- Natural gas accumulates near the ceiling. Check the ceiling of the work area for ignition sources before servicing equipment.
- **Only** disconnect gas lines in a well-ventilated area.
- Do **not** troubleshoot or repair gas leaks while the engine is running.
- Natural gas ignition systems produce high voltage during operation. Do **not** touch ignition wiring or components while the engine is operating. If necessary, use **only** insulated tools.
- Natural gas exhaust systems operate at higher temperatures than similar diesel exhaust systems. Do **not** touch exhaust components. Do **not** route lines or hoses which deteriorate from heat exposure near exhaust components or in the flow path of the exhaust.
- **Always** torque fittings and connections to the required specifications. over or under tightening can damage threads and create leaks.

Liquefied Natural Gas

- Protect eyes.
- Protect skin.
- **Always** be alert for the smell of gas. Liquefied natural gas may **not** have an odor. Non-refined sources of natural gas (landfill gas, biogas, coal bed gas, wellhead gas, etc.) can **not always** be detected by smell.
- **Always** test for fuel leaks as instructed. Odorant can fade.
- Upon entering a room or approaching a vehicle where the smell of gas is present, immediately shutoff all engines and ignition sources.
- Natural gas ignites when there is a 5% - 15% mixture in the air. Asphyxiation can occur when concentration reaches 21% or more.
- Do **not** start equipment or nearby equipment until a suspected gas leak is corrected and the area is ventilated.
- Avoid sparks, arcing switches and equipment, cigarettes, pilot lights, flames, and other sources of ignition.
- Work in areas that do **not** share common ventilation with areas containing ignition sources.
- Store and service natural gas fueled equipment in large, well-ventilated areas, or outside.
- Provide extra ventilation to the work area.
- Natural gas accumulates near the ceiling. Check the ceiling of the work area for ignition sources before servicing equipment.
- **Only** disconnect gas lines in a well-ventilated area.
- Do **not** troubleshoot or repair gas leaks while the engine is running.
- Natural gas ignition systems produce high voltage during operation. Do **not** touch ignition wiring or components while the engine is operating. If necessary, use **only** insulated tools.
- Natural gas exhaust systems operate at higher temperatures than similar diesel exhaust systems. Do **not** touch exhaust components. Do **not** route lines or hoses which deteriorate from heat exposure near exhaust components or in the flow path of the exhaust..
- Liquefied natural gas is stored in vehicle tanks at extremely cold temperatures. If there is a liquefied natural gas spill, evacuate the area immediately and do not attempt to make contact with the liquid.
- **Always** torque fittings and connections to the required specifications. over or under tightening can damage threads and create leaks.
- Vapors accumulate near the floor. Check the work floor, sumps, and low lying areas for ignition sources before servicing equipment.

Liquefied Petroleum Gas

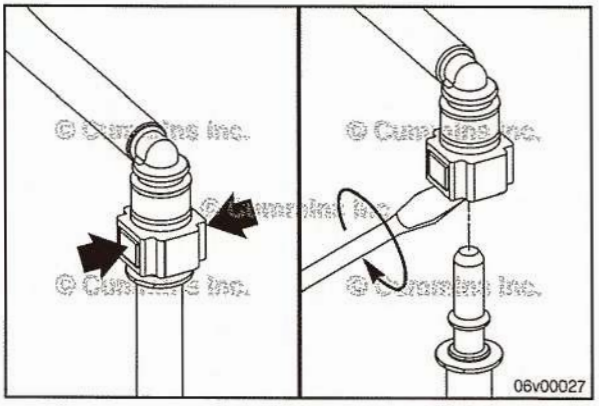
- Protect eyes.
- Protect skin.
- **Always** be alert for the smell of gas. Liquefied petroleum gas is typically treated with an odor producing chemical for leak detection.
- **Always** test for fuel leaks as instructed. Odorant can fade.
- Upon entering a room or approaching a vehicle where the smell of gas is present, immediately shutoff all engines and ignition sources.

Some fuel supply and drain line connections will utilize quick disconnect fittings.

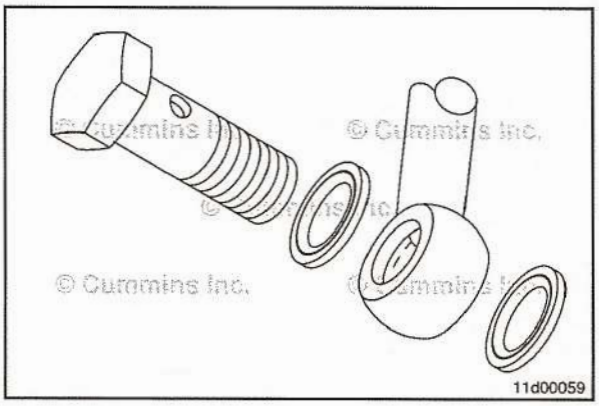
Remove the quick disconnect style fuel lines by pressing in the locking tangs on both sides of the quick disconnect fitting.

To aid removal, a screwdriver can 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.

Install the quick disconnect style fuel lines by pushing the quick disconnect fitting onto the male union until it clicks.



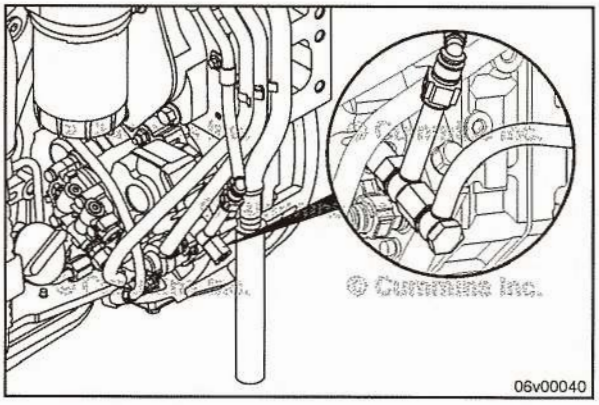
Some fuel supply and drain line connections will use traditional banjo style fittings.



Each of the fuel drain lines combine together at a common fuel drain connection, where the original equipment manufacturer (OEM) connects a fuel drain line to return the fuel to the fuel supply tank.

For rear gear train engines, the common fuel drain connection is at the high-pressure fuel pump port, as shown.

For front gear train engines, the common fuel drain connection is the filter bracket, **not** shown.



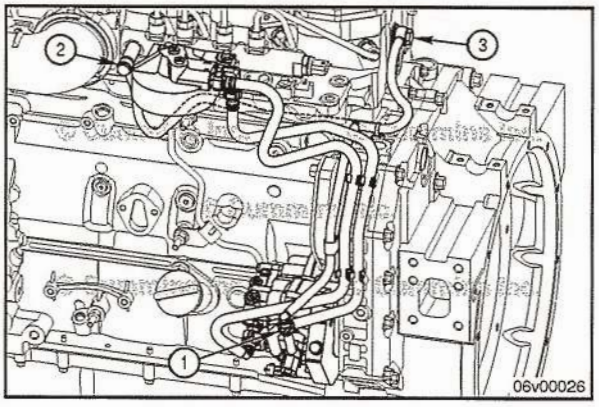
A common step in troubleshooting fuel system related issues is to measure the various fuel system drain flows:

1 High-pressure fuel pump drain flow

2 Fuel pressure relief valve drain flow

3 Injector drain flow

For rear gear train engines, additional quick disconnect fittings have been added to the fuel drain lines to aid in isolating the fuel system drain flows.



Engine Noise Excessive

This is symptom tree t047

When troubleshooting engine noise complaints, make sure the engine accessories (air compressor, fan clutch, refrigerant compressor, or hydraulic pump) are not the cause of the noise. Refer to Engine Noise Diagnostic Procedures - General Information at the end of Section TS before using this symptom tree.

Cause	Correction
STEP 1 Fan drive belt is loose	Check the belt tension and tighten, if necessary. Refer to Procedure 008-002 in Section 8.
OK Go To Next Step	
STEP 2 Fan is loose, damaged, or **not** balanced	Check the fan. Refer to equipment manufacturer service information.
OK Go To Next Step	
STEP 3 Fan clutch, hydraulic pump, or refrigerant compressor noise is excessive	Isolate each component and check for noise. Refer to Procedure 009-016 in Section 9 or see equipment manufacturer service information.
OK Go To Next Step	
STEP 4 Air intake or exhaust leaks	Inspect the air intake and exhaust systems for air leaks. Refer to Procedure 010-024 in Section 10.
OK Go To Next Step	
STEP 5 Air intake or exhaust piping is contacting the chassis or cab	Inspect the air piping, chassis, and cab for contact points. Refer to equipment manufacturer service information.
OK Go To Next Step	
STEP 6 Lubricating oil level is above or below specification	Check the oil level. Add or drain oil, if necessary. Refer to Procedure 007-037 in Section 7.
OK Go To Next Step	
STEP 7 Lubricating oil is thin or diluted	Check the viscosity of the oil sample. Refer to Procedure 007-083 in Section 7 if the lubricating oil is contaminated. If the lubricating oil is contaminated, see the Lubricating Oil Contaminated troubleshooting symptom tree in Section TS.
OK Go To Next Step	
STEP 8 Lubricating oil pressure is below specification	Check the oil pressure. Refer to Procedure 007-037 in Section 7. If the pressure is low, refer to the Lubricating Oil Pressure Low troubleshooting symptom tree in Section TS.
OK Go To Next Step	

STEP 6D: Check the engine driven accessories.

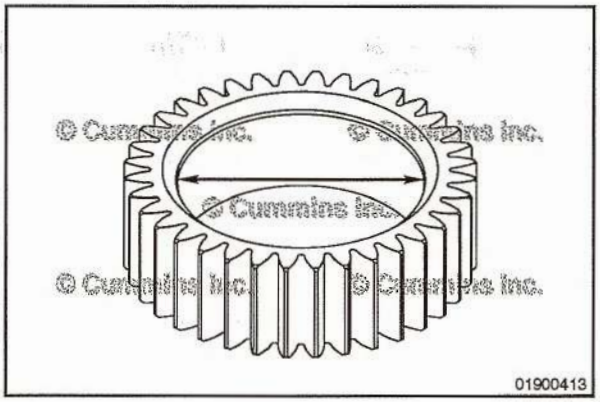
Condition:
- Turn keyswitch ON.
- Turn keyswitch OFF.

Action	Specification/Repair	Next Step
Check for engine driven accessory malfunctions. • Isolate or disconnect the accessories and check for vibration. • Do **not** operate the engine if the sea water pump is disconnected.	Engine driven accessory malfunctioning? **YES** **Repair:** Determine the cause of the malfunctioning accessories and correct the problem. See the Exhaust System section in the Marine Recreational Installation Directions, Bulletin 3884649, and the equipment manufacturer service information.	Repair complete.
	Engine driven accessory malfunctioning? **NO**	6E

STEP 6E: Check the shaft coupling to gear coupling alignment.

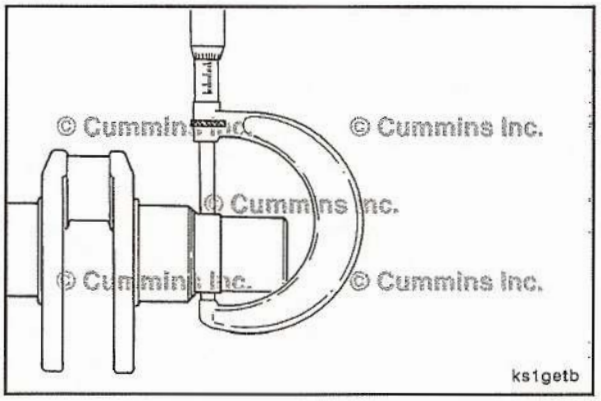
Condition:
- Turn keyswitch OFF.

Action	Specification/Repair	Next Step
Check the shaft coupling to gear coupling alignment. N/A	Shaft coupling to gear coupling misaligned? **YES** **Repair:** Repair or replace as needed. Reference Procedure 016-025 in Section 16 of the appropriate service manual and the Engine Mounting/Drive Systems section in the Marine Recreational Installation Directions, Bulletin 3884649, and gear manufacturer recommendations.	Repair complete.
	Shaft coupling to gear coupling misaligned? **NO**	6F



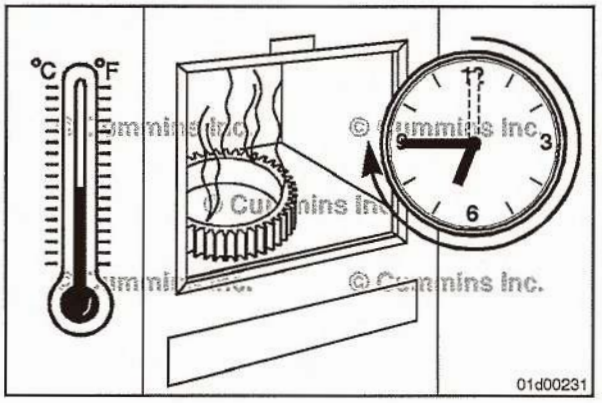
Measure the crankshaft gear bore inside diameter.

Crankshaft Gear Bore Inside Diameter		
mm		in
70.51	MIN	2.776
70.55	MAX	2.778



Measure the crankshaft gear journal outside diameter.

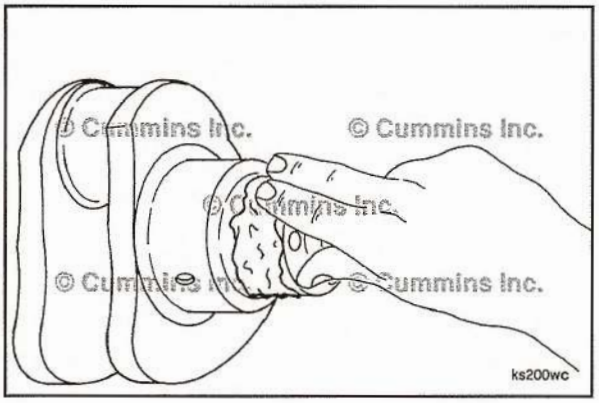
Crankshaft Gear Journal Outside Diameter		
mm		in
70.59	MIN	2.779
70.61	MAX	2.780



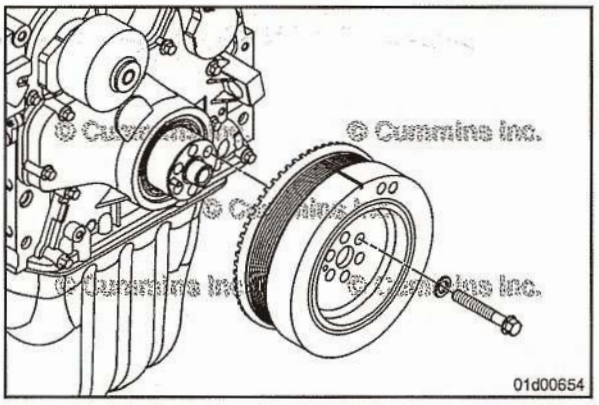
Install

△CAUTION△
Do not exceed the specified heating time or temperature. The crankshaft teeth can be damaged.

Heat the gear in an oven for a minimum of 45 minutes, but **not** more than 2 hours at 177°C [350°F].



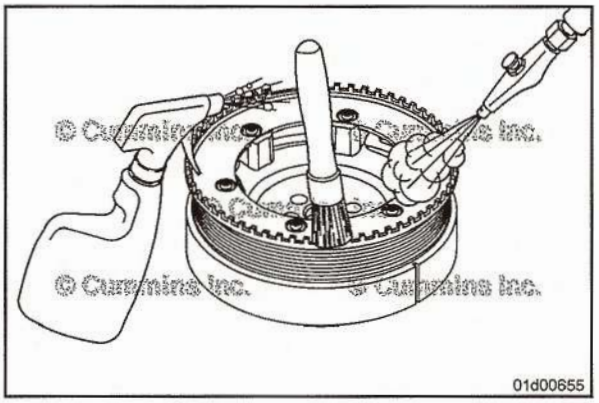
Use assembly lubricant, Part Number 3163087, or equivalent, to lubricate the outside diameter of the crankshaft gear journal.



Remove

NOTE: The crankshaft speed indicator ring is part of the vibration damper assembly and should **not** be removed from the vibration damper.

Remove the vibration damper/crankshaft speed indicator ring.

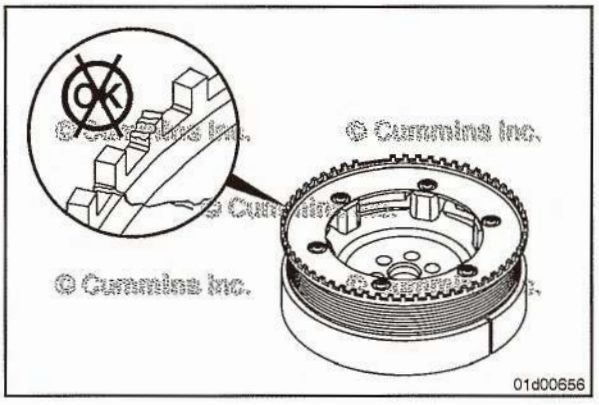


Clean and Inspect for Reuse

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

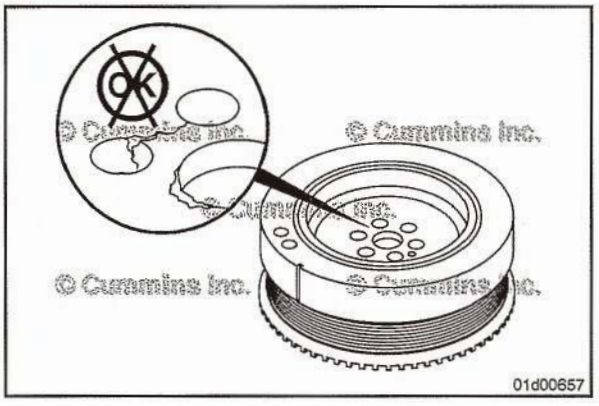
Use soapy water to clean any oil from the vibration damper/crankshaft speed indicator ring.

Dry the vibration damper/crankshaft speed indicator ring with compressed air.



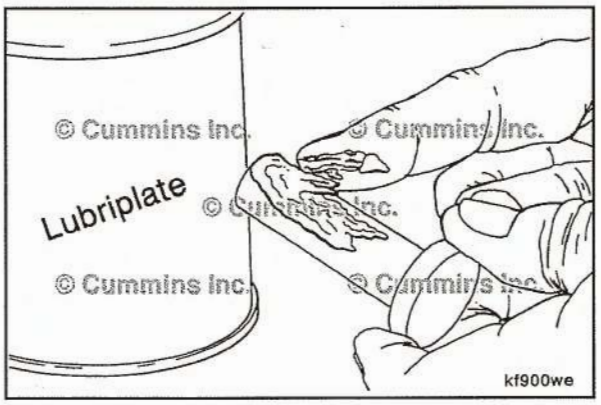
Inspect the crankshaft speed indicator ring for missing teeth, cracks, or damaged surfaces. If any damage is found, the crankshaft speed indicator ring **must** be replaced.

NOTE: If the crankshaft speed indicator ring is damaged, the whole vibration damper assembly **must** be replaced.

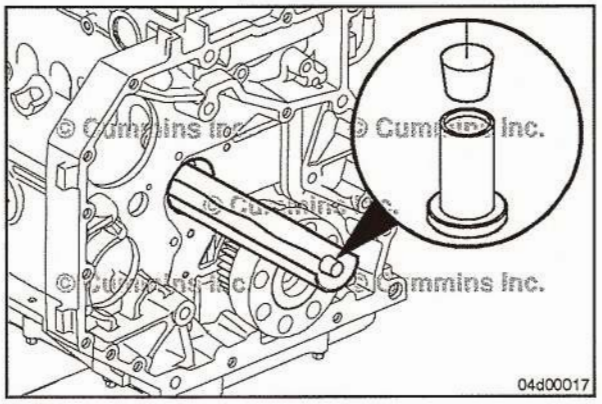


Check the mounting web for cracks.

Check the alignment marks on the inner and outer rings.

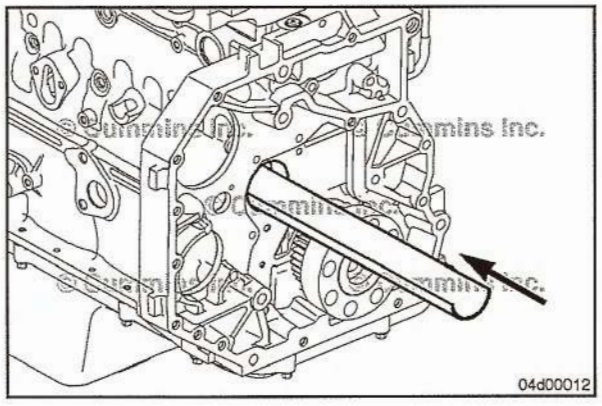


Lubricate the tappets. Use assembly lubricant, Part Number 3163087, or equivalent.

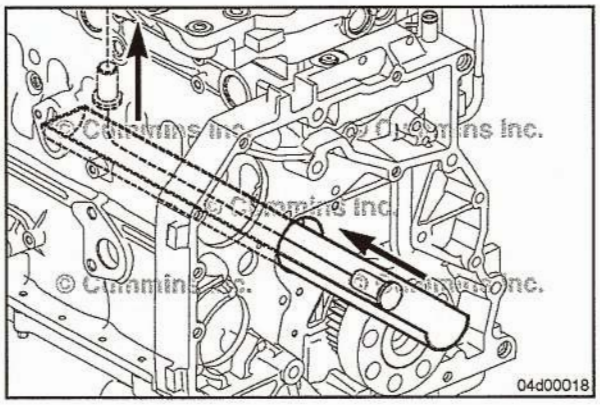


To aid in removing the installation tool after the tappet is installed, work the tool in and out of the tappet several times **before** installing the tappets.

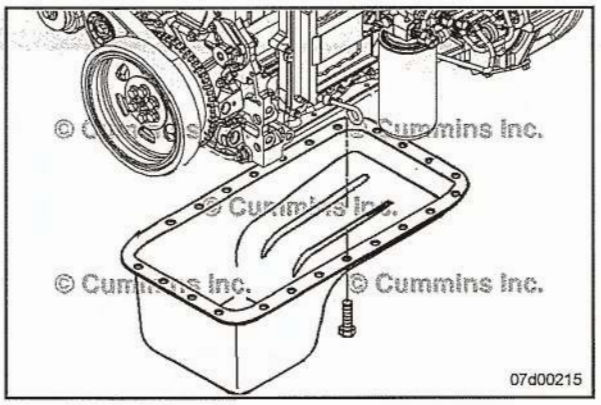
Insert the installation tool into the tappet.



Slide the trough into the camshaft bore.



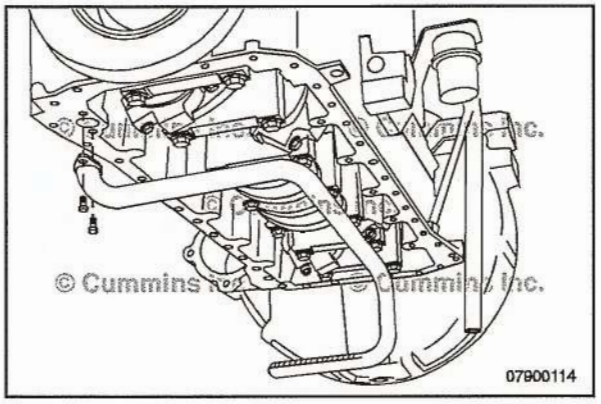
Pull the tool and tappet through the camshaft bore and up into the tappet bore.



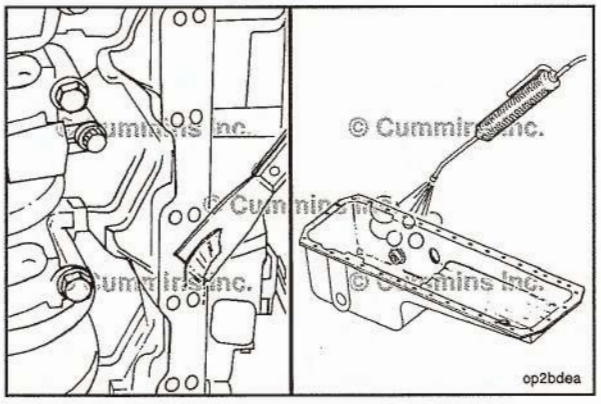
Oil Pan, Formed-in-Place Gasket

Remove the lubricating oil pan.

NOTE: The use of a pry bar or screwdriver to break the formed-in-place gasket seal can damage the lubricating oil pan flange. Use a utility knife to cut the seal and loosen the pan.



Remove the suction tube, if necessary. Refer to Procedure 007-035 in Section 7.



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.

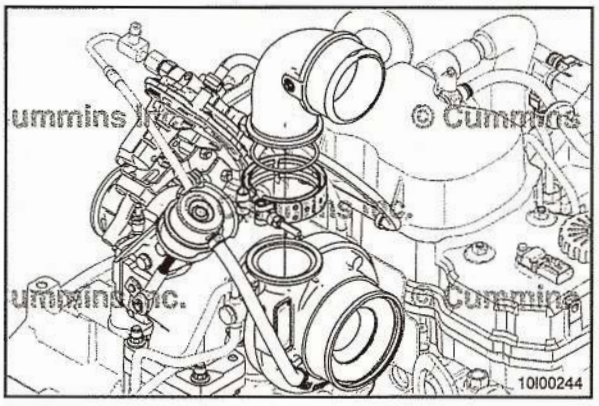
⚠ WARNING ⚠
Wear appropriate eye and face protection when using compressed air. Flying debris and dirt can cause personal injury.

Scrape all remaining gasket material from the oil pan and the block.

NOTE: The use of air or power tools, such as a high speed sander with an abrasive pad, to clean the gasket material can overheat the oil pan and cause damage to the sealing flange.

Steam clean the oil pan. Dry the oil pan with compressed air.

- Disconnect the batteries. See equipment manufacturer service information.
- Clean the outside of the turbocharger compressor outlet connection. Use a clean cloth, making sure to remove all dirt which could fall into the intake when the charge air piping is removed.
- Disconnect the charge air piping and connections from the turbocharger compressor outlet connection. Refer to Procedure 010-019 in Section 10.

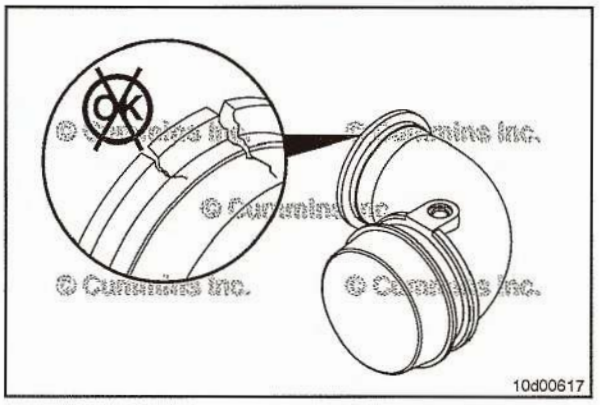


Remove

Loosen the clamp holding the turbocharger compressor outlet connection to the turbocharger.

Remove the turbocharger compressor outlet connection and seal, taking care **not** to drop the seal or any foreign matter into the turbocharger.

Cover both connection points. Use protective caps from Air Handling System Clean Care Kit, Part Number 5296553.



Clean and Inspect for Reuse

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

⚠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.

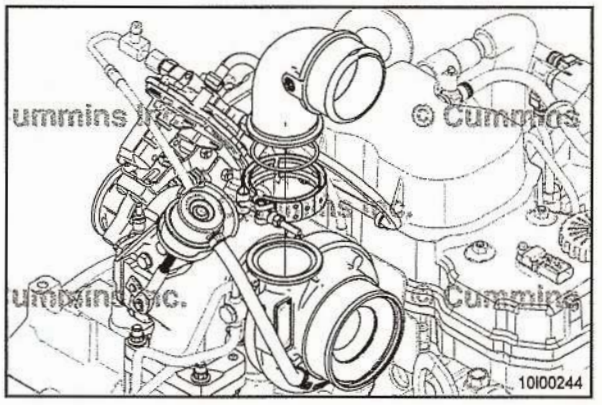
Clean the turbocharger compressor outlet connection. Use solvent. Dry with compressed air.

Inspect the turbocharger compressor outlet connection.

Replace the connection if:

- Cracked
- Abnormally worn
- Otherwise damaged.

Discard the o-ring seal.



Install

Install the turbocharger compressor outlet connection. Use a new o-ring.

Make sure to remove the protective caps.

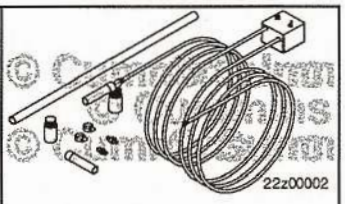
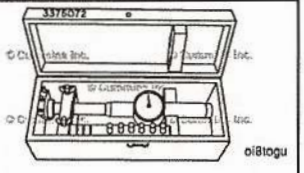
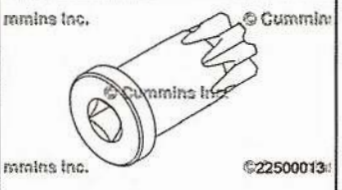
Install the clamp. Tighten.

Torque Value: 10 N•m [89 in-lb]

Service Tools

Compressed Air System

The following special tools are recommended to perform procedures in this section. The use of these tools is shown in the appropriate procedure. These tools can be purchased from a local Cummins® Authorized Repair Location.

Tool No.	Tool Description	Tool Illustration
2892280	**Air Compressor Cleaning Kit** Used to clean and remove internal carbon deposits and other foreign material from Wabco™ air compressor cylinder heads.	
3376619	**Dial Bore Gauge Kit** Used to measure the cylinder bores.	
5299073	**Barring Tool** Used to engage the flywheel ring gear to rotate the crankshaft.	

Aftertreatment Warm Up and DEF Dosing System Test

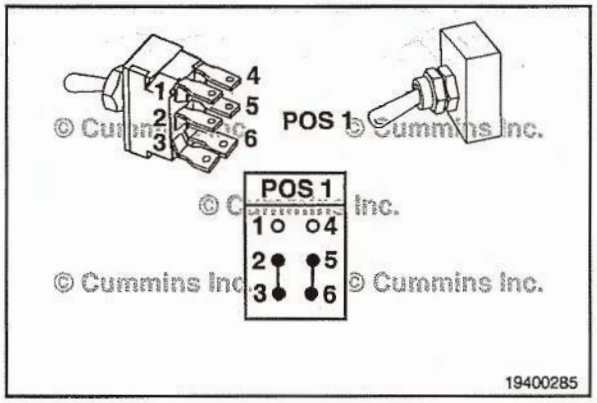
Subtest Status Message	Action
Test Not Available	None, this subtest is **not** available for this engine or application.
Stopped, Check Status Window	The test has aborted. Follow instruction from main test status window.
Not Started	None, this portion of the test is **not** currently running.
Warmup in Progress	None
DEF Doser Test Running	None
Passed	None, the test will automatically continue to the next subtest.
Failed	• Check the DEF for proper concentration and for contamination. • Perform the DEF Dosing Unit Override Test. Refer to Procedure 011-063 in Section 11. If the DEF system passes the Dosing Unit Override Test perform the following: • Inspect the DEF dosing unit intake fitting for debris. Refer to Procedure 011-058 in Section 11. • If debris is found in the intake fitting, replace the fitting and perform the DEF dosing unit airless flush. Refer to Procedure 011-058 in Section 11. Also drain and flush the DEF tank and intake line. See equipment manufacturer service information. • If debris is **not** found in the intake fitting, replace the DEF dosing unit. Refer to Procedure 011-058 in Section 11. Run the Aftertreatment SCR System Test, once the issue is corrected, to validate the repair.

Aftertreatment SCR Deposit Burn Test

Subtest Status Message	Action
Test Not Available	None, this subtest is **not** available for this engine or application.
Stopped, Check Status Window	The test has aborted. Follow instruction from main test status window.
Not Started	None, this portion of the test is **not** currently running.
Running	None
Deposit Burn Complete	None
Deposit Burn Failed	None, the test will continue to run. No repair or inspection will be required unless the Aftertreatment NOx Sensor Rationality Subtest fails.

Aftertreatment NOx Sensor Rationality Test

Subtest Status Message	Action
Test Not Available	None, this subtest is **not** available for this engine or application.
Stopped, Check Status Window	The test has aborted. Follow instruction from main test status window.
Not Started	None, this portion of the test is **not** currently running.
Running	None
Outlet NOx Sensor Passed	Both NOx sensors have passed. Test will automatically continue to the next subtest.
Intake NOx Sensor Failed	• Replace the aftertreatment intake NOx sensor. Refer to Procedure 019-463 in Section 19. Run the Aftertreatment SCR System Test, once the issue is corrected, to validate the repair.
Inspect Outlet NOx Sensor	• Check the decomposition tube for DEF deposits. • Run the DEF System Leak Test. Monitor the DEF dosing valve nozzle for leaks. Refer to Procedure 011-080 in Section 11. • If no DEF deposits are present and the DEF dosing valve is **not** leaking, replace the outlet NOx sensor. Refer to Procedure 019-451 in Section 19. Run the Aftertreatment SCR System Test, once the issue is corrected, to validate the repair.

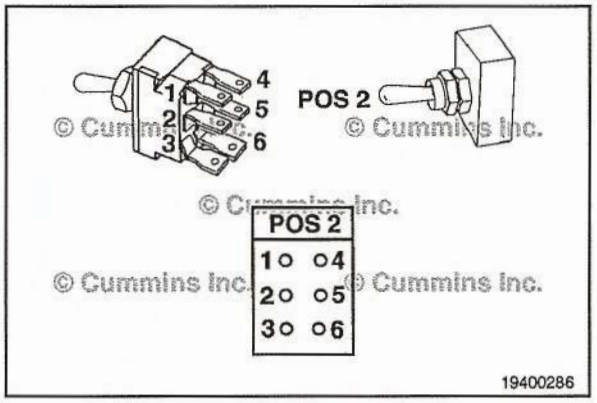


With the switch in position 1, measure the resistance from switch terminal 2 to switch terminal 3. The resistance **must** be 10 ohms or less.

Measure the resistance from switch terminal 5 to switch terminal 6. The resistance **must** be 10 ohms or less.

Measure the resistance from switch terminal 1 to all switch terminals. The resistance **must** be 100K ohms or more.

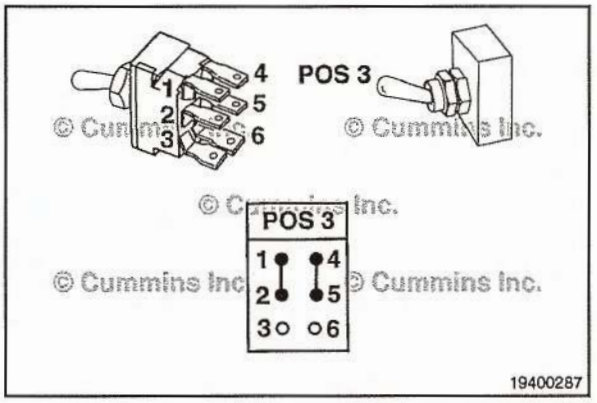
Measure the resistance from switch terminal 4 to all other terminals. The resistance **must** be 100K ohms or more.



Move the switch lever to position 2.

Measure the resistance from switch terminal 1 to all other terminals. The resistance **must** be 100K ohms or more.

Measure the resistance from switch terminal 2 to all other terminals. The resistance **must** be 100K ohms or more.



Move the switch lever to position 3.

Measure the resistance from switch terminal 1 to terminal 2. The resistance **must** be 10 ohms or less.

Measure the resistance from switch terminal 4 to terminal 5. The resistance **must** be 10 ohms or less.

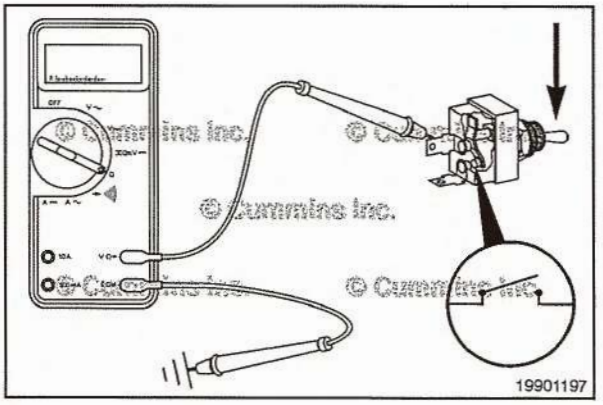
Measure the resistance from switch terminal 3 to all other terminals. The resistance **must** be 100K ohms or more.

Measure the resistance from switch terminal 6 to all other terminals. The resistance **must** be 100K ohms or more.

If the multimeter does **not** show the correct values, the switch has malfunctioned. Verify the switch type and terminal location numbers. Refer to the original equipment manufacturer (OEM) service manual for replacement and to verify the switch type and terminal location.

Insert a test lead into the manual fan clutch switch input pin of the OEM harness connector, and attach the alligator clip to a multimeter probe.

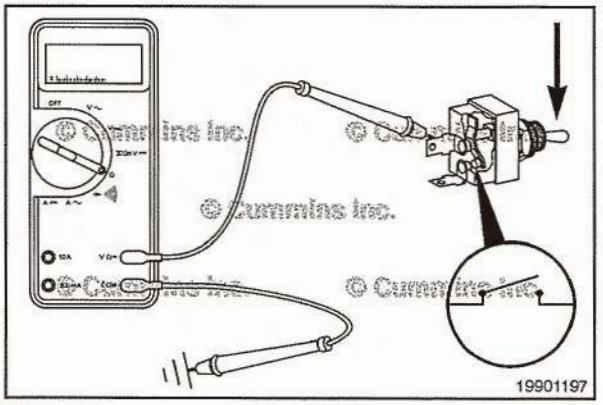
Touch the other multimeter probe to engine block ground and measure the resistance.



The multimeter **must** show a value of 100k ohms or more (open circuit).

If the circuit is **not** open, there is a short circuit to ground in the manual fan clutch circuit, provided the switch has been previously checked and is good.

Repair or replace the OEM harness. Refer to the OEM troubleshooting and repair manual.



Check for Short Circuit from Pin-to-Pin

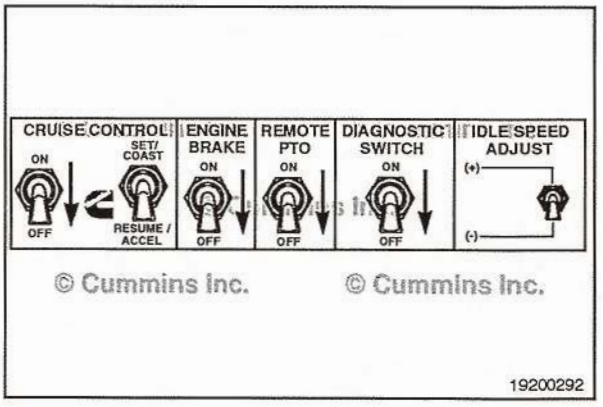
Disconnect the OEM harness connector from the ECM connector.

Disconnect the manual fan clutch switch from the OEM harness.

Disconnect the clutch switch and the idle validation switch.

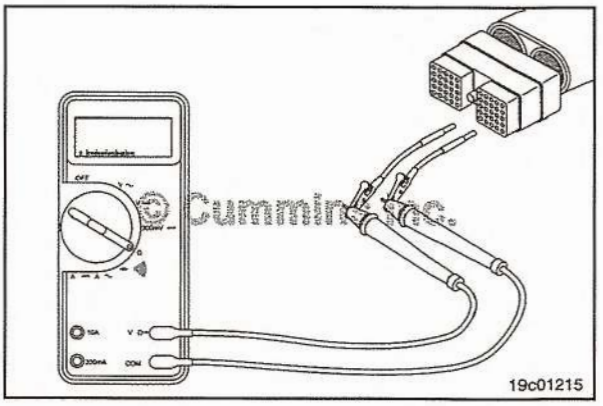
Set all cab switches to the OFF or neutral position.

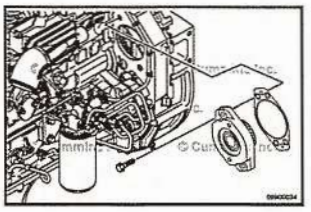
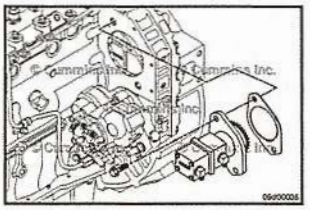
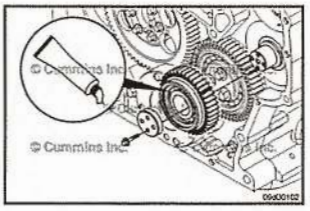
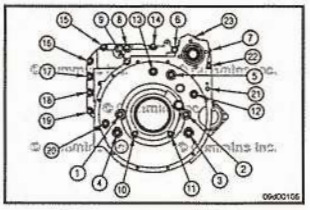
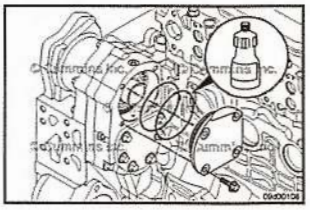
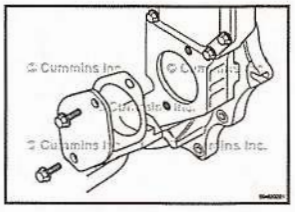
Set the service brake using the trailer brake hand valve. Set the multimeter to measure resistance.

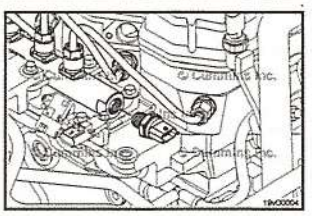
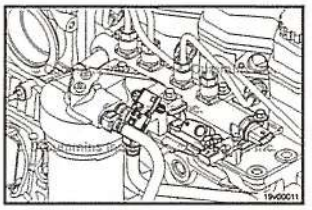
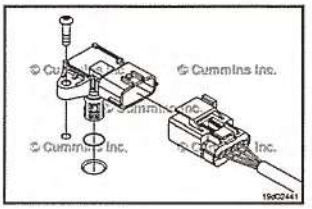
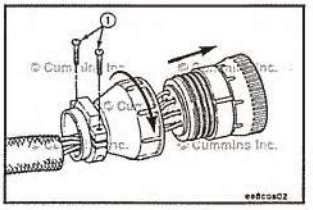
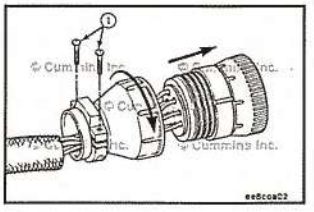
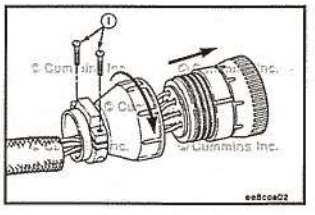


Insert a test lead into the manual fan clutch switch input pin of the OEM harness connector, and attach the alligator clip to a multimeter probe.

Touch the other multimeter probe with attached test lead to all other pins in the connector. Measure the resistance.



Component or Assembly (Procedure)	Ref.No./ Steps	Metric	U.S.	
Drive Units - Group 09 - Torque Values				
Accessory Drive (009-001)				
Accessory Drive To Rear Gear Housing Capscrews		62 N•m	[46 ft-lb]	
Hydraulic Pump Drive (009-016)				
Hydraulic Pump Mounting Capscrew		62 N•m	[46 ft-lb]	
		77 N•m	[57 ft-lb]	
		47 N•m	[35 ft-lb]	
		24 N•m	[212 in-lb]	
		47 N•m	[35 ft-lb]	
		43 N•m	[32 ft-lb]	
		35 N•m	[26 ft-lb]	
REPTO (009-022)				
		12 N•m	[106 in-lb]	
		85 N•m	[63 ft-lb]	
		49 N•m	[36 ft-lb]	
		35 N•m	[26 ft-lb]	
Accessory Drive Cover (009-039)				
Accessory Drive Cover Capscrews		50 N•m	[37 ft-lb]	

Component or Assembly (Procedure)	Ref.No./ Steps	Metric	U.S.	
Rail Fuel Pressure Sensor (019-115)				
Rail Fuel Pressure Sensor		70 N•m	[52 ft-lb]	
Ambient Air Temperature Sensor (019-134)				
Ambient Air Tempurature/Barometric Pressure Sensor		6 N•m	[53 in-lb]	
Intake Manifold Pressure/Temperature Sensor (019-159)				
Intake Manifold Pressure/Temperature Sensor		7 N•m	[62 in-lb]	
Deutsch HD10 Connector Series (019-207)				
		1 N•m	[9 in-lb]	
Deutsch HDP20 and HD30 Connector Series (019-208)				
Clamp Capscrews		1 N•m	[9 in-lb]	
Clamp Capscrews		1 N•m	[9 in-lb]	
Camshaft Position Sensor (019-363)				
Camshaft Position Sensor		10 N•m	[89 in-lb]