Service Bulletin

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Cummins® Coolant Requirements and Maintenance	

Cummins® Coolant Requirements and Maintenance

This Service Bulletin supersedes prior Service Bulletins concerning Cummins Inc. coolant requirements and maintenance; replace those Service Bulletins with this one.

This Service Bulletin outlines the proper application and maintenance of coolant for all Cummins® engines, including gaseous fueled engines. It also updates and simplifies Cummins Inc. recommendations and guidelines for the end user.

Summary of Recommendations

Cummins Inc. cooling system general recommendations are listed below. These recommendations apply to both Standard Service Intervals and Extended Service Intervals. See Section 2 - Standard Service Interval or Section 3 - Extended Service Interval for complete instructions.

- See the engine's corresponding owner's/operation and maintenance manual for specific coolant maintenance, requirements and specifications.
- For most applications, the original equipment manufacturer (OEM) originally filled the cooling system. Check with the OEM on the type of coolant used during the initial fill of the cooling system.
- Fill up and top off cooling systems with a fully formulated antifreeze/coolant meeting Cummins Engineering Standard 14603. Cummins Inc. recommends Fleetguard® antifreeze/coolant. All Fleetguard® coolants meet the requirements of Cummins Engineering Standard 14603. See Table 3 for recommended antifreeze/coolant.
- For engines equipped with wet cylinder liners, test coolant at least twice per year for liner cavitation protection. Add liquid supplemental coolant additive (SCA) as required.
- For engines equipped with coolant filter(s), replace the coolant filter(s) at every recommended coolant filter change interval.
- Beginning in January 2013, all Light Duty, Midrange, and Heavy Duty engines are extended life organic acid technology (OAT) coolant compatible, and as a result the coolant filter is optional.
- Test coolant for replacement limits every 240,000 km [150,000 mi], 4000 hours, or once per year, whichever occurs first. Replace coolant only if replacement limits have been exceeded.

Definition of Terms

Table 1, Definition of Terms

Term	Definition
Extender	Extended Service Additive
SCA	Supplement Coolant Additive (Standard service interval additive)
Coolant	As used in this bulletin, coolant refers to the liquid mixture in the engine or vehicle cooling system that functions to maintain an engine temperature in the designed range. In general, the coolant is made up of water, glycol and additives. Also referred to as “Prediluted” or “Premix”.
Antifreeze	The glycol or glycerin and additive portion of the coolant whose main function is to control corrosion and the freezing/boiling point of the coolant. Also referred to as “Concentrate”.
Fully Formulated	Antifreeze or coolant that contains the correct amount of additives to be used in a heavy duty engine. Fully formulated antifreeze/coolant meets ASTM D6210.

Table 1, Definition of Terms	
Term	**Definition**
Partially Formulated	Antifreeze or coolant that requires a “precharge” of supplemental coolant additive to protect against liner pitting and hot surface scaling. Partially formulated antifreeze/coolant does **not** meet American Society for Testing and Materials (ASTM) D6210.
Treated Water Coolant	Water containing all additives necessary for use as a coolant in heavy duty engines. Treated water coolant does **not** contain glycol or glycerin.
Unit	0.3 units per liter [1 unit per gal] is equal to 1000 ppm of Nitrite (as NO_2).

Section 1 - Introduction

Cummins Inc. coolant recommendations have evolved over time to reflect changes in diesel engine and coolant technology, environmental regulations, and customer needs.

Since 1995, Cummins Inc. has recommended the use of **only** fully formulated coolants meeting ASTM D6210/The Maintenance Council RP 329 (ethylene glycol) and The Maintenance Council RP 330 (propylene glycol) specifications.

However, Cummins Inc. has recently discovered significant weaknesses in some coolants meeting these ASTM specifications. Therefore, a new Cummins Engineering Standard, Cummins Engineering Standard 14603, has been developed to make sure coolant used in Cummins® engines will meet the requirements of all engine components. See Attachment 2 for more information on Cummins Engineering Standard 14603.

Cummins Inc. guidelines prior to 1995 permitted the use of fully formulated antifreezes/coolants meeting ASTM D6210, but primarily addressed the use of partially formulated products meeting ASTM D4985 or GM 6038M, which were referred to as "heavy duty" based on the low-silicate content. These partially formulated coolants contained buffering compounds and corrosion inhibitors, but did **not** provide liner pitting and scale protection. To provide total heavy-duty cooling system protection, a mixing process was required to add SCA. This mixing process provided opportunity for human error, which often resulted in liner or block pitting from under-concentration during initial fill or SCA dilution during top-off of the cooling system. Because of these issues, the use of partially formulated antifreezes is unacceptable.

Fully formulated antifreezes are ideally suited for topping off cooling systems, but do **not** eliminate the need for additive replenishment. Routine additive replenishment has always been required to offset normal additive depletion processes.

During normal additive replenishment, it is possible to achieve an additive concentration that is higher than desired. This is because Cummins Inc. recommended replenishment rates have been aimed to compensate for coolant loss. If no coolant loss is experienced, gradual Extender/SCA concentration increase is possible. Overconcentration can be avoided by monitoring with a test kit.

However, the use of test kits to maintain a concentration near the minimum side of the acceptable range has never been acceptable nor recommended. This practice is responsible for many pitting failures and should **not** be followed.

Coolant Performance Characteristics

Table 2 below lists the various types of coolants and the performance characteristics of each. As mentioned earlier in this section, **only** fully formulated antifreeze/coolant meeting Cummins Engineering Standard 14603 is recommended for use in Cummins® engines.

Table 2, Coolant Type versus Performance Characteristics			
	Light Duty	**Low Silicate and SCA**	**Fully Formulated**
ASTM Specification	D-3306	-	D-6210
Buffering	Yes	Yes	Yes
Corrosion Protection	Yes	Yes	Yes
Foam Control	Yes	Yes	Yes
Silicate Limit	No	Yes	Yes
Liner-Pitting Protection	No	Yes	Yes
Scale/Deposit Control	No	Yes	Yes
SCA Precharge Required	-	No	No

Table 2, Coolant Type versus Performance Characteristics			
	Light Duty	**Low Silicate and SCA**	**Fully Formulated**
Silicate Gelation	Primary cause	Can occur with SCA overdose	No
Total Dissolved Solids Buildup in Coolant	-	Can exceed 5 percent	Remains below 3 percent
Extended Service Interval Capable	No	No	Yes
System Top-Off	SCA added with antifreeze/coolant	SCA added with antifreeze/coolant	Antifreeze/Coolant **only**

Topping Off and Dilution of Cooling Systems

Coolant loss can lead to dilution of corrosion and liner-pitting protection additives due to incorrect top-off practices. This is the root cause of most cases of liner-pitting. The top-off process is simplified by the use of fully formulated antifreezes and coolants because SCA addition is **not** required when topping off the system. Even small leaks at the hose clamps, radiator cores, cylinder head gaskets, and water pumps result in significant coolant loss over time. Dilution of critical additives is avoided, regardless of the amount of coolant loss, by using fully formulated products for system top-off.

Standard Service Interval Coolant versus Extended Service Interval Coolant

Both types of coolant follow the same general test schedule:

- Test at least twice a year for additive and glycol levels
- Test coolant at 240,000 km [150,000 mi], 4000 hours, or once per year, whichever occurs first, to determine if the coolant **must** be replaced.

The advantage to using an extended service interval coolant is that typically the coolant **only** needs additive replenishment and filter change (if equipped) once per year, compared to the standard service interval where the additive and filter (if equipped) is replenished at each lubricating oil change interval. Coolant additives are **not** to be used with organic acid technology (OAT) coolant.

Section 2 of this bulletin details the standard service interval and Section 3 details the extended service interval.

Additional Information

If you have any questions about information in this bulletin or would like more information, please contact 1-800-DIESELS.

Section 2 - Standard Service Interval

This section outlines the recommended maintenance practices for cooling systems when using a standard service interval.

⚠ WARNING ⚠

A small amount of coolant can leak when servicing the coolant filter with the shutoff valve in the OFF position. To reduce the possibility of personal injury, avoid contact with hot coolant.

⚠ WARNING ⚠

Coolant is toxic. Keep away from children and pets. If not reused, dispose of in accordance with local environmental regulations.

For an engine using standard service interval coolant, the additive and glycol levels **must** be tested once every 6 months.

The following steps are required to comply with Cummins Inc. recommendations for initial filling and maintenance of cooling systems.

- Fill the cooling system with premixed fully formulated coolant or with a 50/50 mixture of high-quality water (see Section 9 - Water Quality Requirements) and fully formulated concentrated antifreeze. The fully formulated coolant/antifreeze, either ethylene glycol or propylene glycol, **must** meet Cummins Engineering Standard 14603. Cummins Inc. recommends using Fleetguard® coolants containing DCA4 chemistry; however, Fleetguard® coolants containing DCA2 chemistry are acceptable.

- Top off the cooling system as needed using **only** fully formulated antifreeze/coolant meeting Cummins Engineering Standard 14603.
- Change the coolant filter(s) at every oil change. The coolant filter **must** meet Cummins Engineering Standard 14315.
- Replenish depleted coolant additives at every oil change or as needed by replacing the coolant filter(s) with the correct filter(s) or liquid SCA. Very large cooling systems can require additional liquid SCA if standard coolant filters do **not** provide sufficient SCA replenishment. Consult Cummins® Filtration Technical Assistance for detailed Fleetguard® product information and assistance for filter sizes and part numbers at 800-223-4583 or www.Cumminsfiltration.com.
- Test the coolant twice a year for freeze protection and additive levels. Refractometer measurements provide the most accurate freeze protection measurements. Test strips, although less accurate than a refractometer, will also provide an indication of freeze protection and additive levels. See Section 6 - Coolant Testing for further information and test strip part numbers.
- Test the coolant every 240,000 km [150,000 mi], 4000 hours or once per year, whichever occurs first, to determine if it **must** be replaced. See Section 6 - Coolant Testing for further information and test strip part numbers.
- Replace the coolant **only** if the replacement limits are exceeded.

SCA Levels

Test the SCA level a minimum of twice a year.

- If the SCA concentration level is between 0.3 and 1.3 units/liter [1.2 and 5.0 units per gal], either install a chemical filter containing the appropriate dosage of SCA or add the equivalent liquid SCA dosage and install a chemical free filter. For large cooling systems, it can be necessary to replenish SCA with both a chemical filter and liquid SCA.
- If the SCA concentration level is less than 0.3 units/liter [1.2 units per gal], add 0.15 liters [5 ounces] of Fleetguard® DCA4 or Fleetcool liquid per 3.8 liters [1 gal] of cooling system capacity and install a chemical filter.
- If the SCA concentration level is greater than 1.3 units/liter [5.0 units per gal], install a chemical free filter. Do **not** install a chemical coolant filter or add liquid Extender/SCA. Test the SCA level at each successive oil change. When SCA units drop below 1.3 units per liter [5.0 units per gal], resume installing chemical filters or using the equivalent liquid SCA dosage and installing chemical free filters.
- Consult Cummins® Filtration Technical Assistance for detailed Fleetguard® product information and assistance at 800-223-4583 or www.Cumminsfiltration.com.

Section 3 - Extended Service Interval

This section covers the requirements for coolant products that provide extended service maintenance intervals. Beginning in January 2013, all Light Duty, Midrange, and Heavy Duty engines are extended life organic acid technology (OAT) coolant compatible, and as a result the coolant filter is optional.

Extended service interval coolant is defined as a coolant capable of a minimum general routine service interval of 240,000 km [150,000 mi], 4000 hours, or 1 year, whichever occurs first. It **must** be noted that organic acid technology (OAT) coolants are generally capable of extended service intervals ranging from 500,000 km to 1,000,000 km [300,000 mi to 600,000 mi] or 6000 hours to 7000 hours. Follow maintenance guidelines recommended by the coolant manufacturer.

Successful usage of extended service interval products will be possible **only** if a systematic approach to coolant maintenance is followed by the user. This means using the extended service interval system of coolant products for all coolant maintenance at the fleet shop as well as on the road. Use of the proper coolant is vital for successful extended service interval maintenance. If control of top-off can **not** be accomplished, do **not** consider extended service and use the standard service interval as described in Section 2. Coolant **must** meet the requirements stated in this section.

It is preferred and recommended for all Cummins® engines to top off **only** with fully formulated coolants which meet Cummins Engineering Standard 14603. See Attachment 2 for more information on Cummins Engineering Standard 14603. However, MidRange products, including any Cummins® engine displacing less than 10 liters [610 C.I.D.], may top off with fully formulated coolants meeting a minimum requirement of ASTM D6210.

Cummins Inc. recommends Fleetguard® antifreeze/coolant. All Fleetguard® coolants meet the requirements of Cummins Engineering Standard 14603. See Table 3 for recommended antifreeze/coolant.

Table 3, Cummins Inc. Fleetguard Recommended Coolants			
Classification:	**Conventional**	**Hybrid**	**OAT**
****Life (miles):**	300,000-400,000	1,000,000	1,000,000
Technology	Good	Better	Best
****Life (hours):**	6,000-8,000	20,000	20,000

Table 3, Cummins Inc. Fleetguard Recommended Coolants						
Classification:	**Conventional**		**Hybrid**		**OAT**	
Maintenance Requirements:	High		Medium		Low	
Product Highlights:	The original fully-formulated Heavy Duty coolant. Does not require a pre-charge of SCA.		Life of the engine coolant. Provides a cost effective, premium product with an extended service interval.		Life of the engine coolant - 1M mile coolant without the use of extenders or SCAs. An environmentally friendly, low-maintenance, superior performance, robust product.	
*Cummins Recommended Products:	**Product:**	**Color:**	**Product:**	**Color:**	**Product:**	**Color:**
	Fleetcool	Green	ES Compleat	Blue	ES Compleat OAT	Red
	Compleat	Blue	Fleetcool EX	Fuchsia	Fleetcool OAT	Pink
			PG Plus	Royal Blue	PG Platinum	Dark Red
Performance Standards:	All Fleetguard coolants exceed ASTM D-3306, ASTM D-6210, and CES14603 at a minimum.					

*Product availability varies by region. Please visit www.cumminsfiltration.com or contact your local customer assistance for more information.

**To maintain the protection provided by Fleetguard coolants, the proper level of inhibitor must be present. This is typically achieved by topping off the cooling system with premixed Fleetguard coolant. The user is responsible for ensuring proper additive levels and coolant pH through the use of test strips and the addition of additives or new coolant if necessary. The recommended test intervals are as follows: OAT coolants - 300,000 miles, 6,000 hours, or 1 year; Hybrid coolants - 150,000 miles, 4,000 hours, or 1 year; Conventional coolants - Every oil drain interval or 1 year. The shortest of recommended hours, miles, or 1 year should be used as the test interval. The test interval is a precautionary recommendation intended to prevent maintenance and engine problems from causing progressive, severe engine damage.

Extended Life Coolants (ELC) Plus Silicates

⚠ CAUTION ⚠

Cummins® engines may utilize certain elastomers that are not compatible with all commercially available coolants. These coolants do not meet the elastomer compatibility requirements of CES14603 and are not recommended for use. These products may be harmful to your engine if an initial charge of silicates is not added. If unsure about coolant compatibility, Cummins Inc. recommends contacting the coolant supplier to request a copy of their CES14603 approval letter. Cummins Inc. recommends Fleetguard® coolants.

Many commonly available extended life coolants (ELC) do **not** meet the elastomer compatibility requirements of CES14603, and therefore, are **not** recommended for use by Cummins. These coolants are **only** acceptable for use if the initial coolant fill requirements were met by the vehicle's original equipment manufacturer (OEM), including the addition of silicates. Cummins recommends contacting the coolant supplier to request a copy of their CES14603 approval letter from Cummins if unsure about compatibility.

Heavy-Duty and High Horsepower engines requiring overhauls or repairs involving the replacement of the following components that are using OAT coolants **not** meeting CES 14603, **must** discard the original coolant and replace with new.

- Rocker lever housing
- Lubricating oil cooler housing
- Cylinder head gasket
- Thermostat housing gasket
- Lubricating oil cooler cover gasket
- V cavity gasket

If the replacement coolant does **not** meet the elastomer compatibility section of CES14603, the initial coolant **must** be treated by adding 0.24 liters [8 fl-oz] of liquid silicate fluid for every 45 liters [12 U.S. gal] of total coolant system volume. It is critical to **not** over treat the coolant with silicate fluid. If over-treatment is suspected, drain the cooling system and discard the coolant filter (if equipped). Clean the cooling system immediately. Symptoms of silicate over-treatment can be thickened coolant in the lower radiator tank, water pump seal leakage soon after silicate addition, reduced heater output and/or elevated engine temperatures. Use Fleetguard® Restore Cooling System Cleaner at the rate of 3.8 liters [1 U.S. gal] per 38 to 45 liters [10 to 12 U.S. gal] of water. Do **not** use Fleetguard® Restore Cooling System Cleaner with normal engine coolant.

To obtain order forms or ask questions relative to ordering the silicate fluid:

- Phone: 800-346-9041
- Fax: 800-876-5317

Mail To:

- Silicate Fluid Order Program
- P.O. Box 27388
- Houston, TX 77227-7388

Extended Service Maintenance

- Fill the cooling system with premixed fully formulated coolant or with a 50/50 mixture of high-quality water (see Section 9 - Water Quality Requirements) and fully formulated concentrated antifreeze. The fully formulated coolant or antifreeze, either ethylene glycol or propylene glycol, **must** meet Cummins Engineering Standard 14603. Cummins Inc. recommends using Fleetguard® ES™ Compleat.
- Use of Fleetguard® OAT coolants do **not** require the initial use of an extender additive in liquid form or from a slow-release filter, nor do they require the addition of additives for cavitation-corrosion (cylinder liner-pitting) protection. If using a coolant other than Fleetguard, follow the manufacturers recommendations for service intervals and additive.

Liner Pitting Protection Additive Levels Required at Initial System Fill

Note : Nitrite and molybdate are not used in Fleetguard® OAT coolants for cylinder liner pitting protection but are used in other Fleetgaurd® products. Follow the manufacturers' recommendations specific to each product. Table 4 provides target concentrations for initial fill of coolants that use nitire and molybdate to provide cylinder liner pitting protection.

Table 4, Liner Pitting Protection Additive Levels Required at Initial System Fill	
Additive	**Premixed Antifreeze/ Coolant (ppm)1**
Minimum Nitrite (measured as NO_2)	2000 ppm
Minimum Levels of Nitrite (measured as NO_2) and Molybdate (measured as MoO_4)	1300 ppm [2]

1: Concentrated antifreeze/coolant levels are double the premixed levels.

2: A combination of nitrite (NO_2) and molybdate (MoO_4) can **not** contain less than 500 ppm of either additive

- Top off the cooling system as needed using **only** fully formulated antifreeze/coolant meeting Cummins Engineering Standard 14603.
- The coolant **must** be tested twice per year for freeze protection and additive levels. A Refractometer provides the most accurate freeze protection measurements. Test strips, although less accurate than a refractometer, will also provide an indication of freeze protection and additive levels. See Section 6 - Coolant Testing for further information and test strip part numbers.
- After 240,000 km [150,000 mi], 4000 hours, or 1 year, whichever occurs first, do the following:
- Change the coolant filter(s) (if equipped). The coolant filter **must** meet Cummins Engineering Standard 14315.
- Replenish depleted coolant additives either by using slow-release ES™ chemical filter or adding ES™ Extender liquid. Larger cooling systems may require the use of a chemical filter in conjunction with liquid additive. See the remainder of this section for filter and liquid part numbers.
- Test the coolant to determine if it **must** be replaced. See Section 6- Coolant Testing for further information and test strip part numbers.
- Replace the coolant **only** if the replacement limits are exceeded.

Extender/Extended Service Additive Levels

Test the SCA level a minimum of twice a year.

- Target 0.6 units/liter [2.5 units/gal] in coolant solutions of 40 to 60 percent antifreeze concentrations.
- If the SCA concentration level is between 0.3 and 1.3 units/liter [1.2 and 5.0 units per gal], either install a chemical filter[1] containing the appropriate dosage of Extended Service Additive or add the equivalent liquid Extended Service Additive dosage and install a chemical free filter[1]. For large cooling systems, it can be necessary to replenish SCA with both an Extended Service Additive chemical filter[1] and liquid Extended Service Additive.

- If the SCA concentration level is less than 0.3 units/liter [1.2 units per gal], add 0.15 liters [5 ounces] of Fleetguard® Extender liquid Extended Service Additive per gallon of cooling system capacity and install a chemical filter[1].
- If the SCA concentration level is greater than 1.3 units/liter [5.0 units per gal], install a chemical free filter[1]. Do **not** install a chemical coolant filter[1] or add liquid Extender/Extended Service Additive. Test the SCA level at each successive oil change. When SCA units drop below 1.3 units per liter [5.0 units per gal], resume installing chemical filters[1] or using the equivalent liquid Extended Service Additive dosage and installing chemical free filters[1].
- Consult Cummins® Filtration Technical Assistance for detailed Fleetguard® product information and assistance at 800-223-4583 or www.Cumminsfiltration.com.
- Some OAT coolants use high levels of organic acids for liner pitting protection and do **not** use nitrite and or molybdate. Therefore, these coolants do **not** have SCA numbers.
- Beginning in January 2013, all Light Duty, Midrange, and Heavy Duty engines are Extended Life Coolant organic acid technology (OAT) compatible, and as a result the coolant filter is optional.

Extender Requirements

⚠ CAUTION ⚠

Extenders used in extended service interval systems are not fully formulated and must not be used in treated water coolants. Their usage can result in engine damage. See Section 8.

The Extender replaces the additives in the coolant that are lost due to depletion. It can be added as a liquid directly to the coolant or as a solid contained in a coolant filter.

Cummins Inc. recommends using a Fleetguard® ES™ slow release filter or ES™ Extender liquid.

Performance Requirements

The Extender **must** contain sufficient liner-pitting additives to increase the levels of nitrite or nitrite plus molybdate in the engine coolant by the following amounts:

- At least 800 ppm (0.8 units per gallon) of nitrite (NO_2)
- Or a combined total of at least 520 ppm (0.8 units per gallon) of nitrite (NO_2) and molybdate (MoO_4).

A combination of nitrite and molybdate can **not** contain less than 200 ppm of either additive.

Storage Stability

Liquid Extenders typically have a shelf life of at least 2 years from the time of manufacture when stored at temperatures ranging from -7° to 55°C [19° to 131°F].

Solid material, liquid turbidity, or layering at the top of the liquid is allowed if it will dissolve and disperse by stirring the solution and warming it to a temperature between 2° to 67°C [36° to 153°F].

Solid, slurry, and paste forms of Extender **must** dissolve completely in hot engine coolant. They **must** be formulated and packaged to prevent chemical or physical change during storage temperatures ranging from -7° to 55°C [19° to 131°F] regardless of humidity.

- Consult Cummins® Filtration Technical Assistance for detailed Fleetguard® product information and assistance at 800-223-4583 or www.cumminsfiltration.com.

Section 4 - Unacceptable Maintenance Practices for Cooling Systems

⚠ CAUTION ⚠

All diesel engines with wet liners are subject to liner pitting if the cooling system is not correctly maintained. Underconcentration (below 0.3 units per liter [1.2 units per gal] of Extended Service Additive/SCA results in liner cavitation and possible engine failure. Overconcentration (above 1.3 units per liter [5.0 units per gal] of additives) or the use of high-silicate antifreeze can result in silicate gelation or water pump seal leakage.

Note : Some OAT coolants use high levels of organic acids for liner pitting protection and do **not** use nitrite and or molybdate. Therefore, these coolants do **not** have SCA numbers.

Unacceptable Practices - The following practices are considered unacceptable and may lead to engine failure.

- Use of high-silicate antifreeze.

- Underconcentration or overconcentration of Extended Service Additive/SCAs.
- Use of antifreezes/coolants that are **not** fully formulated for extended service intervals (for instance, GM 6038M or ASTM D4985 antifreeze).
- Use of soluble oils in the cooling system.
- Use of poor-quality water. See Section 9 for water quality requirements.
- Use of antifreeze, Extended Service Additive/SCA or coolant filter(s) that do **not** meet the specifications indicated in this Service Bulletin.
- Use of Treated Water coolant with EGR engines.
- Use of coolants with less than 40 percent antifreeze for EGR engines.
- Use of coolants with less than 25 percent antifreeze for marine engines.

Section 5 - Recommended Maintenance Practices for Cooling Systems of A, B, D, and F Series Engines

The A and B Series engines normally do **not** require Extender/SCA because they do **not** normally experience cylinder bore/liner cavitation corrosion. Also, the A and B Series engines do **not** have an integral coolant filter.

Coolant maintenance requirements for the Cummins® B series engines depend on the application.

Light duty applications can use coolant meeting ASTM D3306 and follow the maintenance schedule in the appropriate Owners manual. However, if ASTM D3306 antifreeze is used, it **must** additionally meet the elastomer capability section of Cummins Engineering Standard 14603.

Use of fully formulated antifreeze/coolant in this engine is acceptable but **not** required. If fully formulated antifreeze/coolant is used, it **must** meet a minimum requirement of ASTM D6210.

The F-Series engines **must** use coolant meeting ASTM D3306, except North America Industrial F-Series which may also use coolant meeting ASTM D6210. The F-Series **must** follow the maintenance schedule in the appropriate Owners or Operation and Maintenance Manual.

Section 6 - Coolant Testing

Coolant testing is required for two reasons:

1. To determine the additive concentration and glycol level of the coolant. This will make sure that adequate liner pitting protection and freeze point protection are achieved.
2. To determine if the coolant **must** be replaced due to contamination.

Coolant testing for additive and glycol levels **must** be performed at least twice a year. The coolant **must** also be tested for replacement limits every 240,000 km [150,000 mi], 4000 hours, or once a year, whichever occurs first.

Additive and glycol testing is also recommended when the following occur:

- Coolant loss between test intervals exceeds 10 to 15 percent of system capacity
- Water pump seal, radiator core, or other external leakage is apparent
- Anytime the coolant condition is unknown, or corrosion is apparent within the cooling system
- Anytime a cooling system component is repaired or replaced.

Coolant Replacement Limits

Table 5 below lists the limits for various coolant contaminants.

Table 5, Coolant Replacement Limits

Contaminant	Allowable Level
Sulfate (SO_4)	1500 ppm, maximum
Chloride (Cl) Fluoride, Bromide	200 ppm, maximum
Oil or fuel contamination	Coolant **must not** contain oil or fuel
pH	6.5, minimum (See Note 1)
Grease, solder bloom, silica gel, rust, or scaling	Coolant **must** be free of these contaminants

1: Concentrated antifreeze/coolant levels are double the premixed levels.

- The minimum pH for a replacement limit can vary according to the product. Consult the product manufacturer for the pH limit. A pH less than 6.5 is always unacceptable. For Fleetguard® ES™ Compleat™ coolant, the coolant **must** be replaced if the pH is below 7.5 pH.

Bromide is typically a contaminant from radiator flux and fluoride is a contaminant from brazing flux. Both bromide and fluoride are corrosive especially to aluminum parts.

If the coolant does **not** meet the replacement limits of sulfate, chloride, or pH, it **must** be drained and replaced with new coolant meeting Cummins Engineering Standard 14603. However, if the coolant is contaminated with oil, fuel, grease, solder bloom, silica gel, rust, or scaling, the system **must** be drained, cleaned, and refilled. See Section 11 for details on cleaning the cooling system.

Coolant Testing Kits

Coolant testing and monitoring are useful tools for tracking and controlling coolant condition and performance. The methods available for testing coolants include field test kits, portable refractometers, and coolant analysis programs. Cummins Inc. recommends using the following Fleetguard® products:

Coolant Additive and Glycol level testing:

- Three-Way™ Heavy Duty Coolant Test Kits

Table 6, Three-Way™ Heavy Duty Coolant Test Kits

Part Number	Quantity	Foil Sealed
CC2602	50	No
CC2602A	4	Yes
CC2602B	100	Yes

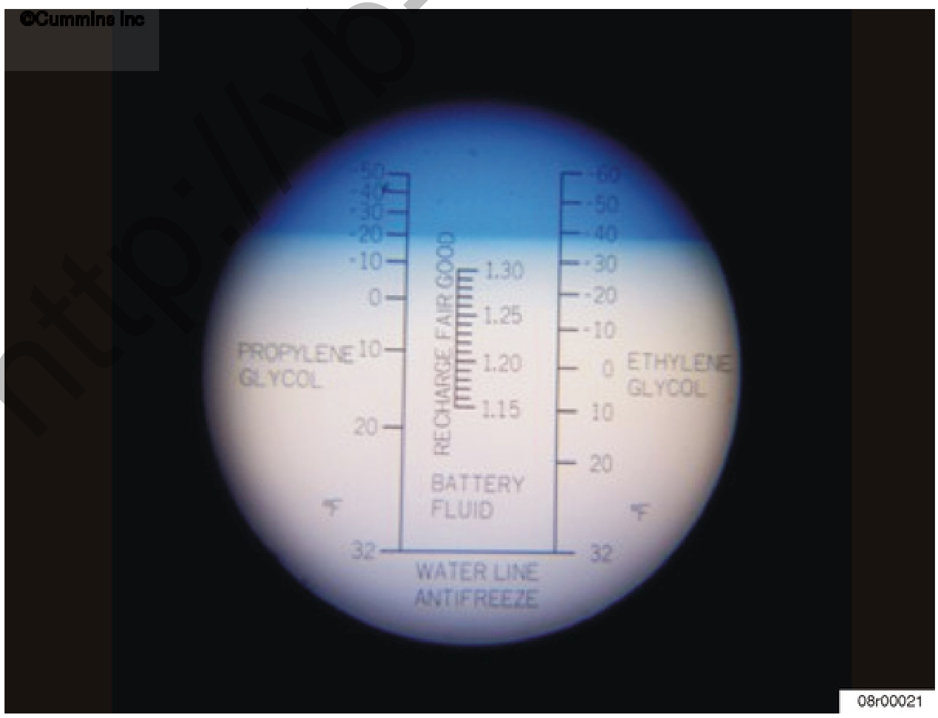
Coolant testing for contamination/replacement limits:

- Quick-Chek™ Test Kits

Table 7, Quick-Chek™ Test Kits

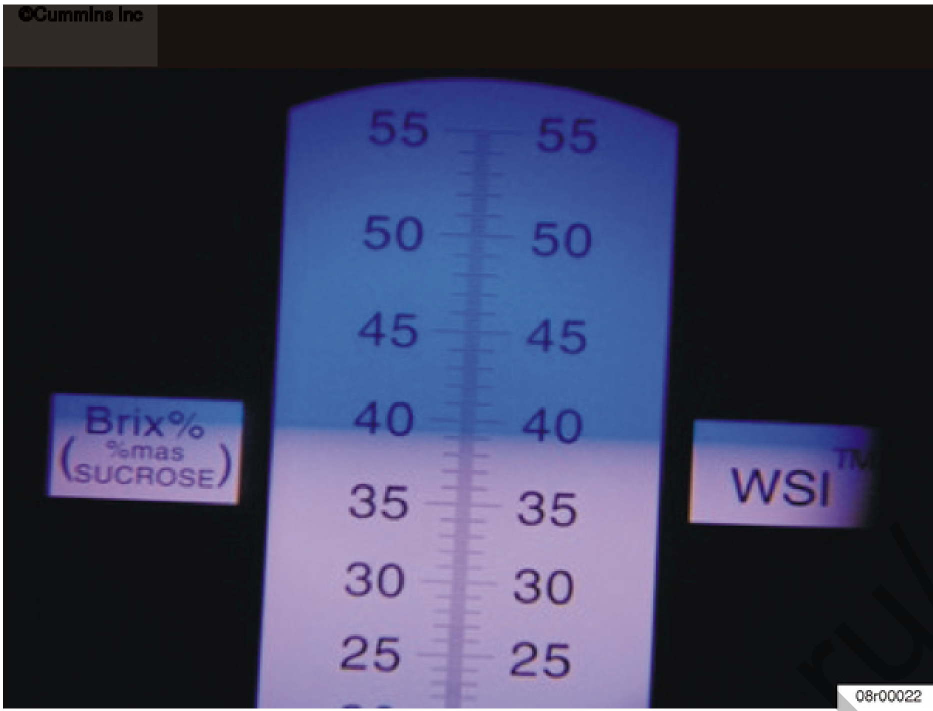
Part Number	Quantity	Foil Sealed
CC2607B	100	Yes
CC2607C	25	Yes

Coolant Freeze Point Testing



Refractometer, Part Number CC2806

For use with ethylene and propylene glycol coolants **only**.



Refractometer, Part Number CC36049

For use with glycerin coolant **only**.

Coolant analysis program.

- Monitor C™ program, part number CC2700

The Three-Way™ heavy duty coolant field test kit is appropriate for testing nitrite-molybdate formulations, such as Fleetguard® DCA-4 as well as nitrite formulations such as Fleetguard® DCA2 (Fleetcool).

Fleetguard® Quik-Chek™ test strips will detect contamination levels that indicate replacement of the coolant is required.

The Monitor C™ program can evaluate most new or used coolant formulations.

Field test kits offer the benefit of on-site measurements and are designed to approximate Extender/SCA levels and freezing points. When required, freezing points can be more accurately determined with on-site refractometer readings.

When using the Fleetguard® Three-Way™ heavy duty coolant test kit, it is important to follow the instructions provided in the kit. Contact Cummins® Filtration Technical Assistance at 800-223-4583 or www.Cumminsfiltration.com for additional information.

Because the kit measures nitrite and molybdate separately, it can reliably measure both Fleetguard® SCA formulations as well as most competitive SCA formulations. Cummins Inc. recommendation for a nitrite-molybdate formulation for pitting protection is explained in Attachment 1 - Summary of Coolant Additive Technology.

⚠ CAUTION ⚠

These types of SCA kits are NOT effective on OAT coolants that are not formulated with nitrite and/or molybdate. Some coolant manufacturers of the OAT coolants have developed specific test kits for these types of coolants. Follow the coolant manufacturers' instructions for coolant testing on OAT coolants.

Correct interpretation of laboratory data can provide additional guidance in coolant treatment effectiveness and early warning detection. Interpretation and further treatment action(s) are generally provided with laboratory results. Therefore, laboratory testing is typically very cost effective for the long term when used to optimize cooling system performance and life. However, it **must not** be used as a method for minimizing treatment.

Coolant analysis programs are performed in laboratories and offer additional, useful information, but require mailing coolant samples to a laboratory. Laboratory measurements typically include the following:

- pH level
- Extender/SCA level
- Freezing point protection
- Buffer level
- Dissolved solids

- Silicate level
- Metal corrosion products.

See Attachment 3 for an example of a Monitor C™ report.

Section 7 - Antifreeze

The primary purpose of antifreeze is to lower the freezing point of the coolant. Additional performance characteristics of coolants that are affected by the use of antifreeze include boiling point and vapor pressure. Antifreeze decreases vapor pressure, which is very beneficial to the reduction of cavitation corrosion liner pitting. This characteristic is the primary basis for Cummins Inc. requirement for increased SCA levels when antifreeze falls below 40 percent by volume.

A 50/50 mixture of antifreeze and water provides optimum boiling and freezing point protection for engines. An antifreeze concentration in excess of 60 percent **must never** be used, except in arctic climates, since it increases the possibility of forming cooling system gel, which results as silicates precipitate out of solution. However, an antifreeze concentration of less than 40 percent increases the possibility of coolant freezing and liner pitting. Therefore, Cummins Inc. recommends an antifreeze concentration range of 40 to 60 percent.

Fluids presently used in antifreeze are ethylene glycol, propylene glycol and glycerin. Diesel engine antifreeze has primarily used ethylene glycol products because they are less expensive than propylene glycol products. However, some applications require less toxic coolant products and have driven the use of propylene glycol. The comparative properties are similar for ethylene glycol and propylene glycol and are listed below. Properties of pure water are shown for comparison. Properties of glycerin are similar to that of propylene glycol. Glycerin is non-toxic. See Table 8 for properties.

Table 8, Properties of Ethylene Glycol, Propylene Glycol, and Glycerin Antifreeze versus Water

Property	Glycerin (percent by volume)			Ethylene Glycol (percent by volume)			Propylene Glycol (percent by volume)			Pure H_2O
Glycol Concentration	40	50	60	40	50	60	40	50	60	0
Specific Gravity, 16°C [60°F]	1.11	1.14	1.16	1.062	1.076	1.088	1.038	1.043	1.047	1.000
Freezing Point °C [°F]	-21 [-5]	-32 [-25]	-53 [-64]	-24 [-12]	-37 [-34]	-52 [-62]	-21 [-6]	-33 [-27]	-49 [-56]	0 [32]
Boiling Point °C [°F] at atmospheric pressure	106 [222]	108 [227]	111 [231]	106 [222]	108 [226]	111 [232]	104 [219]	106 [222]	109 [228]	100 [212]

Note : Glycerin used in antifreeze **must** meet ASTM D7640.

Cummins Inc. does **not** recommend the use of waterless coolant (coolants containing no water). These coolants have different heat transfer properties which can result in hotter engine temperatures. High engine temperatures can thin lubricating oil and cause wear issues. It can negatively affect gasket and seal materials. Cummins Inc. is **not** responsible for malfunctions or damage resulting from what Cummins® determines to be abuse or neglect, including, tampering with key engine parts to accommodate such products. Any unauthorized modifications could void warranty.

Section 8 - Treated Water Coolant

⚠ CAUTION ⚠

The recommendations in this section can in no way be interpreted as an endorsement by Cummins Inc. to use treated water in place of antifreeze/coolant.

⚠ CAUTION ⚠

Engines using cooled exhaust gas recirculation (EGR) must not use treated water coolant. The use of coolant with 40 to 60 percent antifreeze is mandatory on these engines. This is due to increased coolant temperatures.

For purposes of this document, any coolant mixture with less than 40 percent antifreeze is considered to be “treated water” and requires increased supplemental coolant additives (SCA) as described in this section. Cummins Inc. does **not** recommend that water treated with additives be used in place of fully formulated antifreeze/coolant. However, it is recognized that certain applications operating **only** in warm-weather areas may have compelling reasons to use treated water coolants. This section gives some guidance on using treated water coolant in place of antifreeze/coolant if the user chooses to do so.

Customers **must** also be advised that **not** using fully formulated antifreeze at 40 to 60 percent glycol levels will reduce the level of engine protection against boil over, liner pitting, water pump cavitation, corrosion, scale and deposit formation, heater core freeze up, and microbial deterioration. **Not** using antifreeze can also decrease engine and vehicle cooling system component life.

Note : Minimum SCA level required for treated water coolant is 0.8 units per liter [3 units per gal] and **not** 0.3 units per liter [1.2 units per gal] as required in other sections of this bulletin.

Supplemental coolant additive (SCA) levels between 0.8 to 1.3 units per liter [3 to 5 units per gal] **must** be achieved and maintained through routine replenishment. Replenishment is necessary to make up for depleted SCA chemicals that are spent during normal operation. Incorrect concentration levels can be avoided by usage of the test kit described in Section 6. Cummins Inc. requires the use of quality water (see Section 9) and SCA meeting the ASTM D5752 specification, (see Attachment 2). The greater the water concentration, the more important its purity.

⚠ CAUTION ⚠

Marine engines must use a minimum of 25 percent antifreeze/coolant for both initial fill and topping off, and must maintain high SCA levels as described below. Treated water coolants with less than 25 percent antifreeze must never be used in marine engines.

The following steps are required for initial filling and maintenance of treated water cooling systems.

- Fill the cooling system with high-quality water (Marine engines use minimum 25 percent antifreeze with high-quality water) and liquid supplemental coolant additive (Fleetguard® DCA-4 at a level of 5 units per 3.8 liters [1 gal]. Chemical filters **must not** be used to precharge water for use as treated water coolant.
- Fit the system with chemical-free filters. Chemical filters **must not** be used to treat water in a treated water cooling system because the additives they contain may **not** meet the D5752 specification.
- Change the coolant filter(s) at every oil change.
- Top off the cooling system using **only** a mixture of high-quality water (Marine engines use minimum 25 percent antifreeze with high-quality water) and SCA at a level of 5 units per 3.8 liters [1 gal].
- Test the SCA level a minimum of twice per year. See Section 6 - Coolant Testing for further information. If the SCA level is found to be below 3.0 units per 3.8 liters [1 gal], the frequency of testing and replenishment **must** be increased. The SCA level **must never** be allowed to fall below 3.0 units per 3.8 liters [1 gal].
- Test the coolant once per year, 240,000 km [150,000 mi], or 4000 hours, whichever occurs first, to determine if it **must** be replaced. See Section 6 - Coolant Testing for further information and test strip part numbers.
- If SCA concentration level is below 5.0 units per gallon, add liquid SCA to bring the level up to at least 5.0 units per 3.8 liters [1 gal]. Do **not** exceed 6.0 units per 3.8 liters [1 gal].

The recommended SCA is Fleetguard®'s liquid DCA4 containing molybdates as well as nitrites. In addition to providing the needed liner and block protection, the engine's tolerance of excess concentrations of DCA4 is higher as compared to DCA2. Fewer dissolved solids are used in the DCA4 chemical formulation, which reduces the tendency for water pump seal buildup and leakage. SCA formulations that do **not** contain molybdates, such as Fleetguard®'s liquid Fleetcool (DCA-2), can be successfully used if excess concentrations are avoided.

Section 9 - Water Quality Requirements

Cooling systems perform best with distilled or deionized water. If distilled or deionized water is **not** available, the quality of the water used **must** meet all the requirements listed below. Excessive levels of calcium and magnesium contribute to scaling problems, and excessive levels of chloride and sulfate cause cooling system corrosion. If water quality is unknown, it can be tested with the Fleetguard® Monitor C™ program or Water-Chek™ test strip. Water test results can also be obtained from local water utility departments. Test data **must** show the following elements, and the levels **must not** exceed the published limits for use in cooling systems.

Table 9, Maximum Element Level Allowable in Water

Table 9, Maximum Element Level Allowable in Water

Element	Maximum Level Allowable
Calcium, Magnesium (Hardness)	170 ppm (as $CaCO_3$)
Chloride	40 ppm (as Cl)
Sulfate	100 ppm (as SO_4)

Fleetguard® Water-Chek™ Test Strip, Part Number CC2609, can be used to determine the quality of make-up and shop tap water. The Water-Chek™ test strip measures hardness, pH, and chloride levels in make-up water.

Section 10 - Maintenance Records

Accurate maintenance records are important. Maintenance programs **must** be accompanied by accurate record-keeping practices. Records **must** be capable of supplying the information required for the following:

- Support diagnostic and troubleshooting procedures involving the cooling system
- Support the investigation of potentially warrantable failures
- Forecast repairs leading to the prevention of failures.

Routine cooling system maintenance records **must** include the following information:

- Date of service and actions taken during service
- Accumulated vehicle and coolant hours
- Extender/SCA level when measured
- Freezing point or antifreeze concentration as a percent of coolant volume
- Coolant top-off quantity
- Laboratory analysis readings (where available).

Section 11 - Cleaning the Cooling System

⚠ CAUTION ⚠

Failure to purge cleaning chemicals sufficiently can result in contamination of the new coolant during the refill process, which can lead to engine failure.

⚠ CAUTION ⚠

Coolants and cooling system cleaning and flushing fluids that contain 5 ppm or more of lead or 0.5 ppm of benzene are considered hazardous according to federal law in the United States of America. Disposal must be done in accordance with local, state, and federal laws.

Routine cleaning of cooling systems is **not** recommended. However, inadequate maintenance practices, incorrect use of coolant products, or an engine component failure (such as an oil cooler element) can lead to problems that require cleaning the cooling system. Cummins Inc. recommends the use of cleaning products when one or more of the following contaminants are found in the cooling system:

- Silicate gel
- Oil, grease, or fuel
- Scale
- Rust
- Solder bloom.

To remove oil or fuel contamination from a cooling system, a low foaming cleaner specifically designed for oil removal **must** be used. Fleetguard® Restore™ Heavy-Duty Cleaner is an alkaline based product that has been modified to perform as an oil and grease super cleaner. In addition, it can also effectively remove silicate gelation from a cooling system.

For cleaning poorly maintained or severely contaminated cooling systems, an acid based cleaner is recommended. Fleetguard® Restore Plus™ Heavy-Duty Cleaner is an acid based product that is excellent in removing rust, scale, solder bloom, and other corrosion contaminants from the cooling system.

Table 10 below lists various contaminants and the cleaning performance of each cleaner with respect to those contaminants. The correct cleaner **must** be chosen based on the type of contamination.

Table 10, Cooling System Cleaner Application Chart

Contaminant	Fleetguard® Restore™ (Alkaline) or Equivalent Product	Fleetguard® Restore Plus™ (Acid) or Equivalent Product
Silicate gel	Excellent	Poor

Table 10, Cooling System Cleaner Application Chart		
Contaminant	**Fleetguard® Restore™ (Alkaline) or Equivalent Product**	**Fleetguard® Restore Plus™ (Acid) or Equivalent Product**
Oil, grease and fuel	Excellent	Good
Scale	Poor	Excellent
Rust	Poor	Good
Solder bloom	Poor	Good

Cooling systems **must** be cleaned carefully when any of the above conditions are apparent. Overheating can also accompany the above conditions. If the cooling system is overheating, inspect the system to determine if it requires cleaning. It is very important to flush the cooling system of chemical cleaners completely and thoroughly at the conclusion of the cleaning process. This **must** be done with water and will require more than one flushing to purge the cooling system of the cleaning chemicals. See the remainder of this section for recommended cleaning procedure.

⚠ WARNING ⚠

When using chemical products for cleaning, follow the manufacturer's recommendations for use and disposal. Wear goggles and protective clothing to avoid personal injury.

⚠ WARNING ⚠

Some solvents are flammable and toxic. Read the manufacturer's instructions before using.

⚠ CAUTION ⚠

The use of products containing hydrochloric acid will not result in adequate system cleanup and may attack cooling system materials.

⚠ CAUTION ⚠

Prolonged use of any cleaner greater than 3 hours is not recommended.

Cleaning Procedure for Removal of Lubricating Oil and Fuel from the Engine Cooling System Using Fleetguard® Restore™ Liquid Cleaner

Prior to cleaning the cooling system, install adequate coolant system draincocks, fittings, and hoses to allow the coolant to drain quickly. The system **must** be drained immediately upon engine shut down. Therefore, it is suggested that a Tee fitting be installed in the fill line to allow the top tank/expansion tank to drain quickly. In addition, a fabricated Tee connection **must** be installed in the lower radiator out plumbing if sufficient drain ports are **not** available to drain the system quickly.

1. Operate the engine at 1200 to 1500 RPM for 30 minutes with sufficient load to open the thermostat(s) to produce flow through the radiator. Also, make certain that flow is achieved through any cab heater cores or auxiliary heat exchangers.
2. Drain the contaminated coolant from the cooling system using available radiator, cylinder block, and lower radiator hose drain ports. Flush the cooling system with hot tap water as much as possible before beginning the chemical flush procedure. Use caution when handling hot coolant and dispose of the used coolant in an approved manner.
3. Pour 3.8 liters [1 gal] of the liquid cleaner into the radiator and finish filling the system with tap water. This mixture is satisfactory for a 12 - 14 gallon cooling system. For larger cooling systems, add 3.8 liters [1 gal] per 57 liters [15 gal] of system capacity. Do **not** reinstall the radiator cap. Leaving the cap off facilitates inspection of coolant flow in the radiator along with eliminating the cool-down time required for radiator cap removal.

⚠ CAUTION ⚠

Do not use liquid dish soap. Foaming and air lock in the cylinder head(s) can occur causing severe engine damage.

1. Operate the engine at 1200 to 1500 RPM for 30 minutes with sufficient load to open the thermostat(s) (minimum 85°C [185°F] coolant temp) to produce flow through the radiator and/or heat exchanger(s). Operating the engine without load will prolong the cleaning process. To increase operating temperature and decrease cleaning time, disable the fan drive or cover the radiator core completely. Check for flow through the radiator. Failure to get the cooling system hot enough to fully open the thermostat(s) will leave the radiator core contaminated although the engine side will be clean. Be sure to

open and/or set the heater controls in the maximum heating position. If loaded engine operation is **not** possible, block the thermostat(s) open to produce radiator circulation. If coolant does **not** become hot enough, adequate cleaning will take much longer and additional flushes can be required.

2. Shut down the engine and drain the cleaning solution quickly by utilizing all of the available drain cocks and/or via the fabricated lower plumbing arrangement. Draining the cleaning solution quickly reduces the chances that oil residue will stick to the cooling system surfaces, which will prolong the flushing process.
3. After the cleaning solution is drained from cooling system, fill the cooling system with plain tap water. Operate the engine for 15 minutes at 1200 to 1500 RPM while it is still hot.
4. Drain the tap water from the cooling system. The water will contain cleaner and oil residue and **must** be disposed of in an approved manner.
5. If the tap water does contain oil residue, the system **must** be cleaned again. Return to Step 3 above and repeat use of the cleaner until the tap water used to rinse the system has no more oil residue and no oil is observed in the radiator. It may be helpful to inspect the inside of coolant hoses and pipes for evidence of oil adhering to the surfaces.
6. Once the cooling system is thoroughly cleaned, return the system to the original configuration and install new, fully formulated antifreeze/coolant meeting Cummins Engineering Standard 14603.
7. If applicable, install a new coolant filter sized appropriately.

Section 12 - Coolant for Arctic Operation

There are many factors, in addition to engine coolant, that need to be considered when operating Cummins® engines in arctic climates. These are discussed in Cold Weather Operation, Bulletin 3387266, and Operation of Diesel Engines in Cold Climates, Bulletin 3379009. Operation of Diesel Engines in Cold Climates defines arctic conditions as -32°C to -54°C [-25°F to -65°F]. That bulletin recommends use of a 60 percent ethylene glycol antifreeze mixture for coolant for arctic specifications. Cold Weather Operation states that the maximum recommended mixture is 68 percent antifreeze (ethylene glycol).

To update the above recommendations on coolant for arctic operation, a review of the pertinent literature was made and reported recently. The results of the review are:

1. Do **not** use propylene glycol or glycerin coolant in arctic climates because of its higher viscosity compared to ethylene glycol coolants. Applications with remote radiators mounted at some distance above the engine and exposed to low temperatures can result in no coolant flow through the radiator due to high viscosity of propylene glycol coolant solutions. Use ethylene glycol coolants in the recommended range.
2. Use ethylene glycol coolants at 65 percent glycol concentration and stay within the range of 60 to 68 percent glycol.
3. Do **not** over treat the coolant with supplemental coolant additives (SCA's) beyond 0.8 units per liter [3 units per gal] due to the limited solubility of additives at these lower than normal temperatures and higher than normal glycol levels.
4. SCA concentration **must** be maintained between 1.2 and 3 units per 3.8 liters [1 gal].

Section 13 - Recycled Coolants

All documents previously published on recycled coolants are now obsolete. Cummins Inc. requirements for recycled coolant are the same as for new coolant. New and recycled or reclaimed coolant **must** meet Cummins® Engineering Standard 14603. Some recycled products; based on distillation, dual deionization, or reverse osmosis/electrodialysis of used engine coolant, are capable of meeting Cummins® Engineering Standard 14603. However, glycol reclaimed from the following sources has been found to cause serious engine problems in the field:

- glycol bottoms
- polyester manufacturing waste
- aircraft deicers
- medical waste.

Therefore, they would fail the field test portion of Cummins Engineering Standard 14603 and are **not** approved for use in Cummins® engines.

Section 14 - Nitrite Free Engine Coolant

Many fully formulated diesel engine coolants utilize a nitrite ingredient to provide protection against metallic corrosion and specifically for cylinder liner cavitation protection. This technology, although robust for engines utilizing cylinder liners, can present some disadvantages from a maintenance, materials compatibility, and environmental perspective. Parent bore engines do not necessarily need this ingredient, especially when robust coolants that contain different ingredients for cavitation and corrosion protection (such as those found in Fleetguard® ES Compleat™ OAT coolant) are used.

Coolants that depend on nitrites have a significant disadvantage in that the nitrite ingredient will deplete over time and regular additions of coolant additive extenders are needed to ensure adequate levels of nitrite additive are present in the coolant system.

It is important to draw a clear distinction between uses of Nitrites (i.e. NO_{2-}) and Nitrates (i.e. NO_{3-}). Nitrites are strong oxidizing agents that are beneficial for the prevention of ferrous metal corrosion. However, the breakdown of nitrites can lead to an alkaline environment that is particularly corrosive to the cooling system. Many Original Equipment Manufacturers (OEMs) now prohibit the use of nitrite as part of the coolant formulation and certain geographic locations ban its use. Nitrates are oxidizing agents as well, however less reactive than nitrites and less likely to form alkaline by-products. Nitrates provide acceptable metal corrosion inhibition and are beneficial in coolant formulations where it is utilized.

Nitrites can be detrimental in engines that utilize aluminum in major components such as engine blocks, cylinder heads, and heat exchangers. Under certain conditions, nitrites can form alkaline products which will negatively affect the pH balance in the cooling system and induce corrosion. Engines with major components made from aluminum may require nitrite free coolant. See the corresponding Owners manual and Operation and Maintenance manual for your engine.

Attachment 1 - Summary of Coolant Additive Technology

Antifreeze/coolant concentrate is made up of roughly the following components:

- 93 to 95 percent ethylene glycol or propylene glycol
- 2 to 5 percent of an additive package
- 1 to 3 percent water.

The glycol is present to lower the freeze point and increase the boiling point of the coolant. See Section 7 - Antifreeze, for additional benefits of glycol. The small amount of water is either contained in the additives used or is added to aid the blending of the product. This allows the additive package to better dissolve in the glycol and prevents dropout or precipitation during storage. More detail is given in the following section on the various chemicals and functions of the coolant additive package.

Glycerin can also be used as an antifreeze. However, because glycerin concentrate has a high viscosity, it is usually sold as a 50/50 premix.

Coolant Additives and their Function

A fully formulated antifreeze/coolant will perform the following functions to prevent corrosion and maintain efficient heat transfer. See Section 1 - Introduction for a comparison of the functions of light-duty and heavy-duty antifreeze/coolants.

- Buffering
- Additive or Chemical - Phosphate, Borate, or Salts of Organic Acids
- Benefit or Effect - Maintain proper pH, Neutralize acidic material that enters coolant
- Corrosion Inhibitor
- Additive or Chemical - Nitrate, Silicate, Mercaptobenzothiazole (additive to protect yellow metals), Tolyltriazole (additive to protect yellow metals), and Organic Acid Salts
- Benefit or Effect - Prevent corrosion of various cooling system metals
- Liner Pitting Protection/ Control
- Additive or Chemical - Nitrite and Molybdate
- Benefit or Effect - Especially effective at cast iron cavitation-corrosion protection
- Antifoam
- Additive or Chemical - Polyglycols and Silicones
- Benefit or Effect - Prevent the formation of stable foam which can cause heat transfer/corrosion problems
- Scale and Deposit Control
- Additive or Chemical - Phosphonates and water soluble polymers such as polyacrylates
- Benefit or Effect - Prevents the buildup of scale or mineral deposits on heat transfer surfaces
- Antifouling
- Additive or Chemical - Low foaming surfactants/detergents
- Benefit or Effect - Prevent the buildup of oil & dirt that block heat transfer and promote corrosion.

Supplemental Coolant Additives (SCAs) versus Extended Service Additives

SCAs have been around in the form of chromate based products since the mid 1950's. The chromate based SCA's were largely replaced by borate-nitrite products by the mid 1970's because of chromate's toxicity. In the mid 1980's a phosphate-molybdate based product, DCA4 was made available to improve upon the performance of the borate-nitrite products that then dominated the market. The SCAs had three uses.

1. SCA was used to precharge light-duty antifreeze to make it acceptable for heavy-duty service.

2. SCA was added at 15K to 50K mile service interval to offset both dilution and depletion. Dilution occurred as the system was refilled with light-duty coolant.
3. SCA was used as the total additive package for treated water coolants common in warm climates and marine applications.

In the early 1990's the heavy-duty coolant market had begun to change. Most fleets no longer drained coolant at the recommended 240K mile, or 6K hour recommendation, but continued to use the same coolant until engine rebuild. Fully formulated heavy-duty coolant became more readily available and this resulted in an increase in the length of service intervals. Coolant additive replenishment was separated from servicing of the lube system and pushed out to once per year, 150K miles, or 4K hours. SCA's are **not** formulated for long life, extended service operation. Adding SCA to heavy-duty coolant could result in excessive levels of additives in the coolant. Over time, this excessive additive build up or high level of total dissolved solids in the coolant can cause water pump leakage as well as solder and aluminum corrosion.

The first extended service additives, Extended Service Additives or “Extenders”, became available in the late 1980's and were commonplace by the mid 1990's. An antifreeze Extender is formulated to replace additive at the rate that it is consumed or depleted. This assumes that the cooling system is being topped up with a fully formulated heavy-duty coolant so that there are little or no issues with additive dilution. The composition of an Extender is based upon the depletion rate of the various components. The Extender contains a larger amount of those additives that deplete quickly and smaller amounts of those additives that are consumed at a lower rate over time. For instance, Extender contains twice the amount of nitrite and half as much phosphate as the regular SCA. This is based on the fact that nitrite depletes faster than phosphate. Extenders are formulated to maintain a proper balance of additives in the coolant over time. However, they will **not** establish the proper initial additive levels, therefore extenders can **not** be used to formulate treated water coolant.

“Organic Acid Technology (OAT)” Coolants or “Organic Acid” Coolants

For both OAT and organic acid coolant, organic acids make up the large part of the additive package. However, ethylene glycol or propylene glycol still make up 90 to 95 percent of the antifreeze as with conventional antifreeze. For this reason the heat transfer characteristics and the physical properties such as freeze and boil over protection, specific heat, etc. are very similar to other products in the market.

What is an organic acid? First a chemical is classified as organic if it contains the element carbon as part of its structure. Organic acids are just one of the many classes of organic compounds such as alcohols and carbohydrates. Common organic acids are acetic acid, better known as vinegar, and adipic acid, which is the main ingredient in baking powder. In reality it is the sodium or potassium salts of organic acids that are used as corrosion inhibitors and buffers in engine coolants. The same is true for inorganic acids such as nitric and phosphoric that are used in conventional coolants.

The use of organic acids in engine coolants goes back to the early 1950's when benzoic acid was used in hybrid type coolants in Europe. Coolants are classified as “conventional”, “hybrid”, or OAT based largely on how much organic acid is used in the coolant additive package.

1. Conventional - Additive package made up predominately of inorganic type compounds
2. Hybrid - Additive package contains a mixture of inorganic and organic acid components
3. OAT - The additive package consists of 75 to 90 percent organic acids. Also OAT coolants will generally **not** contain the buffers borate and phosphate or the aluminum corrosion inhibitor silicate.

Note : Some OAT coolants do **not** contain nitrites and molybdates, therefore, they do **not** have SCA units. These OAT coolants use organic acids to protect against liner pitting.

DCA-4 versus Fleetcool (DCA-2)

DCA4, DCA-4 Plus & ES™ Liquid Extenders, as well as ES™ Compleat are all based on a phosphate/molybdate/nitrite additive package. These chemicals, along with other additives, provide protection to cooling system components. Many other SCAs or Extenders such as Fleetcool (DCA-2) have a borate-nitrite base and higher levels of silicate. The liner pitting protection of DCA-4 and Fleetcool (DCA-2) is equivalent, however DCA-4 provides the following advantages:

- Reduced risk of water pump leakage due to overtreatment as compared to DCA-2
- DCA-4 is more tolerant of hard make-up water
- DCA-4 is less likely to form silicate gel if overtreated
- DCA-4 provides better solder protection, which reduces “bloom” deposits
- DCA-4 provides aluminum protection without high levels of silicate
- DCA-4 contains surfactants that limit or prevent oil and dirt from fouling metal surfaces within the cooling system.

If the pitting protection performance of DCA4 and DCA2 (Fleetcool™) are equivalent, then why is DCA4 a preferred chemistry?

- It is preferred because of the added benefits described above, and because the SCA package of DCA4 contains fewer dissolved solids to accomplish equivalent performance. DCA4 depends on the combined effect of nitrites and molybdates, whereas DCA2 (Fleetcool™) depends solely on the effect of nitrites. The presence of molybdates enhances the protective qualities of nitrites. However, molybdates alone will **not** provide adequate protection. Therefore, laboratory test results and test kit charts are specifically designed to warn of insufficient nitrite levels by indicating low SCA levels. On the other hand, the absence of molybdates will **not** trigger warnings if nitrite levels are sufficient to provide pitting protection. That is why the CC2602 test kit works well with both DCA4 and DCA2 (Fleetcool™).

How do SCAs/Extended Service Additives protect liners and blocks from pitting damage?

- SCAs/Extended Service Additives work by forming a protective coating on liner and block surfaces that are subjected to cavitation. Cavitation is the driving force responsible for pitting damage. It is caused by the collapse of vapor bubbles created during liner movement following combustion. Vapor bubbles are formed anytime the localized pressure of the coolant drops below the vapor pressure of the coolant. Vapor pressure is a physical characteristic of the coolant that is primarily controlled by the antifreeze-to-water ratio and coolant temperature. The localized pressure is a function of many factors, including engine design, load, piston slap, engine timing, and cooling system pressure.

Attachment 2 - Cummins Inc. Coolant and Filter Specification

Cummins Inc. Coolant Specification

Cummins Engineering Standard 14603 requires that the antifreeze/coolant meet all requirements of ASTM D6210 for glycol coolant. In addition, it **must**:

1. Meet the modified ASTM D1384, the Glassware Corrosion Test. This test has stricter limits for corrosion weight loss for aluminum and solder. The solder tested shall be the standard 70/30 material and also high lead solder, which is used in many copper/brass radiators for heavy duty engine applications. Tests shall be run at both 70 percent antifreeze and 30 percent antifreeze instead of the standard 33-1/3 percent solution **only**.
2. Meet the modified ASTM D2570, Simulated Service Corrosion Testing of Engine Coolants. In addition to the standard ASTM test, various rubber seal and silicon hose materials are tested for compatibility with the coolant. In addition, the standard metal corrosion weight loss limits are stricter for aluminum and solder.
3. Meet Cummins Engineering Standard 14603, Coolant/Elastomer seal compatibility.
4. Be field tested in Cummins® engines.

For an antifreeze/coolant to be registered as meeting Cummins Engineering Standard 14603, the antifreeze/coolant supplier **must** have valid test results from competent, independent testing labs as proof of meeting the above specifications.

Cummins Inc. Coolant Filter Specification

Beginning in January 2013, all Light Duty, Midrange, and Heavy Duty engines are extended life OAT coolant compatible, and as a result the coolant filter is optional. Most Cummins® product built prior to January 1, 2013 were manufactured with a coolant filter head, and use of a coolant filter is recommended. Cummins Engineering Standard 14315 is the Cummins Engineering Standard that covers coolant filter performance. The standard contains the tests required to meet Cummins Inc. performance requirements along with the performance limits for those tests. The tests required in this standard cover the following:

- Media Soak
- Adhesive Durability
- Corrosion Flow versus Restriction
- Capacity and Efficiency
- Bubble
- Gasket Durability
- Element Collapse
- Hydrostatic Pressure
- Impulse Fatigue
- Vibration

Attachment 3 - Example of a Monitor C Report

- **Monitor 'C' Coolant Analysis - CC2700**
- Fleetguard®, Inc.
- Service Engineering
- P.O. Box 6001
- Cookeville, Tennessee 38502
- (615) 526-9551
- 1-800-22-FILTER (1-800-223-4583)

Table 11, Monitor 'C' Coolant Analysis - CC2700		
Customer:	**Account Number:**	
Address:	**Phone:**	**Engine:**
Unit Number 34913504	Fluid Type: Ethylee Glycol Coolant (A/A Water SCA)	
EOT E	N/A	
Date Sampled:	07/12/99	
Date Tested:	08/02/99	
Miles on Unit:	N/A	
Miles/Hrs. on Coolant:	129,518	
Lab Sample Number:	406514	
pH:	8.6	
Percent of Glycol:	73*	
Freezing Point:	-61°C [-78°F]	
Total Dissolved Solids (%)	0.5	
Liner Pitting	N/A	
-SCA (Units per Gallon):	0.6*	
-Nitrite (The Maintenance Council RP 382):	248	
-Molybdate	265	
(The Maintenance Council RP328):		
Corrosion Products		
-Iron:	1	
-Aluminum:	0	
-Copper:	4	
-Lead:	0	
-Silicate (The Maintenance Council RP 328):	60	
-Buffers		
-Phosphate (K2HPO4):	12733	
-Borate (Na2B4O7):	1429	
-Hardness:	0	
-Chloride:	0	
-Sulfate:	0	
Note: *Chemical analysis results are PPM except where noted.		

Note : Monitor C™ Tests are **not** sufficient to evaluate coolant recycling processes

Recommendations: SCA is underconcentrated. Glycol concentration is excessively above recommended range for antifreeze. Use 40 to 60 percent. If system is overheating, drain and flush with heavy-duty cleaner. Fill with fresh 50/50 antifreeze/water mixture. Contact Fleetguard® for proper SCA dosage. precharge system at 1.5 units SCA per gallon, and install a service filter. See "Coolant Analysis with Maintenance Recommendations" in this section.

I have personally reviewed the data and recommendations for your sample.

Diagnostician____Date______________

Attachment 4 - Explanation of Coolant Analysis and Maintenance Recommendations (Monitor C™)

- Unit:
- A measure of liner pitting protection based upon the nitrite-only, or nitrite and molybdate concentration of the coolant.
- Extender/SCA:
- At initial fill, top-off, and coolant change-out, engine coolant will have a minimum level of liner pitting protection of 0.3 units/liter [1.2 units per gal] using antifreeze and/or supplemental coolant additives (SCA). Use of fully formulated coolants meeting ASTM or The Maintenance Council specifications and a correctly-sized service filter will result in a precharge of at least the required minimum 0.4 units/liter [1.5 units per gal].

⚠ CAUTION ⚠

Failure to maintain Extender/SCA concentration level can result in severe engine damage.

For additional information, call Fleetguard® Service Engineering at 800-223-4583 and follow the menu to get to Technical Assistance.

- Glycol or Glycerin:
- Engine manufacturers recommend coolants composed of 50/50 water/glycol or glycerin solutions providing enhanced freeze and boil protection. An operating range of 40 percent to 60 percent antifreeze is acceptable except in arctic climates where 60 to 68 percent Ethylene Glycol is acceptable. Use of glycol percentages exceeding 68 percent can cause SCA drop out, water pump seal leakage, and engine overheating.
- Water Quality:
- For water quality specifications recommended by most major engine manufacturers, see Section 9. Water exceeding any of the specifications in Section 9 **must not** be used. Use distilled water, deionized water, or equivalent. Hardness **must** be determined through testing of make-up water, **not** by testing used coolant.
- pH:
- Coolant pH values have a normal range of 8.5 to 10.5 when precharged with nitrite or nitrite/molybdate SCA. If pH falls below 7.5, rapid nitrite depletion can result. This will be shown as low SCA units. Continued additions of SCA into low pH coolant will have little effect on SCA units per gallon. When pH is less than 7.5, coolant **must** be drained and the cooling system **must** be flushed. Exceptions to this are hybrid or OAT type coolants that can function properly at pH below 7.5. Coolant pH exceeding 11 will corrode aluminum and promote scale formation. The cooling system **must** be drained and flushed. If no serious problems are encountered, the system can be flushed using tap water. If corrosion, scale, or gelation is present, chemical cleaners such as Restore™ or Restore Plus™ **must** be used.
- Total Dissolved Solids:
- Total Dissolved Solids are composed of the basic inhibitor chemicals, silicates, active SCAs, spent SCAs, contaminants, and water hardness compounds. Water pump seals will tolerate gradual buildup of total dissolved solids until a 5 percent level is achieved. If water pump seal leakage occurs, the coolant **must** be tested for Total Dissolved Solids. If the total dissolved solids level is above the acceptable limit, the coolant **must** be drained and replaced.
- Silicates:
- Silicates protect several cooling system metal surfaces. Automotive antifreeze typically contains large amounts of silicate. Use of automotive antifreeze and Extender/SCA leads to additive dropout which causes plugging of radiators, heater cores, and restricts engine coolant passages. Sudden introduction of large amounts of silicate through additions of automotive antifreeze or large doses of nitrite/borate SCA (high silicates) can cause rapid failure of water pump seals. Reports of low silicates and low water hardness in used coolants can be misleading. Both silicates and hardness compounds will precipitate out in the presence of each other. For an accurate evaluation of silicate levels, new undiluted antifreeze **must** be tested.
- Buffering Agents:
- The function of phosphate and borate buffers is to counter acid formation. Acids are the product of thermal degradation of antifreeze. Without adequate buffers, corrosion and rapid additive depletion will occur due to reduction in pH values. The result will be cylinder liner pitting due to rapid nitrite depletion.
- Corrosion Products: Typical sources for corrosion products are:
- IRON: liners, water pump, cylinder block, cylinder head
- ALUMINUM: radiator tanks, radiator cores, heater cores, coolant elbows, piping, spacer plates, thermostat housings
- COPPER: radiator core, heater core, oil cooler, aftercooler (intercooler), injector sleeves
- LEAD: radiator solder, heater core solder, aftercooler core solder.

Document History

Date	Details

xxxx-xx-xx	Module Created
2012-1-3	Updates created to document.
2012-2-27	QSOL Quick Fix|Reason: Incorrect Part Number|Notes: none
2012-7-18	Corrections to typing, table, and graphic errors from last update
2013-2-25	Correction
2013-3-21	QSOL Quick Fix|Reason: Outfile|Notes: none
2013-7-11	The update is required due to the submission of a QSOL ticket (49831). The ticket request was to remove some of the informaiton in section 5 concerning the use of coolant filters on ISB.
2013-7-29	QSOL Quick Fix|Reason: Spelling Error|Notes: none
2013-9-9	Typo
2014-12-17	Added Table 3. Added Section 14. Updated Extended Life Coolants (ELC) Plus Silicates section.
2015-1-7	none
2017-3-23	Added clarification about coolant filter requirements.

Last Modified: 16-May-2017