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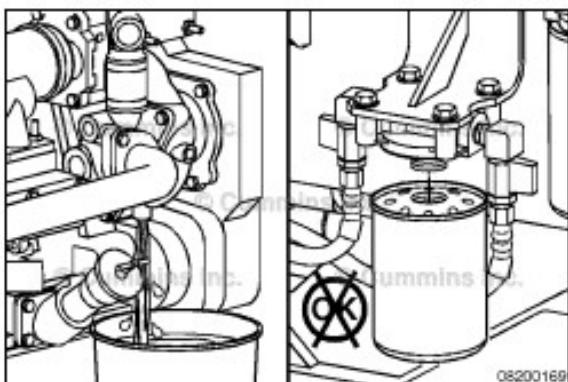
Coolant Thermostat

Remove

▲WARNING▲

Do not remove the pressure cap from a hot engine. Wait until the coolant temperature is below 50°C [120°F] before removing the coolant system pressure cap. Heated coolant spray or steam can cause personal injury.

Remove the pressure cap when the engine is cool.

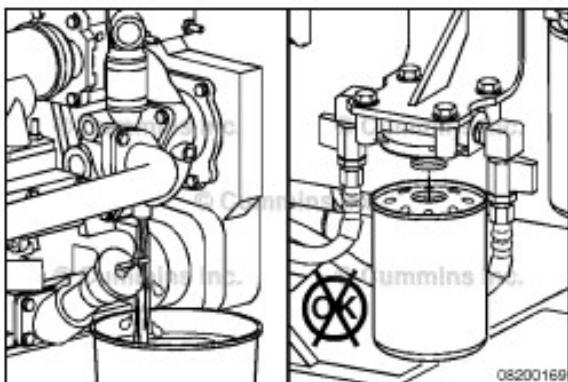


▲WARNING▲

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

Drain the cooling system as follows:

- Open the radiator draincock.
- Remove the lower radiator hose.

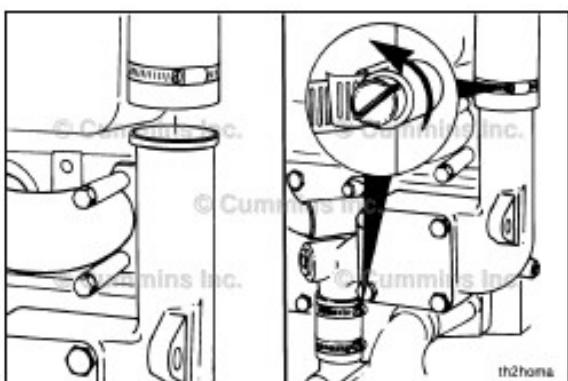


Remove the upper coolant hose from the thermostat housing.

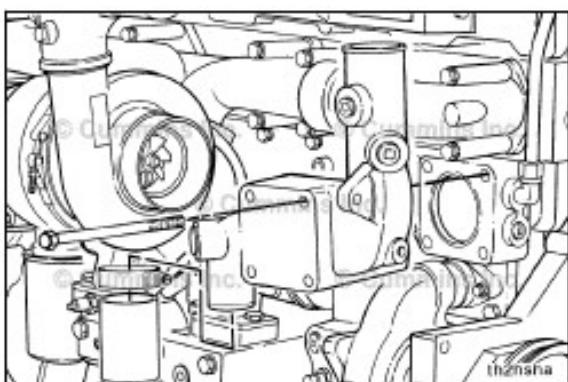


Loosen the coolant bypass hose clamps.

NOTE: Some models could have a converter cooler disc located in the bypass hose.



Remove the four thermostat housing mounting capscrews and the thermostat housing.





Remove the thermostat from the housing.

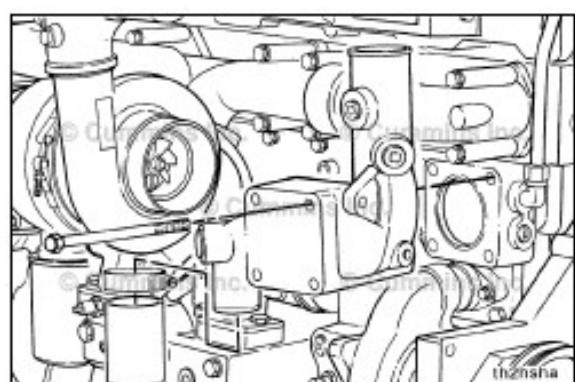


Install

Install the thermostat in the housing.



Install a new o-ring seal in the groove on the thermostat housing mounting surface.



Install the hose on the thermostat housing bypass outlet.

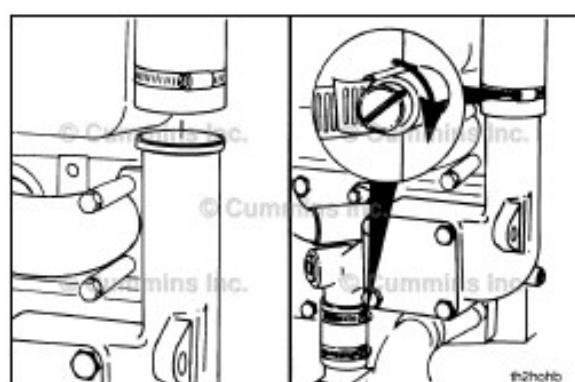


Install the thermostat housing and four mounting capscrews.



Tighten the mounting capscrews.

Torque Value: 54 N·m [40 ft-lb]



Install the drain fitting.



Install the upper coolant hose to the thermostat housing outlet.

Tighten the coolant bypass hose clamps.

Torque Value: 5 N·m [44 in-lb]

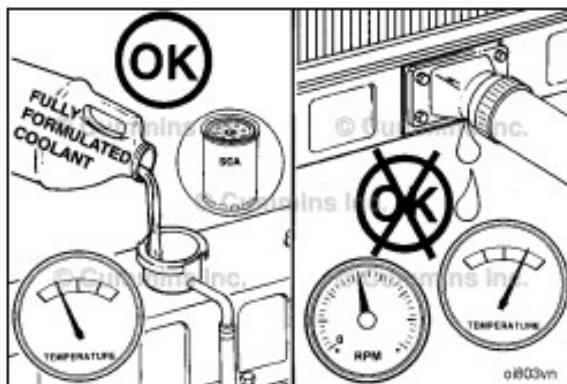
The correct concentration of coolant additives **must** be used in the cooling system. Refer to Procedure 018-004 in Section V.



Fill the cooling system. Refer to Procedure 008-018 in Section 7.



Operate the engine until it reaches 80°C [180°F], and check for coolant leaks.



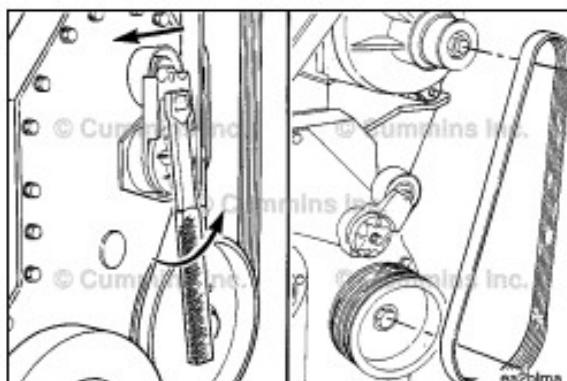
Drive Belt, Alternator Remove



Insert a 3/8-inch breaker bar into the space provided on the tensioner.

Rotate the tensioner away from the belt until it stops.

Remove the alternator belt while holding the tensioner.



Loosen the adjusting screw locknut (1).

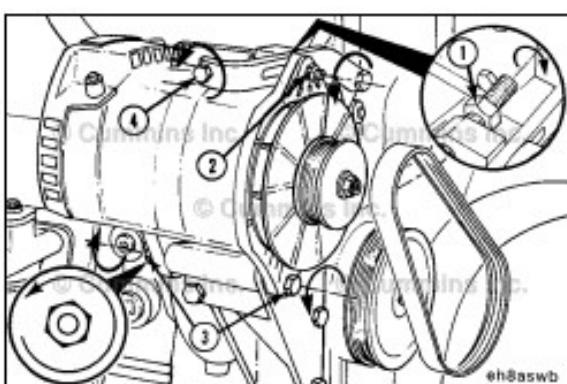


Loosen the adjusting link locking capscrew (2).

Loosen the alternator mounting capscrew (3).

Turn the adjusting screw (4) counterclockwise to release tension.

Remove the alternator belt.



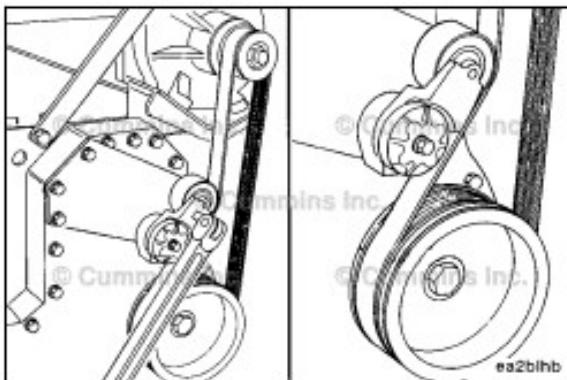
Install

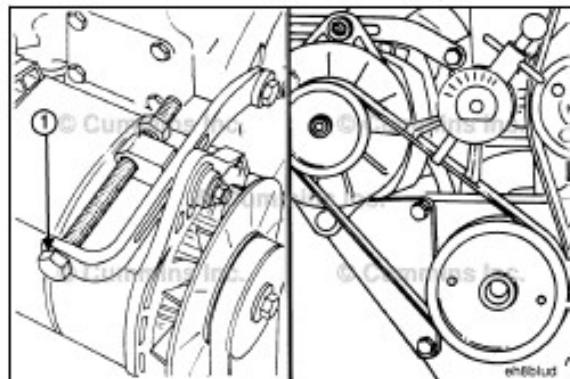


Install a new belt over the pulleys while holding the tensioner back. Be careful **not** to damage the belt while working it over the flanged pulleys.

Release the tensioner, and remove the breaker bar.

Belt drive systems equipped with an automatic belt tensioner **can not** be adjusted. A belt tension gauge will not give an accurate measure of the belt tension. The automatic belt tensioner is designed to maintain the proper belt tension over the life of the belt. **Only** an inspection of the tensioner is required.



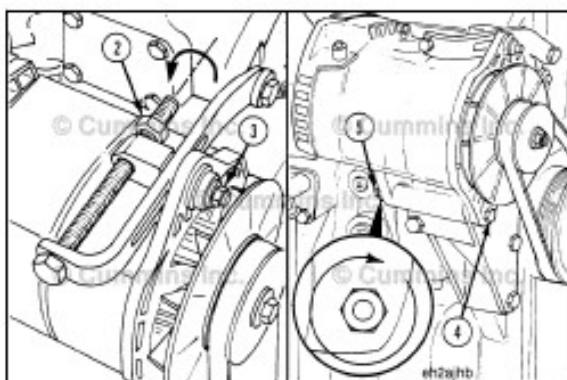


NOTE: A belt is considered used if it has been in operation for ten minutes or longer.

Install a new belt on the alternator pulleys. To prevent damage, do not roll a belt over the pulley or pry on it with a tool.

Turn the adjusting screw (1) clockwise to increase the belt tension.

Use belt tension gauge, Part Number ST-1293, or equivalent, to measure the belt tension. Refer to Procedure 018-005 in Section V for the correct tension value for the belt that is installed.



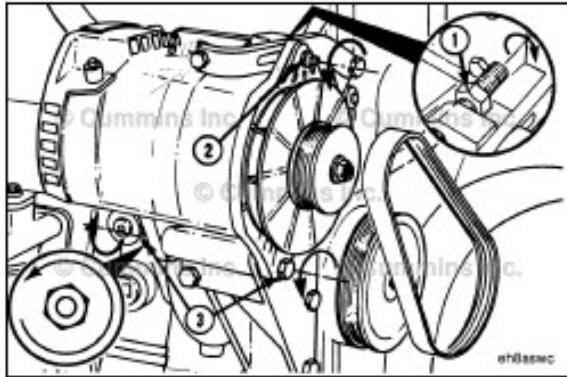
Tighten the adjusting screw locknut (2) against the retainer.

Tighten the adjustment link locking capscrew (3).

Torque Value: 80 N·m [59 ft-lb]

Tighten the pivot capscrew (4) and nut (5).

Torque Value: 47 N·m [35 ft-lb]



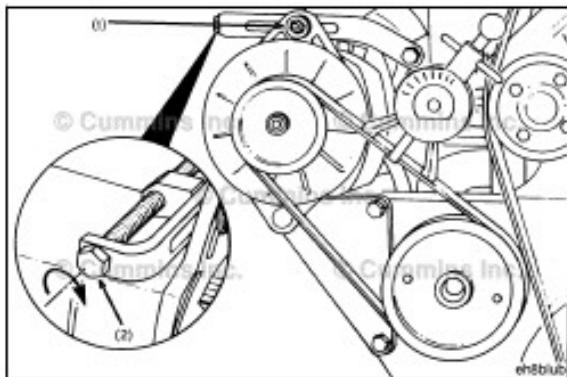
Adjust

Adjustment Link Type

Loosen the adjusting screw locknut (1).

Loosen the adjustment link locking capscrew (2).

Loosen the pivot capscrew and nut (3).



NOTE: A belt is considered used if it has been in operation for ten minutes or longer.

Use belt tension gauge, Part No. ST-1293, to measure belt tension.

Turn the alternator adjusting screw (1) clockwise to tighten the belt. Refer to Procedure 018-005 in Section V.

Tighten the adjusting screw locknut (2) against the retainer.

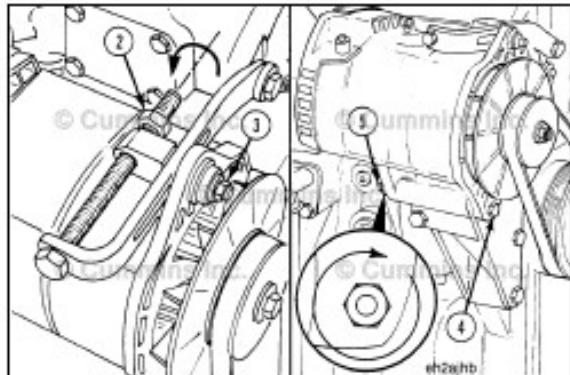


Tighten the adjustment link locking capscrew (3).

Torque Value: 80 N·m [59 ft-lb]

Tighten the pivot capscrew (4) and nut (5).

Torque Value: 47 N·m [35 ft-lb]

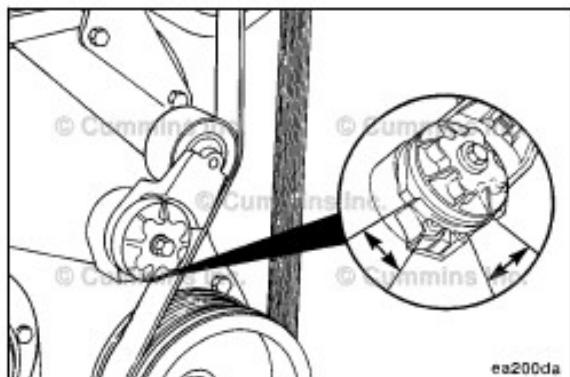


Belt drive systems equipped with an automatic belt tensioner can not be adjusted. A belt tension gauge will not give an accurate measure of the belt tension. The automatic belt tensioner is designed to maintain proper belt tension over the life of the belt. Only inspection of the tensioner is required.



The belt tensioner is designed to operate within the limit of arm movement provided by the cast stops, when the belt length and geometry are correct.

If the tensioner is hitting either of the limits during operation, check the mounting brackets and the belt length. Loose brackets, bracket failure, alternator movement, incorrect belt length, or belt failure can cause the tensioner to hit the limits.



Starting Motor

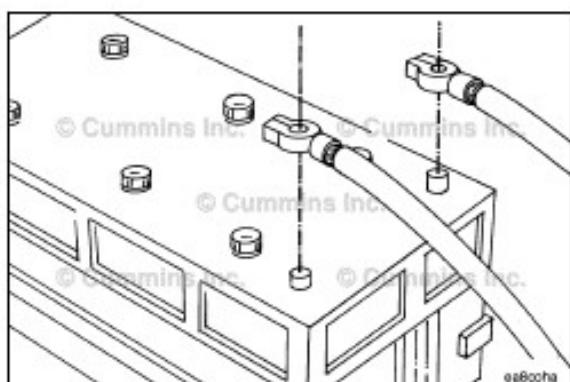
Remove

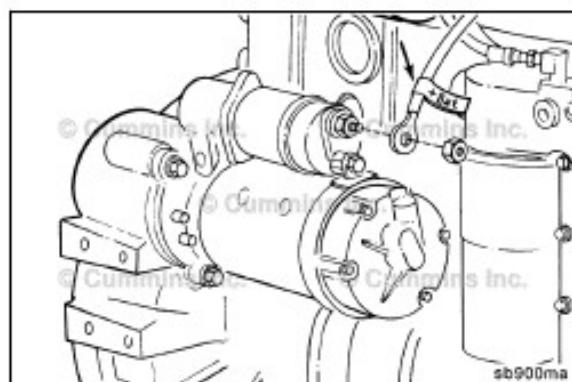


WARNING
Batteries can emit explosive gases. To reduce the possibility of personal injury, always ventilate the compartment before servicing the batteries. To reduce the possibility of arcing, remove the negative (-) battery cable first, and attach the negative (-) battery cable last.

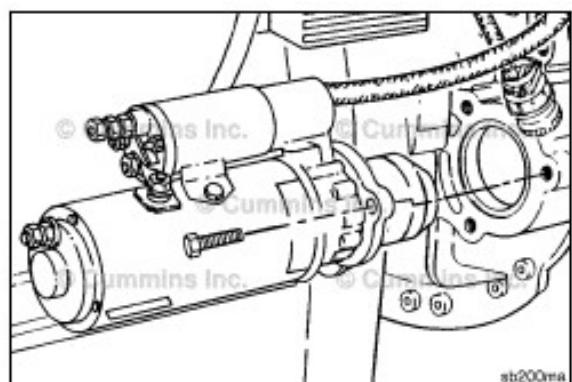
NOTE: The starting motor mounting capscrews can be metric or standard thread sizes. Make sure to install the same-size capscrews that were removed.

Remove the electrical connections from the batteries.

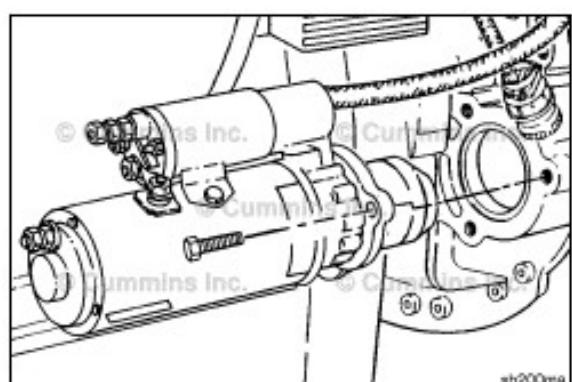




Tag and remove the electrical connections from the starting motor.



Remove the three capscrews and the starting motor.



Install

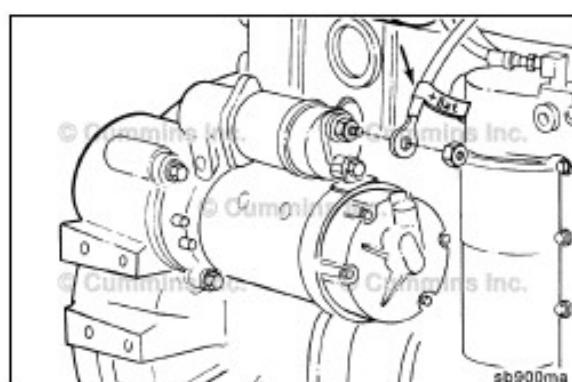
Before installing the starting motor, make sure the capscrews are the correct size and grade.



Install the starting motor and the three mounting capscrews.

Tighten the capscrews.

Torque Value: 90 N·m [66 ft-lb]

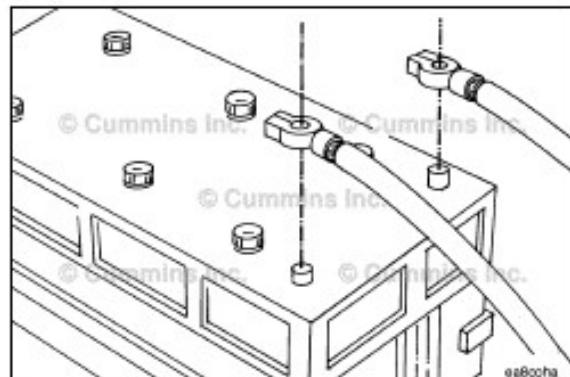


Install and tighten the electrical connections to the starting motor.

▲WARNING▲

Batteries can emit explosive gases. To reduce the possibility of personal injury, always ventilate the compartment before servicing the batteries. To reduce the possibility of arcing, remove the negative (-) battery cable first, and attach the negative (-) battery cable last.

Install and tighten the battery electrical connections.



Notes

Section D - System Diagrams

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System Diagrams - Overview

General Information

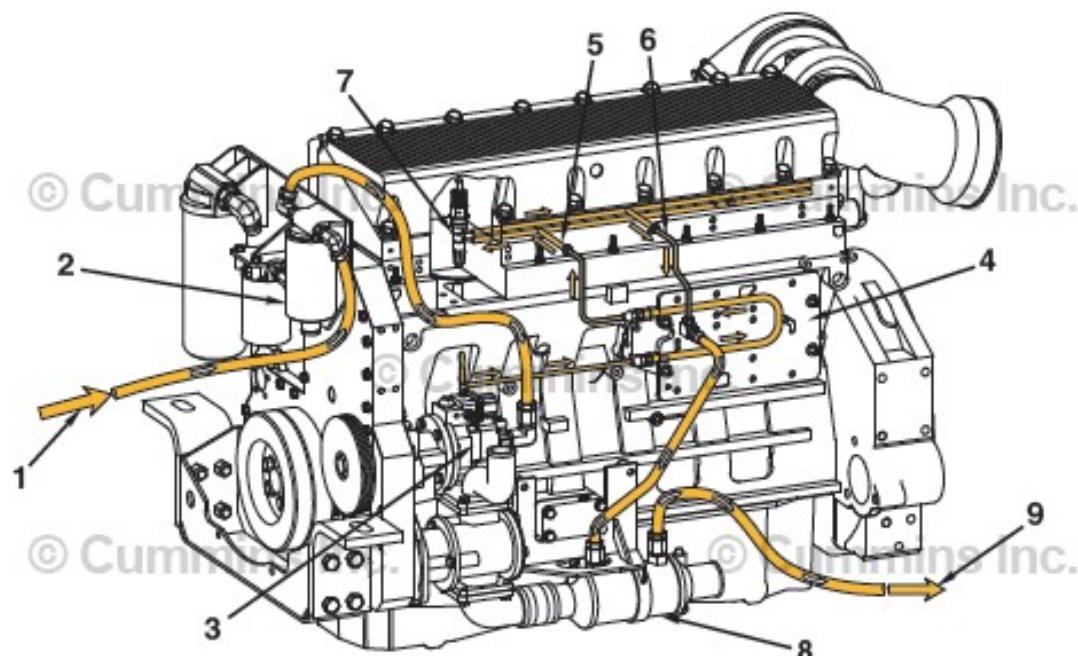
The following drawings show the flow through the engine systems. Although parts can change between different applications and installations, the flow remains the same. The systems shown are:

- Fuel System
- Lubricating Oil System
- Coolant System
- Intake Air System
- Exhaust System
- Compressed Air System.

Knowledge of the engine systems can help you in troubleshooting, service, and general maintenance of your engine.

Flow Diagram, Fuel System

Fuel System

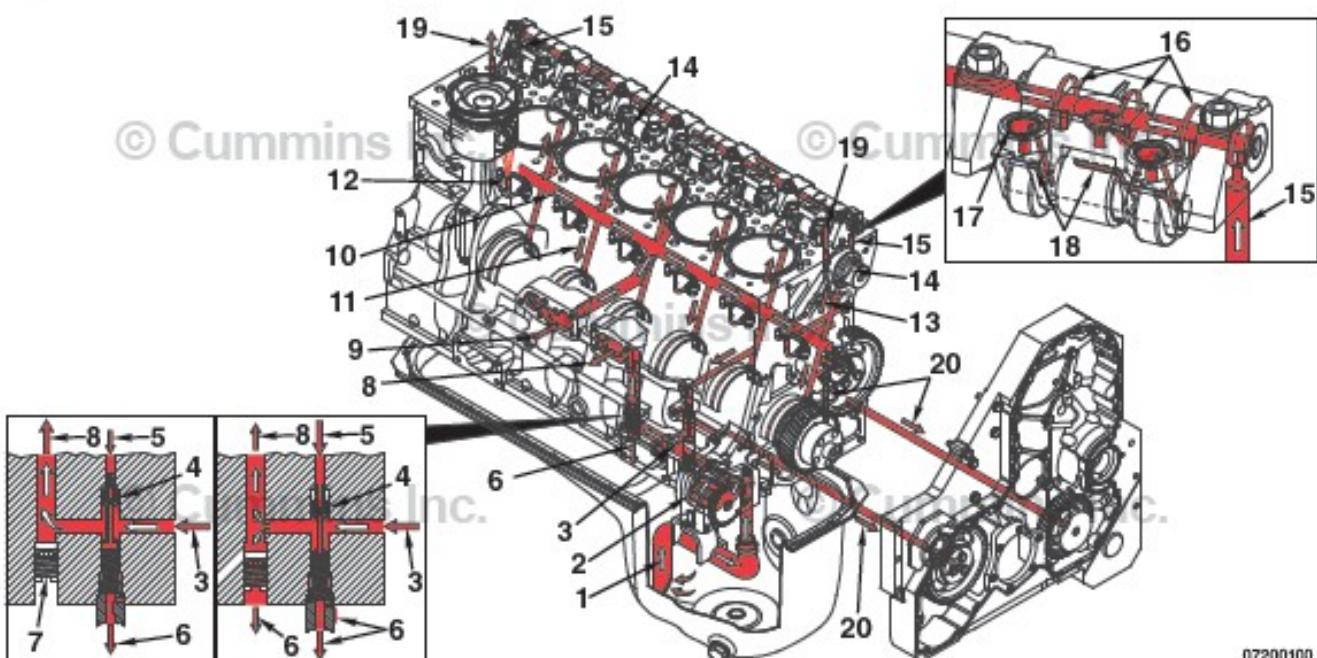


05200168

- 1 Fuel supply from tank
- 2 Fuel filter
- 3 Fuel pump
- 4 ECM cooling plate
- 5 Fuel to injector
- 6 Fuel drain to from injector
- 7 Injector
- 8 Fuel cooler
- 9 Fuel return to supply tank

Flow Diagram, Lubricating Oil System

Engine Views



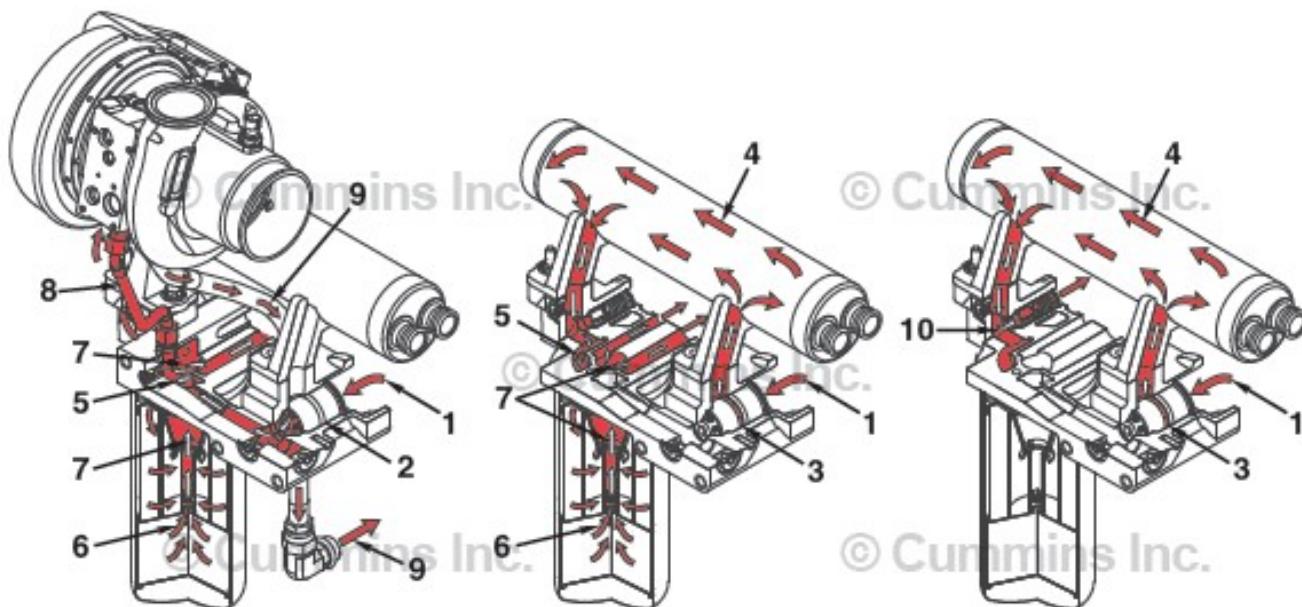
07200100

Lubricating Oil Pump and Power Components

- 1 Oil supply from oil pan
- 2 Oil pump
- 3 Oil flow to pressure regulator
- 4 Pressure regulator
- 5 Oil flow from main oil rifle
- 6 Oil return to oil pan
- 7 High pressure relief valve
- 8 Oil flow to oil cooler
- 9 Oil flow from oil cooler to main oil rifle
- 10 Main oil rifle
- 11 Oil supply to main bearings
- 12 Piston cooling oil rifle
- 13 Oil supply to camshaft
- 14 Oil flow around camshaft bushings
- 15 Oil supply to camshaft followers
- 16 Oil flow around cam follower bushings
- 17 Oil in push rod socket
- 18 Oil flow to camshaft roller pins
- 19 Oil supply to overhead
- 20 Oil supply to idler gears.

Flow Diagram, Lubricating Oil System

Engine Views



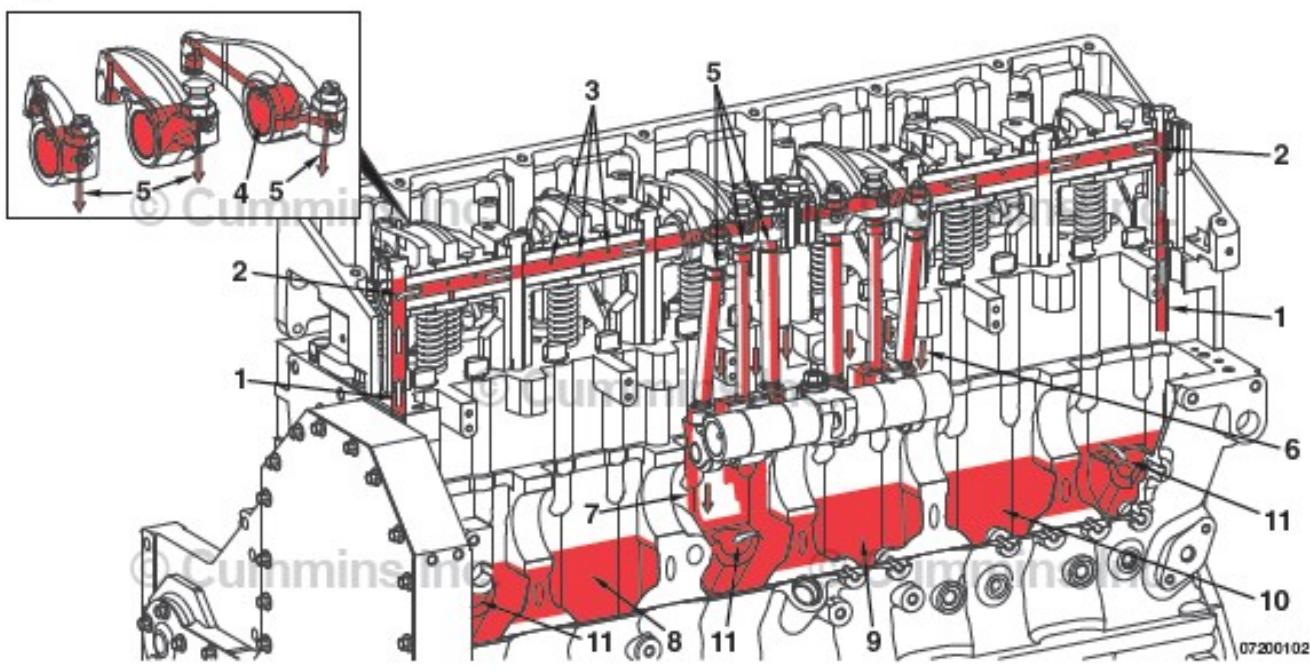
07200101

Turbocharger, Lubricating Oil Filter, Lubricating Oil Filter and Bypass

- 1 Oil flow from oil pump
- 2 Thermostat closed, oil flows directly to oil filter
- 3 Thermostat open, oil flows to oil cooler
- 4 Oil flow through oil cooler
- 5 Oil flow to oil filter
- 6 Oil flow through oil filter
- 7 Filtered oil flow to main oil rifle
- 8 Oil supply to turbocharger
- 9 Oil drain from turbocharger
- 10 Oil flow through filter bypass valve to main oil rifle.

Flow Diagram, Lubricating Oil System

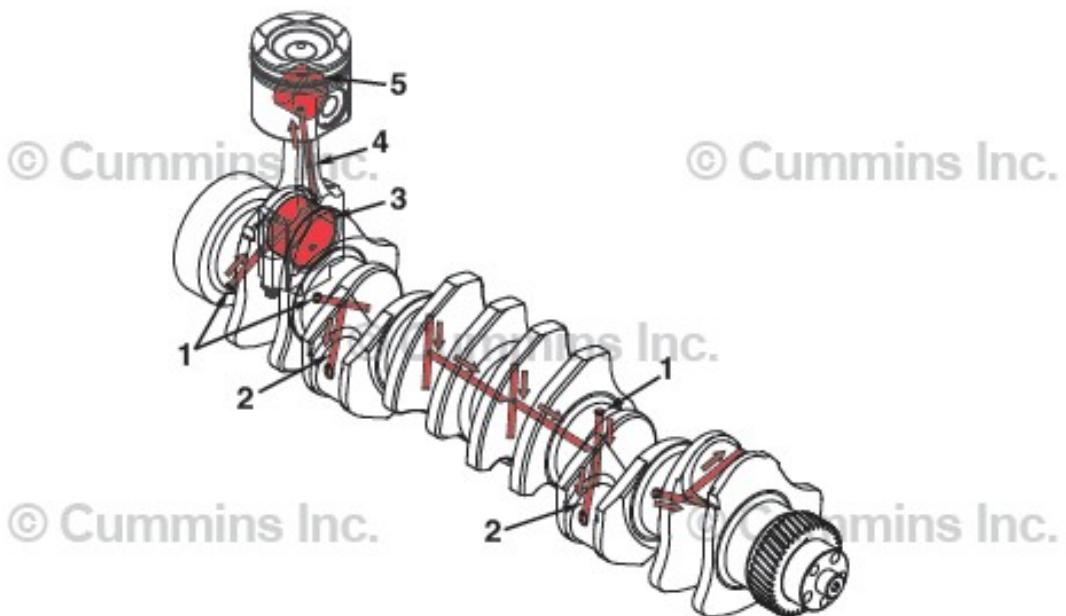
Engine Views



- 1 Oil supply from cylinder block
- 2 Oil supply to rocker lever shaft
- 3 Oil supply to rocker levers
- 4 Oil around rocker lever bushing
- 5 Oil drain to push tubes
- 6 Oil drain to cam follower socket
- 7 Oil drain to oil capacitor
- 8 Oil capacitor for cylinders one and two
- 9 Oil capacitor for cylinders three and four
- 10 Oil capacitor for cylinders five and six
- 11 Oil overflow to oil pan.

Flow Diagram, Lubricating Oil System

Engine Views



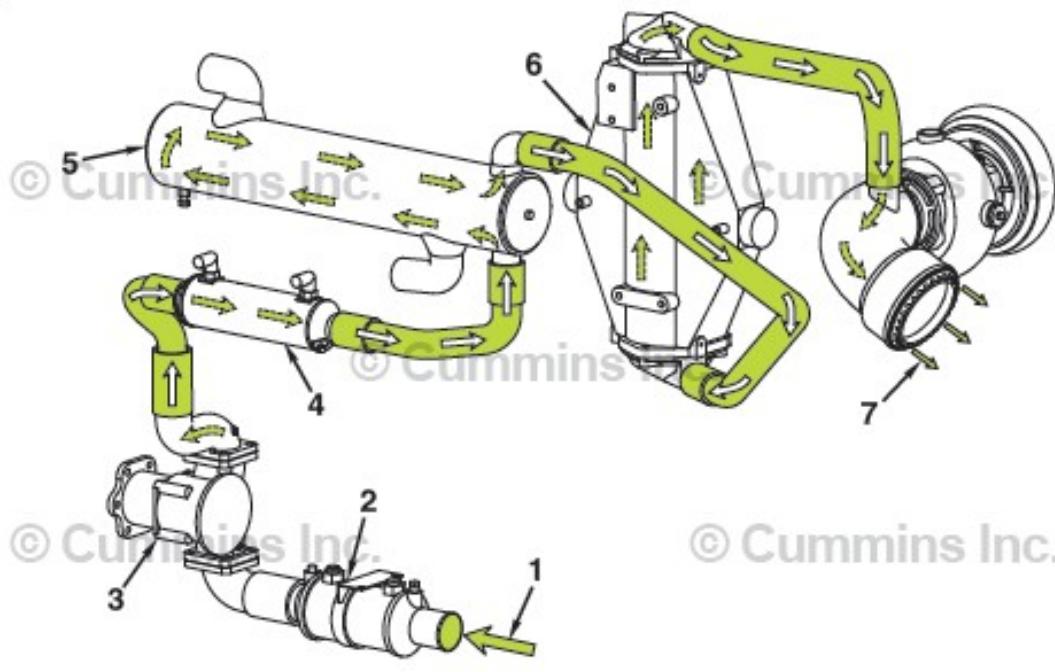
07200104

Crankshaft, Connecting Rod and Piston

- 1 Oil supply from main rifle through crankshaft drilling
- 2 Oil flow to connecting rod bearings
- 3 Oil flow around connecting rod bearing
- 4 Oil flow through connecting rod to piston pin bushing
- 5 Oil flow around piston pin bushing.

Flow Diagram, Cooling System

Flow Diagrams Marine Applications



08200243

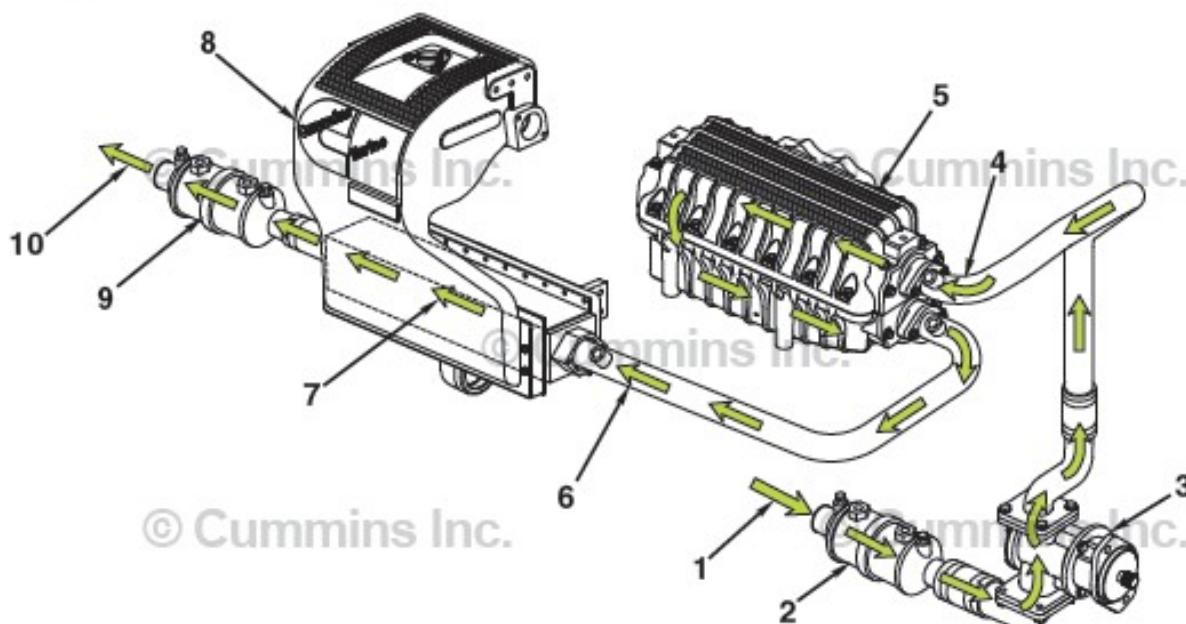
Sea Water Flow (Heat Exchanger)

- 1 Sea water inlet
- 2 Fuel cooler
- 3 Sea water pump
- 4 Gear oil cooler
- 5 Heat exchanger
- 6 Aftercooler
- 7 Sea water outlet.

Flow Diagram, Cooling System

Flow Diagrams

Marine Applications



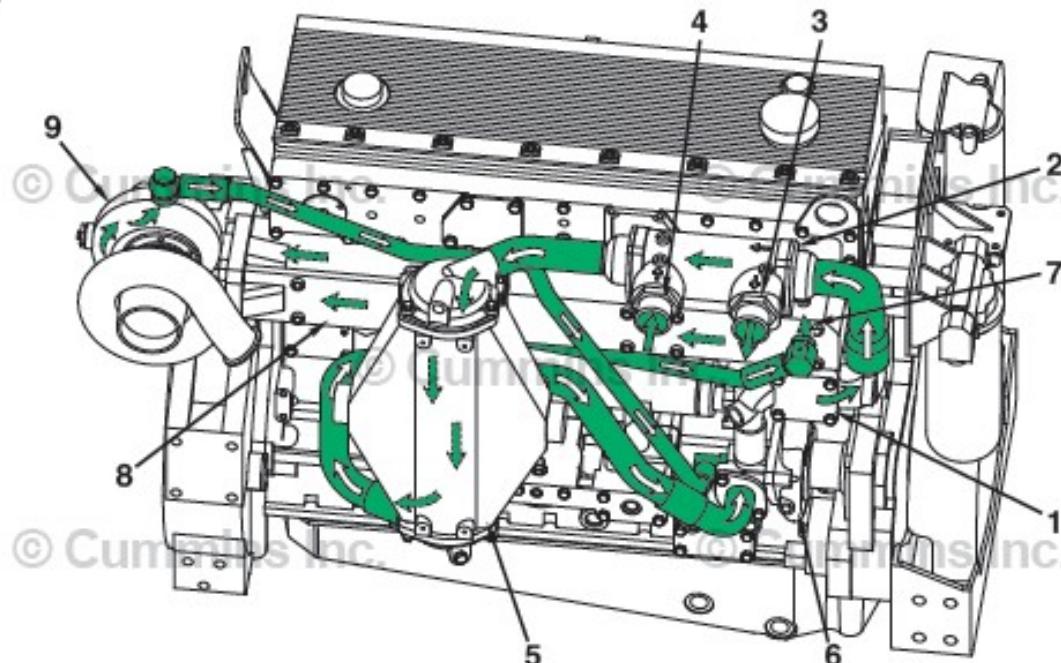
08200160

Sea Water Flow (Heat Exchanger)

- 1 Sea water inlet
- 2 Fuel cooler
- 3 Sea water pump
- 4 Sea water pump to aftercooler
- 5 Aftercooler
- 6 Aftercooler to heat exchanger
- 7 Heat exchanger
- 8 Expansion tank
- 9 Gear oil cooler
- 10 Sea water outlet.

Flow Diagram, Cooling System

Flow Diagrams Marine Applications



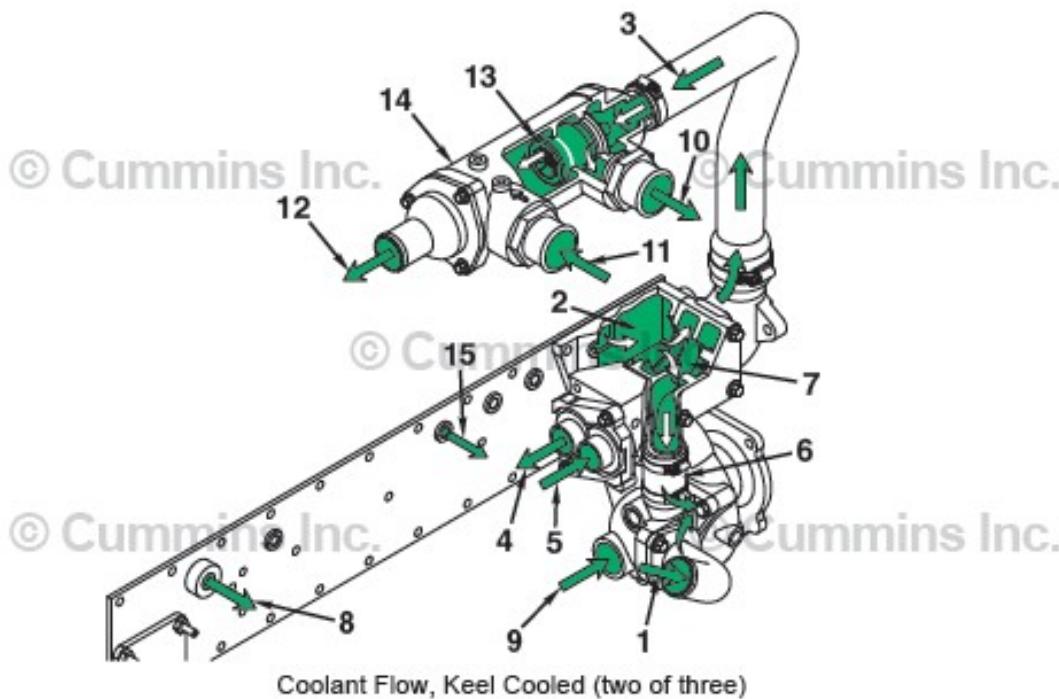
08200242

Coolant Flow, Keel Cooled (one of three)

- 1 Engine thermostat cavity (thermostat removed)
- 2 Keel cooled thermostat housing
- 3 Coolant out to keel cooler
- 4 Coolant in from keel cooler
- 5 Aftercooler
- 6 Water pump
- 7 Coolant flow to exhaust manifold
- 8 Water cooled exhaust manifold
- 9 Water cooled turbine housing.

Flow Diagram, Cooling System

Flow Diagrams Marine Applications

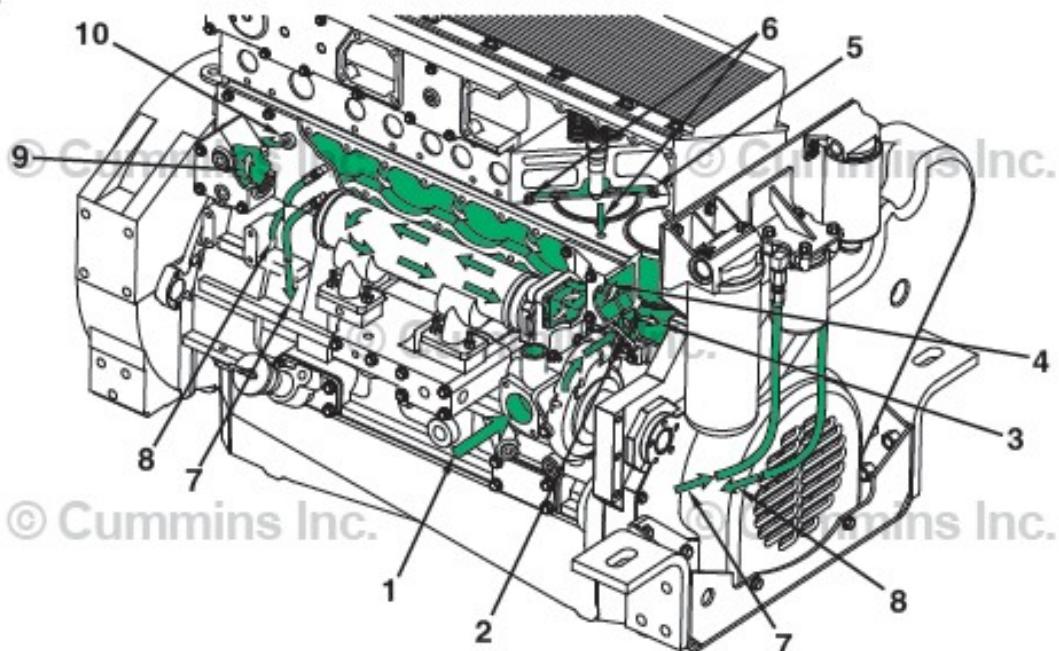


- 1 Water pump coolant inlet
- 2 Upper manifold cavity
- 3 Coolant outlet
- 4 Lower manifold cavity to cooler
- 5 Cooler to upper manifold cavity (before thermostat)
- 6 Coolant bypass hose - plugged
- 7 Engine thermostat cavity (thermostat removed)
- 8 To exhaust manifold
- 9 Turbocharger coolant return to water pump inlet
- 10 To keel cooler
- 11 From keel cooler
- 12 To aftercooler
- 13 LTA thermostat
- 14 LTA thermostat housing
- 15 To turbocharger.

Flow Diagram, Cooling System

Flow Diagrams

Marine Applications

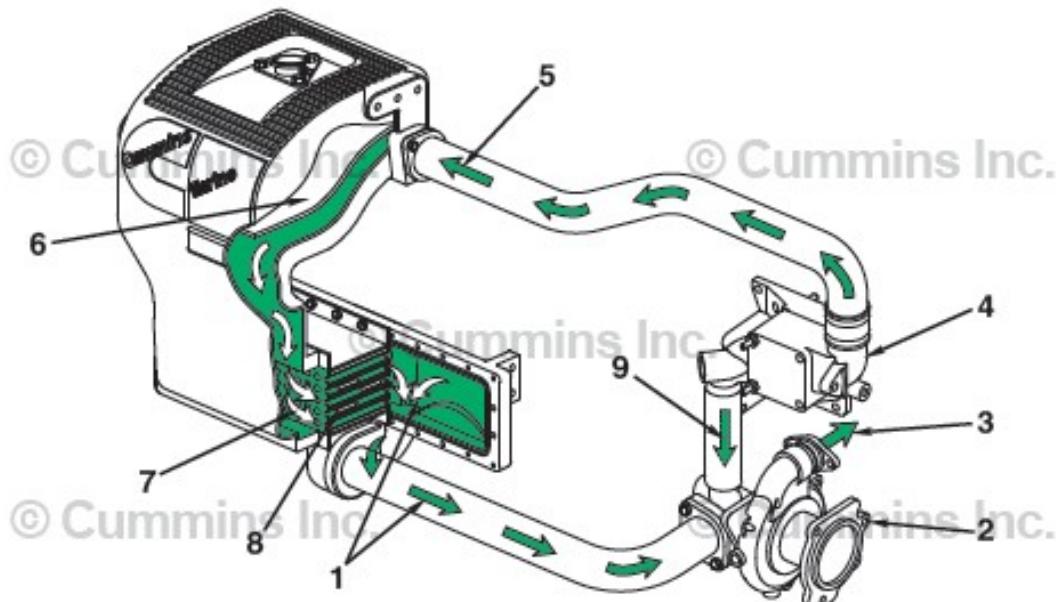


Coolant Flow (three of three)

- 1 Flow to water pump
- 2 Flow to oil cooler and lower manifold cavity
- 3 Flow from lower manifold cavity to cylinder liners
- 4 Flow from oil cooler to thermostat housing
- 5 Flow to cylinder head
- 6 Flow from cylinder head to upper manifold cavity
- 7 Flow to coolant filter
- 8 Flow from coolant filter
- 9 Coolant heater - optional
- 10 Upper manifold to exhaust manifold.

Flow Diagram, Cooling System

Flow Diagrams Marine Applications

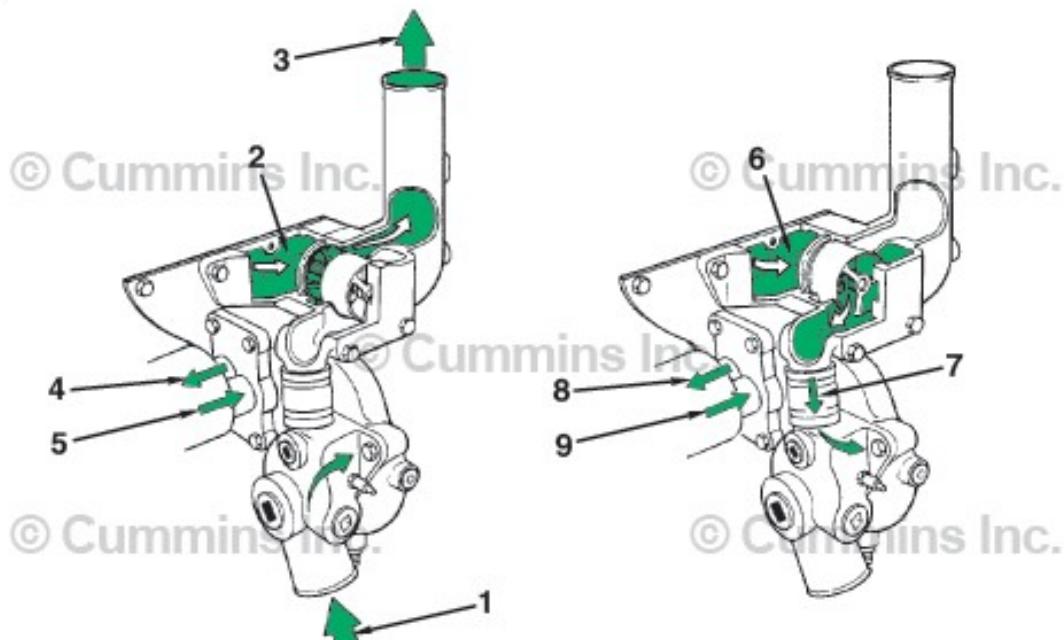


Coolant Flow, Heat Exchanger (one of three)

- 1 Coolant flow to water pump
- 2 Water pump
- 3 Coolant flow to lower manifold cavity
- 4 Thermostat housing
- 5 Thermostat housing to heat exchanger
- 6 Expansion tank
- 7 Heat exchanger sea water core
- 8 Coolant flow through sea water core
- 9 Coolant bypass.

Flow Diagram, Cooling System

Flow Diagrams Marine Applications



Coolant Flow, Heat Exchanger (two of three)

Thermostat Open (1-5)

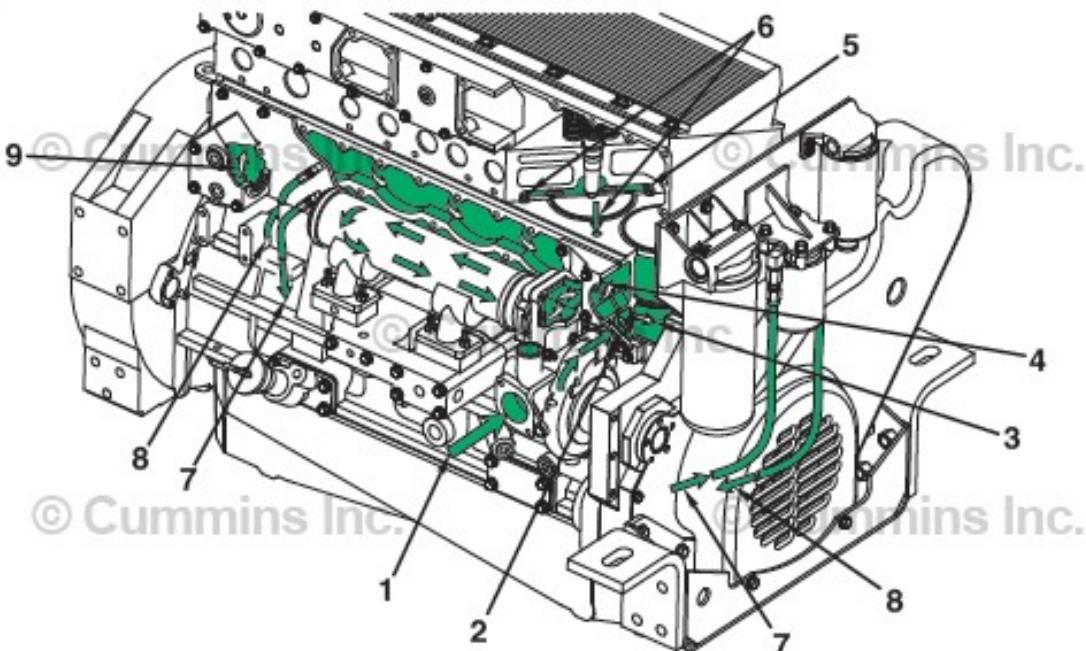
Thermostat Closed (6-9)

- 1 Water pump coolant inlet
- 2 Upper manifold cavity
- 3 Coolant outlet
- 4 Lower manifold cavity to cooler
- 5 Cooler to upper manifold cavity (before thermostat).
- 6 Upper manifold cavity (coolant to thermostat)
- 7 Coolant bypass (return to water pump)
- 8 Lower manifold cavity to cooler
- 9 Cooler to upper manifold cavity (before thermostat).

Flow Diagram, Cooling System

Flow Diagrams

Marine Applications



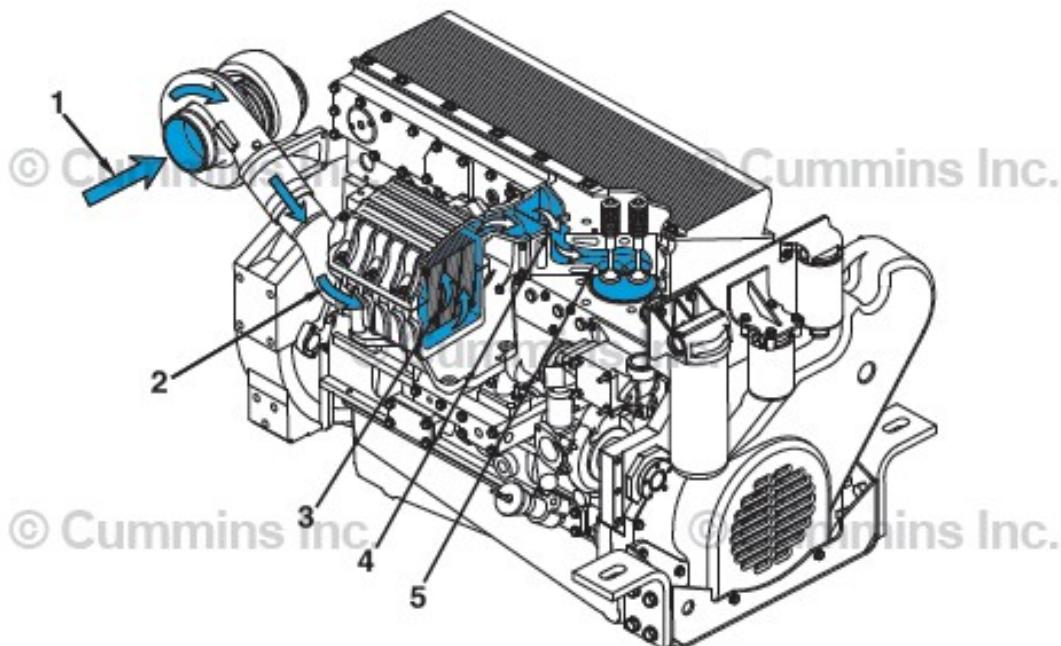
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Coolant Flow, Heat Exchanger (three of three)

- 1 Flow from heat exchanger to water pump
- 2 Flow to oil cooler and lower manifold cavity
- 3 Flow from lower manifold cavity to cylinder liners
- 4 Flow from oil cooler to thermostat housing
- 5 Flow to cylinder head
- 6 Flow from cylinder head to upper manifold cavity
- 7 Flow to coolant filter
- 8 Flow from coolant filter
- 9 Coolant heater - optional.

Flow Diagram, Air Intake System

Flow Diagram Marine Applications



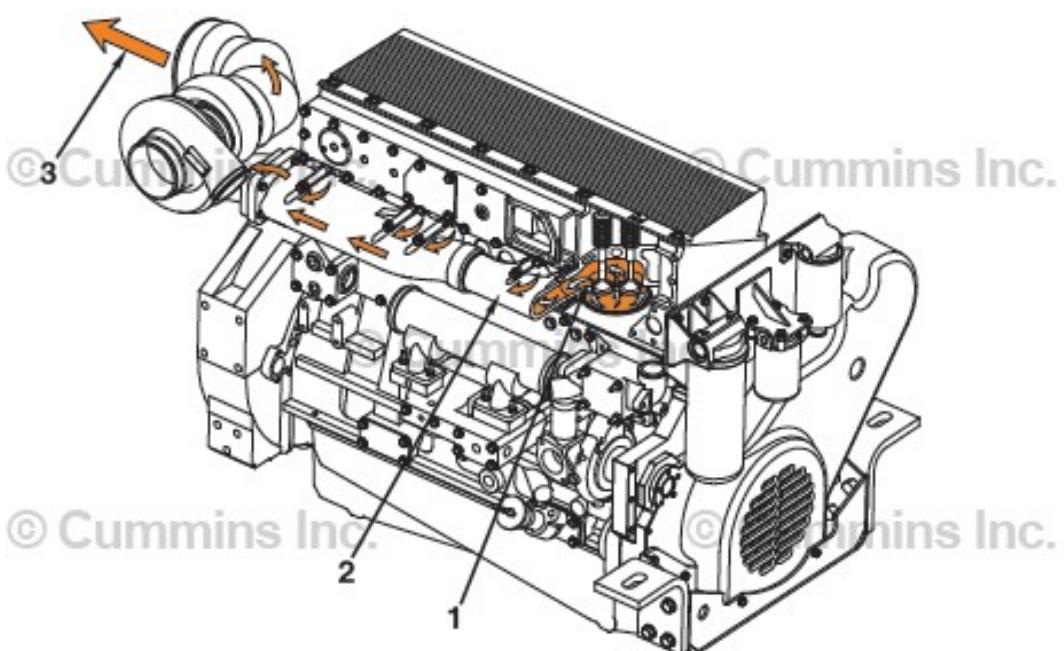
10200078

- 1 Filtered intake air to turbocharger
- 2 Turbocharger air to aftercooler
- 3 Intake air through the aftercooler
- 4 Aftercooled air through intake manifold
- 5 Intake valve ports.

Flow Diagram, Exhaust System

Flow Diagram

Marine Applications



11200027

- 1 Exhaust valve ports
- 2 Exhaust manifold
- 3 Turbocharger exhaust outlet.

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- a. Cummins may terminate this agreement for cause, such cause including, but not limited to, supporting, diagnosing, repairing, modifying or the maintenance of Cummins engines or any component thereof when such activities are not authorized by the owner of such engines.
- b. In the event of termination of this License Agreement, all rights granted by this License Agreement shall revert to Cummins. Upon termination of this License Agreement, Licensee will deliver to Cummins all DVD-ROM Material and other material furnished by Cummins pertaining to the Licensed Software or certify that all such materials have been destroyed.
- c. In the event of termination of this License Agreement, Licensee and Cummins shall remain obligated with respect to the provisions of this License Agreement relating to confidentiality of information.

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15. Notices

Any questions concerning this License Agreement, any inquiries related to the Licensed Software, and any notices to Cummins pursuant to this License Agreement should be directed to Cummins Inc., Electronic Publications Support, MC 95030, 1460 National Road, Columbus, IN 47201. Cummins Inc. may direct that notices be sent to a different person and/or address by so requesting in writing to the other party.

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Licensee understands that the Export Administration Regulations of the Department of Commerce of the United States may prohibit the export of the Licensed Software to certain countries and agrees to conform to those regulations. Licensee also agrees to conform to these regulations. Licensee shall indemnify Cummins against any loss related to Licensee's failure to conform to those regulations.

17. Governing Law

This License Agreement shall be governed by and construed in accordance with the laws of the State of Indiana.

18. Attorneys' Fees

In the event of any legal action or other proceeding that is brought about to enforce this License Agreement, the prevailing or successful party shall be entitled to recover reasonable attorneys' fees as well as other costs incurred in that action or proceeding in addition to any compensation to which it may be entitled.

19. License Agreement Successors and Assigns

This License Agreement is not assignable by Licensee without the prior written consent of Cummins, and any assignment by Licensee in contravention of this provision shall be void and without effect. The terms and conditions of this License Agreement shall inure to the benefit of and be enforceable by Cummins and the successors and assigns of Cummins' interest in this License Agreement and/or Cummins' ownership of the Licensed Software.

Cummins Service Publications Electronic Book on DVD-ROM Information

The enclosed DVD-ROM provides you with the capability to view this publication electronically as well as perform searches. This DVD-ROM is copy protected and will not allow Printing, Changing of Content, Extracting Content or Commenting / Annotating of the PDF file.

This DVD-ROM is read only, and you will not be able to copy files from the DVD-ROM and have them open or function in any manner. The only method to view the electronic publication is from the original DVD-ROM.

This DVD-ROM is intended for use by the owner of the publication only. Copying or distribution of content from this DVD-ROM is expressly prohibited. This DVD-ROM will not function from a network server DVD-ROM drive. It will function only in a DVD-ROM drive directly connected to your computer.

This DVD-ROM requires that you have Local Administrative rights in order to use. See the System requirements section for additional details.

System Requirements:

Use of the Cummins Service Publications Electronic Book on DVD-ROM requires Adobe Acrobat, Adobe Acrobat Reader, or Adobe Reader software to be pre-installed on your computer. This product has been tested for compatibility with Adobe Acrobat software versions 7, 8 and 9. It may function properly with versions later than Adobe Acrobat 9.0, but testing has not been performed. Adobe Reader is available as a free download from www.adobe.com.

The Cummins Service Publications Electronic Book on DVD-ROM product requires the following system components:

- Microsoft Windows Auto-Play must be enabled on your computer (it is enabled by default when Windows is installed)
- DVD-ROM Drive
- Color Monitor with at least 800x600 resolution graphics
- Microsoft Windows XP Professional SP3, Microsoft Windows Vista SP1, Microsoft Windows Vista x64 SP1, Microsoft Windows 7, or Microsoft Windows 7 x64. Testing has not been performed with the x64 bit versions of Vista and Windows 7, but the product is believed to be compatible. Use on other Microsoft Operating Systems may be compatible but testing has not been performed, and while it may function, it is not supported. While we try to maintain compatibility with all popular Microsoft Operating Systems, compatibility with the listed Microsoft Operating Systems is subject to change.
- Recommended memory, processor speed and available hard-disk space is in accordance with respective Microsoft Operating System Guidelines, as well as Adobe Acrobat system requirements.

Note: The Cummins Service Publications Electronic Book on DVD-ROM product is not Macintosh compatible.

About required Local Administrative Rights:

The copy protection software requires direct access to the DVD-ROM on which the protected content is stored. Protected content may not be accessible when logged in using restricted accounts.

In order to allow the software to enable direct access to DVD-ROM drives rights under Microsoft Operating Systems, your logon account/profile must have Local Administrative Rights on the computer you will be using your Cummins Service Publications Electronic Book on DVD-ROM with. If this computer is set up in Restricted Mode, and your logon account/profile does not have Local Administrative Rights, then, with approval of your I.T. department or the owner of your computer, you can choose from the following options to allow the Cummins Service Publications Electronic Book on DVD-ROM to function properly:

- Have your computer account enabled to have Local Administrative rights and then you can run the Cummins Service Publications Electronic Book on DVD-ROM - OR -
- Have a user with Local Administrative Rights logon to your computer and run the DVD-ROM content one time. By doing this, the necessary files will be loaded to your computer and your computer will be enabled to have direct access to DVD-ROM drives. Then restart this computer. It is very important to restart the computer after you have done this. For all future needs, you can run the Cummins Service Publications Electronic Book on DVD-ROM under your own account, without requiring your logon account/profile to have Local Administrative Rights. (Note: This needs to be done only once for any Cummins Service Publications Electronic Book on DVD-ROM and then does not need to be done again for other Cummins Service Publications Electronic Book on DVD-ROM titles you may own that are of the same version of protection software).

Cummins Service Publications Electronic Book on DVD-ROM Information **(continued)**

About the Copy Protection Software:

- This product may upgrade the proprietary copy protection software files it uses that are placed on your computer system to a new version, if an older version exists on your computer. If you have DVD-ROM copy protected items from other companies and they use older versions of the same TrusCont copy protection software that the Cummins Service Publications Electronic Book on DVD-ROM uses, it may render them incompatible for use on your computer.

How to Use the Cummins Service Publications Electronic Book on DVD-ROM:

To use the DVD-ROM, simply insert the DVD-ROM into your computer and it should automatically run, open Adobe Acrobat and open the Electronic Book. (This happens with Microsoft Windows Auto-Play functionality, and Adobe Acrobat pre-loaded by you on your computer).

Helpful Support Tips:

- If Windows Auto-Play is not enabled, try re-enabling it, or navigate with Windows Explorer to your DVD-ROM drive and double click on the DVD-ROM drive letter to open it. Then double-click on the program named "clickhere". (Do not attempt to directly open the PDF file by clicking on the PDF document).
- If the Cummins Service Publications Electronic Book on DVD-ROM does not function, see the prior section on "About required Local Administrative Rights:" in this documentation and verify you have Local Administrative Rights on your computer in order to run the DVD-ROM.
- While this product has been known to be very compatible with DVD-ROM drives available in computers, there are certain models of DVD-ROM drives that may be incompatible with this product.

Special Instructions for Cummins PowerSweep PC Users:

(This only applies to Cummins Inc. & Distributor Employees):

Cummins PowerSweep PC users that DO NOT have Local Administrative rights to their PC will require you to place an order from the Cummins Software Shelf. If you are a Cummins Inc. or Distributor Employee who wants to use these DVD-ROM's, and you have a PowerSweep PC – please order the 'TrusCont' software from the Cummins Software Shelf. The Software Shelf personnel will contact you to arrange a desk side installation from the DVD-ROM that you have. Once software is installed, first reboot your PC, then attempt to read your encrypted DVD-ROM manual while Cummins Software Shelf personnel are present.

Cummins Service Publications Electronic Book on DVD-ROM Information **(continued)**

Electronic Book Technical Support:

Support for this product is available from Monday through Friday weekly, excluding Holidays, from 8 a.m. to 5 p.m. You may call (502) 540-4981 for telephone support. For e-mail support, please e-mail ebooksupport@merrickind.com.

DVD-ROM Media Replacement Options:

Up to 90 days from date of purchase:

Within the first 90 days from your date of purchase, if your copy of an Electronic Book on DVD-ROM does not function, and after a Cummins Electronic Book Technical Support Technician has confirmed the situation and authorized its replacement by providing you an RMA#, you may send back the DVD-ROM for a free replacement. To do so, you must package the DVD-ROM and ship/mail, with postage pre-paid by you, to the below address. You must also include a photocopy of the original invoice for proof of purchase of the publication clearly indicating the bulletin # and the purchase date. The RMA# must be on the address information of the package. If the proof of purchase copy of the invoice is not enclosed, your request will not be able to be processed and will not be returned. Delivery of the replacement will be shipped to you at no charge. Allow 3 to 4 weeks for your receipt of replacement copy. Note: Return only the non-functional DVD-ROM, do not return the entire printed publication. The replacement DVD-ROM maintains the original purchase/invoice date for the purposes of this replacement policy. This policy is subject to change at any time, without notice. For a copy of the most current replacement options policy, please e-mail ebooksupport@merrickind.com with your request.

Media Replacement Ship to Address:

Attn: Cummins Service Publications Electronic Book Technical Support

RMA#: XXXXXX (where XXXXXX is the RMA#)

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Section L - Service Literature

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Additional Service Literature

General Information

The following publications can be purchased:

Bulletin Number	Title of Publication
3666322	Service Manual, ISM, ISMe, and QSM11
3666266	Troubleshooting and Repair Manual, Electronic Control System, ISM and QSM11 Engines
4021381	Troubleshooting and Repair Manual, CM870 Electronic Control System, ISM Engines
4021477	Troubleshooting and Repair Manual, CM875 Electronic Control System, ISM Engines
4021560	Troubleshooting and Repair Manual, CM871 and CM876 Electronic Control System, ISX and ISM Engines
3666269	ISM Wiring Diagram
3666413	QSM11 Wiring Diagram
3666420	Aftermarket ICON™ Wiring Diagram
3666468	QSM11 Marine Wiring Diagram
4021323	QSM11 Power Generation Wiring Diagram
4021384	ISM CM870 Control Module Wiring Diagram
4021478	ISM CM875 Control Module Wiring Diagram
4021559	QSM11-D(M) Marine Wiring Diagram
4021574	ISM CM876 Control Module Wiring Diagram
4021595	QSM11 CM876 Control Module Power Generation Wiring Diagram
4021644	ISM CM876 Without Aftertreatment Wiring Diagram
4021694	QSM11 Marine CM570 with SmartCraft™ 2.X Wiring Diagram
4081953	QSM11 Marine CM570 Electronic Control System with SmartCraft™ 1.0 Wiring Diagram
3666319	Operation and Maintenance Manual, ISM and ISMe
3666422	Operation and Maintenance Manual, ICON™ Idle Control System, Aftermarket Kit and OEM Installations
4021940	Operation and Maintenance Manual, QSM11 Marine
4021942	Operation and Maintenance Manual, QSM11 Industrial
4021939	Owners Manual, QSM11 Marine
4021941	Owners Manual, QSM11 Industrial
4960324	Owners Manual, ISM and ISMe Engines
3666121	Master Repair Manual, Holset® Air Compressors
3666231	Master Repair Manual, Centinel™ System
3379000	Air for Your Engine
3379001	Fuels for Cummins® Engines
3379009	Operation of Diesel Engines in Cold Climates
3666052	Camshaft Reuse Guidelines for Cummins® Engines with Roller Followers or Roller Tappets
3666132	Cummins® Coolant Requirements and Maintenance
3666209	Extended Service Interval, Cooling System Maintenance
3810340	Cummins® Engine Oil and Oil Analysis Recommendations
4021566	Fleetguard® Selective Catalytic Reduction - Urea Specifications
4021927	On-Board Diagnostics (OBD) for Euro Certified Engines

Service Literature Ordering Location Contact Information

Region	Ordering Location
United States and Canada	Cummins Distributors or Credit Cards at 1-800-646-5609 or Order online at www.powerstore.cummins.com
All Other Countries	Cummins Distributors or Dealers

Cummins Customized Parts Catalog

General Information

Cummins is pleased to announce the availability of a parts catalog compiled specifically for you. Unlike the generic versions of parts catalogs that support general high volume parts content; Cummins Customized catalogs contains only the new factory parts that were used to build your engine.

The catalog cover, as well as the content, is customized with you in mind. You can use it in your shop, at your worksite, or as a coffee table book in your RV or boat. The cover contains your name, company name, address, and telephone number. Your name and engine model identification even appears on the catalog spine. Everybody will know that Cummins created a catalog specifically for you.

This new catalog was designed to provide you with the exact information you need to order parts for your engine. This will be valuable for customers that do not have easy access to the Cummins Electronic Parts Catalog or the Cummins Parts Microfilm System.

Additional Features of the Customized Catalog include:

- Engine Configuration Data
- Table of Contents
- Separate Option and Parts Indexes
- Service Kits (when applicable)
- ReCon Part Numbers (when applicable)

Ordering the Customized Parts Catalog

Ordering by Telephone

North American customers can contact their Cummins Distributor or call Gannett Direct Marketing Services at 1-800-646-5609 and order by credit card. Outside North America order on-line or make an International call to Gannett at (++)502-454-6660.

Ordering On-Line

The Customized Parts Catalog can be ordered On-Line from the Cummins Powerstore by credit card.

Contact GDMS or the CUMMINS POWERSTORE for the current price; Freight may be an additional expense.

Information we need to take your Customized Parts Catalog Order. This information drives the cover content of the CPC.

- Customer Name
- Street Address
- Company Name (optional)
- Telephone no.
- Credit Card No.
- Cummins Engine Serial Number (located on the engine data plate)
- Please identify the required media: Printed Catalog, CD-ROM, or PDF File

Unfortunately not all Cummins Engines can be supported by this parts catalog. Engines older than 1984 or newer than 3 months may not have the necessary parts information to compile a catalog. We will contact you if this occurs and explain why we are unable to fill your order.

Customized Parts Catalogs are produced specifically for a single customer. This means they are not returnable for a refund. If we make an error and your catalog is not useable, we will correct that error by sending you a new catalog.

Notes

Section S - Service Assistance

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Routine Service and Parts

General Information

Personnel at Cummins Authorized Repair Locations can assist you with the correct operation and service of your engine. Cummins has a worldwide service network of more than 5,000 Distributors and Dealers who have been trained to provide sound advice, expert service, and complete parts support. Check the telephone directory, refer to the directory in this section, or the Service Locator at www.cummins.com for the nearest Cummins Authorized Repair Location.

Emergency and Technical Service

General Information

The Cummins Customer Assistance Center provides a 24-hour, toll free telephone number to aid in technical and emergency service when a Cummins Authorized Repair Location can not be reached or is unable to resolve an issue with a Cummins product.

If additional assistance is required, call Toll-Free:

1-800-DIESELS

(1-800-343-7357)

- Includes all 50 states, Bermuda, Puerto Rico, Virgin Islands, and the Bahamas.
- East Asia - Customer Assistance Center also for Chinese Domestic Market support Toll-Free:
400-810-5252
- Outside of North America contact your Regional Office. Telephone numbers and addresses are listed in the International Directory.



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Problem Solving

General Information

Normally, any problem that arises with the sale, service, or repair of your engine can be handled by a Cummins Authorized Repair Location in your area. Refer to the telephone directory, the directory in this section, or the Service Locator at www.cummins.com for the nearest Cummins Authorized Repair Location. If the problem has not been handled satisfactorily, follow the steps outlined below:

- 1 If the disagreement is with a Dealer, talk to the Cummins Distributor with whom he has his service agreement.
- 2 If the disagreement is with a Distributor, call the nearest Cummins Division or Regional Office; however, most problems are solved below the Division or Regional office level. Telephone numbers and addresses are listed in this section. Before calling, write down the following information:
 - a Engine model and serial number
 - b Type and make of equipment
 - c Total kilometers [miles] or hours of operation
 - d Warranty start date
 - e Nature of problem
 - f Summary of the current problem arranged in the order of occurrence
 - g Name and location of the Cummins Distributor or Dealer
- 3 If a problem can not be resolved satisfactorily through your Cummins Authorized Repair Location or Division Office, contact:
 - Cummins Customer Assistance Center - 41403, Cummins Inc., Box 3005, Columbus, IN 47202-3005
 - Telephone: +1 800-diesels / +1 800-343-7357 (USA Only)
 - Telephone: +1 812-377-3000 (International)

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Division and Regional Offices - Locations

Australia Regional Office	Cummins Engine Company Pty. Ltd.	2 Caribbean Drive Scoresby, Victoria 3179 Australia Telephone: (61-3) 9765-3222 FAX: (61-3) 9763-0079 NOTE: This office also serves New Zealand.
Cummins Americas Regional Office	Cummins Americas Inc.	3350 SW 148 Avenue Suite 205 Miramar, FL 33027 Telephone: [1-954] 431-5511 Fax: [1-954] 433-5797 NOTE: This office serves Puerto Rico and South America excluding Brazil.
China Beijing	Cummins (China) Investment Co. Ltd	28F, Tower A, GATEWAY, No.18, Xiaguangli North Road, East Third Ring, Chaoyang District Beijing, Beijing ZIP / Postal Code: 100027 China Telephone: [86-10] 84548888 Telefax: [86-10] 67876347
Brazil	Cummins Brasil Ltda.	Rua Jati, 266 07180-900 Guarulhos Sao Paulo Brazil Phone: [55-11] 6465-9811 Fax: [55-11] 6412-1483
Daventry	Cummins Engine Company Ltd (Africa)	Royal Oak Way South Daventry, Northants ZIP / Postal Code: NN11 5NU United Kingdom Telephone: [44-1327] 886000 Telefax: [44-1327] 886106
Daventry	Cummins Engine Co. Ltd (Serving Czech Republic)	Royal Oak Way South Daventry, Northants ZIP / Postal Code: NN11 5NU United Kingdom Telephone: [44-1327] 886000 Telefax: [44-1327] 886106
Daventry	Cummins Engine Company Ltd (Middle East)	Royal Oak Way South Daventry, Northants ZIP / Postal Code: NN11 5NU United Kingdom Telephone: [44-1327] 886000 Telefax: [44-1327] 886106
Dubai United Arab Emirates	Cummins Middle East FZE	Units ZF 5/6 Jebel Ali Free Zone P.O.Box No 17636 Dubai United Arab Emirates Phone: [971-4] 883 8998 Fax: [971-4] 883 7971

India Pune	Cummins India Ltd.	Kothrud Pune ZIP / Postal Code: 411038 India Telephone: +91-20-2538 5435 or 2538 0240 Fax: +91-20-2538 0125 www.cumminsindia.com
Korea Seoul	Cummins Korea Ltd.	25th floor, ASEM tower, 159-1, Samsung-Dong Kangnam-ku, Seoul ZIP / Postal Code: 135-798 South Korea Telephone: [82-2] 3420-0901 Telefax: [82-2] 3452-4113 / 539-6569
SLP Mexico	Cummins, S. de R.L. de C.V.	Arquimedes No. 209 Col. Polanco Mexico, Distrito Federal ZIP / Postal Code: 11560 Mexico Telephone: [52-5] 254-3822 / 3783 / 3622 Telefax: [52-5] 254-3645
Russia Moscow	Cummins Engine Company, Inc.	Park Place Office E708, 113/1 Leninskiy Prospect Moscow ZIP / Postal Code: 117198 Russia Telephone: [7-495] 956-51-22 / 23 Telefax: [7-495] 956-53-62
Singapore	Cummins Diesel Sales Corporation	8 Tanjong Penjuru Singapore ZIP / Postal Code: 609019 Singapore Telephone: [65] 6265-0155

Distributors and Branches - United States

Alabama	Birmingham	Cummins Mid-South, LLC 2200 Pinson Highway P.O. Box 1147 Birmingham, AL 35217 Telephone: (205) 841-0421 FAX: (205) 849-5926
Alabama	Mobile	Cummins Mid-South, LLC 1924 N. Beltline Hwy. Mobile, AL 36617 Telephone: (334) 456-2236 FAX: (334) 452-6419
Alaska	Anchorage	Cummins Northwest, Inc. 2618 Commercial Drive Anchorage, AK 99501-3095 Telephone: (907) 279-7594 FAX: (907) 276-6340
Arizona	Phoenix	Cummins Rocky Mountain, LLC 2239 N. Black Canyon Hwy Phoenix, AZ 85009 Telephone: (602) 252-8021 FAX: (602) 253-6725
Arkansas	Little Rock	Cummins Mid-South, Inc. 6600 Interstate 30 Little Rock, AR 72209 Telephone: Sales: (501) 569-5600 Service: (501) 569-5656 Parts: (501) 569-5613 FAX: (501) 565-2199
California	San Leandro	Cummins West, Inc. 14775 Wicks Blvd. San Leandro, CA 94577-6779 Telephone: (510) 351-6101 FAX: (510) 352-3925
California	Arcata	Cummins West, Inc. 4751 West End Road Arcata, CA 95521 Telephone: (707) 822-7392 FAX: (707) 822-7585
California	Bakersfield	Cummins West, Inc. 4601 East Brundage Lane Bakersfield, CA 93307 Telephone: (805) 325-9404 FAX: (805) 861-8719
California	Fresno	Cummins West, Inc. 5333 N Cornelia Ave Fresno, CA 93722 Telephone: (559) 277-6760 FAX: (559) 277-6769

California	Redding	Cummins West, Inc. 20247 Charlanne Drive Redding, CA 96002 Telephone: (530) 222-4070 FAX: (530) 224-4075
California	Stockton	Cummins West, Inc. 5250 Claremont Ave Suite 204 Stockton, California 95207, USA Telephone: (209) 472-3460 FAX: (209) 472-3450
California	West Sacramento	Cummins West, Inc. 875 Riverside Parkway West Sacramento, CA 95605-1502 Telephone: (916) 371-0630 FAX: (916) 371-2849
California	Los Angeles	Cummins Cal Pacific Inc. 1939 Deere Avenue (Irvine) Irvine, CA 92606 Telephone: (949) 253-6000 FAX: (949) 253-6070
California	Montebello	Cummins Cal Pacific Inc. 1105 South Greenwood Avenue Montebello, CA 90640 Telephone: (323) 728-8111 FAX: (323) 889-7499
California	Bloomington	Cummins Cal Pacific Inc. 3061 S. Riverside Avenue Bloomington, CA 92316 Telephone: (909) 877-0433 FAX: (909) 877-3787
California	San Diego	Cummins Cal Pacific Inc. 310 N. Johnson Avenue El Cajon, CA 92020 Telephone: (619) 593-3093 FAX: (619) 593-0600
California	Ventura	Cummins Cal-Pacific Inc. 3958 Transport St. Ventura, CA 93003 Telephone: (805) 644-7281 FAX: (805) 644-7284
Colorado	Denver	Cummins Rocky Mountain, Inc. 8211 East 96th Ave Henderson, Colorado 80640 Telephone: (303) 287-0201 FAX: (303) 288-7080
Colorado	Grand Junction	Cummins Rocky Mountain, Inc. 2380 U.S. Highway 6 & 50 P.O. Box 339 Grand Junction, CO 81501 Telephone: (970) 242-5776 FAX: (970) 243-5494

Connecticut	Rocky Hill	Cummins Metropower, Inc. 914 Cromwell Ave. Rocky Hill, CT 06067 Telephone: (860) 529-7474 FAX: (860) 529-7524
Florida	Ft. Myers	Cummins Power South, LLC 2671 Edison Avenue Ft. Myers, FL 33916 Telephone: (941) 337-1211 FAX: (941) 337-5374
Florida	Jacksonville	Cummins Power South 755 Pickettville Rd. Jacksonville, FL 32220 Telephone: (904) 378-1902 FAX: (904) 378-1904
Florida	Hialeah (Miami)	Cummins Power South, LLC 9900 N.W. 77th Avenue Hialeah Gardens, FL 33016 Telephone: (305) 821-4200 FAX: (305) 557-2992
Florida	Ocala	Cummins Power South, LLC 321 Southwest 52nd Ave. Ocala, FL 34474-1892 Telephone: (352) 861-1122 FAX: (352) 861-1130
Florida	Orlando	Cummins Power South, LLC 4020 North Orange Blossom Trail Orlando, FL 32810 Telephone: (407) 298-2080 FAX: (407) 290-8727
Florida	Tampa	Cummins Power South, LLC 5421 N. 59th Street Tampa, FL 33610 Telephone: (813) 621-7202 FAX: (813) 621-8250
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ST. LUCIA	Miami (Office in U.S.A.)	Cummins Power South, LLC 9900 N W 77th Ave. Hialeah Gardens, FL 33016 Telephone: (305) 821-4200 Fax: (305) 557-2992
SAN MARINO	- See Italy	Cummins Italia S.p.A. ItalyVia Einaudi, 5 Peschiera Borromeo, Milano 20068 Telephone: (39-02) 51 65 581 Fax: (39-02) 51 65 58 56
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SAUDI ARABIA	Al-Khobar	General Contracting Company - OLAYAN P.O. Box 356 King Abdul Aziz Road Al-Khobar Saudi Arabia Telephone: (966-3) 882-0888 Fax: (966-3) 8828560 / 8827914
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SENEGAL	Dakar	Matforce 10 Avenue Faidherbe Dakar Senegal Telephone: (221-8) 399500 Fax: (221-8) 399531/399550 Equipements et Services (Mining Only) BP 15372-Fann Dakar Senegal Contacts: Mr. Jean Smets Tel: (221-8) 60 77 76 & 24 73 62 Fax: (221-8) 60 95 98
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SIERRA LEONE	- See North/West/East and Central Africa Regional Office - Daventry	Cummins Engine Company Ltd Royal Oak Way South Daventry, Northants ZIP / Postal Code: NN11 5NU United Kingdom Telephone: (44-1327) 886000 Fax: (44-1327) 886106
SINGAPORE	Singapore	Cummins Engine (Singapore) Pte Ltd 8 Tanjong Penjuru Singapore 609019 Singapore Telephone: (65) 6261-3555 Fax: (65) 6261-2405
SLOVAKIA		- See European Regional Office - Gross-Gerau
SOLOMON ISLANDS	The Czech branch covers sales and service for the Czech Republic and Slovakia	Cummins Czech Republic s.r.o. Komercni zona Pruhonice Cestlice Obchodni 132 Praha, Prague 251 01 Czech Republic Telephone: (420-272) 680 110 Fax: (420-272) 680 090
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SRI LANKA	Colombo	Trade Promoters Ltd 272/25, Sudharshana Mawatha Malabe Sri Lanka Telephone: (94-11) 2413002 Fax: (94-11) 5550034
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SYRIA	Damascus	Puzant Yacoubian & Sons Yacoubian Building Abou Baker El Saddik Street Damascus Syria Telephone: (963-11) 212 8600 Fax: (963-11) 212 8611
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VATICAN CITY	- See Italy	Cummins Italia S.p.A. Via Einaudi, 5 Peschiera Borromeo, Milano 20068 Italy Telephone: (39-02) 51 65 581 Fax: (39-02) 51 65 58 56
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ZIMBABWE	Harare	Cummins Zimbabwe (Pvt) Ltd. 72 Birmingham Road Southerton, Zimbabwe Zimbabwe Telephones: (263-4) 621871 / 2 / 3 / 4 / 5 Fax: (263-4) 621880

Notes

Section SS - Seasonal Storage (Marine Only)

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Seasonal Storage General Information

The following recommendations are to prepare your engine for winter storage. Not all recommendations will apply to your application. **Always** follow the manufacturer's recommendation on components not manufactured by Cummins Inc.

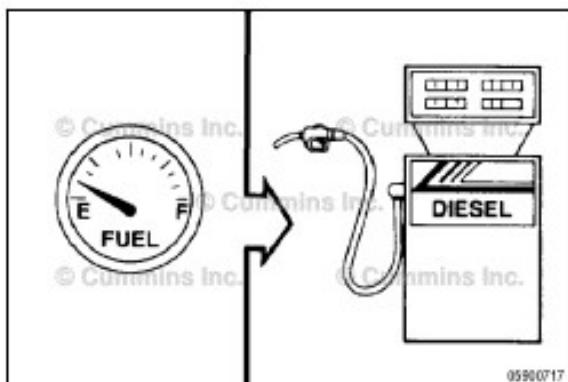
Fill the tank with good quality ASTM number 2D climatized diesel fuel.

Change the fuel filter. Refer to the fuel filter procedure in this manual.

Change the boat fuel-water separator element. Refer to the fuel-water separator element procedure in this manual.

Change the engine lubricating oil and filters. Refer to the lubricating oil and filters procedure in this manual.

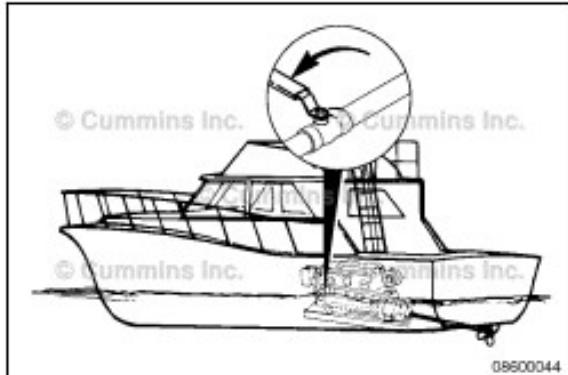
Treat the fuel with diesel conditioner or algaecide to prevent the growth of algae in the fuel tank.



CAUTION

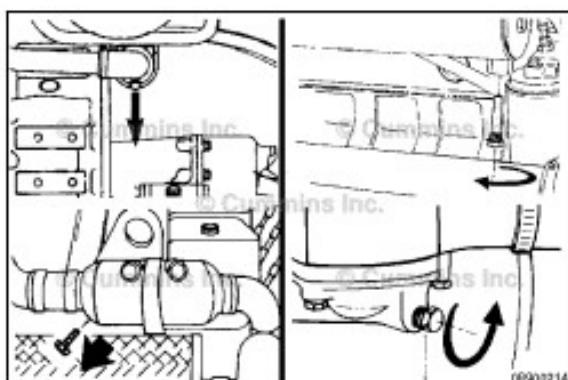
Do not run the engine with the sea water valve closed. This could damage the sea water pump and the engine. It is good practice to disable the engine or to place a tag at the helm(s) when the sea water valve is closed.

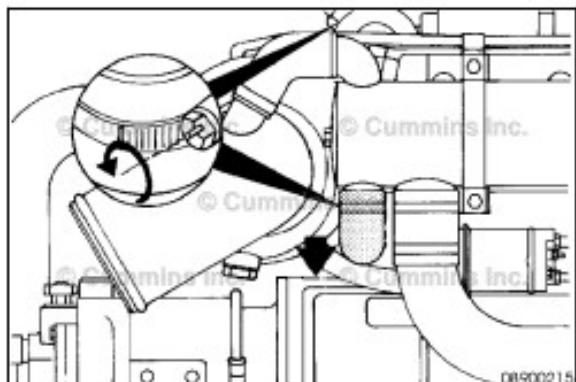
If the vessel is stored in the water, close the sea water valve on the vessel hull.



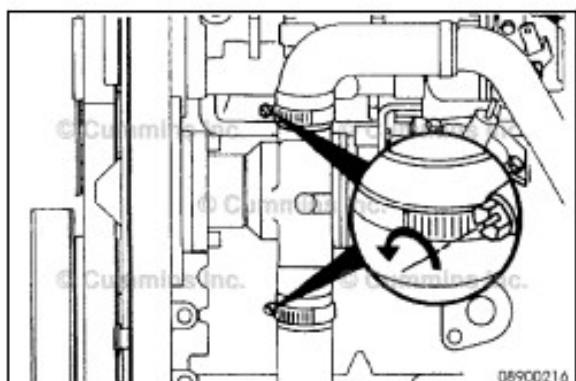
Drain the sea water system:

- Remove the drain plug on the marine gear cooler.
- Remove the zinc anodes from the heat exchanger and the aftercooler. Refer to the zinc anode procedure in this manual.
- Remove the drain plug from the air box side of the sea water aftercooler, if equipped.
- Remove the engine sea water hoses to drain sea water from the engine.

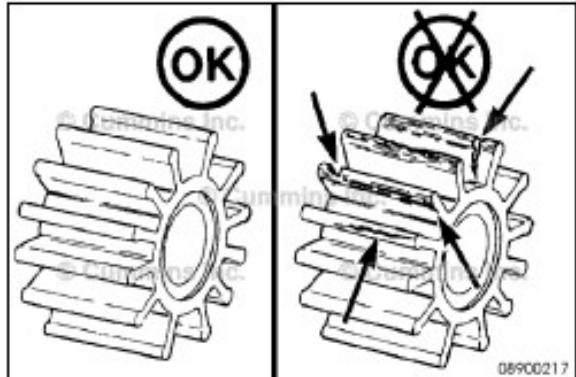




Remove the inlet and outlet hoses from the heat exchanger.



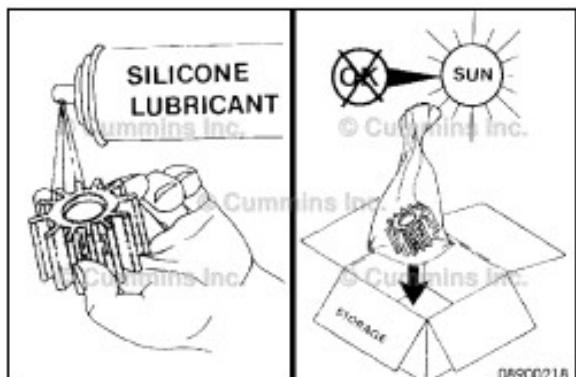
Remove the inlet and outlet hoses from the sea water pump.



NOTE: There are two different types of pumps. Follow the correct procedure for the pump on this engine.

Remove and inspect the sea water pump impeller. Refer to the Sea Water Pump procedure in this manual.

If the sea water pump impeller is damaged or not reusable, do not install a new sea water pump impeller until the vessel is ready to be used.



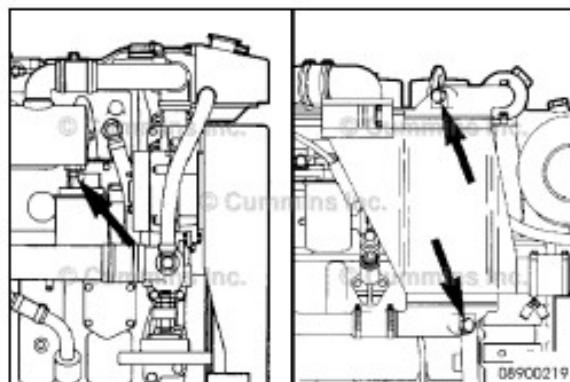
CAUTION

Do not expose the sea water pump impeller to sunlight, fluorescent lighting or any other source of ultra-violet light for an extended period of time. This will cause damage to the sea water pump impeller.

The sea water pump impeller **must** be lubricated with glycerin or a non-petroleum based lubricant such as silicon spray.

Store the sea water pump impeller for the season in a polyethylene bag and in a location that is void of sunlight, fluorescent light, or any other source of ultra-violet light.

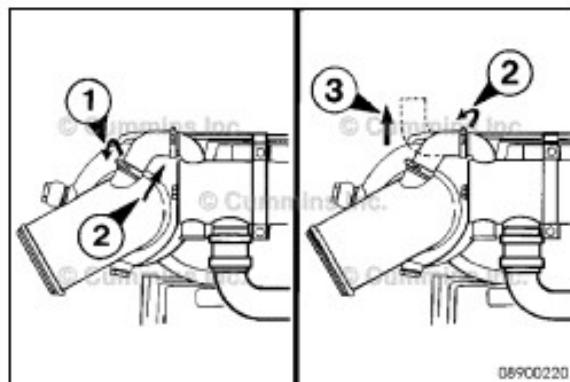
Install the zinc anodes in the heat exchanger and aftercooler. Refer to the zinc anode procedure in this manual.



Loosen the heat exchanger sea water outlet clamps (1) and (2).



Rotate the sea water outlet connection to a vertical position (3).



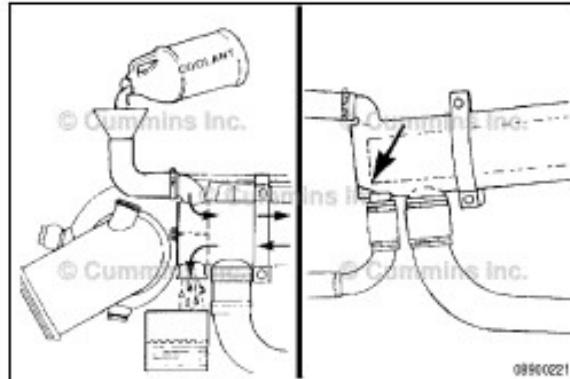
▲ WARNING ▲

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

Place a container under the heat exchanger sea water inlet.

Pour coolant, a 50/50 mixture of antifreeze and water, through the heat exchanger.

Do not allow excess coolant to drain in to the bilge.



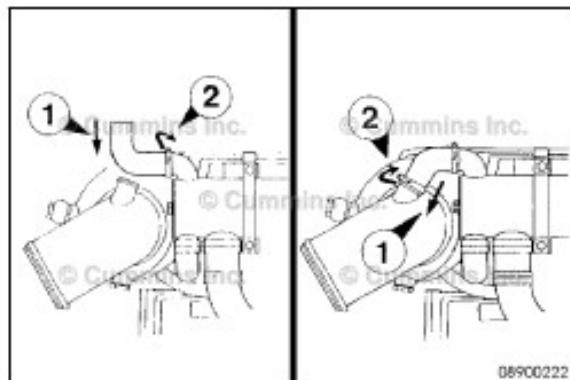
Rotate and connect the sea water outlet connection to the exhaust elbow (1).

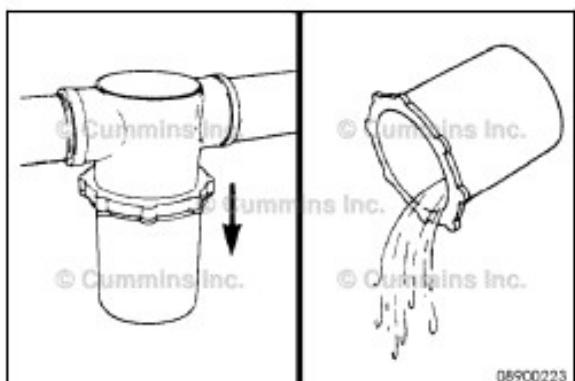


Tighten the hose clamps (2).

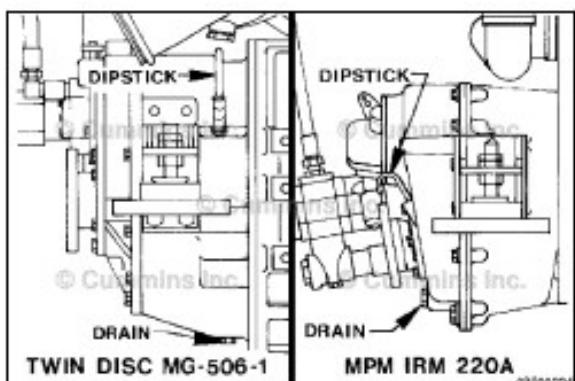


Torque Value: 5 N·m [44 in-lb]

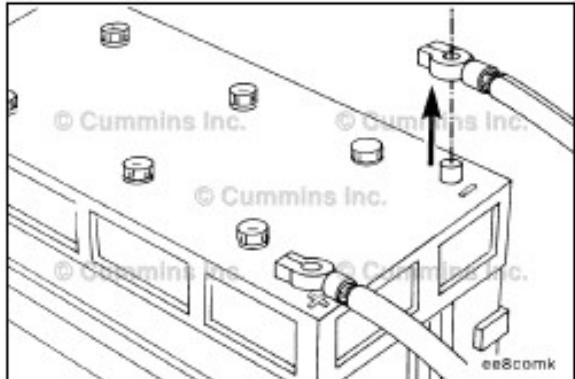




Empty the sea water strainer. Refer to the sea water strainer procedure in this manual.



Perform the recommended maintenance procedures on the marine gear. Refer to the manufacturer owner's manual for recommendations and specifications.



Disconnect and remove the battery. Follow the manufacturer's storage recommendations to store the battery.



Section TS - Troubleshooting Symptoms

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Troubleshooting Procedures and Techniques

General Information

This guide describes some typical engine operating problems, their causes, and some acceptable corrections to those problems. Unless noted otherwise, the problems listed are those which an operator can diagnose and repair.

▲WARNING▲

Performing troubleshooting procedures NOT outlined in this section can result in equipment damage or personal injury or death. Troubleshooting must be performed by trained, experienced technicians. Consult a Cummins Authorized Repair Location for diagnosis and repair beyond that which is outlined, and for symptoms not listed in this section. Before beginning any troubleshooting, refer to General Safety Instructions in Section i of this manual.

Follow the suggestions below for troubleshooting:

- Study the complaint thoroughly before acting
- Refer to the engine system diagrams
- Do the easiest and most logical things first
- Find and correct the cause of the complaint

Troubleshooting Symptoms Charts

General Information

Use the charts on the following pages of this section to aid in diagnosing specific engine symptoms. Read each row of blocks from top to bottom. Follow through the chart to identify the corrective action.

▲ WARNING ▲

Troubleshooting presents the risk of equipment damage, personal injury or death. Troubleshooting must be performed by trained, experienced technicians.

Alternator Not Charging or Insufficient Charging	
Cause	Correction
STEP 1 Alternator belt is loose	Check the alternator belt tension. Refer to Procedure 018-005 (Drive Belt Tension) in Section V.
OK Go To Next Step	
STEP 2 Battery cables or connections are loose, broken, or corroded (excessive resistance)	Check the battery cables and connections.
OK Go To Next Step	
STEP 3 Batteries have failed	Check the condition of the batteries. Replace the batteries, if necessary. Refer to the OEM service manual .
OK Go To Next Step	
STEP 4 Alternator pulley is loose on the shaft	Tighten the pulley. Refer to OEM service manual .
OK Go To Next Step	
STEP 5 Contact a Cummins® Authorized Repair Facility	

Coolant Loss

Cause	Correction
<p>STEP 1 Coolant level is above specification</p> <p>OK Go To Next Step</p>	Check the coolant level. Refer to Procedure 008-066 (Coolant Level) in Section 3 .
<p>STEP 2 Cooling system pressure cap is not correct, is malfunctioning, or has a low-pressure rating</p> <p>OK Go To Next Step</p>	Inspect the pressure cap. Refer to the OEM service manual .
<p>STEP 3 Contact a Cummins® Authorized Repair Facility</p>	

Coolant Temperature Above Normal - Gradual Overheat

Cause

Correction

STEP 1

Coolant level is below specification

Inspect the engine and cooling system for external coolant leaks. Repair if necessary. Add coolant. Refer to Procedure 008-066 (Coolant Level) in Section 3 .

OK

Go To Next Step

STEP 2

Supplemental coolant additive (SCA) level is above specification

Check the SCA level. Adjust as needed. Refer to Procedure 008-046 (Supplemental Coolant Additive (SCA) and Antifreeze Concentration) in Section 4 .

OK

Go To Next Step

STEP 3

Coolant hose is collapsed, restricted, or leaking

Inspect the hoses. Refer to Procedure 008-104 (Sea Water Hoses) in Section 6 .

OK

Go To Next Step

STEP 4

Coolant is overconcentrated with antifreeze

Verify the antifreeze concentration. Refer to Procedure 008-046 (Supplemental Coolant Additive (SCA) and Antifreeze Concentration) in Section 4 .

OK

Go To Next Step

STEP 5

Coolant temperature gauge or sensor is malfunctioning

Test the gauge and the sensor. Repair or replace, if necessary. Refer to the OEM service manual .

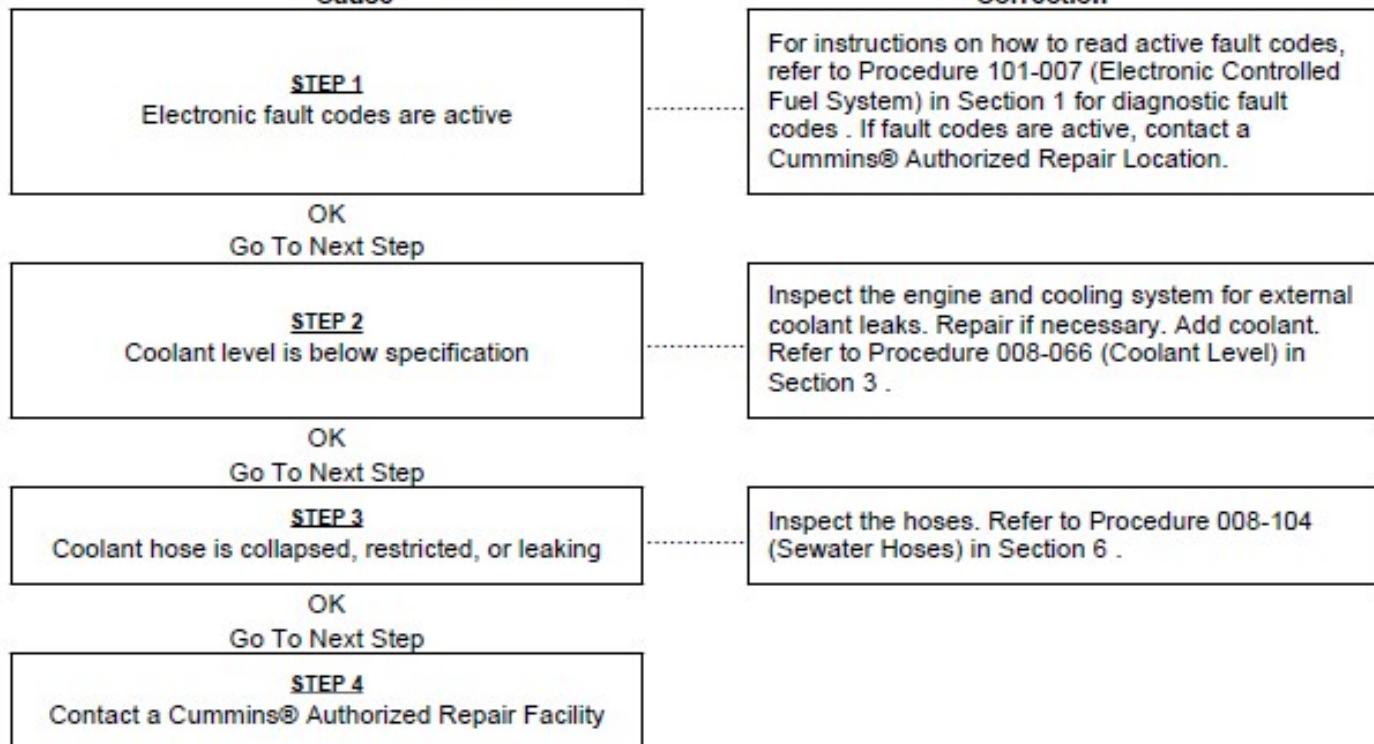
OK

Go To Next Step

STEP 6

Contact a Cummins® Authorized Repair Facility

Coolant Temperature Above Normal - Sudden Overheat



Coolant Temperature Below Normal

Cause	Correction
<p>STEP 1 Electronic fault codes are active</p>	For instructions on how to read active fault codes, refer to Procedure 101-007 (Electronic Controlled Fuel System) in Section 1 for diagnostic fault codes . If fault codes are active, contact a Cummins® Authorized Repair Location.
<p>OK Go To Next Step</p>	
<p>STEP 2 Engine is operating at low ambient temperature</p>	Refer to Procedure 101-015 (Operating the Engine) in Section 1 .
<p>OK Go To Next Step</p>	
<p>STEP 3 Coolant temperature gauge or sensor is malfunctioning</p>	Test the gauge and the sensor. Repair or replace, if necessary. Refer to the OEM service manual .
<p>OK Go To Next Step</p>	
<p>STEP 4 Contact a Cummins® Authorized Repair Facility</p>	

Crankcase Gases (Blowby) Excessive

Cause	Correction
<p>STEP 1 Crankcase ventilation system is plugged</p>	Check and clean the crankcase breather and vent tube.
<p>OK Go To Next Step</p>	
<p>STEP 2 Contact a Cummins® Authorized Repair Facility</p>	

Engine Acceleration or Response Poor

Cause

Correction

STEP 1

Drivetrain is not correctly matched to the engine

Check for correct gearing and drivetrain components. Make sure the propeller size is correct.

OK

Go To Next Step

STEP 2

Contact a Cummins® Authorized Repair Facility

Engine Decelerates Slowly

Cause	Correction
<p><u>STEP 1</u> Electronic fault codes are active</p>	<p>For instructions on how to read active fault codes, refer to Procedure 101-007 (Electronic Controlled Fuel System) in Section 1 . If fault codes are active, contact a Cummins® Authorized Repair Location.</p>
<p>OK Go To Next Step</p>	

STEP 2
Contact a Cummins® Authorized Repair Facility

Cause	Correction
STEP 1 Electronic fault codes are active	For instructions on how to read active fault codes, refer to Procedure 101-007 (Electronic Controlled Fuel System) in Section 1 . If fault codes are active, contact a Cummins® Authorized Repair Location.
OK Go To Next Step	
STEP 2 Battery voltage is low	Check the batteries and the unswitched battery supply circuit. Refer to Procedure 013-007 (Batteries) in Section 6 .
OK Go To Next Step	
STEP 3 Engine cranking speed is too slow	If the cranking speed is slower than 150 rpm, refer to Engine Will Not Crank or Cranks Slowly symptom tree .
OK Go To Next Step	
STEP 4 Fuel shutoff valve (FSOV) solenoid or circuit is malfunctioning (electronically controlled fuel systems)	Check the fuel shutoff valve solenoid and circuit.
OK Go To Next Step	
STEP 5 Fuse(s) malfunctioning	Replace the fuse(s) in the OEM interface harness. Refer to the OEM service manual .
OK Go To Next Step	
STEP 6 Starting aid is necessary for cold weather or starting aid is malfunctioning	Check for the correct operation of the starting aid. Refer to the manufacturer's instructions. Refer to the OEM service manual Section 1 .
OK Go To Next Step	
STEP 7 Fuel filter is plugged	Measure the fuel pressure before and after the fuel filter. Refer to a Cummins® Authorized Repair Location .
OK Go To Next Step	
STEP 8 Fuel shutoff lever (mechanical) partially engaged	Make sure fuel shutoff lever is in the RUN position. Replace if necessary. Refer to a Cummins® Authorized Repair Location .
OK Go To Next Step	

Engine Difficult to Start or Will Not Start (Exhaust Smoke)

Cause

Correction

STEP 9

Air intake system restriction is above specification

Check the air intake system for restriction. Clean or replace the air filter and inlet piping as necessary. Refer to Procedure 010-059 (Air Cleaner Restriction) in Section 6.

OK

Go To Next Step

STEP 10

Contact a Cummins® Authorized Repair Facility

Engine Difficult to Start or Will Not Start (No Exhaust Smoke)

Cause	Correction
STEP 1 Fuel level is low in the tank	Fill the supply tank. Refer to the OEM service manual .
OK Go To Next Step	
STEP 2 Starting motor rotation is not correct	Check the direction of crankshaft rotation. Replace the starting motor if necessary.
OK Go To Next Step	
STEP 3 Battery voltage supply to the electronic control module (ECM) is low, interrupted, or open	Check the battery connections.
OK Go To Next Step	
STEP 4 Fuel connections on the low-pressure side of the pump are loose	Tighten all fuel fittings and connections between the fuel tanks and the fuel pump.
OK Go To Next Step	
STEP 5 Fuel drain line is restricted	Inspect the fuel drain lines for restrictions. Remove any restrictions found. Refer to the OEM service manual .
OK Go To Next Step	
STEP 6 Fuel suction standpipe in the fuel tank is broken	Check and repair the standpipe, if necessary. Refer to the OEM service manual .
OK Go To Next Step	
STEP 7 Contact a Cummins® Authorized Repair Facility	

Engine Noise Excessive

Cause	Correction
<p>STEP 1 Lubricating oil level is below specification</p> <p>OK Go To Next Step</p>	Check the oil level. Refer to Procedure 007-043 (Lubricating Oil Level) in Section 3 .
<p>STEP 2 Lubricating oil is thin or diluted</p> <p>OK Go To Next Step</p>	Refer to Lubricating Oil Contaminated symptom tree .
<p>STEP 3 Drive belt is loose or has high loading</p> <p>OK Go To Next Step</p>	Check the drive belt tension. Adjust as necessary. Refer to Procedure 008-002 (Drive Belt, Cooling Fan) in Section A. Also, refer to Procedure 008-005 (Drive Belt, Alternator) in Section A .
<p>STEP 4 Vibration damper is damaged</p> <p>OK Go To Next Step</p>	Inspect the vibration damper. Refer to Procedure Procedure 001-052 (Vibration Damper, Viscous) in Section 7 .
<p>STEP 5 Contact a Cummins® Authorized Repair Facility</p>	

Engine Noise Excessive — Combustion Knocks

Cause

Correction

STEP 1

Engine is operating at low ambient temperature

Refer to Procedure 101-015 (Operating the Engine) in Section 1.

OK

Go To Next Step

STEP 2

Fuel grade is not correct for the application or the fuel quality is poor

Operate the engine from a tank of high-quality fuel. Refer to Procedure 018-002 (Fuel Recommendations and Specifications) in Section V for specifications.

OK

Go To Next Step

STEP 3

Contact a Cummins® Authorized Repair Facility

Engine Power Output Low

Cause	Correction
<u>STEP 1</u> Electronic fault codes are active OK Go To Next Step	For instructions on how to read active fault codes, refer to Procedure 101-007 (Electronic Controlled Fuel System) in Section 1 for diagnostic fault codes . If fault codes are active, contact a Cummins® Authorized Repair Location.
<u>STEP 2</u> Drivetrain is not correctly matched to the engine OK Go To Next Step	Check for correct gearing and drivetrain components. Make sure the propeller size is correct.
<u>STEP 3</u> Turbocharger is not correct OK Go To Next Step	Check the turbocharger part number and compare it to the Control Parts List (CPL), Bulletin 3379133 or 4021327. Replace the turbocharger if necessary. Refer to Procedure 010-033 (Turbocharger) in Section A .
<u>STEP 4</u> Fuel filter or fuel suction line is restricted OK Go To Next Step	Replace the fuel filter. Check the fuel suction line for restriction. Refer to Procedure 006-015 (Fuel Filter (Spin-on)) in Section 4 .
<u>STEP 5</u> Lubricating oil level is above specification OK Go To Next Step	Check the oil level. Verify the dipstick calibration and oil pan capacity. Fill the system to the specified level. Refer to Procedure 007-043 (Lubricating Oil Level) in Section 3 .
<u>STEP 6</u> Air intake system restriction is above specification OK Go To Next Step	Check the air intake system for restriction. Clean or replace the air filter and inlet piping as necessary. Refer to Procedure 010-024 (Air Leaks, Air Intake and Exhaust Systems) in Section 6 .
<u>STEP 7</u> Air in the fuel system OK Go To Next Step	Check for air in the fuel system. Tighten or replace the fuel connections, fuel lines, fuel tank standpipe, and fuel filters as necessary.
<u>STEP 8</u> Fuel drain line restriction OK Go To Next Step	Check the fuel drain lines for restriction. Clear or replace the fuel lines, check valves, or tank vents as necessary.

Engine Power Output Low

Cause	Correction
<p>STEP 9 Fuel grade is not correct for the application or the fuel quality is poor</p>	Operate the engine from a tank of high-quality fuel. Refer to Procedure 018-002 (Fuel Recommendations and Specifications) in Section V.
<p>OK Go To Next Step</p>	
<p>STEP 10 Intake manifold air temperature is above specification</p>	Refer to the Intake Manifold Air Temperature Above Specification symptom tree .
<p>OK Go To Next Step</p>	
<p>STEP 11 Fuel inlet temperature to pump is above specification</p>	Fill the fuel tank, turn off or bypass the fuel heaters, and check the fuel cooler. Refer to the OEM service manual .
<p>OK Go To Next Step</p>	
<p>STEP 12 Contact a Cummins® Authorized Repair Facility</p>	

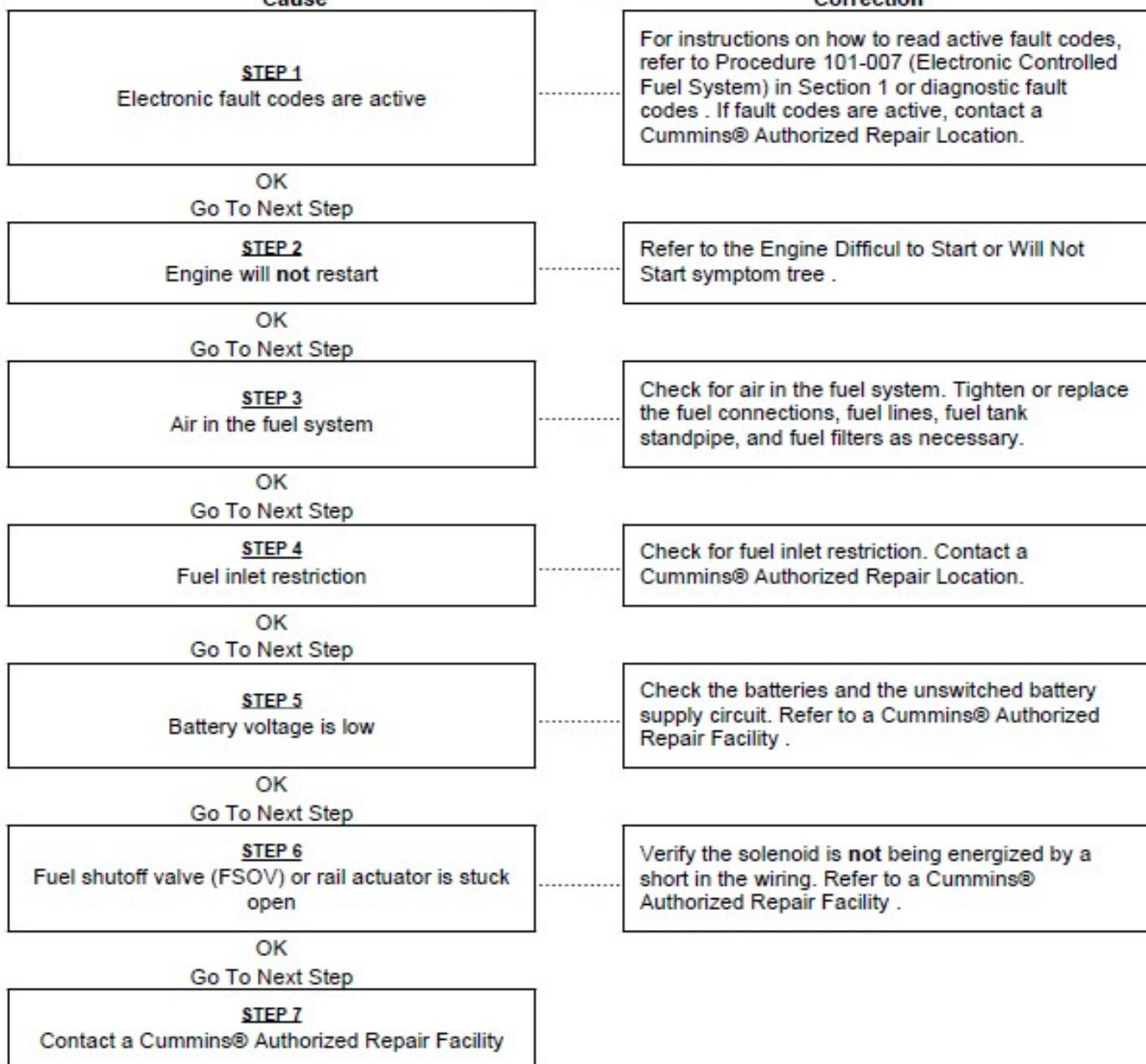
Engine Runs Rough at Idle

Cause	Correction
<p>STEP 1 Engine is operating at low ambient temperature</p> <p>OK Go To Next Step</p>	<p>Engine may not come up to temperature at idle. Operate engine under normal load and check temperature. Refer to Procedure 101-015 (Operating the Engine) in Section 1.</p>
<p>STEP 2 Electronic fault codes are active</p> <p>OK Go To Next Step</p>	<p>For instructions on how to read active fault codes, refer to Procedure 101-007 (Electronic Controlled Fuel System) in Section 1 for the diagnostic fault codes. If fault codes are active, contact a Cummins® Authorized Repair Location.</p>
<p>STEP 3 Engine mounts are worn, damaged, or not correct</p> <p>OK Go To Next Step</p>	<p>Inspect the engine mounts. Replace as needed. Contact a Cummins® Authorized Repair Location.</p>
<p>STEP 4 Air in the fuel system</p> <p>OK Go To Next Step</p>	<p>Check for air in the fuel system. Tighten or replace the fuel connections, fuel lines, fuel tank standpipe and fuel filters as necessary. Vent air from the system. Refer to Procedure 101-007 (Electronic Controlled Fuel System) in Section 1 for the diagnostic fault codes.</p>
<p>STEP 5 Fuel grade is not correct for the application or the fuel quality is poor</p> <p>OK Go To Next Step</p>	<p>Operate the engine from a tank of high-quality fuel. Refer to Procedure 018-002 (Fuel Recommendations and Specifications) in Section V.</p>
<p>STEP 6 Overhead adjustments are not correct</p> <p>OK Go To Next Step</p>	<p>Measure and adjust the overhead settings. Refer to Procedure 003-004 (Overhead Set) in Section 5.</p>
<p>STEP 7 Contact a Cummins® Authorized Repair Facility</p>	

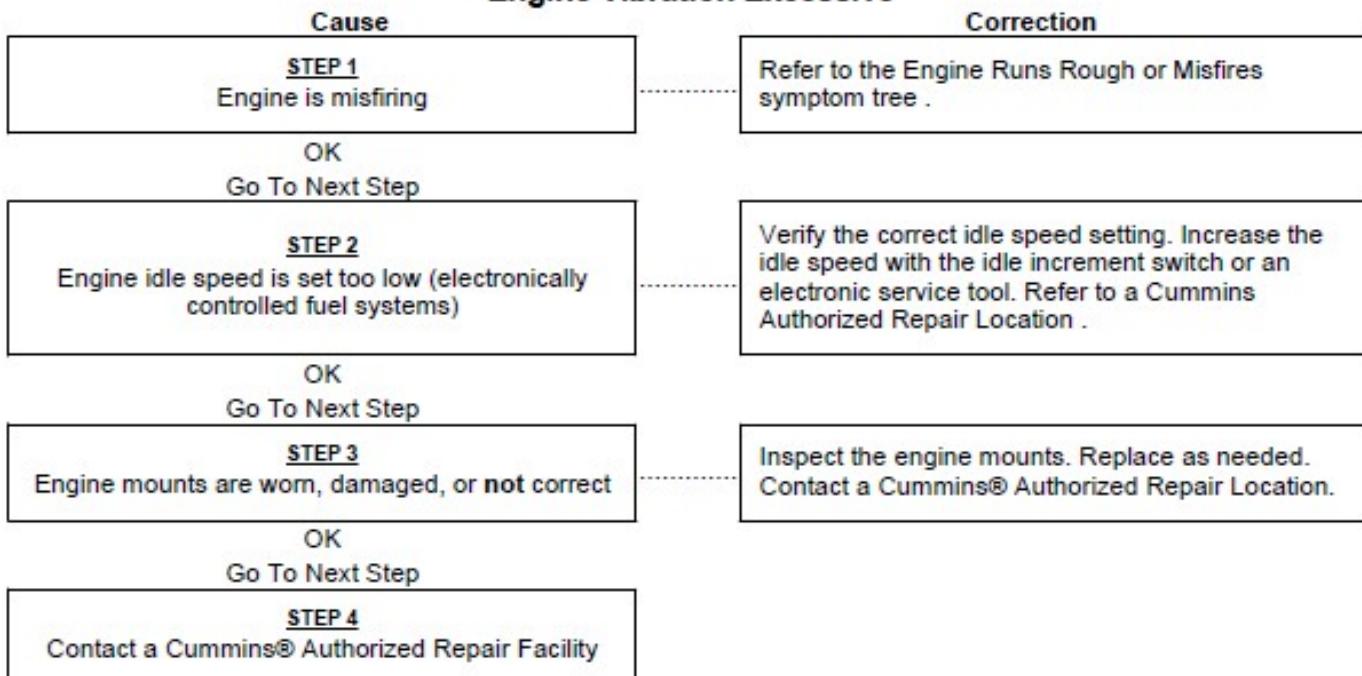
Engine Runs Rough or Misfires

Cause	Correction
STEP 1 Condition occurs only at idle	Refer to the Engine Runs Rough at Idle symptom tree .
OK Go To Next Step	
STEP 2 Engine is operating at low ambient temperature	Refer to Procedure 101-015 (Operating the Engine) in Section 1 .
OK Go To Next Step	
STEP 3 Electronic fault codes are active	For instructions on how to read active fault codes, refer to Procedure 101-007 (Electronic Controlled Fuel System) in Section 1 for diagnostic fault codes . If fault codes are active, contact a Cummins® Authorized Repair Location.
OK Go To Next Step	
STEP 4 Fuel leak	Check the fuel lines, fuel connections, and fuel filters for leaks. Check the fuel lines to the supply tanks. Repair or replace as necessary.
OK Go To Next Step	
STEP 5 Fuel grade is not correct for the application or the fuel quality is poor	Operate the engine from a tank of high-quality fuel. Refer to Procedure 018-002 (Fuel Recommendations and Specifications) in Section V .
OK Go To Next Step	
STEP 6 Air in the fuel system	Check for air in the fuel system. Tighten or replace the fuel connections, fuel lines, fuel tank standpipe, and fuel filters as necessary.
OK Go To Next Step	
STEP 7 Fuel inlet restriction	Check for fuel inlet restriction. Contact a Cummins® Authorized Repair Location.
OK Go To Next Step	
STEP 8 Overhead adjustments are not correct	Measure and adjust the overhead settings. Refer to Procedure 003-004 (Overhead Set) in Section 5 .
OK Go To Next Step	
STEP 9 Contact a Cummins® Authorized Repair Facility	

Engine Shuts Off Unexpectedly or Dies During Deceleration



Engine Vibration Excessive



Engine Will Not Reach Rated Speed (RPM)	
Cause	Correction
<p>STEP 1 Tachometer is not calibrated or is malfunctioning</p>	Compare the tachometer reading with a handheld tachometer or an electronic service tool reading. Calibrate or replace the tachometer as necessary. Refer to the OEM service manual.
<p>OK Go To Next Step</p>	
<p>STEP 2 Fuel inlet restriction</p>	Check for fuel inlet restriction. Contact a Cummins® Authorized Repair Location.
<p>OK Go To Next Step</p>	
<p>STEP 3 Cruise control switch is in the ON position</p>	Put the cruise control switch in the OFF position. Refer to Procedure 101-015 (Operating the Engine) in Section 1 .
<p>OK Go To Next Step</p>	
<p>STEP 4 Vessel is overloaded</p>	Load the vessel correctly. Refer to the OEM .
<p>OK Go To Next Step</p>	
<p>STEP 5 Drivetrain or propeller is damaged or is not correctly matched to the engine</p>	Check for the correct gearing, drivetrain components, or propeller. Refer to the OEM .
<p>OK Go To Next Step</p>	
<p>STEP 6 Contact a Cummins® Authorized Repair Facility</p>	

Engine Will Not Shut Off	
Cause	Correction
<p>STEP 1 Fuel shutoff valve (FSOV) or rail actuator is stuck open</p> <p>OK Go To Next Step</p>	Verify the solenoid is not being energized by a short in the wiring. Refer to a Cummins® Authorized Repair Facility .
<p>STEP 2 Keyswitch circuit is malfunctioning</p> <p>OK Go To Next Step</p>	Check the equipment or vessel keyswitch circuit. Refer to a Cummins® Authorized Repair Facility .
<p>STEP 3 Engine is running on fumes drawn into the air intake</p> <p>OK Go To Next Step</p>	Check the air intake ducts. Locate and isolate the source of the fumes. Repair as necessary. Refer to the OEM .
<p>STEP 4 Fuel tank vents are plugged or damaged</p> <p>OK Go To Next Step</p>	Remove and clean the tank vents. Replace the vents if necessary. Refer to the OEM .
<p>STEP 5 Fuel drain line is restricted</p> <p>OK Go To Next Step</p>	Inspect the fuel drain lines for restrictions. Remove any restrictions found. Refer to the OEM service manual .
<p>STEP 6 Contact a Cummins® Authorized Repair Facility</p>	

Fuel Consumption Excessive

Cause	Correction
<p>STEP 1 Verify the complaint</p> <p>OK Go To Next Step</p>	If low power is relevant, refer to the Engine Power Output Low symptom tree . If acceleration is poor, refer to the Engine Acceleration or Response Poor symptom tree. If fuel consumption is relevant, continue with this tree.
<p>STEP 2 Lubricating oil level is above specification</p> <p>OK Go To Next Step</p>	Check the oil level. Verify the dipstick calibration and oil pan capacity. Fill the system to the specified level. Refer to Procedure 007-002 (Lubricating Oil and Filters) in Section 4 .
<p>STEP 3 Air intake system restriction is above specification</p> <p>OK Go To Next Step</p>	Check the air intake system for restriction. Clean or replace the air filter and inlet piping as necessary. Refer to Procedure 010-059 (Air Cleaner Restriction) in Section 6 .
<p>STEP 4 Fuel leak</p> <p>OK Go To Next Step</p>	Check the fuel lines, fuel connections, and fuel filters for leaks. Refer to the OEM service manual .
<p>STEP 5 Operator technique is not correct</p> <p>OK Go To Next Step</p>	Refer to Procedure 101-015 (Operating the Engine) in Section 1 .
<p>STEP 6 Contact a Cummins® Authorized Repair Facility</p>	

Fuel in Coolant

Cause

STEP 1
Bulk coolant supply is contaminated

Correction

Check the bulk coolant supply. Drain the coolant and replace with noncontaminated coolant. Replace the coolant filters. Refer to Procedure 008-018 (Cooling System) in Section 7 and Procedure 008-006 (Coolant Filter) in Section 4 .

OK
Go To Next Step

STEP 2

Contact a Cummins® Authorized Repair Facility

Fuel in the Lubricating Oil

Cause	Correction
<p>STEP 1 Bulk oil supply is contaminated</p>	<p>Check the bulk oil supply. Drain the oil and replace with noncontaminated oil. Replace the oil filter(s). Refer to Procedure 007-002 (Lubricating Oil and Filters) in Section 4 .</p>
<p>OK Go To Next Step</p>	<p>Review the engine operating instructions in Section 1Procedure 007-002 (Lubricating Oil and Filters) in Section 4 .</p>
<p>OK Go To Next Step</p>	
<p>STEP 3 Contact a Cummins® Authorized Repair Facility</p>	

Lubricating Oil Consumption Excessive

Cause	Correction
<p>STEP 1 Lubricating oil leak (external)</p> <p>OK Go To Next Step</p>	Inspect the engine for external oil leaks. Tighten the capscrews, pipe plugs, and fittings. Replace gaskets if necessary. Refer to Procedure 018-009 (Capscrew Markings and Torque Values) in Section V .
<p>STEP 2 Lubricating oil drain interval is excessive</p> <p>OK Go To Next Step</p>	Verify the correct lubricating oil drain interval. Refer to Procedure 102-002 (Maintenance Schedule) in Section 2. Use the oil recommended in Procedure 018-003 (Lubricating Oil Recommendations and Specifications in Section V .
<p>STEP 3 Lubricating oil does not meet specifications for operating conditions</p> <p>OK Go To Next Step</p>	Change the oil and filters. Refer to Procedure 007-002 (Lubricating Oil and Filters) in Section 4 .
<p>STEP 4 Crankcase ventilation system is plugged</p> <p>OK Go To Next Step</p>	Check and clean the crankcase breather and vent tube. Procedure 007-002 (Lubricating Oil and Filters) in Section 4
<p>STEP 5 Contact a Cummins® Authorized Repair Facility</p>	

Lubricating Oil Contaminated

Cause	Correction
<p>STEP 1 Identify lubricating oil contamination</p> <p>OK Go To Next Step</p>	Perform an oil analysis to determine the contaminants.
<p>STEP 2 Bulk oil supply is contaminated</p> <p>OK Go To Next Step</p>	Check the bulk oil supply. Drain the oil and replace with noncontaminated oil. Replace the oil filter(s). Refer to Procedure 007-002 (Lubricating Oil and Filters) in Section 4 .
<p>STEP 3 Lubricating oil sludge is excessive</p> <p>OK Go To Next Step</p>	Refer to the Lubricating Oil Sludge in the Crankcase Excessive symptom tree .
<p>STEP 4 Fuel in the lubricating oil</p> <p>OK Go To Next Step</p>	Refer to the Fuel in the Lubricating Oil symptom tree .
<p>STEP 5 Internal coolant leaks</p> <p>OK Go To Next Step</p>	Refer to the Coolant Loss - Internal symptom tree .
<p>STEP 6 Contact a Cummins® Authorized Repair Facility</p>	

Lubricating Oil Pressure High

Cause	Correction
<p>STEP 1 Lubricating oil temperature switch, gauge, or sensor malfunctioning or not in the correct location</p>	Check the oil temperature switch, gauge, or sensor for correct operation and location. Refer to the OEM service manual .
OK Go To Next Step	
<p>STEP 2 Coolant temperature is below specification</p>	Refer to the Coolant Temperature Below Normal symptom tree .
OK Go To Next Step	
<p>STEP 3 Lubricating oil does not meet specifications for operating conditions</p>	Change the oil and filters. Refer to Procedure 007-002 (Lubricating Oil and Filters) in Section 4 . Use the oil recommended in Section V.
OK Go To Next Step	
<p>STEP 4 Contact a Cummins® Authorized Repair Facility</p>	

Lubricating Oil Temperature Above Specification

Cause

Correction

STEP 1

Lubricating oil level is above or below specification

Check the oil level. Add or drain oil if necessary.
Refer to Procedure 007-002 (Lubricating Oil Level)
in Section 4 . Check the dipstick calibration.

OK

Go To Next Step

STEP 2

Coolant temperature is above specification

Refer to the Coolant Temperature Is Above
Normal - Sudden Overheat or the Coolant
Temperature Is Above Normal - Gradual Overheat
symptom trees .

OK

Go To Next Step

STEP 3

Lubricating oil temperature switch, gauge, or
sensor malfunctioning or not in the correct location

Check the oil temperature switch, gauge, or sensor
for correct operation and location. Refer to the
OEM service manual .

OK

Go To Next Step

STEP 4

Contact a Cummins® Authorized Repair Facility

Smoke, Black — Excessive

Cause	Correction
<p>STEP 1 Air intake system restriction is above specification</p>	Inspect the air intake system for restriction. Clean or replace filter and inlet piping as necessary. Refer to Procedure 010-059 (Air Cleaner Restriction) in Section 6.
OK Go To Next Step	
<p>STEP 2 Fuel grade is not correct for the application or the fuel quality is poor</p>	Operate the engine from a tank of high-quality fuel. Refer to Procedure 018-002 (Fuel Recommendations and Specifications) in Section V.
OK Go To Next Step	
<p>STEP 3 Fuel drain line restriction</p>	Check the fuel drain lines for restriction. Clear or replace the fuel lines, check valves, or tank vents as necessary. Refer to the OEM service manual.
OK Go To Next Step	
<p>STEP 4 Contact a Cummins® Authorized Repair Facility</p>	

Smoke, White — Excessive

Cause	Correction
<p>STEP 1 Electronic fault codes are active</p> <p>OK Go To Next Step</p>	For instructions on how to read active fault codes, refer to Procedure 101-007 (Electronic Controlled Fuel System) in Section 1 for diagnostic fault codes . If fault codes are active, contact a Cummins® Authorized Repair Location.
<p>STEP 2 Engine block heater is malfunctioning (if equipped)</p> <p>OK Go To Next Step</p>	Check the electrical sources and wiring to the cylinder block heater. Replace the block heater, if necessary. Refer to the OEM service manual .
<p>STEP 3 Coolant temperature is below specification</p> <p>OK Go To Next Step</p>	Refer to the Coolant Temperature Below Normal symptom tree .
<p>STEP 4 Engine is cold</p> <p>OK Go To Next Step</p>	Allow the engine to warm to operating temperature. If the engine will not reach operating temperature, refer to the Coolant Temperature Below Normal symptom tree .
<p>STEP 5 Fuel grade is not correct for the application or the fuel quality is poor</p> <p>OK Go To Next Step</p>	Operate the engine from a tank of high-quality fuel. Refer to Procedure 018-002 (Fuel Recommendations and Specifications) in Section V .
<p>STEP 6 Overhead adjustments are not correct</p> <p>OK Go To Next Step</p>	Measure and adjust the overhead settings. Refer to Procedure 003-004 (Overhead Set) in Section 5 .
<p>STEP 7 Contact a Cummins® Authorized Repair Facility</p>	

Turbocharger Leaks Engine Oil or Fuel

Cause	Correction
<p>STEP 1 Engine is operating for extended periods under light or no-load conditions (slobbering)</p>	<p>Review the engine operating instructions. Refer to Procedure 101-015 (Operating the Engine) in Section 1 .</p>
<p>OK Go To Next Step</p>	
<p>STEP 2 Lubricating oil or fuel is entering the turbocharger</p>	<p>Remove the intake and exhaust piping, and check for oil or fuel.</p>
<p>OK Go To Next Step</p>	
<p>STEP 3 Turbocharger oil drain line is restricted</p>	<p>Remove the turbocharger oil drain line and check for restriction. Clean or replace the oil drain line. Refer to Procedure 010-033 (Turbocharger) in Section A .</p>
<p>OK Go To Next Step</p>	
<p>STEP 4 Contact a Cummins® Authorized Repair Facility</p>	

Notes

Section V - Maintenance Specifications

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General Engine

Specifications

Type.....	Four-cycle, In-line six-cylinder, four-valves per cylinder
Horsepower.....	Refer to engine dataplate
Engine Speed at Maximum Output.....	Refer to engine dataplate
Bore and Stroke.....	125 mm [4.921 in] x 147 mm [5.787 in]
Displacement.....	10.8 liters [659 C.I.D.]
Firing Order.....	1-5-3-6-2-4
Engine Weight (with standard accessories):	
Dry Weight.....	1124 kg [2478 lb]
Crankshaft Rotation (viewed from the front of the engine).....	Clockwise

Fuel System

Specifications

Maximum Fuel Inlet Temperature.....	71°C [160°F]
Fuel Inlet Maximum Restriction:	
Marine Applications	
Clean Fuel Filter.....	152 mm Hg [6 in Hg]
Dirty Fuel Filter.....	203 mm Hg [8 in Hg]
Fuel Drain Maximum Restriction:	
Without Check Valves.....	63mm Hg [2.5 in Hg]
Engine Minimum Cranking Speed.....	120 rpm

Lubricating Oil System

Specifications

Oil Pressure

Minimum at Idle.....	69 kPa [10 psi]
Operating Range.....	207 to 448 kPa [30 to 65 psi]
at torque peak or 1200 rpm (minimum allowable).....	207 kPa [30 psi]

Oil Temperature

Maximum.....	121°C [250°F]
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Oil Pan Capacity

Low.....	26.5 liters [7 gal]
High.....	30.3 liters [8 gal]

Total System Capacity:

With engine Mounted Filter (combination filter holds 2.6 liters [0.7 gal]).....	37 liters [9.8 gal]
With Remote Mounted Filter.....	38 liters [10 gal]

Maximum Operational Angularity of Oil Pan

Front Down:

Rear Sump.....	30 degrees
Front Sump.....	45 degrees

Maximum Operational Angularity of Oil Pan

Rear Down:

Rear Sump.....	25 degrees
Front Sump.....	27 degrees

Maximum Operational Angularity of Oil Pan

Side to Side:

Rear Sump.....	30 degrees
Front Sump.....	42 degrees

Cooling System

Specifications

Coolant Capacity:

Engine with Heat Exchanger.....	29.4 liters [8 gal]
Minimum Drawdown.....	15.2 liters [4 gal]

Standard Thermostat Modulating Range.....71 to 79.4°C [106 to 175°F]

Block coolant Pressure with Closed Thermostat (pressure cap removed)

Maximum.....	246 kPa [36 psi]
--------------	------------------

Coolant Inlet Pressure with Open Thermostat and No Cap:

Minimum.....	.64 mm Hg [2.5 in Hg]
Maximum Coolant Temperature.....	.96°C [205°F]

Minimum Fill Rate.....18.9 liters/min [5 gpm]

Minimum Initial Fill Time.....2 minutes

Maximum Deaeration Time.....10 minutes

Minimum Coolant Expansion Space:

Percent of Cooling system.....5%

External Pressure Loss in Cooling System:

Maximum.....	35 kPa [5 psi]
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Static Pressure of Coolant:

Maximum - Exclusive of Pressure Cap.....103 kPa [15 psi]

Maximum Sea Water Pressure.....103 kPa [15 psi]

Maximum Sea Water Pump Inlet Restriction.....127 mm Hg [5 psi]

Maximum Sea Water Pump Initial Suction Lift.....3 m [10 ft]

Pressure Cap Rating (with heat exchanger).....103 kPa [15 psi]

Maximum Allowable Coolant Flow to Accessories.....37.9 liters/min [10 gal/min]

Air Intake System

Specifications

Maximum Intake Restriction (Clean Element).....	254 mm H ₂ O [10 in H ₂ O]
Maximum Intake Restriction (Dirty Element).....	507 mm H ₂ O [20 in H ₂ O]
Maximum Intake Manifold Temperature.....	.49°C [120°F]
Maximum Engine Room Temperature: Intake air Versus Ambient Air at Rated Condition.....	.35°C [63°F] difference

Exhaust System

Specifications

Exhaust Pipe Size (normally acceptable inside diameter)..... 102 mm [4 in]

Maximum Exhaust Pipe Restriction

H₂O..... 1016 mm H₂O [40 in H₂O]

Hg..... 75 mm Hg [3in Hg]

Electrical System

Specifications

Starting Motor Circuit:

Maximum resistance:	
12-VDC.....	0.00075 ohm
24-VDC.....	0.002 ohm

Starting Motor Circuit:

Maximum Voltage Drop:	
12-VDC.....	1.95-VDC
24-VDC.....	1.7-VDC

Marine Applications

Unaided Cold Start:

Maximum Ambient Temperature.....	-7°C [19°F]
Minimum Cranking Speed Required.....	120 rpm

Minimum recommended battery capacity:

System Voltage	Ambient Temperature			
	-18°C [0°F]		0°C [32°F]	
	Cold Cranking Amperes	Reserve Capacity 1Minutes	Cold Cranking Amperes	Reserve Capacity 1Minutes
12-VDC	1800	640	1280	480
24-VDC ²	900	320	640	240

¹ The number of plates within a given battery size determines reserve capacity. Reserve capacity determines the length of time that sustained cranking can occur.
² Cold Cranking Amperes rating are based on two 12-VDC batteries in series.

A minimum of 6.5 VDC at the power connector is required to power up the ECM.

Cummins®/Fleetguard® Filter Specifications

Specifications

Fleetguard® filters are manufactured by Cummins Filtration Inc., which is a subsidiary of Cummins Inc. Fleetguard® filters are developed through joint testing at Cummins Inc. and at Cummins Filtration Inc. Fleetguard® filters are standard on new Cummins® engines. Cummins Inc. recommends their use.

Fleetguard® products meet all Cummins Inc. Source Approval Test standards to provide the quality filtration necessary to achieve the engine's design life. If other brands are substituted, the purchaser **must** insist on products that the supplier has tested to meet Cummins Inc. high-quality standards.

Cummins Inc. can **not** be responsible for problems caused by non-genuine filters that do **not** meet Cummins Inc. performance or durability requirements.

Filter Types	
Lubricating Oil Filter	
Cummins® Part Number	3101869 and 3101868
Fleetguard® Part Number	LF9001 ¹ or LF9000
Fuel Filter	
Cummins® Part Number	3329289
Fleetguard® Part Number	FS 1000
Turbocharger Control Shutoff Valve Filter	
Cummins® Part Number	3682958
Coolant Filter ²	
Cummins® Part Number	4058965
Fleetguard® Part Number	WF2076
Cummins® Part Number	3100304
Fleetguard® Part Number	WF2071
Cummins® Part Number	3100305
Fleetguard® Part Number	WF2072
Coalescing Filter	
Cummins® Part Number	3683918
Fleetguard® Part Number	CV5060700

- 1 Centinel™ equipped automotive applications **must** use Fleetguard® filter LF9031, Cummins® Part Number 4906633. Non-automotive Centinel™ equipped applications can use Fleetguard® filter LF9001, Cummins® Part Number 3406809.
- 2 Use the correct Fleetguard® coolant filter to maintain the recommended SCA concentration in the system. The correct filter for each application is determined by the total cooling system capacity and oil drain interval. See the following procedure for cooling system capacities. Refer to Procedure 018-018 in Section V.

Fuel Recommendations and Specifications

Fuel Recommendations

⚠️ WARNING ⚠️

Do not bleed the fuel system of a hot engine; this can result in fuel spilling onto a hot exhaust manifold, which can cause a fire.

⚠️ CAUTION ⚠️

Due to the precise tolerances of diesel injection systems, it is extremely important that the fuel be kept clean and free of dirt or water. Dirt or water in the system can cause severe damage to both the fuel pump and the fuel injectors.

⚠️ CAUTION ⚠️

Do not use diesel fuel blended with lubricating oil in engines equipped with an aftertreatment device. Service intervals for aftertreatment devices will be reduced.

Fuel Recommended Properties	
Cummins Inc. recommends the use of fuels that meet the following specifications:	
Property	Recommended Specifications
Viscosity (ASTM D445)	1.3 to 4.1 centistokes [1.3 to 4.1 mm per second] at 40°C [104°F].
Cetane Number (ASTM D613)	40 minimum above 0°C [32°F]. 45 minimum below 0°C [32°F].
Sulfur Content (ASTM D129 or D1552)	Not to exceed 0.05 mass percent for engines without aftertreatment devices. For engines with aftertreatment devices, sulfur content can not exceed 0.0015 (15 ppm) mass percent.
Active Sulfur (ASTM D130)	Copper strip corrosion not to exceed number 3 rating after three hours at 50°C [122°F].
Water and Sediment (ASTM D1796)	Not to exceed 0.05 volume percent.
Carbon Residue (Rams bottom, ASTM D524 or Conradson, ASTM D189)	Not to exceed 0.35 mass percent on 10 volume percent residuum.
Density (ASTM D287)	42 to 30° API gravity at 0.816 to 0.876 g/cc at 15°C [60°F].
Cloud Point (ASTM D97)	6°C [10°F] below lowest ambient temperature at which the fuel is expected to operate.
Ash (ASTM D482)	Not to exceed 0.02 mass percent (0.05 mass percent with lubricating oil blending). Oil blending is prohibited on engines with aftertreatment devices.
Distillation (ASTM D86)	The distillation curve must be smooth and continuous.
Acid Number (ASTM D664)	Not to exceed 0.1 mg KOA per 100 ml.

- 1 For additional information on fuel recommendations and specifications, refer to Fuel for Cummins® Engines, Bulletin 3379001,. See ordering information in the back of this manual.

Lubricating Oil Recommendations and Specifications

AfterMarket Oil Additive Usage

Cummins Inc. does **not** recommend the use of aftermarket oil additives. Present high-quality fully additive engine lubricating oils are very sophisticated, with precise amounts of additives blended into the lubricating oil to meet stringent requirements defined in (1) Cummins® Engineering Specification CES 20076 that is similar to API CH-4, in (2) CES 20078 that is similar to API CI-4, and in (3) CES 20081 that is similar to API CJ-4. These furnished oils meet performance characteristics that conform to the lubricant industry standards. Aftermarket lubricating oil additives are **not** necessary to enhance engine oil performance and in some cases can reduce the finished oil's capability to protect the engine.

New Engine Break-in Oils

Special "break-in" engine lubricating oils are **not** recommended for new or rebuilt Cummins® engines. Use the same lubricating oil that will be used during normal operation.

Coolant Recommendations and

Fully Formulated Coolant/Antifreeze

Cummins Inc. recommends using either a 50/50 mixture of good-quality water and fully formulated antifreeze, or fully formulated coolant when filling the cooling system. The fully formulated antifreeze or coolant **must** meet TMC RP329 or TMC RP330 specifications.

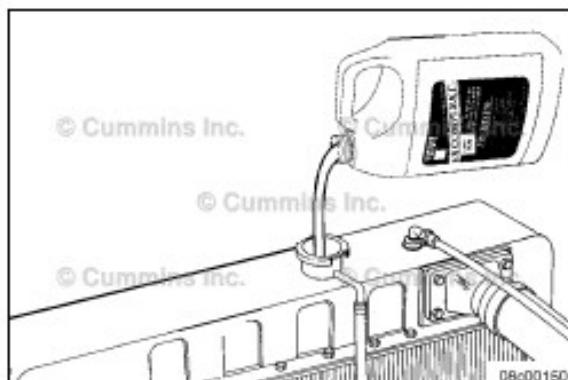
NOTE: Use of products meeting TMC RP329 or RP330 is necessary for 50,000-mile and 150,000-mile service intervals.

NOTE: Low-silicate antifreeze meeting ASTM D4985 is inadequate for these extended service intervals.

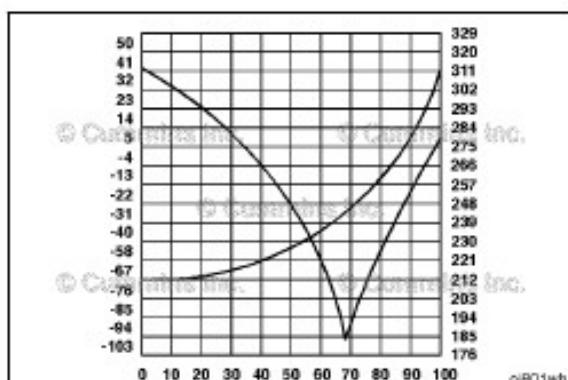
Good-quality water is important for cooling system performance. Excessive levels of calcium and magnesium contribute to scaling problems, and excessive levels of chlorides and sulfates cause cooling system corrosion.

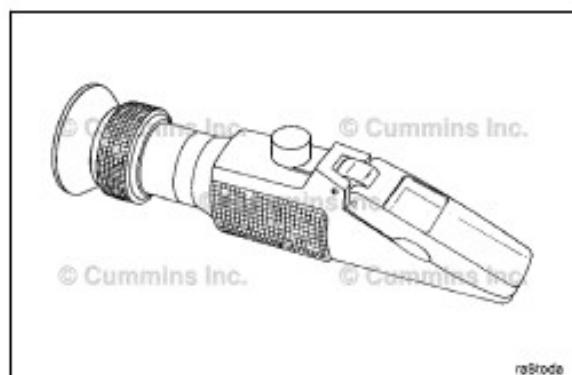
Water Quality	
Calcium Magnesium (Hardness)	Maximum 170 ppm as (CaCO_3 + MgCO_3)
Chloride	40 ppm as (Cl)
Sulfate	100 ppm as (SO_4)

Cummins Inc. recommends using Fleetguard® COMPLEAT ES. It is available in glycol forms (ethylene and propylene) and complies with TMC RP329 and RP330 standards.

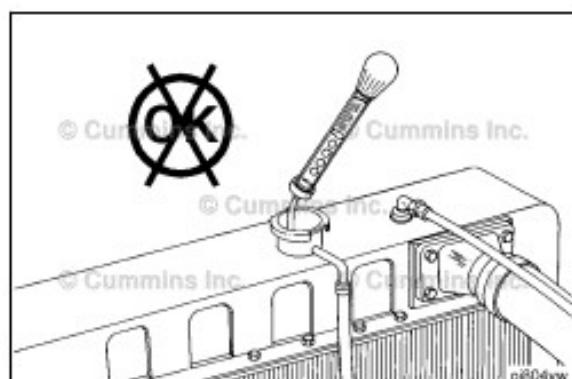


Fully formulated antifreeze **must** be mixed with quality water at a 50/50 ratio (40-percent to 60-percent working range). A 50/50 mixture of antifreeze and water gives a -36°C [-34°F] freezing point and a 110°C [228°F] boiling point, which is adequate for locations in North America. The actual lowest freezing point of ethylene glycol antifreeze is 68 percent. Using higher concentrations of antifreeze will raise the freezing point of the solution and increase the possibility of a silica gel problem.

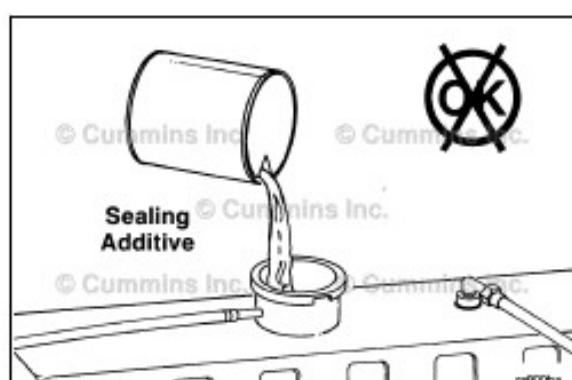




A refractometer **must** be used to measure the freezing point of the coolant accurately.



Do **not** use a floating ball hydrometer. Using a floating ball hydrometer can give an incorrect reading.



Cooling System Sealing Additives

Do **not** use sealing additives in the cooling systems. The use of sealing additives can:

- Build up in coolant low-flow areas
- Clog coolant filters
- Plug radiator and oil cooler.



Cooling System Soluble Oils

Do **not** use soluble oils in the cooling system. The use of soluble oils can:

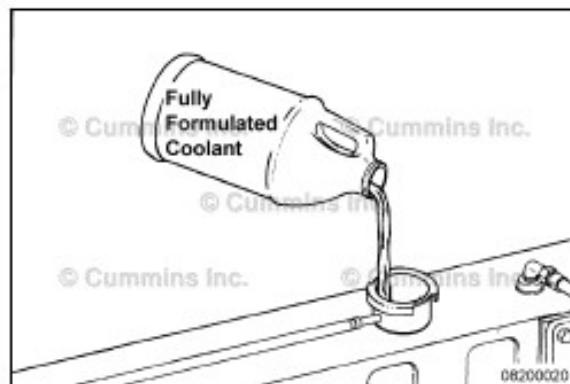
- Allow cylinder liner pitting
- Corrode brass, aluminum, and copper
- Damage heat transfer surfaces
- Damage seals and hoses.

Supplemental Coolant Additive (SCA)

CAUTION

The Signature, ISX, and QSX15 engines use aluminum parts that are in contact with the coolant. Improper coolant, coolant filter selection, and maintenance will likely result in perforation of one of these parts. Insufficient concentration of the coolant additives will result in liner pitting and engine failure.

Fully formulated products contain SCAs and are required to protect the cooling system from scale and fouling, solder corrosion, and general corrosion. The coolant filter is required to protect the cooling system from abrasive materials, debris, and precipitated coolant additives.



Fleetguard® DCA4 Service Filters and Liquid Precharge

Signature, ISX, and QSX15 Series Coolant Filter Options:

WF2125 - This filter is designed for use with Fleetguard®'s extended service cooling system, which extends cooling system service to 1 year, 150,000 miles, or 4000 hours, whichever comes first. This filter is used for cooling systems up to 20 gallons. Refer to Coolant Requirements and Maintenance, Bulletin 3666132. Fleetguard® ES coolant must be used for all fill and top-off, which is critical for extended cooling system maintenance intervals.

WF2126 - This filter is designed for extended service intervals up to 50,000 miles when using TMC RP329 or RP330 coolants and is used for cooling systems up to 20 gallons. Refer to Coolant Requirements and Maintenance, Bulletin 3666132.

WF2127 - This filter has been designed for extended service intervals of 50,000 to 150,000 miles. It has no chemical additives and can be used in the following systems:

- Cooling systems above 20 gallons in capacity.
- See maintenance chart below.

When using WF2127 filter, the following volumes of treatment must be added at the designated mileages:

Cooling System Capacity	50,000-Mile Service Interval with RP329/330 Coolant or Treated Water (Fleetcool or DCA4)	150,000-Mile Service Interval with ES Coolant (ES Liquid)
0 to 20 gallons	1 qt (10 units)	1 qt (15 units)
20 to 40 gallons	2 qt (20 units)	2 qt (30 units)
40 to 60 gallons	3 qt (30 units)	3 qt (45 units)
60 to 80 gallons	4 qt (40 units)	4 qt (60 units)
80 to 100 gallons	5 qt (50 units)	5 qt (75 units)

NOTE: Filters must meet Cummins SAM 10,769. Fleetguard® filters meet Cummins SAM 10,769. The standard filter for the Signature engine is Fleetguard® WF2126. For systems larger than 100 gallons, use 1 quart per 15 gallons. Consult vehicle manufacturer for total cooling system capacity.

Testing SCA Concentration Level CC-2602 Test Kit

Precautions and Instructions for Proper Kit Use

Carefully follow the instructions to test the coolant. Take the appropriate action recommended by the kit.

- The coolant sample to be tested must be between 10 and 54 °C [50 and 130°F]. If the sample is too cold or too hot, you will get incorrect results.
- To get the best color match results, compare test strip pads to the color chart in daylight or under cool white fluorescent lighting. If unsure about a specific color match when a test does fall between two colors on the color chart, choose the lower numbered (or lettered) block. It is safer to underestimate your results than to overestimate.
- The test strips do have a limited shelf life and are sensitive to humidity and extreme heat. Proper handling and storage is necessary to protect the life of the strips.
- Keep the cap tightly sealed on the test strip bottle except when removing a strip. Store away from direct sunlight and in an area where the temperature will generally stay below 32°C [90°F].
- Do not use the test strips after the expiration date stamped on the bottle.

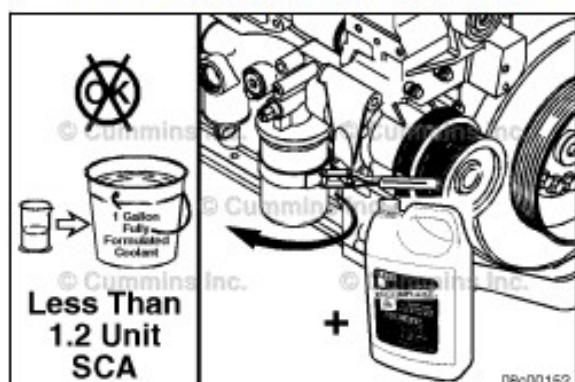
- Discard the kit if the top pad on the unused strips have turned light brown.
- Use one strip at a time and take care **not** to touch any of the pads on the strip. Doing so will contaminate the pads and skew the test results.
- If the strip container is left uncapped for 24 hours, moisture in the air will render the strips useless, even though no discoloration will be evident.
- Only use the color chart supplied with the kit.
- Following the correct test times is very important. Use a clock or stopwatch.
- Do not utilize the test kit to maintain minimum SCA concentration levels (i.e., 1.5 units).
- When performing service that requires draining the cooling system, take special precautions to collect coolant in a clean non-galvanized container, seal coolant to prevent contamination, and save for reuse.

Coolant Testing:

- Probablizer:
 - 3318169S Plug - Installs on the engine for easy coolant sampling
 - 3318168S Cap - Use with Monitor C bottle to sample coolant
 - CC2700 Monitor C™ - Use lab analysis of coolant samples for more detailed analysis.

CC2602 Coolant Test Kit:

- Works with any SCA formulation. Call 1-800-22FILTER (800-223-4583) if you have this test kit and the color chart does **not** show the number of units of SCA gallon of coolant.)



Test Intervals

WARNING

Do not remove the pressure cap from a hot engine. Wait until coolant temperature is below 50°C [120°F] before removing the pressure cap. Heated coolant spray or steam can cause personal injury.

Testing is recommended if the operator is **not** sure of his cooling system condition due to leaks, uncontrolled topping off of the system, or major coolant loss.

If the concentration is below 1.2 units per gallon, replace the filter and precharge with liquid.

Check the SCA concentration level at least every 6 months, and anytime the coolant condition is unknown or corrosion is apparent within the cooling system.

Use Fleetguard® coolant test kit, CC2602, to check the concentration level. Instructions are included with the test kit.

Call the following numbers to get answers to any questions you have about cooling system maintenance:

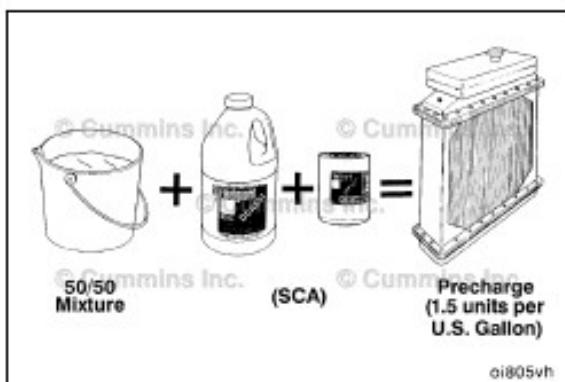
Cummins
1-800-DIESELS
1-800-343-7357

Fleetguard®
1-800-22FILTER
1-800-223-4583

Coolant Replacement Requirements

Drain and flush the cooling system after 6000 hours or 3 years of service. However, if Fleetguard®'s ES coolant and ES filters are used, check chloride, sulfate, and pH levels according to Coolant Requirements and Maintenance, Bulletin 3666132, to determine whether the coolant must be replaced. Refill with either new fully formulated coolant or ES coolant.

NOTE: Dispose of used coolant/antifreeze in accordance with federal, state, and local laws and regulations.



ci805vh

Drive Belt Tension

Tension Chart

SAE Belt Size	Belt Tension Gauge Part No.		Belt Tension New		Belt Tension Range Used*	
	Click-type	Burroughs	N	Ibf	N	Ibf
0.380 in	3822524		620	140	270 to 490	60 to 110
0.440 in	3822524		620	140	270 to 490	60 to 110
1/2 in	3822524	ST-1138	620	140	270 to 490	60 to 110
11/16 in	3822524	ST-1138	620	140	270 to 490	60 to 110
3/4 in	3822524	ST-1138	620	140	270 to 490	60 to 110
7/8 in	3822524	ST-1138	620	140	270 to 490	60 to 110
4 rib	3822524	ST-1138	620	140	270 to 490	60 to 110
5 rib	3822524	ST-1138	670	150	270 to 530	60 to 120
6 rib	3822525	ST-1293	710	160	290 to 580	65 to 130
8 rib	3822525	ST-1293	890	200	360 to 710	80 to 160
10 rib	3822525	3823138	1110	250	440 to 890	100 to 200
12 rib	3822525	3823138	1330	300	530 to 1070	120 to 240
12 rib K section	3822525	3823138	1330	300	890 to 1070	200 to 240
31 rib	-	3164750	1668	375	1330 to 1560	300 to 350

NOTE: This chart does not apply to automatic belt tensioners.

* A belt is considered used if it has been in service for ten minutes or longer.

* If used belt tension is less than the minimum value, tighten the belt to the maximum used belt value.

Engine Component Torque Values

General Information

Component	Wrench Size	Torque Value	
		N·m	ft-lb
Oil Pan Drain Plug	1-1/4	88	65
Turbocharger Mounting Nuts	16 mm	68	50
Fan Drive Idler Pulley Shaft Locknut		165 to 190	120 to 140
Injector/Valve Adjusting Screw Locknut	3/4 in.	61	45
Engine Brake Adjusting Screw Locknut		50	40
Fuel Pump Mounting Capscrews	7/16 in	47	35
Fuel Pump Bracket to Cylinder Block		47	35
Fuel Pump Bracket to Fuel Pump Housing	7/16 in	11	95 in-lb
Rocker Lever Cover Capscrews	13 mm	15	130 in-lb
Injector Hold-down Clamps		75	55
Crankcase Breather Cover Bolts	6 mm	.68	6 in-lb
Aftertreatment V-Band Clamps	10 mm	20	180 in-lb
Differential Pressure Sensing Tube Nuts	5/8	55	40
Aftertreatment Mounting Capscrews	10 mm	20	180 in-lb

Capscrew Markings and Torque Values

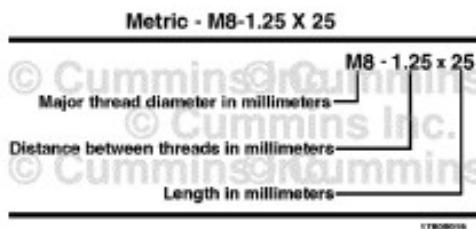
General Information

CAUTION

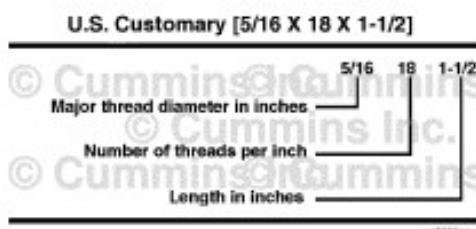
When replacing capscrews, always use a capscrew of the same measurement and strength as the capscrew being replaced. Using the wrong capscrews can result in engine damage.

Metric capscrews and nuts are identified by the grade number stamped on the head of the capscrew or on the surface of the nuts. U.S. Customary capscrews are identified by radial lines stamped on the head of the capscrew.

The following examples indicate how capscrews are identified:



- Always use the torque values listed in the following tables when specific torque values are not available.
- Do not use the torque values in place of those specified in other sections of this manual.
- The torque values in the table are based on the use of lubricated threads.
- When the ft-lb value is less than 10, convert the ft-lb value to in-lb to obtain a better torque with an in-lb torque wrench. Example: 6 ft-lb equals 72 in-lb.



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Capscrew Markings and Torque Values - Metric

Commercial Steel Class

8.8

10.9

12.9

Capscrew Head Markings



17800014

Body Size	Torque				Torque				Torque			
	Cast Iron		Aluminium		Cast Iron		Aluminium		Cast Iron		Aluminium	
Diameter	N·m	ft-lb										
mm												
6	9	5	7	4	13	10	7	4	14	9	7	4
7	14	9	11	7	18	14	11	7	23	18	11	7

Body Size	Torque				Torque				Torque			
	Cast Iron		Aluminium		Cast Iron		Aluminium		Cast Iron		Aluminium	
Diameter	N·m	ft-lb										
8	23	17	18	14	33	25	18	14	40	29	18	14
10	45	33	30	25	65	50	30	25	70	50	30	25
12	80	60	55	40	115	85	55	40	125	95	55	40
14	125	90	90	65	180	133	90	65	195	145	90	65
16	195	140	140	100	280	200	140	100	290	210	140	100
18	280	200	180	135	390	285	180	135	400	290	180	135
20	400	290	—	—	550	400	—	—	—	—	—	—

Capscrew Markings and Torque Values - U.S. Customary

SAE Grade Number

Capscrew Head Markings

These are all SAE Grade 5 (3 line)



17800015



Capscrew Torque - Grade 5 Capscrew

Capscrew Torque - Grade 8 Capscrew

Capscrew Body Size	Cast Iron		Aluminium		Cast Iron		Aluminium	
	N·m	ft-lb	N·m	ft-lb	N·m	ft-lb	N·m	ft-lb
1/4 - 20	9	7	8	6	15	11	8	6
1/4 - 28	12	9	9	7	18	13	9	7
5/16 - 18	20	15	16	12	30	22	16	12
5/16 - 24	23	17	19	14	33	24	19	14
3/8 - 16	40	30	25	20	55	40	25	20
3/8 - 24	40	30	35	25	60	45	35	25
7/16 - 14	60	45	45	35	90	65	45	35
7/16 - 20	65	50	55	40	95	70	55	40
1/2 - 13	95	70	75	55	130	95	75	55
1/2 - 20	100	75	80	60	150	110	80	60
9/16 - 12	135	100	110	80	190	140	110	80
9/16 - 18	150	110	115	85	210	155	115	85
5/8 - 11	180	135	150	110	255	190	150	110
5/8 - 18	210	155	160	120	290	215	160	120
3/4 - 10	325	240	255	190	460	340	255	190
3/4 - 16	365	270	285	210	515	380	285	210
7/8 - 9	490	360	380	280	745	550	380	280
7/8 - 14	530	390	420	310	825	610	420	310
1 - 8	720	530	570	420	1100	820	570	420
1 - 14	800	590	650	480	1200	890	650	480

Fraction, Decimal, Millimeter Conversions

Conversion Chart

Fraction	inch	mm	Fraction	inch	mm
1/64	0.0156	0.397	33/64	0.5156	13.097
1/32	0.0313	0.794	17/32	0.5313	13.494
3/64	0.0469	1.191	35/64	0.5469	13.891
1/16	0.0625	1.588	9/16	0.5625	14.288
5/64	0.0781	1.984	37/64	0.5781	14.684
3/32	0.0938	2.381	19/32	0.5938	15.081
7/64	0.1094	2.778	39/64	0.6094	15.478
1/8	0.1250	3.175	5/8	0.6250	15.875
9/64	0.1406	3.572	41/64	0.6406	16.272
5/32	0.1563	3.969	21/32	0.6563	16.669
11/64	0.1719	4.366	43/64	0.6719	17.066
3/16	0.1875	4.763	11/16	0.6875	17.463
13/64	0.2031	5.159	45/64	0.7031	17.859
7/32	0.2188	5.556	23/32	0.7188	18.256
15/64	0.2344	5.953	47/64	0.7344	18.653
1/4	0.2500	6.350	3/4	0.7500	19.050
17/64	0.2656	6.747	49/64	0.7656	19.447
9/32	0.2813	7.144	25/32	0.7813	19.844
19/64	0.2969	7.541	51/64	0.7969	20.241
5/16	0.3125	7.938	13/16	0.8125	20.638
21/64	0.3281	8.334	53/64	0.8281	21.034
11/32	0.3438	8.731	27/32	0.8438	21.431
23/64	0.3594	9.128	55/64	0.8594	21.828
3/8	0.3750	9.525	7/8	0.8750	22.225
25/64	0.3906	9.922	57/64	0.8906	22.622
13/32	0.4063	10.319	29/32	0.9063	23.019
27/64	0.4219	10.716	59/64	0.9219	23.416
7/16	0.4375	11.113	15/16	0.9375	23.813
29/64	0.4531	11.509	61/64	0.9531	24.209
15/32	0.4688	11.906	31/32	0.9688	24.606
31/64	0.4844	12.303	63/64	0.9844	25.003
1/2	0.5000	12.700	1	1.0000	25.400

Conversion Factor: 1 inch = 25.4 mm

Newton-Meter to Foot-Pound Conversions

Conversion Chart

N•m	ft-lb	N•m	ft-lb	N•m	ft-lb
1	9 in-lb	55	41	155	114
5	44 in-lb	60	44	160	118
6	53 in-lb	65	48	165	122
7	62 in-lb	70	52	170	125
8	71 in-lb	75	55	175	129
9	80 in-lb	80	59	180	133
10	89 in-lb	85	63	185	136
11	97 in-lb	90	66	190	140
12	106 in-lb	95	70	195	144
14	124 in-lb	100	74	200	148
15	133 in-lb	105	77	205	151
16	142 in-lb	110	81	210	155
18	159 in-lb	115	85	215	159
20	15 ft-lb	120	89	220	162
25	18	125	92	225	165
30	22	130	96	230	170
35	26	135	100	235	173
40	30	140	103	240	177
45	33	145	107	245	180
50	37	150	111	250	184

NOTE: To convert from Newton-Meters to Kilogram-Meters divide Newton-Meters by 9.803.

Pipe Plug Torque Values

Torque Table

Thread	Actual Thread O.D.	Torque		Torque	
		In Aluminum Components	In Cast Iron or Steel Components	N·m	ft-lb
in	in	N·m	ft-lb	N·m	ft-lb
1/16	0.32	5	45 in-lb	15	10
1/8	0.41	15	10	20	15
1/4	0.54	20	15	25	20
3/8	0.68	25	20	35	25
1/2	0.85	35	25	55	40
3/4	1.05	45	35	75	55
1	1.32	60	45	95	70
1-1/4	1.66	75	55	115	85
1-1/2	1.90	85	65	135	100

Tap-Drill Chart - U.S. Customary and Metric

General Information

NOTE ON SELECTING TAP-DRILL SIZES: The tap drill sizes shown on this card give the theoretical tap drill size for approximately 60% and 75% of full thread depth. Generally, it is recommended that drill sizes be selected in the 60% range as these sizes will provide about 90% of the potential holding power. Drill sizes in the 75% range are recommended for shallow hole tapping (less than 1 1/2 times the hole diameter) in soft metals and mild steel.

Tap Size		Drill Size									
60%	75%		60%	75%		60%	75%		60%	75%	
		48			4.40mm			7.50mm			13.25mm
		1.95mm			16			19/64			5/8-11
		5/64			4.50mm			7.60mm			17/32
		47			15			7.70mm			13.50mm
		2.00mm			4.60mm			7.75mm			13.75mm
		2.05mm			14			7.80mm			35/64
		46			13			7.90mm			M15x1.5
		3-48			4.70mm			8.00mm			M16x2
		M2.5x.45			4.75mm			O			14.00mm
		2.05mm			3/16			8.10mm			14.25mm
		46			12			8.20mm			9/16
		3-48			4.80mm			P			M16x2
		M2.5x.45			11			8.25mm			14.50mm
		M2.6x.45			4.90mm			8.30mm			37/64
		3-56			10			8.40mm			14.75mm
		4-36			9			Q			15.00mm
		2.20mm			8			8.50mm			19.32
		M2.6x.45			5.10mm			8.60mm			15.25mm
		2.25mm			7			R			39/64
		4-36			13/64			8.70mm			M17x1.5
		4-40			6			11/32			M18x2.5
		4-48			5.20mm			8.75mm			5/8
		42			5			8.80mm			16.00mm
		3/32			5.25mm			S			16.25mm
		M3x.6			6.30mm			8.90mm			41/64
		4-48			4			9.00mm			21/32
		41			5.40mm			T			16.50mm
		2.45mm			3			9.10mm			16.75mm
		40			5.50mm			23/64			43/64
		M3x.6			7/64			9.20mm			17.25mm
		M3x.5			35			9.30mm			21/32
		5-40			5.60mm			U			18.00mm
		36			2			9.40mm			18.25mm
		2.75mm			5.70mm			V			23/32
		5-44			5.75mm			9.50mm			M20x1.5
		37			7/64			3/8			18.50mm
		5-44			2.80mm			9.60mm			47/64
		6-32			34			9.70mm			18.75mm
		6-40			5.75mm			9.75mm			19.00mm
		M3.5x6			32			9.80mm			3/4
		6-40			3.00mm			W			19.25mm
					31			9.90mm			49/64
					3.10mm			25/64			25/32
					1/8			10.00mm			19.50mm
					3.20mm			X			25/32
					M4x.75			10.20mm			19.75mm
					3.25mm			Y			51/64
					30			Z			20.00mm
					3.30mm			13/32			53/64
					M4x.75			21/64			21/25mm
					3.40mm			27/64			27/32
					29			10.50mm			21.50mm
					3.50mm			12/13			21.75mm
					28			10.75mm			55/64
					9/64			11.00mm			M22x2.5
					3.60mm			7/16			22.00mm
					27			11.25mm			7/8
					3.70mm			11.50mm			22.25mm
					26			29/64			57/64
					M4.5x.75			11.75mm			22.50mm
					3.75mm			11.50mm			22.75mm
					10-24			11.50mm			23.00mm
					25			11.75mm			23.25mm
					3.80mm			12.00mm			23.50mm
					24			12.25mm			23.75mm
					3.90mm			12.50mm			59/64
					23			12.75mm			15/16
					5/32			13.00mm			17/32
					22			33/64			29/32
					M5x1						1-14
					4.00mm						1-12
					21						1-10
					20						1-8
					M5x.9						1-6
					4.10mm						1-4
					M5x.8						1-2
					4.20mm						1-1
					19						1-1/2
					4.25mm						1-3/4
					M5x.9						1-5/8
					4.30mm						1-11/16
					18						1-13/16
					11/64						1-15/16
					17						1-17/16

Weights and Measures - Conversion Factors

Conversion Chart

Quantity	U.S. Customary		Metric		From U.S. Customary To Metric Multiply By	From Metric To U.S. Customary Multiply By
	Unit Name	Abbreviation	Unit Name	Abbreviation		
Area	sq. inch	in ²	sq. millimeters	mm ²	645.16	0.001550
			sq. centimeters	cm ²	6.452	0.155
	sq. foot	ft ²	sq. meter	m ²	0.0929	10.764
Fuel Consumption	pounds per horsepower hour	lb/hp-hr	grams per kilowatt hour	g/kW-hr	608.277	0.001645
Fuel Performance	miles per gallon	mpg	kilometers per liter	km/l	0.4251	2.352
	gallons per mile	gpm	liters per kilometer	l/km	2.352	0.4251
Force	pounds force	lbf	Newton	N	4.4482	0.224809
Length	inch	in	millimeters	mm	25.40	0.039370
	foot	ft	millimeters	mm	304.801	0.00328
Power	horsepower	hp	kilowatt	kW	0.746	1.341
Pressure	pounds force per sq. inch	psi	kilopascal	kPa	6.8948	0.145037
	inches of mercury	in Hg	kilopascal	kPa	3.3769	0.29613
	inches of water	in H ₂ O	kilopascal	kPa	0.2488	4.019299
	inches of mercury	in Hg	millimeters of mercury	mm Hg	25.40	0.039370
	inches of water	in H ₂ O	millimeters of water	mm H ₂ O	25.40	0.039370
	bars	bars	kilopascals	kPa	100.001	0.00999
	bars	bars	millimeters of mercury	mm Hg	750.06	0.001333
Temperature	fahrenheit	°F	centigrade	°C	(°F-32) ÷ 1.8	(1.8 x °C) + 32
Torque	pound force per foot	ft-lb	Newton-meter	N·m	1.35582	0.737562
	pound force per inch	in-lb	Newton-meter	N·m	0.113	8.850756
Velocity	miles/hour	mph	kilometers/hour	kph	1.6093	0.6214
Volume: liquid displacement	gallon (U.S.)	gal.	liter	l	3.7853	0.264179
	gallon (Imp*)	gal.	liter	l	4.546	0.219976
	cubic inch	in ³	liter	l	0.01639	61.02545
	cubic inch	in ³	cubic centimeter	cm ³	16.387	0.06102
Weight (mass)	pounds (avoird.)	lb	kilograms	kg	0.4536	2.204623
Work	British Thermal Unit	BTU	joules	J	1054.5	0.000948
	British Thermal Unit	BTU	kilowatt-hour	kW-hr	0.000293	3414
	horsepower hours	hp-hr	kilowatt-hour	kW-hr	0.746	1.341

Section W - Warranty

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This Warranty applies to new Engines sold by Cummins Inc., hereinafter "Cummins", and used in Marine commercial propulsion and marine auxiliary applications anywhere in the world where Cummins approved service is available and delivered to the first user on or after July 1, 2002. This Warranty excludes all Engines branded and sold as Cummins MerCruiser Diesel Products. The "Product" consists of a new Cummins Engine, as well as accessories, which are approved and supplied by Cummins and which are either installed by Cummins or a Cummins authorized distributor. These Products have the following designation:

MARINE COMMERCIAL PROPULSION AND MARINE AUXILIARY (EXCLUDING GENERATOR DRIVE ENGINES)

Intermittent Rating

This power rating is intended for intermittent use in variable load applications where full power is limited to two hours out of every eight hours of operation. Also, reduced power operations must be at or below 200 RPM of the maximum rated RPM. This rating is an ISO3046 Fuel Stop Power Rating and is for applications that operate less than 1,500 hours per year.

Medium Continuous Rating

This power rating is intended for continuous use in variable load applications where full power is limited to six hours out of every twelve hours of operation. Also, reduced power operations must be at or below 200 RPM of the maximum rated RPM. This rating is an ISO3046 Fuel Stop Power Rating and is for applications that operate less than 3,000 hours per year.

Heavy Duty Rating

This power rating is intended for continuous use in variable load applications where full power is limited to eight hours out of every ten hours of operation. Also, reduced power must be at least 200 RPM below the maximum rated RPM. This rating is an ISO3046 Fuel Stop Power Rating and is for applications that operate less than 5,000 hours per year.

Continuous Rating

This power rating is intended for continuous use in applications requiring uninterrupted service at full power. This rating is an ISO3046 Standard Power Rating.

MARINE GENERATOR DRIVE

Prime Power

Engines with this rating are available for an unlimited number of hours per year in variable load applications. Variable load is not to exceed a 70 percent average of the Prime Power rating during any operating period of 250 hours. Total operating time at 100 percent Prime Power shall not exceed 500 hours per year.

A 10 percent overload capability is available for a period of one hour within a twelve hour period of operation. Total operating time at the 10 percent overload power shall not exceed 25 hours per year. This power rating conforms to ISO 8528 guidelines.

Continuous Power

Engines with this rating are available for supplying utility power at a constant 100 percent load for an unlimited number of hours per year. No overload capability is available for this rating.

Continuous Power ratings differ from Prime Power ratings in that the Continuous Load ratings are significantly reduced from the Prime Power ratings. Continuous Load ratings have no load factor or application restrictions. This power rating conforms to ISO 8528 guidelines.

This Warranty covers any failures of the Product, under normal use and service, which result from a defect in Cummins material or factory workmanship (Warrantable Failure). Coverage begins with the sale of the Engine by Cummins and ends at the time and hours stated in the following table. The Duration commences on either the date of delivery of the Product to the first end-user, or the date the unit is first leased, rented or loaned, or when the Product has been operated for 50 hours, whichever occurs first.

Duration

Whichever Occurs First

Rating	Years	Hours
Intermittent	1	1,500
Medium Continuous	1	3,000
Heavy Duty	1	5,000
Continuous	1	Unlimited
Prime Power	1	Unlimited
Continuous Power	1	Unlimited

The Extended Major Components Warranty applies to Engines other than B and C Series. It covers Warrantable Failures of the Engine cylinder block, camshaft, crankshaft and connecting rods (Covered Parts). Bushing and bearing failures are not covered. This Coverage begins with the expiration of the Base Engine Warranty and ends at three years or 10,800 hours of operation, whichever occurs first, after the date of delivery to the first end-user, or the date the unit is first leased, rented or loaned, or when the Product has been operated for 50 hours, whichever occurs first.

These Warranties are made to all Owners in the chain of distribution and Coverage continues to all subsequent Owners until the end of the periods of Coverage.

Cummins will pay for all parts and labor needed to repair the damage to the Product resulting from a Warrantable Failure when performed during normal business hours. All labor costs will be paid in accordance with Cummins published Standard Repair Time guidelines to the Cummins authorized repair location.

When it is necessary for mechanics to make on-site Warranty repairs, Cummins will pay reasonable travel expenses, including meals, mileage and lodging, for mechanics to travel to and from the repair dock.

Cummins will pay for the lubricating oil, antifreeze, filter elements and other maintenance items that are not reusable due to the Warrantable Failure.

Cummins will pay for reasonable labor costs for Engine removal and reinstallation when necessary to repair a Warrantable Failure.

Cummins will pay for the repair or, at its option, replacement of the defective Covered Part and any Covered Part damaged by a Warrantable Failure of the defective Covered Part.

Owner is responsible for the cost of lubricating oil, antifreeze, filter elements and other maintenance items replaced during Warranty repairs unless such items are not reusable due to the Warrantable Failure.

Owner is responsible for the cost of all labor needed to repair the Engine, including the labor cost for Engine removal and reinstallation. When Cummins elects to repair a part instead of replacing it, the Owner is not responsible for the labor needed to repair the part.

Owner is responsible for the cost of all parts required for the repair except for the defective Covered Part and any Covered Part damaged by a Warrantable Failure of the defective Covered Part.

Owner is responsible for the cost of lubricating oil, antifreeze, filter elements and other maintenance items replaced during repair of a Warrantable Failure.

Owner is responsible for the operation and maintenance of the Product as specified in the applicable Cummins Operation and Maintenance Manual. Owner is also responsible for providing proof that all recommended maintenance has been performed.

Before the expiration of the applicable Warranty, Owner must notify a Cummins distributor, authorized dealer, or other repair location approved by Cummins of any Warrantable Failure and make the Engine available for repair by such facility. Locations in the United States and Canada are listed in the Cummins U.S. and Canada Sales and Service Directory; other locations are listed in the Cummins International Sales and Service Directory.

In the event of any Product failure, Owner is responsible for the cost of towing the boat to the repair dock and for all associated docking and harbor charges.

Owner is responsible for communication expenses, meals, lodging and similar costs incurred as a result of a Warrantable Failure.

Owner is responsible for maintaining the Engine hourmeter in good working order at all times and to ensure that the hourmeter accurately reflects the total hours of operation of the Product.

Owner is responsible for the costs to investigate complaints, unless the problem is caused by a defect in Cummins material or factory workmanship.

Owner is responsible for non-Engine repairs, "downtime" expenses, cargo damage, fines, all applicable taxes, all business costs and other losses resulting from a Warrantable Failure.

Cummins is not responsible for failures or damage resulting from what Cummins determines to be abuse or neglect, including, but not limited to: operation without adequate coolants or lubricants; overfueling; overspeeding; lack of maintenance of cooling, lubricating or intake systems; improper storage, starting, warm-up, run-in or shutdown practices; unauthorized modifications to the Engine. Cummins is also not responsible for failures caused by incorrect oil or fuel, or by water, dirt or other contaminants in the fuel or oil.

Cummins is not responsible for failures resulting from:

- 1 Use or application of the Product inconsistent with its rating designation set forth above.
- 2 Incorrect installation.

Before a claim for excessive oil consumption will be considered, Owner must submit adequate documentation to show that oil consumption exceeds Cummins published standards.

Cummins is not responsible for failures of marine maintenance components supplied by Cummins beyond ninety days after the Coverage start date. Marine maintenance components include, but are not limited to: zinc plugs, oil filters, fuel filters, air filters, water filters, fuel/water separator filters, expansion tank pressure caps.

Failure of belts and non-shielded hoses supplied by Cummins are not covered beyond 90 days after the date of delivery of the Product to the first user, or the date the unit is first leased, rented or loaned, or when the Product has been operated for 50 hours, whichever occurs first.

Non-Cummins accessories are covered for the duration of the base Engine Warranty when supplied by Cummins as part of a Marine Propulsion package unit. Otherwise, non-Cummins accessories are not covered.

Parts used in Warranty repairs may be new Cummins parts, Cummins approved rebuilt parts, or repaired parts. Cummins is not responsible for failures resulting from the use of parts not supplied by Cummins.

Parts used to repair a Warrantable Failure may be new Cummins parts, Cummins approved rebuilt parts, or repaired parts. Cummins is not responsible for failures resulting from the use of parts not approved by Cummins.

A new Cummins or Cummins approved rebuilt part used to replace a Warranted Part assumes the identity of the Warranted Part it replaced and is entitled to the remaining Coverage hereunder.

Cummins Inc. reserves the right to interrogate Electronic Control Module (ECM) data for purposes of failure analysis.

CUMMINS DOES NOT COVER WEAR OR WEAROUT OF COVERED PARTS.

CUMMINS IS NOT RESPONSIBLE FOR INCIDENTAL OR CONSEQUENTIAL DAMAGES.

THIS WARRANTY AND THE EMISSION WARRANTY SET FORTH HEREIN ARE THE SOLE WARRANTIES MADE BY CUMMINS IN REGARD TO THESE ENGINES. CUMMINS MAKES NO OTHER WARRANTIES, EXPRESS OR IMPLIED, OR OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE.

In the United States** and Canada, this Warranty gives you specific legal rights, and you may also have other rights which vary from state to state.

Outside the United States** and Canada, in case of consumer sales, in some countries the Owner has statutory rights which cannot be affected or limited by the terms of this Warranty.

Nothing in this Warranty excludes or restricts any contractual rights the Owner may have against third parties.

This Emission Warranty applies to new Engines certified to United States EPA 40 CFR 94 sold by Cummins that are installed on vessels flagged or registered in the United States**.

Cummins warrants to the first user and each subsequent purchaser that the Engine is designed, built and equipped so as to conform at the time of sale by Cummins with all United States Federal emission regulations applicable at the time of manufacture and that it is free from defects in material or factory workmanship which would cause it not to meet these regulations within the longer of the following periods: (A) Five years or 5,000 hours of operation, whichever occurs first, as measured from the date of delivery of the Engine to the first user, or the date the unit is first leased, rented or loaned, or when the Engine has been operated for 50 hours, whichever occurs first, or (B) The Base Engine Warranty.

An Owner may elect to have maintenance, replacement or repair of the emission control parts performed by a facility other than a Cummins distributor, an authorized dealer or a repair location approved by Cummins, and may elect to use parts other than new genuine Cummins or Cummins approved rebuilt parts and assemblies for such maintenance, replacement or repair; however, the cost of such service or parts and subsequent failures resulting from such service or parts will not be covered under this emission control system Warranty.

Failures, other than those resulting from defects in materials or factory workmanship, are not covered by this Warranty.

Cummins is not responsible for failures or damage resulting from what Cummins determines to be abuse or neglect, including, but not limited to: operation without adequate coolants or lubricants; overfueling; overspeeding; lack of maintenance of lubricating, cooling or intake systems; improper storage, starting, warm-up, run-in or shutdown practices; unauthorized modifications of the Engine. Cummins is also not responsible for failures caused by incorrect oil or fuel or by water, dirt or other contaminants in the fuel or oil.

Cummins is not responsible for non-Engine repairs, "downtime" expenses, cargo damage, fines, all applicable taxes, all business costs or other losses resulting from a Warrantable Failure.

CUMMINS IS NOT RESPONSIBLE FOR INCIDENTAL OR CONSEQUENTIAL DAMAGES.

** United States includes American Samoa, the Commonwealth of Northern Mariana Islands, Guam, Puerto Rico, and the U.S. Virgin Islands.

CMD Diamond Recreational Marine Propulsion Coverage

Products Warranted Cummins MerCruiser Diesel

This warranty applies to new Cummins Engines sold by Cummins MerCruiser Diesel., herein after "CMD" that are used in Marine propulsion applications anywhere in the world where Cummins approved service is available* and delivered to the first user on or after September 1, 1998. The 'Product' consists of a new Cummins Engine, as well as accessories as listed below, which are approved and supplied by CMD and which are either installed by CMD or a CMD authorized distributor. These Products have the following designation:

High Output Rating

This power rating is for use in variable load applications where full power is limited to 1 hour out of every 8 hours of operation. Reduced power operation must be at or below cruise speed (rpm). Cruise speed (rpm) is dependent on the engine rated speed (rpm):

Rated Speed (rpm)	Cruise Speed (Reduction from rated speed, rpm)
Less than 2800 rpm	200 rpm
2801 to 3500 rpm	300 rpm
3501 to 4500 rpm	400 rpm
4501 to 5000 rpm	500 rpm

This rating is an ISO3046 Fuel Stop Power Rating and is for pleasure/non-revenue generating applications that operate less than 300 hours per year.

Base Engine Warranty

This warranty covers any failures of the Product, under normal use and service, which result from a defect in Cummins material or factory workmanship (Warrantable Failure). Coverage begins with the sale of the Engine by CMD and continues for the Duration stated below. The Duration commences on either the date of delivery of the Product to the first user, or the date the unit is first leased, rented or loaned, or when the Product has been operated for 50 hours, whichever occurs first.

Extended Major Components Warranty

The Extended Major Components Warranty covers Warrantable Failures of the following Engine parts of castings (Covered Parts):

- Engine Cylinder Block Casting
- Engine Cylinder Head Casting
- Engine Camshaft Forging
- Engine Crankshaft Forging
- Engine Connecting Rods
- Engine Gear Train Gears
- Crankshaft Gear
- Camshaft Gear
- Camshaft Idler Gear
- Accessory Drive Gear
- Fuel Pump Gear
- Engine Gear Cover & Housing
- Flywheel Housing

Bushing and Bearing failures are not covered.

Extended Major Components Warranty continues beyond the expiration of the Base Engine Warranty and continues for the Duration stated below. The Duration commences on either the date of delivery of the Product to the first user, or the date the unit is first leased, rented or loaned, or when the Product has been operated for 50 hours, whichever occurs first.

Consumer Products

The warranty on Consumer Products in the United States is a limited warranty. **CMD IS NOT RESPONSIBLE FOR INCIDENTAL OR CONSEQUENTIAL DAMAGES.** Any implied warranties applicable to Consumer Products terminate concurrently with the expiration of the express warranties applicable to the Product. In the United States, some states do not allow the exclusion of incidental or consequential damages, or limitations on how long an implied warranty lasts, so the limitations or exclusions herein may not apply to you.

These warranties are made to all Owners in the chain of distribution and Coverage continues to all subsequent Owners until the end of the periods of Coverage.

Warranty Coverage						
	Coverage Duration*		Repair Charge Paid By Cummins			
Coverage Category	Months	Hours B,C	Parts	Labor	Removal & Installation Labor	Travel
Base Engine Warranty**	24	600	Yes	Yes	Yes	Yes - Up to 6 hours
Extended Major Components	72	1800	Yes***	Yes	Yes	No

* Whichever occurs first.
 ** Other accessories, ie. Marine Gear and Drive Plate, Instruments, Instrument Panel, Gage Senders, Vibration Isolators, and Fuel/Water Separator are covered for a period of twelve months or 300 hours whichever occurs first.
 *** Covered Parts as listed above.

CMD Responsibilities

During Base Engine Warranty

CMD will pay for all parts and labor needed to repair the damage to the product resulting from a Warrantable Failure when performed during normal business hours. All labor costs will be paid in accordance with Cummins published Standard Repair Time guidelines.

When it is necessary for mechanics to make on-site warranty repairs, CMD will pay up to 6 hours total travel expenses, including meals, mileage and lodging, for mechanics to travel to and from the repair dock.

CMD will pay for the lubricating oil, antifreeze, filter elements, and other maintenance items that are not reusable due to the Warrantable Failure.

CMD will pay for reasonable labor costs for Engine removal and reinstallation when necessary to repair a Warrantable Failure.

During the Extended Major Components Warranty

CMD will pay for the repair or, at its option, replacement of the defective Covered Part and any Covered Part damaged by a Warrantable Failure of the defective Covered Part.

Owner Responsibilities

During the Extended Major Components Warranty

Owner is responsible for the cost of all parts required for the repair except for the defective Covered Part and any Covered Part damaged by a Warrantable Failure of the defective Covered Part.

During the Base Engine and Extended Major Components Warranties

Owner is responsible for the cost of lubricating oil, antifreeze, filter elements, and other maintenance items replaced during warranty repairs unless such items are not reusable due to the Warrantable Failure.

Owner is responsible for the operation and maintenance of the Product as specified in the applicable CMD Operation and Maintenance Manual. Owner is also responsible for providing proof that all recommended maintenance has been performed.

Before the expiration of the applicable warranty, Owner must notify a Cummins distributor, authorized dealer, or other repair location approved by CMD of any Warrantable Failure and make the Product available for repair by such facility.

In the event of any Product failure, Owner is responsible for the cost of towing the boat to the repair dock and for all associated docking and harbor charges.

Owner is responsible for communication expenses, meals, lodging, and similar costs incurred as a result of a Warrantable Failure.

Owner is responsible for maintaining the Engine hourmeter in good working order at all times and to ensure that the hourmeter accurately reflects the total hours of operation of the Product.

Owner is responsible for the costs to investigate complaints, unless the problem is caused by a defect in Cummins material or factory workmanship.

Owner is responsible for non-Engine repairs, "downtime" expenses, cargo damage, fines, all applicable taxes, all business costs, and other losses resulting from a Warrantable Failure.

Limitations

CMD is not responsible for failures or damage resulting from what CMD determines to be abuse or neglect, including, but not limited to: operation without adequate coolants or lubricants; overfueling; overspeeding; lack of maintenance of cooling, lubricating or intake systems; improper storage, starting, warm-up, run-in or shutdown practices; unauthorized modifications to the Engine. CMD is also not responsible for failures caused by incorrect oil or fuel or by water, dirt or other contaminants in the fuel or oil.

CMD is not responsible for failure resulting from:

1. Use or application of the Product inconsistent with its rating designation set forth above.
2. Incorrect installation.

Before a claim for excessive oil consumption will be considered, Owner must submit adequate documentation to show that oil consumption exceeds CMD published standards.

CMD is not responsible for failures of maintenance components supplied by Cummins beyond 90 days after the coverage duration start date. Maintenance components include, but are not limited to: sea water pump impellers; zinc plugs; oil filters; fuel filters; air filters; water filters; fuel/water separator filters; expansion tank pressure caps.

Failure of belts and hoses supplied by Cummins are not covered beyond 90 days after warranty start date.

Except for the accessories noted previously, Cummins does not warrant accessories which bear the name of another company.

Parts used in warranty repairs may be new Cummins parts, Cummins approved rebuilt parts, or repaired parts. CMD is not responsible for failures resulting from the use of parts not supplied by Cummins.

A new Cummins or Cummins approved rebuilt part used to replace a Warranted Part assumes the identity of the Warranted Part it replaced and is entitled to the remaining coverage hereunder.

CUMMINS DOES NOT COVER WEAR OR WEAROUT OF COVERED PARTS.

CUMMINS IS NOT RESPONSIBLE FOR INCIDENTAL OR CONSEQUENTIAL DAMAGES.

THESE WARRANTIES SET FORTH HEREIN ARE THE SOLE WARRANTIES MADE BY CUMMINS IN REGARD TO THESE ENGINES. CUMMINS MAKES NO OTHER WARRANTIES, EXPRESS OR IMPLIED, OR OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE.

In the United States ** and Canada, this warranty gives you specific legal rights, and you may also have other rights which vary from state to state.

Outside the United States ** and Canada, in case of consumer sales, in some countries the Owner has statutory rights which cannot be affected or limited by the terms of this warranty.

Nothing in this warranty excludes or restricts any contractual rights the Owner may have against third parties.

* Locations in the United States and Canada are listed in the Cummins United States and Canada Sales and Service Directory; other locations are listed in the Cummins International Sales and Service Directory.

** United States includes American Samoa, the Commonwealth of Northern Mariana Islands, Guam, Puerto Rico, and the U.S. Virgin Islands.

Marine Propulsion: QSB5.9/QSB6.7/QSC8.3/QLS9/QSM11/SDI/TDI.

This Warranty applies to new Product sold by Cummins MerCruiser Diesel, herein after "CMD", that is branded as Cummins MerCruiser Diesel product and used in Recreational Marine Propulsion applications anywhere in the world where CMD approved service is available* and delivered to the first user on or after May 1, 2011.

This Warranty covers any failures of the Product, under normal use and service, which results from a defect in CMD material or workmanship (Warrantable Failure). The (Product) includes the Engine, controls and other components other than pods or sterndrives as delivered from the CMD factory and accessories with a CMD part number that are added by a CMD approved distributor or OEM. Pods and sterndrives are covered under a separate CMD Warranty.

These Products have the following designation.

The HO rating applies to variable load applications where annual use is less than 500 hours per year and full power is limited to one (1) hour out of every eight (8) hours of operation. Reduced power operation must be at or below cruise speed as defined in the following table.

Rated Speed (rpm)	Cruise Speed (Reduction from rated speed, rpm)
Less than 2,800 rpm	200 rpm
2,801 to 3,500 rpm	300 rpm
3,501 to 4,500 rpm	400 rpm

Use of an Engine with this HO rating in commercial applications will void the Warranty. Specifically, a vessel of less than 100 gross tons carrying more than 6 paying passengers will not be considered a recreational vessel.

This Warranty covers any failures of the Product, under normal use and service, which result from a defect in CMD material or factory workmanship (Warrantable Failure).

This limited Warranty covers the Engine from the date of shipping from the CMD factory to the end of the Coverage duration. The end of the Coverage duration is calculated based on an in-service date. The Base Coverage duration ends two (2) years after the in-service date or 1,000 hours of total operation, whichever occurs first. The in-service date is defined as 1) the date of the initial delivery of the Product to the first end user (through purchase, lease, or loan), or 2) the date when 125 hours of operation for Quantum Series Engines (QSB5.9/QSB6.7/QSC8.3/QLS9/QSM11) or 50 hours for SDI/TDI Engines is accumulated.

The Extended Major Components Warranty covers Warrantable Failures of the following Engine parts or castings (Covered Parts):

Engine Cylinder Block and Head Casting

Engine Camshaft and Crankshaft Forging

Engine Connecting Rod Forging

Engine Gear Train Gears:

- Crankshaft Gear
- Camshaft and Camshaft Idler Gear
- Accessory Drive Gear
- Fuel Pump Gear

Engine Gear Cover Casting

Flywheel Housing Casting

Bushing and bearing failures are NOT covered.

This limited Warranty covers the Engine from the date of shipping from the CMD factory to the end of the Coverage duration. The end of the Coverage duration is calculated based on an in-service date. The Extended Major Components Coverage duration ends six (6) years after the in-service date or 3,000 hours of total operation, whichever occurs first. The in-service date is defined as either 1) the date of the initial delivery of the Product to the first end-user (through purchase, lease or loan), or 2) the date when 125 hours of operation for Quantum Series Engines (QSB5.9/QSB6.7/QSC8.3/QLS9/QSM11) and 50 hours for SDI/TDI Engines is accumulated.

The Warranty on Consumer Products in the United States is a limited Warranty. **CMD IS NOT RESPONSIBLE FOR INCIDENTAL OR CONSEQUENTIAL DAMAGES.** Any implied Warranties applicable to Consumer Products terminate concurrently with the expiration of the express Warranties applicable to the Product. In the United States, some states do not allow the exclusion of incidental or consequential damages, or limitations on how long an implied

Warranty lasts, so the limitations or exclusions herein may not apply to you. These Warranties are made to all Owners in the chain of distribution and Coverage continues to all subsequent Owners until the end of the periods of Coverage.

CMD will pay for all parts and labor needed to repair the damage to the Product resulting from a Warrantable Failure when performed during normal business hours. All labor costs will be paid in accordance with Cummins published Standard Repair Time guidelines. When it is necessary for mechanics to make on-site Warranty repairs, CMD will pay reasonable travel expenses, including meals, mileage and lodging, for mechanics to travel to and from the repair dock. Labor must be performed by an authorized CMD Repair Facility.

CMD will pay for the lubricating oil, antifreeze, filter elements, and other maintenance items that are not reusable due to the Warrantable Failure. CMD will pay for reasonable labor costs for Engine removal and reinstallation when necessary to repair a Warrantable Failure.

CMD will pay for parts and labor and travel for the defective Covered Part and any Covered Part damaged by a Warrantable Failure of the defective Covered Part.

Owner is responsible for the cost of lubricating oil, antifreeze, filter elements, and other maintenance items replaced during Warranty repairs unless such items are not reusable due to the Warrantable Failure.

Owner is responsible for the operation and maintenance of the Product as specified in the applicable Cummins or CMD Operation and Maintenance Manual. Owner is also responsible for providing proof that all recommended maintenance has been performed. Exceeding the operational parameters of the HO rating will void this Warranty. The Owner of the boat is ultimately responsible for ensuring the Engine is properly operated and maintained. The Warranty will be void on any Engines that are misapplied, not maintained properly or misused.

Before the expiration of the applicable Warranty, Owner must notify a CMD distributor, authorized dealer or other repair location approved by CMD of any Warrantable Failure and make the Engine available for repair by such facility. Locations in the United States and Canada are listed in the Cummins U.S. and Canada Sales and Service Directory; other locations are listed in the Cummins International Sales and Service Directory. In the event of any Product failure, Owner is responsible for the cost of towing the boat to the repair dock and for all associated docking and harbor charges.

Owner is responsible for communication expenses, meals, lodging and similar costs incurred as a result of a Warrantable Failure. Owner is responsible for maintaining the Engine hourmeter in good working order at all times and ensuring that the hourmeter accurately reflects the total hours of operation of the Product.

Owner is responsible for the costs to investigate complaints, unless the problem is caused by a defect in CMD material or factory workmanship. Owner is responsible for non-Engine repairs, "downtime" expenses, cargo damage, fines, all applicable taxes, all business costs, and other losses resulting from a Warrantable Failure.

Owner is responsible for the cost of all other parts and labor used for the repair except for the defective Covered Part and any Covered Part damaged by a Warrantable Failure of the defective Covered Part.

CMD is not responsible for failures or damage resulting from what CMD determines to be abuse or neglect, including, but not limited to: operation without adequate coolants or lubricants; overfueling; overspeeding; lack of maintenance of cooling, lubricating or intake systems; improper storage, starting, warm-up, run-in or shutdown practices; unauthorized modifications to the Engine; improper propping that does not allow the Engine to run at its maximum rated speed; submersion, freezing temperatures, improper service, removal of parts, or running the Engine out of water; water ingestion, unless caused by a Warrantable Failure. CMD is also not responsible for failures caused by incorrect oil or fuel, or by water, dirt or other contaminants in the fuel or oil. CMD is not responsible for failure resulting from:

- 1 Use or application of the Product inconsistent with its rating designation and Engine duty cycle set forth above.
- 2 Incorrect installation.
- 3 Engines that do not reach rated rpm because of vessel overloading.

Before a claim for excessive oil consumption will be considered, Owner must submit adequate documentation to show that oil consumption exceeds CMD published standards. CMD does not warrant accessories that are not supplied by a Cummins factory.

CMD is not responsible for failures of maintenance components supplied by Cummins beyond 90 days after the Coverage duration start date. Maintenance components include, but are not limited to: sea water pump impellers; zinc plugs; oil filters; fuel filters; air filters; water filters; and fuel/water separator filters.

Except for the accessories noted previously, CMD does not warrant accessories which bear the name of another company.

Parts used in Warranty repairs may be new Cummins parts, CMD approved rebuilt parts or repaired parts. CMD is not responsible for failures resulting from the use of parts not supplied by Cummins. A new Cummins or Cummins

approved rebuilt part used to replace a Warranted Part assumes the identity of the Warranted Part it replaced and is entitled to the remaining Coverage hereunder.

CMD DOES NOT COVER WEAR OR WEAROUT OF COVERED PARTS. CMD IS NOT RESPONSIBLE FOR INCIDENTAL OR CONSEQUENTIAL DAMAGES.

THESE WARRANTIES SET FORTH HEREIN ARE THE SOLE WARRANTIES MADE BY CMD IN REGARD TO THESE ENGINES. CMD MAKES NO OTHER WARRANTIES, EXPRESS OR IMPLIED, OR OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE.

In the United States** and Canada, this Warranty gives you specific legal rights, and you may also have other rights which vary from state to state.

Outside the United States** and Canada, in the case of consumer sales, in some countries the Owner has statutory rights which cannot be affected or limited by the terms of this Warranty. Nothing in this Warranty excludes or restricts any contractual rights the Owner may have against third parties.

This Emission Warranty applies to new Engines certified to United States EPA 40 CFR 94 sold by CMD that are installed in vessels flagged or registered in the United States**.

CMD warrants to the first user and each subsequent purchaser that the Engine is designed, built and equipped so as to conform at the time of sale by CMD with all U.S. Federal emission regulations applicable at the time of manufacture and that it is free from defects in workmanship or material which would cause it not to meet these regulations within the longer of the following periods:

- 1 The Emission Warranty commences on the date of delivery of the Product to the first user, or the date the unit is first leased, rented or loaned, and ends when the Product has accumulated five years or 1,000 hours of operation, whichever occurs first, or
- 2 The Base Engine Warranty.

The Owner may elect to have maintenance, replacement or repair of the emission control parts performed by a facility other than a Cummins distributor, an authorized dealer or a repair location approved by Cummins, and may elect to use parts other than new genuine Cummins or Cummins approved rebuilt parts and assemblies for such maintenance, replacement or repair; however, the cost of such service or parts and subsequent failures resulting from such service or parts will not be covered under this Emission Control System Warranty.

Failures, except those resulting from a defect in materials or factory workmanship, are not covered by the Warranty.

CMD IS NOT RESPONSIBLE FOR INCIDENTAL OR CONSEQUENTIAL DAMAGES.

In the United States** and Canada, this Warranty gives you specific legal rights, and you may also have other rights which vary from state to state. Outside the United States** and Canada, in the case of consumer sales, in some countries the Owner has statutory rights which cannot be affected or limited by the terms of this Warranty. Nothing in this Warranty excludes or restricts any contractual rights the Owner may have against third parties.

* Service Locations are listed on www.cmdmarine.com.

** United States includes American Samoa, the Commonwealth of Northern Mariana Islands, Guam, Puerto Rico and the U.S. Virgin Islands.

Marine Propulsion

QSB5.9/QSB6.7/QSC8.3/QSL9/QSM11/SDI/TDI

This Warranty applies to new Product sold by Cummins MerCruiser Diesel, herein after "CMD", that is branded as Cummins MerCruiser Diesel product and used in Commercial and Government Marine Propulsion applications anywhere in the world as permitted by US ITAR and Export Compliance regulations where CMD approved service is available* and delivered to the first user on or after May 1, 2011.

This Warranty covers any failures of the Product, under normal use and service, which results from a defect in CMD material or workmanship (Warrantable Failure). The (Product) includes the Engine, controls and other components other than pods or sterndrives as delivered from the CMD factory and accessories with a CMD part number that are added by a CMD approved distributor or OEM. Pods and sterndrives are covered under a separate CMD Warranty.

Commercial use is defined as any work or employment related use of the product, or any use of the product which generates income, or any part of the warranty period, even if the product is only occasionally used for such purposes.

Government use is defined as use by Federal, State, and Local agencies in non-revenue producing applications.

Government Service (GS) Rating

Intended for use in variable load applications where full power is limited to one hour out of every eight hours of operation.

Reduced power operation must be at or below cruise speed (rpm). Cruise speed (rpm) is dependent on the engine rated speed (rpm):

Rated Speed (rpm)	Cruise Speed (Reduction from rated speed, rpm)
2,000 to 2,800 rpm	200 rpm below rated
2,801 to 3,500 rpm	300 rpm below rated
3,501 to 4,500 rpm	400 rpm below rated

The Government Service Rating applies to Government use in variable load applications where annual use is less than 500 hours and full power is one (1) out of every eight (8) hours of operation. Reduced power operation must be at or below cruise speed.

The Light Commercial Rating applies to Commercial use in variable load applications where annual use is less than 500 hours and full power is one (1) out of every eight (8) hours of operation. Reduced power operation must be at or below cruise speed.

This power rating is intended for intermittent use in variable load applications where full power is limited to two hours out of every eight hours of operation. Also, reduced power operations must be at or below 200 rpm of the maximum rated rpm. This rating is an ISO3046 Fuel Stop Power Rating and is for applications that operate less than 1,500 hours per year.

This power rating is intended for continuous use in variable load applications where full power is limited to six hours out of every twelve hours of operation. Also, reduced power operations must be at or below 200 rpm of the maximum rated rpm. This rating is an ISO3046 Fuel Stop Power Rating and is for applications that operate less than 3,000 hours per year.

This power rating is intended for continuous use in variable load applications where full power is limited to eight hours out of every ten hours of operation. Also, reduced power must be at least 200 rpm below the maximum rated rpm. This rating is an ISO3046 Fuel Stop Power Rating and is for applications that operate less than 5,000 hours per year.

This power rating is intended for continuous use in applications requiring uninterrupted service at full power. This rating is an ISO3046 Standard Power Rating.

This warranty covers any failures of the Product, under normal use and service, which result from a defect in CMD material or factory workmanship (Warrantable Failure). Coverage begins with the sale of the Engine by CMD and continues for the Duration stated in the following table. The Duration commences on either the date of delivery of the Product to the first end-user, or the date the unit is first leased, rented or loaned, or when the Product has been operated for 50 hours, whichever occurs first. The Base Coverage duration ends two (2) years after the in-service date or allowed hours of total operation, whichever occurs first.

Warranty Coverage Periods				
Rating	QSB, QSC, QSL, SDI, TDI		QSM11	
	Coverage ends at whichever occurs first, months or hours of usage.		Coverage ends at whichever occurs first, months or hours of usage.	
	Months	Hours	Months	Hours
Government Service (GS)	24	1,000	24	1,000
Light Commercial (LC)	24	1,000	NA	NA
Intermittent Duty (ID)	24	3,000	24	3,000
Medium Duty (MD)	24	5,000	24	6,000
Heavy Duty (HD)	24	5,500	24	8,000
Continuous Duty (CD)	24	6,500	24	9,000

CMD will pay for all parts and labor needed to repair the damage to the Product resulting from a Warrantable Failure when performed during normal business hours. All labor costs will be paid in accordance with Cummins published Standard Repair Time guidelines.

When it is necessary for mechanics to make on-site warranty repairs CMD will pay reasonable travel expenses, including meals, mileage and lodging, for mechanics to travel to and from the repair dock. Labor must be performed by an authorized CMD Repair Facility.

CMD will pay for the lubricating oil, antifreeze, filter elements, and other maintenance items that are not reusable due to the Warrantable Failure.

CMD will pay for reasonable labor costs for Engine removal and reinstallation when necessary to repair a Warrantable Failure.

Owner is responsible for the operation and maintenance of the Product as specified in the applicable CMD Operation and Maintenance Manual. Owner is also responsible for providing proof that all recommended maintenance has been performed. This warranty does not cover normal wear and tear of covered parts. Exceeding the operational parameters of the rating will void this Warranty. The Owner of the boat is ultimately responsible for ensuring the Engine is properly operated and maintained. The Warranty will be void on any Engines that are misapplied, not maintained properly or misused.

Before the expiration of the applicable warranty, Owner must notify a CMD service provider, distributor, authorized dealer, or other repair location approved by CMD of any Warrantable Failure and make the Engine available for repair by such facility. Locations in the United States and Canada are listed in the Cummins U.S. and Canada Sales and Service Directory; other locations are listed in the CMD International Sales and Service Directory.

Owner is responsible for the cost of lubricating oil, antifreeze, filter elements, and other maintenance items replaced during warranty repairs unless such items are not reusable due to the Warrantable Failure.

Owner is responsible for communication expenses, meals, lodging, and similar costs incurred as a result of a Warrantable Failure.

Owner is responsible for non-Engine repairs, "downtime" expenses, cargo damage, fines, all applicable taxes, all business costs, and other losses resulting from a Warrantable Failure.

In the event of any Product failure, Owner is responsible for the cost of towing the boat to the repair dock and for all associated docking and harbor charges.

Owner is responsible for maintaining the Engine hourmeter in good working order at all times and to ensure that the hourmeter accurately reflects the total hours of operation of the Product.

Owner is responsible for the costs to investigate complaints, unless the problem is caused by a defect in CMD material or factory workmanship.

CMD will replace certain maintenance components if they fail within 90 days or less after the base coverage starts. Maintenance components include but are not limited to: sea water pump impellers, zinc plugs, oil filters, fuel filters, air filters, water filters, fuel/water separator filters, expansion tank pressure caps, belts, hoses.

CMD does not warrant components that are not supplied by CMD factory.

Warranty coverage is limited to 2 years or 2,000 hours, whichever expires first for rating other than Government Service.

Warranty coverage is limited to 2 years or 1,000 hours, whichever expires first for the Government Service rating.

The warranty on Consumer Products in the United States is a limited warranty. **CMD IS NOT RESPONSIBLE FOR INCIDENTAL OR CONSEQUENTIAL DAMAGES.** Any implied warranties applicable to Consumer Products terminate concurrently with the expiration of the express warranties applicable to the Product. In the United States, some states do not allow the exclusion of incidental or consequential damages, or limitations on how long an implied warranty lasts, so the above limitations or exclusions may not apply to you.

CMD is not responsible for failures or damage resulting from what CMD determines to be abuse or neglect, including, but not limited to: operation without adequate coolants or lubricants; overfueling; overspeeding; lack of maintenance of cooling, lubricating or intake systems; improper storage, starting, warm-up, run-in or shutdown practices; unauthorized modifications to the engine; improper propping that does not allow the engine to run at its maximum rated speed; submersion, freezing temperatures, improper service, removal of parts, or running the engine out of water; water ingestion, unless caused by a Warrantable failure. CMD is also not responsible for failures caused by incorrect oil or fuel or by water, dirt or other contaminants in the fuel or oil.

Before a claim for excessive oil consumption will be considered, Owner must submit adequate documentation to show that oil consumption exceeds CMD published standards.

CMD is not responsible for failures of maintenance components supplied by CMD beyond 90 days after the coverage duration start date. Maintenance components include, but are not limited to: sea water pump impellers; zinc plugs; oil filters; fuel filters; air filters; water filters; fuel/water separator filters.

Parts used in warranty repairs may be new CMD parts, CMD approved rebuilt parts, or repaired parts. CMD is not responsible for failures resulting from the use of parts not supplied by CMD.

A new CMD or CMD approved rebuilt part used to replace a Warranted Part assumes the identity of the Warranted Part it replaced and is entitled to the remaining coverage hereunder.

CMD DOES NOT COVER WEAR OR WEAROUT OF COVERED PARTS.

CMD IS NOT RESPONSIBLE FOR INCIDENTAL OR CONSEQUENTIAL DAMAGES.

THESE WARRANTIES SET FORTH HEREIN ARE THE SOLE WARRANTIES MADE BY CMD IN REGARD TO THESE ENGINES. CMD MAKES NO OTHER WARRANTIES, EXPRESS OR IMPLIED, OR OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE.

This Emission Warranty applies to new Engines certified to United States EPA 40 CFR 94 sold by CMD that are installed in vessels flagged or registered in the United States**.

CMD warrants to the first user and each subsequent purchaser that the Engine is designed, built, and equipped so as to conform at the time of sale by CMD with all U.S. Federal emission regulations applicable at the time of manufacture and that it is free from defects in workmanship or material which would cause it not to meet these regulations within the longer of the following periods: (A) Five years or 5,000 hours of operation, whichever occurs first. The Emissions Warranty starts from the date of delivery of the Engine to the first user, or the date the unit is first leased, rented, or loaned, or when the Engine has been operated for 50 hours, whichever occurs first, or (B) The Base Engine Warranty.

The owner may elect to have maintenance, replacement, or repair of the emission control parts performed by a facility other than a CMD distributor, an authorized dealer or a repair location approved by CMD, and may elect to use parts other than new genuine CMD or CMD approved rebuilt parts and assemblies for such maintenance, replacement or repair; however, the cost of such service or parts and subsequent failures resulting from such service or parts will not be covered under this emission control system warranty.

Failures, except those resulting from a defect in materials, or factory workmanship, are not covered by this WARRANTY.

CMD IS NOT RESPONSIBLE FOR INCIDENTAL OR CONSEQUENTIAL DAMAGES.

In the United States** and Canada, this warranty gives you specific legal rights, and you may also have other rights which vary from state to state.

Outside the United States** and Canada, in case of consumer sales, in some countries the Owner has statutory rights which cannot be affected or limited by the terms of this warranty.

Nothing in this warranty excludes or restricts any contractual rights the Owner may have against third parties.

* Locations in the United States and Canada are listed in the Cummins United States and Canada Sales and Service Directory; other locations are listed in the Cummins International Sales and Service Directory.

** United States includes American Samoa, the Commonwealth of Northern Mariana Islands, Guam, Puerto Rico, and the U.S. Virgin Islands.

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CALIFORNIA
Proposition 65 Warning

Diesel engine exhaust and some of its constituents are known to the State of California to cause cancer, birth defects, and other reproductive harm.

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