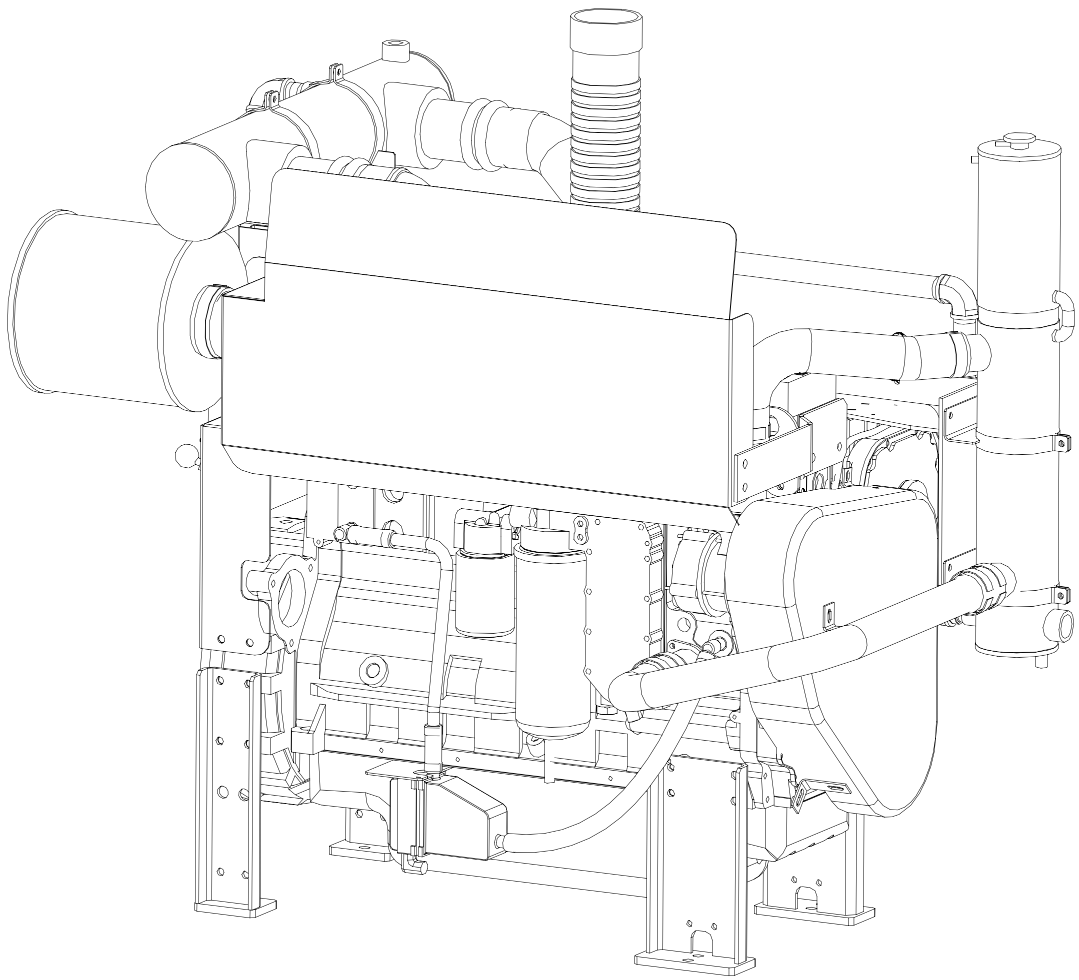
Operation and Maintenance Manual

Fire Pump Drive Engines

CFP8E Series



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FM APPROVED

Drawing No. 9771, Section 0, Rev. A

Foreword

This manual contains information for the correct operation and maintenance of a Cummins Fire Pump engines. It also includes important safety information, engine and systems specifications, troubleshooting guidelines, and listings of Cummins Authorized Repair Locations.

Read and follow all safety instructions. Refer to the General Safety Instructions in Section 1.

Keep this manual with the equipment. If the equipment is traded or sold, give the manual to the new owner.

The information, specifications, and recommended maintenance guidelines in this manual are based on information in effect at the time of printing. Cummins Fire Power, Cummins NPower and Cummins Engine Company, Inc. reserve the right to make changes at any time without obligation. If any differences are found between an engine and the information in this manual, contact the local Cummins Authorized Repair Location.

The latest technology and the highest quality components were used to produce this engine. When replacement parts are needed, we recommend using only genuine Cummins or ReCon® exchange parts. These parts can be identified by the following trademarks:

NOTE: Warranty information is located in Section 16. Make sure you are familiar with the warranty or warranties applicable to your engine.

Index of Sections

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Section 1 – Introduction

Section Contents

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To the Owner and Operator

Preventative maintenance is the easiest and least expensive type of maintenance. Follow the maintenance schedule recommendations outlined in Maintenance Guidelines in Section 4.

Keep records of regularly scheduled maintenance.

Use the correct fuel, oil, coolant, and filters in the engine as specified in Maintenance Specifications in Section 15.

Cummins Fire Power, Cummins NPower and Cummins Engine Company, Inc use the latest technology and the highest quality components to produce its engines. Cummins recommends using only genuine Cummins parts.

Personnel at Cummins Authorized Repair Locations have been trained to provide expert service and parts support. If a problem that can not be resolved by a Cummins Authorized Repair Location occurs, follow the steps outlined in the Service Assistance in Section 14.

About the Manual

This manual contains information needed to operate and maintain an engine correctly as recommended by Cummins Fire Power, Cummins NPower and Cummins Engine Company, Inc. Additional service literature (troubleshooting and repair manual) can be ordered by filling out and mailing the Literature Order Form located in Service Literature in Section 13.

Both metric and U.S. customary values are listed in this manual. The metric value is listed first, followed by the U.S. customary in brackets.

Numerous illustrations and symbols are used to aid in understanding the meaning of the text. Refer to the Symbols subsection in this section for a complete listing of symbols and their definitions.

Each section is preceded by a Section Contents to aid in locating information more quickly.

How to Use the Manual

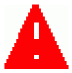
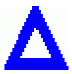
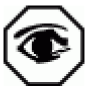
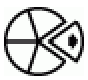
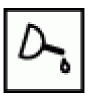
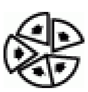
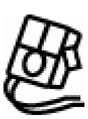
This manual is organized according to intervals at which maintenance on the engine is to be performed. A table that states the required intervals and the checks to be made is located in Section 4. Locate the interval at which maintenance will be performed, then follow the steps given in the referenced section for all the procedures to be performed. All the procedures done under previous maintenance intervals must be performed, also.

Keep a record of all the checks and inspections made. A record form for recording date, mileage/kilometer or hours, and which maintenance checks were performed is located in Section 4.

Refer to the Maintenance Specifications in Section 15 for specifications recommended by Cummins Engine Company, Inc., for your engine. Specifications and torque values for each engine system are given in that section.

Symbols

The following symbols have been used in this manual to help communicate the intent of the instructions. When one of the symbols appears, it conveys the meaning define below:

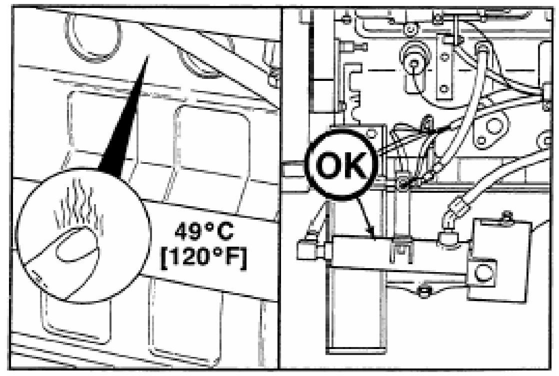
	**WARNING**. Serious personal injury or extensive property damage can result if the warning instructions are not followed.
	**CAUTION**. Minor personal injury can result or a part, an assembly, or the engine can be damaged if the caution instructions are not followed.
	**INSPECTION** is required
	Refer to another location in this manual or another publication for additional information.
	Indicates a **REMOVAL** or **DISASSEMBLY** step.
	**LUBRICATE** the part or assembly.
	**CLEAN** the part or assembly.
	**TIGHTEN** to a specific torque.
	Indicates an **INSTALLATION** or an **ASSEMBLY** step
	**PERFORM** a mechanical or time **MEASUREMENT**.
	**PERFORM** an electrical **MEASUREMENT**.
	Indicates that a **WRENCH** or a **TOOL SIZE** will be given

Illustrations

The illustrations used in this manual are intended to give an example of a problem, and to show what to look for and where the problem can be found.

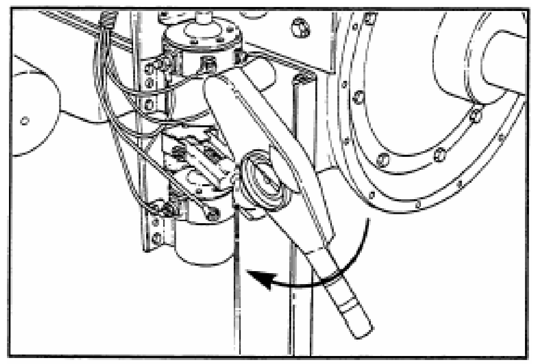
Some of the illustrations are “generic” and might not look exactly like the engine or parts used in your application.

The illustrations can contain symbols to indicate an action required, and an acceptable or not acceptable condition.



The illustrations are also intended to show repair or replacement procedures.

The illustration can differ from your application, but the procedure given will be the same.



General Safety Instructions

WARNING

Improper practices or carelessness can cause burns, cuts, mutilation, asphyxiation or other bodily injury or death.

- Read and understand all of the safety precautions and warnings before performing any repair. This list contains the general safety precautions that must be followed to provide personal safety. Special safety precautions are included in the procedures when they apply.
- Make sure the work area surrounding the product is dry, well lit, ventilated; free from clutter, loose tools, parts, ignition sources and hazardous substances. Be aware of hazardous conditions that can exist.
- **Always** wear protective glasses and protective shoes when working.
- Rotating parts can cause cuts, mutilation or strangulation.
- Do not wear loose-fitting or torn clothing. Remove all jewelry when working.
- Disconnect the battery (negative [-] cable first) and discharge any capacitors before beginning any repair work. Put a "**Do Not Operate**" tag on the controls.
- Use **ONLY** the proper engine barring techniques for manually rotating the engine. Do not attempt to rotate the crankshaft by pulling or prying on the fan. This practice can cause serious personal injury, property damage, or damage to the fan blade(s) causing premature fan failure.
- If an engine has been operating and the coolant is hot, allow the engine to cool before you slowly loosen the filler cap and relieve the pressure from the cooling system.
- Do not work on anything that is supported **ONLY** by lifting jacks or a hoist. Always use blocks or proper stands to support the product before performing any service work.
- Relieve all pressure in the air, oil, and the cooling systems before any lines, fittings, or related items are removed or disconnected. Be alert for possible pressure when disconnecting any device from a system that utilizes pressure. Do not check for pressure leaks with your hand. High pressure oil or fuel can cause personal injury.
- To avoid personal injury, use a hoist or get assistance when lifting components that weigh 23 kg [50 lb] or more. Make sure all lifting devices such as chains, hooks, or slings are in good condition and are of the correct capacity. Make sure hooks are positioned correctly. Always use a spreader bar when necessary. The lifting hooks must not be side-loaded.
- Corrosion inhibitor contains alkali. Do not get the substance in your eyes. Avoid prolonged or repeated contact with skin. Do not swallow internally. In case of contact, immediately wash skin with soap and water. In case of contact, immediately flood eyes with large amounts of water for a minimum of 15 minutes. **IMMEDIATELY CALL A PHYSICIAN. KEEP OUT OF REACH OF CHILDREN**.

General Safety Instructions (Cont.)

- Naptha and Methyl Ethyl Ketone (MEK) are flammable materials and must be used with caution. Follow the manufacturer's instructions to provide complete safety when using these materials. **KEEP OUT OF REACH OF CHILDREN**.
- To avoid burns, be alert for hot parts on products that have just been turned OFF, and hot fluids in lines, tubes, and compartments.
- **Always** use tools that are in good condition. Make sure you understand how to use them before performing any service work. Use **ONLY** genuine Cummins or Cummins ReCon® replacement parts.
- **Always** use the same fastener part number (or equivalent) when replacing fasteners. Do not use a fastener of lesser quality if replacements are necessary.
- Do not perform any repair when fatigued or after consuming alcohol or drugs that can impair your functioning.
- Some state and federal agencies in the United States of America have determined that used engine oil can be carcinogenic and can cause reproductive toxicity. Avoid inhalation of vapors, ingestion, and prolonged contact with used engine oil. Dispose of waste oil in accordance with applicable requirements.

General Cleaning Instructions

WARNING

Abrasive material must be kept out of or removed from oil passages and parts wear points. Abrasive material in oil passages can cause bearing and bushing failures that can progress to major component damage beyond reuse. This is particularly true of main and rod bearings.

WARNING

Excessive sanding or grinding the carbon ring from the top of the cylinder liners can damage the liner beyond reuse. The surface finish will be damaged and abrasive particles can be forced into the liner material which can cause early cylinder wear-out or piston ring failures.

WARNING

When using solvents, acids, or alkaline materials for cleaning, follow the manufacturer's recommendations for use. Wear goggles and protective clothing to reduce the possibility of personal injury.

WARNING

When using a steam cleaner, wear safety glasses or a face shield, as well as protective clothing. Hot steam can cause serious personal injury.

CAUTION

Do not use bead blasting cleaning methods on aluminum pistons skirts or the pin bores in any piston, piston skirt or piston crown. Small particles of the media will embed in the aluminum or other soft metal and result in premature wear of the cylinder liner, piston rings, pins and pin bores. Valves, turbocharger shafts, etc., can also be damaged. Follow the cleaning directions listed in the procedures.

CAUTION

Do not contaminate wash tanks and tank type solvent cleaners with the foreign material and plastic beads. Remove the foreign material and plastic beads with compressed air, hot high pressure water or steam before placing them in tanks or cleaners. The foreign material and plastic beads can contaminate the tank and any other engine parts cleaned in the tank. Contaminated parts may cause failures from abrasive wear.

CAUTION

The bead blasting operation must not disturb the metal surface. If the metal surface is disturbed the engine can be damaged due to increased parts clearance or inadequate surface finish on parts that move against other parts.

Definition of Clean

Parts must be free of debris that can contaminate any engine system. This does not necessarily mean they have to appear as new.

Sanding gasket surfaces until the factory machining marks are disturbed adds no value and is often harmful to forming a seal. It is important to maintain surface finish and flatness tolerances to form a quality sealing surface. Gaskets are designed to fill small voids in the specified surface finish.

Sanding gasket surfaces where edge-molded gaskets are used is most often unnecessary. Edge-molded gaskets are those metal carriers with sealing material bonded to the edges of the gasket to seal while the metal portion forms a metal to metal joint for stability. Any of the small amounts of sealing material that can stick to the parts are better removed with a blunt-edged scraper on the spots rather than spending time polishing the whole surface with an air sander or disc.

For those gaskets that do not have the edge molding, nearly all have a material that contains release agents to prevent sticking. Certainly this is not to say that some gaskets are not difficult to remove because the gasket has been in place a long time, has been overheated or the purpose of the release agent has been defeated by the application of some sealant. The object however is just to remove the gasket without damaging the surfaces of the mating parts without contaminating the engine (don't let the little bits fall where they can not be removed).

Bead blasting piston crowns until the dark stain is removed is unnecessary. All that is required is to remove the carbon build-up above the top ring and in the ring grooves. There is more information on bead blasting and piston cleaning later in this document.

Cummins Inc. does not recommend sanding or grinding the carbon ring at the top of cylinder liners until clean metal is visible. The liner will be ruined and any signs of a problem at the top ring reversal point (like a dust-out) will be destroyed. It is necessary to remove the carbon ring to provide for easier removal of the piston assembly. A medium bristle, high quality, steel wire wheel that is rated above the rpm of the power tool being used will be just as quick and there will be less damage. Yes, one must look carefully for broken wires after the piston is removed but the wires are more visible and can be attracted by a magnet.

Oil on parts that have been removed from the engine will attract dirt in the air. The dirt will adhere to the oil. If possible, leave the old oil on the part until it is ready to be cleaned, inspected and installed, and then clean it off along with any attracted dirt. If the part is cleaned then left exposed it can have to be cleaned again before installation. Make sure parts are lubricated with clean oil before installation. They do not need to be oiled all over but do need oil between moving parts (or a good lube system priming process conducted before cranking the engine).

Bead blasting parts to remove exterior paint is also usually unnecessary. The part will most likely be painted again so all that needs happen is remove any loose paint.

Using Abrasive Pads and Abrasive Paper

The keyword here is "abrasive". There is no part of an engine designed to withstand abrasion. That is they are all supposed to lock together or slide across each other. Abrasives and dirt particles will degrade both functions.

WARNING

Abrasive material must be kept out of or removed from oil passages and parts wear points. Abrasive material in oil passages can cause bearing and bushing failures that can progress to major component damage beyond reuse. This is particularly true of main and rod bearings.

Cummins Inc. does not recommend the use of emery cloth or sand paper on any part of an assembled engine or component including but not limited to removing the carbon ridge from cylinder liners or to clean block decks or counterbores.

Great care must be taken when using abrasive products to clean engine parts, particularly on partially assembled engines. Abrasive cleaning products come in many forms and sizes. All of them contain aluminum oxide particles, silicon carbide, or sand or some other similar hard material. These particles are harder than most of the parts in the engine. Since they are harder, if they are pressed against softer material they will either damage the material or become embedded in it. These materials fall off the holding media as the product is used. If the products are used with power equipment the particles are thrown about the engine. If the particles fall between two moving parts, damage to the moving parts is likely.

If particles that are smaller than the clearance between the parts while they are at rest (engine stopped), but larger than the running clearance then damage will occur when the parts move relative to each other (engine started). While the engine is running and there is oil pressure, particles that are smaller than the bearing clearance are likely to pass between the parts without damage and be trapped in the oil filter. However, particles larger than the bearing clearance will remove material from one part and can become embedded in one of the parts. Once embedded in one part it will abrade the other part until contact is no longer being made between the two parts. If the damage sufficiently degrades the oil film, the two parts will come into contact resulting in early wear-out or failure from lack of effective lubrication.

Abrasive particles can fly about during cleaning it is very important to block these particles from entering the engine as much as possible. This is particularly true of lubricating oil ports and oil drilling holes, especially those located downstream of the lubricating oil filters. Plug the holes instead of trying to blow the abrasive particles and debris with compressed air because the debris is often simply blown further into the oil drilling.

All old gasket material must be removed from the parts gasket surfaces. However, it is not necessary to clean and polish the gasket surface until the machining marks are erased. Excessive sanding or buffing can damage the gasket surface. Many newer gaskets are of the edge molded type (a steel carrier with a sealing member bonded to the steel). What little sealing material that can adhere is best removed with a blunt-edged scraper or putty knife. Cleaning gasket surfaces where an edge-molded gasket is used with abrasive pads or paper is usually a waste of time.

WARNING

Excessive sanding or grinding the carbon ring from the top of the cylinder liners can damage the liner beyond reuse. The surface finish will be damaged and abrasive particles can be forced into the liner material which can cause early cylinder wear-out or piston ring failures.

Tape off or plug all openings to any component interior before using abrasive pads or wire brushes. If really necessary because of time to use a power tool with abrasive pads, tape the oil drillings closed or use plug and clean as much of the surface as possible with the tool but clean around the oil hole/opening by hand so as to prevent contamination of the drilling. Then remove the tape or plug and clean the remaining area carefully and without the tool. DO NOT use compressed air to blow the debris out of oil drilling on an assembled engine! More likely than not, the debris can be blown further into the drilling. Using compressed air is fine if both ends of the drilling are open but that is rarely the case when dealing with an assembled engine.

Cleaning Gasket Surfaces

The object of cleaning gasket surfaces is to remove any gasket material, not refinish the gasket surface of the part.

Cummins Inc. does not recommend any specific brand of liquid gasket remover. If a liquid gasket remover is used, check the directions to make sure the material being cleaned will not be harmed.

Air powered gasket scrapers can save time but care must be taken to not damage the surface. The angled part of the scraper must be against the gasket surface to prevent the blade from digging into the surface. Using air powered gasket scrapers on parts made of soft materials takes skill and care to prevent damage.

Do not scrape or brush across the gasket surface if at all possible.

Solvent and Acid Cleaning

Several solvent and acid-type cleaners can be used to clean the disassembled engine parts (other than pistons. See Below). Experience has shown that the best results can be obtained using a cleaner that can be heated to 90 to 95 °C (180 to 200 °F). Kerosene emulsion based cleaners have different temperature specifications, see below. A cleaning tank that provides a constant mixing and filtering of the cleaning solution will give the best results. Cummins Inc. does not recommend any specific cleaners. Always follow the cleaner manufacturer's instructions. Remove all the gasket material, o-rings, and the deposits of sludge, carbon, etc., with a wire brush or scraper before putting the parts in a cleaning tank. Be careful not to damage any gasket surfaces. When possible, steam clean the parts before putting them in the cleaning tank.

WARNING

When using solvents, acids, or alkaline materials for cleaning, follow the manufacturer’s recommendations for use. Wear goggles and protective clothing to reduce the possibility of personal injury.

Experience has shown that kerosene emulsion based cleaners perform the best to clean pistons. These cleaners should not be heated to temperature in excess of 77 °C (170 °F). The solution begins to break down at temperatures in excess of 82 °C (180 °F) and will be less effective.

Do not use solutions composed mainly of chlorinated hydrocarbons with cresols, phenols and/or cresylic components. They often do not do a good job of removing deposits from the ring groove and are costly to dispose of properly.

Solutions with a pH above approximately 9.5 will cause aluminum to turn black; therefore do not use high alkaline solutions.

Chemicals with a pH above 7.0 are considered alkaline and those below 7.0 are acidic. As you move further away from the neutral 7.0, the chemicals become highly alkaline or highly acidic.

Remove all the gasket material, o-rings, and the deposits of sludge, carbon, etc., with a wire brush or scraper before putting the parts in a cleaning tank. Be careful to not damage any gasket surfaces. When possible use hot high pressure water or steam clean the parts before putting them in the cleaning tank. Removing the heaviest dirt before placing in the tank will allow the cleaner to work more effectively and the cleaning agent will last longer.

Rinse all the parts in hot water after cleaning. Dry completely with compressed air. Blow the rinse water from all the capscrew holes and the oil drillings.

If the parts are not to be used immediately after cleaning, dip them in a suitable rust proofing compound. The rust proofing compound must be removed from the parts before assembly or installation on the engine.

Steam Cleaning

Steam cleaning can be used to remove all types of dirt that can contaminate the cleaning tank. It is a good method for cleaning the oil drillings and coolant passages.

WARNING

When using a steam cleaner, wear safety glasses or a face shield, as well as protective clothing. Hot steam can cause serious personal injury.

Do not steam clean the following components:

- Electrical Components
- Wiring Harnesses
- Injectors
- Fuel Pump
- Belts and Hoses
- Bearings (ball or taper roller)
- Electronic Control Module (ECM)
- ECM Connectors

Plastic Bead Cleaning

Cummins Inc. does not recommend the use of glass bead blast or walnut shell media on any engine part. Cummins Inc. recommends using only plastic bead media, Part Number 3822735 or equivalent on any engine part. Never use sand as a blast media to clean engine parts. Glass and walnut shell media when not used to the media manufacturer's recommendations can cause excess dust and can embed in engine parts that can result in premature failure of components through abrasive wear.

Plastic bead cleaning can be used on many engine components to remove carbon deposits. The cleaning process is controlled by the use of plastic beads, the operating pressure and cleaning time.

CAUTION

Do not use bead blasting cleaning methods on aluminum pistons skirts or the pin bores in any piston, piston skirt or piston crown. Small particles of the media will embed in the aluminum or other soft metal and result in premature wear of the cylinder liner, piston rings, pins and pin bores. Valves, turbocharger shafts, etc., can also be damaged. Follow the cleaning directions listed in the procedures.

CAUTION

Do not contaminate wash tanks and tank type solvent cleaners with the foreign material and plastic beads. Remove the foreign material and plastic beads with compressed air, hot high pressure water or steam before placing them in tanks or cleaners. The foreign material and plastic beads can contaminate the tank and any other engine parts cleaned in the tank. Contaminated parts may cause failures from abrasive wear.

Plastic bead blasting media, Part Number 3822735, can be used to clean all piston ring grooves. Do not sure any bead blasting media on piston pin bores or aluminum skirts.

Plastic Bead Cleaning (Cont)

Follow the equipment manufacturer's cleaning instructions. Make sure to adjust the air pressure in the blasting machine to the bead manufacturer's recommendations. Turning up the pressure can move material on the part and cause the plastic bead media to wear out more quickly. The following guidelines can be used to adapt to manufacturer's instructions:

Bead size: U.S. size Number 16 — 20 for piston cleaning with plastic bead media, Part Number 3822735

Operating Pressure — 270 kPa (40 psi) for piston cleaning. Pressure should not cause beads to break.

Steam clean or wash the parts with solvent to remove all of the foreign material and plastic beads after cleaning. Rinse with hot water. Dry with compressed air.

CAUTION

The bead blasting operation must not disturb the metal surface. If the metal surface is disturbed the engine can be damaged due to increased parts clearance or inadequate surface finish on parts that move against other parts.

When cleaning pistons, it is not necessary to remove all the dark stain from the piston. All that is necessary is to remove the carbon on the rim and in the ring grooves. This is best done by directing the blast across the part as opposed to straight at the part. If the machining marks are disturbed by the blasting process, then the pressure is too high or the blast is being held on one spot too long. The blast operation must not disturb the metal surface.

Walnut shell bead blast material is sometimes used to clean ferrous metals (iron and steel). Walnut shell blasting produces a great amount of dust particularly when the pressure if the air pressure on the blasting machine is increased above media manufacturer's recommendation. Cummins Inc. recommends not using walnut shell media to clean engine parts due to the risk media embedment and subsequent contamination of the engine.

Cummins Inc. now recommends glass bead media NOT used to clean any engine parts. Glass media is too easily embedded into the material particularly in soft materials and when air pressures greater than media manufacturer's recommend are used. The glass is an abrasive so when it is in a moving part, that part is abrading all the parts in contact with it. When higher pressures are used the media is broken and forms a dust of a very small size that floats easily in the air. This dust is very hard to control in the shop, particularly if only compressed air (and not hot water) is used to blow the media after it is removed from the blasting cabinet (blowing the part off inside the cabinet may remove large accumulations but never removes all the media).

Bead blasting is best used on stubborn dirt/carbon build-up that has not been removed by first steam/higher pressure washing then washing in a heated wash tank. This is particularly true of pistons. Steam and soak the pistons first then use the plastic bead method to safely remove the carbon remaining in the grooves (instead of running the risk of damaging the surface finish of the groove with a wire wheel or end of a broken piston ring. Make sure the parts are dry and oil free before bead blasting to prevent clogging the return on the blasting machine.

Always direct the bead blaster nozzle "across" rather than directly at the part. This allows the bead to get under the unwanted material. Keep the nozzle moving rather than hold on one place. Keeping the nozzle directed at one-place too long causes the metal to heat up and be moved around. Remember that the spray is not just hitting the dirt or carbon. If the machining marks on the piston groove or rim have been disturbed then there has not been enough movement of the nozzle and/or the air pressure is too high.

Never bead blast valve stems. Tape or use a sleeve to protect the stems during bead blasting. Direct the nozzle across the seat surface and radius rather than straight at them. The object is to remove any carbon build up and continuing to blast to remove the stain is a waste of time.

Acronyms and Abbreviations

AFC	Air Fuel Control	in.	Inch
Amp	Ampere	in-lb	Inch Pound
API	American Petroleum Institute	kg	Kilograms
ASA	Air Signal Attenuator	kPa	Kilopascal
ASTM	American Society of Testing and Materials	l	Liter
AWG	American Wire Gauge	lb.	pound
C	Celsius	lbf.	Pound force
C.I.D.	Cubic Inch Displacement	m	Meter
CAC	Charge Air Cooler	ml	Milliliter
CARB	California Air Resources Board	mm	Millimeter
cc	Cubic Centimeter	MPa	Megapascal
cm	Centimeter	MPH	Miles Per Hour
CPL	Control Parts List	MPQ	Miles Per Quart
cSt	Centistokes	N	Newton
D.	Diameter	N•m	Newton-meter
DCA	Diesel Coolant Additive	OEM	Original Equipment Manufacturer
E.C.S.	Emission Control System	oz.	Ounce
ECM	Electronic Control Module	ppm	Parts Per Million
EPA	Environmental Protection Agency	psi	Pounds Per Square Inch
EPS	Engine Position Sensor	PTO	Power Takeoff
F	Fahrenheit	qt	Quart
FSO	Fuel Shut-Off	RPM	Revolutions Per Minute
FSOS	Fuel Shut-Off Switch	S.A.E.	Society of Automotive Engineers
ft-lb	Foot-Pound	STC	Step Timing Control
GAL	Gallon (US)	TDC	Top Dead Center
H_2O	Water	US	United States of America
Hg	Mercury	V	Volt
HP	Horsepower	VS	Variable Speed

Section 2 - Engine Identification

Section Contents

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Fire Pump Engines

Cummins' complete line of fire pump engines have been approved as packaged units (engine and all accessories) by Factory Mutual Research and listed by Underwriter's Laboratories, Inc. and Underwriter's Laboratories of Canada. Because of the lengthy and expensive process to design and produce a fire pump engine that meets these requirements, no deviations are permitted without approval. These engines are to be used only for fire protection applications.

Overspeed Switches

Each engine is equipped with an overspeed switch which will activate the fuel pump solenoid valve and shut off the engine when the RPM exceeds a present limit. The overspeed switch senses engine speed during the start cycle and stops the starting motor cranking cycle. The overspeed switch must be adjusted to the required speed limit during the in-service inspection.

Operating Speed

All Cummins fire pump engines are shipped from the factory with the operating speed adjusted to the lowest approved operating speed. Final operating speed adjustment must be made at the time of the in-service inspection to obtain the required fire pump operating speed specified by the pump manufacturer.

Control System

The function of a fire pump controller is to start the engine. These controllers are more sophisticated than standard industrial controllers because they include special items for fire pumps. Several options are available:

The automatic start controller can be used for either automatic or manual stop after the fire demand signal is removed.

Pressure recorders are available to provide a permanent record of water pressure fluctuations and engine starts.

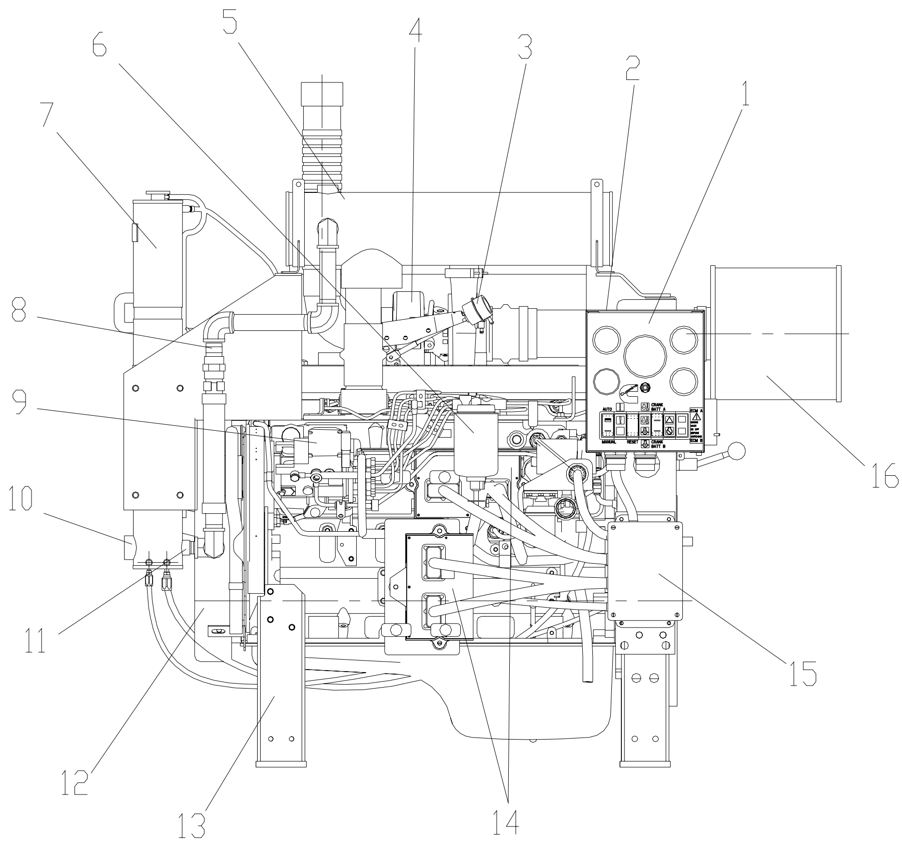
Sequential starting is available for multiple-pump installations to keep all pumps from starting simultaneously.

NOTE: Fire pump controllers are not supplied by Cummins Fire Power, or Cummins Engine Company, Inc.

External Engine Components and Views

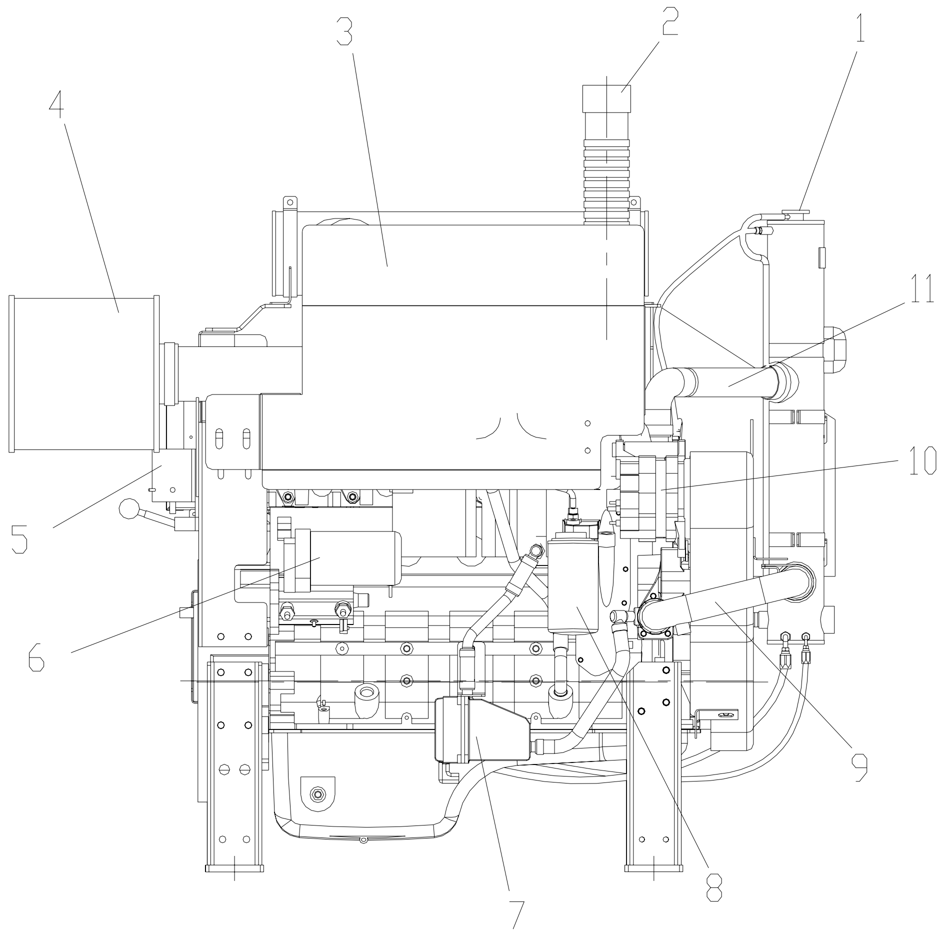
The following illustrations show the locations of the major external engine components, and other service and maintenance points. Some external components will be at different locations for different engine models.

Instrument Panel Side



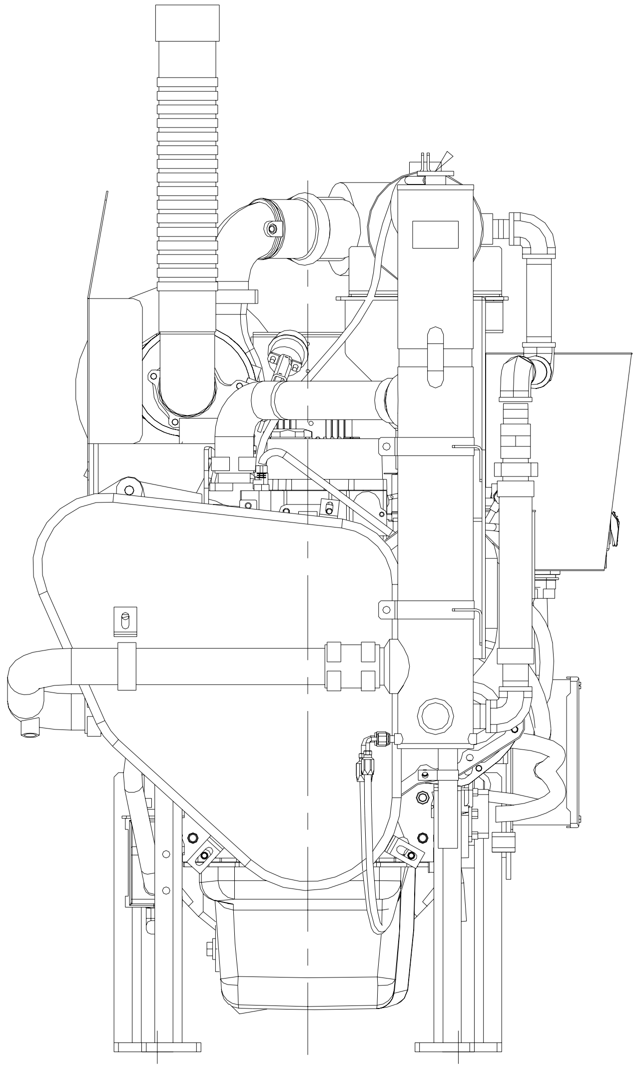
1. Instrument Panel
2. Terminal Box
3. Turbo-boost limiter
4. Turbocharger
5. Charge Air Cooler
6. Fuel Filter
7. Heat Exchanger
8. Water Piping for Charge Air Cooler
9. Fuel Pump
10. Raw Water Outlet
11. Raw Water Inlet
12. Flywheel Housing
13. Engine Support
14. Electronic Control Module (ECM)
15. ECM Switch Holder Box.
16. Air Cleaner Element

Turbocharger Side

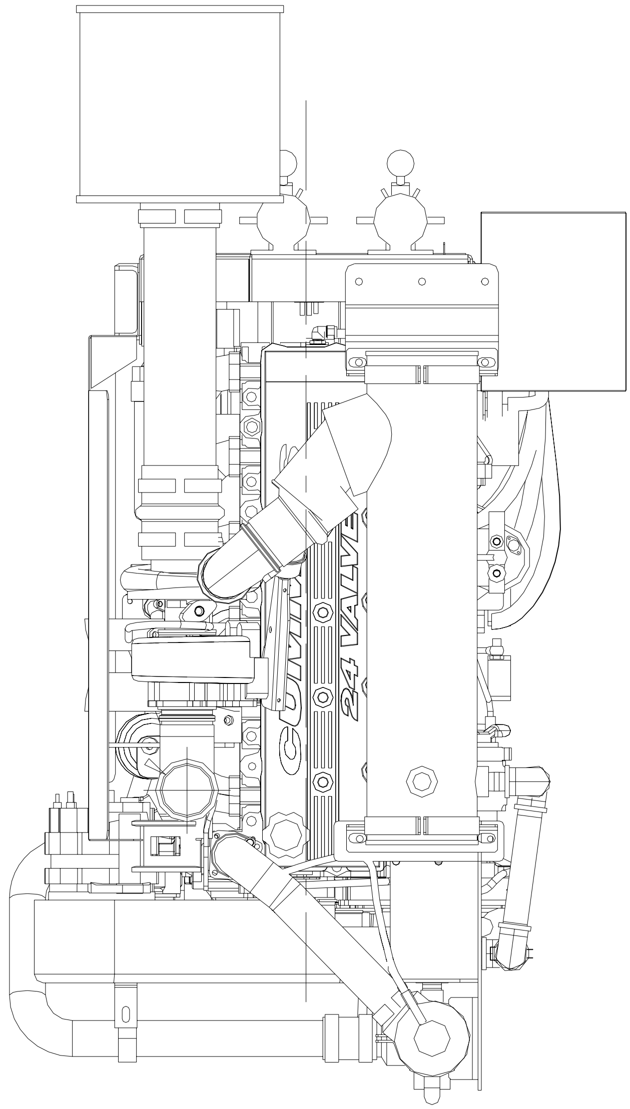


1.	Top Tank Fill	7.	Coolant Heater
2.	Exhaust	8.	Lubricating Oil Filter
3.	Turbocharger and Exhaust Shield	9.	Lower Water Hose/Tube
4.	Air Cleaner Element	10.	Alternator
5.	Manual Start Lever	11.	Upper Water Hose/Tube
6.	Start Motor		

Front View

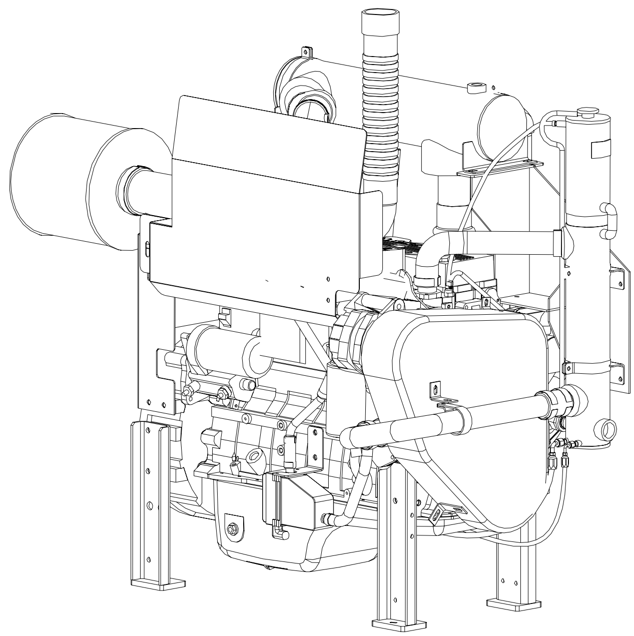


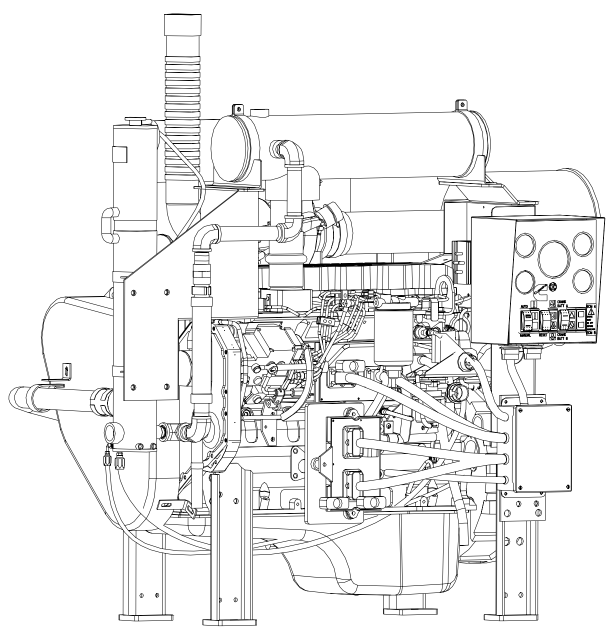
Top View



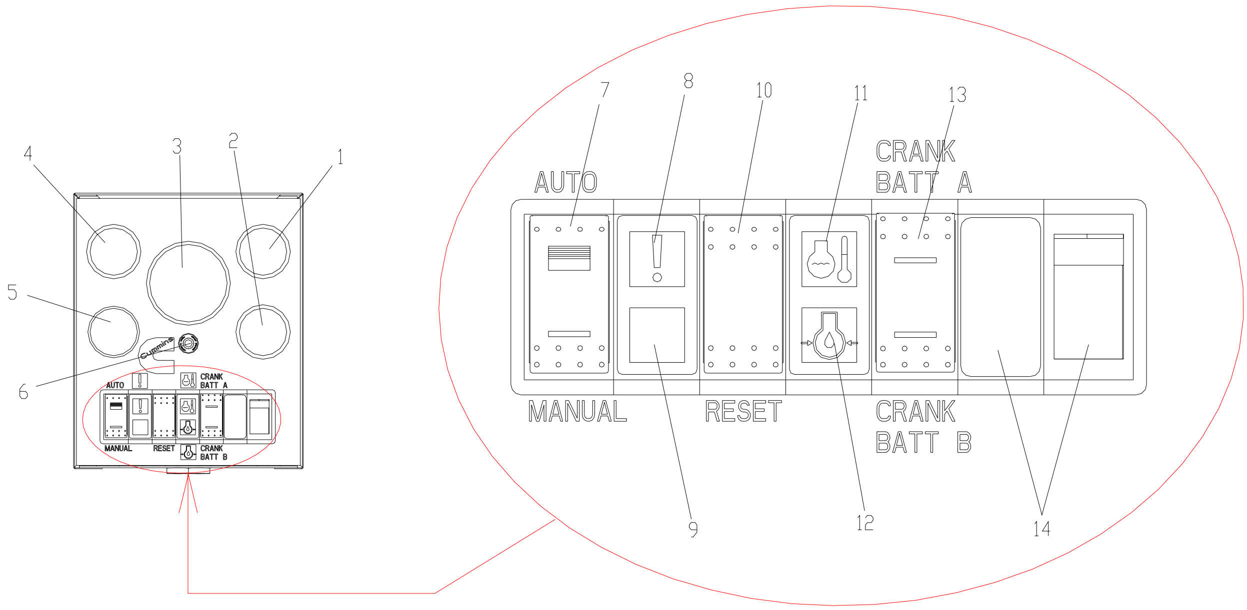
Drawing No. 9771, Section 2, Rev. A

Isometric Views





Instrument Panel

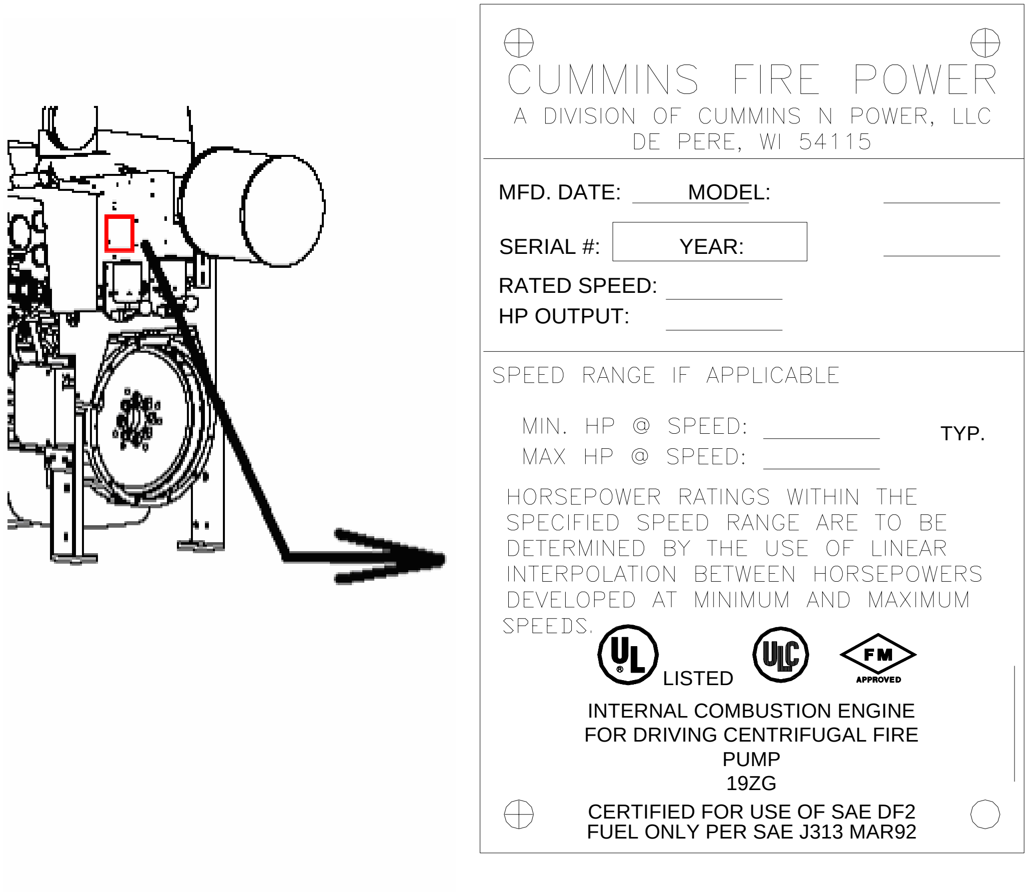


1.	Battery “A” Voltmeter	8.	Overspeed Warning Light
2.	Battery “B” Voltmeter	9.	Not used
3.	Tachometer (with hour-meter)	10.	Overspeed Reset Switch
4.	Water Temperature Gauge	11.	High Water Temperature Warning Light
5.	Lubricating Oil Pressure Gauge	12.	Low Oil Pressure Warning Light
6.	Circuit Breaker.	13.	Battery A/B Switch
7.	ON/OFF Switch (AUTO/MANUAL)	14.	ECM indicators

Fire Pump Identification

The fire pump dataplate shows specific information about your engine. The engine serial number provides information for ordering parts and service needs.

NOTE: The fire pump dataplate must not be changed unless approved by Cummins Fire Power.



Fuel Injection Pump

LATER

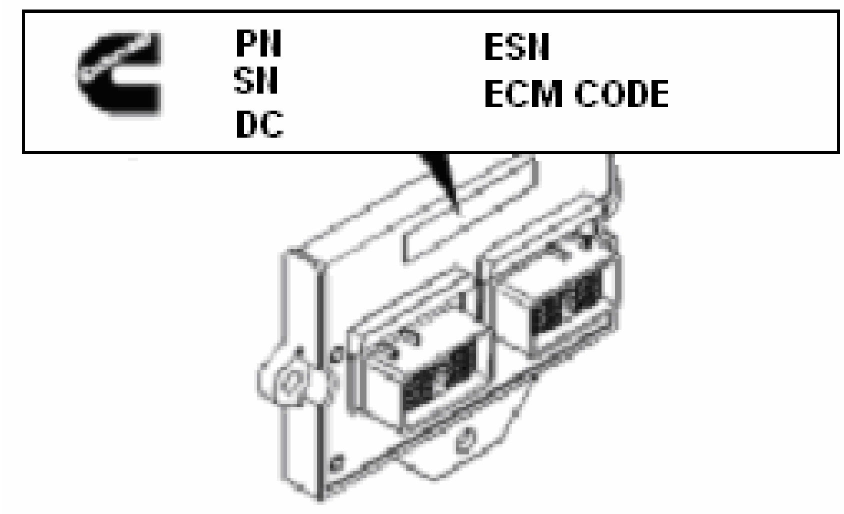
ECM Dataplate

The electronic control module (ECM) dataplate shows information about the ECM and how the ECM was programmed. The dataplate is located on the ECM, above the ECM connectors.

The following information is available on the ECM dataplate:

- ECM part number (PN)
- ECM serial number (SN)
- ECM date code (DC)
- Engine serial number (ESN)
- ECM code: Identifies the software in the ECM.

NOTE: Have the ECM code for your engine available when communicating with a Cummins Authorized Repair Location.



Section 3 – Installation and Operation

Section Contents

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Installation Overview

The first part of this section provides instructions for the initial installation, adjustment, and testing of the Cummins NPower FirePump engine. Appropriate portions of this section should also be used when returning the engine to operation after overhaul or major maintenance. The second parts details normal operations.

Physical Engine Installation

Location

Refer to Drawing CFP8E_GEN in Section 18 for the general fire pump and engine layout.

Refer to Drawing 8711 in Section 18 for the general fire pump engine power module assembly.

WARNING

Do not operate a diesel engine where there are or can be combustible vapors. These vapors can be sucked through the air intake system and cause engine acceleration and overspeeding, which can result in a fire, an explosion, and extensive property damage. Numerous safety devices are available, such as air intake shutoff devices, to minimize the risk of overspeeding in which an engine, because of application, might operate in a combustible environment (from a fuel spill or gas leak, for example). Cummins Engine Company, Inc., does not know how you will use your engine. The equipment owner and operator, therefore, is responsible for safe operation in a hostile environment. Consult your Cummins Authorized Repair Location for further information.

Install the fire pump engine in a sheltered environment protected from extremes of weather. Any enclosure must protect the water supply from freezing. Ensure that the engine and electrical components are not exposed to significant water dripping or sprays. Avoid installation in a dusty or dirty environment. Provide adequate physical protection from other physical damage as may be present in the specific location. (Refer to National Fire Protection Association NFPA20-2003 Chapter 11 for additional installation requirements for installations in the USA.)

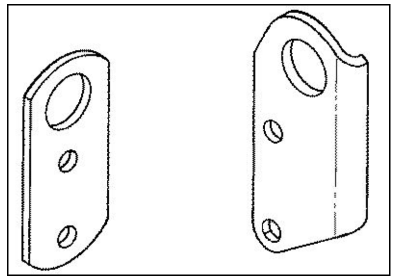
Design the installation to meet the engine's mounting requirements. Refer to General Engine Data in Section 15.

Install the engine on a stable level foundation that is designed for the load and vibration of pump operation.

Install the engine with ample room for servicing of the engine, the pump, fuel supply, and support systems.

Ensure that the engine location is free of any risk of exposure to combustible vapors.

Physical Installation



Use the supplied lifting hooks on the engine to position the engine.

Provide engine support as required to support the wet weight specified in General Engine Data in Section 15.

Position the engine as required for the interface with the pump, piping, and electrical connections.

Level the installation with shims as required.

Secure the engine to the support or floor.

Connect the exhaust piping.

Fuel Supply Installation

NOTE: Refer to National Fire Protection Association NFPA20-2003 Chapter 11 for additional installation requirements for installations in the USA. Ensure that the fuel system is installed in a safe and an effective manner.

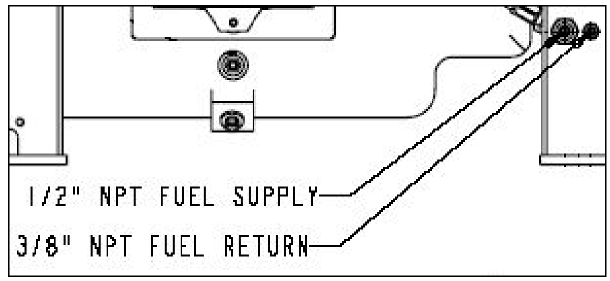
Install an elevated Diesel # 2 fuel tank or other fuel supply arrangement that meets the specifications listed in Fuel System Specifications in Section 15.

Size the fuel tank for the maximum expected full-load engine operation period with the initial fuel level at the minimum level for refueling.

Install a 3/8“ NPT (minimum) fuel return line. Route this line to the bottom of the fuel tank in order to minimize the return head.

Install a 1/2” NPT (minimum) fuel supply line to the fire pump engine.

Provide a pre-filter on the fuel line to the fire engine.



Fire Pump Installation

Install the customer supplied fire pump as per the pump manufacturer's instructions and applicable code requirements. Refer to National Fire Protection Association NFPA20-2003 Chapter 11 for requirements for installations in the USA. Ensure that the engine and pump are correctly aligned.

Raw Water Supply Installation

Overview

Raw water is used to cool the engine cooling fluid. Raw water is supplied from the fire pump prior to the pump discharge flange. It is forced through a cooling loop by fire pump pressure to the heat exchanger. In the heat exchanger, it flows through the tubes in the bundle and is discharged to an open waste cone. The raw water supply must be immediately available when the engine is started.

Refer to the Cooling System Flow Diagrams in Section 11 for a simplified block diagram of the cooling weater system. Refer to Cooling System Specifications in Section 15 for pipe size requirements.

Refer to Drawing 8683 in Section 18 for the optional raw water piping manifold that is available from Cummins Fire Power.

If the piping supplied by the customer, provide raw water supply piping and components equivalent to that can be supplied by Cummins FirePower and as shown in Assembly Diagram, Raw Water Piping in Section 11. Refer to National Fire Protection Association NFPA20-2003 Chapter 11 for installation requirements for installations in the USA. When choosing the components for the raw water supply and by-pass, care must be taken to ensure that the internal cross sectional area of the component is at least as large as the recommended pipe size.

When the raw water piping is installed, adjust both pressure regulator setpoints before operating the pump. Damage to the heat exchanger may occur from improperly regulated raw water supply pressure.

Raw Water Supply & Drain without Cummins Raw Water Manifold

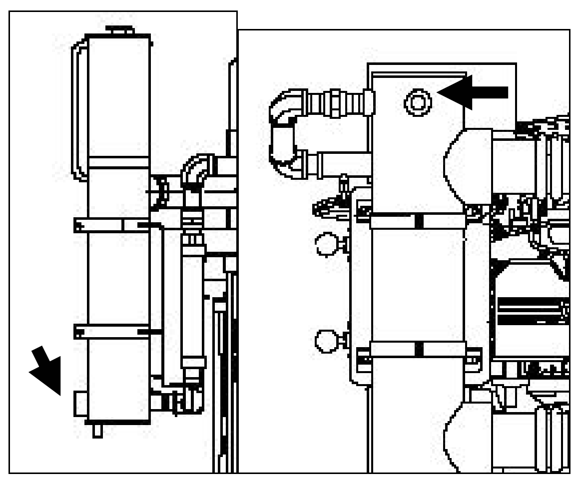
NOTE: Raw water outlet piping from the heat exchanger should be one pipe size larger than the supply piping.

NOTE: The velocity of raw water should be as great as possible without exceeding the maximum shown on the appropriate engine data sheet.

NOTE: Failure to comply will result in engine overheat and failure.

Provide raw water supply to the charge air cooler water inlet.

Provide an open waste cone raw water drain at the outlet from of the heat exchanger.



Raw Water Supply and Drain with Cummins Raw Water Manifold

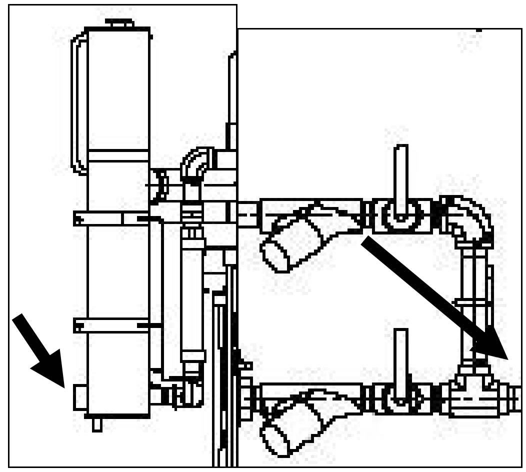
NOTE: Raw water outlet piping from the heat exchanger should be one pipe size larger than the supply piping.

NOTE: The velocity of raw water should be as great as possible without exceeding the maximum shown on the appropriate engine data sheet.

NOTE: Failure to comply will result in engine overheat and failure.

Provide raw water supply to the raw water manifold inlet.

Provide an open waste cone raw water drain at the outlet from the heat exchanger.



Check Raw Water Pressure Regulator Setpoints

NOTE: Adapt this procedure to the actual installation if a Cummins raw water manifold is not supplied.

Temporarily remove raw water inlet piping at the charge air cooler.

Provide temporary drain piping at the raw water manifold outlet.

If closed, open the pressure gauge isolation valve.

NOTE: The normal line has the solenoid valve. The bypass line does not.

If open, close the normal line inlet valve.

Open the bypass line inlet and outlet valves.

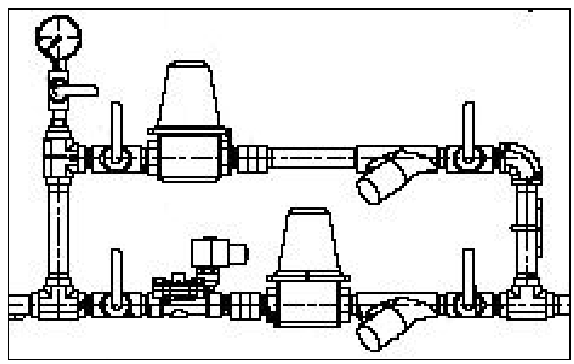
NOTE Temporary water supply pressure should exceed 414 kPa [60 psig].

Provide temporary water supply piping to the raw water manifold.

Adjust the bypass pressure regulator for 414 kPa [60 psig] or slightly less.

Close the bypass line inlet valve.

NOTE: Use the correct voltage for unit.



Provide a temporary 12 VDC power source for the solenoid valve at Pin 13 and Pin 17. Refer to Drawing 8512 Sheet 1 in Section 18.

Open the normal line inlet and outlet valves.

Adjust the normal pressure regulator for 414 kPa [60 psig] or slightly less.

Remove the power jumper and reconnect the wiring.

Re-install the raw water piping from the manifold to the charge air cooler.

Test the pressure regulator setpoints with water flowing through the heat exchanger. Trim the setpoints if required.

Remove the temporary water supply to the manifold.

Re-install the raw water piping at the pump.

Battery and Electrical Installation

Overview

Two redundant sets of batteries must be supplied for the selected operating voltage (12 VDC or 24 VDC).

Batteries must meet the requirement listed in <u>Electrical System Specifications</u> in Section 15.

Batteries may be supplied by Cummins FirePower as an option or may be supplied by the customer.

Refer to National Fire Protection Association NFPA20-2003 Chapter 11 for battery and battery charger requirements for installations in the USA.

Battery Installation

Install the redundant sets of batteries in a well ventilated or otherwise protected location. Provide adequate room for servicing or replacing the batteries. Provide protection from extremes of temperature and weather.

Locate the batteries near the engine or increase the size of the conductors as required by applicable codes.

Ensure that the batteries are configured properly for either 12 VDC or 24 VDC operations as appropriate.

Battery Wiring Installation

NOTE: Install the wiring in accordance with applicable codes and specifications.

Install the Loose Wire Kit wires. Refer to <u>Drawing 9767</u> in Section 18.

If purchased, install the optional battery cable kit (Cummins FirePower Part No. 9609). Otherwise, install equivalent customer supplied wiring.

Signal and Control Installation

NOTE: Install signal and control wiring at Terminal Board TB. Refer to Drawing 8512 Sheet 1 in Section 18.

Ensure that the fire control system is properly installed and configured as per the manufacturer's instructions.

Complete the customer-supplied fire pump controller wiring as per the manufacturer's instructions.

NOTE: Do not connect more than two wires at any point on the fire engine control panel terminal board. If necessary, add a grounding terminal board at the fire control system.

Connect the control power from the fire pump controller at TB-1 (+) and TB-11 (-). This power source is necessary for fire pump operations while in the AUTO mode.

Connect the two redundant crank signals from the fire pump controller to TB-9 (Crank Battery A) and to TB-10 (Crank Battery B). Connect the signal ground to TB-11.

Connect the Crank Terminate input to the fire pump controller from TB-2 with signal ground at TB-11. This 12 or 24 VDC signal is present when the engine is running. This signal indicates that the engine has started and that the crank command from the fire pump controller should stop immediately.

Connect the remote overspeed alarm input to the fire pump controller from TB-3. This 12 or 24 VDC signal is present when the overspeed switch has operated. If this event occurs, the fire engine will stop. The local RESET button must be pressed in order to restart the engine.

Connect the Low Oil Pressure alarm input to the fire pump controller from TB-5. This 0 VDC grounded signal is present when the oil pressure has dropped below the 110 kPa [16 PSIG] setpoint. The engine will continue to operate but immediate attention is necessary in order to prevent excessive damage to the engine or catastrophic engine failure.

Connect the High Water Temperature alarm input to the fire pump controller from TB-5. This 0 VDC grounded signal is present when the engine is running and the coolant temperature has risen above the 93 ^{o}C [200 ^{o}F] setpoint. The engine will continue to operate but immediate attention is necessary in order to prevent excessive damage to the engine or catastrophic engine failure.

If used, provide permanently installed redundant battery charging systems with connections at TB 6 and TB-8 (+) and TB-11 (-). TB-6 (+) and TB-8 (+) and TB-11 (-) should also be used for remote battery voltage indications at the fire control system or elsewhere.

Ensure electrical continuity and adequate insulation resistance for the installed wiring.

Provide the initial charge on the redundant batteries as per the battery charger's instructions.

Check that both voltmeters on the local control panel indicate the approximate battery voltage.

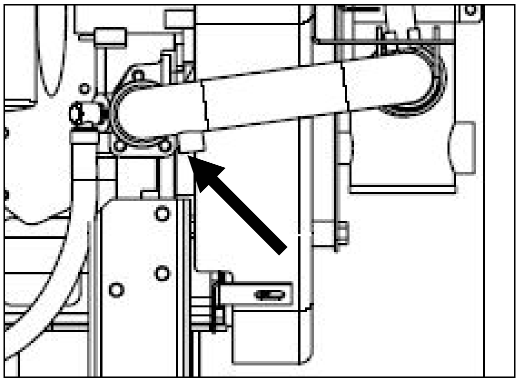
Coolant System Preparation

Check Cooling System Integrity

NOTE: Refer to Drawing 8709 in Section 18 for hose arrangement.

Check that all coolant hoses are properly installed and that the clamps are tight.

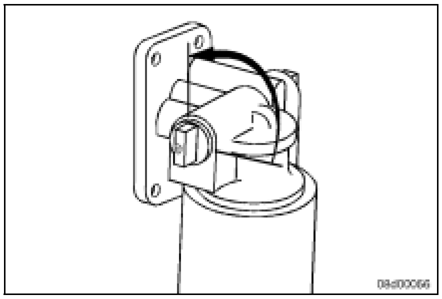
Check that the coolant drain petcock is closed.



CAUTION

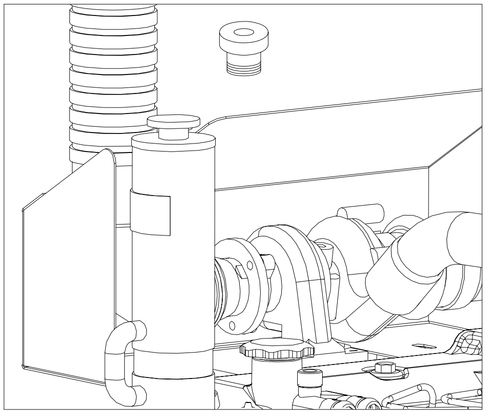
The valve must be in the ON position to prevent engine damage.

Check that the coolant filter valve is open. If required, turn the shutoff to the ON position by rotating the knob from horizontal to vertical in the direction shown.



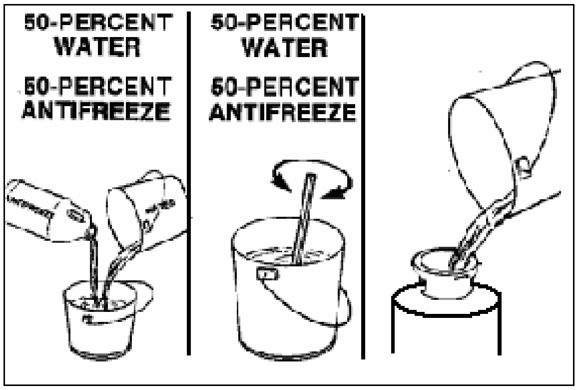
Add Coolant

Remove the pressure cap from the heat exchanger.



Coolant System Preparation (Cont)

Refer to Cooling System Specifications and Coolant Recommendations and Specifications in Section 15.



NOTE: Use a mixture of at least 50 percent antifreeze and 50 percent water.

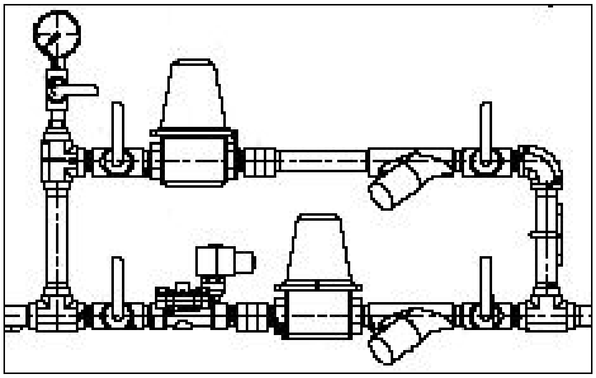
NOTE: Close coolant vents when coolant level reaches the vent.

Add coolant until the coolant level is just below the fill tube in the coolant heat exchanger.

Check for leaks. Correct any leaks.

Install the pressure cap on the heat exchanger.

Check Raw Water Supply Lineup



CAUTION

The raw water lines to and from the fire pump must be open, and there must be sufficient water to the heat exchanger when the engine has started. Insufficient water supply will cause overheating, resulting in engine failure.

Check that the pressure gauge isolation valve is open.

NOTE: The upper line is the bypass line. The lower line with the solenoid valve is the normal line.

Check that the bypass line outlet valve is closed.

Check that the normal line inlet valve is open.

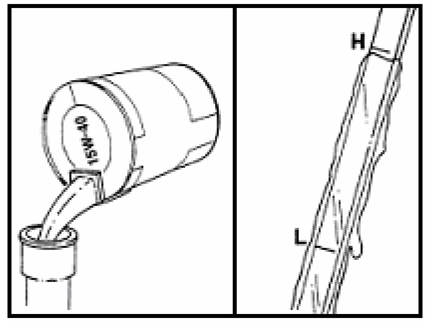
Check that the normal line outlet valve is open.

Lubricating Oil System Preparation

Add Lubricating Oil

NOTE: For oil requirements, refer to Lubricating Oil System Specifications and Lubricating Oil Recommendations and Specifications in Section 15. No change in oil viscosity or type is needed for new or newly rebuilt engines.

Fill the crankcase with lubricating oil to the “H” (high) mark on the dipstick.



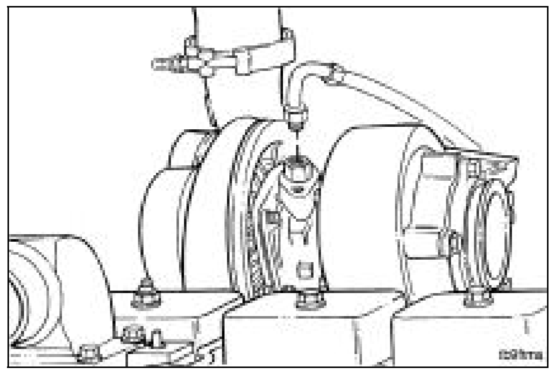
Prime the Turbocharger

CAUTION

New turbochargers must be pre-lubricated before startup. Failure to pre-lube the turbochargers will result in turbocharger bearing failure.

Remove the air intake filter assembly. Refer to Intake Air Filter Removal/Installation in Section 12.

Remove the turbocharger oil inlet line from the turbocharger bearing housing.



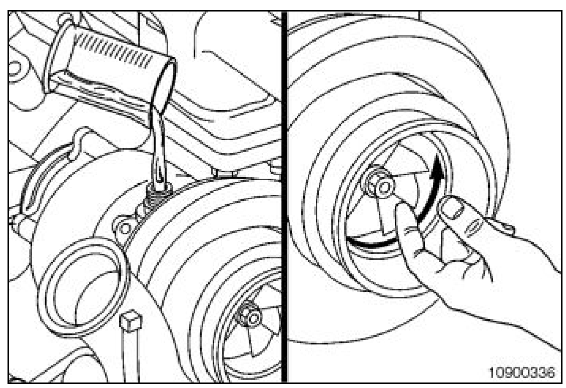
NOTE: Rotate the turbine wheel to allow oil to enter the bearing housing. Any excess oil will drain through the oil drain line.

Lubricate the bearings by pouring 59 to 89 ml [2 to 3 oz] of clean engine lubricating oil into the turbocharger oil supply line fitting.

Tighten the oil supply line.

Torque Value: 24 N•m [18 ft-lb]

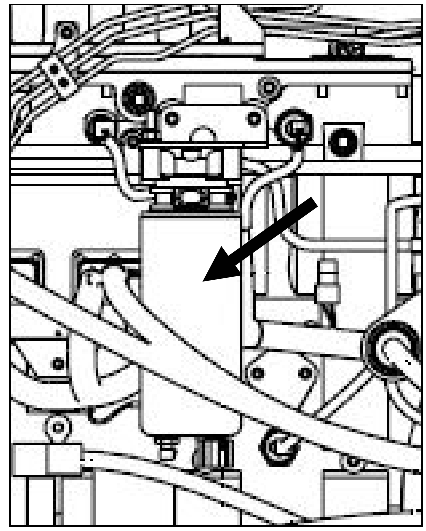
Install the air intake filter assembly. Refer to Intake Air Filter Removal/Installation in Section 12.



Fuel System Preparation

Fill the Fuel Filter

Unscrew the combination fuel filter assembly and remove it from the engine.

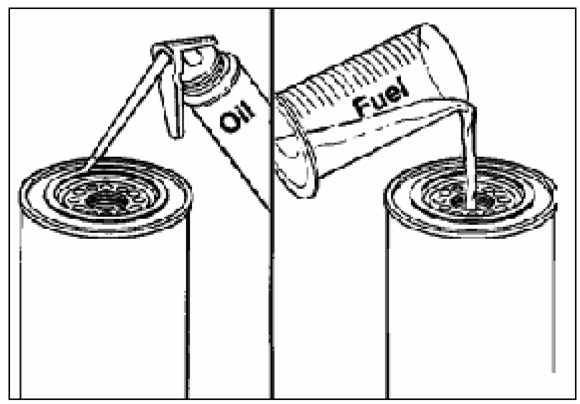


If open, close the water separator drain cock. Refer to Drain Fuel-Water Separator in Section 5.

Lubricate the o-ring seal with clean lubricating oil.

NOTE: Refer to Fuel Recommendations and Specifications in Section 15 for fuel requirements.

Fill the fuel element with fuel.



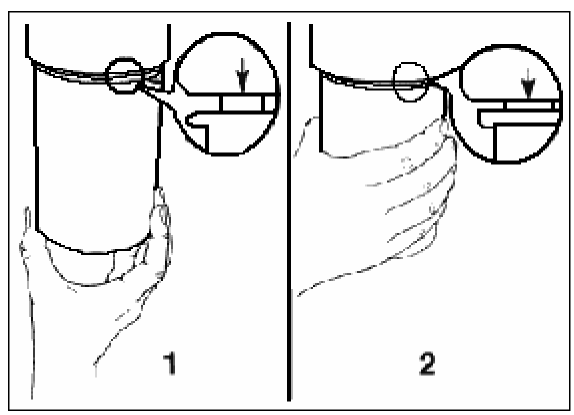
CAUTION

Mechanical over-tightening will distort the threads, filter element seal or filter can.

Install the filter on the filter head.

Tighten the filter until the gasket contacts the filter head surface.

Tighten the filter an additional one-half to three-fourths of a turn, or as specified by the filter manufacturer.



Fuel System Preparation (Cont)

Fill the Fuel Tank

NOTE: Refer to Fuel Recommendations and Specifications in Section 15 for fuel requirements.

Ensure that the fuel tank and piping is clean.

Fill the fuel tank with fuel.

Fill the fuel lines to the engine and fill the fuel pre-filter.

Tighten all fuel supply line fittings to stop possible suction leaks.

Bleed the Fuel Lines

Open any fuel isolation valves and bleed any air from the customer-supplied fuel supply line to the fire engine.

Bleed the fuel pre-filter of any air.

Tighten the fuel supply line connections in order to avoid air leakage when the lift pump draws suction.

Pre-Start Inspections

Perform a visual inspection as follows:

- Check that there is no apparent damage and that all components are installed.
- Check that the drive belt is properly installed.
- Check that all hoses and tubes are properly installed.
- Check that all electrical connections are properly installed.
- Check that the fire pump is properly installed as per the pump manufacturer’s instructions, is correctly aligned, and is free to rotate.

Initial Start

NOTE: Pre-lubrication of the engine is not required. The engine will not start until the minimum cranking oil pressure is detected by the ECM. It can take more cranking time to start the engine after an extended shut down or oil change.

NOTE: The object of this test is to check that the engine starts and operates normally with oil pressure being displayed and raw water flow being established to the coolant heat exchanger. Operation at the factory-adjusted rated speed is also checked.

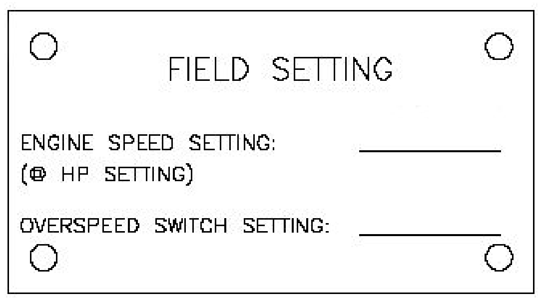
NOTE: If the engine still will not start, troubleshoot as per Engine Cranks But Will Not Start (No Exhaust Smoke) or Engine Difficult to Start or Will Not Start - Exhaust Smoke Present in Section 17.

NOTE: When the engine starts, immediately check that oil pressure is displayed. It should be on-scale within a few seconds. Stop the engine if oil pressure is not displayed within about 15 seconds.

NOTE: When the engine starts, immediately check that raw water flow is established through the coolant heat exchanger. Raw water flow should be established immediately but some delay may occur before the flow exits the heat exchanger drain connection.

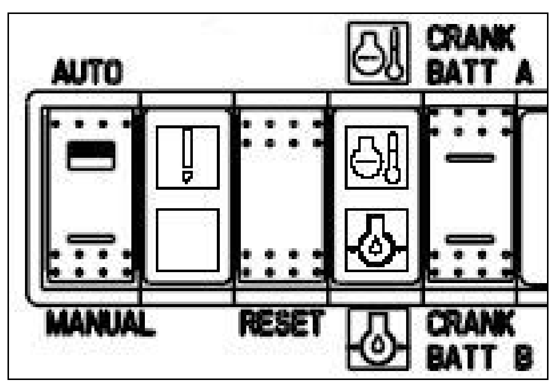
NOTE: Rated speed is displayed on the Field Setting Tag described in Section 2.

NOTE: Electronically controlled engines should operate within a few RPM of the rated speed whether the engine is fully loaded or unloaded. If it becomes necessary to adjust the engine's actual speed to match the rated value, refer to Rated Speed Setpoint Adjustment in this section.



Start the engine using either the CRANK BATT A or the CRANK BATT B switch positions.

Check that the engine starts and operates at rated speed.



Initial Start (Cont)

NOTE: If oil pressure is not present or if the Low Oil Pressure Light does not go out, stop the engine and troubleshoot as per Lubricating Oil Pressure Low in Section 17.

Check that lubricating oil pressure is displayed within 15 seconds after the engine starts.

NOTE: Raw water should be flowing through the heat exchanger and water pressure shown on the local pressure gauge should be no more than 414 kPa (60 psig).

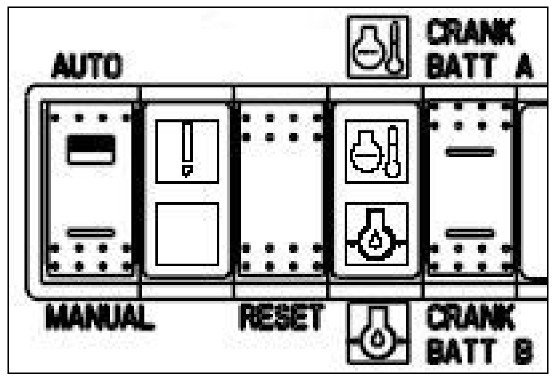
Check that raw water is flowing through the heat exchanger.

Check that raw water supply pressure is correctly adjusted.

Operate the engine for 8 to 10 minutes.

Check for leaks, unusual noises, or other indications of incorrect operation.

Shut off the engine by pressing the AUTO position on the AUTO/MANUAL rocker switch and by momentarily pressing the RESET switch.



Check that raw water flow stops automatically shortly after the engine stops.

Correct any problems found during the inspection before proceeding.

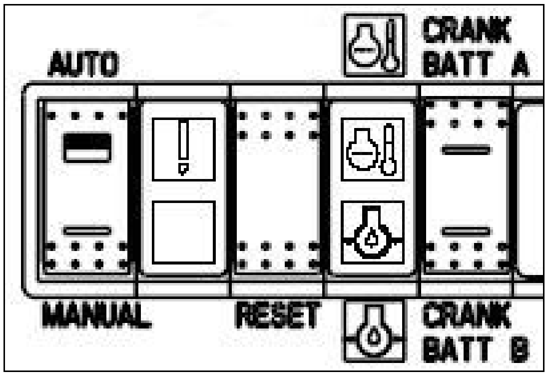
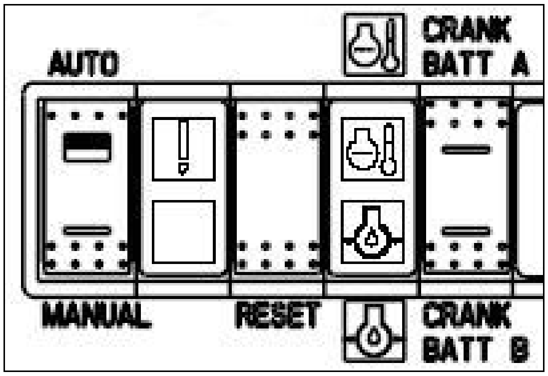
Check the engine lubricating oil level. Refer to Check Lubricating Oil Level in Section 5. Top off if necessary.

Check the coolant heat exchanger's coolant level. Refer to Check Coolant Level in Section 5. Top off if necessary.

Check the raw water strainer. Clean the strainer if necessary.

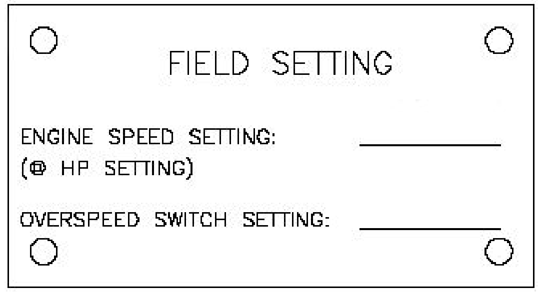
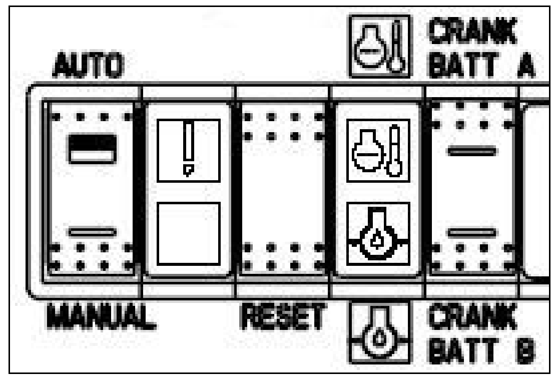
Second Start

NOTE: The object of this test is to check that the engine operates normally with coolant temperature being maintained. Oil pressure is again checked at rated speed.

NOTE: If required, adjust engine operating speed as per Rated Speed Setpoint Adjustment below. Start the engine using either the CRANK BATT A or the CRANK BATT B switch positions. Check that the engine starts and operates at about rated speed.	
Check that the oil pressure is as specified in Lubricating Oil System Specifications 276-414 kPa 40-60 psi in Section 15. **NOTE**: If oil pressure is not within the rated range, troubleshoot as per Lubricating Oil Pressure High or Lubricating Oil Pressure Low in Section 17.	
NOTE: If temperature does not stabilize, stop the engine and refer to Coolant Temperature Above Normal or Coolant Temperature Below Normal (Engine Running) in Troubleshooting Section 17. Check that engine operating temperature stabilizes between about 82 and 95 ^{o}C [180 and 203 ^{o}F].	
Stop the engine by pressing the RESET button. Correct any problems found before proceeding. Check the engine lubricating oil level. Refer to Check Lubricating Oil Level in Section 5. Top off if necessary. Check the coolant heat exchanger's coolant level. Refer to Check Coolant Level in Section 5. Top off if necessary. Check the raw water strainer. Clean the strainer if necessary.	

Rated Speed Setpoint Adjustment

NOTE: If required, use this section to adjust the normal operating speed to the nameplate value.

NOTE: Rated speed is displayed on the Field Setting Tag described in Section 2.	
Start the engine. Observe that the engine starts and accelerates the currently adjusted speed setpoint.	
NOTE: operating speed? Need specific art.	
Adjust the speed setpoint to rated speed.	
Stop the engine.	
Start the engine. Observe that the engine starts and accelerates to the rated speed setpoint.	
Stop the engine.	

Overspeed Setpoint Adjustment and Testing

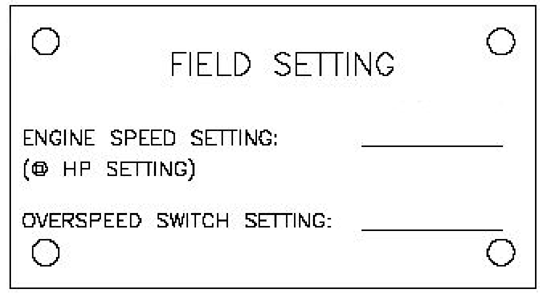
Overview

Overspeed setpoint adjustment and testing is a repetitive process. Use the Adjustment Procedure to change the setpoint. Use the Test Procedure to check the setpoint. Repeat the adjustments and checks until the desired setpoint is demonstrated. When the overspeed setpoint is successfully demonstrated, then check that the engine operates normally while not being tested

NOTE: The overspeed trip setpoint is displayed on the Field Setting Tag described in Section 2.

NOTE: The overspeed setpoint must be set at between 115 and 120% of the engine's rated speed.

The speed switch located on the engine's local control panel has a TEST button which lowers the currently adjusted overspeed by 10%. Thus, an overspeed setpoint of 2112 rpm would be reduced to (2112 * 0.9 =) 1901 RPM when the test button is pressed.



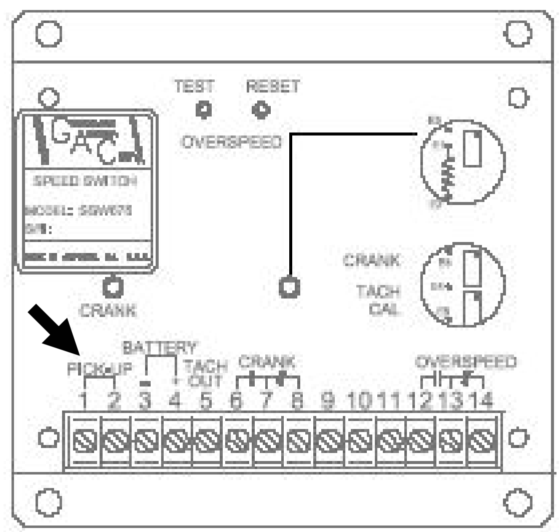
Adjust the Speed Switch:

Lower the cover on the engine's local control panel.

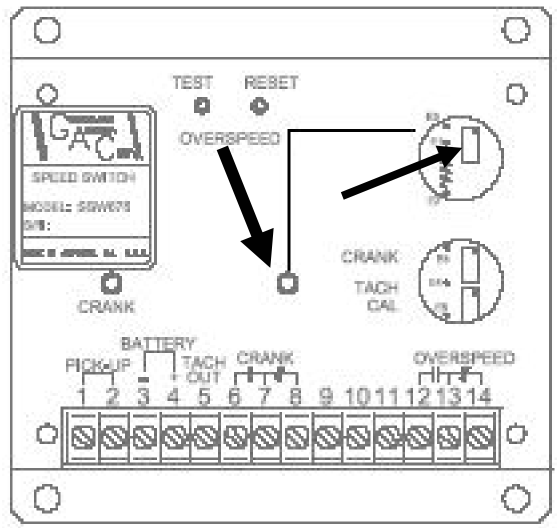
Disconnect the engine speed sensor signal from PICK-UP terminals 1 and 2.

Connect a signal generator capable of providing between 0.25 to 120 VAC RMS signal to the switch. The signal must be proportional to the engine's rated speed.

Provide an overspeed signal at the specified overspeed switch setting frequency.



Overspeed Setpoint Adjustment and Testing (Cont)



Remove the calibrating screw cover from the electronic overspeed switch.

NOTE: Turn the small screw on the potentiometer near the word "OVERSPEED" clockwise to increase trip speed. Turn it counter-clockwise to reduce trip speed.

If the OVERSPEED light is illuminated with the signal present, perform the following steps:

Reduce the signal frequency.

Press the RESET button.

Turn the potentiometer clockwise to raise the setpoint.

Increase the signal frequency to setpoint.

With the OVERSPEED light off, slowly turn the potentiometer counter-clockwise until the light is just illuminated.

NOTE: Repeat the adjustments as required to make the finest adjustment practical.

When the setpoint is adjusted, perform the following steps:

Replace the screw cover at the potentiometer.

Disconnect the signal generator.

Reset the light.

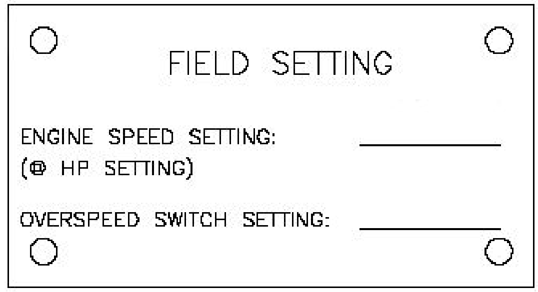
Reconnect the speed sensor input.

Perform the Test Procedure below to check the effect of the adjustment.

Overspeed Setpoint Adjustment and Testing (Cont)

Test Procedure

NOTE: The overspeed trip setpoint is displayed on the Field Setting Tag described in Section 2.



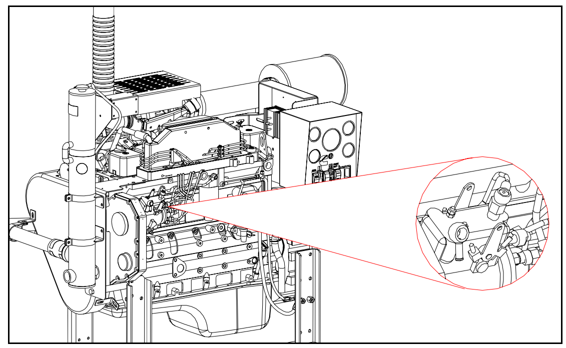
Start the engine.

Observe that the engine starts and operates at about rated speed.

NOTE: Monitor engine speed on the tachometer. Record the observed engine speed when it trips. It must trip between 115 and 120% of rated speed.

NOTE: Do not exceed 120% of rated speed. If the engine does not trip at or below 120%, stop the engine and Adjust the Speed Switch.

Adjust the mechanical throttle adjustment to increase engine speed to the setpoint.



Observe that the engine stops automatically and that the overspeed trip light is illuminated.

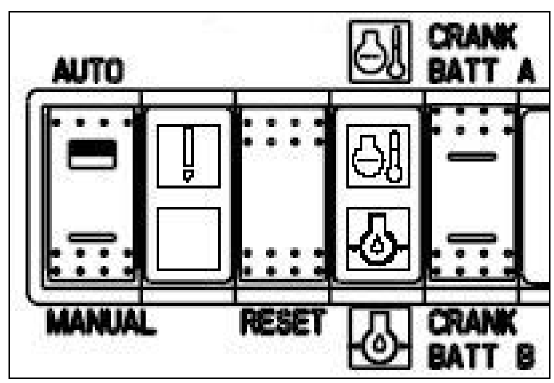
Verify that the engine tripped at a speed between 115 and 120% of rated speed.

Press the RESET button on the speed switch.

Press the RESET switch on the front of the engine control panel.

Observe that the overspeed light has extinguished.

NOTE: If required by the local authority, restart the engine at the current mechanical throttle setpoint to demonstrate a run-away overspeed shutdown as specified by Underwriter's Laboratory UL 1247.



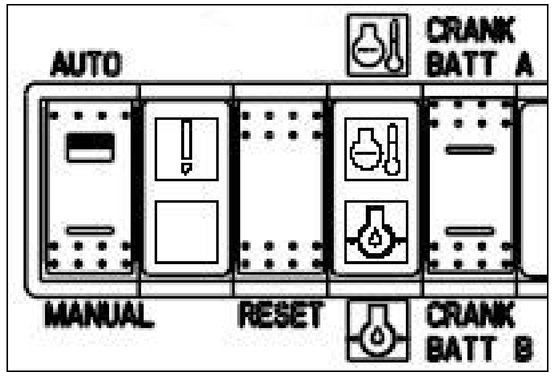
Overspeed Setpoint Adjustment and Testing (Cont)

Set/Check Normal Operation

Start the engine.

Adjust engine speed for rated value. Refer to Rated Speed Setpoint Adjustment (CFP83-F10, F20, F30) or Rated Speed Setpoint Adjustment (CFP83-F40) in this section.

Stop the engine.



Crank Terminate Adjustment and Testing

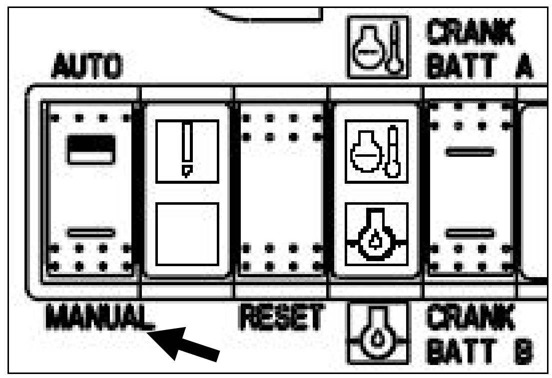
NOTE: The crank terminate signal to the remote fire pump controller informs the controller that the engine has started. This allows the controller to terminate the selected crank signal to the engine. This crank terminate signal is produced by the overspeed switch in the engine's local control panel. The setpoint for the crank terminate signal is adjusted at the factory to a value above normal idling speeds but less than the rated speed. The setpoint should not require adjustment unless it is necessary to test the switch operation or to replace the overspeed speed switch.

NOTE: If using this procedure for troubleshooting, perform the test portion prior to making any adjustments.

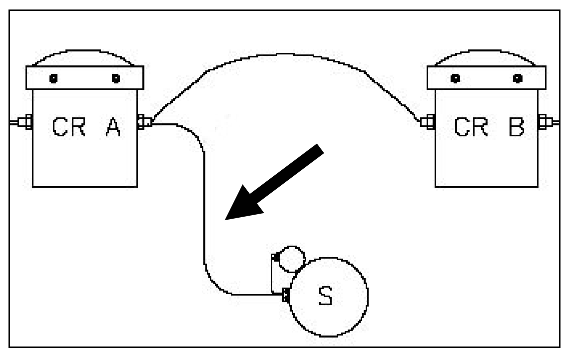
Prepare

Place the fire protection system in a safe mode for engine service.

Place the AUTO/MANUAL rocker switch in the MANUAL position.



Disconnect and insulate the Contactor to Starter Cable (Cummins Fire Power Part No 9762) at the starter. Refer to Drawing 9767 in Section 18.



Crank Terminate Adjustment and Testing (Cont)

Adjust

NOTE: Refer to Drawing 8512 Sheet 1 in Section 18.

Open the engine's local control panel cover.

Disconnect the GRAY/RED (MPU +) wire from PICK-UP terminal 1 at the speed switch.

Disconnect the GRAY/BLK (MPU -) wire from PICK-UP terminal 1 at the speed switch.

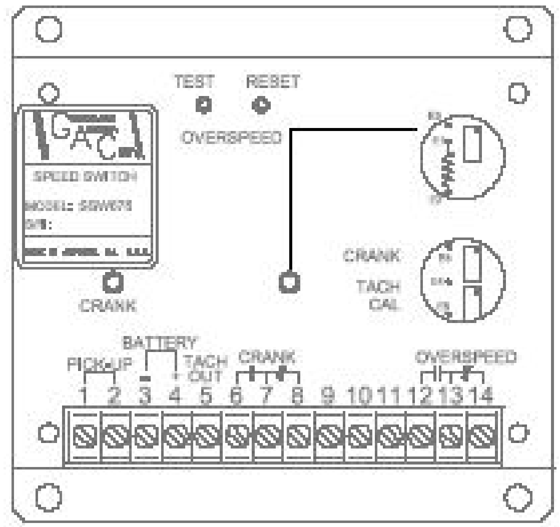
Connect a signal or pulse generator to the switch inputs with the same signal polarity.

Adjust the pulse generator to about 1100 cycles or pulses per second.

Remove the cover from the speed switch CRANK/TACH CAL potentiometers.

If, with this signal, the CRANK LED is illuminated on the speed switch, turn the CRANK potentiometer E5 clockwise until the LED extinguishes.

Then, turn the CRANK potentiometer E5 slowly counterclockwise until the CRANK LED illuminates.

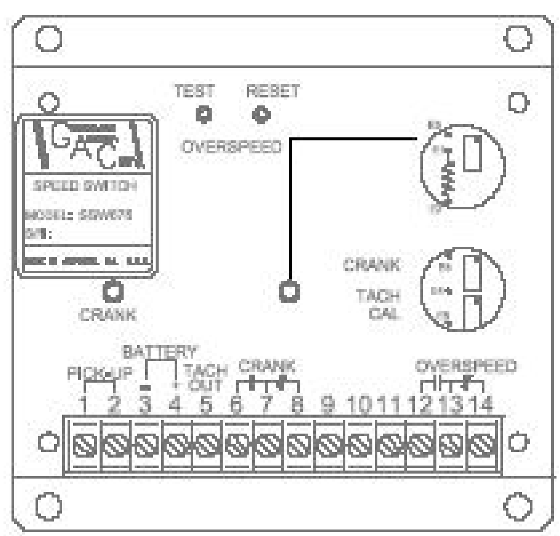


Replace the cover on the speed switch.

Remove the signal generator.

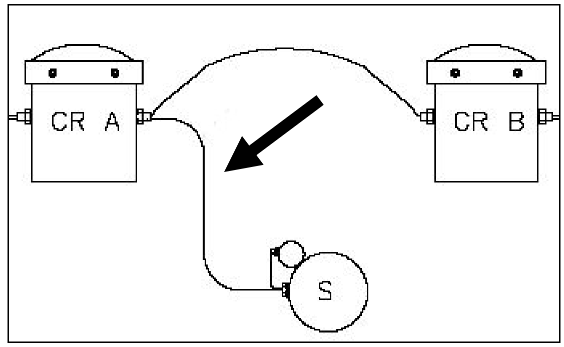
Connect the GRAY/RED (MPU +) wire at PICK-UP terminal 1 at the speed switch.

Connect the GRAY/BLK (MPU -) wire at PICK-UP terminal 1 at the speed switch.

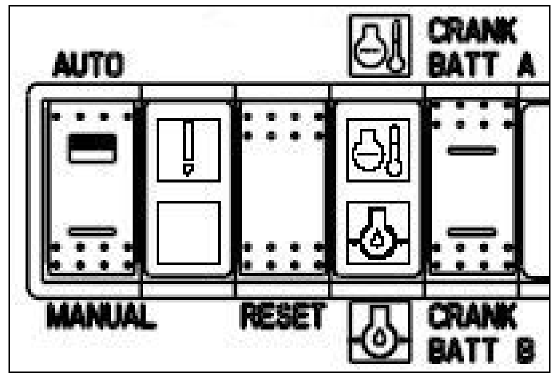


Crank Terminate Adjustment and Testing (Cont)

Reconnect the Contactor to Starter Cable (Cummins Fire Power Part No 9762) at the starter. Refer to <u>Drawing 9767</u> in Section 18.



Test



NOTE: Monitor fire pump controller operations from the controller. Check for the crank terminate signal at the input terminals and observe that the controller removes the crank output to the engine.

Connect a digital voltmeter at crank terminate output of the local control panel between TB2 (+) and TB11 (-). Refer to <u>Drawing 8512 Sheet 1</u> in section 18.

NOTE: The engine's rated speed is displayed on the <u>Field Setting Tag</u> described in Section 2.

Place the AUTO/MANUAL rocker switch in the AUTO position.

Start the engine from the fire pump controller.

Observe that the engine starts and accelerates to about rated speed.

Observe that the CRANK terminal LED on the speed switch is illuminated.

Check that the local digital voltmeter indicates the 12 VDC or 24 VDC signal output voltage.

When testing is done, stop the engine.

Remove the digital voltmeter.

Close the cover on the engine control panel.

Isolated Acceptance Testing

Demonstrate the manual local start, operation, and shutdown of the fire pump from the engine's local starter-solenoid controls. Demonstrate that the engine will operate in the event of blown fuses or other faults in the local control panel. Demonstrate manual engine speed control. Manual raw water valve operations are required.

Demonstrate the manual local start, operation, and shutdown of the fire pump from the engine's control panel. Demonstrate that the engine starts, operates at speed, and stops in the event that the fire pump controller is not functioning.

Demonstrate the start of the fire pump engine using each battery set separately.

Demonstrate that the fire pump engine alternator operates while the engine is running. Demonstrate that any customer supplied battery charging systems operate when the engine is not running.

Demonstrate engine startup, operation, and shutdown of the engine with each of the redundant ECM.

Check that engine fault codes are not being set during normal operations.

Integrated Acceptance Testing

Demonstrate the start-up, operation, and shutdown of the fire pump engine in response to operations of the customer-installed fire pump controller. Perform this testing with the testing of the fire pump controller.

Demonstrate that the fire pump controller provides design indications and/or alarms for simulated engine oil pressure, water temperature, and overspeed faults.

Demonstrate the actual operation of the crank terminate output from the overspeed switch.

Participate in any flushing, pressure testing, flow testing, or capacity testing required for the fire protection system.

Complete the Cummins Fire Power Start-Up Inspection (SUI) Checklist. This is available on the Cummins FirePower wed site (www.cumminsfirepower.com/startup).

When these items have been demonstrated, contact operating personnel responsible for fire protection system that engine is ready for service.

General Operating Information

Cummins fire pumps are tested before being shipped from the factory and are ready to put to work in application regarding to fire emergencies.

Correct care of your engine will result in longer life, better performance, and more economical operation.

Follow the daily maintenance checks listed in Maintenance Guidelines, Section 4.

Check the water temperature and oil pressure indicators, warning lights, and other gauges daily to make sure they are operational.

Normal Remote Starting Procedure

The fire pump engine starts automatically upon receipt of the start command from the customer installed fire control panel. The remote command starts the engine when the AUTO/MANUAL rocker switch at the local; control panel is in the AUTO position. The remote start command consists of either the Crank A or the Crank B signal. Only one should be selected.

The engine continues to operate as long as the run signal is present. When the run signal is lost, the engine promptly stops.

When the engine starts, the crank terminate signal is sent to the fire control panel to indicate that the engine is running. How this is displayed depends upon the fire control panel manufacturer. This indication should be checked in the event that an automatic start is initiated. If the signal is not present, the engine can be started locally by using the Emergency Starting Procedure in this section.

The engine may be stopped locally by selecting the manual position on the AUTO/MANUAL rocker switch and by pressing the local RESET switch.

Normal Local Starting Procedure

Overview

The fire pump engine is started locally for testing and maintenance. Local starts for testing will be performed at rated speed. That is, the engine starts and promptly ramps up to operating speed. If it is necessary to operate the engine at idle speed for maintenance or troubleshooting, the engine speed must be manually reduced. After maintenance or troubleshooting, the speed must be manually reset to the rated value shown on the Field Setting Tag in see Section 2.

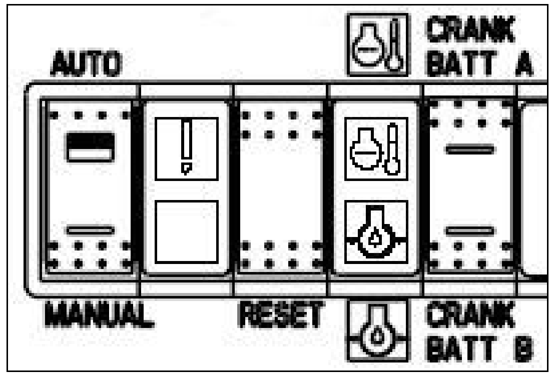
Local Starting Procedure for Testing

CAUTION

To prevent damage to the starter, do not engage the starting motor more than 15 seconds. Wait 15 seconds between each attempt to start (electrical starting motors only).

Start the Engine

Press the MANUAL position on the AUTO/MANUAL rocker switch.



Observe the battery voltages displayed on the engine control panel. Use the battery with the highest indicated voltage.

NOTE: Depress the selected switch for up to 15 seconds or until the engine starts. Repeat up to three times if necessary.

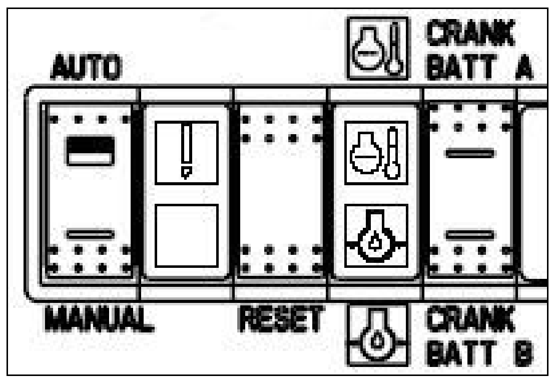
Start the engine using either the CRANK BATT A or the CRANK BATT B rocker switch positions.

NOTE: If the engine does not start after three attempts, check the fuel supply system. Absence of blue or white exhaust smoke during cranking indicates no fuel is being delivered.

Engine oil pressure must be indicated on the gauge within 15 seconds after starting.

Stop the Engine

To stop the engine, select the AUTO position on the AUTO/MANUAL rocker switch and press the RESET switch.



Local Starting Procedure for Maintenance or Troubleshooting

Engines used in fire pumps or standby service are expected to transition from crank to full load within a short period of time.

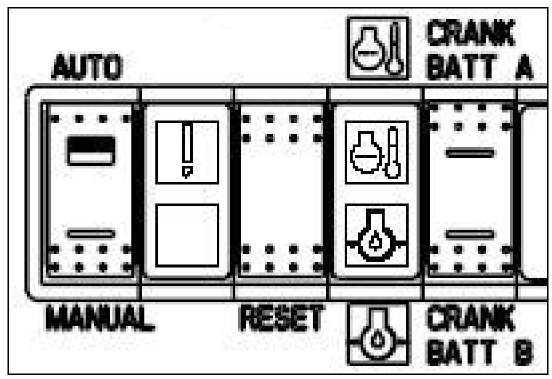
CAUTION

Do not idle the engine for excessively long periods. Long periods of idling (more than 10 minutes) can damage an engine because combustion chamber temperatures drop so low the fuel will not burn completely. This will cause carbon to clog the injector spray holes and piston rings, and can cause the valves to stick. If the engine coolant temperature becomes too low (60°C [140°F]), raw fuel will wash the lubricating oil off the cylinder walls and dilute the crankcase oil; therefore, all moving parts of the engine will not receive the correct amount of lubrication.

Adjust the fuel pump as per LATER to get idle speed.

Manually position the fuel pump at mid throttle position.

Press the MANUAL position on the AUTO/MANUAL rocker switch.



CAUTION

To prevent damage to the starter, do not engage the starting motor more than 15 seconds. Wait 15 seconds between each attempt to start (electrical starting motors only).

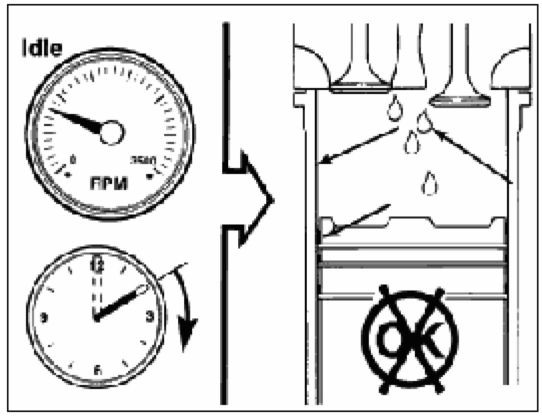
Start the engine using either the CRANK BATT A or the CRANK BATT B switch positions.

NOTE: If the engine does not start after three attempts, check the fuel supply system. Absence of blue or white exhaust smoke during cranking indicates no fuel is being delivered.

Engine oil pressure must be indicated on the gauge within 15 seconds after starting.

CAUTION

Do not operate the engine at low idle for long periods. Long periods at low idle, more than 10 minutes, can damage an engine because combustion chamber temperatures will decrease and the fuel will not completely burn. This will cause carbon to build up around the injector spray holes and piston rings, which can cause the valves to stick. To avoid damage, operate the engine at higher idle.



When the engine starts, immediately position the throttle linkage to an idle speed setting of about 700 RPM.

To stop the engine, select the AUTO position on the AUTO/MANUAL rocker switch and press the RESET switch.

Adjust the engine to operate at rated speed as per in this section.

Jumpering the Batteries

NOTE: If a battery charging system is not provided, the engine can be started using known good batteries to provide a temporary power source. Once the engine is started, disconnect the added batteries and allow the engine's alternator to charge the existing batteries. It may take some time to charge the batteries with this method.

NOTE: For maintainable lead acid batteries as supplied by Cummins N Power, check the state of charge by the measurement of battery cell specific gravity. Refer to Battery Testing in Section 12 for more information.

WARNING

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

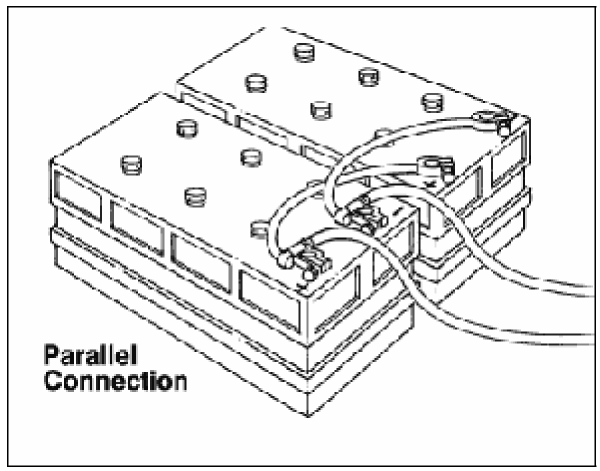
CAUTION

When using jumper cables to start the engine, make sure to connect the cables in parallel: Positive (+) to positive (+) and ground (-) to ground (-).

The accompanying illustration shows a typical parallel battery connection. This arrangement, positive (+) to positive (+), doubles the cranking amperage.

Use this type of connection to jump start the engine.

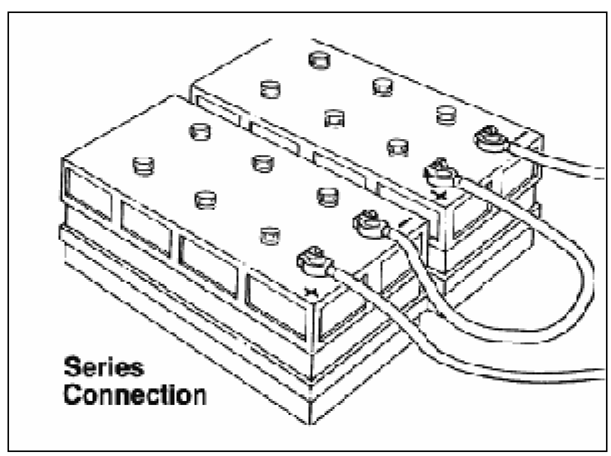
For a 24 VDC system, two or more 12 VDC batteries are connected in the parallel connection as shown. If jumpering a 24 VDC battery setup, another 24 VDC battery pair is required as the source.



The accompanying illustration shows a typical series battery connection.

This arrangement, positive (+) to negative (-), doubles the voltage.

Do not use this type of connection to jump start the engine using a second 12 VDC battery.



Operating the Engine

Monitor Operating Values Frequently

Monitor the oil pressure and coolant temperature gauges frequently. Refer to Lubricating Oil System Specifications or Cooling System Specifications in Section 15 for recommended operating pressures and temperatures. Shut off the engine if any pressure or temperature does not meet the specifications.

Do not exceed a maximum coolant temperature (93°C [220°F]). The pressure cap (or radiator cap) must meet the minimum pressure of 48 kPa [7 psi].

CAUTION

Continuous operation with low coolant temperature (below 60°C [140°F]) or high coolant temperature (above 100°C [212°F]) can damage the engine.

Verify raw water coolant pressure and flow.

Monitor Engine Condition Periodically

Most engine failures give an early warning. Look and listen for changes in performance, sound, or engine appearance that can indicate service or engine repair is needed. Some changes to look for are as follows:

- Engine misfires
- Vibration
- Unusual engine noises
- Fuel, oil, or coolant leaks
- Sudden changes in engine operating temperature or oil pressure
- Excessive smoke
- Loss of power
- An increase in oil consumption
- An increase in fuel consumption

Emergency Manual Starting Procedures

Emergency Manual Starting Procedures

Overview

The engine starts automatically in the event of a fire emergency. However, if it fails to start automatically, the engine can be started locally by either of two means. The Normal Local Starting Procedure in this section can be used to start the engine if it fails to start because of a failure in the remote fire control system. Operating the engine with this procedure will automatically control raw water flow.

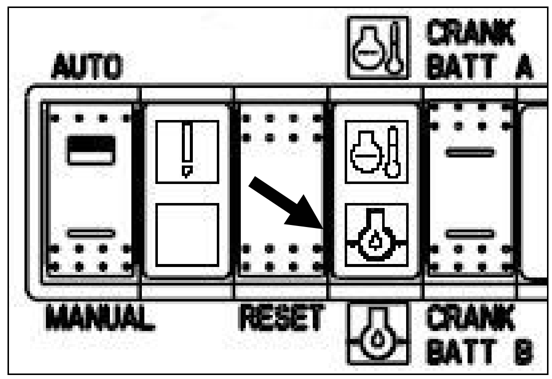
Additionally, manual means are available to start the engine in the event of some local failures. This procedure requires the manual operation of the raw water valves and the use of the manual starting lever on either of the two starting solenoids.

Use the following procedures as specified:

If the red low lube oil pressure light is illuminated, attempt an Emergency Manual Mode Electrical Start.

If the red low lube oil pressure light is not illuminated, attempt an Emergency Manual Mode Non-Electrical Start.

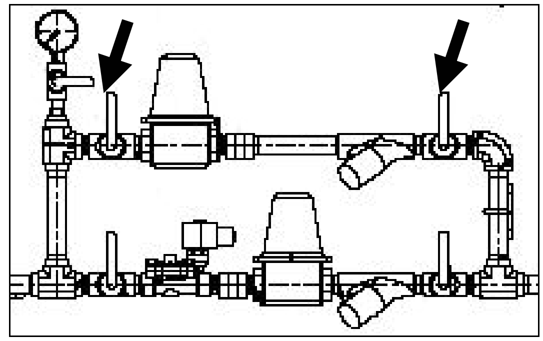
Also, if the fuel shutoff valve is known to be faulted, attempt an Emergency Manual Mode Non-Electrical Start.



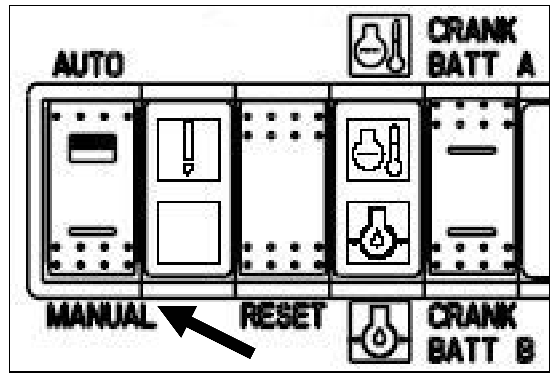
Emergency Manual Mode Electrical Start

Starting the Engine

Open both manual valves in the raw water bypass supply piping.



Press the MANUAL position on the AUTO/MANUAL rocker switch.

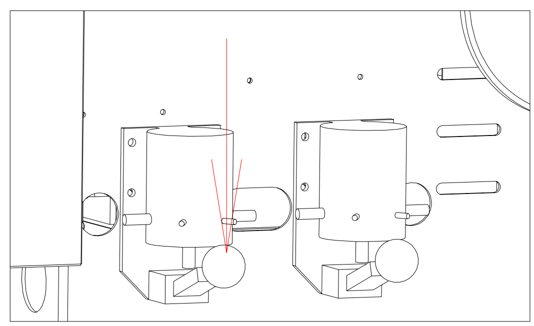


NOTE: Use the lever on either solenoid. If one does not crank the engine, then use the other.

Depress the lever on the selected solenoid to start the engine.

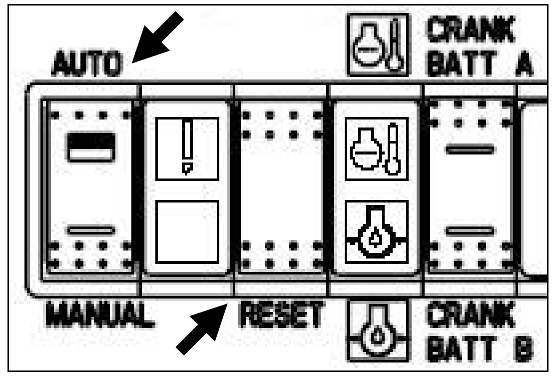
When the engine starts, release the lever.

If the engine cranks but does not start, try the Manual Mode Non-Electrical Start procedure in this section.



Stopping the Engine

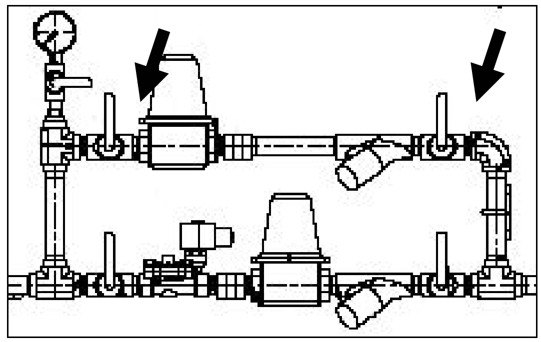
When emergency operation is done, stop the engine by pressing the AUTO position on the AUTO/MANUAL rocker switch and then press the RESTE$T switch..



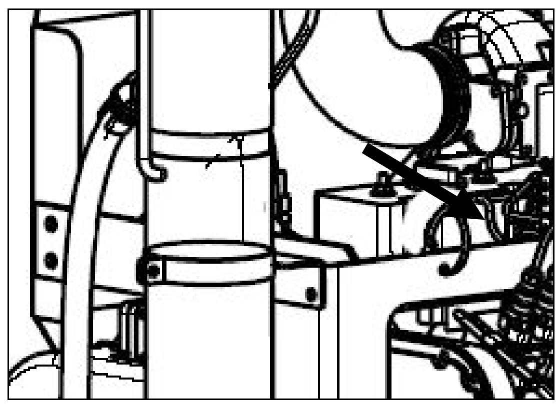
Emergency Manual Mode Non-Electrical Start

Starting the Engine

Open both manual valves in the raw water bypass supply piping.

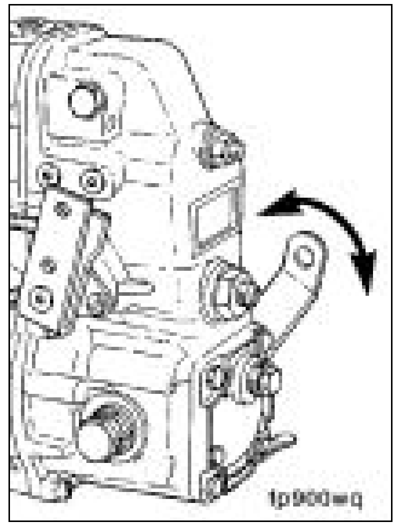


Detach coil of stainless steel wire located on heat exchanger bracket.



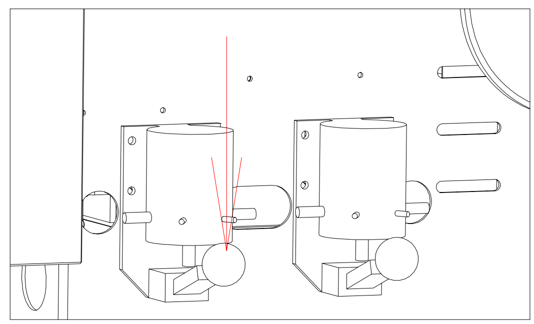
Using stainless steel wire, securely fasten the fuel pump shutoff valve lever in position shown to allow engine to run.

To stop engine, release wire and move lever to stop position (opposite of run).



NOTE: If either crank solenoid lever does not crank the engine, use the other.

Press down on the crank solenoid lever handle until the engine starts.

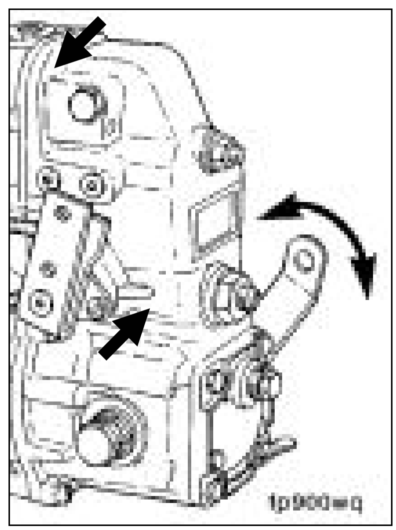


Stopping the Engine

When emergency operation is done, stop the engine by removing the stainless steel wire from the fuel pump shutoff valve lever.

If required, push the lever to the stop position.

Be sure to store the wire on the heat exchanger bracket.



Starting Procedure - After Extended Shutdown or Oil Change

Complete the following steps after each oil change, or after the engine has been shut off for more than 30 days to make sure the engine receives the correct oil flow through the lubricating oil system:

Bump the engine. Refer to Pre-Lubricate the Engine in this section.

Depending upon the nature of the shutdown, perform other installation checks in this section as appropriate.

Start the engine. Refer to Normal Local Starting Procedure in this section.

If required, vent the fuel system. Refer to Air in Fuel in Section 12.

Follow the Normal Starting Procedure in this section. The engine will run at idle only until the minimum oil pressure is detected by the ECM.

Electronic Controlled Fuel System

The engine control system is an electronically operated fuel control system that also provides many operator and engine or equipment features.

The base functions of the control system include fueling and timing control, limiting the engine speed operating range between the low- and high-idle set points, and reducing exhaust emissions while optimizing engine performance.

The control system uses inputs from the operator and its sensors to determine the fueling and timing required to operate at the desired engine speed.

The electronic control module (ECM) is the control center of the system. It processes all of the inputs and sends commands to the fuel system and engine control devices.

The ECM performs diagnostic tests on most of its circuits and will activate a fault code if a problem is detected in one of these circuits. Along with the fault code identifying the problem, a snapshot of engine's operating parameters at the time of fault activation is also stored in memory.

Some fault codes will cause a diagnostic lamp to activate to signal the driver.

The ECM communicates with service tools through an SAE J1939 datalink.

Some engines and equipment will have J1939 networks on them that link many of the "smart" controllers together. Engine control devices can temporarily command engine speed or torque to perform one of the devices' functions.

The control system utilizes a number of sensors to provide information on engine operating parameters. These sensors include:

- Coolant temperature sensor
- Intake air temperature sensor
- Intake manifold pressure sensor
- Oil pressure switch
- Engine speed/position sensor
- Water-in-fuel sensor

Engine Protection System

The engines are equipped with an engine protection system. The system monitors critical engine temperatures and pressures and will log diagnostic faults when an over or under normal operation condition occurs.

If an out-of-range condition exists and engine de-rate action is to be initiated, the operator will be alerted by an in-cab WARNING lamp. The WARNING lamp will blink or flash when out-of-range conditions continue to worsen.

When the red STOP lamp is illuminated, the driver must pull to the side of the work area, when it is safe to do so, to reduce the possibility of engine damage.

NOTE: Engine power and speed will be gradually reduced depending on the level of severity of the observed condition. The engine protection system will not shut down the engine unless the engine protection shutdown feature has been enabled.

Engine Protection Shutdown

This feature automatically shuts off the engine when the temperature, pressure, and coolant level sensors indicate the engine is operating over or under normal operating conditions.

The red STOP lamp in the cab will flash for 30 seconds prior to shutdown to alert the driver.

Engine Protection Shutdown Override

This feature allows the operator to override a pending engine shutdown.

Prior to engine shutdown, the red STOP lamp will flash for 30 seconds to notify the operator that the engine is about to shut down.

The operator can override the engine shutdown through use of an OEM switch.

If the engine is not equipped with a clutch switch, then the OEM will provide a dash-mounted switch marked as the ENGINE PROTECTION SHUTDOWN OVERRIDE switch.

When the operator triggers this switch while the red lamp is flashing, a timer within the ECM will reset and allow the engine to run for an additional 30 seconds before engine shutdown occurs.

Each time the operator triggers the override switch, the timer within the ECM is reset, thus allowing the engine to run for an additional 30 seconds.

Diagnostic Fault Codes

The control system can show and record operation anomalies that present themselves as fault codes. These codes will make troubleshooting easier. The fault codes are recorded in the ECM. They can be read using the fault lamps in the dash or with the INSITE™ service tool.

NOTE: Not all engine or control system anomalies are shown as fault codes.

There are three types of system codes:

- Engine electronic control system fault codes

- Engine protection system fault codes
- Engine maintenance indicator codes

All fault codes recorded will either be active (fault code is currently active on the engine) or inactive (fault code was active at some time, but is not active at the moment).

Most of the electronic fault codes will light a lamp when they are active. There are three possible lamps that can be lit when a fault is active:

The WARNING or CHECK ENGINE lamp is yellow and indicates the need to repair the fault at the first available opportunity.

The STOP or STOP ENGINE lamp is red and indicates the need to stop the engine as soon as it can be safely done. The engine should remain shut down until the fault can be repaired.

The MAINTENANCE or FLUID lamp will illuminate when an engine maintenance function needs to be performed.

NOTE: The names and colors of these lamps can vary by equipment manufacturer.

Some engines will also have a WAIT-TO-START lamp and a WATER-IN-FUEL lamp. The WAIT-TO-START lamp is illuminated during the preheating time that takes place at key-on during cold-weather starting. To minimize cranking time during cold-weather starting, the engine should not be cranked until the WAIT-TO-START lamp has been extinguished.

The WATER-IN-FUEL lamp indicates that the engine's water-in-fuel separator needs to have the water drained out of it. This task should be performed as soon as possible whenever this lamp is illuminated.

The fault code will flash in the following sequence: First, a WARNING (yellow) lamp will flash. Then there will be a short 1- or 2-second pause, after which the number of the recorded fault code will flash in STOP (red) lamp. There will be a 1- or 2-second pause between each number. When the number has finished flashing in red, a yellow lamp will appear again. The three-digit code will repeat in the same sequence.

The lights flash each fault code out two times before advancing to the next code. To skip to the next fault code sooner, move the idle speed adjust switch (if equipped) momentarily to the "(+)" position. You can go back to the previous fault code by momentarily moving the idle speed adjust switch (if equipped) to the "(-)" position. If only one active fault is recorded, the control system will continuously display the same fault code, even when either "(+)" or "(-)" switch is depressed.

The explanation and correction of the fault codes are explained in the Troubleshooting and Repair Manual, Electronic Control System, ISB and QSB5.9 Engines, Bulletin 3666194.

When not using the diagnostic system, turn off the diagnostic switch, or remove the shorting plug. If the diagnostic switch is left on or the shorting plug in, the electronic control module will not log some faults.

Fault Code Snapshot Data

This data makes up additional fault code information that can be obtained by using the INSITE™ service tool. The snapshot data records the value or state of the control system sensors and switches at the time a fault occurred. This data is stored for the first occurrence of the fault, since was last cleared, and for the most recent occurrence. This data can be very valuable when trying to re-create or determine engine operating conditions at the time of a fault.

Electromagnetic Interference (EMI)

General Information

Some engine applications utilize accessories (CB radios, mobile transmitters, etc.) that generate and use radio frequency energy that, if not installed and used properly, can cause electromagnetic interference (EMI) conditions to exist between the accessory and Cummins electronic controlled fuel system. Cummins is not liable for any performance problems with either the fuel system or the accessory due to EMI. EMI is not considered by Cummins to be an engine failure and therefore is not warrantable.

System EMI Susceptibility

Your Cummins product has been designed and tested for minimum sensitivity to incoming electromagnetic energy. Testing has shown that there is no engine performance degradation at relatively high energy levels; however, if very high energy levels are encountered, then some non-critical diagnostic fault code logging can occur. The fuel system EMI susceptibility level will protect your engine from most, if not all, electromagnetic energy-emitting devices that meet the Federal Communications Commission legal requirements.

System EMI Radiation Levels

Your Cummins product has been designed to emit minimum electromagnetic energy. Electronic components are required to pass various Cummins and industry EMI specifications. Testing has shown that when the engine is properly installed, it will not interfere with onboard communication equipment or with the vehicle's, equipment's, or vessel's ability to meet any applicable EMI standards and regulated specifications.

If an interference condition is observed, follow the suggestions below to reduce the amount of interference:

- Locate the receiving antenna as far away from the engine and as high as possible.
- Locate the receiving antenna as far away as possible from all metal obstructions (e.g., exhaust stacks)
- Consult a representative of the accessory supplier in your area to:
- Calibrate accurately the device for proper frequency, power output, and sensitivity (both base and remote site devices must be properly calibrated)
- Obtain antenna reflective energy data measurements to determine the optimum antenna location
- Obtain optimum antenna type and mounting arrangement for your application
- Make sure your accessory equipment model is built for maximum filtering to reject incoming electromagnetic noise.

Emergency Starting With Failed ECM

Stop the engine.

Switch between ECM “A” and ECM “B”.

Restart the engine.

When practical, replace the failed ECM.

Emergency Manual Stopping Procedure

Section 4 - Maintenance Guidelines

Section Contents

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Overview

Cummins Inc. recommends that the engine be maintained according to the Maintenance Schedule in this section.

If the engine is operating in ambient temperatures below -18°C [0°F] or above 38°C [100°F], perform maintenance at shorter intervals. Shorter maintenance intervals are also required if the engine is operated in a dusty environment or if frequent stops are made. Contact your local Cummins Authorized Repair Location for recommended maintenance intervals.

Some of these maintenance procedures require special tools or must be completed by qualified personnel. Contact your local Cummins Authorized Repair Location for detailed information.

If your engine is equipped with a component or accessory not manufactured by Cummins Inc., refer to the component manufacturer's maintenance recommendations.

Use the form provided in this section as a convenient way to record maintenance performed.

Tool Requirements

Most of the maintenance operations described in this manual can be performed with common hand tools (metric and S.A.E. wrenches, sockets, and screwdrivers).

The following is a list of special service tools required for some maintenance operations:

Tool Part Number	Description
CC-2802	Coolant test kit
CC-2800	Refractometer
ST-1273	Pressure gauge
3375045	Torque wrench (0 to 175 ft-lb)
3375049	Oil filter wrench
3376807	Engine coolant and fuel filter wrench
3377161	Digital multimeter
3822525	Belt Tension Gauge, Click-type (for V-ribbed with 6 to 12 ribs)
3824556	Charge air cooler (CAC) pressure kit
3824591	Engine barring gear
3824783	Torque wrench (0 to 300 in-lb)
3824842	M10 Compuchek® fitting
3825157	Fuel Injector Connector Puller
3825156	Fuel Injector Puller

Contact your nearest Cummins Authorized Repair Location for the required service tools.

Sockets	Wrenches	Other
10 mm	8 mm	Engine Barring Gear, Part No. 3377371
12 mm	13 mm	Allen Wrench (8 mm)
13 mm	15 mm	Breaker Bar (3/8-in drive)
15 mm	19 mm	Flat Screwdriver
17 mm	22 mm	Ratchet (3/8-in drive)
18 mm	24 mm	Ratchet (1/2-in drive)
19 mm	17 mm (open end)	Filter Wrenches (75 to 80 mm, 90 to 95 mm, and 118 to 131 mm)
22 mm		Pliers
27 mm		Torque Wrench
		T-Bar Puller (75 mm)

Maintenance Schedule

Daily or Refueling (See Section 5)

Perform the following maintenance activities each day or at each refueling, whichever comes first:

- Air Intake Filter and Piping
- Check Coolant Level
- Check Crankcase Breather Tube
- Check Engine Oil Level
- Drain Fuel-Water Separator

NOTE 1: Must use a heavy-duty year-around antifreeze that meets the chemical composition of GM6038M. The change interval is 500 hours or 1 year, whichever comes first.

Weekly (See Section 6)

Perform the following additional maintenance activities weekly:

- Bleed Fuel Tanks
- Clean Raw Water Strainers
- Check Battery Condition
- Test Run Engine

Every 250 Hours or 6 Months (See Section 7)

Perform the following additional maintenance activities every 250 hours or every six months, whichever comes first:

- Check Engine Coolant Heater
- Check Hose Condition
- General Information
- Inspect Heat Exchanger Zinc Plug
- Check Engine Mounting Bolts
- Check Turbochargers Mounting Nuts
- Inspect Electrical Components
- Check Cooling System Condition
- Check Air Cleaner Service Indicator
- Inspect Air Intake System Piping
- Change Lubricating Oil and Filters
- Change Fuel Filter (Spin-on Type)
- Clean Charge Air Cooler

Maintenance Schedule (Cont)

Every 500 Hours or 1 Year (See Section 8)

Perform the following additional maintenance activities every 500 hours or every year, whichever comes first:

- Drain and Flush Cooling System
- Change Coolant Filter
- Vent Fuel Supply Lines
- Vent Injection Pump

NOTE 1: Must use a heavy-duty year-around antifreeze that meets the chemical composition of GM6038M. The change interval is 500 hours or 1 year, whichever comes first.

Every 1500 Hours or 2 Years (See Section 9)

Perform the following additional maintenance activities every 1500 hours or every two years, whichever comes first:

- Check Overspeed Switch Operation
- Check Drive Belt, Tensioner Bearing and Belt Tension
- Check Valve Lash Clearance

NOTE 1: Initial valve lash clearance adjustment; subsequent adjustments must be performed at 1500-hour or 2-year intervals, whichever comes first.

Every 3000 Hours or 4 Years (See Section 10)

Perform the following additional maintenance activities every 3000 hours or every four years, whichever comes first:

- Inspect Turbocharger
- Inspect Viscous Damper
- Inspect Water Pump

Maintenance Record Form

Maintenance Record					
Engine Serial No.			Engine Model		
Owner's Name			Equipment Name/Number		
Date	**Hours or Time Interval**	**Actual Hours**	**Check Performed**	**Performed By**	**Comments**

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Section 5 – Maintenance Procedures –Daily

Section Contents

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Overview

General Information

Preventative maintenance begins with day-to-day awareness of the engine and its system.

On a daily basis, inspect the engine for the following issues:

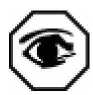
- Leaks
- Loose or damaged parts
- Worn or damaged belts
- Any change in engine appearance
- Odor of fuel

Correct any problems as per the instructions in this manual.

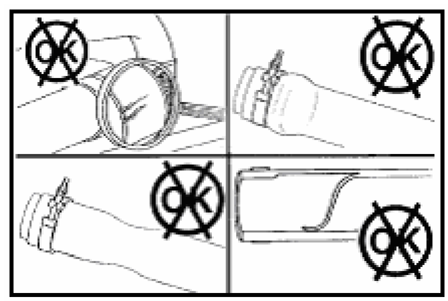
Perform the specific checks in this section only after the engine has been stopped. Do not perform this section if the fire pump is in operation.

Check Air Intake Filter and Piping

Visually inspect the air intake filter and piping daily for wear points and damage to piping, loose clamps, or punctures.



Replace damaged air filter or pipes, and tighten loose clamps, as necessary, to prevent the air system from leaking. Refer to Adjustment, Repair and Replacement in Section 12 for replacement procedures.

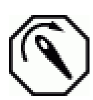


Check for corrosion under the clamps and hoses of the intake system piping. Corrosion can allow corrosive products and dirt to enter the intake system.

Disassemble and clean, as required. Refer to Adjustment, Repair and Replacement in Section 12 for replacement procedures.

Torque loosened clamps.

Torque Value: 8 N•m [72 in-lb]



Check Coolant Level

WARNING

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

CAUTION

Never use a sealing additive to stop leaks in the cooling system. This can result in cooling system plugging and inadequate coolant flow, causing the engine to overheat.

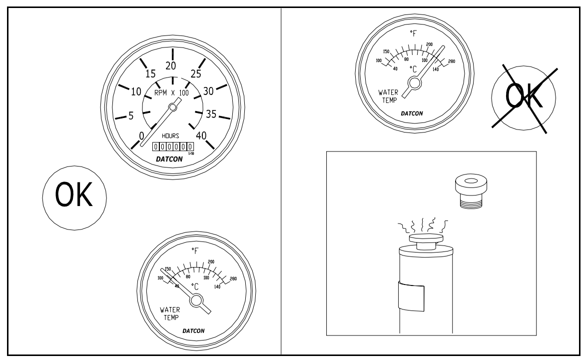
CAUTION

Do not add cold coolant to a hot engine. Engine castings can be damaged. Allow the engine to cool to below 50°C [120°F] before adding coolant.

Press down, unscrew and remove the pressure cap.

NOTE: Coolant level should be just below the bottom of the fill neck. It must be above the raw water tubes.

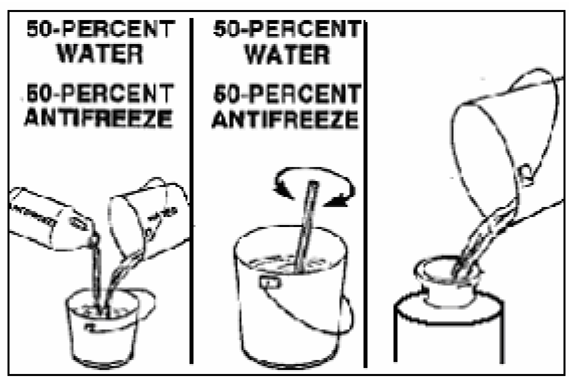
Check coolant level.



NOTE: Make up coolant added to the engine must be mixed with the correct proportions of antifreeze, supplemental coolant additive (if recommended by Cummins), and water to avoid engine damage.

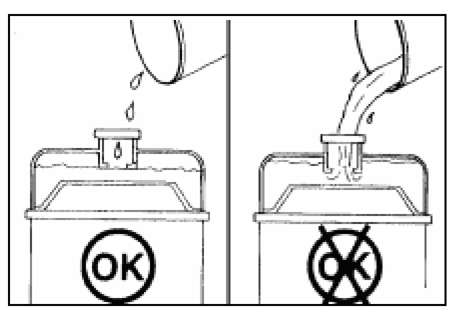
Coolant specifications can be found in <u>Coolant Recommendations and Specifications</u> in Section 15.

If required, prepare a coolant solution.



Fill the cooling system with coolant to the bottom of the fill neck in the coolant heat exchanger.

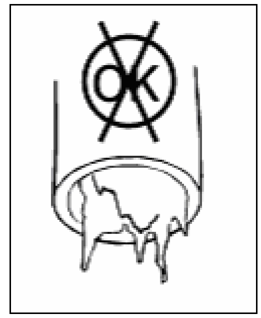
When done, press down and screw in the pressure cap.



Check Crankcase Breather Tube

Inspect the breather tube for sludge, debris, or ice in the tube.

If the breather tube is obstructed or blocked, clean it.



Check Lubricating Oil Level

CAUTION

Never operate the engine with oil level below the L (low) mark or above the H (high) mark. Poor engine performance or engine damage can occur.

NOTE: Wait at least 15 minutes after shutting off the engine to check the oil level. This allows time for the oil to drain into the oil pan.

Check the oil level on the dipstick.

NOTE: If the lube oil is excessively high, troubleshoot as per Oil Level Rises in Section 17.

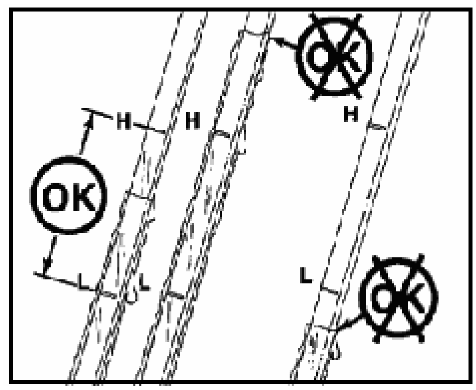
If the lube oil level is greater than the high mark, drain the excessive oil. Refer to Drain Oil in Change Lubricating Oil and Filters in Section 7.

If the lube oil level is below the low mark, add oil. Refer to Fill Oil in Change Lubricating Oil and Filters in Section 7.

NOTE: If the lube oil is excessively low, troubleshoot as per Lubricating Oil Consumption Excessive in Section 17.

Oil Capacity (Low to High Mark Oil): 3.8 liters [4 U.S. qt]

For additional lubricating oil recommendations and oil pan capacity information, refer to Lubricating Oil Recommendations and Specifications and Lubricating Oil System Specifications in Section 15.



Drain Fuel-Water Separator

Cummins Inc. requires a fuel-water separator or fuel filter be installed in the fuel supply system. Drain the water and sediment from the separator daily.

WARNING

Drain the water-fuel separator into a container and dispose of in accordance with local environmental regulations. If more than

NOTE: If more than 59 ml (2 oz) is drained, refilling of the filter is required to prevent hard starting.

Use your hand to open the drain valve. Turn the valve counterclockwise approximately 3½ turns until the valve drops down 25.4 mm [1 in] and draining occurs.

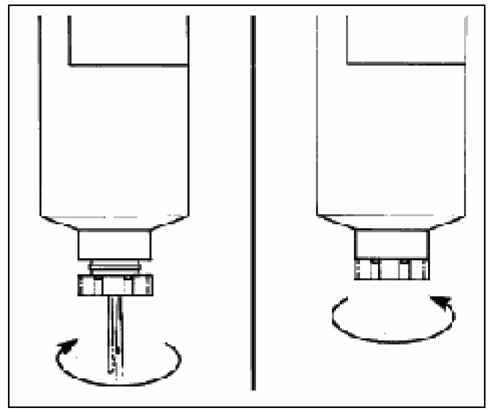
Drain the filter sump until clear fuel is visible.

CAUTION

When closing the drain valve, do not over-tighten the valve. Over-tightening can damage the threads.

Close the valve by lifting the valve and turning it clockwise until it is hand-tight.

If required, refill the filter. Refer to Change Fuel Filter in Section 7 for removal and installation instructions.

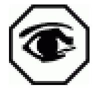


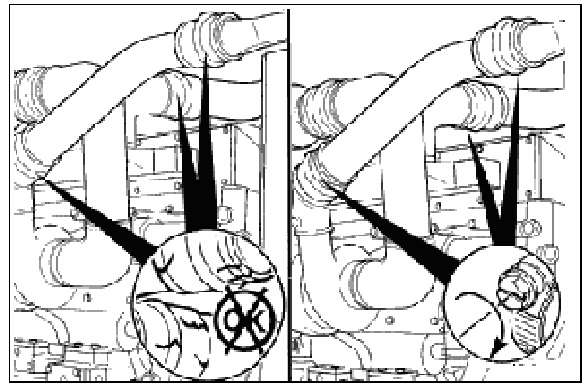
Inspect Charge Air Cooler Piping

Inspect the charge air piping and hoses daily for holes, cracks, or loose connections.

Tighten the hose clamps, if necessary.

Refer to the manufacturer's specifications for the correct torque value.



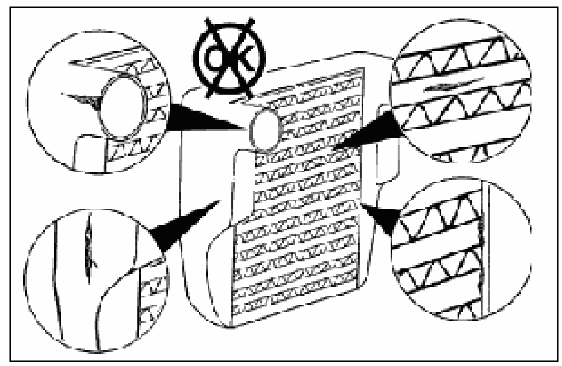


Inspect the charge air cooler for dirt and debris blocking the fins.

Check for cracks, holes, or other damage.

If damage is found, refer to the .



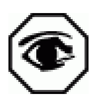


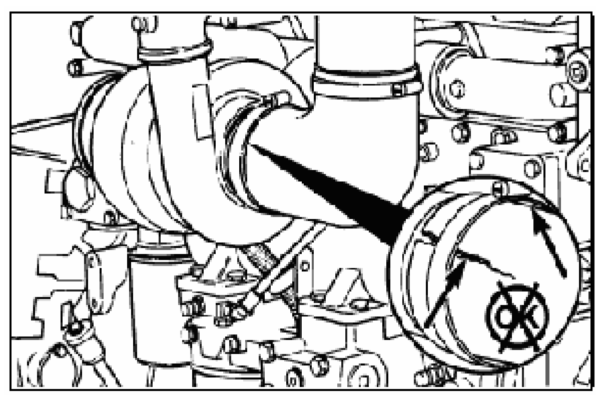
Inspect the intake piping daily for wear points and damage to piping, loose clamps, or punctures that can damage the engine.

Replace damaged pipes and tighten loose clamps as necessary to prevent the air system from leaking.

Torque Value: 8 N•m [72 in-lb]

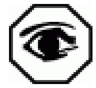
Check for corrosion under the clamps and hoses of the intake system piping. Corrosion can allow corrosive products and dirt to enter the intake system. Disassemble and clean as required.





Check Coolant Heat Exchanger Piping

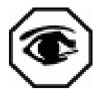
Visually inspect the coolant heat exchanger and piping daily for wear points and damage to piping, loose clamps, or punctures.



Replace damaged tubes, clamps, or pipes, and tighten loose clamps, as necessary, to prevent the coolant system from leaking. Refer to Adjustment, Repair and Replacement in Section 12 for replacement procedures.

Check Coolant Heater Piping

Visually inspect the coolant heat exchanger and piping daily for wear points and damage to piping, loose clamps, or punctures.



Replace damaged tubes, clamps, or pipes, and tighten loose clamps, as necessary, to prevent the coolant system from leaking. Refer to Adjustment, Repair and Replacement in Section 12 for replacement procedures.

Section 6 - Maintenance Procedures – Weekly

Section Contents

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General Information

With the engine not running, perform the daily maintenance checks plus the following:

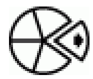
Bleed Fuel Tanks

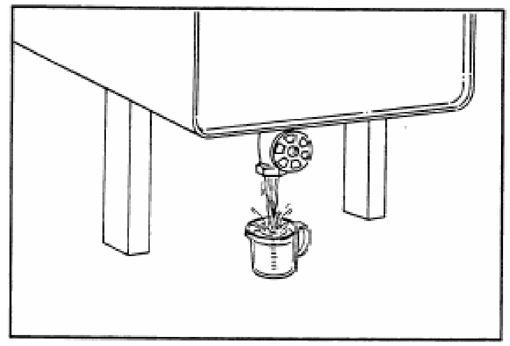
Loosen the fuel tank drain plug or open the drain valve.

Drain approximately 1 cup of fuel to remove water and sediment.

Close the drain valve or tighten the drain plug.

Dispose of the waste fuel in accordance with applicable requirements.





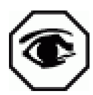
Clean Raw Water Strainers

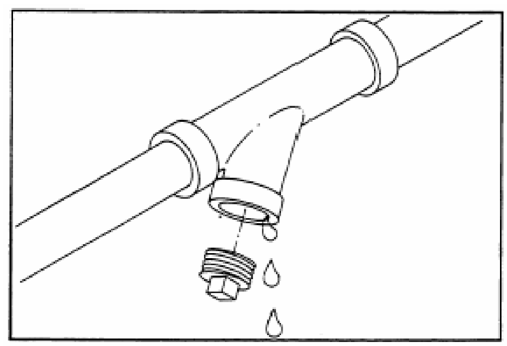
For each raw water strainer, remove the plug.

Inspect and remove any debris.

Install the strainer plugs.

Unless otherwise directed, ensure that the bypass line valves are closed and the normal line valves are open.

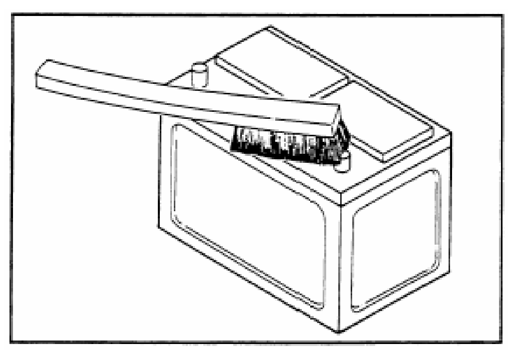




Check Battery Condition

Inspect the condition of the batteries.

Follow the manufacturer's recommendations for inspection and maintenance procedures.

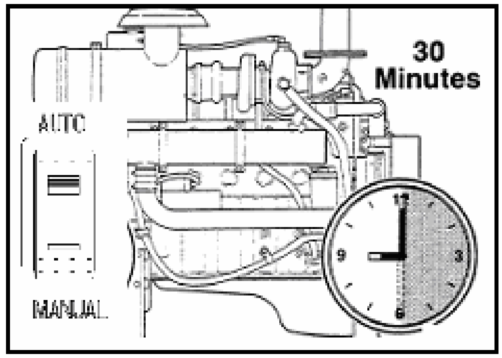


Test Run Engine

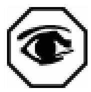
Start Test Run

Select the **MANUAL** position on the AUTO/MANUAL Switch.

Press the **CRANK A** or **CRANK B** switch.



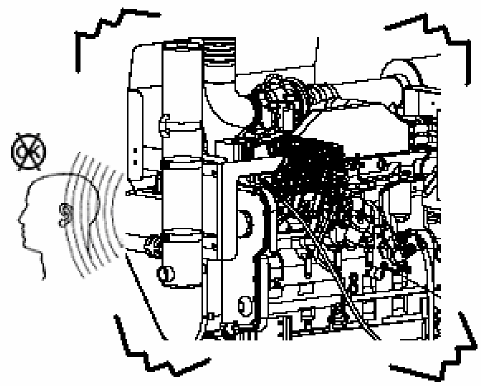
Check Unusual Engine Noise



Run the engine no less than 30 minutes to attain normal running temperature.

During the weekly maintenance check, listen for any unusual engine noise which can indicate that service is required.

Check running indications



Observe that the engine is operating at test speed as follows:

Check oil pressure

Check coolant temperature

Check that both battery voltmeters indicate 12 VDC or 24V DC depending upon the application.

Check that the inlet air restriction indicator has not popped-up.

Check that the ECM Stop signal is not present

Check that the ECM Idle signal is not present

End Test Run

Select the **AUTO** position on the AUTO/MANUAL Switch.

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Section 7 - Maintenance Procedures Every 6 Months or 250 Hours

Section Contents

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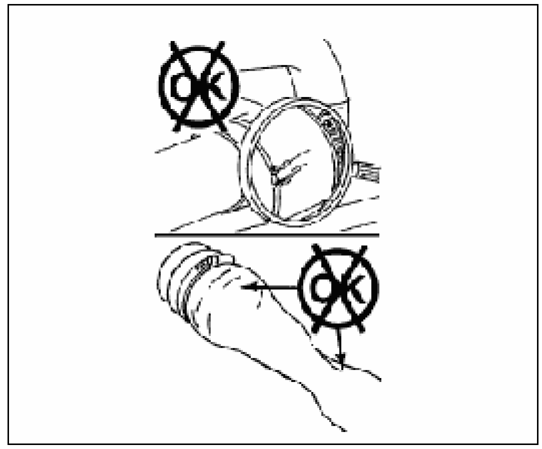
General Information

All checks or inspections listed under daily or previous maintenance intervals must also be performed at this time, in addition to those listed under this maintenance interval.

Check Hose Condition

Inspect the lubricating, fuel, and cooling system hoses and hose connection for leaks or deterioration. Particles of deteriorated hose can be carried through the cooling system and slow or partially stop circulation.

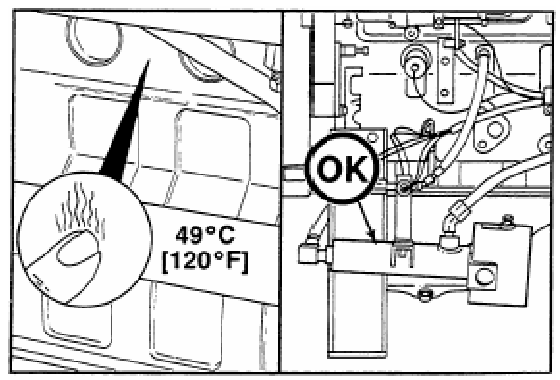


Check Engine Coolant Heater

NOTE: Do not perform this inspection procedure until 24 hours after shutting off the engine.

The engine coolant heater must maintain an engine coolant temperature or 49 °C (120 °F) or above. The engine block must be warm to the touch in the water jacket areas.

If the heater does not appear to be working correctly, contact a Cummins Authorized Repair Location.



Inspect Heat Exchanger Zinc Plug

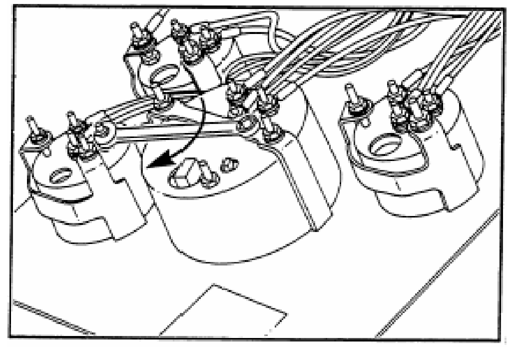
Remove the zinc plug.

Inspect the plug. If it has eroded over 50 percent, replace the plug.

Inspect Electrical Components

Clean and tighten any loose electrical connections.

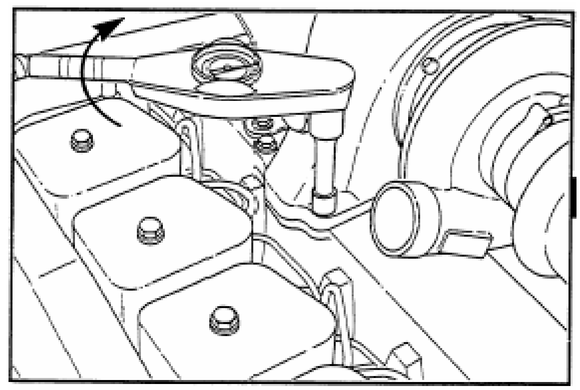
Follow the manufacturer’s recommended procedures for servicing the electrical components and batteries.



Check Turbochargers Mounting Nuts

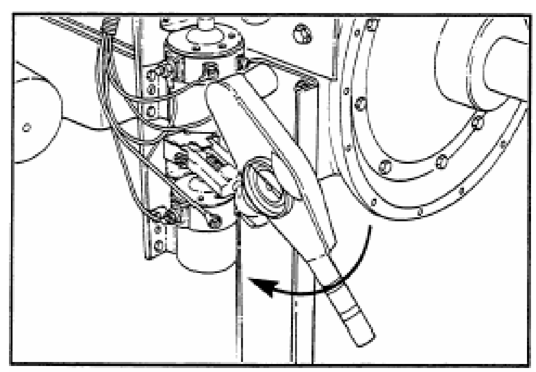
Check the turbocharger mounting nuts. Tighten the mounting nuts.

Torque Value: 65 N•m (50 ft-lb)



Check Engine Mounting Bolts

Check the torque on the engine mounting nuts and bolts. Tighten any that are loose.



Check Cooling System Condition

WARNING

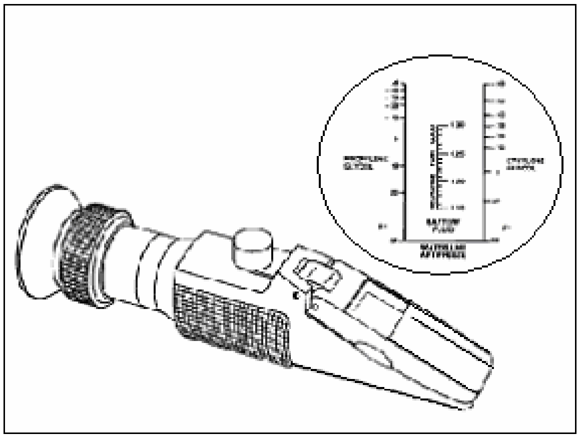
Check the coolant level only when the engine is stopped. Wait until the coolant temperature is below 50 °C (120 °F) before removing the pressure cap. Failure to do so can cause personal injury from heated coolant spray.

Check the antifreeze concentration.

Use a mixture of 50-percent water and 50-percent ethylene glycol-base antifreeze to protect the engine to -37°C [-34°F] year-around.

Antifreeze is essential in any climate. It broadens the operating temperature range by lowering the coolant freezing point and raising its boiling point.

The corrosion inhibitors also protect the cooling system components from corrosion and provide longer component life.



Check Air Cleaner Service Indicator

CAUTION

Never operate the engine without an air cleaner. Unfiltered foreign objects could cause engine damage.

Maximum intake air restriction is 762 mm H2O [30.0 in H2O] for turbocharged engines.

Turbocharged engines must be operated at rated RPM and full load to check maximum intake air restriction. Replace the air cleaner element when the restriction reaches the maximum allowable limit, or clean according to the manufacturer's recommendations.

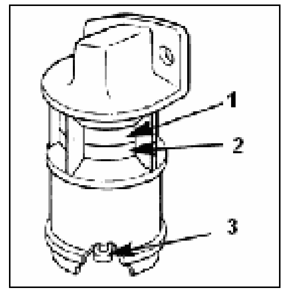
NOTE: Follow the manufacturer's instructions when cleaning or replacing the air cleaner element.

Check the air cleaner service indicator, if equipped.

Change the filter element when the red indicator flag (2) is at the raised position in the window (1).

After the air cleaner has been serviced, push the button (3) to reset the service indicator.

NOTE: Never operate the engine without an air cleaner. Intake air must be filtered to prevent dirt and debris from entering the engine and causing premature wear.



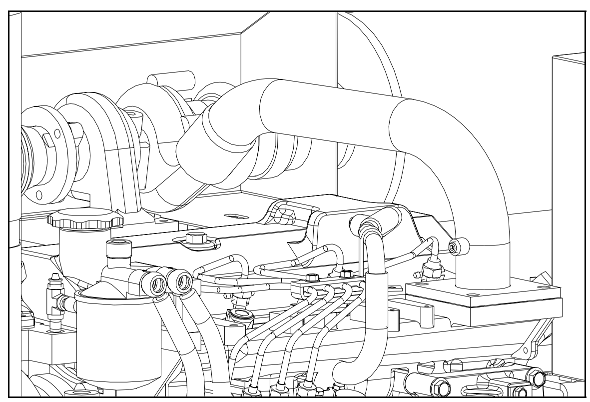
Inspect Air Intake System Piping

Inspect the intake piping for cracked hoses, loose clamps, or punctures that can allow dirt and debris to enter the engine.

Tighten or replace parts as necessary to make sure the air intake system does not leak.

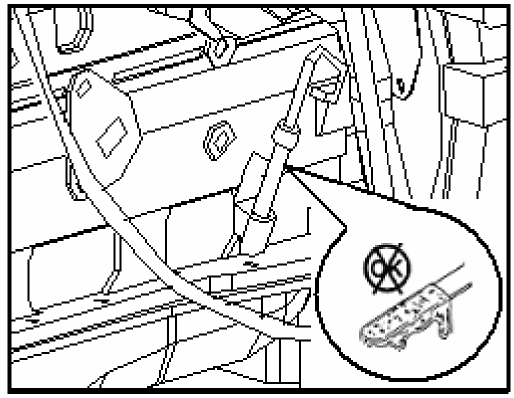
Check for corrosion of the intake system piping under the clamps and hoses. Corrosion can allow corrosive products and dirt to enter the intake system.

Disassemble and clean as required.



Change Lubricating Oil and Filters

Lubricating Oil and Filter Change Interval



Engine oil becomes contaminated and essential oil additives are depleted with use. The amount of contamination is related to the total amount of fuel and oil consumed.

The oil change interval for turbocharged engines is every 6 months or 250 hours.

Change the oil and the filters to remove the contaminants suspended in the oil.

NOTE: If the lubricating oil is drained from the oil pan to make an engine repair, new oil must be used. Do not use oil after it has been drained from the oil pan.

Laboratory and field tests have determined that, when using the recommended quality oils and filters, a turbocharged engine in good condition and equipped with a by-pass oil filter can consume 255 U.S. gallons of fuel for each U.S. gallon of oil in the oil system before the maximum level of oil contamination is reached.

NOTE: Cummins Engine Co. Inc, does not recommend exceeding 25,000 miles and/or 600 hours on oil change intervals.

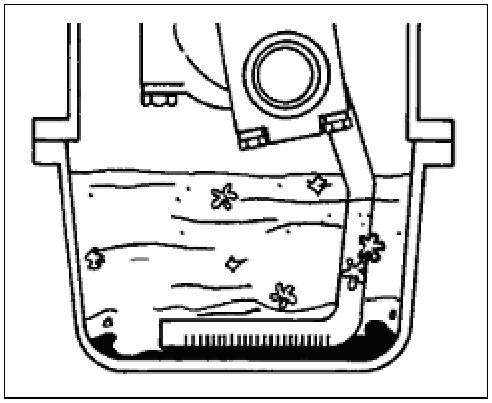
Drain

CAUTION

Avoid prolonged and repeated skin contact with used engine oils. Such prolonged and repeated contact can cause skin disorders or other bodily injury. Wash thoroughly after contact. Keep out of reach of children.

NOTE: If the engine is in service, the oil drain interval of 250 hours or 3 months must be observed.

PROTECT THE ENVIRONMENT: Handling and disposal of used engine oil is subject to federal, state, and local laws and regulations. Use authorized waste disposal facilities, including civic amenity sites and garages providing authorized facilities for receipt of used oil. If in doubt, contact state and local environmental authorities or the Environmental Protection Agency for guidance as to proper handling and disposal of used engine oil.



Change the oil and filters to remove the contaminants suspended in the oil.

NOTE: Drain the oil only when it is hot and the contaminants are in suspension.

CAUTION

Hot oil can cause personal injury.

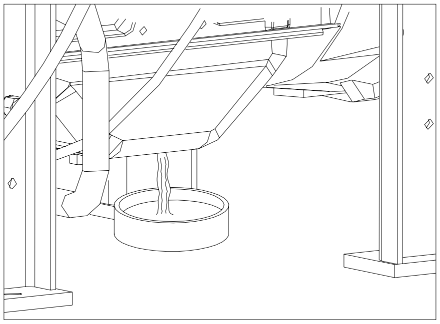
Operate the engine until the water temperature reaches 60°C [140°F].

Shut the engine off.

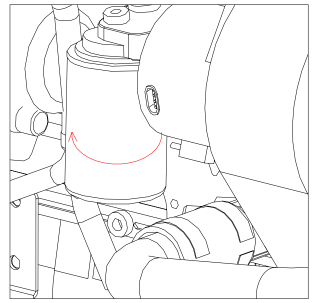
NOTE: Use a container that can hold at least 20 liters [15 qt] of oil.

Remove the oil drain plug.

Drain the oil immediately to make sure all the oil and suspended contaminates are removed from the engine.



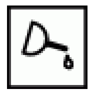
Remove

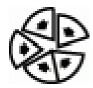


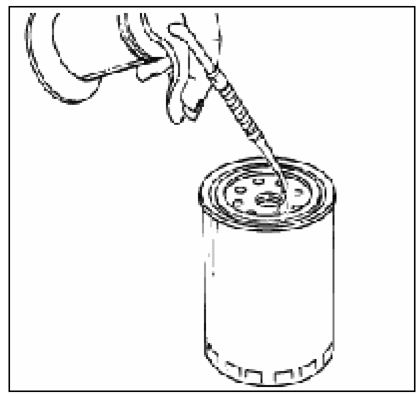
Clean the area around the lubricating oil filter head. Remove the filter. Clean the gasket surface of the filter head.

NOTE: The o-ring can stick on the filter head. Make sure it is removed before installing the new filter.

Install





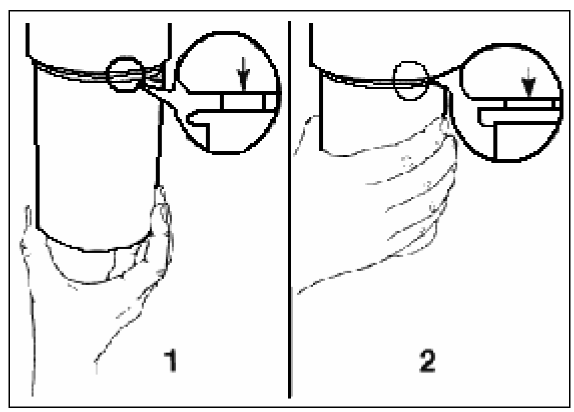


Apply a light film of lubricating oil to the gasket sealing surface before installing the filters.

CAUTION

Mechanical over tightening can distort the threads or damage the filter element seal.

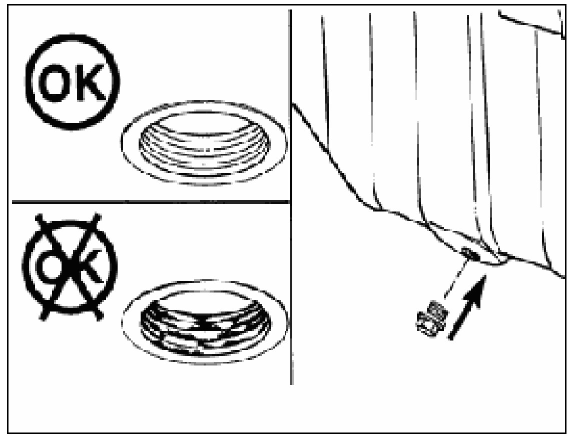
Install the filter as specified by the filter manufacturer.



Check and clean the oil drain plug threads and sealing surface.

Install the oil drain plug.

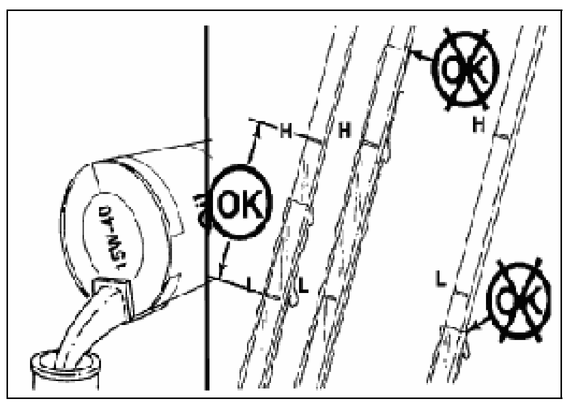
Torque Value: 50 N•m [37 ft-lb]



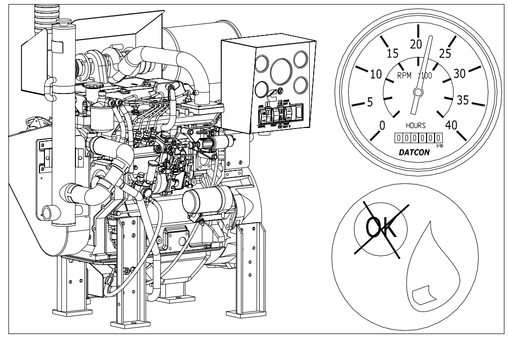
NOTE: Use a high-quality 15W-40 multiviscosity lubricating oil, such as Cummins Premium Blue®, or its equivalent, in Cummins engines. Choose the correct lubricating oil for your operating climate as outlined in Section 15.

Fill the engine with clean oil to the proper level.

NOTE: Capacities assume standard pan. Total system assumes standard pan plus filter.



Operate the engine at idle to inspect for leaks at the filters and the drain plug.

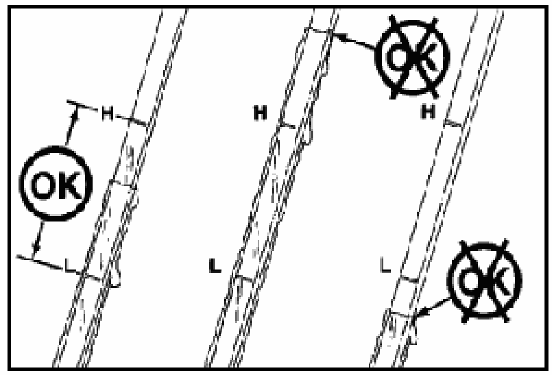


Stop the engine.

Wait approximately 15 minutes to let the oil drain from the upper parts of the engine.

Check the oil level again.

Add oil as necessary to bring the oil level to the H (high) mark on the dipstick.



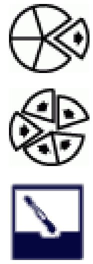
Change Fuel Filter (Spin-on Type)

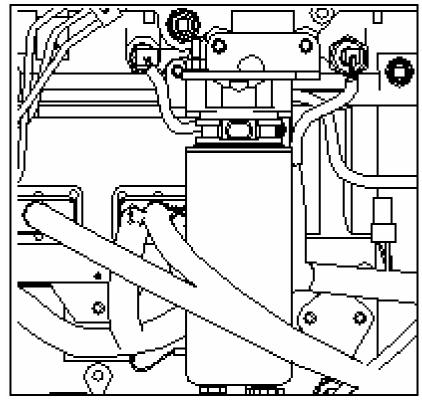
Remove

NOTE: Close any OEM fuel valves (if equipped) to prevent fuel from draining or siphoning.

Clean the area around the fuel filter head. Remove the filters. Clean the gasket surface of the filter head.

Replace the o-ring.

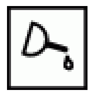


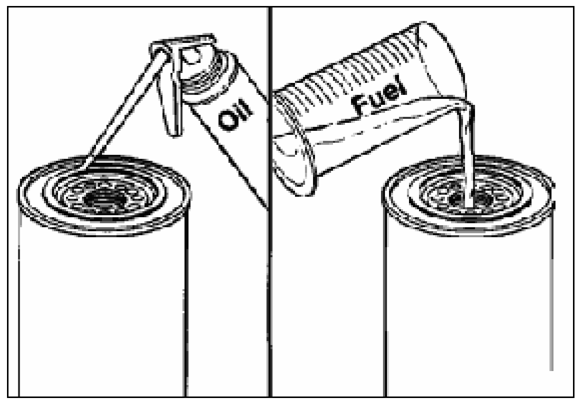


Install

Fill the new filter(s) with clean fuel, and lubricate the o-ring seal with clean lubricating oil.

Fuel-water separator - used in single-filter applications.

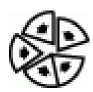


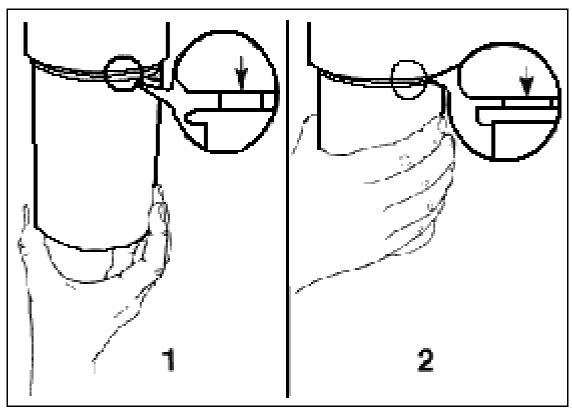


CAUTION

Mechanical over-tightening will distort the threads, filter element seal or filter can.

Install the filter as specified by the filter manufacturer.

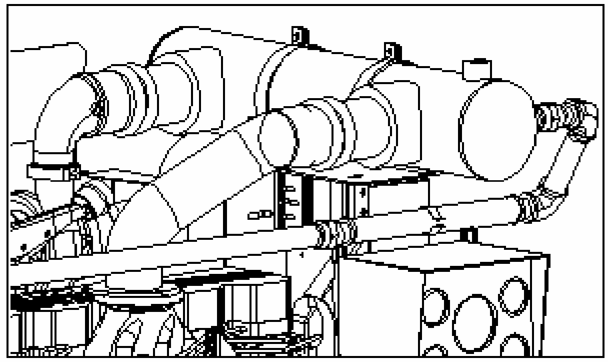




Clean Charge Air Cooler

If the engine experiences a turbocharger failure or any other occasion where oil or debris is put into the charge air cooler, the charge air cooler must be cleaned.

Remove charge air cooler from the engine. Refer to the manufacturer's instructions.



WARNING

When using solvents, acids, or alkaline materials for cleaning, follow the manufacturer's recommendations for use. Wear goggles and protective clothing to avoid personal injury.

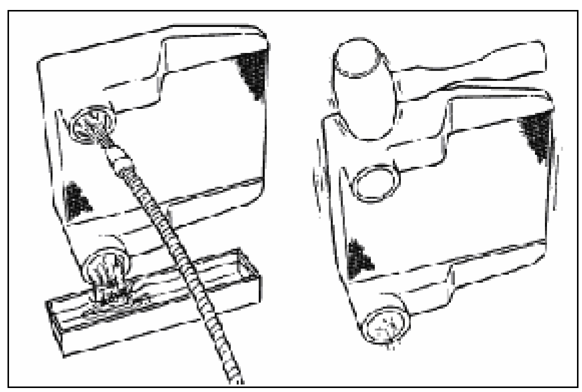
CAUTION

Do not use caustic cleaners to clean the charge air cooler. Damage to the charge air cooler will result.

Flush the charge air cooler internally with solvent in the opposite direction of normal airflow.

Shake the charge air cooler and lightly tap on the end tanks with a rubber mallet to dislodge trapped debris.

Continue flushing until all debris or oil is removed.



WARNING

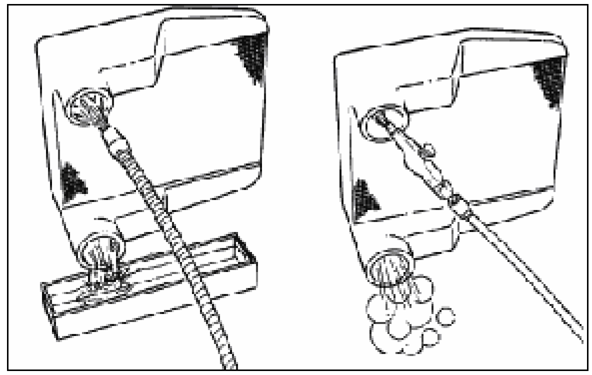
Wear appropriate eye and face protection when using compressed air. Flying debris and dirt can cause personal injury.

After the charge air cooler has been thoroughly cleaned of all oil and debris with solvent, wash the charge air cooler internally with hot, soapy water to remove the remaining solvent.

Rinse thoroughly with clean water.

Blow compressed air into the charge air cooler in the opposite direction of normal airflow until the charge air cooler is dry internally.

Refer to the engine manufacturer's instructions for installation procedures.



Section 8 - Maintenance Procedures Every 1 Year or 500 Hours

Section Contents

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General Information

All checks or inspections listed under daily or previous maintenance intervals must also be performed at this time, in addition to those listed under this maintenance interval.

Drain and Flush Cooling System

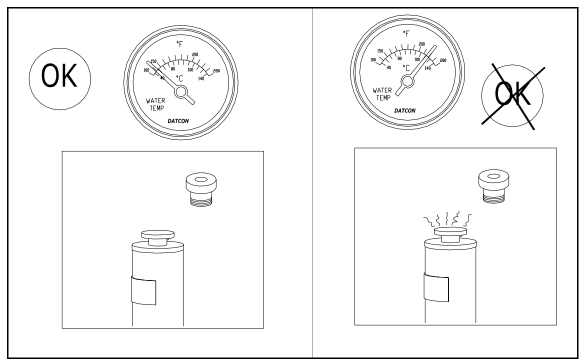
Cleaning and Checking

The cooling system must be clean to work correctly.

Drain the system and flush with clean water.

If the system shows mineral buildup, scale, rust or oil, clean with a heavy duty engine coolant cleaner and follow the manufacturer's directions.

Drain



CAUTION

Avoid prolonged and repeated skin contact with used antifreeze. Such prolonged, repeated contact can cause skin disorders or other bodily injury.

CAUTION

Wait until the temperature is below 50°C [120°F] before removing the coolant system pressure cap. Failure to do so can cause personal injury from heated coolant spray.

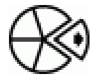
Avoid excessive contact - wash thoroughly after contact.

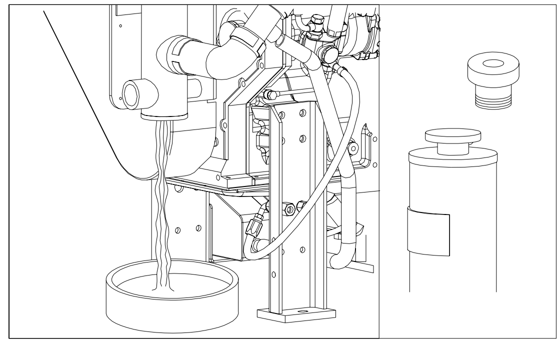
Keep out of reach of children.

Protect the environment: Handling and disposing of used antifreeze can be subject to federal, state, and local laws and regulations. Use authorized waste disposal facilities, including civic amenity sites and garages providing authorized facilities for the receipt of used antifreeze. If in doubt, contact local authorities or the EPA for guidance as to proper handling of used antifreeze.

Drain the cooling system by opening the drain valve on the radiator and removing the plug in the bottom of the water inlet.

A drain pan with a capacity of 20 liters [5 gal] will be adequate in most applications.



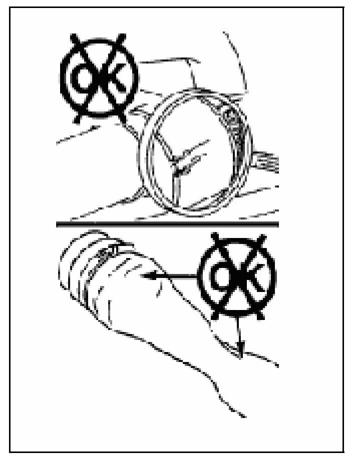


Check for damaged hoses and loose or damaged hose clamps.

Replace as required.

Check the radiator for leaks, damage, and buildup of dirt.

Clean and repair as required.

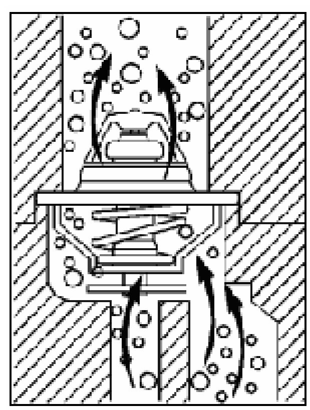


Flush

CAUTION

During filling, air must be vented from the engine coolant passages. The air vents through the "jiggle pin" openings to the top heat exchanger hose and out the fill opening. Additional venting is provided for engines equipped with an after cooler. Open the petcock during filling.

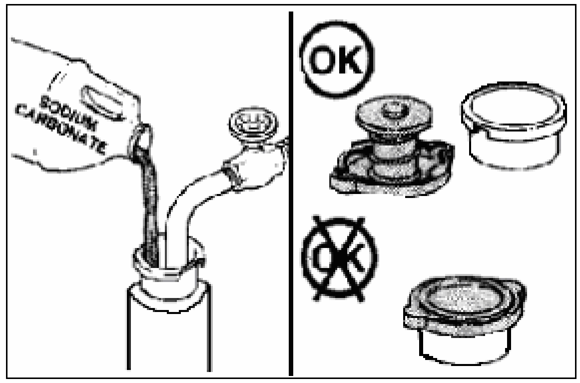
NOTE: Adequate venting is provided for a fill rate of 10 liters/minute [2.6 gal/min].



NOTE: Do not install the heat exchanger cap. The engine is to be operated without the cap for this process.

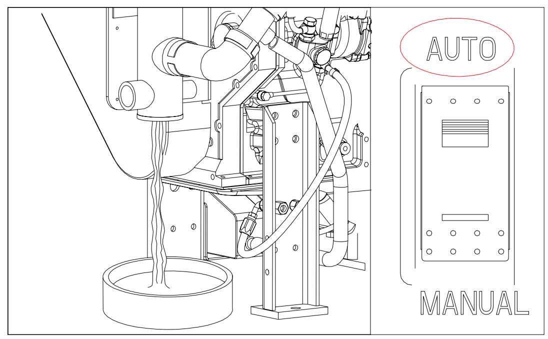
Fill the system with a mixture of sodium carbonate and water (or a commercially available equivalent).

NOTE: Use 0.5 kg [1.0 lb] of sodium carbonate for every 23 liters [6 gal] of water.



Operate the engine for 5 minutes with the coolant temperature above 82°C [180°F].

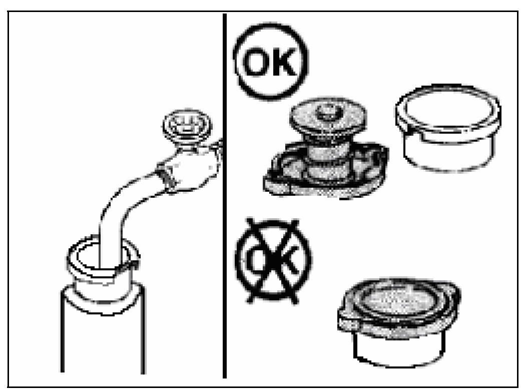
Shut the engine off, and drain the cooling system.



Fill the cooling system with clean water.

NOTE: Be sure to vent the engine and aftercooler for complete filling.

NOTE: Do not install the radiator cap or the new coolant filter.

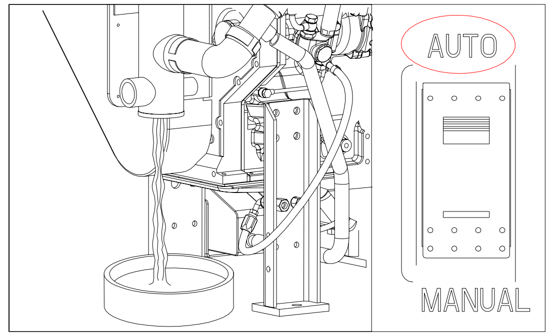


Operate the engine for 5 minutes with the coolant temperature above 82°C [180°F].

Shut the engine off.

Drain the cooling system.

NOTE: If the water being drained is still dirty, the system must be flushed again until the water is clean.

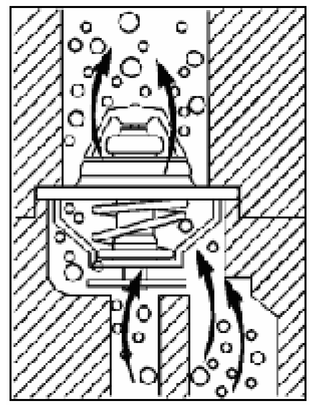


Fill

CAUTION

The system must be filled properly to prevent air locks. During filling, air must be vented from the engine coolant passages.

The system has a design fill rate of 10 liters/minute [2.8 gal/min].

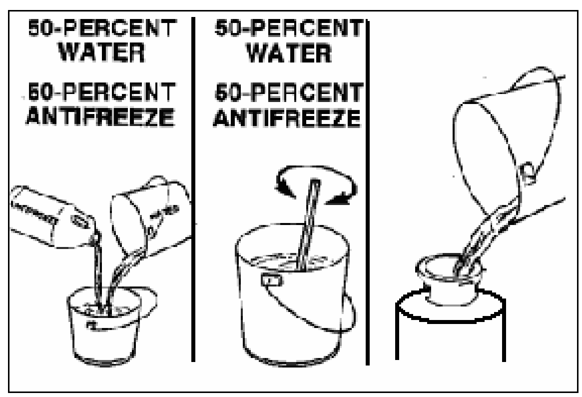


CAUTION

Never use water alone for coolant. Damage from corrosion can be the result of using water alone for coolant.

Use a mixture of 50-percent water and 50-percent ethylene glycol antifreeze to fill the cooling system.

Coolant Capacity (Engine Only): 4.50 liters [1.19 US Gal]



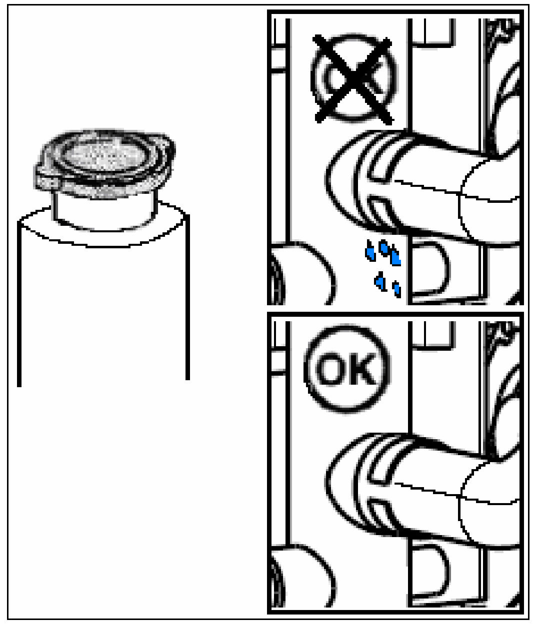
WARNING

Before removing the pressure cap, wait until the coolant temperature is below 50°C [120°F]. Failure to do so can cause personal injury from heated coolant spray.

Install the pressure cap.

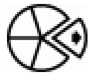
Operate the engine until it reaches a temperature of 82°C [180°F], and check for coolant leaks.

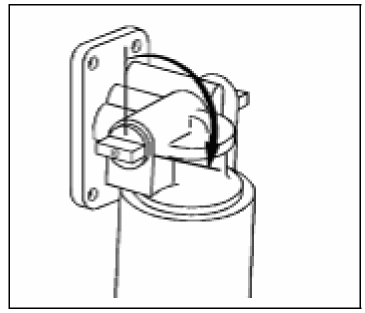
Check the coolant level again to make sure the system is full of coolant, or that the coolant level has risen to the hot level in the recovery bottle on the system, if so equipped.



Change Coolant Filter

Remove



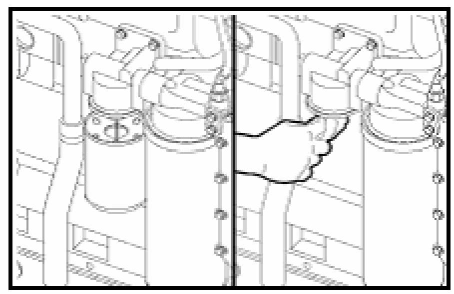


WARNING

Wait until the coolant temperature is below 50°C [122°F] before removing the pressure cap. Remove the coolant system pressure cap and close the shutoff valve before removing the coolant filter. Failure to do so can result in personal injury from heated coolant spray.

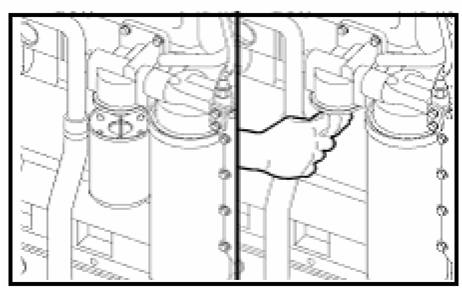
Turn the shutoff valve to the OFF position by rotating the knob from vertical to horizontal in the direction shown.

Remove and discard the coolant filter.

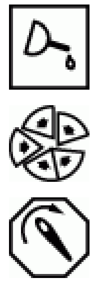


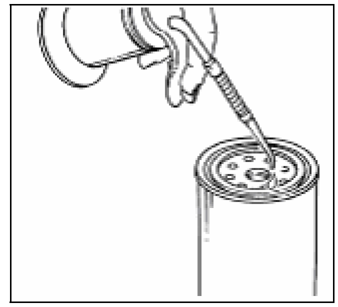
Clean

Clean the gasket surface.



Install





CAUTION

Do not allow oil to get into the filter. Oil will damage the DCA.

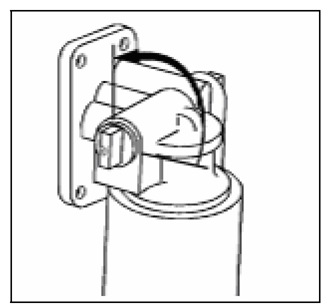
CAUTION

Mechanical over-tightening can distort the threads or damage the filter head.

Apply a thin film of lubricating oil to the gasket sealing surface before installing the new coolant filter.

Install the coolant filter on the filter head. Tighten the filter until the gasket contacts the filter head surface.

Tighten the coolant filter an additional 1/2 to 3/4 of a turn, or as specified by the filter manufacturer.

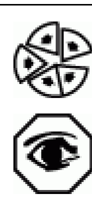


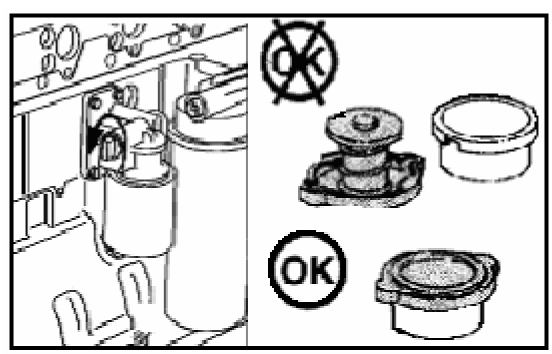
CAUTION

The valve must be in the ON position to prevent engine damage.

Turn the shutoff to the ON position by rotating the knob from horizontal to vertical in the direction shown.

Test Run





Install the coolant system pressure cap.

Operate the engine.

Check for coolant leaks.

After the air has been purged from the system, check the coolant level again.

Vent Fuel Supply Lines

General Information

Controlled venting is provided at the injection pump through the fuel drain manifold. Small amounts of air introduced by changing the filters or injection pump supply line will be vented automatically if the fuel filter is changed in accordance with the instructions. No manual bleeding of fuel lines is required.

NOTE: Manual bleeding is required if any of the following is true:

- The fuel filter is not filled prior to installation
- The injection pump is replaced
- High-pressure fuel line connections are loosened or lines replaced
- Engine is initially started or started after an extended period of no engine operation
- Vehicle fuel tank has run empty

Low Pressure Fuel Line(s)

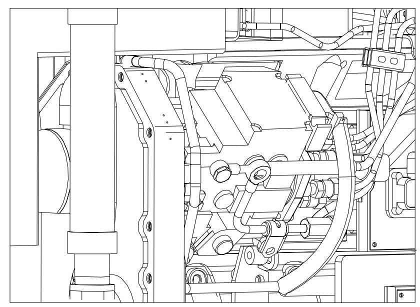
Open the vent screw.

Allow fuel to drain until the fuel flowing from the fitting is free of air.

Tighten the vent screw.

Torque value: 8 N•m (6ft-lb).

The low pressure fuel lines are bled by pumping the hand lever on the filter head.

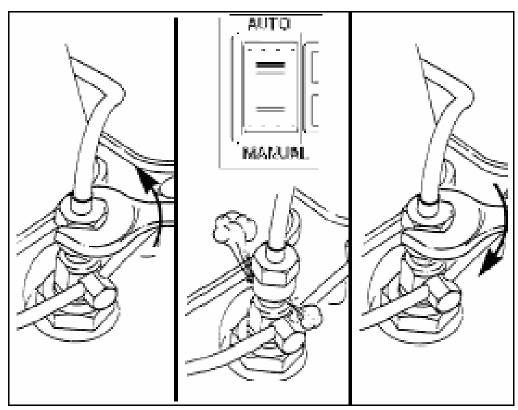


High Pressure Fuel Line(s)

WARNING

The pressure of the fuel in the line is sufficient to penetrate the skin and cause serious bodily harm.

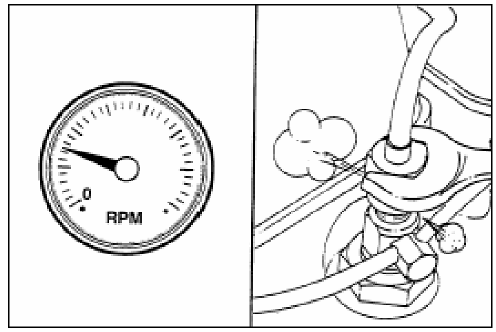
Venting is accomplished by loosening one or more fittings at the injectors and cranking the engine to allow entrapped air to bleed from the lines.



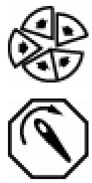
WARNING

Do not bleed a hot engine as this could cause fuel to spill onto a hot exhaust manifold creating a danger of fire.

With the engine at idle, vent one line at the time until the engine runs smoothly.

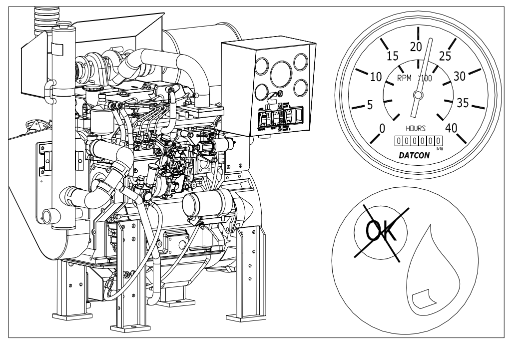


Retighten Line Fittings



Tighten the line fittings and check for leaks.

Torque Value: 22 N•m [16 ft-lb]



Vent Injection Pump

WARNING

The pressure of the fuel in the line is sufficient to penetrate the skin and cause serious personal injury. Wear gloves and protective clothing.

Loosen the fittings at the injectors, and crank the engine to allow entrapped air to bleed from the lines. Tighten the fittings.

WARNING

It is necessary to put the engine in the run position. Because the engine could start, be sure to follow all the safety precautions. Use the normal engine starting procedure.

Start the engine and vent one line at a time until the engine runs smoothly.

NOTE: Do not engage the starter for more than 30 seconds each time when it is used to vent the system: Wait 2 minutes between engagements.

Section 9 - Maintenance Procedures Every 2 Years or 1500 Hours

Section Contents

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General Information

All checks or inspections listed under daily or previous maintenance intervals must also be performed at this time, in addition to those listed under this maintenance interval, except for valve lash adjustment.

Check Overspeed Switch Operation

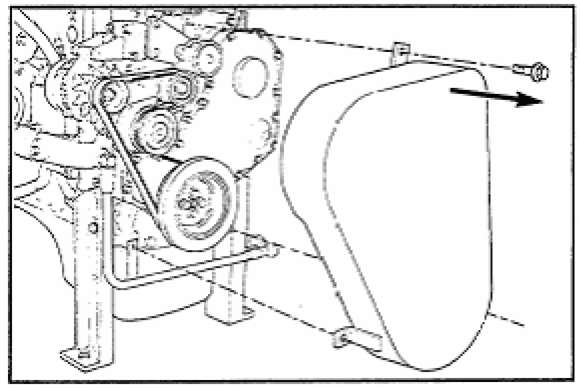
Check the overspeed switch for operation.

Refer to Operating Instructions in Section 1 for settings.

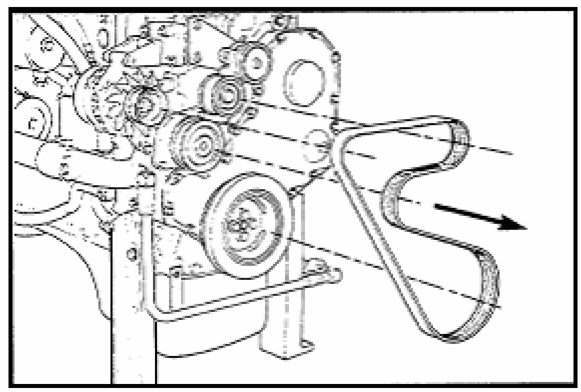
Check Drive Belt, Tensioner Bearing and Belt Tension

Inspect

Remove the belt guard.



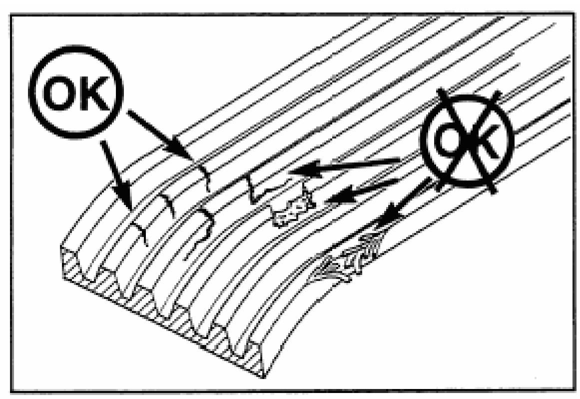
Remove the drive belt.



Visually inspect the belt.

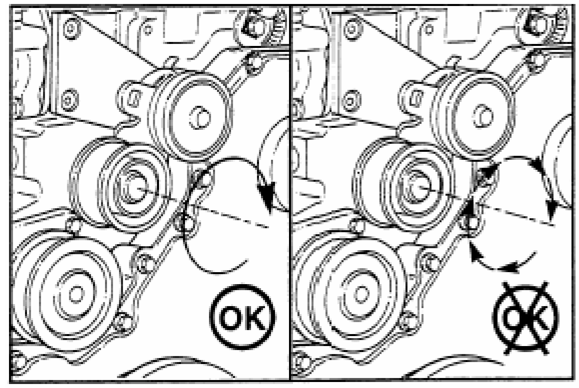
Check the belt for intersecting cracks. Transverse (across the belt width) cracks are acceptable. Longitudinal (direction of belt length) cracks that intersect with transverse cracks are not acceptable.

Replace the belt if it is frayed or has pieces of material missing.



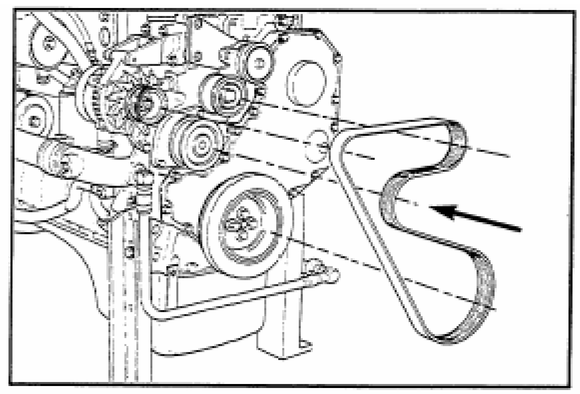
Check the tensioner bearing.

The tensioner pulley should spin freely with no rough spots detected under hand pressure.

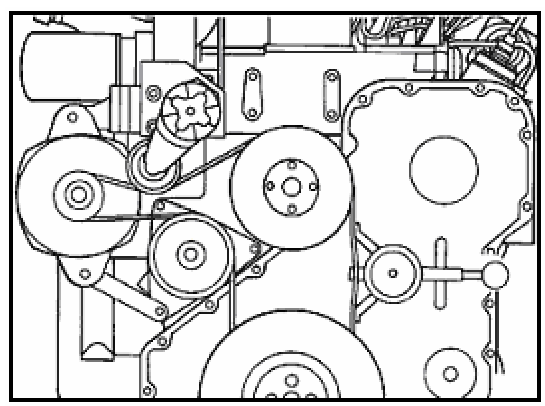


Replace tensioner or bearing if defective.

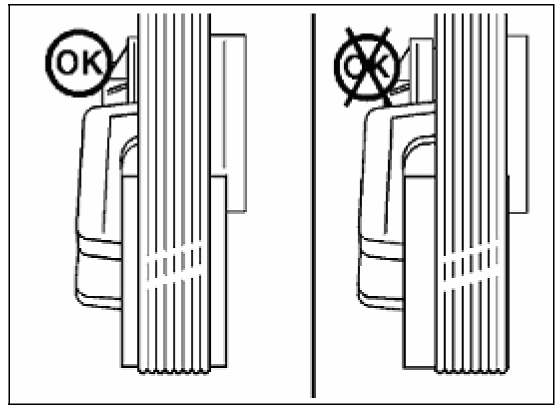
Install the drive belt.



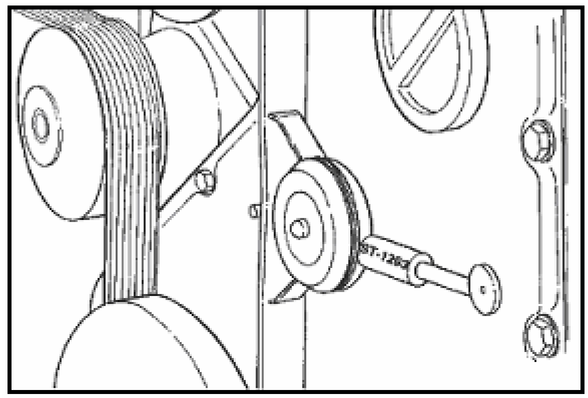
Torque Value: Tension Limit: 360 to 490 N•m [266 to 361 ft-lb].



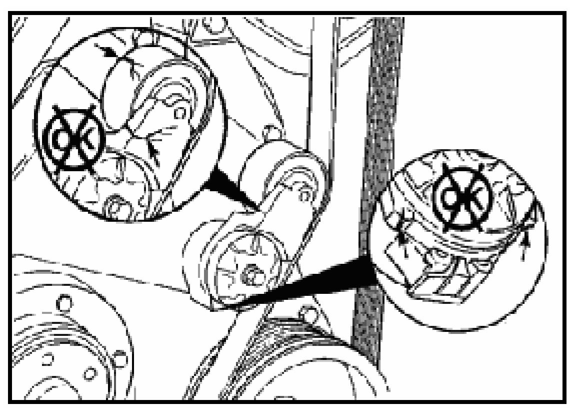
Check the location of the drive belt on the belt tensioner pulley. The belt should be centered on, or centered close to the middle of, the pulley. Unaligned belts, either too far forward or backward, can cause belt wear, belt roll-off failures, or increase uneven tensioner bushing wear.



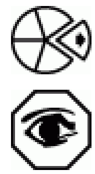
Use the Cummins belt tensioner gauge, Part No. ST-1293, to measure the tension in the drive belt. This needs to be in the range of 360 to 490 N•m [266 to 361 ft-lb] for the C Series.

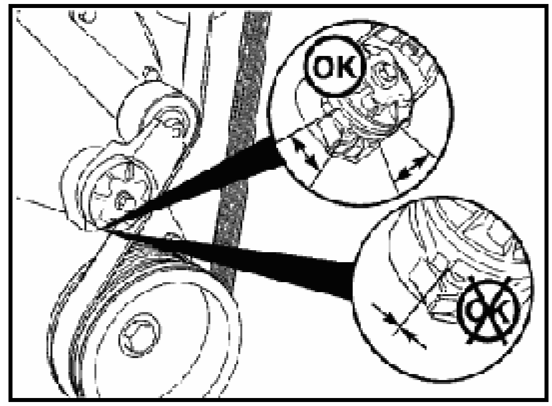


Check the tensioner arm, pulley, and stops for cracks. If any cracks are noticed, the tensioner must be replaced.



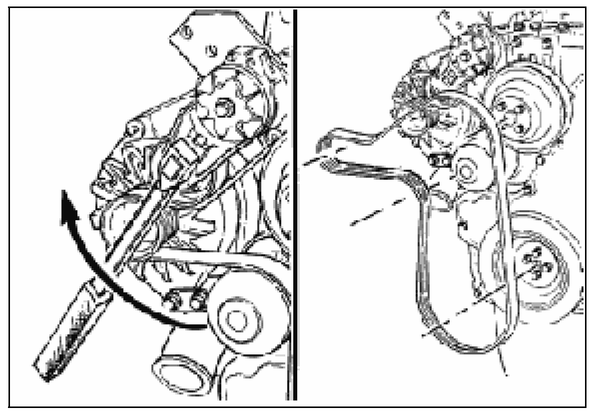
With the belt on, verify that neither tensioner arm stops are in contact with the spring casing stop. If either stop is touching, the drive belt must be replaced. After replacing the belt, if the tensioner arm stops are still in contact with the spring casing stop, replace the tensioner.





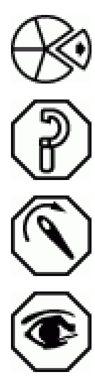
Remove the drive belt, and check the torque of the tensioner capscrew. After checking the torque, use a breaker bar with a 3/8-inch ratchet to rotate the tensioner slowly away from the area of belt contact. If the arm rotates with any roughness or hesitancy, replace the tensioner.

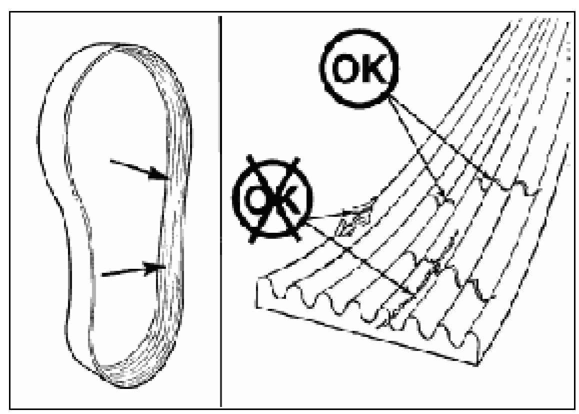
Torque Value: B and C Series engines 43 N•m [32 ft-lb]



Check the belt for damage. Transverse (across the belt width) cracks are acceptable. Longitudinal (direction of the belt length) cracks that intersect with transverse cracks are not acceptable.

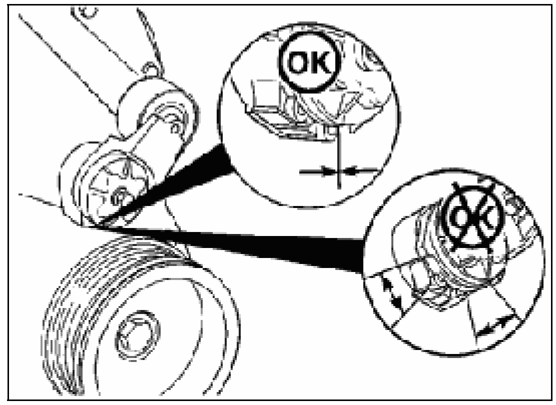
If the belt is frayed or has any piece of material missing, the belt is unacceptable and needs to be replaced.





With the belt removed, verify that the tensioner arm stop is in contact with the spring case stop.

If these two are not touching, the tensioner must be replaced.



With the belt removed, check to be sure that the tensioner pulley rotates freely.

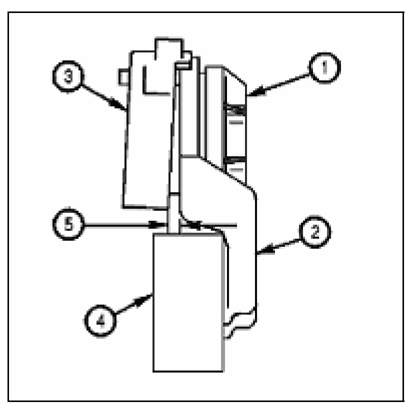
Measure the clearance between the tensioner spring case and the tensioner arm to verify tensioner wear-out and uneven bearing wear.

If the clearance exceeds 3 mm [0.12 in] at any point, the tensioner failed and must be replaced as a complete assembly.

Experience has revealed that tensioners generally will show a larger clearance gap near the lower portion of the spring case, resulting in the upper portion rubbing against the tensioner arm.

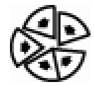
Always replace the belt when a tensioner is replaced.

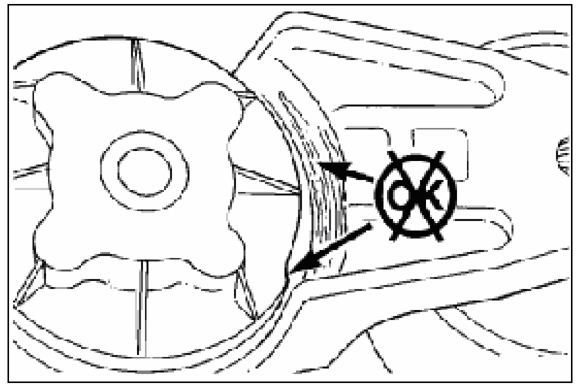
1. Tensioner cap
2. Tensioner arm
3. Spring case
4. Tensioner pulley
5. Clearance gap



Inspect the tensioner for evidence of the tensioner arm contacting the tensioner cap.

If there is evidence of the two areas making contact, the pivot tube bushing has failed and the tensioner must be replaced.

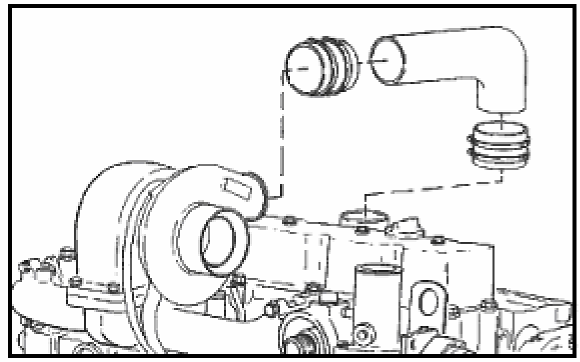




Check Valve Lash Clearance

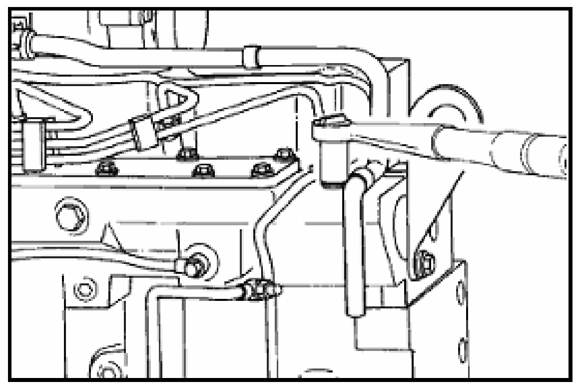
Adjust

Remove the air crossover tube from the engine if equipped.

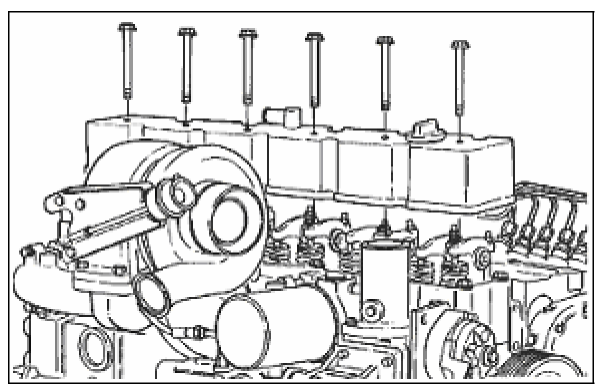


Disconnect the support clamps, hose clamp, and wastegate sensing line.

Remove the crankcase vent tube and any other parts that would prevent removal of the valve cover.

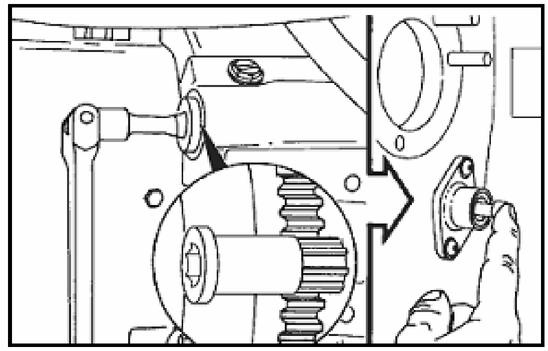


Remove valve cover.

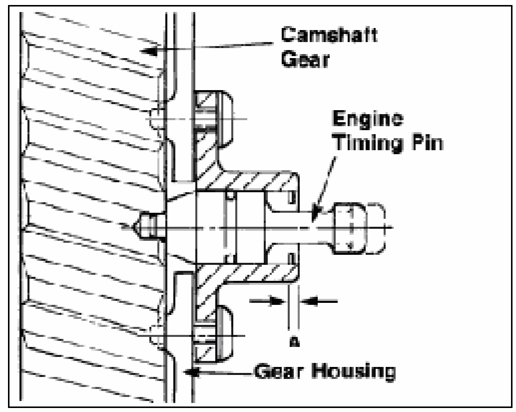


Locate top dead center for cylinder No. 1 by rotating the crankshaft slowly while pressing on the engine timing pin.

The barring gear inserts into the flywheel housing and engages the flywheel ring gear. The engine can then be rotated by hand using a 1/2-inch ratchet or breaker bar.

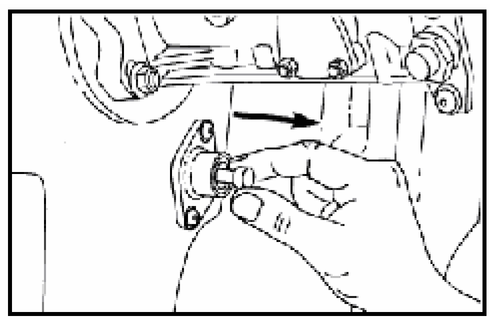


When the engine timing pin engages the hole in the camshaft gear, cylinder No. 1 is at top dead center on the compression stroke.



CAUTION

Be sure to disengage the engine timing pin after locating top dead center to prevent damage to the engine timing pin.

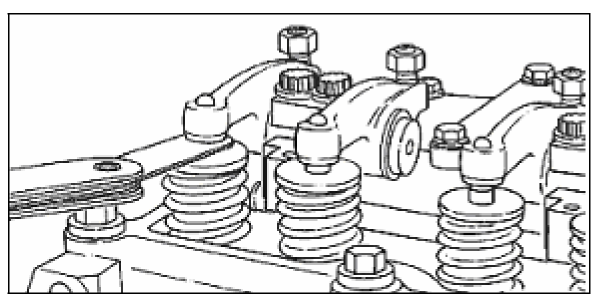


Intake clearance: 0.30 mm [0.012 in].

Exhaust clearance: 0.61 mm [0.024 in].

Check/set valves with engine cold - below 60°C [140°F].

NOTE: The clearance is correct when some resistance is "felt" when the feeler gauge is slipped between the valve stem and the rocker lever.

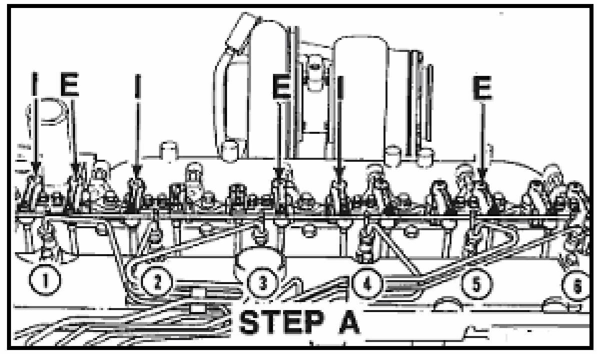


Locate top dead center for cylinder No. 1.

Check/adjust the valves indicated for STEP A (I = intake; E = exhaust).

After tightening the rocker lever locknut, check the valve clearance to make sure the valve clearance has not changed.

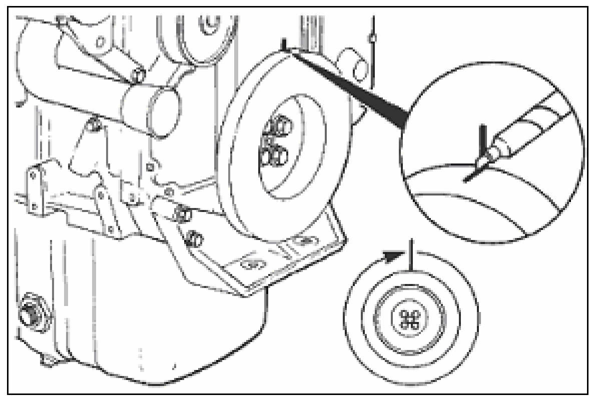
Torque Value: 24 N•m [212 in-lb]



CAUTION

Be sure the engine timing pin is disengaged to prevent damage to the engine timing pin.

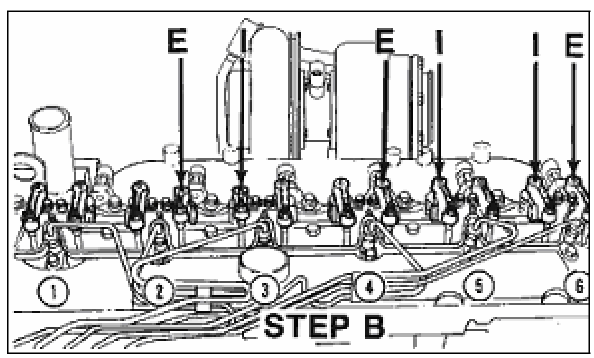
Mark vibration damper and rotate the crankshaft 360 degrees.



Set the valves indicated for STEP B.

After tightening the rocker lever locknut, check the valve clearance to make sure the valve clearance has not changed.

Torque Value: 24 N•m [212 in-lb]



NOTE: If the seal is not damaged, it can be used again.

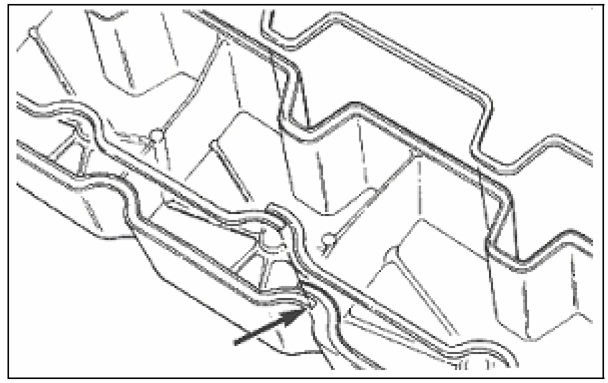
If the seal is damaged, install a new seal.

Install the rubber seal into the groove in the valve cover.

Start the installation at the overlap area shown in the illustration.

Do not stretch the rubber seal.

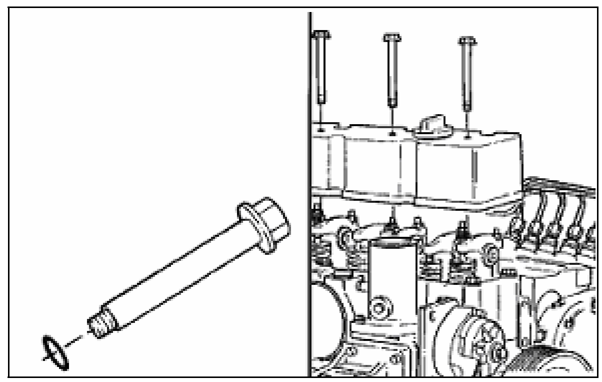
If the seal has more overlap than shown in the illustration, trim the length to provide the correct overlap.



Install new sealing o-rings on the capscrews.

Install the valve cover and wastegate sensing tube.

Torque Value: 24 N•m [212 in-lb]

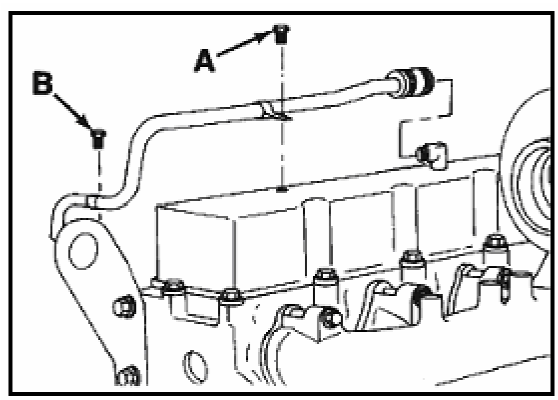


Install the crankcase vent tube, and secure with the support clamps and hose clamp.

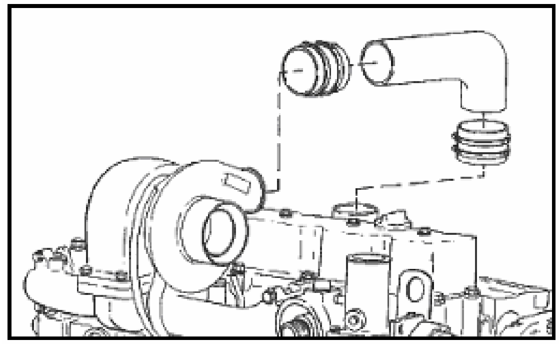
Torque Values:

A = 24 N•m [212 in-lb].

B = 43 N•m [32 in-lb].



Install the air crossover tube and any other parts previously removed to gain access to the valve cover.



Section 10 - Maintenance Procedures Every 4 Years or 3000 Hours

Section Contents

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General Information

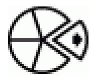
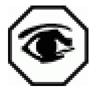
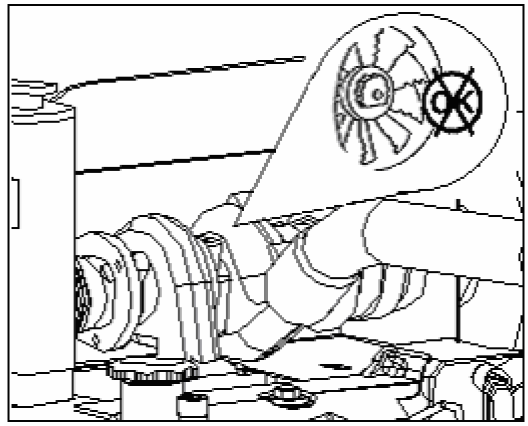
All checks or inspections listed under daily or previous maintenance intervals must also be performed at this time, in addition to those listed under this maintenance interval.

Inspect Turbocharger

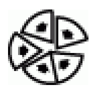
Remove the air intake and the exhaust piping.

Look for damaged or cracked compressor or turbine blades.

Check to see that the turbocharger shaft spins freely.

NOTE: If visual inspections or dimensional checks indicate a problem, contact a Cummins Authorized Location for Assistance.



The turbocharger must be removed for replacement or rebuild if the clearances are beyond the limits.

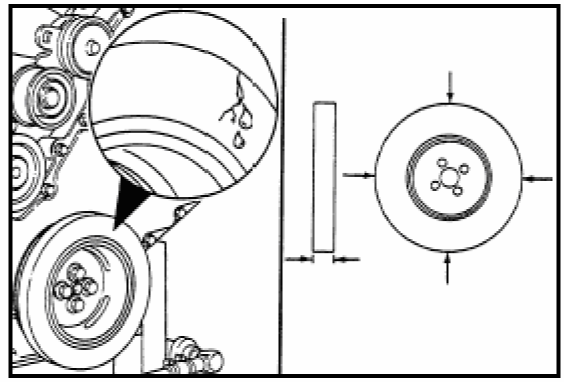
Install the air intake and the exhaust piping.

Inspect Viscous Damper

Check the damper for evidence of fluid loss, dents, and wobble.

Visually inspect the vibration damper thickness for any deformation or raising of the damper front cover plate.

If any variations or deformations are detected, refer to the Troubleshooting and Repair Manual for detailed inspection procedures.

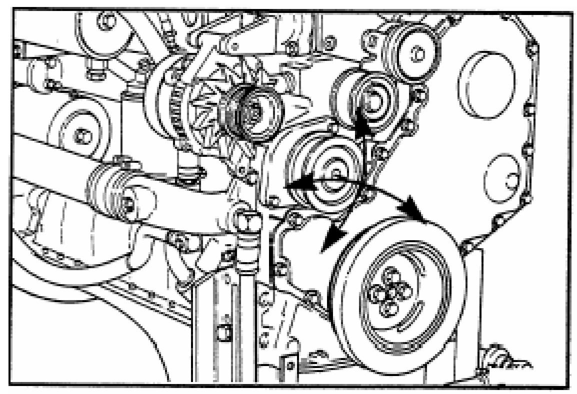


Inspect Water Pump

Inspect the water pump for drive pulley wobble and grease or water leakage around the water pump shaft.

Replace with a new or rebuilt, pre-lubricated unit as necessary.

Refer to the Troubleshooting and Repair Manual for more information.



Section 11 - System Diagrams

Section Contents

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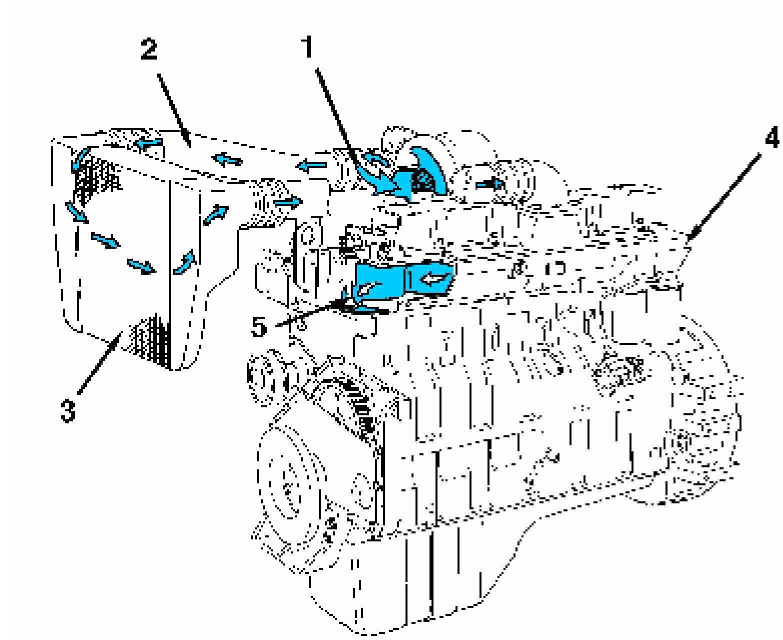
Overview

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 as follows:

- Fuel system
- Lubricating oil system
- Coolant system
- Intake air system
- Exhaust system
- Raw Water Piping

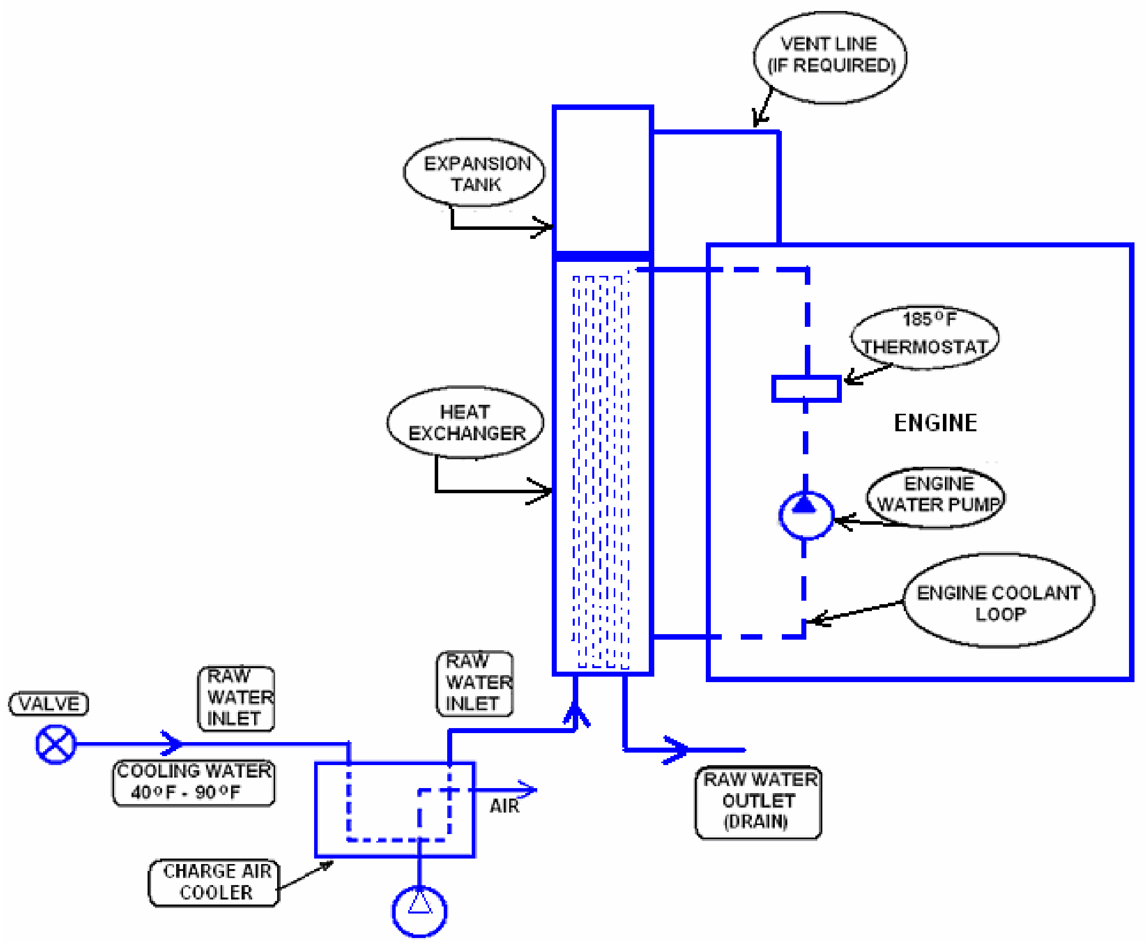
Knowledge of the engine systems can help in troubleshooting, service, and general maintenance of your engine.

Flow Diagram, Air Intake System

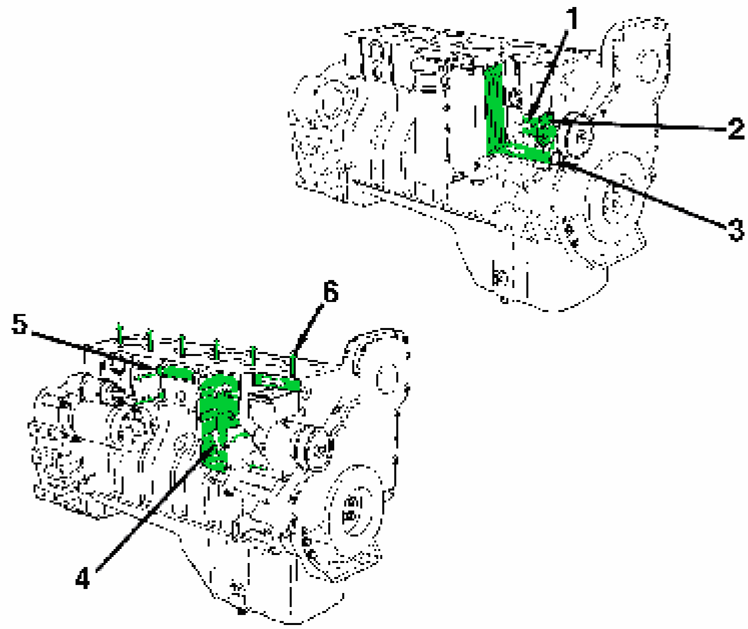


1. Intake air inlet to turbocharger
2. Turbocharger air to charge air cooler
3. Charge air cooler
4. Intake manifold - integral part of cylinder head
5. Intake valve

Flow Diagram, Cooling System

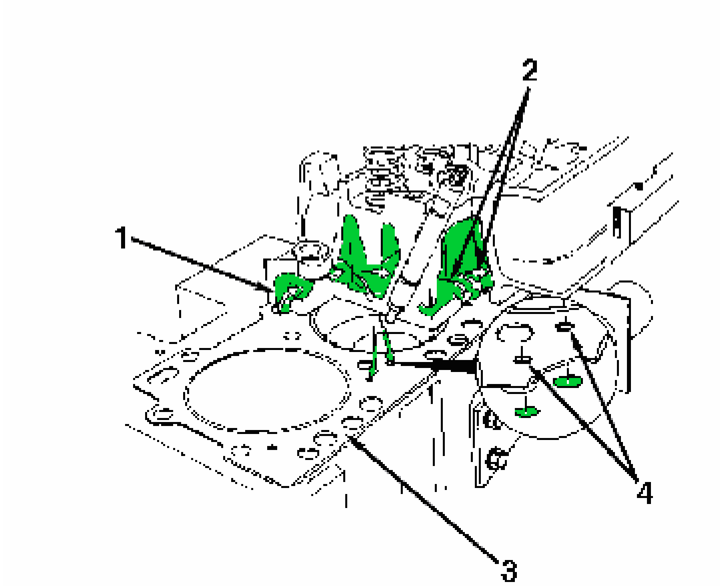


Flow Diagram, Cooling System (Cont)



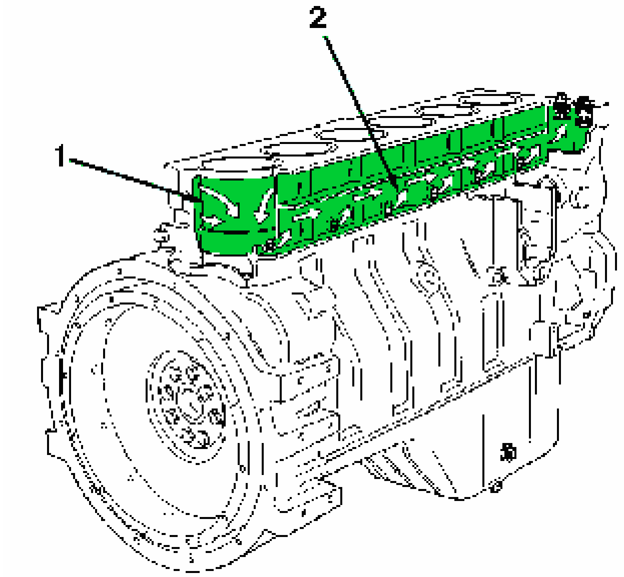
1.	Coolant inlet	4.	Coolant flow past oil cooler
2.	Water pump impeller	5.	Upper coolant manifold
3.	Coolant flow to oil cooler	6.	Coolant flow to cylinder head

Flow Diagram, Cooling System (Cont)



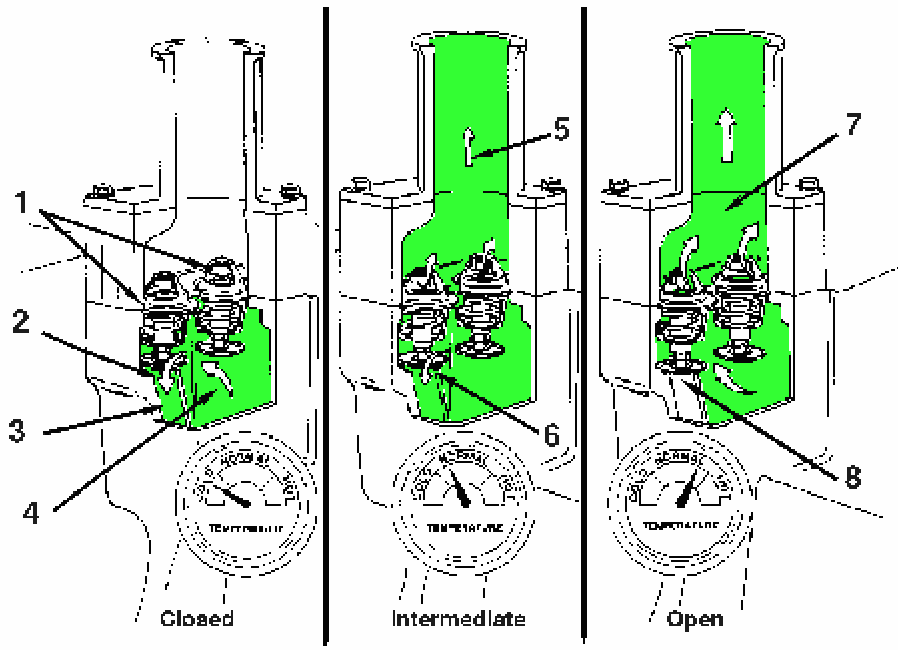
1.	Flow from upper coolant manifold	3.	Cylinder head gasket
2.	Flow to liner cavity	4.	Coolant flow orifice

Flow Diagram, Cooling System (Cont)



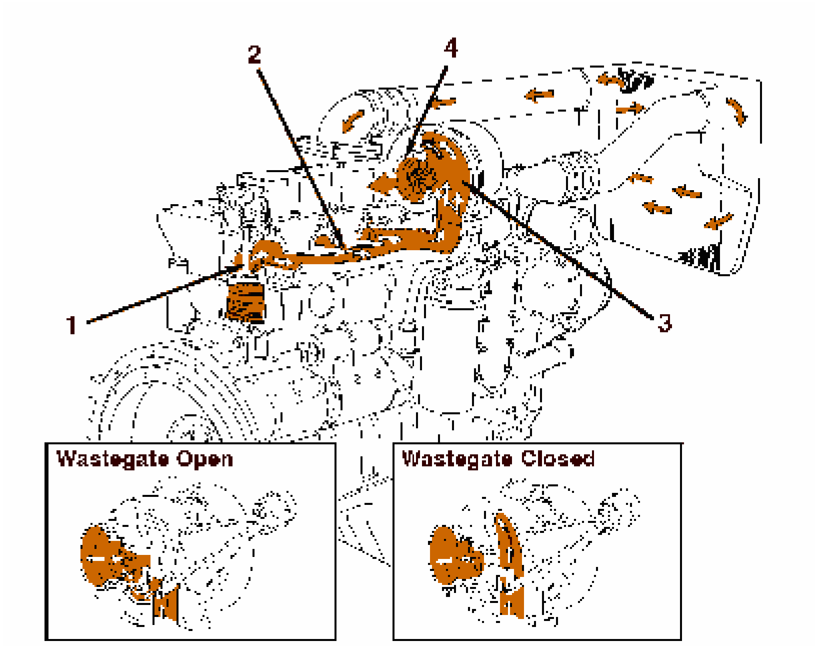
1. Flow past cylinder liners
2. Lower coolant manifold

Flow Diagram, Cooling System (Cont)



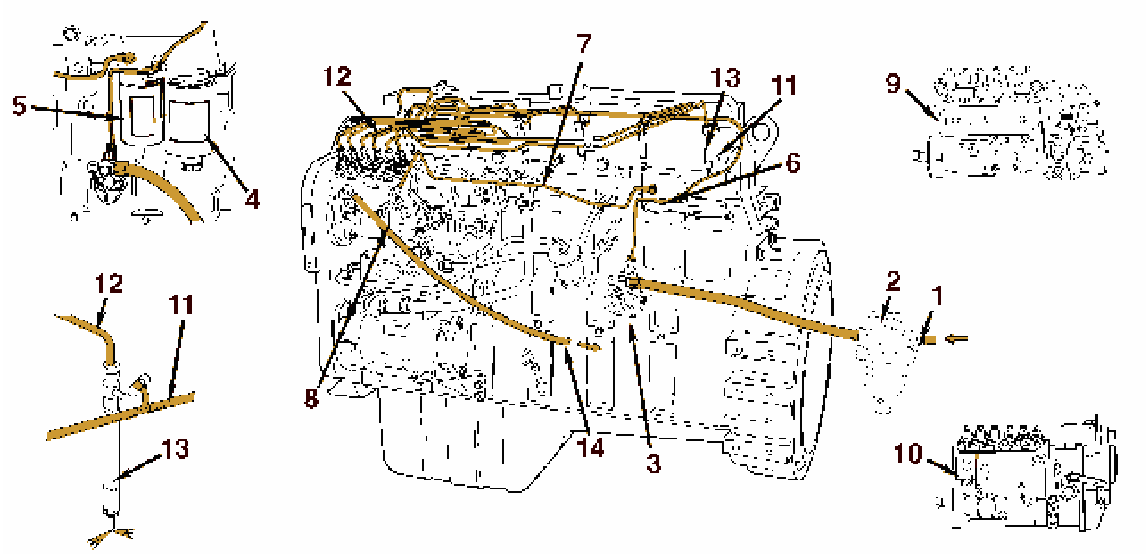
1.	Thermostats	5.	Partial coolant flow to radiator
2.	Flow to water pump inlet	6.	Restricted flow to bypass
3.	Bypass passage	7.	Flow to heat exchanger
4.	Flow from lower coolant manifold	8.	Bypass closed.

Flow Diagram, Exhaust System



1. Exhaust valve
2. Exhaust manifold - pulse type
3. Dual entry to turbocharger
4. Turbocharger exhaust outlet.

Flow Diagram, Fuel System

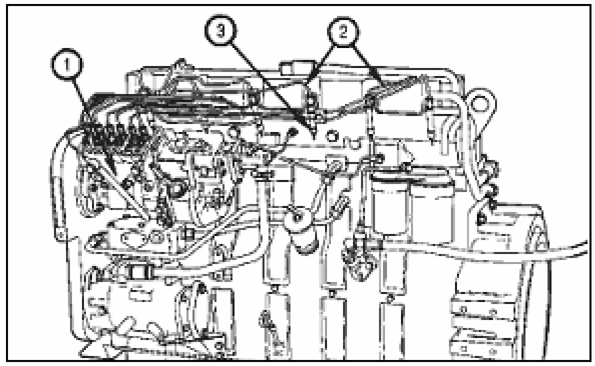


1. Fuel from supply tank
2. Pre-filter or screen
3. Fuel transfer pump
4. Fuel/water separator
5. Fuel filter-Low-pressure supply line
6. Turboboost control line
7. Robert Bosch® PES.MW injection pump
8. Robert Bosch PES.A injection pump
9. Robert Bosch PES.P injection pump
10. Fuel drain manifold
11. High-pressure fuel lines
12. Robert Bosch, 7-mm closed-nozzle, hole-type injectors
13. Fuel return to supply tank.

Fuel System Operation

The function of the fuel system is to inject a metered quantity of clean atomized fuel into the engine cylinders at a precise time near the end of the compression stroke. The components of the fuel system contribute to the delivery of fuel to the cylinders.

The fuel transfer pump is mechanically driven by a plunger running against a special lobe on the camshaft. The fuel transfer pump contains a pumping piston and check valves to control the flow of fuel and bleed back during engine shutdown.

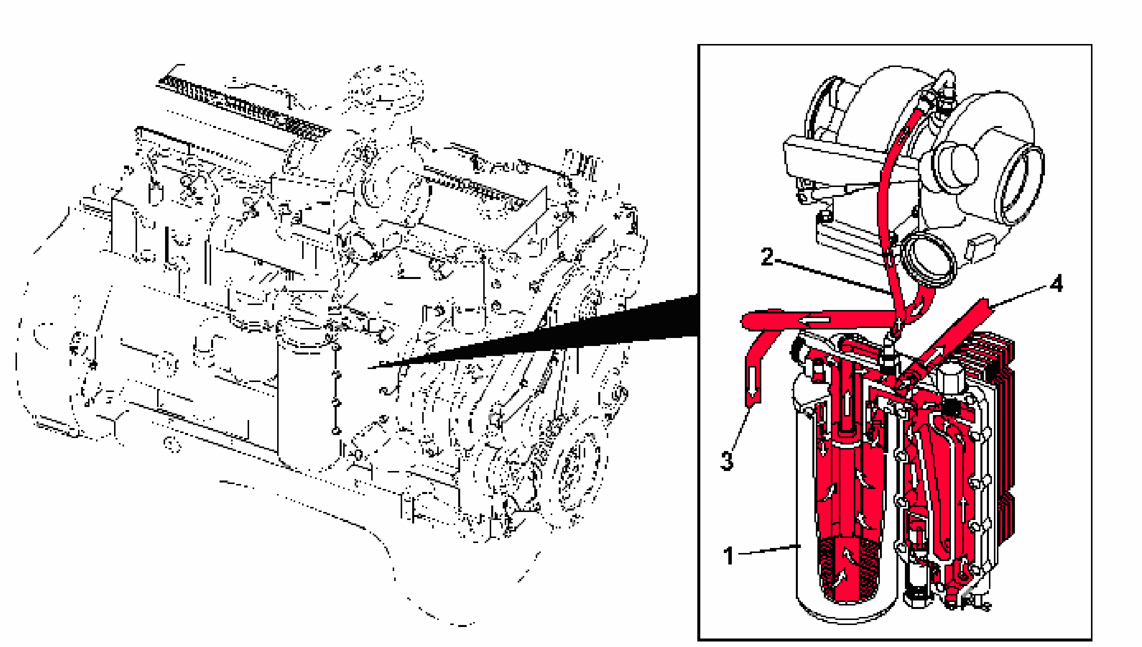


1. Fuel injection pump

2. High-pressure fuel lines

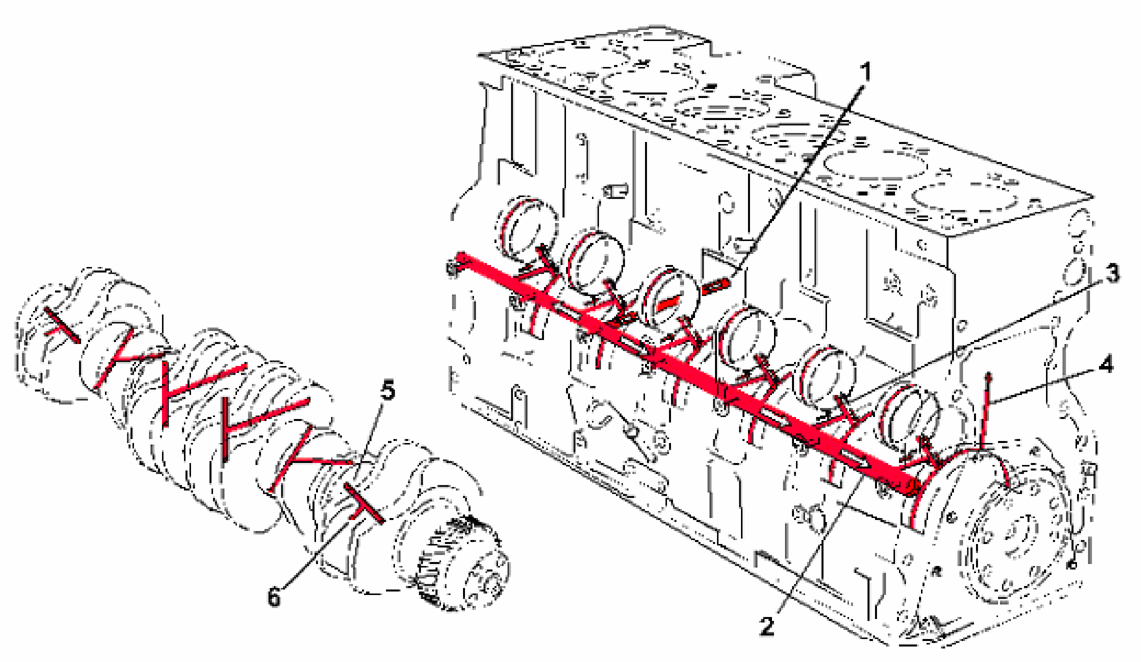
3. Injectors

Flow Diagram, Lubricating Oil System



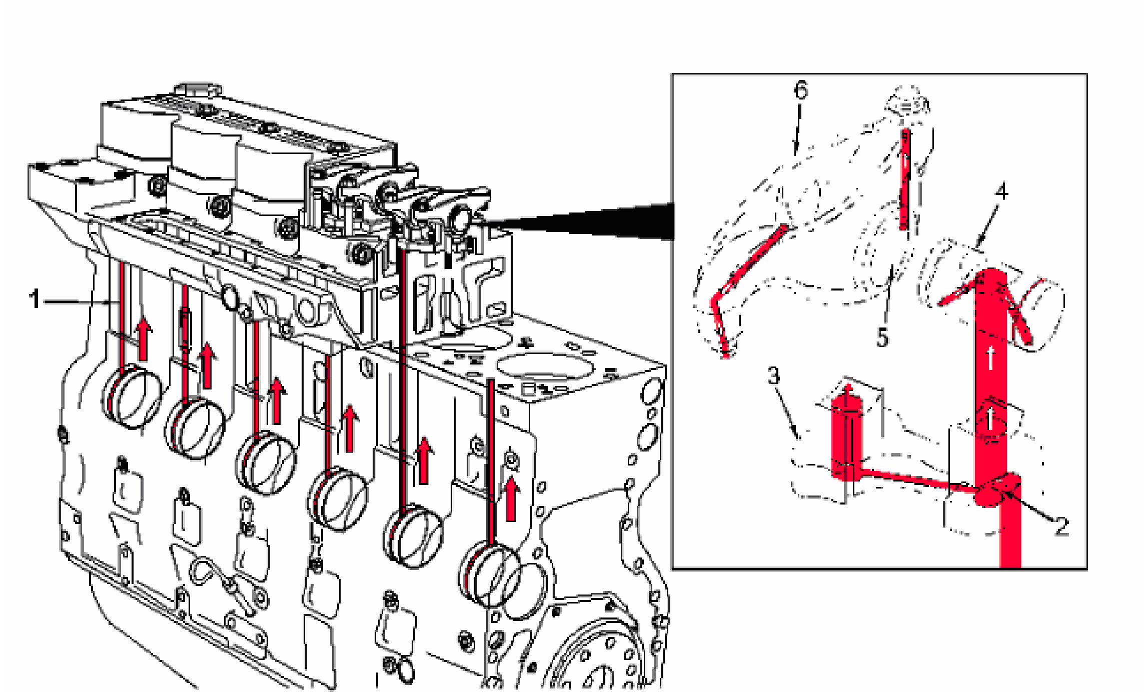
1.	Lubrication oil filter	3.	Turbocharger lubricating oil drain
2.	Turbocharger lubricating oil supply	4.	To main lubricating oil rifle

Flow Diagram, Lubricating Oil System (Cont)



1.	From lubricating oil cooler	4.	To piston cooling nozzle
2.	Main lubricating oil rifle	5.	From main lubricating oil rifle
3.	To camshaft	6.	To connecting rod bearing

Flow Diagram, Lubricating Oil System (Cont)

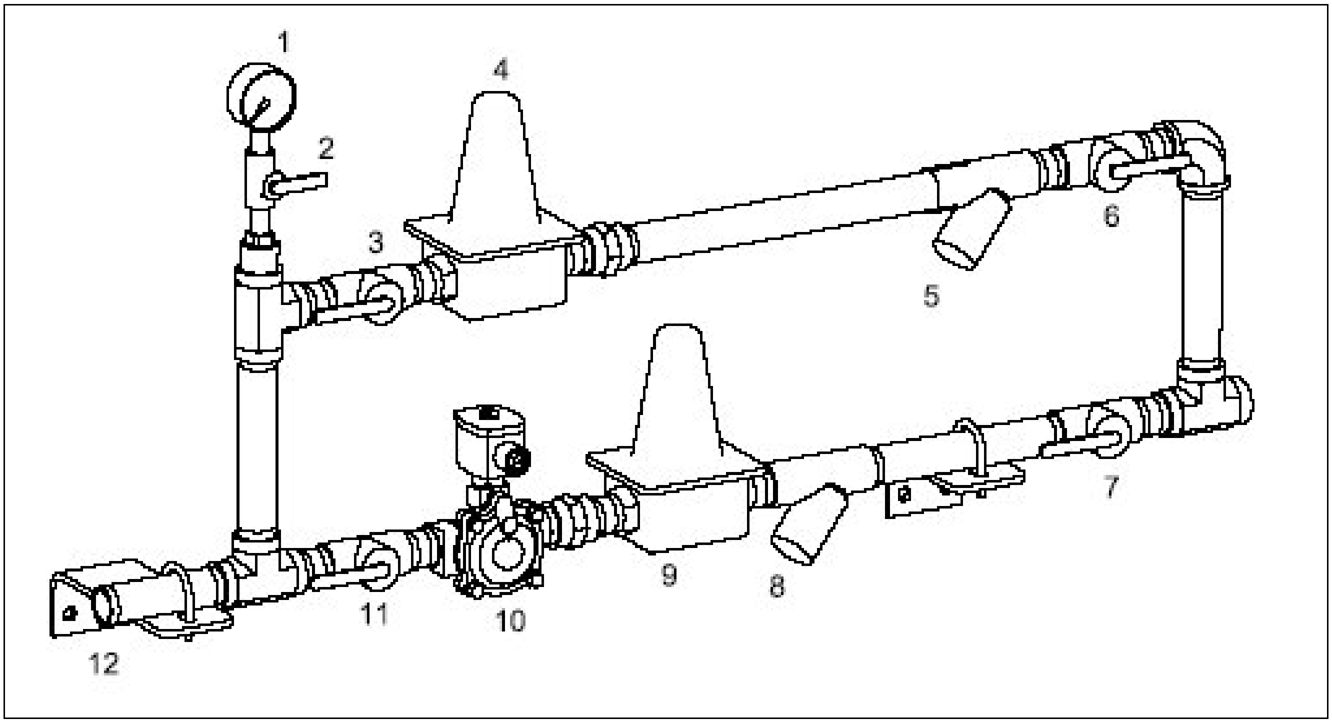


1.	From cam bushings	4.	Rocker lever shaft
2.	Transfer slot	5.	Rocker lever bore
3.	Rocker lever support	6.	Rocker lever

Assembly Diagram, Raw Water Piping

Raw water is used to cool the engine coolant and is supplied from the fire pump prior to the pump discharge flange. It is forced through a cooling loop by fire pump pressure to the engine heat exchanger. Then it is discharged to an open waste cone.

The following raw water manifold is available as an option (Cummins N Power Part No. 8683). If supplied by the customer, National Fire Protection Association (NFPA) Pamphlet No. 20 lists the components that are required. Refer to the Cooling System Specifications in Section 15 for process requirements. Refer to Raw Water Piping, Lineup, and Configuration in Section 3.



1.	Supply Pressure Gauge	7.	Normal Inlet Valve
2.	Supply Pressure Gauge Isolation Valve	8.	Normal Strainer
3.	Bypass Outlet Valve	9.	Normal Pressure Regulator
4.	Bypass Pressure Regulator	10.	Solenoid Operated Valve
5.	Bypass Strainer	11.	Normal Outlet Valve
6.	Bypass Inlet Valve	12.	1” supply to the heat exchanger

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Section 12 – Adjustment, Repair and Replacement

Section Contents

Section Contents (Cont)

Section Contents (Cont)

Section Contents (Cont)

Section Contents (Cont)

Overview

Coverage

This section of this manual addresses the Adjustment, Repair, and Replacement of Cummins NPower Fire Pump Engine components. Work this manual with the associated base engine troubleshooting and repair manuals.

Base engine components are addressed in Cummins Manual No. 4021418, ISC, QSC8.3, ISL, and QSL9 Troubleshooting and Repair Manual.

The electronic engine control module and associated components are addressed in Cummins Manual No. 3666271, ISC, ISCe, ISL, QSC8.3, and QSL9 Electronic Control System Troubleshooting and Repair Manual.

Refer to Service Literature Section 13 for additional information about these manuals.

Requirements

Satisfy all code requirements or local regulations necessary to remove the fire pump from service. This may require contacting the local fire department or other authority.

Obtain the required tools and supplies for the intended service. If fluids are to be drained, get appropriate containers. Dispose of any waste fluids or removed components in accordance with applicable environmental requirements.

Ensure that the area is prepared for the intended service.

When work is completed, ensure that the fire pump is operational and correctly aligned for service. As required, notify the local fire department or other authority.

Maintenance must be performed by trained, experienced technicians. Refer to Service Assistance Section 14 for qualified service assistance.

Belt Guard Removal/Installation

Prepare

WARNING

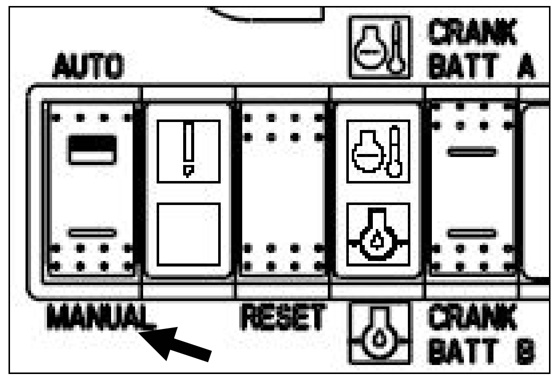
Coolant is toxic. Keep away from children and pets. If not reused, dispose of in accordance with local environmental regulations.

WARNING

Do not remove the pressure cap from a hot engine. Wait until the coolant temperature is below 50°C [122°F] before removing the pressure cap. Heated coolant spray or steam can cause personal injury.

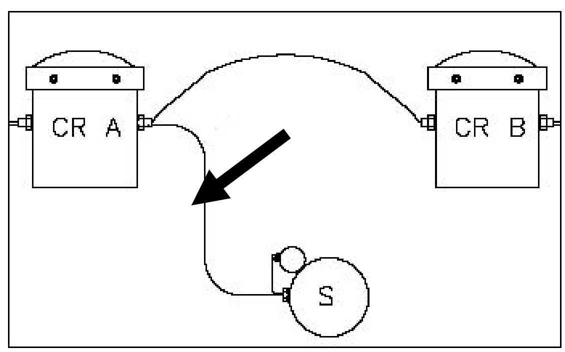
Place the fire protection system in a safe mode for engine service.

Place the AUTO/MANUAL rocker switch in the MANUAL position.

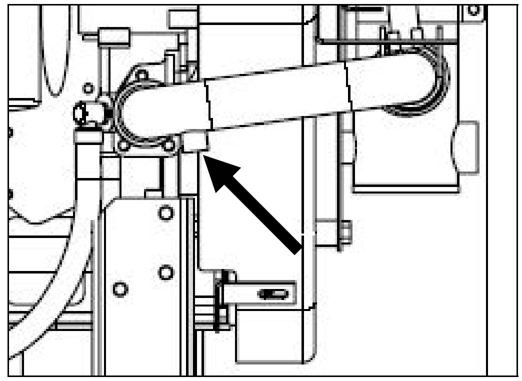
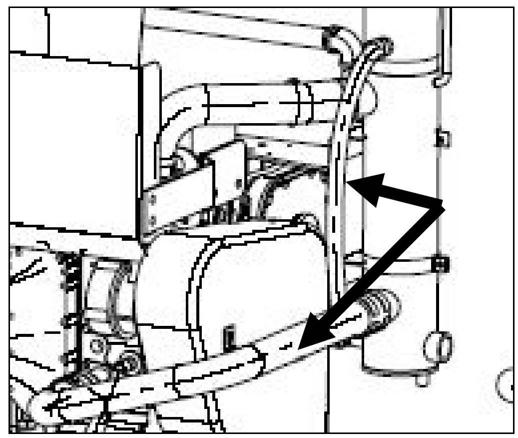
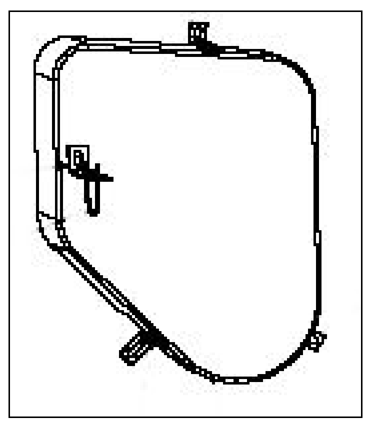


Disconnect or isolate the coolant heater power supply.

Disconnect and insulate the Contactor to Starter Cable (Cummins Fire Power Part No 9762) from the starter (Refer to Drawing 9767 in Section 18).



Belt Guard Removal/Installation (Cont)

Ensure that the engine and engine coolant is cool in order to avoid burns. Remove the engine coolant pressure cap. Drain the engine coolant system. Refer to <u>Drain and Flush Coolant System</u> in Section 8.	
Remove the <u>Lower Engine Coolant and Fill Hose</u> from the heat exchanger.	
Remove Remove the three bolts and the belt guard.	

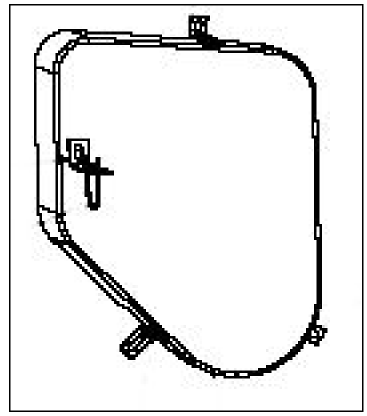
Belt Guard Removal/Installation (Cont)

Install

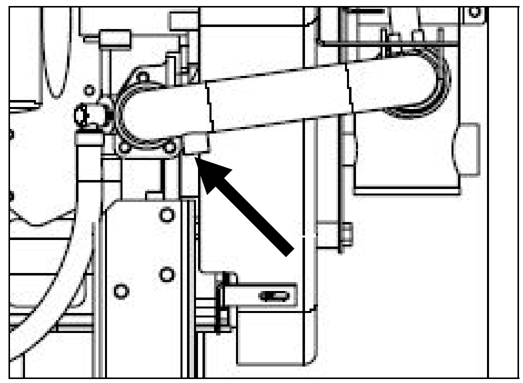
NOTE: Install only Cummins approved replacement belt guard (Cummins Fire Power Part No. 9820) or equivalent.

When other work is completed, install the belt guard using the three bolts.

Torque as per Capscrew Markings and Torque Values in Section 15.

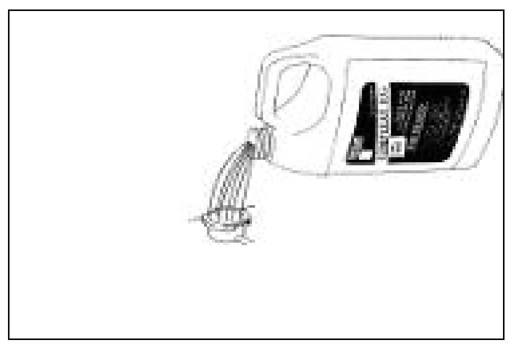


Close coolant drain valve.



Refill the engine coolant. Refer to Drain and Flush Coolant System in Section 8.

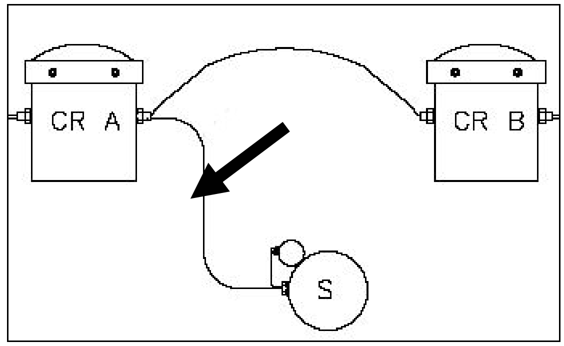
Install the coolant system pressure cap.



Reconnect the coolant heater power supply.

Belt Guard Removal/Installation (Cont)

Reconnect the Contactor to Starter Cable (Cummins Fire Power Part No 9762) at the starter (Refer to Drawing 9767 in Section 18).



NOTE: Start the engine and do a quick check for leaks. If any coolant leaks are observed, stop the engine, repair the leak, check coolant level, then restart the engine.

Start the engine. Refer to Normal Local Starting Procedure in Section 3.

Check for and repair any coolant leaks.

Ensure that repairs are completed satisfactorily.

Stop the engine.

Belt Removal/Installation

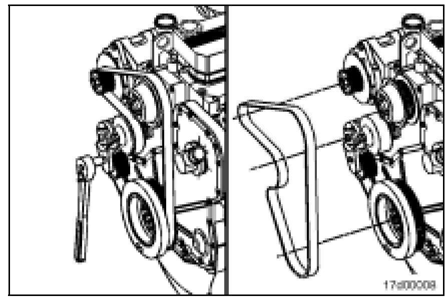
Prepare

Do the preparatory steps and remove the Belt Guard. Refer to Belt Guard Removal / Installation in this section.

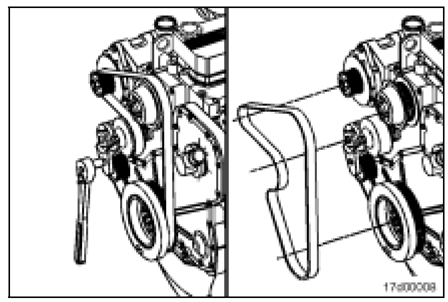
Remove

NOTE: The belt tensioner is spring-loaded and must be pivoted away from the drive belt. Pivoting in the wrong direction can result in damage to the belt tensioner.

Lift the tensioner to remove the drive belt.



Install



NOTE: The belt tensioner is spring-loaded and must be pivoted away from the drive belt. Pivoting in the wrong direction can result in damage to the belt tensioner.

Service Tip: If difficulty is experienced installing the drive belt (i.e., the belt seems too short), position the belt over the grooved pulleys first then while holding the tensioner up, slide the belt over the water pump pulley.

NOTE: Install only Cummins approved replacement v-ribbed belts (Cummins Part No. 3289135) or equivalent.

Lift and hold the belt tensioner. Install the drive belt and release the tensioner.

Follow-Up

When work is completed, install the Belt Guard and do the listed follow up steps. Refer to Belt Guard Removal/Installation in this section.

Check that the drive belt operates without unusual noises.

Automatic Belt Tensioner Removal/Installation

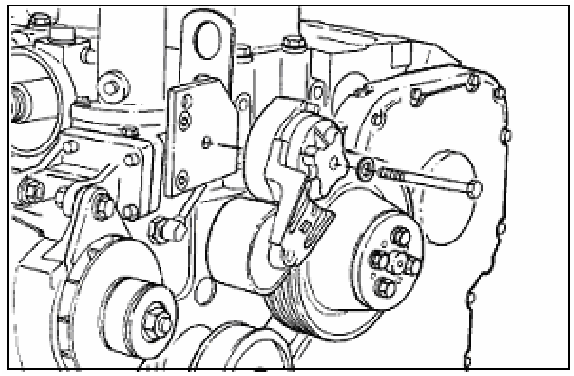
Prepare

Do the preparatory steps and remove the Belt Guard. Refer to Belt Guard Removal/Installation in this section.

Remove the Drive Belt. Refer to Belt Removal/ Installation in this section.

Remove

Remove the belt tensioner from the bracket.

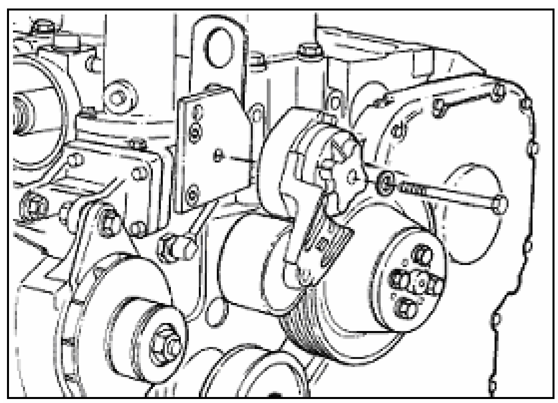


Install

NOTE: Install only Cummins approved replacement belt tensioner (Cummins Part No. 3936213) or equivalent.

Install the belt tensioner and cap screw.

Torque Value: 43 N•m [32 ft-lb]



Follow-Up

When work is completed, install the Drive Belt. Refer to Belt Removal/Installation in this section.

When work is completed, install the Belt Guard and do the listed follow up steps. Refer to Belt Guard Removal/Installation in this section.

Check that the drive belt operates without unusual noises.

Coolant Heat Exchanger Removal/Installation

Prepare

WARNING

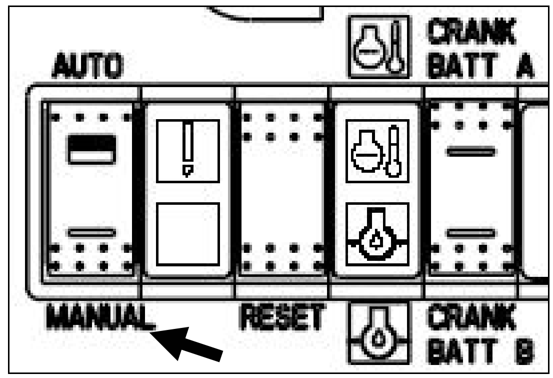
Coolant is toxic. Keep away from children and pets. If not reused, dispose of in accordance with local environmental regulations.

WARNING

Do not remove the pressure cap from a hot engine. Wait until the coolant temperature is below 50°C [122°F] before removing the pressure cap. Heated coolant spray or steam can cause personal injury.

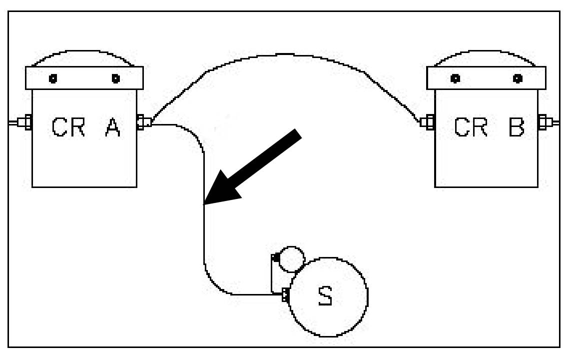
Place the fire protection system in a safe mode for engine service.

Place the AUTO/MANUAL rocker switch in the MANUAL position.



Disconnect or isolate the coolant heater power supply.

Disconnect and insulate the Contactor to Starter Cable (Cummins Fire Power Part No 9762) from the starter (Refer to Drawing 9767 in Section 18).

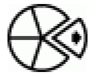


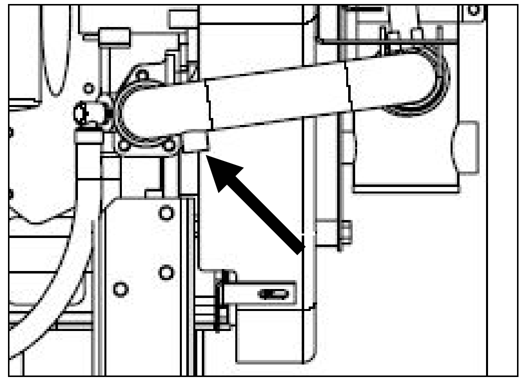
Coolant Heat Exchanger Removal/Installation (Cont)

Ensure that the engine and engine coolant is cool in order to avoid burns.

Remove the engine coolant pressure cap.

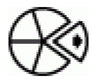
Drain the engine coolant system. Refer to <u>Drain and Flush Coolant System</u> in Section 8.

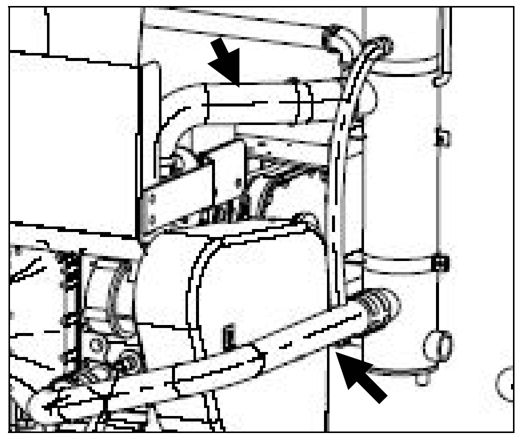




Remove the <u>Upper Engine Coolant Hose</u> from the heat exchanger.

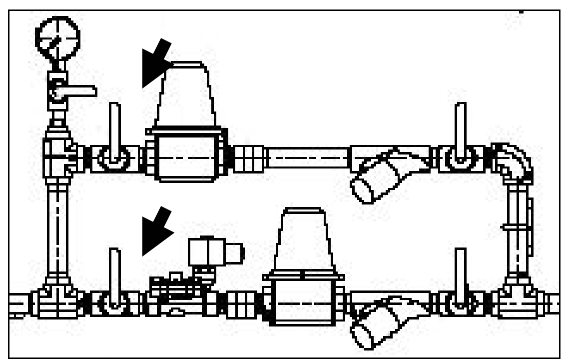
Remove the <u>Lower Engine Coolant and Fill Hose</u> from the heat exchanger.





Close the Raw Water Manifold Bypass Line Outlet Isolation Valve.

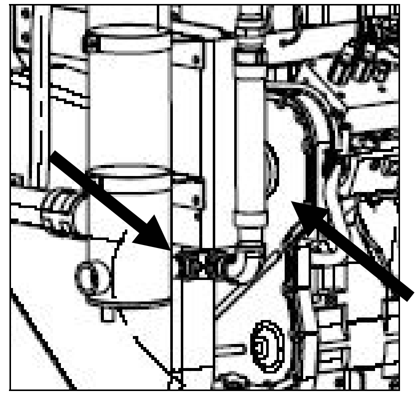
Close the Raw Water Manifold Normal Line Outlet Isolation Valve.



Coolant Heat Exchanger Removal/Installation (Cont)

Remove the 1” NPT raw water inlet piping from the charge air cooler to the heat exchanger. (Refer to Drawing 9595 in Section 18 for raw water supply piping details.)

Also, remove any customer-supplied raw water outlet fittings. Save these components for reuse.



Pressure Test

NOTE: This test is required if internal leakage in the heat exchanger is suspected. It may be performed prior to the removal from the engine.

NOTE: Use teflon tape or other pipe sealant when installing the test setup in order to prevent leaks.

Install a 1-1/4” NPT pipe plug at the raw water outlet of the heat exchanger.

Install a pressure test setup with 700 kPa [100 psi] pressure gauge at the 1” NPT raw water inlet to the heat exchanger.

NOTE: There should be no detectable decrease in the pressure reading for the duration of the test.

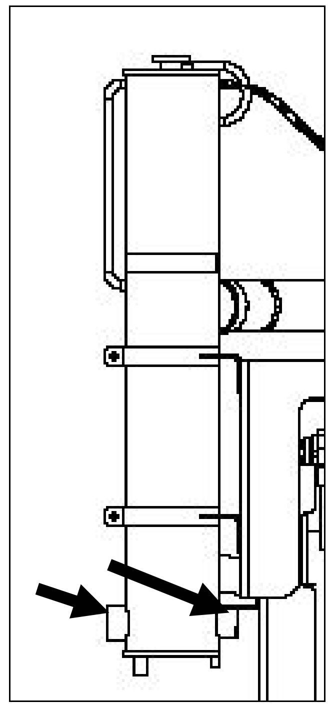
Apply air pressure at 621 kPa [90 psig].

Isolate the pressure source and monitor the pressure gauge for 5 minutes.

After testing, release the pressure.

Remove the pipe plug and the test setup.

If leakage is detected, the heat exchanger must be replaced.



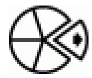
Coolant Heat Exchanger Removal/Installation (Cont)

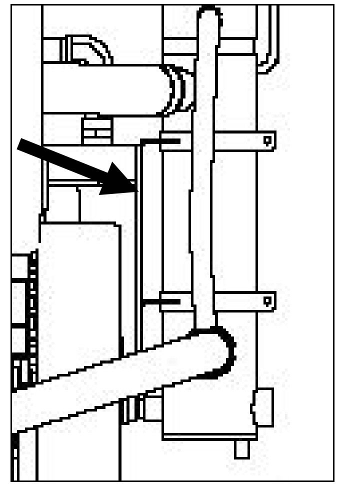
Remove

Provide temporary support for the coolant heat exchanger in order to avoid dropping it.

Remove the four back sets of nuts, washers, and bolts at the heat exchanger mounting clamps.

Remove the heat exchanger and clamps from the engine.

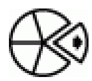


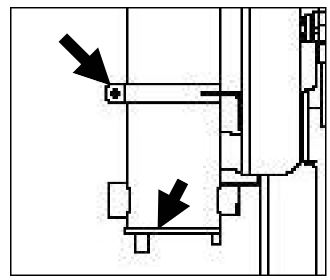


Disassemble

If required for replacement, remove the two front sets of nuts and bolts at the coolant heat exchanger clamps.

If required for replacement, remove the zinc plug and other pipe fittings from the heat exchanger.

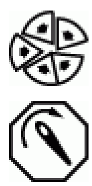


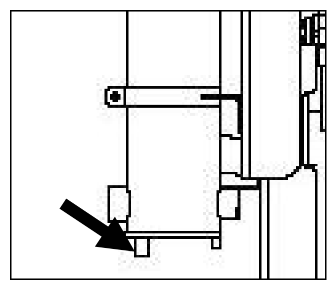


Assemble

NOTE: Use teflon or other pipe sealant when installing threaded pipe fittings.

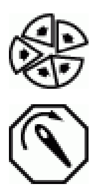
If missing, install the zinc plug (Cummins Fire Power Part No. 9750) and brass fitting (Cummins Fire Power Part No. 9751) in the bottom of the heat exchanger.

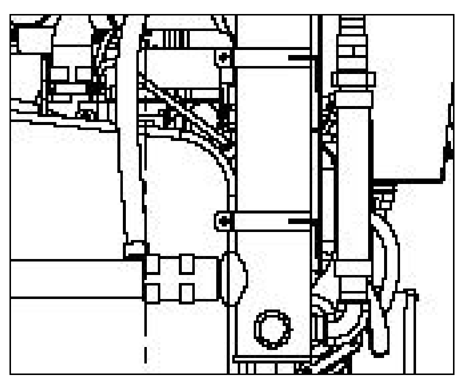




If missing, install the pipe fittings removed from the original heat exchanger. Refer to Drawing 8944 in Section 18 for component information.

If removed, position the two clamps on the heat exchanger and install the two front sets of nuts and bolts at the coolant heat exchanger clamps. Do not tighten at this time. Refer to Drawing 8944 in Section 18 for component information.





Coolant Heat Exchanger Removal/Installation (Cont)

Install

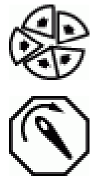
Provide support for the coolant heat exchanger in order to avoid dropping it.

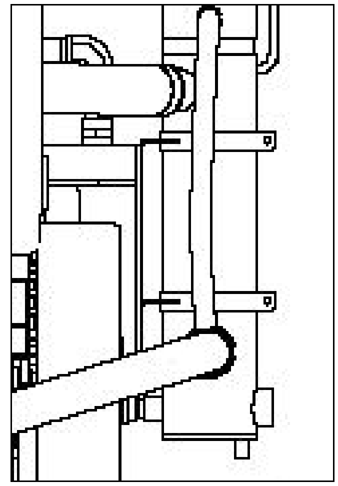
Position the heat exchanger and clamps on the engine's mounting bracket and start the four bolts.

Start the nut and washers on the four bolts.

Align the heat exchanger with the required hose connections and tighten the four back sets of clamp fasteners.

Tighten the two front sets of clamp fasteners.

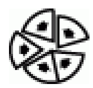


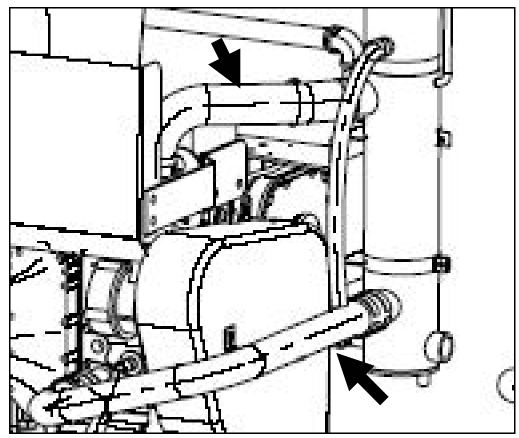


Follow-Up

Install the Upper Engine Coolant Hose at the heat exchanger.

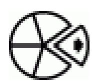
Install the Lower Engine Coolant and Fill Hose at the heat exchanger.

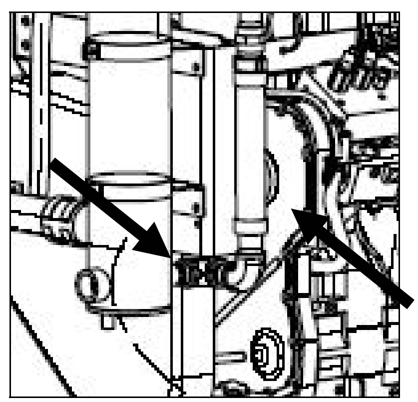




Install the 1" NPT raw water inlet piping from the charge air cooler to the heat exchanger. (Refer to Drawing 9595 in Section 18 for raw water supply piping details.)

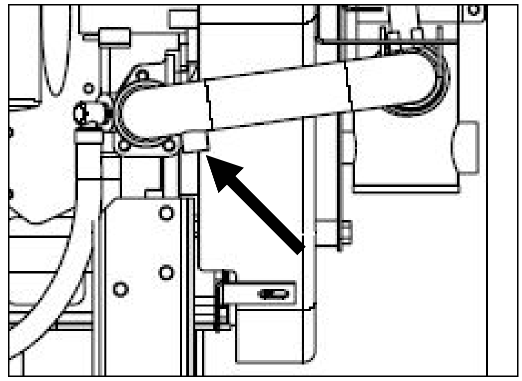
Also, install any customer-supplied raw water outlet fittings.





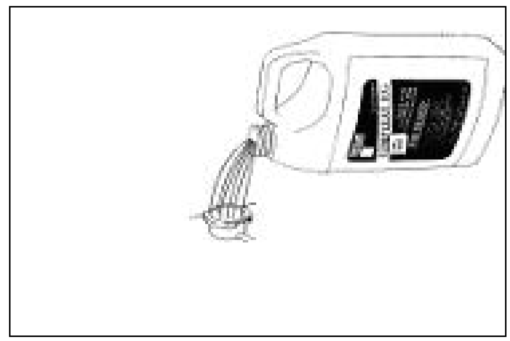
Coolant Heat Exchanger Removal/Installation (Cont)

Close coolant drain valve.



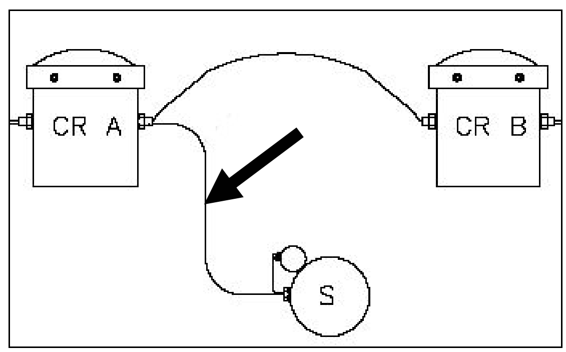
Refill the engine coolant. Refer to Drain and Flush Coolant System in Section 8.

Install the coolant system pressure cap.



Reconnect the coolant heater power supply.

Reconnect the Contactor to Starter Cable (Cummins Fire Power Part No 9762) at the starter (Refer to Drawing 9767 in Section 18).



NOTE: Start the engine and do a quick check for leaks. If any coolant leaks are observed, stop the engine, repair the leak, check coolant level, then restart the engine. If no leaks are present, promptly establish raw water flow through the heat exchanger.

Start the engine. Refer to Normal Local Starting Procedure in Section 3.

Check for and repair any coolant leaks.

Coolant Heat Exchanger Removal/Installation (Cont)

CAUTION

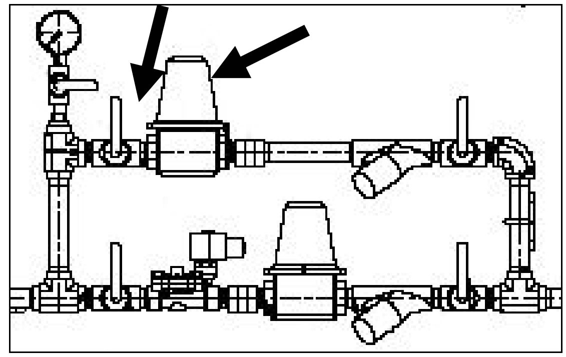
When establishing raw water flow, ensure that the raw water pressure does not exceed 414 kPa (60 psig) at the heat exchanger. Adjust the pressure regulators as required.

Slowly open the Raw Water Manifold Bypass Line Outlet Isolation Valve.

Observe raw water flow through the heat exchanger.

Adjust the bypass pressure regulator if required.

Close the Raw Water Manifold Bypass Line Outlet Isolation Valve.



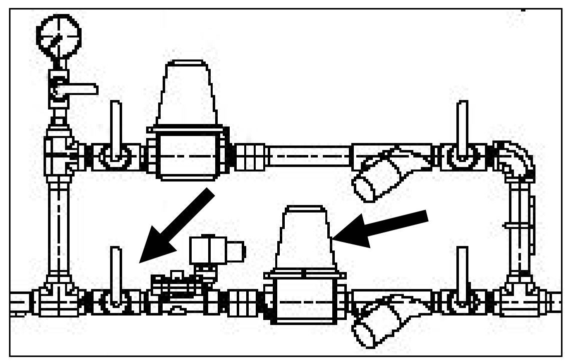
CAUTION

When establishing raw water flow, ensure that the raw water pressure does not exceed 414 kPa (60 psig) at the heat exchanger. Adjust the pressure regulators as required.

Slowly open the Raw Water Manifold Normal Line Outlet Isolation Valve.

Observe raw water flow through the heat exchanger.

Adjust the normal pressure regulator if required.



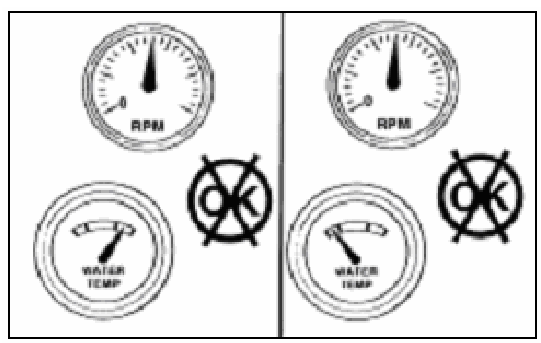
NOTE: If temperature does not stabilize, stop the engine and refer to Coolant Temperature Above Normal or Coolant Temperature Below Normal (Engine Running) in Troubleshooting Section 17.

Check that engine operating temperature stabilizes between about 82 and 93 ^{o}C [180 and 200 ^{o}F].

Check that no coolant hoses are collapsed.

When temperature has stabilized, stop the engine.

Ensure that repairs are completed satisfactorily.

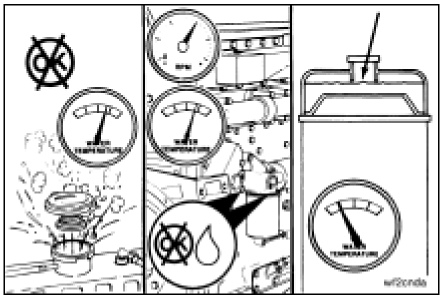


Coolant Heat Exchanger Removal/Installation (Cont)

WARNING

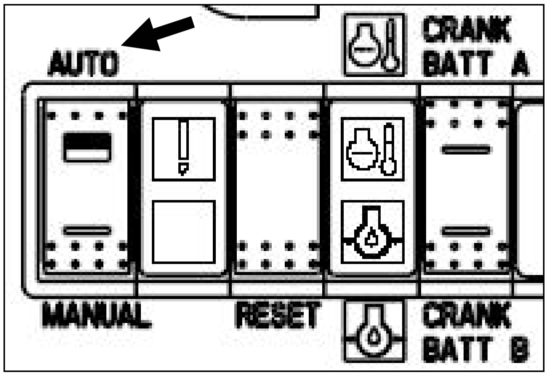
Do not remove the pressure cap from a hot engine. Wait until the coolant temperature is below 50°C [120°F] before removing the pressure cap. Heated coolant spray or steam can cause personal injury.

Check the coolant level. Refer to Check Coolant Level in Section 5. Add coolant if necessary.



Place the AUTO/MANUAL rocker switch in the AUTO position.

Return the fire protection system to operating status.



Coolant Heater Removal/Installation

Prepare

WARNING

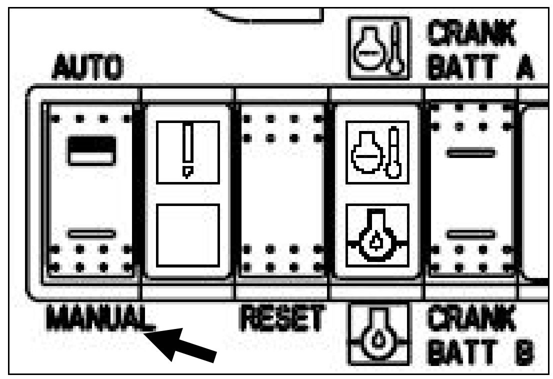
Coolant is toxic. Keep away from children and pets. If not reused, dispose of in accordance with local environmental regulations.

WARNING

Do not remove the pressure cap from a hot engine. Wait until the coolant temperature is below 50°C [122°F] before removing the pressure cap. Heated coolant spray or steam can cause personal injury.

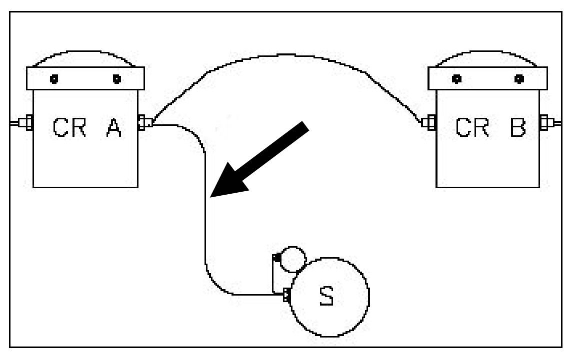
Place the fire protection system in a safe mode for engine service.

Place the AUTO/MANUAL rocker switch in the MANUAL position.



Disconnect or isolate the coolant heater power supply.

Disconnect and insulate the Contactor to Starter Cable (Cummins Fire Power Part No 9762) from the starter (Refer to Drawing 9767 in Section 18).

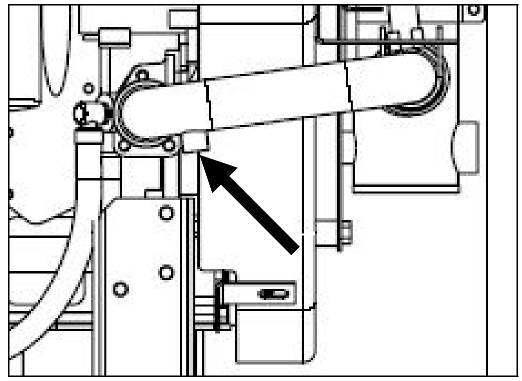


Coolant Heater Removal/Installation (Cont)

Ensure that the engine and engine coolant is cool in order to avoid burns.

Remove the engine coolant pressure cap.

Drain the engine coolant system. Refer to Drain and Flush Coolant System in Section 8.

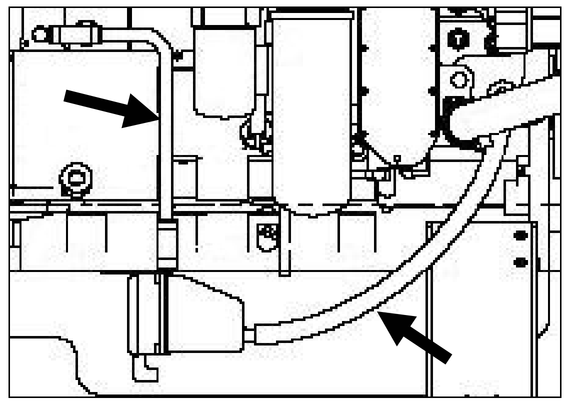


NOTE: Collect the remainder of the coolant in the heater hoses.

NOTE: Refer to Drawing 8941 in Section 18 for detailed component information.

Remove the Upper Coolant Heater Hose.

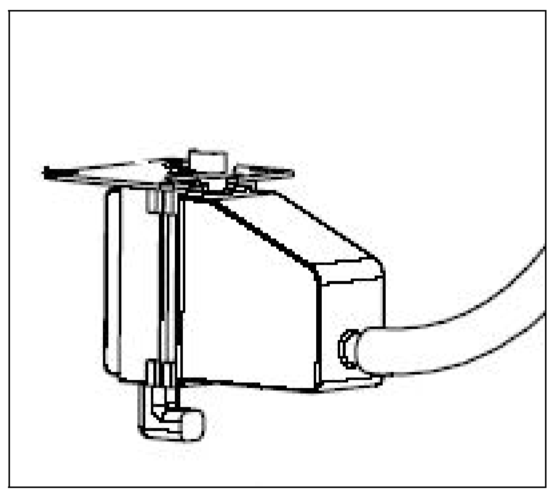
Remove the Lower Coolant Heater Hose.



Remove

Remove the two capscrews, washers, bracket, and coolant heater. Refer to Drawing 8941 in Section 18 for detailed component information.

If required, remove the nuts, bolts, washers and mounting bracket from the coolant heater.



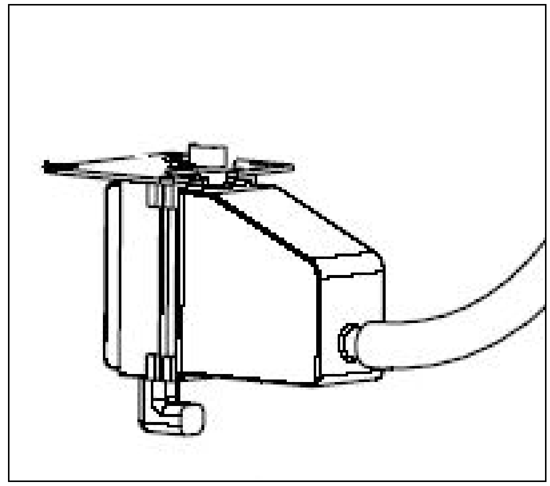
Coolant Heater Removal/Installation (Cont)

Install

If missing, install the nuts, bolts, washers and mounting bracket on the coolant heater. Refer to Drawing 8941 in Section 18 for detailed component information.

Position the coolant heater and mounting bracket and start the two bolts with washers.

Torque the two bolts on the mounting bracket as per Capscrew Markings and Torque Values in Section 15.

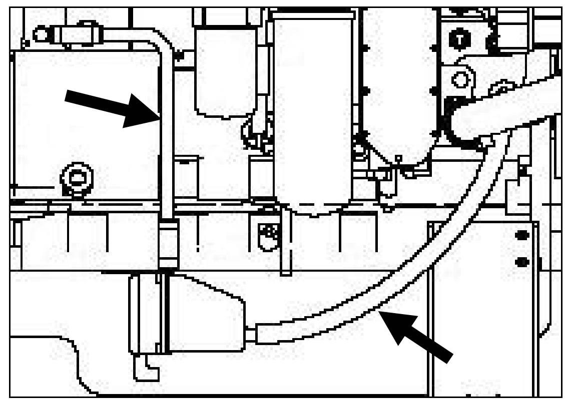


Follow-Up

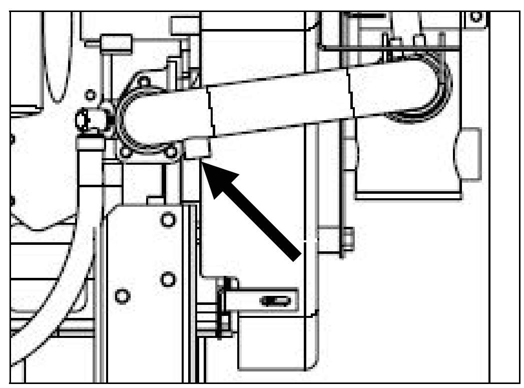
NOTE: Refer to Drawing 8941 in Section 18 for detailed component information.

Install the Upper Coolant Heater Hose.

Install the Lower Coolant Heater Hose.



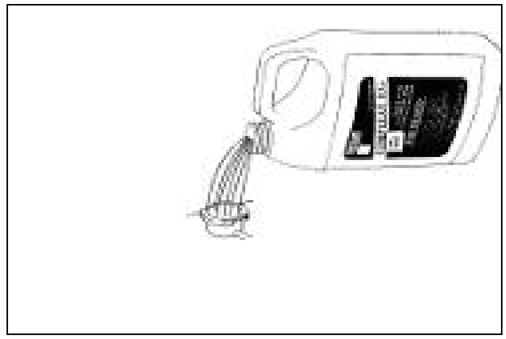
Close the coolant drain valve.



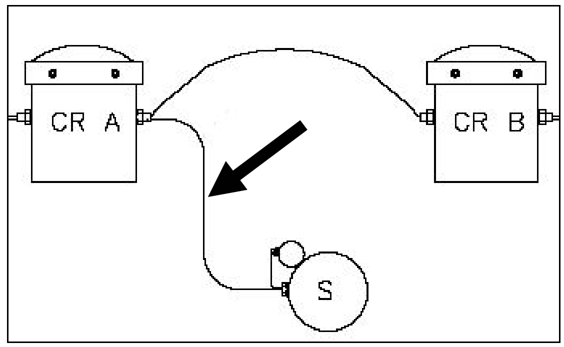
Coolant Heater Removal/Installation (Cont)

Refill the engine coolant. Refer to Drain and Flush Coolant System in Section 8.

Install the coolant system pressure cap.



Reconnect the Contactor to Starter Cable (Cummins Fire Power Part No 9762) at the starter (Refer to Drawing 9767 in Section 18).



NOTE: Start the engine and do a quick check for leaks. If any coolant leaks are observed, stop the engine, repair the leak, check coolant level, then restart the engine.

Start the engine. Refer to Normal Local Starting Procedure in Section 3.

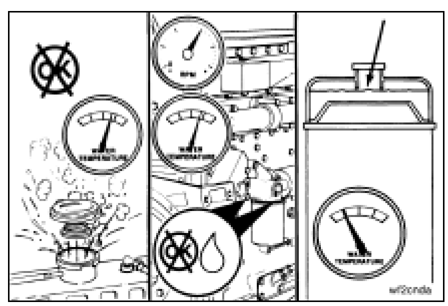
Check for and repair any coolant leaks.

Stop the engine.

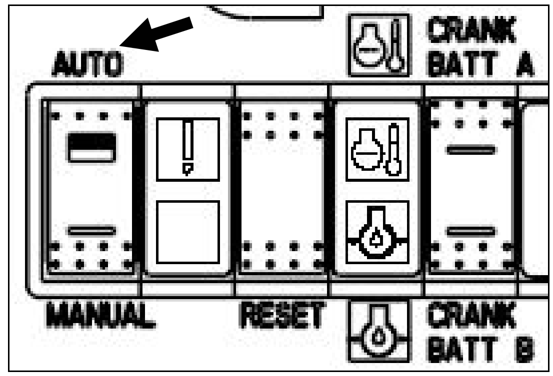
WARNING

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

Check the coolant level. Refer to Check Coolant Level in Section 5. Add coolant if necessary.



Coolant Heater Removal/Installation (Cont)

Reconnect the coolant heater power supply. Observe that the coolant temperature cools down but stabilizes. Check that the engine block remains warm to the touch.	
Place the AUTO/MANUAL rocker switch in the AUTO position. Return the fire protection system to operating status.	

Coolant Hose Removal/Installation

Identify hose clamps and add manufacturer's torque value.

NOTE: This section addresses all coolant tubes and hoses. Only remove those coolant hoses that are necessary. It is not required to remove both ends of the hose for the replacement of other components. Use the following sections as applicable:

Coolant Hose Removal/Installation (Cont)

Prepare

WARNING

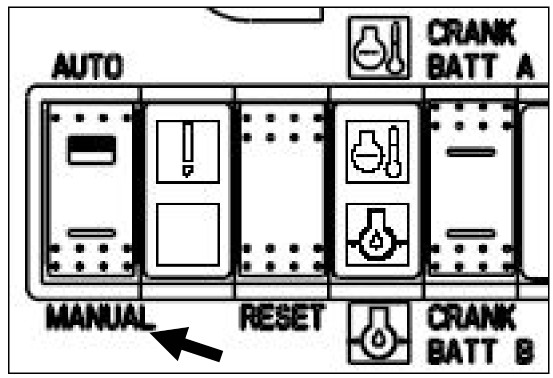
Coolant is toxic. Keep away from children and pets. If not reused, dispose of in accordance with local environmental regulations.

WARNING

Do not remove the pressure cap from a hot engine. Wait until the coolant temperature is below 50°C [122°F] before removing the pressure cap. Heated coolant spray or steam can cause personal injury.

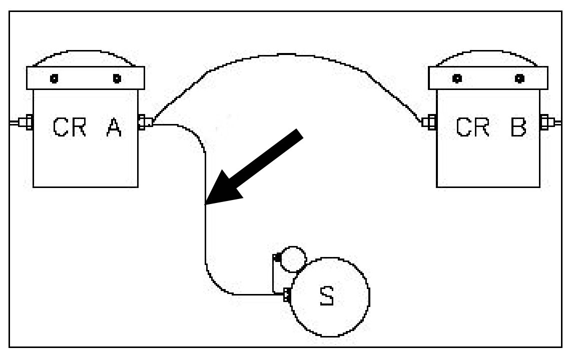
Place the fire protection system in a safe mode for engine service.

Place the AUTO/MANUAL rocker switch in the MANUAL position.



Disconnect or isolate the coolant heater power supply.

Disconnect and insulate the Contactor to Starter Cable (Cummins Fire Power Part No 9762) from the starter (Refer to Drawing 9767 in Section 18).

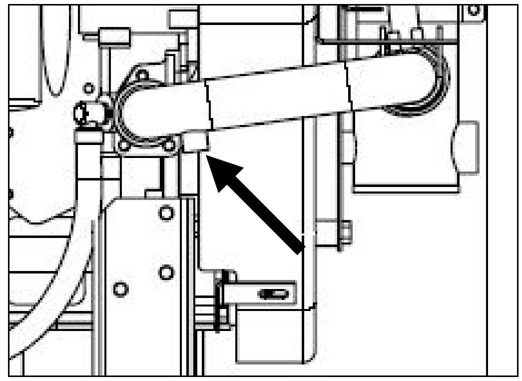


Coolant Hose Removal/Installation (Cont)

Ensure that the engine and engine coolant is cool in order to avoid burns.

Remove the engine coolant pressure cap.

Drain the engine coolant system. Refer to Drain and Flush Coolant System in Section 8.



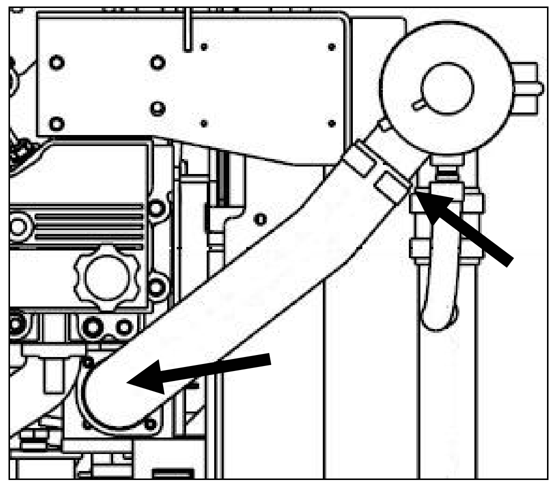
Remove the Upper Engine Coolant Hose

NOTE: Refer to Assembly Drawing 8944 in Section 18 for detailed construction.

Loosen the hose clamp at the heat exchanger.

Loosen the hose clamp at the engine.

Pull the hose from the heat exchanger and engine.



Remove the Lower Engine Coolant and Fill Hoses

NOTE: Refer to Assembly Drawing 8944 in Section 18 for detailed construction.

Remove the nuts and U-bolt supporting the lower engine coolant hose.

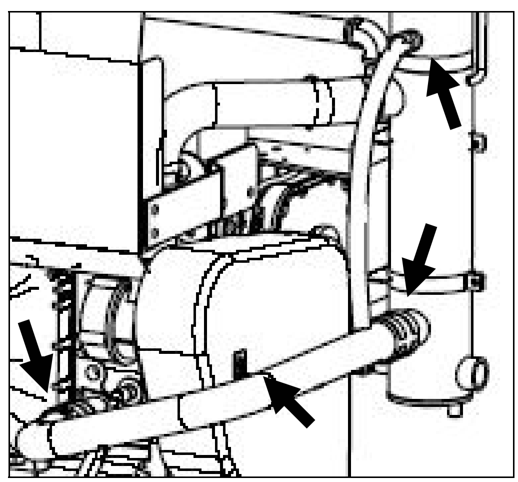
Loosen the fill hose clamp at the heat exchanger.

Loosen the engine coolant hose clamp at the heat exchanger.

Loosen the engine coolant hose clamp at the engine.

Pull the hoses from the heat exchanger and engine.

If required for replacement, disassemble the components.



Coolant Hose Removal/Installation (Cont)

Remove the Upper Coolant Heater Hose

NOTE: Refer to Assembly Drawing 8941 in Section 18 for detailed construction.

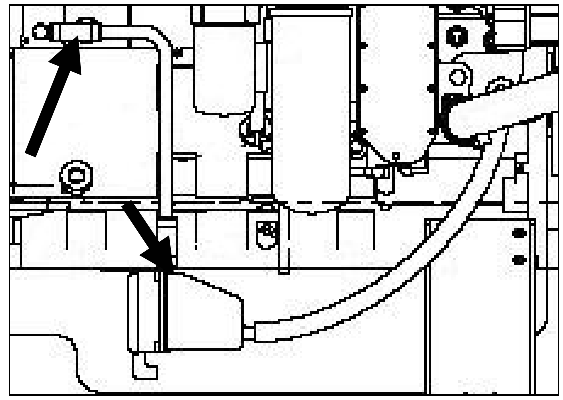
NOTE: Be prepared to collect the residual coolant that may drain from the hose.

Loosen the hose clamp at the engine.

Loosen the hose clamp at the coolant heater.

Pull the hose and tubing from the connections.

Disassemble additional components if this is required for inspection or repairs.



Remove the Lower Coolant Heater Hose

NOTE: Refer to Assembly Drawing 8941 in Section 18 for detailed construction.

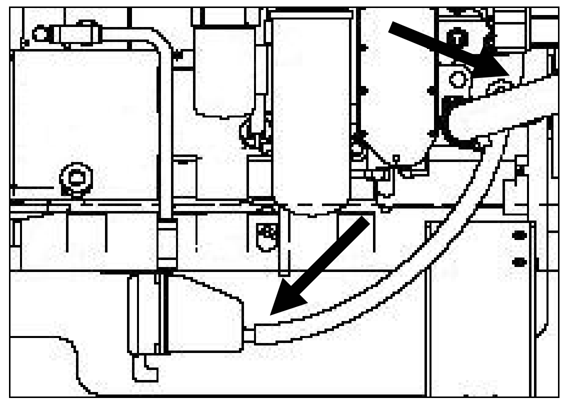
NOTE: Be prepared to collect the residual coolant that may drain from the hose.

Loosen the hose clamp at the engine.

Loosen the hose clamp at the coolant heater.

Pull the hose and tubing from the connections.

Disassemble additional components if this is required for inspection or repairs.



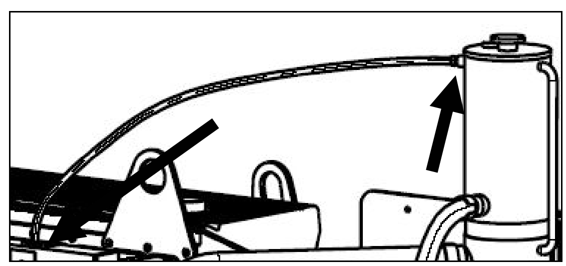
Remove the Coolant Vent Hose

NOTE: Refer to Assembly Drawing 9543 in Section 18 for detailed construction.

Loosen the flair fitting at the coolant heat exchanger.

Loosen the flair fitting at the engine.

Pull the hose from the connections.



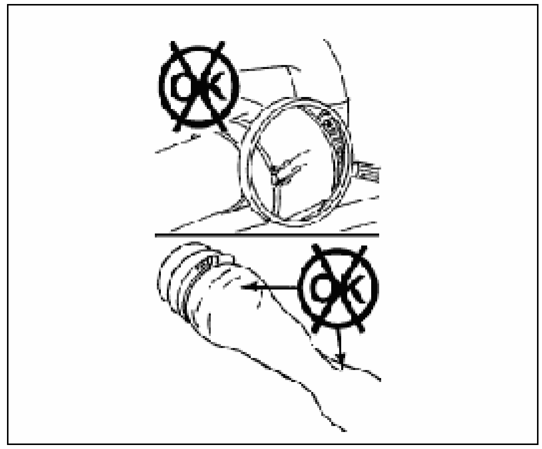
Coolant Hose Removal/Installation (Cont)

Inspect

NOTE: Inspect the cooling system hoses and hose connection for leaks or deterioration. Particles of deteriorated hose can be carried through the cooling system and slow or partially stop circulation.

Inspect the hoses and hose connections.

Replace any hoses or clamps that are damaged.



Install the Upper Engine Coolant Hose

CAUTION

Do not re-install worn or damaged hoses or corroded clamps.

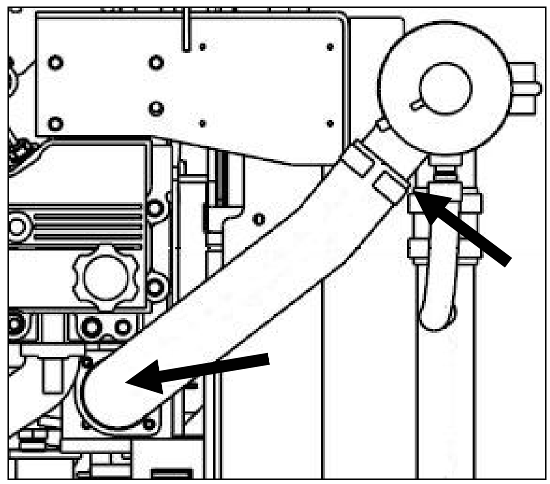
NOTE: Refer to Assembly Drawing 8944 in Section 18 for detailed construction.

Position the hose clamps on the hose.

Push the hose onto the heat exchanger and engine connections.

Tighten the hose clamp at the heat exchanger.

Tighten the hose clamp at the engine.



Coolant Hose Removal/Installation (Cont)

Install the Lower Engine Coolant and Fill Hoses

CAUTION

Do not re-install worn or damaged hoses or corroded clamps.

NOTE: Refer to Assembly Drawing 8944 in Section 18 for detailed construction.

Position the hose clamps on the hoses.

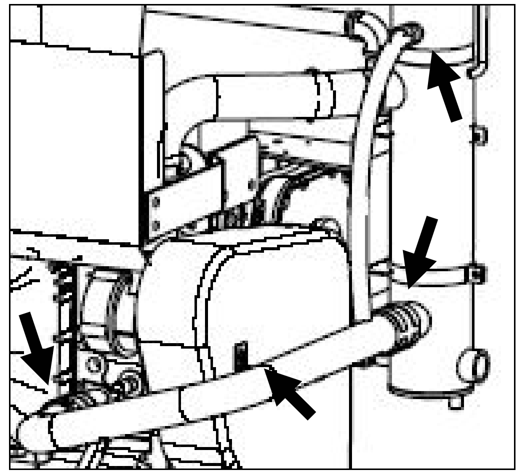
Push the hose on the connections at the heat exchanger and engine.

Position and tighten the lower engine coolant hose clamp at the engine.

Position and tighten the lower engine coolant hose clamp at the heat exchanger.

Position and tighten the upper fill hose clamp at the heat exchanger.

Install the nuts and U-bolt supporting the lower hose. Tighten the capscrew as per Capscrews Markings and Torque Values in Section 15.



Install the Upper Coolant Heater Hose

CAUTION

Do not re-install worn or damaged hoses or corroded clamps.

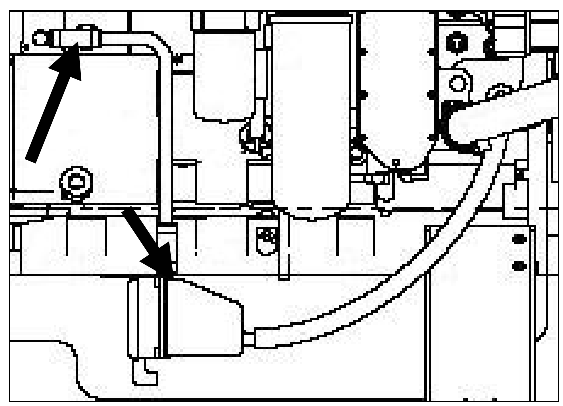
NOTE: Refer to Assembly Drawing 8941 in Section 18 for detailed construction.

Position the hose clamps on the hoses.

Push the hose on the connections at the coolant heater and the engine.

Position and tighten the lower engine coolant hose clamp at the engine.

Position and tighten the lower engine coolant hose clamp at the coolant heater.



Coolant Hose Removal/Installation (Cont)

Install the Lower Coolant Heater Hose

CAUTION

Do not re-install worn or damaged hoses or corroded clamps.

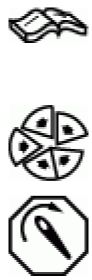
NOTE: Refer to Assembly Drawing 8941 in Section 18 for detailed construction.

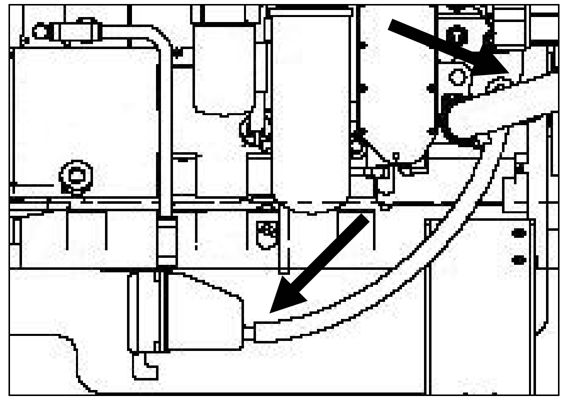
Position the hose clamps on the hoses.

Push the hose on the connections at the coolant heater and the engine.

Position and tighten the lower engine coolant hose clamp at the engine.

Position and tighten the lower engine coolant hose clamp at the coolant heater.





Install the Coolant Vent Hose

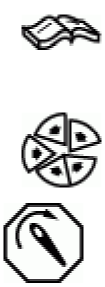
CAUTION

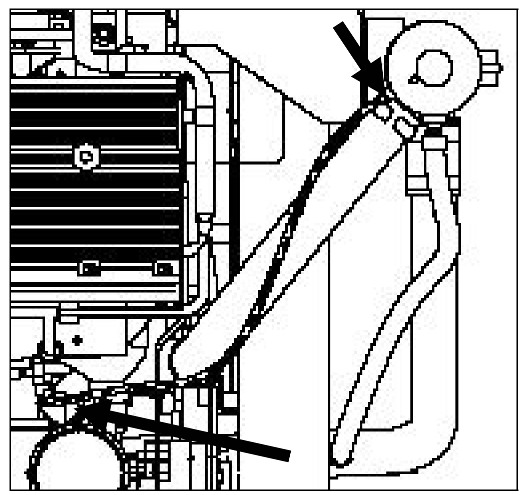
Do not re-install worn or damaged hoses or corroded clamps.

NOTE: Refer to Assembly Drawing 9543 in Section 18 for detailed construction.

Connect the hose flair connector at the heat exchanger.

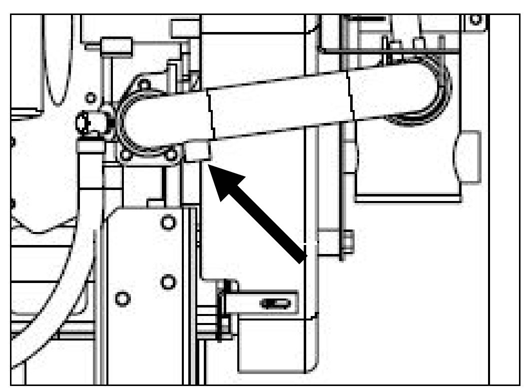
Connect the hose flair connector at the engine coolant vent connection.





Follow-Up

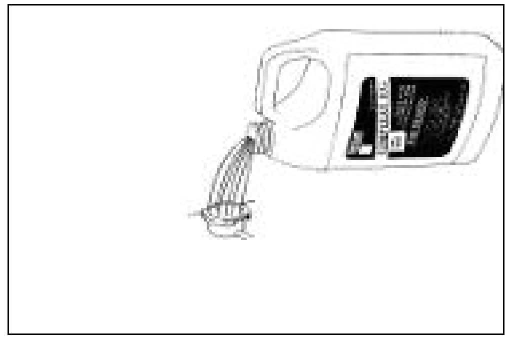
Close the coolant drain valve.



Coolant Hose Removal/Installation (Cont)

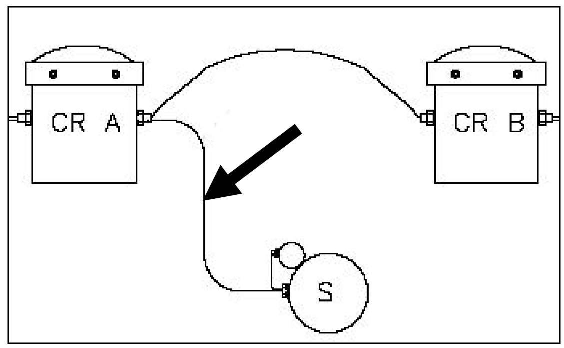
Refill the engine coolant. Refer to Drain and Flush Coolant System in Section 8.

Install the coolant system pressure cap.



Reconnect the coolant heater power supply.

Reconnect the Contactor to Starter Cable (Cummins Fire Power Part No 9762) at the starter (Refer to Drawing 9767 in Section 18).



NOTE: Start the engine and do a quick check for leaks. If any coolant leaks are observed, stop the engine, repair the leak, check coolant level, then restart the engine.

Start the engine. Refer to Normal Local Starting Procedure in Section 3.

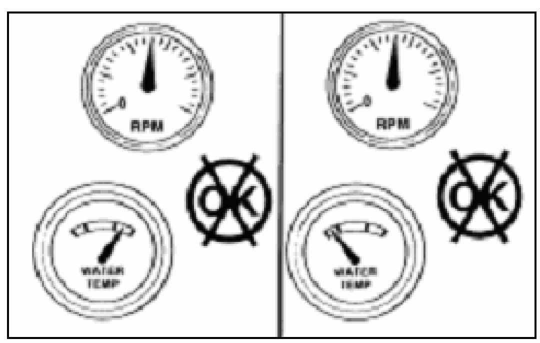
Check for and repair any coolant leaks.

Check that engine operating temperature stabilizes between about 82 and 93 ^{o}C [180 and 200 ^{o}F].

Check that no coolant hoses are collapsed.

When temperature has stabilized, stop the engine.

Ensure that repairs are completed satisfactorily.

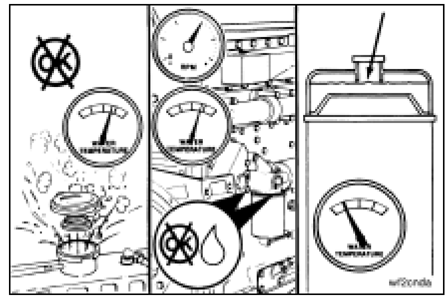


Coolant Hose Removal/Installation (Cont)

WARNING

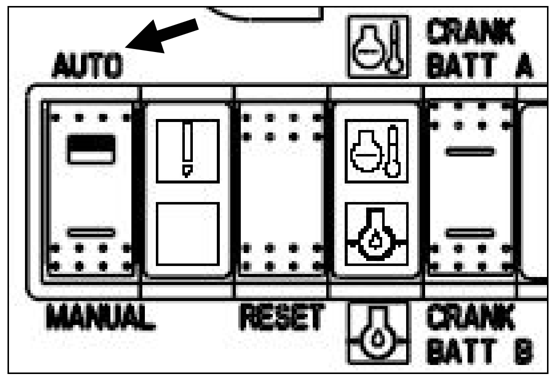
Do not remove the pressure cap from a hot engine. Wait until the coolant temperature is below 50°C [120°F] before removing the pressure cap. Heated coolant spray or steam can cause personal injury.

Check the coolant level. Refer to Check Coolant Level in Section 5. Add coolant if necessary.



Place the AUTO/MANUAL rocker switch in the AUTO position.

Return the fire protection system to operating status.



Raw Water Pressure Regulator Removal/Installation

NOTE: This section applies only to pressure regulators supplied by Cummins Fire Power. These procedures should be modified for alternative piping or components as supplied by the customer.

NOTE: This section applies to both the normal and bypass lines. Use the appropriate sections as follows:

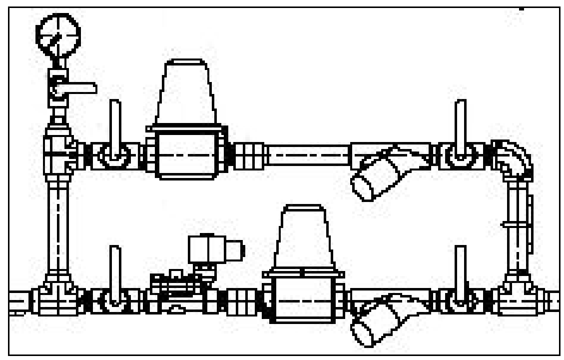
- Prepare (Bypass Line)
- Prepare (Normal Line)
- Remove (Bypass Line)
- Remove (Normal Line)
- Install (Bypass Line)
- Install (Normal Line)
- Follow-Up (Bypass Line)
- Follow-Up (Normal Line)

Prepare (Bypass Line)

Place the AUTO/MANUAL Switch at the local panel in the MANUAL position.

Close the Raw Water Manifold Bypass Line Inlet Isolation Valve.

Close the Raw Water Manifold Bypass Line Outlet Isolation Valve.

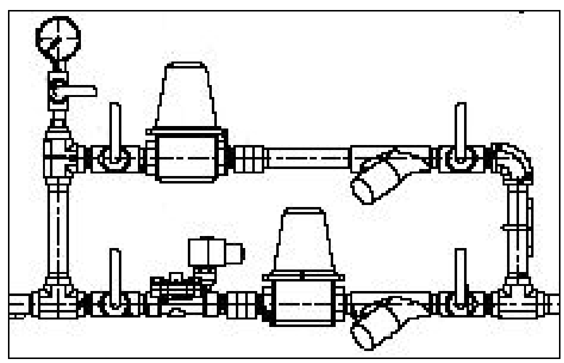


Prepare (Normal Line)

Place the AUTO/MANUAL Switch at the local panel in the MANUAL position.

Close the Raw Water Manifold Normal Line Inlet Isolation Valve

Close the Raw Water Manifold Normal Line Outlet Isolation Valve.



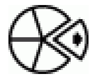
Raw Water Pressure Regulator Removal/Installation (Cont)

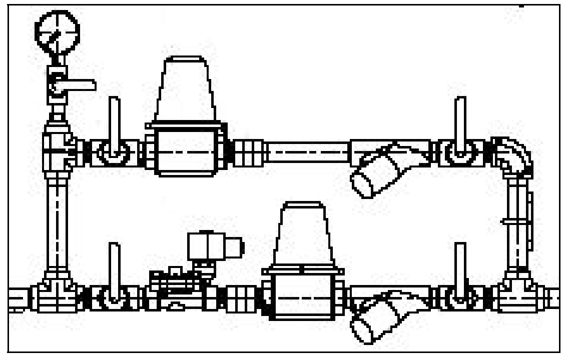
Remove (Bypass Line)

Loosen the pipe union upstream of the pressure regulator.

Unscrew the pressure regulator from the outlet isolation valve.

As required, remove the pipe nipples from the pressure regulator.



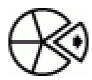


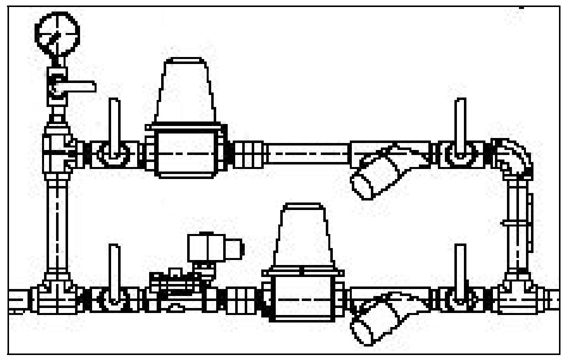
Remove (Normal Line)

Loosen the pipe union downstream of the pressure regulator.

Unscrew the pressure regulator from the solenoid valve.

As required, remove the pipe nipples from the pressure regulator.





Install (Bypass Line)

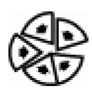
When the pressure regulator is repaired or replaced, prepare it for installation.

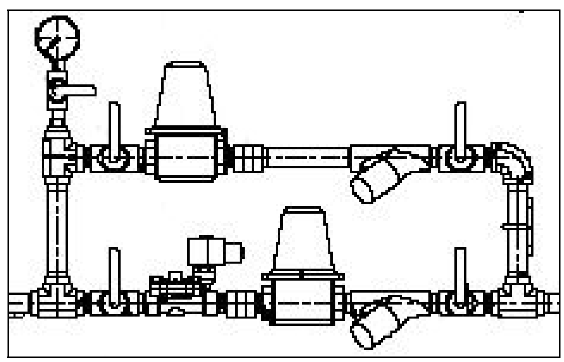
NOTE: Use pipe dope or silicon sealant on threaded fittings.

As required, install the pipe nipples on the pressure regulator. Tighten with a pipe wrench or equivalent.

Screw the pressure regulator onto the outlet isolation valve.

Align and connect the pipe union. Tighten with a pipe wrench or equivalent.





Raw Water Pressure Regulator Removal/Installation (Cont)

Install (Normal Line)

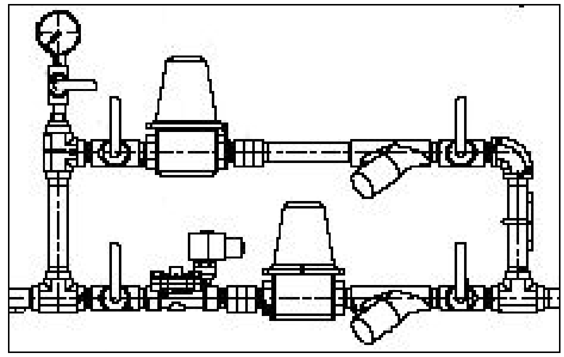
When the pressure regulator is repaired or replaced, prepare it for installation.

NOTE: Use pipe dope or silicon sealant on threaded fittings.

As required, install the pipe nipples on the pressure regulator. Tighten with a pipe wrench or equivalent.

Screw the pressure regulator onto the solenoid valve.

Align and connect the pipe union. Tighten with a pipe wrench or equivalent.

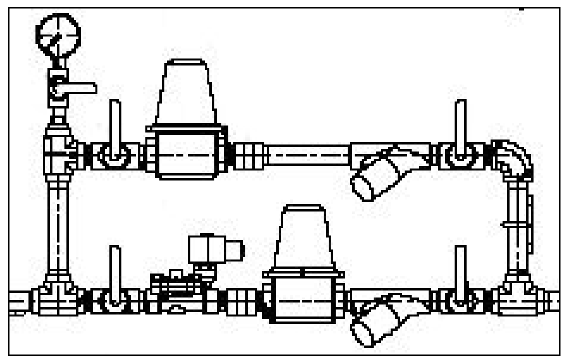


Follow-Up (Bypass Line)

Check the pressure regulator setpoint (refer to Section 3).

If required, open the Raw Water Manifold Bypass Line Inlet Isolation Valve.

If required, open the Raw Water Manifold Bypass Line Outlet Isolation Valve.



Verify that raw water flow is established through the heat exchanger.

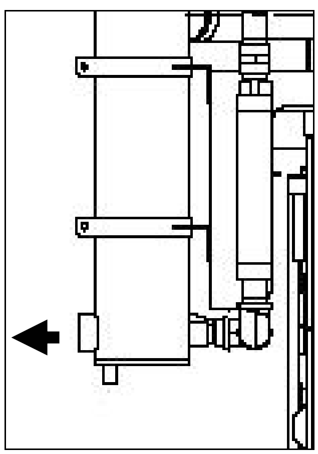
When flow is verified, close the bypass line outlet valve.

Ensure that the normal line inlet and outlet valves are both open.

Ensure that the pressure gauge isolation valve is open.

Ensure that repairs are completed satisfactorily.

Place the AUTO/MANUAL Switch at the local panel in the AUTO position.



Raw Water Pressure Regulator Removal/Installation (Cont)

Follow-Up (Normal Line)

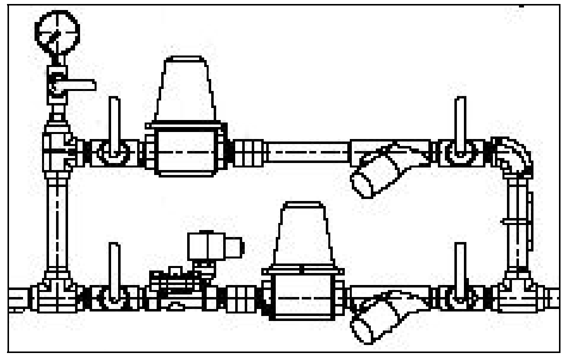
Check the pressure regulator setpoint (refer to Section 3).

If required, open the Raw Water Manifold Normal Line Inlet Isolation Valve.

If required, open the Raw Water Manifold Normal Line Outlet Isolation Valve.

As required, close the bypass line outlet valve.

Ensure that the pressure gauge isolation valve is open.



Start the engine to operate the raw water solenoid valve. (Refer to Section 3),

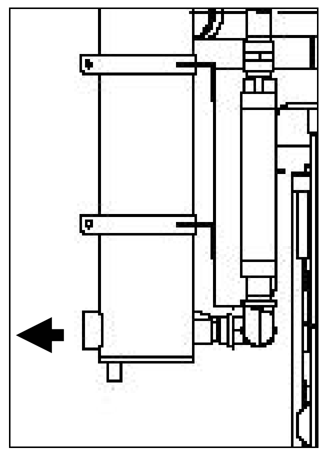
Verify that raw water flow is established through the heat exchanger.

When flow is verified, stop the engine.

Observe that raw water flow stops.

Ensure that repairs are completed satisfactorily.

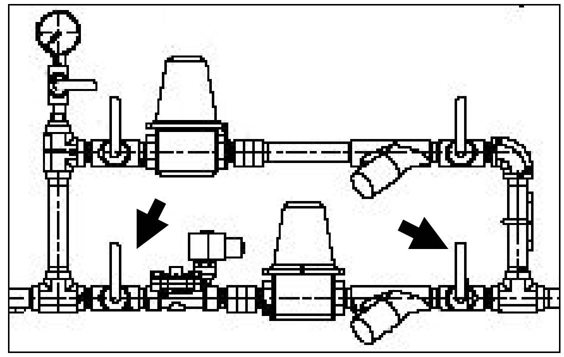
Place the AUTO/MANUAL Switch at the local panel in the AUTO position.



Raw Water Solenoid Valve Removal/Installation

NOTE: This section applies to solenoid valves supplied by Cummins Fire Power.

Prepare



Place the AUTO/MANUAL Switch at the local panel in the MANUAL position.

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.

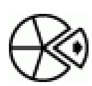
Disconnect the positive battery cables from both batteries.

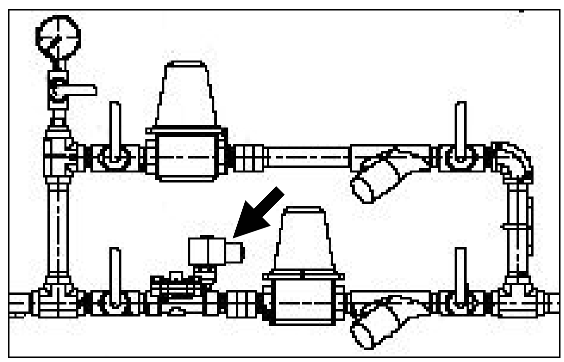
Disconnect any customer supplied battery chargers.

Close the Raw Water Manifold Normal Line Inlet Isolation Valve.

Close the Raw Water Manifold Normal Line Outlet Isolation Valve.

Remove





NOTE: Minimize the loss of wire when cutting the splices.

NOTE: Tag each end of the wire before making the cut.

Cut the butt-splices at the connection between the two solenoid valve pigtail wires and the fire pump electrical harness.

Loosen the union fitting between the solenoid valve and the pressure regulator.

Unscrew the solenoid valve from the outlet isolation valve or inlet nipple.

Remove the solenoid valve.

If appropriate for replacement, remove the pipe fittings from the solenoid valve.

Raw Water Solenoid Valve Removal/Installation (Cont)

Install

NOTE: Install only Cummins approved replacement solenoid valves [Cummins Fire Power Part No. 8210G14-12VDC (12 VDC) or 8210G14-24VDC (24 VDC)].

NOTE: Use thread sealant when making threaded plumbing connections.

If removed, install the inlet and outlet fittings on the solenoid valve.

Position the solenoid valve and start threading it into the outlet valve or onto the outlet valve nipple.

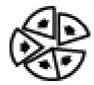
Thread the valve until it is tight and so that the electrical housing is facing up.

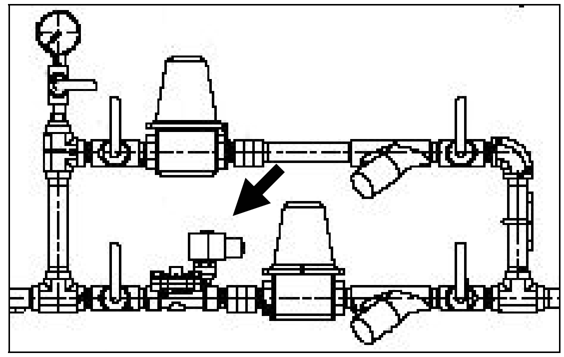
Align and tighten the union connection.

NOTE: Use termination techniques that meet all local requirements. Cummins recommends crimped and insulated butt splices.

NOTE: The solenoid valve's green pigtail lead is not used. The other two leads are not polarity dependent.

Splice the two solenoid pigtail leads to the fire pump harness solenoid leads.





Raw Water Solenoid Valve Removal/Installation (Cont)

Follow-Up

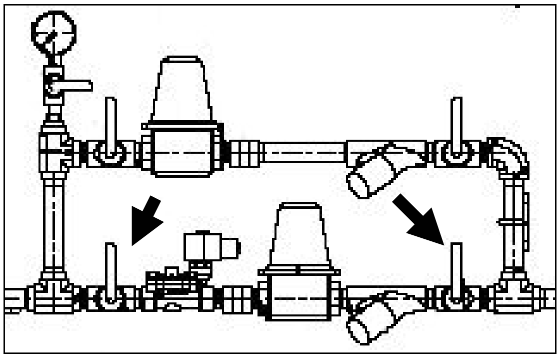
WARNING

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.

Connect the positive battery cables at both batteries,

Open the Raw Water Manifold Normal Line Inlet Isolation Valve.

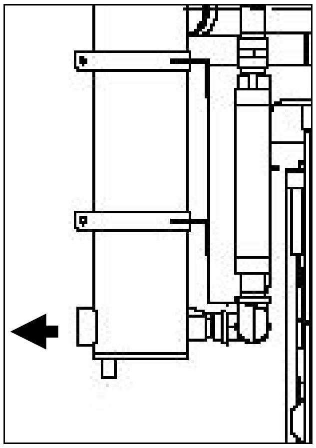
Open the Raw Water Manifold Normal Line Outlet Isolation Valve.



Operate the engine. Refer to Operating Instructions in Section 3.

Check for leaks. Repair any leaks.

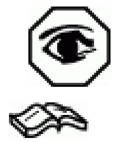
Check that raw water flow starts when the engine starts.



Raw Water Solenoid Valve Removal/Installation (Cont)

Stop the engine.

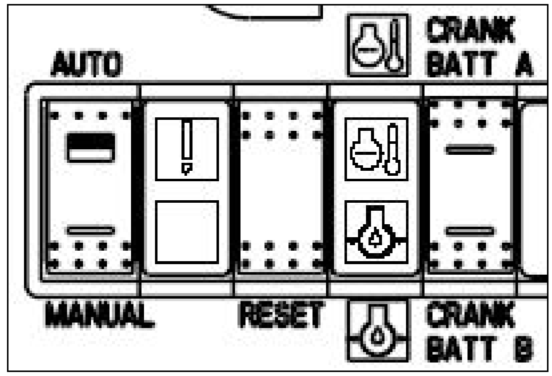
Check that raw water flow stops shortly after the engine stops.



If raw water flow does not start when the engine starts, refer to Coolant Temperature Above Normal in Troubleshooting Section 17.

If raw water flow does not stop shortly after the engine stops, refer to in Troubleshooting Section 17.

If operation is correct, place the AUTO/MANUAL Switch at the local panel in the AUTO position.



Water Temperature Gauge Removal/Installation

Prepare

Place the AUTO/MANUAL Switch at the local panel in the MANUAL position.

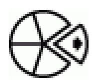
WARNING

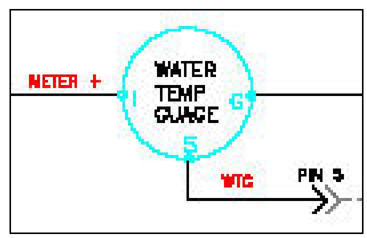
Batteries can emit explosive gases. To reduce the possibility of personal injury, always ventilate the compartment before servicing the batteries. To reduce the possibility of arcing, remove the negative (-) battery cable first and attach the negative (-) battery cable last.

Disconnect the positive battery cables from both batteries.

Disconnect any customer supplied battery chargers.

Remove





Use a nut driver or equivalent to remove the control panel's mounting bolt.

Pull the control panel out from the enclosure so that it is supported by the piano hinge on the bottom.

NOTE: Check and tag all wires with location tags prior to removal.

Remove the two dark blue [METER +] wires from the [I] terminal on the gauge.

Remove the single black ground wire from the [G] terminal on the gauge.

Remove the single [WTG] wire from the [S] terminal on the gauge.

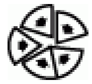
NOTE: Catch the gauge as the meter bracket is removed.

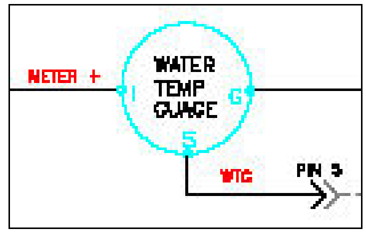
Remove the two nuts and the meter bracket from the back of the panel.

Remove the gauge from the panel.

Water Temperature Gauge Removal/Installation (Cont)

Install





Position the gauge in the panel. Orient it for ease of reading.

Position the meter bracket on the gauge's mounting studs. Start the nuts.

Tighten the nuts hand tight plus a full turn.

Connect the two dark blue [METER +] wires on the [I] terminal on the gauge.

Connect the single black ground wire on the [G] terminal on the gauge.

Connect the single [WTG] wire on the [S] terminal on the gauge.

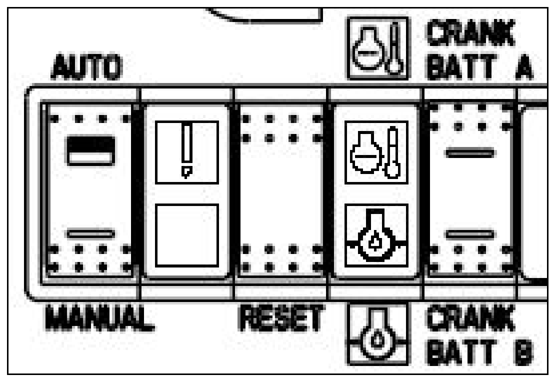
Raise the control panel and install the panel mounting bolt.

Follow-Up

Reconnect the batteries and any battery chargers.

Observe that the [WATER TEMP] gauge indicates a reasonable value for ambient cooling water temperature.

If the gauge does indicate correctly, place the AUTO/MANUAL Switch at the local panel in the AUTO position.



Coolant Temperature Sender Removal/Installation

Prepare

WARNING

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

WARNING

Do not remove the pressure cap from a hot engine. Wait until the temperature is below 50°C [122°F] before removing the pressure cap. Heated coolant spray or steam can cause personal injury.

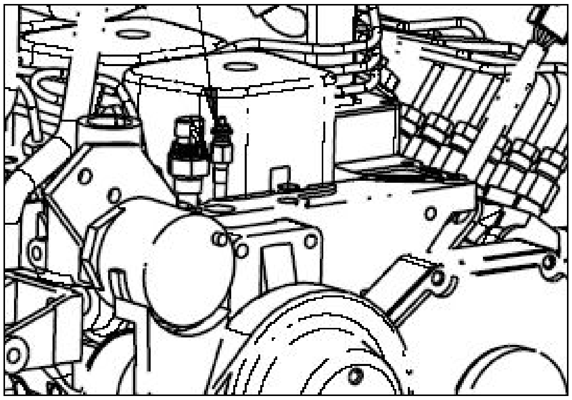
Place the AUTO/MANUAL Switch at the local panel in the MANUAL position.

Drain the coolant. Refer to Drain and Flush Cooling System in Section 8.

Remove

Disconnect the temperature sensor wiring.

Remove the temperature sensor.



Install

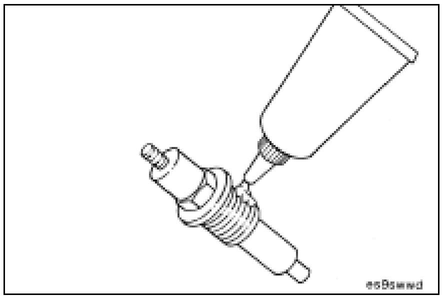
NOTE: Apply liquid teflon sealant to the threads when installing the temperature sensor.

Install the temperature sensor.

Torque Value:

- **(Cast Iron) 50 N•m [37 ft-lb]**
- **(Aluminum) 30 N•m [22 ft-lb]**

Reconnect the wiring.



Coolant Temperature Sender Removal/Installation (Cont)

Follow-Up

Fill coolant to proper level. Refer to Drain and Flush Cooling System in Section 8.

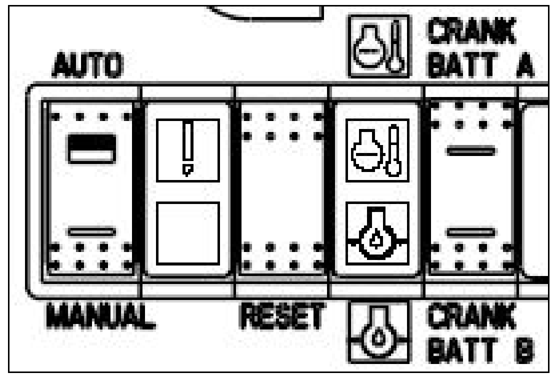
Operate the engine. Refer to Operating Instructions in Section 3.

Check for leaks. Repair any leaks.

Check that engine operating temperature stabilizes between about 82 and 93 °C [180 and 199 °F].

If temperature does not stabilize in the desired range, stop the engine and refer to refer to Coolant Temperature Above Normal or Coolant Temperature Below Normal (Engine Running) in Troubleshooting Section 17.

If operation is correct, stop the engine and place the AUTO/MANUAL Switch at the local panel in the AUTO position.



Coolant Temperature Switch Removal/Installation

Prepare

WARNING

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

WARNING

Do not remove the pressure cap from a hot engine. Wait until the temperature is below 50°C [122°F] before removing the pressure cap. Heated coolant spray or steam can cause personal injury.

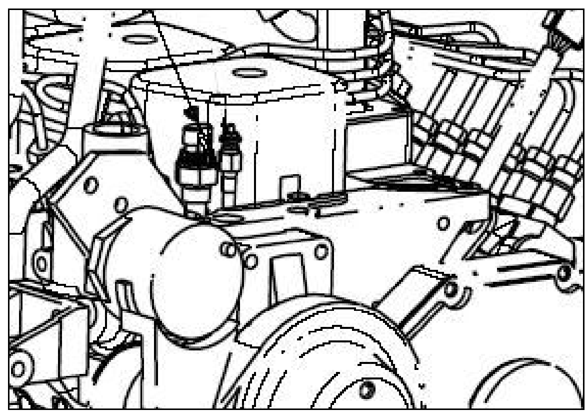
Place the AUTO/MANUAL Switch at the local panel in the MANUAL position.

Drain the coolant. Refer to Drain and Flush Cooling System in Section 8.

Remove

Disconnect the temperature switch wiring.

Remove the temperature switch.



Install

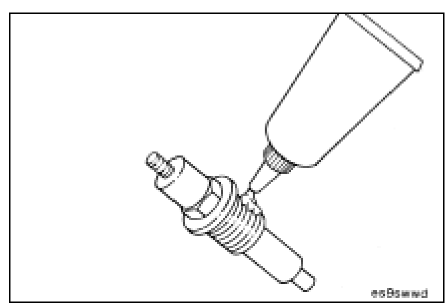
Apply liquid teflon sealant to the threads when installing the temperature switch.

Install the temperature switch.

Torque Value:

- **(Cast Iron) 50 N•m [37 ft-lb]**
- **(Aluminum) 30 N•m [22 ft-lb]**

Reconnect the wiring.



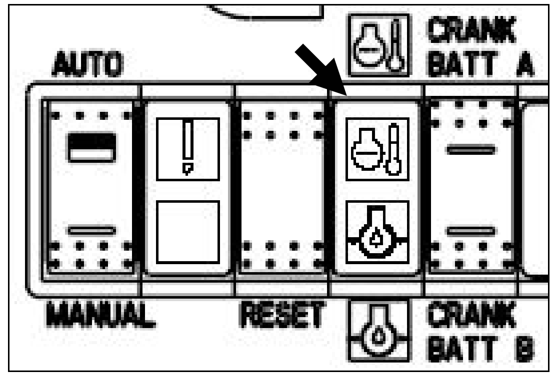
Coolant Temperature Switch Removal/Installation (Cont)

Follow-Up

Fill coolant to proper level. Refer to Drain and Flush Cooling System in Section 8.

Operate the engine. Refer to Operating Instructions in Section 3.

Check that the High Water Temperature Light on the control panel does not illuminate.

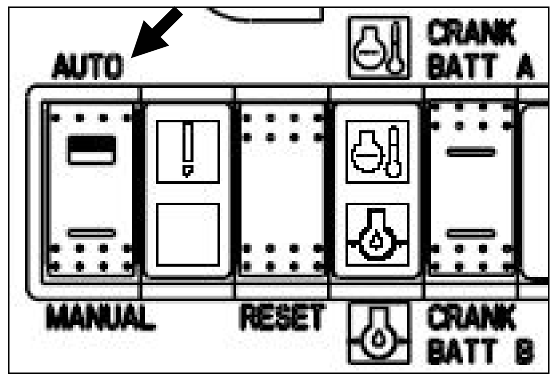


Check for leaks. Repair any leaks.

Observe that engine operating temperature stabilizes between about 82 and 93 ^{o}C [180 and 199 ^{o}F].

Stop the engine.

If operation is correct, place the AUTO/MANUAL Switch at the local panel in the AUTO position.



Coolant Thermostat Removal/Installation

Prepare

WARNING

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

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 pressure cap. Heated coolant spray or steam can cause personal injury.

CAUTION

Always use the correct thermostat, and never operate the engine without a thermostat installed. The engine can overheat if operated without a thermostat because the path of least resistance for the coolant is through the bypass to the pump inlet. An incorrect thermostat can cause the engine to overheat or run too cold.

Place the AUTO/MANUAL Switch at the local panel in the MANUAL position.

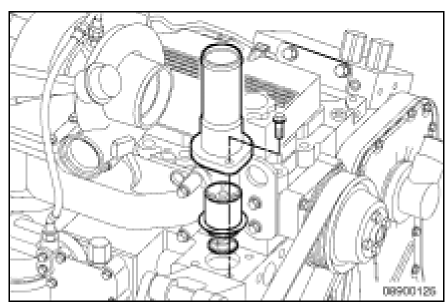
Drain the coolant. Refer to Drain and Flush Cooling System in Section 8.

Disconnect the coolant hose. Refer to Remove Upper Engine Coolant Hose in this section.

Remove

Remove the two mounting capscrews and the water outlet connection.

Remove the thermostat and both the upper and lower seals.

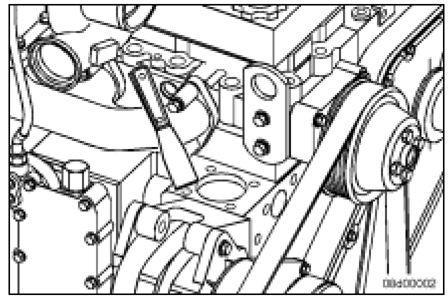


Coolant Thermostat Removal/Installation (Cont)

Clean

NOTE: Do not let any debris fall into the thermostat cavity when cleaning the gasket surfaces. Stuff a clean rag in the hole.

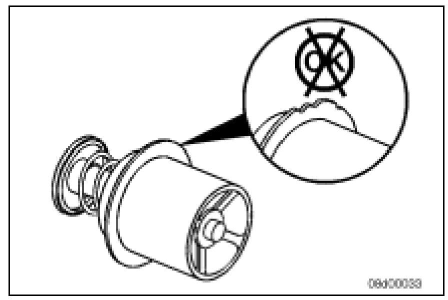
Clean the mating surfaces on the water outlet connection and on the engine with a putty knife and clean cloth.



Inspect for Reuse

Inspect the thermostat for obvious damage such as obstructions caused by debris, broken springs, or stuck or missing vent pins.

Make sure the thermostat is clean and free from corrosion.



NOTE: Do not allow the thermostat or thermometer to touch the side of the container.

NOTE: The fully open distance between the thermostat flange and housing is 9.4 mm [0.370 in].

Suspend the thermostat and a 100°C [212°F] thermometer in a container of water.

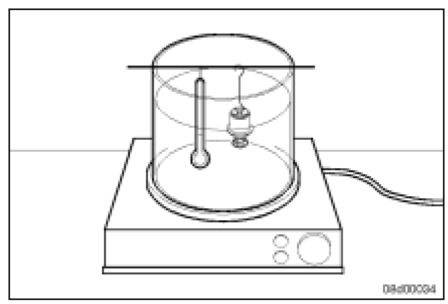
Heat the water slowly so the wax element in the thermostat has sufficient time to react to the rising water temperature.

Check the thermostat as follows:

Requirements

- **Starts to open within ±1°C [±2°F] of 82°C [180°F].**
- **Fully open within ±1°C [±2°F] of 93°C [199°F].**

If the thermostat does not operate within the required range, it must be replaced.



Coolant Thermostat Removal/Installation (Cont)

Install

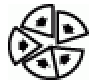
CAUTION

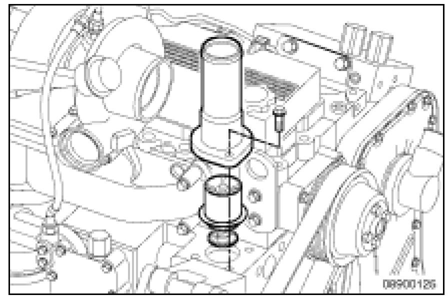
Always use the correct thermostat, and never operate the engine without a thermostat installed. The engine can overheat if operated without a thermostat because the path of least resistance for the coolant is through the bypass to the pump inlet. An incorrect thermostat can cause the engine to overheat or run too cold.

If used, remove the rag from the hole in the engine block.

NOTE: Make sure that the top and bottom seals are in place.

Install the thermostat (Cummins Part No. 3940632) and two new thermostat seals (Cummins Part No. 145581) into the thermostat housing.



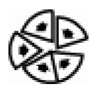


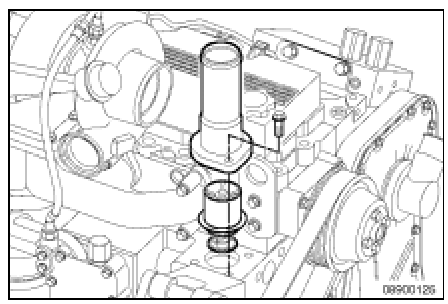
Install the water outlet connection (thermostat housing).

Install the two capscrews.

Torque Value: 24 N•m [18 ft-lb]

Install the water outlet hose. Refer to Install Upper Engine Coolant Hose in this section.





Follow-Up

Fill the cooling system. Refer to Drain and Flush Cooling System in Section 8.

Operate the engine. Refer to Operating Instructions in Section 3.

Check for leaks. Repair any leaks.

Check that engine operating temperature stabilizes between about 82 and 93 °C [180 and 199 °F]. If temperature does not stabilize, stop the engine and refer to Coolant Temperature Above Normal or Coolant Temperature Below Normal (Engine Running) in Troubleshooting Section 17.

If operation is correct, place the AUTO/MANUAL Switch at the local panel in the AUTO position.

Coolant Thermostat Tests

The thermostat controls the coolant temperature. When the coolant temperature is below operating temperature, coolant is bypassed to the inlet of the water pump. When the coolant temperature reaches the operating range, the thermostat opens, sealing off the bypass, and forcing coolant to flow to the radiator. The thermostat begins opening at 82°C [180°F].

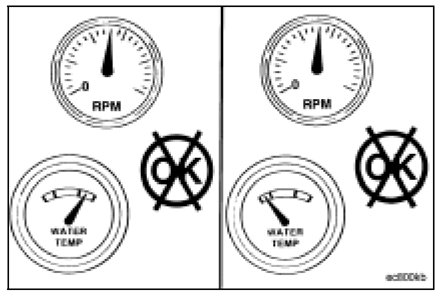
CAUTION

Never operate the engine without a thermostat. Without a thermostat, the path of least resistance for the coolant is through the bypass to the pump inlet. This will cause the engine to overheat.

An incorrect or malfunctioning thermostat can cause the engine to run too hot or too cold.

Coolant Thermostat Leak Test

The engine thermostat and thermostat seal must operate properly in order for the engine to operate in the most efficient heat range. Overheating or overcooling will shorten engine life.

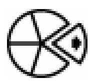


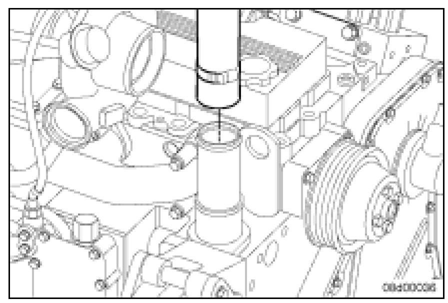
WARNING

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

WARNING

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





Allow the engine to cool well below 83 °C [181 °F].

Place the AUTO/MANUAL Switch at the local panel in the MANUAL position.

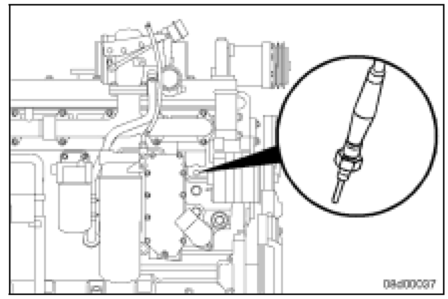
Drain the coolant. Refer to Drain and Flush Cooling System in Section 8.

Loosen the hose clamp on the Upper Engine Coolant Hose.

Remove the hose from the thermostat housing.

Coolant Thermostat Tests (Cont)

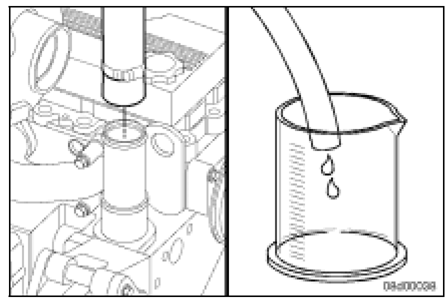
Use INSITE™ to monitor the coolant temperature. Install a thermocouple or temperature gauge that is known to be accurate, in the cylinder block on the engine side of the thermostat.



Install a hose of the same size on the thermostat housing outlet long enough to reach a remote, dry container used to collect coolant.

Install and tighten a hose clamp on the housing outlet.

Place the other end of the hose in a dry container.



CAUTION

Always vent the engine and aftercooler during filling to remove air from the coolant system, or overheating will result.

Refill the cooling system. Refer to Drain and Flush Cooling System in Section 8.

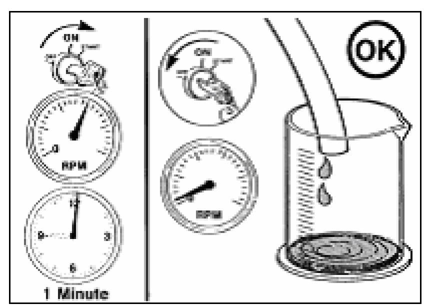
NOTE: The engine coolant temperature must be below the thermostat opening temperature of 82 °C [180 °F] to perform this test.

Operate the engine at rated rpm for 1 minute. Refer to Operating Instructions in Section 3.

Shut off the engine.

NOTE: The amount of coolant collected must not be more than 100 cc [3.3 fl oz].

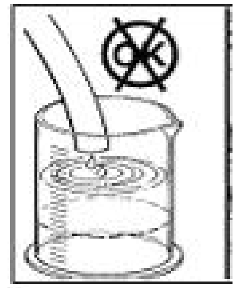
Measure the amount of coolant collected in the container.



Coolant Thermostat Tests (Cont)

If more than 100 cc [3.3 fl oz] of coolant is collected, the thermostat is leaking and must be replaced. Refer to <u>Coolant Thermostat Removal/Installation</u> in this section.

If leakage is not present, then continue to perform the <u>Coolant Thermostat Function Test</u> below.

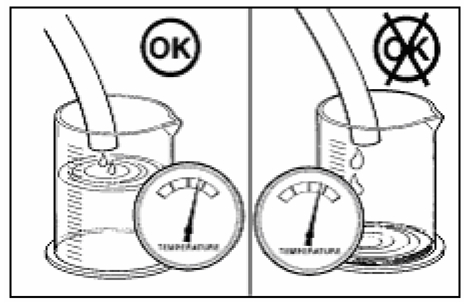


Coolant Thermostat Function Test

Start the engine and allow the engine to approach operating temperature.

Monitor the water temperature with an electronic service tool or a gauge.

Monitor the operation of the thermostat.



Thermostat Initial Opening Temperature:

- **MIN: 81 ^{o}C [178 ^{o}F]**
- **MAX: 83 ^{o}C [182 ^{o}F]**

Stop the engine when the coolant starts to flow.

If the coolant does not start flowing into the container during the initial opening temperature range, the thermostat must be replaced. Refer to <u>Coolant Thermostat Removal/Installation</u> in this section.

Follow-Up

Remove any test instruments.

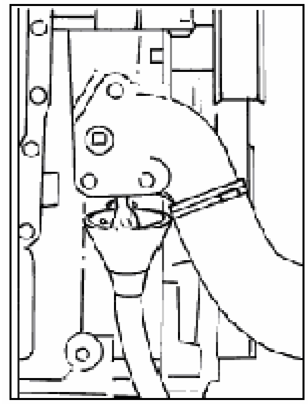
Install the heat exchanger hose and tighten hose clamp.

Return any coolant to the engine.

If operation is correct, place the AUTO/MANUAL Switch at the local panel in the AUTO position.

Coolant Water Pump Removal/Installation

Prepare



WARNING

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

WARNING

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

Place the AUTO/MANUAL Switch at the local panel in the MANUAL position.

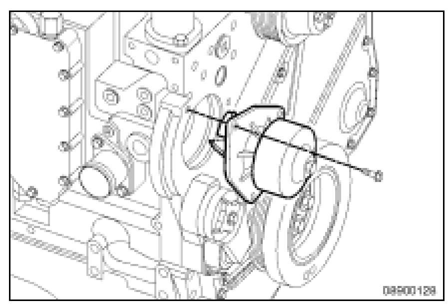
Drain engine coolant as required for the intended service. Refer to Drain and Flush Coolant System in Section 8.

If installed, remove the Belt Guard. Refer to Belt Guard Removal/Installation in this section.

If installed, remove the Drive Belt. Refer to Belt Removal/Installation in this section.

Remove

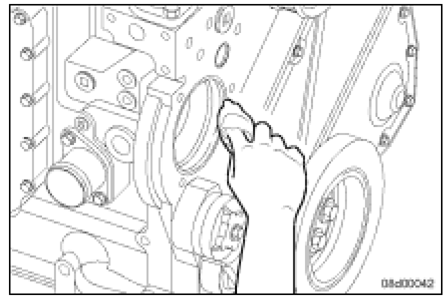
Remove the three water pump capscrews and the water pump.



Coolant Water Pump Removal/Installation (Cont)

Clean and Inspect for Reuse

Clean the o-ring sealing surface on the water pump housing.



Inspect the water pump housing and impeller for cracks or damage.

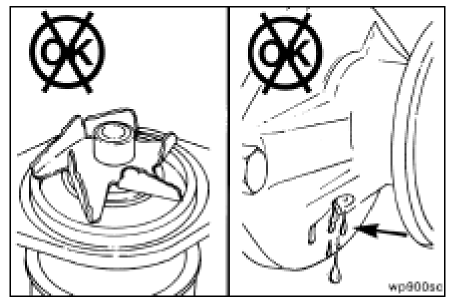
NOTE: A streak or chemical buildup at the weep hole is not justification for water pump replacement. If a steady flow of coolant or oil is observed, replace the water pump with a new or rebuilt unit.

Inspect the water pump weep hole for an indication of a steady leak.

NOTE: A small screwdriver or a small tool can be used to remove any debris.

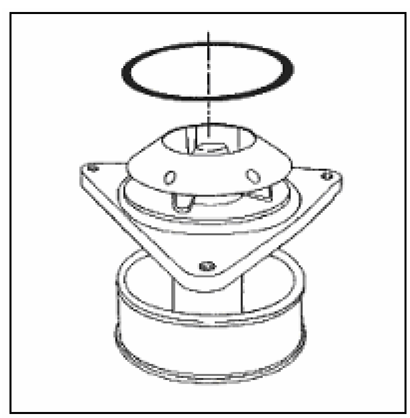
Inspect the weep hole to make sure it is open. A plugged weep hole can cause the water pump to fail.

If the water pump has failed, replace it with a new unit (Cummins Part No. 3286293 or 3973114) with new O-Ring (Cummins Part No. 3940386).



Install

Install a new o-ring (Cummins Part No. 3940386) into the groove in the water pump.

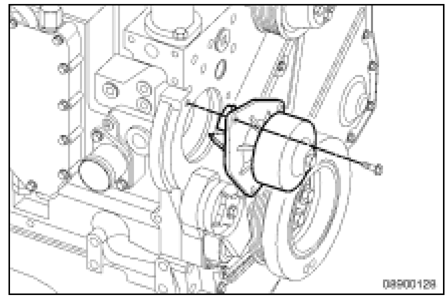


Coolant Water Pump Removal/Installation (Cont)

Install the water pump and three water pump mounting capscrews.

Tighten the water pump mounting capscrews.

Torque Value: 24 N•m [212 in-lb]



Follow-Up

Install the Drive Belt. Refer to Belt Removal/Installation in this section.

Install the Belt Guard. Refer to Belt Guard Removal/Installation in this section.

Close the coolant drain valves.

Refill engine coolant as required Refer to Drain and Flush Coolant System in Section 8.

NOTE: Perform the appropriate actions in Initial Start-Up (see Section 3).

Perform a test run. Refer to Operating Instructions in Section 3.

Check for leaks. Repair any leaks.

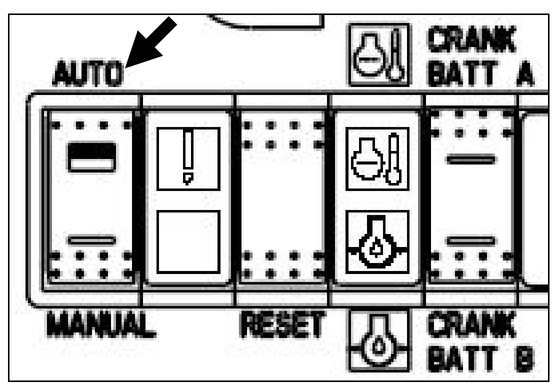
Check that the alternator is charging.

Check that engine operating temperature stabilizes between about 82 and 93 ^{o}C [180 and 199 ^{o}F]. If temperature does not stabilize, stop the engine and refer to Coolant Temperature Above Normal or Coolant Temperature Below Normal (Engine Running) in Troubleshooting Section 17.

Stop the engine.

Ensure that repairs are completed satisfactorily.

Place the AUTO/MANUAL Switch at the local panel in the AUTO position.



Coolant Filter Assembly Removal/Installation

Prepare

WARNING

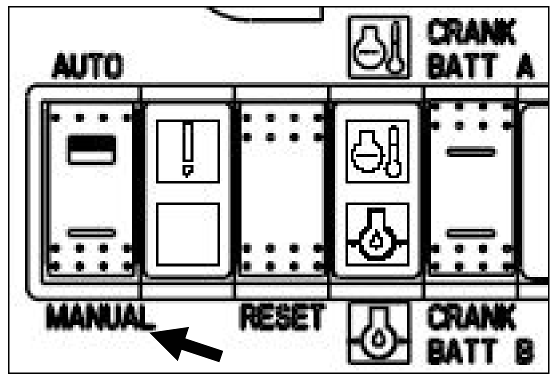
Do not remove the pressure cap from a hot engine. Wait until the coolant temperature is below 50°C [120°F] before removing the pressure cap. Heated coolant spray or steam can cause personal injury.

WARNING

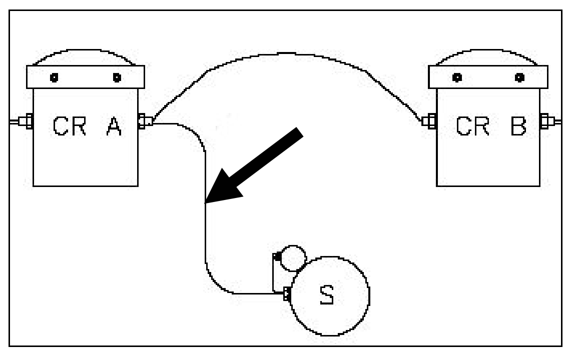
Coolant is toxic. Keep away from children and pets. If not reused, dispose of in accordance with local environmental regulations.

Place the fire protection system in a safe mode for engine service.

Place the AUTO/MANUAL rocker switch in the MANUAL position.

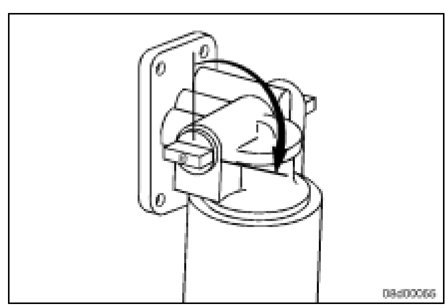


Disconnect and insulate the Contactor to Starter Cable (Cummins Fire Power Part No 9762) from the starter (Refer to Drawing 9767 in Section 18).



Remove the coolant system pressure cap.

Turn the shutoff valve to the OFF position by rotating the knob from vertical to horizontal in the direction shown.



Coolant Filter Assembly Removal/Installation (Cont)

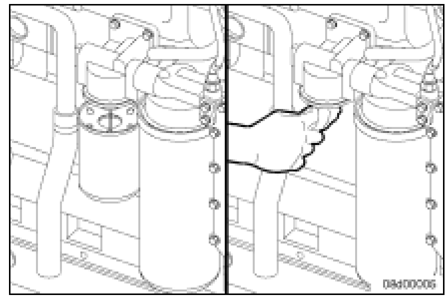
Remove

WARNING

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

Remove and discard the coolant filter.

Clean the filter housing with a dry clean rag.

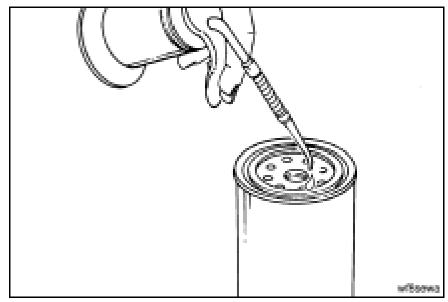


Install

CAUTION

Do not allow oil to get into the filter.

Apply a thin film of lubricating oil to the gasket sealing surface before installing the new coolant filter.

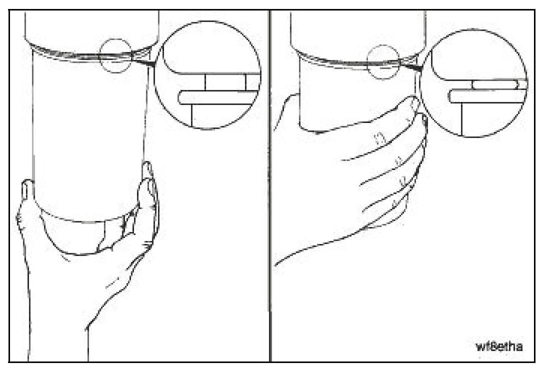


CAUTION

Mechanical over-tightening can distort the threads or damage the filter head.

Install the coolant filter on the filter head. Tighten the filter until the gasket contacts the filter head surface.

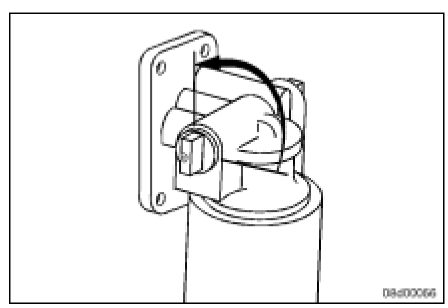
Tighten the coolant filter an additional 1/2 to 3/4 of a turn, or as specified by the filter manufacturer.



CAUTION

The valve must be in the ON position to prevent engine damage.

Turn the shutoff to the ON position by rotating the knob from horizontal to vertical in the direction shown.



Coolant Filter Assembly Removal/Installation (Cont)

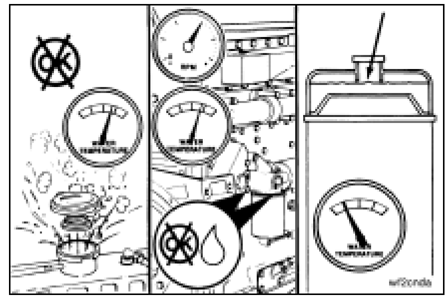
Follow-Up

Install the coolant system pressure cap.

Start the engine. Refer to Normal Local Starting Procedure in Section 3.

Check for and repair any coolant leaks.

After the air has been purged from the system, stop the engine.



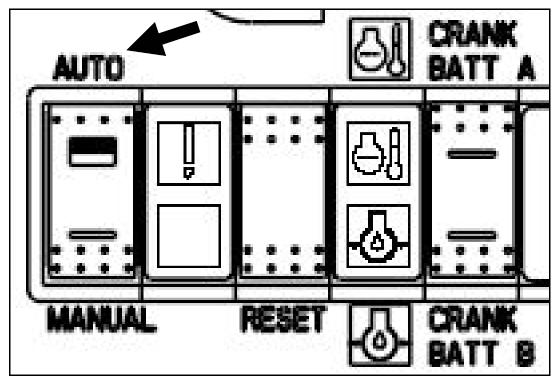
WARNING

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

Check the coolant level. Refer to Check Coolant Level in Section 5. Add coolant if necessary.

Place the AUTO/MANUAL rocker switch in the AUTO position.

Return the fire protection system to operating status.



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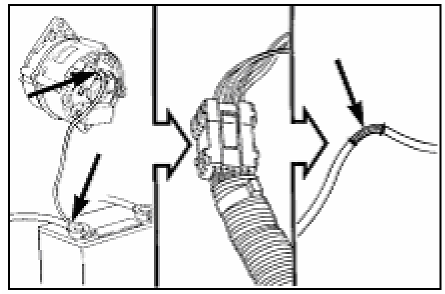
Alternator Checks and Testing

Alternator Wiring Integrity Check



NOTE: Refer to Drawing 8512 Sheet 1, Drawing 8512 Sheet 2, and Drawing 9767 in Section 18 for schematic details.

WARNING

Batteries can emit explosive gases. To reduce the possibility of personal injury, always ventilate the battery compartment before servicing the batteries.

WARNING

To reduce the possibility of arcing, remove the negative (-) battery cable first and attach the negative (-) battery cable last.

Check the battery and all wiring connections for damage. Refer to Battery Cables and Connections in this section.

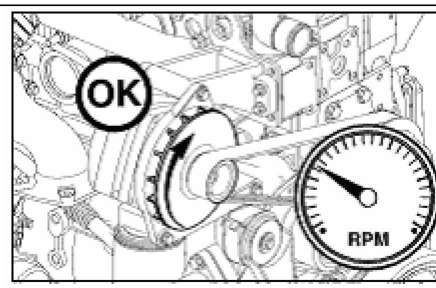
Check all connections for tightness and cleanliness. Include both the slip connectors at the alternator and connections at the battery.

NOTE: Continuity should be in the single digit Ohms or less. Resistance to ground should be in the mega-Ohm range. Refer to any applicable customer criteria.

Using a digital multimeter or other test equipment, check for continuity between terminals. Check also the insulation resistance to ground.

Correct any electrical faults.

Alternator Mechanical Check



Start the engine. Refer to Normal Local Starting Procedure in Section 3.

Visually check the drive belt and alternator pulley to be sure the alternator is rotating.

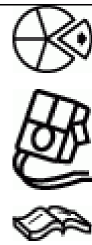
Note any unusual noises such as from belt whine or alternator mechanical fault.

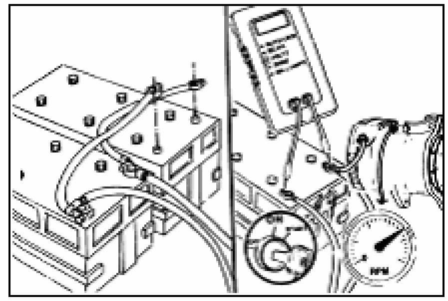
Stop the engine.

Correct any mechanical failures.

Alternator Checks and Testing (Cont)

Alternator Voltage Output Test





CAUTION

Batteries must have been satisfactorily load tested and must be charged with a resting voltage of more than 12.4 Volts for this testing.

CAUTION

Batteries must have been satisfactorily load tested and must be charged with a resting voltage of more than 12.4 Volts for this testing.

NOTE: Conduct this testing at normal shop temperature.

NOTE: Voltage should not exceed 15.5 V (for a 12 VDC system) or 31 V (for a 24 VDC system).

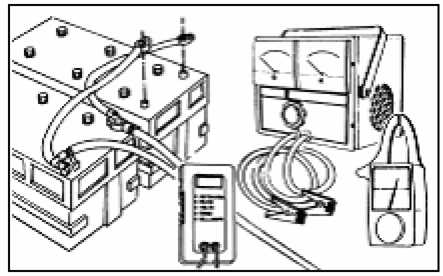
Start the engine and operate at rated speed. Refer to Normal Local Starting Procedure in Section 3.

Measure the alternator voltage output to the batteries with digital multimeter, Cummins Part Number 3377161.

Stop the engine.

Replace the alternator if the voltage exceeds specification. Refer to Alternator Removal/Installation in this section.

Alternator Checks and Testing (Cont)



Alternator Amperage Output Test

NOTE: Conduct this testing at normal shop temperature.

NOTE: Refer to Electrical Specifications in Section 15 for the minimum required alternator output. Use the value listed for the system voltage.

Connect a carbon pile load in parallel across the battery terminals. Refer to Jumpering the Batteries in Section 3 for how to make a parallel connection.

Connect a clamp-on (induction) ammeter across the alternator output cable.

Start the engine and operate at rated speed. Refer to Normal Local Starting Procedure in Section 3.

Adjust the carbon pile for maximum indication.

Note the amperage indicated on the ammeter.

Stop the engine.

Remove the test equipment.

Replace the alternator if the output is not 90% or more of the specification value. Refer to Alternator Removal/Installation in this section.

Alternator Removal/Installation

Prepare

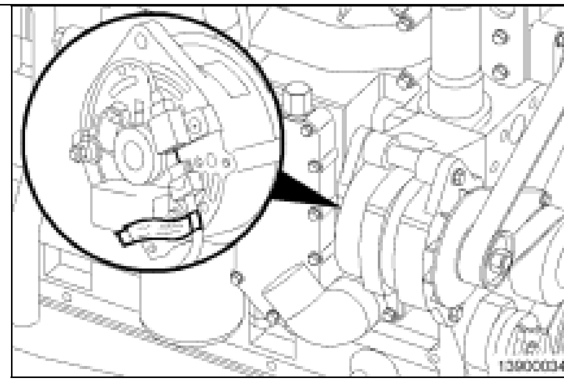
Remove the belt guard. Refer to Belt Guard Removal/Installation in this section.

Remove the drive belt. Refer to Belt Removal/Installation in this section.

NOTE: Refer to Drawing 8513 Sheet 1 in Section 18 for wiring harness information.

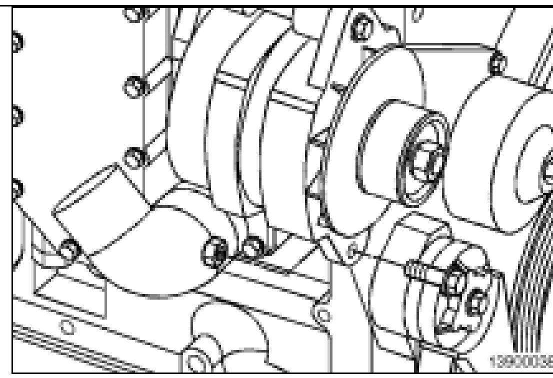
NOTE: Ensure that the connectors are clearly tagged for the correct reconnection.

Disconnect the engine wiring harness connectors from the alternator.



Remove

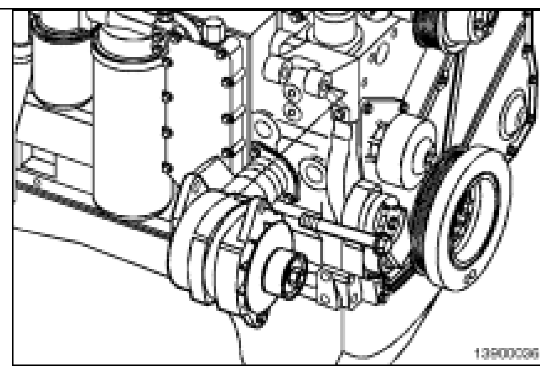
Remove the alternator link capscrew.



Remove the alternator mounting capscrew.

Remove the alternator.

NOTE: If the alternator bracket must also be removed, go to Alternator Bracket Removal/Installation in this section.

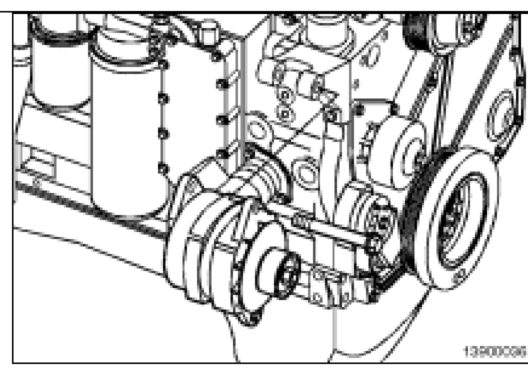


Install

Ensure that the alternator bracket is installed. Refer to Alternator Bracket Removal/Installation in this section.

Install the alternator and alternator capscrews in the reverse order of removal.

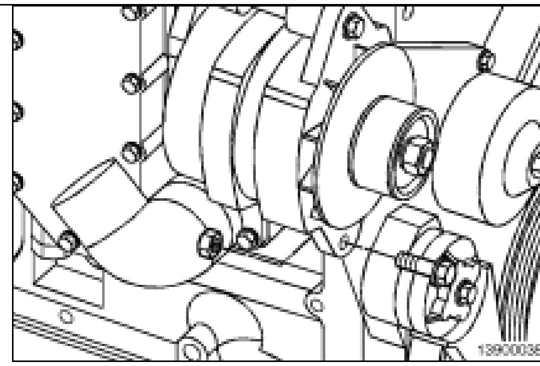
Torque Value: 43 N•m [32 ft-lb]



Alternator Removal/Installation (Cont)

Install the alternator link capscrew.

Torque Value: 24 N•m [18 ft-lb]



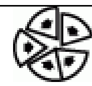
Follow-Up

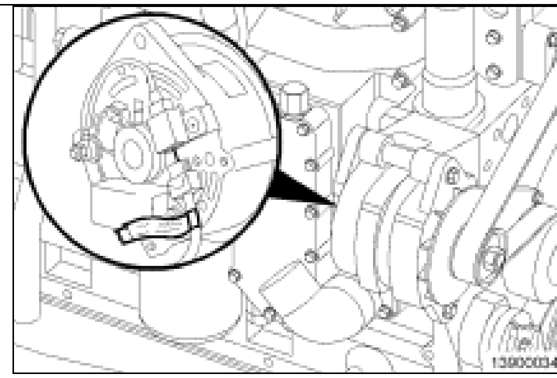
NOTE: Refer to Drawing 8513 Sheet 1 in Section 18 for wiring harness information.

Connect the engine wiring harness connectors to the alternator.

Install the drive belt. Refer to Belt Removal/Installation in this section.

Install the belt guard. Refer to Belt Guard Removal/Installation in this section.





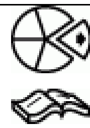
Alternator Bracket Removal/Installation

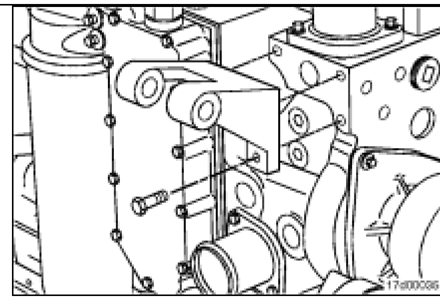
Prepare

Remove the alternator. Refer to Alternator Removal/Installation in this section.

Remove

Remove the alternator bracket mounting capscrews and bracket.

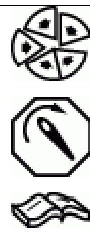


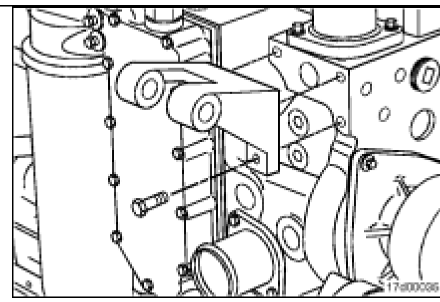


Install

Install the mounting bracket and bracket mounting capscrews.

Torque Value: 24 N•m [18 ft-lb]





Follow-Up

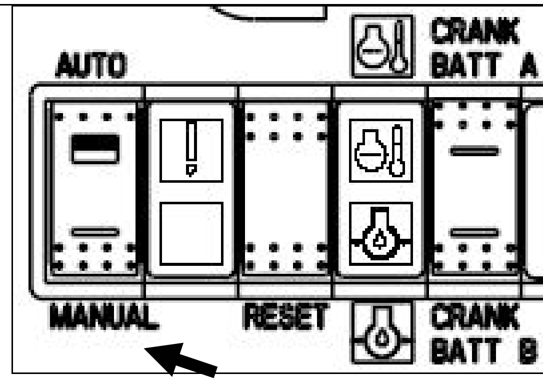
Install the alternator. Refer to Alternator Removal/Installation in this section.

Battery Isolator Removal/Installation

Prepare

Place the fire protection system in a safe mode for engine service.

Place the AUTO/MANUAL rocker switch in the MANUAL position.



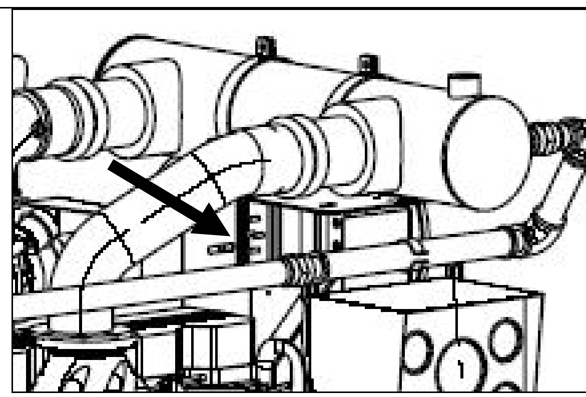
NOTE: Refer to Battery Removal/Installation in this section for detailed instructions for disconnecting the battery cable clamps.

Disconnect the negative battery cable from Battery A.

Disconnect the negative battery cable from Battery B.

Remove

NOTE: Ensure that all battery isolator wires are clearly tagged for reconnection. Also note the orientation of the existing isolator.



Battery Isolator Removal/Installation (Cont)

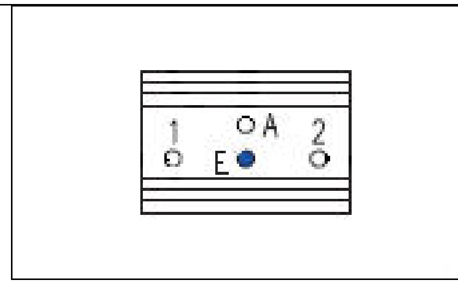
Disconnect the battery cable from terminal 1.

Disconnect the battery cable from terminal 2.

Disconnect the alternator cable from terminal A.

Disconnect the alternator excitation cable from terminal E.

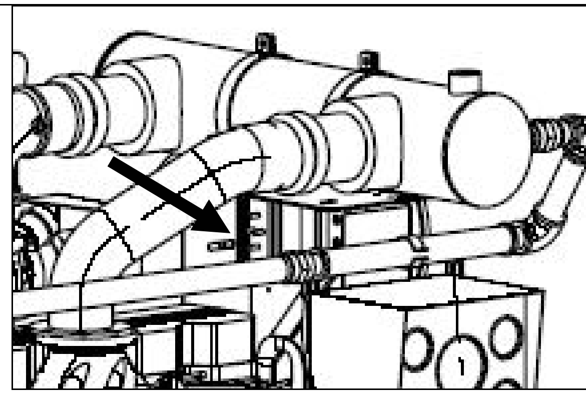
Remove the four mounting nuts and the battery isolator



Install

Align and position the battery isolator on the four mounting studs.

Install the four mounting nuts.



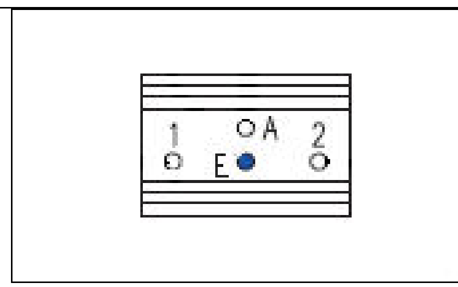
Connect the battery cable at terminal 1.

Connect the battery cable at terminal 2.

Connect the alternator cable at terminal A.

Connect the alternator excitation cable at terminal E.

Ensure that all four rubber caps are in position.



Follow-Up

NOTE: Refer to Battery Removal/Installation in this section for detailed instructions for connecting the battery cable clamps.

Connect the negative battery cable at Battery A.

Connect the negative battery cable at Battery B.

Battery Isolator Removal/Installation (Cont)

NOTE: Refer to Drawing 8512 Sheet 2 for schematic details. Measure voltages at the most convenient location.

With the engine off, verify the following voltages at the battery isolator terminals to ground:

- Terminal 1 indicates battery voltage.
- Terminal 2 indicates the other battery voltage.
- Terminal E indicates no voltage.

Start the engine. Refer to Normal Local Starting Procedure in Section e3.

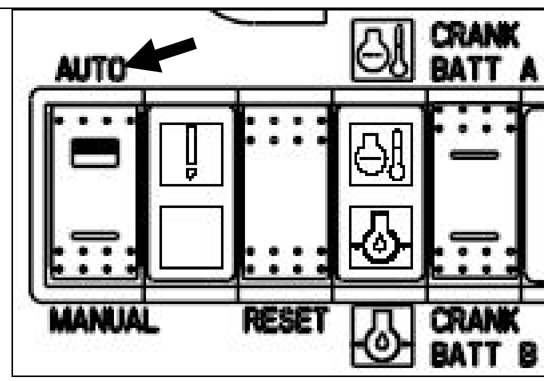
With the engine running, verify the following voltages at the battery isolator terminals to ground:

- Terminal 1 indicates battery voltage.
- Terminal 2 indicates the other battery voltage.
- Terminal E indicates battery voltage.
- Terminal A indicates about 1 volt higher than battery voltage.

Stop the engine.

Place the AUTO/MANUAL rocker switch in the AUTO position.

Return the fire protection system to operating status.



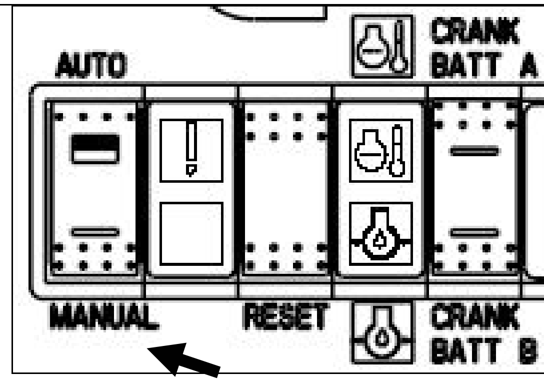
Engine Harness Removal/Installation

NOTE: There are two harness assemblies on this fire pump engine. This section addresses the engine harness connected to the control panel. The ECM harness is addressed in ECM Harness Removal/Installation also in this section.

Prepare

Place the fire protection system in a safe mode for engine service.

Place the AUTO/MANUAL rocker switch in the MANUAL position.



NOTE: Refer to Battery Removal/Installation in this section for detailed instructions for disconnecting the battery cable clamps.

Disconnect the negative battery cable from Battery A.

Disconnect the negative battery cable from Battery B.

Remove

NOTE: Refer to Drawing 8513 Sheet 1 in Section 18 for a depiction of the engine wiring harness.

NOTE: Ensure that each terminal is properly labeled for ease of reconnection.

Disconnect the harness connection at each terminal.

Install

NOTE: Refer to Drawing 8513 Sheet 1 in Section 18 for a depiction of the engine wiring harness.

Connect the harness connection at each terminal.

Engine Harness Removal/Installation (Cont)

Follow-Up

NOTE: Refer to Battery Removal/Installation in this section for detailed instructions for connecting the battery cable clamps.

Connect the negative battery cable at Battery A.

Connect the negative battery cable at Battery B.

NOTE: Refer to Second Start in Section 3 for the suggested checks.

Start the engine. Refer to Normal Local Starting Procedure in Section 3.

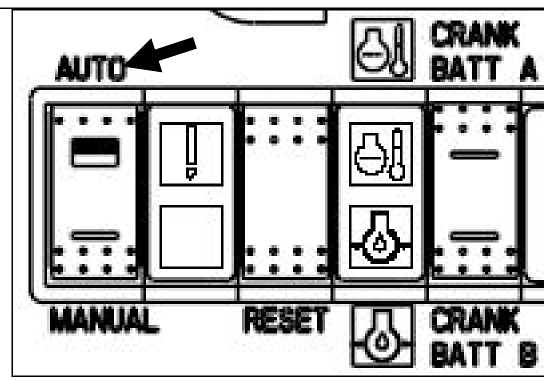
Observe that the engine starts with no unusual noises or vibrations.

Verify that the engine reaches operating temperature.

Stop the engine.

Place the AUTO/MANUAL rocker switch in the AUTO position.

Return the fire protection system to operating status.

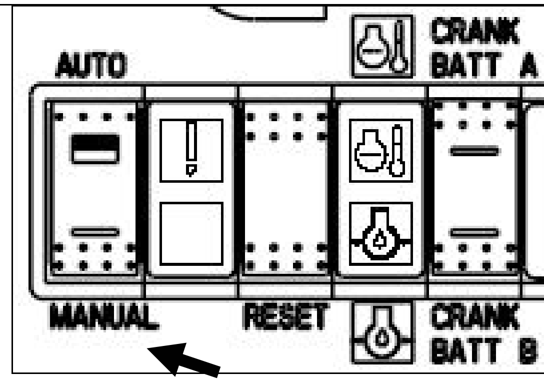


Voltmeter Removal/Installation

Prepare

Place the fire protection system in a safe mode for engine service.

Place the AUTO/MANUAL rocker switch in the MANUAL position.

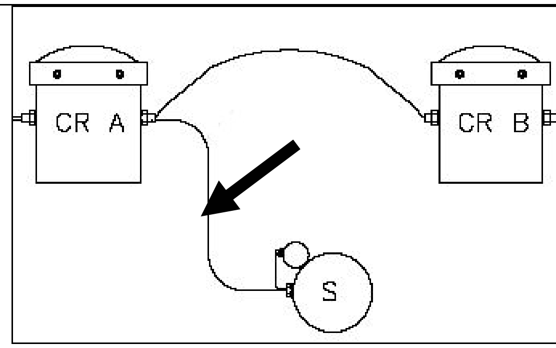


Disconnect and insulate the Contactor to Starter Cable (Cummins Fire Power Part No 9762) from the starter (Refer to Drawing 9767 in Section 18).

NOTE: Refer to Control Panel Fuse Replacement in this section for fuse location information.

Remove the electrical fuse from the fuse block as follows:

- For Voltmeter A, remove Fuse F1
- For Voltmeter B, remove Fuse F2



Remove

NOTE: Refer to Drawing 8512 Sheet 1 in Section 18 for electrical schematic details.

Open the local control panel.

NOTE: Ensure that the wires are clearly tagged for reconnection.

Loosen the nuts on the stud and remove the wires.

Remove the nuts on the mounting bracket and remove the voltmeter from the panel.

Voltmeter Removal/Installation (Cont)

Install

Orient the voltmeter in the cutout in the electrical panel.

Position the mounting bracket on the gauge.

Install the mounting nuts.

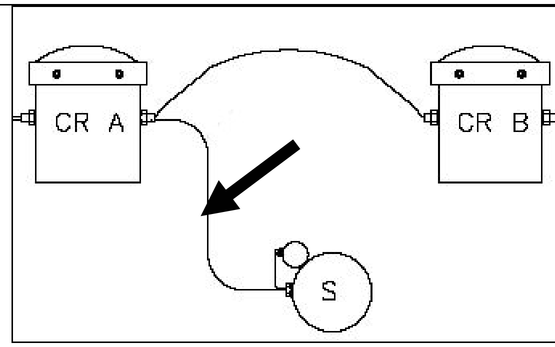
Reconnect the electrical wires on the studs in the same positions as they were originally installed.

Tighten the nuts on the studs.

Follow-up

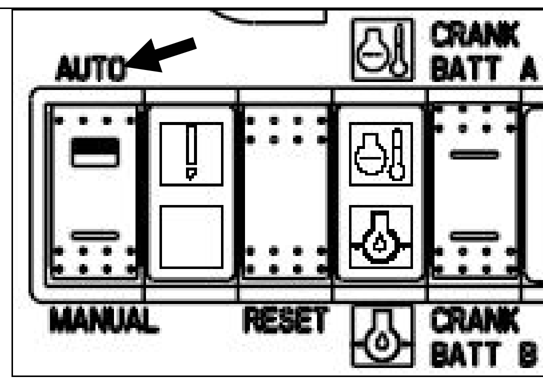
Reinstall the electrical fuse in the fuse block.

When the batteries are functional and charged, reconnect the Contactor to Starter Cable (Cummins Fire Power Part No 9762) at the starter (Refer to Drawing 9767 in Section 18).



Place the AUTO/MANUAL rocker switch in the AUTO position.

Return the fire protection system to operating status.



Battery Testing

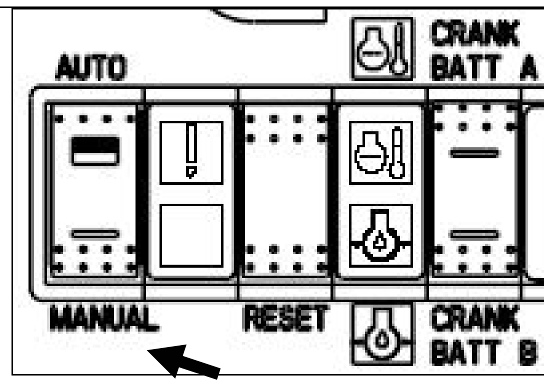
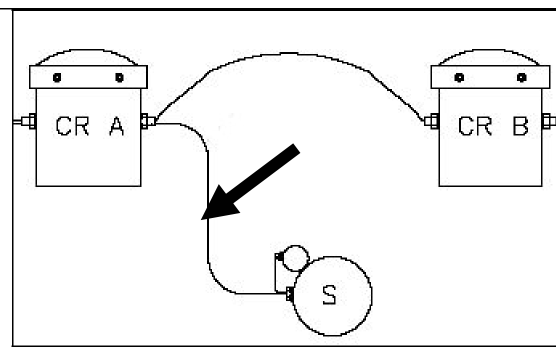
WARNING

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

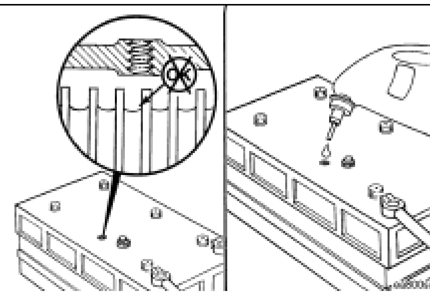
WARNING

Acid is extremely dangerous and can damage the machinery and can also cause serious burns. Always provide a strong tank of soda water as a neutralizing agent when servicing the batteries. Wear goggles and protective clothing to avoid serious burns.

NOTE: This section is for conventional batteries only. Maintenance-free batteries may be supplied by the customer. These are sealed and do not require the addition of water. Also, specific gravity cannot be checked. If the batteries are not supplied by Cummins Fire Power, follow the battery manufacturer's recommendations for testing and servicing their batteries.

Prepare Place the fire protection system in a safe mode for engine service. Place the AUTO/MANUAL rocker switch in the MANUAL position.	
Disconnect and insulate the Contactor to Starter Cable (Cummins Fire Power Part No 9762) from the starter (Refer to Drawing 9767 in Section 18).	

Battery Testing (Cont)



Check Electrolyte Level

Remove all cell covers for both sets of batteries.

Check the electrolyte level in each cell of each battery.

NOTE: Cummins recommends the use of a self-leveling filler. If a syringe type filler is used, use care to prevent overflow or splashing of acid from the cell.

⚠CAUTION⚠

Do not overfill the cell. Fill only to the level indication.

⚠CAUTION⚠

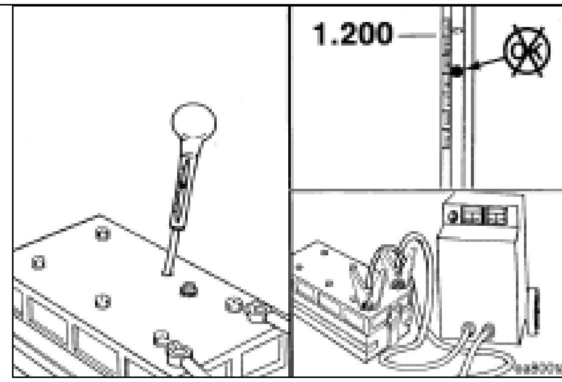
If a syringe type filler is used, use care to prevent overflow or splashing of acid from the cell.

As required, fill each battery cell with distilled water.

Install all cell covers for both sets of batteries.

If water was added, recharge the battery prior to checking specific gravity.

Battery Testing (Cont)



Check Specific Gravity

NOTE: If water has been added to a dry cell, recharge the battery to mix the added water with the existing battery electrolyte. This will prevent incorrect readings.

NOTE: The battery must be more than about ¼ charged before the hydrometer readings can be accurate. Accurate readings may require several hours of charging for a fully discharged battery.

Use a hydrometer to measure the specific gravity of each cell.

State of Charge and Specific Gravity*

% Charged	Non-Tropical	Tropical
100%	1.265	1.225
75%	1.225	1.185
50%	1.190	1.150
25%	1.155	1.115
0%	1.120	1.080

* At 26.7 ^{o}C [80 ^{o}F]

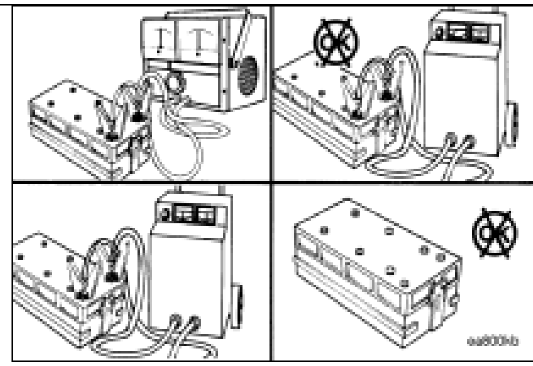
Check the battery fluid column in the refractometer to determine the state of charge of each battery cell.

NOTE: Evaluate the state of charge in respect to the local requirements. A cold location will require a greater specific gravity than a hot climate for the necessary cranking amperes.

If charge is low, charge the batteries. Refer to Battery and Electrical Installation in Section 3.

Battery Testing (Cont)

Check Battery Output



CAUTION

Do not connect battery charging cables to any electronic control system part. This can damage the electronic control system parts.

NOTE: Use the inductive charging-cranking systems analyzer, Cummins Part Number 3377193, to test the output amperage of either maintenance-free or conventional vent cap batteries. Follow the instructions provided with the test equipment.

NOTE: The required battery output in cold cranking amperes is provided in Electrical System Specifications kin Section 15. Use the listed value for the system voltage.

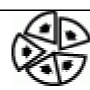
Test both sets of batteries.

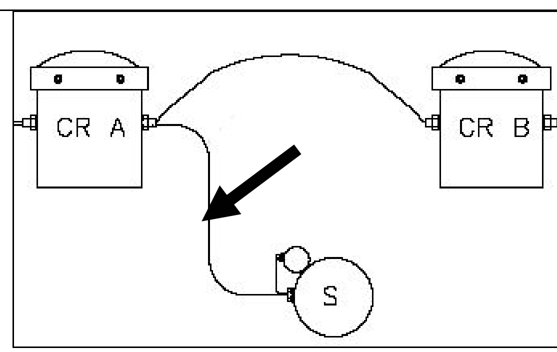
NOTE: For customer supplied batteries, refer to the manufacturer's literature for charging instructions.

If the output amperage is low, charge the battery. Refer to <u>Battery and Electrical Installation</u> in Section 3.

Replace the battery if it will not charge to the manufacturer's specifications or will not maintain a charge.

Follow-up



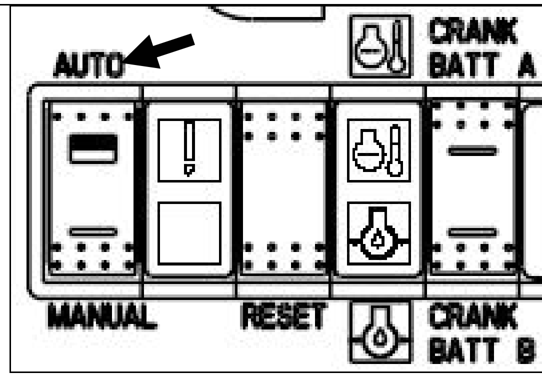


When the batteries are functional and charged, reconnect the Contactor to Starter Cable (Cummins Fire Power Part No 9762) at the starter (Refer to <u>Drawing 9767</u> in Section 18).

Battery Testing (Cont)

Place the AUTO/MANUAL rocker switch in the AUTO position.

Return the fire protection system to operating status.



Battery Removal/Installation

WARNING

Batteries can emit explosive gases. To avoid injury, always ventilate the compartment before servicing the batteries.

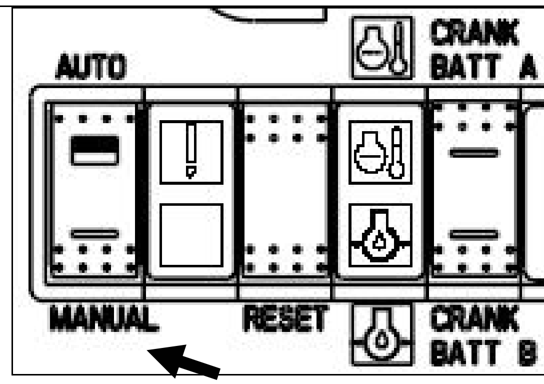
WARNING

Acid is extremely dangerous and can damage the machinery and can also cause serious burns. Always provide a strong tank of soda water as a neutralizing agent when servicing the batteries. Wear goggles and protective clothing to avoid serious burns.

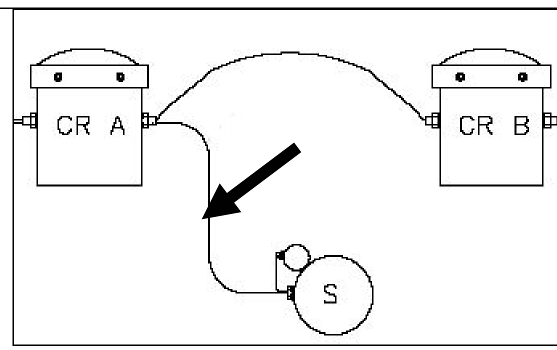
Prepare

Place the fire protection system in a safe mode for engine service.

Place the AUTO/MANUAL rocker switch in the MANUAL position.



Disconnect and insulate the Contactor to Starter Cable (Cummins Fire Power Part No 9762) from the starter (Refer to Drawing 9767 in Section 18).



Clear and ventilate the battery storage area.

Collect the necessary tools and safety equipment.

Battery Removal/Installation (Cont)

Remove

NOTE: Use the correct battery tools. Use end wrenches to loosen the battery clamps. Use a battery cable puller to remove tight cable clamps from the battery terminal. Use a battery carrier to lift and carry the battery.

Remove any battery support hardware.

WARNING

To reduce the possibility of arcing, remove the negative (-) battery cable first.

Loosen the battery cable clamps.

Remove the negative battery cable first.

Remove the positive battery cable first.

WARNING

Do not tip the battery and spill the acid.

Using a battery carrier, lift and remove the battery.

If disposing of the battery, dispose of it in accordance with all applicable environmental regulations.

Clean

NOTE: Use the correct battery tools. Use a terminal cleaning brush for the battery terminal. Use a putty knife and wire brush to remove dirt and corrosion from the battery body and any support.

Clean the battery posts to remove all corrosion and to expose the metal.

Remove any other corrosion or debris from the battery body or battery support.

Battery Removal/Installation (Cont)

Install

NOTE: Use the correct battery tools. Use a battery cable clamp spreader to install tight cable clamps on the battery terminal. Use end wrenches to tighten the battery clamps

WARNING

Do not tip the battery and spill the acid.

Using a battery carrier, carry and position the battery.

WARNING

To reduce the possibility of arcing, attach the negative (-) battery cable last.

Spread the positive cable clamp and position the clamp on the post.

Tighten the positive cable clamp.

Spread the negative cable clamp and position the clamp on the post.

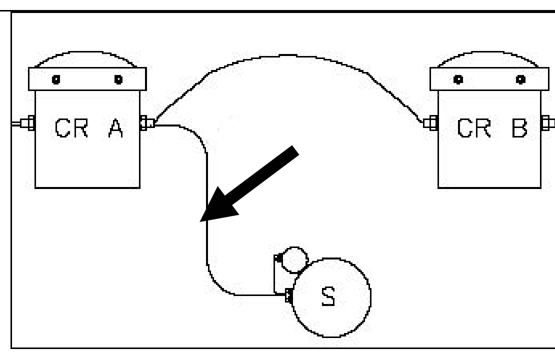
Tighten the negative cable clamp.

Install any battery support hardware.

Follow-Up

If new batteries are installed, charge the batteries. Refer to Battery and Electrical Installation in Section 3.

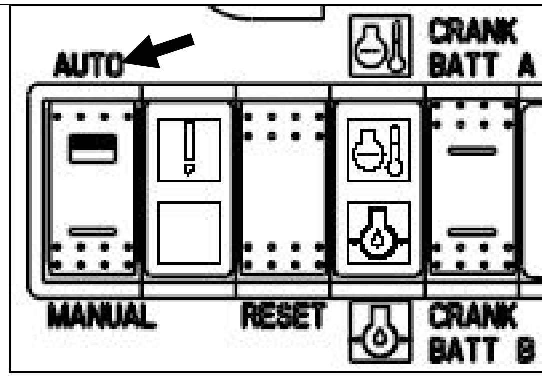
When the batteries are charged, reconnect the Contactor to Starter Cable (Cummins Fire Power Part No 9762) at the starter (Refer to Drawing 9767 in Section 18).



Battery Removal/Installation (Cont)

Place the AUTO/MANUAL rocker switch in the AUTO position.

Return the fire protection system to operating status.



Check Battery Cables and Connections

WARNING

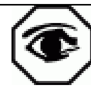
Batteries can emit explosive gases. To reduce the possibility of personal injury, always ventilate the compartment before servicing the batteries.

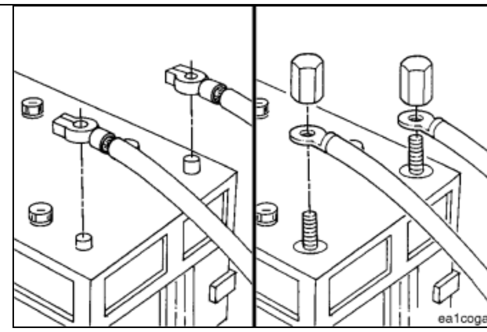
WARNING

To reduce the possibility of arcing, remove the negative (-) battery cable first and attach the negative (-) battery cable last.

NOTE: There are two possible heavy-duty battery connections:

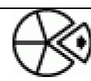
- Battery terminal and clamp
- Threaded battery terminal and nut

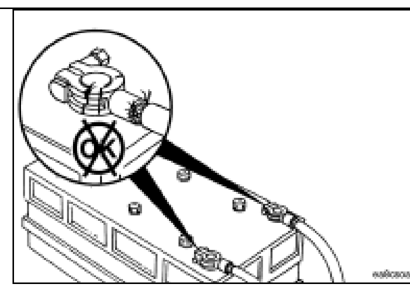




Remove and inspect the battery cables and connections for cracks or corrosion.

Replace broken terminals, connectors, or cables.

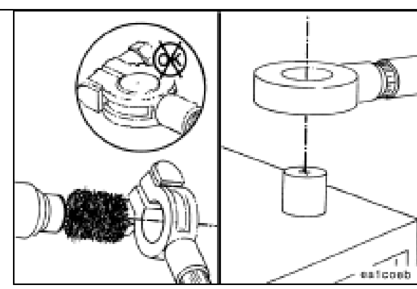




If the connections are corroded, use a battery brush or wire brush to clean the connections until shiny.

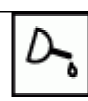
Alternatively, if a brush won't do the job, use an acid neutralizing solution to remove the corrosion.

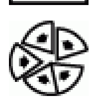
Brush or wipe all residue or debris from the terminals.

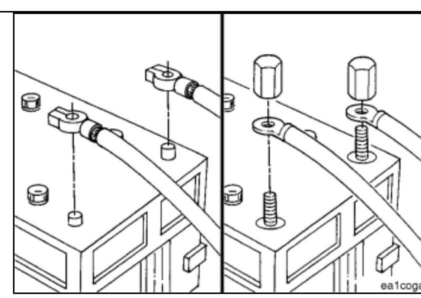


NOTE: Coat the terminals with a high temperature grease to prevent corrosion.

Install the cables and tighten the battery connections.





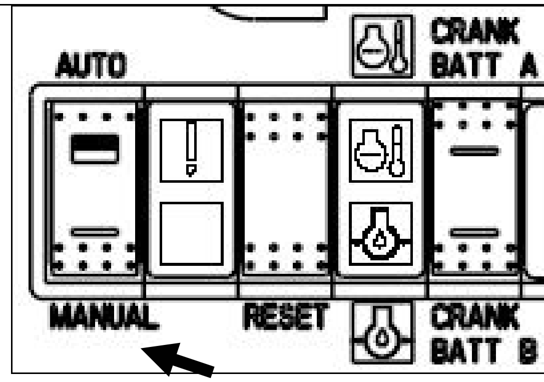


Starter Motor Assembly Removal/Installation

Prepare

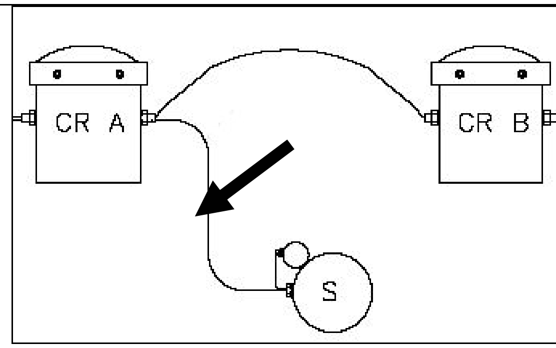
Place the fire protection system in a safe mode for engine service.

Place the AUTO/MANUAL rocker switch in the MANUAL position.



Disconnect and insulate the Contactor to Starter Cable (Cummins Fire Power Part No 9762) from the starter (Refer to Drawing 9767 in Section 18).

Remove the grounding strap from the starter, if used.

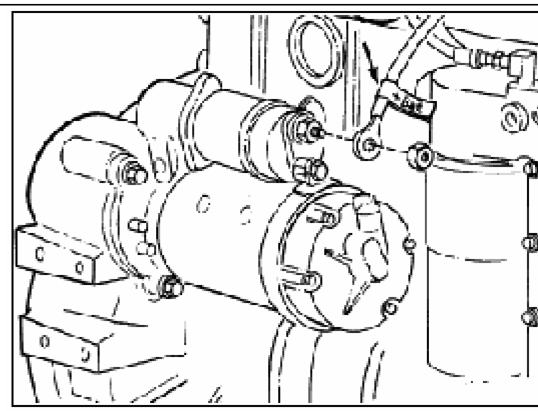


Remove

Disconnect the ground cable from the battery.

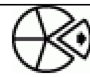
Identify each electrical wire with a tag indicating location.

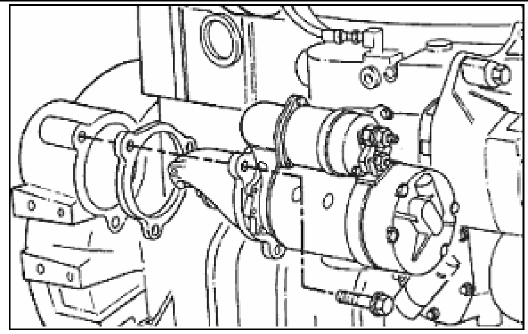
Remove the battery cable from the solenoid.



Starter Motor Removal/Installation (Cont)

Remove the starting motor and spacer.

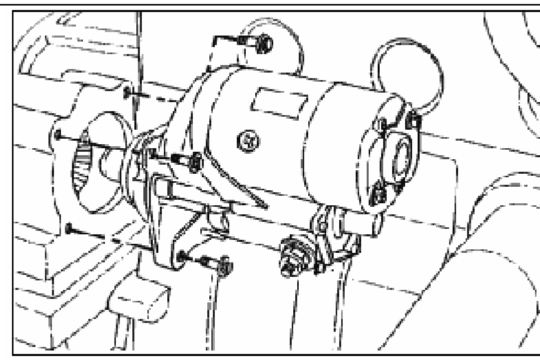




Install

Install the starter motor in the reverse order of removal.

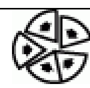
Torque Value: 43 N•m [32 ft-lb]

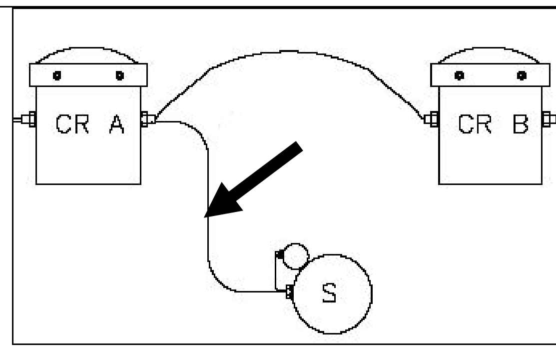


Follow-Up

Reconnect the Contactor to Starter Cable (Cummins Fire Power Part No 9762) at the starter (Refer to Drawing 9767 in Section 18).

Install the grounding strap to the starter, if used.





Start the engine. Refer to Normal Local Starting Procedure in Section 3.

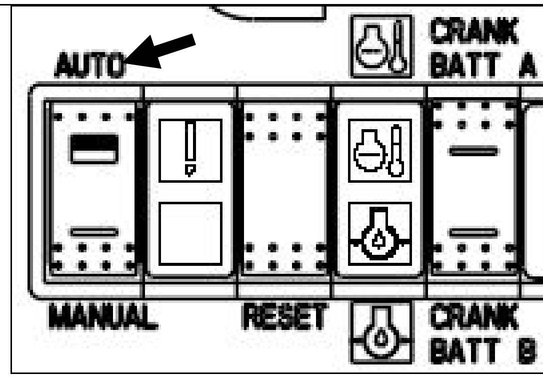
Observe that the engine starts with no unusual noises or vibrations.

Stop the engine.

Starter Motor Removal/Installation (Cont)

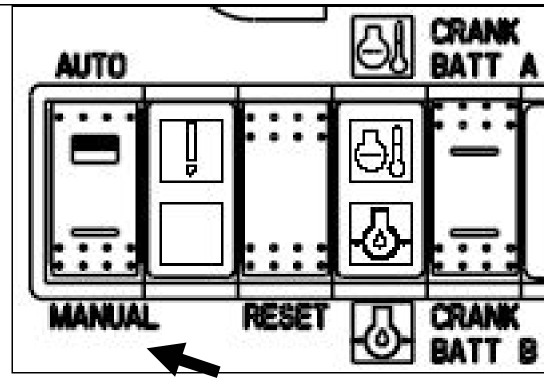
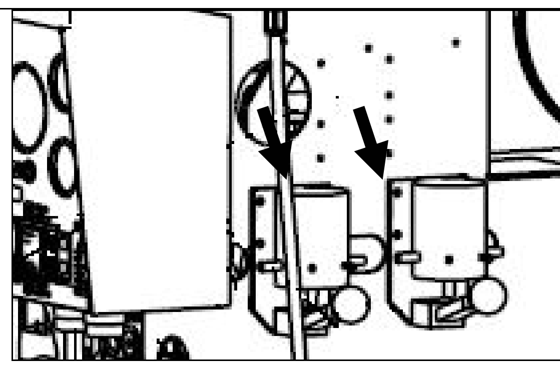
Place the AUTO/MANUAL rocker switch in the AUTO position.

Return the fire protection system to operating status.

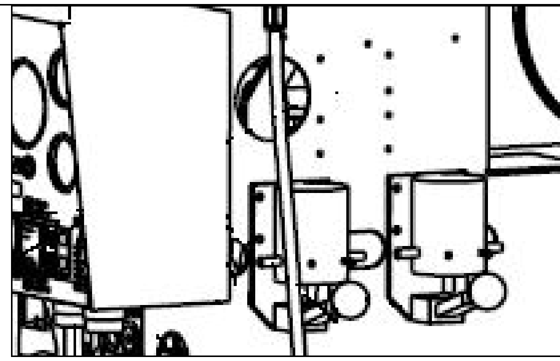


Crank Solenoid Assembly Removal/Installation

NOTE: Use this procedure to remove and install either or both of the crank solenoid assemblies. The crank solenoid assembly sub-components are not serviceable parts as supplied by Cummins Fire Power.

Prepare Place the fire protection system in a safe mode for engine service. Place the AUTO/MANUAL rocker switch in the MANUAL position.		
NOTE: Refer to Battery Removal/Installation in this section for detailed instructions for disconnecting the battery cable clamps. Disconnect the negative battery cable from Battery A. Disconnect the negative battery cable from Battery B.		
Remove **NOTE**: Refer to Drawing 8512 Sheet 1 in Section 18 for schematic information related to the crank solenoid assemblies. **NOTE**: Ensure that the wires are clearly identified for ease of reconnection. **NOTE**: Observe the location of flat and lock washers for ease of reconnection. **NOTE**: Save the nuts, bolts, flat washers, and lock washers for reuse. Disconnect all electrical connectors from the solenoid's four terminal studs. Loosen the four sets of mounting nuts, bolts, and washers. Remove the crank solenoid and fasteners from the engine.		

Crank Solenoid Assembly Removal/Installation (Cont)



Install

NOTE: Install the correct component. For 12 VDC systems, use Cummins NPower Part No 8824. For 24 VDC systems, use Cummins NPower Part No 8846.

Position the four bolts through the mounting holes.

Position the crank solenoid on the bolts, add the lock washers, and start the nuts.

Tighten the four mounting nuts.

NOTE: Refer to Drawing 8512 Sheet 1 in Section 18 for crank solenoid schematic information.

Position the flat washers, cable lugs, lock washers, and nuts on the studs in the same order as was removed.

Tighten the nuts on the studs.

With power still disconnected, verify that the lever handle on the crank solenoid operates freely.

Follow-Up

NOTE: Refer to Battery Removal/Installation in this section for detailed instructions for reconnecting the battery cable clamps.

Connect the negative battery cable from Battery A.

Connect the negative battery cable from Battery B.

Crank Solenoid Assembly Removal/Installation (Cont)

Demonstrate Local Electrical Start

NOTE: If Crank Solenoid A was replaced, start the engine using CRANK BATT A. Alternatively; use B if B was replaced.

Start the engine electrically from the local control panel.

Verify that the engine starts normally with no unusual indications.

Stop the engine.

Demonstrate Local Manual Start

NOTE: If Crank Solenoid A was replaced, start the engine using CRANK BATT A. Alternatively; use B if B was replaced.

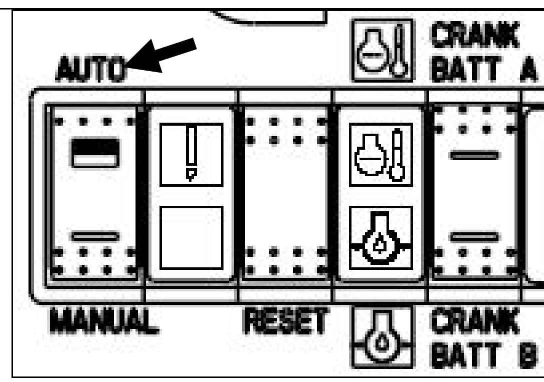
Start the engine manually from the crank solenoid lever handle.

Verify that the engine starts normally with no unusual indications.

Stop the engine.

Place the AUTO/MANUAL rocker switch in the AUTO position.

Return the fire protection system to operating status.

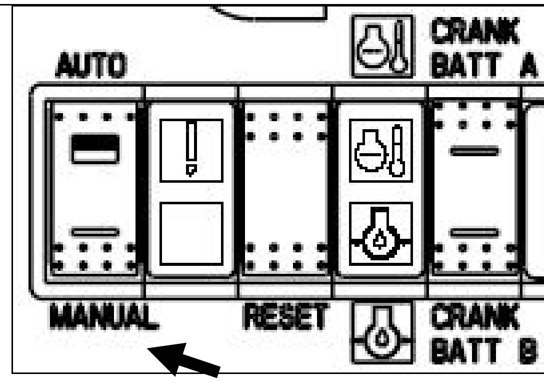


Control Panel Fuse Replacement

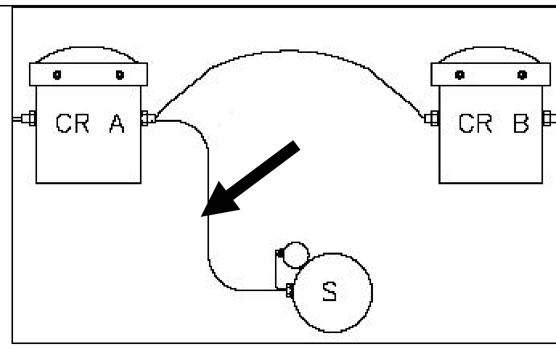
Prepare

Place the fire protection system in a safe mode for engine service.

Place the AUTO/MANUAL rocker switch in the MANUAL position.



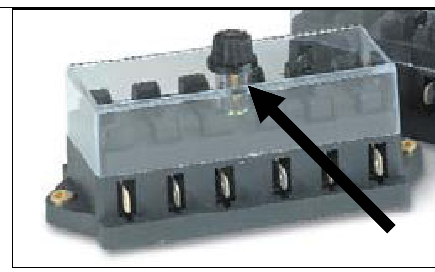
Disconnect and insulate the Contactor to Starter Cable (Cummins Fire Power Part No 9762) from the starter (Refer to Drawing 9767 in Section 18).



Remove

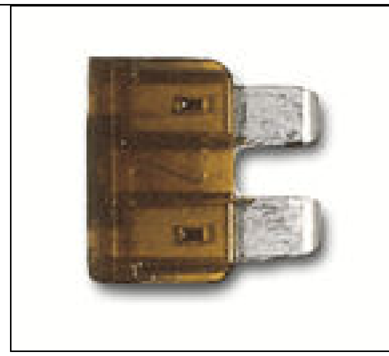
Open the fire pump engine's local control panel.

Loosen the cover screw and remove the fuse block cover.



Control Panel Fuse Replacement (Cont)

NOTE: The fuses are ATO/ATC ¼” blade type automotive fuses. The 20 Amp fuses (Fuse 1, 2, and 3) are colored yellow. The five amp fuse is colored tan.



NOTE: Refer to Drawing 8512 Sheet 1 in Section 18 for schematic details.

NOTE: The fuses are ordered from top to bottom as follows:

- 5 A Fuse F4 (Control Panel Indications)
- 20 A Fuse F1 (Battery A)
- 20 A Fuse F2 (Battery B)
- 20 A Fuse F3 (Crank Circuit)

Select the fuse for testing or replacement.

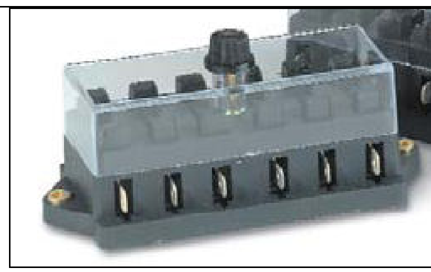
Pull the fuse from the fuse block.

Check for continuity either visually or with an ohmmeter.

Check for short circuits to ground on any fuse circuit that had an open circuited fuse. Correct any faults.

If necessary, remove, test, or replace the engine harness. Refer to Engine Harness Removal/Installation in this section.

Install



Replace any fuse with an open circuit. Place the new fuse into the fuse block and press it in until the fuse is properly inserted.

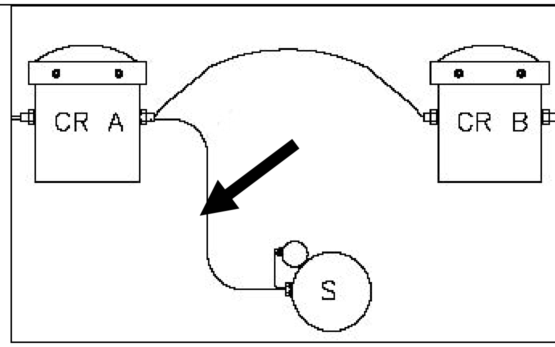
Install the fuse block cover and tighten the cover screw,

Close the control panel.

Control Panel Fuse Replacement (Cont)

Follow-Up

Reconnect the Contactor to Starter Cable (Cummins Fire Power Part No 9762) from the starter (Refer to Drawing 9767 in Section 18).



NOTE: If Fuse 1 or Fuse 2 was replaced, start the engine using CRANK BATT A or CRANK BATT B respectively.

Start the engine. Refer to Normal Local Starting Procedure in Section 3.

Observe that the engine starts with no unusual indications.

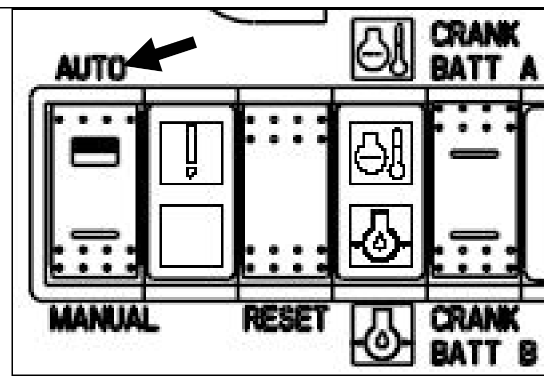
Observe that engine speed is indicated.

Observe that raw water flow has started.

Stop the engine.

Place the AUTO/MANUAL rocker switch in the AUTO position.

Return the fire protection system to operating status.



Exhaust Manifold Removal/Installation

Prepare

Remove the heat shield.

Remove the air intake piping from the turbocharger.

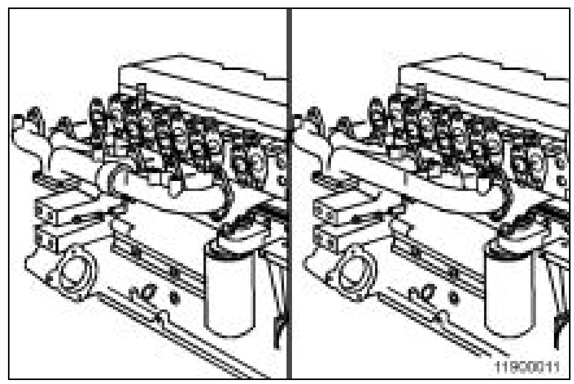
Remove the air outlet piping from the turbocharger.

Remove the exhaust outlet piping from the turbocharger.

Remove the turbocharger.

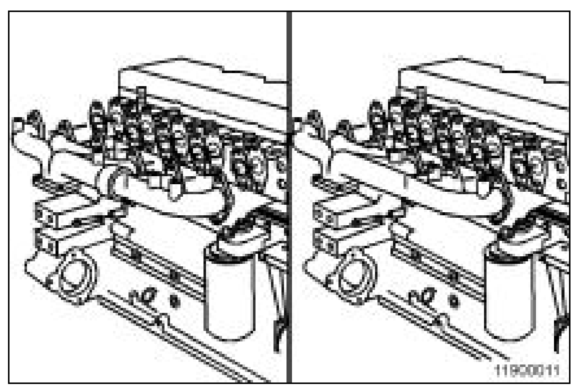
Remove

Refer to Exhaust Manifold, Dry (45-011-007) in ISC, QSC8.3, ISL, and QSL9 Troubleshooting and Repair Manual, Bulletin Number 4021418.



Clean

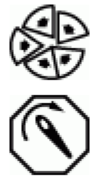
Refer to Exhaust Manifold, Dry (45-011-007) in ISC, QSC8.3, ISL, and QSL9 Troubleshooting and Repair Manual, Bulletin Number 4021418.

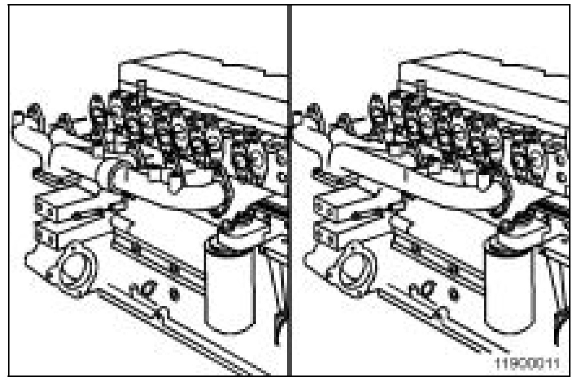


Exhaust Manifold Removal/Installation (Cont)

Install

Refer to Exhaust Manifold, Dry (45-011-007) in ISC, QSC8.3, ISL, and QSL9 Troubleshooting and Repair Manual, Bulletin Number 4021418.





Follow-Up

Install the turbocharger.

Install the exhaust outlet piping at the turbocharger.

Install the air outlet piping at the turbocharger.

Install the air intake piping at the turbocharger.

Install the heat shield.

Exhaust Restriction Measurement

Measure

NOTE: The maximum acceptable exhaust restriction is listed in Exhaust System Specifications in Section 15.

NOTE: A new pressure tap in the customer-supplied exhaust piping may be required.

Install pressure gauge, Cummins Part Number ST-1273, in the exhaust piping at the connection to the fire pump.

Operate the engine at rated speed and load. Refer to Normal Local Starting Procedure in Section 3.

Observe the exhaust restriction.

Stop the engine. Refer to Normal Local Starting Procedure in Section 3.

Remove the pressure gauge and plug the pressure tap.

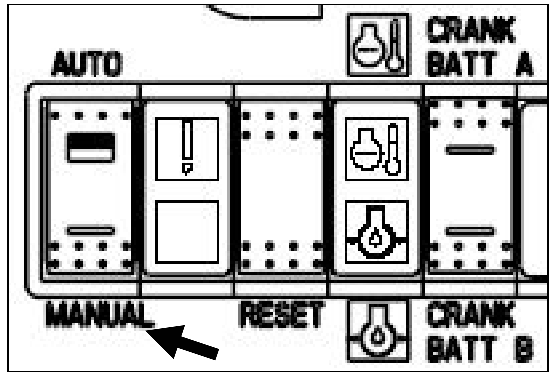
If the backpressure exceeds specification, modify the exhaust piping accordingly.

Exhaust Shield Removal/Installation

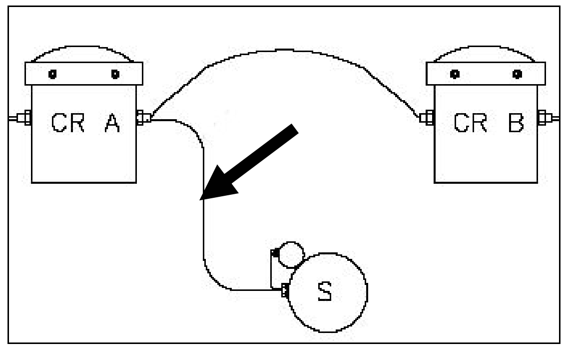
Prepare

Place the fire protection system in a safe mode for engine service.

Place the AUTO/MANUAL rocker switch in the MANUAL position.



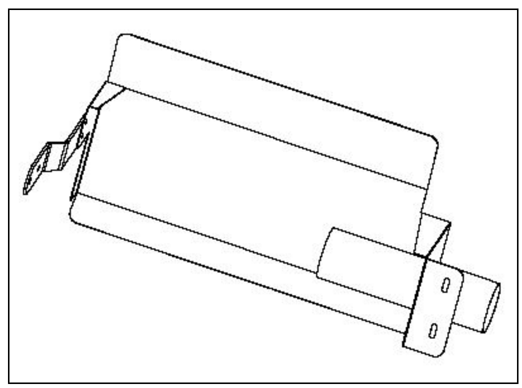
Disconnect and insulate the Contactor to Starter Cable (Cummins Fire Power Part No 9762) from the starter (Refer to Drawing 9767 in Section 18).



Remove

Remove the exhaust shield and fasteners. Refer to Drawing 9515 in Section 18.

Need fastener info

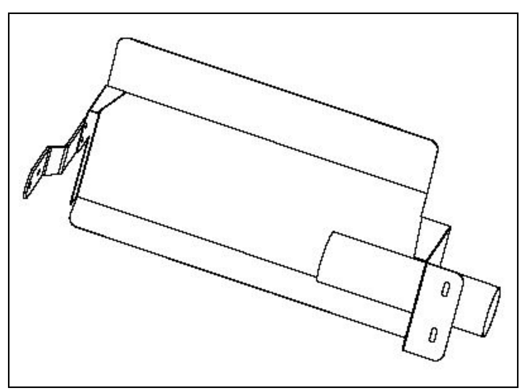


Install

Install the exhaust shield and fasteners. Refer to Drawing 9515 in Section 18.

Need fastener info

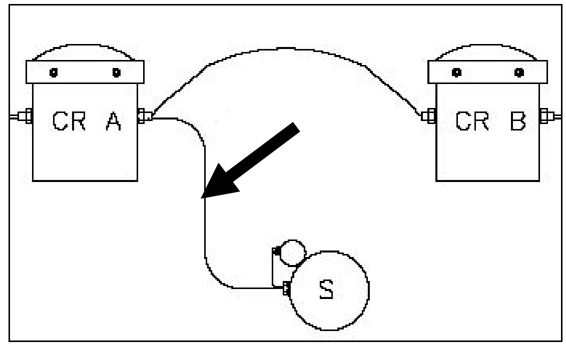
Torque Values?



Exhaust Shield Removal/Installation (Cont)

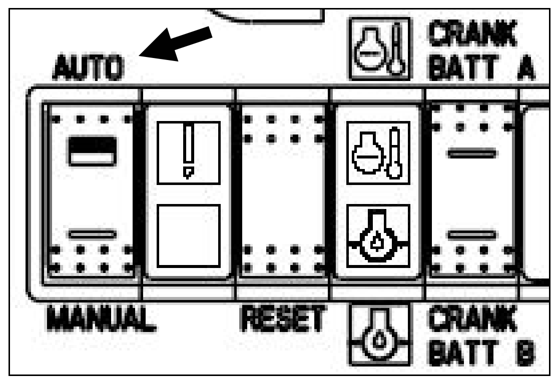
Follow-Up

If work is completed, reconnect the Contactor to Starter Cable (Cummins Fire Power Part No 9762) at the starter (Refer to Drawing 9767 in Section 18).



If functional components were removed, repaired, or replaced, perform the appropriate installation checks and engine starts as listed in Section 3. Verify that the components operate properly.

If testing is completed, place the AUTO/MANUAL rocker switch in the AUTO position.



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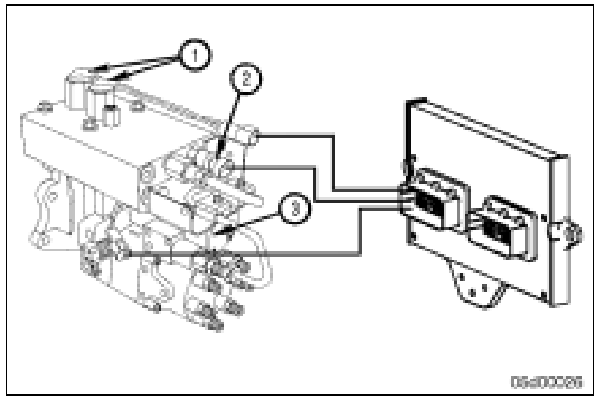
CAPS Fuel System Overview

The CAPS fuel system is a distributor-type injection system. CAPS stands for Cummins Accumulator Pump System. An accumulator is used to store pressurized fuel for the injection event. There are four components that provide or receive input to the electronic control module (ECM). There are two pumping control valves (1) that are controlled by the ECM. These valves control the pressure in the accumulator. The accumulator fuel pressure/temperature (2) sensor is located on the accumulator and provides the ECM with pressure and temperature information. The injection control valve (3) is also controlled by the ECM and regulates fuel injected into the cylinder.



The CAPS injection pump can be divided into six distinct units/modules. They are the gear pump, cam housing, accumulator, rate shape tube, injection control valve (ICV), and distributor. Fuel flows through the modules in the following order:

gear pump - 5

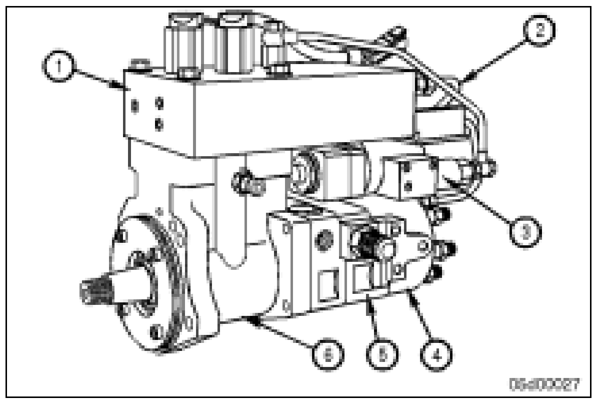
cam housing - 6

accumulator - 1

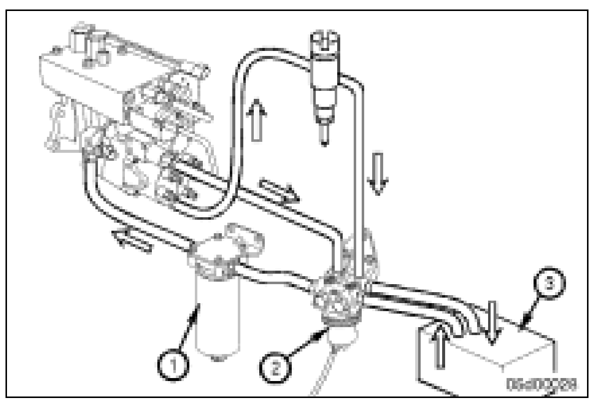
rate shape tube - 2

injector control valve (ICV) - 3

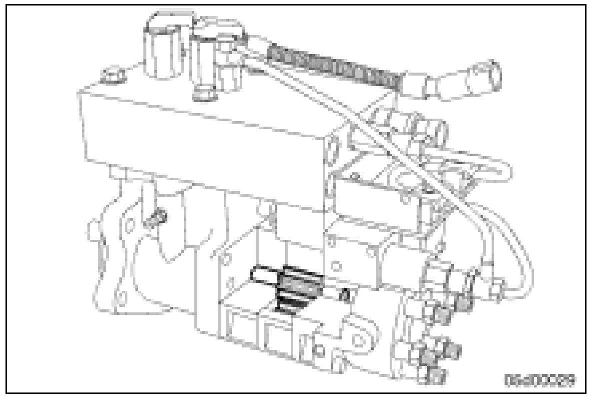
distributor - 4.



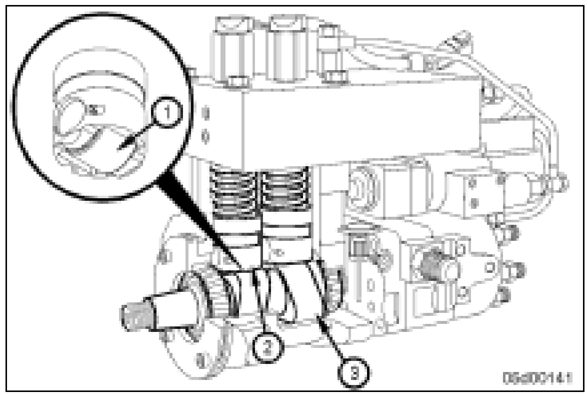
A lift pump is used for priming the pump at start-up. The lift pump runs for approximately 30 seconds after key-on. Once the engine is started, the gear pump is able to maintain prime without any assistance from the lift pump.



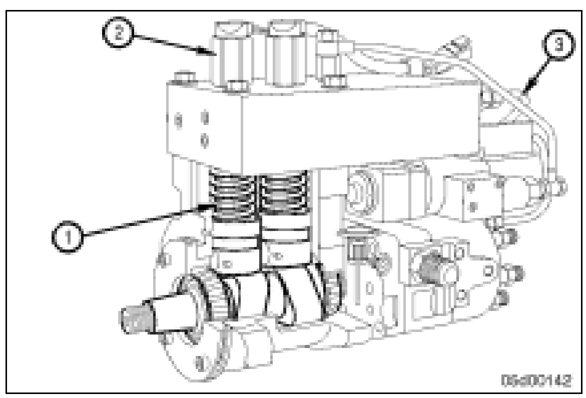
The gear pump supplies fuel to the pumping plungers through internal drillings in the cam housing. The gear pump also supplies fuel to the distributor for lubrication. The fuel pressure is regulated to approximately 160 psi at rated engine rpm. The gear pump has an internal filter to catch any debris generated downstream of the main, external fuel filter. The pump camshaft is driven off the engine camshaft; therefore, pump rpm is one-half engine rpm. The gear pump is driven by the pump camshaft through an internal coupling. The gear pump shaft then turns the distributor rotor through a second internal coupling.



Each of the two pumping plungers is driven by a three lobed camshaft (3). The camshaft is located in the cam housing module by tapered roller bearings. The bearings that support the camshaft, as well as the tappets (2), rollers (1), and camshaft itself are lubricated with engine oil. These are the only components in the pump lubricated with engine oil.

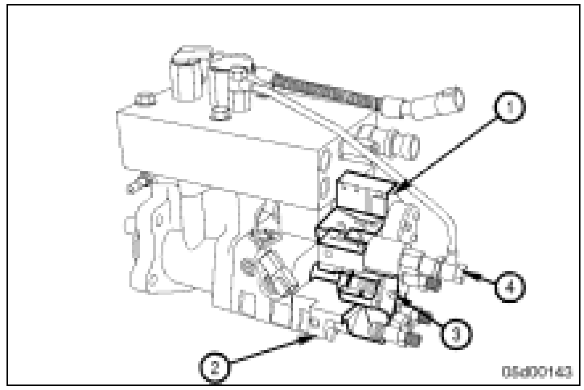


A pumping control valve (2) is located above each pumping plunger (1). The supply fuel from the gear pump flows around the plunger of this normally open valve into the chamber above the plunger. The volume above each pumping plunger is filled, by the gear pump, as the plungers travel downward. As the plunger starts to move upward, the fuel is pushed backward into the gear pump. When the pumping control valve closes, the fuel is pushed into the accumulator and then held by check valves. The time when the pumping control valve is energized (closed) is based on engine speed, accumulator pressure, and throttle position. A 0- to 24,000-psi pressure sensor is located in the accumulator. The pressure sensor provides direct feedback to the ECM, so the desired accumulator pressure is maintained. This pressure sensor also has temperature sensing capabilities built into it. Fuel moves from the accumulator to the



distributor and through the rate shape tube (3).

Fuel is delivered to the injection control valve (1) by the rate shape tube and through a drilling in the distributor (2). The ICV controls both fueling and timing. The injection control valve contains an inner pin and outer valve. The outer valve is moved by magnetic force generated inside the ICV by a current from the ECM. The inner pin is moved by spring force and fuel pressure. When the two pins are in the closed position, no fuel flows through the control valve. The position of these internal parts controls fuel flow to the distributor rotor (3) and to the drain (4). The injection control valve opens and closes once for each injection event.



The distributor (1) directs the fuel to the correct injector using the rotor. The drain fuel from the ICV is routed through the ICV pressure regulator (4) and is returned to the tank.

The position of the rotor directs the fuel to one of six drillings in the distributor housing. These drillings communicate the fuel to six fuel pump delivery valves (3). There is one injector line per delivery valve. The injection line carries the fuel to the injector.

Fuel Pump Delivery Valve Removal/Installation

Prepare

WARNING

When using a steam cleaner, wear safety glasses or a face shield, as well as protective clothing. Hot steam can cause serious personal injury.

WARNING

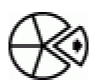
Wear appropriate eye and face protection when using compressed air. Flying debris and dirt can cause personal injury.

Thoroughly steam-clean the distributor outlet fitting and fuel pump area.

Dry with compressed air.

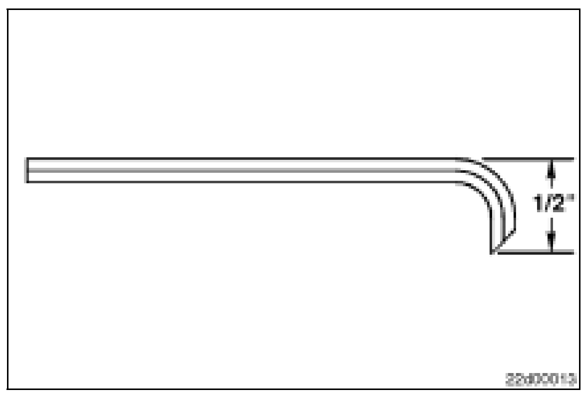
Remove the high-pressure fuel supply lines. Refer to Procedure 006-051.

Remove



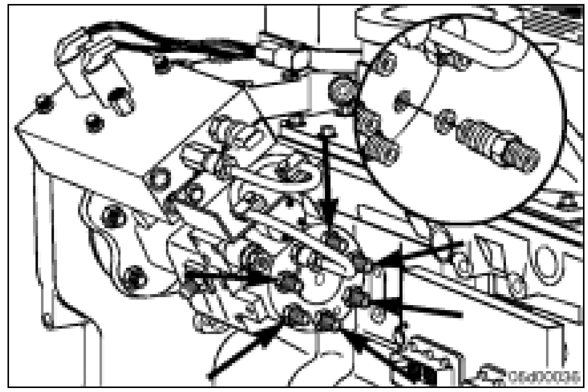
Remove the distributor outlet fitting and the seal disk.

NOTE: A tool like the one shown here can be made from a 1/8 in or 3/16 in Allen wrench. Use it to remove the seal disc. Refer to Procedure 005-084 for instruction on how to make the tool.



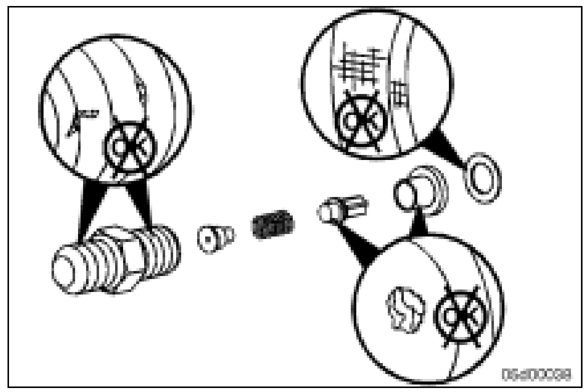
NOTE: The outlet fitting valve and seat are a matched set; do not "mix and match" valves and seats with other outlet fitting assemblies.

If either the outlet fitting valve or seat is damaged, the entire outlet fitting assembly must be replaced. Also, the seal washers must always be replaced.

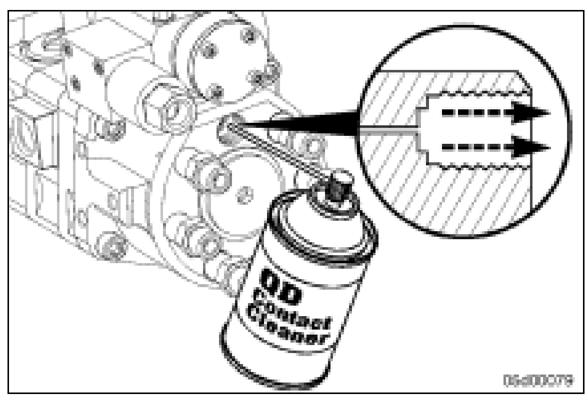


Clean and Inspect for Reuse

Check for broken parts, debris, or sticking of the outlet fitting valve. Replace the outlet fitting assembly if any parts are damaged. Always replace the seal washer.



Use QD contact cleaner, Part Number 3824510, to clean the delivery valve port in the distributor.



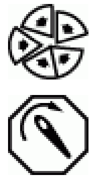
Install

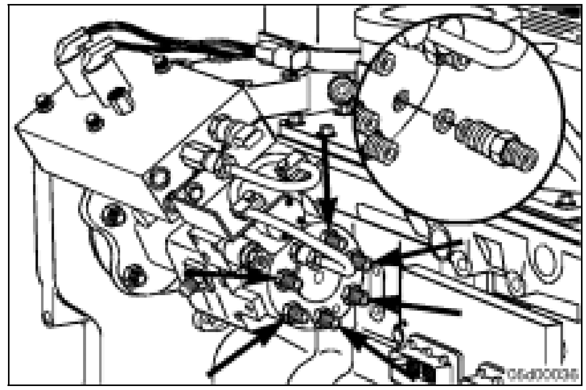
Install a new seal washer into the distributor outlet fitting hole. Make sure the washer is fully seated in the bottom of the hole.

Install the outlet fitting assembly hand tight.

Tighten the outlet fitting assemblies.

Torque Value: 81 N•m [60 ft-lb]





Follow-Up

Install the high-pressure fuel supply lines. Refer to Procedure 006-051.

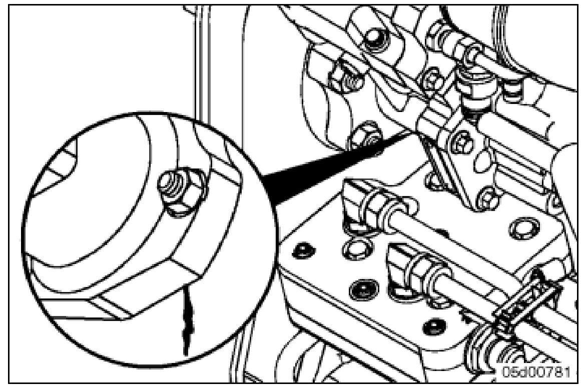
Operate the engine and inspect for fuel leaks.

Fuel Pump Gear Pump Check

Initial Check

The gear pump shaft incorporates a double seal. The first seals oil in the fuel pump cam housing; the second seals fuel in the gear pump. If either seal fails, a leak will drip from the weep hole. The weep hole is located near the gear pump mounting flange on the inboard side (toward the engine block).

A gear pump gasket seals oil at the gear pump to cam housing interface.



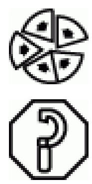
Measuring gear pump pressure with the engine cranking (useful if engine will not start).

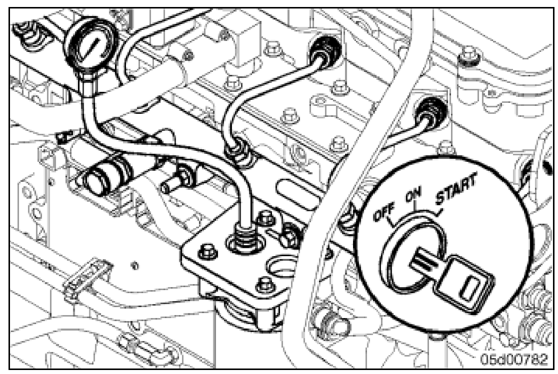
Install a pressure gauge at the on engine fuel filter head (M10 x 1.5 Compuchek® fitting, Part Number3824842).

Monitor the gear pump pressure while the engine is cranking.

Measurements Gear Pump Pressure at Cranking (minimum): 69 kPa [10 psi]

If the gear pump pressure is lower than 69 kPa [10 psi] during cranking, make sure that the engine cranking speed is at least 150 rpm. Make sure that the lift pump pressure during cranking is at least 35 kPa [5 psi]. Refer to Procedure 005-045.





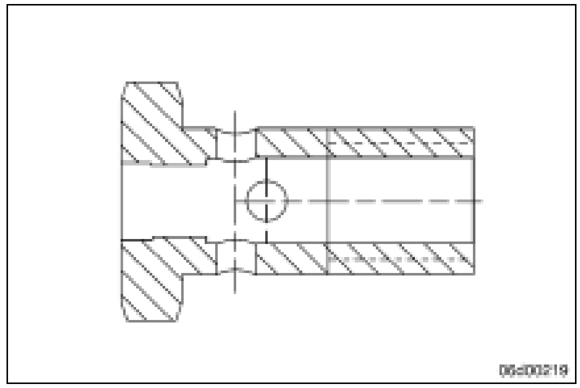
Construction of Banjo Pressure Gauge Adapter

A banjo-style pressure gauge adapter can be used to measure pressure or vacuum at any point in the low-pressure fuel system where a banjo bolt exists at a fuel line.

The ISC and ISL engines with high-pressure common rail fuel systems use M12 x 7/16-inch banjo bolt connection. This tool can be used for measurement of drain line restriction (pressure) at the fuel drain manifold.

Make a banjo bolt flow adapter tool by drilling and tapping the hex face of an M12 x 7/16-inch banjo bolt, Part Number 3903035 or similar banjo bolt.

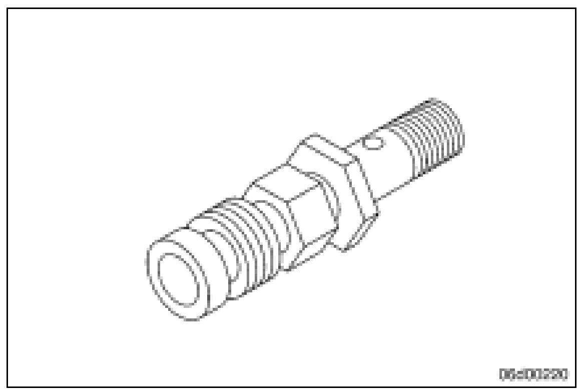
Drill and tap the banjo bolt to the size of Compuchek® fitting (or other hose union) being used (example 1/8-inch NPT Compuchek® fitting, Part Number 3377244, or M10 Compuchek® fitting, Part Number 3824842).



Assemble the banjo pressure gauge adapter as follows.

Install the Compuchek® fitting, or other type fitting, in the hexagon face of the banjo bolt.

Attach a hose or pressure gauge to the banjo pressure adapter.



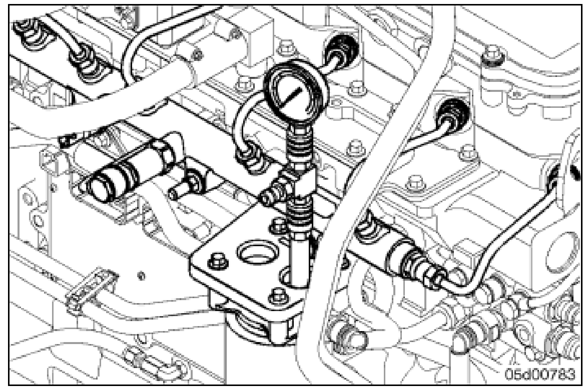
Measuring Gear Pump Pressure at Rated Condition

Install a M10 x 1.5 Compuchek® fitting, Part Number 3824842, at the diagnostic port on the outlet of the fuel filter head.

Construct a “T” adapter fitting using one quick-disconnects, Part Number 3376859, and two 1/8-inch NPT Compuchek® fitting, Part Number 3042618.

Install a 0.043-inch orificed diagnostic fuel line (Part Number 3164621) at the outlet of the fuel filter head. Run the fuel hose back to the fuel tank.

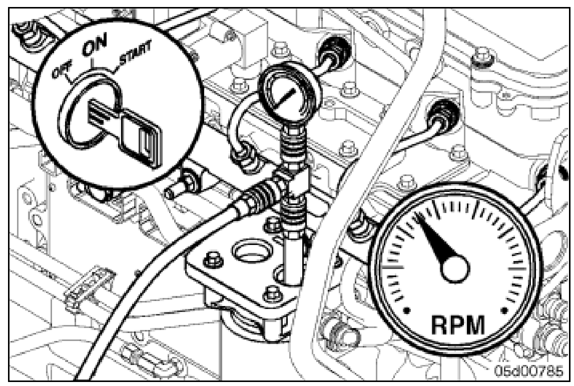
Install a 0 to 1034 kPa [0 to 150 psi] pressure gauge at the “T” adapter fitting.



Operate the engine at high idle and observe the gear pump pressure.

Measurements Minimum Gear Pump Pressure 483 kPa [70 psi]

If the gear pump pressure is low, check for excessive inlet vacuum. Refer to Procedure 006-020.



Fuel Pump Gear Pump Removal/Installation

Prepare

Clean the fuel, oil and debris from the gear pump.

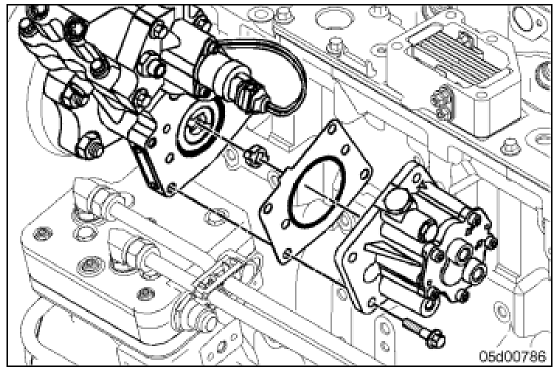
Remove the fuel supply lines from the gear pump. Refer to Procedure 006-024.

Remove

Remove the four bolts that hold the gear pump to the fuel pump.

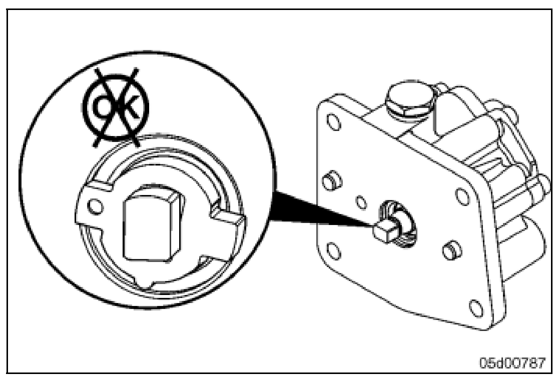
Remove the drive coupling if it remains attached to the rear of the fuel pump camshaft.

Remove the gear pump gasket.

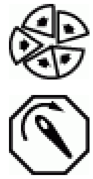


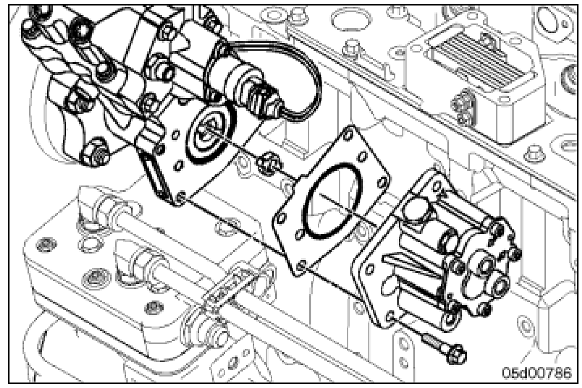
Clean and Inspect for Reuse

Inspect the drive coupling for wear. If worn, the drive coupling must be replaced.



Install





Install the drive coupling into the back of the high-pressure pump camshaft.

Insert the mounting bolts through the gear pump flange.

Install a new gasket onto the bolts.

Index the gear pump input shaft to engage the drive coupling and install the gear pump.

Install the four gear pump bolts and tighten.

Torque Value: 34 N•m [25 ft-lb]

Follow-Up

Install the fuel supply lines. Refer to Procedure 006-024.

Adjust Fuel Pump Timing

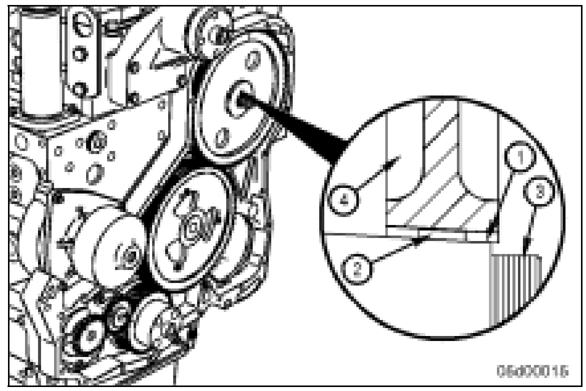
Prepare

Remove the gear cover. Refer to Procedure 001-031.

Remove the fuel pump camshaft nut. Refer to Procedure 005-016 or 005-229.

Inspect for Reuse

Check that the fuel pump camshaft alignment dowel is present in the fuel pump drive gear keyway. If the alignment dowel is not visible, remove the injection pump, determine the cause of misalignment, and repair or replace any damaged components.



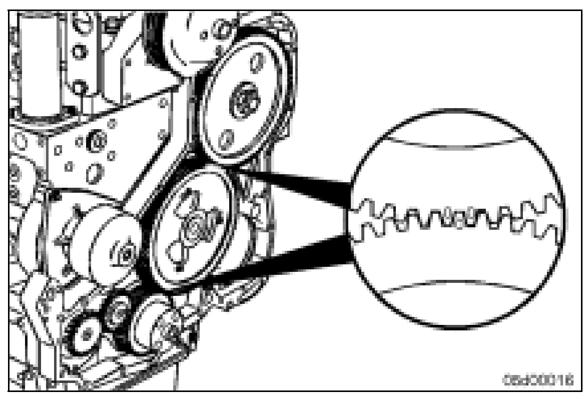
Fuel pump gear keyway

Fuel pump timing dowel pin

Fuel pump camshaft

Fuel pump gear

If this inspection is being performed due to a performance complaint, and the problem first occurred after gear train removal and replacement then check the timing of the camshaft gear to the crankshaft gear and the camshaft gear to the fuel pump drive gear. Refer to Procedure 001-012.



If the engine camshaft gear is mistimed in relation to the crankshaft gear, intake and exhaust valve events will not be optimized. Also, for CAPS injection pump fuel systems, the primary speed sensor reads the tonewheel on the camshaft gear and fuel injection timing will be incorrect.

Follow-Up

Install and tighten the injection pump camshaft nut. Refer to Procedure 005-016 or 005-229.

Install the front gear cover. Refer to Procedure 001-031.

Fuel Lift Pump Check

Initial Check

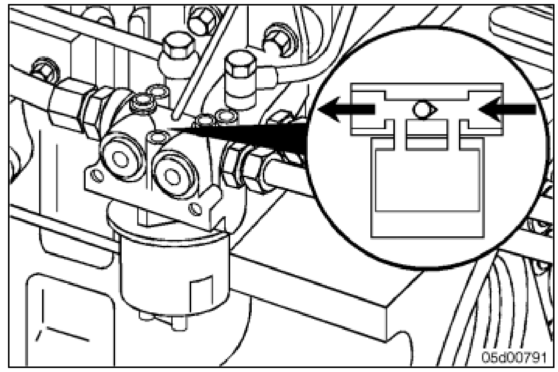
Block Mounted Lift Pump

A malfunctioning electric fuel lift pump can cause slow engine starts or may result in an engine failing to start. The fuel lift pump can be cleaned and repaired to a limited extent.

The lift pump will operate for 30 to 60 seconds when the key is switched ON. The lift pump will also operate while the engine is cranking.

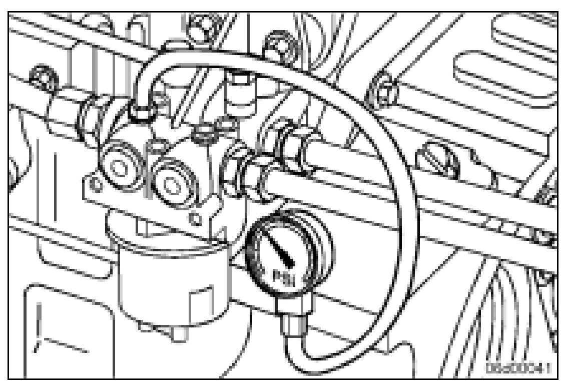
The lift pump is contained in an assembly that includes fuel supply and drain manifolds. These manifolds provide for OEM connection of fuel supply and return hoses. The fuel supply manifold also contains M10 STORM fittings which allow for pressure and vacuum measurement of the fuel supply at the electric lift pump.

A bypass check valve in the fuel supply manifold ensures that the system is primed by the lift pump. This check valve opens under vacuum created by the fuel injection pump once the engine is started. High vacuum measured between the electric lift pump and the fuel filter may indicate that this check valve has become plugged.



The output of the fuel lift pump can be checked through the following test:

Measure the output pressure using a pressure gauge at the lift pump outlet port.



The lift pump check valve restriction can be determined using the following test:

Install a 0 to 762 mm Hg [0 to 30 in Hg] vacuum gauge at the inlet and outlet M10 STORM ports on the electric lift pump head

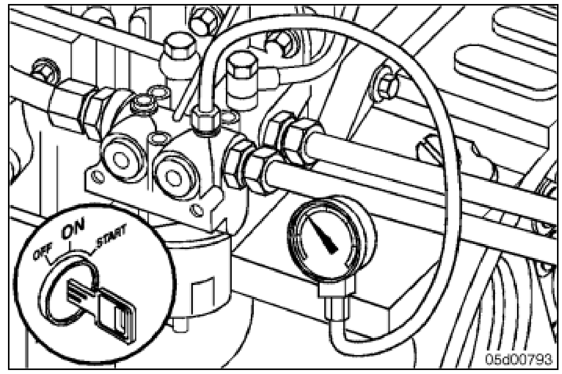
Operate the engine at rated power condition

Record the inlet restriction at the inlet and outlet of the lift pump.

Refer to Procedure 006-020.

Maximum Fuel Lift Pump Inlet Restriction:

102 mm-hg 4 in-hg



Initial Check

ECM Cooling Plate Mounted Lift Pump

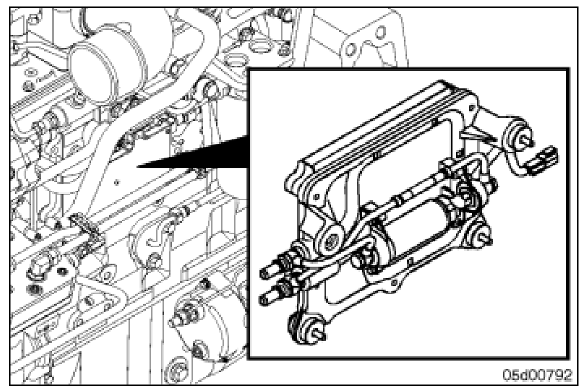
A malfunctioning electric fuel lift pump can cause slow engine starts or may result in an engine failing to start. The fuel lift pump can be cleaned and repaired to a limited extent.

The lift pump will operate for 30 to 60 seconds when the key is switched ON. The lift pump will also operate while the engine is cranking.

A lift pump is mounted to the back of the ECM cooling plate.

A bypass check valve in the ECM cooling plate ensures that the system is primed by the lift pump. This check valve opens under vacuum created by the gear pump once the engine is started. High vacuum measured between the electric lift pump and the gear pump may indicate that this check valve has become plugged.

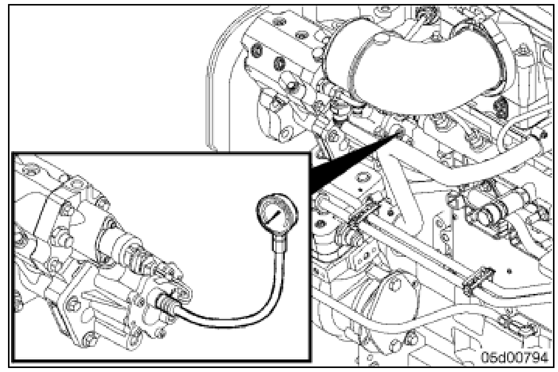
The ECM cooling plate check valve is integral with the lower (outlet) fitting of the ECM cooling plate.



The output of the fuel lift pump can be checked through the following test:

Measure the output pressure using a pressure gauge at the inlet to the high-pressure pump gear pump assembly.

Install a pressure gauge at the inlet port of the high-pressure pump gear pump.



Turn the key switch ON and measure the lift pump pressure using a pressure gauge at the gear pump inlet.

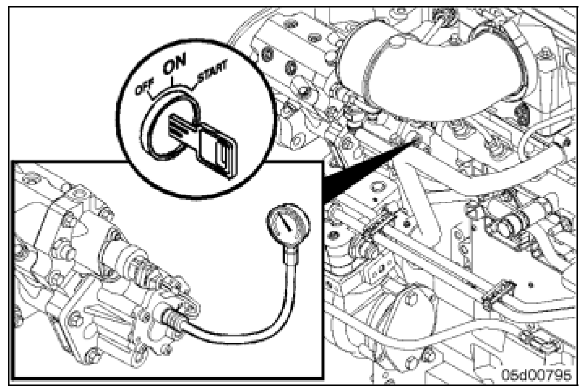
NOTE: At initial key-on, the lift pump will run for 30 seconds then stop.

Measurements

Minimum Pressure 34 kPa [5 psi]

NOTE: If the lift pump pressure is low while the lift pump runs, make sure that the ECM cooling plate check valve is not blocked open.

NOTE: If the lift pump pressure is low while the lift pump runs, make sure that fuel is primed. For example, following fuel filter replacement it is necessary to cycle the fuel lift pump three or four times before air is purged.



Fuel Lift Pump Removal/Installation

Prepare

Block Mounted Lift Pump

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.

Disconnect the negative (-) battery cable first.

NOTE: Thoroughly clean fittings and components before removal. Make sure that the debris, water, steam or cleaning solution does not reach inside the fuel system.

Remove the fuel lift pump inlet and outlet fuel lines. Refer to Procedure 006-024.

Disconnect the fuel pump power lead.

Prepare

ECM Cooling Plate Mounted Lift Pump

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.

Disconnect the negative (-) battery cable first.

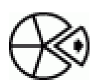
Disconnect the electric fuel priming pump from the engine wiring harness.

NOTE: Thoroughly clean fittings and components before removal. Make sure that the debris, water, steam or cleaning solution does not reach inside the fuel system.

Remove the fuel supply lines. Refer to Procedure 006-024.

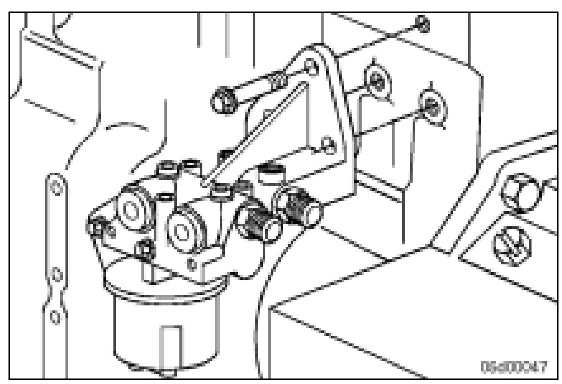
Remove the ECM cooling plate. Refer to Procedure 006-006.

Remove



Block Mounted Lift Pump

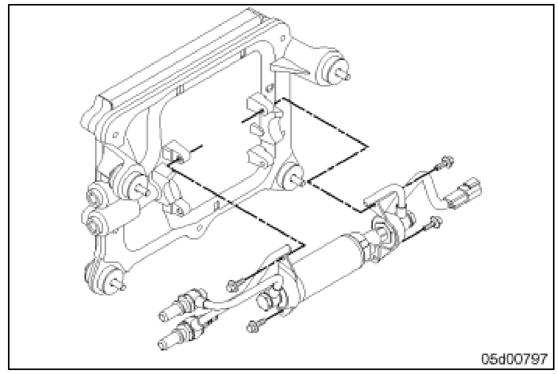
Remove the three capscrews and the electric lift pump from the engine block.



Remove

ECM Cooling Plate Mounted Lift Pump

Remove the electric lift pump from the ECM cooling plate.



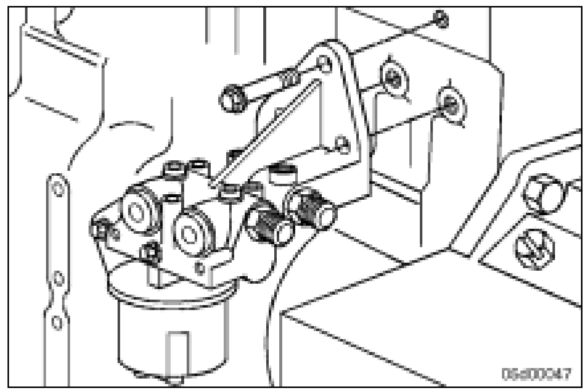
Install

Block Mounted Lift Pump

Install the fuel lift pump to block using the three mounting capscrews.

Tighten the capscrews.

Torque Value: 12 N•m [106 in-lb]



Install

ECM Cooling Plate Mounted Lift Pump

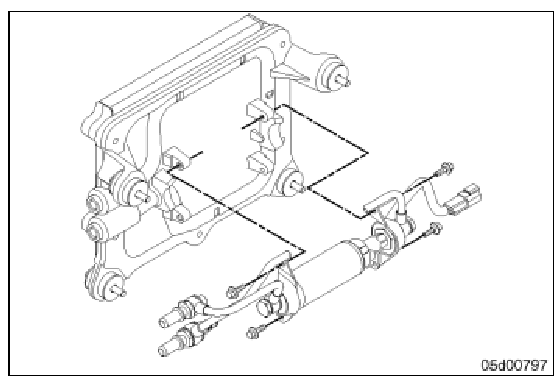
Install the electric lift pump to the ECM cooling plate.

Tighten the mounting capscrews.

Torque Value: 10 N•m [89 in-lb]

NOTE: The ECM cooling plate check valve must be free of debris and installed into the lower ECM cooling plate port (outlet port).

NOTE: Hold the fuel lines as shown so that they can not come into contact with each other or the engine block.



Follow-Up

Block Mounted Lift Pump

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.

Connect the power lead to the fuel lift pump.

Install all removed fuel lines. Refer to Procedure 006-024.

Connect the battery, negative (-) cable last.

Follow-Up

ECM Cooling Plate Mounted Lift Pump

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 the ECM cooling plate to the engine block. Refer to Procedure 006-006.

Install all fuel lines. Refer to Procedure 006-024.

Connect the battery, negative (-) cable last.

CAPS Fuel Injection Pump Rotor Removal/Installation

Prepare

WARNING

When using solvents, acids, or alkaline materials for cleaning, follow the manufacturers recommendations for use. Wear goggles and protective clothing to reduce the possibility of personal injury.

WARNING

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

WARNING

Wear appropriate eye and face protection when using compressed air. Flying debris and dirt can cause personal injury.

Steam clean the fuel injection pump and the engine in the vicinity of the fuel pump.

Dry with compressed air. Pay special attention to the distributor area.

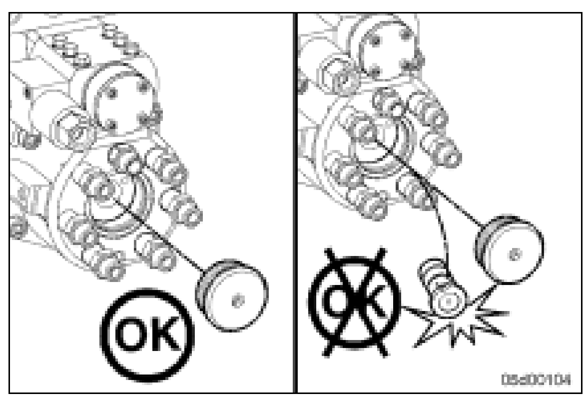
Remove

CAUTION

The rotor can slide out during the removal of the distributor plug. If the rotor is dropped, the entire distributor module must be replaced. Do not attempt to start the engine with the distributor plug removed. Doing so can cause the rotor to be ejected from the distributor, causing damage to the rotor.

ISL Only: Remove the air bleed line. Refer to Procedure 006-056.

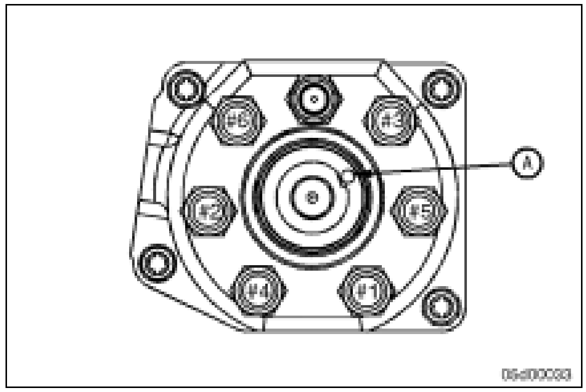
Remove the distributor plug, being sure the rotor does not fall out.



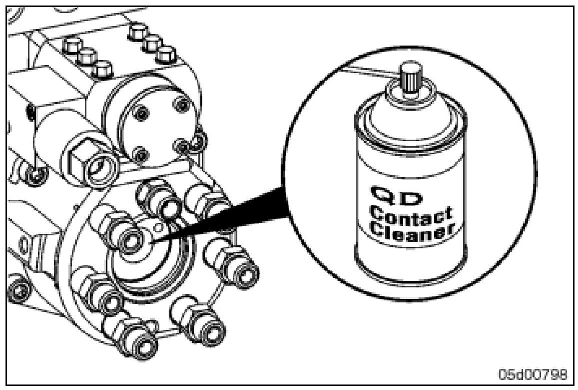
Clean and Inspect for Reuse

Check the position of the notch on the rotor. It must line up with the alignment mark (A) on the outside of the distributor (when the engine is barred to TDC for the number 1 cylinder). If the alignment is correct, the rotor is properly timed to the engine.

If a mechanical problem exists, indicated by misalignment of the rotor, the entire fuel pump will have to be replaced; refer to Procedure 005-016.

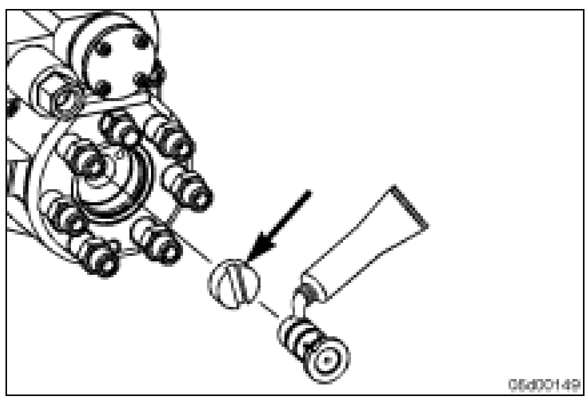


Clean the rotor bore with QD contact cleaner, Part Number 3824510.



Install

Use Lubriplate™ 105, or equivalent, between the drive coupling and the rotor to prevent it from falling off during assembly.



CAUTION

The rotor must be properly timed to the fuel pump camshaft. Improper assembly will cause the rotor to be 180 degrees out of time.

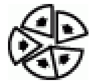
Insert the rotor and coupling into the distributor module completely.

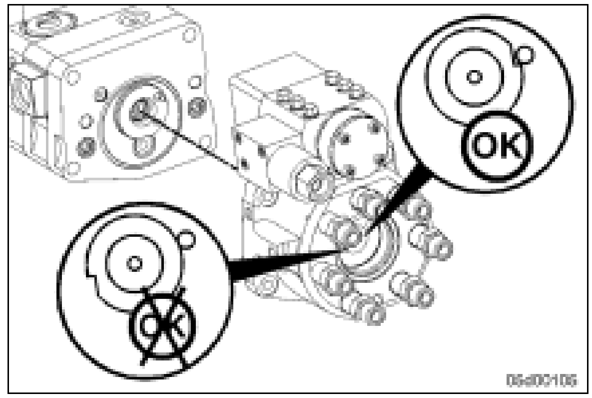
Lightly rotate the rotor with finger-pressure until it drops into the slot in the drive coupling.

When properly engaged, the notch in the rotor will align with the hole in the distributor while the engine is at Number cylinder TDC.

If the rotor will not engage, remove the rotor and drive coupling and try again. Do not tighten the rotor cap if the coupling will not engage.

If not properly timed, remove the rotor and drive coupling and repeat the previous step. Make sure the fuel pump camshaft dowel pin is pointing toward the top of the fuel pump before installing.



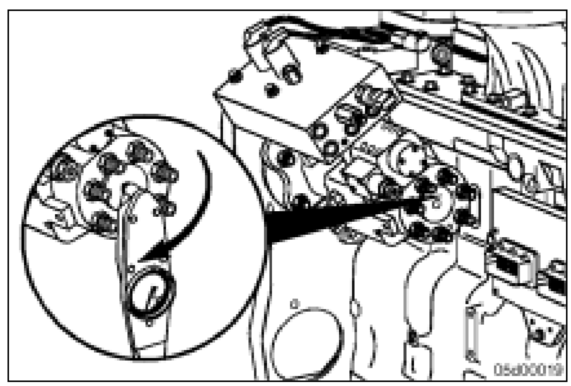


Install the distributor plug and torque.

Torque Value: 14 N•m [10 ft-lb]

NOTE: Be sure the rotor is fully engaged before replacing the plug.

ISL Only: Install the air bleed line. Refer to Procedure 006-056.



Follow-Up

Injection Control Valve Removal/Installation

Prepare

WARNING

When using a steam cleaner, wear safety glasses or a face shield, as well as protective clothing. Hot steam can cause serious personal injury.

WARNING

Wear appropriate eye and face protection when using compressed air. Flying debris and dirt can cause personal injury.

CAUTION

Fault codes can occur if steam sprays directly on the electrical connections on top of the accumulator block.

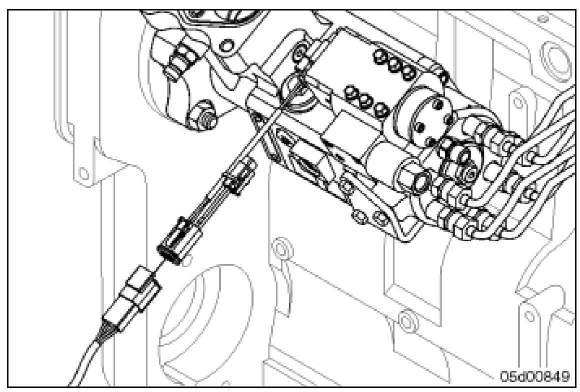
Thoroughly steam-clean the entire fuel pump.

Dry the fuel pump with compressed air.

Remove the fuel injection pump accumulator. Refer to Procedure 005-085.

Remove

Unplug the engine wiring harness from the injection control valve connector.



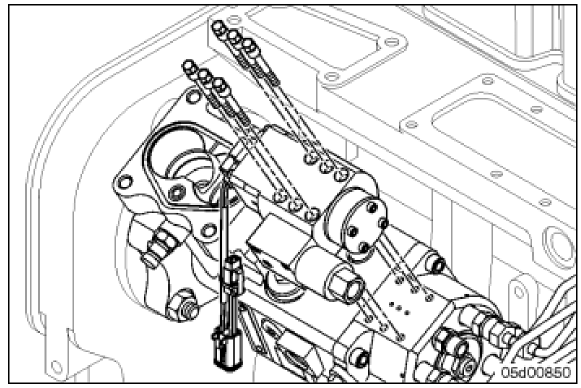
Remove the injection control valve drain line.

Remove the six injection control valve mounting screws.

Remove the injection control valve from the distributor module.

Do not misplace parts during disassembly.

Secure the six bolts, sealing plate, and both crush tubes into a parts bag. The parts are to be returned with the core.



Clean and Inspect for Reuse

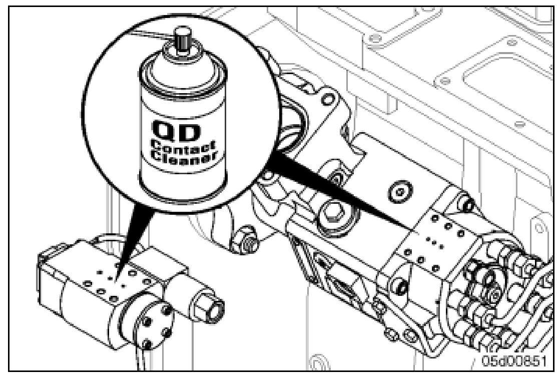
Clean the mounting surface of the distributor module and injection control valve.

Use QD contact cleaner, Part Number 3824510.

Spray or wipe debris away from the three distributor module drillings. Do not allow debris to enter the distributor module drillings.

Inspect the distributor module sealing face for cracks, indentations, and damage.

Replace the distributor module if damage is found.



Install

Install guide pins, Part Number 3165166, in the upper left and lower right corner of the distributor module.

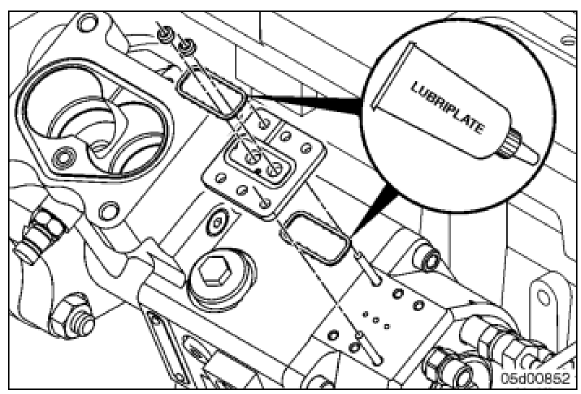
Install the o-rings into the sealing plate using Lubriplate™ to hold them in place.

Slide the sealing plate down over the guide pins.

The o-rings must be securely seated in the sealing plate before proceeding.

Insert crush tubes into the sealing plate.

Check the position of the crush tubes. They must sit flush on the distributor module and must not be installed at an angle.



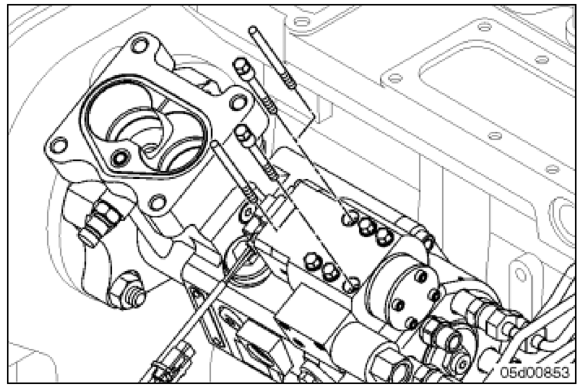
Install the injection control valve on top of the distributor module using guide pins.

Check that the o-rings are still in their grooves.

Install four bolts through the injection control valve and tighten finger tight.

Remove the two guide pins.

Install the two remaining bolts, finger tight, through the injection control valve.

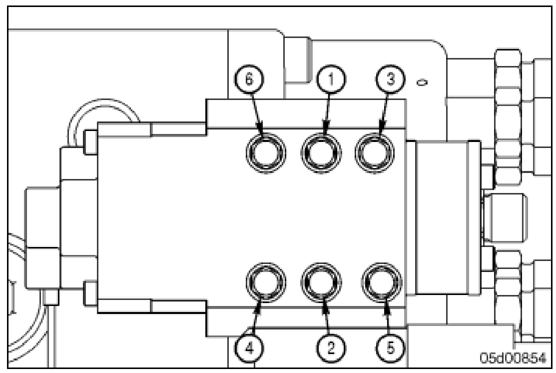


CAUTION

Bolts must be torqued as described or the injection control valve/distributor module will not function properly. Use a high-quality, calibrated torque wrench.

Torque bolts in sequence for each pass for six passes. Refer to the accompanying illustration for the torque sequence.

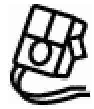
Pass	Torque Value
1.	1.8 N•m [16 in-lb]
2.	3.6 N•m [32 in-lb]
3.	5.6 N•m [50 in-lb]
4.	5.6 N•m [50 in-lb]
5.	5.6 N•m [50 in-lb]
6.	5.6 N•m [50 in-lb]

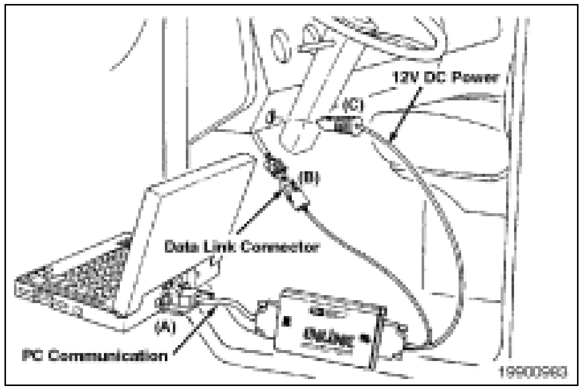


Install the injection control valve drain line.

Click Test

Use INSITE™, with the keyswitch in the ON position, to run the control valve click test.



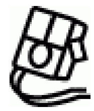


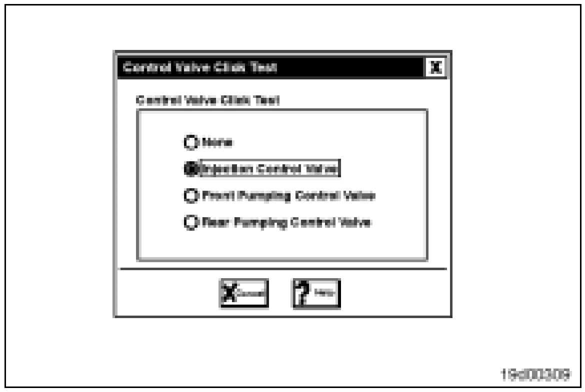
Select Injection Control Valve to initiate the test.

A click will be heard until None is selected on the Control Valve Click Test screen.

If no click is heard, troubleshoot any active fault codes.

The click test will need to be performed after any repairs are made to clear the fault codes.





Follow-Up

Install the fuel injection pump accumulator. Refer to Procedure 005-085.

Install the air bleed line. Refer to Procedure 006-056.

Install the drive gear cover.

Connect the fuel pressure sensor and the fuel temperature sensors to the engine harness.

Connect the pumping control valve connector to the engine harness.

Connect the stator connector to the engine harness.

Click test the injection control valve stator to check for proper operation. Refer to Click Test in this procedure.

Start the engine and check for fuel leaks or active fault codes.

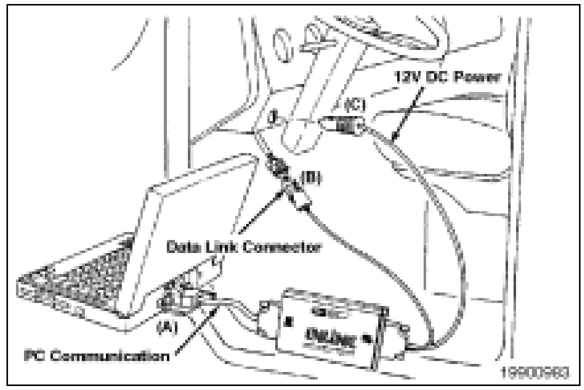
Recheck for fuel leaks or active fault codes.

Pumping Control Valve Tests

Prepare

Click Test

Use INSITE™, with the keyswitch in the ON position, to run the control valve click test.

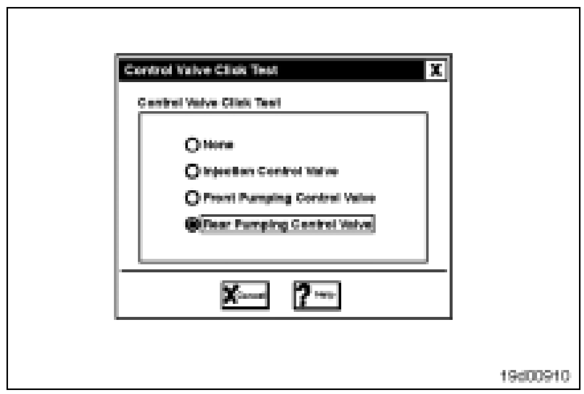


Select the Pumping Control Valve to be tested to initiate the test. Select either front control valve or rear control valve.

A “click” will be heard until the other pumping control valve is selected, or None is selected on the Control Valve Click Test screen.

If no “click” is heard, troubleshoot any active fault codes.

NOTE: The click test will need to be performed after any repairs are made to clear the fault codes.

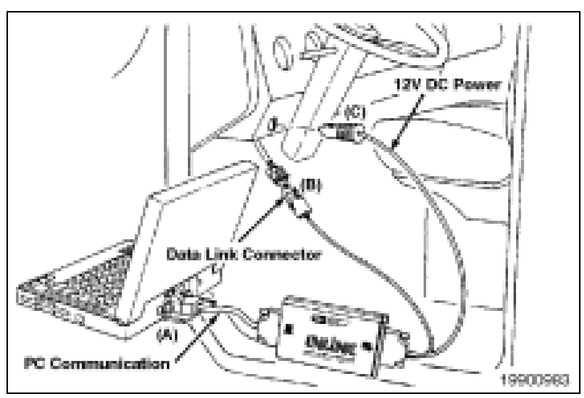


Cutout Test

The plunger cutout test can be used to check performance of the front and rear pumping plungers.

NOTE: When performing this test, the engine load must be the same when each pumping plunger is cut out.

Use INSITE™, with the engine running at idle, to perform this test.



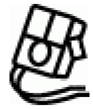
Select the pumping control valve to be cut out.

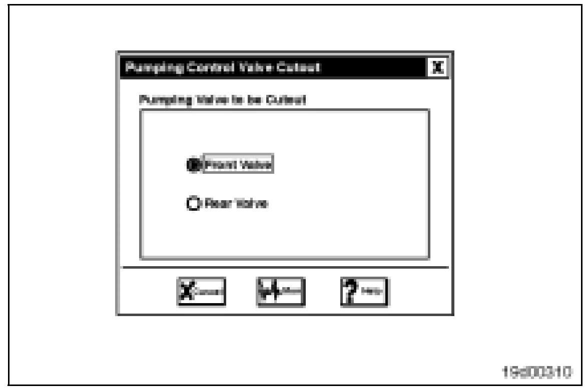
Select the monitor button and monitor valve close angle, engine speed, and accumulator pressure while the selected plunger is cut out.

Record valve close angle, engine speed, and accumulator pressure after the engine stabilizes.

After testing with one pumping control valve disabled, select “None” so that the engine will run with both valves enabled. Switching directly from “Front” to “Rear” or “Rear” to “Front” will cause the engine to misfire or hesitate.

Cut out the other pumping control valve, and record valve close angle, engine speed, and accumulator pressure after the engine stabilizes.





Compare the results when the rear pumping control valve is cut out, against the results when the front pumping control valve is cut out.

If the engine dies when one of the pumping control valves is cut out, replace the accumulator. Refer to procedure 005-085.

NOTE: The valve close angle must not vary more than 15 degrees crank angle.

If the valve close angle varies more than 15 degrees between the front and rear valves then replace the accumulator module. Refer to Procedure 005-085.

NOTE: Troubleshoot any active fault codes before replacing the pump.

Follow-Up

Rate Shape Snubber Removal/Installation

Prepare

WARNING

When using solvents, acids, or alkaline materials for cleaning, follow the manufacturer's recommendations for use. Wear goggles and protective clothing to reduce the possibility of personal injury.

WARNING

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

WARNING

Wear appropriate eye and face protection when using compressed air. Flying debris and dirt can cause personal injury.

Thoroughly steam-clean the rate shape tube and fuel pump area.

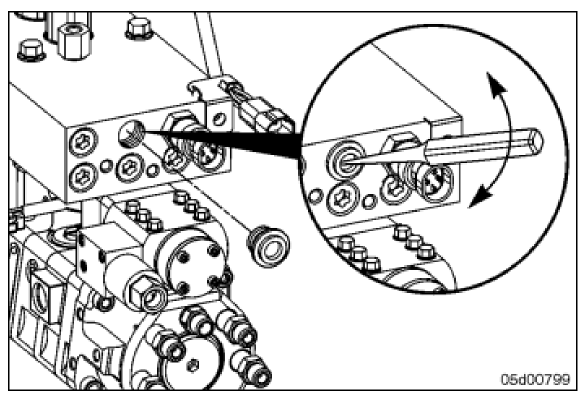
Dry with compressed air.

Remove the rate shape tube assembly. Refer to Procedure 005-090.

Remove

Remove the rate shape snubber assembly.

Use a center punch to pry the seal disc from the accumulator.



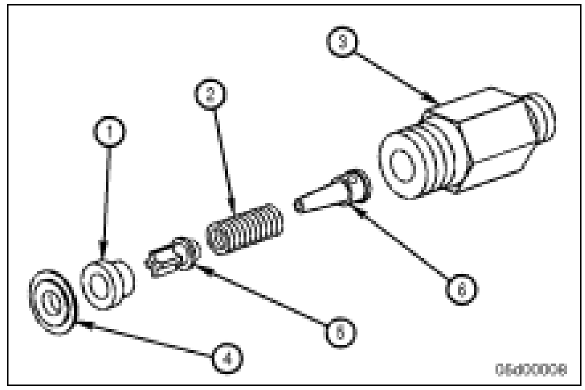
Inspect for Reuse

The parts in the assembly are as shown:

1. Snubber valve seat
2. Spring
3. Rate shape snubber body
4. Seal disc
5. Snubber valve
6. Spring post.

Replace the snubber assembly if the snubber spring is broken.

Do not reuse snubber seal discs.

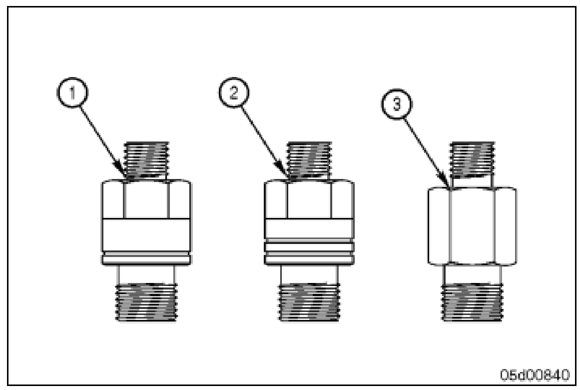


Early design snubber valves are not reusable.

Part Number 3800351, first snubber valve assembly released for CAPS (one groove, not reusable)

Part Number 3800764, second snubber valve assembly released for CAPS (two grooves, not reusable)

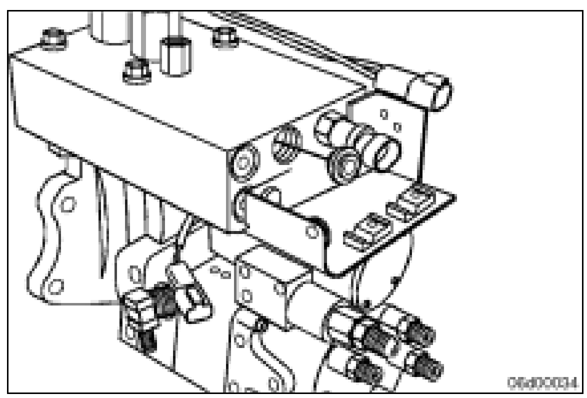
Part Number 4010544, current snubber valve assembly released for CAPS (no grooves, may be reused); always replace the seal disk.



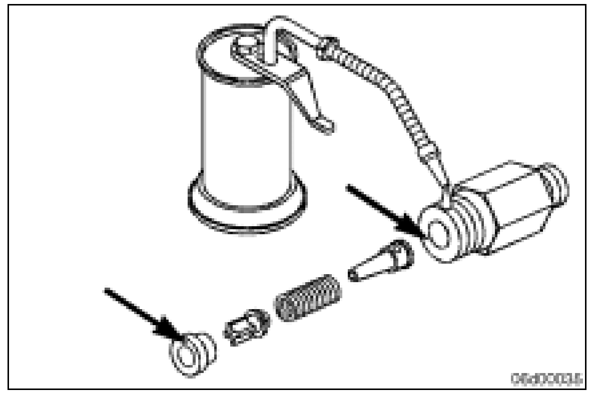
Install

Clean the bore for the distributor outlet fitting with QD cleaner prior to installation of the new snubber assembly.

Install a new seal disc into the accumulator.



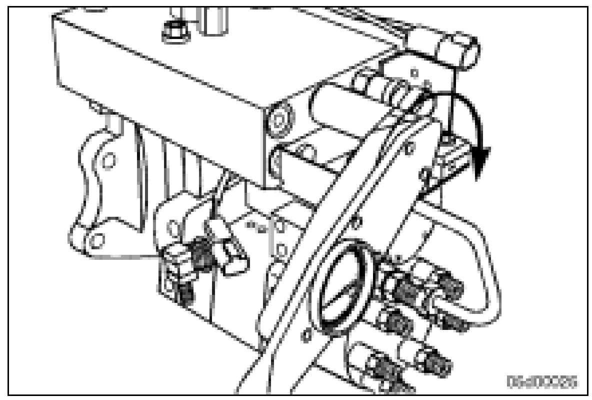
Apply lubricating oil to the face of the snubber seat and to the face and threads of the snubber fitting.



Install the snubber assembly.

Torque Value: 14 N•m [124 in-lb]

Rotate 80 degrees



Follow-Up

Install the rate shape tube assembly. Refer to Procedure 005-090.

Operate the engine and check for leaks.

Fuel Pump Distributor Inlet Fitting

Prepare

WARNING

When using a steam cleaner, wear safety glasses or a face shield, as well as protective clothing. Hot steam can cause serious personal injury.

WARNING

Wear appropriate eye and face protection when using compressed air. Flying debris and dirt can cause personal injury.

Thoroughly steam-clean the distributor outlet fitting and fuel pump area.

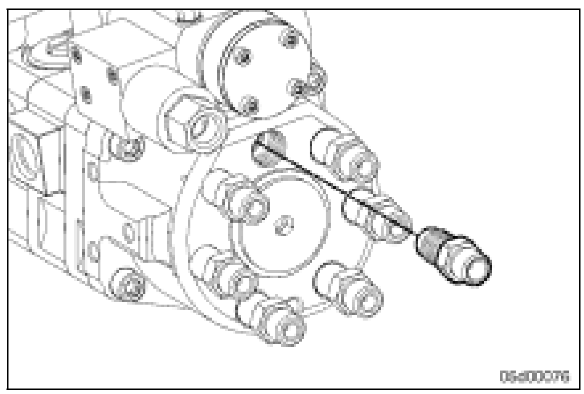
Dry with compressed air.

Remove the rate shape tube assembly. Refer to Procedure 005-090.

Remove

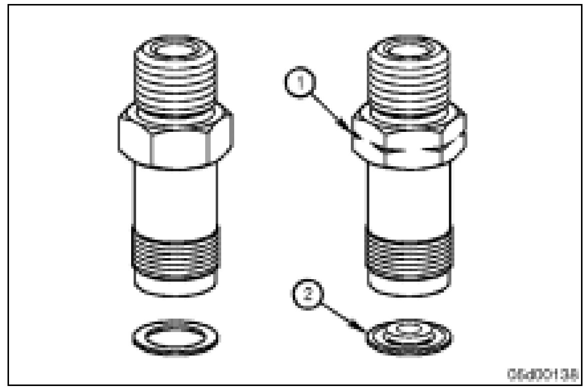
Remove the distributor inlet fitting and the seal disc.

NOTE: A tool like the one shown in this procedure can be made from a 1/8-inch or 3/16-inch Allen wrench. Use it to remove the seal disc.



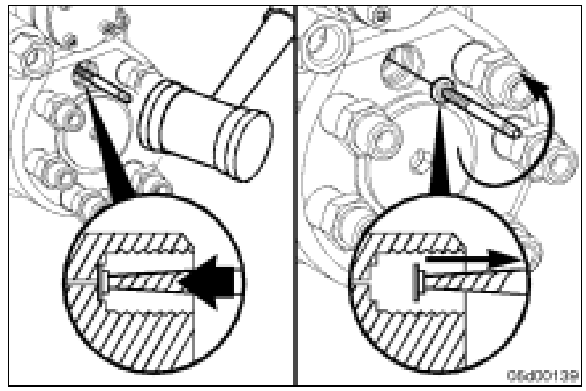
Two (2) types of inlet fittings and sealing washers may be in use. A flat washer will be installed in most new pumps and a piloted washer will be installed in some ReCon® pumps. The piloted washer is provided in service kits to aid installation.

Different removal techniques are necessary based on the type of sealing washer being removed.



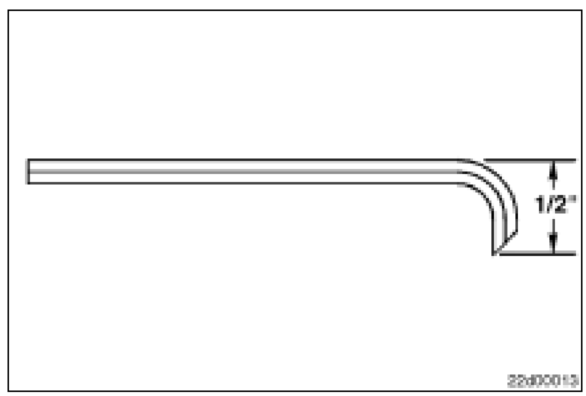
Removal of “piloted seal washer”

Using a plastic hammer, tap a spiral easy out into the center hole of the sealing washer. Turn the easy out counterclockwise to dislodge the washer.



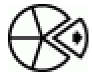
Removal of a “flat washer”

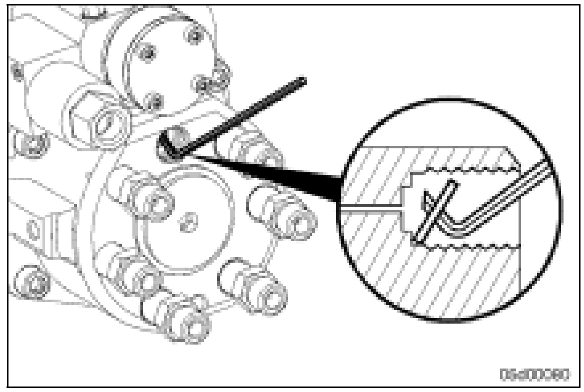
The flat sealing washer is swaged into the inlet fitting bore during installation. A special tool can be made to aid in its removal by grinding the short leg of a 1/8-inch or 3/16-inch Allen wrench so that the wrench is no longer than 13-mm [1/2-in] long (measured from the outside of the long leg). This tool acts as a mini heal bar to pry out the sealing washer without damaging the back of the hole.



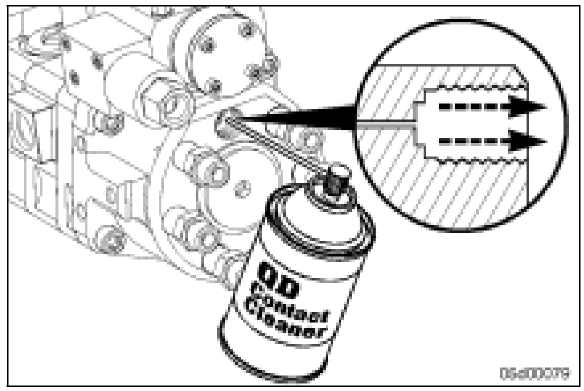
Pry out the old sealing washer using the modified Allen wrench.

Quite a bit of force is required to remove the sealing washer.





Clean and Inspect for Reuse

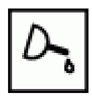


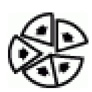
CAUTION

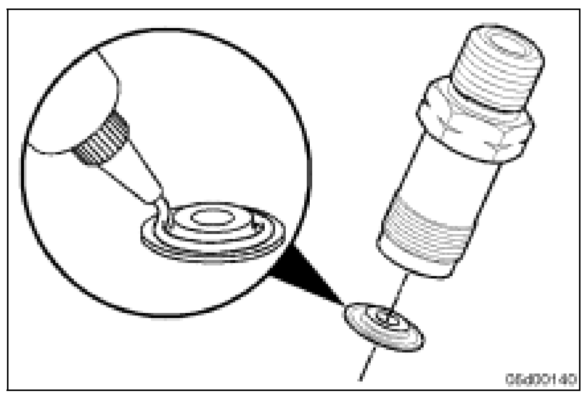
Any debris left in this fitting during assembly will run through the fuel pump. Damage the to fuel pump can occur.

Using QD contact cleaner, Part Number 3824510, clean the inlet fitting bore from the bottom of the bore outward.

Install







CAUTION

Any dirt trapped in this fitting during assembly will run through the fuel pump. Damage to the fuel pump can occur.

Use clean grease to retain the sealing washer to the inlet fitting while it is being installed into the bore. Use Lubriplate™ 105, or equivalent.

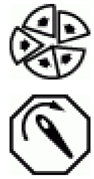
Install sealing washer into counterbore in the inlet fitting.

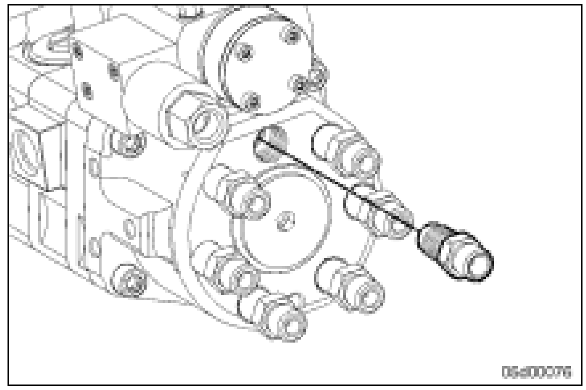
Install a new inlet fitting.

Tighten the fitting after sealing washer is seated correctly.

Torque Value: 5.7 N•m [50 in-lb]

Rotate 120 degrees clockwise





Follow-Up

Install the rate shape tube assembly. Refer to Procedure 005-090.

Start the engine and check for fuel leaks at the rate shape tube connections.

Road-test the vehicle. Recheck for fuel leaks or active fault codes.

Fuel Pump Accumulator Module

Prepare

WARNING

When using a steam cleaner, wear safety glasses or a face shield, as well as protective clothing. Hot steam can cause serious personal injury.

WARNING

Wear appropriate eye and face protection when using compressed air. Flying debris and dirt can cause personal injury.

CAUTION

Make sure that steam does not spray directly on the electrical connections on the top of the accumulator block, or fault codes will possibly occur.

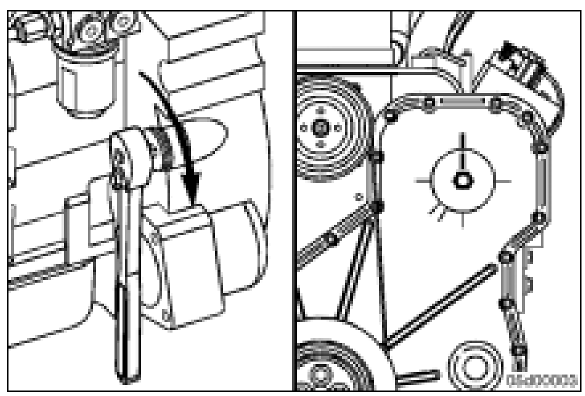
Thoroughly steam-clean the entire fuel pump.

Dry the fuel pump with compressed air.

Remove

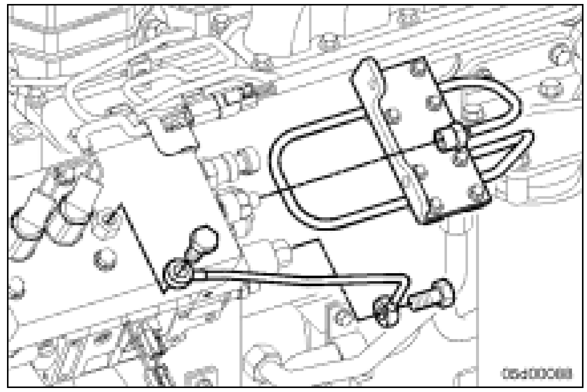
Remove the fuel pump drive gear cover.

Locate top dead center for cylinder number 1 by barring the engine slowly until the line on the pump gear lines up with the line on the gear cover.

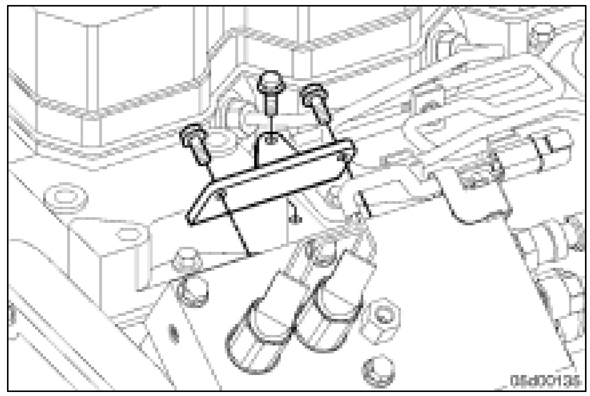


Remove the rate shape tube assembly. Refer to Procedure 005-090.

Remove the air bleed line. Refer to Procedure 006-056.



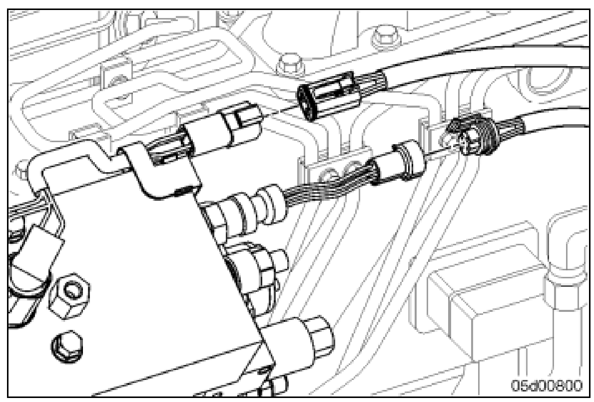
Remove the fuel pump upper support bracket.



Disconnect the 4-pin Deutsch connector for the pumping control valves.

Disconnect the pressure and temperature sensors.

NOTE: The pressure sensor connector has a potted pigtail connector. This sensor can only be disconnected at the engine harness end of the pigtail harness.



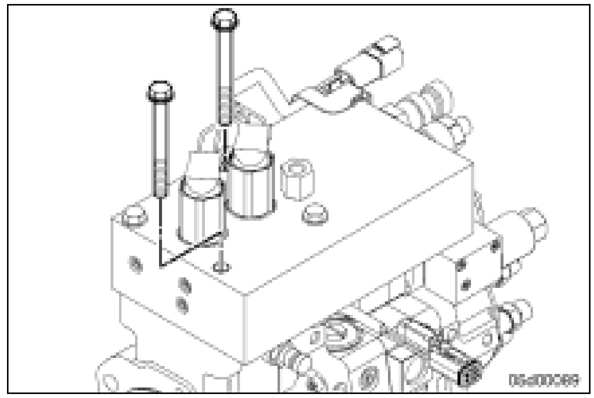
WARNING

The accumulator module weighs 11 kg [25 lb] and is free to move once the capscrews are removed. Do not drop; personal injury can occur.

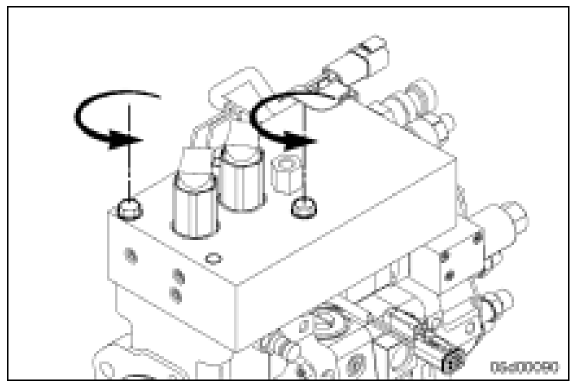
CAUTION

Do not use air tools. The use of air tools will possibly damage the fuel pump.

Remove two of the four capscrews that are located diagonally from one another.



Remove the last two capscrews. Alternately loosen the capscrew to avoid binding. Loosen each capscrew about one turn at a time.

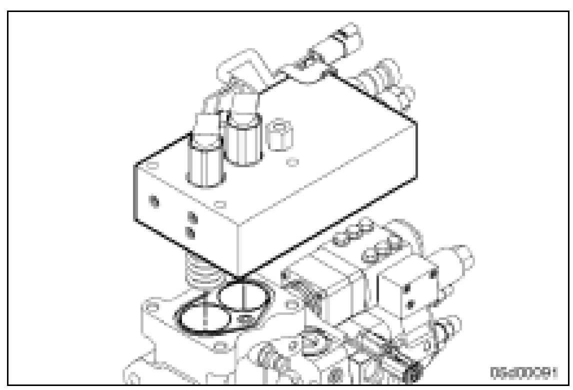


WARNING

The accumulator module weighs 11 kg [25 lb] and is free to move once the capscrews are removed. Do not drop; personal injury can occur.

Remove the accumulator module.

Use as much care as possible to avoid dislodging the springs from the bottom of the accumulator.



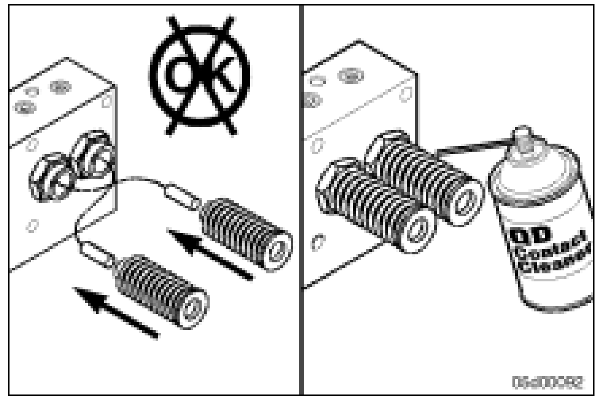
If the springs are dislodged, the ceramic plungers can fall out. The plungers are matched to each bore.

Reseat the springs fully onto plunger barrels.

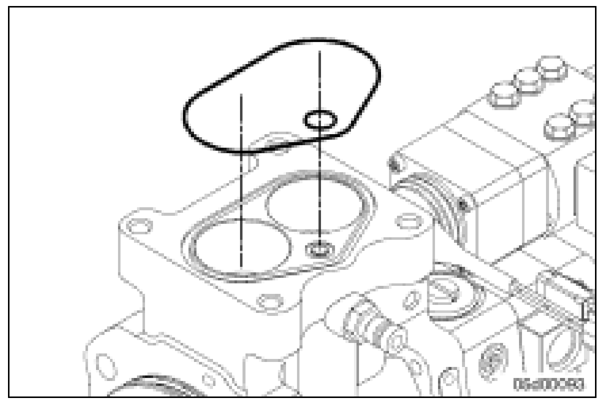
Do not interchange the plungers.

NOTE: Before replacing a ceramic plunger, special care needs to be taken to clean it.

Use QD contact cleaner, Part Number 3824510, to clean the plunger.



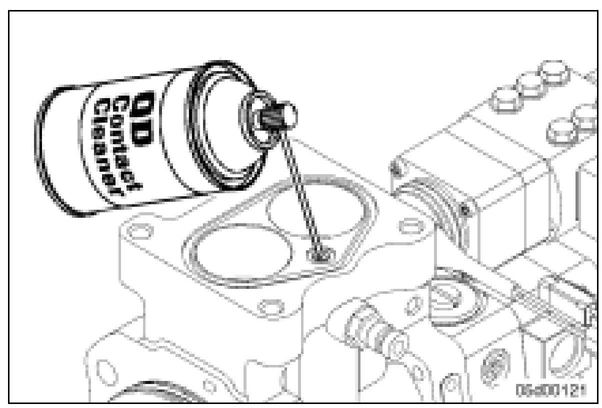
Remove the oil seal ring and fuel passage o-rings.



Clean and Inspect for Reuse

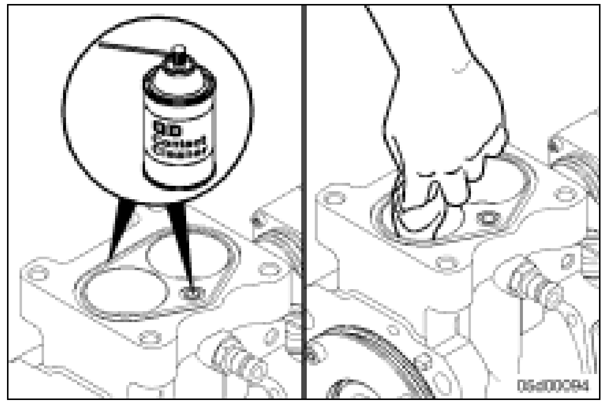
Clean the small fuel passage using the plastic tube provided with the contact cleaner.

Use QD contact cleaner, Part Number 3824510.



Clean the o-ring groove and mounting surface on the cam housing and the accumulator.

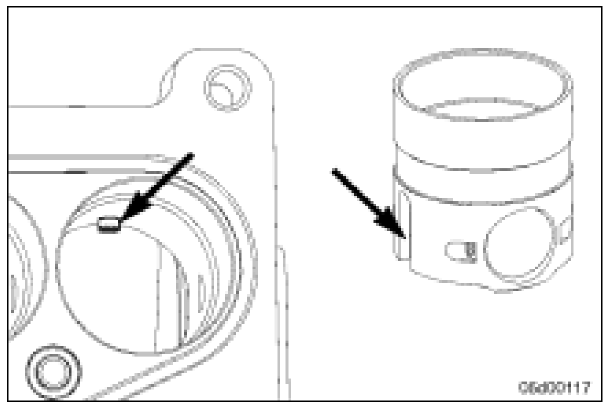
Make sure the top of the tappets in the cam housing are clean. Wipe out debris with a clean towel.



Check the tappets for proper alignment.

The tappets have a slot on the side that engages a pin on the engine side of the cam housing. The pin keeps the roller aligned with the camshaft. Make sure the tappet assembly is properly aligned. Make sure the tappet guide pins and guide pin grooves are not worn excessively.

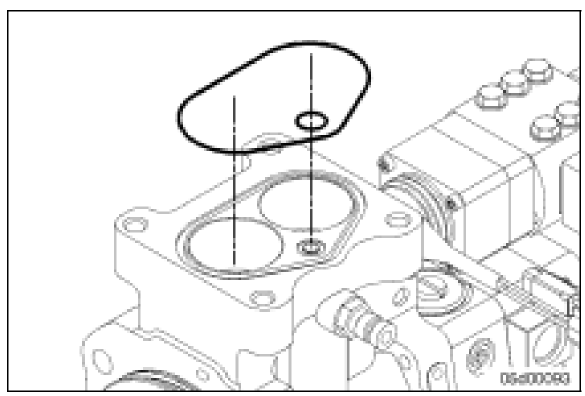
With the tappets removed, the tappet rollers and camshaft can be inspected. Linear scratches on the cam and rollers is expected; pitting on the nose of the camshaft is not.



Install

Install a new oil ring seal and fuel passage o-ring.

Apply Lubriplate™ 105, or equivalent, to the o-ring grooves to hold the o-rings in place.

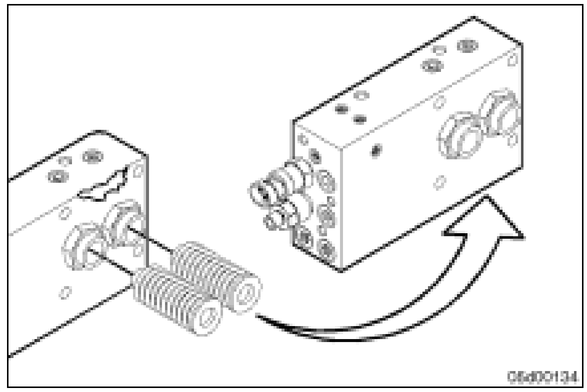


CAUTION

The ceramic plungers can fall out when removing the plastic caps or old springs. Do not interchange the plungers. If they fall out, use QD contact cleaner, Part Number 3824510, to clean the plungers thoroughly before replacing them.

If replacing the accumulator module with a new one, remove the springs from the old accumulator module.

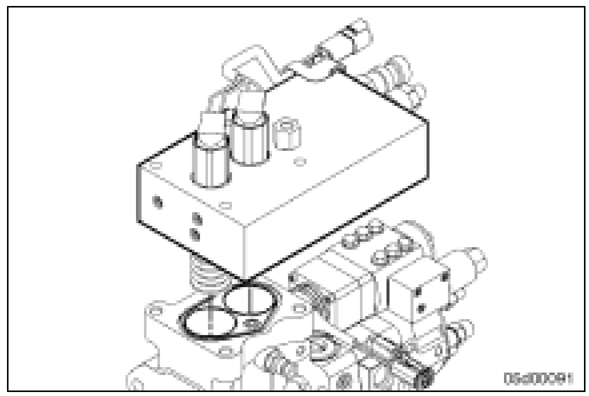
Fully install the springs on the plunger barrels of the new accumulator module.



NOTE: The use of two 10-mm x 80-mm studs will aid in the installation.

Install the accumulator module.

NOTE: Use care to avoid dislodging the springs on the accumulator and the o-rings on the cam housing.



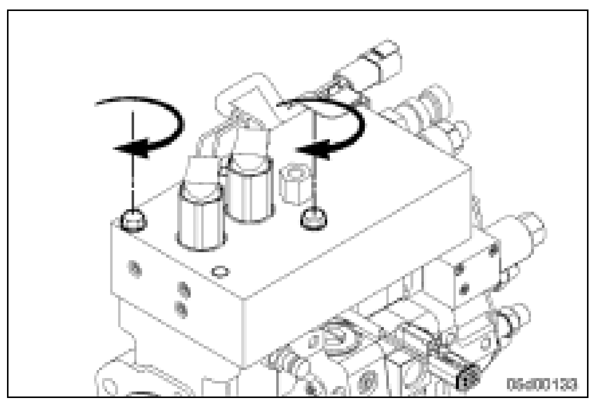
CAUTION

Do not use air tools. The use of air tools will possibly damage the fuel pump.

Install two of the four capscrews.

Draw the accumulator module down evenly. Only turn each capscrew about one turn at a time.

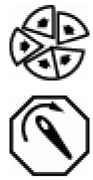
Make sure the o-rings are still in their grooves before the accumulator is fully tightened to the cam housing. Use a mirror if necessary.

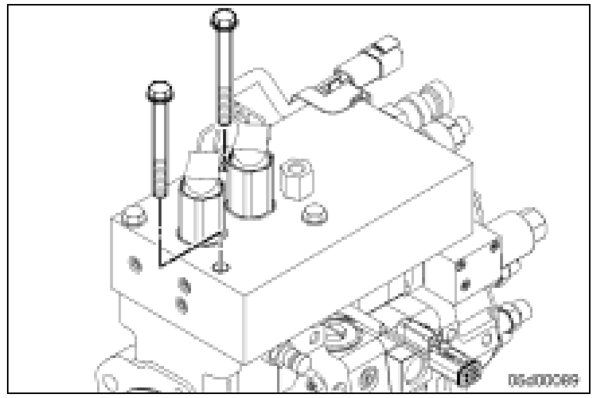


Install remaining two capscrews.

Tighten the four capscrews.

Torque Value: 68 N•m [50 ft-lb]

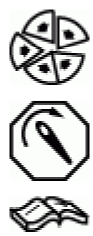


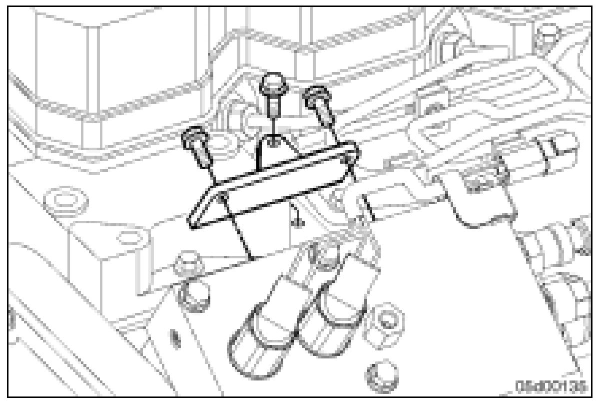


Install the upper support bracket.

Tighten the capscrews.

Torque Value: 44 N•m [32 ft-lb]





Follow-Up

Finishing Steps

Install rate shape tube assembly. Refer to Procedure 005-090.

Install the air bleed line. Refer to Procedure 006-056.

Install the drive gear cover.

Connect the fuel pressure sensor and the fuel temperature sensors to the engine harness.

Connect the pumping control valve connector to the engine harness.

Start the engine and check for fuel leaks or active fault codes.

Road-test the vehicle.

Recheck for fuel leaks or active fault codes.

Fuel Pump Distributor and Injection Control Valve Module

Prepare

WARNING

When using a steam cleaner, wear safety glasses or a face shield, as well as protective clothing. Hot steam can cause personal injury.

WARNING

Wear appropriate eye and face protection when using compressed air. Flying debris and dirt can cause personal injury.

CAUTION

Fault codes can occur if steam sprays directly on the electrical connections on top of the accumulator block.

Thoroughly steam-clean the entire fuel pump.

Dry the fuel pump with compressed air.

Remove the air bleed line. Refer to Procedure 006-056.

Remove the fuel pump from the engine, if necessary. Refer to Procedure 005-016.

Mount the fuel pump in the vise ring. Orient the pump with the distributor facing upward to aid in disassembly.

Remove the rate shape tube assembly. Refer to Procedure 005-090.

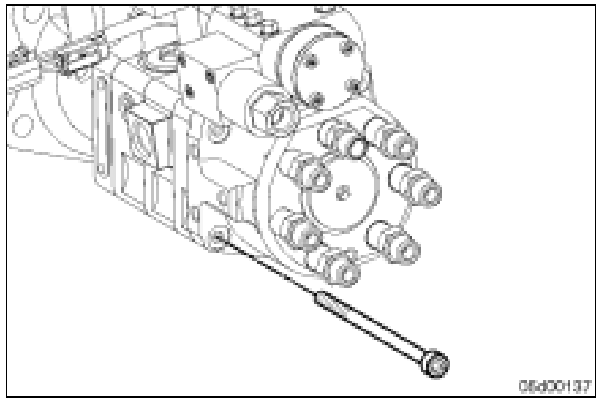
Remove

CAUTION

The capscrews also fasten the gear pump module. The gear pump is free to move after the capscrews are removed.

Loosen but do not remove the distributor plug.

Remove the four mounting capscrews on the distributor.

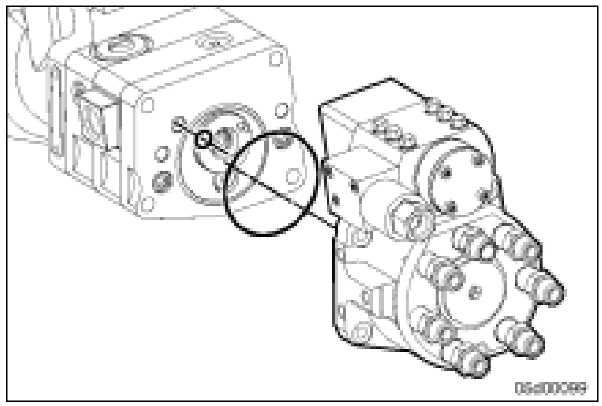


Remove the injection control valve/distributor module.

Remove the drive coupling.

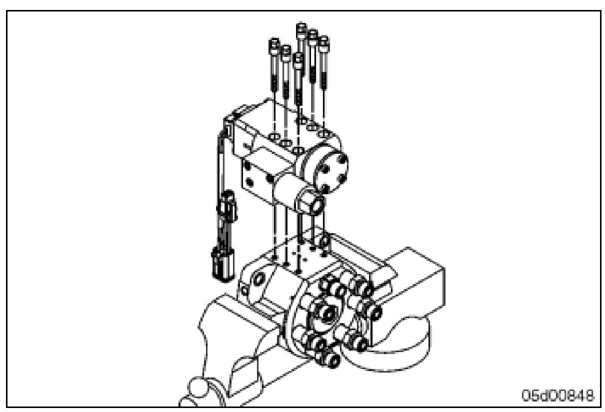
Discard the two o-rings.

Place the injection control valve/distributor module on a clean bench vise.



Remove the injection control valve from the distributor module and install the injection control valve on the new distributor module. Refer to Procedure 005-078.

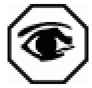
NOTE: Injection control valves built before January 2001 are not reusable. If removing an injection control valve built before January 2001, use the appropriate injection control valve kit to complete the repair.

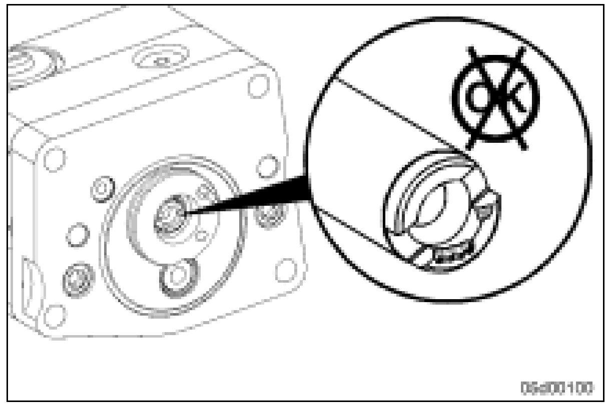


Clean and Inspect for Reuse

Inspect coupling and gear pump shaft ends for excessive wear. Wear may be found on the inside corners of the coupling groove; such wear is not common.

A polished surface is acceptable.

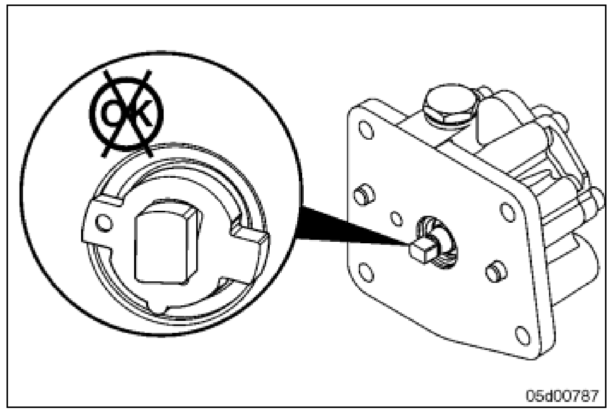




Replace the gear pump module if wear is visible.

Replace the gear pump module if the gear pump driveshaft is damaged.

NOTE: A distributor rotor seizure can cause damage to the gear pump. If rotor seizure is suspected, inspect the gear pump. Refer to Procedure 005-089.

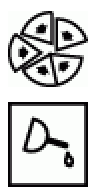


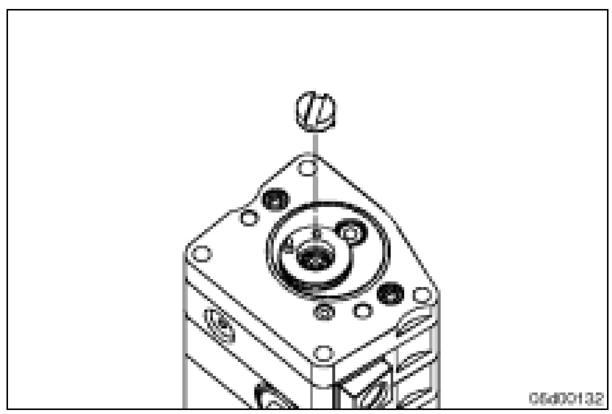
Install

Install the drive coupling.

Center the coupling on the gear pump shaft.

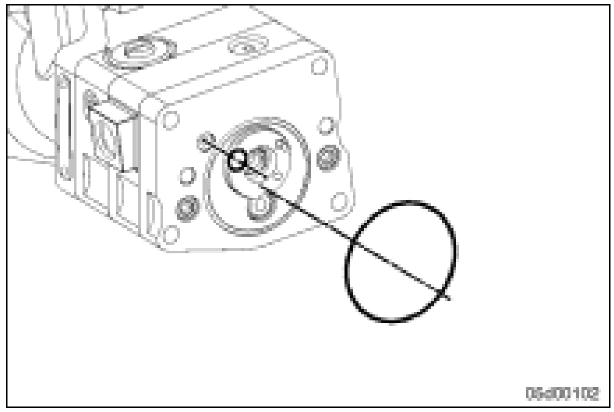
Apply Lubriplate™ 105, or equivalent, to the coupling to keep it from sliding in the shaft groove during assembly.





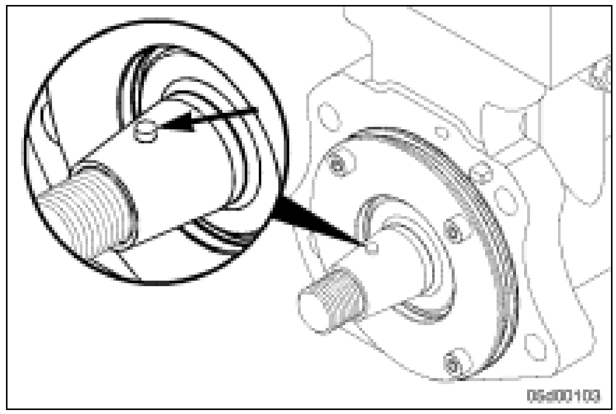
Install new o-rings.

Apply Lubriplate™ 105, or equivalent, to the o-rings to keep them from falling out during assembly.



The dowel pin must be facing up toward the top of the pump.

If the shaft needs to be rotated, install the fuel pump drive nut onto the shaft to provide a means for rotating the shaft.



CAUTION

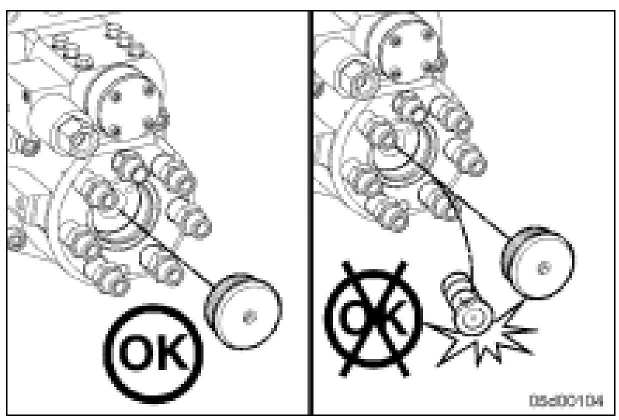
The rotor can slide out once the distributor plug is removed.

CAUTION

Do not drop the rotor. Damaging the rotor will necessitate replacement of the entire distributor module.

Remove the large plug from the end of the distributor.

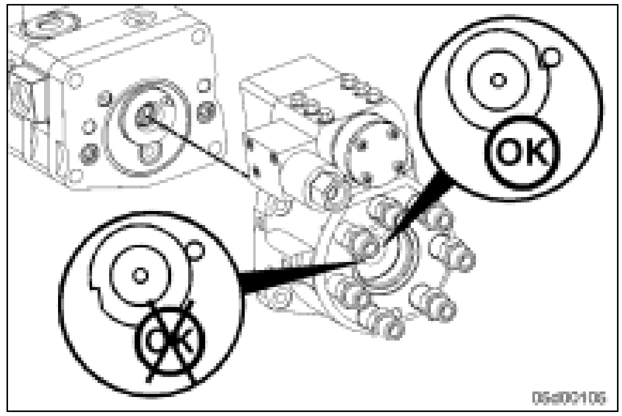
Do not remove the rotor.



Install the distributor module.

Lightly rotate the rotor with finger pressure until it drops into the slot in the drive coupling.

When properly engaged, the notch in the rotor will align with the hole in the distributor (when the engine is at top dead center for number 1 cylinder).

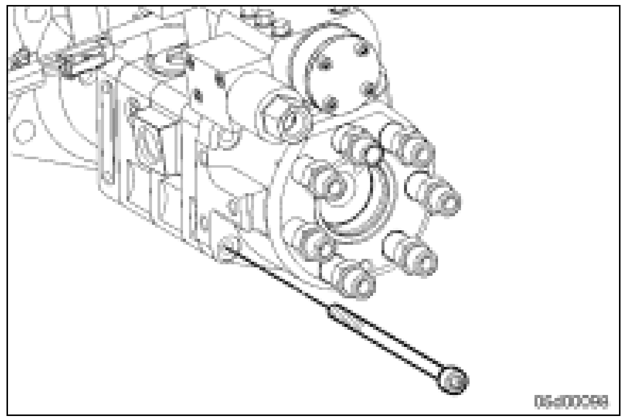


Do not pinch the o-rings.

Install the four distributor capscrews.

Tighten the capscrews.

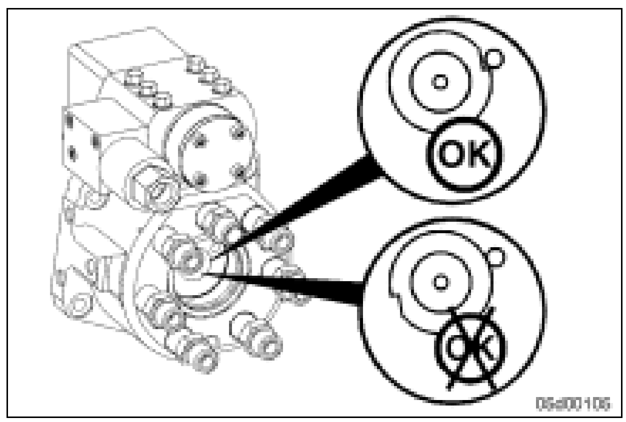
Torque Value: 48 N•m [35 ft-lb]



CAUTION

The rotor must be properly timed to the fuel pump camshaft. Improper assembly will cause the rotor to be 180 degrees out of time.

If not properly timed, reinstall the drive coupling and rotor. Refer to Procedure 005-072.

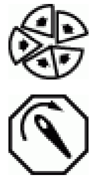


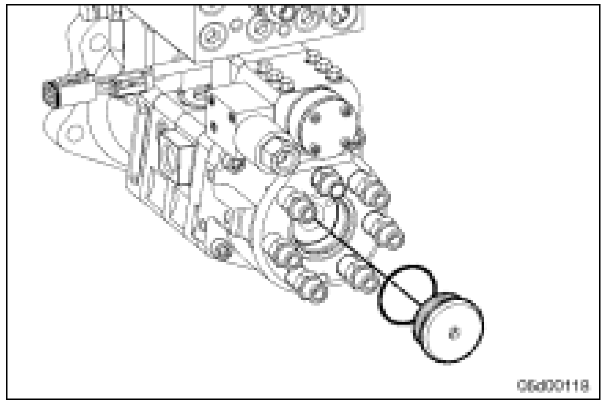
Install a new o-ring on the distributor plug.

Install the large plug at the end of the distributor.

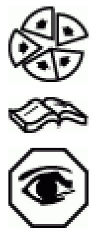
Tighten the distributor plug.

Torque Value: 14 N•m [120 in-lb]





Follow-Up



Install the rate shape tube assembly. Refer to Procedure 005-090.

Install the fuel pump on the engine. Refer to Procedure 005-016.

Install the air bleed line. Refer to Procedure 006-056.

Run the injection control valve click test using INSITE™. Refer to Procedure 005-078.

Start the engine and check for fuel leaks or active fault codes.

Road-test the vehicle for at least one mile. Recheck for fuel leaks or active fault codes.

Fuel Pump Cam Housing Module

Prepare

WARNING

When using a steam cleaner, wear safety glasses or a face shield, as well as protective clothing. Hot steam can cause personal injury.

WARNING

Wear appropriate eye and face protection when using compressed air. Flying debris and dirt can cause personal injury.

CAUTION

Make sure that steam does not spray directly on the electrical connections on the top of the accumulator block, or fault codes will possibly occur.

Thoroughly steam-clean the entire fuel pump.

Dry the pump with compressed air.

Bar the engine to TDC.

Remove

CAPS Fuel System

Remove the air bleed line (1). Refer to Procedure 006-056.

Remove the fuel pump from the engine. Refer to Procedure 005-016.

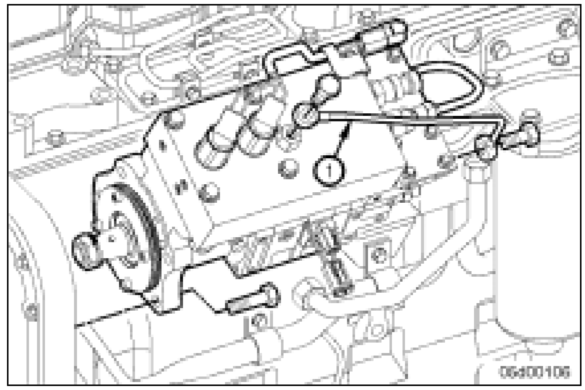
Mount the fuel pump to the mounting plate, Part Number 3162897, and orient the fuel pump with the distributor facing upward to aid in disassembly.

Remove the rate shape tube assembly. Refer to Procedure 005-090.

Remove the accumulator module. Refer to Procedure 005-085.

Remove the distributor module. Refer to Procedure 005-086.

Remove the gear pump module. Refer to Procedure 005-089.

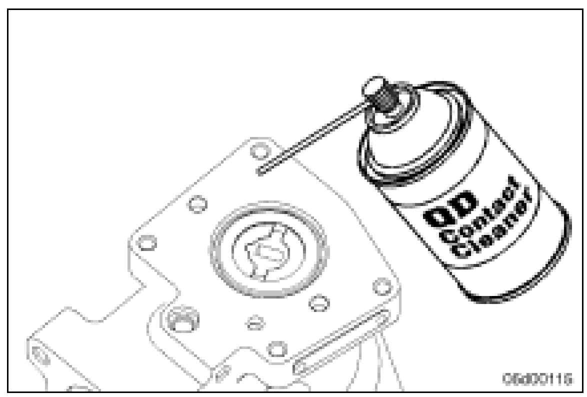


Clean and Inspect for Reuse

Clean the mounting surfaces of the cam housing.

Use QD contact cleaner, Part Number 3824510.

Inspect the camshaft coupling interface for wear. If the camshaft is worn excessively, replace the cam housing module.



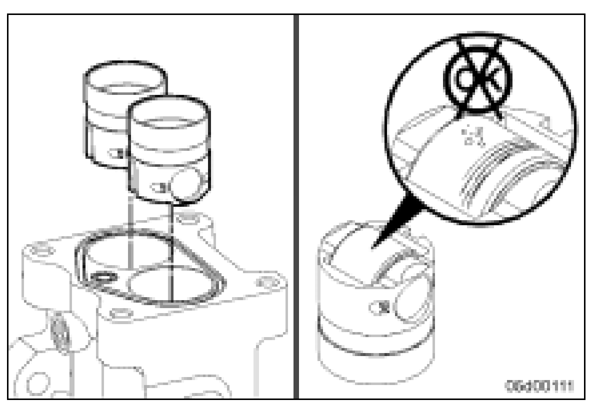
CAUTION

If the tappets are removed, be sure to install them in the same bore they were removed from.

Remove the roller tappets from the cam housing bores.

Inspect the roller surfaces for pitting and wear.

Make sure the roller rotates freely and smoothly.



Replace the cam housing module if the rollers are worn.

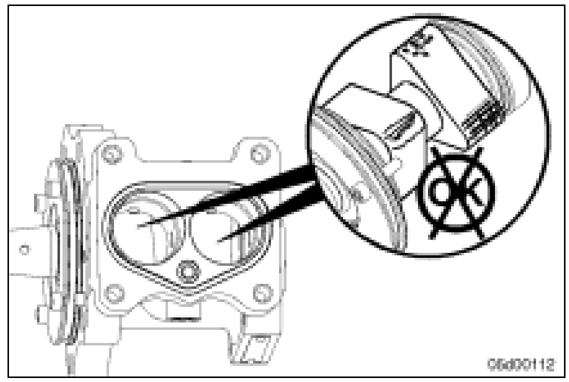
NOTE: It is normal to see lines (scratches) worn in the direction of roller travel. The cam housing or tappets should be replaced if the rollers are pitted.

Examine the tappets guide pin slots. If the guide pin slot is worn more than 25-percent of its original width, the tappet must be replaced.

Inspect the guide pins. If the guide pins are worn or if oil leaks at the cam housing guide pin press fit, the cam housing must be replaced.

Inspect the camshaft lobes for pitting and wear. Replace the cam housing if there is any pitting or wear.

Inspect for raised burrs in the tappet bore. Replace the cam housing if raised burrs are present. Scratching or polishing is normal.

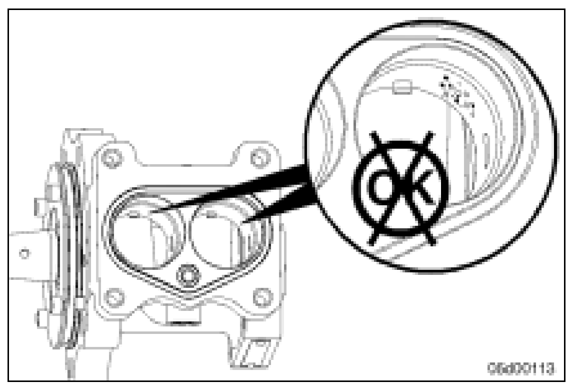


Inspect the tappet bores for scuffing or wear leading into the housing.

Polishing will occur in vertical bands at many places around the inside of the bores.

Polish in the bores is acceptable.

Replace the cam housing if there is severe tappet guide pin wear (more than 25-percent of tappet pin is worn).

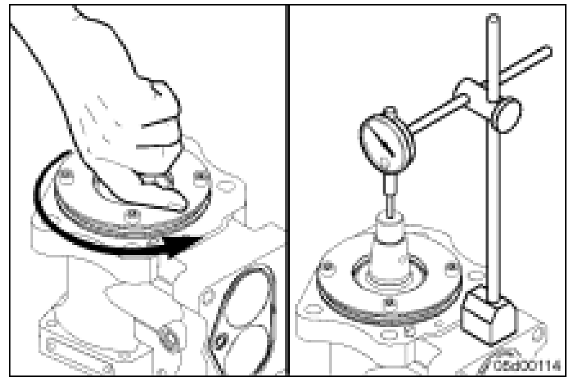


Using fingers, make sure the camshaft turns freely. The bearings must turn smoothly and freely during rotation.

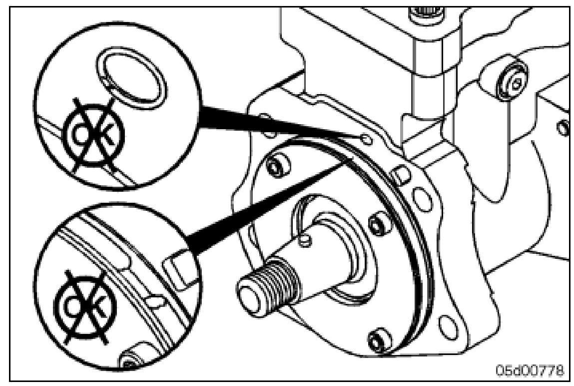
Replace the cam housing if the bearings are tight or rough.

Check the camshaft for end-play.

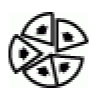
MAX Camshaft End-Play 0.05 mm [0.002 in]



Inspect the oil feed and pump mounting o-ring.

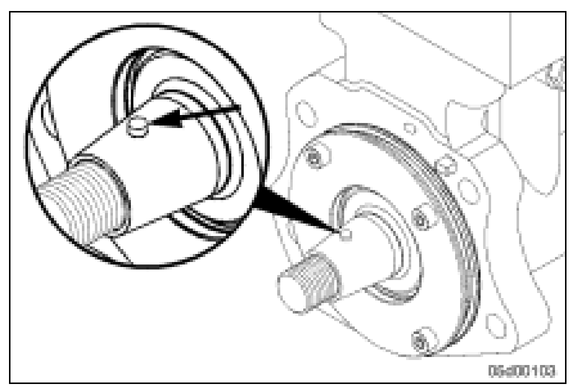


Install



CAPS Fuel System

Make sure the timing dowel pin in the camshaft points toward the top of the fuel pump.

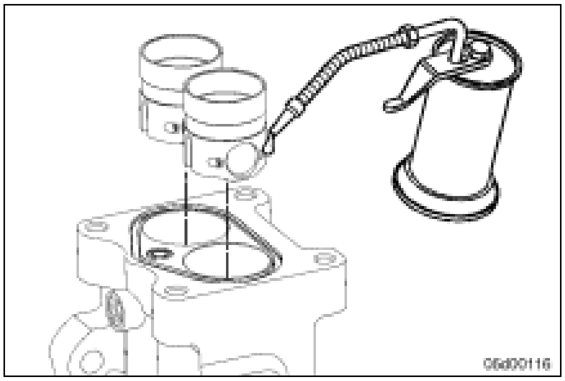


Lubricate the tappets and camshaft lobes with clean 15W-40 engine oil.

Install the roller tappets into the cam housing. Be sure that the tappets guide grooves are oriented correctly onto the tappet guide pins. Also, be sure that the tappet assemblies are installed in their original bores.

Check the tappets for proper alignment.

The tappets have a slot on the side that engages a pin on the engine side of the cam housing. The pin keeps the roller aligned with the camshaft. Make sure the tappet is properly aligned.

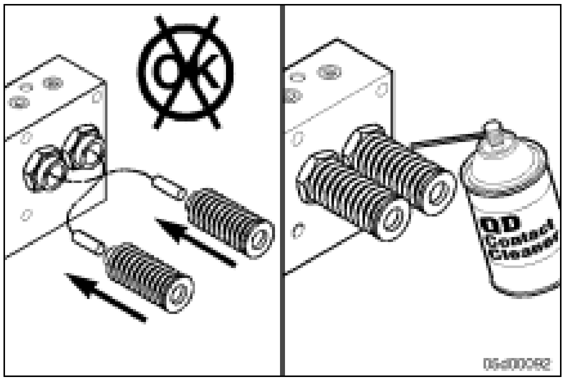


CAUTION

The ceramic plungers will possibly fall out when removing the springs. Do not interchange the plungers or change their upwards orientation. If the plungers are removed, use QD contact cleaner, Part Number 3824510, to clean them before replacing.

NOTE: When assembling the fuel injection pump, take care to keep the ceramic pumping plungers in their original orientation in the accumulator module.

If not already done, install the spring and tappet retainers onto the accumulator or fuel pump barrel assemblies.



Install the gear pump module. Refer to Procedure 005-089.

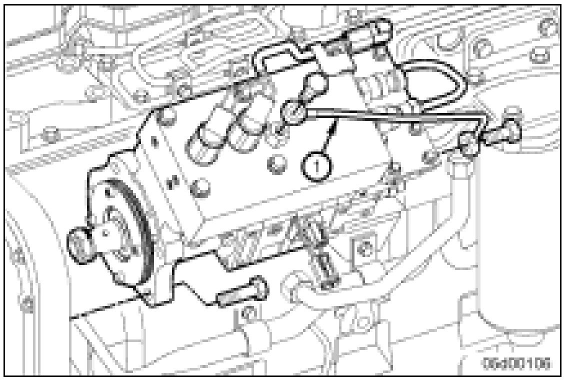
Install the distributor module. Refer to Procedure 005-086.

Install the accumulator module. Refer to Procedure 005-085.

Install the rate shape tube assembly. Refer to Procedure 005-090.

Install the fuel pump onto the engine. Refer to Procedure 005-016.

Install the air bleed line. Refer to Procedure 005-056.



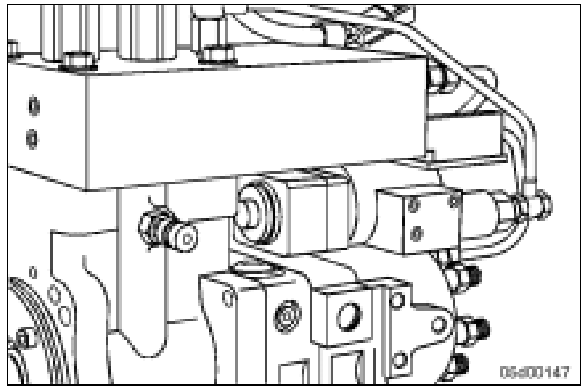
Follow-Up

Start the engine and check for fuel leaks or active fault codes.

Perform repeat throttle snaps to create increased accumulator or fuel rail pressure.

Fuel Pump Gear Pump Module Check

Initial Check



Measure the outlet pressure at the diagnostic fitting on the CAPS pump at a rated flow condition and compare to the following chart.

Engine Speed (rpm)

Gear Pump Pressure kPa [psi]

Engine Speed (rpm)	**Gear Pump Pressure kPa [psi]**
200	14 [2]
700	138 [20]
1300	379 [55]
2200	827 [120]

Fuel Pump Gear Pump Module Removal/Installation

Prepare

WARNING

When using a steam cleaner, wear safety glasses or a face shield, as well as protective clothing. Hot steam can cause serious personal injury.

WARNING

Wear appropriate eye and face protection when using compressed air. Flying debris or dirt can cause personal injury.

CAUTION

Make sure that steam does not spray directly on the electrical connections on the top of the accumulator block, or fault codes will possibly occur.

Thoroughly steam-clean the entire fuel pump.

Dry the fuel pump with compressed air.

Remove the air bleed line. Refer to Procedure 006-056.

Remove the fuel pump from the engine. Refer to Procedure 005-016.

Mount the fuel pump in a vise ring. Orient the pump with the distributor facing upward to aid in disassembly.

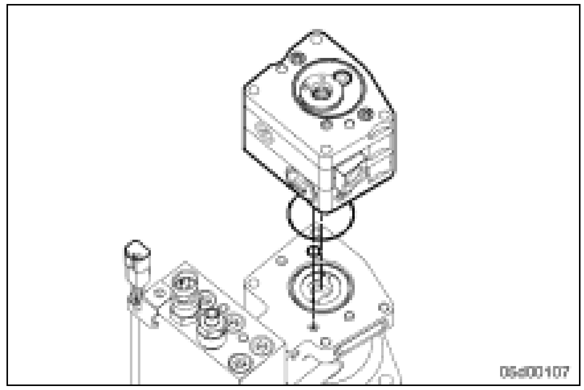
Remove the rate shape tube. Refer to Procedure 005-090.

Remove the distributor module. Refer to Procedure 005-086.

Remove

Remove the gear pump module.

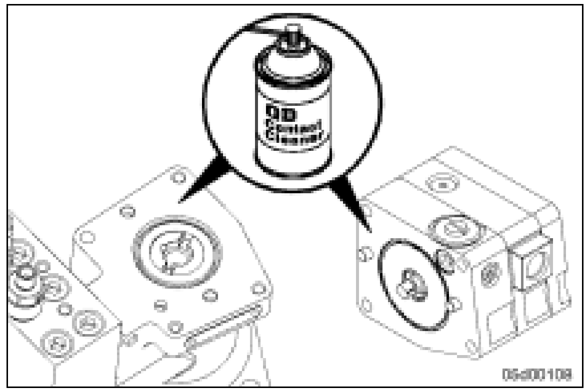
NOTE: Do not remove the two capscrews. The gear pump will slide off the dowel pins once the distributor is removed.



Clean and Inspect for Reuse

Clean the mounting surfaces of the gear pump and cam housing.

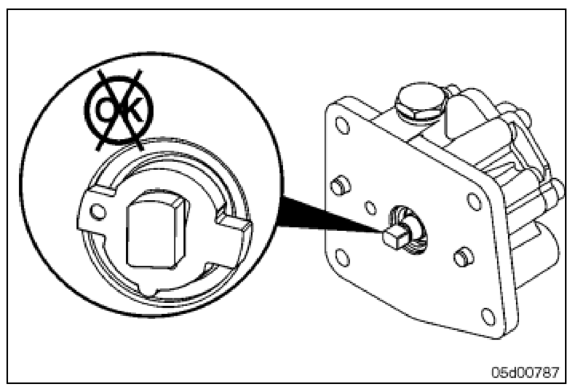
Use QD contact cleaner, Part Number 3824510.



Inspect the drive coupling and shaft ends for excessive wear.

A polished surface is acceptable.

Replace the coupling if wear is visible.



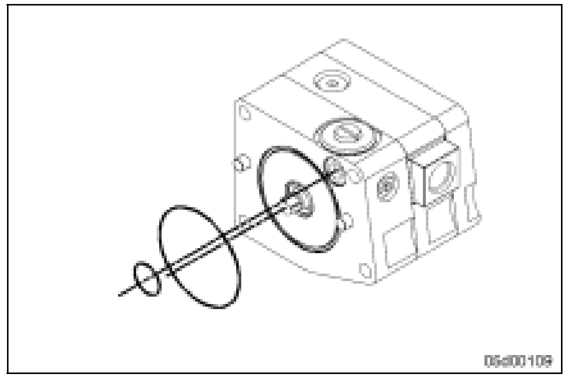
Install

CAUTION

The larger o-rings on either end of the gear pump differ in size. The longer o-ring goes to the side facing the cam housing.

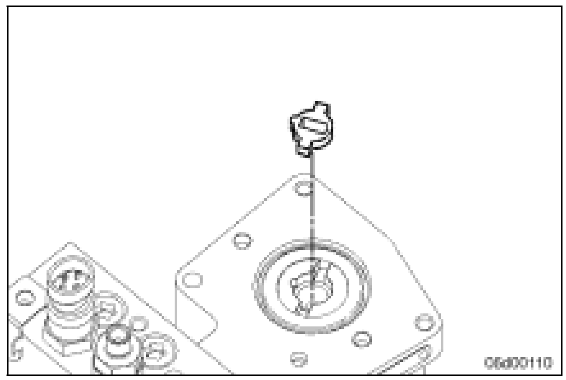
Install new o-rings.

Apply Lubriplate™ 105, or equivalent, to the o-rings to keep them from falling out during assembly.



Install the drive coupling.

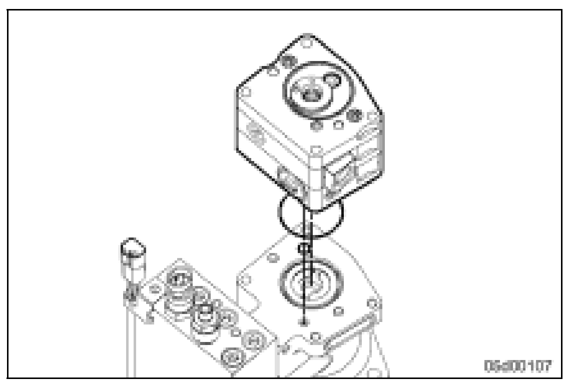
Center the coupling in the shaft.



Align the gear pump shaft with drive the coupling and install the gear pump module.

Make sure the o-rings are not pinched.

Make sure the timing dowel pin is facing toward the top of the fuel pump.



Follow-Up

Install the distributor module. Refer to Procedure 005-086.

Install the rate shape tube. Refer to Procedure 005-090.

Install the fuel pump on the engine. Refer to Procedure 005-016.

Install the air bleed line. Refer to Procedure 006-056.

Start the engine and check for fuel leaks or active fault codes.

Road-test the vehicle for at least one mile. Recheck for fuel leaks or active fault codes.

Fuel Pump Rate Shape Tube

Prepare

WARNING

When using solvents, acids, or alkaline materials for cleaning, follow the manufacturer's recommendations for use. Wear goggles and protective clothing to reduce the possibility of personal injury.

WARNING

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

WARNING

Wear appropriate eye and face protection when using compressed air. Flying debris and dirt can cause personal injury.

CAUTION

Make sure that direct steam spray stream does not contact the electrical connections on the top of the accumulator block; fault codes will possibly occur.

Thoroughly steam-clean the entire fuel pump.

Dry the fuel pump with compressed air.

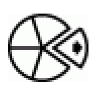
Remove

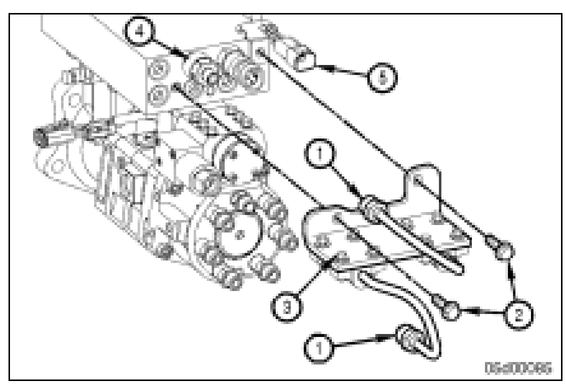
Loosen the two rate shape tube nuts (1).

Remove the two bracket capscrews (2).

Remove the rate shape tube assembly.

Do not loosen or remove the isolator capscrews (3).





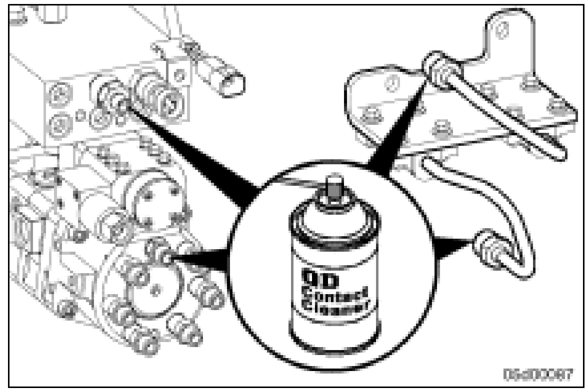
Clean and Inspect for Reuse

Clean the ends of the rate shape tube.

Clean out the rate shape tube with contact cleaner if debris is suspected of entering the tube.

Flush any dirt from the snubber fitting and distributor inlet fitting.

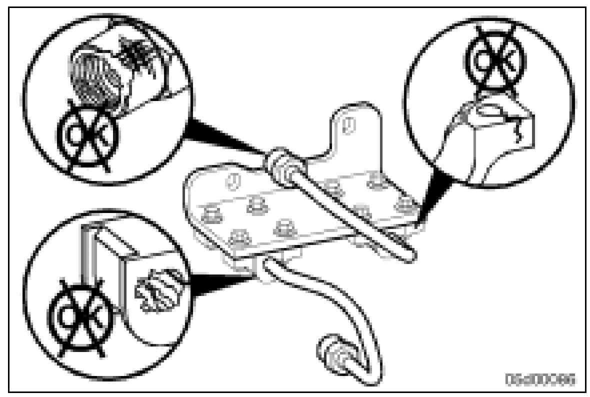
Use QD contact cleaner, Part Number 3824510.



Inspect isolators for signs of wear or cracks.

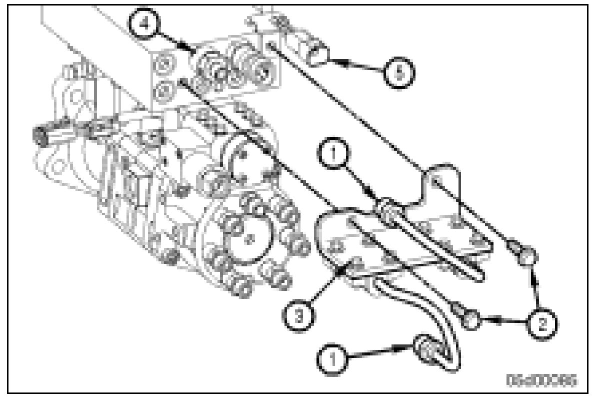
Replace the rate shape tube assembly if any isolator is worn, cracked, or missing.

Inspect the ends of the rate shape tube for damage.



Install

Install the rate shape tube assembly using the following steps:



Install the tube nuts (1) and capscrews (2) finger tight

Tighten the rate shape tube nuts (1)

Torque Value: 46 N•m [34 ft-lb]

Tighten the two bracket capscrews (2).

Capscrew 41 N•m [30 ft-lb]

Thermistor Adapter 34 N•m [25 ft-lb]

NOTE: If any force is required to flex the rate shape tube in order to start the tube nuts, the rate shape tube must be replaced with a new tube.

NOTE: Make sure the harness clip is installed between the bracket and capscrew, not between the bracket and accumulator.

Follow-Up

Start the engine and check for fuel leaks at the rate shape tube connections.

Fuel Pump Head Outlet Fitting

Prepare

WARNING

Wear appropriate eye and face protection when using compressed air. Flying debris or dirt can cause personal injury.

Thoroughly clean the entire fuel pump.

Dry the fuel pump with compressed air.

Remove the high-pressure fuel line from the fuel pump actuator housing. Refer to Procedure 006-051.

Remove the fuel drain line from the actuator housing. Refer to Procedure 006-013.

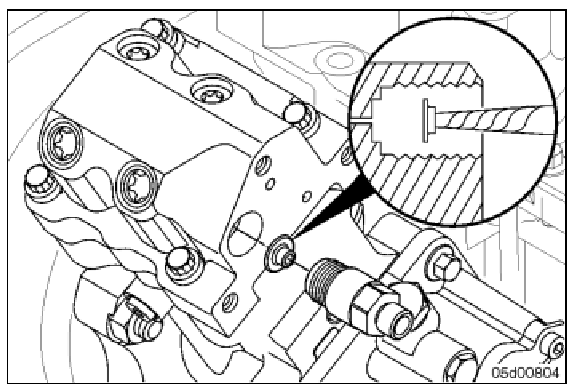
Remove the fuel supply line from the fuel pump actuator housing. Refer to Procedure 006-024.

Remove the fuel pump actuator housing from the high-pressure fuel pump. Refer to Procedure 005-228.

Remove

Remove the fuel pump head outlet fitting and the seal washer from the threaded hole in the back of the high-pressure pump head.

NOTE: It is necessary to remove the seal washer with the aid of a tapered punch. Insert a tapered punch into the center of the seal washer and work the seal out from the bore in the back of the high-pressure pump head.



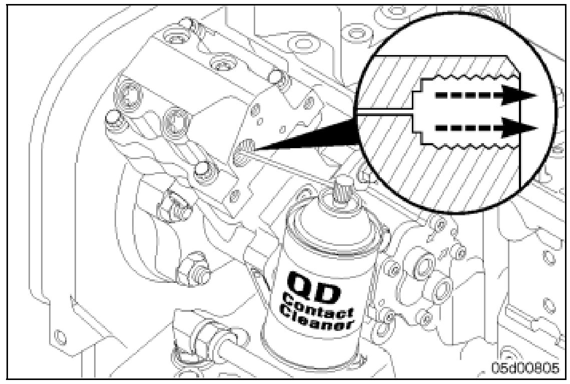
Clean and Inspect for Reuse

Clean the threaded hole in the high-pressure pump head with QD contact cleaner, Part Number 3824510.

Inspect the threads and cavity in the high-pressure pump head for burrs or debris.

Inspect the seal washer end of the outlet fitting. There should be a polished crown that is free of nicks or inclusions. If the crown is damaged or severely flattened, the male union must be replaced.

Clean any burrs with a wire brush then flush the bore clean.



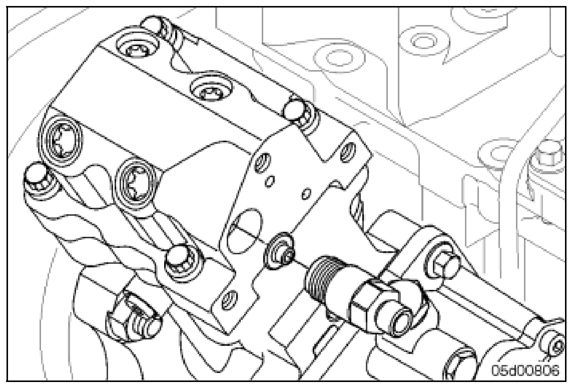
Install

NOTE: This joint is designed to seal in excess of 179,264 kPa [26,000 psi]. Seal washers must not be reused.

Install a new seal washer onto the outlet fitting. The seal washer should pilot into the outlet fitting. A small amount of very clean grease, such as Lubriplate™, will help in keeping the seal attached to the outlet fitting during installation.

Torque Value: 5.6 N•m [50 in-lb]

Rotate 120 degrees



Follow-Up

Install the fuel pump actuator housing to the high-pressure fuel pump. Refer to Procedure 005-228.

Install the high-pressure fuel line to the fuel pump actuator housing. Refer to Procedure 006-051.

Install the fuel drain line to the actuator housing. Refer to Procedure 006-013.

Install the fuel supply line to the fuel pump actuator housing. Refer to Procedure 006-024.

Operate the engine and check for leaks.

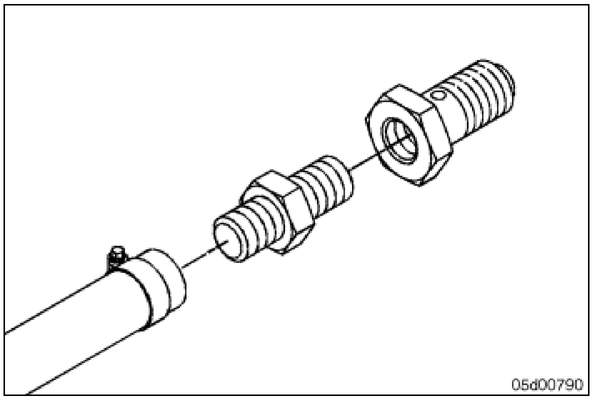
Perform several throttle snaps so that increased fuel rail pressure may be developed.

Fuel Pump Head Checks

Initial Check

This test utilizes a flow adapter fitting. The purpose of the flow adapter fitting is to route the drain flow of the fuel pump only into a collection device so that leakage may be measured.

This tool, Part Number 3164618, can be purchased or constructed according to the procedures in Procedure 006-026.

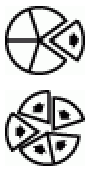


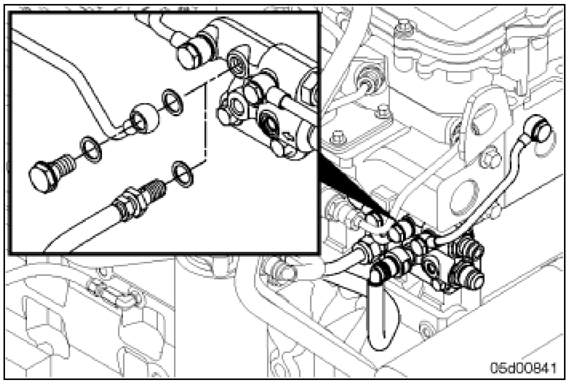
Test Setup

Remove the banjo bolt from the fuel pump drain line at the fuel drain manifold.

Install a banjo flow adapter fitting at the fuel drain manifold and route a hose from this adapter to a bucket or the vehicle's fuel tanks.

The pump drain line connects at the center connection point on the fuel drain manifold.

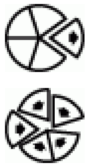


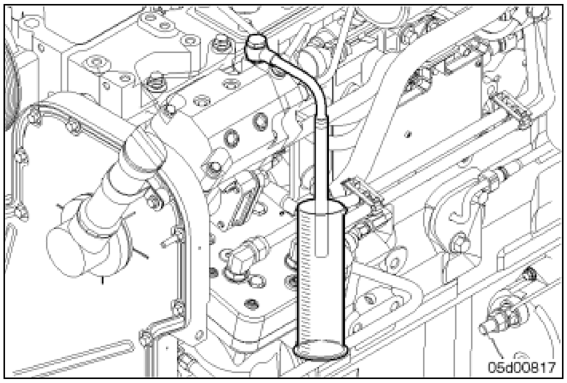


Alternate Test Setup

If the drain manifold is not easily accessed, a M14 banjo may be attached at the pump head drain port with a fuel hose that is routed to the collection container.

In this setup a bolt, nut, and washers are needed to prevent drain flow from flowing backwards and leaking from the unused drain line.

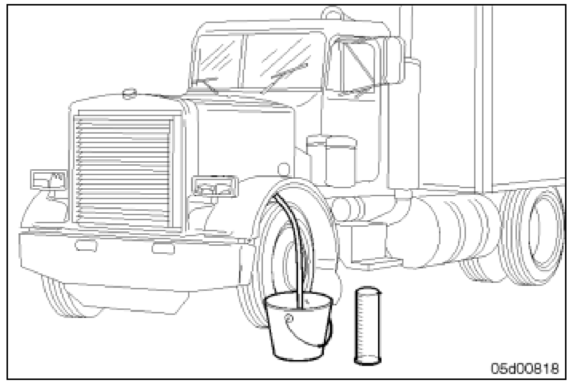




CAUTION

The high-pressure leakage test in the INSITE™ electronic service tool will cause the engine to operate at elevated pressures while the engine idles. The engine noise will change when this test is being performed due to the higher fuel injection pressures. Safety glasses should be worn while working near the running engine. Fuel lines should not be adjusted while performing this test.

Close the engine cover(s) while performing these tests.



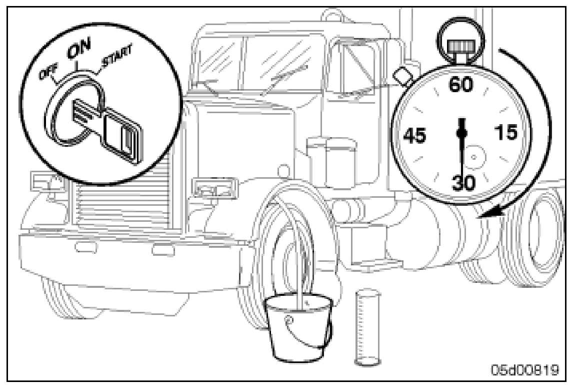
Test (Engine Will Not Start)

Turn the keyswitch ON and allow the lift pump to complete its cycle. Afterward the cycle is completed, begin cranking the engine until fuel exits the drain line.

When fuel begins to exit the drain line, route the drain flow to a graduated cylinder and continue cranking for 30 seconds.

Maximum Volume of Fuel During Cranking: 200 cc [7 oz] in 30 seconds

If 200 cc [7 oz] pump head drain flow is collected in less than 30 seconds of cranking, the pump head has failed and must be replaced.



Test (Engine Will Start)

If the engine will start, perform the high-pressure leakage test using Cummins INSITE™ electronic service tool.

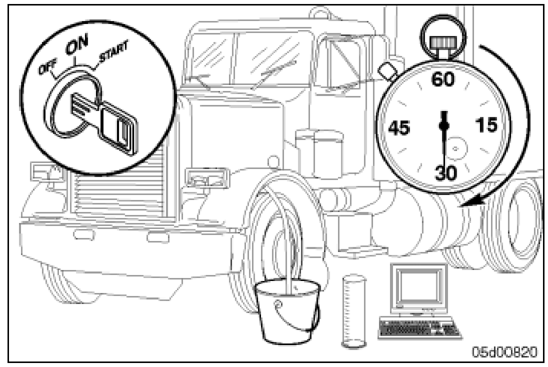
Connect the INSITE™ electronic service tool.

Start the engine and allow the engine to idle with fuel flowing into a collection device.

Begin the high-pressure leakage test using INSITE™.

Measure the time necessary to collect 300 cc [10 oz] of fuel pump head drain flow while performing the high-pressure leakage test.

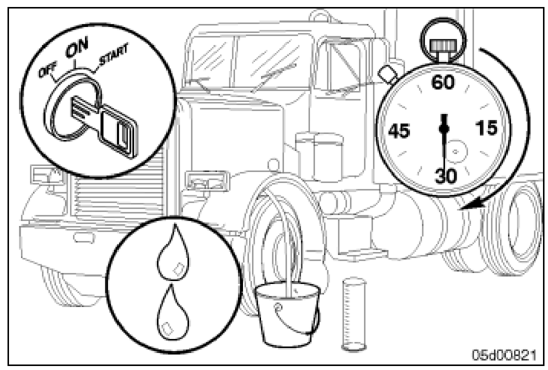
Use a graduated cylinder for this measurement.



Maximum Volume of Fuel During High-Pressure Leakage Test: 300 cc [10 oz] in 30 seconds

If 300 cc [10 oz] pump head drain flow is collected in less than 30 seconds, the pump head has failed and must be replaced.

This specification is valid for engines operating on diesel fuels. Low fuel viscosity will increase the leakage rate; for example, kerosene or aviation fuels will result in excessive leakage. Verify the fuel type before replacing a fuel pump head for excessive leakage.



Fuel Pump Head Removal/Installation

Prepare

Remove the high-pressure fuel line from the high-pressure pump. Refer to Procedure 006-051.

Remove the fuel drain line from the fuel pump actuator housing. Refer to Procedure 006-013.

Remove the fuel supply line from the fuel pump actuator housing. Refer to Procedure 006-024.

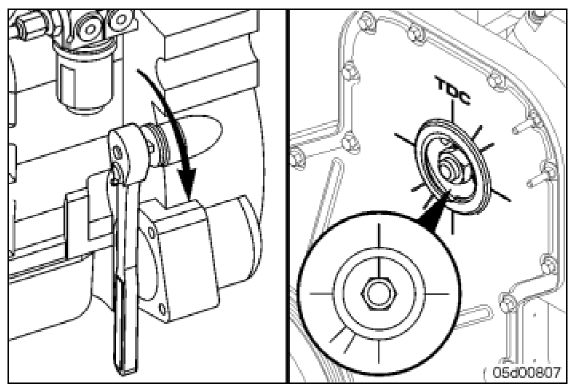
Disconnect the wire harness from the fuel pump actuator.

Remove the fuel pump actuator housing. Refer to Procedure 005-228

Remove

Remove the fuel pump drive gear cover.

Locate top dead center for cylinder number 1 by barring the engine slowly until the line on the pump gear lines up with the line on the gear cover.

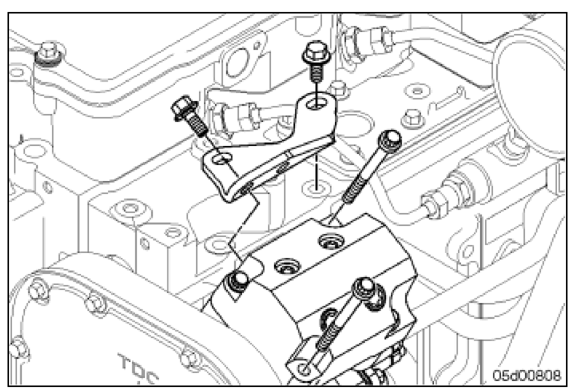


CAUTION

Do not use air tool. The use of air tools will possibly damage the fuel pump.

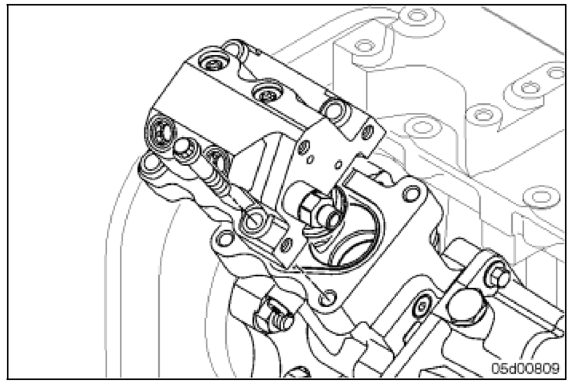
Remove the upper support bracket.

Remove two of the four capscrews that are located diagonally from one another.



Remove the last two capscrews. Alternately loosen the capscrew to avoid binding. Loosen each capscrew about one turn at a time.

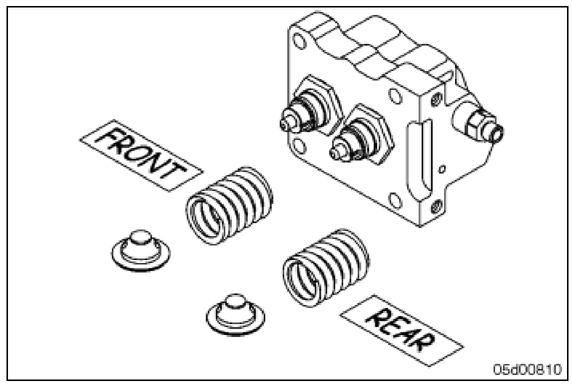
Carefully lift the fuel pump head from the cam housing, being careful to keep the tappet springs attached to the pump head, and place the head on a clean surface.



Clean and Inspect for Reuse

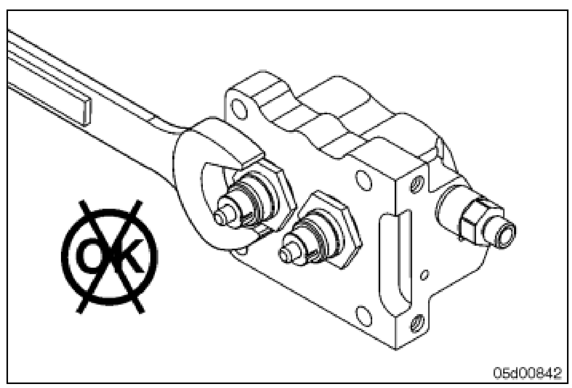
Remove the springs and spring retainers from the barrel retainers.

Make certain to keep track of which spring came from the front and rear. It is recommended that these parts be installed in the same order even if a new high-pressure pump head is installed.



CAUTION

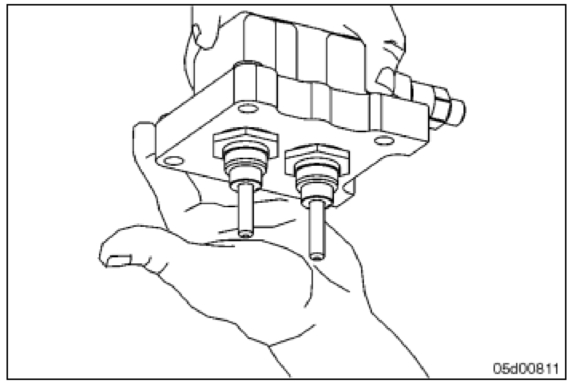
Do not remove the barrel retainers. Damage to the pump head and barrel retainers will result.



If the plungers are pressed fully upward, the fluid above the plunger and the inlet check valve seal can hold it in place.

Special care must be taken to be sure these parts are kept extremely clean if removed. Cover the cam housing with a clean shop towel while the head is removed.

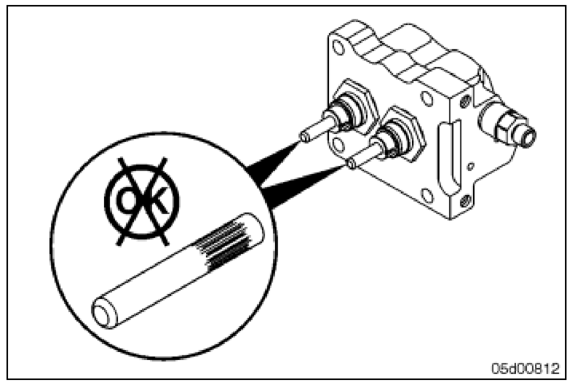
Do not use cleaning agents, other than contact cleaner, on pump components.



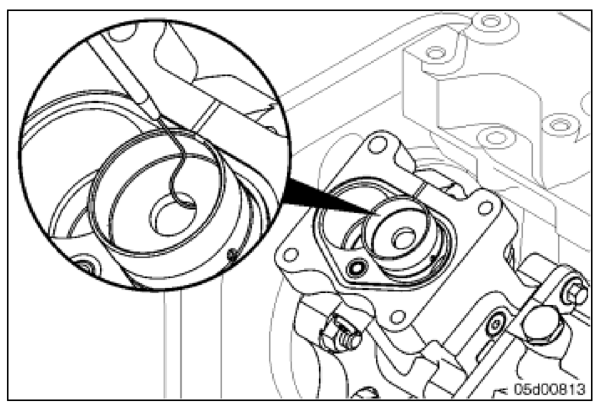
CAUTION

Each plunger must be installed in the same orientation and in the same barrel, or engine damage can result. Marking the bottoms of the plungers with a felt tip marker will help to ensure that correct orientation is maintained.

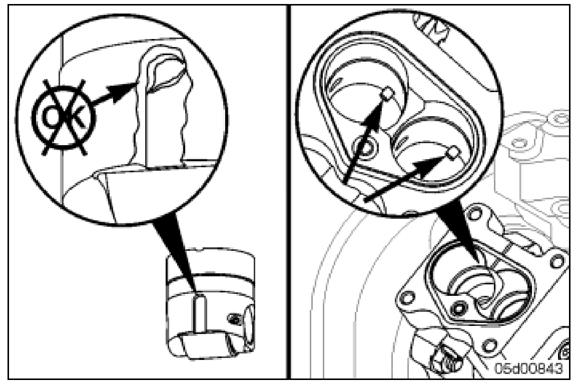
If the plungers are removed, inspect the plungers. Slight discoloration can be evident. Deep scoring must not be evident. If scoring or scratches exist that can be felt, the fuel pump head must be replaced.



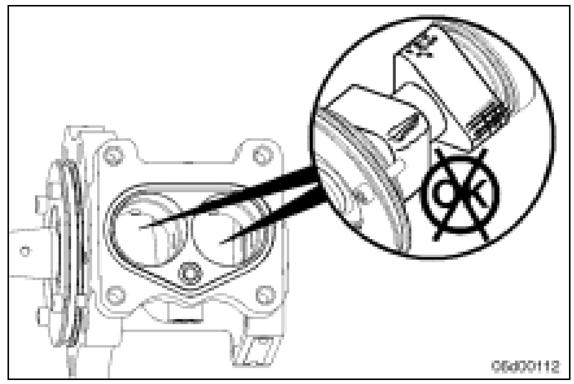
While the fuel pump head is removed, inspect the cam housing. The tappets can be removed using an o-ring pick as the removal tool.



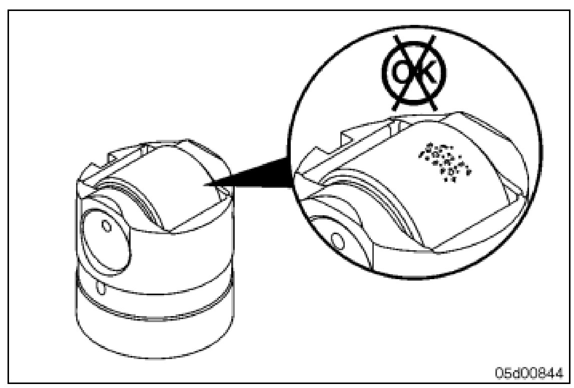
Inspect the tappet guide pins and tappet guide pin grooves for excessive wear. If more than 25-percent guide pin or groove wear is observed, the fuel pump must be replaced.



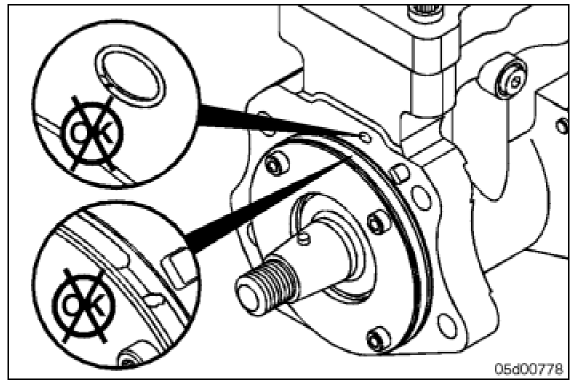
With the cam housing tappets removed, inspect the camshaft for wear. If excessive pitting on the nose of the camshaft is observed, the fuel pump must be replaced.



Inspect the tappet rollers for wear. If excessive pitting on the rollers is observed, the tappet(s) must be replaced.



If damage to the camshaft, tappets, or cam housing is observed, it is possible the fuel pump is not receiving adequate lubricating oil. When replacing the fuel pump, inspect the gear housing to make sure no blockages exist in the oil supply to the fuel pump.

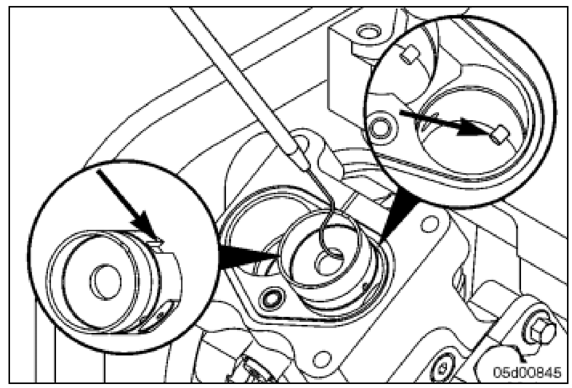


Install

Install the tappets in their original tappet bores.

Be certain the tappets are installed in their original locations.

Be certain that the tappet guide pins engage the guide the guide pin grooves.



Install new fuel pump head o-rings onto the cam housing.

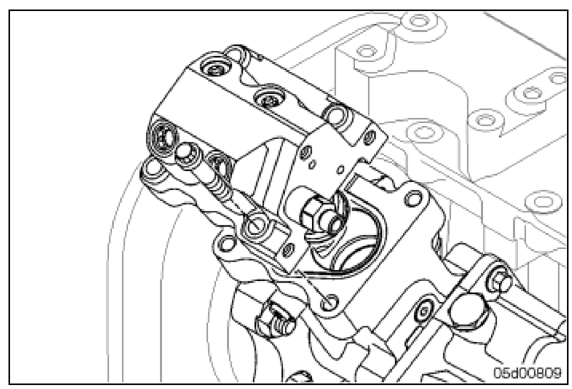
If installing a new or rebuilt pump head, install the new tappet springs and retainers provided with the pump head.

Place the high-pressure pump head onto the high-pressure pump cam housing.

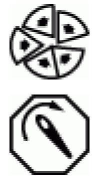
Draw the high-pressure pump head down by alternately tightening the four high-pressure pump head bolts until the head just contacts the cam housing.

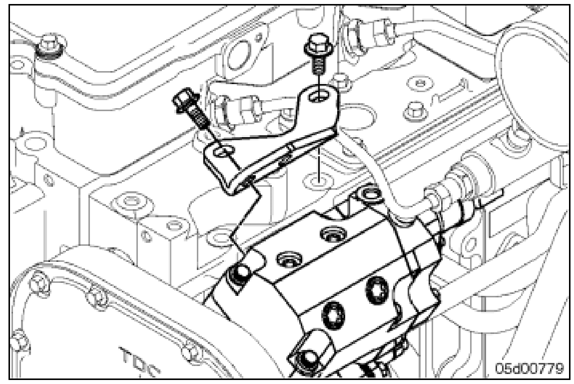
Tighten the four high-pressure pump head bolts to their final torque.

Torque Value: 68 N•m [50 ft-lb]



Connect the upper support bracket to the high-pressure pump head in the following order:





Connect the upper support bracket bolts to the high-pressure pump head and tighten finger tight.

Connect the upper support bracket bolts to the cylinder head and tighten to their final torque.

Support Bracket to Cylinder Head 43 N•m [32 ft-lb]

Tighten the bolts that attach to the high-pressure pump head to their final torque.

Support Bracket to Pump Head 43 N•m [32 ft-lb]

Follow-Up

Install the fuel pump actuator housing. Refer to Procedure 005-228.

Connect the high-pressure fuel supply line. Refer to Procedure 006-051.

Connect the fuel drain line from the fuel pump actuator housing. Refer to Procedure 006-013.

Connect the fuel supply line from the fuel pump actuator housing. Refer to Procedure 006-024.

Connect the engine harness to the fuel pump actuator.

Operate the engine and check for leaks.

Fuel Pump Actuator Housing

Prepare

Disconnect the wire harness from the fuel pump actuator.

Disconnect the fuel supply line from the fuel pump actuator housing. Refer to Procedure 006-024.

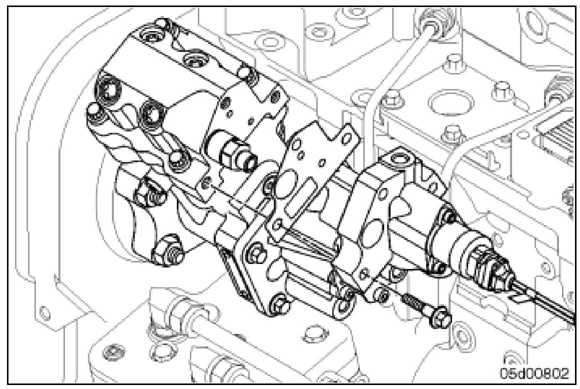
Disconnect the high-pressure fuel line from the fuel pump actuator housing. Refer to Procedure 006-051.

Disconnect the fuel drain from the fuel pump actuator housing. Refer to Procedure 006-013.

Remove

Remove the three bolts that hold the fuel pump actuator housing to the high-pressure fuel pump head.

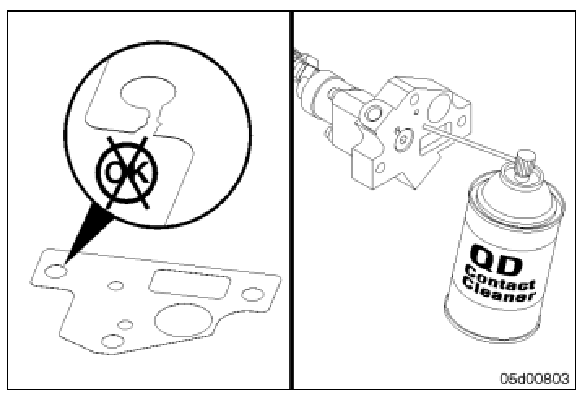
Remove the fuel pump actuator housing and the gasket.



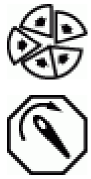
Clean and Inspect for Reuse

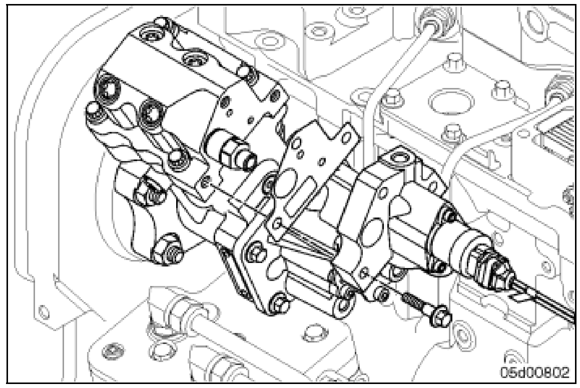
Inspect the fuel pump actuator housing gasket. Do not reuse the gasket if the material is damaged, cracked, or torn.

Be sure that the mounting surfaces of the high-pressure pump head and the fuel control valve adapter block are clean. Use contact cleaner to clean these surfaces.



Install





Insert the three mounting bolts through the fuel pump actuator housing.

Install the gasket over the bolts. The gasket must be installed dry.

Install the actuator housing.

Tighten the mounting bolts.

Torque Value: 34 N•m [25 ft-lb]

Follow-Up

Connect the high-pressure fuel line to the fuel pump. Refer to Procedure 006-051.

Connect the fuel supply line to the fuel pump. Refer to Procedure 006-024.

Connect the fuel drain line to the fuel pump. Refer to Procedure 006-013.

Connect the wire harness to the fuel pump actuator.

Fuel Injection Pump Removal/Installation

Prepare

Disconnect the injection pump supply line. Refer to Procedure 006-024.

Remove the injector supply lines. Refer to Procedure 006-051.

Disconnect the fuel drain line. Refer to Procedure 006-013.

Disconnect the pumping control valve 4-pin Deutsch connector.

Disconnect the injection control valve 4-pin Deutsch connector.

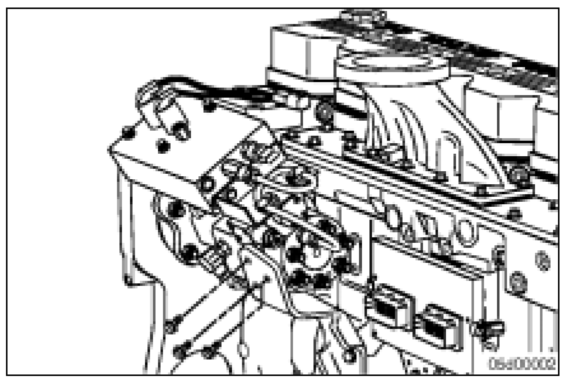
Disconnect the accumulator pressure sensor.

Disconnect the accumulator temperature sensor.

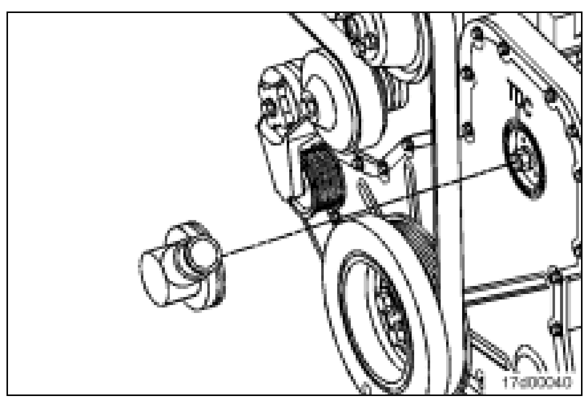
Remove

Remove the injection pump upper support bracket.

Remove the injection pump tail support bracket.

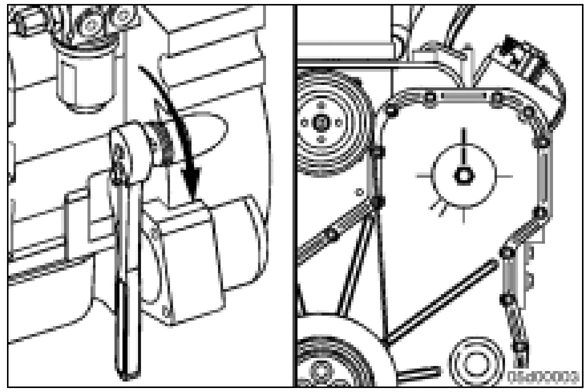


Remove the fuel pump gear access plug.

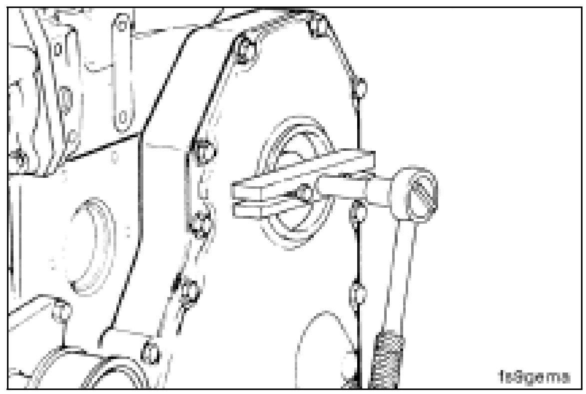


Locate top dead center for cylinder number 1 by barring engine slowly until the line on the pump gear lines up with the line on the gear cover.

Remove the fuel pump drive gear retaining nut and washer.

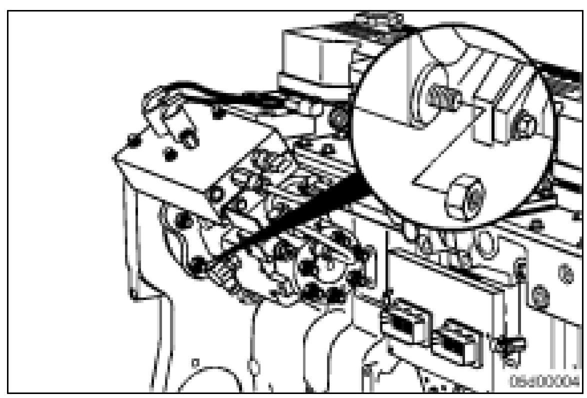


Pull the fuel injection pump drive gear loose from the pump driveshaft.



Remove the four mounting nuts.

Remove the fuel injection pump.

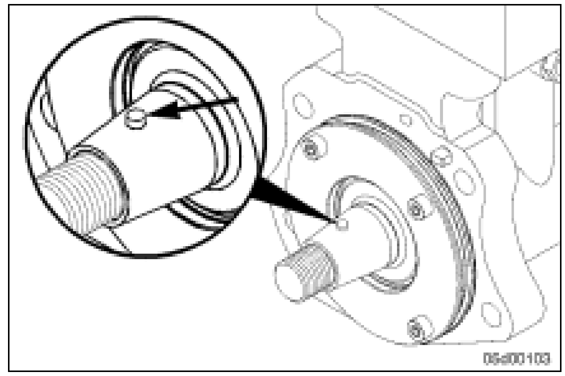


Clean and Inspect for Reuse

The fuel pump driveshaft key must not be sheared.

If the key is sheared, the cam housing module of fuel pump must be replaced and the drive gear must be replaced.

Check that the locating dowel is installed in the cam housing.



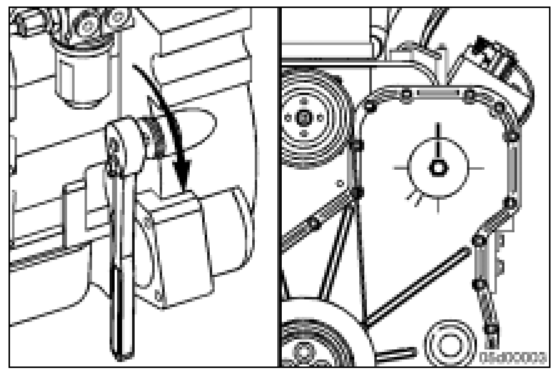
Install

Be sure the engine is at number 1 cylinder top dead center. The fuel pump gear timing mark should align with the top dead center mark on the gear housing.

Clean the fuel injection pump drive shaft with an evaporative cleaner.

Clean the fuel pump gear inside diameter with an evaporative cleaner.

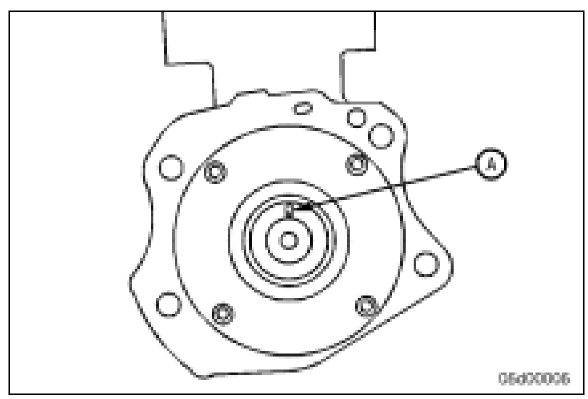
The fuel pump drive gear inside diameter and the drive shaft outside diameter must be clean and dry before installing the gear.



Make sure the fuel injection pump is at its top dead center position.

The fuel injection pump is at number 1 cylinder top dead center when the dowel pin in the shaft (A) is perpendicular to the top of the accumulator.

Be sure that the dowel is installed in the pump driveshaft.



Make sure the o-ring seals for the oil feed orifice (A) and pilot (B) are correctly installed and are not damaged.

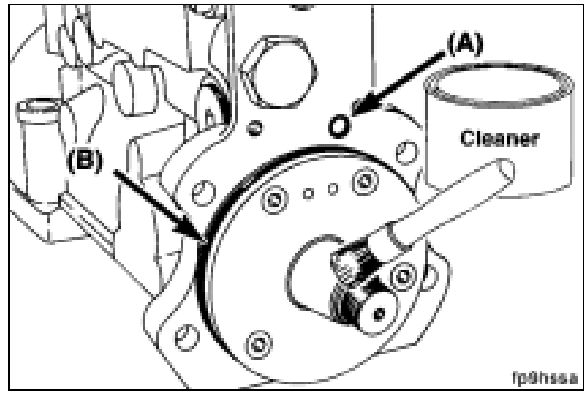
Lubricate the mounting flange with cleaner.

The fuel pump drive gear inside diameter and the shaft outside diameter must be clean and dry before installing the gear.

Slide the fuel injector pump shaft through the drive gear and position the fuel injection pump flange onto the mounting studs.

Make sure the dowel pin in the shaft (A) lines up with the keyway in the fuel injection pump gear.

Make sure the dowel pin in the fuel injection pump flange lines up with the hole in the gear housing.



Install the mounting nuts.

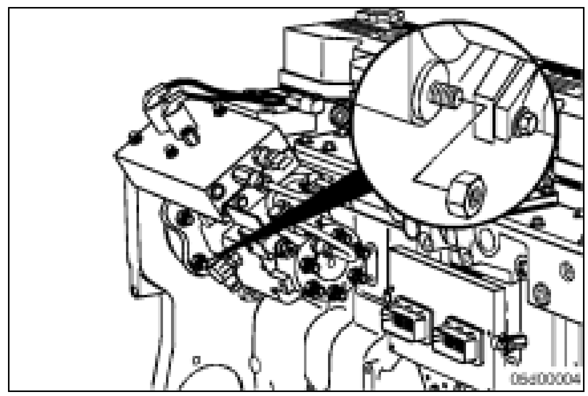
Install the fuel injection pump upper support bracket.

Install the fuel injection pump tail support bracket.

Fuel Pump Mounting Nuts: 44 N•m [32 ft-lb]

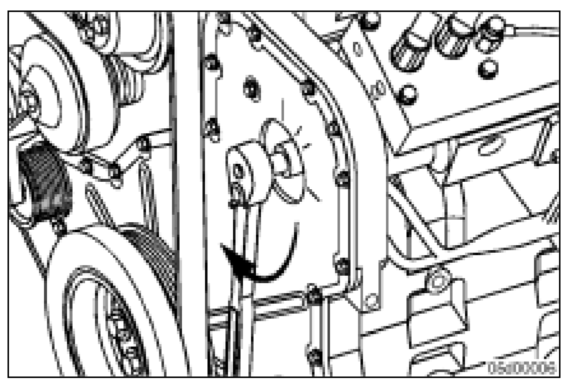
Fuel Pump Support Brackets (8.8 or 9.8 capscrews): 44 N•m [32 ft-lb]

Fuel Pump Support Brackets (10.9 capscrews): 65 N•m [48 ft-lb]



Tighten the fuel injection pump drive gear nut.

Torque Value: 108 N•m [132 ft-lb]



Follow-Up

Install the gear cover access cap hand tight.

Connect the injection pump supply line. Refer to Procedure 006-024.

Connect the injector supply lines. Refer to Procedure 006-051.

Connect the fuel drain line. Refer to Procedure 006-013.

Connect the pumping control valve 4-pin Deutsch connector.

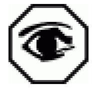
Connect the injection control valve 4-pin Deutsch connector.

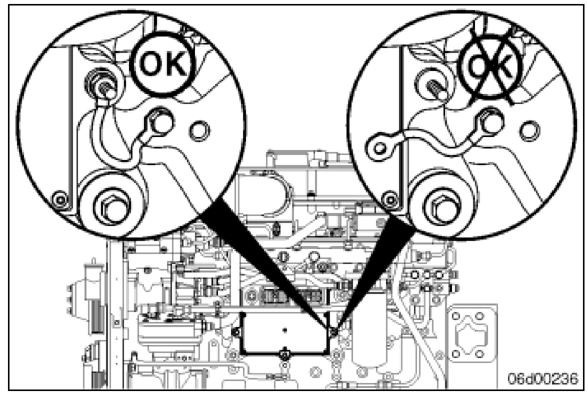
Connect the accumulator pressure sensor to the engine harness.

Connect the accumulator temperature sensor to the engine harness.

Operate the engine and check for leaks.

Fuel Cooled ECM Cooling Plate Removal/Installation





Initial Check

The ECM cooling plate assembly provides a vibration isolated mounting location for the ECM. The cooling plate also provides ECM cooling and incorporates the fuel lift pump. A check valve at the outlet port in the ECM cooling plate makes sure that the fuel system is primed while the fuel lift pump is running.

Check the ECM cooling plate for damaged vibration isolators, loose capscrews, or fuel leaks.

Make sure that the ground strap is properly installed. A missing or poorly connected ground strap may cause intermittent engine performance problems.

The ground strap must be connected between the head of the ECM mounting bolt and the ECM.

The ground strap must be connected to an unpainted block surface that is free of corrosion.

Prepare

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.

Disconnect the negative (-) battery cable first.

Disconnect the harness connections from the ECM.

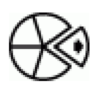
Disconnect the ECM ground strap.

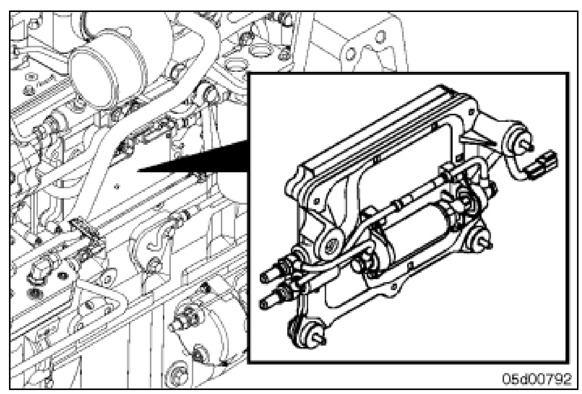
Disconnect the engine harness from the electric fuel priming pump.

Disconnect the fuel supply lines from the ECM cooling plate. Remove the suction fuel lines, if necessary.

Remove the ECM from the cooling plate. Refer to Procedure 019-031 in Troubleshooting and Repair Manual, CM850 Electronic Control System, ISC, QSC8.3, ISL and QSL9 Engines, Bulletin

Remove





Remove the ECM cooling plate capscrews and the ECM cooling plate form the engine block.

NOTE: The electric fuel priming pump and priming pump fuel lines will be attached to the ECM cooling plate while the cooling plate is being removed.

Disassemble

Remove the following components from the ECM cooling plate:

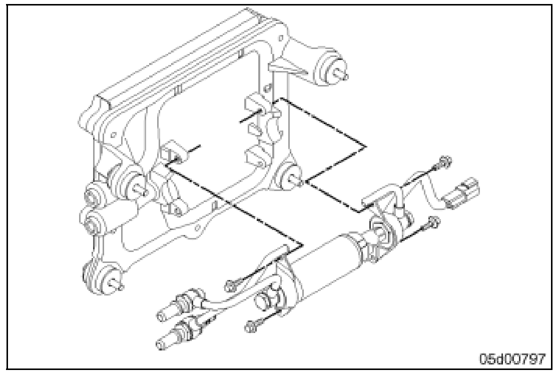
Male banjo quick disconnect fitting

Male banjo check valve fitting

Fuel lift pump supply lines

Fuel lift pump brackets

Fuel lift pump.



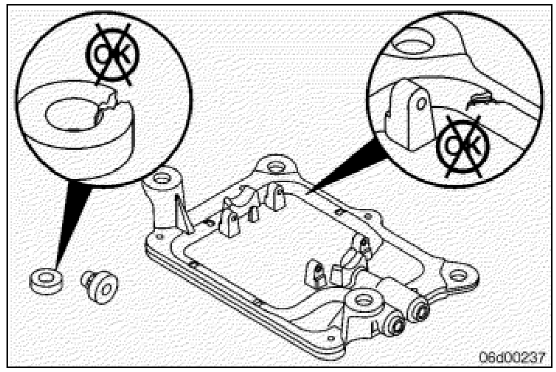
Inspect for Reuse

Inspect the ECM cooling plate for leaks (note that the fuel passages are contained in a tube that is cast into the cooling plate).

Replace any damaged vibration isolators.

Inspect for leaks in the electric fuel supply pump priming circuit; look for cracked fuel tubes, damaged o-rings or damaged seal washers.

Inspect the check valve for debris or damage.



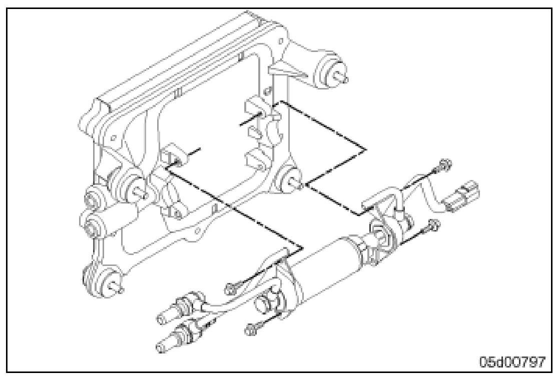
Assemble

Install the electric fuel priming pump. Refer to Procedure 005-045.

Install the fuel priming circuit fuel lines. Refer to Procedure 005-045.

Be sure the lines are supported while tightening the banjo screws. The lines must not be permitted to bind.

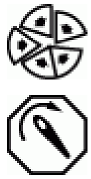
Be sure the ECM check valve is installed into the bottom (outlet) fitting of the ECM cooling plate.

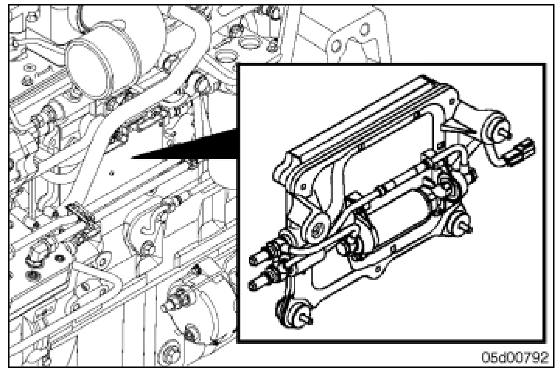


Install

Install the ECM cooling plate assembly on the engine block. Tighten the capscrews.

Torque Value: 24 N•m [18 ft-lb]





Follow-Up

CAUTION

Failure to properly install the ECM ground strap may cause intermittent engine symptoms including intermittent engine stalls. One end of the ground strap must be installed between the ECM housing and the head of the bottom most ECM mounting capscrew. The other end of the ground strap must be tightly bolted to an unpainted block surface that is free from corrosion.

NOTE: Be sure the vibrations isolators are installed correctly. The isolators fit in a single direction into the chamfered locators.

Install the ECM on the ECM cooling plate. Refer to Procedure 019-031 in Troubleshooting and Repair Manual, CM850 Electronic Control System, ISC, QSC8.3, ISL and QSL9 Engines, Bulletin 4021416.

Install the fuel supply lines. Refer to 006-024.

Cycle the keyswitch a few times to allow the system to prime.

Operate the engine and check for leaks.

Measure Fuel Drain Line Restriction

Prepare

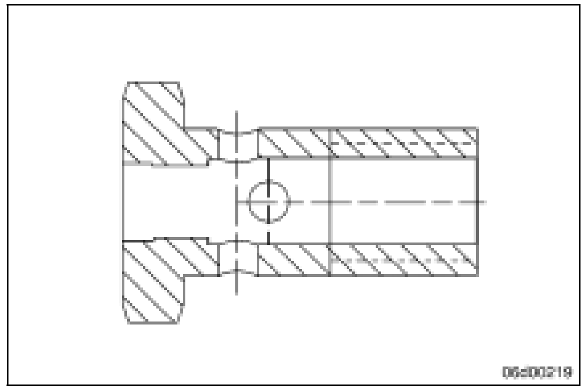
Obtain or construct a M12 banjo pressure gauge tool.

A banjo-style pressure gauge adapter may be used to measure pressure or vacuum at any point in the low-pressure fuel system where a banjo bolt exists at a fuel line.

The ISC and ISL engines with high-pressure common rail fuel systems use M12 x 1.5 banjo bolt connections. This tool may be used for measurement of drain line restriction (pressure) at the fuel drain manifold.

Make a banjo bolt pressure gauge tool by drilling and tapping the hex face of a M12 x 1.5 banjo bolt, Part Number 3903035, or equivalent.

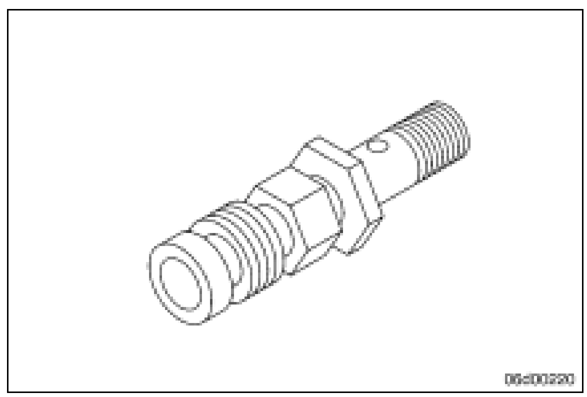
Drill and tap the banjo bolt to the size of Compuchek® fitting, or other hose union, being used (example 1/8-inch NPT Compuchek® fitting, Part Number 3377244, or M10 Compuchek® fitting, Part Number 3824842).



Assemble the banjo pressure gauge adapter.

Install the Compuchek® or other type fitting in the hex face of the banjo bolt.

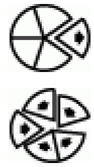
Attach a hose or pressure gauge to the banjo pressure adapter.

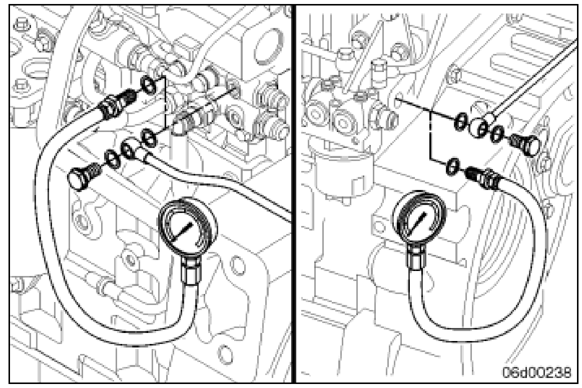


Install the M12 banjo pressure gauge adapter in place of the injector drain line banjo at the fuel drain manifold (Cummins Common Rail fuel systems).

Install the M12 banjo pressure gauge adapter in place of the banjo bolt that attaches the injector drain line to the electric lift pump drain manifold (CAPS fuel systems).

Install a 0 to 762 mm Hg [0 to 30 in Hg] pressure gauge at the M12 banjo pressure gauge adapter.





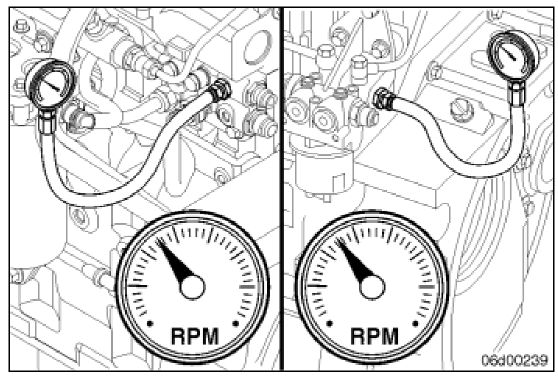
Measure

Operate the engine at rated speed and no load.

Observe the reading on the gauge.

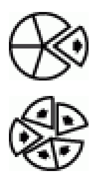
Maximum Fuel Drain Line Pressure 254.0 mm-hg [10.0 in-hg]

If the drain line pressure is out of specification, check for bends or kinks in the drain lines. Look for places where the OEM fuel lines may be pinched by wire ties or p-clips. Check for block fuel tank vents.



Follow-Up

Remove all test fittings and reinstall drain lines. Refer to Procedure 006-013.



Fuel Drain Lines Removal/Installation

Prepare

Remove

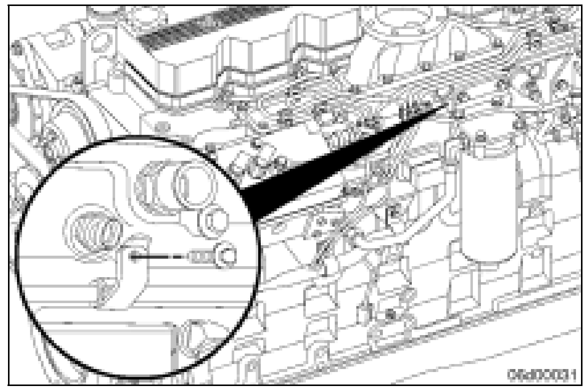
CAPS Fuel System

There are two drain lines on the engine:

The fuel injection pump drain line routes fuel from the fuel injection pump to the fuel lift pump drain manifold. This line has a p-clip brace that attaches to the cylinder head.

The injector drain line which routes fuel from the rear of the cylinder head to the fuel lift pump drain manifold.

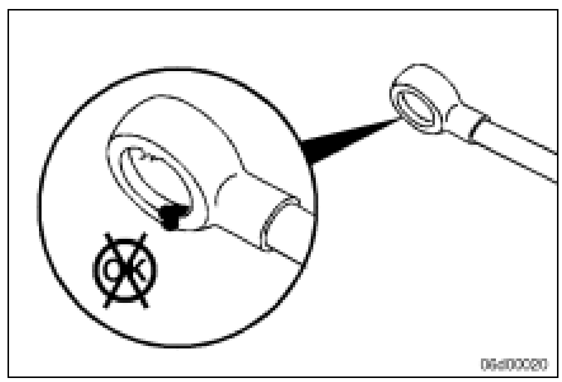
These lines are removed by removing the banjo bolts and sealing washers.



Inspect for Reuse

Inspect the lines for damage.

Inspect the banjo seal washers for damage.



Install

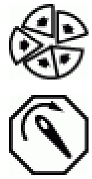
CAPS Fuel System

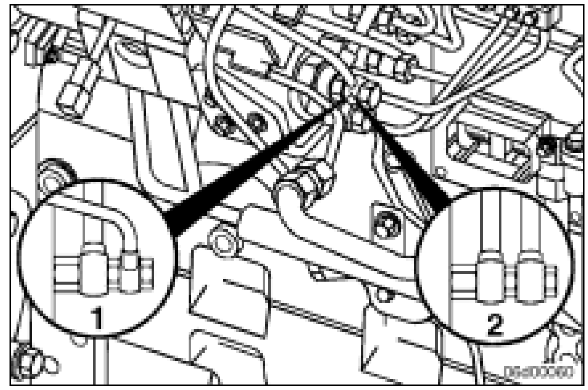
Connect the fuel drain line at the fuel pump banjo fitting at the rear of the cylinder head and at the lift pump. Use two (2) wrenches when installing the drain line at the fuel pump return.

Style One (1) 24 N•m [18 ft-lb]

Style Two (2) 24 N•m [18 ft-lb]

Refer to Procedure 006-056 for the air bleeding installation procedure.

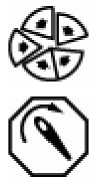


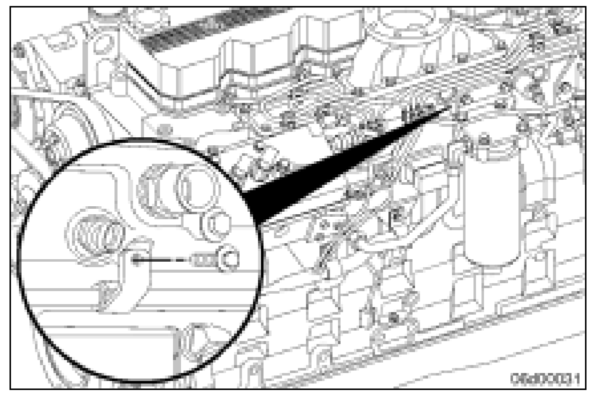


Install and tighten the clamp capscrews.

M12 Banjo Bolts 24 N•m [18 ft-lb]

P-Clip Capscrew 24 N•m [18 ft-lb]





Follow-Up

Operate the engine under a load and check for leaks.

Spin-On Type Fuel Filter

General Information

CAPS Fuel System

The CAPS fuel system requires the use of a single fuel filter. The filter must have the following characteristics:

water-separating

10-micron rating

water-in-fuel sensor

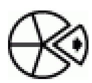
water-drain valve

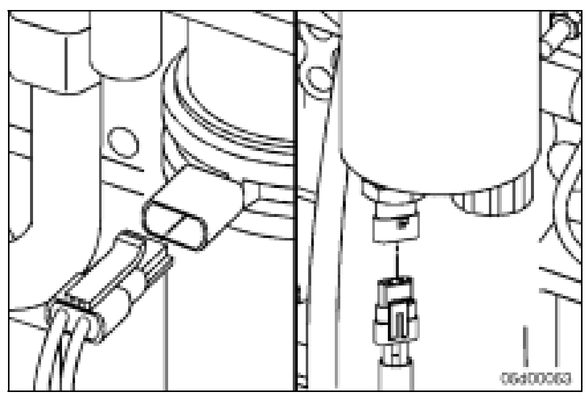
engine mounted or chassis mounted.

Fleetguard® FS1022 meets these requirements.

Prepare

Remove





Disconnect the wiring harness from the water-in-fuel sensor, if equipped.

Disconnect the wiring harness from the fuel heater, if equipped.

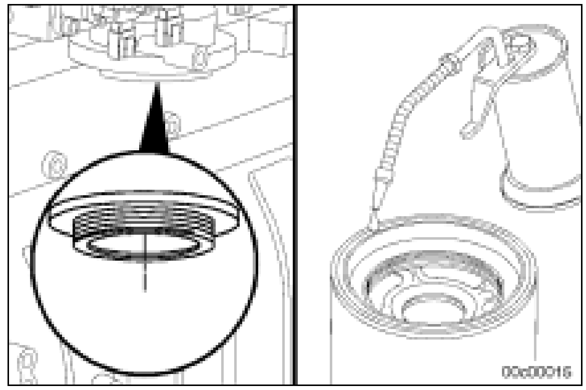
Loosen and remove the fuel filter.

Make sure the seal ring does not stick to the filter head.

Remove the ring with an o-ring pick, if necessary.

Install

CAPS Fuel System



CAUTION

Mechanical over-tightening can distort the threads as well as damage the filter element seal or filter canister.

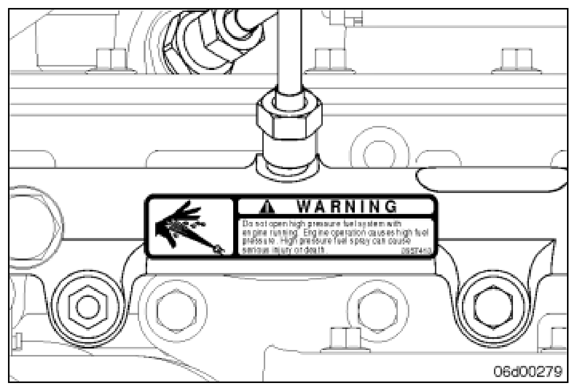
Do not fill the fuel filter with fuel before installation; instead, prime the fuel system using the fuel lift pump.

Be sure the center seal ring is installed onto the filter spud.

Install the filter as specified by the filter manufacturer.

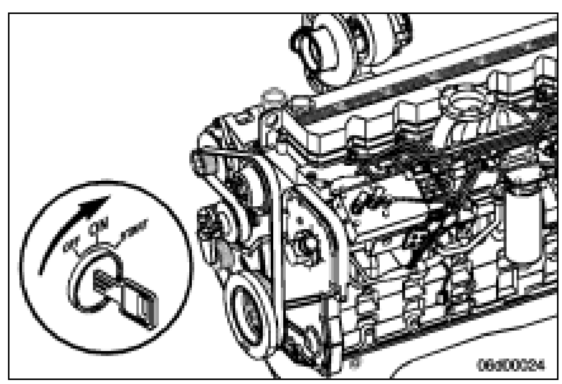
Connect the water-in-fuel sensor and the fuel heater, if equipped.

Prime



WARNING

Do not open the high-pressure fuel system with the engine running. Engine operation causes high fuel pressure. High-pressure fuel spray can cause serious injury or death.



Cycle the keyswitch and allow the lift pump to run. The lift pump will run for 30 seconds. Afterwards, turn the keyswitch off and back on again allowing the lift pump to run again.

Allow the lift pump to run for three or four 30-second cycles before attempting to start the engine.

Follow-Up

Operate the fuel lift pump to help prime the fuel system. Turn the keyswitch to RUN, but do not attempt to start the engine. This will cause the ECM to operate the fuel lift pump through a priming cycle which lasts at least 30 seconds. Cycle the lift pump several times by keying off, waiting 10 seconds and keying back on again.

Once the engine is started, slowly increase the engine speed while air is purged from the fuel plumbing.

Measure Fuel Inlet Restriction

Prepare

Set-Up

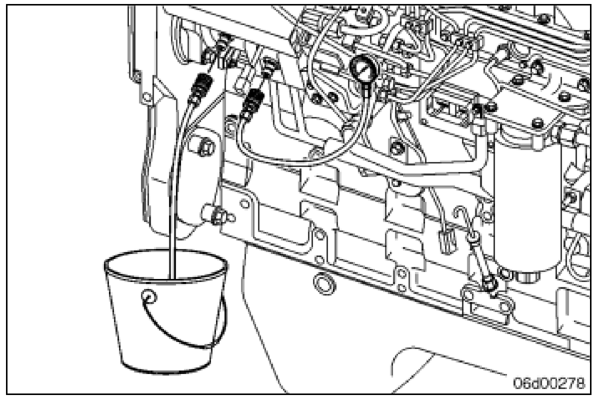
Obtain a 0.043-inch orificed diagnostic fuel line, Part Number 3164621. This tool can also be constructed. Refer to Procedure 006-003.

Obtain a container suitable for collection of fuel that exits the diagnostic fuel line. A 5-gallon bucket is recommended.

Install a 1/8-inch NPT Compuchek® diagnostic fitting, Part Number 3042618, at the inlet to the fuel injection pump (Cummins Accumulator Pump System only).

Attach the 0.043-inch orificed diagnostic fuel line at the fuel injection pump cam housing Compuchek® fitting. Route this hose into a collection container or into the fuel tank.

Attach a 0 to 762 mm Hg [0 to 30 in Hg] vacuum gauge at the gear pump inlet Compuchek® port.



Measure

Operate the engine at idle and measure the inlet vacuum.

Maximum Fuel Inlet Restriction (CAPS Fuel Systems)

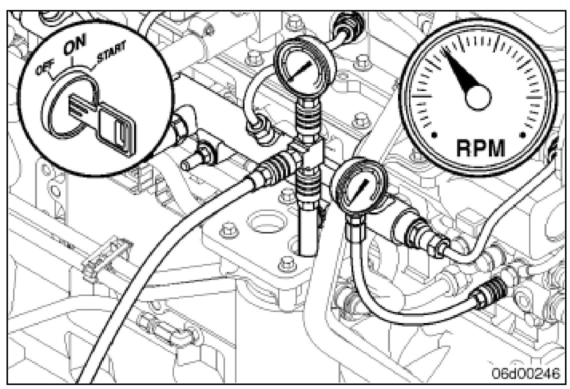
At OEM connection 102.0 mm Hg [4.0 in Hg]

At inlet to fuel gear pump (dirty filter) 254.0 mm Hg [10.0 in Hg]

Maximum Fuel Inlet Restriction (Cummins Common Rail Fuel System)

At OEM connection (dirty filter) loaded condition 203.2 mm Hg [8.0 in Hg]

At inlet to fuel gear pump (dirty filter) loaded condition 304.8 mm Hg [10.0 in Hg]



If the inlet restriction is excessive, look for the root cause:

Suction side fuel filters plugged

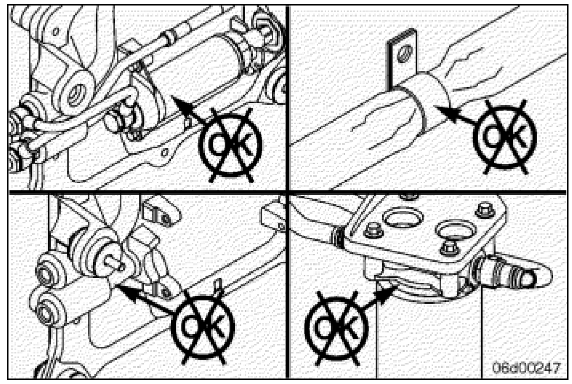
Fuel heater valves are restricted

ECM cooling plate plugged

ECM cooling plate check valve restriction

OEM fuel lines pinched or restricted

Fuel tank stand pipes restricted.



NOTE: Do not leave Compuchek® fittings installed on the suction side of the gear pump. A Compuchek® fitting on the suction side of the gear pump can allow air to enter the fuel flow resulting in performance problems.

Disconnect all diagnostic test fittings and reinstall all plugs.

Follow-Up

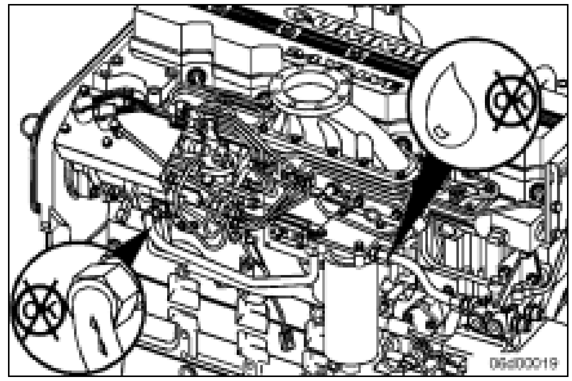
Low Pressure Fuel Supply Lines Removal/Installation

Initial Check

Inspect all fuel supply lines and fittings. Look for cracks in the lines or leaking fittings.

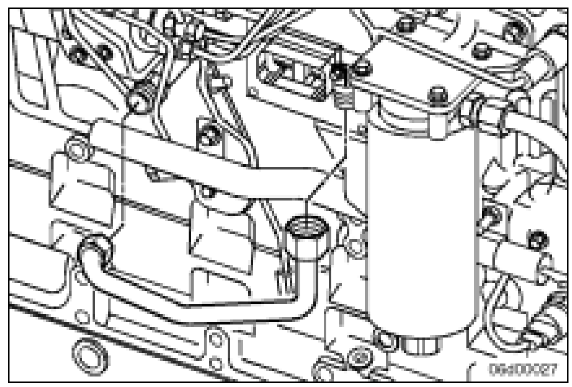
Inspect the straight thread o-ring metric hose fitting. Make sure that the lock nuts tighten against the o-ring rather than bottom out against the end of the fitting's threads (example: Cummins Accumulator Pump System fuel pump inlet and Cummins Accumulator Pump System fuel filter head).

Inspect the quick-disconnect style fittings for damaged o-ring connections or broken locking tangs.

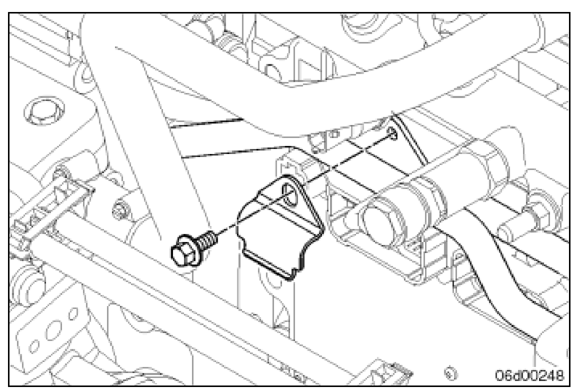


Remove

Remove the fuel supply lines.

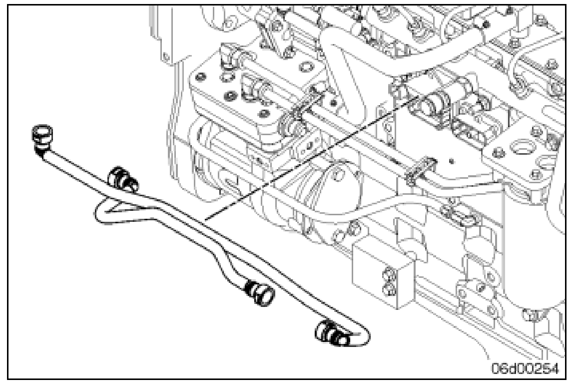


For quick disconnect style fuel lines, remove the clasp from the fuel line brace. This will allow the lines to move so they can be disconnected.



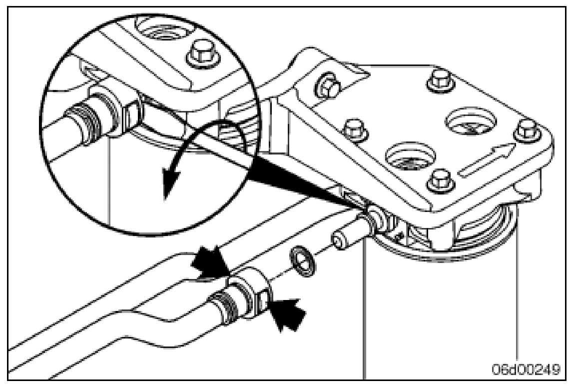
Loosen all quick disconnect lines from the brace.

To remove the gear pump outlet line, the gear pump inlet line must be removed first.

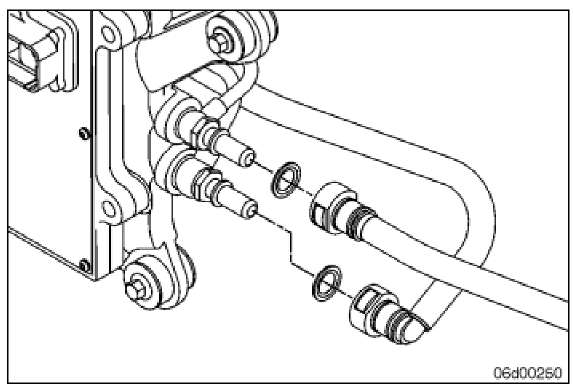


Remove the quick disconnect style fuel lines by pressing in the locking tangs on both sides of the quick disconnect fitting.

To aid removal, a screwdriver may be inserted between the fuel line end and quick disconnect male union. After pressing the opposing locking tangs, twisting the flat blade of the screwdriver helps to remove the fuel line.



If fuel leaks or suction side air entry is suspected, remove the fuel hoses or quick disconnect fittings.



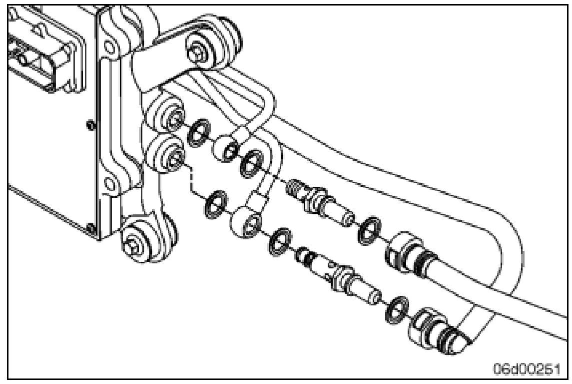
Inspect for Reuse

Inspect for burrs or debris on metal connectors that may cause leaks.

On straight thread o-ring metric connectors, be certain the o-rings are not frayed or cut.

On quick disconnect style fittings, be certain the o-rings are not frayed or cut, and that the lock tangs are not damaged.

Inspect the banjo seal washers. Replace and damaged washers.

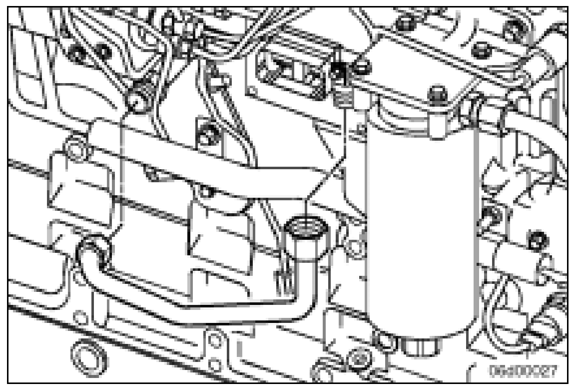


Install

Install the fuel supply lines.

Number 10 Flare Fitting: 37 N•m [27 ft-lb]

M12 Quick Disconnect Union: 24 N•m [18 ft-lb]



Install the quick disconnect fuel lines (Cummins Common Rail Fuel Systems only).

Install the quick disconnect fittings.

Torque Value 24 N•m [18 ft-lb]

Make sure that the quick disconnect style fuel lines clasp onto the quick disconnect fittings.

Make sure the lines are routed and connected correctly. If the lines are connected incorrectly, the engine will not run.

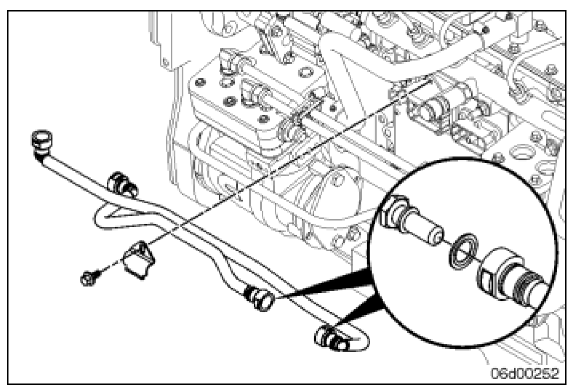
For quick-disconnect style lines used with the Cummins Common Rail Fuel System, fuel lines are routed in the following order:

OEM connection to the upper fitting at the ECM cooling plate

Lower ECM cooling plate fitting to the upper gear pump fitting

Lower gear pump fitting to the 2-micron fuel filter inlet

2-micron fuel filter outlet to the fuel pump fuel



control actuator housing.

The fuel supply line brace holds the fuel lines in the following order:

The inside line connects the upper gear pump fitting to the lower ECM cooling plate fitting

The middle line connects the 2-micron filter outlet to the fuel pump fuel control actuator housing

The outside line connects the lower gear pump fitting to the 2-micron filter inlet.

Install the fuel line brace clasp (quick disconnect style fuel lines only) and the brace, if necessary.

Fuel Line Brace 24 N•m [18 ft-lb]

Fuel Line Brace Clasp 24 N•m [18 ft-lb]

Follow-Up

Operate the engine and check for leaks.

Fuel Injectors Removal/Installation

Preparatory Steps

CAPS Fuel System

CAUTION

Attempting to remove the injector without first removing the fuel connector will cause damage to the injector body and/or fuel connector.

Remove the rocker lever cover. Refer to Procedure 003-011.

Remove the engine brake, if equipped. Refer to Procedure 020-004.

Remove the fuel connector. Refer to Procedure 006-052.

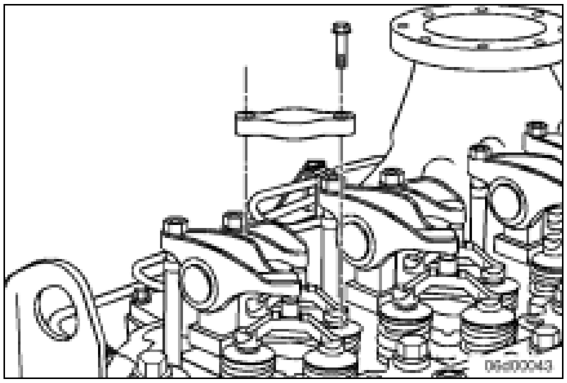
Remove

CAPS Fuel System

Remove the injector hold-down bolt that is nearest the exhaust manifold side of the engine.

Remove the injector hold-down.

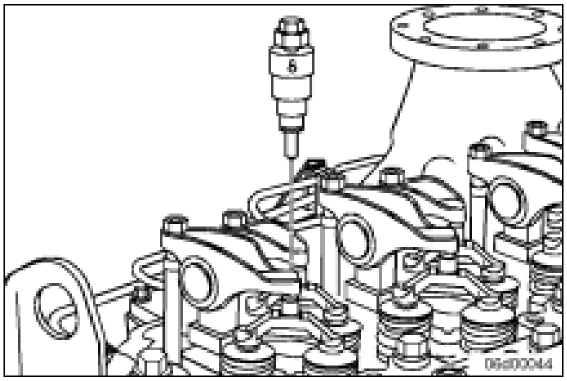
Remove the high-pressure fuel connector. Refer to Procedure 006-051.



Using the injector puller, Part No. 3825156, pull the injector out of the head.

Alternatively, a rocker cover capscrew can be installed into the top of the injector and used to pull the injector from the cylinder head.

Be sure that the injector seal washer is removed from the injector bore.



Test

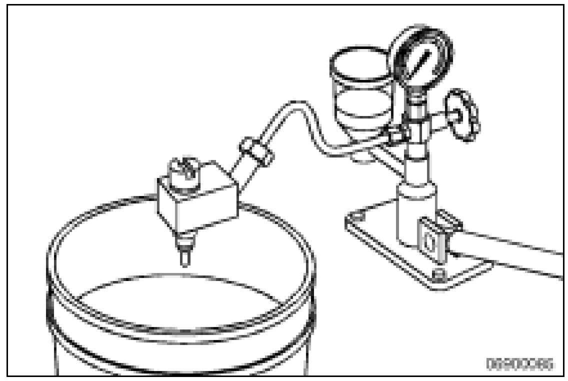
Mechanical Injectors

WARNING

While testing the injectors, keep hands and body parts away from the injector nozzle. Fuel coming from the injector is under extreme pressure and can cause serious injury by penetrating the skin.

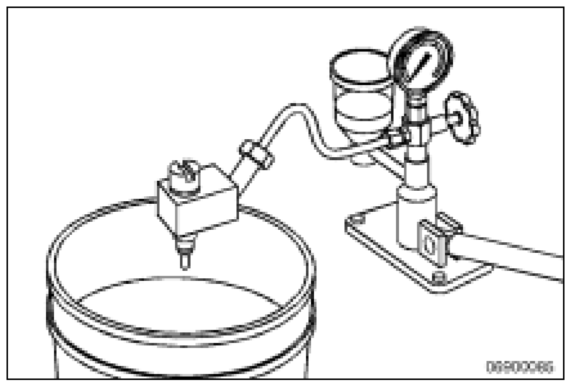
Install the injectors on an injector test stand. Open the bypass valve for the pressure gauge so the spray pattern can be checked.

Use injector test fixture, Part Number 3162269, with the injector nozzle test, Part Number 3376946.

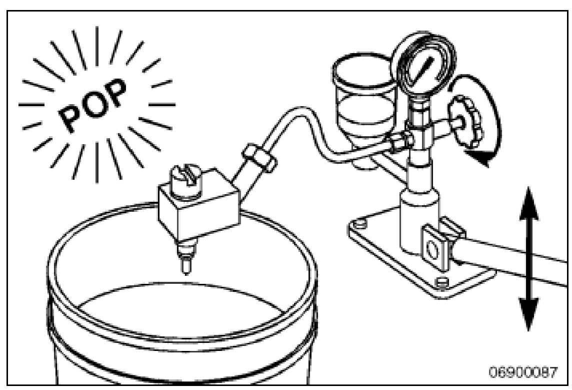


Operate the test stand lever quickly several times to check the spray pattern of the injectors. Verify that the correct number of plumes are present for the number of holes in the injector. Also pay close attention to the size and shape of each plume. If possible, compare the spray pattern to that of a new injector with the same assembly number.

NOTE: The injector spray pattern is an excellent indicator of the nozzle hole condition. Check each plume carefully. It is possible that only a single hole has been damaged resulting in degraded engine performance.



Close the bypass valve for the pressure gauge and operate the test stand lever to check the nozzle opening pressure. There must be a good crisp pop when the nozzle opens and the pressure must be within specification for the assembly number. Refer to the Master Repair Manual, Injection Pumps and Injectors, Midrange Engines, Bulletin 3666037-05 or later.

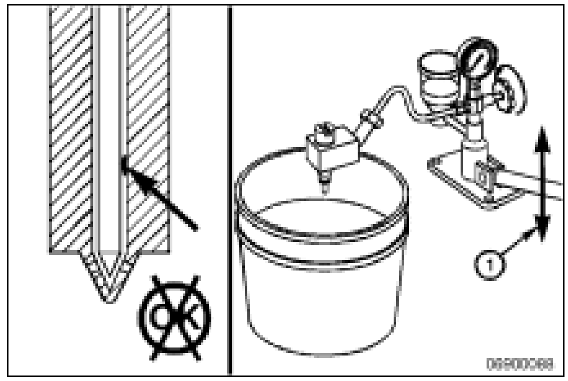


If the nozzle opening pressure is excessively low and/or the nozzle sprays excessive fuel, the injector needle can be sticking. The needle can be stuck due to poor lubrication or debris.

Sometimes it is possible to unstick an injector needle by using the injector test stand. Open the bypass valve for the pressure gauge and operate the test stand lever rapidly for 10 to 20 strokes.

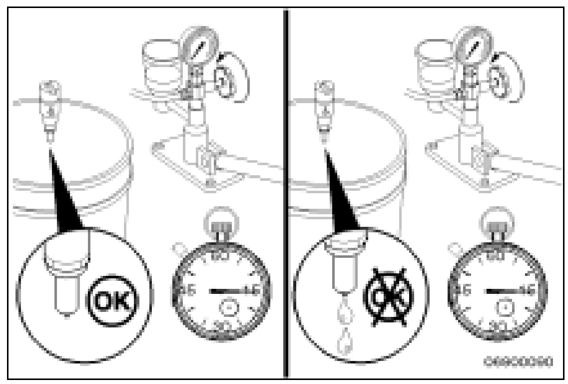
Recheck the nozzle opening pressure and spray pattern to see if the injector has returned to normal operation.

If the injector is still out of specification, replace the injector.



Check the injector for drip and/or excessive leak down. Close the bypass valve for the pressure gauge and build pressure to within 10 bars of the opening pressure of the nozzle.

A drop of fuel must not form within 15 seconds.



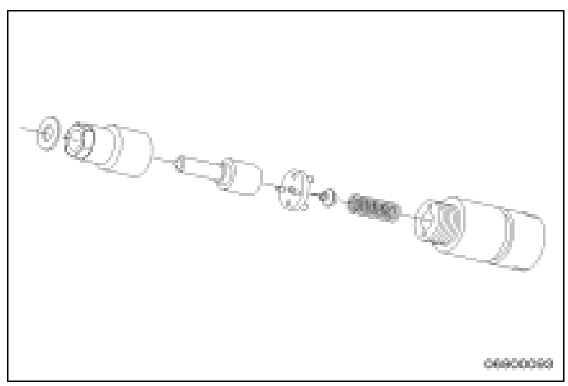
Disassemble

Mechanical Injectors

Place the injector in the injector clamp and remove the nozzle retaining nut.

NOTE: Injectors covered under warranty by the manufacturer must not be repaired. Refer to the manufacturer's warranty instructions.

Remove the nozzle, intermediate plate, spring, and shims from the injector.

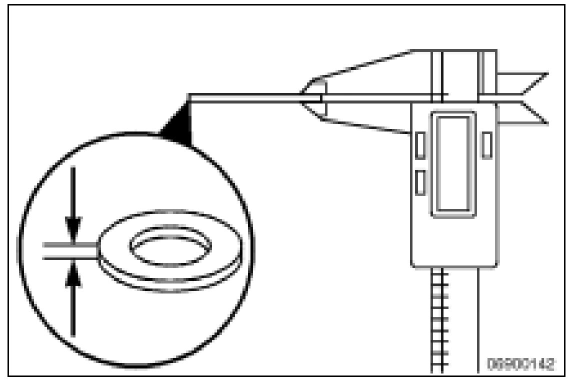


Clean and Inspect for Reuse

Verify the injector sealing washer is the correct thickness. The incorrect sealing washer can cause high pressure fuel leaks, and/or performance problems due to incorrect injector protrusion.

Refer to the injector part number for correct sealing washer shim thickness.

NOTE: All ISC and ISL engines which use mechanical (“POP”) style injectors use a 1.5 mm [0.06 in] injector seal washer.



WARNING

When using solvents, acids, or alkaline materials for cleaning, follow the manufacturer's recommendations for use. Wear goggles and protective clothing to avoid personal injury.

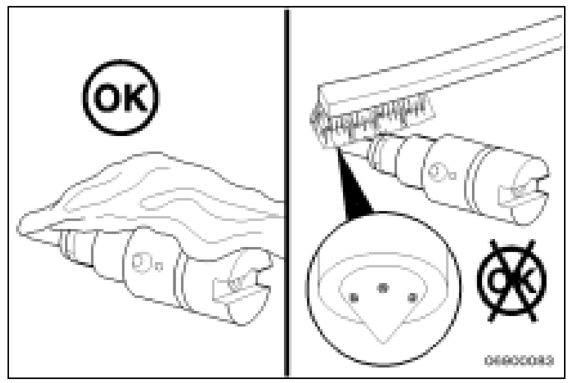
WARNING

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

CAUTION

Do not use a steel wire brush or glass beading to clean the injectors. This will damage the nozzle holes and cause performance problems.

Clean injector tip and body with safety solvent and soft clean rag.

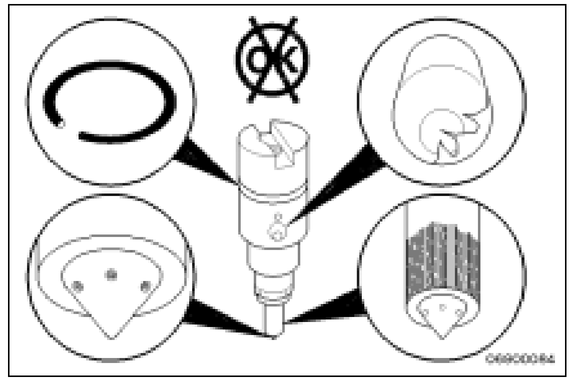


Inspect the o-ring for damage.

Look for burrs on the inlet to the injector.

Check the nozzle holes for any signs of damage such as hole erosion or hole plugging.

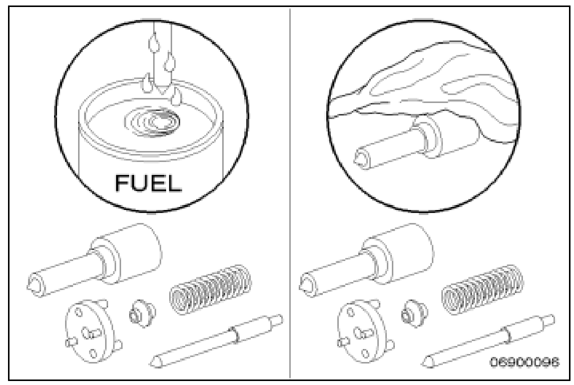
Spray safety solvent on the injector body and inspect the fuel inlet passage for small cracks which can allow high pressure fuel to leak to the injector drain passage.



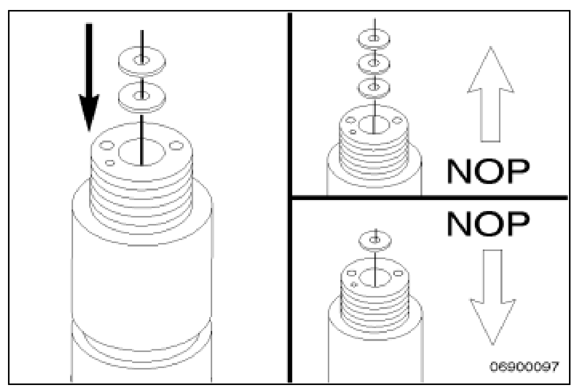
Assemble

Mechanical Injectors

Clean the injector internal components with clean diesel fuel and a clean rag. Make sure there is no debris in the internal parts of the injector.

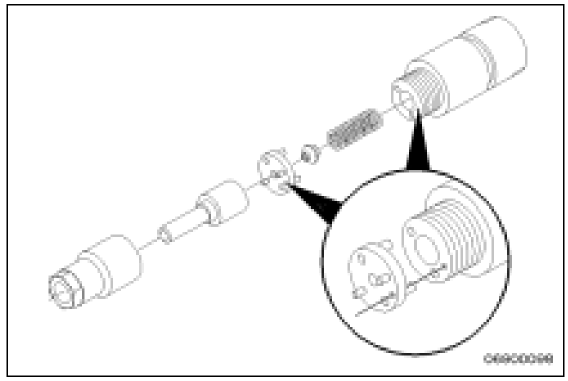


Install shims necessary to modify the nozzle opening pressure. More shims raise the nozzle opening pressure, less shims lower the nozzle opening pressure.



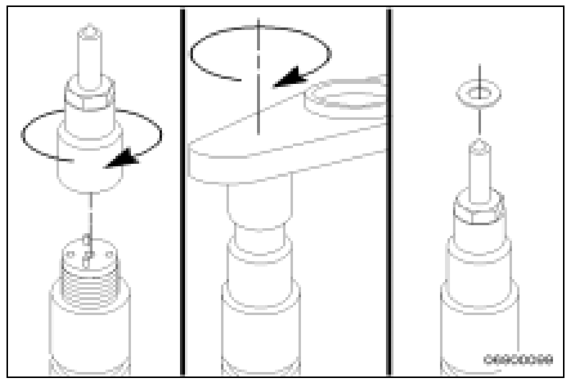
Install the spring, button, intermediate plate, and nozzle/needle.

Make sure that the intermediate plate is in the correct orientation with the supply hole on the plate lining up with the supply hole on the holder.



Install the retaining nut finger tight. Place the injector in the injector clamp and tighten the retaining nut. Install the sealing washer and body o-ring.

Torque Value: 47 N•m [35 ft-lb]



Install

CAPS Fuel System

Make sure that the injector bore is clean and that only one (1) sealing washer is installed on the injector nozzle.

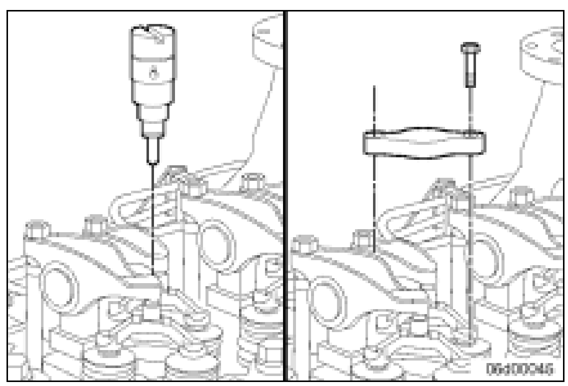
Lubricate the injector o-ring with clean engine oil.

Place the injector in the head in the proper orientation.

Place the injector hold-down clamp on top of the injector and make sure that the injector is fully seated in the injector bore.

Install the injector hold-down and tighten.

Torque Value: 10 N•m [89 in-lb]



Follow-Up

CAPS Fuel System

Install the fuel connector. Refer to Procedure 006-052.

Install the rocker lever cover. Refer to Procedure 003-011.

Install the high pressure fuel lines. Refer to Procedure 006-051.

Operate the engine and check for leaks.

High Pressure Injector Supply Lines Removal/Installation

Initial Check

CAPS Fuel System

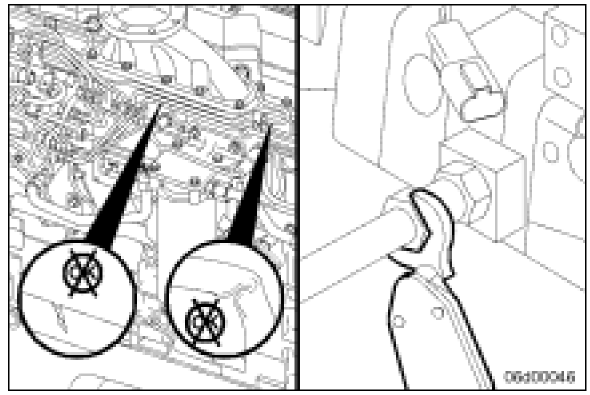
Inspect the lines for cracks, chafing, or leaks. Make sure that the lines are tightened to the proper specification.

Check the fuel pump connection.

Torque Value: 24 N•m [18 ft-lb]

Check the cylinder head connection.

Torque Value: 38 N•m [28 ft-lb]



Initial Check

Cummins Common Rail Fuel System

Check the fuel pump connection.

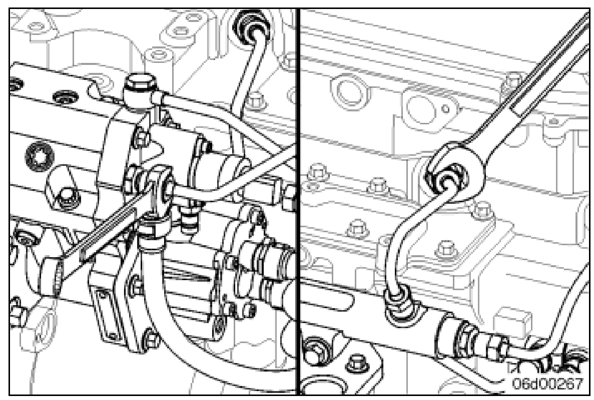
Torque Value: 38 N•m [28 ft-lb]

Check the cylinder head connection.

Torque Value: 38 N•m [28 ft-lb]

Check the fuel rail connection.

Torque Value: 38 N•m [28 ft-lb]



Prepare

Remove

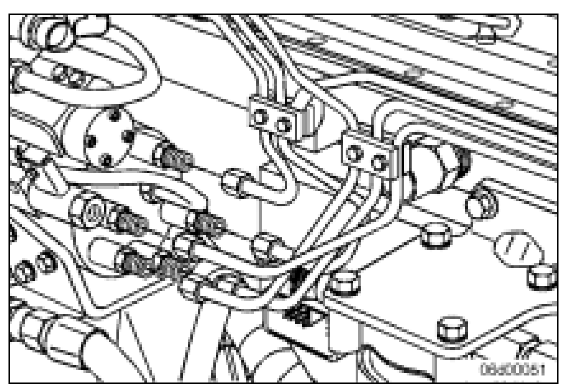
CAPS Fuel System

Remove the fuel line from the injection pump.

NOTE: Use two (2) wrenches to prevent the outlet fitting from turning.

Remove the fuel line clamp capscrews from the intake cover. This must be done before injection lines can be pulled loose from cylinder head.

Remove the fuel line from the cylinder head.



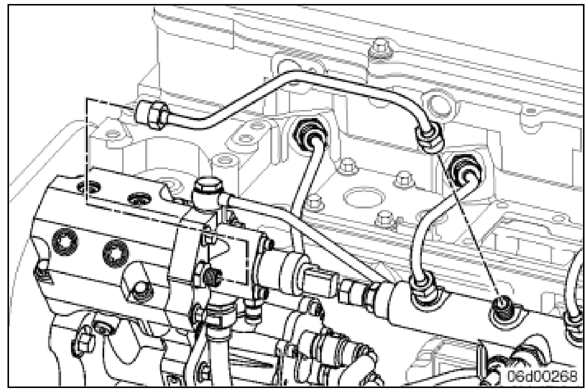
Remove

Cummins Common Rail Fuel System

If necessary, remove the air intake connection or turbo control actuator.

Loosen the fuel line at the fuel rail and the fuel connector or high-pressure pump outlet fitting.

Remove the high-pressure fuel line.

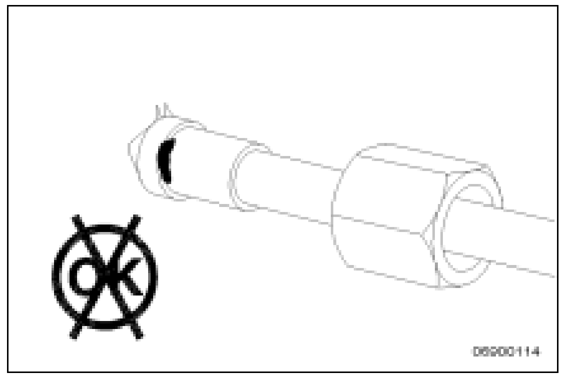


Clean and Inspect for Reuse

Check the ferrules of the lines for any signs of burrs or foreign material.

Inspect the sealing surface on the cone for severe deformation that would prohibit reuse.

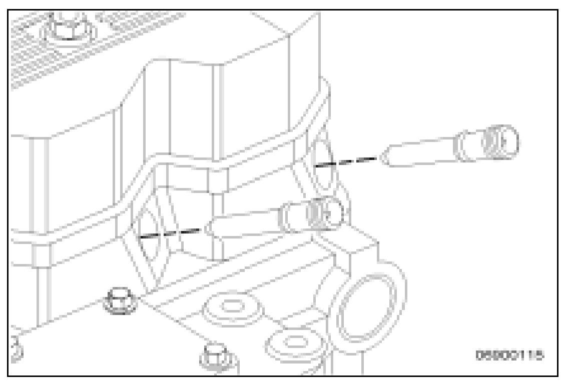
Check for cracks and deformation.



Install

CAPS Fuel System

Before installing the injector supply lines, make sure that the fuel connector is fully and properly seated against the injector. Refer to Procedure 006-052.



Install the fuel lines in the reverse order of removal.

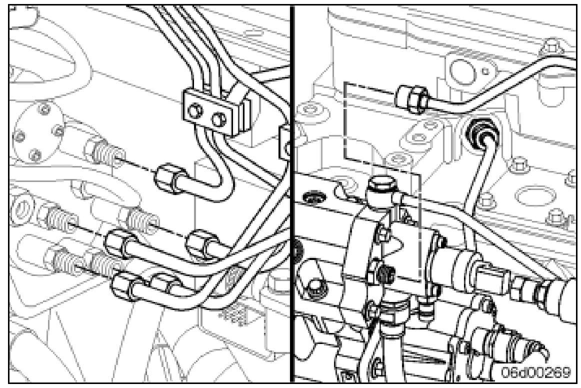
Check the fuel pump connection.

Torque Value: 24 N•m [18 ft-lb]

Check the cylinder head connection.

Torque Value: 38 N•m [28 ft-lb]

Operate the engine and check for leaks.

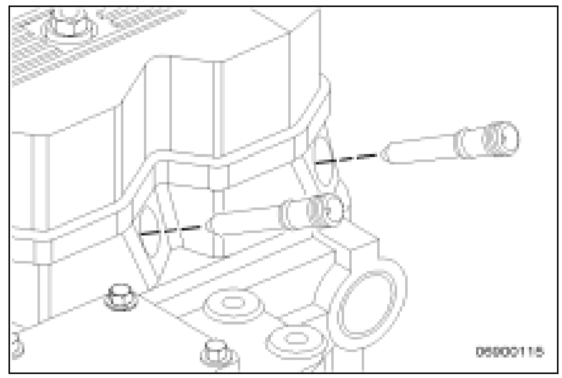


Install

Cummins Common Rail Fuel System

Before installing the injector supply lines, make sure that the fuel connector is fully and properly seated against the injector. Refer to Procedure 006-052.

For Cummins Common Rail Fuel Systems, be certain that the high-pressure connector retaining nut is tightened. Refer to Procedure 006-052.



Install the fuel lines in the reverse order of removal.

Check the fuel pump connection.

Torque Value: 38 N•m [28 ft-lb]

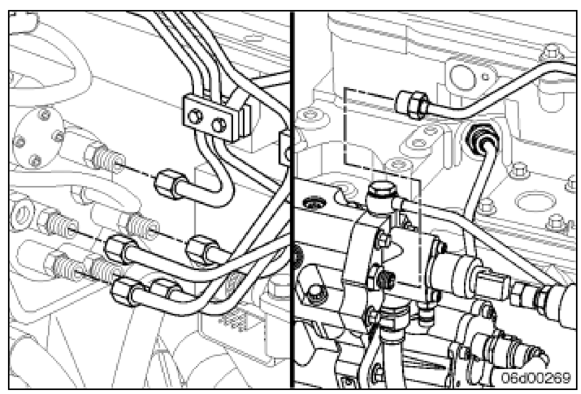
Check the cylinder head connection.

Torque Value: 38 N•m [28 ft-lb]

Check the fuel rail connection.

Torque Value: 38 N•m [28 ft-lb]

Operate the engine and check for leaks.



Follow-Up

Head Mounted Fuel Connector

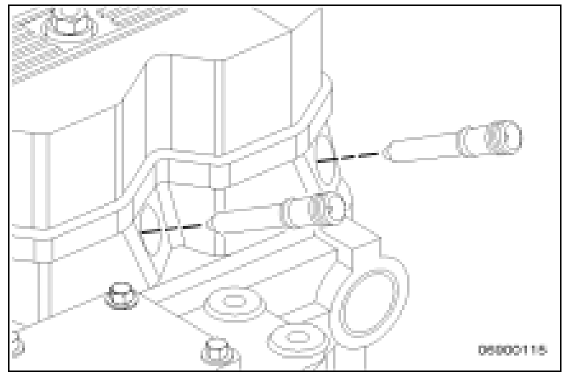
Prepare

Remove

CAPS Fuel System

Remove injector supply line. Refer to Procedure 006-051.

Use fuel connector puller, Part Number 3825157, to remove the fuel connector from the cylinder head.



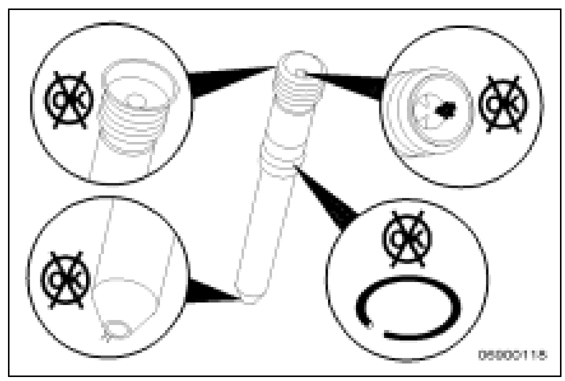
Inspect for Reuse

A new high-pressure connector must be installed if a new injector is being installed.

Inspect the fuel connector. Look for burrs or deformation around the inlet and outlet sides of the connector.

Check the edge filter for signs of plugging or material contamination. Do not reuse a high-pressure fuel connector debris is present.

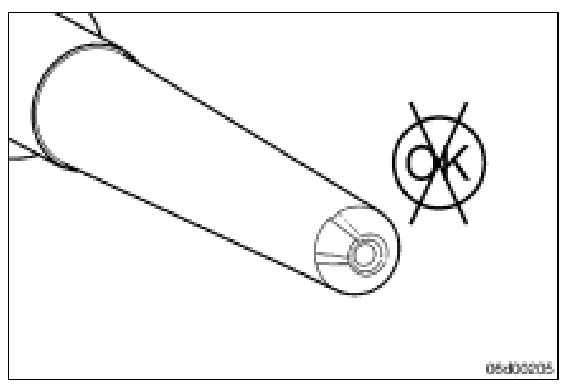
Check the o-ring for tearing or deterioration.



Inspect the outlet sealing surface of the high-pressure connector for wear, an uneven seating surface, or signs of leakage.

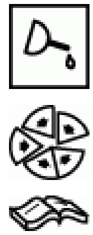
When a high-pressure fuel leak is present, small lines or cuts in the connector will be eroded into the seating surface.

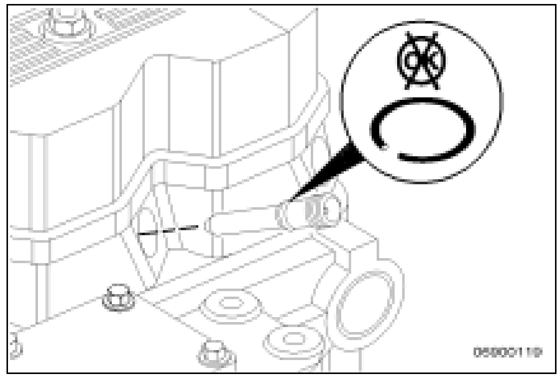
The high-pressure connector and injector must be replaced when this failure is observed.



Install

CAPS Fuel System





Oil the fuel connector o-ring with clean engine oil.

Carefully push the fuel connector into the head until it stops against the injector. Be certain the injector is fully seated in the injector bore before installing the fuel connector. Refer to Procedure 006-026.

Install the high-pressure fuel lines. Refer to Procedure 006-051.

Operate the engine and check for leaks.

Follow-Up

Fuel Pump Air Bleed Line

Prepare

WARNING

When using a steam cleaner, wear safety glasses or a face shield, as well as protective clothing. Hot steam can cause serious personal injury.

WARNING

Wear appropriate eye and face protection when using compressed air. Flying debris and dirt can cause personal injury.

CAUTION

Do not use the air bleed line as a handle or step. Doing this may result in cracks or damaged air bleed line that will cause fuel leaks. Make sure that steam does not spray directly on the electrical connections on the top of the accumulator block or fault codes will possibly occur.

Thoroughly steam-clean the entire fuel pump.

Dry the fuel pump with compressed air.

Remove

ISC and QSC8.3 With CAPS Injection Pump

WARNING

To reduce the possibility of an air bleed line leak due to a broken air bleed line, use two wrenches during removal and installation. Failure to do so may result in a cracked fuel line. In certain applications, with the fuel tank above the head of the engine, this will result in fuel draining from the fuel tank.

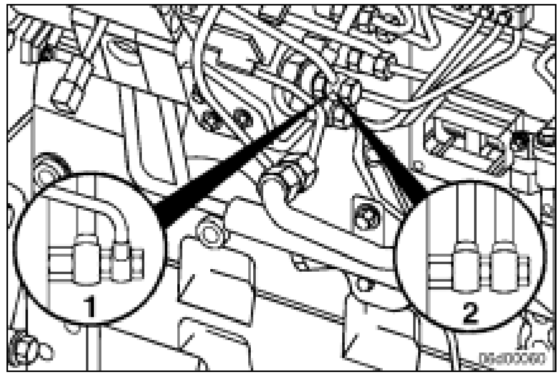
NOTE: There are three styles of air bleed lines. Identify your style and use the appropriate procedures that follow.

Style One (1):

Remove the banjo capscrew at the injection control valve drain fitting of the fuel pump. Use two wrenches to prevent the line from being bent.

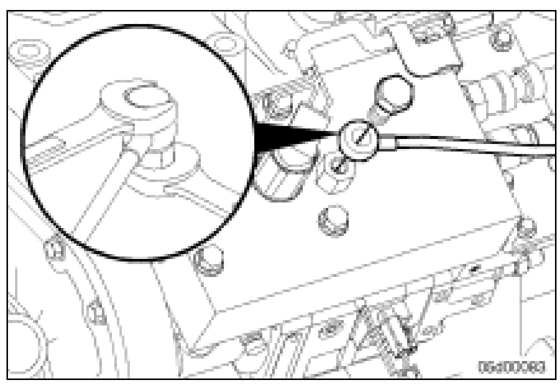
Style Two (2):

Remove the banjo capscrew at the injection control valve drain fitting of the fuel pump. Remove the hollow banjo fitting holding the air bleed line. Use two wrenches to prevent the line from being bent.



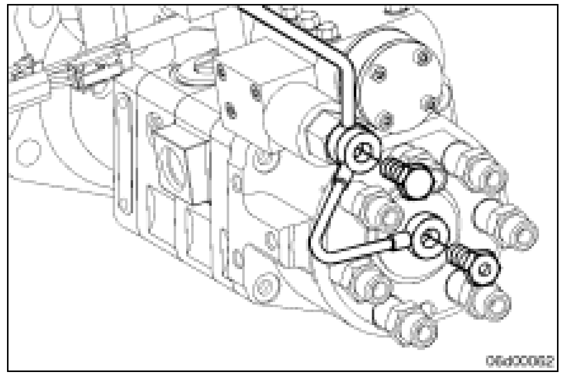
Remove the banjo capscrew at the air bleed fitting on top of the fuel pump. It is located on the accumulator module next to the two pumping control valves.

Use two wrenches to prevent the air bleed fitting from turning.



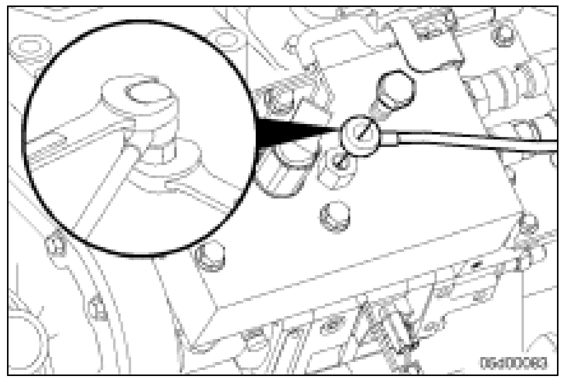
ISL and QSL9 With CAPS Injection Pump

Remove the banjo bolt from the injection control valve drain fitting and the distributor plug.



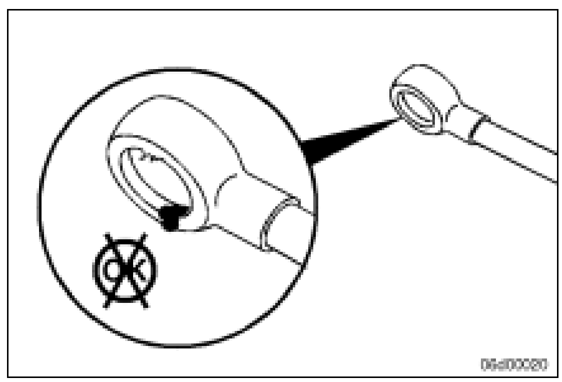
Remove the banjo capscrew at the air bleed fitting on top of the fuel pump. It is located on the accumulator module next to the two pumping control valves.

Use two wrenches to prevent the air bleed fitting from turning.



Inspect for Reuse

Inspect the lines for pinches, bends, or damaged connectors.

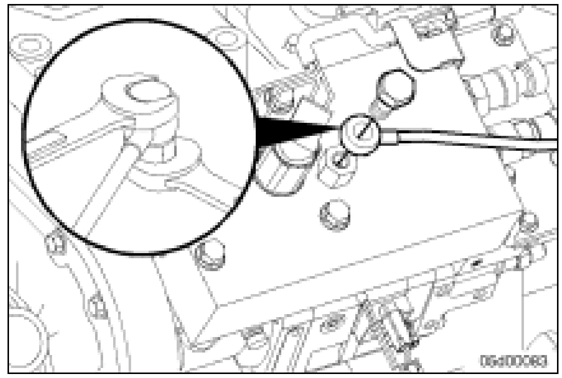


Install

ISC and QSC8.3 With CAPS Injection Pump

WARNING

To reduce the possibility of an air bleed line leak due to a broken air bleed line, use two wrenches during removal and installation. Failure to do so may result in a cracked fuel line. In certain applications, with the fuel tank above the head of the engine, this will result in fuel draining from the fuel tank.

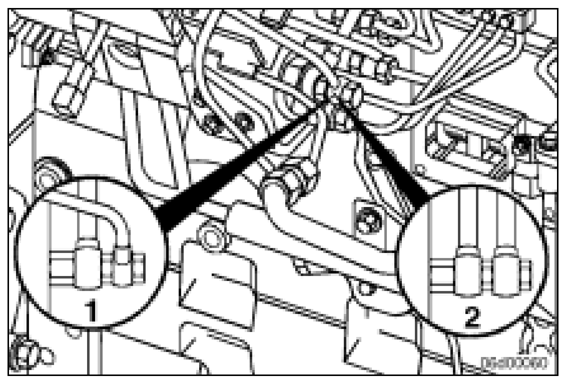


Install the banjo capscrew at the air bleed fitting on top of the fuel pump. Use two wrenches to prevent the line from being bent.

Torque Value: 8 N•m [70 in-lb]

NOTE: Use new sealing washers.

Style One (1):



Install the banjo capscrew drain fitting on the fuel pump at the injection control valve. Use two wrenches to prevent the line from being bent.

Torque Value: 8 N•m [70 in-lb]

NOTE: Use new sealing washers.

Style Two (2):

Install the hollow banjo fitting at the injection control valve drain fitting to secure the air bleed line. Use two wrenches to prevent the line from being bent.

Torque Value:24 N•m [18 ft-lb]

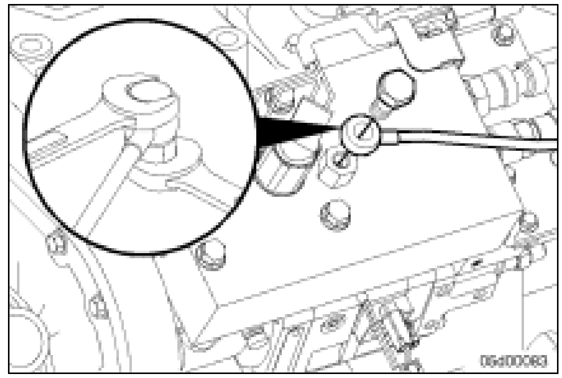
Install banjo capscrew. Use two wrenches to prevent the line from being bent.

Torque Value:24 N•m [18 ft-lb]

NOTE: Use new sealing washers.

ISL and QSL9 With CAPS Injection Pump

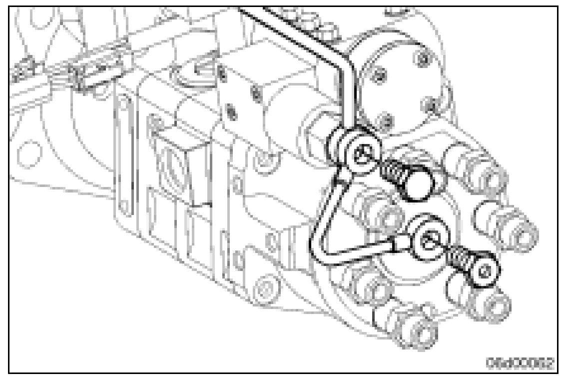
Install the banjo capscrew at the air bleed fitting on top of the fuel pump. Use two wrenches to prevent the air bleed fitting from turning.



Install the banjo capscrew in the injection control valve drain fitting and the distributor plug.

Torque Value: 8 N•m [70 in-lb]

NOTE: Use new sealing washers.

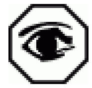


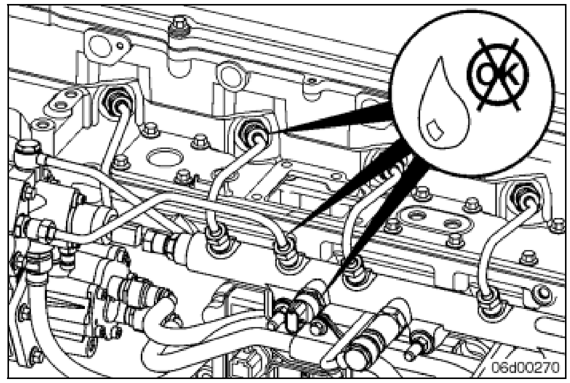
Follow-Up

Operate the engine and check for leaks.

Fuel Rail

Initial Check





WARNING

The pressure within the fuel rail is extremely high. High pressure can penetrate the skin. Stand clear of the engine while it is running.

WARNING

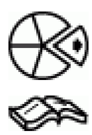
The fuel pump high-pressure fuel lines and fuel rail contain very high-pressure fuel. To avoid the possibility of personal injury and property damage, never loosen any fittings while the engine is running.

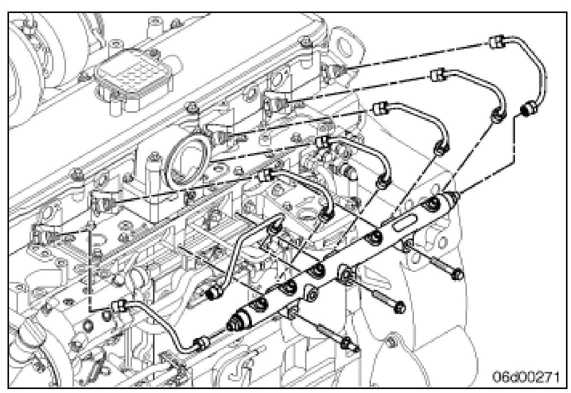
Inspect the fuel pressure sensor, high-pressure fuel line connections, and male unions for leaks.

Prepare

Disconnect the fuel pressure sensor from the engine wiring harness. Refer to Procedure 019-043 in Troubleshooting and Repair Manual, CM850 Electronic Control System, ISC and ISL Engines, Bulletin 4021416.

Remove





Remove the high-pressure fuel lines from the fuel rail. Refer to Procedure 006-051.

Remove the fuel drain line from the fuel rail pressure relief valve. Refer to Procedure 006-013.

Remove the capscrews that secure the fuel rail to the cylinder head. Remove the fuel rail assembly.

Install

Install the fuel rail assembly. Follow the proper sequence to make sure that high-pressure fuel lines are properly aligned.

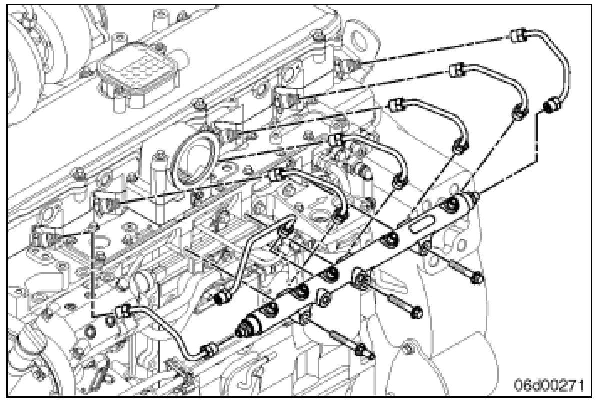
Install the fuel rail assembly capscrews finger-tight.

Install the high-pressure fuel lines finger-tight.

Tighten the fuel rail assembly capscrews.

Torque Value: 43 N•m [32 ft-lb]

Tighten the high-pressure fuel lines. Refer to Procedure 006-051.



Follow-Up

Install the fuel drain line to the fuel pressure relief valve. Refer to Procedure 006-013.

Install the fuel pressure sensor to the engine wiring harness. Refer to Procedure 019-043 in Troubleshooting and Repair Manual, CM850 Electronic Control System, ISC and ISL Engines, Bulletin 4021416.

Operate the engine and check for leaks.

Fuel Pressure Relief Valve

Initial Check

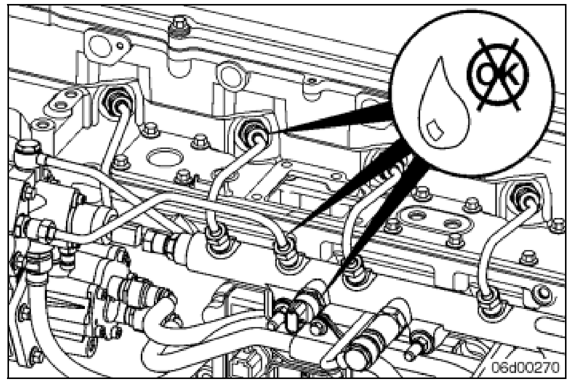
WARNING

The pressure within the fuel rail is extremely high. High-pressure can penetrate the skin. Stand clear of the engine while it is running.

WARNING

The fuel pump high-pressure fuel lines and fuel rail contain very high pressure fuel. To avoid the possibility of personal injury, never loosen any fittings while the engine is running.

Operate the engine and check for external fuel leaks.



Check for a fuel rail pressure relief valve that leaks excessive fuel to drain.

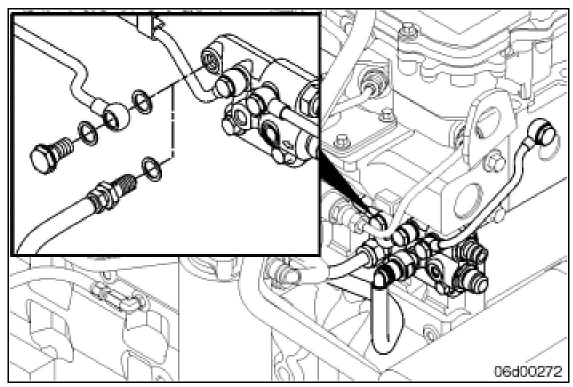
Measurement of fuel rail pressure relief valve leakage requires use of a fuel return hose, Part Number 3164618. If necessary this tool can be constructed. Refer to Procedure 006-026. The tool is used to isolate the leakage from just the fuel rail pressure relief valve so that it can be measured into a graduated cylinder.

NOTE: If Fault Code 449 or 2311 is active, do not replace the fuel rail pressure relief valve without first determining the cause of the fault condition. Refer to the appropriate troubleshooting tree(s).

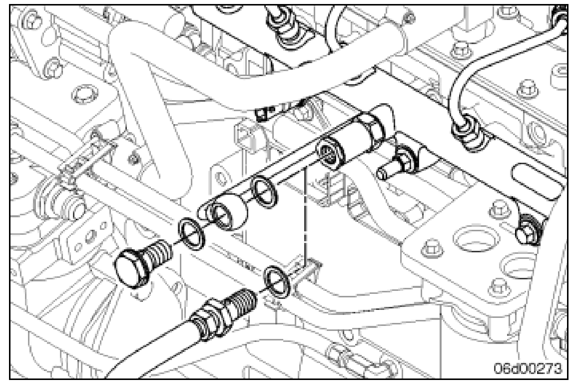
Remove the M12 banjo bolt that connects the fuel rail pressure relief valve drain line to the fuel drain manifold.

Install a fuel return hose, Part Number 3164618, at the fuel drain manifold.

Route the fuel return hose into a collection device.



Alternatively, fuel rail pressure relief valve leakage measurement tool, Part Number 4164617, can be installed at the fuel rail pressure relief valve.



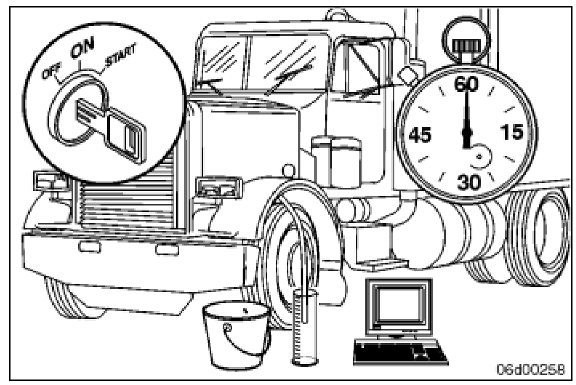
Test

Start the engine and allow the engine to idle.

Measure the leakage.

Specification:

Less than 30 drops per minute must drain from the fuel rail pressure relief valve while the engine runs at idle.



CAUTION

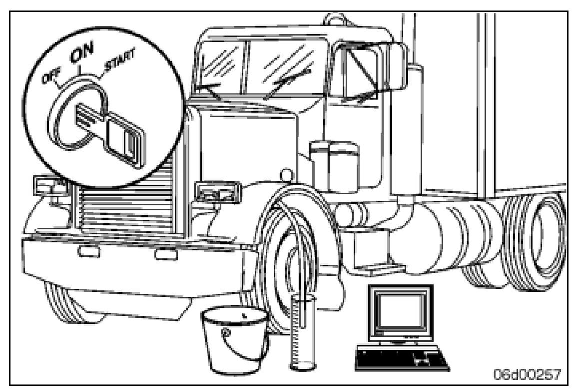
Fuel is at high pressure during this test. After connecting the test fitting, close the engine cover and stand clear of high-pressure fuel lines.

While the engine is running at idle, use the INSITE™ High Pressure Leak Test to create higher fuel rail pressure. INSITE™ will command 1500 BAR fuel rail pressure while the engine is at idle during this test.

Specification:

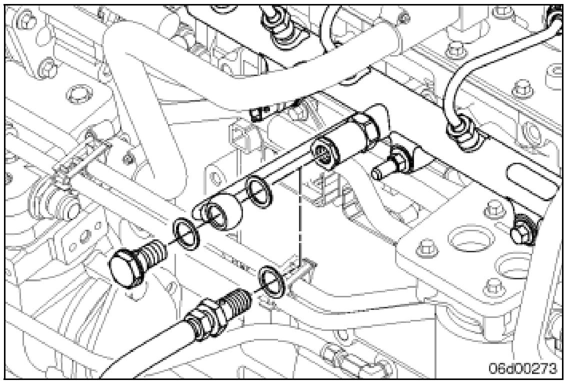
Less than 30 drops of fuel per minute must drain from the fuel rail pressure relief valve.

If fuel rail pressure relief valve leakage is excessive, it must be replaced. However, make certain that Fault Code 449 or 2311 is not active indicating that a system failure is causing the fuel rail pressure relief valve to open.



Remove the fuel return hose and install the fuel drain line banjo bolt. Refer to Procedure 006-013.

Operate the engine and check for leaks.

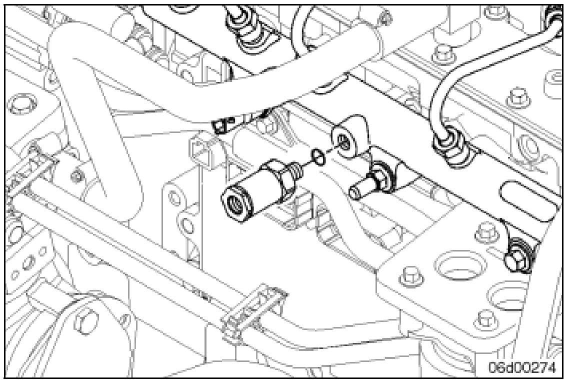


Remove

Remove the fuel drain line from the fuel rail pressure relief valve. Refer to Procedure 006-013.

Remove the fuel pressure relief valve adapter and copper seal washer.

Remove the fuel pressure relief valve.

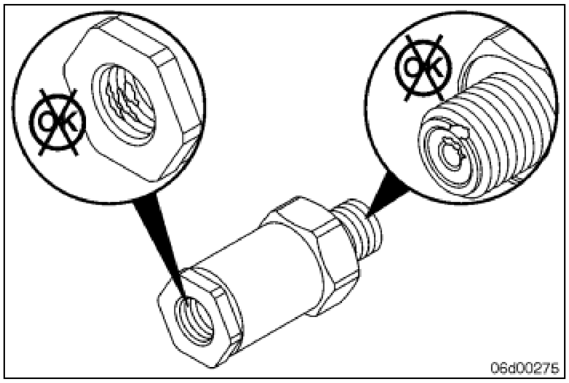


Inspect for Reuse

If the fuel pressure relief valve exhibits excessive leakage to drain, it must not be reused.

Inspect the high-pressure seal surface on the fuel pressure relief valve and also in the fuel rail for damage. Do not reuse components if the high-pressure seal joint is damaged.

Inspect the copper seal washer and adapter fitting for damage.



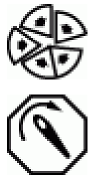
Install

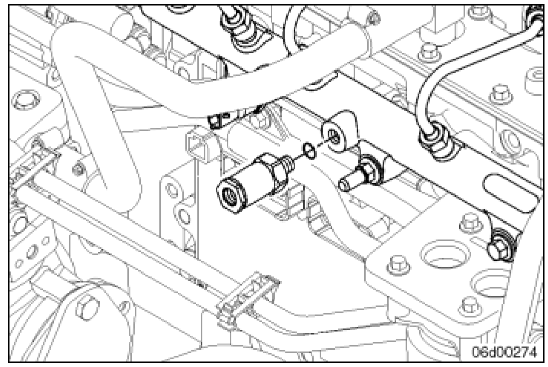
Install the fuel pressure relief valve with Lubriplate™ on the threads.

Torque Value: 100 N•m [74 ft-lb]

If the reducer has been removed from the fuel rail pressure relief valve, install the reducer with a new copper seal washer.

Torque Value: 37 N•m [27 ft-lb]





Follow-Up

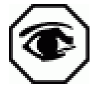
Install the fuel drain line to the fuel pressure relief valve. Refer to Procedure 006-013.

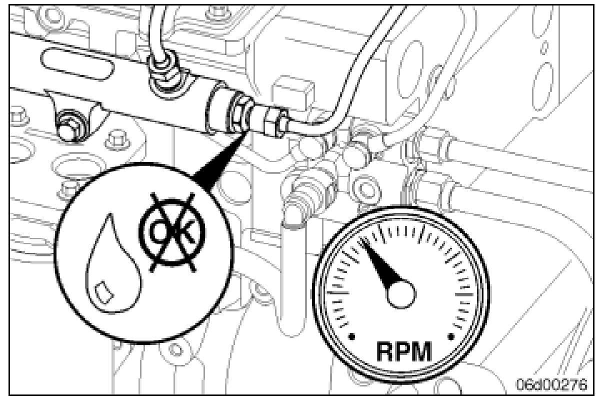
Operate the engine and check for leaks.

Fuel Rail High Pressure Fitting

Initial Check

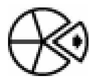
Operate the engine and check for external leaks.

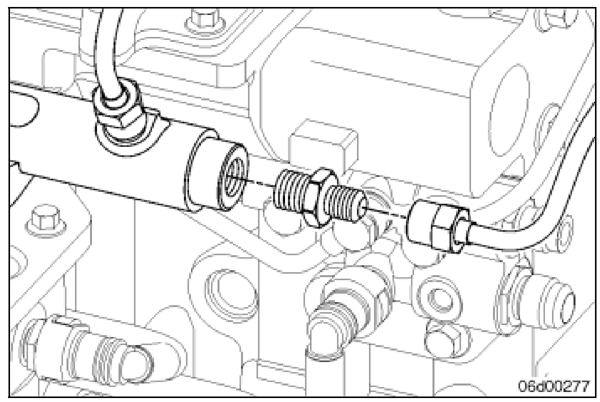




Remove

Remove the high-pressure fitting only if a leak is detected.





Install

Flush the outlet fitting using contact cleaner.

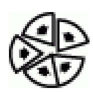
Apply Lubriplate™ to the high-pressure fitting threads.

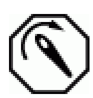
Install the high-pressure fitting.

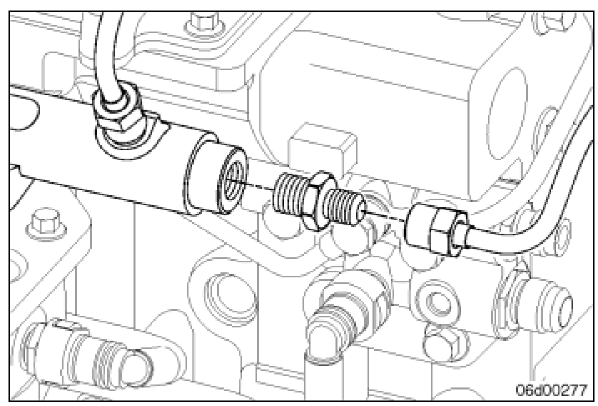
Torque Value: 100 N•m [74 ft-lb]

Reinstall the high-pressure fuel line. Refer to Procedure 006-051.

Operate the engine and check for leaks. If a leak occurs after replacing the fitting, replace the rail.







Follow-Up

Air in Fuel

Prepare

Setup

Obtain a 1.09 mm [0.043 in] orificed diagnostic fuel line, Part Number 3164621. This tool can also be constructed following the steps below.

Obtain a container suitable for collection of fuel that exits the diagnostic fuel line (a five gallon bucket is recommended).

Construct a sight tube (CAPS fuel systems only) using the following steps.

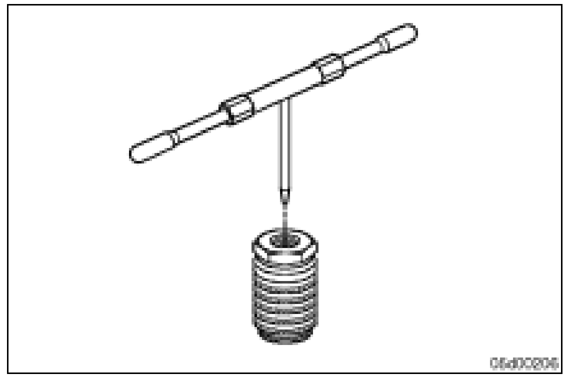
Construct a 1.09 mm [0.043 in] orificed diagnostic fuel line.

NOTE: This tool is available for purchase, Part Number 3164621.

A 0.043-inch orifice diagnostic fuel line is used in procedures to create rated flow through the low pressure fuel system without the need to operate the engine under load.

Tap a female quick connect, Part Number 3376859.

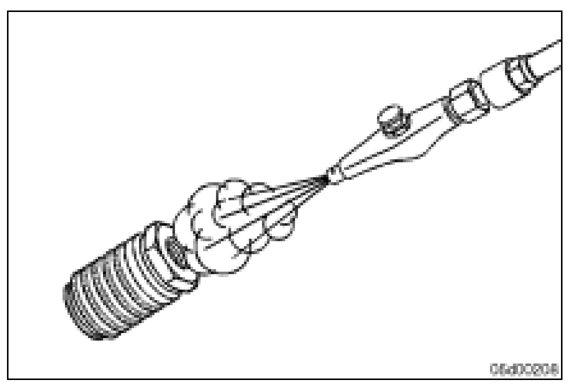
Tap size: 8-36 national fine (U.S.)



WARNING

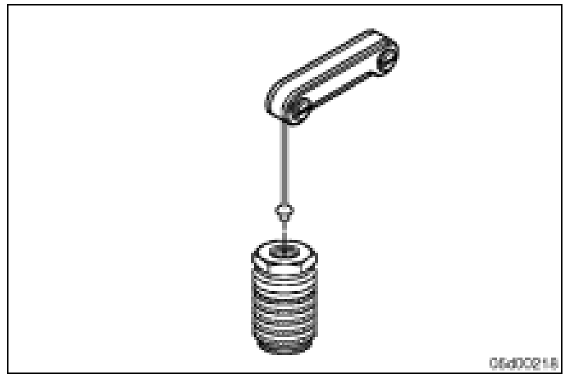
Wear appropriate eye and face protection when using compressed air. Flying debris and dirt can cause personal injury.

Clean the female quick connect, Part Number 3376859, with compressed air.



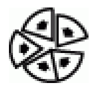
Assemble a 1.09 mm [0.043 in] injector orifice, Part Number 3045018, with washer, to the female quick connect, Part Number 3376859.

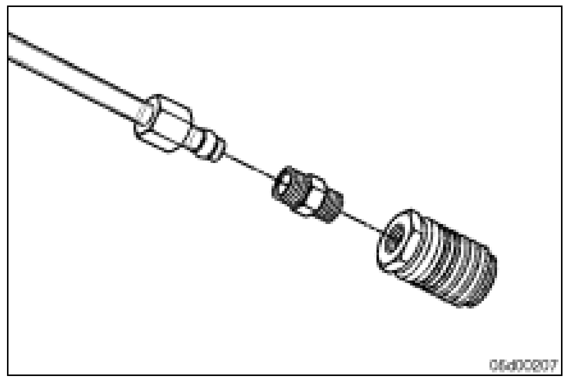
NOTE: To obtain correct flow, use a 1.09 mm [0.043 in] injector orifice, Part Number 3045018.



Attach the orifice to an appropriate length (it must reach from the fuel pump to the fuel tank) of 1/4-inch, or larger, tubing.

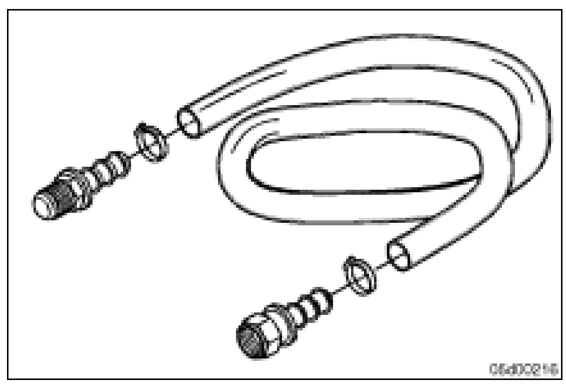
NOTE: It is recommended that this tool be marked and identified as having a 1.09 mm [0.043 in] orifice installed. This is to ensure that there is no confusion when using this tool in the future.





Construct a sight tube (CAPS fuel systems only):

Assemble two (one male and one female, 7/8-14 thread barb-tite fittings and hose clamps to a 61 cm [2 ft] long number-10 clear hose approved for use with diesel fuel.

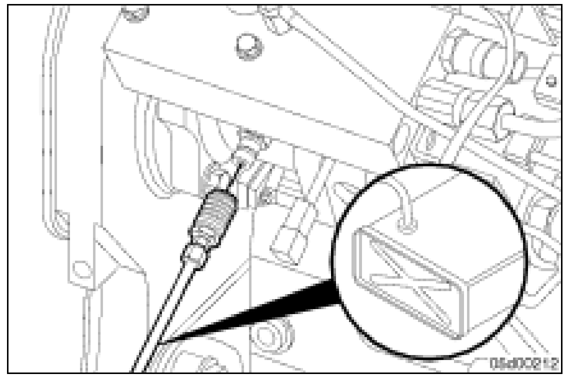


Measure

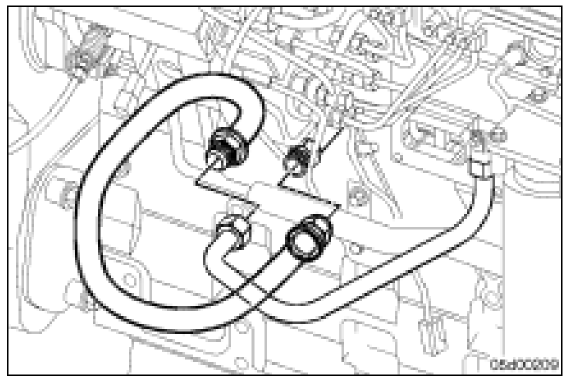
CAPS Fuel System

Attach the 1.09 mm [0.043 in] diagnostic fuel line at the fuel injection pump's diagnostic fitting.

Run the outlet of the diagnostic fuel line into the fuel collection container (or the vehicles fuel tank).



Install the sight glass between the fuel filter head and the fuel injection pump inlet.



Run the engine from idle to high idle several times to purge the air induced while installing the diagnostic fuel line.

Run the engine up to high idle while another technician checks for air in the system.

NOTE: A small amount of air in the inlet line is acceptable. Ignore any air that is observed in the tube running back to the fuel tank.

Afterwards, operate the engine at idle and observe any air in the fuel supply. If air is observed, isolate the air to the following components:

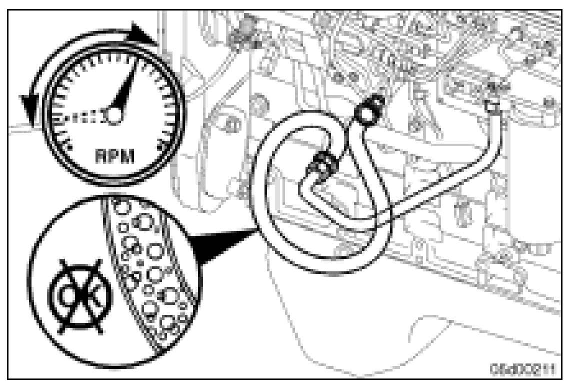
Fuel filter assembly

Fuel heater

Fuel lift pump assembly

OEM fuel plumbing

Fuel tank stand-pipe

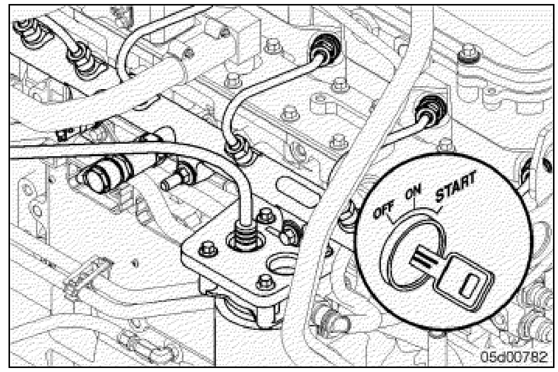


Cummins Common Rail Fuel System

NOTE: A symptom of air-in-fuel for the ISC and ISL engine equipped with a Cummins Common Rail Fuel System is an audible surge associated with fuel system pressure fluctuations due to air in the fuel supply.

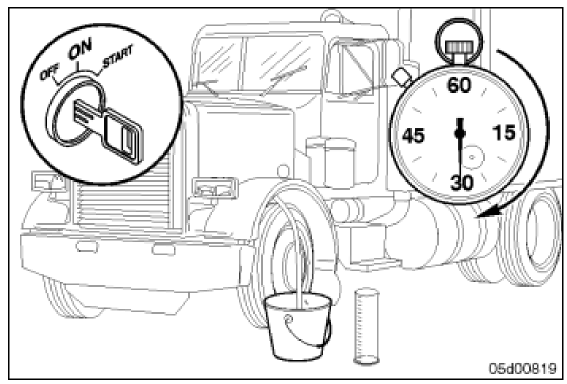
The following test method will simulate rated fuel flow through the system so that air in fuel problems may be diagnosed.

Install a Compuchek® fitting, Part Number 3824842, at the inlet to the 2 um fuel filter and attach the 1.09 mm [0.043 in] diagnostic fuel line.



Route the outlet of the 0.043-inch diagnostic fuel line into a collection device of suitable size (a 5-gallon bucket is recommended).

Start the engine and run the engine from idle to high idle several times to purge the air induced while installing the diagnostic fuel line.



Observe the fuel flow exiting the diagnostic fuel line while the engine runs at idle.

A few bubbles exiting the line is expected. A foamy appearance is indication of a leak that allows air to enter, a severe inlet restriction that causes cavitation, or a system that is not yet primed. If fuel inlet restriction (refer to Procedure 006-020) is not excessive, the source of air entry should be isolated to one of the following:

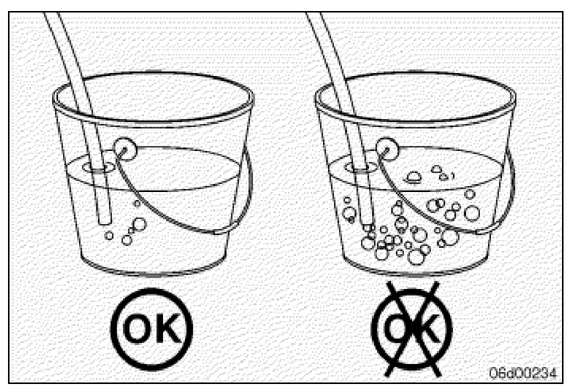
Suction fuel lines

ECM cooling plate assembly

OEM fuel lines

Suction-side fuel filter assemblies

Stand-pipe(s) in the fuel tank(s)



Follow Up

Remove all test fuel lines and install the low pressure fuel lines. Refer to Procedure 006-024.

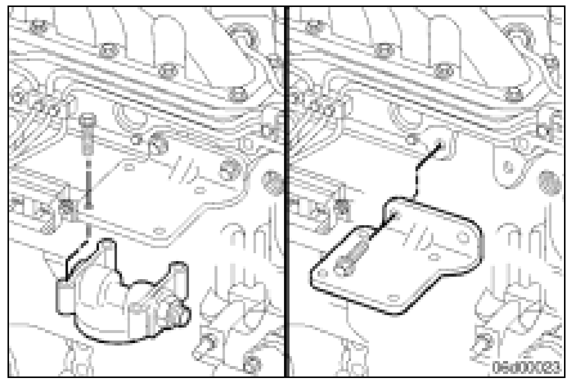
Fuel Filter Head Bracket Removal/Installation

Prepare

Remove the fuel filter. Refer to Procedure 006-015.

Remove the fuel supply lines from the filter head. Refer to Procedure 006-024.

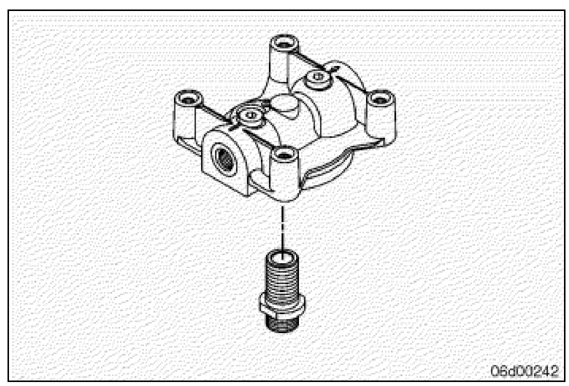
Remove



Remove the four (4) capscrews retaining the filter head.

Remove the filter head bracket from the engine.

Disassemble



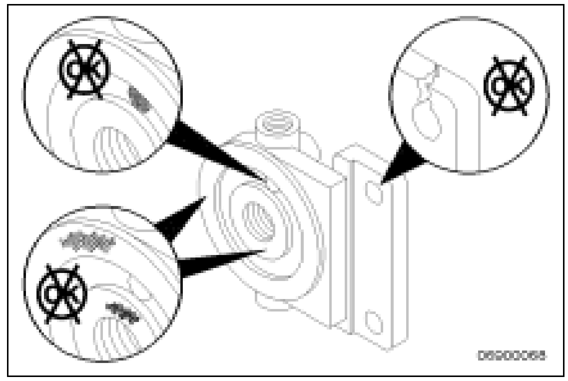
Fuel heater equipped engines have a filter spud that can be removed for the purpose of removing the fuel heater.

Remove the fuel heater and filter spud, if equipped.

Clean and Inspect for Reuse

Inspect the filter head for cracks, passage blockage, material or debris on the sealing surfaces.

Clean any loctite from the filter adapter threads.



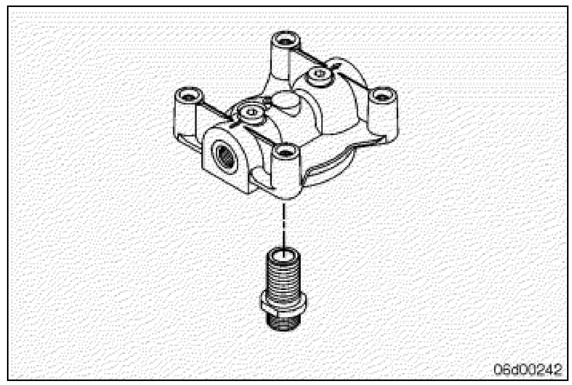
Assemble

Apply Loctite™ 277, or equivalent, to the filter adapter threads that are engaging the filter head.

Assemble the filter head.

Install the filter adapter and fuel heater (if equipped).

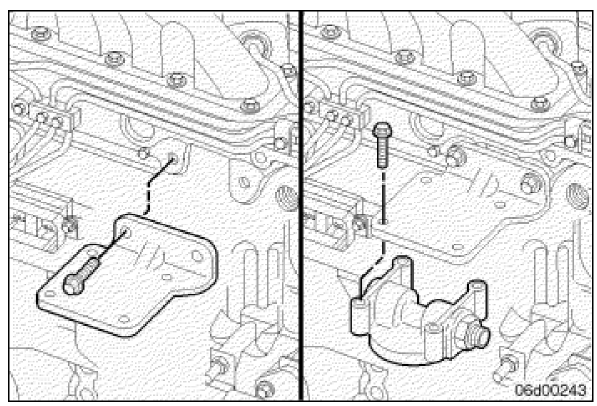
Torque Value: 27 N•m [20 in-lb]



Install

Install the bracket and filter head. Tighten the retaining capscrews.

Torque Value: 43 N•m [32 ft-lb]



Follow-Up

Install the fuel filter. Refer to Procedure 006-015.

Install the fuel supply lines. Refer to Procedure 006-024.

Operate the engine and check for leaks.

Fuel Pump Removal/Installation

Prepare

Remove the fuel supply lines from the fuel pump. Refer to Procedure 006-024.

Remove the fuel drain line from the fuel pump. Refer to Procedure 006-013.

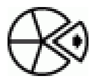
Disconnect the engine harness from the fuel pump actuator.

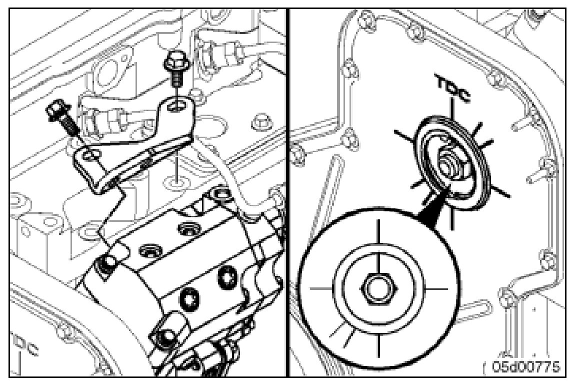
Remove the fuel pump gear access cover.

Remove

Remove the fuel pump upper support bracket.

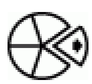
Locate top dead center for cylinder Number 1 by barring the engine until the line on the fuel pump gear aligns with the front cover mark for top dead center.

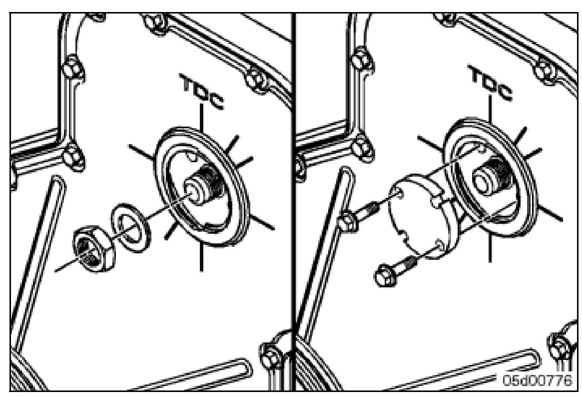




Remove the fuel pump gear nut and washer.

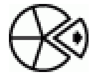
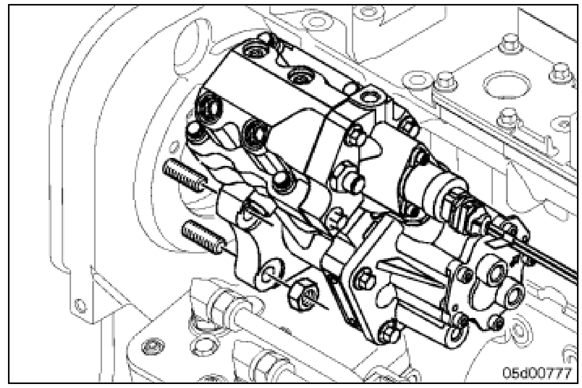
Pull the fuel injection pump drive gear loose from the pump drive shaft. This can be done using Cummins Gear Puller, Part Number 3824469.





Remove the four mounting nuts that hold the fuel pump to the gear housing.

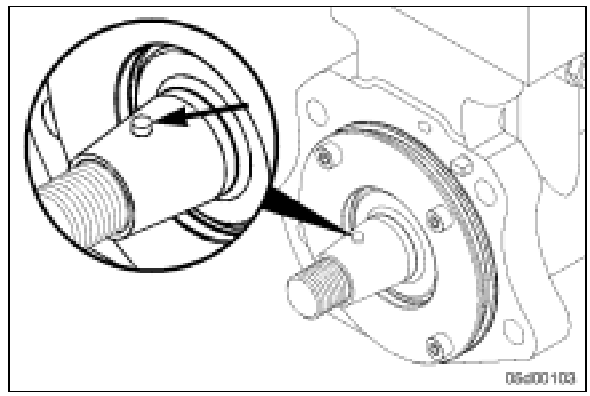
Remove the fuel pump.

Inspect for Reuse

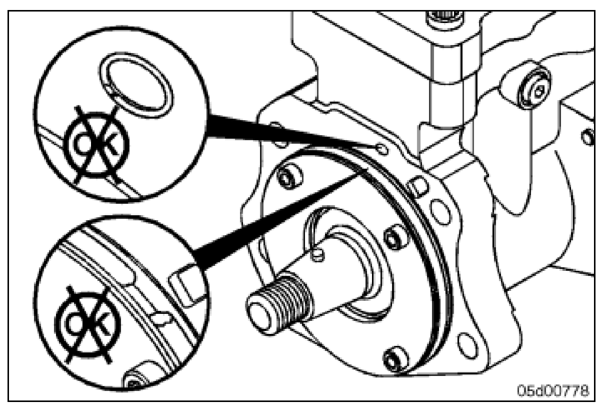
The dowel pin in the fuel pump driveshaft must not be sheared.

If the dowel is sheared, the cam housing or fuel pump must be replaced and the drive gear must be replaced.

Be sure that the pilot o-ring is not cut or damaged.

Be sure that the pump oil supply o-ring is not damaged.

Install

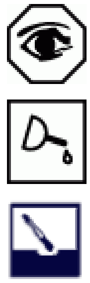
Be sure that the engine is at Number 1 cylinder top dead center. The fuel pump gear timing mark should align with the top dead center mark on the front cover.

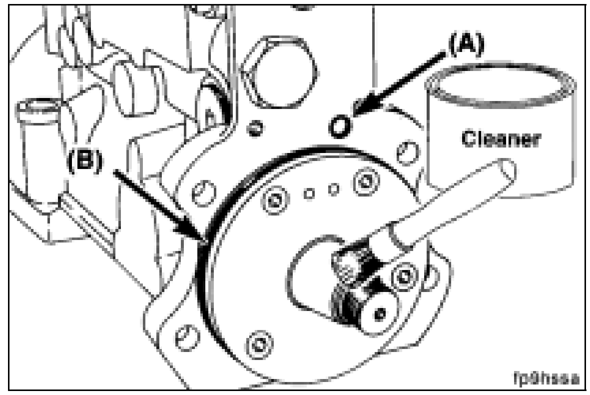
Lubricate the pilot o-ring with clean engine oil.

Clean the nose of the camshaft with an evaporative cleaner.

Clean the fuel pump gear inside diameter with an evaporative cleaner.

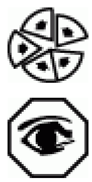
The fuel pump drive gear inside diameter and the drive shaft outside diameter must be clean and dry before installing the gear.

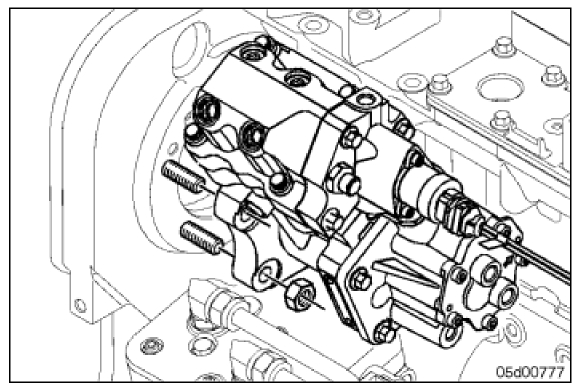




Slide the fuel injection pump shaft through the drive gear and position the fuel injection pump flange onto the mounting studs.

Make sure the dowel pin in the drive shaft lines up with the keyway in the fuel injection pump gear.





Installation Sequence:

Install the pump mounting nuts (leave loose).

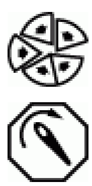
Install the support bracket bolts (leave loose).

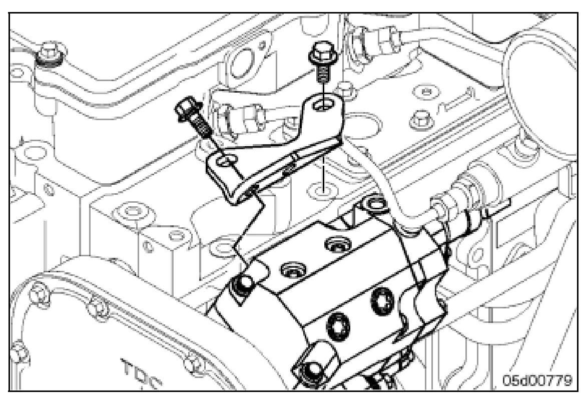
Tighten the pump mounting nuts.

Torque Value: 44 N•m [32 ft-lb]

Tighten the support bracket bolts.

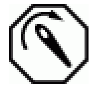
Torque Value: 65 N•m [48 ft-lb]

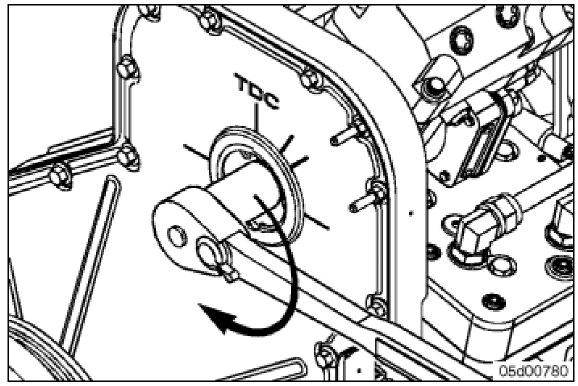




Tighten the fuel injection pump drive gear nut.

Torque Value: 180 N•m [132 ft-lb]





Follow-Up

Install the access cover in the front cover.

Install the fuel supply lines to the fuel pump. Refer to Procedure 006-024.

Install the fuel drain line to the fuel pump. Refer to Procedure 006-013.

Connect the wire harness to the fuel pump actuator.

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Intake Air Filter Removal/Installation

Prepare

Remove

Install

Follow-Up

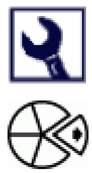
Air Crossover Removal/Installation

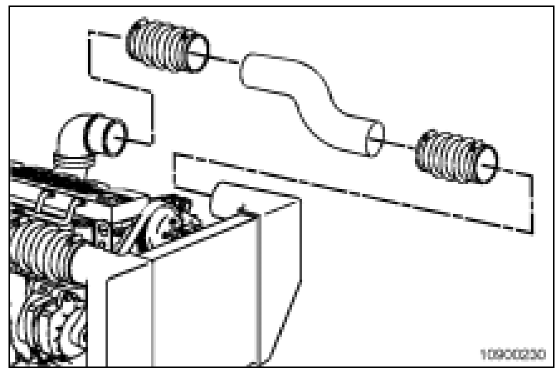
Prepare

Remove

Loosen the hose clamps, and position the crossover tube so that it can be removed.

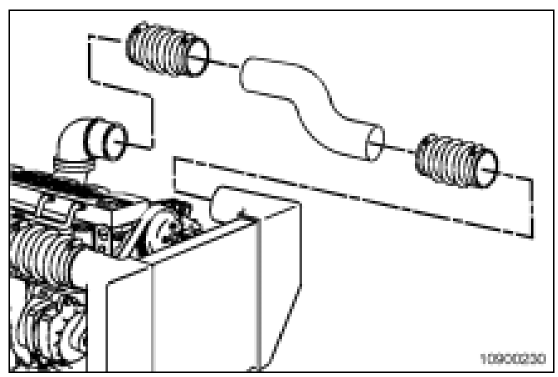
Remove the tube.





Inspect for Reuse

Check the crossover tube for cracks, holes, and worn sections. Replace with a new hose and clamps if necessary.

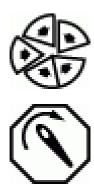


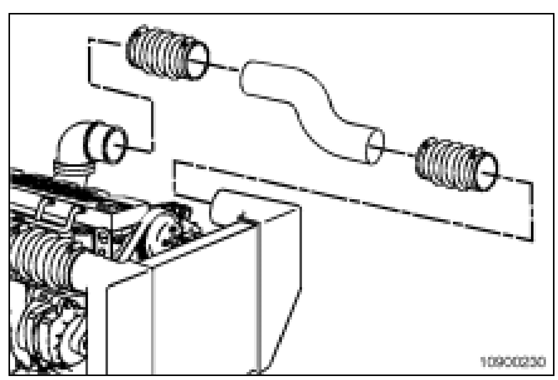
Install

Install the crossover tube and clamps in the reverse order of removal.

Tighten the clamps.

Torque Value: 5 N•m [44 in-lb]





Follow-Up

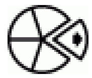
Air Inlet Connection Removal/Installation

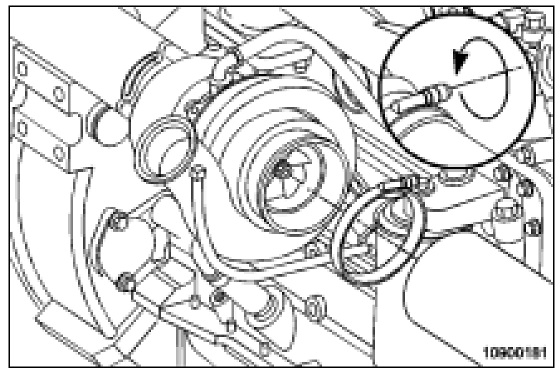
Prepare

Remove

Loosen air inlet clamps.

Remove the air inlet connection.



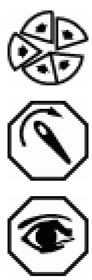


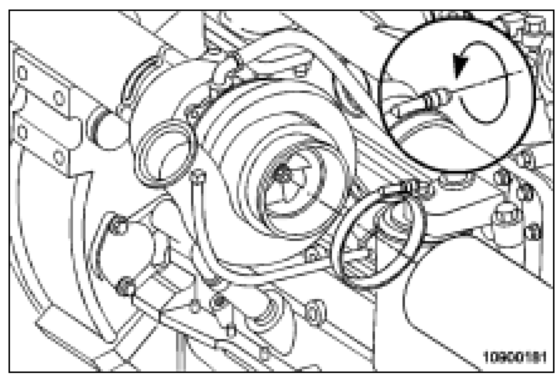
Install

Install the air inlet connection.

Tighten air inlet clamps.

Run engine and check for leaks.





Follow-Up

Air Leaks, Air Intake and Exhaust Systems

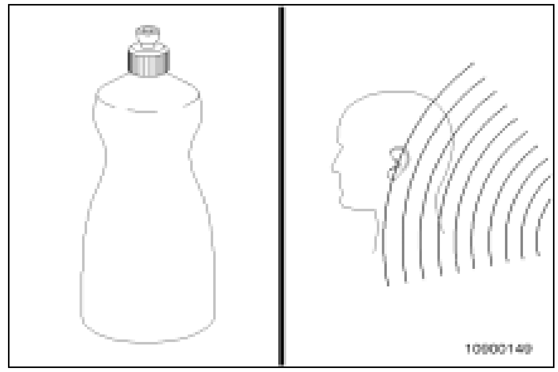
Initial Check

Leaks in the intake air system are most commonly identified by:

Inspection of piping for cracked or loose clamps.

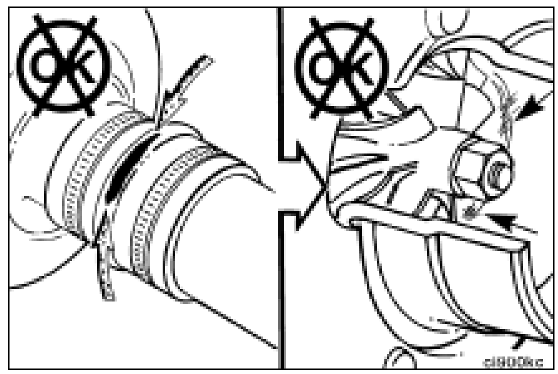
Applying a solution of soapy water in the suspected area and inspecting for bubbles.

Listening for a high-pitched whining or sucking sound in the suspected area.



CAUTION

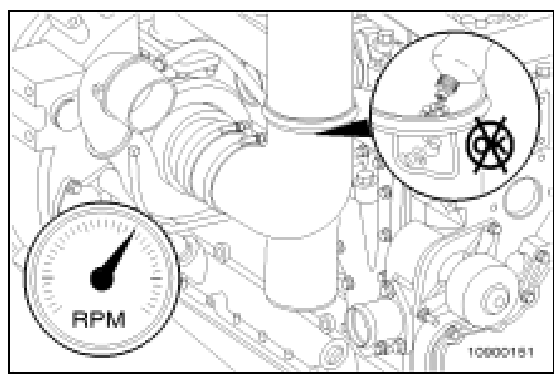
Engine intake air must be filtered to prevent dirt and debris from entering the engine. If intake air piping is damaged or loose, unfiltered air will enter the engine and cause premature wear.



Inspect the inlet air piping for cracked hoses and damaged or loose clamps.

Operate the engine at high idle, and use a solution of soapy water to spot intake air leaks.

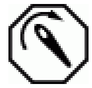
If an air leak exists, the soap bubbles will be drawn in with the air.

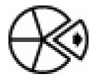


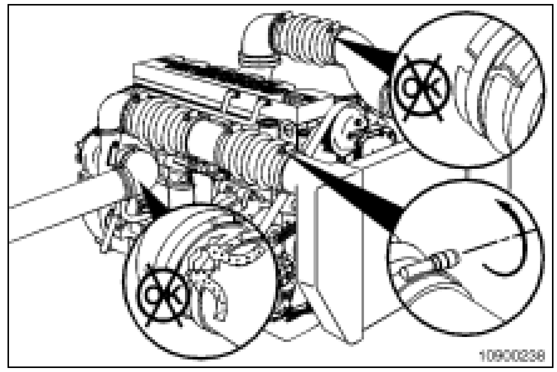
Replace damaged pipes and tighten loose clamps to make sure the air inlet system does not leak.

Check for corrosion of the inlet system piping under the clamps and hoses. Corrosion can allow corrosive products and dirt to enter the intake system.

Disassemble and clean as required.

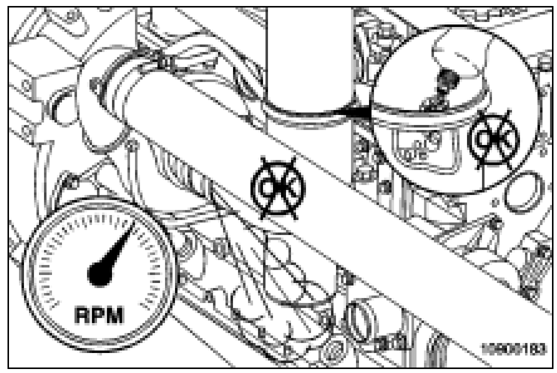






Pressure Side Intake System

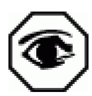
Leaks in the intake system will reduce the amount of air to the cylinders during engine operation and decrease engine performance.

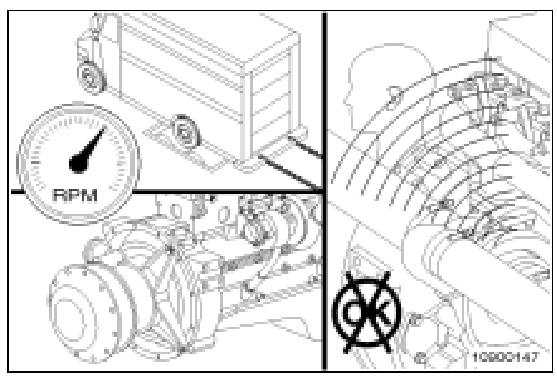


Operate the engine at full throttle and rated rpm with maximum load.

Listen for a high-pitched whistling sound from the turbocharger, nearby piping, and connections.

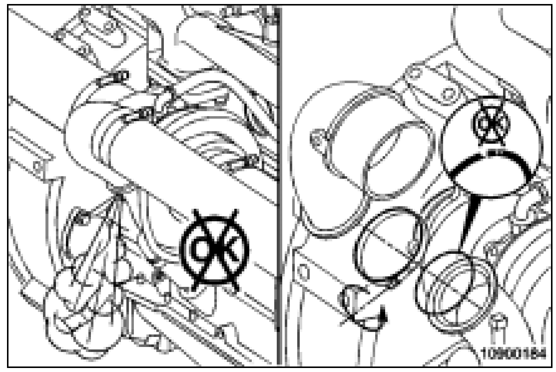
Apply a soapy water solution to sealing surfaces and inspect for bubbles. Bubbles can be easily detected.





Leaks can also be found at the turbocharger outlet connection.

Inspect for damage, replace sealing o-ring, and tighten loose clamps.

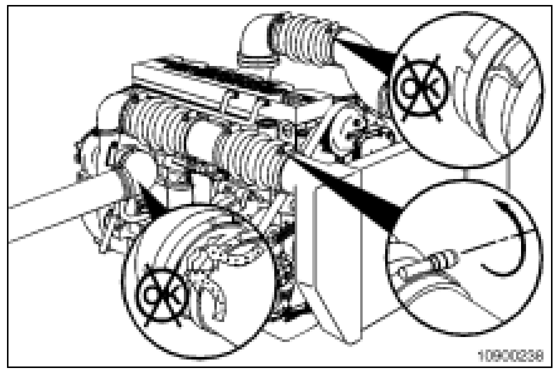


Any Charge Air Cooler Tubing or Connecting Hoses

Inspect the hose and tubing for damage.

Tighten loose clamps.

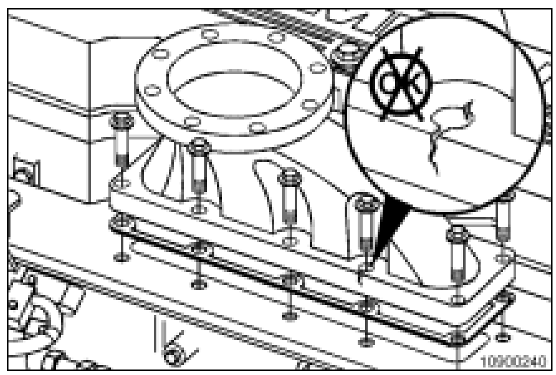
Refer to the equipment manufacturer's specifications for the correct torque value.



Air Intake Connection

Inspect for damage.

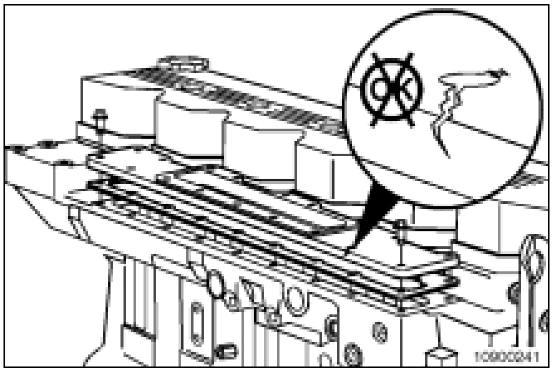
If necessary, replace the gasket or tighten loose clamps. Refer to Procedure 010-080.



Intake Manifold

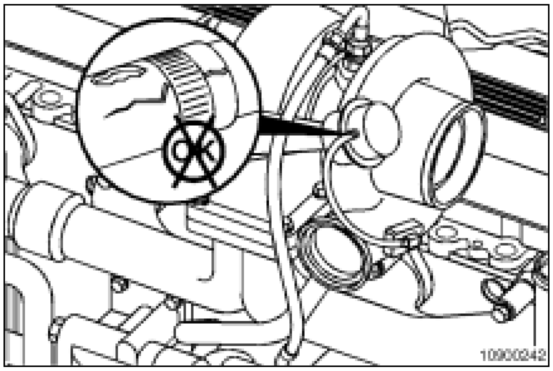
Inspect for damage.

Replace the gasket, if necessary. Refer to Procedure 010-108.



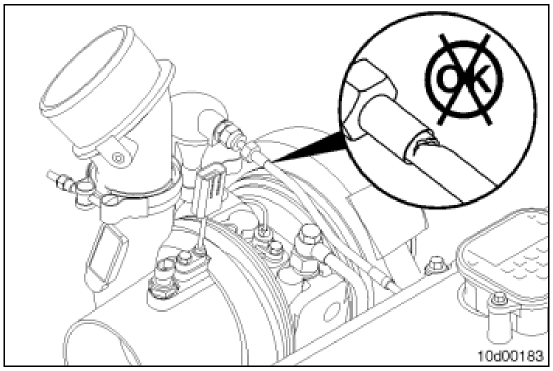
Wastegate Capsule/Plumbing

Inspect for damage.



Variable Geometry Turbocharger Actuator Plumbing

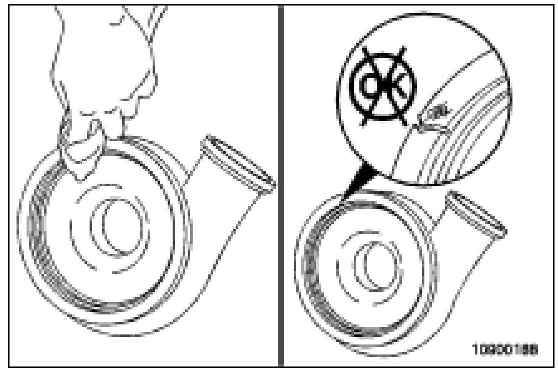
Inspect for cracks and/or air leaks.



Compressor Housing Sealing Surface

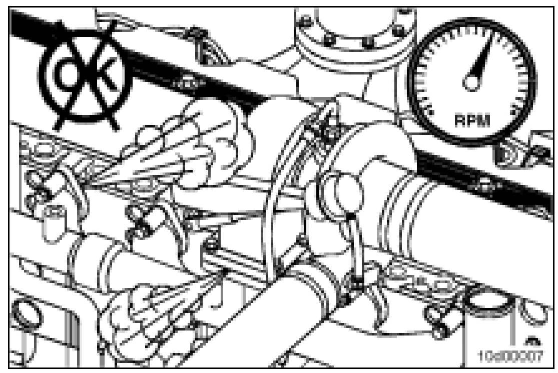
Inspect for damage.

Clean surface.



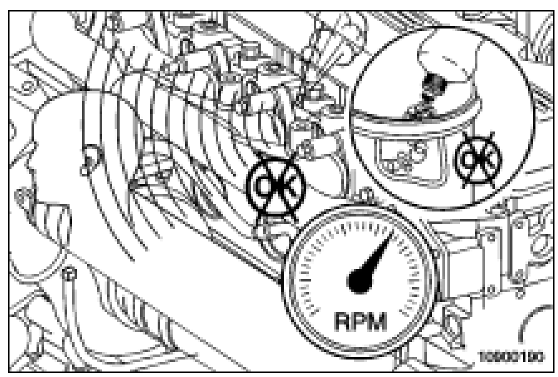
Exhaust System

Leaks in the exhaust system will cause the turbocharger to operate at a lower speed, reducing the amount of air going to the cylinders during engine operation.

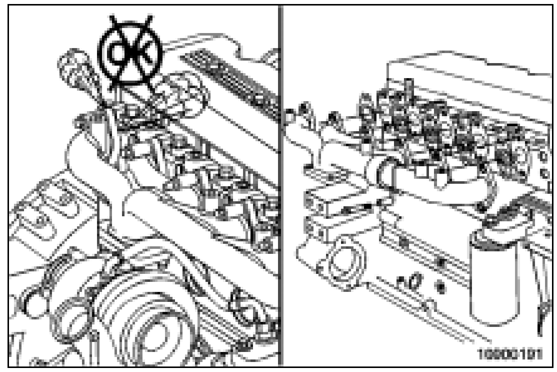


Operate the engine at full throttle and rated rpm with maximum load.

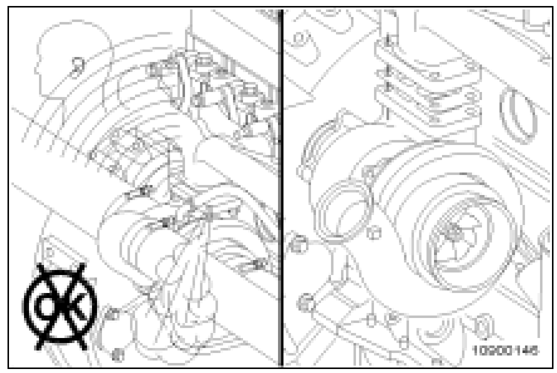
Leaks can be identified by noise, soapy water, or discoloration caused by the escaping hot gases.



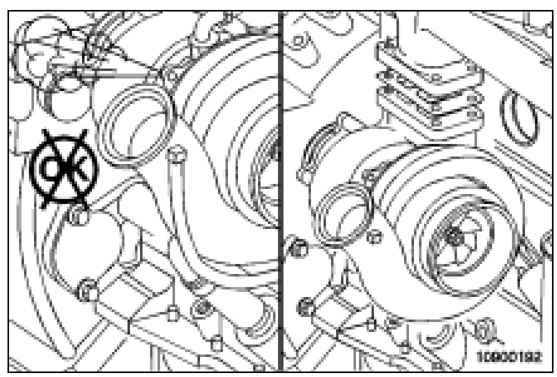
Inspect the exhaust manifold gaskets for leaks.



Inspect the turbocharger mounting gaskets for leaks.

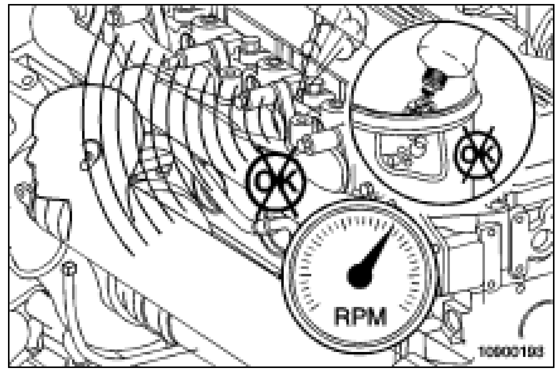


Inspect the turbine housing sealing surface for leaks.



Operate the engine at full throttle and rated rpm with maximum load.

Listen and inspect again for leaks.



Follow-Up

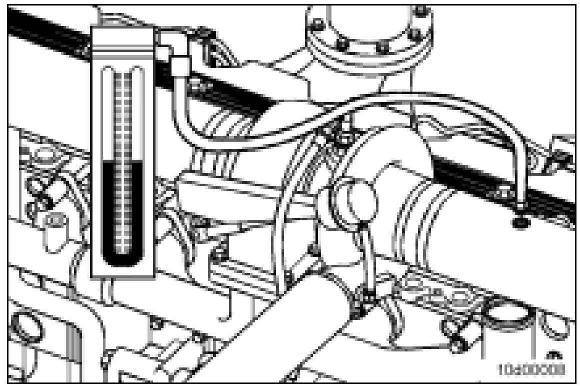
Air Intake Restriction Removal/Installation

Prepare

Measure

Install a vacuum gauge or water manometer in the intake air piping.

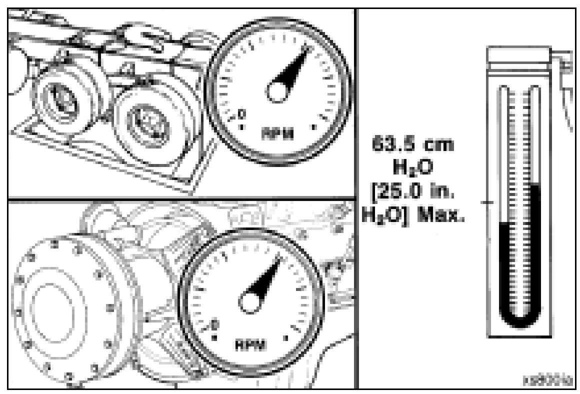
The gauge adapter must be installed at a 90-degree angle to the airflow in a straight section of pipe, one pipe diameter before the turbocharger.



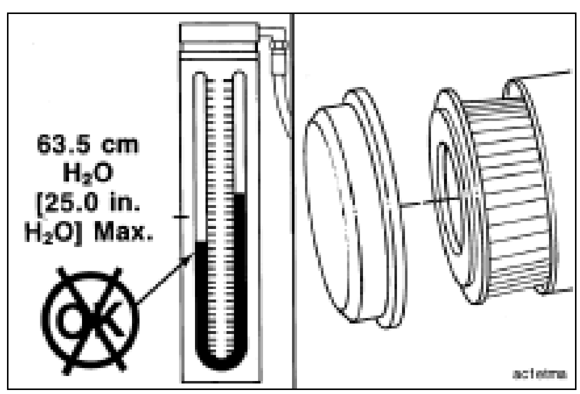
Operate the engine at full throttle and rated rpm with maximum load.

Record the data on the gauge or manometer.

MAX Inlet Air Restriction63.5 cm H2O [[25.0 in H2O]

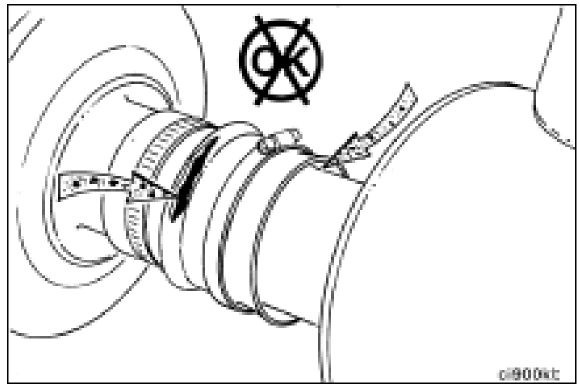


If restriction exceeds specifications, replace or clean the air filter element. Refer to the equipment manufacturer's instructions.



Inspect the intake piping for damage. Refer to the equipment manufacturer's repair instructions.

Remove the test equipment.



Follow-Up

Turbocharger Checks

Prepare

Initial Check

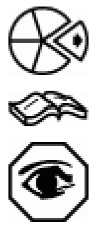
Remove the intake pipe from the turbocharger. See the Remove step in this procedure.

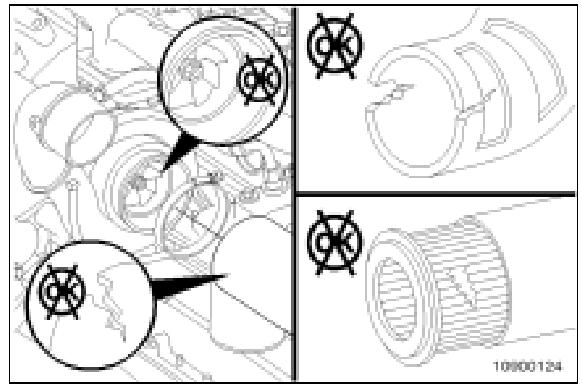
Inspect the turbocharger compressor impeller blades for damage.

Replace the turbocharger if damage is found. See the Remove and Install steps in this procedure.

If the compressor impeller is damaged, inspect the intake piping and filter element for damage.

Repair any damage before operating the engine.

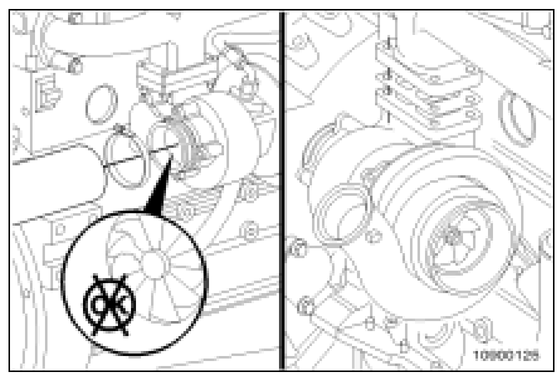




Remove the exhaust pipe from the turbocharger. See the Remove step in this procedure.

Inspect the turbine wheel for damage.

Replace the turbocharger if damage is found. See the Remove and Install steps in this procedure.

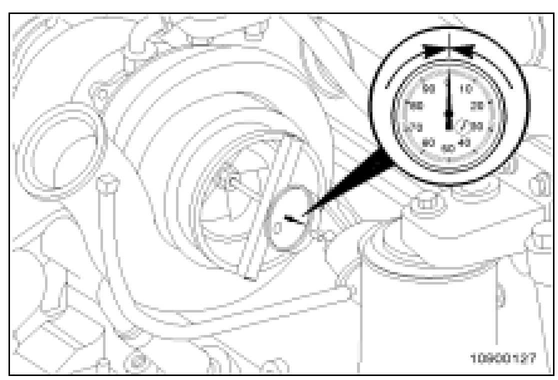


Axial Clearance Check

Use dial depth gauge, Part Number ST-537.

Push the rotor assembly away from the gauge.

Set the gauge on zero.



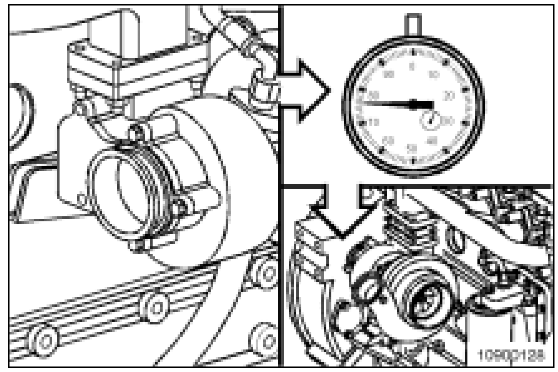
Push the rotor assembly toward the gauge and record the reading.

Axial Clearance

Minimum 0.025 mm [0.001 in]

Maximum 0.127 mm [0.005 in]

Replace the turbocharger if the clearance does not meet the specifications. See the Remove and Install steps in this procedure.

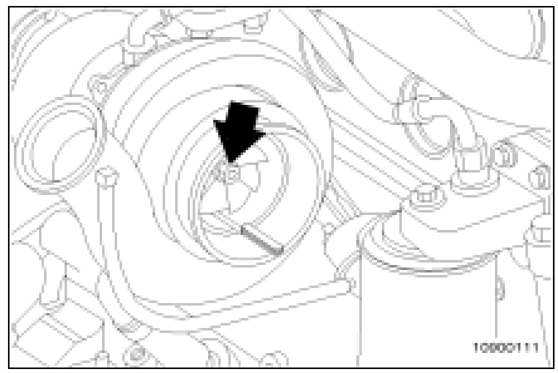


Radial Clearance Check

Use a wire-type feeler gauge to measure the clearance between the turbocharger compressor wheel and turbocharger compressor housing.

Gently push the compressor wheel toward the compressor housing and gauge.

Record the clearance.



With the feeler gauge in the same location, gently push the turbocharger compressor wheel away from the turbocharger compressor housing and measure the clearance between the compressor wheel and housing.

Subtract the smaller clearance from the larger clearance. This is the radial bearing clearance.

Wastegate Radial Bearing Clearance

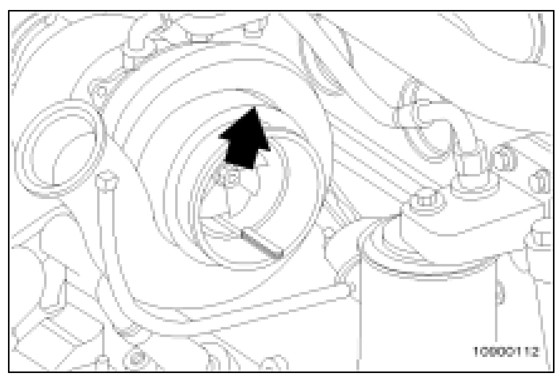
MIN 0.330 mm [0.013 in]

MAX 0.508 mm [0.020 in]

For variable geometry turbocharger check the radial movement of the rotor system by pushing the turbocharger compressor wheel toward the wall of the compressor cover with light finger pressure. The turbocharger passes inspection if the wheel does not contact the compressor cover wall.

Repeat the procedure on the turbocharger turbine wheel.

Replace the turbocharger if the radial bearing clearance does not meet specifications. See the

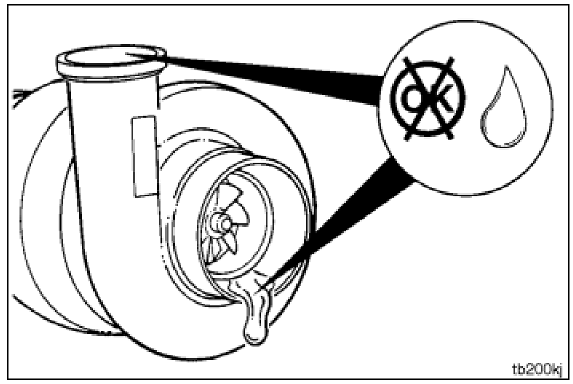


Remove and Install steps in this procedure.

Leak Check

Inspect the turbocharger compressor intake and discharge for oil.

If oil is present in the compressor intake as well as in the discharge, check upstream in the turbocharger for the source of the oil.

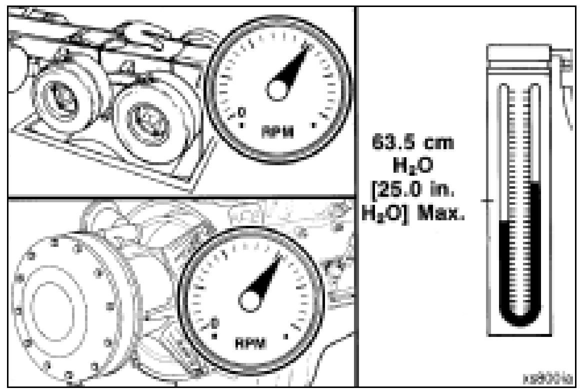


If oil is present only in the discharge side, install the air intake and charge air cooler piping. Refer to the OEM service manual.

Check for intake restriction. Refer to Procedure 010-031.

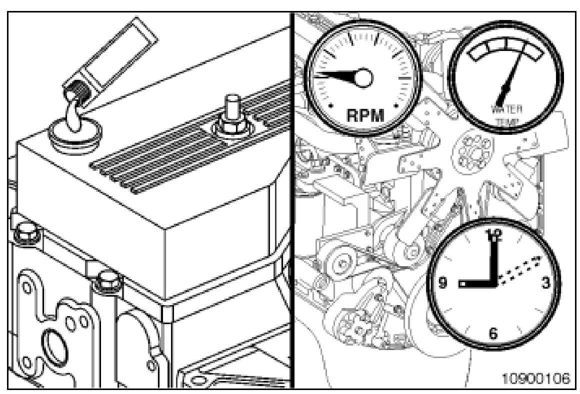
If no intake restriction is found, replace the turbocharger. See the Remove and Install steps in this procedure.

NOTE: If the engine experiences a turbocharger failure or any other occasion where oil is put into the charge air system, the charge air system must be inspected and cleaned. Refer to Procedure 010-027.



Add 1 unit of fluorescent tracer, Part Number 3376891, to each 38 liters [10.0 gal] of engine lubricating oil.

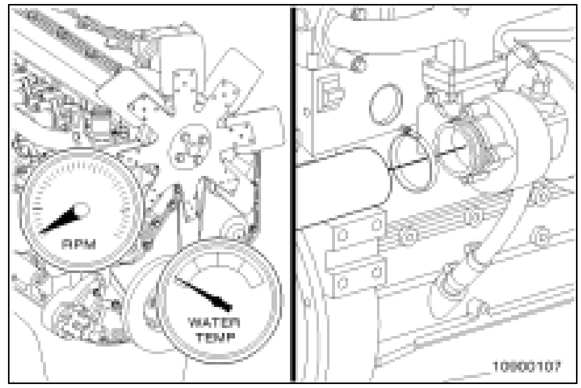
Operate the engine at low idle for 10 minutes.



Shut off the engine.

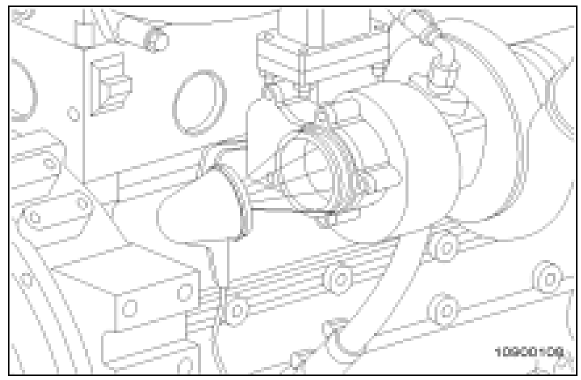
Allow the turbocharger to cool.

Remove the exhaust pipe from the turbine housing. See the Remove step in this procedure.



Use a high-intensity black light, Part Number 3163339, to inspect the turbine outlet for leaks.

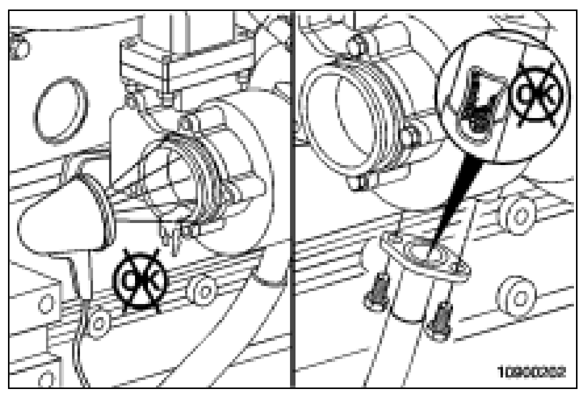
A yellow glow indicates an oil leak. A dark blue glow indicates fuel in the oil.



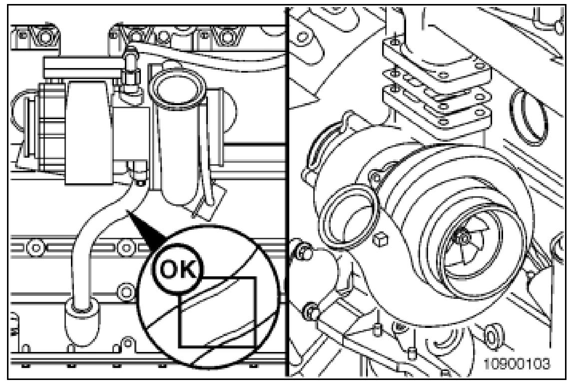
If oil is found on the turbine housing, remove the oil drain line and check for restrictions. Refer to Procedure 010-045.

Clear any restrictions found.

Install the turbocharger drain line. Refer to Procedure 010-045.



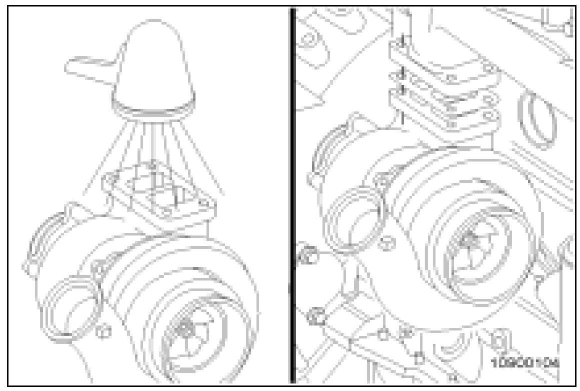
If the oil drain line was not restricted, remove the turbocharger. See the Remove and Install steps in this procedure.



Use a high-intensity black light, Part Number 3163339, to inspect the turbine inlet for leaks.

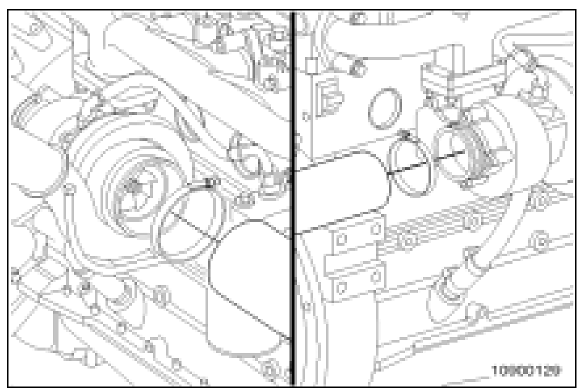
A yellow glow indicates an oil leak from the engine.

If a yellow glow is not seen in the turbine inlet, replace the turbocharger. See the Remove and Install steps in this procedure.



Install the exhaust pipe to the turbocharger turbine outlet and tighten the clamp. See the Install step in this procedure.

Install the intake pipe to the turbocharger compressor inlet and tighten the clamp. See the Install step in this procedure.



Follow-Up

Turbocharger Removal/Installation

Prepare

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 pressure cap. Heated coolant spray or steam can cause personal injury.

WARNING

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

Drain the coolant, variable geometry turbocharger only. Refer to Procedure 008-018.

Remove the oil supply line from the turbocharger. Refer to Procedure 010-046.

Remove the oil drain line from the turbocharger. Refer to Procedure 010-045.

Remove the turbocharger coolant lines, variable geometry turbocharger only. Refer to Procedure 010-041.

Disconnect the turbocharger actuator air supply line, variable geometry turbocharger only. Refer to Procedure 010-118.

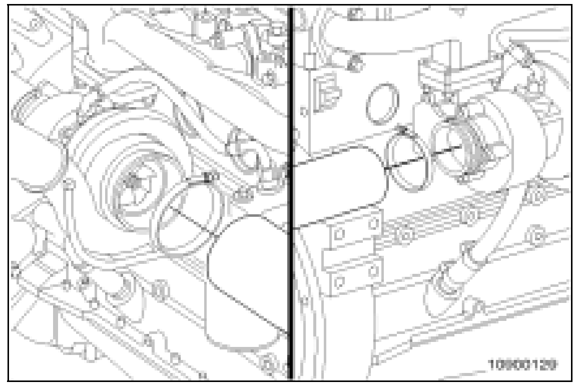
Disconnect the turbocharger speed sensor, variable geometry turbocharger only. Refer to Procedure 019-390 in the CM850 Electronic Control System ISC and ISL Engines Troubleshooting and Repair Manual, Bulletin 4021416.

Disconnect the turbocharger compressor air inlet temperature sensor, if equipped. Refer to Procedure 019-035 in the CM850 Electronic Control System ISC and ISL Engines Troubleshooting and Repair Manual, Bulletin 4021416.

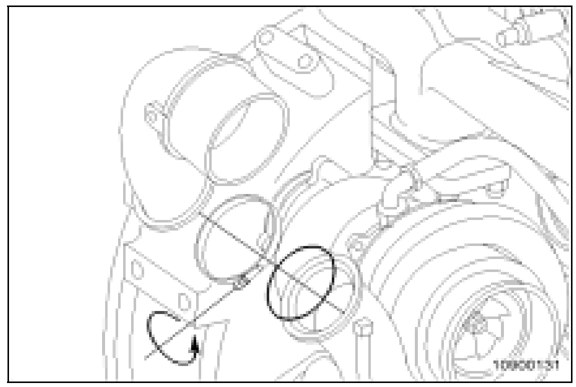
Remove

Remove the exhaust piping.

Remove the turbocharger compressor air inlet pipe.

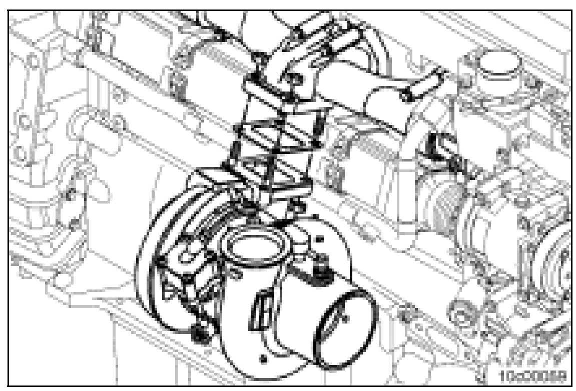


Remove the turbocharger compressor outlet elbow, v-band clamp, and o-ring from the turbocharger compressor outlet.



Remove the four turbocharger mounting nuts.

Remove the turbocharger and gasket.



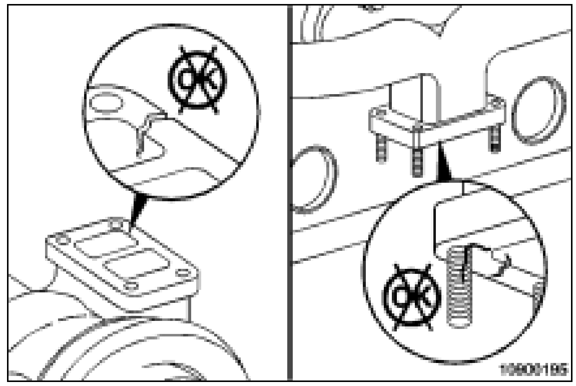
Clean and Inspect for Reuse

Clean the turbocharger and exhaust manifold gasket surfaces.

Inspect the turbocharger and exhaust manifold gasket surfaces, and mounting studs for cracks and damage.

Replace the turbocharger if any cracks are found in the mounting flange surfaces. See the Remove and Install steps in this procedure.

Replace the exhaust manifold if any cracks are found in the mounting flange surfaces. Refer to Procedure 011-007.



WARNING

When using solvents, acids, or alkaline materials for cleaning, follow the manufacturer's recommendations for use. Wear goggles and protective clothing to reduce the possibility of personal injury.

WARNING

When using a steam cleaner, wear safety glasses or a face shield, as well as protective clothing. Hot steam can cause serious personal injury.

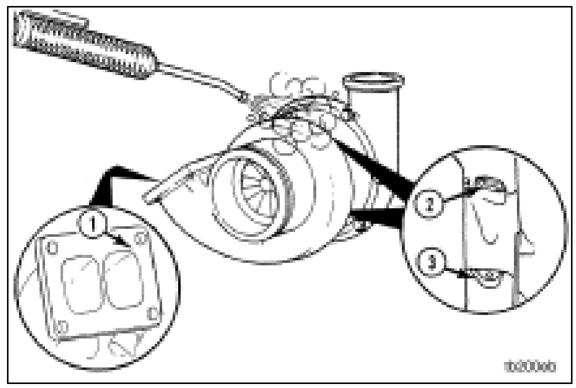
WARNING

Wear appropriate eye and face protection when using compressed air. Flying debris and dirt can cause personal injury.

Remove all carbon deposits and gasket material from surfaces (1, 2, and 3).

Use solvent or steam to clean the exterior of the turbocharger.

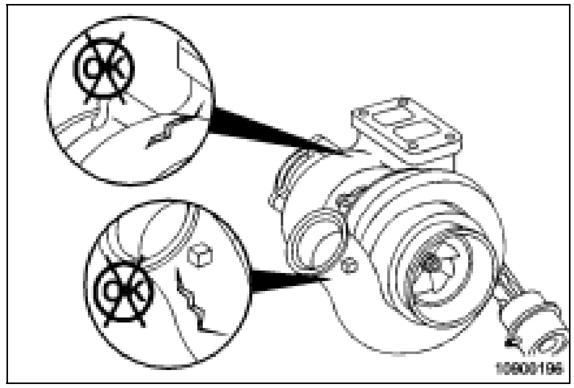
Dry with compressed air.



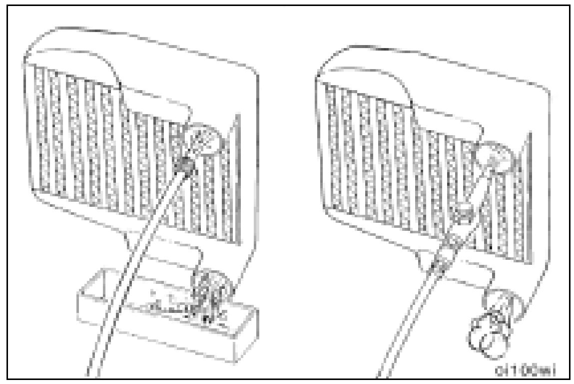
Inspect the turbine and compressor housings.

If cracks that go all the way through the outer walls are found, the turbocharger must be replaced.

NOTE: A charge air cooler failure can cause progressive damage to the turbine housing. If the turbine housing is damaged, check the charge air cooler. Refer to Procedure 010-027.



NOTE: If the engine experiences a turbocharger failure or any other occasion where oil or debris is put into the charge air system, the charge air system must be inspected and cleaned. Refer to Procedure 010-027.



Install

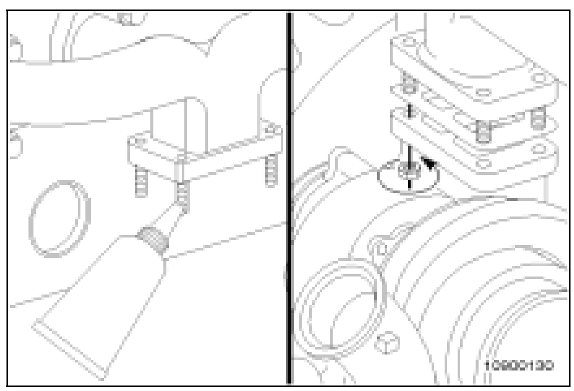
Apply a film of high-temperature anti-seize compound to the turbocharger mounting studs.

Use a new gasket and install the turbocharger.

Install and tighten the four mounting nuts.

NOTE: The torque values given have been established using anti-seize compound as a lubricant.

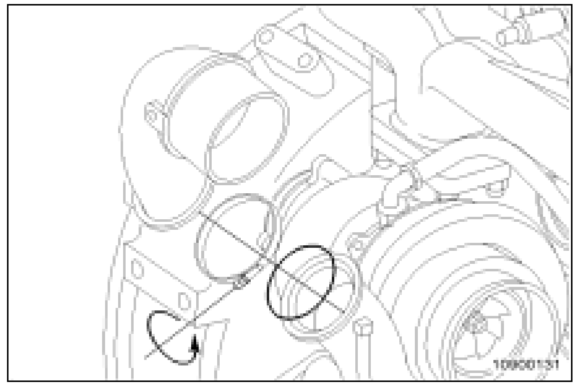
Torque Value: 45 N•m [33 ft-lb]



Install the turbocharger compressor outlet elbow, v-band clamp, and new o-ring seal on the turbocharger compressor discharge outlet.

Tighten the clamp.

Torque Value: 8 N•m [71 in-lb]

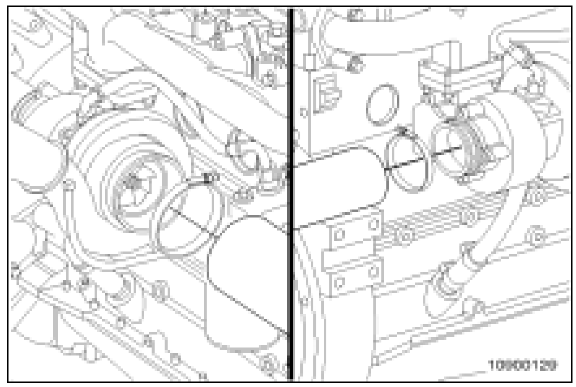


Install the intake pipe to the turbocharger compressor inlet and tighten the clamp.

Torque Value: 8 N•m [71 in-lb]

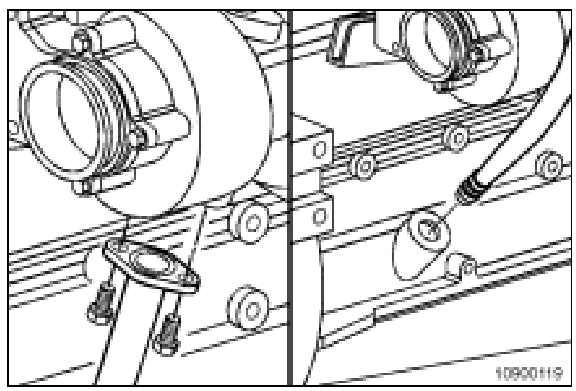
Install the exhaust pipe to the turbocharger turbine outlet and tighten the clamp.

Torque Value: 8 N•m [71 in-lb]



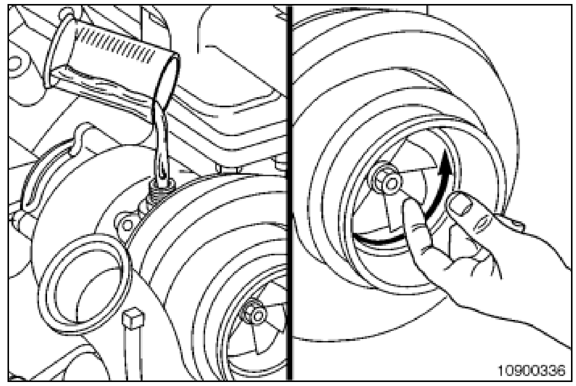
Prime

Install the turbocharger oil drain line. Refer to Procedure 010-045.



Lubricate the bearings by pouring 59 to 89 ml [2 to 3 oz] of clean 15W40 engine oil into the turbocharger oil supply line fitting. Rotate the turbine wheel to allow oil to enter the bearing. housing.

Install the turbocharger oil supply line. Refer to Procedure 010-046.



Follow-Up

Install the turbocharger coolant lines, variable geometry turbocharger only. Refer to Procedure 010-041.

Connect the turbocharger actuator air supply line, variable geometry turbocharger only. Refer to Procedure 010-118.

Connect the turbocharger speed sensor, variable geometry turbocharger only. Refer to Procedure 019-390 in the CM850 Electronic Control System ISC and ISL Engines Troubleshooting and Repair Manual, Bulletin 4021416.

Connect the turbocharger compressor air inlet temperature sensor, if equipped. Refer to Procedure 019-035 in the CM850 Electronic Control System ISC and ISL Engines Troubleshooting and Repair Manual, Bulletin 4021416.

Fill the cooling system, variable geometry turbocharger only. Refer to Procedure 008-018.

Operate the engine and check for leaks.

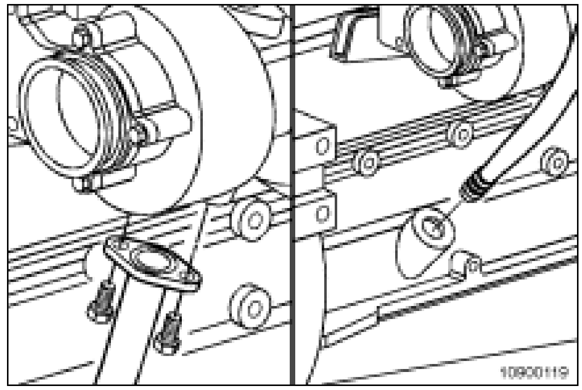
Turbocharger Oil Drain Line Removal/Installation

Prepare

Remove

Remove the capscrews from the oil drain tube.

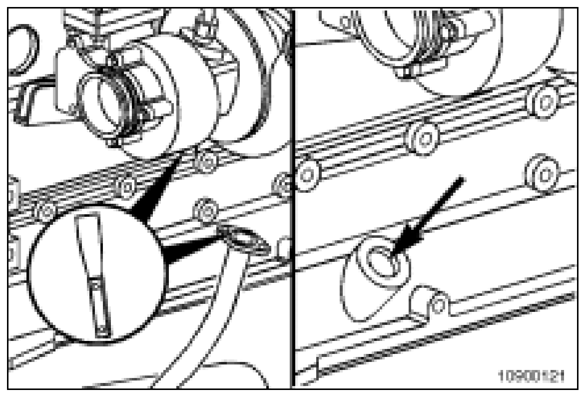
Pull the drain line out of the drain line boss.



Clean and Inspect for Reuse

Clean the gasket sealing surfaces.

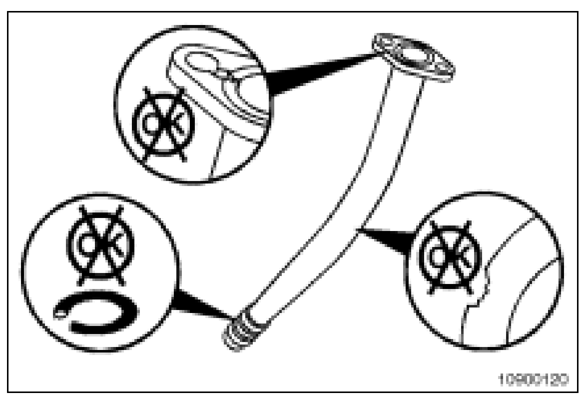
Clean the o-ring seating bore and make sure it is free of dirt and debris.



Inspect the line for cracks, wear, and damage.

Inspect the o-ring for fretting and cracking. Replace if necessary.

Check the rubber section of the drain line for deterioration.



Install

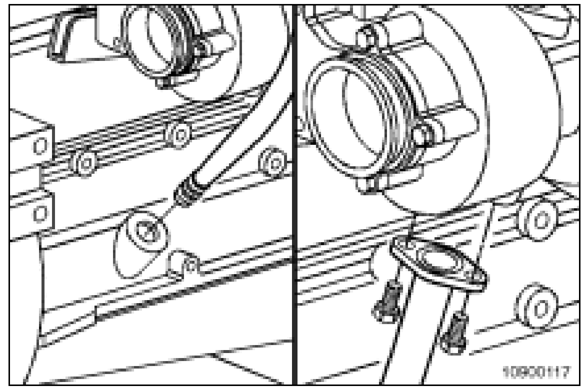
Apply a thin film of oil to the drain line o-rings.

Push the drain line into the drain line boss. Be sure both o-rings are completely seated in the bore.

Install a new gasket.

Install and tighten the turbocharger oil drain line.

Torque Value: 27 N•m [20 ft-lb]



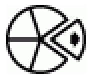
Follow-Up

Operate the engine and check for leaks.

Turbocharger Oil Supply Line Removal/Installation

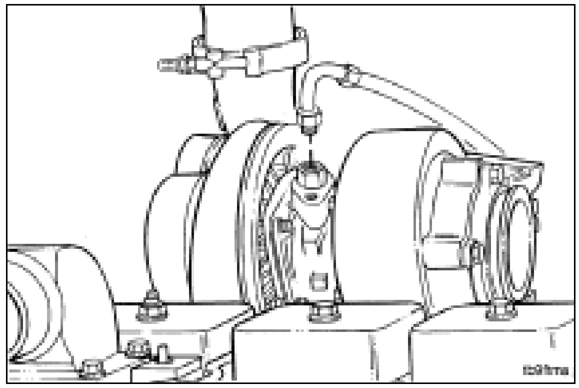
Prepare

Remove

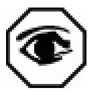


Remove the oil supply line from the oil filter head (1).

Remove the oil supply line from the turbocharger bearing housing (2).

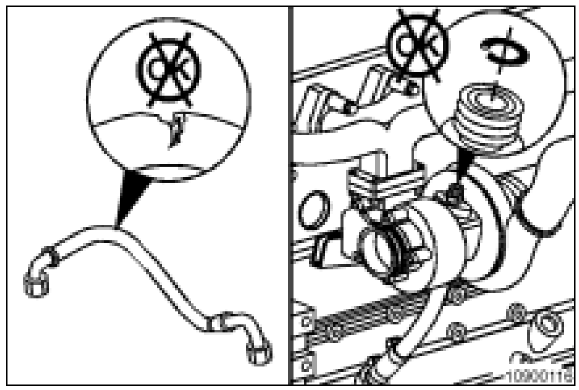


Inspect for Reuse

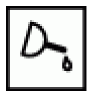


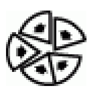
Inspect the line for cracks, wear, and damage.

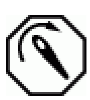
Inspect o-rings for cracking and fretting. Replace as necessary.



Install







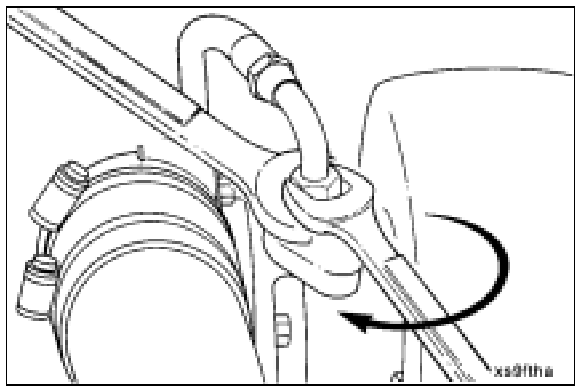
Apply a thin film of oil to the o-ring seals.

Fill the turbocharger oil inlet with clean oil.

Install the oil supply line at both the filter head and the turbo bearing housing.

Tighten the oil supply line to final torque.

Torque Value: 24 N•m [18 ft-lb]



Follow-Up

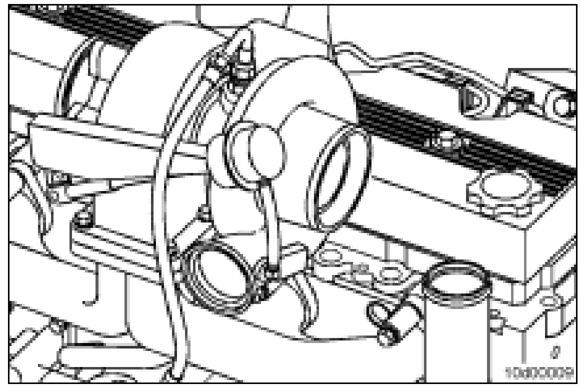
Turbocharger Wastegate Actuator Checks

Initial Check

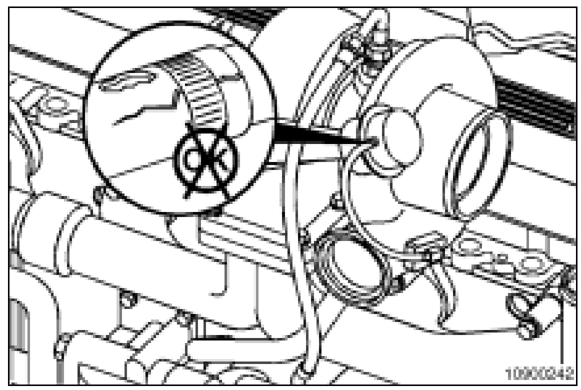
CAUTION

All wastegates come pre-calibrated and can not be adjusted in the field. Attempts to adjust the wastegate can result in engine damage.

The integral wastegate line takes boost from the turbocharger compressor outlet to the wastegate capsule.

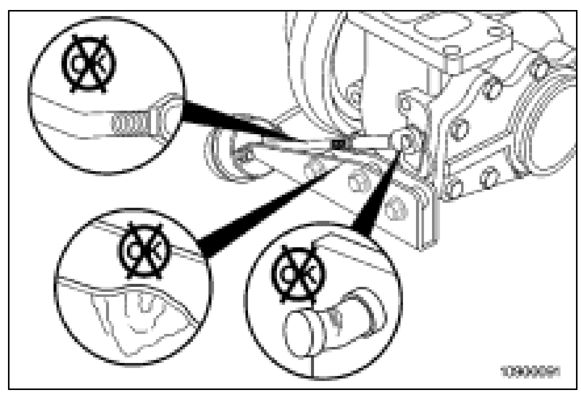


Inspect the integral wastegate actuator hose for cracks or holes. Replace the hose if damaged.



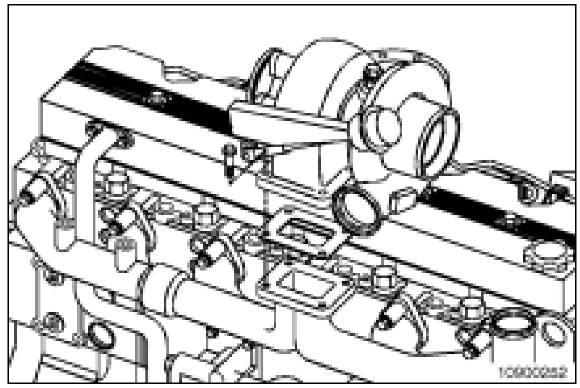
Inspect the wastegate mounting bracket, actuator rod, and lever for damage. A bent wastegate mounting bracket, actuator rod, or lever can cause improper operation.

If the wastegate mounting bracket, actuator rod, or lever is bent, it must be replaced.



Test

In some applications the turbocharger must be removed to test the wastegate actuator. Refer to Procedure 010-033.



Disconnect the integral boost line from the wastegate capsule.

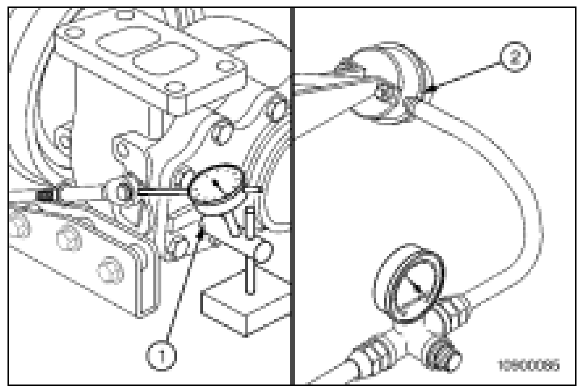
Attach a dial indicator (1) as shown, so that its shaft is in line with the wastegate actuator rod. Set the indicator to zero.

Connect clean, regulated air pressure and a pressure gauge to the capsule. Apply 200 kPa [29 psi] to make sure the wastegate is functioning properly.

The rod must move approximately 5 mm [0.200 in] without any sticking or air leakage.

Air must not be heard, such as air leaking through a functional wastegate capsule.

A small amount of travel when air pressure is first applied is normal. The tolerance is being removed from the system.

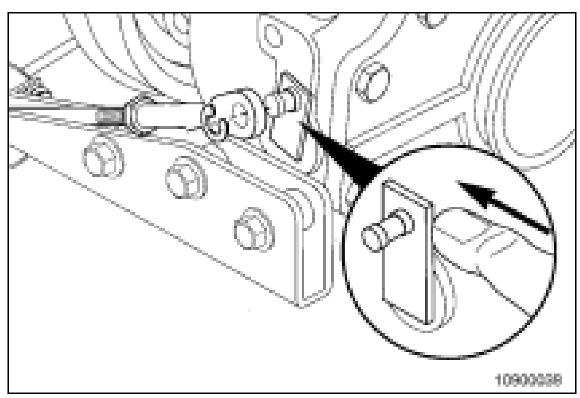


If no movement of the actuator rod is detected, detach the actuator control rod from the wastegate lever pin.

Actuate the lever by hand to be sure that the shaft rotates freely and is not seized.

If the wastegate lever can not be moved by hand, replace the turbocharger. Refer to Procedure 010-033.

If the wastegate lever moves freely by hand, replace the turbocharger wastegate actuator.

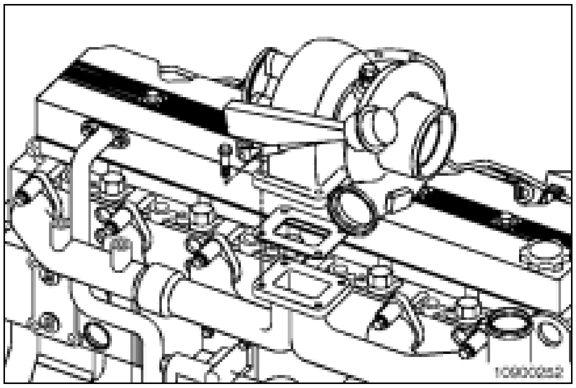


Turbocharger Wastegate Actuator Removal/Installation

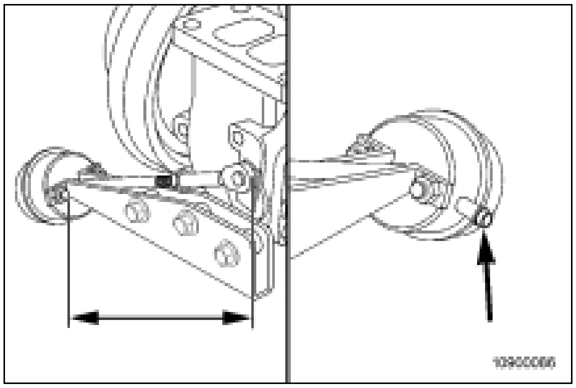
Prepare

Remove

In some applications the turbocharger must be removed in order to remove the wastegate actuator. Refer to Procedure 010-033.

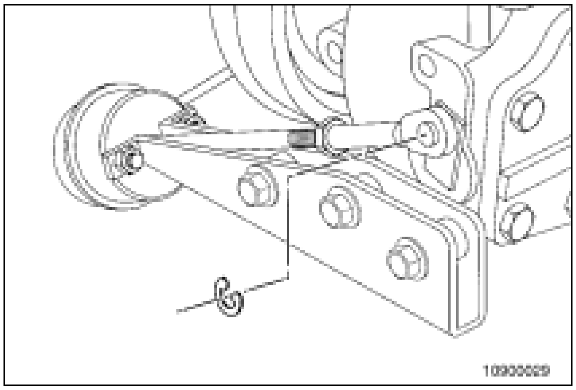


Prior to removal, note position length of the control rod from the boost capsule housing and orientation of the boost capsule hose connector in relation to the mounting bracket.



Remove the retaining clip from the control lever.

Remove the integral boost line from the wastegate capsule.



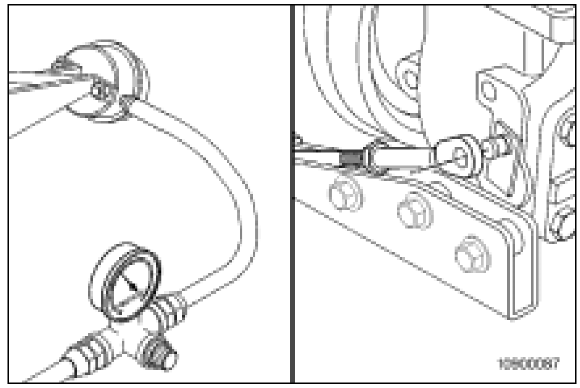
CAUTION

Be careful not to bend the control lever. Engine damage can result.

Air Regulator with Pressure Gauge

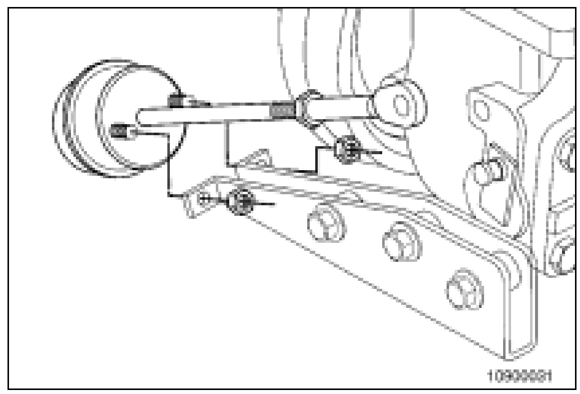
Remove the boost capsule actuator rod end from the turbocharger wastegate lever. This can be accomplished by slowly applying regulated air pressure to the boost capsule until the control rod is activated.

Remove the control rod from the turbocharger wastegate lever pin.



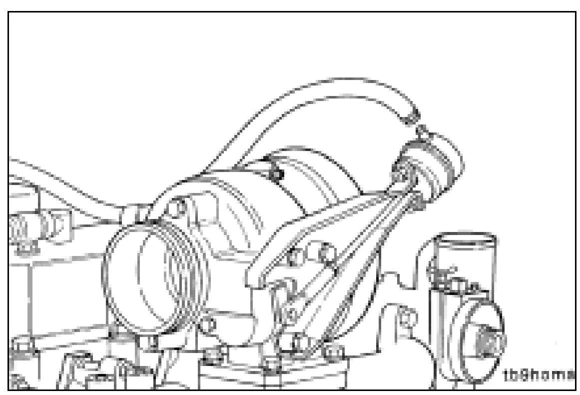
If the boost capsule diaphragm material is ruptured and will not hold air pressure, manually pull the control rod outward in order to overcome boost capsule spring tension for removal of the control rod from the turbocharger wastegate lever pin.

Loosen the boost capsule mounting capscrews, disconnect the air supply hose, and remove the assembly from the mounting bracket.



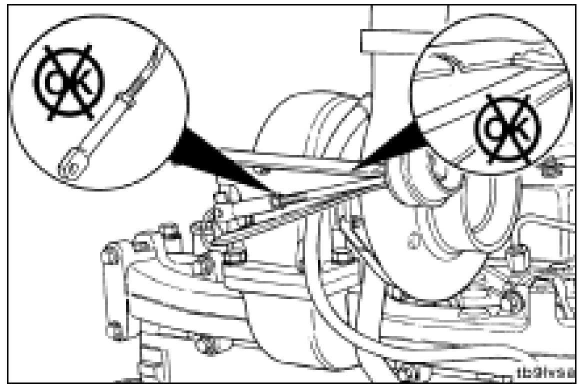
Clean and Inspect for Reuse

Inspect the wastegate actuator hose for cracks or holes. Replace the hose if damaged.



Inspect the wastegate mounting bracket, actuator rod, and lever for damage. A bent wastegate mounting bracket, actuator rod, or lever can cause improper operation.

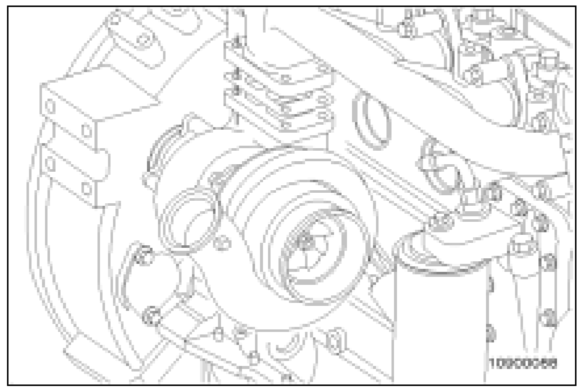
If the wastegate mounting bracket, actuator rod, or lever is bent, it must be replaced.



Install

Pre-calibrated Wastegate Actuator

In most applications, the turbocharger must be removed in order to remove the wastegate actuator. Refer to Procedure 010-033.

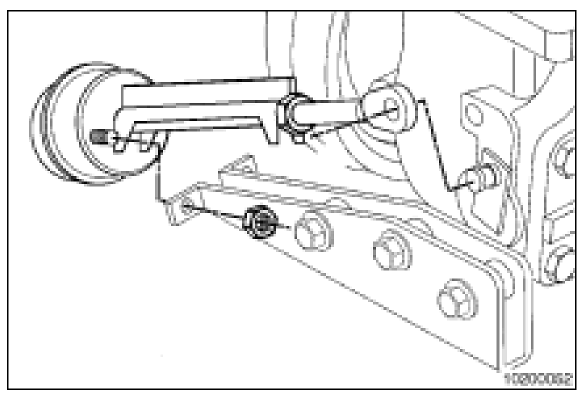


Fit the actuator mounting studs into the holes in the bracket, and fit both actuator mounting capscrews.

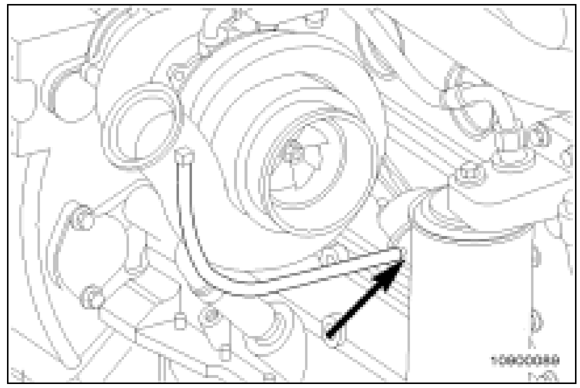
Refit the end-link onto the crank-pin. Install the control rod retaining clip.

Torque Value: 8 N•m [71 in-lb]

Cut the tie wrap and remove the tie wrap and spacer piece.



Refit the air supply hose to the actuator using the new hose clamp provided.



Follow-Up

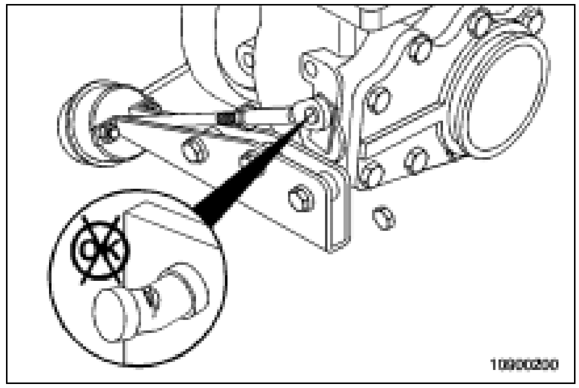
Turbocharger Wastegate Valve Body Inspection

Prepare

Check

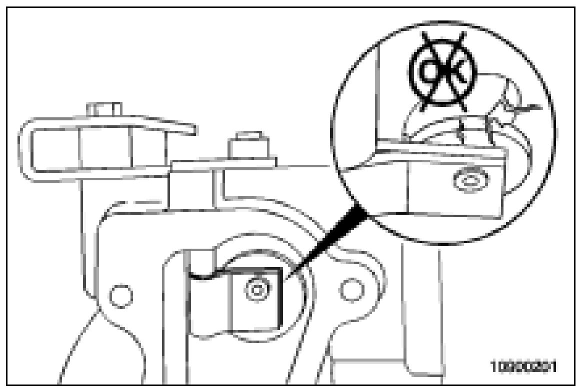
Inspect the lever pin.

Replace the turbocharger if worn excessively, Refer to Procedure 010-033.



Inspect the valve and valve seat for cracks or erosion.

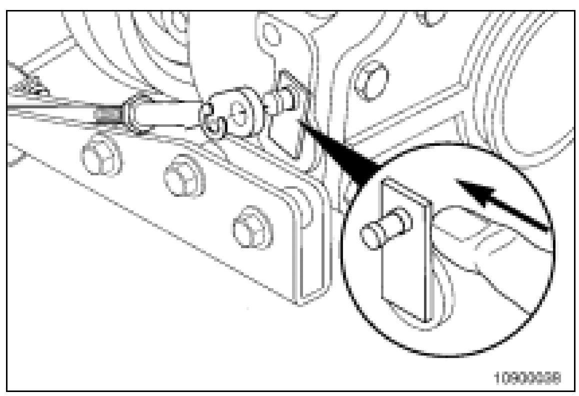
Replace the turbocharger if damage is found. Refer to Procedure 010-033.



Actuate the lever by hand to verify that the shaft rotates freely and is not seized.

Check for excessive movement between the shaft and bushing.

Replace the turbine housing if the shaft and bushing are damaged or seized.



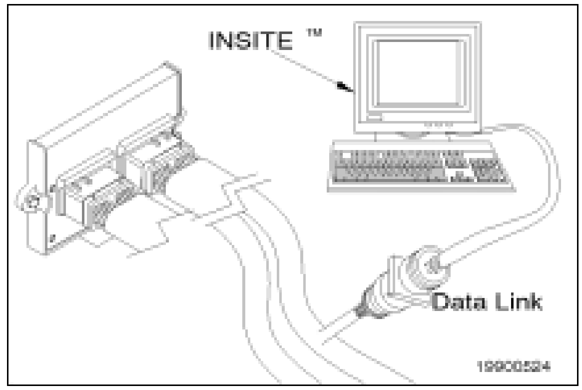
Follow-Up

Measure Intake Manifold Pressure

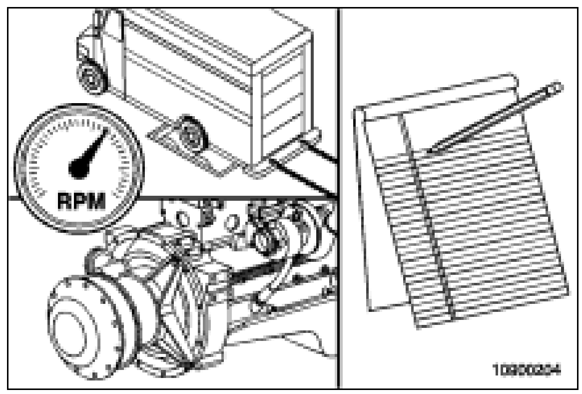
Prepare

Measure

Measure boost pressure at the intake manifold by using INSITE™ for hookup and monitoring procedures.



Operate the engine at rated rpm and full load. Record the boost reading.



Follow-Up

Air Intake Connection Removal/Installation

Prepare

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.

Disconnect the batteries and grid heater wiring.

Remove the air inlet crossover tube. Refer to Procedure 010-019.

Remove the air inlet connection, if equipped. Refer to Procedure 010-022.

Remove the injector supply lines, if required. Refer to Procedure 006-051.

Remove

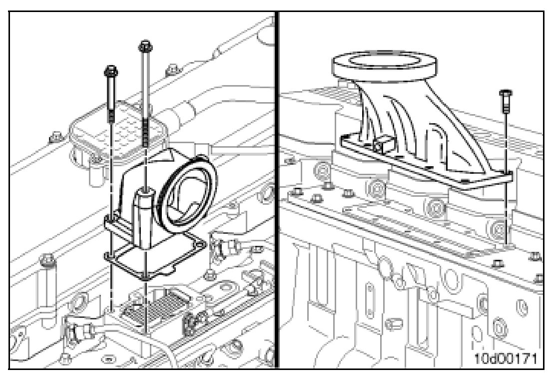
Remove the mounting capscrews.

Remove the air intake connection.

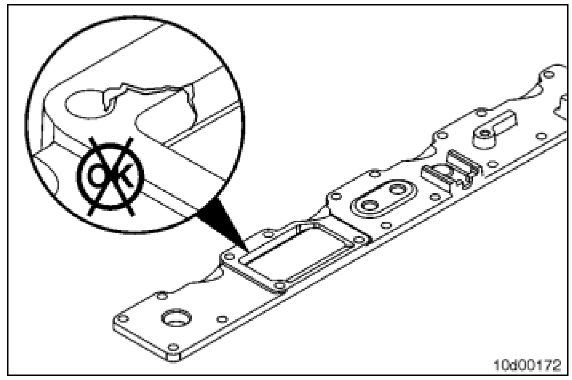
Tape off the intake manifold opening to prevent debris from entering the intake system.

NOTE: Be sure not to tape over the entire manifold edges so that the surface can be cleaned.

NOTE: On engines with the grid heater mounted on top of the intake manifold cover, the grid heater will now be loose.



Clean and Inspect for Reuse

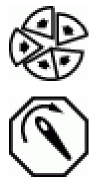


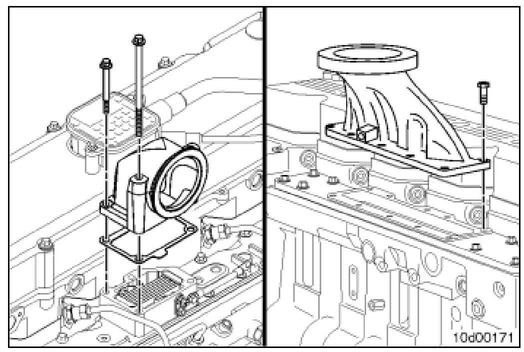
Clean the sealing surfaces.

NOTE: Keep gasket material and any other material out of the air intake.

Inspect the air intake connection for cracks or other damage.

Install





Install the air intake connection and a new gasket.

Torque Value: 24 N•m [18 ft-lb]

NOTE: Some capscrews are shared with fuel line braces on some engines.

NOTE: On some engines, the air intake connection mounts on top of the grid heater and shares capscrews.

Follow-Up

Install the injector supply lines, if removed. Refer to Procedure 006-051.

Connect the air inlet connection, if equipped. Refer to Procedure 010-022.

Install the air crossover tube. Refer to Procedure 010-019.

Connect the cold starting aid and batteries.

Operate the engine and check for leaks.

Air Intake Manifold Cover Removal/Installation

Prepare

Disconnect the cold starting aid.

Remove the air crossover tube. Refer to Procedure 010-019.

Disconnect the air inlet connection, if equipped. Refer to Procedure 010-022.

Remove the air intake connection. Refer to Procedure 010-080.

Remove the injector supply lines, if required. Refer to Procedure 006-051.

Remove the turbocharger control valve, if equipped. Refer to Procedure 019-388 in Troubleshooting and Repair Manual, CM870 Electronic Control System, ISC and ISL Engines, Bulletin 4021416.

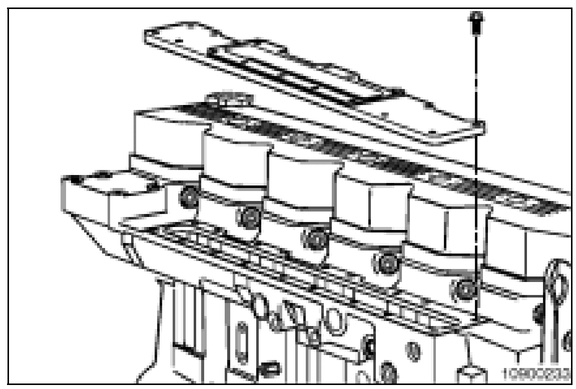
Remove

Some engines have a grid heater mounted on top of the intake manifold cover. Remove the grid heater, if equipped. Refer to Procedure 010-029.

Remove the mounting capscrews and the intake cover.

Tape off the intake manifold opening to prevent debris from entering the intake system.

NOTE: Be sure not to tape over the entire manifold edges so that the surface can be cleaned.



Clean and Inspect for Reuse

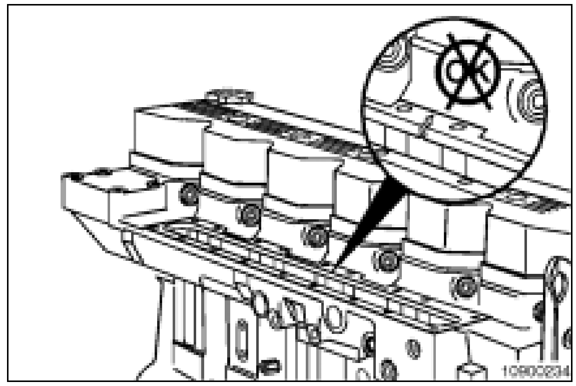
Clean the sealing surfaces.

NOTE: Keep the gasket material and any other material out of the air intake.

Remove the tape.

Inspect the intake manifold for cracks or other damage.

NOTE: When inspecting the intake manifold for oil or debris from an air system failure, also inspect the cylinder head for oil and debris.

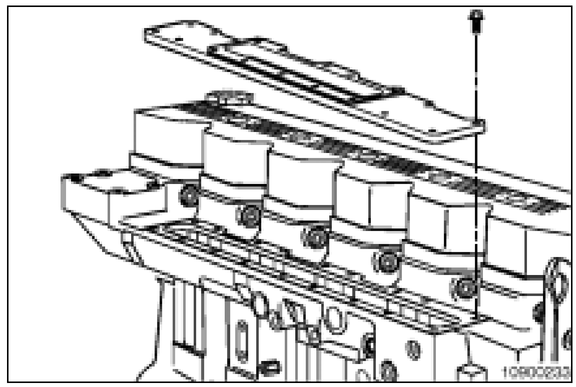


Install

Install the cover with intake air heater (if equipped) and a new gasket.

Torque Value: 24 N•m [18 ft-lb]

NOTE: Some capscrews are shared with fuel line braces on some engines.



Follow-Up

Install the grid heater, if equipped. Refer to Procedure 010-029.

Install the injector supply lines, if removed. Refer to Procedure 006-051.

Install the air intake connection. Refer to Procedure 010-080.

Install the air inlet connection, if used. Refer to Procedure 010-022.

Install the turbocharger control valve, if equipped. Refer to Procedure 019-388 in Troubleshooting and Repair Manual, CM870 Electronic Control System, ISC and ISL Engines, Bulletin 4021416.

Install the air crossover tube. Refer to Procedure 010-019.

Connect the cold starting aid.

Operate the engine and check for leaks.

Charge Air Cooler (CAC) Removal and Installation

Prepare

Remove

Install

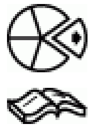
Follow-Up

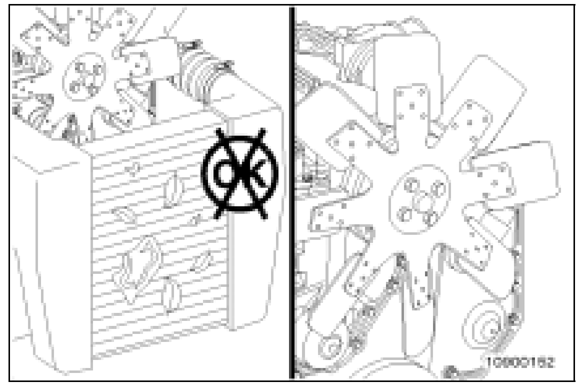
Clean the Charge Air Cooler

Clean

If the engine experiences a turbocharger failure or any other occasion where oil or debris is put into the charge air cooler, the charge air cooler must be cleaned.

Remove the charge air cooler piping and charge air cooler from the vehicle. Refer to the equipment manufacturer's instructions.





WARNING

When using solvents, acids, or alkaline materials for cleaning, follow the manufacturer's recommendations for use. Wear goggles and protective clothing to reduce the possibility of personal injury.

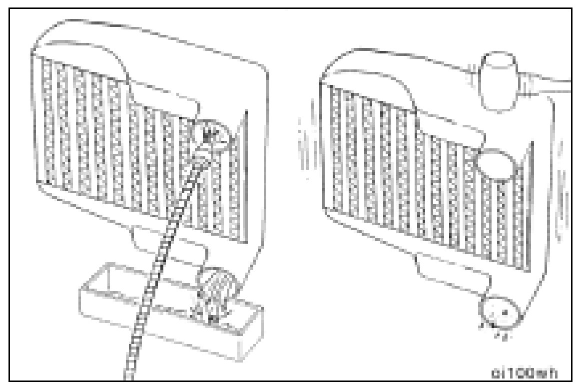
CAUTION

Do not use caustic cleaners to clean the charge air cooler. Damage to the charge air cooler will result.

Flush the charge air cooler internally with solvent in the opposite direction of normal airflow. Shake the charge air cooler, and lightly tap on the end tanks with a rubber mallet to dislodge trapped debris. Continue flushing until all debris or oil is removed (i.e., the water runs clear).

NOTE: Make sure that the tubes are in the vertical direction when flushing.

If the debris can not be totally removed from the charge air cooler, the charge air cooler must be replaced.



WARNING

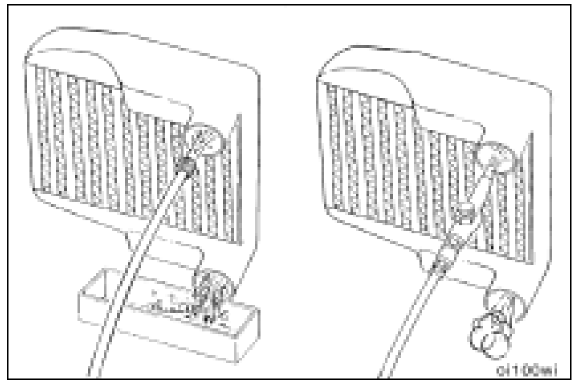
Wear appropriate eye and face protection when using compressed air. Flying debris and dirt can cause personal injury.

CAUTION

The charge air cooler must be rinsed, dried, and free of solvent, oil, and debris, or engine damage will result.

After the charge air cooler has been thoroughly cleaned of all oil and debris with solvent, wash the charge air cooler internally with hot soapy water to remove the remaining solvent. Rinse thoroughly with clean water.

Blow compressed air through the inside of the charge air cooler in the opposite direction of normal air flow until the charge air cooler is dry internally.



Inspect Charge Air Cooler (CAC)

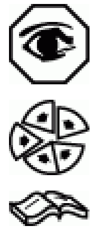
Inspect for Reuse

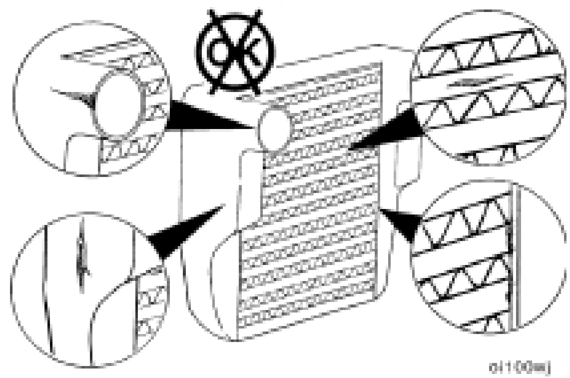
Inspect the charge air cooler for cracks, holes, or damage.

Inspect the tubes, fins, and welds for tears, breaks, or other damage. If any damage causes the charge air cooler to fail the air leak check, the charge air cooler must be replaced. Refer to Procedure 010-024.

Install the charge air cooler and charge air cooler piping on the vehicle. Refer to the vehicle manufacturer's instructions.

NOTE: Always clean and inspect the charge air cooler piping and hoses prior to installation.





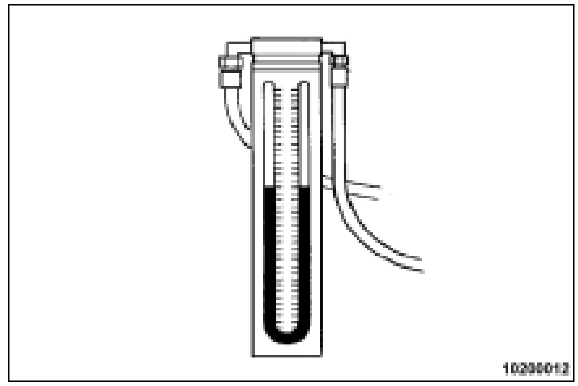
Charge Air Cooler Pressure Test

Pressure Test

Mercury Manometer, Part Number ST-1111-3

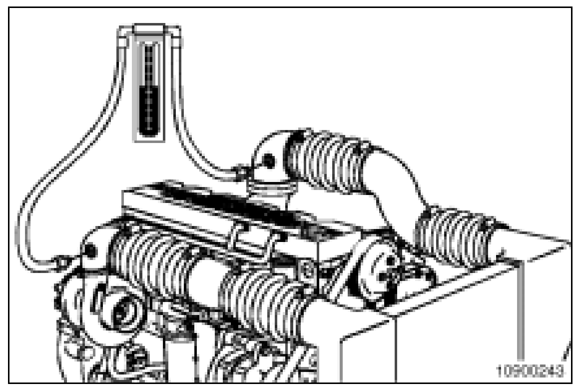
Preferred Method

Measure the charge air cooler system pressure drop with a mercury manometer.



Install one end of a mercury manometer, Part Number ST-1111-3, in the 1/8-inch fitting in the turbocharger compressor outlet elbow.

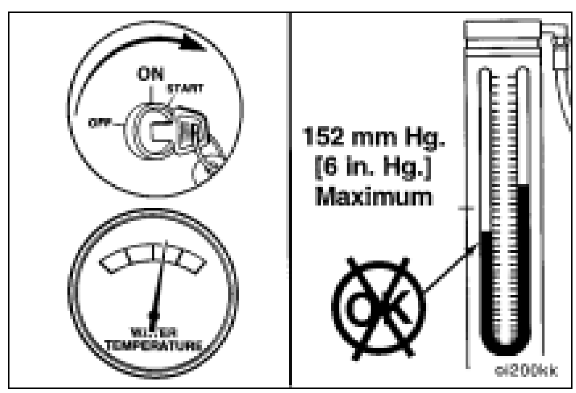
Install the other end of the mercury manometer in the intake manifold.



Operate the engine at rated rpm and load. Record the readings on the manometer.

If the differential pressure is greater than 152 mm Hg [6 in Hg], check the charge air cooler and associated piping for plugging, restrictions, or damage.

Clean or replace, if necessary.



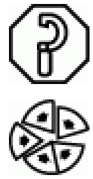
Pressure Gauge, Part Number ST-1273

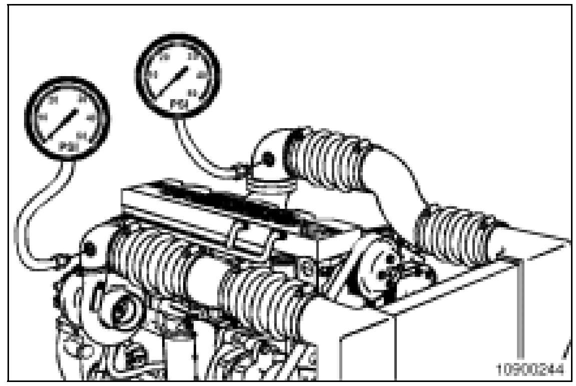
Optional Method

Obtain two pressure gauges, Part Number ST-1273. Check both gauges on the same pressure source at 206 kPa [30 psi] to maintain consistency.

Install one pressure gauge in the 1/8-inch fitting in the turbocharger compressor outlet elbow.

Install the other pressure gauge in the intake manifold.

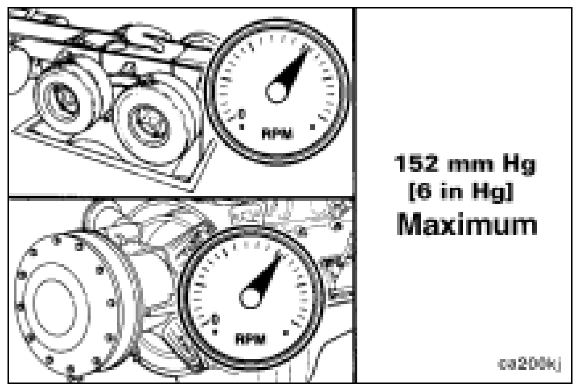




Operate the engine at rated rpm and load. Record the readings on the two gauges.

If the differential pressure is greater than 152 mm Hg [6 in Hg], check the charge air cooler and associated piping for plugging, restrictions, or damage.

Clean or replace, if necessary.



Charge Air Cooler Leak Test

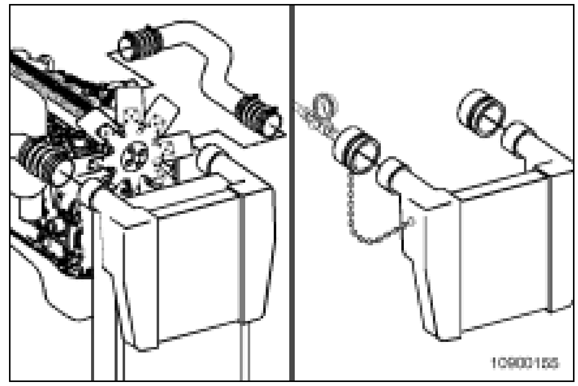
Leak Test

WARNING

To prevent possible injury if either plug blows off during the test, secure safety chains on the test plugs to any convenient capscrew on the radiator assembly. This test must be performed with securely fastened safety chains.

To check the charge air cooler for cracked tubes or header, remove the inlet and outlet hoses from the cooler. The charge air cooler does not have to be removed from the chassis.

Install a plug or cap over the outlet side of the cooler. Install a pressure gauge and a regulated shop air supply line with a shutoff valve to the inlet side of the cooler.

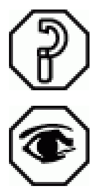


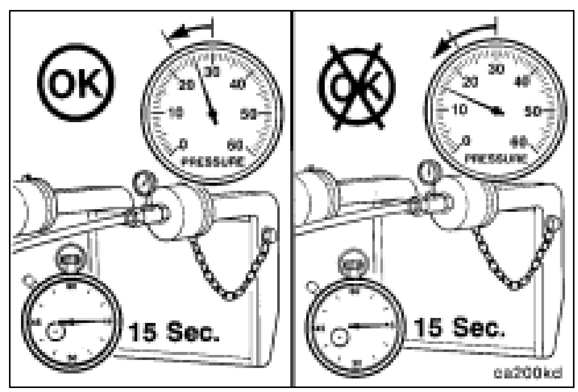
Apply air pressure to the cooler until the pressure gauge reads a steady 207 kPa [30 psi] of air pressure.

Shutoff the air flow to the cooler, and start a stopwatch at the same time. Record the leakage at 15 seconds.

If the pressure drop is 48 kPa [7 psi] or less in 15 seconds, the cooler is operational.

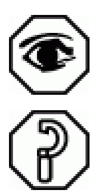
If the pressure drop is greater than 48 kPa [7 psi] in 15 seconds, check all connections again.

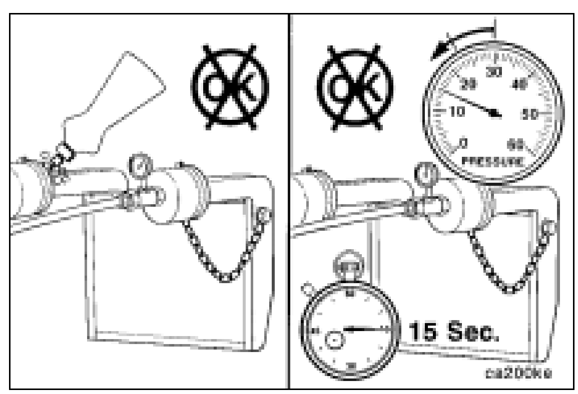




Determine if the pressure drop is caused by a leak in the charge air cooler or by a leaky connection. Use a spray bottle filled with soapy water applied to all hose connections, and watch for bubbles to appear at the location of the leak.

If the pressure drop is caused by a leaky connection, repair the connection, and repeat the test. If the leak is within the charge air cooler, repeat the test to verify the accuracy of the pressure drop measurement. Similar pressure drop readings must be obtained at least three consecutive tests before the reading





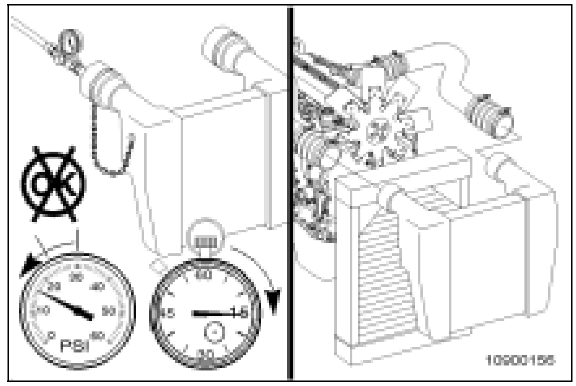
can be considered accurate.

NOTE: If a charge air cooler leaks more than 48 kPa [7 psi] in 15 seconds, it will appear as a major leak in a leak tank.

If the pressure drop is greater than 48 kPa [7 psi] in 15 seconds, the charge air cooler must be replaced.

Refer to the equipment manufacturer's service manual for replacement instructions.

NOTE: Charge air coolers are not designed to be 100-percent leak-free. If the pressure drop is less than 48 kPa [7 psi] in 15 seconds, then the charge air cooler does not need to be replaced.

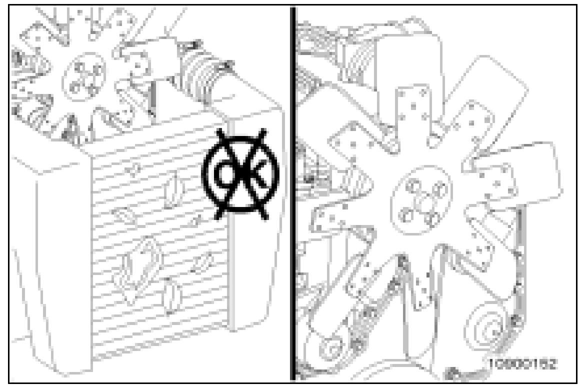


Charge Air Cooler (CAC) Temperature Differential Test

Temperature Differential Test

Inspect the charge air cooler fins for obstructions to air flow. Remove obstructions such as a winterfront or debris. Manually lock shutters in the OPEN position, if equipped.

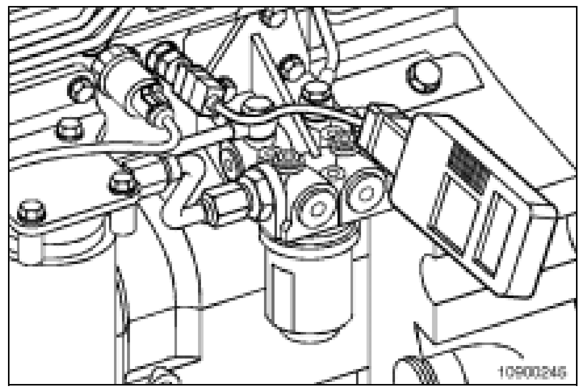
Lock the fan drive in the ON mode to prevent erratic test results. This can be done by installing a jumper wire across the temperature switch.



Install fluke digital thermometer, Part Number 3822666, into the intake manifold at the 1/8-inch NPT tap near the air horn connection with the intake manifold.

Another alternative is to use the monitor mode on the INSITE™ electronic service tool.

Install another thermocouple at the air cleaner inlet to measure ambient air temperature.



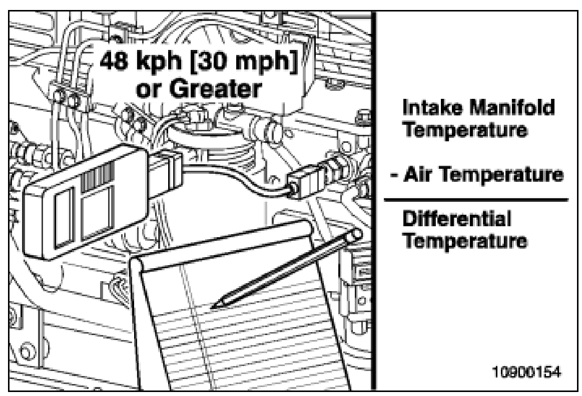
Perform a road test with the engine at peak power and a vehicle speed of 48 kph [30 mph] or greater.

Record the intake manifold temperature and the ambient air temperature.

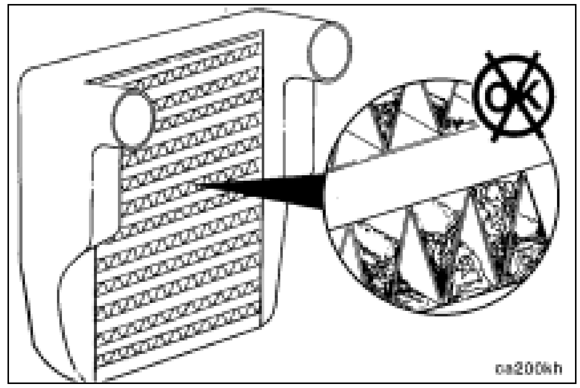
Calculate the differential temperature:

Intake Manifold Temperature minus Ambient Air Temperature equals Differential Temperature

Maximum Differential Temperature equals 28°C [50°F].

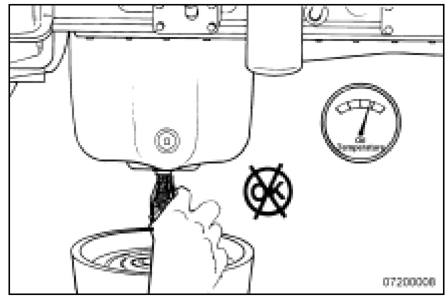


If the temperature differential is greater than the specifications, check the charge air cooler for dirt and debris on the fins and clean as necessary. If the problem still exists, check the charge air cooler for debris in the fins or between the charge air cooler and radiator. Confirm full fan engagement.



Fill and Drain Lubricating Oil

Drain



WARNING

To reduce the possibility of personal injury, avoid direct contact of hot oil with your skin.

WARNING

Some state and federal agencies have determined that used engine oil can be carcinogenic and cause reproductive toxicity. Avoid inhalation of vapors, ingestion, and prolonged contact with used engine oil. If not reused, dispose of in accordance with local environmental regulations.

NOTE: Use a container that can hold at least 23.6 liters [25 qt] of lubricating oil.

NOTE: For composite oil pans, hold the external locking nut in position with a separate wrench while removing the drain plug. This will prevent the bulkhead from loosening during drain plug removal.

Operate the engine until the coolant temperature reaches 60°C [140°F]. Shut off the engine.

Remove the oil drain plug.

Drain the oil immediately to make sure all the oil and suspended contaminants are removed from the engine.

Fill

CAUTION

For composite oil pans, always use a new sealing washer on the oil drain plug. Hold the external locking nut in place while tightening the oil drain plug.

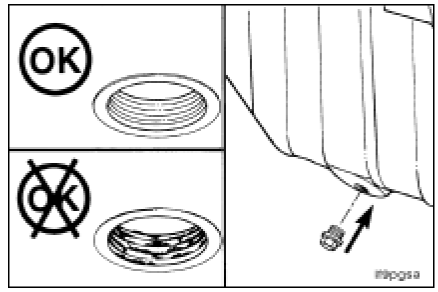
Clean and check the lubricating oil drain plug threads and sealing surface.

Install the lubricating oil pan drain plug.

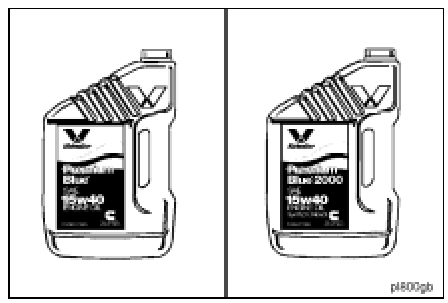
Steel Oil Pan Torque Value 80 N•m [59 ft-lb]

Cast Aluminum Oil Pan Torque Value 60 N•m [45 ft-lb]

Composite Oil Pan Torque Value 60 N•m [45 ft-lb]



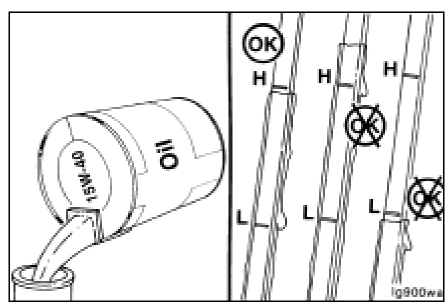
NOTE: Use a high quality 15W-40 multiviscosity oil, such as Cummins Premium Blue®, or equivalent, in Cummins engines. Choose the correct oil for your operating climate as outlined in the Operation and Maintenance Manual.



Fill the engine with clean lubricating oil to the proper level.

NOTE: When filling the oil pan, use the fill tube on the side of the engine rather than on top of the rocker lever cover.

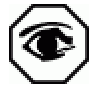
Refer to Section V for lubricating oil pan capacities.

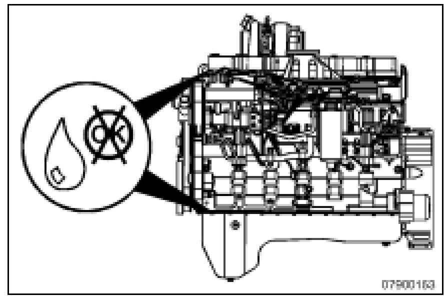


WARNING

If no oil pressure is noted within 15 seconds after the engine is started, shut down the engine to reduce the possibility of internal damage.

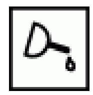
Idle the engine to inspect for leaks at the drain plug.

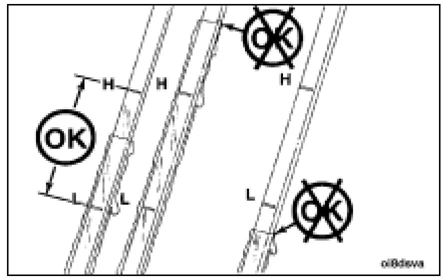




Shut off the engine. Wait approximately 10 minutes to let the oil drain from the upper parts of the engine. Check the level again.

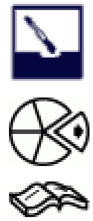
Add oil as necessary to bring the oil level to the "H" (high) mark on the dipstick.

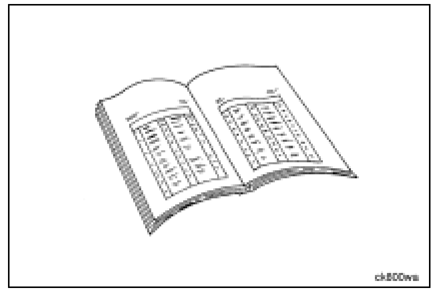




Lubricating Oil Cooler Removal/Installation

Prepare





WARNING

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

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 pressure cap. Heated coolant spray or steam can cause personal injury.

WARNING

To reduce the possibility of personal injury, avoid direct contact of hot oil with your skin.

WARNING

State and federal agencies have determined that used engine oil can be carcinogenic and cause reproductive toxicity. Avoid inhalation of vapors, ingestion, and prolonged contact with used engine oil. If not reused, dispose of in accordance with local environmental regulations.

Drain the coolant. Refer to Procedure 008-018.

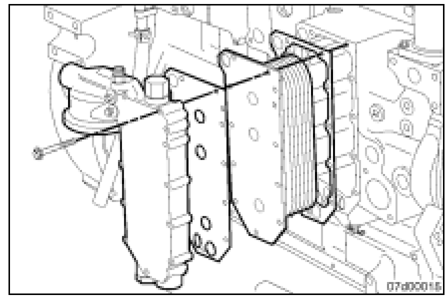
Clean the area around the lubricating oil cooler cover.

Remove the lubricating oil filter. Refer to Procedure 007-013.

Remove the turbocharger oil supply line. Refer to Procedure 010-046.

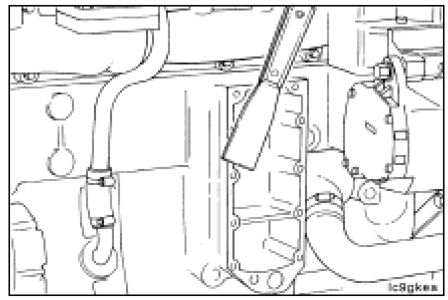
Remove

Remove the lubricating oil cooler cover, gaskets and cooler element.



Clean

Clean the sealing surfaces of the cylinder block and the oil cooler cover.



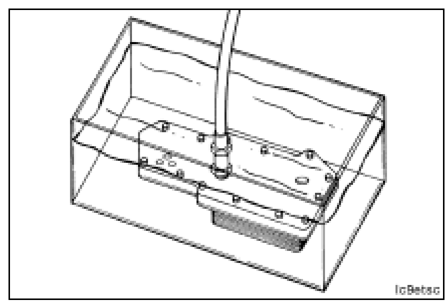
Leak Test

Pressure-test the lubricating oil cooler element using leak test kit, Part Number 3823876.

Air Pressure Test

Minimum 449 kPa [65 psi]

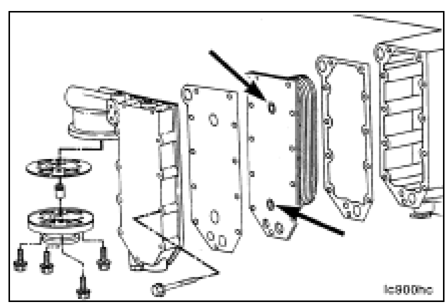
Maximum 518 kPa [75 psi]



Install

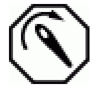
NOTE: Be sure to remove the shipping plugs from a new element.

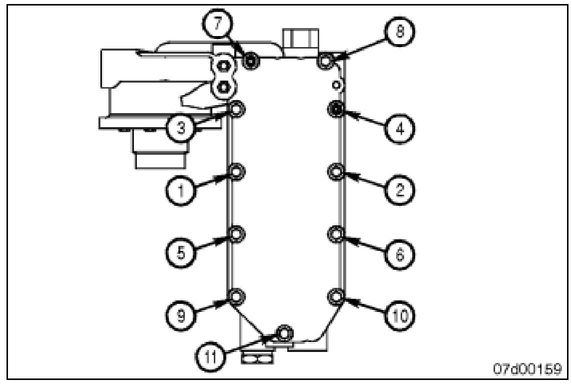
Assemble the lubricating oil cooler gaskets, element, and cooler cover.



Tighten the capscrews in the sequence shown in the illustration.

Torque Value: 24 N•m [18 ft-lb]

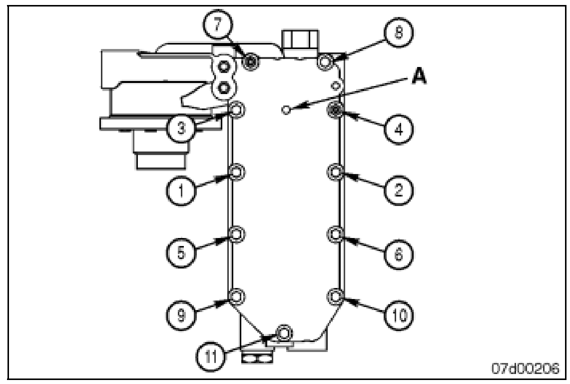




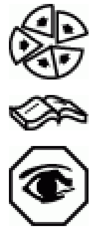
Tighten the capscrews in the sequence shown in the illustration, in two steps. The arrow (A) points to the dimple.

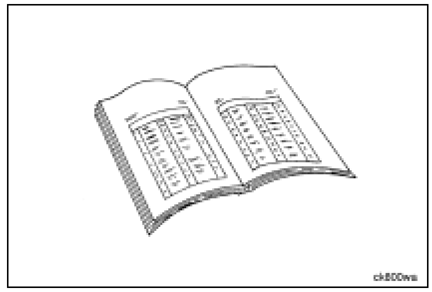
Step one: Torque Value: 24 N•m [18 ft-lb]

Step two: Torque Value: 32 N•m [24 ft-lb]



Follow-Up





WARNING

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

WARNING

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WARNING

State and federal agencies have determined that used engine oil can be carcinogenic and cause reproductive toxicity. Avoid inhalation of vapors, ingestion, and prolonged contact with used engine oil. If not reused, dispose of in accordance with local environmental regulations.

Install the turbocharger oil supply line. Refer to Procedure 010-046.

Install the lubricating oil filter. Refer to Procedure 007-013.

Fill the engine with coolant. Refer to Procedure 008-018.

Operate the engine and check for leaks.

Stop the engine and check the coolant and lubricating oil levels.

Lubricating Oil Dipstick Tube Removal/Installation

Prepare

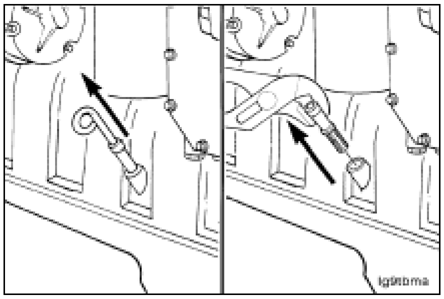
Clean the area around the dipstick tube before removing to prevent debris from entering the oil system.

Remove

Remove dipstick from the dipstick tube.

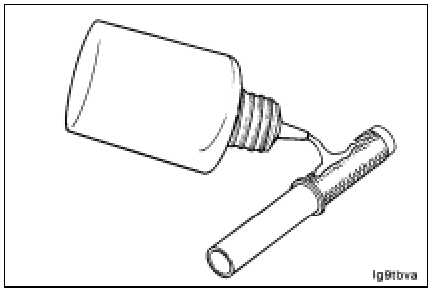
Remove dipstick tube from the cylinder block.

Service Tip: Use a dent puller and a M8 x 1.25 x 21-mm self-tapping capscrew. Thread the capscrew into the dipstick tube and remove the tube.



Install

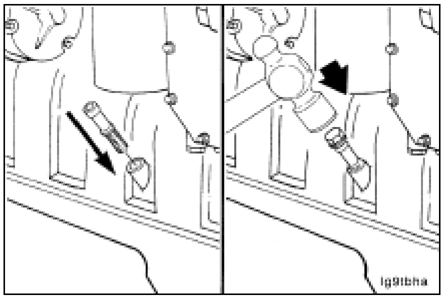
Apply a thin bead of Loctite™ 609, part number 3823718 or equivalent, around the bottom of the knurled end of the tube.



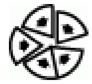
Place the knurled end of the tube into the dipstick tube bore in the cylinder block.

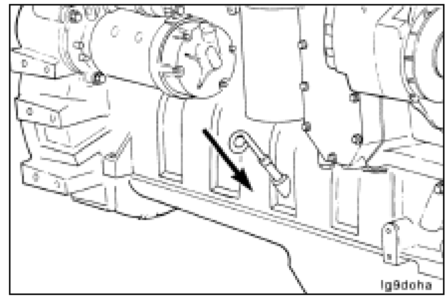
Use a flat washer and hex head capscrew to drive the tube into the cylinder block.

Lightly drive the dipstick tube until it seats against the block casting.



Install the dipstick into the dipstick tube.



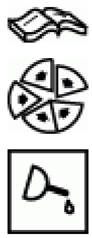


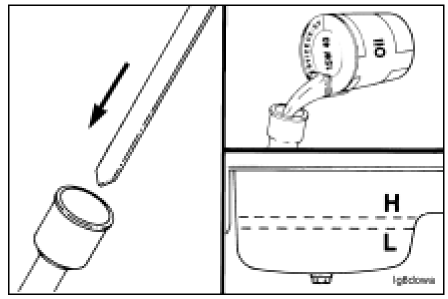
Follow-Up

Lubricating Oil Dipstick Calibration

Prepare

Calibrate





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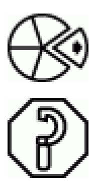
WARNING

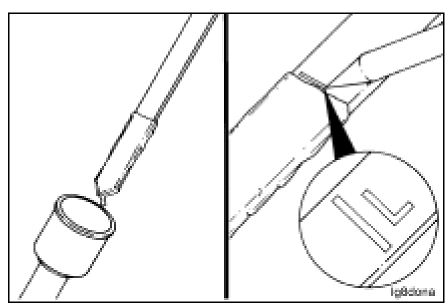
To reduce the possibility of personal injury, avoid direct contact of hot oil with your skin.

Drain the lubricating oil. Refer to Procedure 007-037.

Install the dipstick in the dipstick tube housing.

Use clean 15W-40 oil to fill the oil pan to the specified LOW oil level. Refer to Lubricating Oil System Specifications in Procedure 018-017 of this manual for the correct engine oil capacity.





CAUTION

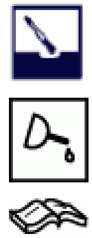
Use care when marking the dipstick. The dipstick will break if the scribe mark is too deep.

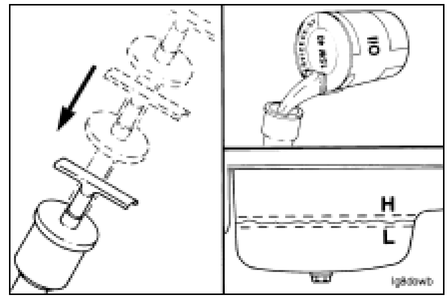
Remove the dipstick and scribe a mark across the stick at the oil level. Label the mark with an L to indicate the "LOW" oil level.

NOTE: If a new blank dipstick is being used, cut the dipstick off approximately 38 mm [1.5 in] below the LOW oil level mark.

Wipe off the dipstick and install it in the dipstick tube housing.

Fill the oil pan to the specified HIGH oil level. Refer to Lubricating Oil System Specifications in Procedure 018-017 of this manual for the correct engine oil capacity.

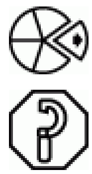


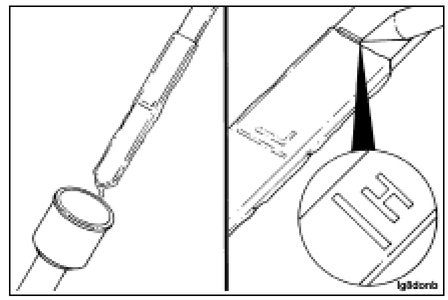


CAUTION

Use care when marking the dipstick. The dipstick will break if the scribe mark is too deep.

Remove the dipstick and scribe a mark across the stick at the oil level. Label the mark with an H to indicate the HIGH oil level.





Follow-Up

Lubricating Oil Filter Removal/Installation

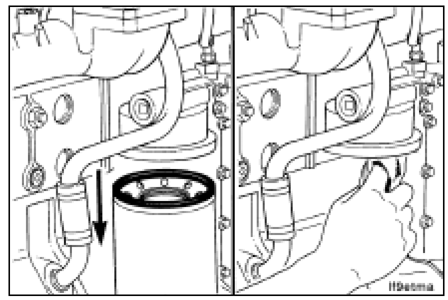
Prepare

Remove

Clean the area around the lubricating oil filter head.

Remove the oil filter with oil filter wrench, Part Number 3375049.

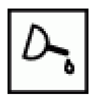
Clean the gasket surface of the filter head.

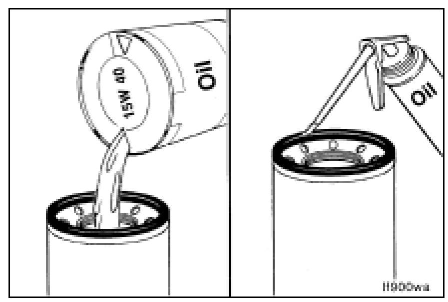


Install

Lubricate the oil filter gasket with clean engine oil.

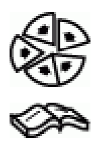
Fill the oil filter with clean engine oil.

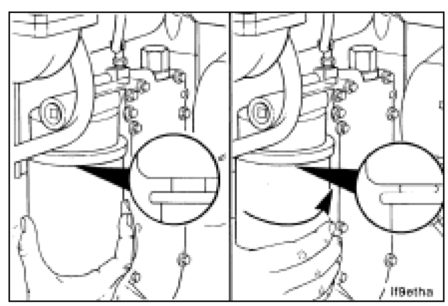




Install the filter on the oil filter head. Tighten the filter until the gasket contacts the filter head surface.

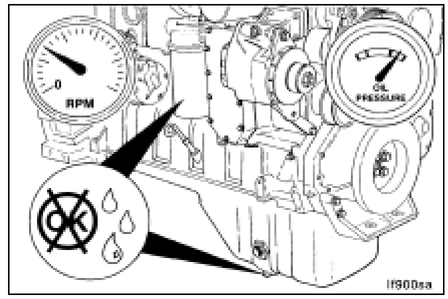
Use oil filter wrench, Part Number 3375049, to tighten the filter an additional ½ to ¾ of a turn, or follow the instructions supplied with the oil filter.





Follow-Up

Operate the engine and check for leaks.



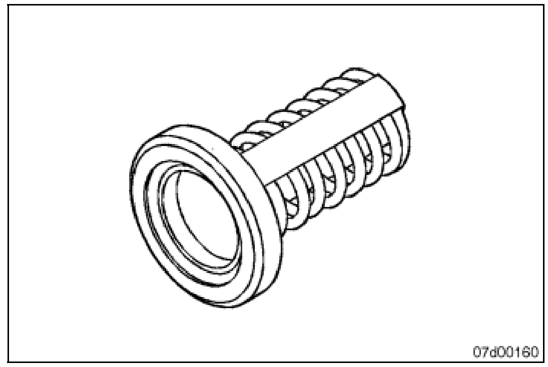
Lubricating Oil Bypass Valve Removal/Installation

General Information

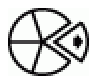
Whenever the pressure drop across the lubricating oil filter exceeds a predetermined set point, the oil filter bypass valve opens and allows lubricating oil to bypass the lubricating oil filter.

This condition can occur during cold ambient (cold lubricating oil) engine start-ups.

The purpose of the bypass valve is to maintain lubricating oil flow to the engine and prevent an oil filter collapse.



Prepare

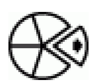


Remove the lubricating oil filter. Refer to Procedure 007-013.

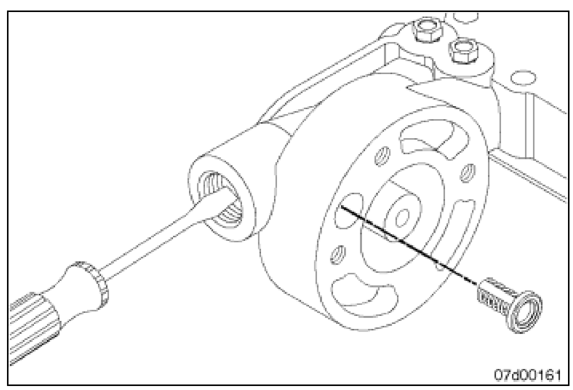
Remove the lubricating oil filter head. Refer to Procedure 007-015.

Remove the 3/4-inch pipe plug from the end of the oil filter head.

Remove



Using a screwdriver, gently push down on the top of the bypass valve to remove it from the bore.



Clean and Inspect for Reuse

WARNING

When using solvents, acids, or alkaline materials for cleaning, follow the manufacturer's recommendations for use. Wear goggles and protective clothing to reduce the possibility of personal injury.

WARNING

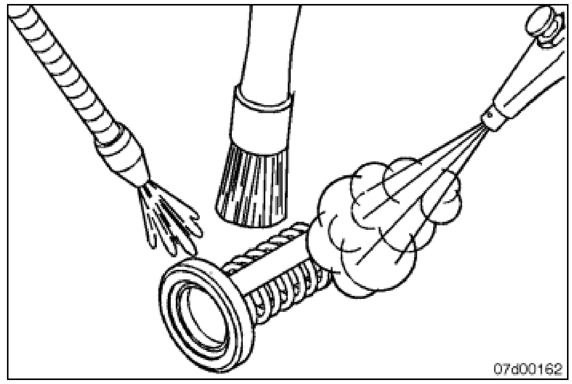
Some solvents are flammable and toxic. Read the manufacturer's instructions before using.

WARNING

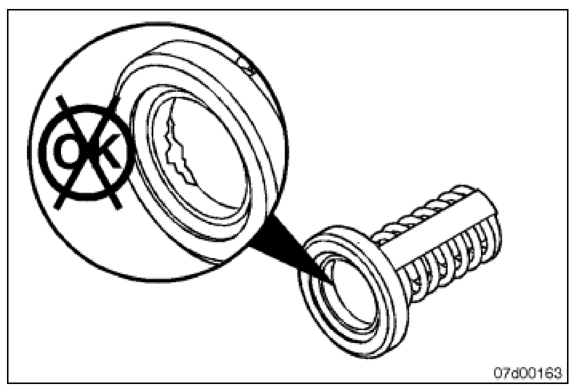
Wear appropriate eye and face protection when using compressed air. Flying debris and dirt can cause personal injury.

Clean the bypass valve with solvent.

Dry with compressed air.



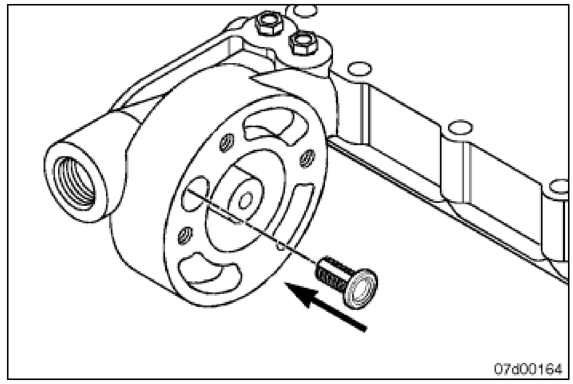
Inspect the bypass valve seat for damage.
Make sure the valve fully closes.



Install

Insert the bypass valve into the bore. The spring should be pointing upward into the bore.

Gently seat the bypass valve into the bore until it seats.



Install the 3/4-inch pipe plug into the end of the oil filter head.

Torque Value: 45 N•m [33 ft-lb]

Follow-Up

Install the lubricating oil filter head. Refer to Procedure 007-015.

Install the lubricating oil filter. Refer to Procedure 007-013.

Lubricating Oil Filter Head Removal/Installation

Prepare

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 pressure cap. Heated coolant spray or steam can cause personal injury.

WARNING

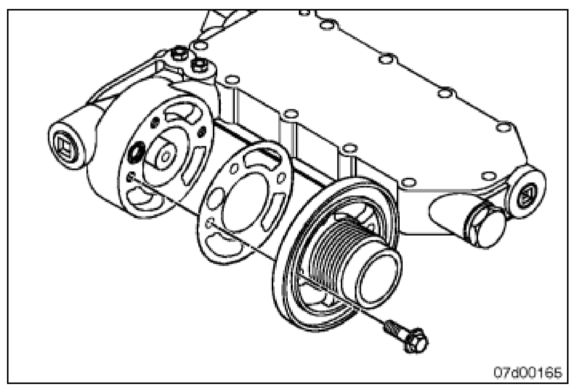
Coolant is toxic. Keep away from children and pets. If not reused, dispose of in accordance with local environmental regulations.

Drain the coolant. Refer to Procedure 008-018.

Remove the lubricating oil cooler. Refer to Procedure 007-003.

Remove

Remove the lubricating oil filter head capscrews, filter head, and gasket.



Clean and Inspect for Reuse

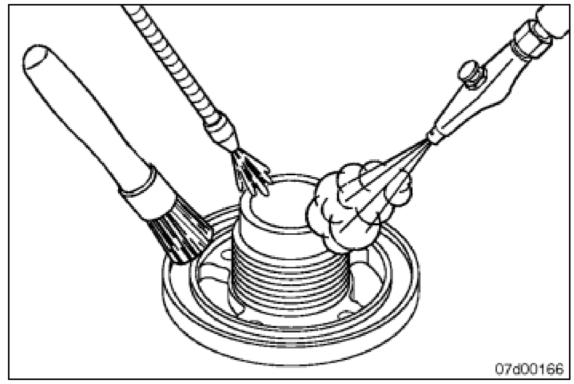
WARNING

When using solvents, acids, or alkaline materials for cleaning, follow the manufacturer's recommendations for use. Wear goggles and protective clothing to reduce the possibility of personal injury.

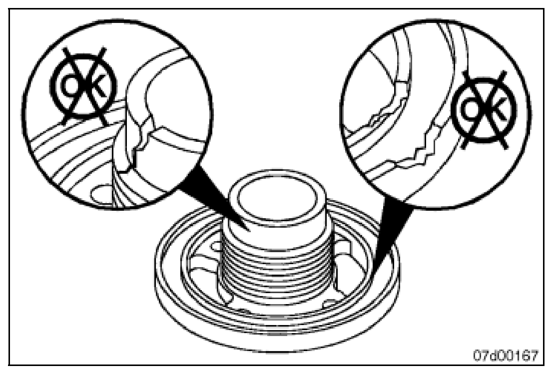
WARNING

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

Use solvent to clean the adapter.



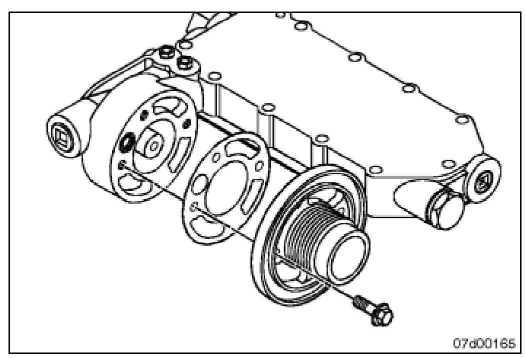
Inspect the adapter for cracks and other damage.



Install

Install the oil filter head, gasket, and capscrews.

Torque Value: 24 N•m [18 ft-lb]



Follow-Up

Install the lubricating oil cooler. Refer to Procedure 007-003.

Fill the cooling system. Refer to Procedure 008-018.

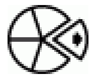
Operate engine and check for leaks.

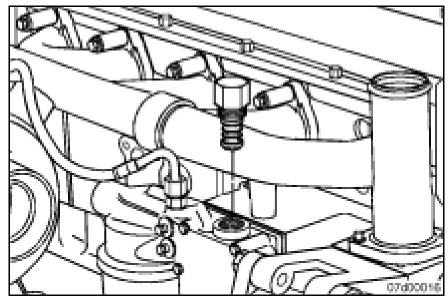
Lubricating Oil High Pressure Relief Valve Removal/Installation

Prepare

Remove

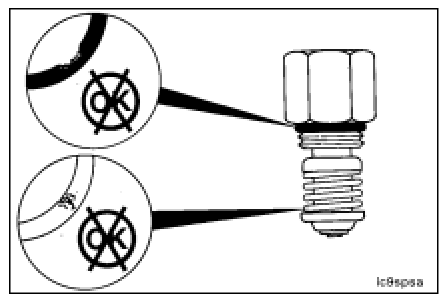
Remove the oil cooler bypass valve.





Inspect for Reuse

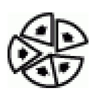
Inspect for a damaged o-ring, broken spring or other damage.

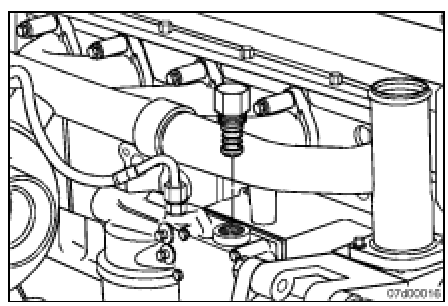


Install

Install the oil cooler bypass valve.

Torque Value: 50 N•m [37 ft-lb]





Follow-Up

Lubricating Oil Pan Removal/Installation

Prepare

WARNING

To reduce the possibility of personal injury, avoid direct contact of hot oil with your skin.

WARNING

Some state and federal agencies have determined that used engine oil can be carcinogenic and cause reproductive toxicity. Avoid inhalation of vapors, ingestion, and prolonged contact with used engine oil. If not reused, dispose of in accordance with local environmental regulations.

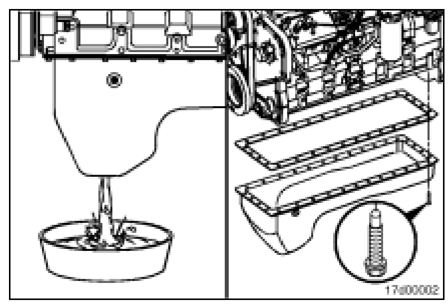
Drain the lubricating oil. Refer to Procedure 007-037.

Remove

Remove the lubricating oil pan and gasket.

If suction tube must be removed, refer to Procedure 007-035.

If the engine is equipped with a block stiffener plate, refer to Procedure 001-089.



Clean and Inspect for Reuse

WARNING

When using a steam cleaner, wear safety glasses or a face shield, as well as protective clothing. Hot steam can cause serious personal injury.

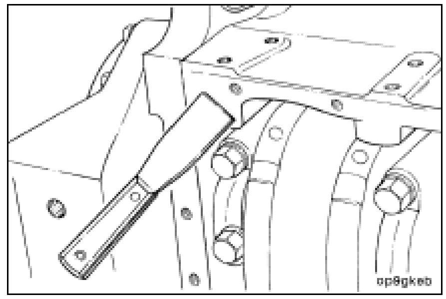
WARNING

Wear appropriate eye and face protection when using compressed air. Flying debris and dirt can cause personal injury.

Remove all gasket material from the cylinder block and oil pan surface.

Steam-clean the oil pan.

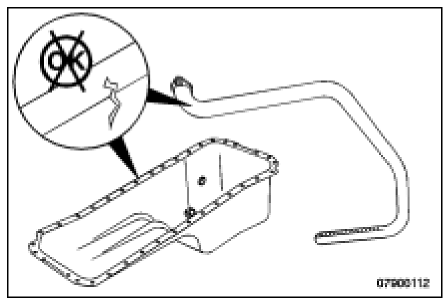
Dry with compressed air.



Inspect the oil pan, suction tube, and tube braces for damage.

NOTE: If cracks are found, replace the damaged part. Do not attempt to repair the oil pan by welding.

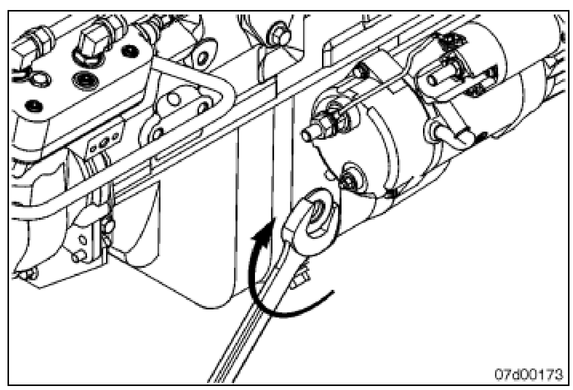
If the suction tube must be replaced; refer to Procedure 007-035.



Composite Oil Pan Only

Make sure the bulkhead fitting is tight. If it is found to be loose, replace the o-ring and tighten the bulkhead.

Torque Value: 24 N•m [20 ft-lb]

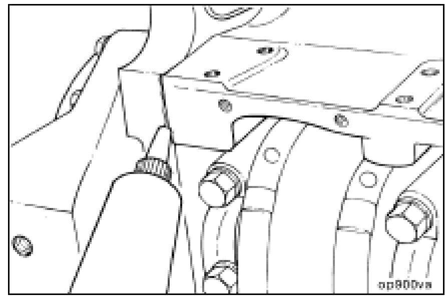


Install

Use Three-Bond™ RTV sealant, or equivalent, to fill the joints between the lubricating oil pan rail, gear housing, and rear seal housing.

If the suction tube has been removed; refer to Procedure 007-035 for installation instructions.

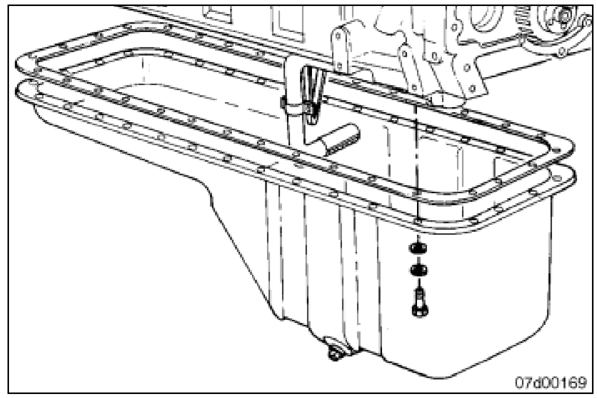
If the engine is equipped with a block stiffener plate, refer to Procedure 001-089.



Install the gasket and lubricating oil pan.

Install the oil pan corner braces, if equipped.

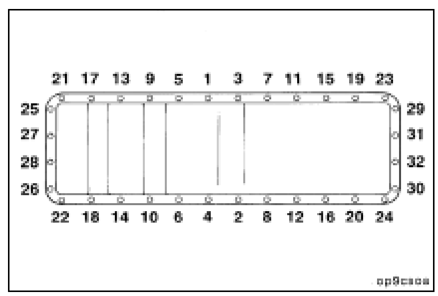
NOTE: New noise isolators must be used with oil pans using the isolated gasket system.



Assemble the washers and capscrews to secure the lubricating oil pan as illustrated.

Tighten all capscrews in the sequence shown in the accompanying chart.

Torque Value: 28 N•m [21 ft-lb]



Follow-Up

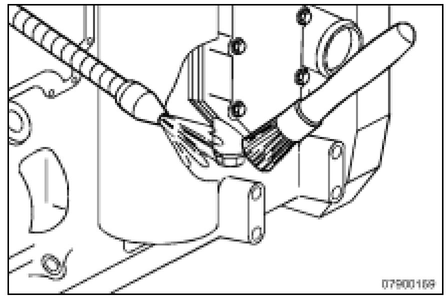
Fill the lubricating oil system. Refer to Procedure 007-037.

Operate the engine and check for leaks.

Lubricating Oil Pressure Regulator Removal/Installation

Prepare

Remove



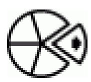
WARNING

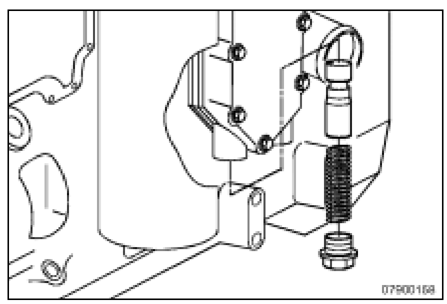
When using solvents, acids, or alkaline materials for cleaning, follow the manufacturer's recommendations for use. Wear goggles and protective clothing to reduce the possibility of personal injury.

WARNING

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

Thoroughly clean the area around the pressure regulator plug with clean solvent to prevent debris from falling into the plunger bore when the plug is removed.

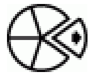


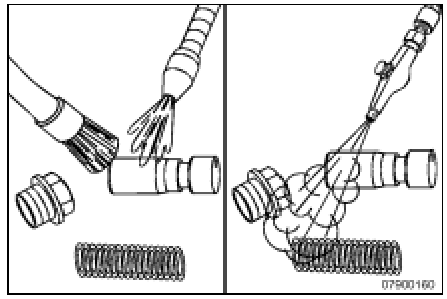


Remove the threaded plug, spring, and plunger.

Service Tip: The plunger normally can be removed by inserting one finger into the plunger bore until snug and pulling down. If the plunger can not be removed in this manner, the plunger is probably stuck and will require removal of the housing for cleaning the plunger.

Clean and Inspect for Reuse





WARNING

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WARNING

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

WARNING

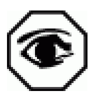
Wear appropriate eye and face protection when using compressed air. Flying debris and dirt can cause personal injury.

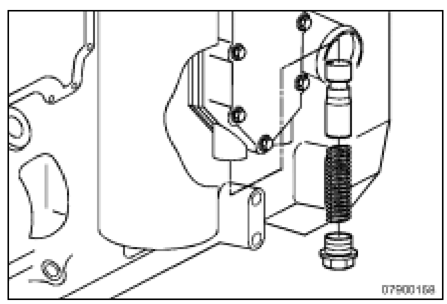
NOTE: If the plunger bore requires cleaning, remove the housing to avoid flushing debris into the engine.

Thoroughly clean all components with clean solvent.

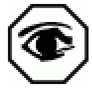
Dry with compressed air.

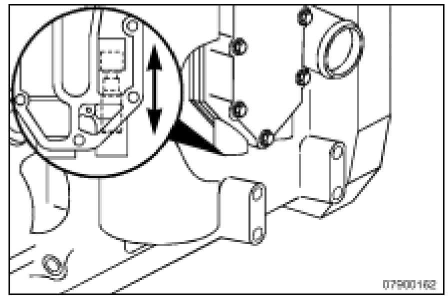
Inspect the plunger and plunger bore. Polished areas on the plunger and bore are acceptable.





Verify that the plunger moves freely in the bore.

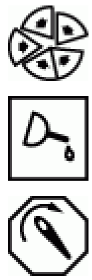


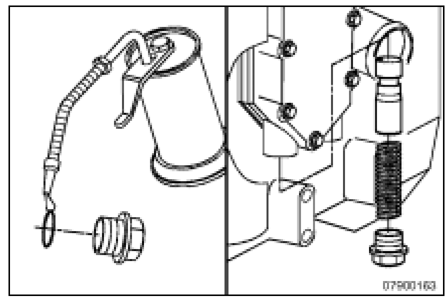


Install

Install a new sealing o-ring on the threaded plug and lubricate with clean engine oil. Install the pressure regulator assembly.

Torque Value: 80 N•m [59 ft-lb]





Follow-Up

Lubricating Oil Pump Removal/Installation

Prepare

Remove the fan drive belt. Refer to Procedure 008-002.

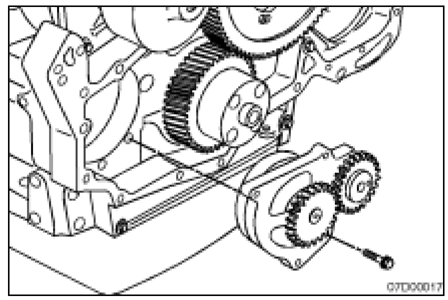
Remove the vibration damper. Refer to Procedure 001-052.

Remove the front cover. Refer to Procedure 001-031.

Remove

Remove the four mounting capscrews.

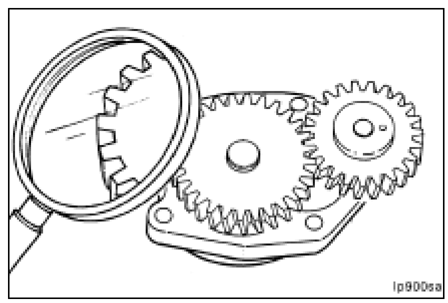
Remove the pump from the bore in the cylinder block.



Disassemble

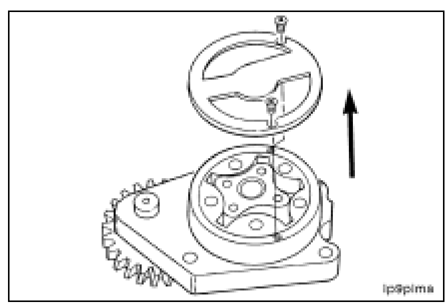
If the lubricating oil pump is to be inspected for reuse, follow these steps.

Inspect the lubricating oil pump gears for chips, cracks, or excessive wear.

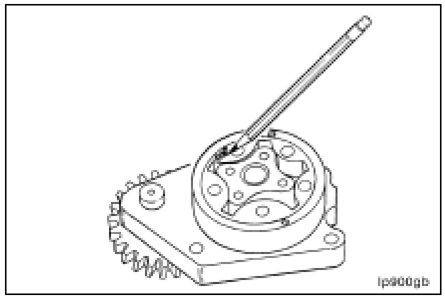


Remove the back plate.

NOTE: The ISC, QSC8.3, ISL, and QSL9 lubricating oil pump uses a large diameter 5/6 rotor set. The graphics in this manual illustrate a 4/5 rotor set.

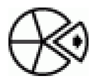


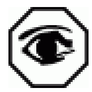
Mark TOP on the gerotor planetary.

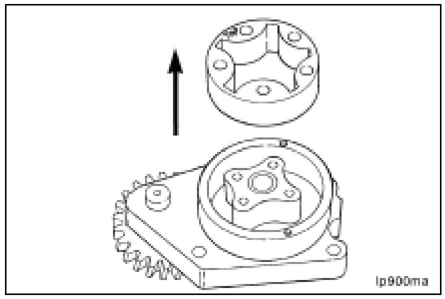


Remove the gerotor planetary.

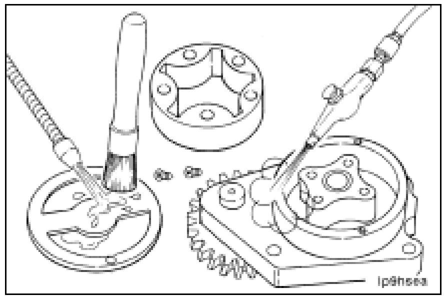
Inspect for excessive wear or damage.







Clean and Inspect for Reuse



WARNING

When using solvents, acids, or alkaline materials for cleaning, follow the manufacturer's recommendations for use. Wear goggles and protective clothing to reduce the possibility of personal injury.

WARNING

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

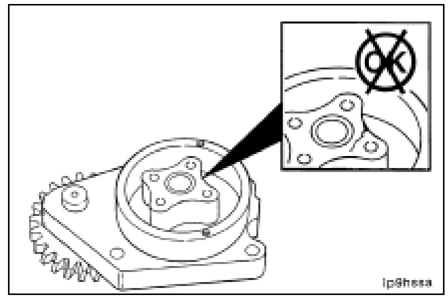
WARNING

Wear appropriate eye and face protection when using compressed air. Flying debris and dirt can cause personal injury.

Clean all parts in solvent.

Dry with compressed air.

Inspect the lubricating oil pump housing and gerotor drive for damage and excessive wear.

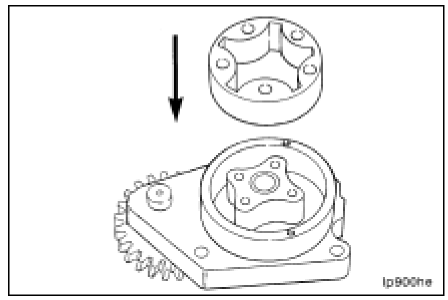


Assemble

CAUTION

Make sure that the gerotor planetary is installed in the original position.

Install the gerotor planetary.

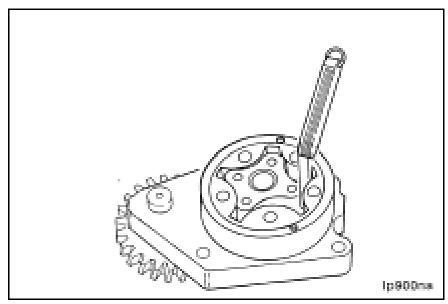


Measure the tip clearance.

Tip Clearance

Minimum 0.025 mm [0.001 in]

Maximum 0.1778 mm [0.007 in]

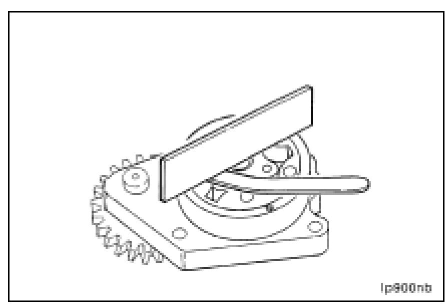


Measure the clearance of the gerotor drive/gerotor planetary to port plate.

Gerotor Drive/Gerotor Planetary to Port Plate Clearance

Minimum 0.025 mm [0.001 in]

Maximum 0.127 mm [0.005 in]

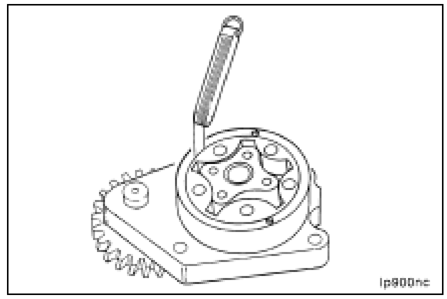


Measure the clearance of the gerotor planetary to the body bore.

Gerotor Planetary to Body Bore Clearance

Minimum 0.1778 mm [0.007 in]

Maximum 0.381 mm [0.015 in]

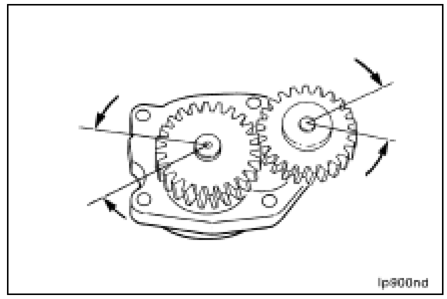


Measure the backlash.

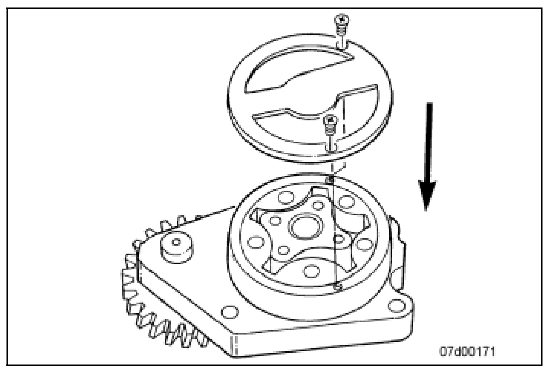
Lubricating Oil Pump Gears Backlash Limits (Used Pump)

Minimum 0.076 mm [0.003 in]

Maximum 0.330 mm [0.013 in]



Install the back plate.

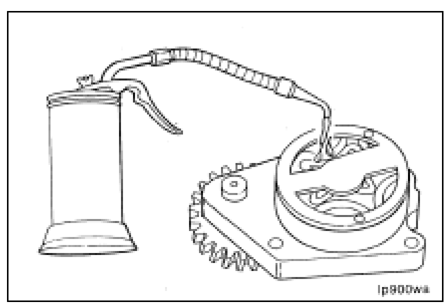


Install

CAUTION

Failure to fill the pump with oil during installation can result in a failure of the lubricating oil pump to prime at initial engine start-up, resulting in severe engine damage.

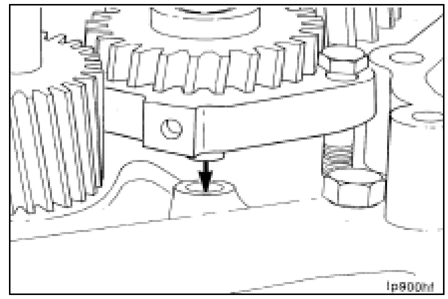
Lubricate the lubricating oil pump with clean 15W-40 engine oil.



CAUTION

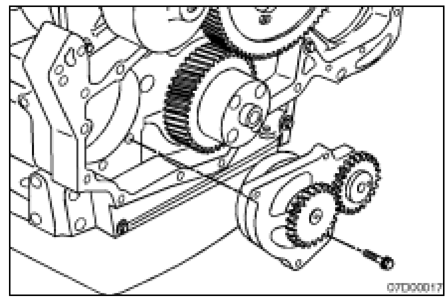
Make sure the idler gear pin is installed in the locating bore in the cylinder block.

Install the lubricating oil pump.



Tighten capscrews in an X pattern, starting with the upper right capscrew.

Torque Value: 24 N•m [18 ft-lb]



NOTE: Be sure the gear backlash is correct if installing a new lubricating oil pump.

Measure the gear backlash.

Lubricating Oil Pump Gears Backlash Limits (Installed)

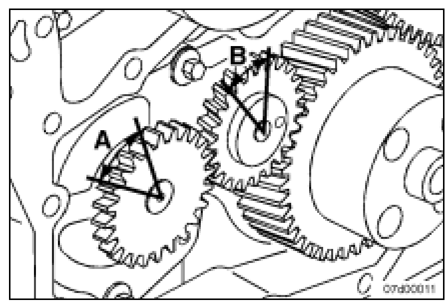
A Minimum 0.076 mm [0.003 in]

A Maximum 0.330 mm [0.013 in]

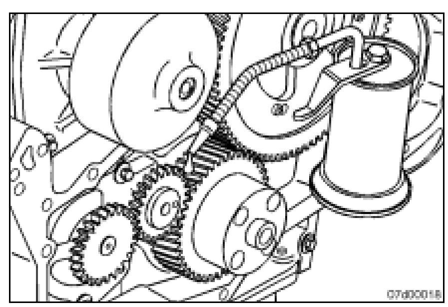
B Minimum 0.076 mm [0.003 in]

B Maximum 0.330 mm [0.013 in]

NOTE: If the adjoining gear moves when you measure the backlash, the reading will be incorrect.

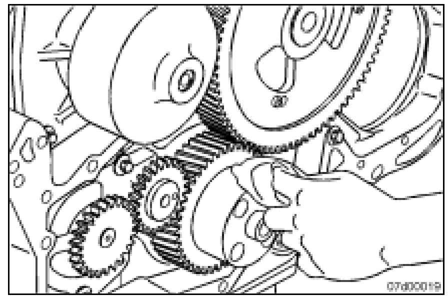


Lubricate the front gear train with clean 15W-40 engine oil.



CAUTION

The seal lip and the sealing surface on the crankshaft must be free from all oil residue to prevent seal leaks.



Thoroughly clean the front seal area of the crankshaft.

NOTE: Always replace the front seal when removing and installing the front cover. Refer to Procedure 001-031.

Follow-Up

Install the front cover. Refer to Procedure 001-031.

Install the vibration damper. Refer to Procedure 001-052.

Install the fan drive belt. Refer to Procedure 008-002.

Lubricating Oil Suction Tube Removal/Installation

Prepare

WARNING

To reduce the possibility of personal injury, avoid direct contact of hot oil with your skin.

WARNING

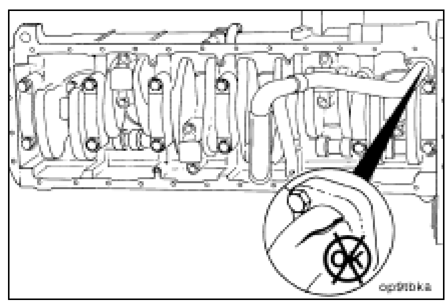
Some state and federal agencies have determined that used engine oil can be carcinogenic and cause reproductive toxicity. Avoid inhalation of vapors, ingestion, and prolonged contact with used engine oil. If not reused, dispose of in accordance with local environmental regulations.

Drain the lubricating oil. Refer to Procedure 007-037.

Remove the lubricating oil pan and gasket. Refer to Procedure 007-025.

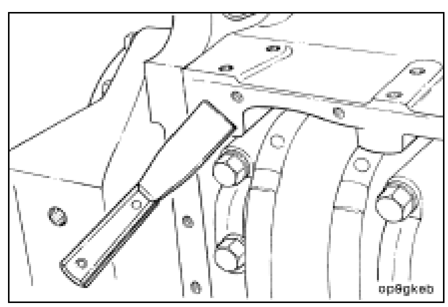
Remove

Remove the lubricating oil suction tube.

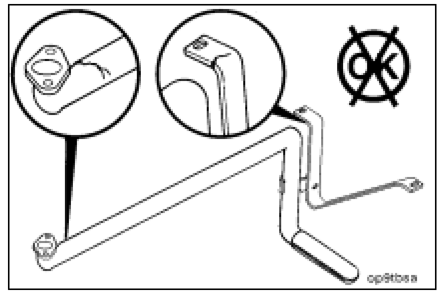


Clean and Inspect for Reuse

Clean the gasket surfaces.



Inspect the suction tube for cracks.



Install

Install the lubricating oil suction tube and new gasket.

Install all capscrews finger tight and check for correct alignment.

Torque the lubricating oil suction tube to the block.

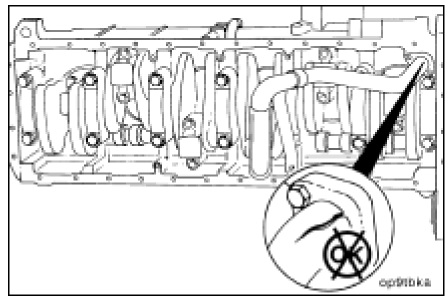
Torque Value: 10 N•m [89 in-lb]

Torque the lubricating oil suction tube brace to the engine block.

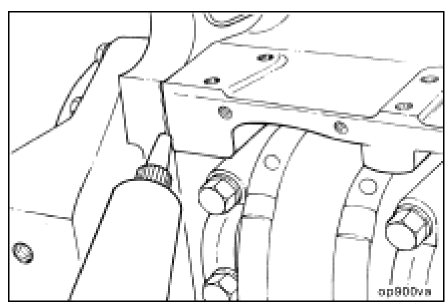
Torque Value: 10 N•m [89 in-lb]

Torque the lubricating oil suction tube to the brace.

Torque Value: 10 N•m [89 in-lb]



Use Three-Bond™ 1207-C, or equivalent, to fill the joints between the lubricating oil pan rail, gear housing, and rear seal housing.



Follow-Up

Install the lubricating oil pan and gasket. Refer to Procedure 007-025.

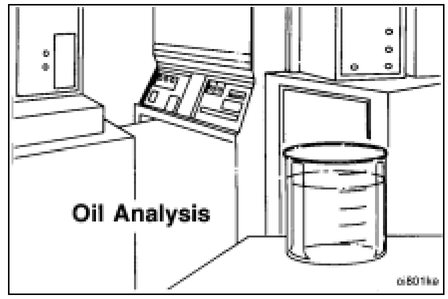
Operate the engine and check for leaks.

Lubricating Oil and Filter Analysis

Inspect

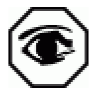
An analysis of used oil can help diagnose internal engine damage and determine if it was caused by one of the following:

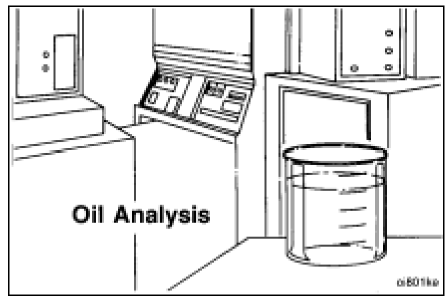
- Intake air filter malfunction
- Coolant leaks
- Oil diluted with fuel
- Metal particles causing wear



For additional oil analysis information, Refer to Cummins Engine Oil Recommendations, Bulletin 3810340.

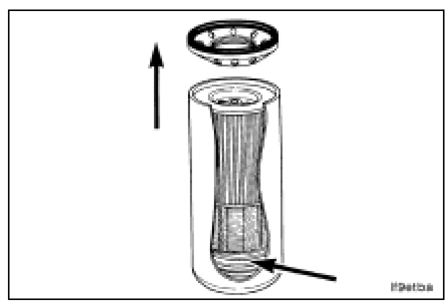
NOTE: Do not take apart an engine for repair based solely on the results of an oil analysis. Inspect the oil filters. If the oil filter shows evidence of internal damage, find the source of the problem, and repair the damage. Refer to the appropriate procedure(s) based on the following oil filter inspection.





WARNING

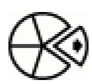
Restrain the full flow lubricating oil filter, and carefully cut the filter (upper section of combination filter) open. The filter element spring is under compression and can cause personal injury.

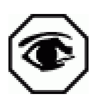


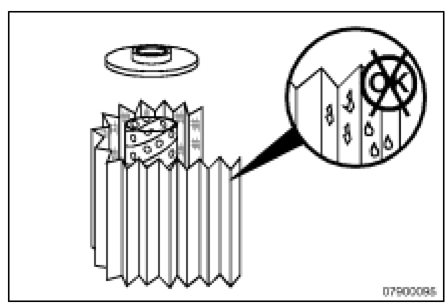
Use the tube cutter, Part No. 3376579, to open the full-flow oil filter (upper section of the bypass filter).

Inspect the filter element for evidence of moisture or metal particles.

Metal	Possible Source
Copper	Bearings and Bushings







Chromium	Piston Rings
Iron	Cylinder Liners
Lead	Bearing Overlay Material
Aluminum	Piston Wear or Scuffing

Oil Pressure Switch Removal/Installation

Prepare

Remove

Install

Follow-Up

Oil Pressure Sender Removal/Installation

Prepare

Remove

Install

Follow-Up

Oil Pressure Gauge Removal/Installation

Prepare

Remove

Install

Follow-Up

Speed Sensor Removal/Installation

Prepare

Remove

Install

Follow-Up

Tachometer Removal/Installation

Prepare

Remove

Install

Follow-Up

Overspeed Switch Removal/Installation

Prepare

Remove

Install

Follow-Up

Tachometer Calibration

Primary ECM Removal/Installation

Prepare

Remove

Install

Follow-Up

Secondary ECM Removal/Installation

Prepare

Remove

Install

Follow-Up

ECM Harness Removal/Installation

Prepare

Remove

Install

Follow-Up

ECM Engine Speed Sensor

Prepare

Remove

Install

Follow-Up

ECM Engine Position Sensor

Prepare

Remove

Install

Follow-Up

ECM Oil Pressure Sensor

Prepare

Remove

Install

Follow-Up

ECM Boost Pressure Sensor

Prepare

Remove

Install

Follow-Up

ECM Coolant Temperature Sensor

Prepare

Remove

Install

Follow-Up

ECM Fuel Pressure Sensor

Prepare

Remove

Install

Follow-Up

ECM Fuel Temperature Sensor

Prepare

Remove

Install

Follow-Up

ECM Ambient Air Pressure Sensor

Prepare

Remove

Install

Follow-Up

ECM Air Temperature Sensor

Prepare

Remove

Install

Follow-Up

Section 13 – Service Literature

Section Contents

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Additional Service Literature

General Information

The following publications can be purchased at your selected Service Literature Ordering Location:

Bulletin	Title of Publication
3379001	Fuel for Cummins Engines Bulletin
3810340	Cummins Engine Oil Recommendations Bulletin
3666132	Coolant Requirements and Maintenance Bulletin
3379009	Operation - Cold Weather Bulletin
3379000	Air for Your Engine
3666194	Troubleshooting and Repair Manual, Electronic Control System, ISB and QSB5.9 Engines, Volumes I and II
4021398	Troubleshooting and Repair Manual, Industrial QSB3.9-30, QSB4.5-30, and QSB5.9-30 Series Engines
4021399	QSB3.9-30, QSB4.5-30, and QSB5.9-30 Wiring Diagram

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
U.K., Europe, Mid-East, Africa, and Eastern European Countries	Cummins Engine Co., Ltd. Royal Oak Way South Daventry Northants, NN11 5NU, England
South and Central America (excluding Brazil and Mexico)	Cummins Americas, Inc. 16085 N.W. 52nd Avenue Hialeah, FL 33104
Brazil and Mexico	Cummins Inc. International Parts Order Dept., MC 40931 Box 3005 Columbus, IN 47202-3005
Far East (excluding Australia and New Zealand)	Cummins Diesel Sales Corp. Literature Center 8 Tanjong Penjuru Jurong Industrial Estate Singapore
Australia and New Zealand	Cummins Diesel Australia Maroondah Highway, P.O.B. 139 Ringwood 3134 Victoria, Australia

Section 14 – Service Assistance

Section Contents

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Routine Service and Parts

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 yellow pages or refer to the directory in this section for the nearest Cummins Authorized Repair Location.

Emergency and Technical Service

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 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.

Outside of North America contact your Regional Office. Telephone numbers and addresses are listed in the International Directory.

See also www.cummins.com

oi800vv

Problem Solving

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 yellow pages for the one nearest you. If the problem has not been handled satisfactorily, follow the steps outlined below:

If the disagreement is with a Dealer, talk to the Cummins Distributor with whom he has his service agreement.

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:

- Engine model and serial number
- Type and make of equipment
- Total kilometers [miles] or hours of operation
- Warranty start date
- Nature of problem
- Summary of the current problem arranged in the order of occurrence
- Name and location of the Cummins Distributor or Dealer

If a problem can not be resolved satisfactorily through your Cummins Authorized Repair Location or Division Office, write to:

Cummins Customer Assistance Center - 41403,

Cummins Engine Company, Inc.,

Box 3005, Columbus, IN 47202-3005

Section 15 – Maintenance Specifications

Section Contents

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General Engine Data

NOTE: The following engine and system specification data is extracted from the curves and data sheets that were current when this document was prepared. Refer to Performance Curve Drawing 9722 and Data Sheet Drawing 9723 for the most current information. Contact Cummins Fire Power at 920-337-9750 if current information is required.

Refer to the base engine troubleshooting and repair manual for base engine coverage (see Service Literature in Section 13).

Type	4 Cycle; In-Line; 6 Cylinder
Firing Order	1-5-3-6-2-4
Rotation, Viewed from the Front of the Engine	Clockwise
Compression Ratio:	17.1:1
Valves per cylinder: Inlet/Exhaust	2 / 2
Cummins Base Engine Fuel Rating	FR-91061
Cummins Engine Co. Base Engine	QSC8.3-C340
Installation Drawing	8711 (see Section 18)
Configuration Number	D413032CX03
Fuel System	C.A.P.S.
Aspiration	Turbocharged, Charge Air Cooled

	Metric	**US**
Bore	114mm	4.49 in
Stroke	135mm	5.31 in.
Displacement	8.3 liter	506 in.3
Intake Valve Clearance	0.25 mm	0.010 in
Exhaust Valve Clearance	0.51 mm	0.020 in
Dry Weight	723kg	1595 lb
Wet Weight	813kg	1792 lb

NOTE: The engine features a no-adjust overhead. The valve train is designed such that adjustment of the valve lash is not required for normal service during the first 5,000 hours. The valve train operates acceptably within the limits of 0.152- to 0.381-mm [0.006- to 0.015-in] intake valve lash and 0.381- to 0.762-mm [0.015- to 0.030-in] exhaust valve lash.

Fuel System Specifications

Fuel	Type Number 2 Diesel Only
Recommended primary fuel filter	Fleetguard 3843760

	Metric	**US**
Minimum supply line size	12.7 mm D.	0.5 in. D.
Minimum drain line size	9.53 mm D.	0.375 in. D.
Maximum fuel line length between supply tank & fuel pump	12.2 m	40 ft.
Maximum fuel height above C/L crankshaft	2030 mm	80 in.
Maximum restriction @ lift pump-inlet - with clean filter	102 mm Hg	4 in. Hg
Maximum restriction @ lift pump-inlet - with dirty filter	203 mm Hg	8 in. Hg
Maximum return line restriction - without check valves	254 mm Hg	10 in. Hg
Minimum fuel tank vent capability	0.707 m^3/hr	25 ft^3/hr
Maximum fuel temperature @ lift pump inlet	71 ^oC	160 ^oF

Lubricating Oil System Specifications

Recommended lube oil filter	Fleetguard 3318853

	Metric	US
Oil pressure range at rated	276-414 kPa	40-60 PSI
Oil capacity of pan (high - low)	18.9-15.1 liter	20-16 U.S. quarts
Total system capacity	23.8 liter	6.3 U.S. Gal.

Cooling System Specifications

Recommended Cooling Water Filter	Fleetguard WF2072

	Metric	US
Maximum raw water working pressure range at heat exchanger	414 kPa	60 PSI
Recommended minimum water supply pipe size to heat exchanger	25.4 mm D.	1.0 in. D.
Recommended minimum water discharge pipe size from heat exchanger	31.7 mm D.	1.25 in. D.
Coolant water capacity (engine side)	10.4 liter	2.8 U.S. Gal.
Modulating thermostat range	82-93 ^oC	180-199 ^oF
Minimum raw water flow with water temperatures to 90 ^oF (32 ^oC)	1.89 liter/s	30 U.S. GPM

Air Intake System Specifications

NOTE: Engine intake air must be filtered to prevent dirt and debris from entering the engine. If intake air piping is damaged or loose, unfiltered air will enter the engine and cause premature wear.

Recommended air cleaner element	(Standard) Donaldson B105006 (Optional) K&N RU5045

	Metric	US
Maximum temperature rise between ambient air and engine air inlet	15 ^oC	30 ^oF
Maximum inlet restriction with dirty filter	635 mm H_2O	25 in. H_2O

Exhaust System Specifications

	Metric	US
Maximum exhaust back pressure imposed by complete exhaust system	10.2 kPa	40.8 in. H_2O
Exhaust pipe size normally acceptable	101.6 mm D.	4 in. D.

Electrical System Specifications

Start Circuit

The start circuit consists of a single starter motor and redundant starter control relays as well as using redundant power sources either 12 V or 24 V comprised of 12 V wet type storage batteries (optional at shipment).

The battery, starter and starter solenoid positive terminals are booted with a non-conducting cover or otherwise insulated from unintended grounding. Battery cable leads from the batteries to the designated connection points in the starting circuit are minimum 6.53 mm D. (No. 2 AWG), neoprene or rubber insulated with a 1.5 mm (0.060 in.) minimum insulation thickness rated 80°C (176 °F) minimum. The starter and starter solenoid are all metal enclosed.

Wiring for automatic starting (negative ground)	Standard
Reference wiring diagram	8512 (see Section 18)
B.C.I. Group Size	8D

	12V	**24V**
Minimum recommended battery cold cranking amperes (CCA)[1]	1250 Amps	625 Amps
Minimum recommended battery reserve capacity	360 Minutes	180 Minutes
Maximum resistance of starting circuit	0.002 Ohms	0.004 Ohms
Typical cranking speed	120 RPM	120 RPM
Alternator (standard), internally regulated	95 Amps	45 Amps
Battery Cable Size (Metric) (For less than 1.5 meters long)	10.6 mm D.	10.6 mm D.
Battery Cable Size (US) (For less than 5 feet long)	00 AWG	00 AWG

(1) Cold soak at -18 °C (0 °F) or above

Cummins/Fleetguard® Filter Specifications

General Information

Fleetguard®/Nelson is a subsidiary of Cummins Inc. Fleetguard®/Nelson filters are developed through joint testing at Cummins and Fleetguard®/Nelson. Fleetguard®/Nelson filters are standard on new Cummins engines. Cummins Inc. recommends their use.

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

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

Fuel Recommendations and Specifications

Fuel Recommendations

WARNING

Do not mix gasoline, alcohol, or gasohol with diesel fuel. This mixture can cause an explosion.

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.

Use only number 2 diesel (ASTM no. 2D) fuel.

Any adjustment to compensate for reduced performance with a fuel system using alternate fuel is not warrantable.

Additional information for fuel recommendations and specifications can be found in Fuel for Cummins Engines, Bulletin No. 3379001. See Section 13, Service Literature for ordering information.

Lubricating Oil Recommendations and Specifications

Oil Performance Recommendations

Using quality engine lubricating oils, along with appropriate oil drain and filter change intervals, is a critical factor in maintaining engine performance and durability. Refer to Service Literature in Section 14 for reference to related Cummins service bulletins.

Cummins Engine Company, Inc. recommends the use of a high-quality SAE 15W-40 heavy-duty engine oil (such as Cummins Premium Blue®), which meets the American Petroleum Institute (API) performance classification CH4/SG.

A sulfated ash limit of 1.0 mass percent is suggested for optimum valve and piston deposit and oil consumption control. The sulfated ash must not exceed 1.85 mass percent.

New Engine Break-In Oils

Do not use special “break-in” lubricating oils for new or rebuilt Cummins engines. Use the same type of oil during the “break-in” as that which is used in normal operation.

Recommended Oil Change Intervals

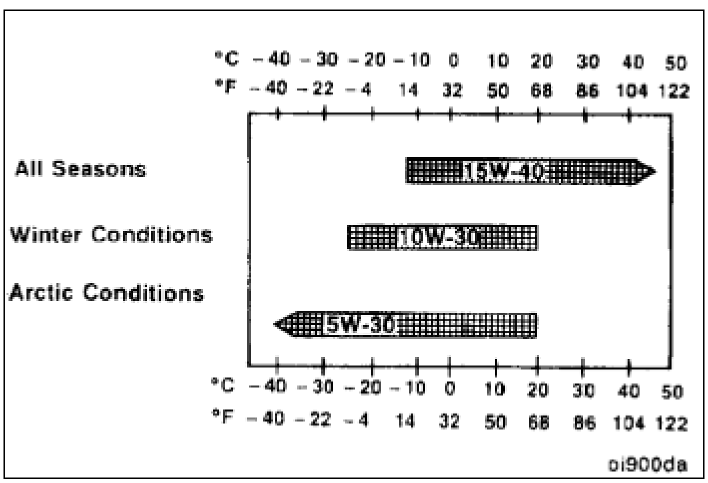
The oil change interval for turbocharged engines is every 6 months or 250 hours.

Oil Viscosity Recommendations

The use of multiviscosity lubricating oil has been found to improve oil consumption control and improve engine cranking in cold temperatures while maintaining lubrication at high operating temperatures.

While 15W-40 oil is recommended for most climates, refer to the accompanying table for oil viscosity recommendations for extreme climates.

NOTE: Limited use of low-viscosity oils, such as 10W-30, can be used for easier starting and providing sufficient oil flow at ambient temperatures below -35°C [23°F]. However, continuous use of low viscosity oils can decrease engine life because of wear. Refer to the accompanying chart.



Coolant Recommendations and Specifications

General Information

Heavy-duty diesel engines require a balanced coolant mixture of water and antifreeze. Drain and replace the mixture every 1 year or 1500 hours of operation (whichever occurs first) to eliminate buildup of harmful chemicals.

Antifreeze is essential in any climate. It broadens the operating temperature range by lowering the coolant freezing point and by raising its boiling point. Do not use more than 50-percent antifreeze in the mixture unless additional freeze protection is required. Never use more than 68-percent antifreeze under any condition.

Use soft water in the coolant mixture. Contaminants in hard water neutralize the corrosion inhibitor components. Water must not exceed 300-ppm hardness or contain more than 100 ppm of either chloride or sulfate.

Specifications

Use low-silicate antifreeze that meets ASTM4985 test (GM6038M spec.) criteria.

Refer to Service Literature in Section 14 for reference to related Cummins service bulletins.

Concentration

Antifreeze must be used in any climate for both freeze and boiling point protection. Cummins recommends a 50-percent concentration level (40-percent to 60-percent range) of ethylene glycol or propylene glycol in most climates. Antifreeze at 68-percent concentration provides the maximum freeze protection and must never be exceeded under any condition. Antifreeze protection decreases above 68 percent.

Ethylene Glycol	Propylene Glycol
40% = -23°C [-10°F]	40% = -21°C [-6°F]
50% = -37°C [-34°F]	50% = -33°C [-27°F]
60% = -54°C [-65°F]	60% = -49°C [-56°F]
68% = -71°C [-90°F]	68% = -63°C [-82°F]

Concentration Testing

Antifreeze concentration must be checked using a refractometer (such as Fleetguard® Part No. CC2800). “Floating ball” types of density testers or hydrometers are not accurate enough for use with heavy-duty diesel cooling systems.

Engine Component Torque Values

Torque Table

Component.	Wrench Size.	N•m	ft-lb
Aftercooler Mounting	10 mm	24	18
Aftercooler Water Hose Clamp	8 mm	5	44
Alternator Link (Delco 10-15 SI)	13 mm	24	18
Alternator Link (Delco 20-27 SI)	3/4 in	43	32
Alternator Mtg. Bolt 10-15 Sl	15 mm	43	32
Alternator Mtg. 27 Sl	18 mm	77	57
Alternator Support (Upper)	10 mm	24	18
Belt Tensioner Flat Bracket	Allen 5 mm	24	18
Belt Tensioner Mounting	15 mm	43	32
Crankshaft Damper and Pulley	15 mm	137	101
Crossover Clamp	5/16 in	5	44
Tee Bolt Type Clamp	11 mm	8	71
Exhaust Outlet Pipe, V Band Clamp	7/16 in	8	71
Fuel Filter	75 to 85 mm	Install as specified by filter manufacturer	
Fuel Filter Adapter Nut	24 mm	32	24
Lubricating Oil Filter	75 to 85 mm	3/4 Turn after Contact	
Lubricating Oil Cooler Assembly	10 mm	24	18
Lubricating Oil Pan Drain Plug (steel)	17 mm	80	59
Lubricating Oil Pan Drain Plug (aluminum)	17 mm	55	41
Lubricating Oil Pan Heater Plug	27 mm	80	59
Lubricating Oil Pressure Regulator Plug	19 mm	80	59
Starter Mounting	10 mm	43	32
Thermostat Housing	10 mm	24	18
Water Inlet Connection	15 mm	43	32
Water Pump Mounting	13 mm	24	18
Valve Cover	15 mm	12	106
Water-in-Fuel Sensor	19 mm	Hand-Tighten	
Top - Load Filter Lid	10 mm	Hand-Tighten	

Sealants

General Information

Use either the sealants listed below or sealants containing equivalent properties.

Item Description	Sealing Method
Pipe plugs	Pre-coated Teflon™ or pipe sealer
Gaskets	No sealant required
Cups plugs	Loctite 277 or Cummins sealant, Part Number 3375068
O-rings	Lubriplate™ 105
Rear camshaft expansion plug	Loctite 277 or Cummins sealant, Part Number 3375068
Fuel pump studs	Loctite 242
Turbocharger drain (in block)	Loctite 277 or Cummins sealant, Part Number 3375068
Dipstick tube (in block)	Loctite 277 or Cummins sealant, Part Number 3375068
Wet flywheel housing to block	Three-Bond™ sealant, Part Number 3823494
Rear seal (in rear cover)	No sealant required
Timing pin housing capscrews	No sealant required
Side oil fill	Loctite 277 or Cummins sealant, Part Number 3375068
Oil pan at gear housing joint	Three-Bond™ sealant, Part Number 3823494

Capscrew Markings and Torque Values

General Information

CAUTION

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

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.

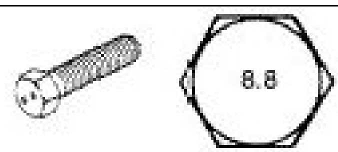
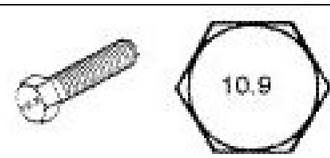
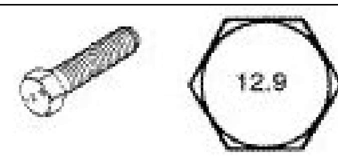
When the ft-lb value is less than 10, convert the ft-lb value to in-lb to obtain a better torque with an in-lb torque wrench. Example: 6 ft-lb equals 72 in-lb.

Metric Capscrew Identification

Sample:	**M8-1.25 x 25**		
Value:	**M8**	**1.25**	**X 25**
Meaning:	Major thread diameter in millimeters	Distance between threads in millimeters	Length in millimeters

Metric Capscrew Head Markings

Metric capscrews and nuts are identified by the grade number stamped on the head of the capscrew or on the surface of the nuts.

Commercial Steel Class	**8.8**	**10.9**	**12.9**
Capscrew Head Markings			

Metric Capscrew Torque Values

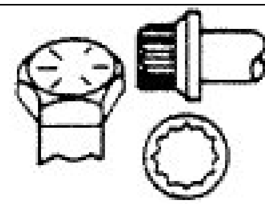
Class:	**8.8**				**10.9**				**12.9**			
Diameter	**Cast Iron**		**Aluminum**		**Cast Iron**		**Aluminum**		**Cast Iron**		**Aluminum**	
mm	**N•m**	**ft-lb**	**N•m**	**ft-lb**	**N•m**	**ft-lb**	**N•m**	**ft-lb**	**N•m**	**ft-lb**	**N•m**	**ft-lb**
6	9	5	7	4	13	10	7	4	14	9	7	4
7	14	9	11	7	18	14	11	7	23	18	11	7
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	—	—	—	—	—	—

US Customary Capscrew Identification

Sample:	5/16 x 18 x 1-1/2		
Value:	**5/16**	**18**	**1-1/2**
Meaning:	Major thread diameter in inches	Number of threads per inch	Length in inches

U.S. Customary Capscrew Head Markings

U.S. Customary capscrews are identified by radial lines stamped on the head of the capscrew.

SAE Grade 5 **w/ three lines**	**SAE Grade 8**
	

U.S. Customary Capscrew Torque Values

Grade	**SAE Grade 5**				**SAE Grade 8**			
Capscrew Body Size	**Cast Iron**		**Aluminum**		**Cast Iron**		**Aluminum**	
	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

Section 16 – Warranty Information

CUMMINS FIRE POWER
2 YEAR OR 2000 HR. Fire Pump Driver
LIMITED WARRANTY

Cummins Fire Power warrants diesel fire pump drivers to be free from defects in material and workmanship under normal fire pump driver use and service. The warranty start date is the date of start up, or 18 months from the date of factory shipment (whichever occurs first). This warranty is extended to the original using customer for two (2) year or 2000 hours (whichever occurs first) from the warranty start date.

Repair, replacement or adjustment, at Cummins Fire Power's discretion, will be furnished if the part, upon Cummins Fire Power's inspection, is found to be properly installed, maintained and operated in accordance with instruction manuals furnished by Cummins Fire Power.

This warranty does not apply to malfunctions caused by damage, unreasonable use, misuse, repair or service by unauthorized persons, or normal wear and tear.

Any implied or statutory warranties, including any warranty of merchantability or fitness of purpose, is expressly limited to the duration of this warranty. In no event is Cummins Fire Power, liable for incidental or consequential damages.

This Warranty Shall Not Apply to:

* Cost of maintenance, adjustments, installation or start-up.
* Failures due to normal wear, accident, misuse, abuse, neglect or improper installation.
* Alterations or modifications not authorized in writing by Cummins Fire Power.
* Failures caused by defects in the system in which the set is installed.
* Rental equipment/expense while repairs are being made.
* Starting batteries.
* Components added to the engine after shipment from Cummins Fire Power.

No person is authorized to give any other warranties or to assume any other liabilities on Cummins Fire Power's behalf.

All claims must be brought to the attention of Cummins Fire Power, or an authorized distributor within thirty (30) days of discovery of the part or parts failing to meet this warranty.

See Cummins Inc. warranty bulleting number 3381321 for additional details.

THERE ARE NO OTHER EXPRESS OR IMPLIED WARRANTIES BEYOND THE DESCRIPTION OF THE FACE HEREOF.

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Section 17 – Troubleshooting

Section Contents

Page

Section Contents (Cont)

Troubleshooting Procedures and Techniques

General information

This guide describes some typical engine operating problems, their causes, and some acceptable corrections to those problems.

WARNING

Performing troubleshooting procedures NOT outlined in this in 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 contained in this manual, and for symptoms not listed in this in section.

Before beginning any troubleshooting, refer to the General Safety Instructions in Section 1 of this manual.

Follow the suggestions below for troubleshooting:

Study the complaint thoroughly before acting.

Refer to the Engine Identification diagrams in Section 2, the System Diagrams in Section 11, and the Assembly Drawings in Section 18.

Do the easiest and most logical things first.

Find and correct the cause of the complaint.

Troubleshooting Symptoms Charts

WARNING

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

Use the charts on the following pages of this in 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.

Alternator Overcharging with the Engine Running

NOTE: If the batteries are overcharged while the engine is not running, troubleshoot the customer supplied battery charging system.

Cause	Correction
Batteries have failed	Check the condition of the batteries. Replace any defective batteries.
OK ↓	
The internal voltage regulator in the alternator is malfunctioning.	Test the alternator electrically. Refer to Alternator Checks and Testing in Section 12. If required, replace the alternator. Refer to Alternator Removal/Installation Section 12.
OK ↓	
Contact an Authorized Cummins Repair Facility.	

Neither Battery is Charging with the Engine Running

NOTE: If one or both batteries do not charge with the engine stopped, troubleshoot the customer supplied battery charging system.

NOTE: If only one battery is maintaining charge, go to Only One Battery is Charging with the Engine Running.

Cause	Correction
Battery cables or connections are loose, broken, or corroded (excessive resistance).	Check the battery cables and connections. Ensure that all connections are free of corrosion and that no cables are broken.
OK	
Alternator rotor is not turning.	Test the alternator mechanically. Refer to Alternator Checks and Testing in Section 12. If the alternator shaft does not spin freely because of a bad bearing, replace the alternator (refer to Alternator Removal/Installation in Section 12). If the alternator does not turn because of a bad drive belt, replace the drive belt (refer to Belt Removal/Installation in Section 12). If the alternator does not charge because of poor drive belt tension, replace the automatic tensioner (refer to Automatic Belt Tensioner Removal/Installation in Section 12). If the alternator pulley spins freely on the shaft because of a broken key, replace the alternator (refer to Alternator Removal/Installation in Section 12).
OK	
Battery Isolator input has faulted.	Test continuity from the alternator to the battery isolator input (refer to Drawing 8512 Sheet 2 in Section 18). Repair any open circuit. Test continuity through the battery isolator. If an internal open circuit is detected, replace the battery isolator (refer to Battery Isolator Removal/Installation in Section 12).
OK	

Neither Battery is Charging with the Engine Running (Cont)

Cause	Correction
Alternator excitation is lost.	Test the alternator electrically. Refer to Alternator Checks and Testing in Section 12. If required, replace the replaceable diode. Refer to Drawing 8512 Sheet 1 in Section 18. If required, locate and repair the open circuit or short to ground in the alternator excitation wiring.
OK	
Alternator internal voltage regulator is malfunctioning.	Test the alternator electrically. Refer to Alternator Checks and Testing in Section 12. If required, replace the alternator. Refer to Alternator Removal/Installation Section 12.
OK	
Battery temperature is above specification.	Position the batteries away from heat sources.
OK	
Contact an Authorized Cummins Repair Facility.	

Only One Battery is Charging with the Engine Running

NOTE: If one or both batteries do not charge with the engine stopped, troubleshoot the customer supplied battery charging system.

NOTE: If neither battery is maintaining charge, go to Neither Battery is Charging with the Engine Running.

Cause	Correction
Battery has failed.	Test battery condition. If the battery has failed, replace the failed battery units.
OK	
Battery cables or connections are loose, broken, or corroded (excessive resistance).	Check the battery cables and connections. Ensure that all connections are free of corrosion and that no cables are broken.
OK	
Battery isolator has failed.	Remove the battery isolator. Refer to Battery Isolator Removal/Installation in Section 12. Test the internal diodes for open circuit or short to ground. Refer to the Schematic, Electrical Wiring, 8512 Sheet 2 Section 18. If required, obtain a replacement battery isolator. Install the battery isolator. Refer to Battery Isolator Removal/Installation in Section 12.
OK	
Voltmeter is providing false indication.	Go to Voltage Indications Differ in this section.
OK	
Contact an Authorized Cummins Repair Facility.	

Voltage Indications Differ

NOTE: The two voltmeters may differ slightly due to calibration differences between the meters. Normal differences in battery condition may also cause differences in indication. These are normal differences and require no action. A voltage difference of more than three or four volts should be investigated.

Cause	Correction
One battery is discharged or failing.	Check battery condition. Replace failing battery elements. Check wiring for corrosion. Ensure good electrical contact. Charge discharged batteries by running the engine or with an external battery charger. If the battery does not charge with the engine running, go to Only One Battery is Charging with the Engine Running.
OK	
Fuse 1 or Fuse 2 is open. (Refer to Drawing 8512 Sheet 1 in Section 18.)	Check for apparent wire damage or shorts to grounds. Replace the failed fuse. If the fuse operates again, locate and correct the overload or repair the short circuit.
OK	
Open circuit or short to ground in indicator wiring.	Locate and repair the electrical fault. (Refer to Drawing 8512 Sheet 1 in Section 18.)
OK	
Voltmeter has failed.	Remove wiring at the voltmeter and apply test voltage. If necessary, replace the faulted voltmeter. Refer to Voltmeter Removal/Installation in Section 12.
OK	
Contact an Authorized Cummins Repair Facility.	

Coolant Contamination

Cause	Correction
Coolant is rusty and has debris.	Drain and flush the cooling system. Refer to Drain and Flush Cooling System in Section 8. If the drained coolant has excessive rust or debris, change the coolant more frequently or contact a Cummins Authorized Repair Facility. Otherwise, refill with correct mixture of antifreeze and water. Refer to Drain and Flush Cooling System in Section 8.
OK ↓	
Lubricating oil cooler is leaking oil into the coolant. Coolant begins to have the texture and color of chocolate pudding.	Drain and flush the cooling system. Refer to Drain and Flush Cooling System in Section 8. Check the lubricating oil cooler for coolant leaks and cracks. Refer to Lubricating Oil Cooler Removal/Installation in Section 12. Replace the oil cooler gasket or other parts. Refill with correct mixture of antifreeze and water. Refer to Drain and Flush Cooling System in Section 8. If the problem persists, the cylinder block may be cracked or porous. Refer to a Cummins Authorized Repair Facility.
OK ↓	

Coolant Contamination (Cont)

Coolant Heat Exchanger is leaking raw water into the coolant. Coolant volume increases and pressure is relieved when the unit is operating. Antifreeze concentration decreases.	Drain and flush the cooling system. Refer to Drain and Flush Cooling System in Section 8. Remove Coolant Heat Exchanger. Refer to Coolant Heat Exchanger Removal/Installation in Section 12. Perform a pressure test of the raw water side of the heat exchanger. Refer to Coolant Heat Exchanger Removal/Installation in Section 12. If the heat exchanger leaks, it should be replaced. Install a known good Coolant Heat Exchanger. Refer to Coolant Heat Exchanger Removal/Installation in Section 12. Check and adjust raw water pressure regulator setpoints. Refer to Raw Water Piping, Lineup, and Configuration in Section 3. Check and, if required, replace the Zinc Plug. Refer to Inspect Heat Exchanger Zinc Plug in Section 7. Refill with correct mixture of antifreeze and water. Refer to Drain and Flush Cooling System in Section 8.
OK	
Coolant is inadvertently contaminated with unknown liquids.	Drain and flush the cooling system. Refill with correct mixture of antifreeze and water. Refer to Drain and Flush Cooling System in Section 8.
OK	
Contact an Authorized Cummins Repair Facility.	

Excessive Coolant Loss

Cause	Correction
Adequate coolant was not added following previous maintenance activities.	Check the coolant level. Refer to Check Coolant Level in Section 5. Add coolant as required and check engine operation. If coolant loss persists, check for other problems.
OK	
Inadvertent coolant leak is present.	Inspect the engine for coolant leaking from drain cocks or vents. Close the leaking drain or vent. Add coolant as required and check engine operation.
OK	
Cooling system hose is leaking.	Inspect the hoses. Refer to Check Hose Condition in Section 7. Replace and/or tighten loose hose clamps. Replace any damaged hoses. Refer to Coolant Hose Removal/Installation in Section 12. Add coolant as required and check engine operation.
OK	
Pressure cap is malfunctioning or has low-pressure rating.	Check that the pressure cap does not relieve coolant under normal operating conditions. Replace a leaking pressure cap. . Add coolant as required and check engine operation.
OK	
Mechanical coolant leak.	Inspect the engine for coolant leaking from manifold, expansion and pipe plugs, fittings, lubricating oil cooler, water pump seal, cylinder block, and other components that have coolant flow. Repair leaking components. Add coolant as required and check engine operation.
OK	

Excessive Coolant Loss (Cont)

Engine is overheating.	Refer to the Coolant Temperature Above Normal symptom tree.
OK	
Refer to a Cummins Authorized Repair Facility.	

Coolant Temperature Above Normal

NOTE: The thermostat's normal operating temperature range is 82-95 ^{o}C [180-203 ^{o}F]. The High Water Temperature lamp on the local control panel illuminates at ^{o}C [^{o}F]. The lamp will only illuminate if the engine is running. If the lamp is illuminated or if temperature is otherwise excessive, the engine should be stopped as soon as practical and the problem corrected.

Cause	Correction
Raw water flow is improperly aligned.	Check that the raw water manifold is aligned for normal flow through the solenoid valve (preferred) or bypass flow around the solenoid valve (alternative). (Refer to Section 18). Align flow if required.
OK	
Raw water pressure regulator is improperly adjusted.	**NOTE**: Pressure should be about 414 kPa [60 psig] or slightly less. Check the raw water pressure indication. If pressure is indicated but is low, adjust the regulator (Refer to Check Raw Water Pressure Regulator Setpoints in Section 3.) If pressure is not indicated or is excessively low, go to Raw water solenoid has failed in this table.
OK	
Raw water solenoid has failed.	If pressure is excessively low when aligned for normal flow, open the bypass valves. Then, when practical, troubleshoot the raw water solenoid valve. Refer to Raw Water Solenoid Valve Fails to Operate in this section. If the solenoid valve operates, replace the pressure regulator. (Refer to Raw Water Pressure Regulator Removal/Installation in Section 12.) If pressure is excessively low when aligned for bypass flow, open the normal valves. Then, when practical, replace the pressure regulator. (Refer to Raw Water Pressure Regulator Removal/Installation in Section 12.)
OK	

Coolant Temperature Above Normal (Cont)

Cause	Correction
Raw water piping or heat exchanger is plugged.	Check the raw water strainer for blockage. Refer to Drawing Section 18. Clean the strainer if necessary. Check the Cummins supplied raw water piping for blockage. Refer to Drawings LATER in Section 18. Clean the piping if necessary. Check the customer supplied raw water piping for blockage. Remove any blockage. Check for flow through the heat exchanger. If necessary, replace the heat exchanger. Refer to Coolant Heat Exchanger Removal/Installation in Section 12.
OK	
Coolant level is below specification.	Check the coolant level. Refer to Check Coolant Level in Section 5. Add coolant as required. If coolant level was excessively low, go to Excessive Coolant Loss in this section.
OK	
Cooling system hose is collapsed or restricted.	Inspect the hoses. Refer to Check Hose Condition in Section 7. Replace any damaged hoses. Refer to Coolant Hose Removal/Installation in Section 12.
OK	
Coolant thermostat is malfunctioning.	Remove and test the coolant thermostat. Refer to Coolant Thermostat Removal/Installation in Section 12. Replace the thermostat is it is defective.
OK	
Coolant water pump is malfunctioning.	Remove and inspect the water pump. Refer to Coolant Water Pump Removal/Installation in Section 12. Replace the thermostat is it is defective.
OK	

Coolant Temperature Above Normal (Cont)

Cause	Correction
Lubricating oil is contaminated with coolant or fuel.	Check the appearance of the lubricating oil. If the color and texture is abnormal, refer to the Lubricating Oil Contaminated symptom tree.
OK	
Cooling system hose is collapsed, restricted, or leaking.	Inspect the hoses. Refer to Check Hose Condition in Section 7. Replace any damaged hoses. Refer to Coolant Hose Removal/Installation in Section 12.
OK	
Coolant mixture of antifreeze and water is not correct.	Verify the concentration of antifreeze in the coolant. Refer to Check Cooling System Condition in Section 5. Add antifreeze or water to correct the concentration. Refer to Coolant Recommendations and Specifications in Section 15.
OK	
Lubricating oil level is above or below specification.	Check the oil level. Refer to Check Engine Oil Level in Section 5. Add or drain oil, if necessary.
OK	
Coolant temperature sender is malfunctioning.	Replace the temperature sender. Refer to Coolant Temperature Sender Removal/Installation in Section 12.
OK	
Coolant temperature gauge is malfunctioning.	Replace the temperature gauge. Refer to Coolant Temperature Gauge Removal/Installation in Section 12.
OK	

Coolant Temperature Above Normal (Cont)

Cause	Correction
Coolant temperature switch is malfunctioning.	Remove the temperature switch. Refer to Coolant Temperature Switch Removal/Installation in Section 12. Test the temperature switch. Repair or replace the switch, if necessary.
OK	
Refer to a Cummins Authorized Repair Facility.	

Coolant Temperature Below Normal (Engine Off)

Cause	Correction
The 120 VAC power supply to the coolant heater is not connected.	Connect the power supply. Correct any electrical faults in the supply circuit.
OK	
The heater's overload thermostat has operated.	Ensure that there is coolant in the heater. Allow time for the automatic overload reset to occur.
OK	
Coolant is not free to circulate through the heater.	Ensure that the coolant hoses are clear. Refer to Coolant Hose Removal/Installation in Section 12.
OK	
The coolant heater has failed electrically.	Replace the coolant heater. Refer to Coolant Heater Removal/Installation in Section 12.
OK	
Contact a Cummins Authorized Repair Facility	

Coolant Temperature Below Normal (Engine Off)

Cause	Correction
The 120 VAC power supply to the coolant heater is not connected.	Connect the power supply. Correct any electrical faults in the supply circuit.
OK ↓	
The heater's overload thermostat has operated.	Ensure that there is coolant in the heater. Allow time for the automatic overload reset to occur.
OK ↓	
Coolant temperature sender is malfunctioning.	Replace the temperature sender. Refer to Coolant Temperature Sender Removal/Installation in Section 12.
OK ↓	
Coolant temperature gauge is malfunctioning.	Replace the temperature gauge. Refer to Coolant Temperature Gauge Removal/Installation in Section 12.
OK ↓	
Coolant is not free to circulate through the heater.	Ensure that the coolant hoses are clear. Refer to Coolant Hose Removal/Installation in Section 12.
OK ↓	
The coolant heater has failed electrically.	Replace the coolant heater. Refer to Coolant Heater Removal/Installation in Section 12.
OK ↓	
Contact a Cummins Authorized Repair Facility	

Coolant Temperature Below Normal (Engine Running)

Cause	Correction
Electronic fault codes are active	For instructions on how to read active fault codes, refer to Section 3. If fault codes are active, contact a Cummins Authorized Repair Facility.
OK	
Coolant thermostat has failed open.	Test operation of the thermostat. Refer to Coolant Thermostat Tests in Section 12. If necessary, replace the thermostat. Refer to Coolant Thermostat Removal/Installation in Section 12.
OK	
Coolant temperature sender is malfunctioning.	Replace the temperature sender. Refer to Coolant Temperature Sender Removal/Installation in Section 12.
OK	
Coolant temperature gauge is malfunctioning.	Replace the temperature gauge. Refer to Coolant Temperature Gauge Removal/Installation in Section 12.
OK	
Contact an Authorized Cummins Repair Facility.	

Raw Water Drain Steaming

NOTE: The raw water drain from the Coolant Heat Exchanger may steam if raw water flow is inadequate when the engine is running. It may also steam shortly after the engine is stopped. If coolant is leaking into the raw water drain piping, the steaming may last for some time while the engine cools. Antifreeze may also be observed in the raw water drain.

Cause	Correction
Raw water flow did not start when the engine started.	Check engine coolant temperature. Go to Coolant Temperature Above Normal in this section.
OK ↓	
Engine coolant is leaking into the raw water piping in the coolant heat exchanger.	When practical, remove the coolant heat exchanger and perform the pressure test. Refer to Coolant Heat Exchanger Removal/Installation in Section 12. If pressure is not maintained, replace the heat exchanger.
OK ↓	
Contact an Authorized Cummins Repair Facility.	

Raw Water Solenoid Valve Fails to Operate

NOTE: The raw water solenoid failure may fail to open or to close. The normally closed valve may fail to open when the engine starts. This fault will prevent raw water flow through the normal valves. Bypass flow should be aligned in this event. The valve may also fail to close because of mechanical blockage. In this event, the raw water flow from the heat exchanger does not stop when it should. Depending upon the fire protection system piping, the open solenoid valve may drain all water from the fire protection system piping that is higher than the engine's piping.

Cause	Correction
Solenoid valve fails to close when the engine stops.	Replace the solenoid valve. Refer to Raw Water Solenoid Valve Removal/Installation in Section 12. Clean the raw water strainer more frequently. Increase the frequency of operational testing.
OK	
Solenoid valve fails to energize,	Check electrical continuity and insulation from ground to the solenoid. Repair any open or short circuits in the wiring.
OK	
Solenoid fails to open mechanically.	**NOTE**: Apply the correct operating voltage, either 12 VDC or 24 VDC depending upon the model. Apply temporary voltage to the solenoid. If the solenoid fails to operate, replace it. Refer to Raw Water Solenoid Valve Removal/Installation in Section 12.
OK	
Contact an Authorized Cummins Repair Facility.	

Auto Start Failure - Does not Crank on A

NOTE: The fire pump engine will not crank automatically when solenoid A is selected at the fire protection system. However, it does start automatically when solenoid B is selected.

Cause	Correction
The electrical connection from the fire protection system to Terminal Board TB 9 has failed.	Test continuity and insulation from ground between the fire protection system and the engine control panel. Locate and repair any electrical fault in the field wiring or in the fire protection system panel.
OK	
The electrical connection from Terminal Board TB 9 to Relay K1 has failed.	Test continuity and insulation from ground between the TB 9 and Relay K1. Locate and repair any electrical fault. Refer to Drawing 8512 Sheet 1 in Section 18.
OK	
Relay K1 has failed.	Check de-energized continuity at Relay K1 pin 87 to 30. Replace K1 if the circuit is open.
OK	
Contact an Authorized Cummins Repair Facility.	

Auto Start Failure - Does not Crank on B

NOTE: The fire pump engine will not crank automatically when solenoid B is selected at the fire protection system. However, it does start automatically when solenoid A is selected.

Cause	Correction
The electrical connection from the fire protection system to Terminal Board TB 10 has failed.	Test continuity and insulation from ground between the fire protection system and the engine control panel. Locate and repair any electrical fault in the field wiring or in the fire protection system panel.
OK ⬇	
The electrical connection from Terminal Board TB 10 to Relay K2 has failed.	Test continuity and insulation from ground between the TB 10 and Relay K2. Locate and repair any electrical fault. Refer to Drawing 8512 Sheet 1 in Section 18.
OK ⬇	
Relay K2 has failed.	Check de-energized continuity at Relay K2 pin 87 to 30. Replace K1 if the circuit is open.
OK ⬇	
Contact an Authorized Cummins Repair Facility.	

Auto Start Failure - Does not Crank on A or B

NOTE: The fire pump engine will not crank automatically when either solenoid A or solenoid B is selected at the fire protection system. However, it does crank and start when started locally. If local starting problems are identified, go to the applicable Manual Start Failure troubleshooting table.

Cause	Correction
The Fire Protection System fails to produce either redundant start signal to the fire pump.	Locate and correct the common mode fault in the Fire Protection System.

Auto Start Failure – Cranks but does not Start

NOTE: The fire pump engine will crank automatically when either solenoid A or solenoid B is selected at the fire protection system. However, the engine does not start. The engine will start locally. If local starting problems are identified, go to the applicable Manual Start Failure troubleshooting table.

Cause	Correction
The overspeed switch as actuated. The overspeed lamp is illuminated on the local control panel.	Press the RESET switch on the local control panel.
OK	
Control power from the Fire Protection System is not available at local control panel TB1.	When practical, locate and correct the fault in the Fire Protection System or the field wiring to the local control panel.
OK	
Circuit Breaker CB is open in the local control panel.	Check whether Circuit Breaker CB at the local control panel is open. Refer to Drawing 8512 Sheet 1 in Section 18. If open, reset the circuit breaker. Locate and correct any electrical faults in the control panel. Press the RESET switch on the local control panel.
OK	
The AUTO/MANUAL Rocker Switch fails to select AUTO mode.	When practical, open Circuit Breaker CB at the local control panel and test switch operation electrically. Refer to Drawing 8512 Sheet 1 in Section 18. If required, replace the switch or repair other electrical faults. When done, close Circuit Breaker CB at the local control panel and
OK	

Auto Start Failure – Cranks but does not Start

The overspeed switch has failed.	Check power and grounding to the overspeed switch. Refer to Drawing 8512 Sheet 1 in Section 18. Repair any electrical faults. If required, test and adjust the overspeed setting. Refer to Overspeed Setpoint Adjustment and Testing in Section 3. Replace the overspeed switch. Refer to Overspeed Switch Removal/Installation in Section 12.
	
Contact an Authorized Cummins Repair Facility.	

Auto Start Failure – Engine Starts but Crank Terminate does not Occur

Cause	Correction
The overspeed switch not correctly adjusted or has failed.	When practical, with the engine running, verify speed sensor input to the overspeed switch. Refer to Drawing 8512 Sheet 1 in Section 18. If signal is not present, go to The speed sensor has failed. The tachometer also indicates zero speed in this table. Adjust the overspeed switch crank terminate setpoint. Refer to Section 3. If required, replace the overspeed switch. Refer to Overspeed Switch Removal/Installation in Section 12.
OK ↓	
Fuse 3 has opened. The raw water solenoid valve also fails to open.	Open the raw water bypass valves. When practical, replace Fuse F3. Locate and repair any local electrical fault. Refer to Drawing 8512 Sheet 1 in Section 18.
OK ↓	
The speed sensor has failed. The tachometer also indicates zero speed.	When practical, locate and repair any electrical fault in the speed sensor circuitry. Refer to Drawing 8512 Sheet 1 in Section 18. If necessary, replace the speed sensor. Refer to Speed Sensor Removal/Installation in Section 12.
OK ↓	
An electrical fault is present in the Fire Protection System.	When practical, test continuity and insulation from ground in the fire protection system and the engine control panel. Locate and repair any electrical fault in the fire protection system panel.
OK ↓	
An electrical fault is present between Control Panel TB 2 and the Fire Protection System.	When practical, test continuity and insulation from ground between the fire protection system and the engine control panel. Locate and repair any electrical fault in the field wiring.
OK ↓	

Auto Start Failure – Engine Starts but Crank Terminate does not Occur (Cont)

An electrical fault is present in the control panel between Fuse F3 and TB 2.	When practical, test continuity and insulation from ground between Fuse F3 and TB 2. Locate and repair any electrical fault. Refer to Drawing 8512 Sheet 1 in Section 18.
OK ↓	
Contact an Authorized Cummins Repair Facility.	

Manual Start Failure from Solenoid Lever - Does not Crank on A

NOTE: The fire pump engine will not crank locally from the solenoid lever when solenoid A is actuated. However, it does start when solenoid B is actuated.

Cause	Correction
Battery A is discharged or has failed.	Recharge or replace the battery.
OK ↓	
An electrical fault is present between Battery A and the starter motor.	When practical, test continuity and insulation from ground between Battery A and the starter motor. Locate and repair any electrical fault. Refer to Drawing 8512 Sheet 1 in Section 18.
OK ↓	
Solenoid A's switch contact does not close.	Remove and test Solenoid A lever and switch operation. Refer to Crank Solenoid Assembly Removal/Installation in Section 12. If required, replace Solenoid A.
OK ↓	
Contact an Authorized Cummins Repair Facility.	

Manual Start Failure from Solenoid Lever - Does not Crank on B

NOTE: The fire pump engine will not crank locally from the solenoid lever when solenoid B is actuated. However, it does start when solenoid A is actuated.

Cause	Correction
Battery B is discharged or has failed.	Recharge or replace the battery.
OK	
An electrical fault is present between Battery B and the starter motor.	When practical, test continuity and insulation from ground between Battery B and the starter motor. Locate and repair any electrical fault. Refer to <u>Drawing 8512 Sheet 1</u> in Section 18.
OK	
Solenoid B's switch contact does not close.	Remove and test Solenoid B lever and switch operation. Refer to <u>Crank Solenoid Assembly Removal/Installation</u> in Section 12. If required, replace Solenoid B.
OK	
Contact an Authorized Cummins Repair Facility.	

Manual Start Failure from Solenoid Lever - Does not Crank on A or B

NOTE: The fire pump engine will not crank locally when either solenoid lever is actuated.

Cause	Correction
Starter motor has failed.	Replace the starter motor. Refer to Starter Motor Removal/Installation in Section 12.
OK ↓	
An electrical fault is present in the power or ground circuit for the starter motor.	Test continuity and insulation from ground between the battery splice, the ground connection, and the starter motor. Locate and repair any electrical fault. Refer to Drawing 8512 Sheet 1 in Section 18.
OK ↓	
Engine is seized.	Bar the engine over to break the seizure.
OK ↓	
Contact an Authorized Cummins Repair Facility.	

Manual Start Failure from Control Panel - Does not Crank on A

NOTE: The fire pump engine will not crank locally from the control panel when CRANK BATT A is selected. However, it does start when CRANK BATT B is selected.

Cause	Correction
The CRANK BATT A switch fails to make contact.	When practical, test the electrical operation of the CRANK BATT A switch. Refer to Drawing 8512 Sheet 1 in Section 18. Replace the switch if faulted.
OK ↓	
Relay K1 fails in the local manual mode.	When practical, test the electrical operation of the Relay K1. Refer to Drawing 8512 Sheet 1 in Section 18. Replace the relay if faulted.
OK ↓	
Solenoid A fails to energize due to electrical fault in the power or ground circuit.	Test continuity and insulation from ground between the CRANK BATT A switch, Relay K1, and the starter Solenoid. Also, check the solenoid coil connection to ground. Locate and repair any electrical fault. Refer to Drawing 8512 Sheet 1 in Section 18.
OK ↓	
Solenoid A fails to operate.	When practical, test the electrical operation of the Solenoid A. Refer to Drawing 8512 Sheet 1 in Section 18. Replace the solenoid if faulted.
OK ↓	
Contact an Authorized Cummins Repair Facility.	

Manual Start Failure from Control Panel - Does not Crank on B

NOTE: The fire pump engine will not crank locally from the control panel when CRANK BATT B is selected. However, it does start when CRANK BATT A is selected.

Cause	Correction
The CRANK BATT B switch fails to make contact.	When practical, test the electrical operation of the CRANK BATT B switch. Refer to Drawing 8512 Sheet 1 in Section 18. Replace the switch if faulted.
OK ↓	
Relay K2 fails in the local manual mode.	When practical, test the electrical operation of the Relay K2. Refer to Drawing 8512 Sheet 1 in Section 18. Replace the relay if faulted.
OK ↓	
Solenoid B fails to energize due to electrical fault in the power or ground circuit.	Test continuity and insulation from ground between the CRANK BATT B switch, Relay K2, and the starter Solenoid. Also, check the solenoid coil connection to ground. Locate and repair any electrical fault. Refer to Drawing 8512 Sheet 1 in Section 18.
OK ↓	
Solenoid B fails to operate.	When practical, test the electrical operation of the Solenoid B. Refer to Drawing 8512 Sheet 1 in Section 18. Replace the solenoid if faulted.
OK ↓	
Contact an Authorized Cummins Repair Facility.	

Manual Start Failure from Control Panel - Does not Crank on A or B

NOTE: The fire pump engine will not crank locally from the control panel when either CRANK BATT A or CRANK BATT B is selected. However, it does start when a solenoid lever is actuated.

Cause	Correction
The MANUAL mode rocker switch contact fails to close.	When practical, test the electrical operation of the AUTO/MANUAL rocker switch. Refer to Drawing 8512 Sheet 1 in Section 18. Replace the solenoid if faulted.
OK ⬇	
An electrical fault exists in the signal power circuit or the ground to the Relays K1 and K2.	Test continuity and insulation from ground between the AUTO/MANUAL rocker switch and the relays. Also, check the relay connection to ground. Locate and repair any electrical fault. Refer to Drawing 8512 Sheet 1 in Section 18.
OK ⬇	
Fuse F3 has opened. The raw water solenoid valve also fails to open.	Open the raw water bypass valves. When practical, replace Fuse F3. Locate and repair any local electrical fault. Refer to Drawing 8512 Sheet 1 in Section 18.
OK ⬇	
An electrical fault exists in the signal power circuit or the ground to the overspeed switch's crank circuit.	Test continuity and insulation from ground between Fuse F3 and the overspeed switch's crank circuit. Also, check the crank circuit output to the CRANK BATT switches. Locate and repair any electrical fault. Refer to Drawing 8512 Sheet 1 in Section 18.
OK ⬇	
Overspeed switch crank circuit fails to reset with engine shutdown.	If required, test and adjust the crank setting. Refer to Overspeed Setpoint Adjustment and Testing in Section 3. If required, replace the overspeed switch. Refer to Overspeed Switch Removal/Installation in Section 12.
OK ⬇	
Contact an Authorized Cummins Repair Facility.	

Engine Cranks Normally But Will Not Start (No Exhaust Smoke)

Cause	Correction
Electronic fault codes are active.	**NOTE**: For instructions on how to read active fault codes, refer to . If fault codes are active, contact a Cummins Authorized Repair Facility.
OK	
Electronic control module (ECM) is locked up.	Disconnect the battery cables for 30 seconds. Then, reconnect the battery cables, and start the engine.
OK	
Battery voltage supply to the electronic control module (ECM) is low, interrupted, or open.	Check the battery connections, the fuses, and the battery supply circuit.
OK	
No fuel in supply tank	Check and replenish fuel supply. Check fittings and hose connections and hose conditions.
OK	
Air is 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 Vent air from the system. Refer to Air in Fuel in Section 12.
OK	
Fuel drain line is restricted.	Check the fuel drain lines for restriction. Clear or replace the fuel lines, check valves, or tank vents as necessary.
OK	
Fuel filter is clogged.	Replace the fuel filter. Refer to Change Fuel Filter in Section 8.
OK	

Engine Cranks Normally But Will Not Start (No Exhaust Smoke) (Cont)

Cause	Correction
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 Fuel Recommendations and Specifications in Section 15.
OK	
Fuel injection pump is malfunctioning.	Perform the fuel injection pump test.
OK	
Fuel injection pump timing is not correct.	Check and adjust the fuel pump timing. Refer to Fuel Adjust Fuel Pump in Section 12.
OK	
Fuel tank is empty.	Fill the fuel supply tank.
OK	
Fuel pre-filter is clogged.	Clean the customer-supplied fuel pre-filter.
OK	
Fuel pump overflow valve is malfunctioning.	Check the overflow valve. Replace if necessary.
OK	
Fuel suction line is restricted.	Check the fuel suction line for restriction.
OK	
Fuel connections on the suction side of the fuel lift pump are loose.	Tighten all the fuel fittings and connections between the fuel tanks and fuel lift pump.
OK	
Fuel suction standpipe in the fuel tank is broken.	Check and repair the standpipe, if necessary.
OK	

Engine Cranks Normally But Will Not Start (No Exhaust Smoke) (Cont)

Cause	Correction
Fuel supply is not adequate.	Check the flow through the filter to locate the source of the restriction.
OK	
Fuel tank air breather hole is clogged.	Clean the fuel tank breather.
OK	
Fuel lift pump is malfunctioning.	Check the fuel lift pump for correct operation. Check the pump output pressure. Replace the fuel lift pump if necessary. Refer to Fuel Lift Pump Removal/ Installation in Section 12.
OK	
Injection pump driveshaft or driveshaft key is damaged.	Repair or replace the injection pump. Refer to Fuel Injection Pump Removal/Installation in Section 12.
OK	
Fuel injectors are plugged.	Replace the fuel injectors. Refer to Fuel Injectors Removal/Installation in Section 12.
OK	
Moisture in the wiring harness connectors.	Dry the connectors with Cummins electronic cleaner, Part Number 3824510.
OK	
Throttle linkage misadjusted or damaged.	Adjust or repair the linkage.
OK	
Starting motor rotation is not correct.	Check the direction of crankshaft rotation. Replace the starting motor if necessary. Refer to Starter Motor Assembly Removal/Installation in Section 12.
OK	

Engine Cranks Normally But Will Not Start (No Exhaust Smoke) (Cont)

Cause	Correction
Starting motor is not turning the engine.	Replace the starting motor if necessary. Refer to Starter Motor Assembly Removal/Installation in Section 12.
OK	
Contact an Authorized Cummins Repair Facility.	

Engine Cranks Slowly But Does Not Start

NOTE: Typical engine cranking speed is 120 RPM. Engine cranking speed can be checked with a hand-held tachometer, stroboscope, or electronic service tool.

Cause	Correction
The batteries are cold.	Ensure that the batteries are protected from extreme temperatures.
OK	
The battery cables or connections are loose, broken, or corroded creating excessive resistance.	Check the battery cables and connections. Ensure that connections are clean and tight
OK	
The battery is not properly charged or has failed.	Recharge the battery. If the battery doers not take the charge, replace it.
OK	
Lubricating oil level is too high.	Check the oil level. Refer to Check Engine Oil Level in Section 5. Drain any excess oil.
OK	
Lubricating oil is the wrong grade or type.	Check the grade and type of oil. Refer to Lubricating Oil Recommendations and Specifications in Section 15. If the wrong type or grade of oil is present, drain and replace it. Refer to Change Lubricating Oil and Filters in Section 7.
OK	
Engine temperature is too low.	Troubleshoot as per Coolant Temperature Below Normal (Engine Off) in this section.
OK	
Starting motor is malfunctioning	Replace the starting motor. Refer to Starter Motor Assembly Removal/Installation in Section 12.
OK	
Contact a Cummins Authorized Repair Facility	

Engine Difficult to Start or Will Not Start - Exhaust Smoke Present

NOTE: If the engine cranks slowly, refer to Engine Cranks Slowly But Does Not Start in this section.

Cause	Correction
Electronic fault codes are active	**NOTE**: For instructions on how to read active fault codes, refer to Section 3. If fault codes are active, contact a Cummins Authorized Repair Facility.
OK	
Fuel tank level is low.	Fill the fuel tank. Fill and bleed the fuel lines to the engine.
OK	
Fuel drain line is restricted.	Check the fuel drain lines for restriction. Clear or replace the fuel lines, check valves, or tank vents as necessary.
OK	
Fuel filter is clogged.	Replace the fuel filter. Refer to Change Fuel Filter in Section 8.
OK	
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 Fuel Recommendations and Specifications in Section 15.
OK	
Fuel injection pump is malfunctioning.	Perform the fuel injection pump test.
OK	
Fuel injection pump timing is not correct.	Check and adjust the fuel pump timing. Refer to Fuel Adjust Fuel Pump in Section 12.
OK	

Engine Difficult to Start or Will Not Start - Exhaust Smoke Present (Cont)

Cause	Correction
Fuel pre-filter is clogged.	Clean the customer-supplied fuel pre-filter.
OK	
Fuel pump overflow valve is malfunctioning.	Check the overflow valve. Replace if necessary.
OK	
Fuel suction line is restricted.	Check the fuel suction line for restriction.
OK	
Fuel connections on the suction side of the fuel lift pump are loose.	Tighten all the fuel fittings and connections between the fuel tanks and fuel lift pump.
OK	
Fuel suction standpipe in the fuel tank is broken.	Check and repair the standpipe, if necessary.
OK	
Fuel tank air breather hole is clogged.	Clean the fuel tank breather.
OK	
Fuel lift pump is malfunctioning.	Check the fuel lift pump for correct operation. Check the pump output pressure. Replace the fuel lift pump if necessary. Refer to Fuel Lift Pump Removal/ Installation in Section 12.
OK	
Fuel injectors are plugged.	Replace the fuel injectors. Refer to Fuel Injectors Removal/Installation in Section 12.
OK	
Throttle linkage misadjusted or damaged.	Adjust or repair the linkage.R.
OK	

Engine Difficult to Start or Will Not Start - Exhaust Smoke Present (Cont)

Cause	Correction
Intake air flow is restricted.	Check the air intake system for restriction. Refer to Check Air Cleaner Service Indicator in Section 7. Replace the air filter if required.
OK	
Exhaust air flow is restricted.	Check the exhaust air piping for restriction. Remove any restriction.
OK	
Contact a Cummins Authorized Repair Facility	

Engine Acceleration or Response Poor

Cause	Correction
Electronic fault codes are active	**NOTE**: For instructions on how to read active fault codes, refer to Diagnostic Fault Codes in Section 3. If fault codes are active, contact a Cummins Authorized Repair Facility.
OK	
Fuel drain line is restricted.	Check the fuel drain lines for restriction. Clear or replace the fuel lines, check valves, or tank vents as necessary.
OK	
Fuel filter is clogged.	Replace the fuel filter. Refer to Change Fuel Filter in Section 8.
OK	
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 Fuel Recommendations and Specifications in Section 15.
OK	
Fuel injection pump is malfunctioning.	Perform the fuel injection pump test.
OK	
Fuel injection pump timing is not correct.	Check and adjust the fuel pump timing. Refer to Fuel Adjust Fuel Pump in Section 12.
OK	
Fuel pre-filter is clogged.	Clean the customer-supplied fuel pre-filter.
OK	
Fuel pump overflow valve is malfunctioning.	Check the overflow valve. Replace if necessary.
OK	

Engine Acceleration or Response Poor (Cont)

Fuel suction line is restricted.	Check the fuel suction line for restriction.
OK	
Fuel connections on the suction side of the fuel lift pump are loose.	Tighten all the fuel fittings and connections between the fuel tanks and fuel lift pump.
OK	
Fuel suction standpipe in the fuel tank is broken.	Check and repair the standpipe, if necessary.
OK	
Fuel tank air breather hole is clogged.	Clean the fuel tank breather.
OK	
Fuel lift pump is malfunctioning.	Check the fuel lift pump for correct operation. Check the pump output pressure. Replace the fuel lift pump if necessary. Refer to Fuel Lift Pump Removal/ Installation in Section 12.
OK	
Fuel injectors are plugged.	Replace the fuel injectors. Refer to Fuel Injectors Removal/Installation in Section 12.
OK	
Throttle linkage misadjusted or damaged.	Adjust or repair the linkage.R.
OK	
Intake air flow is restricted.	Check the air intake system for restriction. Refer to Check Air Cleaner Service Indicator in Section 7. Replace the air filter if required.
OK	
Exhaust air flow is restricted.	Check the exhaust air piping for restriction. Remove any restriction.
OK	

Engine Acceleration or Response Poor (Cont)

Exhaust air is leaking.	Check the exhaust piping for loose or damaged piping connections and missing pipe plugs. Check the turbocharger and exhaust manifold mounting. If required, replace the turbocharger. Refer to Turbocharger Removal/Installation in Section 12.
OK	
The charge air cooler is restricted or leaking	Inspect the charge air cooler for air restrictions or leaks. If required, replace the charge air cooler. Refer to Charge Air Cooler Removal/Installation in Section 12.
OK	
Refer to a Cummins Authorized Repair Facility.	

Engine Noise Excessive - Mechanical

Cause	Correction
Lubricating oil is thin or diluted	Check the oil level. Refer to Check Lubricating Oil Level in Section 5. If the oil level is above the high mark, go to Oil Level Rises in this section. Otherwise, ensure that the correct type and grade of lubricating oil is being g used. Refer to the Lubricating Oil Recommendations and Specifications in Section 15.
OK ⬇	
Lubricating oil pressure is below specification	**NOTE**: Oil pressure should range between 69 and 345 kPa [10 to 50 PSI] with the engine running. Check the oil pressure on the local control panel. If the pressure is low, refer to the Lubricating Oil Pressure Low symptom tree in this section.
OK ⬇	
Vibration damper is damaged.	Inspect the vibration damper. Refer to Inspect Vibration Damper in Section 10. If the vibration damper is damaged, refer to a Cummins Authorized Repair Facility.
OK ⬇	
Engine mounts are worn or damaged.	Inspect the engine mounts. If the engine mounts are worn or damaged, refer to a Cummins Authorized Repair Facility. Reference?
OK ⬇	
Coolant temperature is above specification	Check the coolant temperature indication on the local control panel. If the high coolant temperature light is illuminated, refer to the Coolant Temperature Above Normal symptom tree in this section.
OK ⬇	

Engine Noise Excessive – Mechanical (Cont)

Drive belt is squeaking due to insufficient tension or high loading.	Check the automatic belt tensioner. If required, replace the tensioner. Refer to Automatic Belt Tensioner Removal/Installation in Section 12.
OK	
Intake air flow is restricted.	Check the air intake system for restriction. Refer to Check Air Cleaner Service Indicator in Section 7. Replace the air filter if required.
OK	
Exhaust air flow is restricted.	Check the exhaust air piping for restriction. Remove any restriction.
OK	
Air leakage between the turbocharger and head	Tighten the clamp between turbocharger and head. Repair leaks between turbocharger and head.
OK	
Turbocharger does not rotate freely	Replace the turbocharger. Refer to Turbocharger Removal/Installation in Section 12.
OK	
Contact a Cummins Authorized Repair Facility	

Engine Noise Excessive — Combustion Knocks

Cause	Correction
Electronic fault codes are active	**NOTE**: For instructions on how to read active fault codes, refer to Diagnostic Fault Codes in Section 3. If fault codes are active, contact a Cummins Authorized Repair Facility.
OK	
Engine is overloaded.	Check for added mechanical loading from damaged or defective pump, changes in suction head, or changes in discharge piping restriction.
OK	
Fuel grade is not correct for the application or the fuel quality is poor.	Operate the engine using the correct fuel. Refer to Fuel Recommendations and Specifications in Section 15.
OK	
Air in present in the fuel supply to the engine.	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 Air in Fuel in Section 12.
OK	
The fuel injection pump's timing is not correct.	Check and adjust the fuel injection pump timing. Refer to Adjust Fuel Pump in Section 12.
OK	
The fuel injection pump is failing.	Replace the fuel injection pump. Refer to Fuel Injection Pump Removal/Installation in Section 12.
OK	

Engine Noise Excessive — Combustion Knocks (Cont)

Coolant temperature is below specification.	Refer to the Coolant Temperature Below Normal (Engine Running) symptom tree in this section.
OK ↓	
Contact a Cummins Authorized Repair Facility	

Engine Runs Rough at Idle

NOTE: Operation at idle speed is for maintenance only.

Cause	Correction
Electronic fault codes are active	**NOTE**: For instructions on how to read active fault codes, refer to Section 3. If fault codes are active, contact a Cummins Authorized Repair Facility.
OK	
Engine is cold.	Allow the engine to warm to operating temperature. If the engine will not reach operating temperature, refer to the Coolant Temperature Below Normal (Engine Running) symptom tree.
OK	
Idle speed is set too low.	Adjust the idle speed.
OK	
Air is present 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 Vent air from the system. Refer to Air in Fuel in Section 12.
OK	
Fuel filter is becoming plugged.	Replace the fuel filter. Refer to Change Fuel Filter in Section 7.
OK	
Fuel supply to the engine is inadequate.	Locate and correct5 the restriction in fuel flow to the engine.
OK	

Engine Runs Rough at Idle (Cont)

The fuel lift pump is malfunctioning.	Check the fuel lift pump for correct operation. Check the pump output pressure. Replace the fuel lift pump if necessary. Refer to Fuel Lift Pump Removal/ Installation in Section 12.
OK	
Engine mounts are worn or damaged.	Check the engine mounts. If damaged, refer to a Cummins Authorized Repair Facility.
OK	
Fuel grade is not correct for the application or the fuel quality is poor	Operate the engine on the required fuel. Refer to Fuel Recommendations and Specifications in Section 15.
OK	
Fuel pump overflow valve is malfunctioning	Check the overflow valve. Replace if necessary.
OK	
Fuel injection pump timing is incorrect	Check and adjust the injection pump timing. Refer to Adjust Fuel Pump in Section 12.
OK	
Injector is malfunctioning	Inspect the injectors. Replace the injectors as necessary. Refer to Fuel Injectors Removal/Installation in Section 12.
OK	
Fuel injection pump is malfunctioning	Remove the fuel injection pump. Refer to Fuel Injection Pump Removal/Installation in Section 12. Check the calibration of the fuel injection pump. Replace the pump if necessary.
OK	
Contact a Cummins Authorized Repair Facility	

Engine Runs Rough or Misfires Under Load

Cause	Correction
Electronic fault codes are active	**NOTE**: For instructions on how to read active fault codes, refer to Section 3. If fault codes are active, contact a Cummins Authorized Repair Facility.
OK ↓	
Engine is cold.	Allow the engine to warm to operating temperature. If the engine will not reach operating temperature, refer to the Coolant Temperature Below Normal (Engine Running) symptom tree.
OK ↓	
Air is present 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 Vent air from the system. Refer to Air in Fuel in Section 12.
OK ↓	
Fuel filter is becoming plugged.	Replace the fuel filter. Refer to Change Fuel Filter in Section 7.
OK ↓	
Fuel supply to the engine is inadequate.	Locate and correct the restriction in fuel flow to the engine.
OK ↓	
The fuel lift pump is malfunctioning.	Check the fuel lift pump for correct operation. Check the pump output pressure. Replace the fuel lift pump if necessary. Refer to Fuel Lift Pump Removal/ Installation in Section 12.
OK ↓	

Engine Runs Rough or Misfires Under Load (Cont)

Engine mounts are worn or damaged.	Check the engine mounts. If damaged, refer to a Cummins Authorized Repair Facility.
OK	
Fuel grade is not correct for the application or the fuel quality is poor.	Operate the engine on the required fuel. Refer to Fuel Recommendations and Specifications in Section 15.
OK	
Fuel pump overflow valve is malfunctioning.	Check the overflow valve. Replace if necessary.
OK	
Fuel injection pump timing is incorrect.	Check and adjust the injection pump timing. Refer to Adjust Fuel Pump in Section 12.
OK	
Injector is malfunctioning.	Inspect the injectors. Replace the injectors as necessary. Refer to Fuel Injectors Removal/Installation in Section 12.
OK	
Fuel injection pump is malfunctioning.	Remove the fuel injection pump. Refer to Fuel Injection Pump Removal/Installation in Section 12. Check the calibration of the fuel injection pump. Replace the pump if necessary.
OK	
Contact a Cummins Authorized Repair Facility.	

Engine Speed Surges at Idle

NOTE: Operation at idle speed is for maintenance only.

Cause	Correction
Electronic fault codes are active	**NOTE**: For instructions on how to read active fault codes, refer to Diagnostic Fault Codes in Section 3. If fault codes are active, contact a Cummins Authorized Repair Facility.
OK	
Fuel level is low in the tank.	Fill the fuel tank. Fill and bleed the fuel lines to the engine.
OK	
Engine idle speed is set too low.	Adjust the idle speed.
OK	
Air is in the fuel supply to the engine.	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 Air in Fuel in Section 12.
OK	
The fuel filter is plugged.	Replace the fuel filter. Refer to Change Fuel Filter in Section 7.
OK	
Fuel flow to the engine is not adequate.	Locate and correct the restriction in the customer-supplied fuel lines to the engine.
OK	
The fuel lift pump is malfunctioning.	Check the fuel lift pump for correct operation. Check the pump output pressure. Replace the fuel lift pump if necessary. Refer to Fuel Lift Pump Removal/ Installation in Section 12.
OK	

Engine Speed Surges at Idle (Cont)

Cause	Correction
Fuel grade is not correct for the application or the fuel quality is poor.	Operate the engine with the required fuel. Refer to Fuel Recommendations and Specifications in Section 15.
OK ↓	
The fuel injection pump is malfunctioning.	Remove the fuel pump. Refer to Fuel Injection Pump Removal/Installation in Section 12. Calibrate the fuel pump. If required, replace the fuel injection pump.
OK ↓	
A fuel supply line restriction exists between the fuel injection pump and the injectors.	Check the fuel supply line or passage for sharp bends or restriction. Remove any restrictions
OK ↓	
A fuel injector is malfunctioning.	Replace the malfunctioning injector. Refer to Fuel Injectors Removal/Installation in Section 12.
OK ↓	
Moisture is present in the wiring harness connectors.	Dry the connectors with Cummins electronic cleaner, Part Number 3824510.
OK ↓	
Contact a Cummins Authorized Repair Facility	

Engine Speed Surges Under Load

Cause	Correction
Electronic fault codes are active.	**NOTE**: For instructions on how to read active fault codes, refer to Diagnostic Fault Codes in Section 3. If fault codes are active, contact a Cummins Authorized Repair Facility.
OK	
Pump suction head or pump discharge head changes.	Some variation in speed response to load changes is normal. Excessive speed changes may occur upon sudden failures in either suction or discharge piping systems.
OK	
Fuel level is low in the tank.	Fill the fuel tank. Fill and bleed the fuel lines to the engine.
OK	
Air is in the fuel supply to the engine.	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 Air in Fuel in Section 12.
OK	
The fuel filter is plugged.	Replace the fuel filter. Refer to Change Fuel Filter in Section 7.
OK	
Fuel flow to the engine is not adequate.	Locate and correct the restriction in the customer-supplied fuel lines to the engine.
OK	
The fuel lift pump is malfunctioning.	Check the fuel lift pump for correct operation. Check the pump output pressure. Replace the fuel lift pump if necessary. Refer to Fuel Lift Pump Removal/ Installation in Section 12.
OK	

Engine Speed Surges Under Load (Cont)

Cause	Correction
Fuel grade is not correct for the application or the fuel quality is poor.	Operate the engine with the required fuel. Refer to Fuel Recommendations and Specifications in Section 15.
OK	
The fuel injection pump is malfunctioning.	Remove the fuel pump. Refer to Fuel Injection Pump Removal/Installation in Section 12. Calibrate the fuel pump. If required, replace the fuel injection pump.
OK	
A fuel supply line restriction exists between the fuel injection pump and the injectors.	Check the fuel supply line or passage for sharp bends or restriction. Remove any restrictions
OK	
A fuel injector is malfunctioning.	Replace the malfunctioning injector. Refer to Fuel Injectors Removal/Installation in Section 12.
OK	
Moisture is present in the wiring harness connectors.	Dry the connectors with Cummins electronic cleaner, Part Number 3824510.
OK	
Contact a Cummins Authorized Repair Facility	

Engine Vibration Excessive at Rated Speed

Cause	Correction
Electronic fault codes are active.	**NOTE**: For instructions on how to read active fault codes, refer to Diagnostic Fault Codes in Section 3. If fault codes are active, contact a Cummins Authorized Repair Facility.
OK ↓	
Engine runs rough or is misfiring.	Refer to the Engine Runs Rough or Misfires Under Load symptom tree in this section.
OK ↓	
Fuel injection pump is adjusted incorrectly	Adjust or replace the injection pump. Refer to Adjust Fuel Pump and/or Fuel Injection Pump Removal/ Installation in Section 12.
OK ↓	
Engine mounts are worn or damaged.	Inspect the engine mounts. Refer to Check Engine Mounting Bolts in Section 7. Replace the engine mounts as needed. Refer to a Cummins Authorized Repair Facility
OK ↓	
Vibration damper is malfunctioning.	Inspect the vibration damper. Refer to Inspect Vibration Damper in Section 10. Replace, if necessary. Refer to a Cummins Authorized Repair Facility
OK ↓	
Alternator bearing is worn or damaged.	Check if the alternator is vibrating excessively. Replace the alternator if necessary. Refer to Alternator Removal/Installation in Section 12.
OK ↓	

Engine Vibration Excessive at Rated Speed (Cont)

Water pump bearing is worn or damaged.	Check if the water pump is vibrating excessively. Replace the pump if necessary. Refer to Water Pump Removal/Installation in Section 12.
OK	
Automatic belt tensioner bearing is worn or damaged.	Check if the belt tensioner is vibrating excessively. Replace the tensioner if necessary. Refer to Automatic Belt Tensioner Removal/Installation in Section 12.
OK	
Contact a Cummins Authorized Repair Facility	

Engine Stops During Operation

Cause	Correction
Normal automatic mode shutdown occurs when the fire protection systems removes the signal power feed to the local control panel.	No action required This is a desirable outcome.
OK	
The selected engine control module (ECM) has detected a serious fault condition. The ECM's STOP light is displayed.	For instructions on how to read active fault codes, refer to Diagnostic Fault Codes in Section 3. If fault codes are active, contact a Cummins Authorized Repair Facility.
OK	
In the automatic mode, the signal power feed is lost from the fire protection system to the control panel.	Locate and correct the electrical fault in the fire protection system or the field wiring to the engine control panel.
OK	
Signal power is lost by the operation of the circuit breaker the engine control panel.	Press the circuit breaker reset button on the engine control panel . Locate and correct the electrical fault in engine control panel. Refer to Drawing 8512 Sheet 1 in Section 18.
OK	
An overspeed trip has occurred. The overspeed trip light is illuminated on the local control panel. Remote indications may also be present. Alternatively, a related overspeed switch failure has occurred. The trip indications may not be present.	Go to Engine Overspeed Trip in this section.
OK	
Power supply or grounding fault exists at the Electronic Control Module.	Locate and correct the electrical fault in the power supply or grounding for the Electronic Control Module.
OK	

Engine Stops During Operation (Cont)

Cause	Correction
The selected ECM has failed.	Select the alternate ECM. When practical, replace the failed ECM. Refer to the Electronic Control Module (ECM) (Primary) Removal/Installation or Electronic Control Module (ECM) (Secondary) Removal/Installation in Section 12.
OK ↓	
Fuel tank level is low.	Fill the fuel tank. Fill and bleed the fuel lines to the engine.
OK ↓	
Clogged fuel tank air breather hole.	Clean the fuel tank breather.
OK ↓	
Customer-supplied fuel pre-filter is clogged.	Clean the fuel pre-filter. Fill and bleed the fuel lines to the engine.
OK ↓	
Fuel piping to engine is clogged.	Clean and repair the fuel piping to the engine.
OK ↓	
The fuel filter is clogged.	Replace the fuel filter. Refer to Change Fuel Filter in Section 7.
OK ↓	
Air is trapped in the low pressure fuel lines at the engine.	Bleed the fuel lines. Refer to Air in Fuel in Section 12.
OK ↓	
Fuel lift pump has failed.	Check the fuel lift pump for correct operation. Check the pump output pressure. Replace the fuel lift pump if necessary. Refer to Fuel Lift Pump Removal/ Installation in Section 12.

OK ↓	
Fuel injection pump has failed.	Replace the fuel injection pump. Refer to Fuel Injection Pump Removal/Installation in Section 12.
OK ↓	
Contact an Authorized Cummins Repair Facility.	

Engine Will Not Reach Rated Speed (RPM)

Cause	Correction
Electronic fault codes are active	**NOTE**: For instructions on how to read active fault codes, refer to Diagnostic Fault Codes in Section 3. If fault codes are active, contact a Cummins Authorized Repair Facility.
OK	
Programmable parameters or selected features are not correct.	Check the programmable parameters and the selected features with an electronic service tool. Set the parameters and features again if necessary. Refer to a Cummins Authorized Repair Facility.
OK	
Load is excessive for engine horsepower rating.	Reduce the engine load.
OK	
Throttle adjustment is not correct.	Check the throttle adjustment. Refer to Section 3.
OK	
Fuel shutoff lever (mechanical) partially engaged.	Make sure fuel shutoff lever is in the RUN position. Refer to Section 3. Replace if necessary. Refer to Section 12.
OK	
Tachometer is not calibrated.	Compare the tachometer reading with a handheld tachometer or an electronic service tool reading. If out of calibration, calibrate the tachometer as necessary at the CAL adjustment on the back of the gauge. Refer to Tachometer Calibration in Section 12.
Tachometer is malfunctioning.	Replace the tachometer. Refer to Tachometer Removal/Installation in Section 12.
OK	

Engine Will Not Reach Rated Speed (RPM) (Cont)

Cause	Correction
Engine power output is low.	Refer to the Engine Acceleration or Response Poor symptom tree in this section.
OK	
Fuel grade is not correct for the application, or the fuel quality is poor.	Operate the engine with the required fuel. Refer to Fuel Recommendations and Specifications in Section 15.
OK	
Fuel filter is clogged.	Replace the fuel filter. Refer to Change Fuel Filter in Section 8.
OK	
Fuel suction line is restricted.	Check the fuel suction line for restriction.
OK	
Air-fuel tube leaking, wastegate diaphragm ruptured, or wastegate plumbing damaged.	Tighten the fittings, repair plumbing, replace wastegate diaphragm.
OK	
Charge air cooler restricted (if equipped).	Inspect the air cooler for internal and external restrictions. Replace the restricted cooler if necessary.
OK	
Fuel supply is not adequate.	Locate and correct the restriction in the customer-supplied fuel lines to the engine.
OK	

Engine Will Not Reach Rated Speed (RPM) (Cont)

Cause	Correction
Exhaust back pressure too high.	**NOTE**: The maximum allowable exhaust back pressure is specified in Exhaust System Specifications in Section 15. Measure the exhaust back pressure. Correct the problem is it is above specification.
OK ⬇	
Fuel lift pump is malfunctioning.	Check the fuel lift pump for correct operation. Check the pump output pressure. Replace the fuel lift pump if necessary. Refer to Fuel Lift Pump Removal/ Installation in Section 12.
OK ⬇	
Fuel injection pump is malfunctioning.	Remove the fuel pump. Refer to Fuel Injection Pump Removal/Installation in Section 12. Calibrate the fuel pump. .If required, replace the fuel injection pump.
OK ⬇	
Contact an Authorized Cummins Repair Facility.	

Engine Will Not Shut Off Remotely

Cause	Correction
Stop circuit malfunction in the fire pump controller of field wiring.	**NOTE**: In the AUTO mode, the fire pump engine stops upon loss of signal power from the fire pump controller. Check the engine stop circuit in the fire pump controller. Correct any faults. Check for short to voltage on the signal wiring from the fire pump controller to the engine control panel. Correct any faults. Check operation of the switch contacts of the AUTO/MANUAL switch at the engine control panel. Replace the switch if the switch contacts fail to operate properly.
OK ↓	
Electronic fault codes are active.	**NOTE**: For instructions on how to read active fault codes, refer to Diagnostic Fault Codes in Section 3. If fault codes are active, contact a Cummins Authorized Repair Facility.
OK ↓	
Engine running on fumes drawn into the air intake.	Identify and isolate the source of the combustible fumes.
OK ↓	
Contact an Authorized Cummins Repair Facility.	

Engine Will Not Shut Off Locally

Cause	Correction
The AUTOMANUAL Rocker Switch has failed.	**NOTE**: In the MANUAL mode, the fire pump engine stops when the AUTO/MANUIAL switch is returned to the AUTO mode. Check operation of the switch contacts of the AUTO/MANUAL switch at the engine control panel. Replace the switch if the switch contacts fail to operate properly.
OK	
Inadvertent power source is present from the fire pump controller.	**NOTE**: In the MANUAL mode, the fire pump engine stops when the AUTO/MANUIAL switch is returned to the AUTO mode. Check for inadvertent voltage on the wiring to TB 1 at the engine control panel. Correct any wiring errors.
OK	
Electronic fault codes are active.	**NOTE**: For instructions on how to read active fault codes, refer to Diagnostic Fault Codes in Section 3. If fault codes are active, contact a Cummins Authorized Repair Facility.
OK	
Engine running on fumes drawn into the air intake.	Identify and isolate the source of the combustible fumes.
OK	
Contact an Authorized Cummins Repair Facility.	

Exhaust Smoke Excessive At Idle, White

Cause	Correction
Starting procedure is not correct	Verify the correct starting procedure. Refer to Section 3.
OK	
Coolant temperature is below specification	Refer to the OEM service manual.
OK	
Intake manifold air temperature is below specification	Refer to the OEM service manual.
OK	
Fuel rate is low, fuel pressure is low, intake manifold pressure is low	Check the fuel pump output pressure, pulsation damper, and pressure regulator. Replace the fuel pump if necessary.
OK	
Injection timing incorrect	Check injection timing. Refer to the OEM service manual.
OK	
Fuel pump return overflow valve is malfunctioning	Inspect the return overflow valve. Replace if necessary. Refer to the OEM service manual.
OK	
Injector sealing washer not correct	Check to see if an extra sealing washer is installed under injector. Remove any additional sealing washer. Only one is required. Refer to the OEM service manual.
OK	

Exhaust Smoke Excessive At Idle, White (Cont)

Cause	Correction
Injector sealing washer not correct	Remove injector and install the proper sealing washer. Refer to the OEM service manual.
OK	
Injector is malfunctioning	Inspect the injectors. Replace the injectors as necessary. Refer to the OEM service manual.
OK	
Coolant flow through the radiator is not correct	Refer to the OEM service manual.
OK	
Fuel injection pump is malfunctioning	Remove the fuel pump. Refer to the OEM service manual. Calibrate the fuel pump.
OK	
Contact a Cummins Authorized Repair Facility	

Exhaust Smoke Excessive At Idle, Black

Exhaust Smoke Excessive Under Load

Cause	Correction
Engine is being lugged down	Use lower gear.
OK	
Air in the fuel system	Check for air in the fuel system. Completely bleed air from the fuel system. Refer to the OEM service manual.
OK	
Air filter is restricted	Check the air filter for restrictions. Refer to Section 4.
OK	
Fuel injection pump timing is not correct	Put the engine at top dead center. Check and adjust the fuel timing. Refer to the OEM service manual.
OK	
Intake or exhaust leak	Check intake and exhaust systems for loose or damaged piping connections and/or missing pipe plugs. Check turbocharger and exhaust manifold mounting. Refer to the OEM service manual.
OK	
Injector sealing washer not correct	Check to see if an extra sealing washer is installed under injector. Remove any additional sealing washer. Only one is required. Refer to the OEM service manual.
OK	

Exhaust Smoke Excessive Under Load (Cont)

Cause	Correction
Injector is malfunctioning	Inspect the injectors. Replace the injectors as necessary. Refer to the OEM service manual.
OK	
Turbocharger is malfunctioning	Monitor the turbocharger boost pressure with an electronic service tool. Refer to the OEM service manual.
OK	
Engine is cold	Allow the engine to warm to operating temperature. If the engine will not reach operating temperature, Refer to the Coolant Temperature Below Normal (Engine Running) symptom tree.
OK	
Fuel injection pump is malfunctioning	Remove the fuel pump. Refer to the OEM service manual. Calibrate the fuel pump.
OK	
Air-fuel (AFC) control is leaking or obstructed	Check the AFC for leaks. Repair any leaks found, if necessary. Check and clean AFC tubing and fittings for obstructions. Refer to the OEM service manual.
OK	
Contact a Cummins Authorized Repair Facility	

Fuel Consumption Is Excessive

Cause	Correction
Electronic fault codes are active.	**NOTE**: For instructions on how to read active fault codes, refer to Section 3. If fault codes are active, contact a Cummins Authorized Repair Facility.
OK	
Fuel is leaking.	Check the fuel lines, fuel connections, and fuel filters for leaks. Check the fuel lines to the supply tanks. Repair any leaks.
OK	
Poor-quality fuel is being used.	Assure good-quality No. 2 diesel fuel is being used. Refer to Fuel Recommendations and Specifications in Section 15.
OK	
Intake or exhaust restriction	Refer to troubleshooting logic for Exhaust Smoke Excessive Under Load in this section.
OK	
Defective or clogged injection nozzle	Replace the defective or clogged injection nozzle.
OK	
Incorrect injection timing	Adjust injection timing.
OK	
Injection pump is adjusted incorrectly causing excessive injection	Adjust or replace the injection pump.
OK	

Fuel Consumption Is Excessive (Cont)

Cause	Correction
Hour meter is not calibrated	Check the hour meter. Calibrate or replace the hour meter if necessary.
OK ↓	
Air intake or exhaust leaks	Check for loose or damaged piping connections and missing pipe plugs. Check the turbocharger and exhaust manifold mounting. Repair any leaks.
OK ↓	
Air intake system restriction is above specification	Check the air intake system for restriction. Refer to Check Air Cleaner Service Indicator in Section 7. Replace the air filter as necessary.
OK ↓	
Lubricating oil level above specification	Check the oil level. Refer to Check Engine Oil Level in Section 5. Drain excess oil and correct the deficiency in maintenance processes.
OK ↓	
Contact an Authorized Cummins Repair Facility.	

Fuel or Lubricating Oil Leaking From Exhaust Manifold

Cause	Correction
Intake air restriction is high	Check the air intake system for restriction. Refer to Check Air Cleaner Service Indicator in Section 7. Replace the air filter if required.
OK	
Turbocharger drain line is restricted	Remove the turbocharger drain line and check for restriction. If required, clean or replace the drain line.
OK	
Injector needle valve sticking.	Inspect the injectors. Replace if necessary.
OK	
Turbocharger oil seal is leaking	Check the turbocharger for oil seals and for leaks. Refer to the Turbocharger Leaks Engine Oil or Fuel symptom tree in this section.
OK	
Contact an Authorized Cummins Repair Facility.	

Lubricating Oil Contaminated

NOTE: If excessive sludge is present in the oilpan, refer to Lubricating Oil Sludge in the Crankcase Excessive in this section.

Cause	Correction
Bulk oil supply is contaminated	Check the bulk oil supply. Replace it is necessary. Refer to Lubricating Oil Recommendations and Specifications in Section 15. Drain the oil and replace with non-contaminated oil. Also, replace the oil filter. Refer to Change Lubricating Oil and Filters in Section 7.
OK	
Fuel is present in the lubricating oil.	Refer to the Fuel in Lubricating Oil symptom tree.
OK	
Coolant is present in the lubricating oil.	Refer to the Coolant in Lubricating Oil symptom tree in this section.
OK	
Metal is present in the lubricating oil.	Contact an Authorized Cummins Repair Facility.
OK	
Identify unknown lubricating oil contamination.	Analyze the oil and inspect the filters to identify the contamination. Contact an Authorized Cummins Repair Facility.
OK	
Contact an Authorized Cummins Repair Facility.	

Fuel in the Lubricating Oil

Cause	Correction
Engine idle time is excessive	Low oil and coolant temperatures can be caused by long idle time (greater than 10 minutes). Shut off the engine rather than idle for long periods. If idle time is necessary, raise the idle speed.
OK	
Injector o-rings are damaged or missing	Remove and check the injectors. Replace the injector o-rings. Refer to Injector (006-026) in the Troubleshooting and Repair Manual, ISC, QSC8.3, ISL, and QSL9 Series Engines, Engines, Bulletin 4021418.
OK	
Injector is malfunctioning	Perform the automated cylinder performance test. Replace injectors as necessary. Refer to Injector (006-026) in the Troubleshooting and Repair Manual, ISC, QSC8.3, ISL, and QSL9 Series Engines, Engines, Bulletin 4021418.
OK	
Fuel injection pump is malfunctioning	Inspect the cam housing for cracks and damage. Refer to Fuel Pump Cam Housing Module (005-088) in the Troubleshooting and Repair Manual, ISC, QSC8.3, ISL, and QSL9 Series Engines, Engines, Bulletin 4021418.
OK	
Fuel injection pump is malfunctioning	Replace the accumulator module. Refer to Fuel Pump Accumulator Module (005-085) in the Troubleshooting and Repair Manual, ISC, QSC8.3, ISL, and QSL9 Series Engines, Engines, Bulletin 4021418.
OK	
Fuel injection pump is malfunctioning	Inspect the injection pump gear pump module oil seal. Replace gear pump module if there are signs or leakage. Refer to Fuel Pump Gear Pump (005-025) in the Troubleshooting and Repair Manual, ISC, QSC8.3, ISL, and QSL9 Series Engines, Engines, Bulletin 4021418.

OK ↓	
Cylinder head is cracked or porous	Remove intake and exhaust manifolds. Check for evidence of coolant leak. If necessary, operate engine at low idle. Pressure-test the cylinder head. Refer to Cylinder Head (002-004) in the Troubleshooting and Repair Manual, ISC, QSC8.3, ISL, and QSL9 Series Engines, Engines, Bulletin 4021418.
OK ↓	
Internal engine damage	Analyze the oil and inspect the filters to locate an area of probable damage. Refer to an Authorized Cummins Repair Facility.
OK ↓	
Contact an Authorized Cummins Repair Facility.	

Coolant in the Lubricating Oil

Cause	Correction
Lubricating oil cooler is malfunctioning	Check the oil cooler. Refer to Lubricating Oil Cooler (007-003) in the Troubleshooting and Repair Manual, ISC, QSC8.3, ISL, and QSL9 Series Engines, Engines, Bulletin 4021418.
OK	
Cylinder head core and expansion plugs leaking or misassembled	Check cylinder head. Refer to Cylinder Head (002-004) in the Troubleshooting and Repair Manual, ISC, QSC8.3, ISL, and QSL9 Series Engines, Engines, Bulletin 4021418.
OK	
Cylinder head gasket is leaking	Check the cylinder head gasket. Refer to Cylinder Head Gasket (002-021) in the Troubleshooting and Repair Manual, ISC, QSC8.3, ISL, and QSL9 Series Engines, Engines, Bulletin 4021418.
OK	
Cylinder head is cracked or porous	Pressure-test the cylinder head. Refer to Cylinder Head (002-004) in the Troubleshooting and Repair Manual, ISC, QSC8.3, ISL, and QSL9 Series Engines, Engines, Bulletin 4021418.
OK	
Cylinder block is cracked or porous	Remove the oil pan. Pressure-test the cooling system to check for leaks. Refer to Cooling System Diagnostics (008-020) in the Troubleshooting and Repair Manual, ISC, QSC8.3, ISL, and QSL9 Series Engines, Engines, Bulletin 4021418.
OK	
Contact an Authorized Cummins Repair Facility.	

Lubricating Oil Consumption Excessive

Cause	Correction
Verify the oil consumption rate.	Check the amount of oil added versus the operating hours.
OK	
An external lubricating oil leak is present.	Inspect the engine for external oil leaks. Tighten the capscrews, pipe plugs, and fittings. Replace gaskets, if necessary.
OK	
Crankcase ventilation system is plugged	Check and clean the crankcase breather and vent tube. Refer to Crankcase Breather Tube (003-018) and Crankcase Breather (Internal) (003-002) in Troubleshooting and Repair Manual ISC, ISCe, QSC8.3, ISL and QSL9 Engines, Bulletin Number 4021418-00.
OK	
Lubricating oil does not meet specifications for operating conditions	Change the oil and filters. Refer to Change Lubricating Oil and Filters in Section 7. Use the oil type recommended in Lubricating Oil Recommendations and Specifications in Section 15.
OK	
Lubricating oil drain interval is excessive	Verify the correct lubricating oil drain interval. Refer to Change Lubricating Oil and Filters in Section 7.
OK	
Lubricating oil cooler is leaking	Check the lubricating oil cooler for coolant leaks. Refer to Lubricating Oil Cooler (007-003) in Troubleshooting and Repair Manual ISC, ISCe, QSC8.3, ISL and QSL9 Engines, Bulletin Number 4021418-00.
OK	

Lubricating Oil Consumption Excessive (Cont)

Cause	Correction
Turbocharger oil seal is leaking	Check the turbocharger compressor and turbine seals. Refer to Turbocharger (010-033) in Troubleshooting and Repair Manual ISC, ISCe, QSC8.3, ISL and QSL9 Engines, Bulletin Number 4021418-00.
OK	
Piston rings are not seated correctly (after an engine rebuild or piston installation)	Check blowby. Refer to Engine Testing (Chassis Dynamometer) (014-002) in Troubleshooting and Repair Manual ISC, ISCe, QSC8.3, ISL and QSL9 Engines, Bulletin Number 4021418-00. If blowby is excessive, check the piston rings for correct seating. Refer to Piston (001-043) and Piston Rings (001-047) in Troubleshooting and Repair Manual ISC, ISCe, QSC8.3, ISL and QSL9 Engines, Bulletin Number 4021418-00.
OK	
Piston or piston rings are worn or damaged	Check the pistons and piston rings for wear or damage. Refer to Air Leaks, Air Intake and Exhaust Systems (010-024) in Troubleshooting and Repair Manual ISC, ISCe, QSC8.3, ISL and QSL9 Engines, Bulletin Number 4021418-00.
OK	
Internal engine damage	Analyze the oil and inspect the filters to locate an area of probable damage. Refer to Lubricating Oil and Filter Analysis (007-083) in Troubleshooting and Repair Manual ISC, ISCe, QSC8.3, ISL and QSL9 Engines, Bulletin Number 4021418-00.
OK	
Contact a Cummins Authorized Repair Facility	

Lubricating Oil Pressure High

Cause	Correction
Lubricating oil pressure sensor or gauge is malfunctioning or is not in the correct location	Check the oil pressure switch or gauge for correct operation and location. Refer to the OEM service manual.
OK ⬇	
Engine is cold	Allow the engine to warm to operating temperature. If the engine will not reach operating temperature, Refer to the Coolant Temperature Below Normal (Engine Running) symptom tree.
OK ⬇	
Lubricating oil does not meet specifications for operating conditions	Change the oil and filters. Use the oil type recommended in Section 15 of the engine operation and maintenance manual.
OK ⬇	
Lubricating oil pressure is above specification	Check the oil pressure. Refer to the OEM service manual.
OK ⬇	
Contact a Cummins Authorized Repair Facility	

Lubricating Oil Pressure Low

Cause	Correction
Lubricating oil level is low	Check and replenish lubricating oil.
OK	
Lubricating oil pressure sensor or gauge is malfunctioning or is not in the correct location	Check the oil pressure switch or gauge for correct operation and location. Refer to the OEM service manual.
OK	
Lubricating oil is diluted with fuel	Change the oil. If the oil becomes diluted again, contact an Authorized Cummins Repair Facility.
OK	
Lubricating oil is diluted with water	Check for a missing dipstick, rain caps, or oil fill caps. Change the oil. Refer to the OEM service manual.
OK	
Lubricating oil does not meet specifications for operating conditions	Change the oil and filters. Use the oil type recommended in Section 15 of the engine operation and maintenance manual the OEM service manual.
OK	
Lubricating oil leak (external)	Inspect the engine for external oil leaks. Tighten the capscrews, pipe plugs, and fittings. Replace gaskets, if necessary. Refer to the OEM service manual.
OK	

Lubricating Oil Pressure Low (Cont)

Cause	Correction
Lubricating oil viscosity not correct	Make sure the correct lubricating oil is being used. Refer to Section 5.
OK	
Lubricating oil high-pressure relief valve is malfunctioning or lubricating pump pressure regulator	Remove and inspect the high-pressure relief valve. Refer to the OEM service manual.
OK	
Lubricating oil filter is plugged	Change the oil and filter. Refer to Section 4.
OK	
Contact a Cummins Authorized Repair Facility	

Oil Level Rises

NOTE: Oil level may increase due to thermal expansion as the engine warms up and then decrease as the engine cools down. Slight variations due to temperature changes are normal.

Cause	Correction
Excessive oil has been added to the engine.	Drain the excess oil. Refer to Change Lubricating Oil and Filters in Section 7.
OK	
Fuel is leaking into the oil system.	Troubleshoot as per Lubricating Oil Contaminated in this section.
OK	
Coolant is leaking into the oil system.	Troubleshoot as per Lubricating Oil Contaminated in this section.
OK	
Contact an Authorized Cummins Repair Facility.	

Lubricating Oil Sludge in the Crankcase Excessive

Turbocharger Leaks Engine Oil or Fuel

Crankcase Gases (Blowby) - Excessive

Engine Overspeed Trip

NOTE: An engine overspeed trip occurs when the engine's speed exceeds the value specified on the Field Setting Tag described in Section 2. The trip isolates the fuel supply to the engine and it stops immediately. The trip is indicated on the local control panel and inside the local control panel on the speed switch. Additionally, a trip output is supplied to the fire protection system for remote display.

Cause	Correction
Engine actually operated at too great a speed due to catastrophic load failure such as pipe break, pump mechanical failure, or loss of suction.	Correct the cause of the load failure.
OK ↓	
Engine actually operated at too great a speed due to configuration error.	Check rated speed setting as specified on the Field Setting Tag described in Section 2. Refer to Rated Speed Setpoint Adjustment and Testing in Section 3.
OK ↓	
Overspeed switch is set at too low a setpoint.	Check overspeed speed setting as specified on the Field Setting Tag described in Section 2. Refer to Overspeed Setpoint Adjustment and Testing in Section 3.
OK ↓	
Speed switch wiring failure has occurred.	Check continuity and insulation from ground for the signal power wiring and ground wiring to the speed switch. Refer to Drawing 8512 Sheet 1 in Section 18. Replace defective components and repair electrical faults.
OK ↓	
Speed switch failure has occurred.	If the speed switch fails to operate as per Overspeed Setpoint Adjustment and Testing in Section 3, replace the speed switch. Refer to Overspeed Switch Removal/Installation in Section 12.
OK ↓	
Contact an Authorized Cummins Repair Facility.	

Tachometer Does Not Indicate Engine Speed

Cause	Correction
Fuse F4 has opened.	If required, replace Fuse F4. Locate and correct the electrical fault that caused the fuse to operate. Refer to Drawing 8512 Sheet 1 in Section 18.
OK	
An electrical fault exists in the tachometer power and grounding circuits.	Check continuity and insulation from ground for the power wiring and ground wiring to the tachometer. Refer to Drawing 8512 Sheet 1 in Section 18. Replace defective components and repair electrical faults.
OK	
An electrical fault exists in the speed sensor input circuit. This fault may also cause a failure in the crank terminate signal to the fire protection system.	Check continuity and insulation from ground for the speed sensor circuit. Refer to Drawing 8512 Sheet 1 in Section 18. Replace defective components and repair electrical faults.
OK	
The speed sensor has failed.	With the engine running, check the signal from the speed sensor with an oscilloscope or pulse counter. Replace the speed sensor is it has failed. Refer to Speed Sensor Removal/Installation in Section 12.
OK	
The tachometer has failed.	Check the operation of the tachometer with a pulse generator. Replace the tachometer is it has failed. Refer to Tachometer Removal/Installation in Section 12.
OK	
Contact an Authorized Cummins Repair Facility.	

Engine Decelerates Slowly

Neither ECM Active

Either ECM Not Active

STOP Light On, Engine Stops

WARN Light On, Engine Running

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Section 18 – Assembly Drawings [1]

Description	Drawing No.	Sheet No	Revision
Assembly, Panel, Instrument, 12VDC	8508		C
Schematic, Electrical Wiring, 12 Volt	8512	1	J
Schematic, Electrical Wiring, 12 Volt	8512	2	D
Schematic, Electrical Wiring, 12 Volt (ECM Components)	8512	3	E
Harness, Engine, Non-Electronic, Non-3.3L	8513	1	J
Harness, Engine, Non-Electronic, Non-3.3L	8513	2	J
Assembly, Panel, Instrument, 24 VDC (Non ECM)	8532		
Assembly, Panel, Instrument, Electronic, 12VDC	8583		D
Assembly, Drive Shaft Guard	8600		C
SAE #3 Shaft Guard QSB, QSC, 4B, 6B, 6C	8602		C
Assembly, Stub-Shaft, SAE #3, 2.25” QSB, QSC, 4B, 6B, 6C	8619		B
Assembly, Raw Water Cooling, 1” Generic	8683		D
Drawing, Installation, Firepump, CFP8E (QSC8.3-C340)	8711		D2
Options, Engine, Firepump, Industrial, QSC8.3	8737		A
Exhaust, 4” Bellows w/ Elbow	8780		C
Enclosure Assembly, Instrument Panel, Pivot Face	8825		C
Instrument Sensor Locations (Non-ECM)	8875		
Wiring Harness Testing Extension	8878	4	
ECM Wiring Harness, QSB, QSC	8878	5	
Assembly, Engine Mounting, C8.3, QSC	8907		B
Assembly, Heat Shield, QSC8.3	8937		A
Assembly, Coolant Heater, QSC8.3	8941		C
Assembly, Heat Exchanger, QSC8.3	8944		C
Assembly, Charge Air Cooling, CFP08E, CFP83-F40	8967		A
Assembly, Operator Station, QSC8.3	9502		B
Assembly, Air Cleaner, QSC8.3	9531		B
ECM Junction Board Wiring, QSC	9548		B
Assembly, Sensor Package, C8.3, QSC (Non-ECM)	9574		A
Assembly, Fuel System Plumbing, QSC8.3	9590		
Assembly, Plumbing, CAC Heat Exchanger, QSC8.3	9591		
Junction Box Assembly, Secondary ECM, QSC	9593		C
Assembly, Plumbing, CAC Heat Exchanger, QSC, QSM	9595		A
Assembly, Pulley Guard, QSC	9627		B
Kit, Loose Wires, 4B, 6B, 6C, QSB, QSC	9767		A
Assembly, Secondary ECM & BRKT, QSC	9784		A
General Layout, Firepump, CFP8E	CFP8E_GEN		

(1): Also see Engine Identification in Section 2 the System Diagrams in Section 11. The most current revisions to these drawings and related documents are accessible at http://www.cumminsfirepower.com/products.html.

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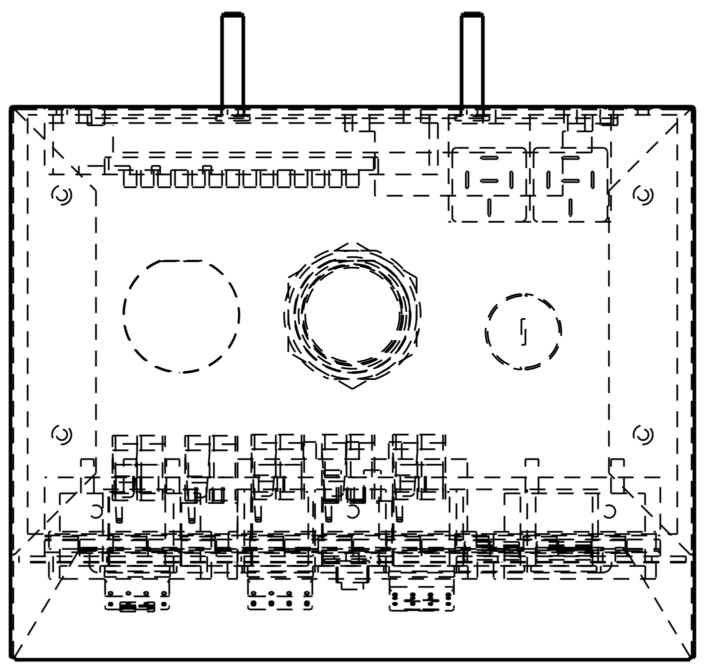
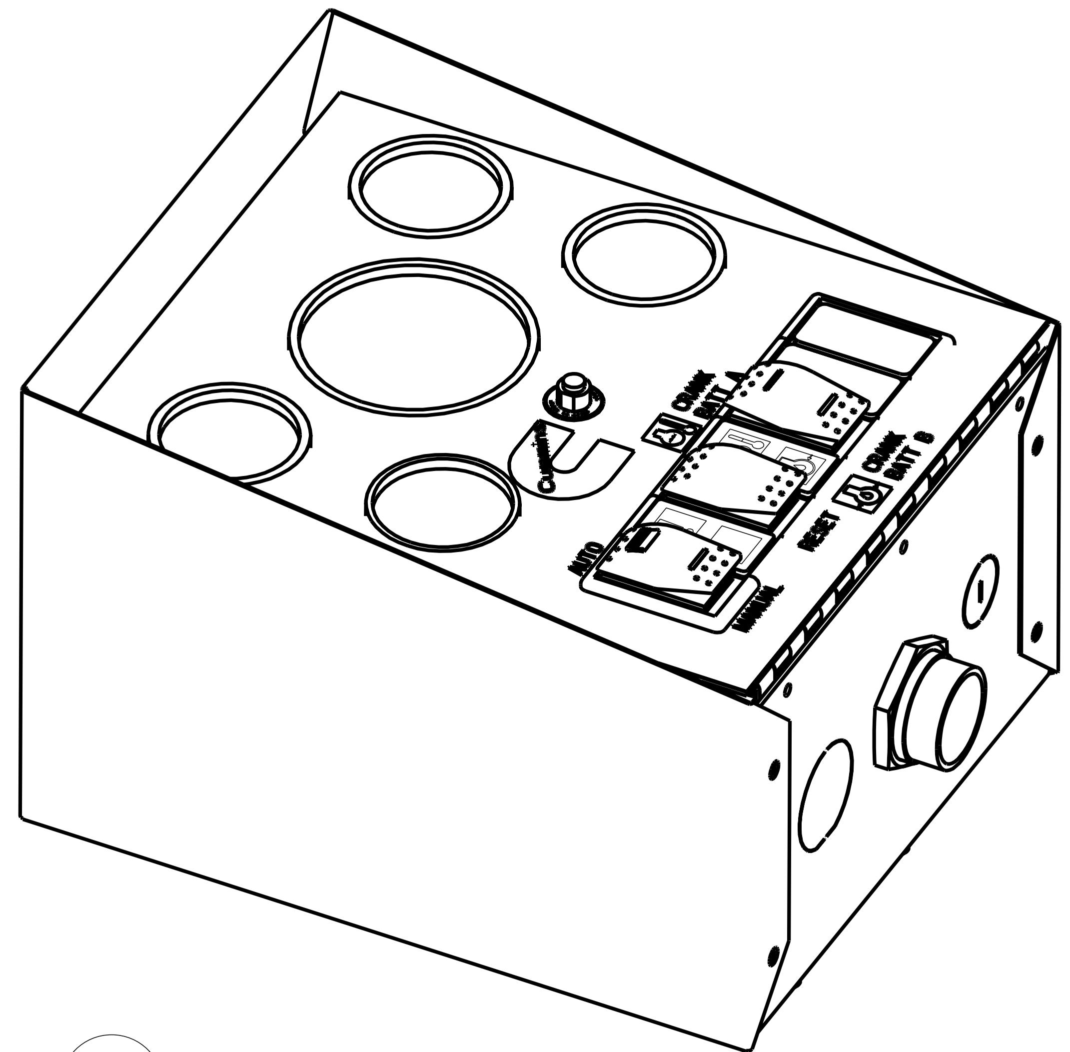
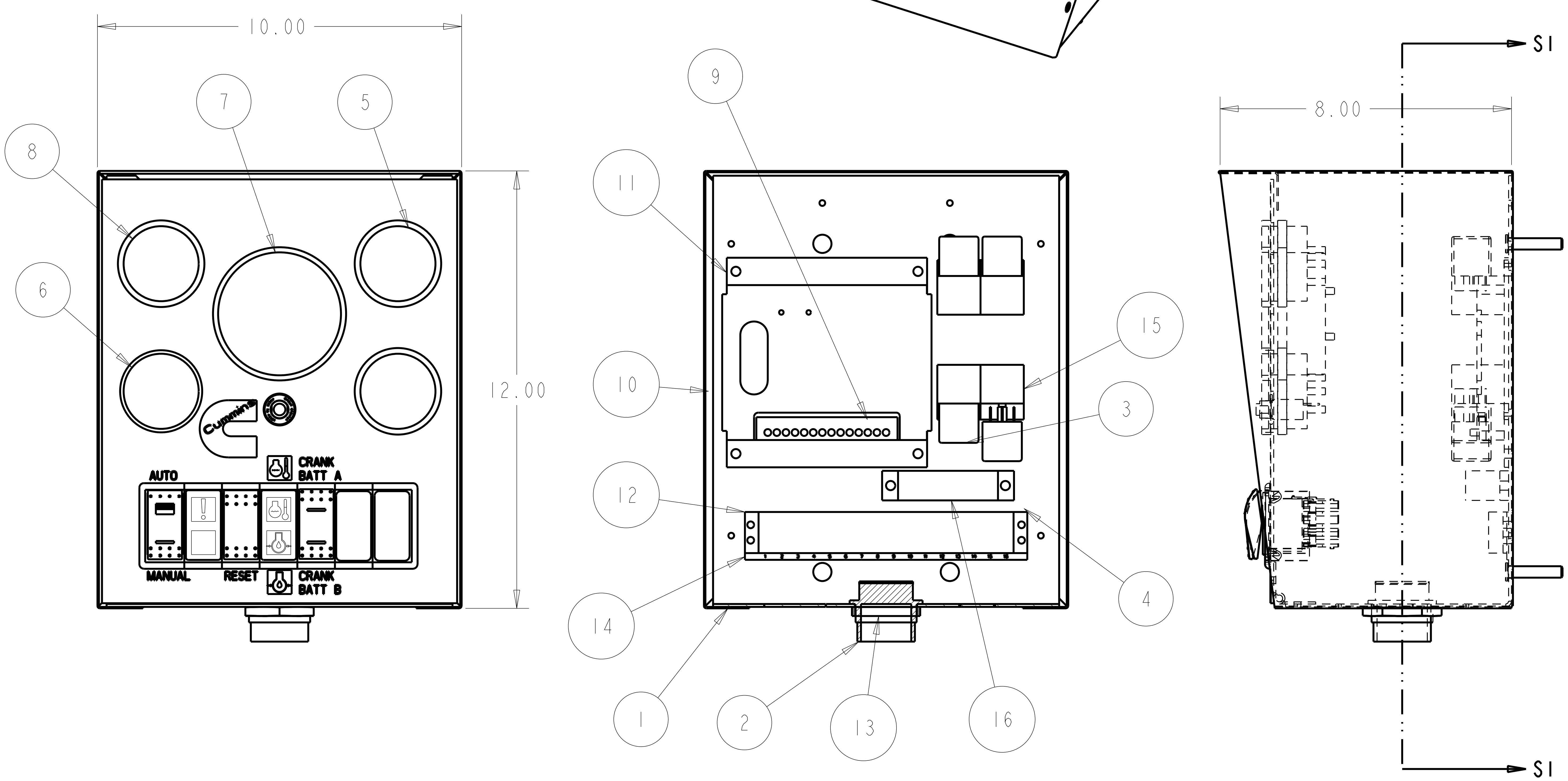




BILL OF MATERIAL

ITEM	QTY	DESCRIPTION	PART NUMBER
1	1	ENCLOSURE, FIREPUMP INSTRUMENT, 12 VOLT	8825
2	1	HARNESS, GAUGE PANEL, FIREPUMP, E.ECTRONIC ENGINES	8826
3	4	RELAY, INSTRUMENT PANEL, 40 AMP, 12vdc	8857
4	1	ASSEMBLY, SWITCH GANG, FIREPUMP	8870
5	2	GUAGE, VOLTMETER, INSTRUMENT PANEL, FIREPUMP	8827
6	1	GUAGE, OIL PRESSURE, INSTRUMENT PANEL, FIREPUMP	8828
7	1	GUAGE, TACHOMETER/HOUR METER, FIREPUMP	8829
8	1	GUAGE, WATER, INSTRUMENT PANEL, FIREPUMP	8830
9	1	CIRCUIT BREAKER, INSTRUMENT PANEL, FIREPUMP	8831
10	1	DECAL, INSTRUMENT PANEL, FIREPUMP	8835
11	1	MODULE, OVERSPEED, FIREPUMP	8836
12	1	TERMINAL STRIP, INSTRUMENT PANEL, CINCH 16-141, FIREPUMP	8837
13	1	NUT, JAM, 1-11/16-18 UNEF, FIREPUMP	8897
14	1	STRIP, MARKING, TERMINAL BLOCK, FIREPUMP	9527
15	4	RELAY HOLDER, FIREPUMP	9528
16	1	MODULE, DIODE, INSTRUMENT PANEL, FIREPUMP	9529



SECTION S1-S1

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DEPERE, WISCONSIN

UNLESS OTHERWISE SPECIFIED ALL DIMENSION TOLERANCES ARE

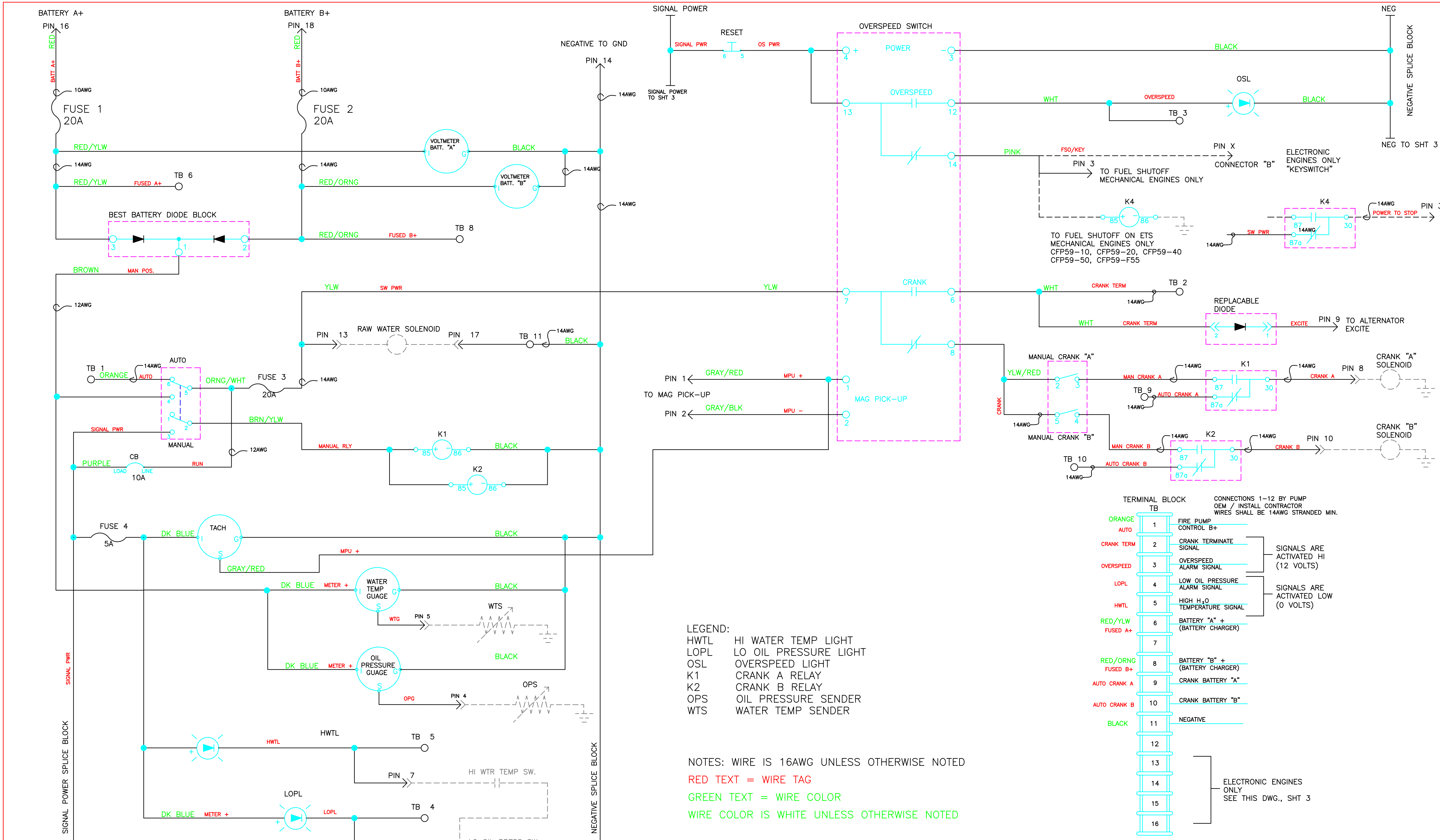
ANGULAR DIMENSIONS ± 1°

IMPERIAL UNITS	METRIC UNITS
MACHINE TOLERANCES .X = ± 0.06 .XX = ± 0.010 .XXX = ± 0.001	MACHINE TOLERANCES X = ± 1.5 X.X = ± 0.5 X.XX = ± 0.05
WELD TOLERANCES .X = ± 0.25 .XX = ± 0.12 .XXX = ± 0.06	WELDED TOLERANCES X = ± 5 X.X = ± 3 X.XX = ± 1.50

TITLE 1: ASSEMBLY, INSTRUMENT PANEL
TITLE 2: FIREPUMP

DWG UNITS: IN/LB/S	DRAWN BY: DAVE N			DATE: 16-FEB-2004
	APPD BY:			DATE:
EST WEIGHT: 17.878	SCALE: 0.375	DO NOT SCALE	SHEET 1OF1	DRAWING NO: 8508 / REV: C

REV	DESCRIPTION OF REVISION	REV BY	DATE
C	REV PER DECAL. REV BACK PLATE	SD	JUL04
A/B	ADDED 8826, UPDATED VIEW	SD	11MAY04



LEGEND:

HWTL	HI WATER TEMP LIGHT
LOPL	LO OIL PRESSURE LIGHT
OSL	OVERSPEED LIGHT
K1	CRANK A RELAY
K2	CRANK B RELAY
OPS	OIL PRESSURE SENDER
WTS	WATER TEMP SENDER

NOTES: WIRE IS 16AWG UNLESS OTHERWISE NOTED
RED TEXT = WIRE TAG
GREEN TEXT = WIRE COLOR
WIRE COLOR IS WHITE UNLESS OTHERWISE NOTED

HARNESS PLUG "A"
PINS 1-7, 9, 11, 13, 15, 17, 19 ARE 16AWG SXL WIRE
PINS 16 & 18 ARE 10AWG SXL WIRE (12 GA CAVITIES)
PINS 12, 14, 16 & 18 ARE 14AWG SXL WIRE (12 GA CAVITIES)

REV	DESCRIPTION OF REVISION	BY	DATE
I	ADDED FUEL SOLENOID RELAY FOR ETS FUEL SYSTEMS	RJS	18OCT2004
H	REVISED WT & OP GUAGE INPUTS; DIODE & SW #'S	RJS	28OCT04
G	REVISED FOR IMPROVED APPEARANCE	SAH	14SEPT04
F	REVISED PER ENGINEERING	SAH	15JUL04
D	REVISED FOR UL TESTING	SAH	2JUL04
C	REVISED FOR PRODUCTION	SAH	16JUN04
B	RE-LAYED OUT TO MIMIC OPERATOR PANEL	CAC	01JUN04
A	MADE MULTIPLE SHEET	CAC	24MAY04

UNLESS OTHERWISE NOTED
ALL DIMENSIONS ARE IN INCHES
APPLY MACHINE TOLERANCES
.X = ± 0.06
.XX = ± 0.010
.XXX = ± 0.001
APPLY WELDED TOLERANCES
.X = ± 0.25
.XX = ± 0.12
.XXX = ± 0.06

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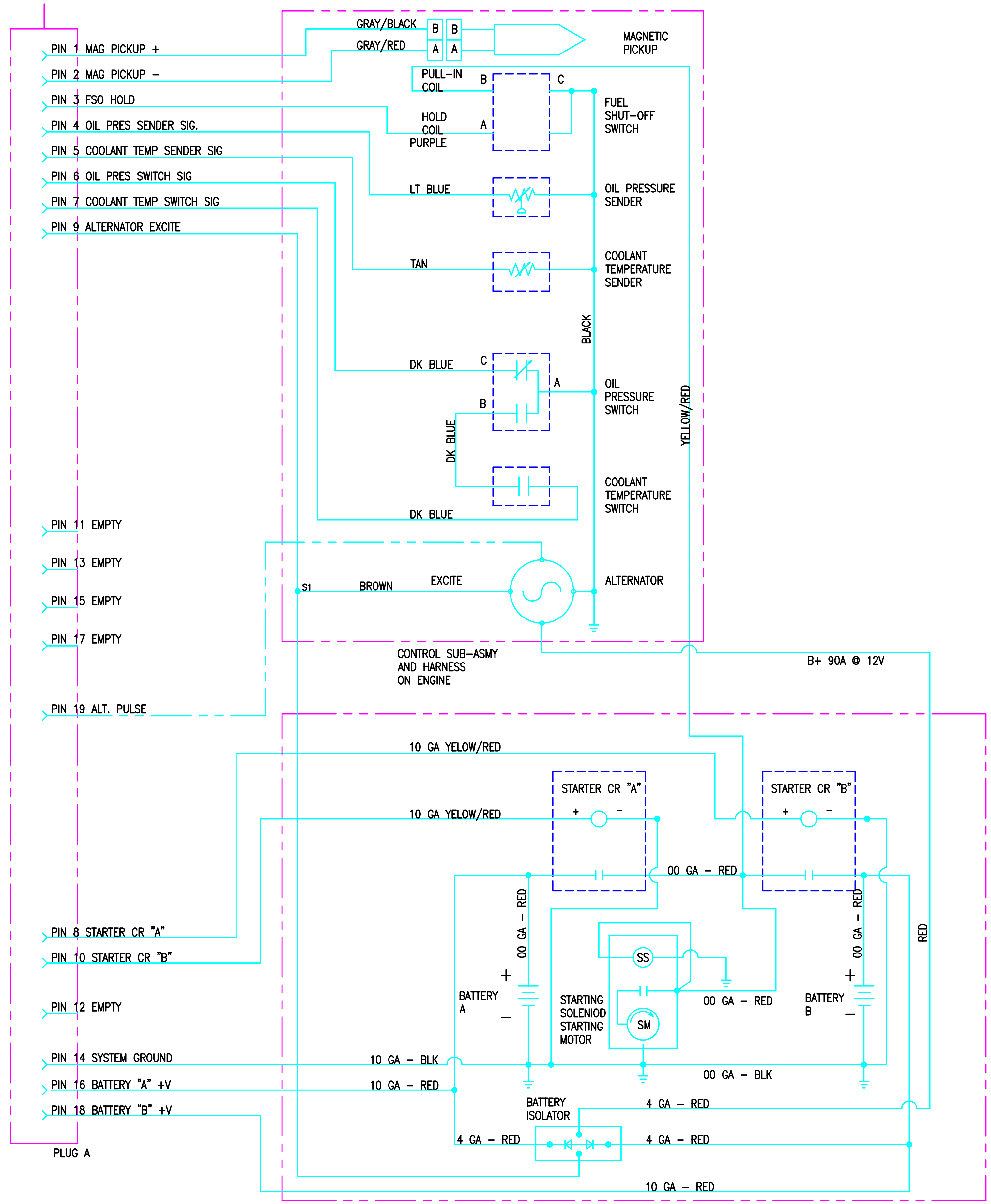
DWG SCALE: 10	DRAWN BY: CMC	DATE: 07JUN2004
PLOT SCALE:	APPD BY:	DATE:
DESCRIPTION: SCHEMATIC, GAUGE BOX		
REFERENCE: FIRE PUMP		DRAWING NUMBER: 8512SHT1_J

HARNESS PLUG "A"
PINS 1–7, 9, 11, 13, 15, 17, 19 ARE 16AWG SXL WIRE
PINS 16 & 18 ARE 10AWG SXL WIRE (12 GA CAVITIES)
PINS 12, 14, 16 & 18 ARE 14AWG SXL WIRE (12 GA CAVITIES)



REV	DESCRIPTION OF REVISION	BY	DATE
D	ADDED BAT ISO EXCITE WIRE	RJS	11JAN05
C	MOVED FUSES TO SHEET 1	SAH	2JUL04
B	ADDED TACH SIGNAL LINE TO ALTERNATOR	SLD	17JUN04
A	CREADED MULTIPLE SHEETS	CAC	REVDATE

UNLESS OTHERWISE NOTED
ALL DIMENSIONS ARE IN INCHES
APPLY MACHINE TOLERANCES
.X = ± 0.06
.XX = ± 0.010
.XXX = ± 0.001
APPLY WELDED TOLERANCES
.X = ± 0.25
.XX = ± 0.12
.XXX = ± 0.06

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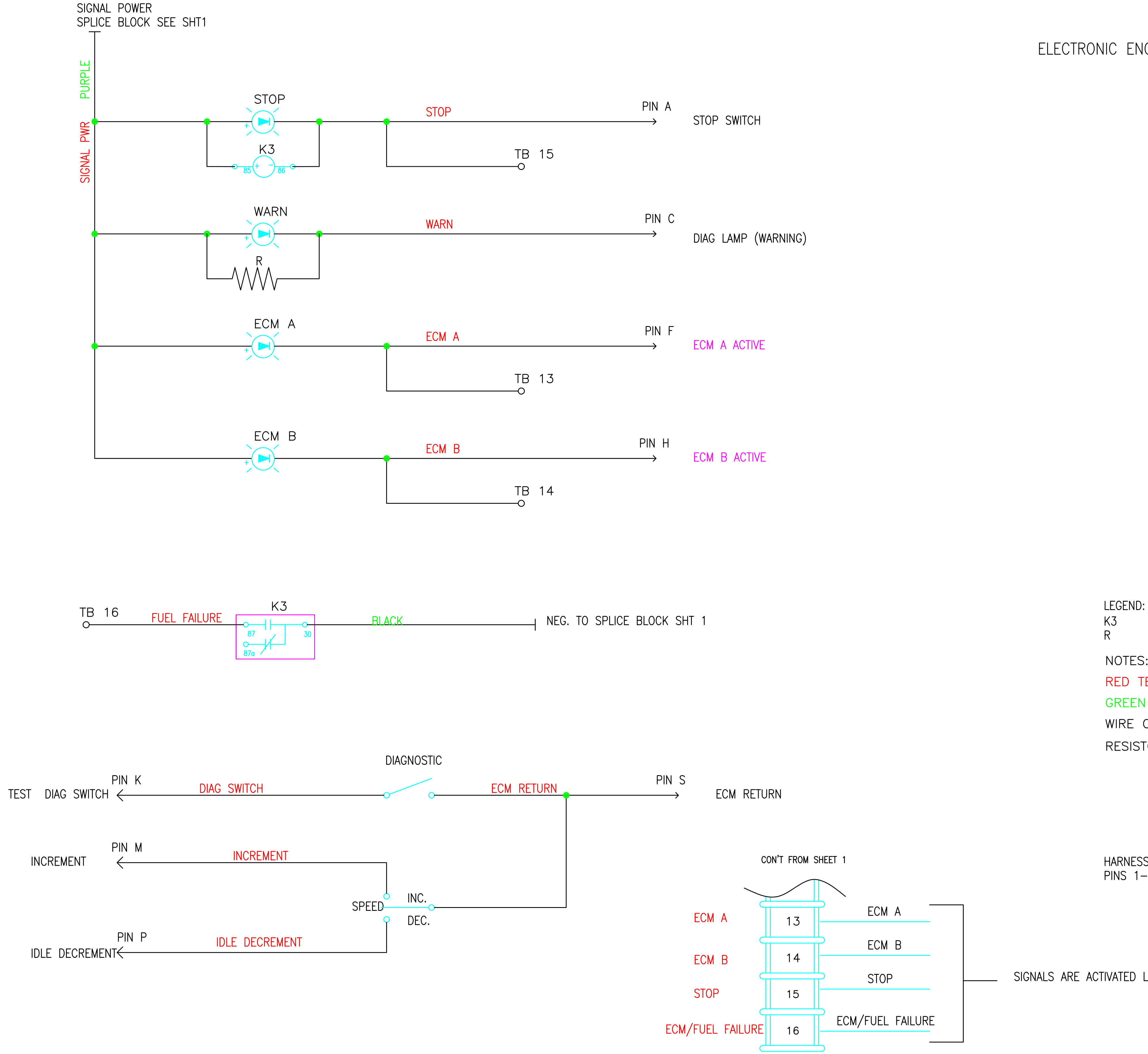
DWG SCALE: 10	DRAWN BY: CMC	DATE: 19MAY2004
PLOT SCALE:	APPD BY:	DATE:

DESCRIPTION: SCHEMATIC, ENGINE WIRING

REFERENCE: FIRE PUMP

DRAWING NUMBER: 8512SHT2_D

ELECTRONIC ENGINES ONLY



LEGEND:
K3 ECM/FUEL FAIL RELAY
R RESISTOR

NOTES: WIRE IS 16AWG UNLESS OTHERWISE NOTED
RED TEXT = WIRE TAG
GREEN TEXT = WIRE COLOR
WIRE COLOR IS WHITE UNLESS OTHERWISE NOTED
RESISTOR VALUE = 2.5–3.0k OHMS 1/4 WATT MIN.

HARNESS PLUG "B"
PINS 1-7, 9, 11, 13, 15, 17, 19 ARE 16AWG SXL WIRE

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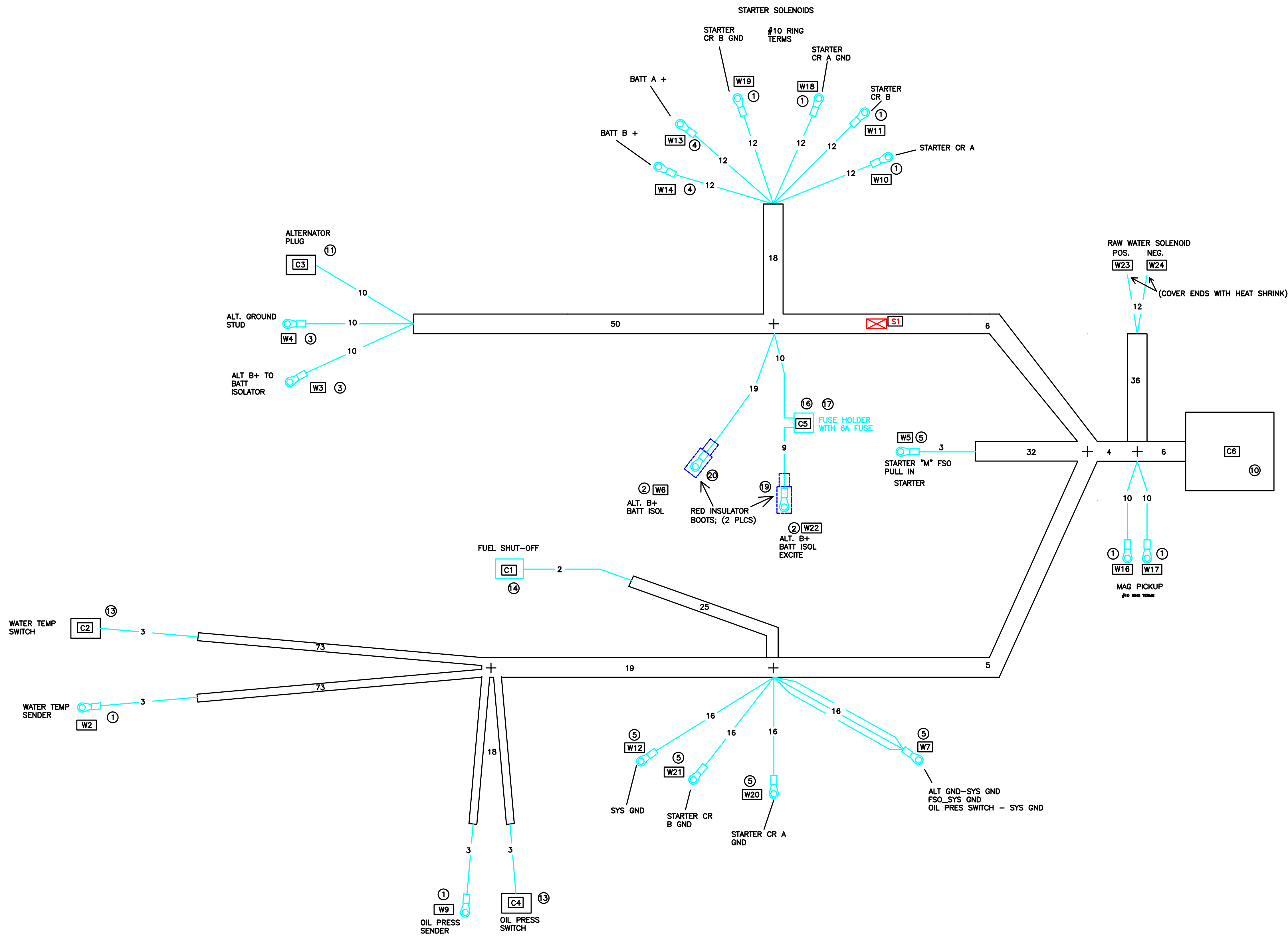
REV	DESCRIPTION OF REVISION	BY	DATE
E	MOVED K3	RJS	11/16/04
D	REVISED FOR NEW CONNECTOR	SAH	10/13/04
C	REVISED PER PROTOTYPE TESTING	SAH	9/21/04
B	REVISED PER ENGINEERING	SAH	8/11/04
A	REVISED TO MEET NEW UL	SAH	7/1/04

UNLESS OTHERWISE NOTED
ALL DIMENSIONS ARE IN INCHES
APPLY MACHINE TOLERANCES
.X = ± 0.06
.XX = ± 0.010
.XXX = ± 0.001
APPLY WELDED TOLERANCES
.X = ± 0.25
.XX = ± 0.12
.XXX = ± 0.06

DWG SCALE: 10	DRAWN BY: CMC	DATE:	
PLOT SCALE:	APPD BY:	DATE:	
DESCRIPTION: SCHEMATIC, CONTROL PANEL, ECM UPFIT			
REFERENCE: FIREPUMP QSB, QSC, QSM		DRAWING NUMBER: 8512SHT3_E	



THIS HARNESS TO BE OVER-BRAIDED WITH BLACK AND RED NYLON. ALL BLACK NYLON WILL BE CONSIDERED.

THIS HARNESS TO BE USED ON THE FOLLOWING FIREPUMP ENGINES ONLY - 4B, 6B, AND 6C

ALL DIMENSIONS IN INCHES

REV	DESCRIPTION OF REVISION	BY	DATE
J	REDREW TO FIT ECM ENGINES; ADDED ITEMS 19 & 20	RJS	4JAN05

UNLESS OTHERWISE NOTED
ALL DIMENSIONS ARE IN INCHES
APPLY MACHINE TOLERANCES
.X = ± 0.06
.XX = ± 0.010
.XXX = ± 0.001
APPLY WELDED TOLERANCES
.X = ± 0.25
.XX = ± 0.12
.XXX = ± 0.06

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DWG SCALE: —	DRAWN BY: SAH	DATE: 29JUN2004
PLOT SCALE: —	APPD BY: —	DATE: —

DESCRIPTION
WIRING_HARNESS_SCHEMATIC

REFERENCE:
FIRE_PUMPS_NON-3.3LITER

DRAWING NUMBER:
8513SHT1_J

CIRCUIT DATA

CIRCUIT NO.	FROM DESIG-NATOR	FROM CAVITY POS./ TERMINAL	TO DESIG-NATOR	TO CAVITY POS./ TERMINAL	WIRE COLOR	WIRE SIZE (AWG)	INSUL TYPE	STAMP
	C1	B	W5	1/2" RNG	WHT	16	SXL	FSO PULL-IN
	C1	C	W7	1/2" RNG	WHT	16	SXL	FSO GND
	C2	A	C4	B	WHT	16	GXL	OPS TO WTS
	C3	C	S1	-	WHT	16	SXL	EXCITE
	C4	A	W7	1/2" RNG	WHT	16	GXL	OPS GND
	C5	A	S1	-	WHT	16	SXL	EXCITE
	C5	B	W22	1/4" RNG	WHT	16	SXL	BATT EXCITE
	C6	1	W16	#10 RING	WHT	16	SXL	MPU +
	C6	2	W17	#10 RING	WHT	16	SXL	MPU -
	C6	3	C1	A	WHT	16	SXL	FSO/KEY
	C6	4	W9	#10 RNG	WHT	16	SXL	OPG
	C6	5	W2	#10 RNG	WHT	16	SXL	WTG
	C6	6	C4	C	WHT	16	GXL	LOPL
	C6	7	C2	B	WHT	16	GXL	HWTL
	C6	8	W10	#10	WHT	14	SXL	CRANK A
	C6	9	S1	-	WHT	16	SXL	EXCITE
	C6	10	W11	#10 RING	WHT	14	SXL	CRANK B
	C6	13	W23	NO TERM	WHT	14	SXL	RW SOL +
	C6	14	W12	1/2"	WHT	10	GXL	SYS GND
	C6	16	W13	3/8"	WHT	10	GXL	BATT A+
	C6	17	W24	NO TERM	WHT	14	SXL	RW SOL-
	C6	18	W14	3/8"	WHT	10	GXL	BATT B+
	W18	#10	W20	1/2" RNG	WHT	14	SXL	CRNK A GND
	W19	#10	W21	1/2" RNG	WHT	14	SXL	CRNK B GND
	W3	5/16" RNG	W6	1/4" RNG	WHT	6	GXL	ALT B+
	W4	5/16" RNG	W7	1/2" RNG	WHT	6	GXL	ALT GND

WIRING HARNESS CONTENT

REF NO.	SUPPLIER	SUPPLIER PART NO.	QTY.	DESCRIPTION
1			8	#10 RING TERMINAL
2			2	1/4" RING TERMINAL
3			2	5/16" RING TERMINAL
4			2	3/8" RING TERMINAL
5			5	1/2" RING TERMINAL
10	DEUTSCH	HDP26-24-19SN	1	MAIN CONNECTOR
11	PACKARD	12047950/12186566	1	ALT PLUG CONN. ASMBLY
13	PACKARD	12162280	2	WTS/OPS CONN. W/SOCKETS & SEAL
14	PACKARD	12015793	1	FSO CONN. W/SOCKETS
15	PACKARD	12010717	1	FSO CONN. W/PINS
16	PACKARD	12033769	1	FUSE HOLDER
17	PACKARD	12033731	1	FUSE HOLDER COVER
18			1	FUSE 6 AMP
19	stella-maris	485N9V02	1	RED INSULATOR BOOT
20	stella-maris	400N9V02	1	RED INSULATOR BOOT

REV	DESCRIPTION OF REVISION	BY	DATE
J	ADDED ITEMS 19 & 20	RJS	4JAN05

UNLESS OTHERWISE NOTED
-
ALL DIMENSIONS ARE IN INCHES
-
APPLY MACHINE TOLERANCES
.X = ± 0.06
.XX = ± 0.010
.XXX = ± 0.001
-
APPLY WELDED TOLERANCES
.X = ± 0.25
.XX = ± 0.12
.XXX = ± 0.06

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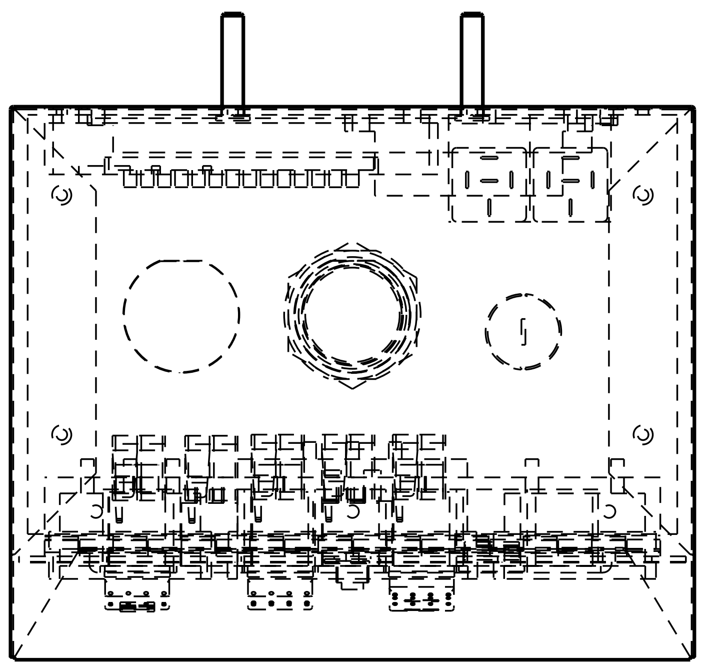
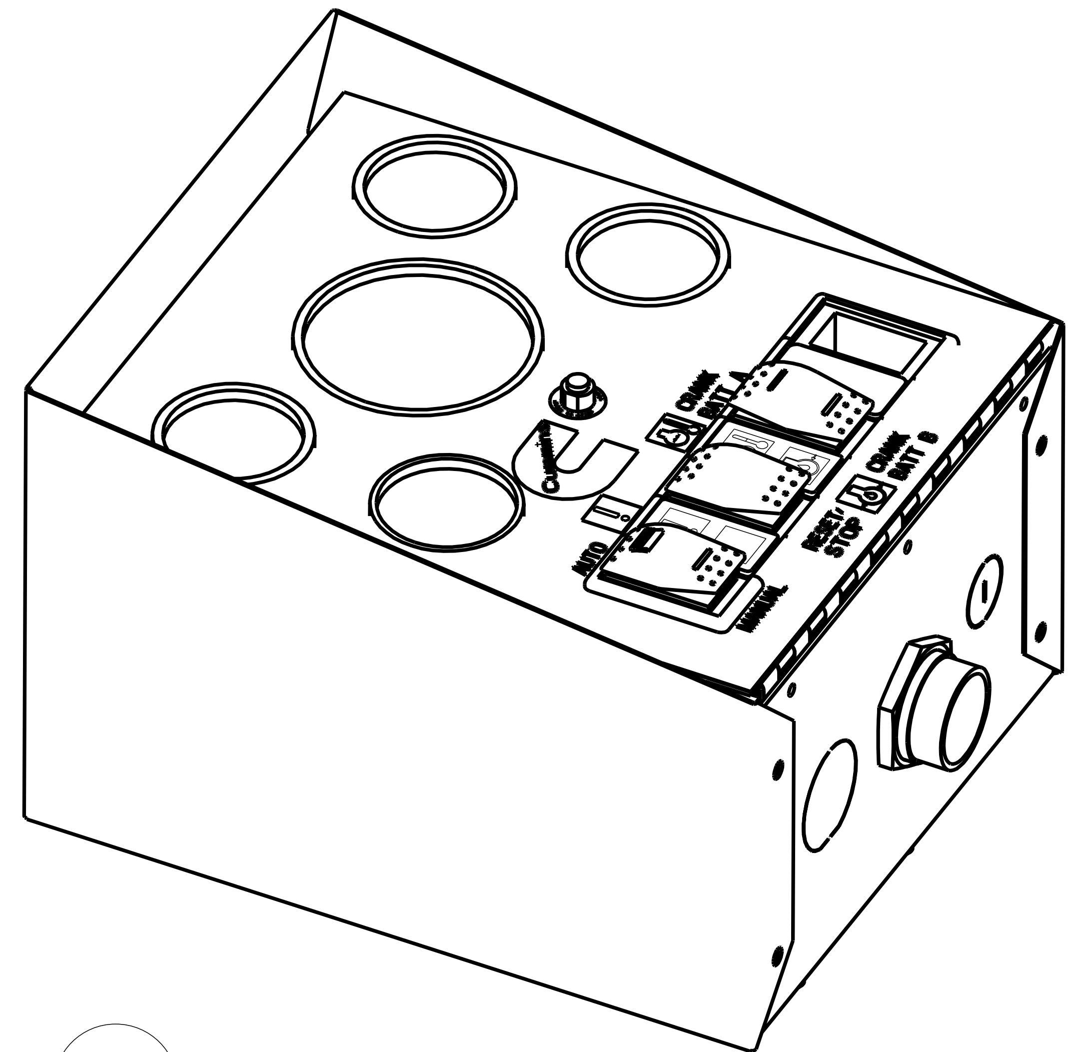
DWG SCALE:	DRAWN BY: SAH	DATE: 1 OCT 04
PLOT SCALE:	APPD BY:	DATE:

DESCRIPTION: WIRING HARNESS SCHEMATIC

REFERENCE: FIRE PUMP CONTROL PANEL

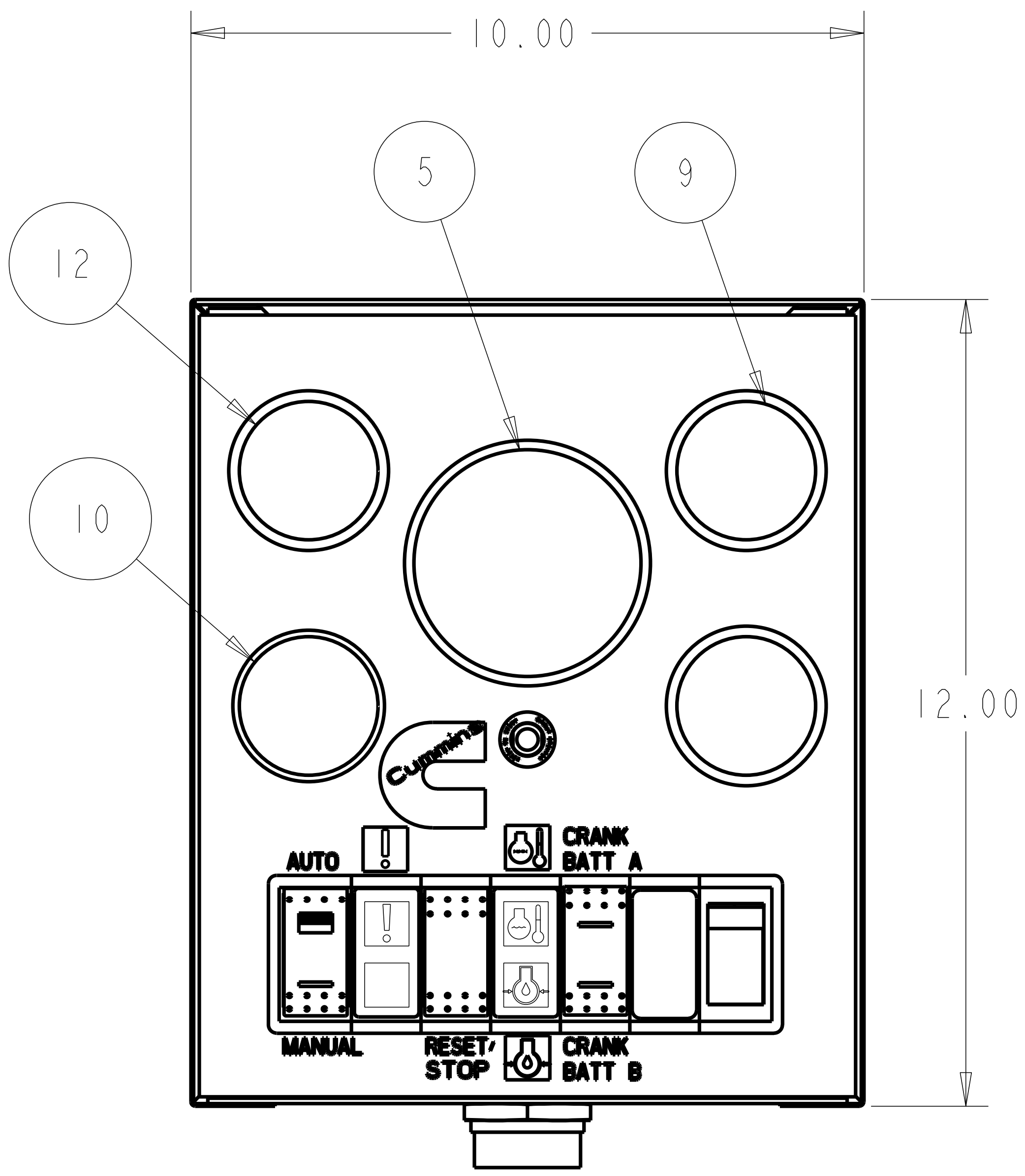
DRAWING NUMBER: 8513SHT2_J

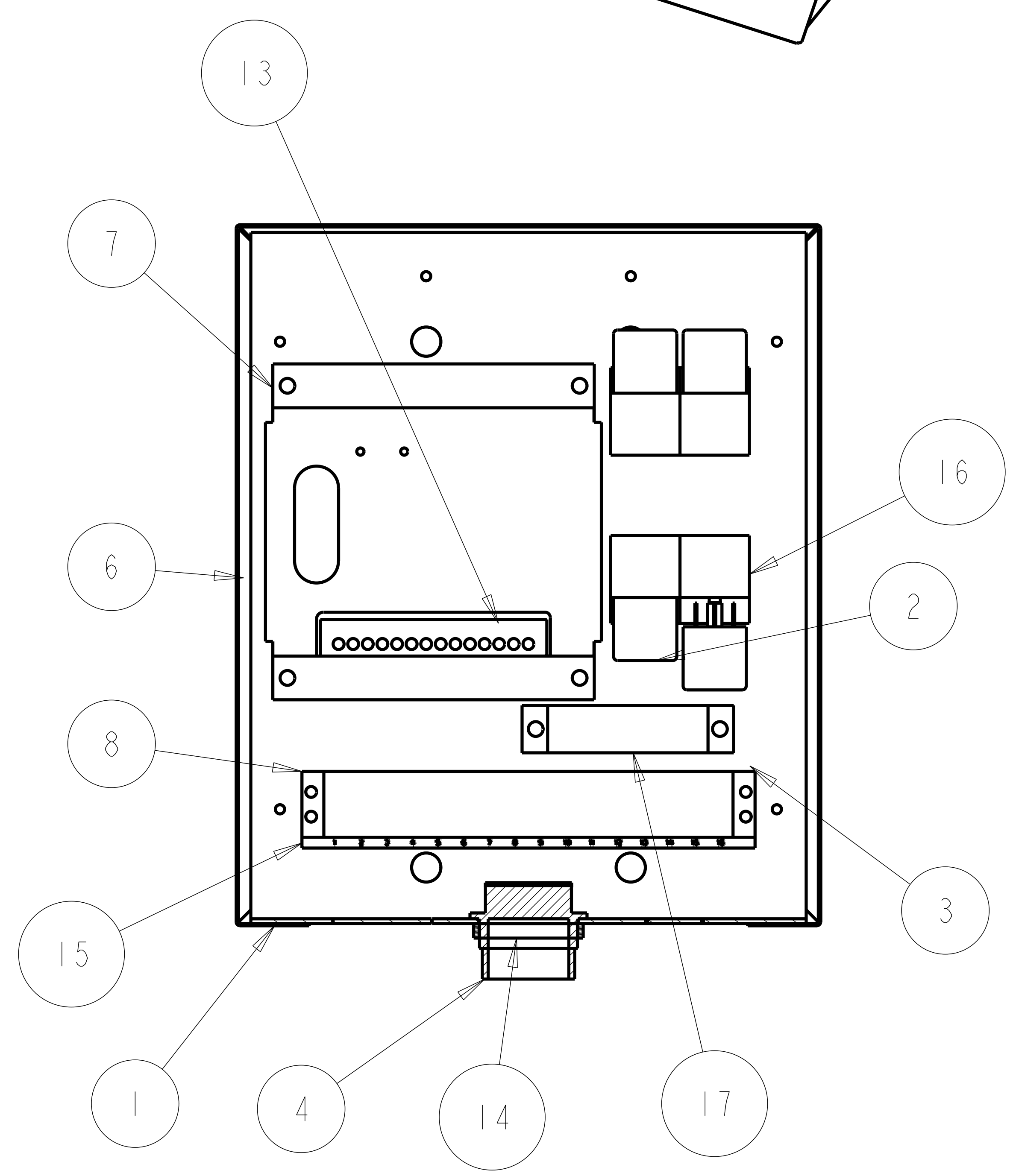




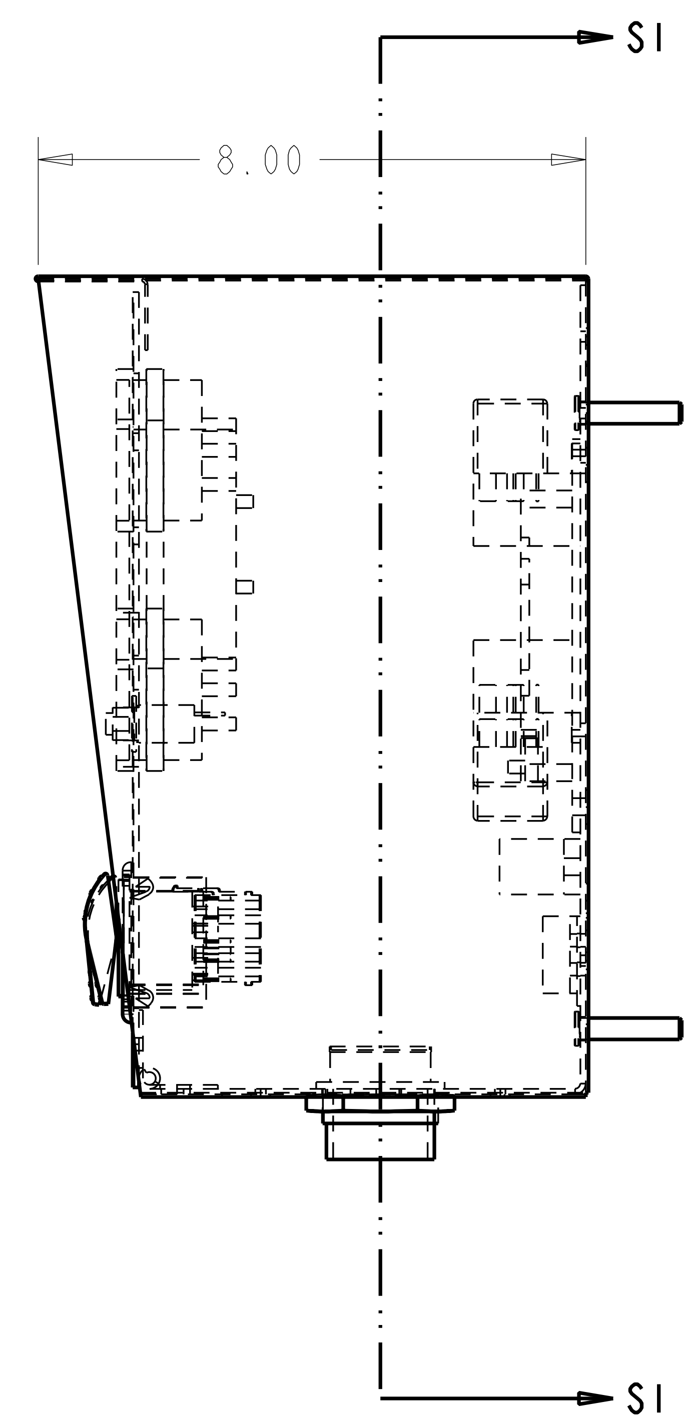
BILL OF MATERIAL

ITEM	QTY	DESCRIPTION	PART NUMBER
1	1	ENCLOSURE, FIREPUMP INSTRUMENT	8825
2	4	RELAY, INSTRUMENT PANEL, 40 AMP, 24vdc	8858
3	1	ASSEMBLY, SWITCH GANG, 24vdc, FIREPUMP	8871
4	1	HARNESS, GAUGE PANEL, 24vdc, FIREPUMP	8925
5	1	GUAGE, TACHOMETER/HOUR METER, FIREPUMP	8829
6	1	DECAL, INSTRUMENT PANEL, FIREPUMP	8835
7	1	MODULE, OVERSPEED, FIREPUMP	8836
8	1	TERMINAL STRIP, INSTRUMENT PANEL, CINCH 16-141, FIREPUMP	8837
9	2	GUAGE, VOLTMETER, INSTRUMENT PANEL, 24vdc, FIREPUMP	8840
10	1	GUAGE, OIL PRESSURE, INSTRUMENT PANEL, 24vdc, FIREPUMP	8841
11	2	VOLTAGE ADAPTER, 24vdc TO 12vdc	8842
12	1	GUAGE, WATER, INSTRUMENT PANEL, 24vdc, FIREPUMP	8843
13	1	CIRCUIT BREAKER, INSTRUMENT PANEL, 24vdc, FIREPUMP	8844
14	1	NUT, JAM, 1-11/16-18 UNEF, FIREPUMP	8897
15	1	STRIP, MARKING, TERMINAL BLOCK, FIREPUMP	9527
16	4	RELAY HOLDER, FIREPUMP	9528
17	1	MODULE, DIODE, INSTRUMENT PANEL, FIREPUMP	9529





SECTION S1-S1



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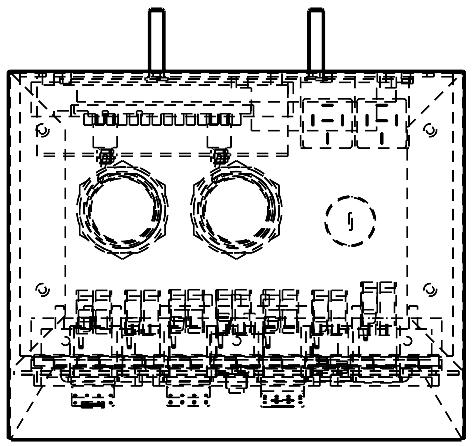
WELD TOLERANCES .X = ± 0.25 .XX = ± 0.12 .XXX = ± 0.06	WELDED TOLERANCES X = ± 5 X.X = ± 3 X.XX = ± 1.50

TITLE 1: ASSEMBLY, INSTRUMENT PANEL, 24vdc
TITLE 2: FIREPUMP

DWG UNITS: IN/LB/S	DRAWN BY: DAVE N	DATE: 19NOV2004
	APPD BY:	DATE:

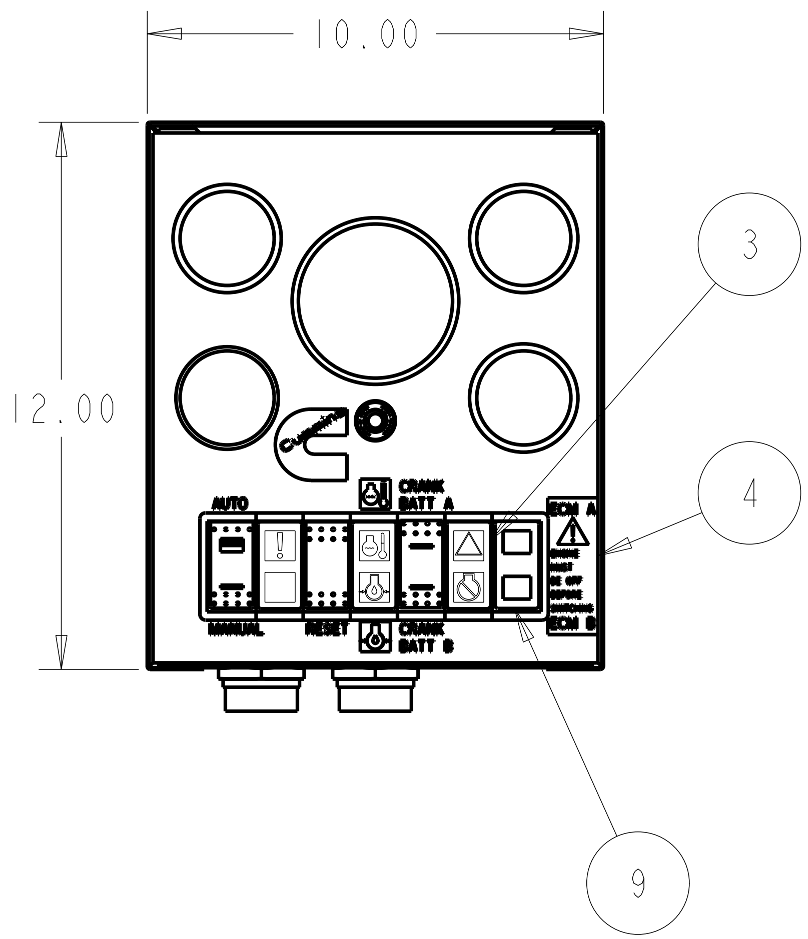
EST WEIGHT:	SCALE:	DO NOT SCALE	SHEET	DRAWING NO:	REV:
17.878	0.375		1OF1	8532	

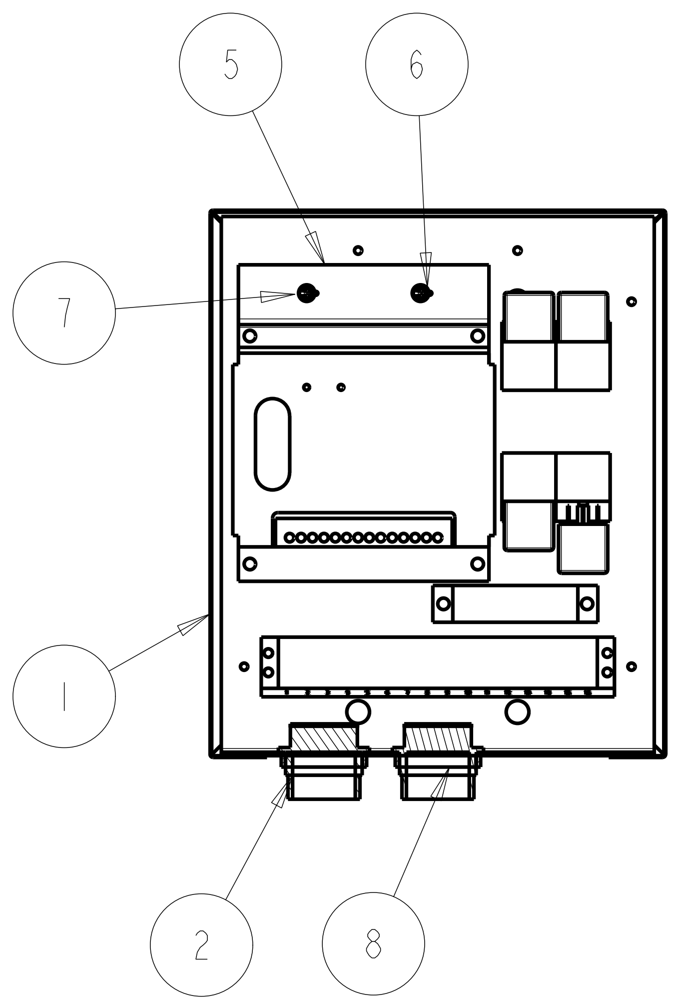
REV	DESCRIPTION OF REVISION	REV BY	DATE



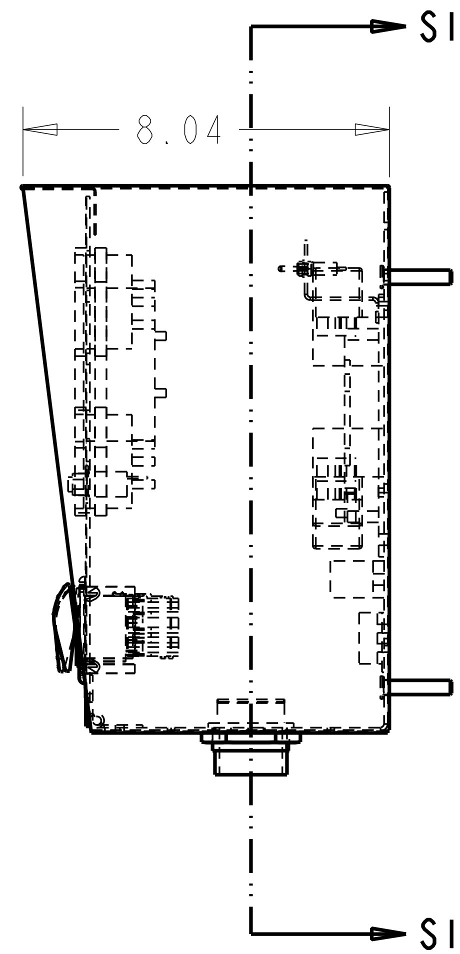
BILL OF MATERIAL

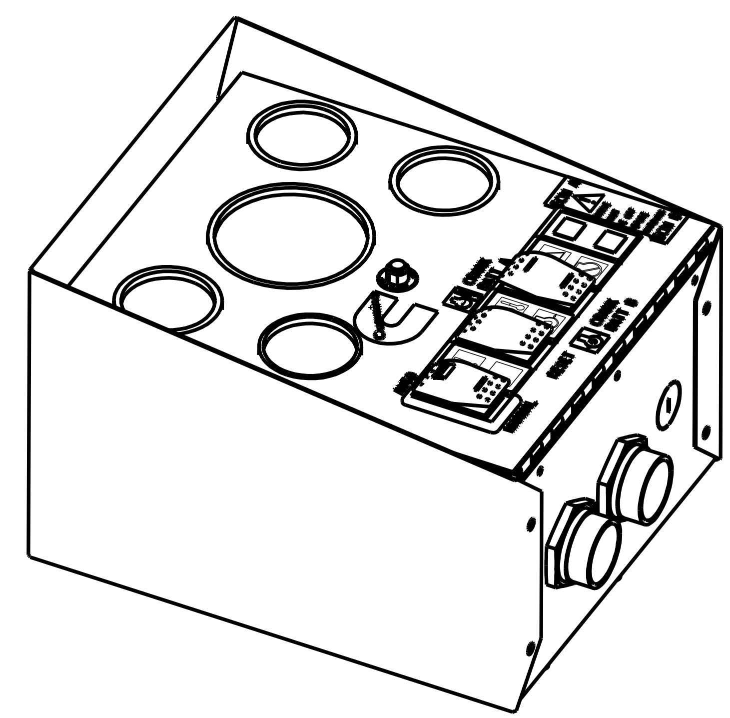
ITEM	QTY	DESCRIPTION	PART NUMBER
1	1	ASSEMBLY, INSTRUMENT PANEL, FIREPUMP	8508
2	1	HARNESS, GAUGE PANEL, FIREPUMP, E.ECTRONIC ENGINES	8894
3	1	ILLUMINATION PANEL, ENGINE FAULT	8872
4	1	DECAL, INSTRUMENT PANEL, FIREPUMP, ELECTRONIC ENGINES	8886
5	1	BRACKET, TOGGLE SWITCH MOUNTING, FIREPUMP GAUGE PANEL - E-ENG	8887
6	1	SWITCH, TOGGLE, MINIATURE, SUSTAINED ON-OFF-ON	8888
7	1	SWITCH, TOGGLE, MINIATURE, MOMENTARY (ON)-OFF-(ON)	8889
8	1	NUT, JAM, 1-11/16-18 UNEF, FIREPUMP	8897
9	1	ILLUMINATION PANEL, CARLING #VP1HH-B2255-00000, FIREPUMP	9545





SECTION S1-S1





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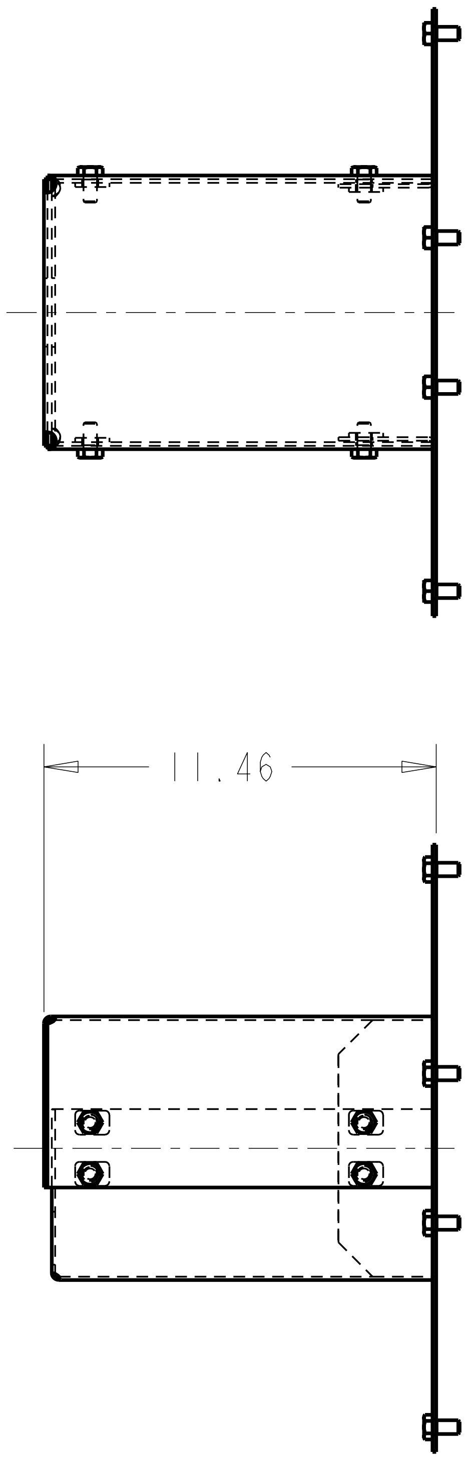
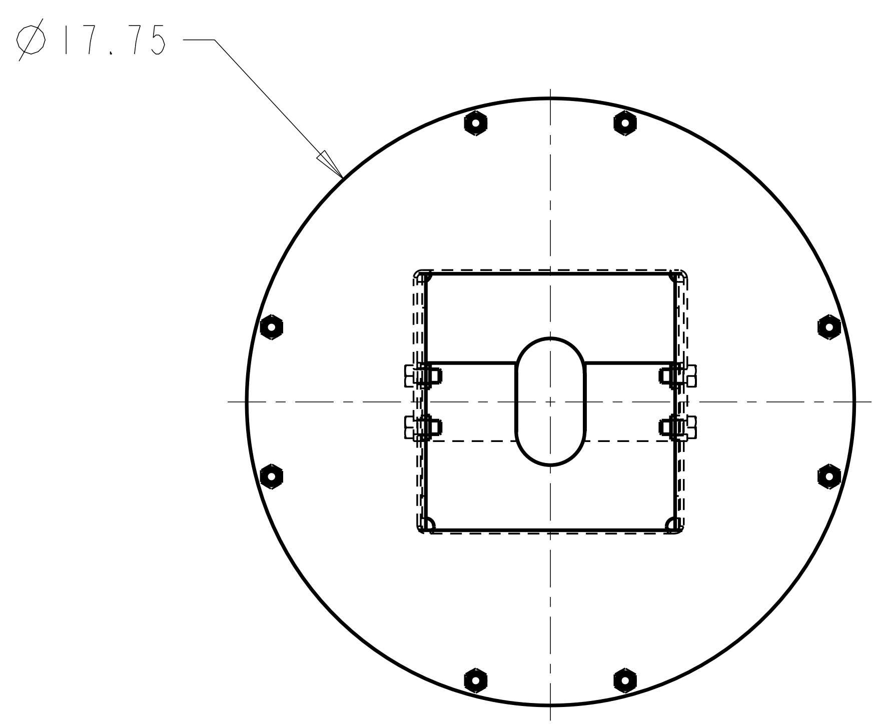
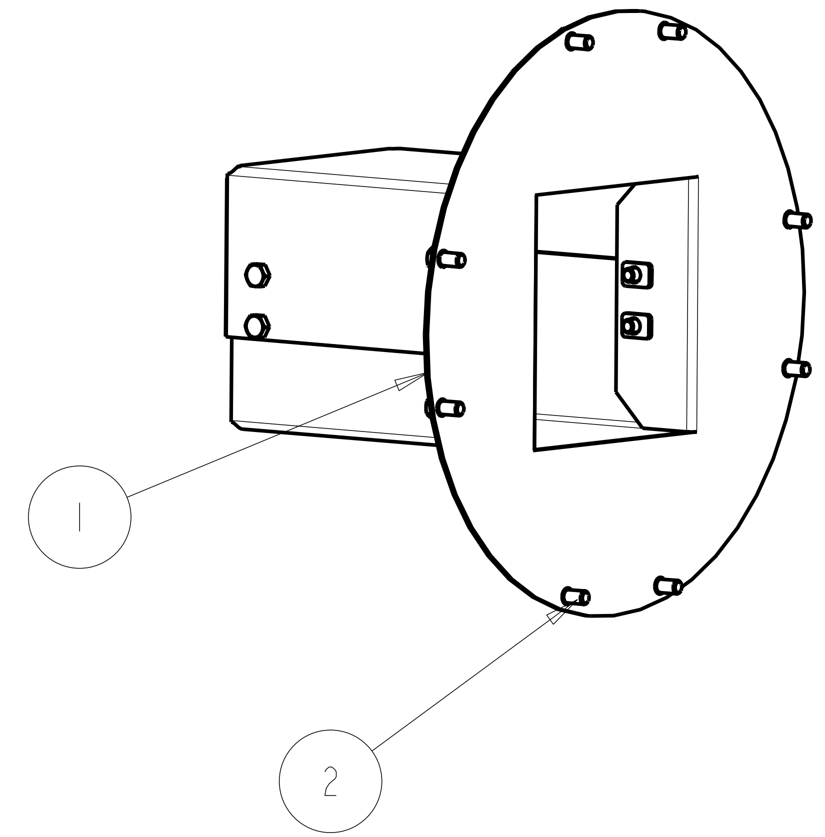
TITLE 1: ASSEMBLY, INSTRUMENT PANEL
TITLE 2: 12 VOLT ELECTRONIC ENGINES

DWG UNITS: IN/LB/S	DRAWN BY: DAVE N			DATE: 16-FEB-2004	
	APPD BY:			DATE:	
EST WEIGHT: 17.907	SCALE: 0.250	DO NOT SCALE	SHEET 1OF1	DRAWING NO: 8583	REV: D

REV	DESCRIPTION OF REVISION	REV BY	DATE	REV	DESCRIPTION OF REVISION	REV BY	DATE
D	REV PER FRONT PANEL	DAVE N	26JUL04	B	REV PER 8513	SD	MAY04
C	GENERAL UPDATE	DAVE N	12JUL04	A	RELEASED FOR CONSTRUCTION	SD	MAR04







BILL OF MATERIAL

ITEM	QTY	DESCRIPTION	PART NUMBER
1	1	GUARD, SHAFT, SAE#3, FIREPUMP	8602
2	16	SCREW, CAP, HEX HEAD, M10 x 20	HHCS_M10_20

REV	DESCRIPTION OF REVISION	REV BY	DATE
C	ADDED HARDWARE	DAVE N	11NOV2004
A/B	MISC REVISIONS	DAVE N	JUN04

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ANGULAR DIMENSIONS ± 1°

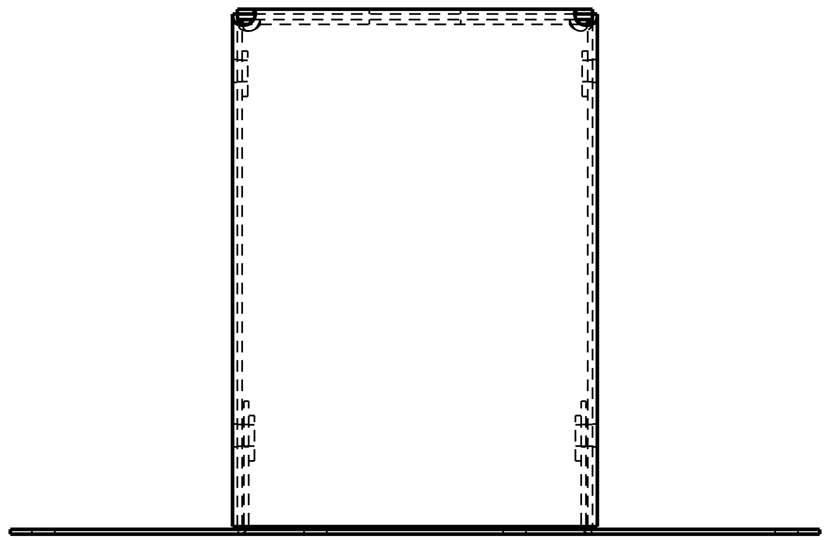
IMPERIAL UNITS	METRIC UNITS
MACHINE TOLERANCES .X = ± 0.06 .XX = ± 0.010 .XXX = ± 0.001 - WELD TOLERANCES .X = ± 0.25 .XX = ± 0.12 .XXX = ± 0.06	MACHINE TOLERANCES X = ± 1.5 X.X = ± 0.5 X.XX = ± 0.05 - WELDED TOLERANCES X = ± 5 X.X = ± 3 X.XX = ± 1.50

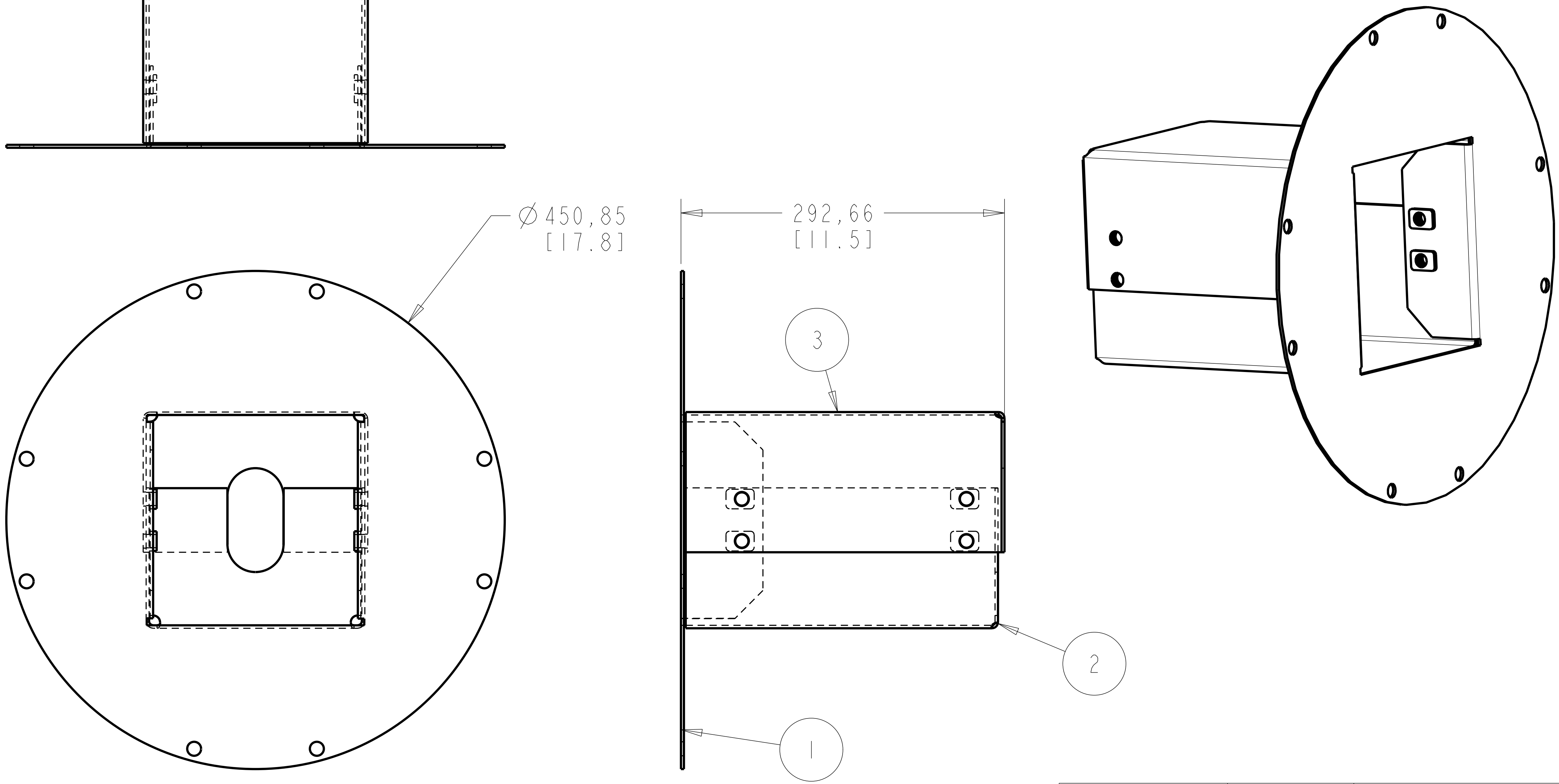
TITLE 1: ASSEMBLY, DRIVE SHAFT GUARD
TITLE 2: FIREPUMP

DWG UNITS: IN/LB/S	DRAWN BY: DAVE N			DATE: 23-FEB-2004	
	APPD BY:			DATE:	
EST WEIGHT: 24.213	SCALE: 0.188	DO NOT SCALE	SHEET 1OF1	DRAWING NO: 8600	REV: C

BILL OF MATERIAL

ITEM	QTY	DESCRIPTION	PART NUMBER
1	1	BACKPLATE, SHAFT GUARD, SAE #3, FIREPUMP	8603
2	1	BOTTOM, SHAFT GUARD, FIREPUMP	8604
3	1	TOP, SHAFT GUARD, FIREPUMP	8605





NOTES:
1) WELD NUTS INSTALLED ON LOWER LEVEL DRAWINGS

REV	DESCRIPTION OF REVISION	REV BY	DATE
C	REV PER SUB COMPONENTS	DAVE N	15DEC04
A/B	MISC REVISOINS	DAVE N	AUG04

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UNLESS OTHERWISE SPECIFIED ALL DIMENSION TOLERANCES ARE

ANGULAR DIMENSIONS ± 1°

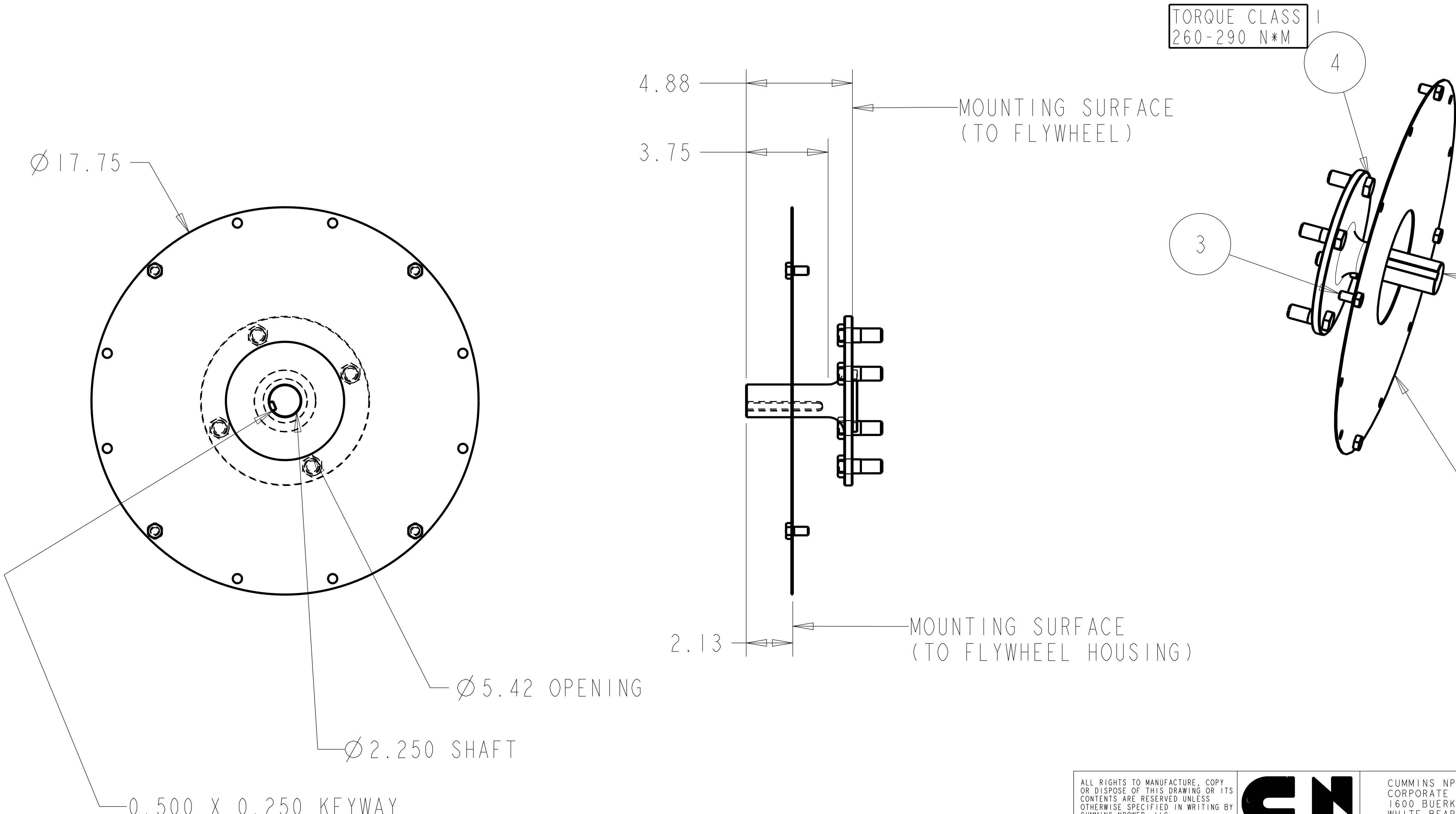
IMPERIAL UNITS	METRIC UNITS
MACHINE TOLERANCES .X = ± 0.06 .XX = ± 0.010 .XXX = ± 0.001 - WELD TOLERANCES .X = ± 0.25 .XX = ± 0.12 .XXX = ± 0.06	MACHINE TOLERANCES X = ± 1.5 X.X = ± 0.5 X.XX = ± 0.05 - WELDED TOLERANCES X = ± 5 X.X = ± 3 X.XX = ± 1.50

TITLE 1: GUARD, SHAFT, SAE#3
TITLE 2: FIREPUMP

DWG UNITS: IN/LB/S	DRAWN BY: PJA			DATE: 18jan2004	
	APPD BY:			DATE:	
EST WEIGHT: 10.983	SCALE: 0.250	DO NOT SCALE	SHEET 1OF1	DRAWING NO: 8602	REV: C

BILL OF MATERIAL

ITEM	QTY	DESCRIPTION	PART NUMBER
1	1	GUARD, STUB SHAFT, SAE #3 FLYWHEEL, FIREPUMP	8611
2	1	STUB SHAFT, SAE #3 FLYWHEEL, HAYES #, FIREPUMP	9624
3	4	SCREW, CAP, HEX HEAD, M10 x 20	HHCS_M10_20
4	4	SCREW, CAP, HEX HEAD, M10 x 50	HHCS_M16_50



REV	DESCRIPTION OF REVISION	REV BY	DATE
B	GUARD WAS 9553	DAVE N	20JAN05
A	ADDED HARDWARE	DAVE N	21OCT04

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ALL DIMENSION TOLERANCES ARE

ANGULAR DIMENSIONS ± 1°

IMPERIAL UNITS	METRIC UNITS
MACHINE TOLERANCES .X = ± 0.06 .XX = ± 0.010 .XXX = ± 0.001 - WELD TOLERANCES .X = ± 0.25 .XX = ± 0.12 .XXX = ± 0.06	MACHINE TOLERANCES X = ± 1.5 X.X = ± 0.5 X.XX = ± 0.05 - WELDED TOLERANCES X = ± 5 X.X = ± 3 X.XX = ± 1.50

TITLE 1: ASSEMBLY, STUB SHAFT, 2.25" DIA
TITLE 2: FIREPUMP

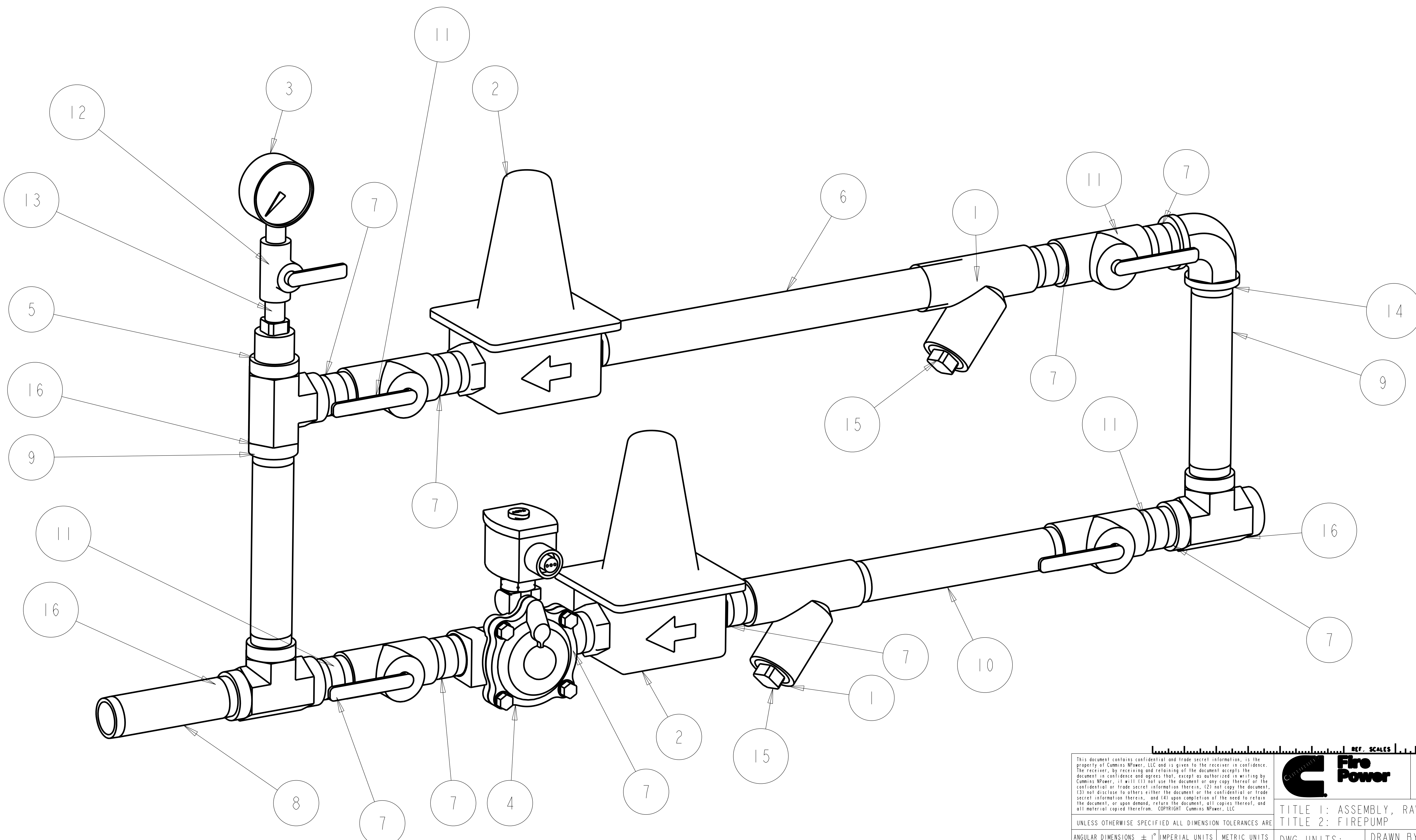
DWG UNITS: IN/LB/S	DRAWN BY: DAVE N			DATE: 15OCT2004
	APPD BY: -			DATE: -
EST WEIGHT: 42238.628	SCALE: 0.200	DO NOT SCALE	SHEET 1OF1	DRAWING NO: 8619	REV: B

VALVES SHOWN OPEN - NOT IN OPERATING POSITION
FOLLOW HANDLE ORIENTATION

BILL OF MATERIAL			
ITEM	QTY	DESCRIPTION	PART NUMBER
1	2	STRAINER, WITH PLUG, 1" NPT	1_77SM1
2	2	REGULATOR, 1" NPT, 400 PSI MAX, 25 TO 75 PSI OUT	1_N45DBU
3	1	GUAGE, PRESSURE, 1/4" NPT, 0-100 PSI RANGE	8892
4	1	VALVE, SOLENOID, 1" NPT, 12VDC, 150 PSI MAX	8210G4-12VDC
5	1	REDUCER BUSHING, BLK, 1" NPT x 1/4" NPT	BBGB
6	1	NIPPLE, BLK, 1 x 14	BNG14
7	9	NIPPLE, BLK, 1 X 2-1/2	BNGL
8	1	NIPPLE, BLK, 1 x 6	BNGU
9	2	NIPPLE, BLK, 1 x 8	BNGX
10	1	NIPPLE, BLK, 1 x 9	BNGY
11	4	VALVE, BALL, 1" NPT	FA60203-1
12	1	VALVE, BALL, 1/4" NPT	FA60204-1
13	1	NIPPLE, BLK, 1/4 X CLOSE	LTL-CPN14
14	1	ELBOW, BLK, 1" NPT	LTL-E190
15	2	PLUG, BLK, 1" NPT	LTL-SCSP1
16	3	TEE, BLK, 1"	LTL-ST1

9683-01 FOR VERTICLE TURBINE PUMP:
REMOVE VALVE ASCO #8210G4 AND
REPLACE WITH 6-1/2" LONG NIPPLE BNG6.5

9683-02 FOR 24vdc OPERATION:
REMOVE #8210G4-12vdc AND
REPLACE WITH #8210G4-24vdc



D	REV PER PART NUMBERS	DAVE N	20SEP06
REV	**DESCRIPTION OF REVISION**	**REV BY**	**DATE**

REF. SCALES

Fire Power

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TITLE 1: ASSEMBLY, RAW WATER COOLING, 1"
TITLE 2: FIREPUMP

UNLESS OTHERWISE SPECIFIED ALL DIMENSION TOLERANCES ARE

ANGULAR DIMENSIONS ± 1°	IMPERIAL UNITS	METRIC UNITS
THIRD ANGLE PROJECTION	MACHINE TOLERANCES .XX = ± 0.010 .XXX = ± 0.005	MACHINE TOLERANCES .X = ± 0.4 .XX = ± 0.2
	FORM TOLERANCES .XX = ± 0.030 .XXX = ± 0.015	FORM TOLERANCES .X = ± 0.8 .XX = ± 0.4
	FAB TOLERANCES .XX = ± 0.060 .XXX = ± 0.030	FAB TOLERANCES .X = ± 1.5 .XX = ± 0.8

DWG UNITS: IN/LB/S	DRAWN BY: DAVE N			DATE: 01NOV2004
	APPD BY:			DATE:
EST WEIGHT: 104224.787	SCALE: 0.375	DO NOT SCALE	SHEET 1OF1	DRAWING NO: 8683	REV: D

BILL OF MATERIAL

ITEM	QTY	DESCRIPTION	PART NUMBER
1	1	ASSEMBLY, ENGINE, QSC8.3-C340, FIREPUMP	8737
2	1	ASSEMBLY, MOUNTING, ENGINE, FIREPUMP, 6C8.3	8907
3	1	ASSEMBLY, HEAT SHIELD, FIREPUMP, QSC8.3	8937
4	1	ASSEMBLY, COOLANT HEATING, C8.3	8941
5	1	ASSEMBLY, HEAT EXCHANGER, QSC8.3, FIREPUMP	8944
6	1	ASSEMBLY, CHARGE AIR, C8.3, FIREPUMP	8967
7	1	ASSEMBLY, OPERATORS STATION, QSCC8.3, FIREPUMP	9502
8	1	ASSEMBLY, AIR CLEANER, QSC8.3, FIRE PUMP	9531
9	1	ASSEMBLY, FUEL SYSTEM PLUMBING, QSC8.3, FIREPUMP	9590
10	1	ASSEMBLY, PIPING, CAC HEAT EXCHANGER, QSC8.3, FIREPUMP	9591
11	1	ASSEMBLY, SECONDARY ECM, QSC8.3, FIREPUMP	9593
12	1	ASSEMBLY, GUARD, PULLEY, QSC, FIREPUMP	9627
13	1	FLEX, EXHAUST, 4" CUFF, FIREPUMP	8780

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REV	DESCRIPTION OF REVISION	REV BY	DATE
D1/2	GRAPHICS UPDATE	DAVE N	20JAN05
D	REV PER HEAT EXCHANGER	DAVE N	25OCT04
C	REV PER HEAT EXCHANGERS	DAVE N	09SEP04
B	ADDED MODEL INFO	DAVE N	23JUL04
A	MISC REVSIONS	DAVE N	JUN04

UNLESS OTHERWISE SPECIFIED ALL DIMENSION TOLERANCES ARE
ANGULAR DIMENSIONS ± 1°

IMPERIAL UNITS	METRIC UNITS
MACHINE TOLERANCES .X = ± 0.06 .XX = ± 0.010 .XXX = ± 0.001	MACHINE TOLERANCES X = ± 1.5 X.X = ± 0.5 X.XX = ± 0.05
WELD TOLERANCES .X = ± 0.25 .XX = ± 0.12 .XXX = ± 0.06	WELDED TOLERANCES X = ± 5 X.X = ± 3 X.XX = ± 1.50

TITLE 1: ASSEMBLY, POWER MODULE, CFP8E-F10
TITLE 2: FIREPUMP, QSC8.3-C340

DWG UNITS: IN/LB/S	DRAWN BY: DAVE N			DATE: 13MAY2004
	APPD BY:			DATE:
EST WEIGHT: 238654.051	SCALE: 0.150	DO NOT SCALE	SHEET 1OF1	DRAWING NO: 8711 / REV: D

PN 8737
SO 35329
Model QSC8.3
Config D413032CX03

Rev	Option	Desc
	FIRE 25	QSC8.3
	AP 9348	APPROVAL,AGENCY
	BB 9107	BLOCK,CYLINDER
	BB 9108	HOUSING,FRONT GE
	BR 9068	BREATHER,CRANKCA
	CH 9033	AID,COO HEATER S
	CP 9184	COMPRESSOR,AIR
	DA 9073	DAMPER,VIBRATION
	DF 9059	DRIVE,FRO GER TR
	DO 9348	SOFTWARE,CUS INT
	EC 9015	THERMOSTAT
	EH 9311	MOUNTING,ALTERNA
A	EE9242	Alternator, 12V, 95A, Delco 11SI
A	FA 9201	DRIVE,FAN
A	FA 9717	MOUNTING,FAN DRI
	FF 9151	LOCATION,FUEL FI
	FF 9526	FILTER,FUEL
	FF 9810	PLUMBING,FUEL FI
	FH 9207	HOUSING,FLYWHEEL
	FP97940	COUPLING,FUEL PU
	FP98655	PUMP,FUEL INJECT
	FP99221	CALIBRATION,FUEL
	FR91061	RATING,FUEL
	FS 9226	PUMP,FUEL TRANSF
	FT97074	PLUMBING,FUEL
	FW 9349	FLYWHEEL
A	FW 9335	Flywheel, 8/10
	GG 9706	COVER,FRONT GEAR
	GG 9752	MOUNTING,GEAR CO
	HC 9010	PLUMBING,CABIN H
A	IC 9142	CONNECTION,AIR I
	IT 9006	CONNECTION,AIR T
	LA 9028	ARRANGEMENT,LIFT
	LC 9060	HEAD,OIL FILTER
	LC 9702	COOLER,ENGINE OI
	LF 9049	FILTER,FULL FLOW
	LF 9130	FILTER,LUBRICATI
	LG 9343	GAUGE,OIL LEVEL
	LO 9004	OIL,LUBRICATING
	LP 9011	PUMP,LUBRICATING
	LP 9713	PUMP,LUBRICATING
	OB 9101	ARRANGEMENT,OIL
	OP 9153	PAN,OIL
	PH 9840	MODULE,ENGINE CO
	PP 8151	PARTS,PERFORMANC
	PP97176	HEAD,CYLINDER
	PP97421	INJECTOR
	PP97774	TURBOCHARGER
	RL 9705	LEVER,ROCKER
	RP 9013	VENT,ENGINE COOL
	SB 9054	BATTERY
	SC97416	SOFTWARE,CALIBRA
	SK 9003	ARRANGEMENT,SHIP
	SM 9080	MOUNTING,STARTIN
A	SP 9057	SPACER,FAN PILOT
	SR 9003	SHIELD,DEBRIS
	SS 9238	PAINT
	ST 9237	MOTOR,STARTING
	TB 9439	ARRANGEMENT,TURB
	TK 9006	COOLER,TOR CONVE
	TP97014	PLUMBING,TURBOCH
	VC 9062	COVER,VALVE
	VC 9728	MOUNTING,VALVE C
	WF 9028	LOCATION,CRN RES
	WF 9101	RESISTOR,CORROSI
	WI 9064	CONNECTION,WATER
	WO 9028	CONNECTION,WATER
	WP 9016	PUMP,WATER

A

REV	DESCRIPTION OF REVISION	BY	DATE
A	REDRAWN PER ENGINE SPEC	DAVE N	16OCT2004

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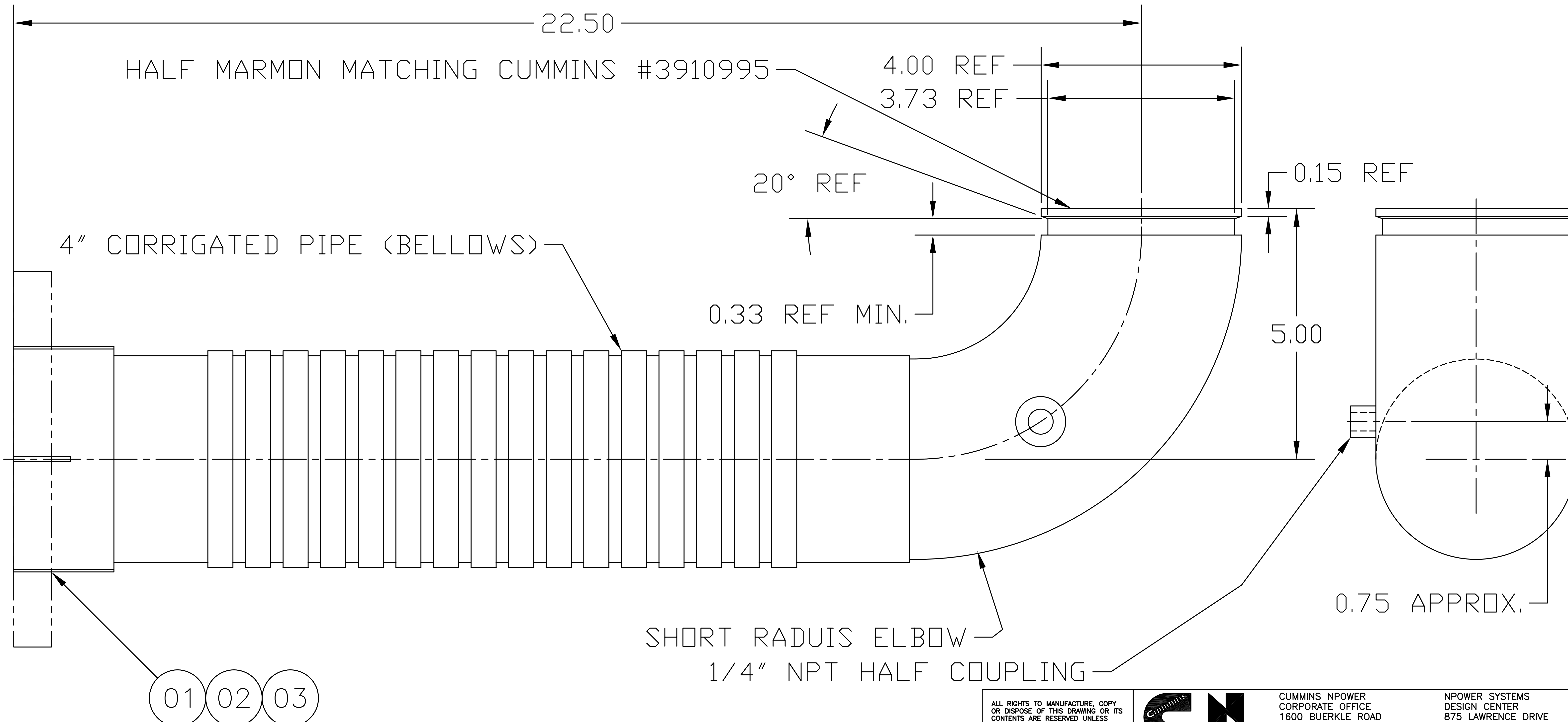
ALL DIMENSIONS ARE IN INCHES
APPLY MACHINE TOLERANCES
.X = ± 0.06
.XX = ± 0.010
.XXX = ± 0.001
APPLY WELDED TOLERANCES
.X = ± 0.25
.XX = ± 0.12
.XXX = ± 0.06

DWG SCALE: NTS	DRAWN BY: DAVE N	DATE: 23SEP2004
PLOT SCALE:	APPD BY:	DATE:

DESCRIPTION
ASSEMBLY, ENGINE, QSC8.3-C340

REFERENCE: CFP8E-F10
DRAWING NUMBER: 8737A

ITEM	QTY	DESCRIPTION	MATERIAL
01	A/R	4" MALE NPT	
02	A/R	4" I.D. CUFF	
03	A/R	4" 125# ANSI FLANGE	



REV	DESCRIPTION OF REVISION	BY	DATE
C	ADDED HALF COUPLING	DAVE N	21JAN2005
B	REWORKED BOM TO TABULATE END OPTIONS	DAVE N	18NOV2004
A	ITEM 2 WAS FLEX	CMC	18MAY2004

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APPLY MACHINE TOLERANCES
.X = ± 0.06
.XX = ± 0.010
.XXX = ± 0.001
APPLY WELDED TOLERANCES
.X = ± 0.25
.XX = ± 0.12
.XXX = ± 0.06

DWG SCALE: 1/2" = 1"	DRAWN BY: DAVE N	DATE: 09MAR2004
PLOT SCALE:	APPD BY:	DATE:

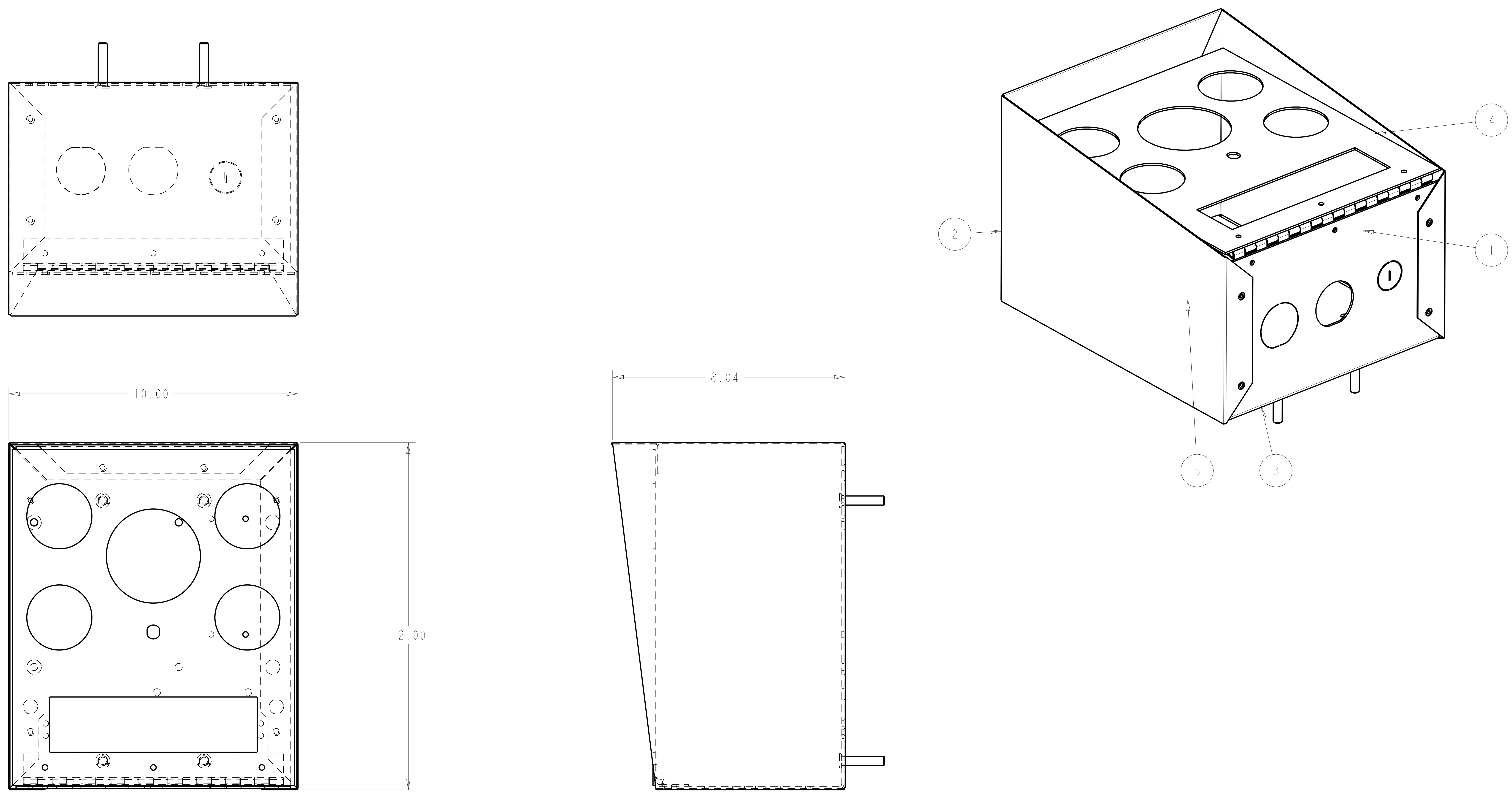
DESCRIPTION
EXHAUST, 90°, HALF MARMON TABULATED

REFERENCE:
FIREPUMP, 4" TURBO OUTLET

DRAWING NUMBER:
8780C

BILL OF MATERIAL

ITEM	QTY	DESCRIPTION	PART NUMBER
1	1	HINGE, INSTRUMENT PANEL COVER, FIREPUMP	8867
2	1	ENCLOSURE, INSTRUMENT PANEL, FIREPUMP	8864
3	1	ENCLOSURE BACK, INSTRUMENT PANEL, FIREPUMP	8865
4	1	FACE PLATE, INSTRUMENT PANEL, FIREPUMP	8866
5	4	STUD, WELD, M8 x 40mm LG	WELDSTUD_M8_X_40MM



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ANGULAR DIMENSIONS ± 1°

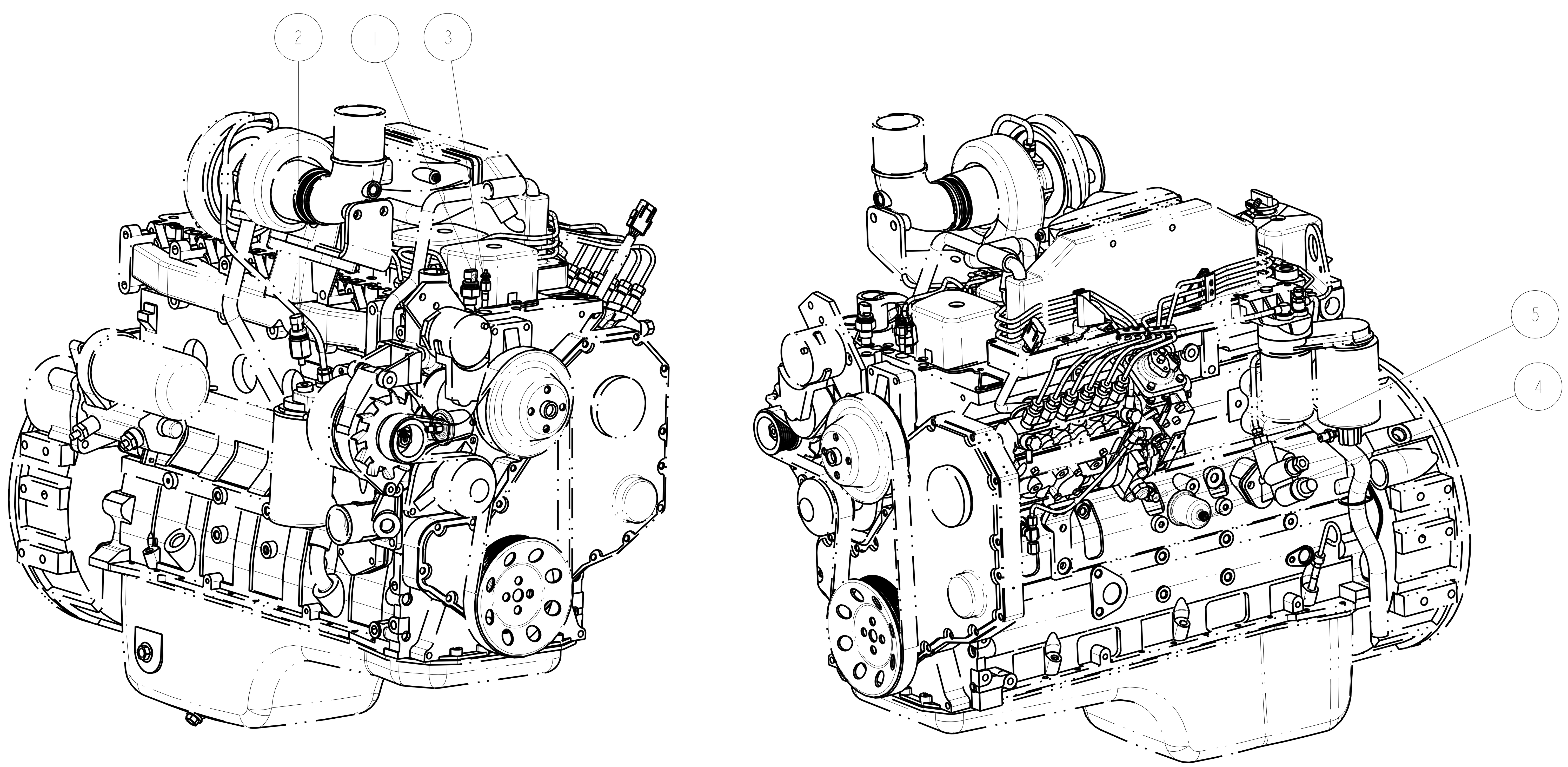
TITLE 1: ENCLOSURE, FIREPUMP INSTRUMENT
TITLE 2:

IMPERIAL UNITS	METRIC UNITS
MACHINE TOLERANCES .X = ± 0.06 .XX = ± 0.010 .XXX = ± 0.001	MACHINE TOLERANCES X = ± 1.5 X.X = ± 0.5 X.XX = ± 0.05
WELD TOLERANCES .X = ± 0.25 .XX = ± 0.12 .XXX = ± 0.06	WELDED TOLERANCES X = ± 5 X.X = ± 3 X.XX = ± 1.50

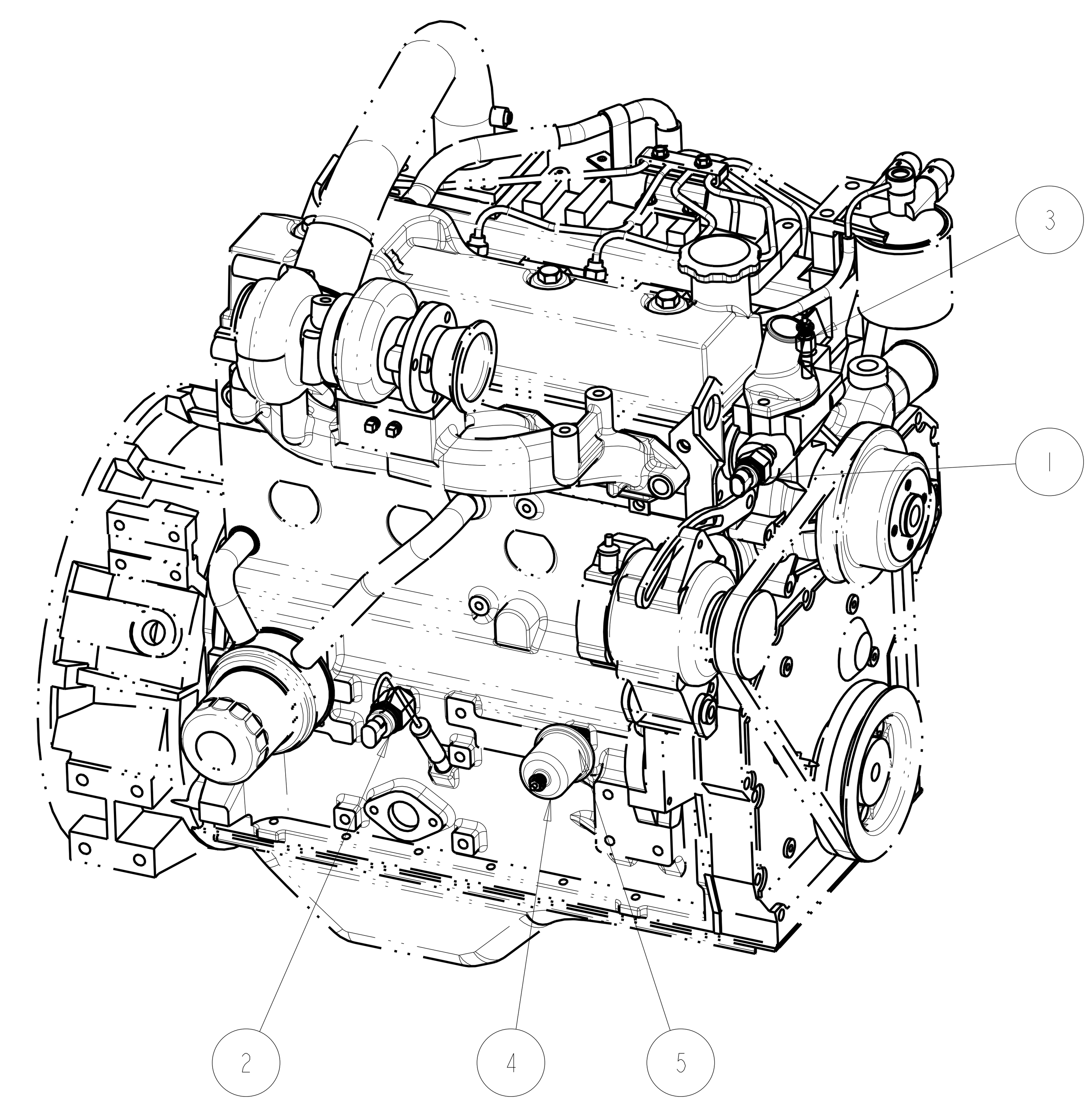
REV	DESCRIPTION OF REVISION	REV BY	DATE
C	STUD WAS 5/16	DAVE N	28FEB05
B	GENERAL UPDATES	DAVE N	12JUL04
A	MISC REVISIONS	SD	MAR04

DWG UNITS: IN/LB/S	DRAWN BY: S.DANFORTH			DATE: 03/MAR/2004	
	APPD BY: S.DANFORTH			DATE: 03/MAR/2004	
EST WEIGHT: 9.524	SCALE: 0.500	DO NOT SCALE	SHEET 1OF1	DRAWING NO: 8825	REV: C

BILL OF MATERIAL			
ITEM	QTY	DESCRIPTION	PART NUMBER
1	1	SWITCH, WATER TEMPERATURE, 200F SETTING	8860
2	1	SWITCH, OIL PRESSURE, 16 PSI SETTING	8861
3	1	TRANSDUCER, WATER TEMPERATURE, DATCON P/N 02022-00	8862
4	1	TRANSDUCER, WATER TEMPERATURE, DATCON P/N 02022-00	8863
5	1	ADAPTER, ISO6149 M10 TO 1/8 NPTF	M10P870MN-S



TYPICAL INSTALLATION - B & C ENGINES



TYPICAL INSTALLATION B3.3 ENGINES

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ALL DIMENSION TOLERANCES ARE

ANGULAR DIMENSIONS $\pm 1°$

TITLE 1: KIT, INSTRUMENT SENSOR
TITLE 2: FIREPUMP GAUGE PANEL

IMPERIAL UNITS	METRIC UNITS
MACHINE TOLERANCES .X = $\pm$ 0.06 .XX = $\pm$ 0.010 .XXX = $\pm$ 0.001	MACHINE TOLERANCES X = $\pm$ 1.5 X.X = $\pm$ 0.5 X.XX = $\pm$ 0.05

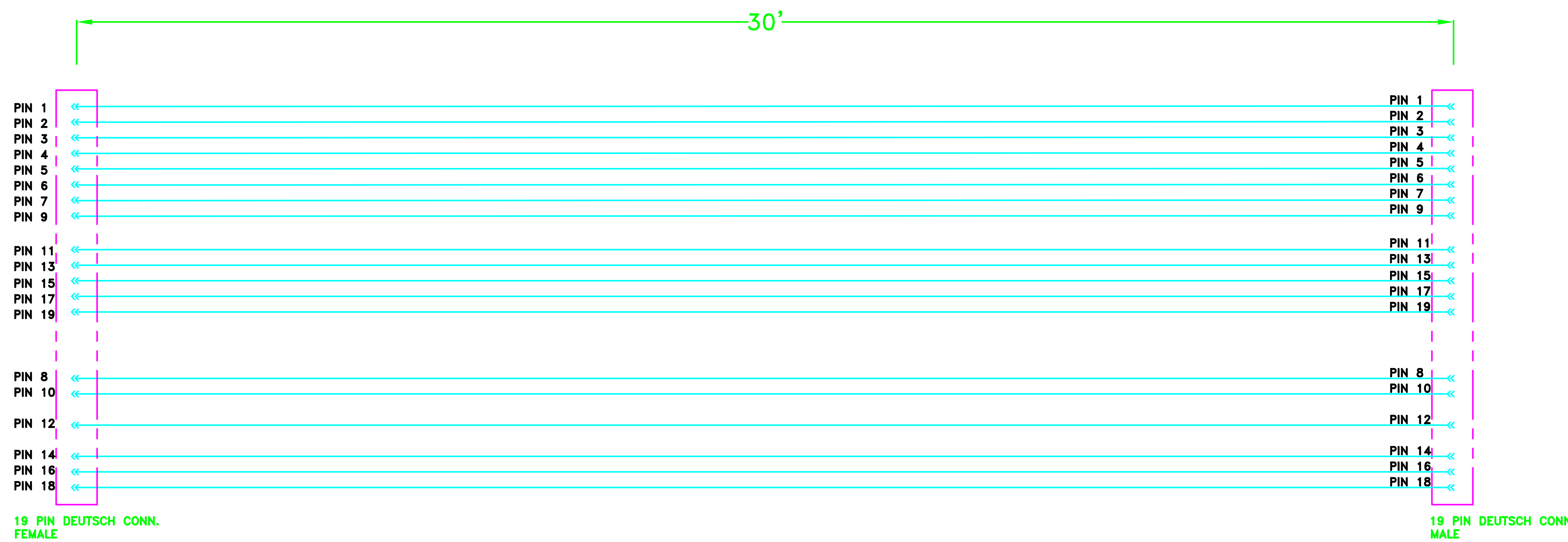
DWG UNITS: IN/LB/S

DRAWN BY: S.DANFORTH | DATE: 12MAY04

APPD BY: | DATE:

EST WEIGHT: | SCALE: | DO NOT | SHEET | DRAWING NO: | REV

PINS 10AWG SXL WIRE (12AWG CAVITIESPINS 1-7, 9, 11, 13, 15, 17, 19
ARE 16AWG SXL WIRE
PINS 8, 10,12, 14,16 &18
ARE 10AWG SXL WIRE (12 AWG CAVITIES)



REV	DESCRIPTION OF REVISION	BY	DATE

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APPLY MACHINE TOLERANCES
.X = ± 0.06
.XX = ± 0.010
.XXX = ± 0.001
APPLY WELDED TOLERANCES
.X = ± 0.25
.XX = ± 0.12
.XXX = ± 0.06

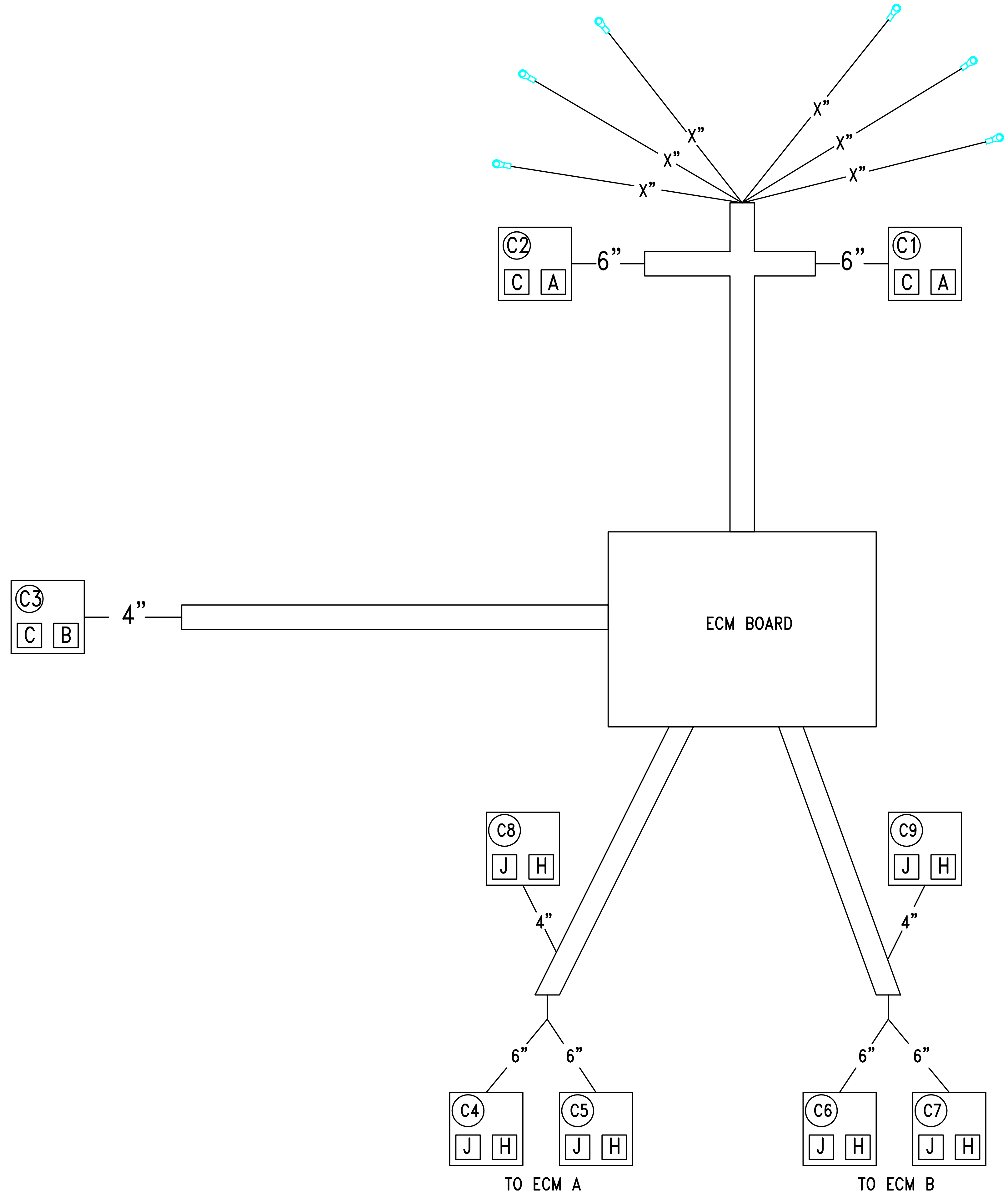
DWG SCALE:	DRAWN BY: ALLGEYER	DATE: 29JUNE2004
PLOT SCALE:	APPD BY:	DATE:

DESCRIPTION
WIRING HARNESS EXTENTION FOR TESTING

REFERENCE:
FIRE PUMPS W/ ECM

DRAWING NUMBER:
8878 SHT4

ITEM	QTY.	VENDOR	VENDOR P/N	DESCRIPTION
A		DEUTSCH	DRC26-50S03	50 PIN SOCKET "A"
B		DEUTSCH	DRC26-50S05	50 PIN SOCKET "B"
C		DEUTSCH	0528-001-5005	50 PIN SOCKET COVER
D		DEUTSCH	HDP26-24-19SN	19 PIN SOCKET
E		DEUTSCH	HD36-24-23ST	23 PIN SOCKET
F		MOLEX	09-50-3171	17 PIN PLUG TYPE KK
G		MOLEX	09-50-3081	8 PIN PLUG TYPE KK
H		DUETSCH	DT04-3P-P006	3 PIN RECP FOR J1939
J		DEUTSCH	DT06-3S-E008	PLUG FOR J1939 CONN.
K				#10 RING TERM
L				5/16" RING TERM
M				1/2" RING TRM



REV	DESCRIPTION OF REVISION	BY	DATE

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UNLESS OTHERWISE NOTED
—
ALL DIMENSIONS ARE IN INCHES
—
APPLY MACHINE TOLERANCES
.X = ± 0.06
.XX = ± 0.010
.XXX = ± 0.001
—
APPLY WELDED TOLERANCES
.X = ± 0.25
.XX = ± 0.12
.XXX = ± 0.06

DWG SCALE:	DRAWN BY: SAH	DATE: 7/19/04
PLOT SCALE:	APPD BY:	DATE:

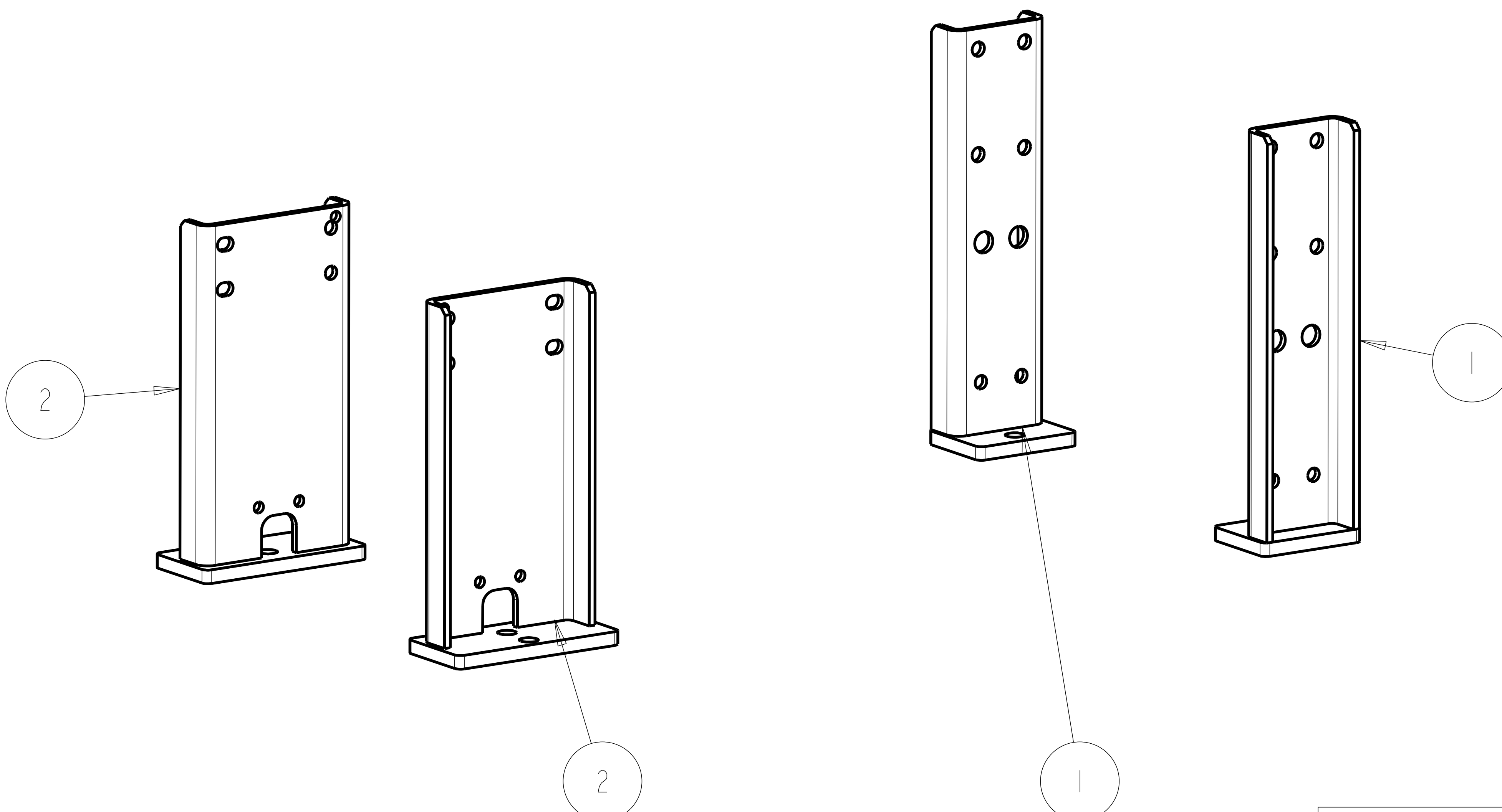
DESCRIPTION
WIRING HARNESS FOR REDUNDANT ECM

REFERENCE:
FIRE PUMPS, QSB/QSC

DRAWING NUMBER:
8878 SHT5

BILL OF MATERIAL

ITEM	QTY	DESCRIPTION	PART NUMBER
1	2	LEG, ENGINE SUPPORT, REAR, FIREPUMP, 6B/4B	8412
2	2	SUPPORT, ENGINE, FRONT, FIREPUMP, C8.3	8908



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ANGULAR DIMENSIONS ± 1°

IMPERIAL UNITS	METRIC UNITS
MACHINE TOLERANCES .X = ± 0.06 .XX = ± 0.010 .XXX = ± 0.001 - WELD TOLERANCES .X = ± 0.25 .XX = ± 0.12 .XXX = ± 0.06	MACHINE TOLERANCES X = ± 1.5 X.X = ± 0.5 X.XX = ± 0.05 - WELDED TOLERANCES X = ± 5 X.X = ± 3 X.XX = ± 1.50

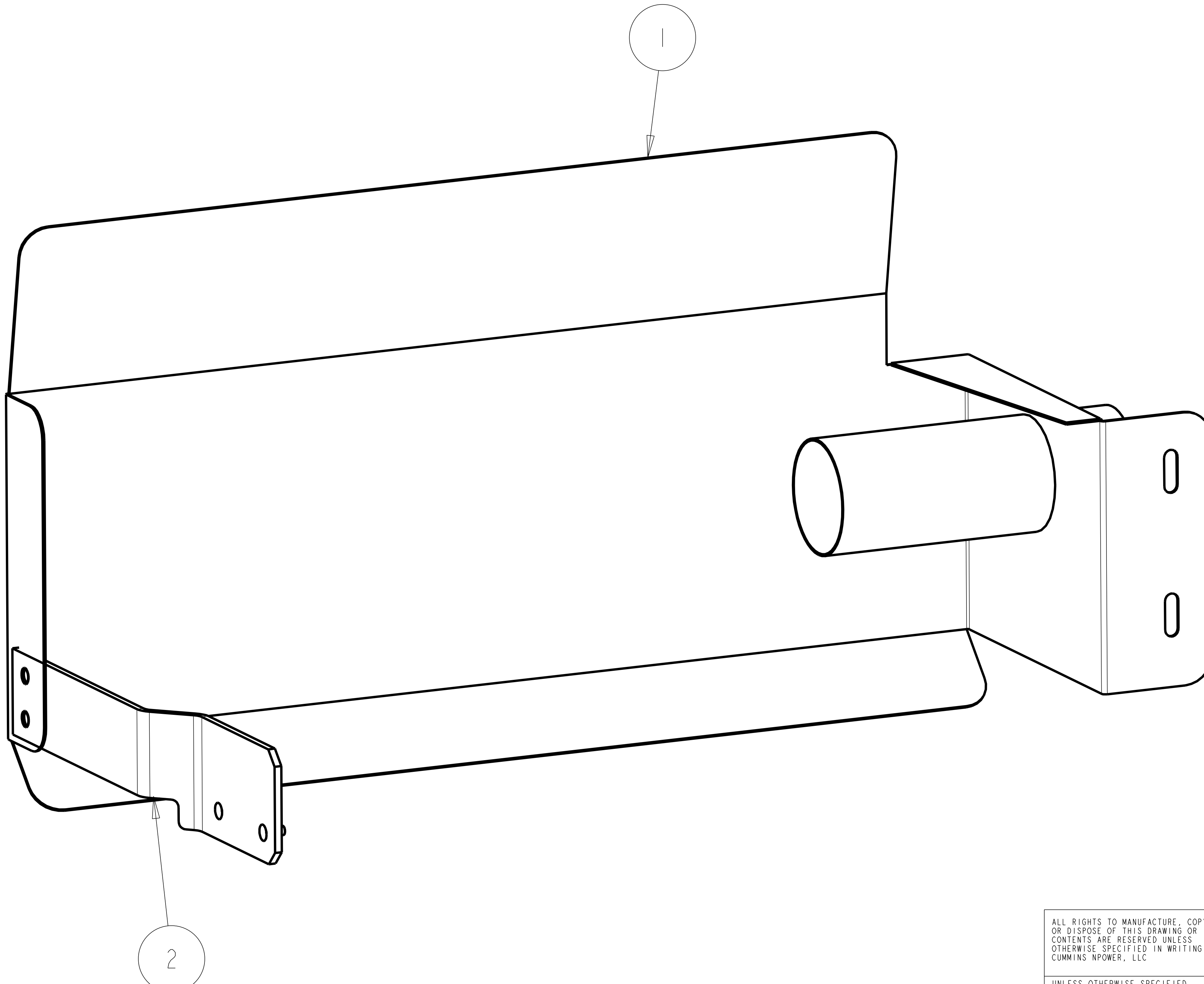
TITLE 1: ASSEMBLY, MOUNTING, ENGINE
TITLE 2: FIREPUMP, 6C8.3

DWG UNITS: IN/LB/S	DRAWN BY: DAVE N			DATE: 28APR2004	
	APPD BY:			DATE:	
EST WEIGHT: 238534.059	SCALE: 0.200	DO NOT SCALE	SHEET 1OF1	DRAWING NO: 8907	REV: B

REV	DESCRIPTION OF REVISION	REV BY	DATE
A/B	REV PER FRONT SUPPORT	DAVE N	26AUG04

BILL OF MATERIAL

ITEM	QTY	DESCRIPTION	PART NUMBER
1	1	HEAT SHIELD, TURBO, QSC8.3, FIREPUMP	9530
2	1	BRACKET, MOUNTING, TURBO, FRONT, FIREPUMP, C8.3	8915



A			
REV	**DESCRIPTION OF REVISION**	**REV BY**	**DATE**

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ANGULAR DIMENSIONS ± 1°

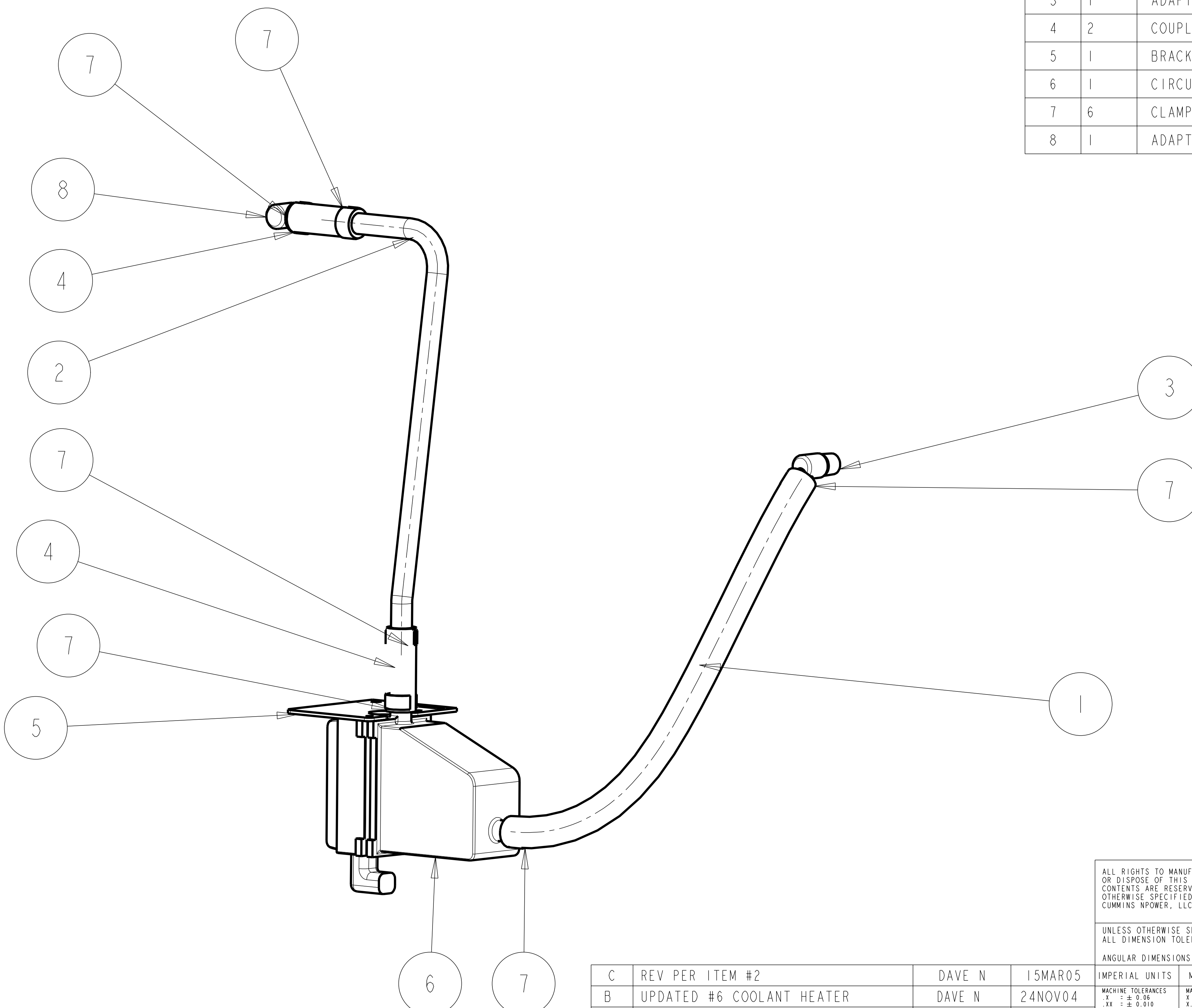
TITLE 1: ASSEMBLY, HEAT SHIELD
TITLE 2: FIREPUMP, QSC8.3

IMPERIAL UNITS	METRIC UNITS
MACHINE TOLERANCES .X = ± 0.06 .XX = ± 0.010 .XXX = ± 0.001 - WELD TOLERANCES .X = ± 0.25 .XX = ± 0.12 .XXX = ± 0.06	MACHINE TOLERANCES X = ± 1.5 X.X = ± 0.5 X.XX = ± 0.05 - WELDED TOLERANCES X = ± 5 X.X = ± 3 X.XX = ± 1.50

DWG UNITS: IN/LB/S	DRAWN BY: DAVE N			DATE: 07JUL2004	
	APPD BY:			DATE:	
EST WEIGHT: 34.424	SCALE: 0.250	DO NOT SCALE	SHEET 1OF1	DRAWING NO: 8937	REV: A

BILL OF MATERIAL

ITEM	QTY	DESCRIPTION	PART NUMBER
1	1	HOSE, 3/4" ID #70232GL X 26" LG	8942
2	1	TUBE, COOLANT HEATER, C8.3	8943
3	1	ADAPTER, BARBED, 1/2" NPT X 3/4" TUBE, 45 DEG	1-2_HB_45
4	2	COUPLING, HOSE, 3/4" I.D. #80242GL X 3" LG, FIREPUMP	8562
5	1	BRACKET, MOUNTING, COOLANT HEATER, FIREPUMP	9542
6	1	CIRCULATION HEATER, P&T #3315033, 2250W , 120V , 176 DEG F	9599
7	6	CLAMP, 1" NOMINAL #92216	CLAMP_100
8	1	ADAPTER, 1/2" NPT X 3/4" 90 DEG BARB	R-269HB-12-8



REV	DESCRIPTION OF REVISION	REV BY	DATE
C	REV PER ITEM #2	DAVE N	15MAR05
B	UPDATED #6 COOLANT HEATER	DAVE N	24NOV04
A	REV PER COOLANT HEATER	DAVE N	04SEP04

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TITLE 1: ASSEMBLY, COOLANT HEATING, C8.3
TITLE 2:

IMPERIAL UNITS	METRIC UNITS
MACHINE TOLERANCES .X = ± 0.06 .XX = ± 0.010 .XXX = ± 0.001	MACHINE TOLERANCES X = ± 1.5 X.X = ± 0.5 X.XX = ± 0.05
WELD TOLERANCES .X = ± 0.25 .XX = ± 0.12 .XXX = ± 0.06	WELDED TOLERANCES X = ± 5 X.X = ± 3 X.XX = ± 1.50

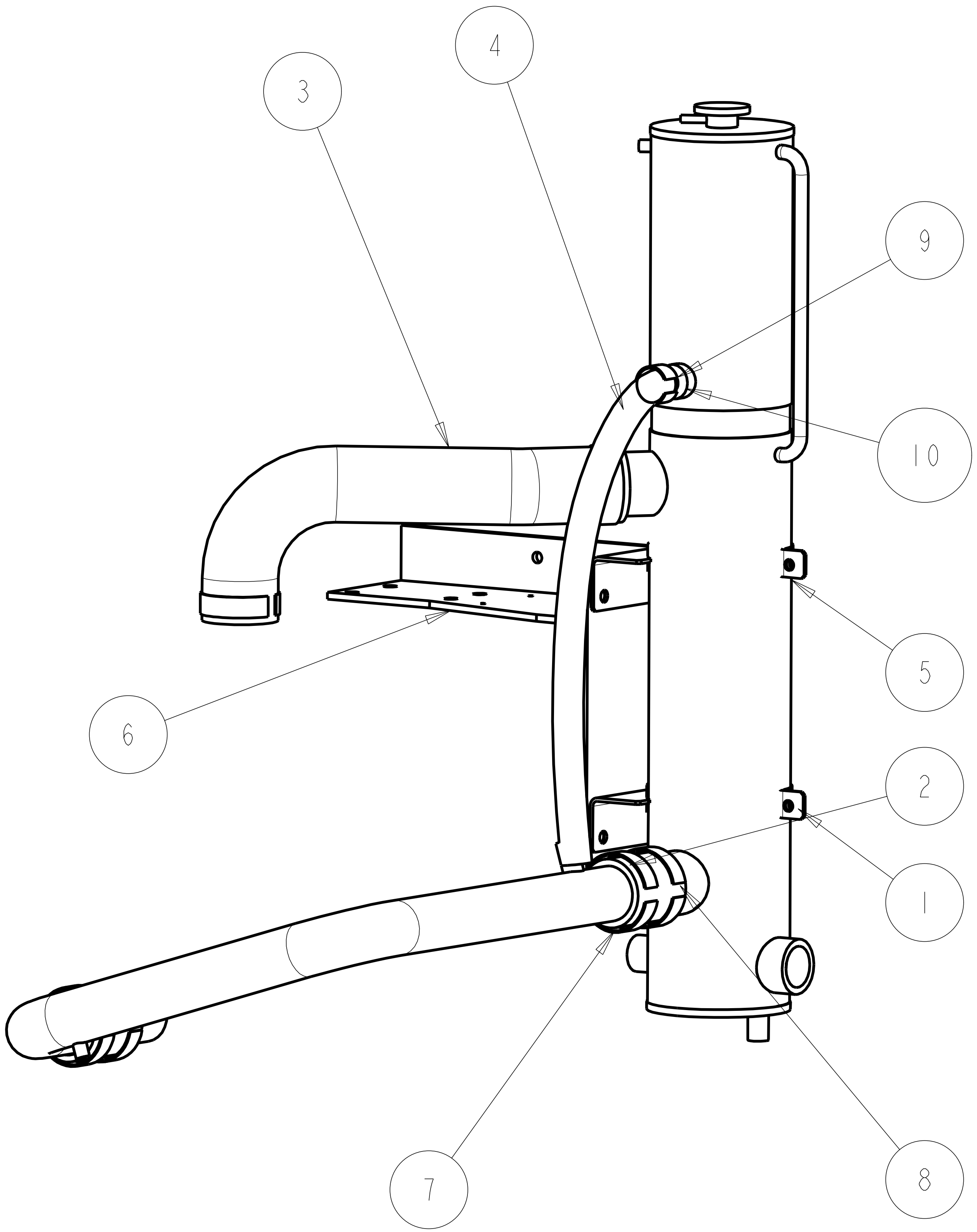
DWG UNITS: IN/LB/S

DRAWN BY: DAVE N — DATE: 04MAY2004

APPD BY: — DATE:

EST WEIGHT: 565.840

SCALE: 0.250 — DO NOT SCALE — SHEET 1OF1 — DRAWING NO: 8941 — REV: C



BILL OF MATERIAL

ITEM	QTY	DESCRIPTION	PART NUMBER
1	2	CLAMP, SUPPORT, HEAT EXCHANGER, CHAMP #300385	8819
2	1	TUBE, WATER INLET, FIREPUMP, c8.3	8920
3	1	HOSE, WATER OUTLET, FIREPUMP, C8.3	8946
4	1	FILL HOSE, 3/4" ID X 20" LG #70232GL, -	70232GL_8919
5	1	HEAT EXCHANGER, 5", #CM012904-1	8687
6	1	BRACKET, SUPPORT, HEAT EXCHANGER, FIREPUMP, C8.3	8922
7	6	CLAMP, 2-1/2" NOMINAL	8928
8	2	HOSE, CONNECTION, 2.0 ID, FIREPUMP	8929
9	1	CLAMP, 1" NOMINAL, #92216	92216
10	1	ADAPTER, 3/4" NPT X 3/4" OD	R-68HB_12-8

REV	DESCRIPTION OF REVISION	REV BY	DATE
C	REV PER HX. ADDED FILL HOSE	DAVE N	23OCT04
A/B	MISC REVISIONS	DAVE N	20OCT04

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ANGULAR DIMENSIONS ± 1°

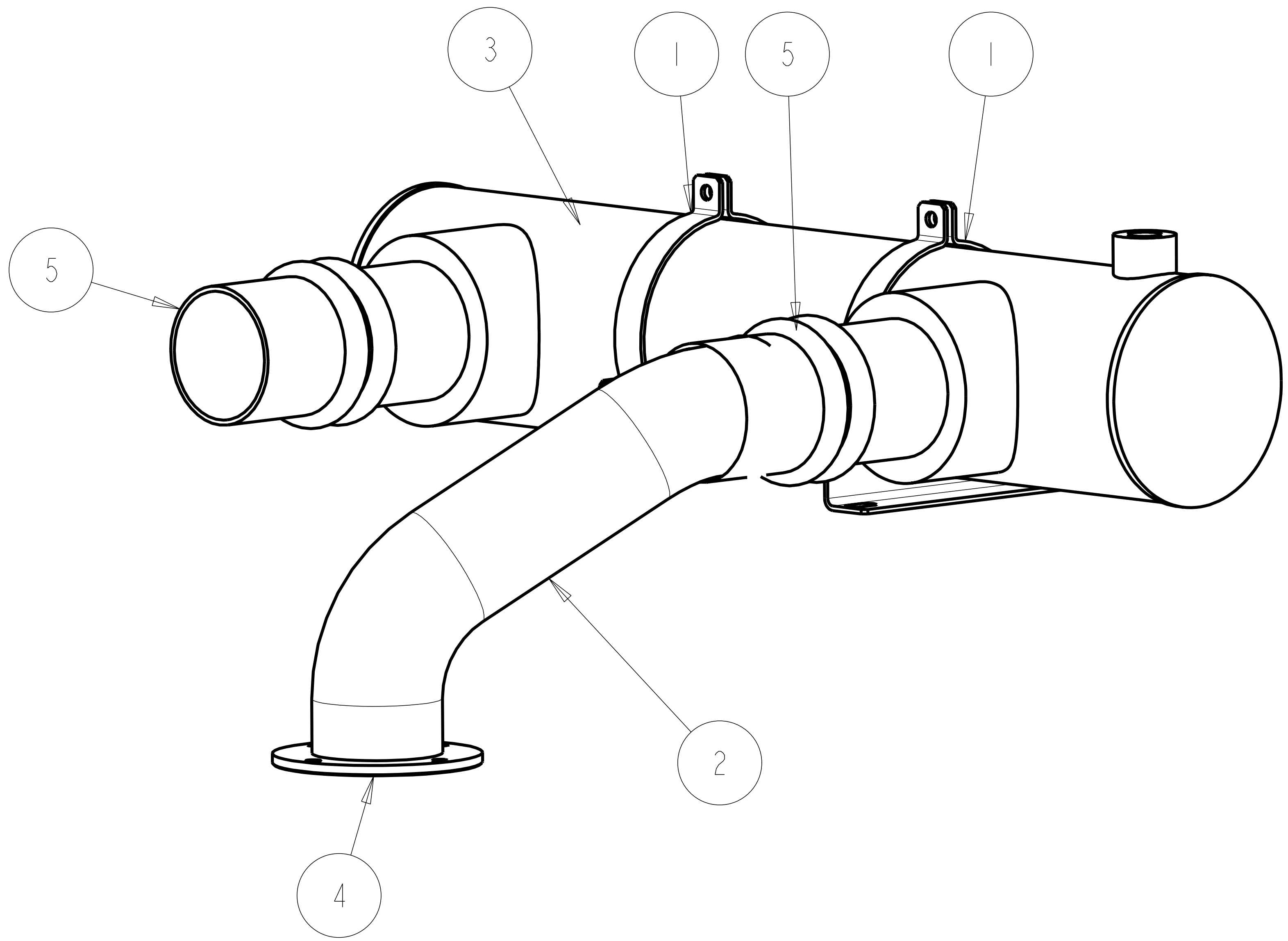
IMPERIAL UNITS	METRIC UNITS
MACHINE TOLERANCES .X = ± 0.06 .XX = ± 0.010 .XXX = ± 0.001 - WELD TOLERANCES .X = ± 0.25 .XX = ± 0.12 .XXX = ± 0.06	MACHINE TOLERANCES X = ± 1.5 X.X = ± 0.5 X.XX = ± 0.05 - WELDED TOLERANCES X = ± 5 X.X = ± 3 X.XX = ± 1.50

TITLE 1: ASSEMBLY, HEAT EXCHANGER, QSC8.3
TITLE 2: FIREPUMP

DWG UNITS: IN/LB/S	DRAWN BY: DAVE N		DATE: 12MAY2004
	APPD BY:		DATE:
EST WEIGHT: 42238.628	SCALE: 0.200	DO NOT SCALE	SHEET 1OF1	DRAWING NO: 8944	REV: C

BILL OF MATERIAL

ITEM	QTY	DESCRIPTION	PART NUMBER
1	2	CLAMP, HEAT EXCHANGER, 6" DIA, CMAP #CP090496-2	8965
2	1	CAC CONNECTION, CHARGE AIR, C8.3, FIREPUMP	8970
3	1	CAC - SHELL & TUBE	8966
4	1	GASKET, CAC CONNECTION, CUMMINS NO. 3917892, FIREPUMP	9504
5	2	COUPLING, RUBBER, 3-1/2", CUMMINS 3071050	1C9159



A	REV PER HEAT EXCHANGER	DAVE N	04SEP04
REV	**DESCRIPTION OF REVISION**	**REV BY**	**DATE**

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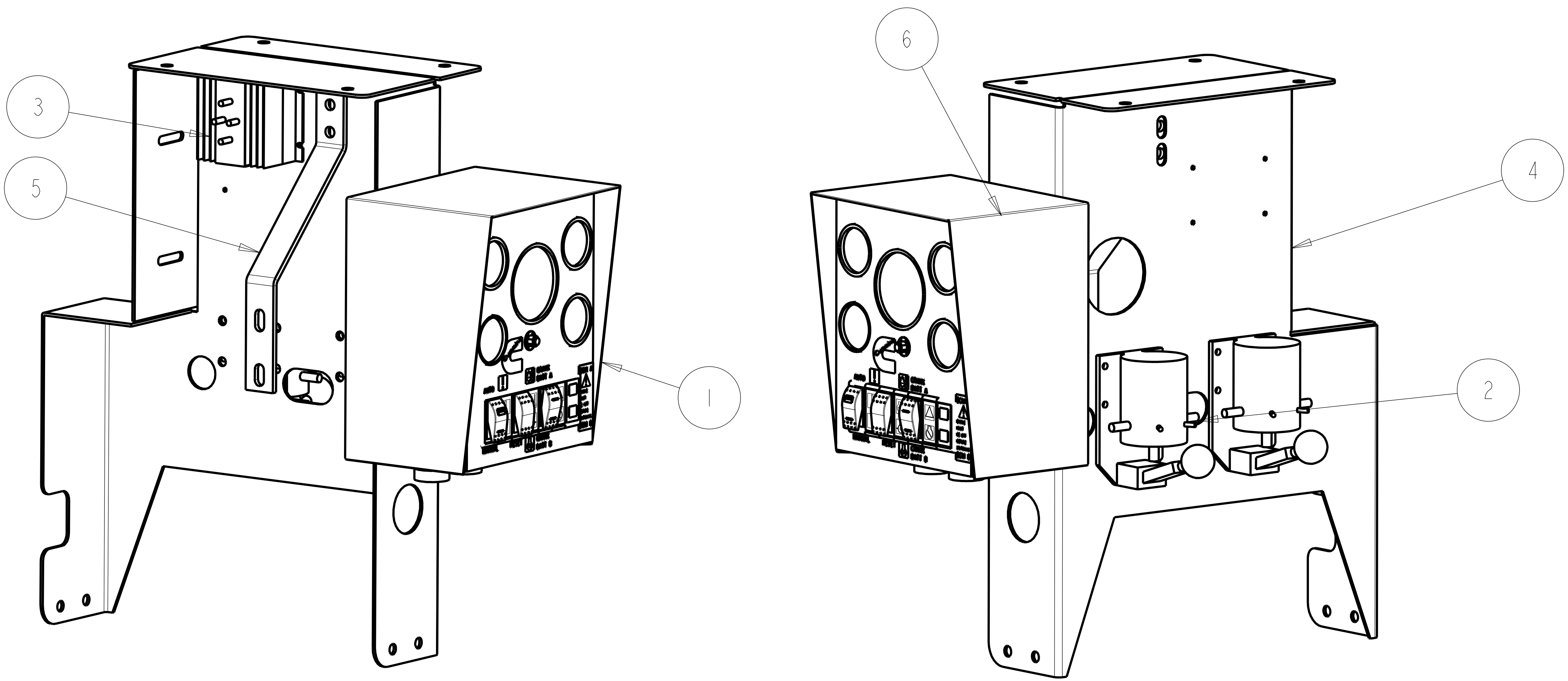
IMPERIAL UNITS	METRIC UNITS
MACHINE TOLERANCES .X = ± 0.06 .XX = ± 0.010 .XXX = ± 0.001 - WELD TOLERANCES .X = ± 0.25 .XX = ± 0.12 .XXX = ± 0.06	MACHINE TOLERANCES X = ± 1.5 X.X = ± 0.5 X.XX = ± 0.05 - WELDED TOLERANCES X = ± 5 X.X = ± 3 X.XX = ± 1.50

TITLE 1: ASSEMBLY, CHARGE AIR, C8.3
TITLE 2: FIREPUMP

DWG UNITS: IN/LB/S	DRAWN BY: DAVE N		DATE: 18JUN2004	
	APPD BY:		DATE:	
EST WEIGHT: 42238.628	SCALE: 0.250	DO NOT SCALE	SHEET 1OF1	DRAWING NO: 8967	REV: A

BILL OF MATERIAL

ITEM	QTY	DESCRIPTION	PART NUMBER
1	1	ASSEMBLY, INSTRUMENT PANEL, 12 VOLT ELECTRONIC ENGINES	8583
2	2	CONTACTOR, MANUAL OVERIDE, FIREPUMP	8824
3	1	BATTERY ISOLATOR, FIREPUMP	8838
4	1	BRACKET, MOUNTING, OPERATORS STATION, C8.3, FIREPUMP	9500
5	1	BRACKET, STIFFENER, OPERATOR STATION, FIREPUMP	9501
6	4	ISOLATOR, VIBRATION MOUNT, , McMASTER #9307K42	9503



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IMPERIAL UNITS	METRIC UNITS
MACHINE TOLERANCES .X = ± 0.06 .XX = ± 0.010 .XXX = ± 0.001 - WELD TOLERANCES .X = ± 0.25 .XX = ± 0.12 .XXX = ± 0.06	MACHINE TOLERANCES X = ± 1.5 X.X = ± 0.5 X.XX = ± 0.05 - WELDED TOLERANCES X = ± 5 X.X = ± 3 X.XX = ± 1.50

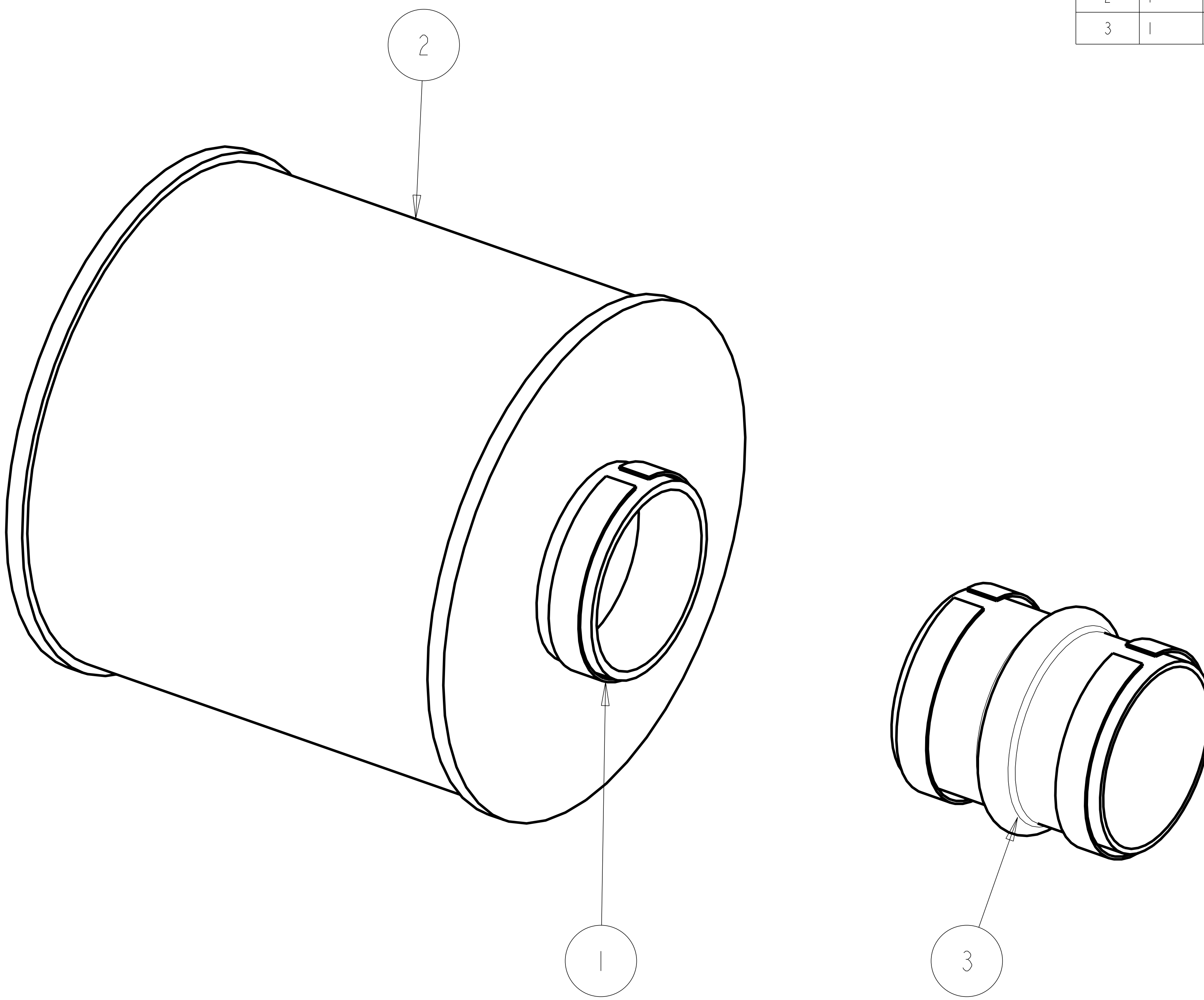
TITLE 1: ASSEMBLY, OPERATORS STATION, QSCC8.3
TITLE 2: FIREPUMP

DWG UNITS: IN/LB/S	DRAWN BY: DAVE N			DATE: 07JUL2004	
	APPD BY:			DATE:	
EST WEIGHT: 42238.628	SCALE: 0.200	DO NOT SCALE	SHEET 1OF1	DRAWING NO: 9502	REV: B

REV	DESCRIPTION OF REVISION	REV BY	DATE
A/B	REV PER MOUNTING BRACKET	DAVE N	07SEP04

BILL OF MATERIAL

ITEM	QTY	DESCRIPTION	PART NUMBER
1	3	CLAMP, 4" NOMINAL	8815
2	1	AIR CLEANER, 4" HIGH FLOW, DONALDSON P/N B105006	9525
3	1	COUPLING, RUBBER, 4", NELSON #89835K	89835K



REV	DESCRIPTION OF REVISION	REV BY	DATE
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ANGULAR DIMENSIONS ± 1°

IMPERIAL UNITS	METRIC UNITS
MACHINE TOLERANCES .X = ± 0.06 .XX = ± 0.010 .XXX = ± 0.001 - WELD TOLERANCES .X = ± 0.25 .XX = ± 0.12 .XXX = ± 0.06	MACHINE TOLERANCES X = ± 1.5 X.X = ± 0.5 X.XX = ± 0.05 - WELDED TOLERANCES X = ± 5 X.X = ± 3 X.XX = ± 1.50

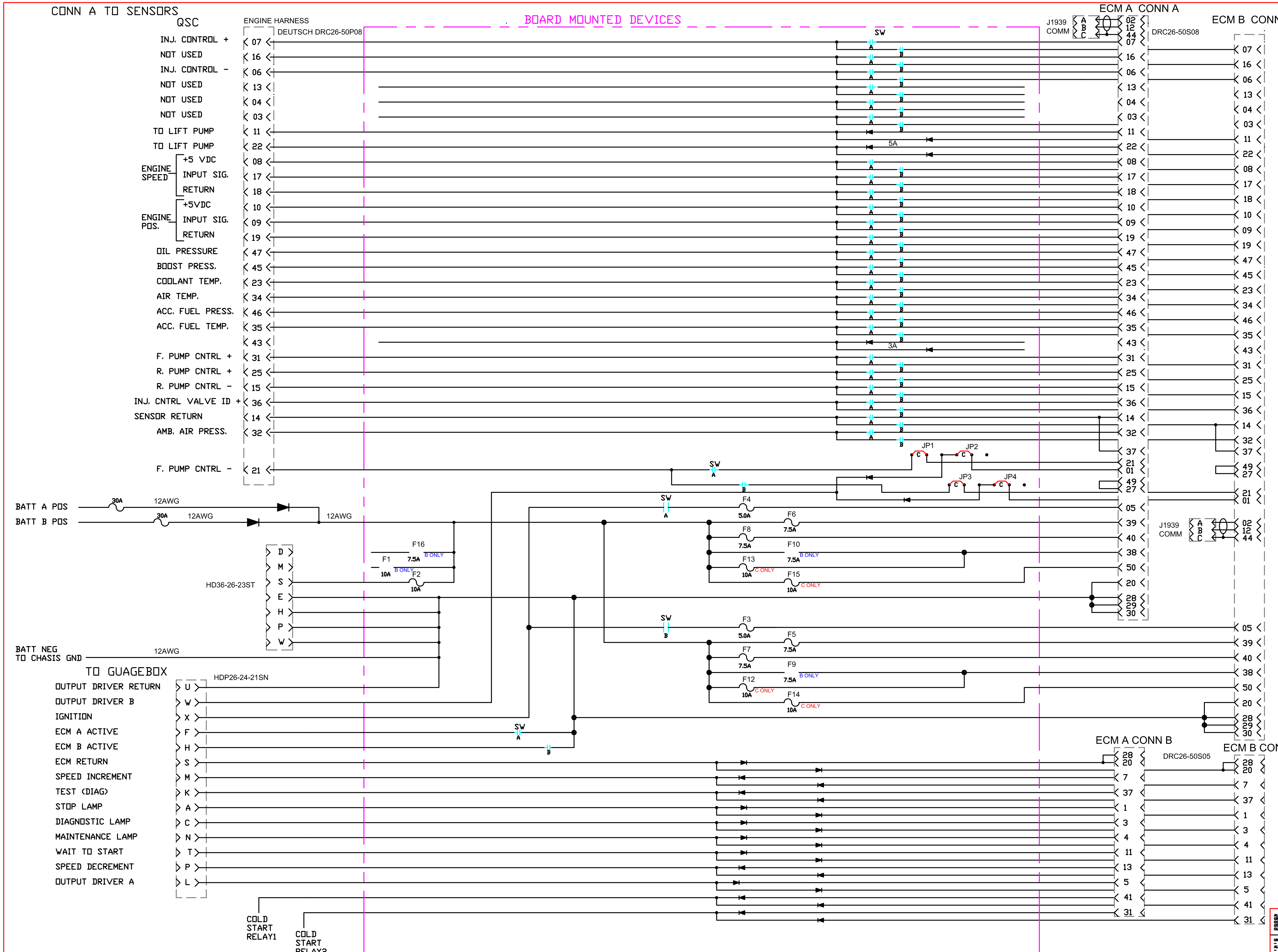
TITLE 1: ASSEMBLY, AIR CLEANER, QSC8.3
TITLE 2: FIRE PUMP

DWG UNITS: IN/LB/S	DRAWN BY: DAVE N	DATE: 07JUL2004
	APPD BY:	DATE:

EST WEIGHT:	SCALE:	DO NOT	SHEET	DRAWING NO:	REV:
12.033	0.375	SCALE	1OF1	9531	A

QSC

REDUNDANT ECM SYSTEM



LEGEND

- SW = SWITCH
- JP = JUMPER
- = JUMPER FOR QSB ENGINES
- = JUMPER FOR QSC ENGINES
- R1 = RESISTOR
- = 12V SYSTEM JUMPER
- = 24V SYSTEM JUMPER

NOTES:
USE 18AWG WITH THE FOLLOING EXCEPTIONS
CONN 2 ,12 & 44 ON CONN A USE SHIELDED CABLE
20AWG MIN, TWISTED PAIR
BATTERY CONNECTIONS USE 12AWG

REV	DESCRIPTION OF REVISION	BY	DATE
B	REVISED FOR DIFFERENT CONNECTOR	SAH	10/13/04
A	REVISED PER PROTOTYPE TEST	SAH	9/22/04

UNLESS OTHERWISE NOTED
ALL DIMENSIONS ARE IN INCHES
APPLY MACHINE TOLERANCES
.X = ± 0.06
.XX = ± 0.010
.XXX = ± 0.001
APPLY WELDED TOLERANCES
.X = ± 0.25
.XX = ± 0.12
.XXX = ± 0.06

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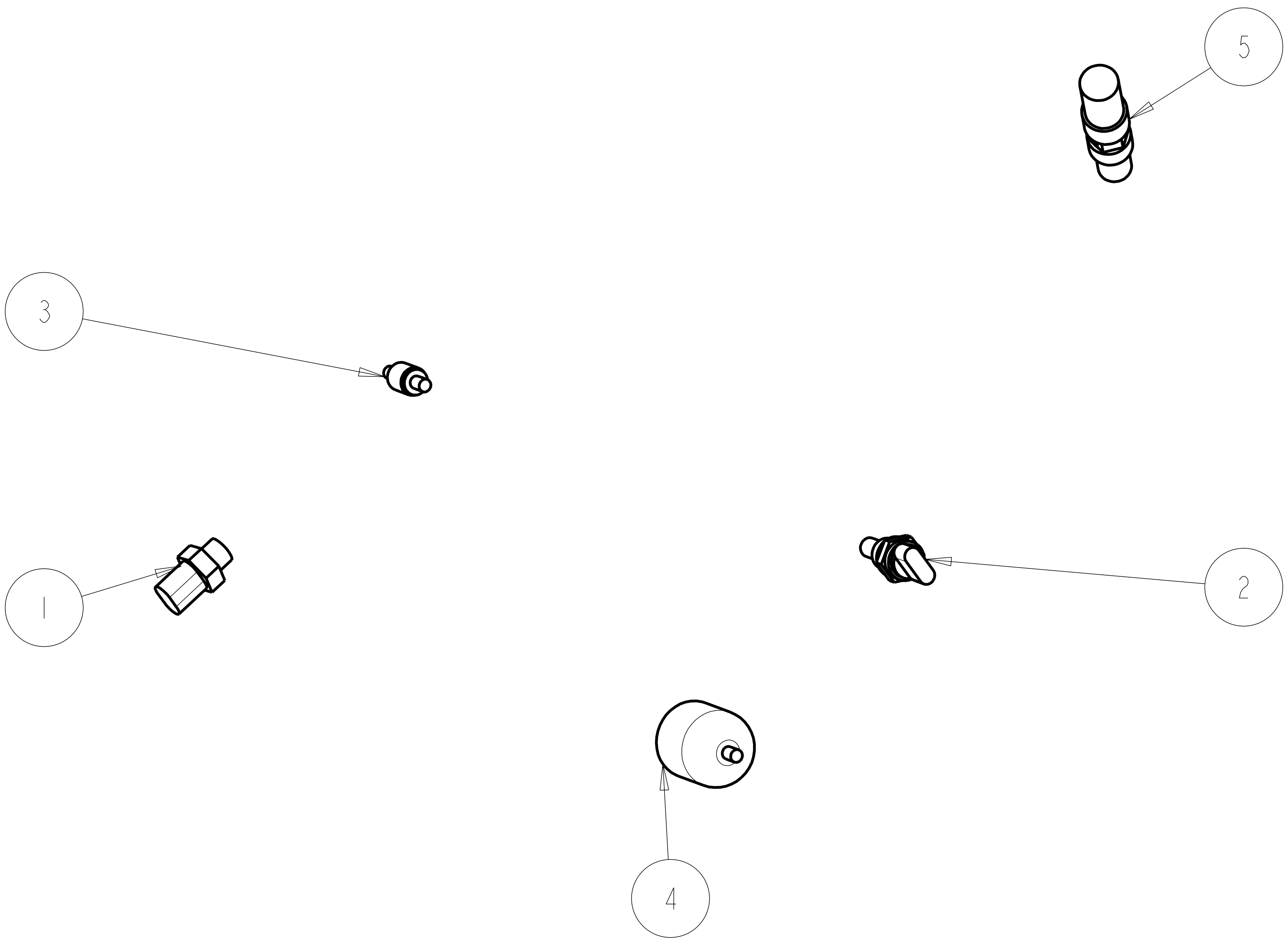
DWG SCALE:	DRAWN BY: SAH	DATE: 2SEP2004
PLOT SCALE:	APPD BY:	DATE:
DESCRIPTION: SCHEMATIC, REDUNDANT ECM JUNCTION BOARD		
REFERENCE: FIRE PUMPS, QSC		DRAWING NUMBER: 9548

BILL OF MATERIAL

ITEM	QTY	DESCRIPTION	PART NUMBER
1	1	SWITCH, WATER TEMP, 200F SETTING, RS#85879-A3	8860
2	1	SWITCH, OIL PRESSURE, 16 PSI, RS#85858-A3	8861
3	1	SENDER, WATER TEMPERATURE, DATCON #02022-00	8862
4	1	SENDER, OIL TEMPERATURE, DATCON #02504-00	8863
5	1	SENSOR, MAG PICK UP	9569



REV	DESCRIPTION OF REVISION	REV BY	DATE
A	UPDATED PER ASSEMBLY	DAVE N	26AUG04

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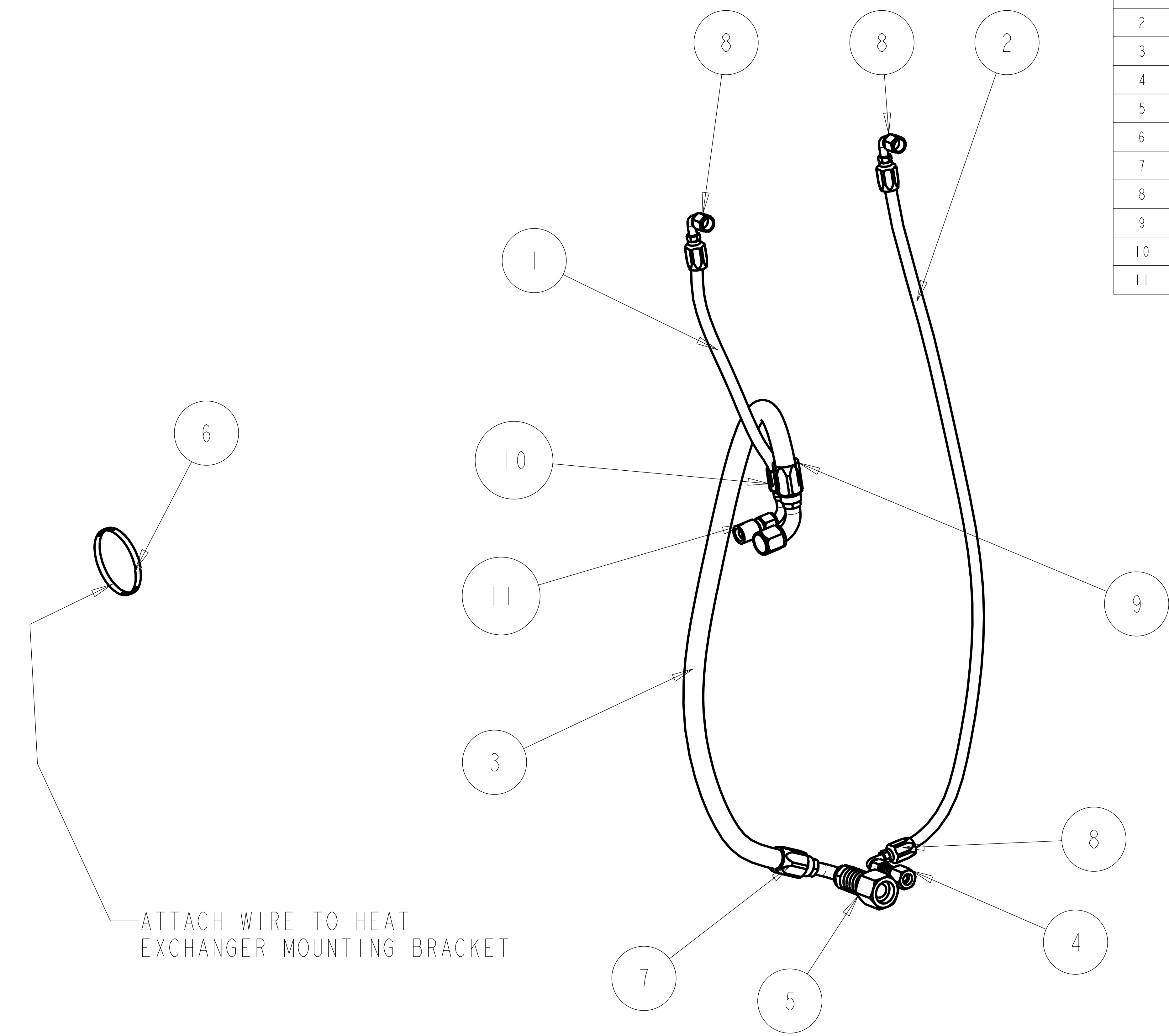
IMPERIAL UNITS	METRIC UNITS
MACHINE TOLERANCES .X = ± 0.06 .XX = ± 0.010 .XXX = ± 0.001 - WELD TOLERANCES .X = ± 0.25 .XX = ± 0.12 .XXX = ± 0.06	MACHINE TOLERANCES X = ± 1.5 X.X = ± 0.5 X.XX = ± 0.05 - WELDED TOLERANCES X = ± 5 X.X = ± 3 X.XX = ± 1.50

TITLE 1: ASSEMBLY, SENSOR PACKAGE, C8.3
TITLE 2: FIREPUMP

DWG UNITS: IN/LB/S	DRAWN BY: DAVE N	DATE: 21AUG2004
	APPD BY: -	DATE: -

EST WEIGHT:	SCALE:	DO NOT	SHEET	DRAWING NO:	REV:
42238.628	0.375	SCALE	1OF1	9574	A



BILL OF MATERIAL

ITEM	QTY	DESCRIPTION	PART NUMBER
1	1	FUEL LINE, RETURN, 261-6 X 16" LG	9590_RETUR2
2	1	FUEL LINE, RETURN, #261-6 X 34" LG	9590_RETURN
3	1	FUEL LINE, SUPPLY, #261-10 X 28" LG	9590_SUPPLY
4	1	BULKHEAD, #6 X 1/4" NPT	6_WGTX-S
5	1	BULKHEAD, #10 SAE 37 DEG FLARE	10_WGTX-S
6	1	WIRE, FUEL SOLENOID OVERIDE, .045 STEEL, COIL OF 36ÿÿÿÿÿA,	- 9589
7	1	#10 FEMALE JIC 37 DEG. SWIVEL 90 DEG. ELBOW	23920-10-10
8	4	ELBOW, HOSE, FEMALE JIC 37 DEG. SWIVEL 90 DEG. ELBOW	23920-6-6
9	1	FEMALE_SAE_45_DEG_SWIVEL_90_DEG_ELBOW, #27920-10-10	27920-10-10
10	1	FEMALE_SAE_45_DEG_SWIVEL_90_DEG_ELBOW, #27920-6-6	27920-6-6
11	1	ADAPTER, #8 x #6 45 DEG FLARE, #46F-8-6, FILL_ME_IN	46F-8-6

REV	DESCRIPTION OF REVISION	REV BY	DATE
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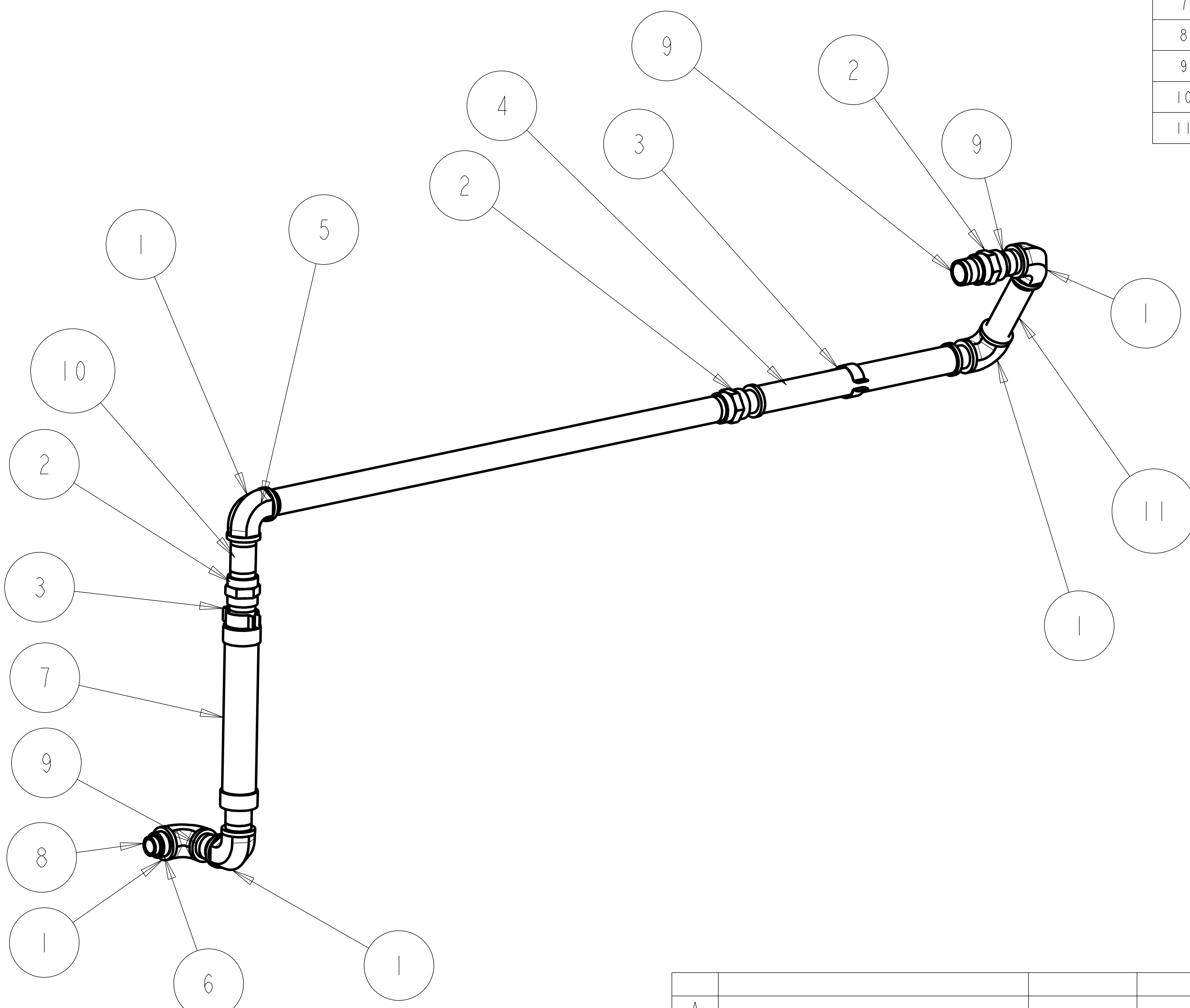
IMPERIAL UNITS	METRIC UNITS
MACHINE TOLERANCES .X = ± 0.06 .XX = ± 0.010 .XXX = ± 0.001 - WELD TOLERANCES .X = ± 0.25 .XX = ± 0.12 .XXX = ± 0.06	MACHINE TOLERANCES X = ± 1.5 X.X = ± 0.5 X.XX = ± 0.05 - WELDED TOLERANCES X = ± 5 X.X = ± 3 X.XX = ± 1.50

TITLE 1: ASSEMBLY, FUEL SYSTEM PLUMBING, QSC8.3
TITLE 2: FIREPUMP

DWG UNITS: IN/LB/S	DRAWN BY: DAVE N			DATE: 08SEP2004	
	APPD BY: -			DATE: -	
EST WEIGHT: 42238.628	SCALE: 0.200	DO NOT SCALE	SHEET 1OF1	DRAWING NO: 9590	REV:



BILL OF MATERIAL

ITEM	QTY	DESCRIPTION	PART NUMBER
1	5	ELBOW, BLK, 1" NPT	100_DD-S
2	3	UNION, 1" NPT, BLK	100_GG-S
3	2	CLAMP, PIPE, 1-1/4"	9536
4	1	FUEL COOLER, 1" NPT	9586
5	1	PIPE, BLK, 1 x 32-5/8	9591-PIPE
6	1	BUSHING, 1" NPT X 3/4" NPT	BUSH_075_100
7	1	FLAX, 1-1/4x13	MM-1-12
8	1	NIPPLE, BLK, 3/4x2	NPL_75_200
9	3	NIPPLE, BLK, 1 x 2-1/2"	NPL_100_250
10	1	NIPPLE, BLK, 1 x 3-1/2"	NPL_100_350
11	1	NIPPLE, BLK, 1 x 6	NPL_100_600

REV	DESCRIPTION OF REVISION	REV BY	DATE
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TITLE 1: ASSEMBLY, PIPING, CAC HEAT EXCHANGER, QSC8.3
TITLE 2: FIREPUMP

IMPERIAL UNITS	METRIC UNITS
MACHINE TOLERANCES .X = ± 0.06 .XX = ± 0.010 .XXX = ± 0.001 - WELD TOLERANCES .X = ± 0.25 .XX = ± 0.12 .XXX = ± 0.06	MACHINE TOLERANCES X = ± 1.5 X.X = ± 0.5 X.XX = ± 0.05 - WELDED TOLERANCES X = ± 5 X.X = ± 3 X.XX = ± 1.50

DWG UNITS: IN/LB/S

DRAWN BY: DAVE N | DATE: 08SEP2004

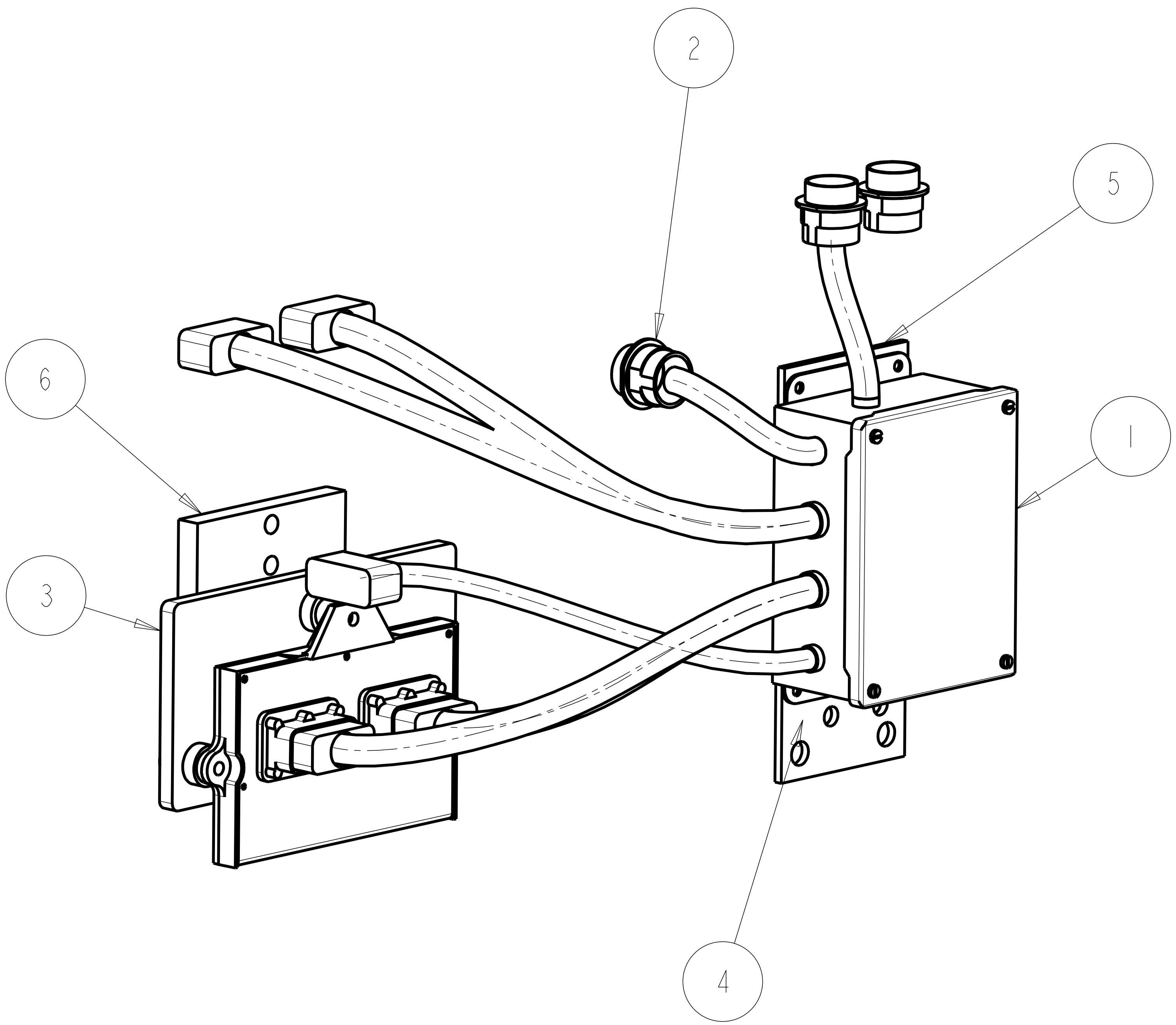
APPD BY: | DATE:

EST WEIGHT: 42238.628

SCALE: 0.150 | DO NOT SCALE | SHEET 1OF1 | DRAWING NO: 9591 | REV:

BILL OF MATERIAL

ITEM	QTY	DESCRIPTION	PART NUMBER
1	1	JUNCTION BOX, ECM SWITCH, FIREPUMP	9547
2	1	HARNESS, SECONDARY ECM, QSB5.9, FIREPUMP	9548
3	1	ASSEMBLY, SECONDARY ECM, FIREPUMP	9784
4	2	SPACER, MOUNTING, SECONDARY ECM	9508
5	1	BRACKET, MOUNTING, ECM SWITCH BOX, FIREPUMP	9579
6	1	PLATE, MOUNTING, SECONDARY ECM, FIREPUMP	9785



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TITLE 1: ASSEMBLY, SECONDARY ECM, QSC8.3
TITLE 2: FIREPUMP

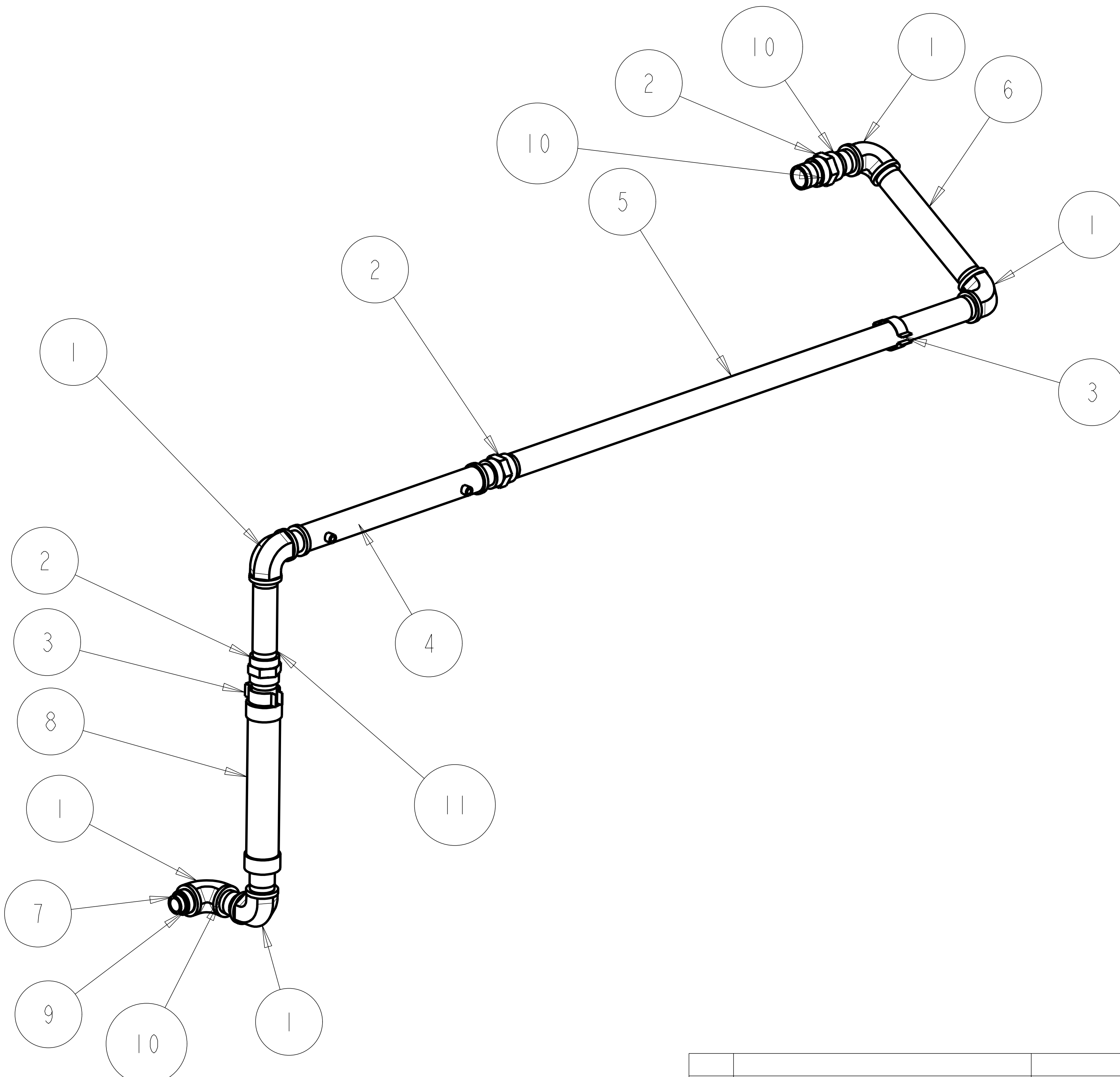
IMPERIAL UNITS	METRIC UNITS
MACHINE TOLERANCES .X = ± 0.06 .XX = ± 0.010 .XXX = ± 0.001 - WELD TOLERANCES .X = ± 0.25 .XX = ± 0.12 .XXX = ± 0.06	MACHINE TOLERANCES X = ± 1.5 X.X = ± 0.5 X.XX = ± 0.05 - WELDED TOLERANCES X = ± 5 X.X = ± 3 X.XX = ± 1.50

REV	DESCRIPTION OF REVISION	REV BY	DATE
C	REV PER ECM & MTG	DAVE N	21DEC04
B	REDRAWN	DAVE N	21OCT04
A	CORRECTED TITLE BLOCK	DAVE N	16SEP04

DWG UNITS: IN/LB/S	DRAWN BY: DAVE N			DATE: 01SEP2004	
	APPD BY: -			DATE: -	
EST WEIGHT: 42238.628	SCALE: 0.250	DO NOT SCALE	SHEET 1OF1	DRAWING NO: 9593	REV: C

BILL OF MATERIAL

ITEM	QTY	DESCRIPTION	PART NUMBER
1	5	ELBOW, BLK, 1" NPT	100_DD-S
2	3	UNION, 1" NPT, BLK	100_GG-S
3	2	CLAMP, PIPE, 1-1/4"	9536
4	1	FUEL COOLER, 1" NPT	9586
5	1	PIPE, BLK, 1 x 36-3/4	9595-PIPE
6	1	PIPE, BLK, 1 x 9-1/2	9595-PIPE2
7	1	NIPPLE, BLK, 1 x Close	BUSH_075_100
8	1	FLAX, 1-1/4x13	MM-1-12
9	1	NIPPLE, BLK, 3/4x2	NPL_75_200
10	3	NIPPLE, BLK, 1 X 2-1/2	NPL_100_250
11	1	NIPPLE, BLK, 1 x 6	NPL_100_600



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UNLESS OTHERWISE SPECIFIED
ALL DIMENSION TOLERANCES ARE

ANGULAR DIMENSIONS ± 1°

TITLE 1: ASSEMBLY, PIPING, CAC HEAT EXCHANGER, QSC8.3
TITLE 2: FIREPUMP

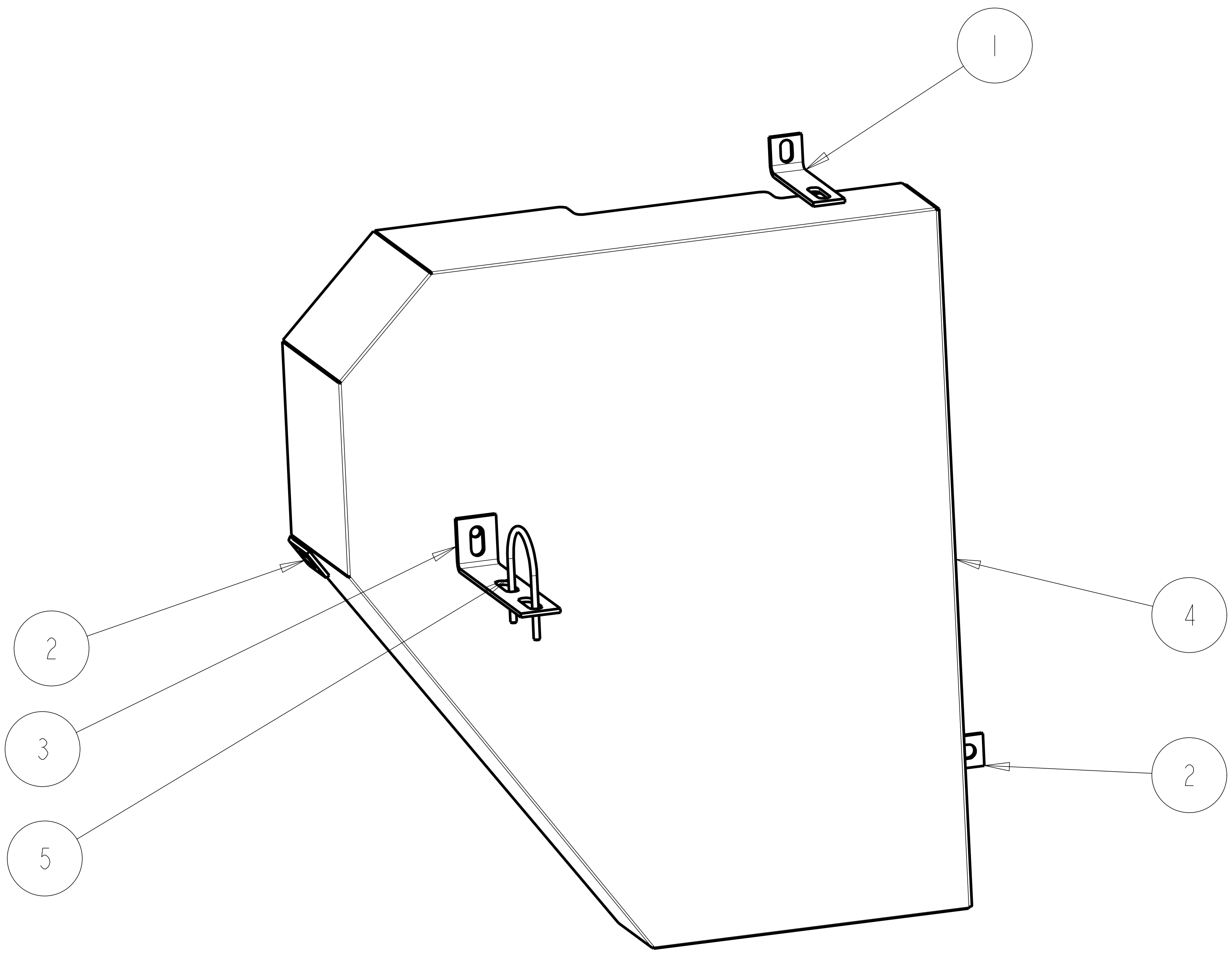
IMPERIAL UNITS	METRIC UNITS
MACHINE TOLERANCES .X = ± 0.06 .XX = ± 0.010 .XXX = ± 0.001 - WELD TOLERANCES .X = ± 0.25 .XX = ± 0.12 .XXX = ± 0.06	MACHINE TOLERANCES X = ± 1.5 X.X = ± 0.5 X.XX = ± 0.05 - WELDED TOLERANCES X = ± 5 X.X = ± 3 X.XX = ± 1.50

DWG UNITS: IN/LB/S	DRAWN BY: DAVE N			DATE: 08SEP2004	
	APPD BY:			DATE:	
EST WEIGHT: 42238.628	SCALE: 0.150	DO NOT SCALE	SHEET 1OF1	DRAWING NO: 9595	REV: A

REV	DESCRIPTION OF REVISION	REV BY	DATE
A	REV PER HEAT EXCHANGER	DAVE N	10SEP04

BILL OF MATERIAL

ITEM	QTY	DESCRIPTION	PART NUMBER
1	1	BRACKET, MOUNTING, GUARD, FIREPUMP	8592
2	2	BRACKET, MOUNTING, GUARD, FIREPUMP	8593
3	1	BRACKET, MOUNTING, TUBE SUPPORT, FIREPUMP	8657
4	1	GUARD, PULLEY, QSC, FIREPUMP	9628
5	1	U-BOLT, 2"	U200



REV	DESCRIPTION OF REVISION	REV BY	DATE
B	REV AS BUILT	DAVE N	24FEB05
A	RELEASED	DAVE N	20JAN05

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NPOWER SYSTEMS
DESIGN CENTER
875 LAWRENCE DRIVE
DEPERE, WISCONSIN

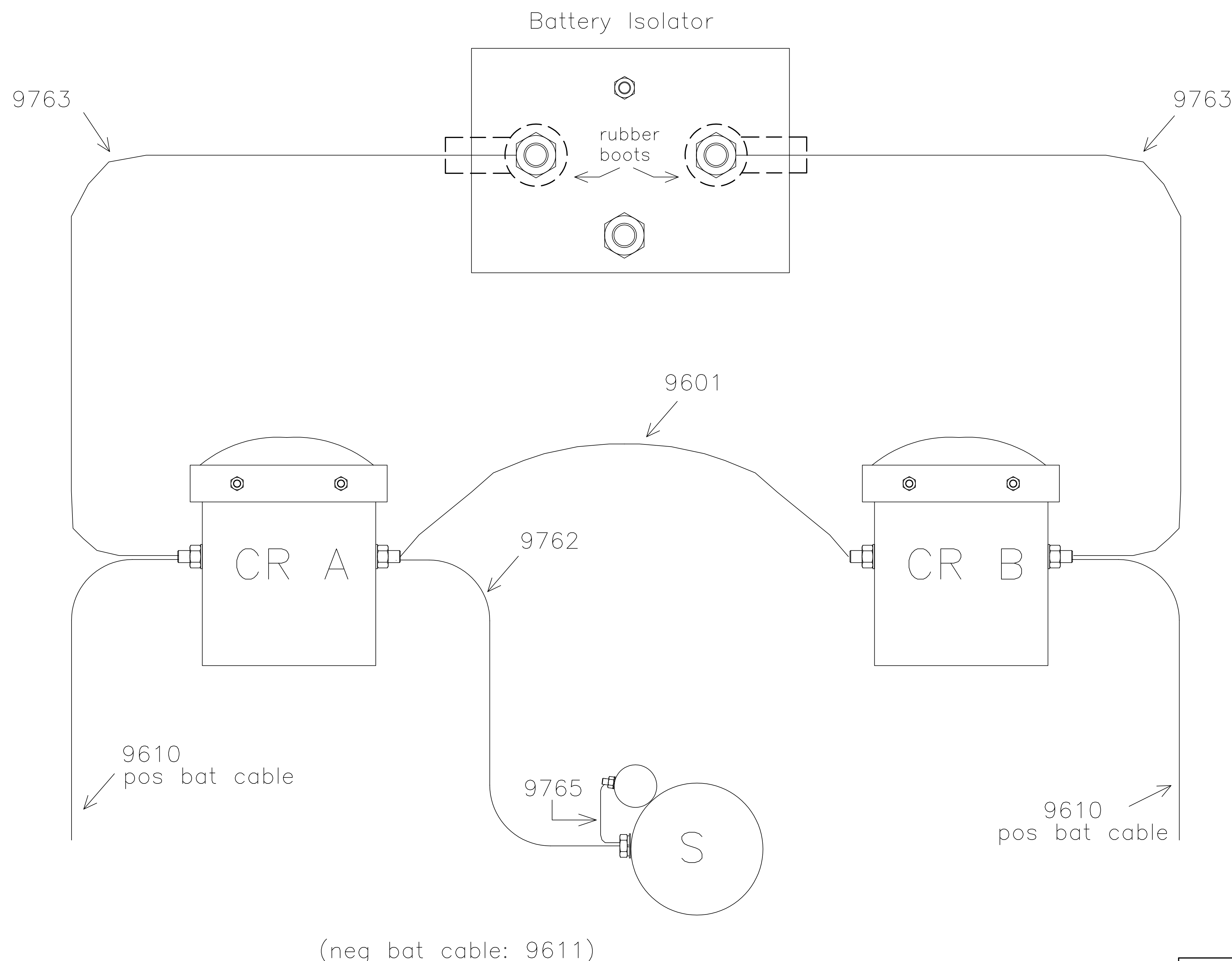
UNLESS OTHERWISE SPECIFIED
ALL DIMENSION TOLERANCES ARE

ANGULAR DIMENSIONS ± 1°

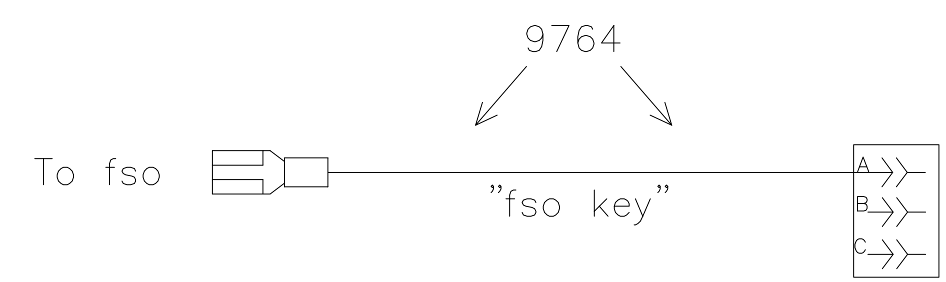
IMPERIAL UNITS	METRIC UNITS
MACHINE TOLERANCES .X = ± 0.06 .XX = ± 0.010 .XXX = ± 0.001 - WELD TOLERANCES .X = ± 0.25 .XX = ± 0.12 .XXX = ± 0.06	MACHINE TOLERANCES X = ± 1.5 X.X = ± 0.5 X.XX = ± 0.05 - WELDED TOLERANCES X = ± 5 X.X = ± 3 X.XX = ± 1.50

TITLE 1: ASSEMBLY, GUARD, PULLEY, QSC
TITLE 2: FIREPUMP

DWG UNITS: IN/LB/S	DRAWN BY: DAVE N		DATE: 20JAN2005	
	APPD BY:		DATE:	
EST WEIGHT: 12.262	SCALE: 0.250	DO NOT SCALE	SHEET 1OF1	DRAWING NO: 9627	REV: B



P/N	**DESCRIPTION**	**QTY**
9601	Cable, Battery Contactor Jumper	1
9762	Cable, Contactor to Starter	1
9763	Cable, Isolator to Battery	2
9764	Wire, FSO Connector	1
9765	Wire, Starter Solenoid Jumper	1
9609	Battery Cable Kit (optional)	1



REV	DESCRIPTION OF REVISION	BY	DATE
A	ADDED WIRING DIAGRAM	RJS	5 JAN 05

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UNLESS OTHERWISE NOTED
–
ALL DIMENSIONS ARE IN INCHES
–
APPLY MACHINE TOLERANCES
.X = ± 0.06
.XX = ± 0.010
.XXX = ± 0.001
–
APPLY WELDED TOLERANCES
.X = ± 0.25
.XX = ± 0.12
.XXX = ± 0.06

DWG SCALE:	DRAWN BY: RJS	DATE: 6 DEC 2004
PLOT SCALE:	APPD BY:	DATE:

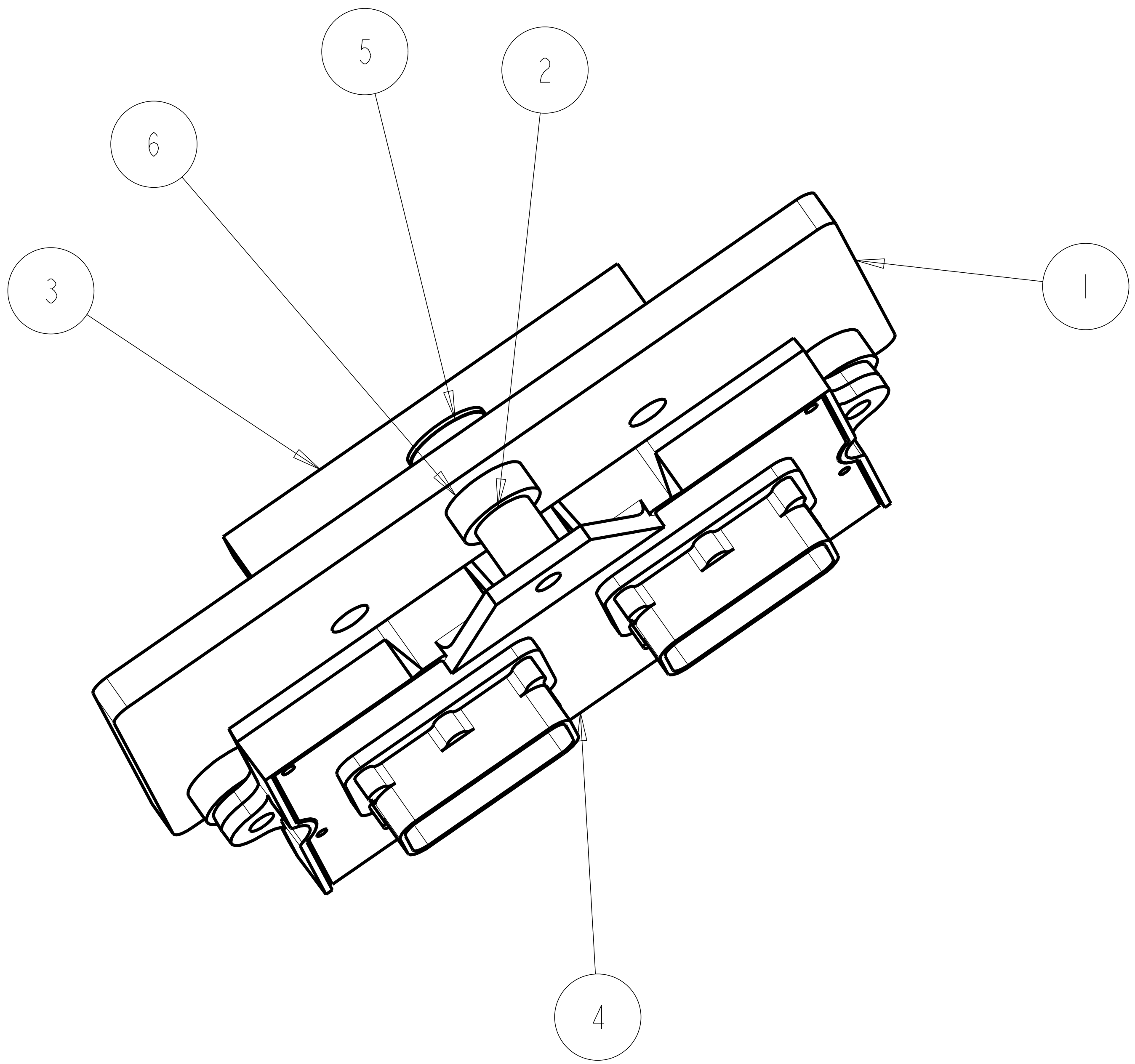
DESCRIPTION
KIT, LOOSE WIRES

REFERENCE:
4B, 6B, 6C, QSB, & QSC

DRAWING NUMBER:
9767_A

BILL OF MATERIAL

ITEM	QTY	DESCRIPTION	PART NUMBER
1	1	BRACKET, ECM, BACK-UP, FIREPUMP	9506
2	1	SPACER, SECONDARY ECM MOUNTING	9507
3	2	STANDOFF, SECONDARY ECM MOUINTING, FIREPUMP	9509
4	1	ECM, CECO # 3944105	3944125
5	3	ISOLATOR, VIBRATION, CUMMINS NO 3955219	3955219
6	3	ISOLTATOR, VIBRATION, CUMMINS NO. 3955220	3955220



REV	DESCRIPTION OF REVISION	REV BY	DATE
A	RELEASED	DAVE N	21DEC04

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UNLESS OTHERWISE SPECIFIED ALL DIMENSION TOLERANCES ARE

ANGULAR DIMENSIONS ± 1°

IMPERIAL UNITS	METRIC UNITS
MACHINE TOLERANCES .X = ± 0.06 .XX = ± 0.010 .XXX = ± 0.001 - WELD TOLERANCES .X = ± 0.25 .XX = ± 0.12 .XXX = ± 0.06	MACHINE TOLERANCES X = ± 1.5 X.X = ± 0.5 X.XX = ± 0.05 - WELDED TOLERANCES X = ± 5 X.X = ± 3 X.XX = ± 1.50

TITLE 1: ASSEMBLY, SECONDARY ECM
TITLE 2: FIREPUMP

DWG UNITS: IN/LB/S

DRAWN BY: DAVE N

DATE: 21JUN2004

APPD BY:

DATE:

EST WEIGHT: 42238.628

SCALE: 0.500

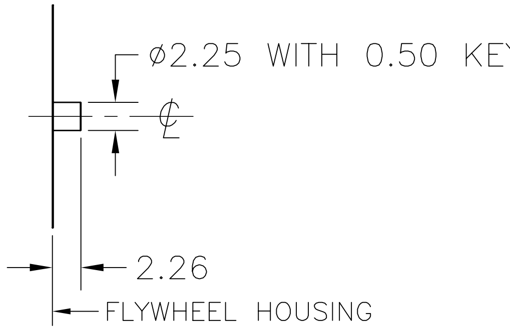
DO NOT SCALE

SHEET 1OF1

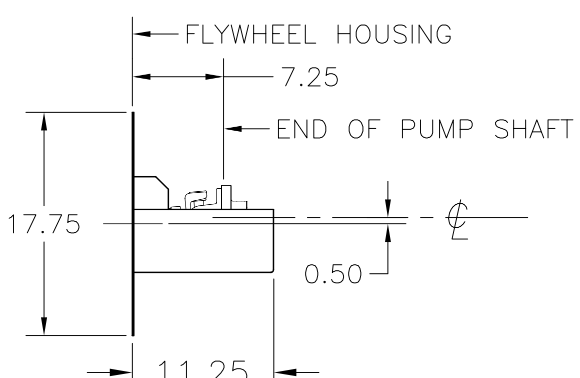
DRAWING NO: 9784

REV: A

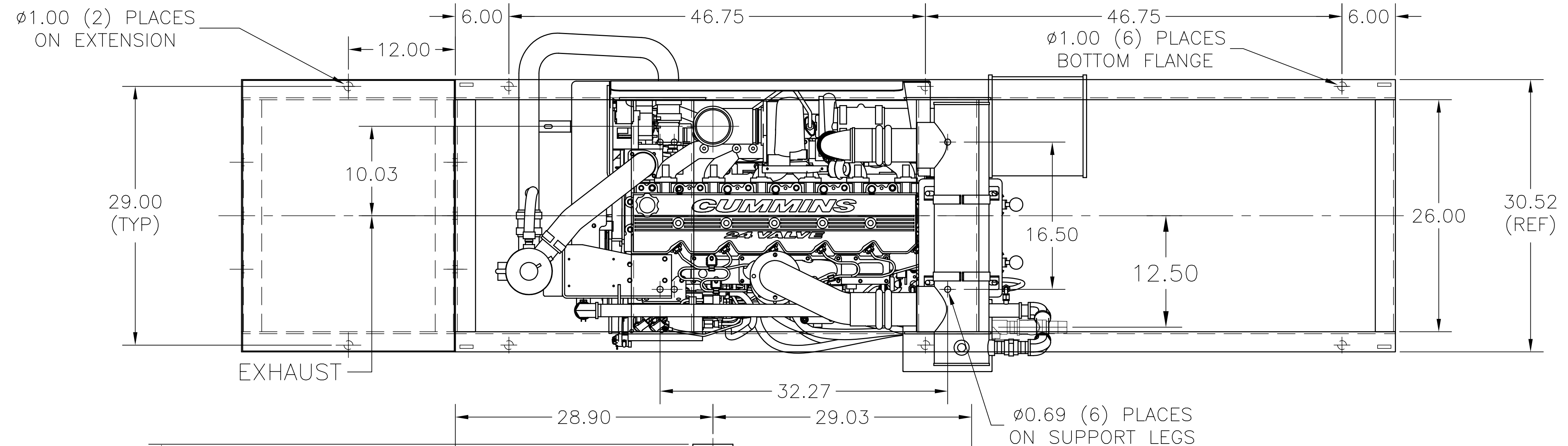
SAE #3	FLYWHEEL HOUSING
1/2" NPT	FUEL SUPPLY
3/8" NPT	FUEL RETURN
1" NPT	RAW WATER SUPPLY
1-1/4" NPT	RAW WATER RETURN
115v. PLUG	COOLANT HEATER
4" DIA.	EXHAUST CONNECTION

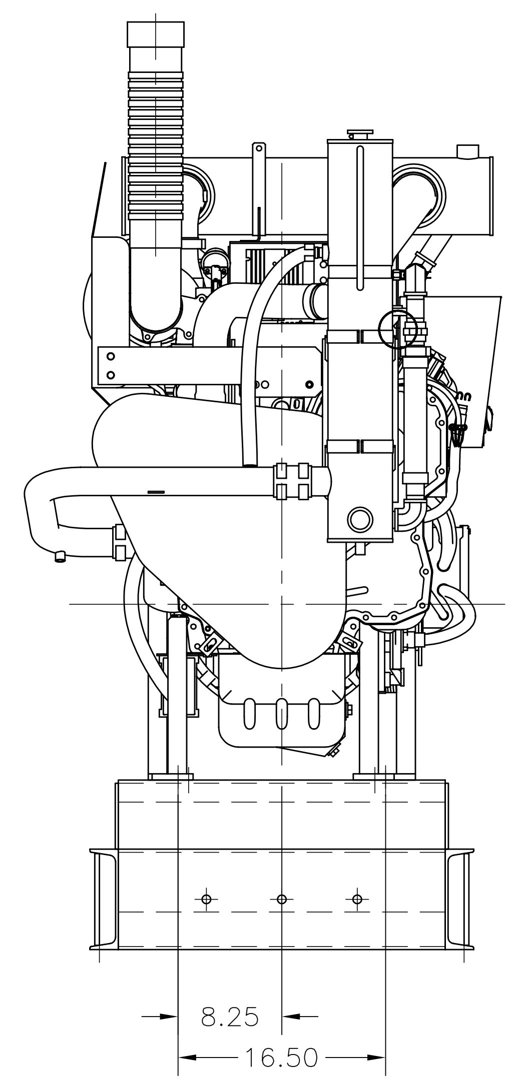


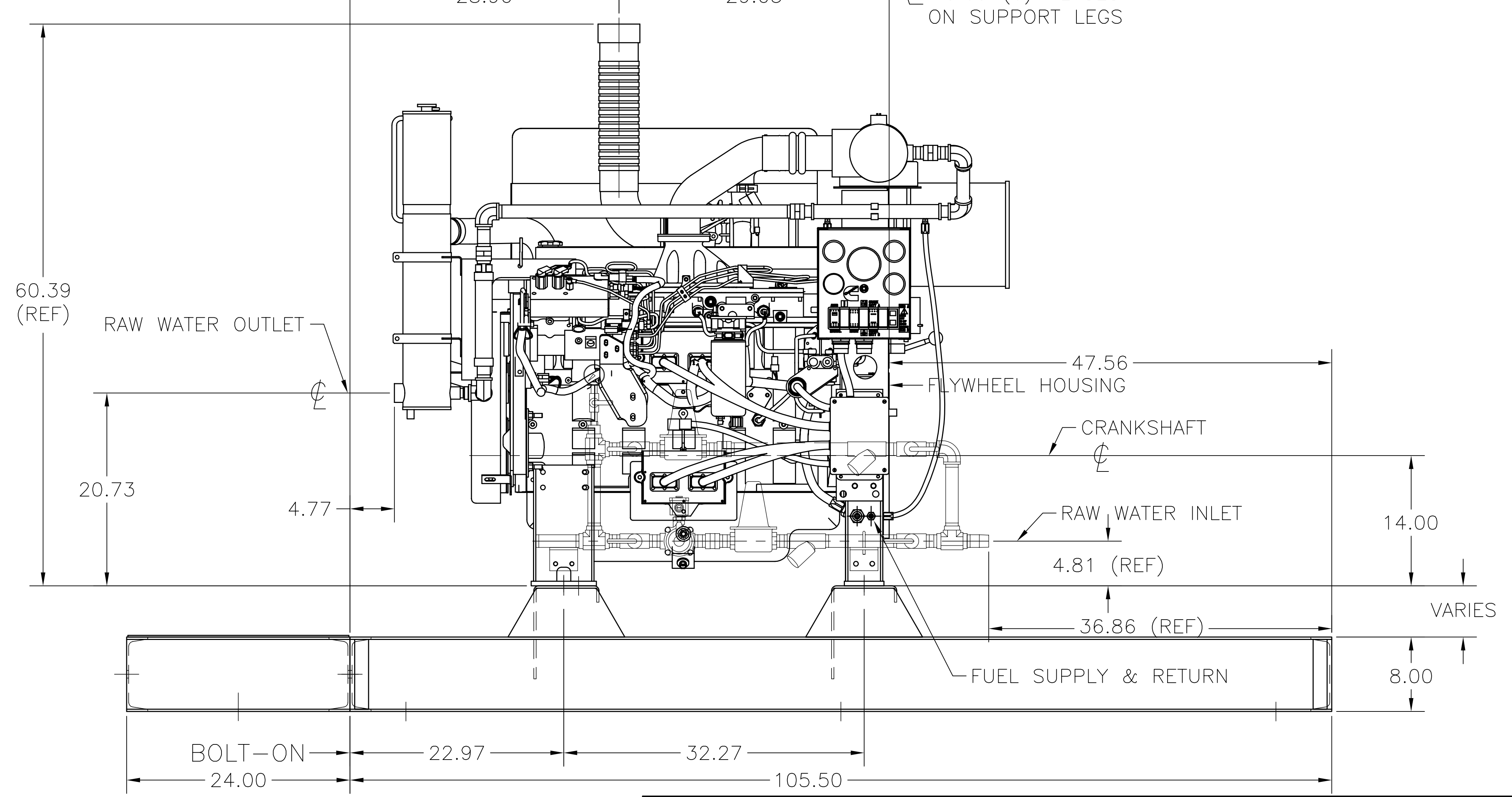
STUB SHAFT & GUARD



1480 DRIVE SHAFT & GUARD







NOTES
1) DETAILS REMOVED FOR CLARITY
2) OPTIONAL COMPONENTS SHOWN
3) SUBJECT TO CHANGE WITHOUT NOTICE
4) LEG EXTENSION LENGTH DETERMINED BY PUMP SIZE
5) SEE ASSEMBLY DRAWING AND DATA SHEET FOR ADDITIONAL INFORMATION
6) DRIVE SHAFT MUST NOT RUN AT 0° ANGLE

REV	DESCRIPTION OF REVISION	BY	DATE
B	UPDATED PER STD. BASE	RCM	22APR2005

Fire Power

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.XXX = ± 0.001
APPLY WELDED TOLERANCES
.X = ± 0.25
.XX = ± 0.12
.XXX = ± 0.06

DWG SCALE: 1/16	DRAWN BY: CNP	DATE: NOV2004
PLOT SCALE:	APPD BY:	DATE:

DESCRIPTION
GENERAL LAYOUT, FIREPUMP, CFP8E

REFERENCE:

DRAWING NUMBER:
CFP8E_GEN