide compounds, and ammonia compounds. Your Cat dealer has specific guidelines for these corrosive compounds. Consult your Cat dealer regarding the best methods for measuring and controlling these compounds in your gaseous fuel supply.

When these corrosive compounds are present in gaseous fuels, perform additional tests on used gas engine oils. These additional tests may also be used if an oil related issue cannot be resolved through the standard set of S·O·S Services tests.

Some gaseous fuels may contain significant amounts of corrosive compounds. These corrosive compounds can form highly corrosive acids in the engine oil. The S·O·S Services tests for Oxidation, Nitration, and Viscosity will indicate that these acids have degraded the oil. In many applications, these tests are sufficient to alert the customer regarding problems with oil deterioration. However, TAN and TBN are recommended in addition to the standard S·O·S Services tests.



There are two ASTM test methods for the TBN test: "D2896" and "D4739". The "D2896" method is run to establish the TBN of new oils. "D2896" is best used when sulfur compounds are present. "D2896" does not always show a consistent decrease in base number with oil deterioration. The "D4739" method is more effective when monitoring the deterioration of used engine oils. "D4739" usually shows a consistent decrease in base number, as an oil deteriorates. "D4739" responds to sulfuric acids and formic acids. A trained analyst, in the S·O·S Services program, should be utilized to interpret TBN results. The S·O·S analyst understands the correlation of TBN results to: corrosive wear, oil oxidation, and oil nitration.

Another test that is sometimes used to evaluate oil condition is Total Acid Number (TAN). The preferred method for TAN testing is ASTM "D664". The TAN test is a measure of the acids that are formed in the used oil. TAN values will increase as oil deteriorates. Like the TBN tests, the TAN test has limitations. Sometimes, the TAN test does not measure all of the acids that are present in the oil. A trained analyst, in the S·O·S Services program, should be utilized to interpret TAN results. The S·O·S analyst understands the correlation of TAN results to: corrosive wear, oil oxidation, and oil nitration.

Because of the specialized nature, all S·O·S Services laboratories may not be equipped to run TBN and TAN tests. If your S·O·S Services lab cannot run these tests, your dealership can make arrangements to run these tests at another laboratory.

TAN and TBN results combined with the normal S·O·S data can be helpful in trending the oil condition.

**Note: S·O·S Services oil analysis for all bio gas sites and any site that may have corrosive compounds in the gaseous fuel should include: Oxidation, Nitration, Viscosity, Wear Metal, TAN, and TBN test results.**

## Silicon Containing Gases

Cat gas engines that operate on landfill gases may experience high levels of silicon in the lubricating oil. One possible source of this silicon is from a family of gases called siloxanes. Siloxanes are organic compounds composed of silicon, oxygen, and methyl groups. After combustion, this type of silicon enters the oil through the blow-by gasses and the oil film on the cylinder liners.

The silicon compounds from siloxane gases are much less abrasive than silicon compounds found in dirt. Gas engines can operate with silicon levels up to 125 ppm when the source of the silicon is siloxane gases. A trained analyst should be utilized to determine the safe level of silicon and the source of the silicon. Elevated silicon levels caused by dirt entry will severely damage internal engine components. Refer to the Special Publication, LEBW4977, "Gaseous Fuels - Application and Installation Guide" for more information on siloxane gases and other contaminants.

## S·O·S Services Oil Analysis Guidelines

A trained analyst, at your Cat dealership, interprets the results of these oil analysis tests. S·O·S Services oil interpretation is built on a system of trend analysis, correlating data, and historical guidelines. The S·O·S Services analyst understands the interactions of each test. Analysts use this information to make an accurate interpretation of the oil analysis test results.

The table below lists the guidelines that are used to evaluate used engine oils.

Table 4

Oil Analysis Guidelines for non-corrosive <sup>(1)</sup> , low silicon <sup>(1)</sup> , gaseous fuels		
Test Parameter	S-O-S Services Oil Analysis	General Oil Analysis
Water	0.5% Maximum	0.5% Maximum
Glycol	0.1% Maximum	0.1% Maximum
Viscosity "ASTM D445", at 100° C (212° F)	+3 centistoke (cSt) change from new oil viscosity	+3 centistoke (cSt) change from new oil viscosity
Elemental Analysis	Cat statistical norms and trend analysis <sup>(2)</sup>	Trend Analysis and statistical limits established by the testing laboratory <sup>(3)</sup>
Oxidation	Cat guidelines and trend analysis	0.25 absorbance / cm <sup>-1</sup> based on "ASTM D7418" differential scan method, and trend analysis
Nitration	Cat guidelines and trend analysis	0.25 absorbance / cm <sup>-1</sup> based on "ASTM D7418" differential scan method, and trend analysis
Additional Oil Analysis Guidelines for corrosive <sup>(1)</sup> , high silicon <sup>(1)</sup> , gaseous fuels		
Total Acid Number (TAN) by "ASTM D664"	3.0 maximum or 2.0 greater TAN than the new oil	3.0 maximum or 2.0 greater TAN than the new oil
Total Base Number (TBN) by "ASTM D2896"	50% of new oil TBN	50% of new oil TBN

<sup>(1)</sup> Consult your Cat dealer for specific guidelines regarding sulfur compounds, halide compounds, ammonia compounds, and silicon compounds found in corrosive gaseous fuels.

<sup>(2)</sup> A trend can be established from the results of three oil analyses.

<sup>(3)</sup> Consult with your independent laboratory regarding guidelines for elemental analysis.

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

## Trend Analysis

Illustration 2 is an example of a graph for the trends of wear metal analysis and of infrared analysis.

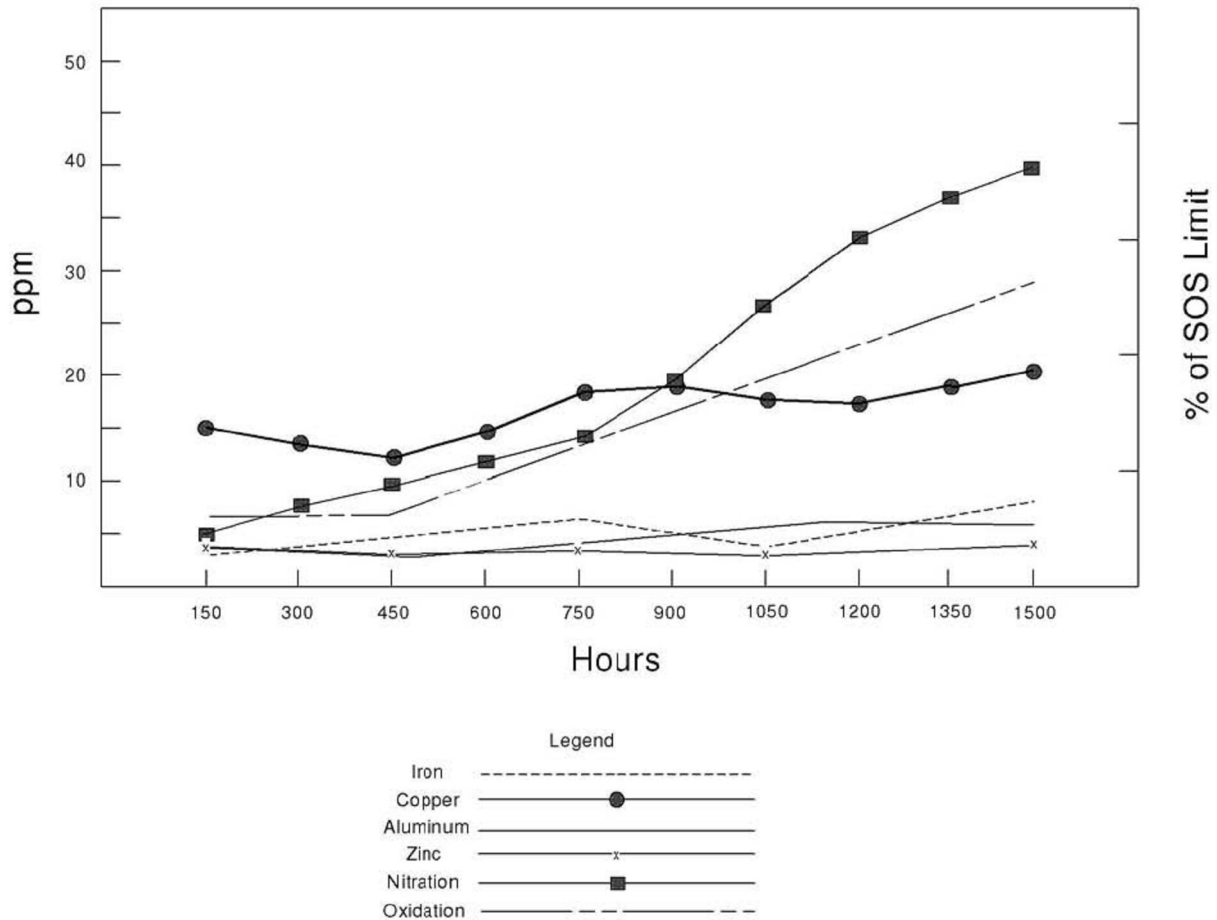


Illustration 2

g01934716

The analysis of the wear metals in Illustration 2 shows typical normal levels. However, the level of nitration has exceeded the acceptable limit. The oxidation is also increasing. In conclusion, this analysis indicates that the engine oil must be replaced.

In the absence of analysis, change the engine oil according to the engine Operation and Maintenance Manual, "Maintenance Interval Schedule".

- Cat HYDO Advanced 10
- Cat Bio HYDO Advanced

### Cat HYDO Advanced 10 (Hydraulic Oil)

Cat HYDO Advanced 10 (SAE 10W) is designed to provide extended oil drain intervals and to provide extra protection to Cat hydraulic system components.

Cat HYDO Advanced 10 is a combination of premium additives and premium base stock that pass severe qualification testing requirements in order to provide superior protection for Cat hydraulic systems.

i03116230

## Hydraulic Oil

**SMCS Code:** 1348; 4250; 5050; 5095; 7581

### Applications

- Hydraulic Systems
- Hydrostatic Transmissions

Caterpillar offers two hydraulic oil products:

**Cat HYDO Advanced 10 has a 50% increase in the standard oil drain interval for machine hydraulic systems (3000 hours versus 2000 hours) over second and third choice oils when following the maintenance interval schedule for oil filter changes and for oil sampling that is stated in the Operation and Maintenance Manual for your particular machine. 6000 hour oil drain intervals are possible with Cat HYDO Advanced 10 when using S·O·S Services oil analysis. Consult your Caterpillar dealer for details.**

Cat HYDO Advanced 10 offers the following benefits: protection against mechanical wear, rusting, and corrosive wear in hydraulic systems and in hydrostatic transmission systems. Cat HYDO Advanced 10 should be used to achieve maximum life and maximum performance from hydraulic system components and from hydrostatic transmissions. In order to gain the most benefit from the improved performance designed into Cat HYDO Advanced 10, when switching to Cat HYDO Advanced 10, cross contamination with the previous hydraulic oil should be kept to less than 10%. Cat HYDO Advanced 10 is preferred in most hydraulic systems and in most hydrostatic systems when ambient temperature is between -20 °C (-4 °F) and 40 °C (104 °F).

**Note: Cat HYDO Advanced 10 fully replaced Cat HYDO oil. Cat HYDO is no longer available.**

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

- Cat DEO ULS Multigrade
- Cat DEO Multigrade
- Cat DEO ULS SYN
- Cat Arctic DEO SYN
- Cat TDTO
- Cat Arctic TDTO
- Cat TDTO-TMS
- Cat MTO

**Note:** Cat oil availability will vary by region.

**Note:** Cat HYDO Advanced 10 can be used in hydraulic systems of other Original Equipment Manufacturers (OEMs). Refer to you manufacture's requirements for application details.

## Commercial Hydraulic Oils

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

---

### NOTICE

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

---

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

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

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

**Note: Industrial hydraulic oils are not recommended for use as service fill in Caterpillar machine hydraulic systems.**

## Cat Bio HYDO Advanced (Hydraulic Oil)

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

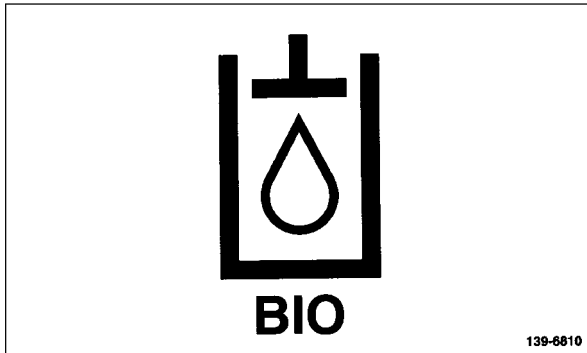


Illustration 3

g00103844

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

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

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

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

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

## Commercial Biodegradable Hydraulic Oil

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

### NOTICE

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

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

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

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

### NOTICE

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

Systems with illustration 3 are filled with biodegradable hydraulic oil. This symbol is located on the hydraulic tank.

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

i04127531

## Lubricating Grease

**SMCS Code:** 1000; 7581

### NOTICE

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

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

### NOTICE

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

Cat provides various greases that vary in performance from a moderate performance to a high performance. Cat greases service the entire line of Cat products in the wide variety of climates throughout the world. From this variety of Cat grease products, you can find a Cat grease that will meet or exceed the performance requirements for almost every 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 Cat dealer for a list of greases that have the performance specifications and the available container sizes.

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

If a single grease is needed for use for all of the equipment at one site, always choose a grease that meets or exceeds the requirements of the most demanding application. Remember that the products which barely meet the minimum performance requirements can be expected to barely produce the minimum parts life. False economy is being used if a grease is purchased with the lowest cost as the only consideration. Instead, use the grease that yields the lowest total operating cost. This cost should be based on an analysis that includes parts, labor, downtime, and the amount of grease that is required.

**Note:** When the grease in a joint is changed from one type of grease to another, Cat recommends purging all of the old grease from the joint because some greases are not chemically compatible. Consult your supplier in order to determine if the greases are compatible.

**If in doubt, Purge!**

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

## Cat Multipurpose Grease

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

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

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

## Cat White Assembly Grease

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

## Cat Advanced 3Moly Grease

Cat Advanced 3Moly Grease is an NLGI grade 2 grease. This grease is made with petroleum base oil and a lithium complex thickener. This grease also has 3% Molybdenum Disulfide ( $\text{MoS}_2$  or “Moly”). Cat Advanced 3Moly Grease is formulated for use in applications with low severity to high severity at moderate temperatures. The molybdenum in Cat Advanced 3Moly Grease is a special grade with a median particle size of 3 microns meeting the special requirements of some rolling element bearings.

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

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

## Severe Applications

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

## Hammer Grease

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

## Cat Ultra 5Moly Grease

Cat Ultra 5Moly Grease are available in NLGI grades 0, 1, and 2. Cat Ultra 5Moly Greases are made with special blends of petroleum base oils and a Calcium Sulfonate Complex thickener. These greases also have 5% Molybdenum Disulfide ( $\text{MoS}_2$  or "Moly") and added tackifier. Cat Ultra 5Moly Greases are specially formulated in order to protect heavily loaded joints against galling, wear, and corrosion. This protection is sustained while work is being done in moderate temperatures and with wet working conditions or dry working conditions.

Cat Ultra 5Moly Greases are formulated with special blends of naphthenic petroleum base oils that have low pour points. Cat Ultra 5Moly Greases will pump at lower temperatures. The pumpability at lower temperatures means added insurance that all of the grease joints in the machine will be adequately lubricated. Pumpability is important when the critical lubrication points rely on an automatic lubrication system.

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

Even under severely loaded conditions, the grease should preferably have a long working life. A Calcium Sulfonate Complex thickener with a properly blended naphthenic oil and/or a synthetic base oil is required. Cat uses these ingredients in Cat Ultra 5Moly Greases.

Cat Ultra 5Moly Greases also have 5% Moly, instead of the 0% to 3% that is found in most other greases. This additional Moly greatly improves the ability of the grease to protect parts from damage in applications with severe impact (slamming). The Moly in Cat Ultra 5Moly Grease is a special grade with a median particle size of 3 microns meeting 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. An example of this application is swing gears for excavators. Many conventional greases do not have enough of the tacky characteristic in order to allow the grease to stay in place. In addition, many of these greases do not have the performance in order to protect the gear teeth adequately in these applications.

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

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

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

## Cat Desert Gold Grease

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

Cat Desert Gold Grease is an NLGI grade 2 grease. This grease is made with a synthetic base oil that has a high viscosity and a Calcium Sulfonate Complex thickener. This grease also has 5% Molybdenum Disulfide ( $\text{MoS}_2$  or "Moly") and tackifier.

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

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

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

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

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

Cat Desert Gold Grease can be used in applications that require the lubricant to last for long periods. Cat grease has a high performance and long life.

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

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

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

## Cat Arctic Platinum

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

Cat Arctic Platinum Grease is made with a synthetic base oil that has a low viscosity and a Calcium Sulfonate Complex thickener. The performance is enhanced with 5% Molybdenum Disulfide ( $\text{MoS}_2$  or "Moly") and tackifier.

Because the base oil is synthetic, Cat Arctic Platinum Grease has a minimal change in viscosity as the temperatures drop. The Cat Arctic Platinum Grease has a minimal change in viscosity and flows easily as the temperature drops. Cat Arctic Platinum Grease pumps easily at low temperatures. In fact, Cat Arctic Platinum Grease NLGI grade 0 can be pumped through standard automatic lubrication systems that are machine mounted and at temperatures down to  $-50\text{ }^{\circ}\text{C}$  ( $-58\text{ }^{\circ}\text{F}$ ). 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 for protection against galling, wear, fretting, water washout, and corrosion.

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

Cat Arctic Platinum Grease has 5% of molybdenum instead of 0% or 3% that is found in most of the other greases. This additional molybdenum greatly improves the ability of the grease in order to protect parts from damage in applications with severe impact (slamming). In addition, the molybdenum in Cat Arctic Platinum Grease is a special grade. This molybdenum has a median particle size of 3 microns in order to meet the special requirements of some rolling element bearings.

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

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



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

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

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

## Cat High Speed Ball Bearing Grease

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

Cat High Speed Ball Bearing Grease is formulated not to contain lead, antimony, barium, zinc, phosphorous, or chlorine additives. When Cat High Speed Ball Bearing Grease is compared to many others, the Cat High Speed Ball Bearing Grease is more environmentally friendly.

## Grease Application Charts

### Type of Grease

Severe Applications consist of the following:

- heavy loads
- frequent oscillations
- heavy shock loads

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

N/R = Not Recommended

Table 5

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

**Type of Grease (continued)**

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

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

Green (Environmentally) Friendly means that the grease is not formulated to contain Lead, Antimony, Barium, Zinc, Phosphorous, or Chlorine additives.

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

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

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

Table 6

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

---

# Fuel Specifications

i03127807

## 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.

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

---

The information that is provided is the latest recommendations for the Cat gas engines that are covered by this Special Publication. This information supersedes all previous recommendations which have been published for the Cat gas 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

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

---

### NOTICE

**Refer to the engine Operation and Maintenance Manual for any fuel information that may be specific to that application.**

---

Gaseous fuels consist primarily of hydrocarbons (combinations of hydrogen and carbon) and some inert gases. Pipeline natural gas has been used for many years. Other types of fuels such as wellhead gas, bio-gas, and manufactured gas need to be reviewed for acceptability.

Each commercial fuel gas is a mixture of gases. Some of the gases are combustible and some of the gases are inert. The compositions of these gas mixtures have extreme variations.

Cat gas engines will operate successfully on a broad range of gaseous fuels. Adjustments must be made to the fuel system when the engine is commissioned or when the fuel is changed. Consult your Caterpillar dealer about the proper adjustments.

Permissible fuels must be analyzed in order to determine the following characteristics:

- Composition
- Contaminants
- Heat value
- Methane number
- Specific gravity

Field gas can have varying characteristics of combustion. Field gas can contain numerous harmful impurities. The impurities can alter the BTU value. The impurities can also alter the methane number. The impurities include everything from water up to complex hydrocarbons that can lead to detonation and severe engine damage. In order to minimize these effects, Caterpillar recommends the following guidelines:

- Evaluate the fuel with the most current revision level of Caterpillar Methane Number Program, LEKQ6378.
- Methane values below 30 are not recommended for use in a Cat engine. Fuels with a methane number that is below 30 must first be processed in order to remove harmful impurities in the fuel and raising the methane number into the acceptable range.
- If necessary, use an engine that is configured for a fuel that has a high energy. Consult the appropriate manual for the engine in order to determine the recommended engine timing.
- Reduce the oil change interval according to the results of the oil analysis.

Before the engine arrangement is ordered, use the methane number in order to determine the following characteristics for the new engine:

- Compression ratio
- Fuel system components

- Ignition timing
- Rated load

For a detailed explanation of methane numbers, refer to the most current revision level of Special Publication, LEBW4977, "Gaseous Fuels - Application and Installation Guide".

The High Heat Value (HHV) is a measurement of the total heat that is generated by combustion of a fuel. When any hydrocarbon is used as a fuel in an internal combustion engine, water is one of the products of combustion. The water is converted into steam before leaving the engine. The conversion requires heat. The steam removes the heat and the energy is not used by the engine. The HHV minus the heat that is used to vaporize the water equals the Low Heat Value (LHV) of the fuel. The LHV is sometimes known as the fuel energy content. Generally, fuel with a lower LHV releases heat less rapidly.

i03615747

## Fuel Effects on Maintenance Costs

**SMCS Code:** 1280

There are many sources of the fuel that is used in gas engines. These different sources may have an effect on the engine maintenance intervals. These sources include pipeline natural gas, wellhead gas, bio-gas, and propane.

With pipeline natural gas, maintenance intervals might be extended. Due to the harmful effects of impurities that contaminate gases such as bio-gas, shorter maintenance intervals would be expected. These maintenance intervals can be improved by processing the gas in order to remove damaging impurities.

For more information on types of fuels, refer to the appropriate topics in this Special Publication, "Fuel Specifications" section. For specific information on the maintenance intervals, refer to the Operation and Maintenance Manual for the engine.

i03615781

## Propane

**SMCS Code:** 1280

### NOTICE

Propane and blends of propane may cause detonation in high compression engines. Propane fuel should never be used with G3600 engines.

Propane is transported to a site as a liquid. The liquid is converted into a gas at the site.

For the guidelines in this Special Publication, propane must meet these HD-5 specifications ("Gas Processors Association, GPA Standard 2140-97, Liquefied Petroleum Gas Specifications and Test Methods"):

- 95 percent propane
- Remaining 5 percent is not heavier than butane.

The engine must be properly equipped for the use of propane. The use of pistons with a low compression ratio and a derating is required.

HD-5 propane has a Low Heat Value (LHV) between 2427 to 2532 kJ/0.305 m<sup>3</sup> (2300 to 2400 Btu/ft<sup>3</sup>). Due to the higher heat of combustion that is produced by propane, engines that use this fuel will have higher exhaust port temperatures than engines that use dry natural gas.

The higher exhaust temperatures tend to reduce the service life of the cylinder head, of the exhaust manifold, and of the turbocharger.

i03615900

## Wellhead Gas

**SMCS Code:** 1280-G6

Wellhead gas (field gas) is a mixture of hydrocarbons and inert gases that is drawn directly from the wellhead in the gas field. Wellhead gas has minimal processing before entering the fuel manifold. This fuel is commonly used in engines that power gas compressors.

The composition of gas from the wellheads in different gas fields varies, and the composition of the gas from different wellheads within the same gas field can vary. Different compositions have different characteristics of combustion. As a result, the gas from one source may be acceptable for use but the gas from a different source may not be acceptable. Heavier hydrocarbons such as pentane and butane can cause detonation and other problems. For these reasons, a fuel analysis is required to determine if the fuel is acceptable for a particular Cat engine.

**Note:** The composition of the gas from a field can change over time. Allow some adaptability for this change during the life of the project.

Some gas fields contain significant amounts of hydrogen sulfide. In these cases, follow the precautions that are recommended in this Special Publication, "Sour Gas" topic.

The site may have equipment such as scrubbers, liquid separators, and heat exchangers that remove water and liquid hydrocarbons from the gas. However, vapor can still be drawn into the engine. The maintenance costs are variable for engines that use wellhead gas. Sometimes, overhauls are needed at intervals that are sooner than the expected time. However, the practices and factors at many sites enable overhaul intervals that are longer than the expected times: efficient preventive maintenance, proper engine oil, and operation below the rated load.

Follow the guide for fuel usage that is in the Engine Performance publication. These publications are available from your Caterpillar dealer.

Consult your Caterpillar dealer before operating the engine with fuel that has hydrocarbons that are heavier than butane.

**Note: Use the Cat Methane Program, LEKQ6378 to determine if the fuel is suitable for the particular engine application.**

i03127810

## Sour Gas

**SMCS Code:** 1280

Many gaseous fuels contain sulfur compounds. These compounds are primarily composed of hydrogen sulfide ( $H_2S$ ). Gaseous fuels with more than 0.43 mg  $H_2S$ /MJ (.45  $\mu g$   $H_2S$ /Btu) or above 10 ppm are considered to be sour gas. The following gases are within this category:

- Some wellhead gases
- Landfill gas
- Digester gas

Required maintenance is increased by the introduction of hydrogen sulfide into the fuel. For sour gas, Caterpillar recommends engine arrangements for landfill gas.

The use of gases that have hydrogen sulfide can damage the engine. Products of combustion (water vapor and sulfur oxides) form sulfurous acid and sulfuric acid.

Analyze the gas before use. If the gas has more than 0.43 mg of  $H_2S$ /MJ (.450  $\mu g$  of  $H_2S$ /Btu), treat the gas in order to reduce the content of hydrogen sulfide. For more information, see this Special Publication, "Hydrogen Sulfide Effects on Engine Maintenance Costs".

i03616061

## Dry Natural Gas (Pipeline)

**SMCS Code:** 1280-G6

Dry natural gas is a mixture of methane and traces of heavier hydrocarbons. Dry natural gas has been processed in order to remove liquids. This gas has a low tendency to detonate.

For dry natural gas, the acceptable limit of hydrogen sulfide is 0.43 mg/MJ (0.45  $\mu g$ /Btu).

The heat value of dry natural gases may vary. This depends on the composition of the gas. Dry natural gas usually has an LHV that is between 33.53 to 34.65 kJ/L (900 to 930 Btu/cu ft). Cat Gas Engines are adjusted at the factory with a dry natural gas that is within this range.

i03127811

## Bio-Gas

**SMCS Code:** 1280-G5

Bio-gas is generally classified as gas that is obtained from these sources:

- Landfills
- Facilities that produce digester gas

Although these gases are both the result of organic decomposition, the compositions are different.

## Landfill Gas

The decomposition of organic material produces landfill gas. The composition of landfill gas depends on the materials that are in the landfill. The gas is collected through a grid of pipes that are laid out within the landfill.

Landfill gas may contain contaminants that can cause harmful effects on engines:

- Chlorine
- Fluorine
- Siloxanes
- Sulfur
- Water vapor

Fuel analysis is required in order to provide guidelines for treatment of the fuel.

The sulfur compounds in landfill gas cause the same engine problems as sulfur in sour gas. When landfill gas is used, follow the precautions that are recommended for sour gas.

Landfills can also contain chlorine and fluorine compounds in the form of volatile organic compounds and chlorofluorocarbons. When these substances are burned in engines, corrosive hydrochloric acid and hydrofluoric acid can be produced.

Landfill gas can corrode both the equipment that handles the gas and the engine. Vapor is produced by combustion. If that vapor condenses in the crankcase, a solution that is potentially corrosive to the engine can form.

Landfill gas and digester gas can contain siloxanes. Siloxanes are formed when silica ions attach to the methane hydrocarbon chain. These gaseous compounds enter the combustion chamber with the fuel. This creates deposits in the cylinders.

In addition, calcium from engine oils contributes to deposits. Hence, deposits in the combustion chamber are generally a combination of these materials: silicon, calcium, and some traces of other elements.

Siloxane particles can be abrasive to exhaust valve faces and to valve seats. This causes the valves to become pitted and indented. The particles can also build up on the valve seat. The buildup can cause guttering of the valves.

Deposits also form on the pistons and on the bottom deck of the cylinder heads. These deposits can increase the compression ratio, which can lead to detonation and/or preignition. Detonation and/or preignition can loosen the deposits. The deposits that are loosened can be trapped between the valve and the valve seat. The valve will be held open. Guttering of the valve will result.

The formation of deposits depends on the following factors:

- Composition of the fuel
- Operating conditions
- Type of lubrication oil

Most landfill applications will generate some deposits in the combustion chamber and in the turbocharger. Siloxanes are a major contributor to these deposits. The fuel requires treatment in order to remove the siloxanes. For information on equipment for processing landfill gas, refer to the most current revision level of Special Publication, LEBW4977, "Gaseous Fuels - Application and Installation Guide".

**Note:** The amount of silicon in the fuel can be measured with a test that was developed by Caterpillar and by Bio-Engineering Services. The test kit enables a sample of the fuel to be analyzed. The fuel can also be analyzed for other harmful contaminants such as chlorines, fluorines, sulfur, and halides. The Portable Silicon Evaluation Unit (#SI 110V) is used to process fuel samples on site, and the Silicon Sample Sets (#SI 20) are the fluid sets that are processed by the Portable Silicon Evaluation Unit. The processed fluid sets are then sent to the laboratory for analysis. Details can be obtained from the following address:

Bio-Engineering Services  
36 Virginia Street  
Southport, Merseyside PR8 6RU England  
Telephone: 44 (0) 1704-539094  
Fax: 44 (0) 1704-501660

**Note:** Caterpillar is not responsible for the performance or quality of aftermarket products.

During normal combustion, some exhaust gas is forced past the piston rings and into the crankcase. The contaminants in this blowby are vented away from the crankcase by positive crankcase ventilation. The contaminants are diluted and purged.

The formation of water in the crankcase and in the valve mechanisms can result in an acid solution which allows corrosion to occur. A high jacket water coolant temperature helps to prevent the condensation of water in the crankcase. Engines that are used for landfill gas have a high temperature jacket water cooling system as standard equipment.

In order to protect the service life of the engine, it is necessary to follow the guidelines for operation and maintenance that are recommended by Caterpillar. Engines operating on Landfill gas need to have a positive crankcase ventilation system to help decrease acid formations. Landfill gas also requires regular, careful maintenance of the spark plugs. Misfire causes the engine to run rough and the cylinder temperatures are reduced. Cooler cylinders allow deposits to build up faster in the combustion chamber, in the exhaust manifold, and in the turbocharger. Exhaust port temperatures can indicate the performance of the spark plugs. An exhaust port temperature that decreases more than 66 °C (150 °F) below the average operating temperature may indicate the misfire of a spark plug. Inspect the spark plug in accordance with the engine Operation and Maintenance Manual, "Ignition System Spark Plug - Inspect/Adjust/Replace" article.

**Note:** For more information on bio-gas, refer to the most current revision level of Special Publication, LEBW4977, "Gaseous Fuels - Application and Installation Guide".

## Digester Gas

A variety of materials can produce digester gas:

- Sewage

Digester gas has properties that are similar to the properties of landfill gas. Digester gas usually has some sulfur and siloxanes. However, the chlorofluorocarbons that are commonly found in landfill gas are not usually found in digester gas. The same precautions for treatment of the fuel and protecting the engine are required. Until experience proves otherwise, the same maintenance recommendations are used.

- Ag Biogas

Ag Biogas is a methane based fuel created from an anaerobic digestion process of animal waste or a combination of animal waste and agricultural products. It does not include landfill, gasifier (syngas) or wastewater treatment plant type gas producing applications. Ag biogas usually has some variable amounts of sulfur, which can reduce maintenance intervals. Regular maintenance of the product will depend on quality of the fuel. Oil sampling and data trending will determine optimum oil change interval. Spark plugs may have reduced life as well based on the quality of the fuel.

## Hydrogen Sulfide Effects on Engine Maintenance Costs

**SMCS Code:** 1280

Sour gas refers to fuels that contain more than 0.43 mg of H<sub>2</sub>S/MJ (0.450 µg of H<sub>2</sub>S/Btu). The following gases are within this category:

- Some wellhead gases
- Landfill gas
- Digester gas

Sweet gas pertains to fuels that have less than 0.43 mg of H<sub>2</sub>S/MJ (.450 µg of H<sub>2</sub>S/Btu). Typically, propane and processed dry natural gas are in this category.

Without precautions, maintenance costs are greatly increased by the introduction of hydrogen sulfide into the engine's fuel. For sour gas, Caterpillar recommends engine arrangements for landfill gas.

The use of gases that have hydrogen sulfide can damage the engine. Products of combustion (water vapor and sulfur oxides) form sulfurous acid and sulfuric acid. Sulfur reacts easily with bright metals such as copper. Therefore, oil coolers are usually the first components that are affected by the acids. Other engine parts that are attacked by the acids include the following components:

- Valves
- Valve guides
- Piston pin bushings
- Piston rings
- Cylinder liners
- Exhaust manifolds
- Aftercoolers

Analyze the gas before use. If the gas has more than 0.43 mg of H<sub>2</sub>S/MJ (.450 µg of H<sub>2</sub>S/Btu), treat the gas in order to reduce the content of hydrogen sulfide.

Various devices can reduce the content of hydrogen sulfide. Examples are chemically active filters, reactive beds, and solutions. The performance of the devices deteriorates as the reactive chemicals are depleted. The devices must be serviced or replaced in order to maintain effectiveness.



Take the following precautions even if the gas is treated in order to reduce the level of hydrogen sulfide. This will help to protect the engine against intervals when the devices for treating the fuel deteriorate. Even brief intervals of operation with high sulfur fuels can damage the engine, unless precautions are taken.

- Maintain the temperature of the coolant outlet to a minimum of 110 °C (230 °F). Do not allow the rise in temperature across the engine to exceed 8.3 °C (15 °F). A rise in temperature of 5.6 °C (10 °F) is preferable.

Lower jacket water coolant temperatures permit water vapor and hydrogen sulfide to condense on the cylinder liners. Higher temperatures will reduce this condensation.

- Establish an oil analysis program in order to ensure that the oil change intervals are not extended beyond the condemning limits of the oil. The oil analysis will also be able to detect other problems that may occur.

i03129864

## Hydrogen Sulfide Effects on Engine Maintenance Costs

**SMCS Code:** 1280

The use of gases that have hydrogen sulfide can damage the engine. Products of combustion (water vapor and sulfur oxides) form sulfurous acid and sulfuric acid. Sulfur reacts easily with bright metals such as copper. Therefore, oil coolers are usually the first components that are affected by the acids. Other engine parts that are attacked by the acids include the following components:

- Fuel valves
- Valve mechanisms
- Piston pin bushings
- Piston rings
- Cylinder liners
- Exhaust manifolds
- Aftercoolers

Various devices can reduce the content of hydrogen sulfide. Examples are chemically active filters, reactive beds, and solutions. The performance of the devices deteriorates as the reactive chemicals are depleted. The devices must be serviced or replaced in order to maintain effectiveness.

Take the following precautions even if the gas is treated in order to reduce the level of hydrogen sulfide. This will help to protect the engine against intervals when the devices for treating the fuel deteriorate. Even brief intervals of operation with high sulfur fuels can damage the engine, unless precautions are taken.

- Use an engine configuration that has a fuel system that is designed for sour gas and a positive crankcase ventilation system..
- Maintain the temperature of the coolant outlet to a minimum of 110 °C (230 °F). Lower jacket water coolant temperatures permit water vapor and hydrogen sulfide to condense on the cylinder liners. Higher temperatures will reduce this condensation. Do not allow the rise in temperature across the engine to exceed 8.3 °C (15 °F). A rise in temperature of 5.6 °C (10 °F) is preferable.
- Establish an oil analysis program in order to ensure that the oil change intervals are not extended beyond the condemning limits of the oil. The oil analysis will also be able to detect other problems that may occur.

For additional information on gaseous fuels and on treatment of the fuel, refer to the following publication:

- Special Publication, LEBW4977, "Gaseous Fuels - Application and Installation Guide"

i04127289

## Fuel Filtration

**SMCS Code:** 1260; 1280

---

### NOTICE

**The customer is responsible for supplying clean, dry fuel to the engine.**

**Fuel filters are no less important than air filters to protect gas engines from dirt and debris. A proper fuel filter removes impurities that can damage the internal components of the engine.**

---

The gas must be supplied to the engine at a pressure that is acceptable. For optimum operation, use a fuel filter that is properly sized for the gas pressure.

For many gas engines, fuel filters are a provision of the design for the application. These devices are included in the normal maintenance of the plant. Therefore, Cat does not include a standard fuel filter as a part of each gas engine. However, fuel filters are available from your Cat dealer.

---

**Note: Use a fuel filter that is designed to capture a minimum of 99 percent of the particles that are 1 micron in diameter.**

Consult your Cat dealer about the requirements for filtering your fuel.

Table 7

Inlet & Outlet	Filter Group	1.0 Micron	.01 Micron
1 1/4 inch NPTF	321-6969	4P4719	
2 inch NPTF	321-6970	4P4720	140-1125
3 inch NPTF	321-6971	4P4721	140-1126

# Cooling System Specifications

i03614065

## General Coolant Information

**SMCS Code:** 1350; 1395

### NOTICE

Refer to the engine Operation and Maintenance Manual for any coolant information that may be specific to that application.

## Functions of Cooling System

The cooling systems of modern gas engines are precisely balanced. The performance of the cooling system affects many of the engine components. Optimum performance can only be obtained by proper installation and maintenance of the cooling system.

The engine cooling system is designed to meet specific guidelines. The proper coolant/antifreeze will provide the following functions:

- Adequate heat transfer
- Compatibility with the cooling system components such as hoses, seals, and piping
- Protection from water pump cavitation
- Protection from other cavitation erosion
- Protection from freezing and from boiling
- Protection from the buildup of corrosion, of sludge, and of scale

If a cooling system fails to perform any of the above functions, the following conditions can occur:

- Overheating
- Overcooling
- Leaks from hoses, from seals, and from piping
- Cavitation erosion
- Damage from freezing or from boiling
- Plugging of passages for the coolant/antifreeze in components such as radiators, aftercoolers, oil coolers, and other heat exchangers

Many engine failures are related to the above conditions: cracking of the cylinder head and/or of the engine block, piston seizure, leakage of the water pump, failure of the water pump, and pitting of the cylinder liners and cylinder block.

These problems can be avoided through proper maintenance of the cooling system. Periodically evaluate the maintenance practices in order to make sure that the cooling system is properly maintained.

## Properties of Coolant/Antifreeze

Coolant/antifreeze is normally composed of three elements: water, glycol, and additives. Each element must meet specific guidelines.

### Water

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

### NOTICE

Never use water alone without Supplemental Coolant Additives (SCA) or without inhibited coolant. Water alone is corrosive at engine operating temperatures. Water alone does not provide adequate protection against boiling or freezing.

**Deionized water or distilled water is recommended for use in engine cooling systems.**

If distilled water or deionized water is not available, use water with the properties that are listed in Table 8.

Table 8

Caterpillar Minimum Acceptable Water Requirements		
Property	Maximum Limit	ASTM Test
Chloride (Cl)	40 mg/L (2.4 grains per US gal)	"D512", "D4327"
Sulfate (SO <sub>4</sub> )	100 mg/L (5.9 grains per US gal)	"D516"
Total Hardness	170 mg/L (10 grains per US gal)	"D1126"
Total Solids	340 mg/L (20 grains per US gal)	"D1888"
Acidity	pH of 5.5 to 9.0	"D1293"

**NOTICE**

Use of water that does not meet the recommendations for the cooling system will damage the cooling system.

Do not use these types of water in the cooling system: sea water, softened water that has been conditioned with salt, hard water, and tap water.

Only use water that meets the recommendations for the cooling system.

If you are not sure about the properties of your water, consult one of the following sources for a water analysis:

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

**Glycol**

Glycol in the coolant helps to provide protection against boiling and freezing.

**Note: Glycol used in finished coolants or in concentrates is inhibited using appropriate additives.**

Most conventional heavy-duty coolant/antifreezes use ethylene glycol. In many applications, propylene glycol may also be used. In a 50/50 mixture with water, ethylene and propylene glycol provide similar protection against freezing and boiling.

Use a mixture that will provide protection against the lowest ambient temperature. For a comparison of the protection against freezing, refer to Table 9.

Table 9

Antifreeze Protection		
% Mixture Glycol and Water	Lowest Protective Temperature	
	Ethylene Glycol	Propylene Glycol
50 / 50	-37 °C (-34 °F)	-32 °C (-26 °F)
60 / 40	-51 °C (-60 °F)	

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

The minimum recommended mixture is 50 percent glycol and 50 percent water. For optimum performance, Caterpillar recommends a 50/50 mixture of a water/glycol solution.

Protection against freezing is reduced if the mixture is greater than 60 percent of ethylene glycol.

Protection against freezing is reduced if the mixture has more than 50 percent of propylene glycol.

**NOTICE**

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

In order to check the concentration of glycol, use the 1U-7298 Coolant/Battery Tester (Degree Celsius) or use the 1U-7297 Coolant/Battery Tester (Degree Fahrenheit). The testers give readings that are immediate and accurate. The testers can be used with ethylene or propylene glycol.

**Additives**

**Note: Glycol used in finished coolants or in concentrates is inhibited using appropriate additives.**

Additives help 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 Supplemental Coolant Additive (SCA).

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, of coolers, and of small passages

For further information, see this Special Publication, "Supplemental Coolant Additive (SCA)" article.

## Requirements for Venting of the Cooling System

In order to achieve optimum service life for the water cooled components in the gas engine, the cooling system must be able to purge air. Air can be introduced into the cooling system by different means:

- Air can be trapped in the cooling system when the system is filled or when the system is refilled.
- Air that is entrained in the mixture of coolant/antifreeze can be released by cavitation.
- Combustion gas can leak into the cooling system.

For maximum service life of the water cooled components, all of the air must be purged from the water jacket of each component. The presence of air can allow some of the coolant/antifreeze to convert into steam. This changes the properties of the coolant/antifreeze. Removal of the air reduces the possibility of the conversion. Removal of the air improves the service life of the coolant/antifreeze.

The preferred method for venting of the engine cooling system is the installation of vent lines. Follow these guidelines:

- The vent line must be routed from the highest point of the cooling system on the engine to a point that is higher than any of the engine water cooled components.
- Each component that is in a position which can trap air must be vented. For example, the turbocharger and the exhaust bypass valve are usually located at the highest points of the cooling system. One line cannot remove the air from both components. If only one of the components is vented, the other component can still trap air. Both of the components must be vented.
- For each cooling circuit, route the vent line into the bottom of the expansion tank.
- The vent line must have a continuous upward slope. In order to avoid blockage in the vent line, ensure that the vent line is routed in a manner that will avoid trapped fluid. Do not allow any dips in the routing of the vent line.

- Always remove the pressure cap in order to fill the cooling system. Leave the pressure cap loose during the first few minutes of engine operation in order to allow air to be fully purged.

In some applications, it may not be possible to install the recommended vent lines. In these cases, automatic vent lines must be installed. Install an automatic valve that is 0.6 to 0.9 m (2.00 to 3.00 ft) above the highest point of the cooling system on the engine.

**Note:** An automatic valve requires periodic service. Ensure that the valve is not plugged. If coolant/antifreeze leaks from a valve, correct the condition immediately. A valve that malfunctions can allow air to enter the cooling system after the engine is shut down. A vent line is always preferred over an automatic valve.

i03613784

## Coolant Recommendations

**SMCS Code:** 1350; 1352; 1395

## General Recommendations

### NOTICE

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

During shipping and storage, the engine must be protected from damage that can be caused by freezing of the cooling system. If the engine is shipped to a site with freezing temperatures and/or if the engine is stored in a location with freezing temperatures, the cooling system must contain antifreeze that will withstand the lowest ambient temperature. Frequently check the concentration of glycol in the coolant/antifreeze. Ensure that the concentration is adequate in order to prevent freezing. Otherwise, the cooling system must be completely drained, including pumps and coolers..

For engines in any location, periodically check the concentration of the additives in the coolant/antifreeze. Ensure that the concentration is adequate in order to help prevent corrosion and other harmful conditions.

### 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.

---

NOTICE

Fill the cooling system no faster than 19 L (5 US gal) per minute to avoid air locks.

---

After a cooling system has been refilled, monitor the level of the coolant/antifreeze in the expansion tank. Maintain the level above the minimum mark until all of the air has been purged from the system. Then maintain the proper level for normal operation.

During normal operation, frequently check the level of the coolant/antifreeze in the expansion tank. If the level is low, add the proper mixture of coolant/antifreeze.

For engines in any location, check the concentration of the conditioner in the coolant/antifreeze according to the engine Operation and Maintenance Manual, "Maintenance Interval Schedule". Obtain an S·O·S coolant analysis (Level 1) or use the appropriate test kit. Ensure that the concentration is adequate in order to help prevent corrosion and other harmful conditions.

To further monitor the cooling system, obtain regular S·O·S coolant analyses (Level 2) according to the engine Operation and Maintenance Manual, "Maintenance Interval Schedule".

---

## Recommended Coolant/Antifreeze

---

NOTICE

Do not use Extended Life Coolant (ELC) with Cat Gas Engines.

ELC was not formulated for use in Cat Gas Engines.

**Do not use heat transfer fluids in Cat Gas Engines.**

Use only the coolant/antifreeze that is recommended.

---

**Preferred** – Cat Natural Gas Engine Coolant (NGEC)

Cat coolants have been developed and tested in order to provide the full performance and service life that has been designed and built into Cat cooling systems. Cat NGEC coolant is currently used to fill Cat gas engines at the factory. This coolant is offered by Caterpillar dealers for continued use when the coolant is changed. Consult your Caterpillar dealer for more information on Cat coolants.

Alternatively, use Cat Diesel Engine Antifreeze/Coolant (DEAC) or a commercial heavy-duty coolant/antifreeze that meets "ASTM D6210" or "ASTM D4985" specifications.

Commercial coolants are, as a group, second choice.

Commercial heavy duty coolant/antifreeze can contain either ethylene glycol or propylene glycol. The coolant/antifreeze must contain 200 ppm (parts per million) silicates to 500 ppm silicates in concentrate or 100 ppm to 275 ppm silicates in a 50/50 mix. The coolant/antifreeze must be mixed with water that meets the properties that are listed in the Table in the "General Coolant Information" topic. The coolant/antifreeze must also have the correct concentration of Supplemental Coolant Additive (SCA).

---

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.

---

**Acceptable** – In applications that do not require protection from boiling or from freezing, a mixture of Cat SCA and water that meets the properties that are listed in the "Caterpillar Minimum Acceptable Water Requirements" Table in the "General Coolant Information" topic is acceptable.

**Note:** The preferred coolant/antifreeze and the acceptable mixture of SCA and water require different concentrations of SCA. Refer to the "Supplemental Coolant Additive (SCA)" topic.

Table 10 is a list of the coolant/antifreeze that is recommended for Cat Gas Engines. The service life of the coolant/antifreeze that is used in Cat Gas Engines is also listed. **In order to achieve this service life, the coolants must be properly maintained. The maintenance program includes S·O·S coolant analysis.**

Table 10

Recommended Coolant/Antifreeze and Service Life of the Coolant/Antifreeze	
Coolant/Antifreeze	Service Life <sup>(1)</sup>
Cat NGEC	Three Years
Cat DEAC	
Commercial Heavy-Duty Coolant/Antifreeze that meets "ASTM D6210"	Two Years
Commercial Heavy-Duty Coolant/Antifreeze that meets "ASTM D4985"	One Year
Cat SCA and Water	Two Years
Commercial SCA and Water	One Year

(1) The service life of coolant is also limited by use (service hours). Refer to the specific engine Operation and Maintenance Manual, "Maintenance Interval Schedule".

i03613600

## Supplemental Coolant Additive (SCA)

**SMCS Code:** 1350; 1352; 1395

### Recommended Supplemental Coolant Additive (SCA)

The use of SCA helps to prevent the following conditions from occurring:

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

**Preferred** – Cat Supplemental Coolant Additive (SCA)

**Acceptable** – A commercial SCA that provides 1400 mg/L (82 grains per US gal) or 1400 ppm of nitrites in the final mixture of coolant/antifreeze

**Note:** A 50/50 concentration of Cat NGEC or of Cat DEAC does not require a treatment with an SCA at the initial fill. Commercial heavy-duty coolant/antifreeze that meets "ASTM D6210" or "ASTM D4985" specifications may require a treatment with an SCA at the initial fill. Read the label or the instructions that are provided by the OEM of the product.

Commercial SCAs, as a group, are second choice additives.

To ensure that the correct amount of SCA is in the cooling system, the concentration of SCA must be tested on a scheduled basis. Obtain an S-O-S coolant analysis (Level 1) or use a test kit to check the concentration of the SCA according to the engine Operation and Maintenance Manual, "Maintenance Interval Schedule".

### WARNING

**Cooling system coolant additive contains alkali. To help prevent personal injury, avoid contact with the skin and eyes. Do not drink cooling system coolant additive.**

### Coolant/Antifreeze and SCA

**Note:** Mixtures of glycol and water require a lower concentration of SCA than mixtures of only water and SCA. Mixtures of glycol and water require three to six percent of SCA.

#### NOTICE

Do not exceed the recommended six percent supplemental coolant additive concentration.

Test the concentration of the SCA with an S-O-S coolant analysis (Level 1) or with the 4C-9301 Coolant Conditioner Test Kit.

Instructions are provided with the 4C-9301 Coolant Conditioner Test Kit.

**Note:** Cat SCA has a nitrite base. Many commercial types of SCA have a base of phosphate that cannot be checked with a Caterpillar test kit. If a commercial SCA is used, follow the recommendations for testing that are provided by the OEM of the product.

If a commercial SCA is used, the final mixture of coolant/antifreeze must have 1400 mg/L (82 grains per US gal) or 1200 ppm of nitrites.

Maintain a concentration level of nitrites in the cooling system that is between 1200 mg/L (70 grains per US gal) and 2400 mg/L (140 grains per US gal).

### Water and SCA

A cooling system that uses a mixture of water only and SCA requires more SCA than a cooling system that uses a mixture of glycol and water. The mixture of only water and SCA requires six to eight percent of SCA.

**NOTICE**

Do not exceed the recommended eight percent supplemental coolant additive concentration.

Test the concentration of SCA with an S·O·S coolant analysis (Level 1) or with the 4C-9301 Coolant Conditioner Test Kit. Follow the instructions that come with the kit, including the addition of SCA if needed.

**Excessive Concentrations of SCA**

An excessive concentration of SCA can result in the formation of deposits.

If the concentration of SCA is greater than the recommended level, drain some of the coolant/antifreeze. Refill the cooling system with water and operate the engine in order to fully dilute the mixture. Then, test the concentration again. Repeat this process until the concentration is acceptable.

i03613361

**Cooling System Maintenance**

**SMCS Code:** 1350; 1352; 1395

Cooling system maintenance has a direct effect on engine operation and on the service life of the engine. Maintain the coolant to the standards that are recommended in the engine Operation and Maintenance Manual. Refer to the Operation and Maintenance Manual, "Maintenance Interval Schedule". Follow these guidelines:

- Use the recommended coolant/antifreeze.
- Maintain the proper concentration of Supplemental Coolant Additive. Use the correct method of testing.
- Maintain the protection against freezing.
- Clean the cooling system and refill the system according to the engine Operation and Maintenance Manual.
- Consult your Caterpillar dealer about S·O·S Coolant Analysis.

**Note:** Cat cleaners can be used in order to clean the cooling system. Follow the instructions on the label. Consult your Caterpillar dealer for availability.

**Fluid Products for the Cooling System**

Table 11

Quantities and Part Numbers of Cat Natural Gas Engine Coolant (NGEC)			
Type	3.8 L (1 US gal)	19 L (5 US gal)	208 L (55 US gal)
50% Glycol 50% Water	233-9797	233-9798	233-9799

Table 12

Quantities and Part Numbers of Cat Diesel Engine Antifreeze/Coolant (DEAC)			
Type	3.8 L (1 US gal)	208 L (55 US gal)	Bulk
Undiluted Concentrate	8C-3684	8C-3686	2P-9868
50% Glycol 50% Water			3E-9439
40% Glycol 60% Water			119-5147

Table 13

Quantities and Part Numbers of Cat Supplemental Coolant Additive (SCA)			
0.47 L (1 pint)	0.95 L (1 qt)	18.9 L (5 US gal)	208 L (55 US gal)
8T-1589	3P-2044	8C-3680	5P-2907

Table 14

Quantities and Part Numbers of Cat Cooling System Cleaner - Quick Flush			
0.95 L (1 qt)	3.8 L (1 US gal)	18.9 L (5 US gal)	208 L (55 US gal)
4C-4610	4C-4611	4C-4612	4C-4613



## Test Tools for the Cooling System

Table 15

Test Tools for the Cooling System and Function of the Tools	
Part	Function
245-5829 Coolant/Battery Tester	Check the freezing point of the coolant/antifreeze.
4C-9301 Coolant Conditioner Test Kit	Check the concentration of the SCA in the coolant.
4C-9297 Test Strip (Coolant Conditioner)	Test strips for checking the concentration of the SCA in mixtures of glycol and water
164-3310 Infrared Thermometer	Measure surface temperatures without contacting the surface.
164-3320 Infrared Thermometer Gp (110 Volt AC Adapter)	
166-9030 Infrared Thermometer Gp (220 Volt AC Adapter)	

i03155761

## S·O·S Services Coolant Analysis

**SMCS Code:** 1350; 1352; 1395; 7542-008; 7542

Testing the engine coolant is important to ensure that the engine is protected from internal cavitation and from corrosion. The analysis also tests the ability of the coolant to protect the engine from boiling and from freezing.

Coolant analysis can be performed at your Caterpillar dealership. Caterpillar S·O·S coolant analysis is an excellent way to monitor the condition of your coolant and your cooling system.

The most critical aspect of coolant analysis is the interpretation of the results. The analyst must be properly trained in order to provide a correct diagnosis. The analyst must understand several variables.

Different coolants have different formulations and different condemning limits. Different commercial labs may use different methods to test for the same variable. These other considerations are also important for interpreting the results of a coolant analysis:

- The number of hours on the sample
- The equipment that uses the coolant
- The application of the equipment

Analysts at Caterpillar S·O·S fluid labs are trained to determine the acceptability of coolants. These analysts have knowledge of the equipment and applications. These qualifications enable the analysts to detect problems before damage occurs.

### NOTICE

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

Caterpillar S·O·S coolant analysis is a program with two levels. The program is based on periodic samples. The samples are analyzed. The results are reported, and appropriate recommendations are made according to the results.

### S·O·S Coolant Analysis (Level 1)

A coolant analysis (Level 1) is a test of the properties of the coolant that includes the following items:

- Glycol concentration for protection from boiling and freezing
- Ability to protect from erosion and corrosion
- pH
- Conductivity
- Water hardness
- Visual analysis
- Analysis of the odor

The results are reported, and appropriate recommendations are made.

---

## **S·O·S 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 inside of the cooling system. The following services are provided:

- Full Level 1 analysis
- Identification of the source 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 possible electrolysis within the engine cooling system

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

i03616240

### Reference Material

**SMCS Code:** 1000

The following literature can be obtained through any Caterpillar dealer.

**Note:** The information that is contained in the listed publications is subject to change without notice. Consult your local Caterpillar dealer for the most current recommendations.

**Note:** Refer to this Special Publication, the respective product data sheet, and to the appropriate Operation and Maintenance Manual for product application recommendations.

### Coolants

- Data sheet, PEHJ0067, "Cat ELC (Extended Life Coolant)" (Worldwide)
- Special Publication, P MEP5027, "Cat Label - ELC Radiator Label" (25 per package)
- Data sheet, PEHP9554, "Cat DEAC (Diesel Engine Antifreeze/Coolant) (Concentrate)"
- Special Publication, SEBD0518, "Know Your Cooling System"
- Special Publication, SEBD0970, "Coolant and Your Engine"

### Filters

- Data sheet, PEHP6028, "Cat Ultra High Efficiency Air Filters"
- Data sheet, PEHP7032, "Radial Seal Air Filters"
- Data sheet, PEHP9013, "Air Filter Service Indicator"
- Data sheet, PEHP7046, "Fuel Contamination Control"
- Data sheet, PEHJ0068, "Cat Advanced Efficiency Engine Oil Filter"

### Fuels

- Application and Installation Guide, LEKQ7256, "Fuels, Fuel Systems"
- Application and Installation Guide, LEKQ7260, "Low Energy Fuels"

### Lubricants

- Data sheet, PEHP0006, "Cat NGE0 EL350"
- Data sheet, PEHP9574, "Natural Gas Engine Oil(NGE0 EL250)"
- Data sheet, PEHP0004, "Cat NGE0"
- Special Publication, PEGJ0035, "Grease Selection Guide"
- Data sheet, PEHP0002, "Cat Advanced 3Moly Grease" (NLGI grade 2)
- Data sheet, NEHP6010, "Cat Ultra 5Moly Grease" (NLGI grades 1 and 2)
- Data sheet, NEHP6011, "Cat Arctic Platinum Grease" (NLGI grade 0)
- Data sheet, NEHP6012, "Cat Desert Gold Grease" (NLGI grade 2)
- Data sheet, NEHP6015, "Cat High Speed Ball Bearing Grease" (NLGI grade 2)
- Data sheet, PEHJ0088, "Cat Multipurpose Grease" (NLGI grade 2)

### Miscellaneous

- Software Program, LEKQ6378, "Methane Number Program"
- Special Instruction, SEHS9298, "Installation and Maintenance of Gaseous Fuel Filters"
- Special Publication, PECP9067, "One Safe Source"
- Special Publication, SEBF8029, "Index to Guidelines for Reusable Parts and Salvage Operations"
- Special Publication, PEDP9131, "Fluid Contamination - The Silent Thief"
- Special Publication, AECQ1042, "Caterpillar Product Line Brochure"
- Special Publication, PEWJ0074, "Cat Filter and Fluid Application Guide"

- Special Publication, NENG2500, "Caterpillar Dealer Service Tool Catalog"
- Special Publication, PECJ0003, "Cat Shop Supplies and Tools" catalog
- Special Publication, SENR3130, "Torque Specifications"

## S·O·S Services

- Special Publication, PEDP7036, "S·O·S Fluids Analysis Cornerstone"
- Special Publication, PEHP7052, "Making the Most of S·O·S Services"
- Special Publication, PEHP7076, "Understanding S·O·S Services Tests"
- Special Publication, PEHP6001, "How To Take a Good Oil Sample"
- Special Publication, PEHP7057, "S·O·S Coolant Analysis"

## Additional Reference Material

The "Engine Fluids Data Book" can be obtained from the following locations: local technological society, local library, and local college. If necessary, consult EMA at the following address:

Engine Manufacturers Association  
Two North LaSalle Street, Suite 2200  
Chicago, Illinois, USA 60602  
E-mail: [ema@enginemanufacturers.org](mailto:ema@enginemanufacturers.org)  
(312) 827-8700  
Facsimile: (312) 827-8737

The "Society of Automotive Engineers (SAE) Specifications" can be found in your SAE handbook. This publication can also be obtained from the following locations: local technological society, local library, and local college. If necessary, consult SAE at the following address:

SAE International  
400 Commonwealth Drive  
Warrendale, PA, USA 15096-0001  
Telephone: (724) 776-4841

The "American Petroleum Institute Publication No. 1509" can be obtained from the following locations: local technological society, local library, and local college. If necessary, consult API at the following address:

American Petroleum Institute  
1220 L St. N.W.  
Washington, DC, USA 20005  
Telephone: (202) 682-8000

The International Organization for Standardization (ISO) offers information and customer service regarding international standards and standardizing activities. ISO can also supply information on the following subjects that are not controlled by ISO: national standards, regional standards, regulations, certification, and related activities. Consult the member of ISO in your country.

International Organization for Standardization (ISO)  
1, rue de Varembe  
Case postale 56  
CH-1211 Genève 20  
Switzerland  
Telephone: +41 22 749 01 11  
Facsimile: +41 22 733 34 30  
E-mail: [central@iso.ch](mailto:central@iso.ch)  
Web site: <http://www.iso.ch>

European classifications are established by the Conseil International Des Machines a Combustion (CIMAC) (International Council on Combustion Engines).

CIMAC Central Secretariat  
Lyoner Strasse 18  
60528 Frankfurt  
Germany  
Telephone: +49 69 6603 1567  
Facsimile: +49 69 6603 1566

# Index

## A

Aftermarket Oil Additives ..... 14

## B

Bio-Gas ..... 30  
 Digester Gas ..... 32  
 Landfill Gas ..... 30

## C

Commercial Oils ..... 9  
 7000 Hour Field Performance Evaluation ..... 9  
 Coolant Recommendations ..... 37  
 General Recommendations ..... 37  
 Recommended Coolant/Antifreeze ..... 38  
 Cooling System Maintenance ..... 40  
 Fluid Products for the Cooling System ..... 40  
 Test Tools for the Cooling System ..... 41  
 Cooling System Specifications ..... 35

## D

Dry Natural Gas (Pipeline) ..... 30

## E

Engine Oil ..... 6  
 Engine Oil and Bio-Gas Fuels ..... 8  
 Engine Oil and Sour Gas Fuels ..... 8  
 S·O·S Services Oil Analysis ..... 8

## F

Field Evaluation of Commercial Oil ..... 9  
 Criteria for the Evaluation ..... 10  
 Guidelines for the Use of A Proven Lubricant In  
 Other Engines (Interchanging) ..... 12  
 Operating Conditions for the Field Performance  
 Evaluation ..... 9  
 Responsibilities ..... 11  
 Foreword ..... 5  
 Literature Information ..... 4  
 Maintenance ..... 4  
 Safety ..... 4  
 Fuel Effects on Maintenance Costs ..... 29  
 Fuel Filtration ..... 33  
 Fuel Specifications ..... 28

## G

General Coolant Information ..... 35  
 Functions of Cooling System ..... 35  
 Properties of Coolant/Antifreeze ..... 35  
 Requirements for Venting of the Cooling  
 System ..... 37  
 General Fuel Information ..... 28  
 General Lubricant Information ..... 6  
 Engine Oil ..... 6  
 Hydraulic Oil ..... 6  
 Lubricating Grease ..... 6

## H

Hydraulic Oil ..... 19  
 Applications ..... 19  
 Cat Bio HYDO Advanced (Hydraulic Oil) ..... 20  
 Cat HYDO Advanced 10 (Hydraulic Oil) ..... 19  
 Commercial Biodegradable Hydraulic Oil ..... 21  
 Commercial Hydraulic Oils ..... 20  
 Hydrogen Sulfide Effects on Engine Maintenance  
 Costs ..... 32–33

## I

Important Safety Information ..... 2

## L

Lubricant Specifications ..... 6  
 Lubricating Grease ..... 21  
 Cat Advanced 3Moly Grease ..... 22  
 Cat Arctic Platinum ..... 24  
 Cat Desert Gold Grease ..... 23  
 Cat High Speed Ball Bearing Grease ..... 25  
 Cat Multipurpose Grease ..... 22  
 Cat Ultra 5Moly Grease ..... 23  
 Cat White Assembly Grease ..... 22  
 Grease Application Charts ..... 26

## M

Maintenance Section ..... 6

## O

Oil Change Interval (and Oil Sampling) ..... 15

## P

Propane ..... 29

---

**R**

Re-refined Base Stock Oils ..... 14  
Reference Information Section ..... 43  
Reference Material ..... 43  
    Additional Reference Material ..... 44  
    Coolants ..... 43  
    Filters ..... 43  
    Fuels ..... 43  
    Lubricants ..... 43  
    Miscellaneous ..... 43  
    S·O·S Services ..... 44  
Reference Materials ..... 43

**S**

S·O·S Services Coolant Analysis ..... 41  
    S·O·S Coolant Analysis (Level 1) ..... 41  
    S·O·S Coolant Analysis (Level 2) ..... 42  
S·O·S Services Oil Analysis ..... 16  
    Corrosive Gaseous Fuels ..... 16  
    S·O·S Services Oil Analysis Guidelines ..... 17  
    Silicon Containing Gases ..... 17  
Sour Gas ..... 30  
Supplemental Coolant Additive (SCA) ..... 39  
    Recommended Supplemental Coolant Additive  
    (SCA) ..... 39  
Synthetic Base Stock Oils ..... 14

**T**

Table of Contents ..... 3

**W**

Wellhead Gas ..... 29

# 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: \_\_\_\_\_

