

Engine Mechanical

Section 3A - QSD 2.0 Engines

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Engine Specifications

Description	Specifications
	QSD 2.0
Engine type	In-line 4 cylinder diesel
Induction Type	Turbocharged and Aftercooled 16 Valve
Displacement	2.0 liter (122 cu. in.)
Firing order	1-3-4-2
Bore	83 mm (3.700 in.)
Stroke	92 mm (3.622 in.)
Rated engine RPM (see Conditions Affecting Operation—Propeller Selection for additional information).	Refer to CMD's Marine Performance Curves And Data Sheet (www.Cummins.com)
Idle RPM in neutral (engine at normal operating temperature).	700 RPM
Oil pressure at idle	2.4 bar [240 kPa] (35 PSI)
Oil pressure at 4000 RPM	6.6 bar [660 kPa] (95 PSI)
Thermostats (water)	83° C (181° F)
Thermostats (oil)	95° C (203° F)
Coolant temperature	80–85° C (176–185° F)
Electrical system	12-volt negative (–) ground
Alternator rating	14V, 110 A
Recommended battery rating	750 CCA, 950 MCA, or 180 Ahm

Engine Component Specifications

Camshaft

Camshaft		
Lobe lift	Exhaust	34.501 mm (1.3583 in.)
	Intake	34.337 mm (1.3519 in.)
Journal outer diameter	All	27.947 – 27.960 mm (1.1003 – 1.1008 in.)
Thrust clearance (end play)		0.02 – 0.15 mm (0.0020 – 0.0060 in.)
Bending		0.025 mm (0.00098 in.)

Connecting Rod

Connecting Rod	
Thrust clearance	0.1 – 0.35 mm (0.0039 – 0.0138 in.)
Width	29.900 – 27.950 mm (1.1772 – 1.1004 in.)
Piston pin diameter	30.987 – 31.013 mm (1.2200 – 1.2210 in.)
Crankshaft bearing journal diameter	53.000 – 53.018 mm (2.0866 – 2.0873 in.)
Journal bearing oil clearance	0.024 – 0.042 mm (0.0009 – 0.0017 in.)

Crankshaft

Crankshaft	
Thrust clearance (end play)	0.09 – 0.32 mm (0.0039 – 0.0138 in.)
Main journal outer diameter	60.002 – 60.020 mm (2.3623 – 2.3630 in.)
Connecting rod journal outer diameter	50.008 – 50.026 mm (1.9688 – 1.9695 in.)

Crankshaft	
Journal bearing oil clearance	0.024 – 0.042 mm (0.00094 – 0.00165 in.)

Cylinder Block

Cylinder Block	
Piston projection limit	0.194 – 0.542 mm (0.00764 – 0.02134 in.)
Head surface deformation	0.06 mm (0.00236 in.)
Flatness	0.1 mm (0.00394 in.)

Cylinder Diameter

Cylinder Diameter	
Standard diameter	83.000 mm (3.2677 in.)
Taper	0.05 / 100 mm (0.0020 / 3.9370 in.)
Maximum out of round	0.006 mm (0.00024 in.)

Cylinder Head

Cylinder Head	
Camshaft journal inner diameter	28.000 – 28.021 mm (1.1021 – 1.1032 in.)
Camshaft journal clearance	0.040 – 0.074 mm (0.00157 – 0.00291 in.)
Height	129.9 – 130.1 mm (5.1142 – 5.1220 in.)
Head to block surface deformation	0.13 mm overall, 0.05 in. 100 mm (0.00511 overall, 0.0020 in. 3.9370 in.)
Head to manifold surface deformation (intake and exhaust)	0.13 mm overall, 0.05 in. 100 mm (0.00511 overall, 0.0020 in. 3.9370 in.)

Flywheel

Flywheel	
Ring gear teeth	112

Head Gasket Selection

Head Gasket		
		Gasket Size To Be Used
Piston projection above cylinder block	0.194 – 0.337 mm	1.1 mm
	0.337 – 0.440 mm	1.2 mm
	0.440 – 0.542 mm	1.3 mm

Oil Pump

Oil Pump		
Clearance between rotors	Not available at time of printing	
Clearance between outer rotor and housing		
Rotor end float		
inner diameter of rotor housing		
Rotor and gear coupling rolling torque resistance		

Oil Thermostat

Oil Thermostat		
Oil thermostat (fully open)	95.0° C (203.0° F)	

Piston

Piston		
Diameter	83.000 mm (3.2677 in.)	
Clearance	0.070 – 0.090 mm (0.0028 – 0.0035 in.)	

Piston Pin

Piston Pin		
Diameter	27.993 – 27.998 mm (1.1021 – 1.1023 in.)	
Length	66.800 – 67.000 mm (2.6299 – 2.6378 in.)	
Clearance	0.102 – 0.307 mm (0.0040 – 0.0121 in.)	

Piston Rings

Piston Rings		
Ring groove clearance	First compression (top ring)	0.090 mm (0.0035 in.)
	Second compression	0.070 – 0.110 mm (0.0028 – 0.0043 in.)
	Oil control	0.030 – 0.070 mm (0.0012 – 0.0028 in.)
End gap	First compression (top ring)	0.200 – 0.350 mm (0.0079 – 0.0138 in.)
	Second compression	0.400 – 0.600 mm (0.0157 – 0.0236 in.)
	Oil control	0.200 – 0.400 mm (0.0079 – 0.0157 in.)

Valve

Valve		
Face diameter	Intake	28.47 mm–28.73 mm (1.1209 in.–1.1311 in.)
	Exhaust	24.27 mm–24.53 mm (0.9555 in.–0.9657 in.)
Seat inner diameter	Intake	27.000 mm (1.0630 in.)
	Exhaust	22.7 mm (0.8937 in.)
Valve guide inner Diameter	Intake	5.975 – 6.000 mm (0.2352 – 0.2362 in.)
	Exhaust	5.975 – 6.000 mm (0.2352 – 0.2362 in.)
Valve stem outer diameter	Intake	5.573 – 5.953 mm (0.2194 – 0.2344 in.)
	Exhaust	5.905 – 5.925 mm (0.2325 – 0.2333 in.)
Valve length	Intake	93.59 – 93.61 mm (3.6846 – 3.6854 in.)
	Exhaust	93.59 – 93.61 mm (3.6846 – 3.6854 in.)

Valve	
Valve stem deviation	0.038 mm (0.0015 in.)
Valve spring free height	38.500 mm (1.5157 in.)

Valve Clearance

Valve Clearance		
Clearance	Intake	Hydraulically controlled
	Exhaust	








Valve Seat

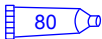

Cylinder Head		
Valve seat inner diameter	Intake	27.000 mm \pm 0.038 mm (1.0630 in. \pm 0.0015 in.)
	Exhaust	22.700 mm \pm 0.038 mm (0.8937 in. \pm 0.0015 in.)

Valve Spring



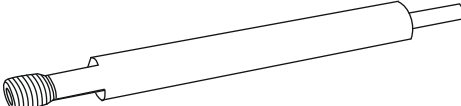

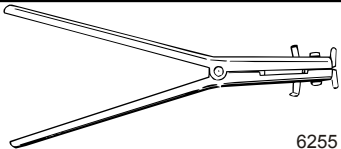
Valve Spring Specifications			
Free standing height	Intake		38.500 mm (1.5157 in.)
	Exhaust		
Spring inclination	Intake	Service limit	Parallel
	Exhaust		

Lubricant, Sealant, Adhesives

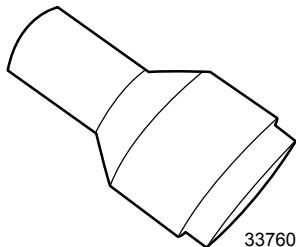
Tube Ref No.	Description	Where Used	Part No.
	Hylomar 3000 (obtain locally)	Engine bed plate	Obtain Locally
	Needle Bearing Assembly Lubricant	Valve stem locks	92-802868A 1
		Connecting rod bearings and crankshaft journal	
	Loctite 271 Threadlocker	Stern drive coupler or inboard drive plate bolt	92-809819
	Loctite 567 PST Pipe Sealant	Lower oil pump housing screws	92-809822
	Loctite Master Gasket Kit	Front camshaft cap	92-12564 2
		Rear camshaft cap	
	Loctite 222 Threadlocker	Rear mount bracket screws	92-809818
	Loctite 290	Outer diameter of expansion plugs	Obtain Locally

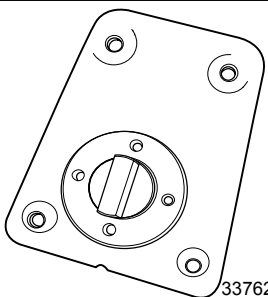
Tube Ref No.	Description	Where Used	Part No.
	SAE Engine Oil 30W	Valve stems	Obtain Locally
		Camshaft	
		Valve lifter contact surfaces	
		Valve lash adjusters	
		O-ring seal	
		Oil pump rotors	
		Crankshaft main bearings	
		Crankshaft journal and connecting rod bearing surfaces	
		Crankshaft journal and bearing surface	
		Connecting rod bushing, piston pin bore, and piston pin	
		Cylinder bore and piston rings	
		Connecting rod bearings and crankshaft journal	
		Connecting rod crankshaft journal and rod bearing surfaces	
	Loctite 5900 Ultra Black RTV Silicone Sealant	Oil pump housing	92-809826

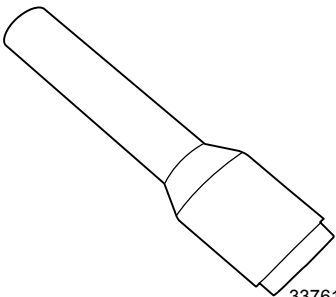
Special Tools

Cylinder TDC Tool	91-898127
 18063	Gauges TDC from the injector seat with the injector removed.
CMD Crankshaft Timing Tool	90-879150020
 32629	Locks crankshaft position with cylinder number 1 at TDC.
Compression Test Adapter	91-881737
 33465	Replaces a fuel injector during a cylinder pressure check.
Dial Indicator	91-58222A1
 9479	Measures gear backlash and pinion gear location.
Piston Ring Expander	91-24697
 6255	Expands piston rings for removal and installation.

QSD 2.0 Special Tools

Front Camshaft oil seal installer	Part Number
 33760	87-9150016

Camshaft timing tool	Part Number
 33762	87-9150021

Crankshaft front oil seal installer	Part Number
 33761	87-915001

General Information

Repair Procedure Information

Some of the repairs in this section must be completed with the engine removed from the boat. Engine removal depends upon the type of repair and boat design. Place the engine on a repair stand for major repairs.

This section primarily covers servicing the cylinder heads and engine block. Some external components that are not mentioned in the procedural steps must be removed. Refer to appropriate sections of this manual for complete service information concerning any component that hinders service or repairs to the cylinder heads and engine block.

When engine removal is not required, ensure that the battery cables are disconnected at the battery before performing any onboard repair procedures.

Lubricate all moving parts during reassembly with clean engine oil or as specified. Apply appropriate lubricant, sealant, or adhesive to all fasteners as specified.

CAUTION

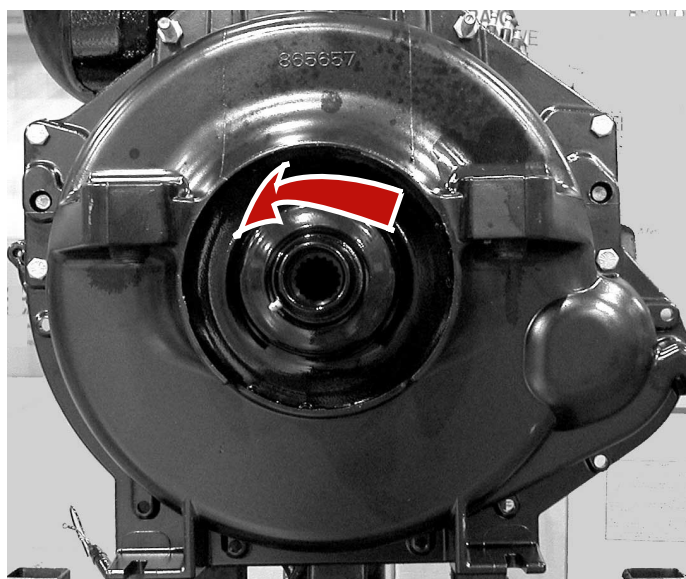
Using compressed air can cause serious injury. Always wear eye protection when working with compressed air to prevent injury from ruptured hoses or flying debris.

Engine Rotation

Engine rotation is described as observed from the rear of the engine (flywheel end) looking forward (water pump end).

Propeller rotation direction is not necessarily the same as engine rotation.

IMPORTANT: All engines covered by this service manual are left-hand (LH) rotation.

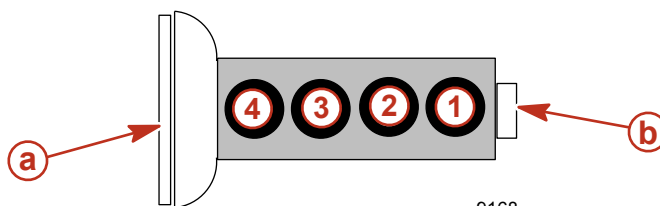


12403

Left hand rotation (counter clockwise)

Engine Firing Order

Firing Order	
QSD 2.0	1-3-4-2



9168

Engine

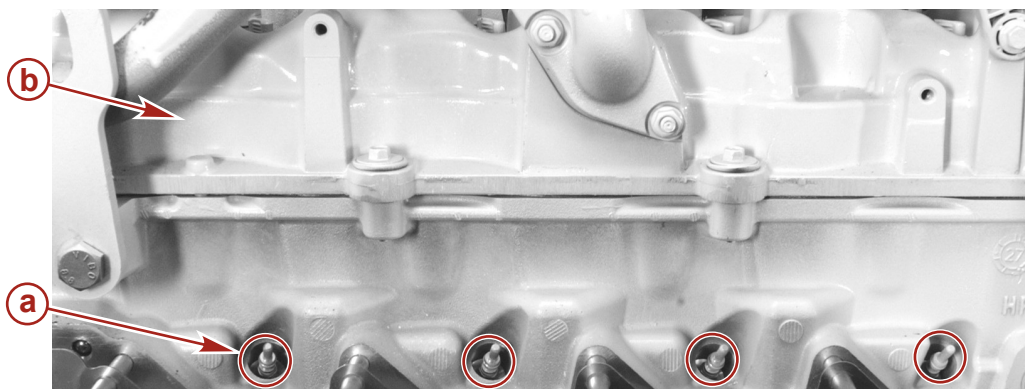
a - Flywheel end

b - Water pump end (front)

Manual Engine Rotation

IMPORTANT: You can remove the non-operational glow plugs from the starboard side of the cylinder head to ease engine rotation. QSD model engines do not utilize glow plugs.

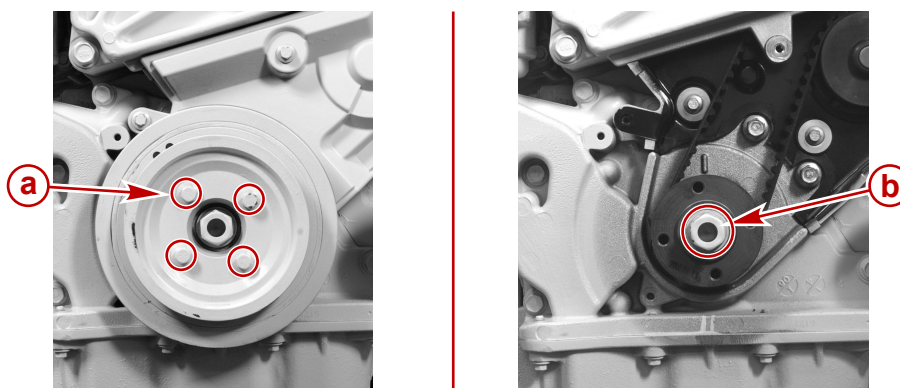
1. Remove the plugs in the glow plug holes to release compression when turning the crankshaft.



33334

- a** - Glow plugs
b - Valve cover

2. Attach an appropriately sized socket to the crankshaft pulley nut. Turn the engine with a large socket drive or break-over bar.



33335

- a** - Crankshaft pulley nuts
b - Crankshaft timing sprocket with pulley removed

3. Install any glow plugs removed during service once the service or repair is complete.

Description	Nm	lb-in.	lb-ft
Glow plug	9	80	–

Establishing Top Dead Center

IMPORTANT: Do not restrict or eliminate fuel supplied to the high pressure fuel injection pump. The high pressure fuel injection pump is lubricated by fuel and engine rotation without fuel flow may cause injection pump damage.

Some procedures require that cylinder number one is at top dead center (TDC). Other procedures will require that one of the other cylinders be at TDC. Two special tools are available to establish TDC.

The cylinder TDC tool temporarily replaces the fuel injector in the selected cylinder and uses an attached dial gauge to verify actual piston position.

Cylinder TDC Tool	91-898127
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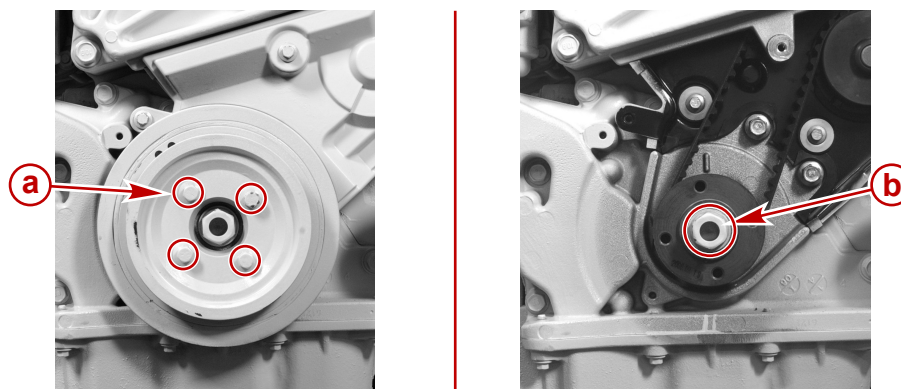
The crankshaft timing tool engages a machined slot in the crankshaft through a access hole in the engine block. It will keep the crankshaft from rotating and position cylinder number one at TDC

CMD Crankshaft Timing Tool	90-879150020
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NOTE: You may choose to remove the screw plugs in the glow plug holes to release compression when turning the crankshaft.

PREFERRED METHOD

1. Attach an appropriately sized socket and drive to the crankshaft timing sprocket nut.

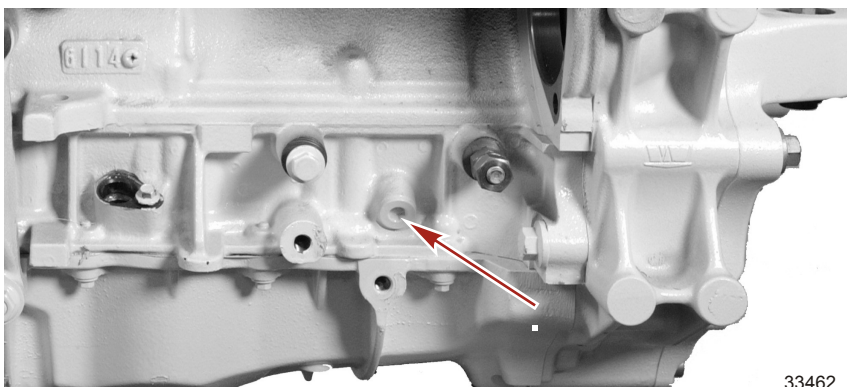


33335

a - Crankshaft pulley nuts

b - Crankshaft timing sprocket nut with pulley removed

2. Remove the plug from the access hole in the cylinder block.



33462

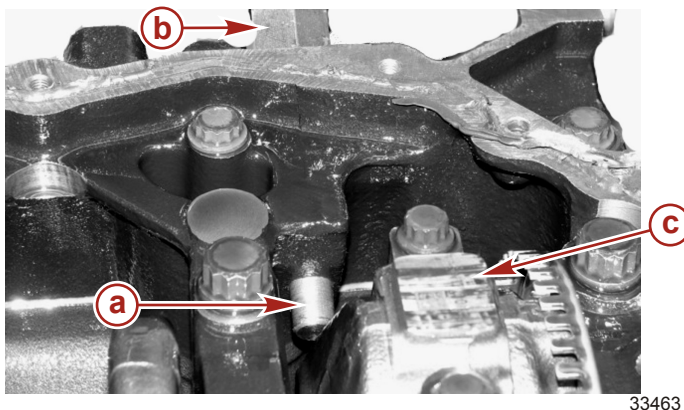
Crankshaft timing tool access plug (components removed for clarity)

NOTE: Do not force or drive the crankshaft timing tool in the cylinder block.

3. Insert the crankshaft timing tool into the access hole until it stops.

CMD Crankshaft Timing Tool	90-879150020
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4. Rotate the crankshaft clockwise while maintaining moderate hand pressure on the crankshaft timing tool.



Engine shown disassembled to illustrate tool function

- a** - Crankshaft timing tool tip
- b** - Crankshaft timing tool handle
- c** - Crankshaft counterweight

5. At cylinder number one TDC the crankshaft timing tool will slide into a notch machined into the crankshaft locking it into position and preventing further engine rotation. Cylinder number one is now set at TDC.
6. Make a reference marks on the crankshaft timing sprocket and timing cover and the camshaft timing belt sprocket and cylinder head.
7. Remove the crankshaft timing tool.
8. When appropriate, turn the crankshaft clockwise 180° to bring the next cylinder in firing order up to TDC.

Firing Order	
QSD 2.0	1-3-4-2

9. Repeat step 8 for any remaining cylinders needing TDC established.

ALTERNATIVE METHOD

IMPORTANT: Use this procedure only if the service being performed requires the removal of the high pressure fuel lines. If the high pressure fuel lines are removed they must be replaced.

1. Remove the fuel injector from cylinder number one. See **Section 5D—Fuel Injectors**.
2. Install the cylinder TDC tool into the cylinder head.
3. Rotate the engine clockwise until the dial gauge attached to the cylinder TDC tool indicates that cylinder number one is at TDC.
4. Make a reference mark on the crankshaft timing pulley and timing cover.
5. When appropriate, turn the crankshaft clockwise 180° to bring the next cylinder in firing order up to TDC.

Firing Order	
QSD 2.0	1-3-4-2

6. Repeat step 5 for any remaining cylinders needing TDC established.

Engine Compression Testing

IMPORTANT: The high pressure fuel pump is cooled and lubricated by fuel flow. Restricting or eliminating the fuel supplied to the high pressure fuel pump will cause pump damage.

A loss of engine compression causes loss of power, increased fuel consumption, rough idle, hard starts, exhaust smoke, and engine overheating.

1. Start the engine and allow it to reach normal operating temperature.
2. Stop the engine and disconnect the crankshaft position sensor.
3. Confirm that the battery is fully charged. Change or charge the battery if necessary.

IMPORTANT: Remove all fuel injectors prior to performing the compression test to allow the engine to achieve the cranking RPMs needed (300 RPM minimum) for a proper test.

4. Remove the fuel injectors. Refer to **Section 5C—Fuel Injectors**.

IMPORTANT: Prolonged or continuous operation will damage the starter motor. Operate the starter for less than 10 seconds with 30 second cool down intervals.

5. Clean the injector bores and crank the engine for no more than 10 seconds to clear the cylinders of any fluid or debris contamination.

Compression Test Adapter	91-881737
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6. Install the compression tester adapter tool.
7. Install and torque the injector clamp to retain the compression test adapter.

Description	Nm	lb-in.	lb-ft
Injector clamp	30	–	22

8. Connect a compression gauge to the compression tester adapter tool and set the gauge to a zero "0" reading.

IMPORTANT: Prolonged or continuous operation will damage the starter motor. Operate the starter for less than 10 seconds with 30 second cool down intervals

9. Operate the starter long enough for the cylinder being tested to cycle through four compression strokes but for no longer than 10 seconds. The engine should be cranking at approximately 300 RPM minimum.
10. Check the compression gauge reading and compare to the following specifications.

Engine compression QSD 2.0	
Compression at approximately 300 RPM minimum	2600 kPa (377 psi)
Pressure difference between cylinders	260 kPa (37.7 psi) maximum

11. Repeat steps 6 through 10 for each cylinder.
12. Remove the compression gauge and the compression tester adapter tool.
13. If readings are within specifications, install the injectors in the cylinder heads from which they were removed previously. Refer to **Section 5C— Fuel Injectors**.

Cylinder Compression Test Results	
Result	Possible Condition
Compression builds up quickly and evenly and meets specifications.	Normal
Compression is low on the first stroke and tends to build up on following strokes but compression does not meet specification. Compression improves considerably if a small amount of oil is added to the cylinder.	Faulty piston rings
Compression remains low on all strokes and does not improve with the addition of a small amount of oil to the cylinder.	Faulty valves

Engine Break-In

20-HOUR BREAK-IN PERIOD

IMPORTANT: The first 20 hours of operation are a break-in period for the engine. Correct break-in is essential to obtain minimum oil consumption and maximum engine performance. During this break-in period, observe the following rules:

- Do not operate below 1500 RPM for extended periods of time during the first 10 hours. Advance the throttle above 1500 RPM as soon as conditions permit safe operation.
- Do not consistently operate at one speed for extended periods.
- Do not exceed 3/4 throttle during the first 10 hours, during the next 10 hours do not operate at full throttle for more than five minutes at a time.
- Do not accelerate at full-throttle from idle speed.
- Do not operate at full throttle until the engine reaches normal operating temperature.
- High oil consumption is normal during the break-in period. Frequently check the engine oil level.

AFTER THE 20-HOUR BREAK-IN PERIOD

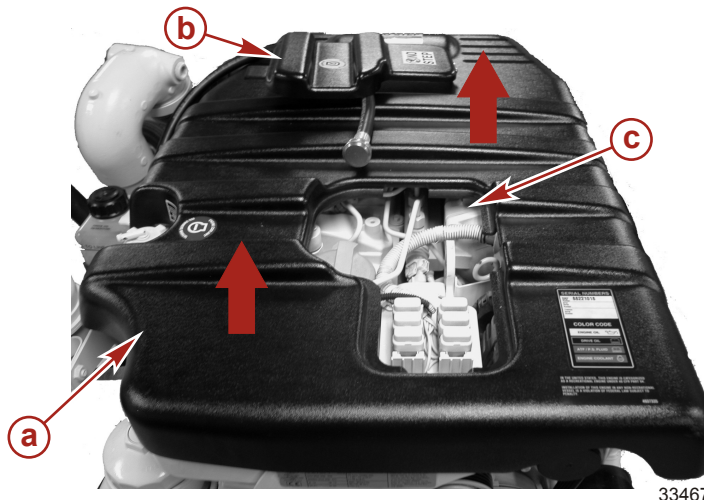
To help extend the life of your power package, Cummins MerCruiser Diesel recommends:

- Changing the engine oil and filter, and the transmission fluid on inboard models, at the interval indicated in the **Maintenance Schedule**.
- Using a propeller that allows the engine to operate at the rated engine RPM when at full throttle with a maximum boat load.
- Operating at 3/4 throttle or lower. See the duty cycle information listed in **Section 1A: Operation—Duty Cycle**.

Engine Cover

Removal

1. Remove the engine fuse panel cover.
2. Lift straight up and detach the engine cover from the ball stud mounts.



- a** - Engine cover
- b** - Fuse panel cover
- c** - Engine access

3. Replace the fuse panel cover during storage.

Cleaning

1. Clean the engine cover with warm soapy water.
2. Air dry the cover.

Inspection

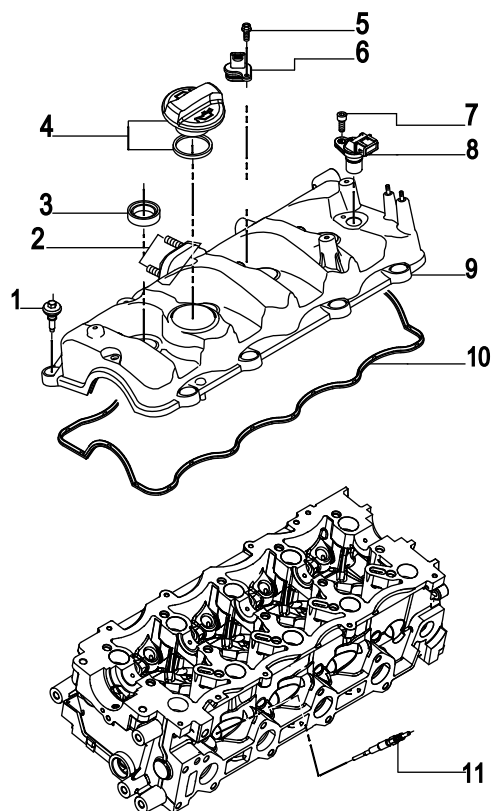
1. Inspect the engine cover for cracks or deterioration.
2. Inspect the rubber grommets for deterioration.
3. Inspect the hardware used with each grommet.
4. Replace damaged parts.

Installation

1. Remove the fuse panel cover.
2. Set the engine cover over the ball stud mounts.
3. Press the engine cover down above each mount to reattach the engine cover.
4. Replace the fuse panel cover.

Valve Cover

Exploded View—2.0L Valve Cover



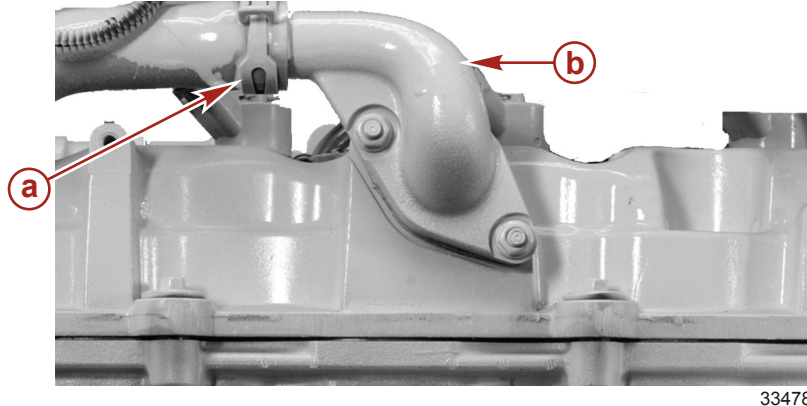
32909

Exploded View—2.0L Valve Cover

Ref. No.	Qty.	Description	Torque		
			Nm	lb-In.	lb-ft
1	8	Valve cover screw and grommet	12	106	–
2	2	Stud			
3	4	Oil seal, injector body			
4	1	Oil fill cap			
5	4	Screw	5.6	50	–
6	4	Cap, injector clamp			
7	1	Screw	8	71	–
8	1	Camshaft position sensor			
9	1	Valve cover			
10	1	Valve cover gasket			
11	4	Glow plug (sealing cylinder head holes)	14	124	–

Removal

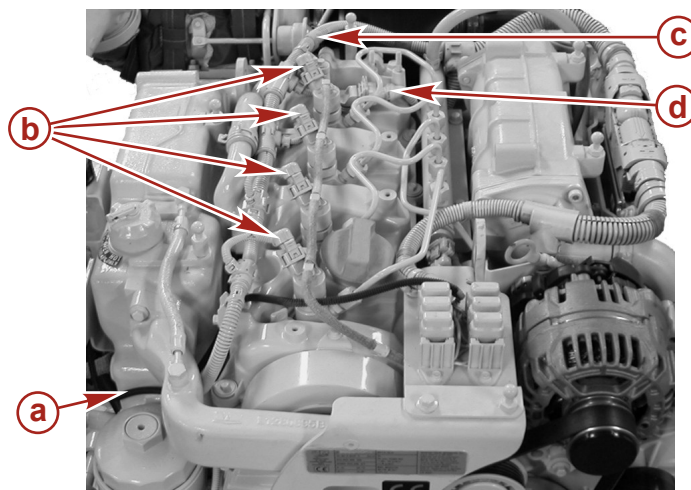
1. Remove the engine cover.
2. Remove the oil separator vent hose from the elbow on the valve cover.



33478

- a** - Clamp
- b** - Oil vent hose elbow

3. Label and then disconnect the gear lube monitor (if equipped), fuel injectors, and camshaft position sensor engine harness connectors.

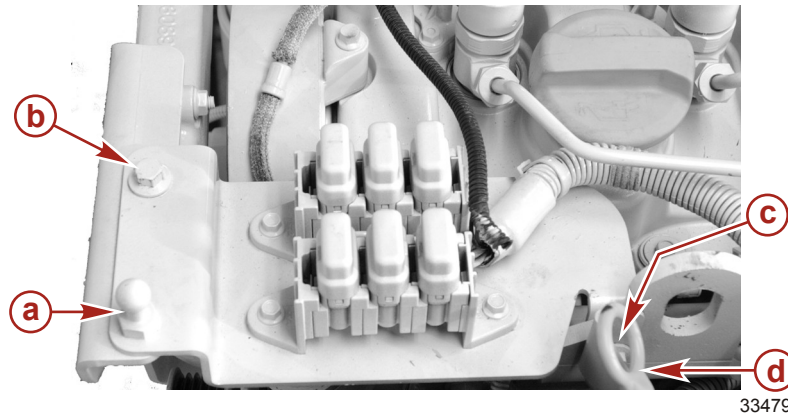


33480

- a** - Gear lube monitor connector
- b** - Fuel injector connector
- c** - Engine harness
- d** - Camshaft position sensor connector

4. Detach the right side engine harness from its anchors and move aside.

5. Remove the nut and bolt retaining the oil dipstick tube and engine fuse panel to the front lifting eye bracket.



- a** - Special screw
- b** - Screw
- c** - Nut and bolt
- d** - Engine oil dipstick

6. Remove the screws retaining the engine fuse panel.

NOTE: Leave the engine fuse panel attached to the engine wiring harness and move aside.

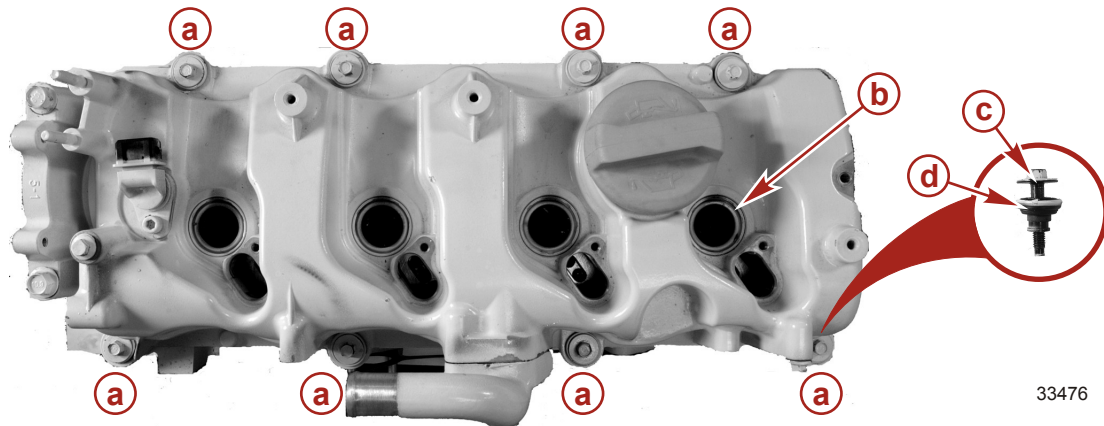
7. Remove the screw anchoring the upper timing cover to the valve cover.

8. Remove the camshaft position sensor. Refer to **Section 5G—ECS Repair**.

9. Remove the fuel injectors. Refer to **Section 5C—Fuel Injectors**.

NOTE: The valve cover screw grommets press into the valve cover when tightened and may remain in the valve cover when the screw is completely extracted from the cylinder head. Remove the valve cover screws and grommets as an assembly.

10. Remove the screws and grommets retaining the valve cover to the cylinder head.



- a** - Valve cover screw
- b** - Injector body oil seals
- c** - Screw
- d** - Grommet

NOTE: Two dowel pins align the valve cover and the cylinder head. Pull straight up to remove.

11. Lift the valve cover straight up to remove it from the cylinder head.

12. Remove and discard the valve cover gasket.

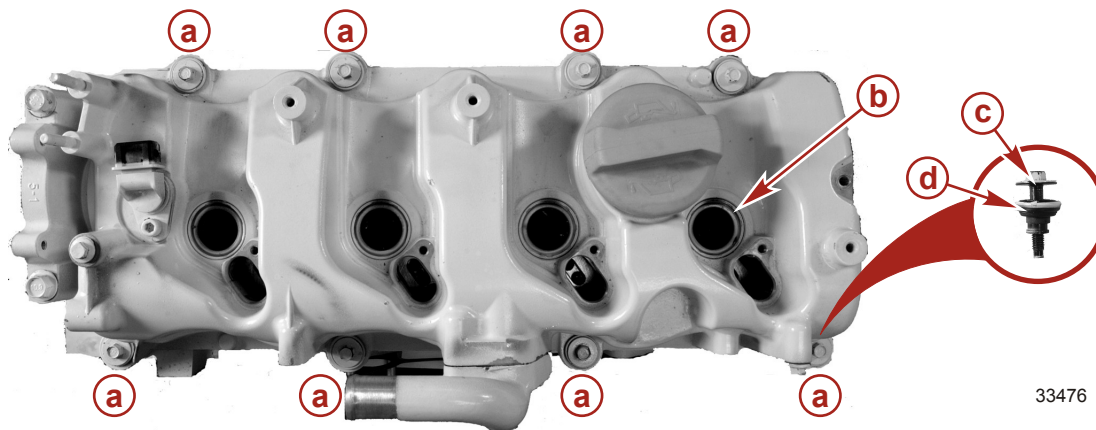
Cleaning

IMPORTANT: Do not drop anything into the cylinder head openings.

1. Clean the gasket material from all sealing surfaces.
2. Clean the valve cover.
3. Clean the sealing surfaces on the cylinder head and valve cover with cleaning solvent.
4. Remove the copper sealing washer from the injectors or injector seats. See **Section 5C**.

Inspection

1. Inspect the sealing surfaces for deep nicks and scratches.
2. Inspect the valve cover and vent hose connectors for damage.
3. Inspect the fuel injector body oil seals.

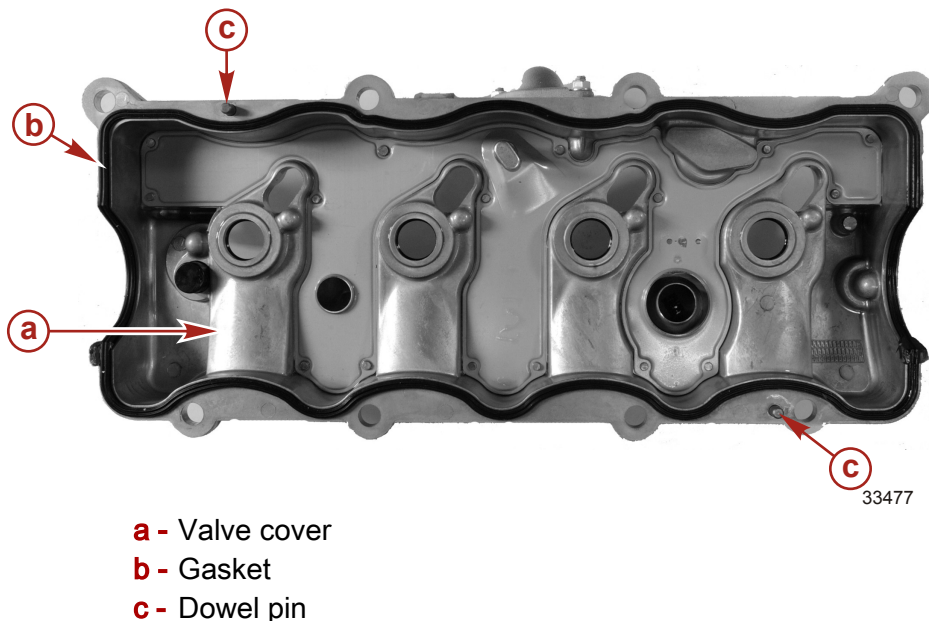


- a** - Valve cover screw
- b** - Injector body oil seals
- c** - Screw
- d** - Grommet

4. Inspect the valve cover screw grommets.
5. Replace or repair parts as needed.

Installation

1. Install a new valve cover gasket into the groove in the bottom of the valve cover.



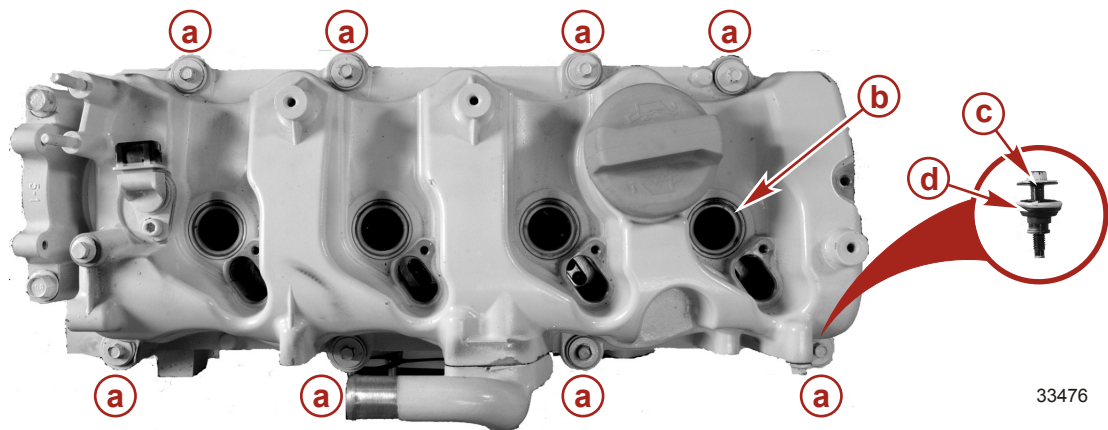
2. Apply sealant to the sealing surface of the front and rear main bearing caps.



Sealant application

NOTE: Two dowel pins align the valve cover and the cylinder head. Align the dowels and push straight down on the valve cover when installing it on the cylinder head.

3. Install the valve cover to the cylinder head.

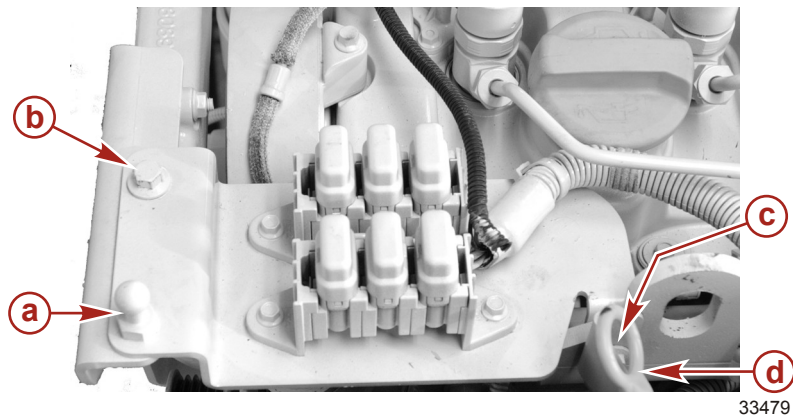


- a - Valve cover screw
- b - Injector body oil seals
- c - Screw
- d - Grommet

4. Install and lightly tighten the valve cover screws.
IMPORTANT: Do not over tighten the valve cover screws.
5. Tighten the valve cover screws to specification.

Description	Nm	lb-in.	lb-ft
Valve cover screws	12	106	–

6. Reposition the engine fuse panel.
7. Install the nut and bolt retaining the oil dipstick tube and engine fuse panel to the front lifting eye bracket.



- a - Special screw
- b - Screw
- c - Nut and bolt
- d - Engine oil dipstick

8. Tighten the nut and bolt retaining the oil dipstick tube and engine fuse panel to the front lifting eye bracket to specification.

Description	Nm	lb-in.	lb-ft
Oil dipstick tube nut and bolt	10.8	96	–

9. Install the screws retaining the front of the engine fuse panel.

10. Tighten both screws that attach the the front of the engine fuse panel to specification.

Description	Nm	lb-in.	lb-ft
Engine fuse panel screw	24.5	–	18
Engine fuse panel screw	24.5	–	18

11. Install the screw attaching the upper timing cover to the valve cover.

12. Tighten the upper timing cover screw to specification.

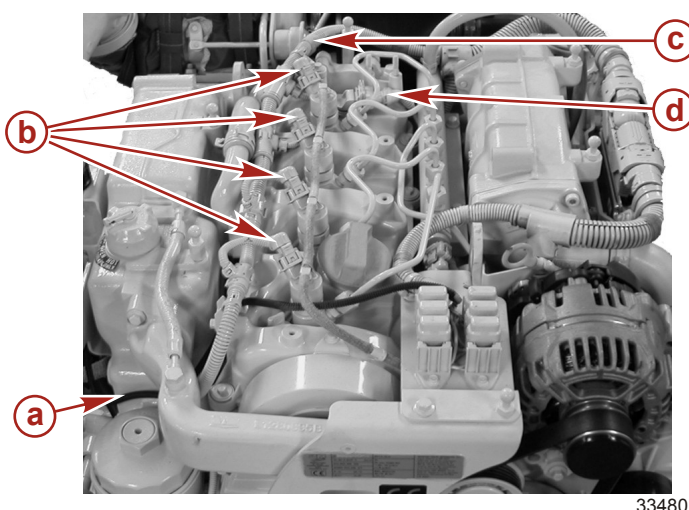
Description	Nm	lb-in.	lb-ft
Timing cover screw	10.8	96	–

13. Install the camshaft position sensor. Refer to **Section 5G—ECS Repair**.

14. Install the fuel injectors. Refer to **Section 5C—Fuel Injectors**.

15. Reposition and attach the right side engine harness to the original anchor points.

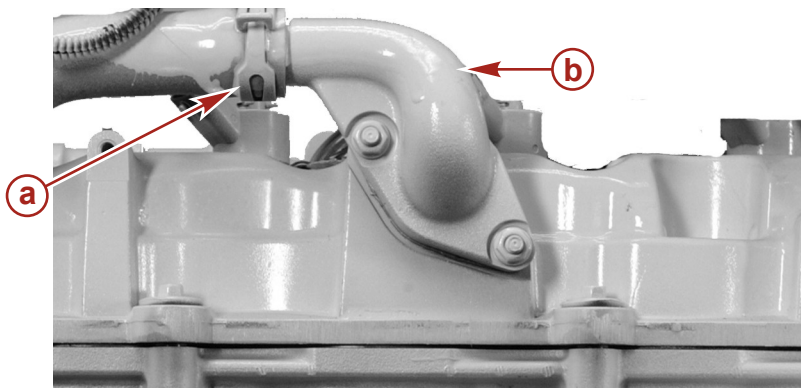
16. Reconnect the gear lube monitor (if equipped), fuel injectors, and camshaft position sensor engine harness connectors.



33480

- a** - Gear lube monitor connector
- b** - Fuel injector connector
- c** - Engine harness
- d** - Camshaft position sensor connector

17. Attach the oil separator vent hose to the elbow on the valve cover.



33478

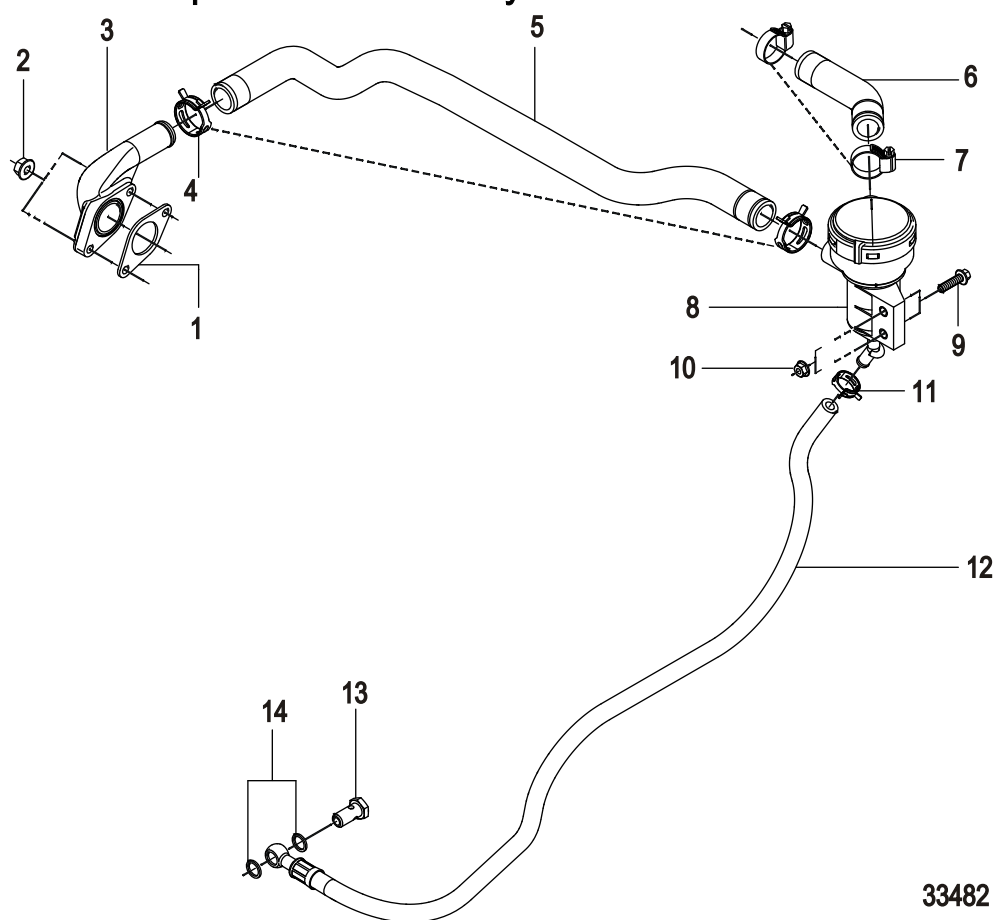
- a** - Clamp
- b** - Oil vent hose elbow

18. Start the engine and check for fuel or oil leaks.
19. Allow the engine to reach operating temperature and recheck for leaks.
20. Install the engine cover.

Notes:

Oil Separator and Vent System

Exploded View—Oil Separator and Vent System

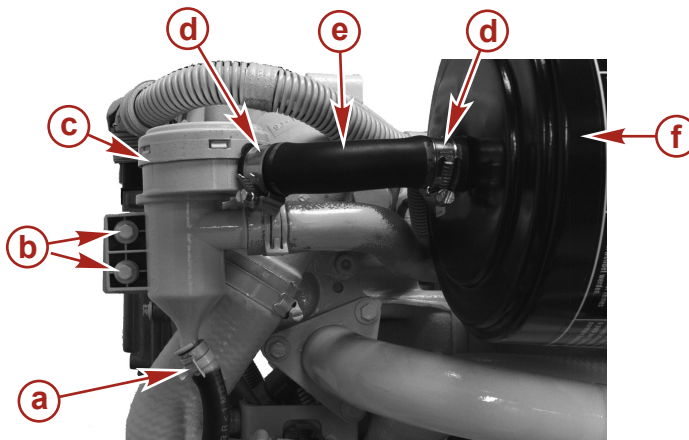


Exploded View—Oil Separator and Vent System

Ref. No.	Qty.	Description	Torque		
			Nm	lb-in.	lb-ft
1	1	Gasket			
2	2	Nut	12.7	112	–
3	1	Elbow			
4	2	Hose clamp			
5	1	Hose, oil separator to valve cover vent			
6	1	Hose, oil separator to air filter housing			
7	2	Hose clamp	5.6	50	–
8	1	Oil Separator			
9	2	Screw			
10	2	Nut	10.8	96	–
11	1	Hose clamp			
12	1	Hose, oil separator to engine oil pan fitting			
13	1	Hollow bolt	24.5	–	18
14	2	Sealing Washer			

Removal

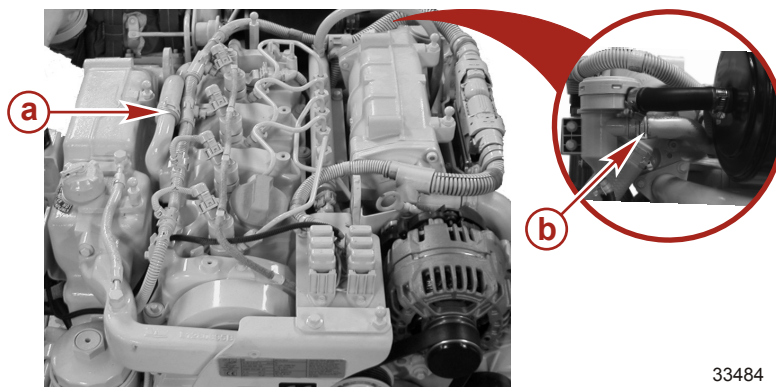
1. Disconnect the oil separator to air filter housing hose.



33483

- | | |
|-------------------------------------|-------------------------------|
| a - Oil separator drain hose | d - Hose clamp |
| b - Flange screw | e - Hose |
| c - Oil separator | f - Air filter housing |

2. Disconnect the valve cover vent hose from the oil separator and the valve cover.

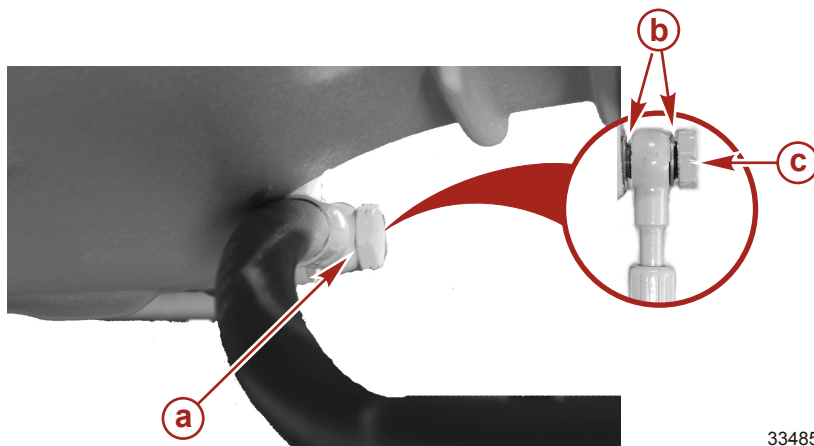


33484

- | |
|-------------------------------------|
| a - Valve cover connection |
| b - Oil separator connection |

3. Disconnect the oil drain hose from the oil separator.
4. Remove the flange screws retaining the oil separator to the engine bracket.
5. Remove the oil separator.

6. If necessary for service, remove the hollow bolt fitting attaching the oil drain hose to oil pan. Discard the sealing washers.



33485

- a** - Oil drain hose fitting
- b** - Sealing washer
- c** - Hollow bolt

Cleaning

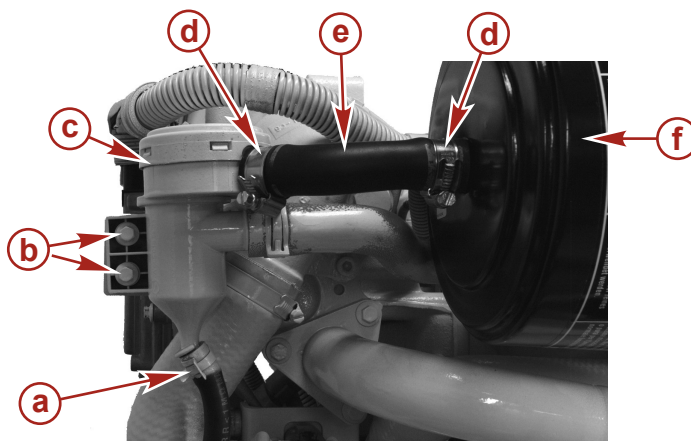
1. Put on safety glasses.
2. Wash the oil separator in cleaning solvent.
3. Dry the components with compressed air.
4. Wipe the hoses and fittings with a clean shop cloth.

Inspection

1. Inspect the hoses and the hose fittings for cracks or deterioration.
2. Inspect the oil separator for cracks or signs of leaking.
3. Replace or repair damaged parts.

Installation

1. Install the oil separator to the engine bracket with the two flange screws.



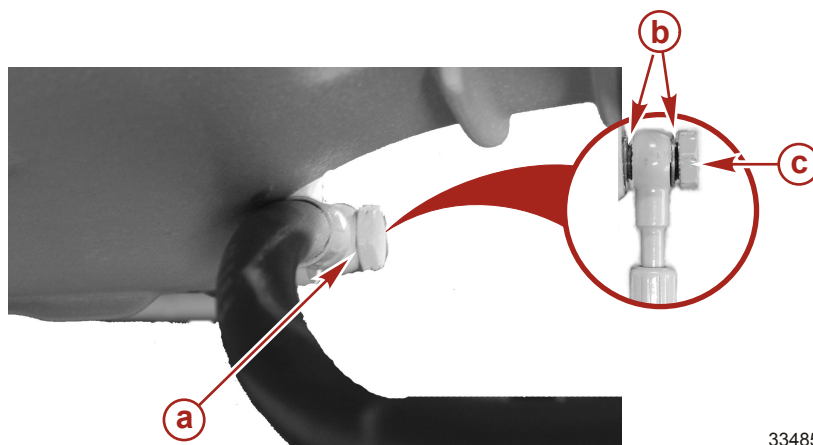
33483

- a** - Oil separator drain hose
- b** - Flange screw
- c** - Oil separator
- d** - Hose clamp
- e** - Hose
- f** - Air filter housing

2. Tighten the oil separator flange screws to specification.

Description	Nm	lb-in.	lb-ft
Oil separator flange screws	10.8	96	–

3. Connect the oil drain hose to the oil separator with a spring type hose clamp.
4. If removed for service, attach the oil drain hose to the oil pan with the hollow bolt fitting using new sealing washers.

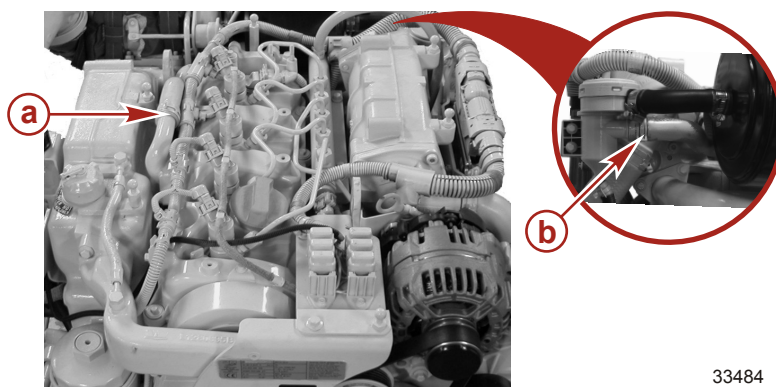


33485

- a** - Oil drain hose fitting
- b** - Sealing washer
- c** - Hollow bolt

Description	Nm	lb-in.	lb-ft
Hollow bolt	24.5	–	18

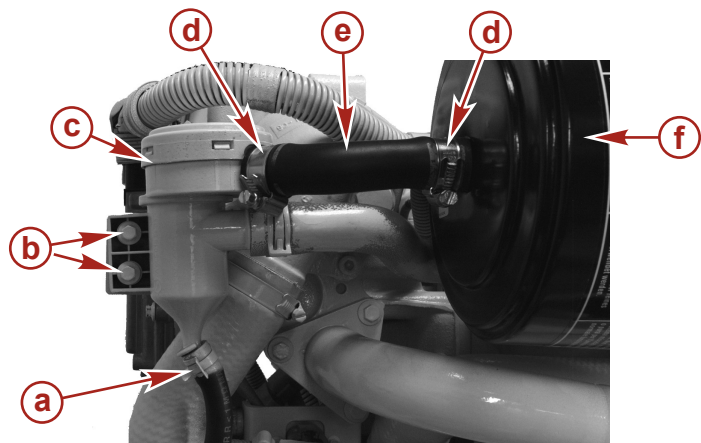
5. Connect the valve cover vent hose to the oil separator and the valve cover. Secure with spring type hose clamps



33484

- a** - Valve cover connection
- b** - Oil separator connection

6. Connect the oil separator to air filter housing hose with screw hose clamps.



- a** - Oil separator drain hose

b - Flange screw

c - Oil separator
- d** - Hose clamp

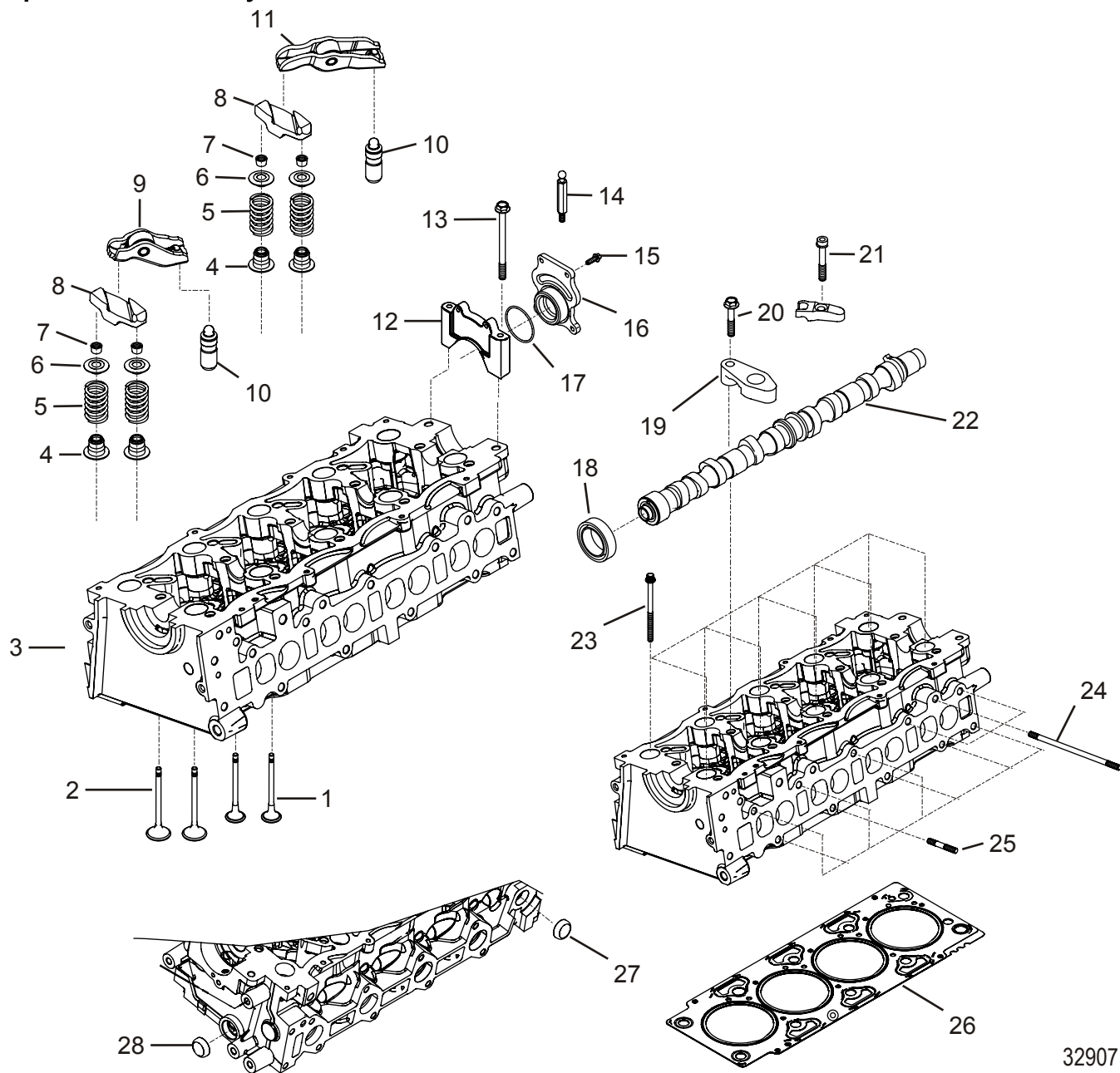
e - Hose

f - Air filter housing

Description	Nm	lb-in.	lb-ft
Hose clamp	5.6	50	–

Cylinder Head

Exploded View—Cylinder Head



32907

Exploded View—Cylinder Head

Ref. No.	Qty.	Description		Torque		
				Nm	lb-in.	lb-ft
1	8	Exhaust valve				
2	8	Intake valve				
3	1	Cylinder head				
4	16	Valve stem seal				
5	16	Valve spring				
6	16	Valve spring plate				
7	16	Valve spring retainer				
8	8	Rocker arm bridge				
9	4	Rocker arm, intake valve				
10	8	Valve lash adjuster				
11	4	Rocker arm, exhaust valve				
12	1	Bearing cap				
13	2	Screw		28	–	21
14	1	Ball stud screw		24.5	–	18
15	4	Screw		10.8	96	–
16	1	Cover				
17	1	O-ring seal				
18	1	Seal				
19	5	Camshaft cap				
20	10	Screw		28	–	21
21	4	Injector clamp and bolt		30	–	22
22	1	Camshaft				
23	10	Head bolt	First pass	65	–	48
			Second pass	+120°	–	+120°
			Third pass	+120°	–	+120°
24	3	Stud				
25	8	Stud				
26	1	Head gasket				
27	1	Expansion plug				
28	1	Expansion plug				

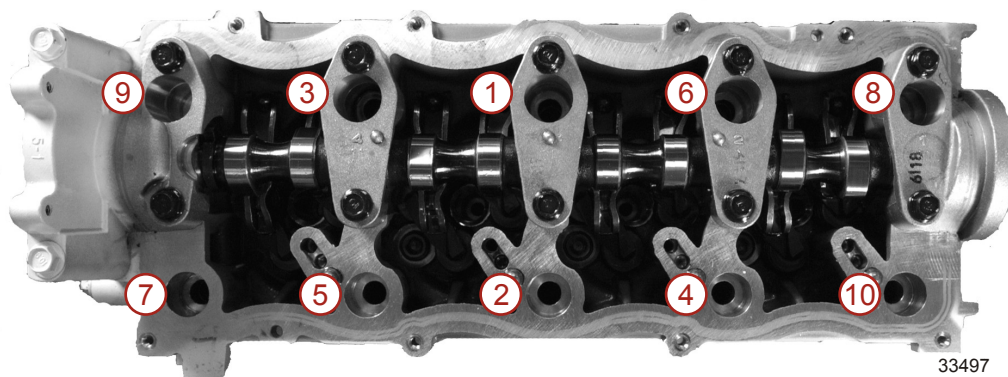
Removal

IMPORTANT: Mark or store components the components during removal for reassembly in their original location.

1. Remove the intake manifold and aftercooler assembly. Refer to **Section 7A—Intake Manifold and Aftercooler Assembly**.
2. Remove the exhaust manifold and fluid cooler assembly. Refer to **Section 7B—Exhaust Manifold**.
3. Remove the valve cover. See **Section 3A—Valve Cover**.
4. Remove the engine timing belt. See **Section 3A—Engine Timing Belt and Components**.

IMPORTANT: To avoid distorting the cylinder heads, only remove the cylinder heads when the engine is cold.

5. Loosen the cylinder head bolts in sequence as illustrated.



Cylinder head bolt loosening sequence

6. Remove the cylinder head bolts.
7. Remove the cylinder head.
8. Remove and discard the cylinder head gasket. Note the thickness of the cylinder head gasket.
9. Store and service the cylinder head on a non-marring surface.

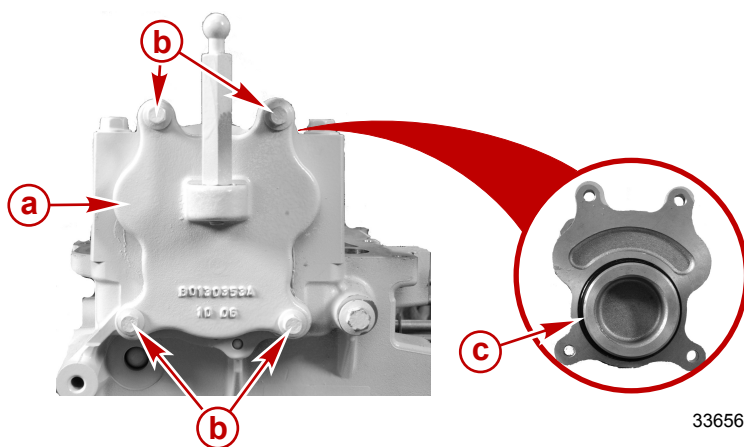
Disassembly

IMPORTANT: Mark or store components to aid diagnosis and for reassembly in their original location.

1. Remove the cylinder head from the engine. See **Section 3A—Cylinder Head**.
2. Remove the camshaft. See **Section 3A—Camshaft**.

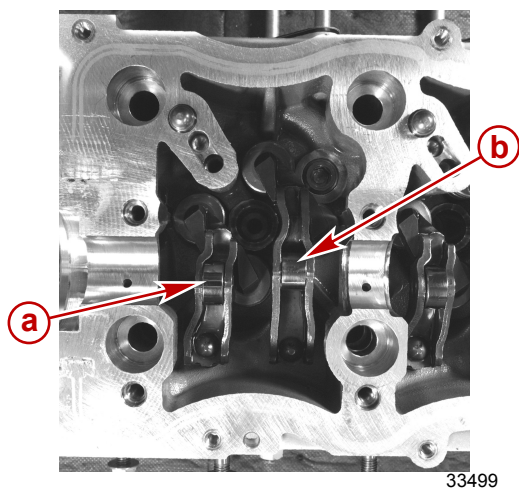
NOTE: The rear cylinder head cover is not reinstalled until after the engine has been timed and the timing belt installed.

3. Remove the rear cylinder head cover. Remove and discard the O-ring.



- a** - Rear cylinder head cover
b - Screw
c - O-ring

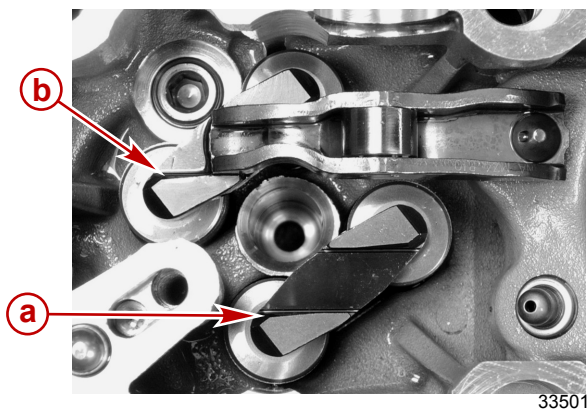
4. Remove the intake and exhaust rocker arms.



- a** - Intake rocker arm
b - Exhaust rocker arm

NOTE: Lifting up on the side of one end of the rocker arm bridge will help to disengage it from the valve stem.

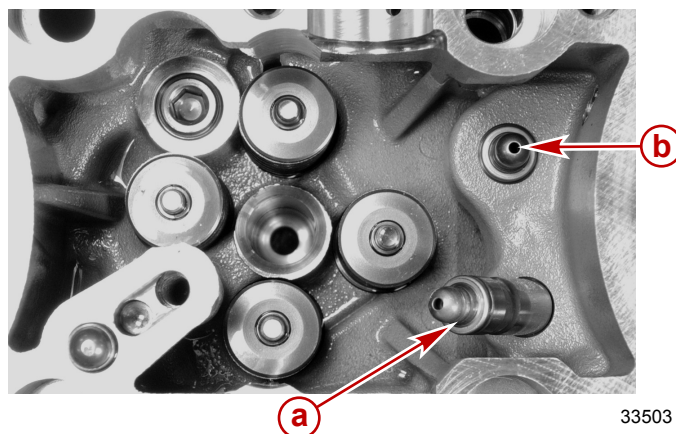
5. Remove the intake and exhaust rocker arm bridges.



- a** - Intake rocker arm bridge
b - Exhaust rocker arm bridge

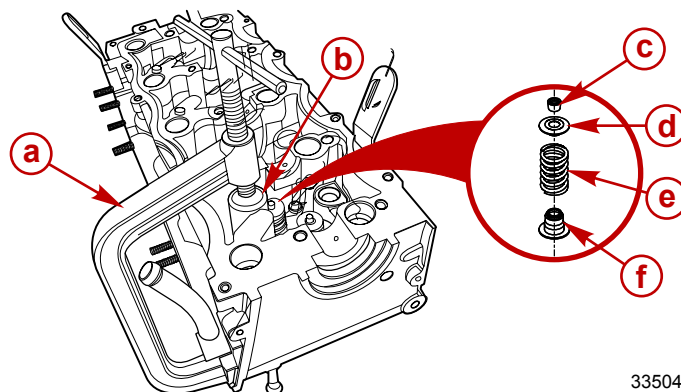
NOTE: A magnetic pickup may be used to remove the hydraulic valve lifters.

6. Remove the intake and exhaust valve lash adjusters.



- a** - Intake valve lash adjuster
b - Exhaust valve lash adjuster

7. Using a valve spring compressor with an appropriately sized adaptor, remove the valve spring retainers, spring plates, and valve springs.



- a** - Valve spring compressor
b - Adapter
c - Valve spring retainer
d - Valve spring plate
e - Valve spring
f - Valve stem seal

8. Remove the valves from the cylinder head and label or store them for reassembly in their original locations.
9. If replacing the cylinder head, remove the cylinder head studs. Mark each stud type to identify its installation location.

Cleaning

1. Clean the gasket material and the sealer from the engine block and cylinder head sealing surfaces.
2. Clean all the carbon from the combustion chambers and valve ports using a carbon remover brush.
3. Clean the carbon from valves using a wire wheel.
4. Wash the cylinder head and components in a cleaning solvent.
5. Clean the cylinder head bolt threads and engine block bolt hole threads to ensure that no dirt, old oil, or coolant remain.
6. Put on safety glasses and dry the components with compressed air, including cylinder head bolt threads and engine block bolt hole threads.

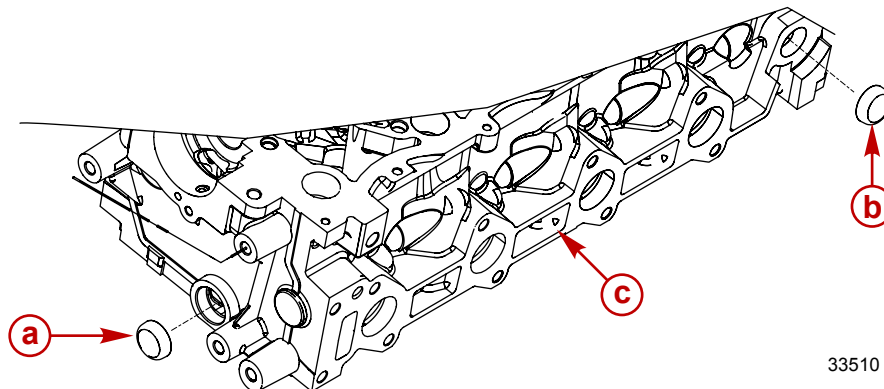
Inspection

GENERAL

1. Inspect the injector seats for damage.
2. Inspect all gasket surfaces for grooves or pitting that will affect engine sealing.
3. Inspect all screw holes for thread damage.
4. Inspect the camshaft bearing caps and bosses for cracks.
5. Inspect the combustion chamber for cracks, pitting, melting, or any other damage.
6. Inspect the oil galleries for debris.
7. Inspect the cylinder head deck surface for signs of a coolant leak, combustion gas escape, and any other damage.
8. Inspect the valve seats for cracks or erosion.
9. Inspect the intake or exhaust passages for any restrictions.
10. Replace or repair damaged parts.

EXPANSION PLUGS

1. Inspect expansion plugs for signs of a leak or corrosion.
2. Remove and replace expansion plugs if leaking or damaged.



33510

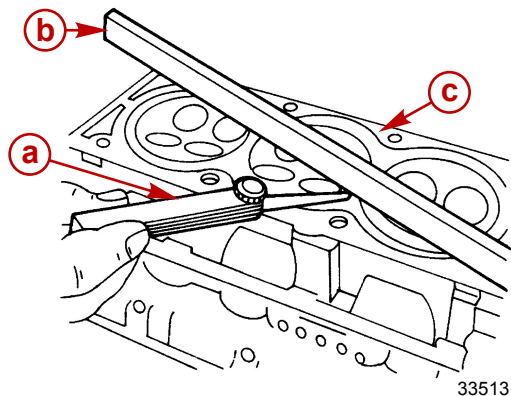
- a** - Rear expansion plug
- b** - Exhaust side expansion plug
- c** - Cylinder head

NOTE: These plugs may be removed with a sharp punch or they may be drilled and pried out.

CYLINDER HEAD

IMPORTANT: The QSD 2.0 cylinder head can not be reconditioned. Replace any cylinder head that does not meet specifications.

1. Measure the cylinder head deck surface flatness and compare to specification.



- a** - Feeler gauge
- b** - Machinist straight edge
- c** - Cylinder head deck

Cylinder Head		
Cylinder head deck surface flatness	Scaled deformation	0.05 mm / 100 mm (0.0020 in. / 3.9370 in.)
	Overall deformation	0.13 mm (0.00511 in.)

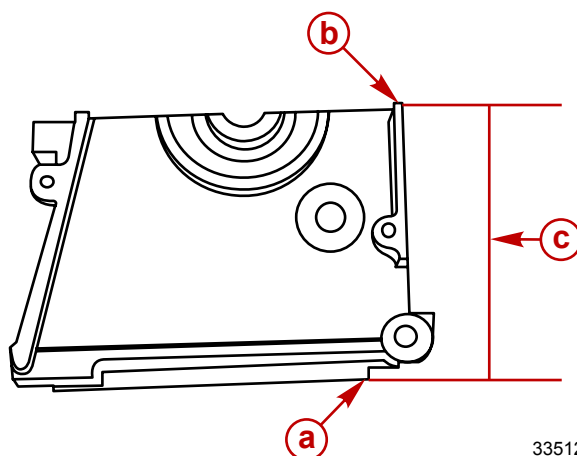
2. Measure the intake manifold mating surface deformation against specification.

Cylinder Head		
Intake manifold mating surface deformation	Scaled deformation	0.05 mm / 100 mm (0.0020 in. / 3.9370 in.)
	Overall deformation	0.13 mm (0.00511 in.)

3. Measure exhaust manifold mating surface deformation against specification.

Cylinder Head		
Exhaust manifold mating surface deformation	Scaled deformation	0.05 mm / 100 mm (0.0020 in. / 3.9370 in.)
	Overall deformation	0.13 mm (0.00511 in.)

4. Measure the cylinder head deck height against specification.

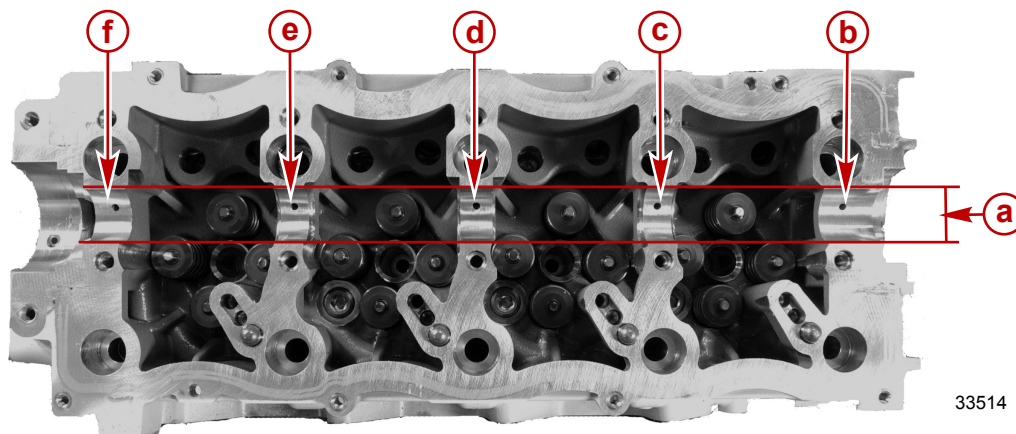


- a** - Cylinder head deck
b - Top of intake side of cylinder head
c - Deck height

33512

Cylinder Head	
Deck height	129.9 mm–130.1 mm (5.1142 in.–5.1220 in.)

5. Measure cylinder head camshaft journal diameter against specification.



33514

- a** - Journal diameter measurement
b - Journal 1
c - Journal 2
d - Journal 3
e - Journal 4
f - Journal 5

Cylinder Head	
Cylinder head camshaft journal clearance (all)	28.000 mm–28.021 mm (1.1021 in.–1.1032 in.)

6. Reference camshaft journal diameter. See **Section 3A—Camshaft**.
 7. Calculate camshaft journal clearance and compare to specification.

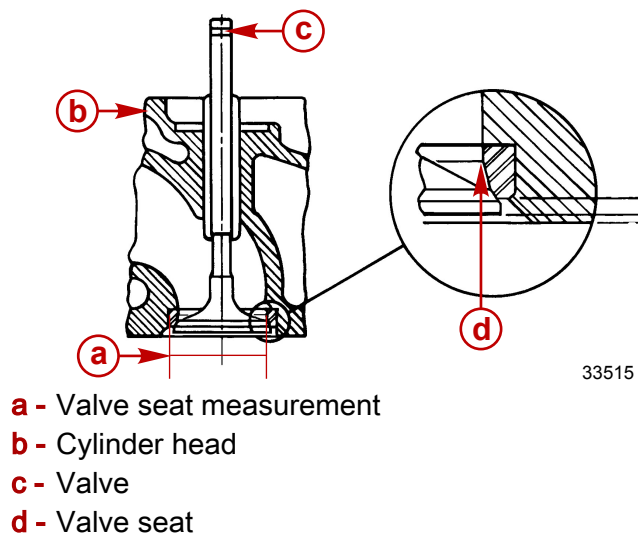
Cylinder Head	
Camshaft journal clearance (cylinder head camshaft journal diameter less camshaft journal diameter)	0.04 mm–0.074 mm (0.00157 in.–0.00291 in.)

8. The cylinder head is not repairable. Replace the cylinder head if it does not meet specification.

VALVE SEATS

IMPORTANT: The QSD 2.0 cylinder head can not be reconditioned. Replace any cylinder head that does not meet specifications.

1. Measure exhaust and intake valve seat inner diameters and compare to specification.

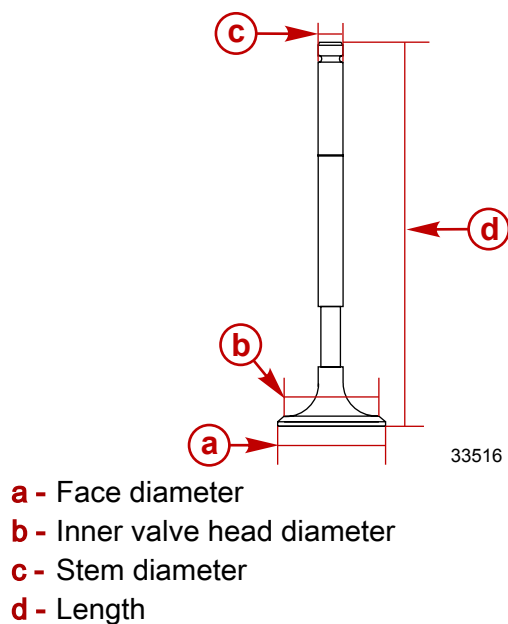


Cylinder Head		
Valve seat inner diameter	Intake	27.000 mm \pm 0.038 mm (1.0630 in. \pm 0.0015 in.)
	Exhaust	22.700 mm \pm 0.038 mm (0.8937 in. \pm 0.0015 in.)

2. Replace the cylinder head if it does not meet specification.

VALVES

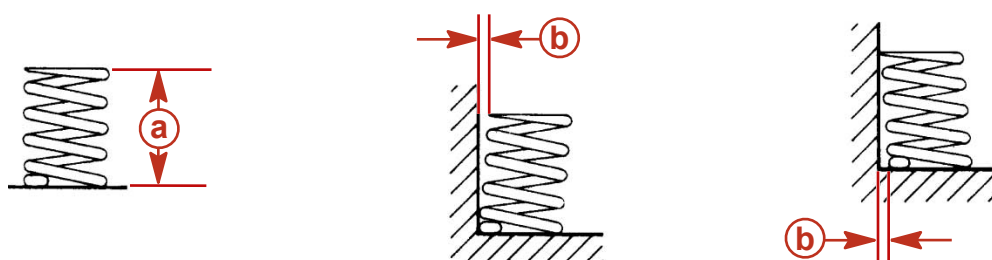
1. Inspect valves for damage, warping, or both. Replace if necessary.
2. Measure the valve. Replace the valve if it does not meet specification.



Valve Specifications		
Face diameter	Intake	28.47 mm–28.73 mm (1.1209 in.–1.1311 in.)
	Exhaust	24.27 mm–24.53 mm (0.9555 in.–0.9657 in.)
Inner head diameter	Intake	5.975 mm–6.000 mm (0.2352 in.–0.2362 in.)
	Exhaust	
Stem diameter	Intake	5.573 mm–5.953 mm (0.2194 in.–0.2344 in.)
	Exhaust	5.905 mm–5.925 mm (0.2325 in.–0.2333 in.)
Length	Intake	93.59 mm–93.61 mm (3.6846 in.–3.6854 in.)
	Exhaust	

VALVE SPRINGS

1. Inspect the valve springs for discoloration due to excessive heat.
2. Inspect the valve spring valve locks, the retainers, and the washer for wear, distortion, or cracks.
3. Measure the free standing height of each spring. Replace the valve spring if it does not meet specification.
4. Measure the valve spring inclination. Replace the valve spring if it does not meet specification.



13694

a - Free standing height

b - Spring inclination

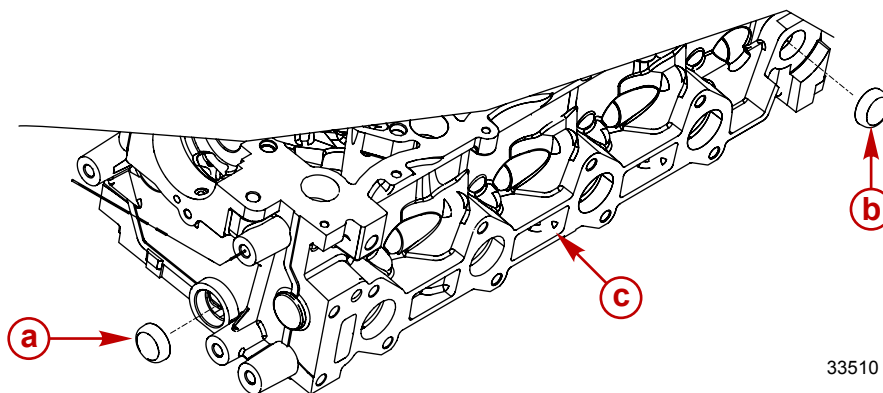
Valve Spring Specifications			
Free standing height	Intake	38.500 mm (1.5157 in.)	
	Exhaust		
Spring inclination	Intake	Service limit	Parallel
	Exhaust		

Repair


EXPANSION PLUGS

1. Apply sealant to the outer diameter of the expansion plugs.

2. Install the plugs flush to the outer surface of the cylinder head.



- a** - Rear expansion plug
b - Exhaust side expansion plug
c - Cylinder head

Tube Ref No.	Description	Where Used	Part No.
 67	Loctite 290	Outer diameter of expansion plugs	Obtain Locally

VALVE SEAT RECONDITIONING

IMPORTANT: The QSD 2.0 cylinder head can not be reconditioned. Replace any cylinder head that does not meet specifications.

VALVE RECONDITIONING

IMPORTANT: The QSD 2.0 valves can not be reconditioned. Replace any valves that do not meet specifications.

CYLINDER HEAD RESURFACING

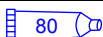
IMPORTANT: The cylinder heads on these marine diesel engines are treated with a protective nickel coating to resist corrosion and should not be resurfaced. Resurfacing will remove the nickel coating. Do not resurface the cylinder heads.

Assembly

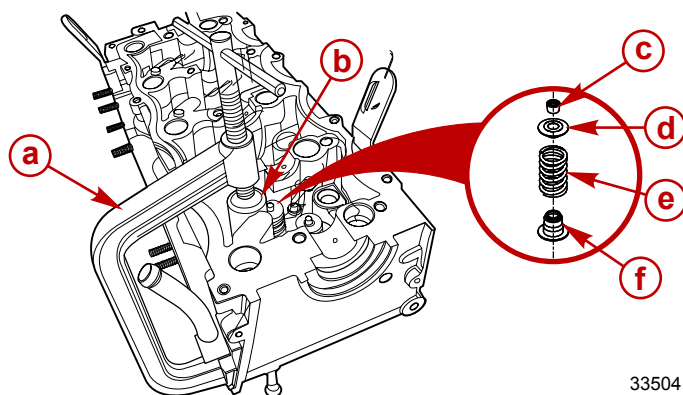
1. Install the valves.

NOTE: Install each reused valve in the port from which it was removed and new valves in the remaining ports.

- a. Lubricate the valve stems with engine oil.

Tube Ref No.	Description	Where Used	Part No.
 80	SAE Engine Oil 30W	Valve stems	Obtain Locally

- b. Install the valve stem seal.




33504

- a** - Valve spring compressor
b - Adapter
c - Valve spring retainer
d - Valve spring plate
e - Valve spring
f - Valve stem seal


- c. Install the valve spring on the valve stem.
 d. Install the valve spring plate.
 e. Using a valve spring compressor with an appropriately sized adaptor, compress the stacked valve spring components.

NOTE: Use lubricant to hold valve locks in place before releasing the compressor tool.

- f. Coat the valve spring retainer with lubricant to hold in place.

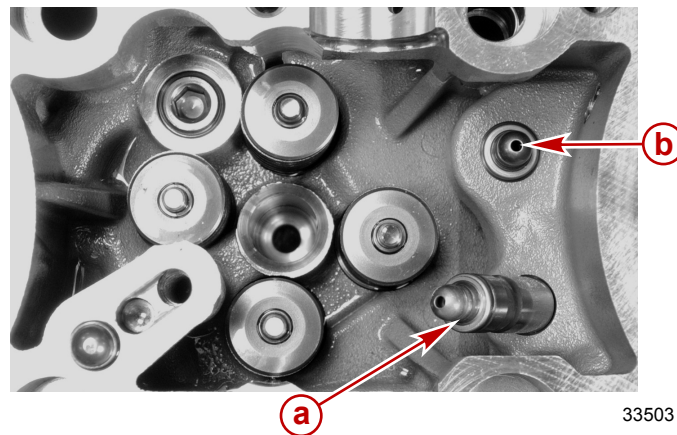
Tube Ref No.	Description	Where Used	Part No.
 4	Needle Bearing Assembly Lubricant	Valve stem locks	92-802868A 1

- g. Install the valve spring retainer.
 h. Remove the valve spring compressor.
 i. Repeat this procedure for each valve.
 2. Coat the valve lash adjusters with engine oil.

Tube Ref No.	Description	Where Used	Part No.
 80	SAE Engine Oil 30W	Valve stems	Obtain Locally

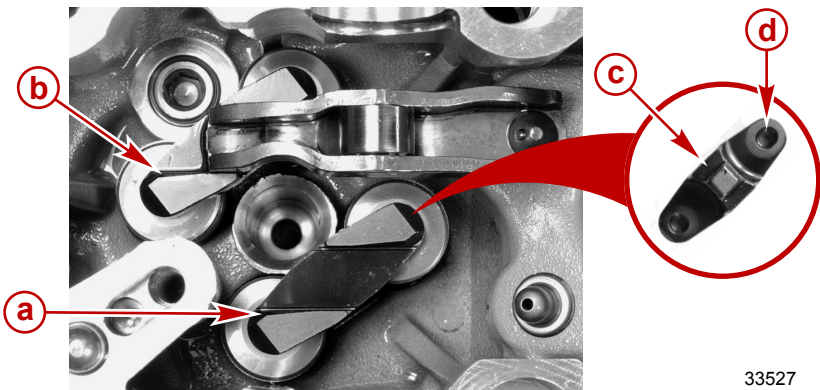
3. Install the intake and exhaust valve lash adjusters.

NOTE: Install reused valve lash adjusters into their original bores.



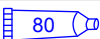
- a** - Intake valve lash adjuster
- b** - Exhaust valve lash adjuster

4. Reposition the intake and exhaust rocker arm bridges with the elongated hole oriented to the intake side of the cylinder head.



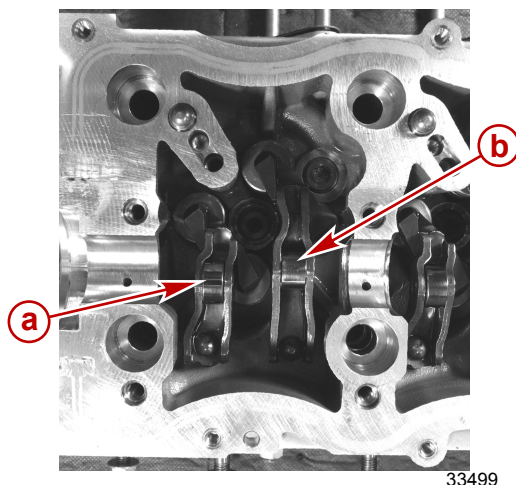
- a** - Intake rocker arm bridge
- b** - Exhaust rocker arm bridge
- c** - Underside of rocker arm bridge
- d** - Elongated hole

5. Press straight down to lock the rocker arm bridges in place.
6. Coat the intake and exhaust rocker arms with engine oil.

Tube Ref No.	Description	Where Used	Part No.
 80	SAE Engine Oil 30W	Valve stems	Obtain Locally

NOTE: Ensure that the end of the rocker arm fits into the slot machined in the rocker arm bridge.

7. Install the intake and exhaust rocker arms.



- a** - Intake rocker arm
b - Exhaust rocker arm

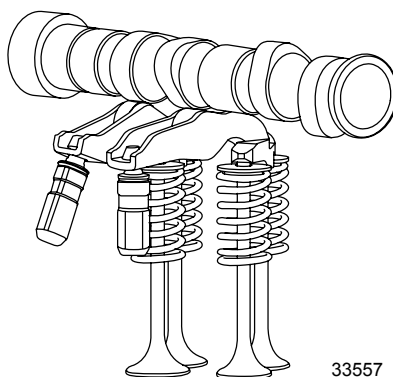
8. Install the camshaft. See **Section 3A—Camshaft**.
9. Install the cylinder head on the engine. See **Section 3A—Cylinder Head**.

CYLINDER HEAD STUDS

IMPORTANT: It is not necessary to remove the cylinder head studs unless replacing the cylinder head.

NOTE: The cylinder head studs are of varying lengths and must be installed in the correct location.

Valve Train Geometry



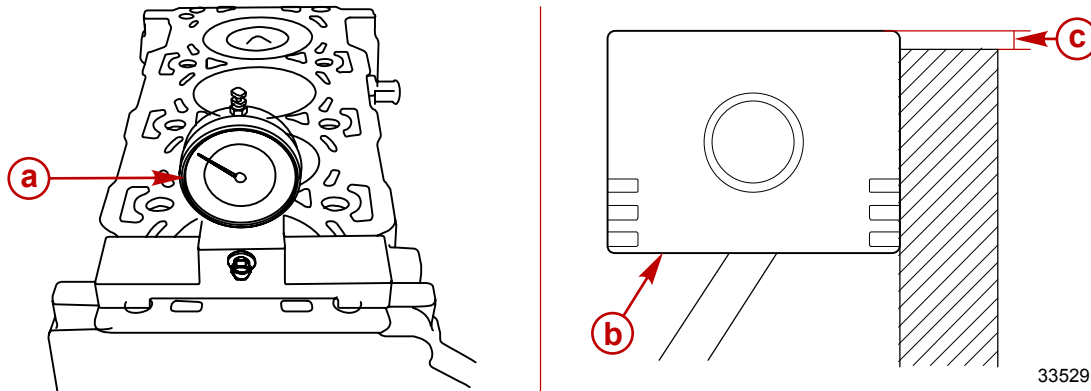
Valve train geometry

Head Gasket Selection

IMPORTANT: Use the correct head gasket. Incorrect head gasket thickness will adversely affect engine operation and may cause internal engine damage.

1. Confirm that cylinder number 1 is at top dead center (TDC). See **Section 3A—General Information**.
2. Clean the cylinder block deck and piston.

3. Measure the piston projection above the cylinder block deck with a dial gauge and record the results.



- a** - Dial gauge
b - Piston
c - Projection measurement

4. Rotate the crankshaft 180° to position the next cylinder at TDC.
5. Measure the piston projection above the cylinder block deck with a dial gauge and record the results.
6. Repeat steps four and five for each remaining cylinder.
7. Average the piston projection measurements and select the correct cylinder head gasket according to specification.

Piston Projection	Head Gasket Thickness
0.194-0.337 mm	1.1 mm
0.337-0.440 mm	1.2 mm
0.440-0.542 mm	1.3 mm

Installation

1. Clean out the cylinder head bolt holes in the cylinder block. Ensure that no contaminants (dirt, old oil or coolant) remain in the holes.

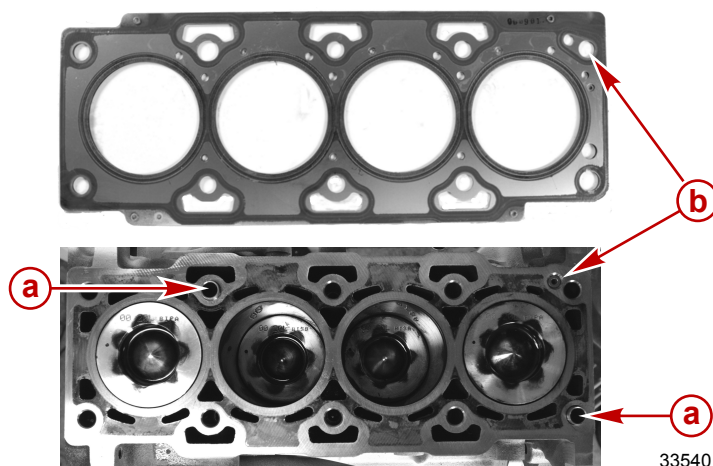
IMPORTANT: Cylinder head bolts may be installed as many as three times, then must be replaced with new bolts. Replace the cylinder head bolts if you do not know the number of times they have been used.

2. If reusing, clean the cylinder head bolt threads.
3. Clean the top of the pistons and cylinder head and block gasket surfaces.

IMPORTANT: The cylinder head gasket must be installed dry. Do not use any sealant or adhesive on the gasket.

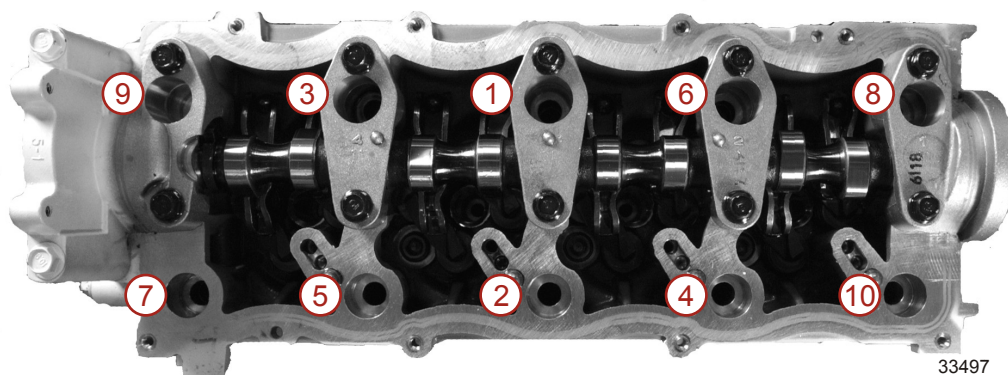
4. Select the correct thickness of cylinder head gasket. See **Section 3A—Head Gasket Selection**.

5. Position the cylinder head gasket on the engine block.



- a** - Cylinder head alignment pin
b - Vent hole block and gasket alignment

6. Position the cylinder head on the engine block. Do not disturb the positioning of the cylinder head gasket.
 7. Install and hand-tighten the cylinder head bolts.
 8. Tighten the cylinder head bolts in the illustrated sequence to the specified torque.

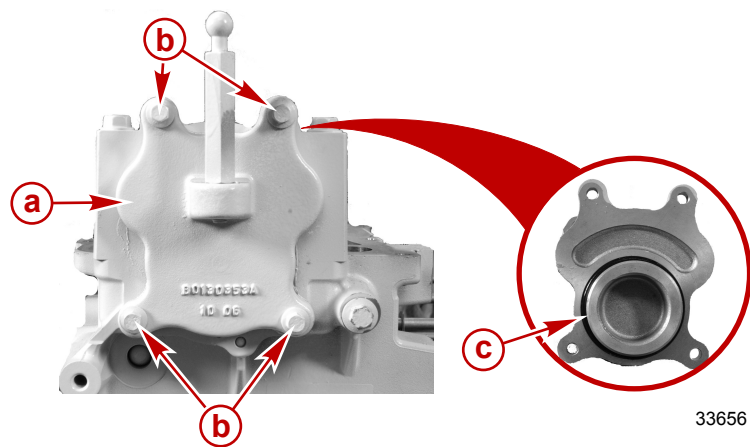


Cylinder head bolt torque sequence

Description		Nm	lb-in.	lb-ft
Cylinder head bolt	First	65	–	48
	Second	+120°		
	Final	+120°		

9. Install the engine timing belt. See **Section 3A—Engine Timing Belt and Components**.
 10. Install the rear cylinder head cover with a new O-ring.

11. Tighten the cylinder head rear cover screws to specification.



- a - Rear cylinder head cover
- b - Screw
- c - O-ring

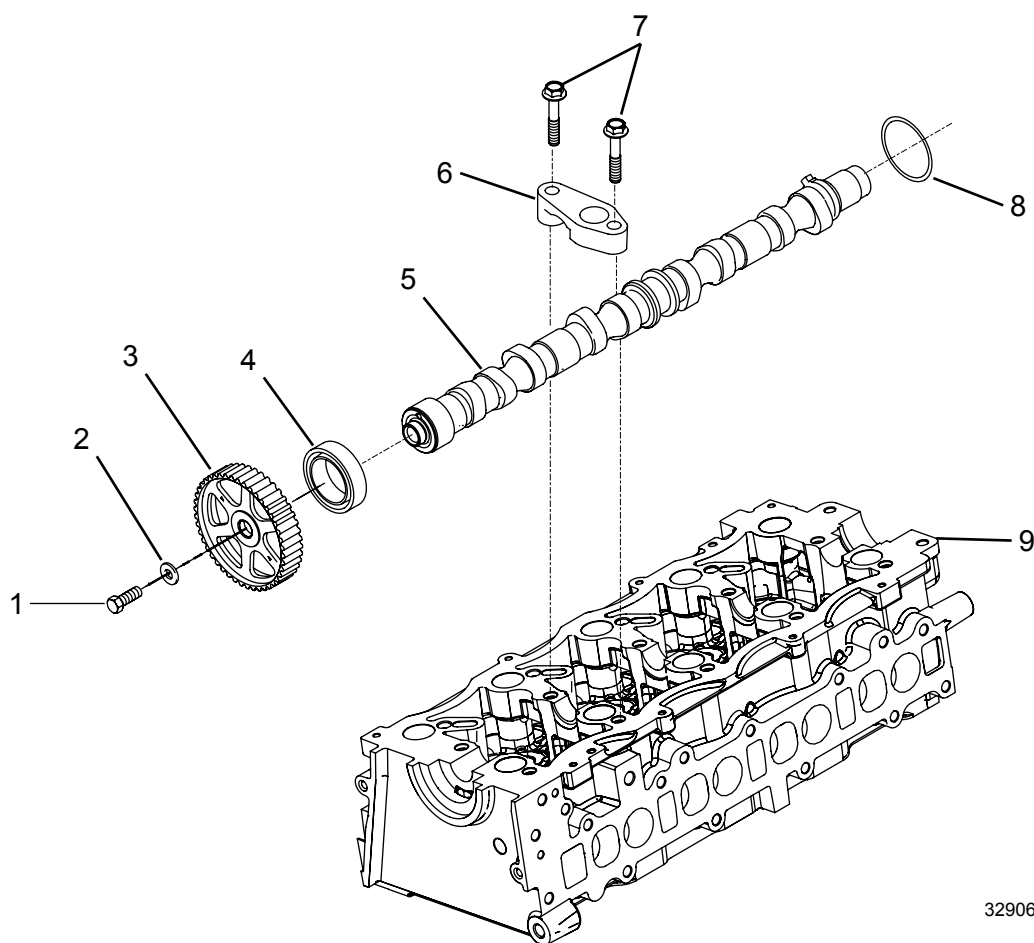
Description	Nm	lb-in.	lb-ft
cylinder head rear cover screw	10.8	96	–

12. Install the valve cover. See **Section 3A—Valve Cover**.
13. Install the intake manifold and aftercooler assembly. Refer to **Section 7A—Intake Manifold and Aftercooler Assembly**.
14. Install the exhaust manifold and fluid cooler assembly. Refer to **Section 7B—Exhaust Manifold**.
15. Complete the engine assembly.
16. Start the engine and check for any fuel or other fluid leaks.
17. Allow the engine to reach operating temperature and recheck for fuel and other fluid leaks.

Notes:

Camshaft

Exploded View—Camshaft



32906

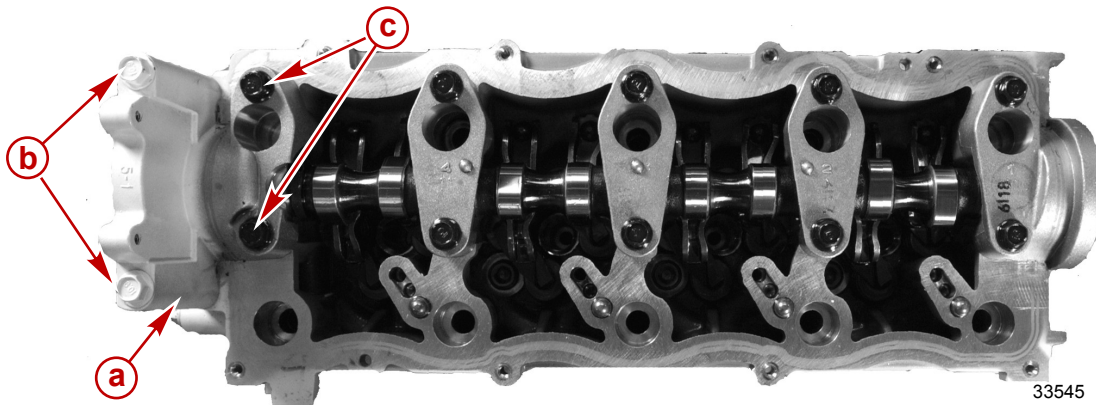
Exploded View—Camshaft

Ref. No.	Qty.	Description	Torque		
			Nm	lb–In.	lb–ft
1	1	Lockwasher			
2	1	Screw	133	–	98
3	1	Camshaft sprocket			
4	1	Seal			
5	1	Camshaft			
6	5	Camshaft cap			
7	10	Screw	28	–	21
8	1	O-ring seal			
9	1	Cylinder head			

Removal

IMPORTANT: Mark or store the components during removal for reassembly in their original location. The camshaft caps are numbered according to their installed position.

1. Remove the valve cover. See **Section 3A—Valve Cover**.
2. Remove the coolant manifold. Refer to **Section 6A—Coolant Manifold**.
3. Remove the timing belt. See **Section 3A—Engine Timing Belt and Components**.
4. Remove the camshaft timing sprocket.
5. Remove the cylinder head from the engine. See **Section 3A—Cylinder Head**.
6. Remove the rear camshaft cover and cap assembly.



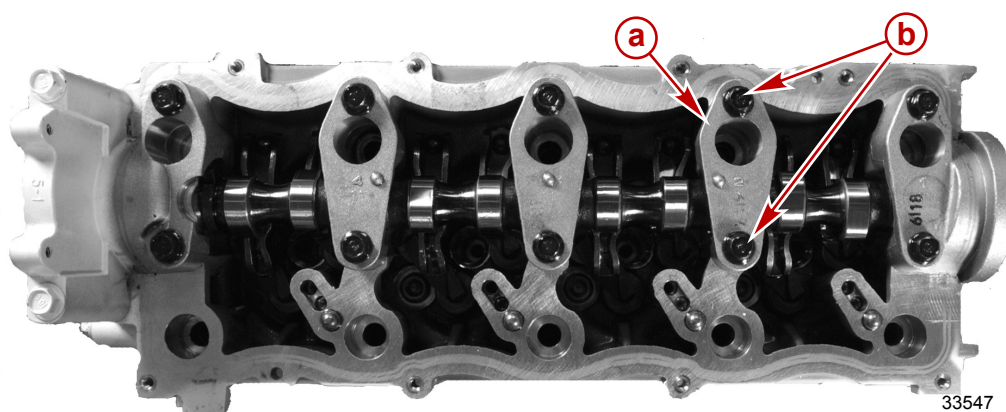
- a** - Rear camshaft cover and cap assembly
- b** - Screw
- c** - Screw

7. Remove the front camshaft cap and seal retainer assembly.



- a** - Camshaft cap and seal retainer assembly
- b** - Screw

8. Remove the three center camshaft caps.



- a** - Camshaft cap
b - Screw


9. Remove the camshaft from the cylinder head.
10. Store and service the camshaft on a clean non-marring surface.

Cleaning

1. Clean the gasket material and the sealer from the engine block and cylinder head sealing surfaces.
2. Clean all the carbon from the combustion chambers and valve ports using a carbon remover brush.
3. Clean the carbon from valves using a wire wheel.
4. Wash the cylinder head and components in a cleaning solvent.
5. Clean the cylinder head bolt threads and engine block bolt hole threads to ensure that no dirt, old oil, or coolant remain.
6. Put on safety glasses and dry the components with compressed air, including cylinder head bolt threads and engine block bolt hole threads.

Measuring Camshaft Lobe Lift

1. Remove the valve cover. See **Section 3A—Valve Cover**.
2. Remove the camshaft. See **Section 3A—Camshaft**.
3. Remove the rocker arms. See **Section 3A—Rocker Arm**.
4. Thoroughly coat the camshaft with engine oil.

Tube Ref No.	Description	Where Used	Part No.
 80	SAE Engine Oil 30W	Camshaft	Obtain Locally

5. Install the camshaft and camshaft sprocket. Do not reinstall the rocker arms. See **Section 3A—Camshaft**.
6. Secure a dial indicator to the cylinder head so the dial indicator tip rests on the lobe being measured. Adjust the dial indicator so that it will respond through the cam lobe's entire range of motion..

Dial Indicator	91-58222A1
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7. Turn the camshaft until the dial indicator tip rests on the base circle of the camshaft lobe.
8. Set the dial indicator to "0" (zero).

9. Turn the camshaft two complete revolutions while reading the dial indicator. Record the dial indicator measurement at maximum lobe lift.
10. Measure all lobes of camshaft in the same manner.
11. Replace the camshaft if it is worn below specification.

Camshaft			
Lobe lift	Production	Intake	34.501 mm (1.3583 in.)
		Exhaust	34.337 mm (1.3519 in.)

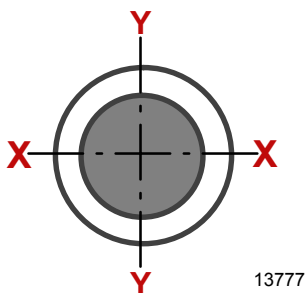
Inspection

GENERAL

1. Inspect the rocker arm contact surfaces for wear or damage.
2. Inspect the camshaft caps for wear or damage.
3. Replace any worn or damaged components.

CAMSHAFT JOURNAL DIAMETER


1. Use a micrometer to measure each camshaft journal diameter in two directions ("X-X") and ("Y-Y"). If the measured value does not fall within specification the camshaft must be replaced.



Camshaft		
Journal diameter	All	27.947 – 27.960 mm (1.1003 – 1.1008)

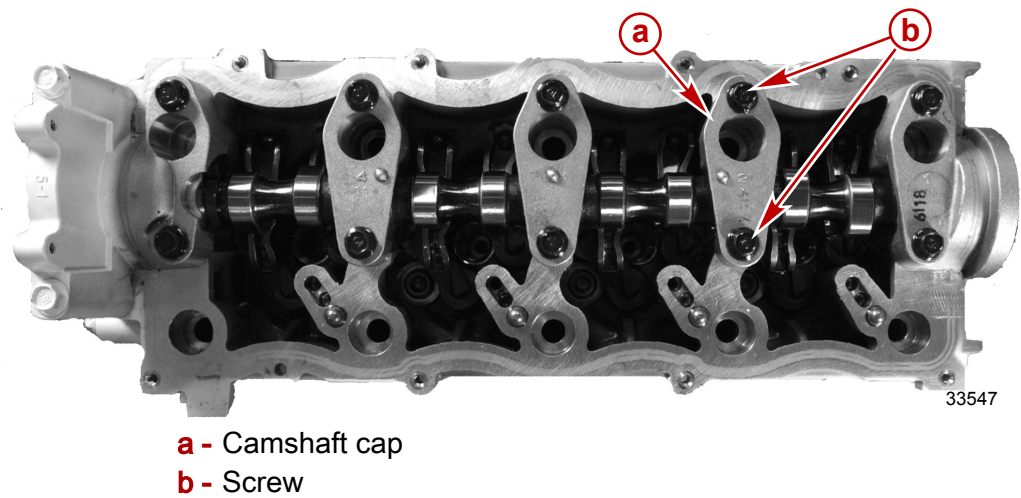
Installation

1. Coat the camshaft with engine oil.

Tube Ref No.	Description	Where Used	Part No.
 80	SAE Engine Oil 30W	Camshaft	Obtain Locally

2. Align the camshaft journals and lay the camshaft in the cylinder head.

3. Install the three center camshaft caps and hand tighten the retaining screws.

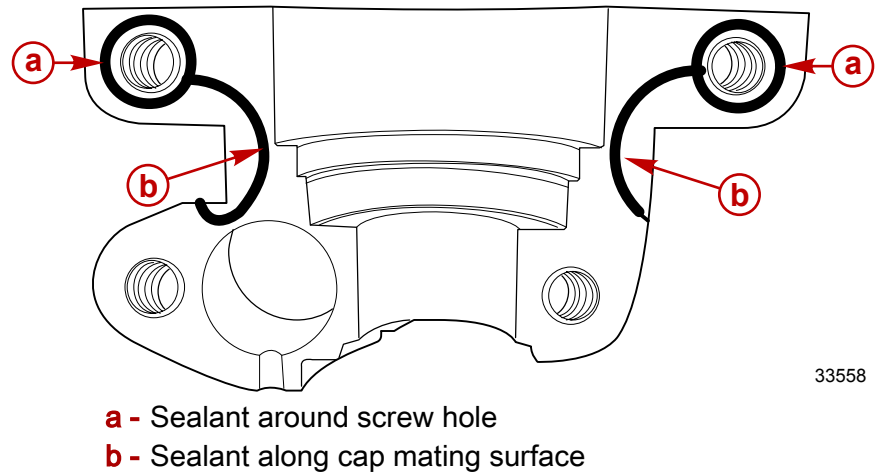



4. Tighten each of the center camshaft cap screws to specification.

Description	Nm	lb-in.	lb-ft
Camshaft cap screw	28	–	21

NOTE: Do not allow sealant to contact the camshaft cap bearing surface.

5. Apply sealant to the front camshaft cap and seal retainer assembly as indicated.



Tube Ref No.	Description	Where Used	Part No.
 12	Loctite Master Gasket Kit	Front camshaft cap	92-12564 2

6. Install the front camshaft cap and seal retainer assembly and hand tighten the retaining screws.



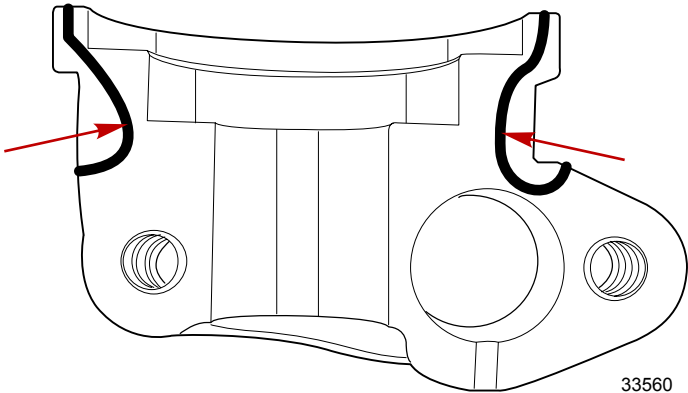
- a** - Front camshaft cap and seal retainer assembly
b - Screw

7. Tighten the front camshaft cap and seal retainer assembly screws to specification.

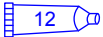
Description	Nm	lb-in.	lb-ft
Camshaft cap screw	28	–	21

NOTE: Do not allow sealant to contact the camshaft cap bearing surface.

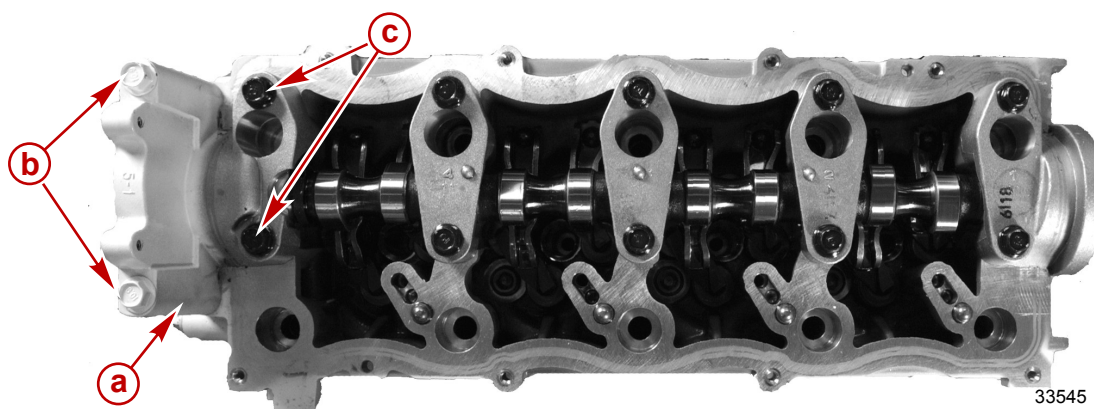
8. Apply sealant to the rear camshaft cover and cap assembly as indicated.



Sealant application

Tube Ref No.	Description	Where Used	Part No.
 12	Loctite Master Gasket Kit	Rear camshaft cap	92-12564 2

9. Install the rear camshaft cover and cap assembly and hand tighten the retaining screws.



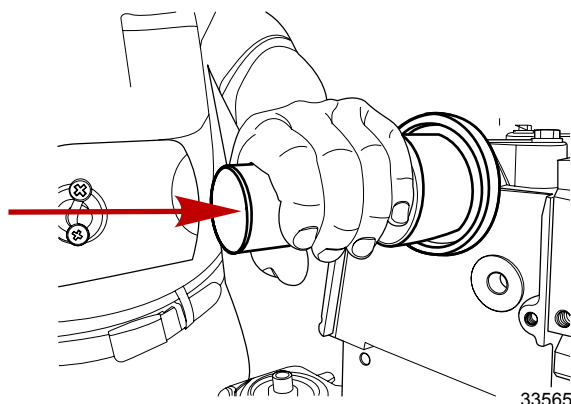
- a** - Rear camshaft cover and cap assembly
b - Screw
c - Screw

10. Tighten the rear camshaft cover and cap screws to specification.

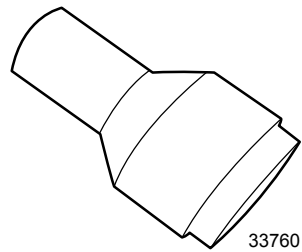
Description	Nm	lb-in.	lb-ft
Camshaft cap screw	28	–	21

11. Install the cylinder head. See **Section 3A—Cylinder Head**.

12. Install a new front camshaft seal using the camshaft oil seal installer.



Installing a new front camshaft seal

Front Camshaft oil seal installer	Part Number
	87-9150016

13. Install the camshaft timing sprocket using the washer screw.

14. Tighten the camshaft timing sprocket screw to specification.

Description	Nm	lb-in.	lb-ft
Timing sprocket screw	133	–	98

15. Install the timing belt. See **Section 3A—Engine Timing Belt and Components**.

- 16. Install the coolant manifold. Refer to **Section 6A—Coolant Manifold**.
- 17. Install the valve cover. See **Section 3A—Valve Cover**.
- 18. Check for leaks when you start the engine.

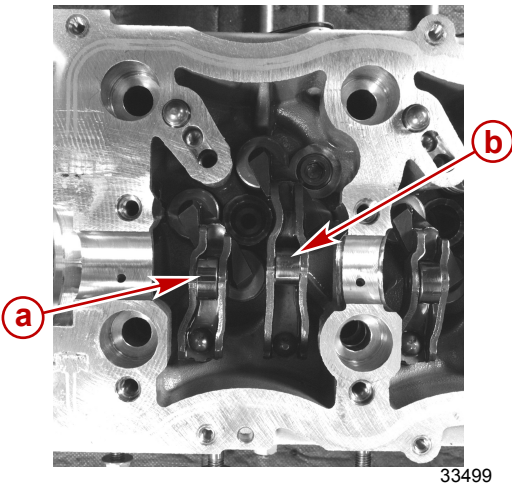
Rocker Arm

Removal

IMPORTANT: Mark or store the components during removal for reassembly in their original location.

***NOTE:** When servicing the rocker arms turn the crankshaft until cylinder number 1 piston is approximately 40°–45° before TDC.*

- 1. Remove the valve cover. See **Section 3A—Valve Cover**.
- 2. Remove the camshaft. See **Section 3A—Camshaft**.
- 3. Remove the rocker arms.



a - Intake rocker arm
b - Exhaust rocker arm

Cleaning

- 1. Put on safety glasses.
- 2. Wash the components in cleaning solvent.
- 3. Dry the components with compressed air.

Inspection

- 1. Inspect the rocker arms for excessive wear, cracks or other damage.
- 2. Inspect the roller bearing for lateral or axial runout and a grooved wear pattern.
- 3. Replace any excessively worn or damaged rocker arms.

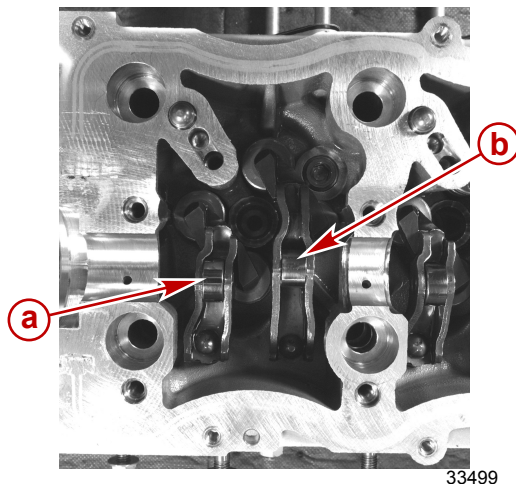
Installation

***NOTE:** When servicing the rocker arms turn the crankshaft until cylinder number 1 piston is approximately 40°–45° before TDC.*

- 1. Lightly coat the rocker arms with engine oil.

Tube Ref No.	Description	Where Used	Part No.
 80	SAE Engine Oil 30W	Valve lifter contact surfaces	Obtain Locally

2. Install the rocker arms by placing them in the slot machined into the rocker arm bridge and ensuring that the round socket is fitted over the valve lash adjuster.



- a** - Intake rocker arm
b - Exhaust rocker arm

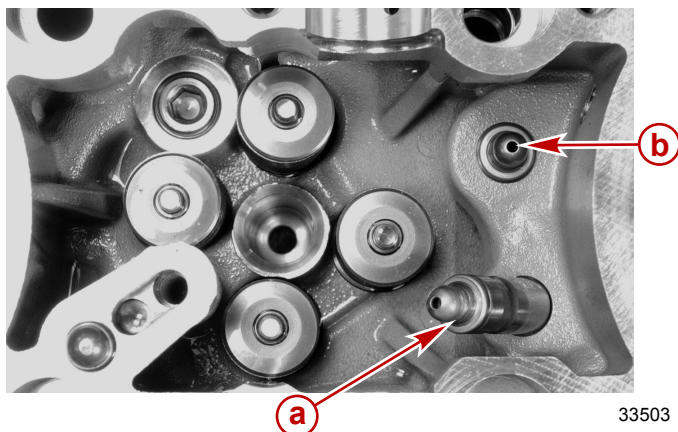
3. Install the camshaft. See **Section 3A—Camshaft**.
4. Install the valve cover. See **Section 3A—Valve Cover**.
5. Check for leaks when first operating the engine.

Valve Lash Adjusters

Removal

IMPORTANT: Mark or store the components during removal for reassembly in their original location.

1. Remove the valve cover. See **Section 3A—Valve Cover**.
2. Remove the camshaft. See **Section 3A—Camshaft**.
3. Remove the rocker arms. See **Section 3A—Rocker Arm**.
4. Remove the intake and exhaust valve lash adjusters.



- a** - Intake valve lash adjuster
b - Exhaust valve lash adjuster

Cleaning

IMPORTANT: Do not clean the camshaft with any type of abrasive.

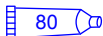
1. Put on safety glasses.
2. Clean the camshaft and camshaft caps with solvent.
3. Clean the camshaft timing sprocket bolt hole threads.
4. While wearing safety glasses, dry the camshaft and components with compressed air.

Inspection

1. Inspect the hydraulic valve lash adjusters for
 - mechanical damage or collapse.
 - bore oil supply holes for any obstruction.
 - grooves or scoring
2. Replace any hydraulic valve lash adjusters that are excessively worn or damaged.

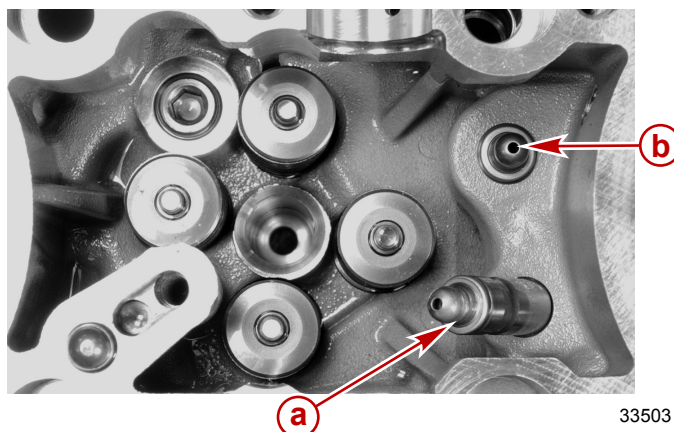
Installation

1. Coat the hydraulic valve lash adjusters with engine oil.

Tube Ref No.	Description	Where Used	Part No.
 80	SAE Engine Oil 30W	Valve lash adjusters	Obtain Locally

2. Install the intake and exhaust valve lash adjusters.

NOTE: Install reused valve lash adjusters into their original bores.



- a** - Intake valve lash adjuster
b - Exhaust valve lash adjuster

3. Install the rocker arms. See **Section 3A—Rocker Arm**.
4. Install the camshaft. See **Section 3A—Camshaft**.
5. Install the valve cover. See **Section 3A—Valve Cover**.
6. Check for leaks when first operating the engine.

Notes:

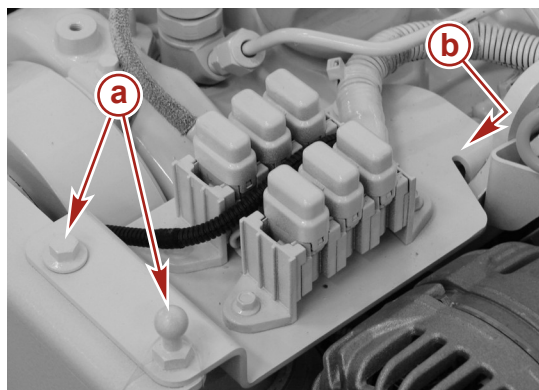


Exploded View—Timing Belt and Cover

Ref. No.	Qty.	Description	Torque		
			Nm	lb-in.	lb-ft
1	4	Screw	34	–	25
2	1	Crankshaft serpentine belt pulley			
3	1	Lower timing belt cover			
4	3	Screw	47	–	35
5	1	Front engine plate			
6	3	Screw	11	97	–
7	1	Upper timing belt cover			
8	9	Screw	11	97	–
9	1	Screw	235	–	175
10	1	Crankshaft timing belt sprocket			
11	1	Nut	86.3	–	64
12	1	Key			
13	1	High pressure fuel pump sprocket			
14	1	Back timing belt cover			
15	1	Screw	133	–	98
16	1	Flat washer			
17	1	Camshaft timing belt sprocket			
18	1	Gasket			
19	1	Water pump			
20	6	Screw	52	–	38

Removal

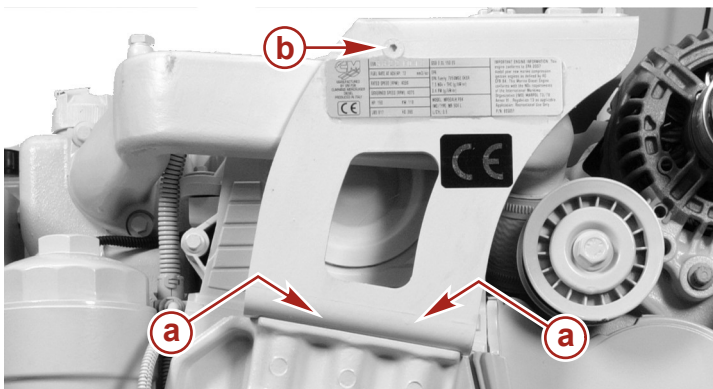
1. Remove the top engine cover. See **Section 3A—Engine Cover**.
2. **On sterndrive models:** remove the power steering pump belt. Refer to **Section 9A—Power-assisted Steering System**.
3. Remove the serpentine belt. Refer to **Section 1B—Serpentine Belt**.
4. Remove bolts attaching the the engine fuse panel to the front engine bracket and move the fuse panel aside.



33119

- a** - Screws
b - Nut and bolt

5. Remove the two screws attaching the front engine bracket to the front engine plate.

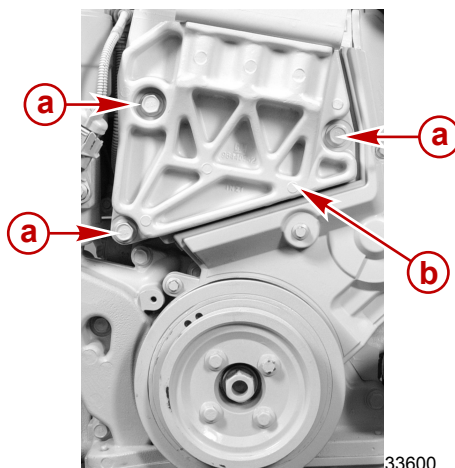


33117

- a** - Front engine bracket screws
b - Nut (on backside)

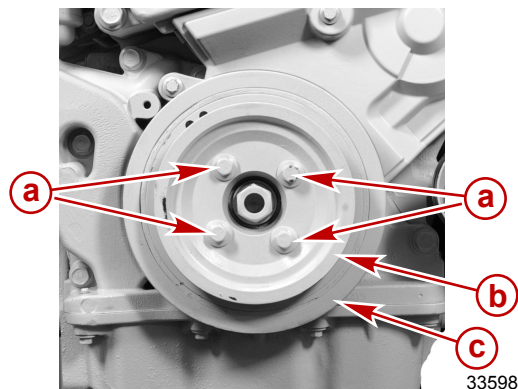
6. Remove the nut attaching the front engine bracket to the engine coolant manifold.
7. Remove the front engine bracket.

8. Remove the three screws securing the front engine plate and remove the plate.



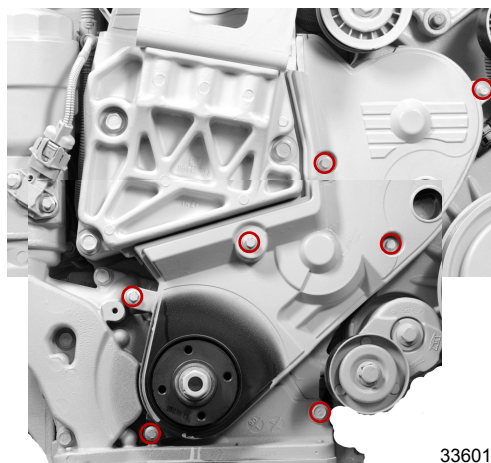
- a** - Screw
b - Front engine plate

9. Remove the four screws attaching the drive belt pulleys to the crankshaft timing belt sprocket.



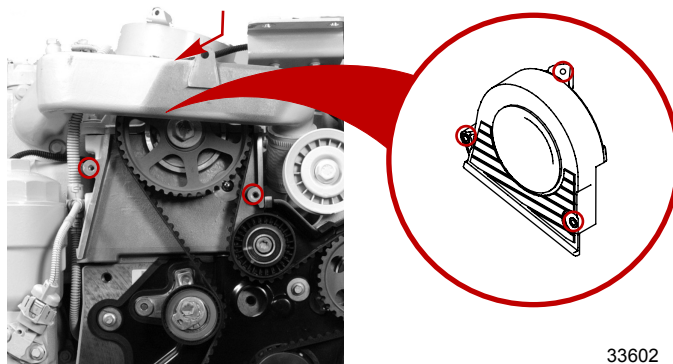
- a** - Screw
b - Accessory belt pulley (sterndrive only)
c - Serpentine belt pulley

10. Remove the seven lower timing belt cover screws and remove the lower timing belt cover.



Lower timing belt cover screws

11. Remove the three upper timing belt cover screws and remove the upper timing belt cover.



Upper timing belt cover screws

Cleaning

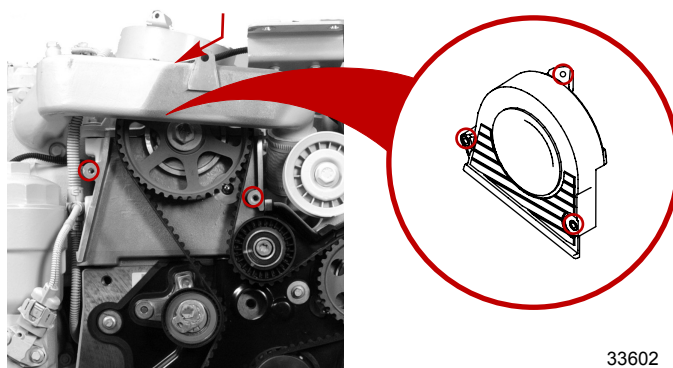
1. Put on safety glasses.
2. Clean the upper and lower timing covers with detergent and water. Rinse thoroughly and dry with compressed air.
3. Clean the crankshaft pulley contact surfaces and crankshaft nut with cleaning solvent and dry with compressed air.
4. Clean the crankshaft threads.

Inspection

1. Inspect the parts for cracks, bending, or other damage.
2. Replace as needed.

Installation

1. Install the upper timing belt cover using the three attaching screws.

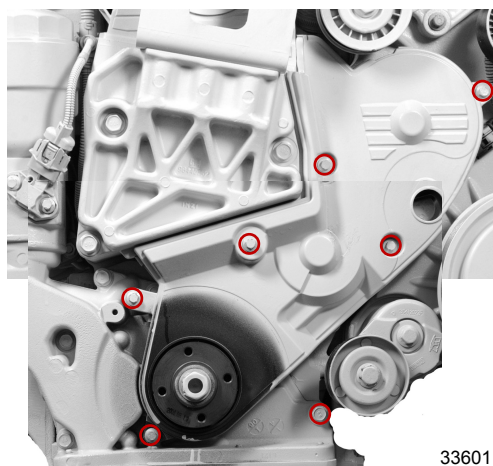


Upper timing belt cover screws

2. Tighten the upper timing belt cover screws to specification.

Description	Nm	lb-in.	lb-ft
Upper timing belt cover screw	11	97	–

3. Install the lower timing belt cover using the seven attaching screws.

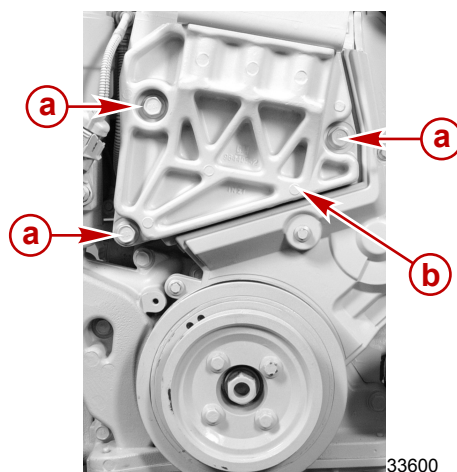


Lower timing belt cover screws

4. Tighten the lower timing belt cover screws to specification.

Description	Nm	lb-in.	lb-ft
Lower timing belt cover screw	11	97	–

5. Install the front engine plate using the three screws.



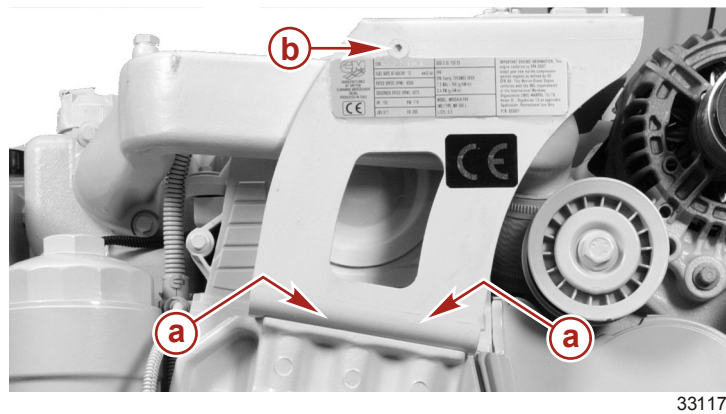
a - Screw

b - Front engine plate

6. Tighten the front engine plate screws to specification.

Description	Nm	lb-in.	lb-ft
Front engine plate screw	47	–	35

7. Attach the front engine bracket to the front engine plate.

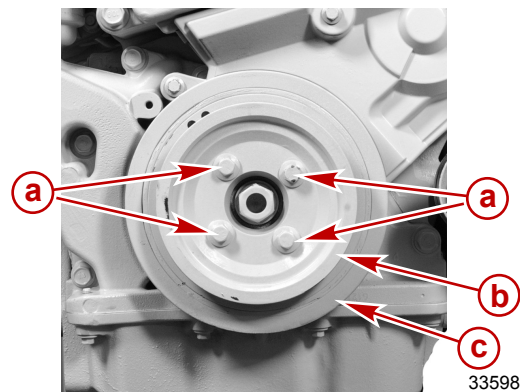


- a** - Front engine bracket screws
- b** - Nut (on backside)

8. Install the nut attaching the front engine bracket to the engine coolant manifold.
9. Tighten the front engine bracket screws and nut to specification.

Description	Nm	lb-in.	lb-ft
Front engine bracket screw	33	–	24
Front engine bracket nut	11	97	–

10. Install the four screws and the drive belt pulleys to the crankshaft timing belt sprocket.

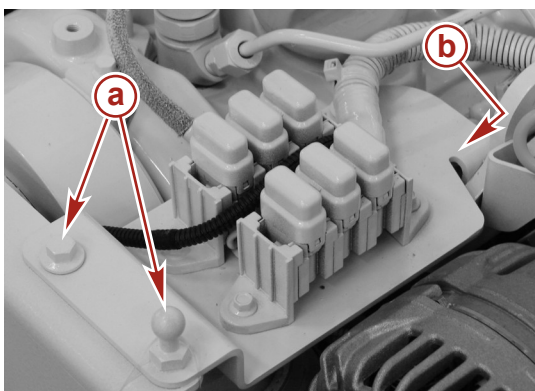


- a** - Screw
- b** - Accessory belt pulley (sterndrive only)
- c** - Serpentine belt pulley

11. Torque the crankshaft drive belt pulley screws to specification.

Description	Nm	lb-in.	lb-ft
Pulley Screw	32.4	–	24

12. Reattach the engine fuse panel to the front engine bracket.



33119

- a** - Screws
b - Nut and bolt

13. Tighten the engine fuse panel screws and nut to specification.

Description	Nm	lb-in.	lb-ft
Engine fuse panel screw	24.5	–	18
Engine fuse panel nut	10.8	96	–

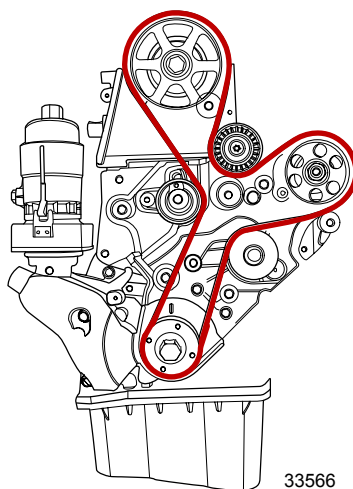
14. Install the serpentine belt. Refer to **Section 1B—Serpentine Belt**.

15. **On sterndrive models:** install the power steering pump belt. Refer to **Section 9A—Power-assisted Steering System**.

16. Install the top engine cover. See **Section 3A—Engine Cover**.

Engine Timing Belt and Components

Timing Belt Routing



33566

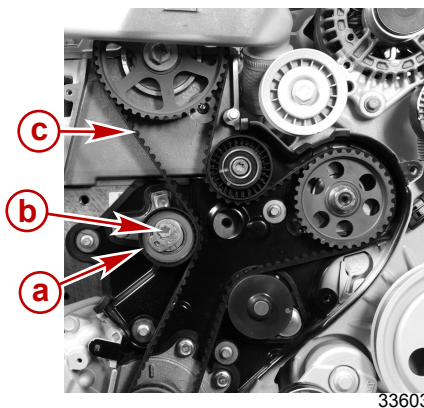
Timing belt routing

Removal

1. Disconnect the negative battery cable.
2. Set cylinder number 1 at top dead center and leave secured with the crankshaft timing tool. See **Section 3A—General Information**.

CMD Crankshaft Timing Tool	90-879150020
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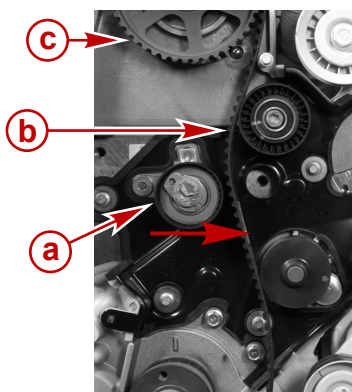
3. Remove the timing belt cover. See **Section 3A—Timing Belt Cover**.
4. Loosen the timing belt tensioner screw and allow the tensioner to rotate and relieve pressure on the belt.



33603

- a** - Tensioner pulley
- b** - Tensioner screw
- c** - Timing belt

5. Slide the timing belt over the tensioner and off of the camshaft sprocket.

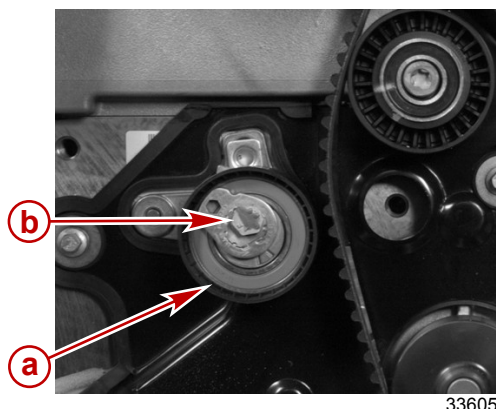


33604

- a** - Tensioner
- b** - Timing belt
- c** - Camshaft sprocket

6. Remove the timing belt.

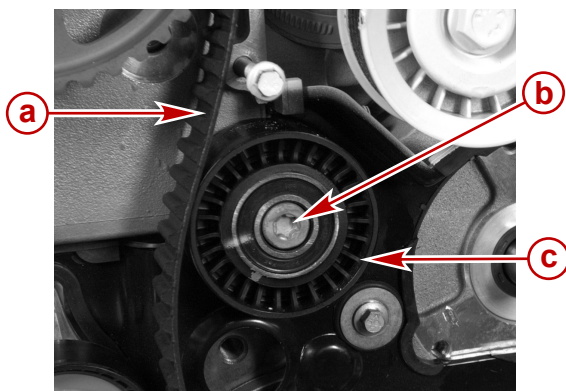
7. If service requires, remove the center screw attaching the timing belt tensioner.



33605

- a** - Tensioner pulley
b - Tensioner center screw

8. If service requires, remove the left-hand thread screw attaching the timing belt idler pulley.

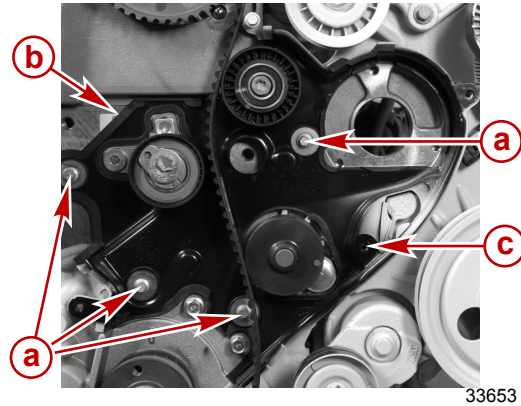


33638

- a** - Loose timing belt
b - Left-handed thread screw
c - Idler pulley

9. If service requires, remove the high pressure fuel pump sprocket. Refer to **Section 5E—High Pressure Fuel Pump**.
10. If service requires, remove the camshaft sprocket. See **Section 3A—Camshaft**.

11. If service requires, remove the four remaining screws and washers attaching the rear timing belt cover.



- a** - Screw and washer
- b** - Rear timing belt cover
- c** - Screw (removed with lower front cover)

Cleaning

IMPORTANT: Do not clean the timing belt with solvent.

1. Wear safety glasses.
2. Clean the timing belt idler and tensioner pulley assemblies with solvent. Dry with compressed air.
3. The timing belt may be wiped down with a clean cloth.
4. Clean the rear timing belt cover with warm water and detergent. Dry with compressed air.

Inspection

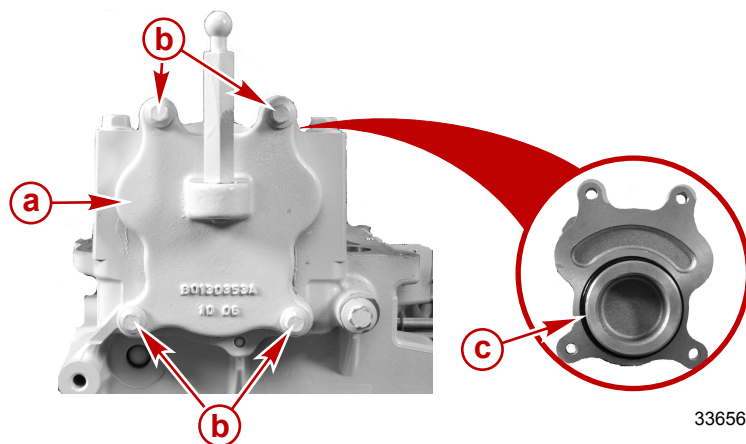
1. Inspect the idler pulley assembly for a worn or damaged pulley, thrust washer, and bearing.
2. Inspect the timing belt tensioner assembly for a worn or damaged pulley and bearing.
3. Confirm timing belt tensioner mechanism operation.
4. Inspect the rear timing belt cover for damage.
5. Replace worn or damaged components.

Installation

IMPORTANT: The crankshaft and camshaft timing tools must be used to properly time the engine during timing belt installation.

1. Confirm that the engine crankshaft timing tool is installed to position cylinder number one at top dead center. See **Section 3A—General Information**.

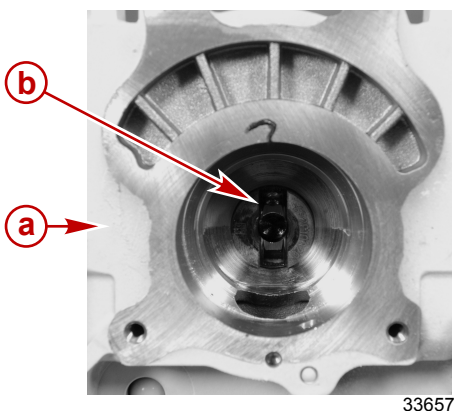
2. If not previously done, remove the rear cylinder head cover from the cylinder head and discard the O-ring seal. See **Section 3A—Cylinder Head**.



- a** - Rear cylinder head cover
- b** - Screw
- c** - O-ring seal

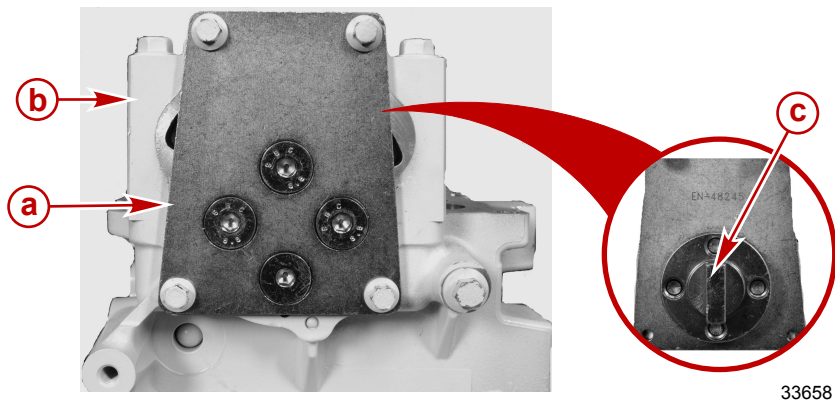
IMPORTANT: Align the timing slot machined in the camshaft vertically to properly engage the camshaft timing tool.

3. Use the timing marks made prior to disassembly to roughly position the camshaft in preparation for installing the camshaft timing tool.

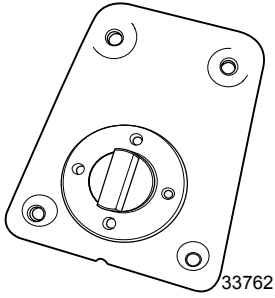


- a** - Rear of cylinder head
- b** - Camshaft timing slot (aligned vertically)

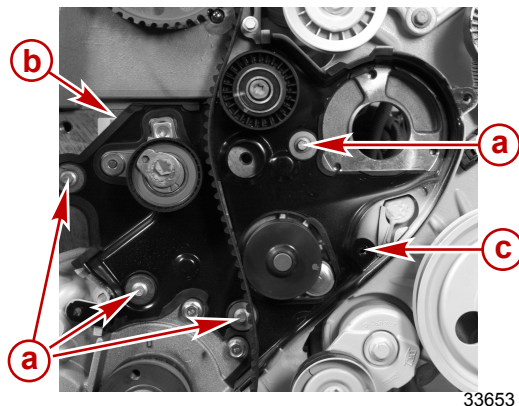
4. Install the camshaft timing tool on to the rear of the cylinder head using the rear cylinder head cover screws.



- a** - Camshaft timing tool
b - Rear of cylinder head
c - Tool alignment key

Camshaft timing tool	Part Number
	87-9150021

5. If previously removed, install the rear timing belt cover with the screws as indicated.



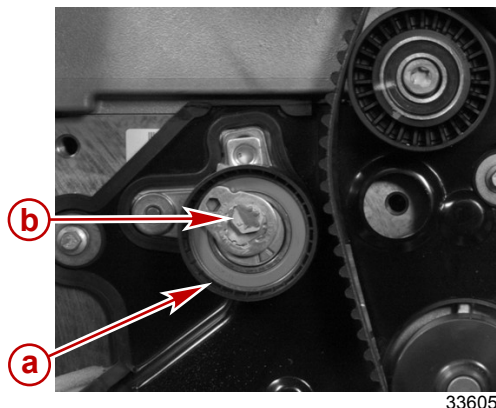
- a** - Screw and washer
b - Rear timing belt cover
c - Screw (install with lower front cover)

6. Tighten the rear timing belt cover to specification.

Description	Nm	lb-in.	lb-ft
Rear timing belt cover screw	11	97	—

NOTE: Timing belt tension is maintained by fully tightening the tensioner screw after timing belt installation and tensioner adjustment.

7. If previously removed, install the timing belt tensioner. Do not tighten the tensioner screw at this time.

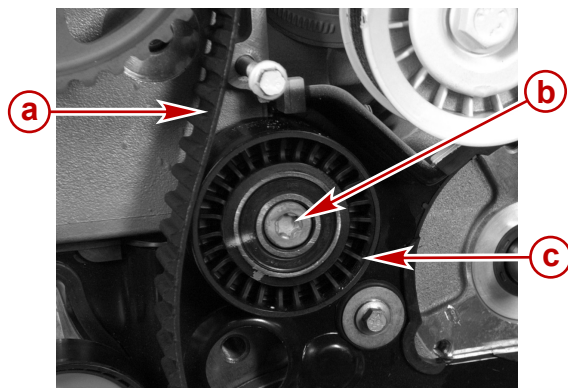


33605

- a** - Tensioner pulley
b - Tensioner center screw

NOTE: The timing belt idler pulley attaching screw has a left-hand thread.

8. If previously removed, install the timing belt idler pulley.

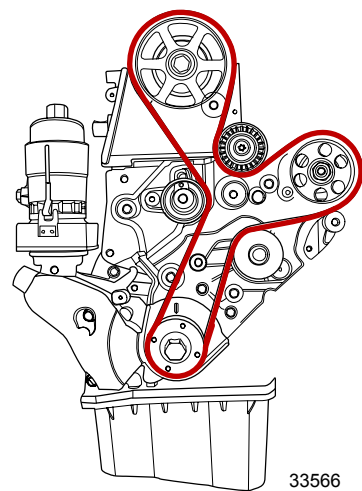


33638

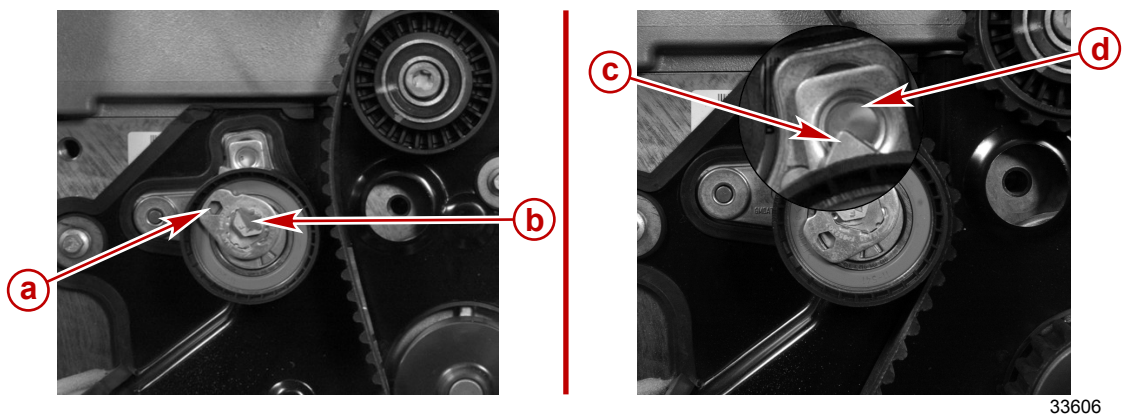
- a** - Loose timing belt
b - Left-handed thread screw
c - Idler pulley

9. If previously removed, install the high pressure fuel pump sprocket. Refer to **Section 5E—High Pressure Fuel Pump**.
10. If previously removed, install the camshaft sprocket. See **Section 3A—Camshaft**.

11. Route the timing belt as indicated.



12. Place the correct size Allen wrench into the timing belt tensioner adjustment hole and an appropriate wrench or socket drive on the tensioner attaching screw.
13. Rotate the tensioner clockwise by turning the Allen wrench inserted into the tensioner adjustment hole until the tensioner pointer is as close to the middle of the adjustment window as possible. Hold this position and tighten the tensioner attaching screw.



Tools not shown to maintain clarity

- a** - Adjustment hole
- b** - Attaching screw
- c** - Pointer
- d** - Adjustment window

14. Tighten the timing belt tensioner attaching screw to specification.

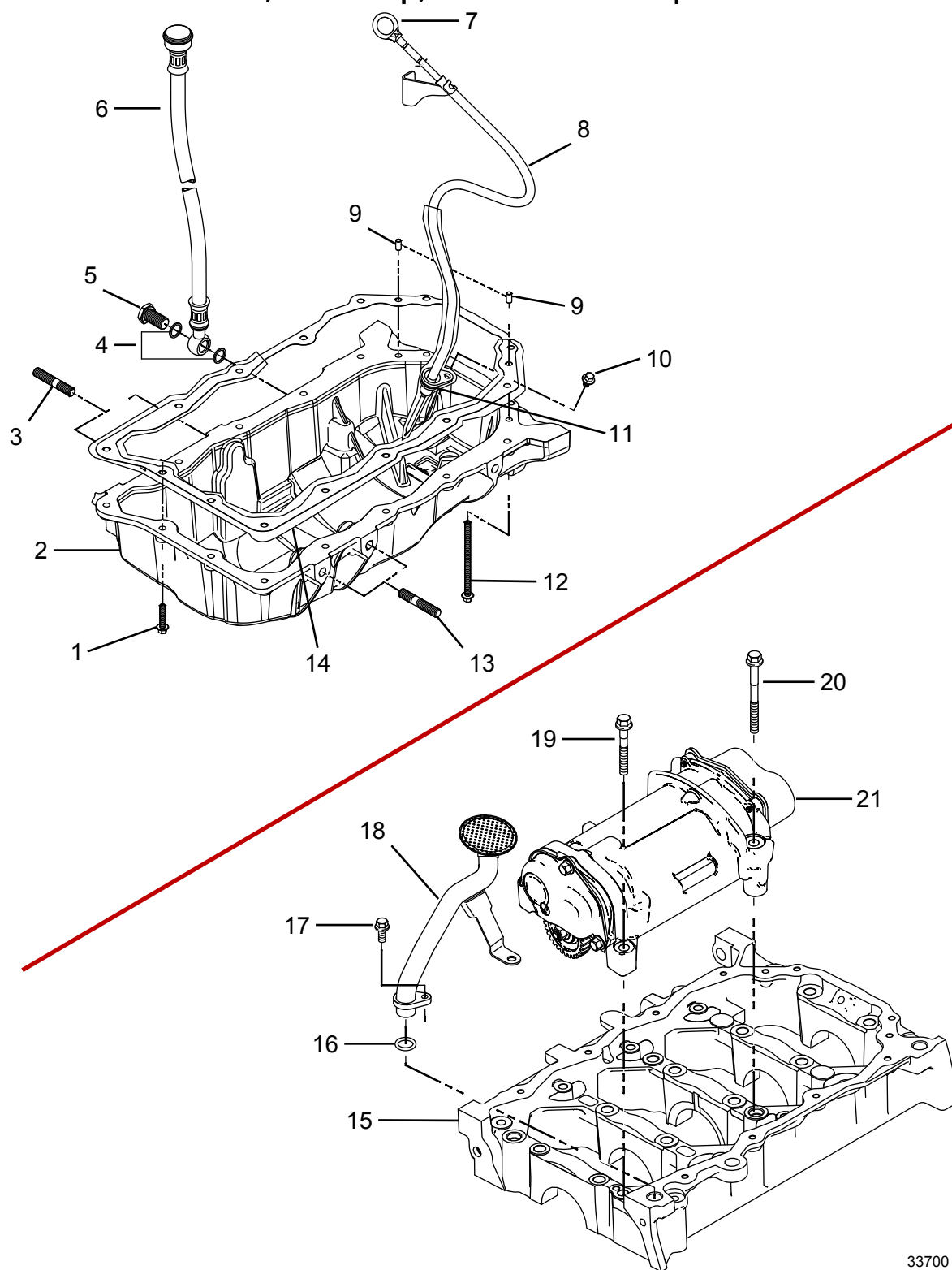
Description	Nm	lb-in.	lb-ft
Timing belt tensioner attaching screw	25	–	18

15. Install the timing belt cover. See **Section 3A—Timing Belt Cover**.
16. Reinstall and connect any other components disturbed during service.
17. Confirm proper engine operation and performance before returning the vessel to full operation.

Notes:

Oil Pan, Oil Pickup, and Related Components

Exploded Views—Oil Pan, Oil Pickup, And Related Components



33700

Exploded Views—Oil Pan, Oil Pickup, And Related Components

Ref. No.	Qty.	Description	Torque		
			Nm	lb-in.	lb-ft
1	12	Screw	11	97	–
2	1	Oil Pan			
3	4	Stud			
4	2	Sealing washer			
5	1	Hollow bolt	16.7	147	–
6	1	Oil drain hose			
7	1	Dipstick			
8	1	Dipstick tube			
9	2	Pin			
10	1	Screw	11	97	–
11	1	O-Ring			
12	2	Screw	24	–	18
13	4	Stud			
14	1	Oil pan gasket			
15	1	Engine bed plate			
16	1	O-ring			
17	1	Screw	11	97	–
18	1	Oil pickup assembly			
19	2	Screw	55	–	41
20	2	Screw	55	–	41
21	1	Engine balancer			

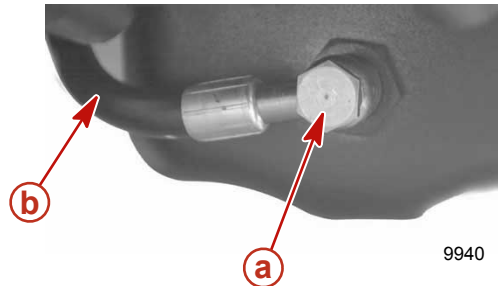
Removal

OIL DIPSTICK AND TUBE

1. Drain or pump the oil out of the engine. Refer to **Section 1B—Engine Oil**.
2. Remove the engine oil dipstick.
3. Remove the dipstick tube nut and bolt from the engine fuse panel.
4. Remove attaching screw and dipstick tube.

OIL DRAIN HOSE

1. Ensure that the engine oil has been drained.
2. Remove the hollow bolt with sealing washers and disconnect the oil drain hose from the oil pan.

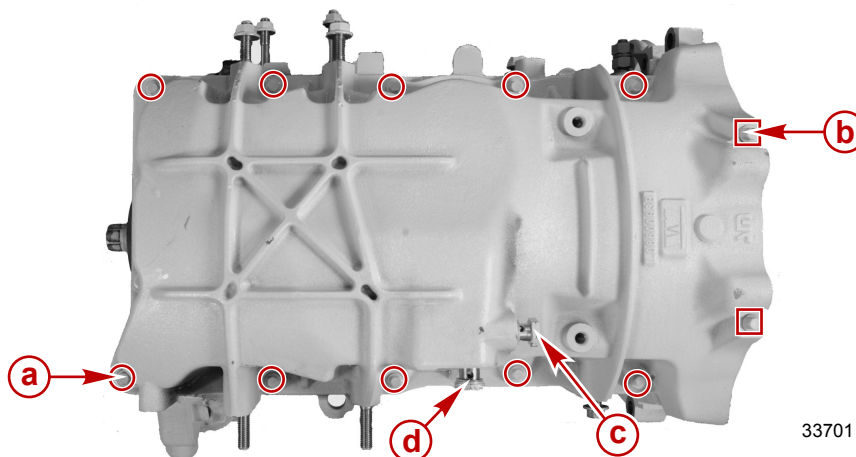


a - Hollow bolt with sealing washers **b** - Oil drain hose

3. Remove the J-clip anchoring the oil drain hose to the engine.
4. Remove the oil drain hose and fitting.

OIL PAN

1. Ensure that the engine oil has been drained.
2. Remove the oil separator vent hose from the oil pan. See **Section 3A—Oil Separator and Vent System**.
3. Remove the left and right side front engine mount brackets. See **Section 3A—Engine Mounts and Brackets**.
4. Remove the oil pan screws.

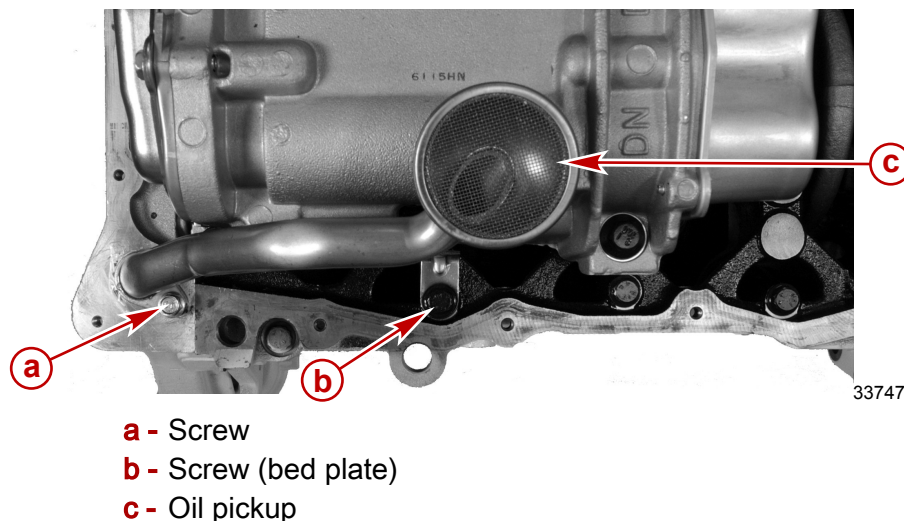


a - Oil pan screw (short)
b - Oil pan screw (long)
c - Oil drain fitting
d - Oil separator fitting

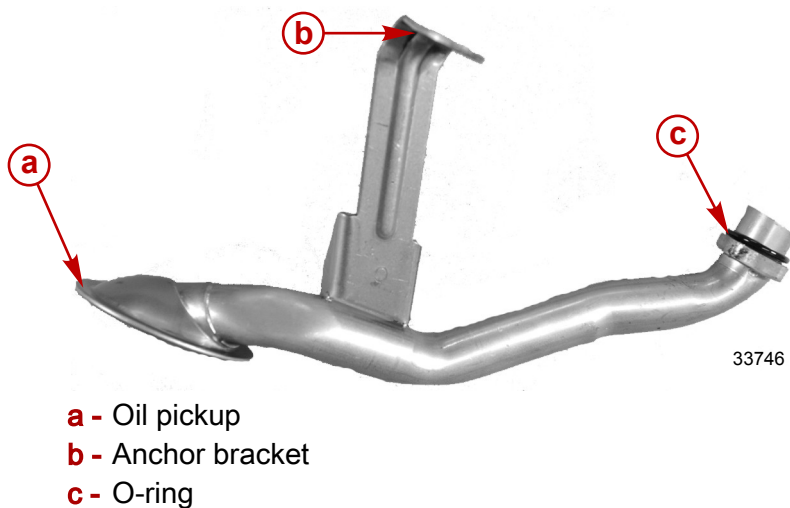
5. Remove the oil pan.
6. Remove the oil pan gasket and discard.

OIL PICKUP

1. Remove the oil pickup tube and strainer mounting screws.



2. Remove the oil pickup tube and strainer.
3. Remove and discard the oil pickup tube O-ring.



Cleaning

1. Clean the cylinder block bolt holes to ensure that no dirt or oil remain.
2. Clean the sealer from cylinder block and oil pan flange sealing surfaces.
3. Wash the non-rubber parts in cleaning solvent (rubber parts can be damaged by cleaning solvents).
4. Put on safety glasses and dry the parts with compressed air, including the cylinder block bolt holes.
5. Clean the pick up tube seat in the cylinder block.
6. Clean the dipstick tube seat in the cylinder block.

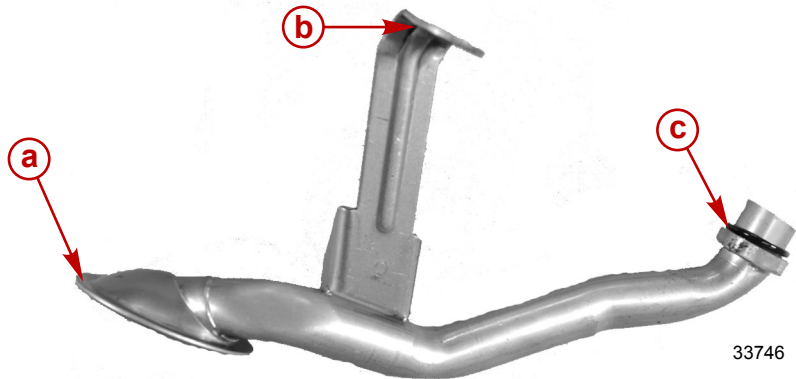
Inspection

1. Inspect the components for fatigue cracks or damage.

- 2. Check all welds for leaks.
- 3. Replace parts if necessary.

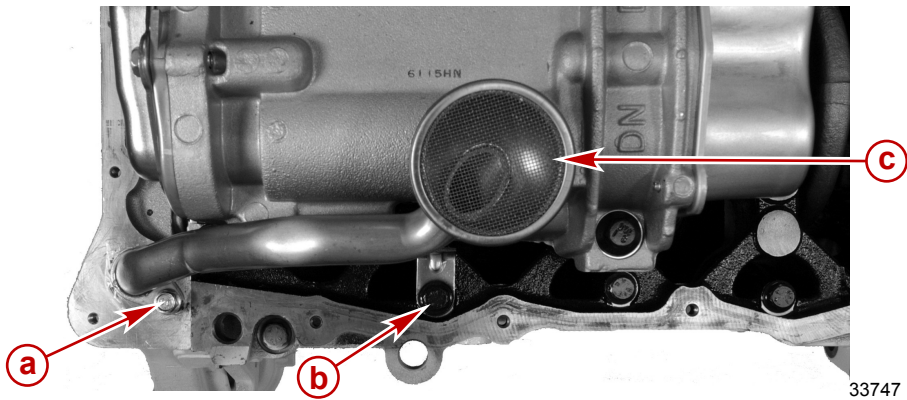
Installation
OIL PICKUP

- 1. Install a new O-ring on the oil pickup tube.



- a - Oil pickup
- b - Anchor bracket
- c - O-ring

- 2. Install the oil pickup tube and strainer.



- a - Screw
- b - Screw (bed plate)
- c - Oil pickup

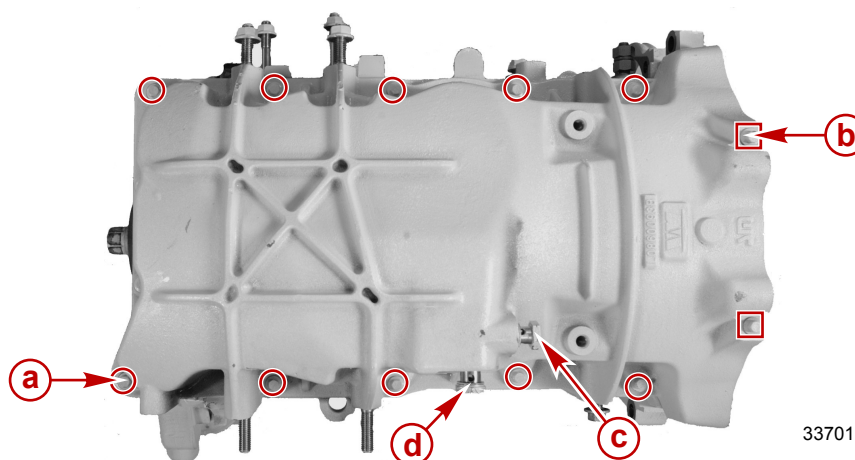
- 3. Tighten the oil pickup tube and strainer mounting screws to specification.

Description	Nm	lb-in.	lb-ft
Oil pickup tube and strainer screw	11	97	–
Oil pickup tube bracket screw	35	–	26

OIL PAN

- 1. Position a new oil pan gasket.

2. Install the oil pan and hand tighten the oil pan screws.



- a** - Oil pan screw (short)
- b** - Oil pan screw (long)
- c** - Oil drain fitting
- d** - Oil separator fitting

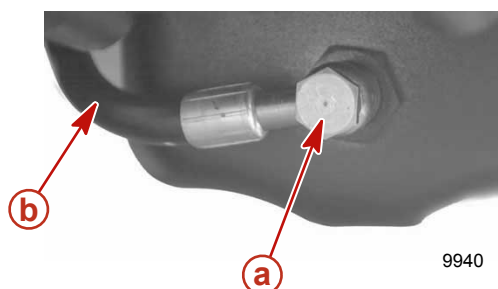
3. Tighten the oil pan screws to specification.

Description	Nm	lb-in.	lb-ft
Oil pan screw	11	97	–

4. Install the left and right side front engine mount brackets. See **Section 3A—Engine Mounts and Brackets**.
5. Install the oil separator vent hose. See **Section 3A—Oil Separator and Vent System**.

OIL DRAIN HOSE

1. Install the oil drain hose and fitting with new sealing washers.



- a** - Hollow bolt with sealing washers
- b** - Oil drain hose

2. Tighten the hollow bolt fitting to specification.

Description	Nm	lb-in.	lb-ft
Hollow bolt	24.5	–	18

3. Install the J-clip anchoring the oil drain hose to the engine and tighten securely.

OIL DIPSTICK AND TUBE

1. Install a new O-ring on the engine oil dipstick tube.
2. Position the oil dipstick tube and press into block.
3. Install the screw attaching the dipstick tube to the block.

4. Tighten the screw attaching the dipstick tube to the block to specification.

Description	Nm	lb-in.	lb-ft
Dipstick tube screw	11	97	–

5. Install the nut and bolt attaching the dipstick tube to the engine fuse panel.

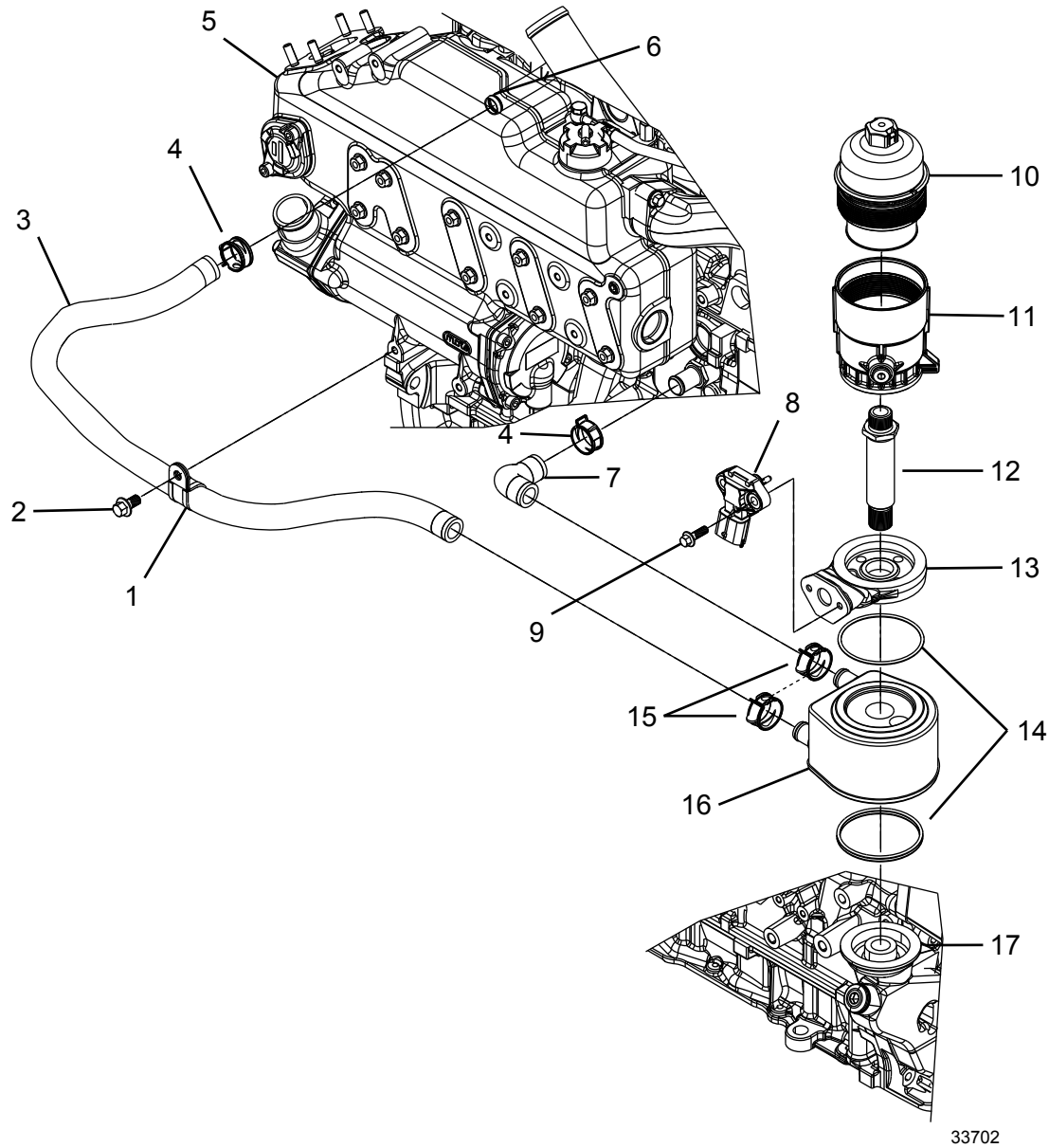
Description	Nm	lb-in.	lb-ft
Dipstick tube nut	11	97	–

6. Fill the engine with oil. Refer to **Section 1B—Engine Oil**.

Notes:

Oil Filter and Coolant Oil Cooler Assembly

Exploded View—Oil Filter and Coolant Oil Cooler



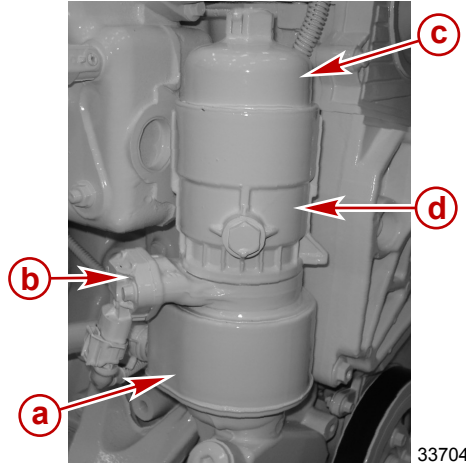
Exploded View—Oil Filter and Coolant Oil Cooler

Ref. No.	Qty.	Description	Torque		
			Nm	lb-in.	lb-ft
1	1	J-clamp			
2	1	Screw	12	98	–
3	1	Coolant supply hose			
4	2	Spring clamp			
5	1	Heat exchanger and exhaust manifold assembly			
6	1	Coolant supply pipe			
7	1	Coolant return hose			
8	1	Oil pressure and temperature sensor			
9	1	Screw	5.6	50	–
10	1	Oil filter housing cover	22.5	–	16
11	1	Oil filter housing	35	–	26
12	1	Oil feed pipe	60	–	44
13	1	Adaptor			
14	2	O-ring seal			
15	2	Spring clamp			
16	1	Oil cooler			
17	1	Engine block			

Removal

IMPORTANT: Catch or contain any oil and coolant that leaks or spills during service.

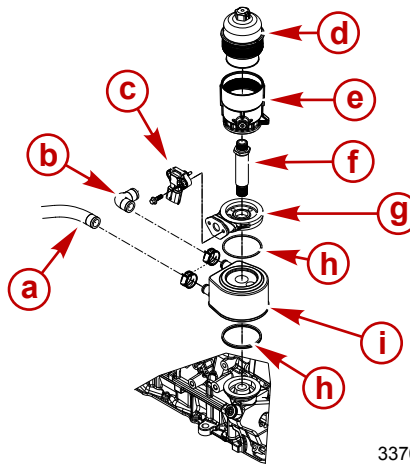
1. Disconnect the engine oil pressure and temperature sensor connector.



33704

- a** - Oil cooler
- b** - Engine oil pressure and temperature sensor
- c** - Cover
- d** - Oil filter housing

2. Remove the engine oil pressure and temperature sensor.
3. Remove the coolant supply hose from the oil cooler.



33705

- a** - Coolant supply hose
- b** - Coolant return hose
- c** - Engine oil pressure and temperature sensor
- d** - Cover
- e** - Oil filter housing
- f** - Oil feed pipe
- g** - Adapter
- h** - O-ring
- i** - Oil cooler
- j** - O-ring

4. Remove the coolant return hose from the oil cooler.
5. Position both hoses to minimize coolant loss.
6. Remove the oil filter housing cover and oil filter.
7. Turn the oil filter housing by hand counter clockwise to remove it from the oil feed pipe.
8. Remove the oil feed pipe with an appropriately sized wrench.

9. Lift off the oil filter housing adapter. Remove and discard the O-ring seal.
10. Lift off the oil cooler. Remove and discard the O-ring seal.

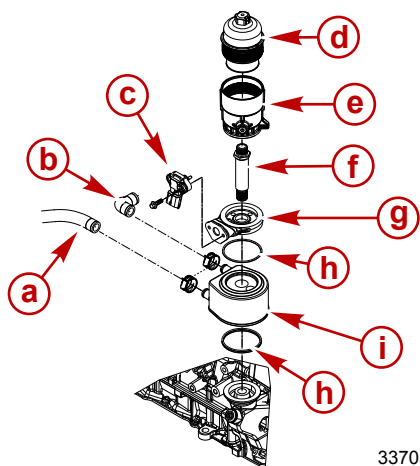
Cleaning And Inspection

1. Clean all sealing surfaces.
2. Inspect each part for cracks or other damage which would render it unserviceable.

Installation

IMPORTANT: Catch or contain any oil and coolant that leaks or spills during service.

1. Install the oil cooler with a new O-ring on the engine block

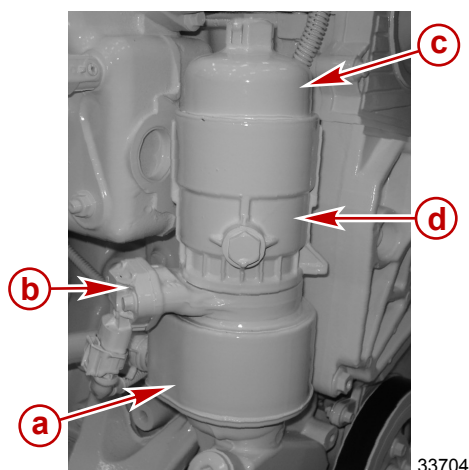


- | | |
|---|--------------------------|
| a - Coolant supply hose | f - Oil feed pipe |
| b - Coolant return hose | g - Adapter |
| c - Engine oil pressure and temperature sensor | h - O-ring |
| d - Cover | i - Oil cooler |
| e - Oil filter housing | j - O-ring |

2. Install the oil filter housing adapter with a new O-ring.
3. Install the oil feed pipe with an appropriately sized wrench.
4. Tighten the oil feed pipe to specification.

Description	Nm	lb-in.	lb-ft
Oil feed pipe	60	—	44

5. Turn the oil filter housing by hand clockwise to remove it from the oil feed pipe.



- a** - Oil cooler
b - Engine oil pressure and temperature sensor
c - Cover
d - Oil filter housing

6. Tighten the oil filter housing to specification.

Description	Nm	lb-in.	lb-ft
Oil filter housing	35	–	26

7. Install a new oil filter.
 8. Install the oil filter housing cover.
 9. Tighten the oil filter housing cover to specification.

Description	Nm	lb-in.	lb-ft
Oil filter housing cover	22.5	–	16

10. Install the coolant return hose to the oil cooler and secure with a spring clamp.
 11. Install the coolant supply hose to the oil cooler and secure with a spring clamp.
 12. Install the engine oil pressure and temperature sensor and screw.
 13. Tighten the engine oil pressure and temperature sensor screw to specification.

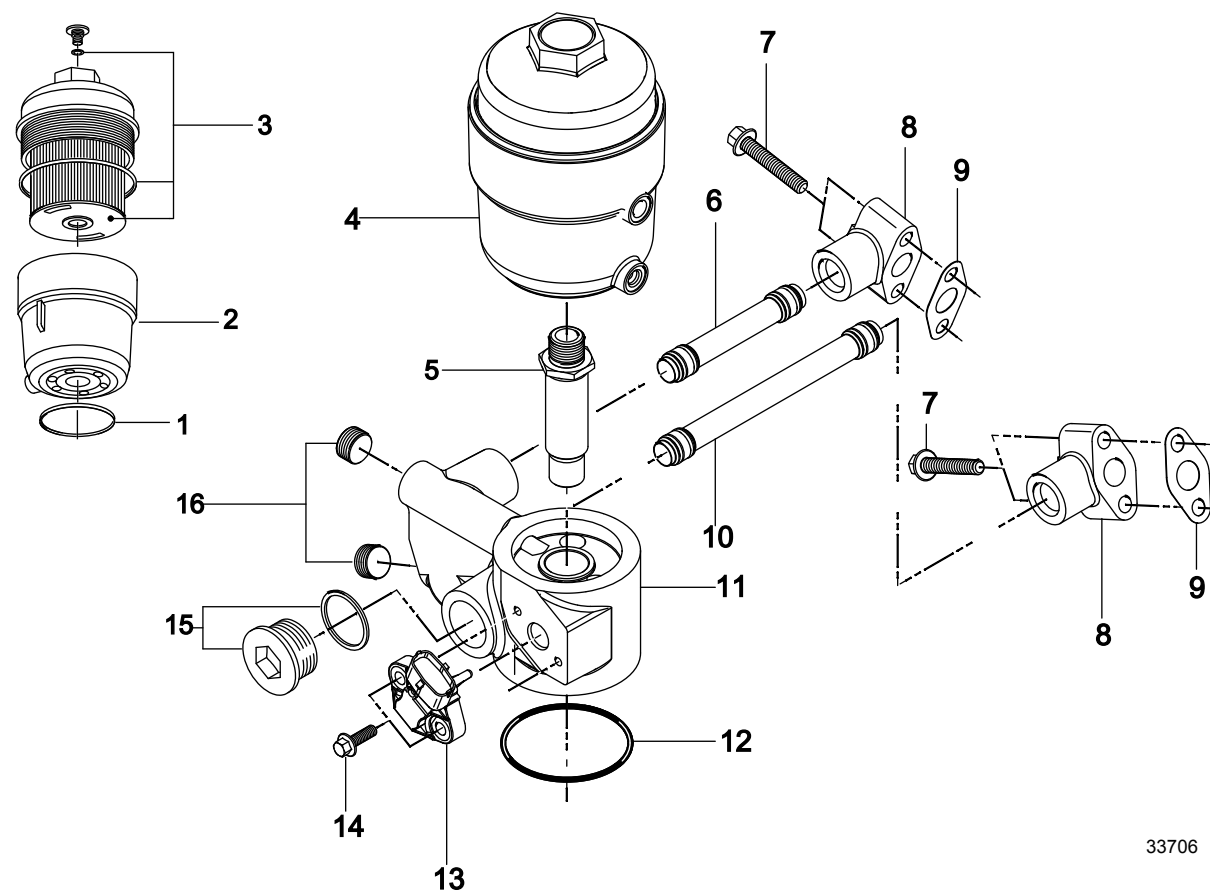
Description	Nm	lb-in.	lb-ft
Screw	5.6	50	–

14. Connect the engine oil pressure and temperature sensor connector.
 15. Check the oil level and fill as needed. Refer to **Section 1B—Engine Oil**.
 16. Check the coolant level and fill as needed. Refer to **Section 1B—Closed-Cooling System**.
 17. Check for leaks when first operating engine.

Notes:

Oil Filter and Seawater Oil Cooler Assembly

Exploded View—Oil Filter and Seawater Oil Cooler



33706

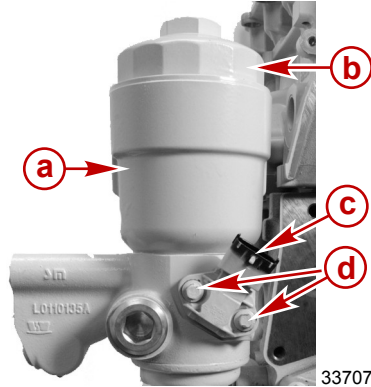
Exploded View—Oil Filter and Seawater Oil Cooler

Ref. No.	Qty.	Description	Torque		
			Nm	lb-in.	lb-ft
1	1	J-clamp			
2	1	Screw	12	98	–
3	1	Coolant supply hose			
4	2	Spring clamp			
5	1	Heat exchanger and exhaust manifold assembly			
6	1	Oil outlet pipe (with four O-rigs)			
7	1	Oil inlet pipe (with four O-rigs)			
8	1	Oil pressure and temperature sensor			
9	1	Screw	5.6	50	–
10	1	Oil filter housing cover	22.5	–	16
11	1	Oil filter housing	35	–	26
12	1	Oil feed pipe	60	–	44
13	1	Adaptor			
14	2	O-ring seal			
15	2	Spring clamp			
16	1	Oil cooler			
17	1	Engine block			

Removal

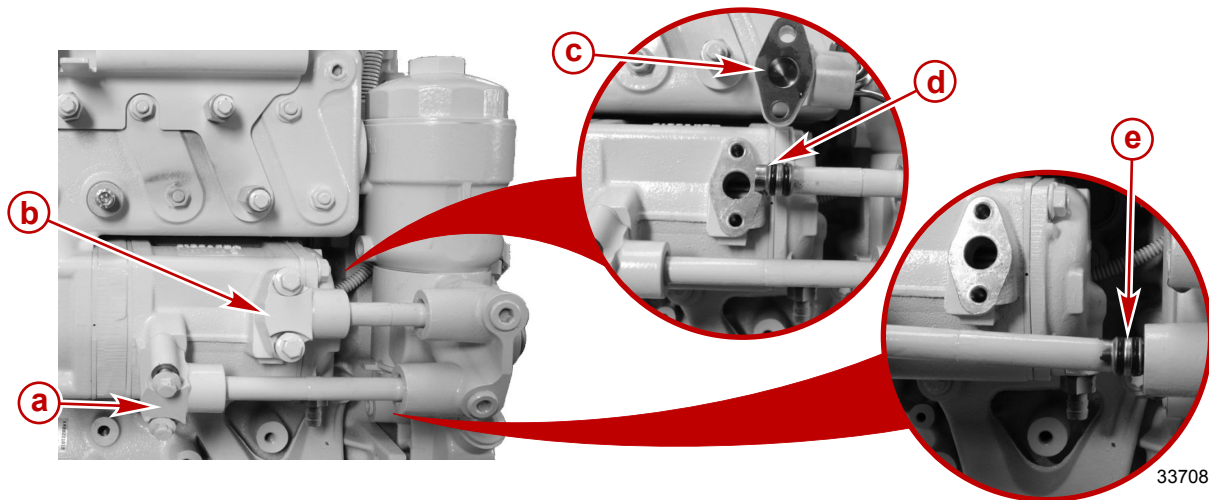
IMPORTANT: Catch or contain any oil and coolant that leaks or spills during service.

1. Disconnect the engine oil pressure and temperature sensor connector.



- a** - Oil filter housing
- b** - Cover
- c** - Engine oil pressure and temperature sensor
- d** - Screw

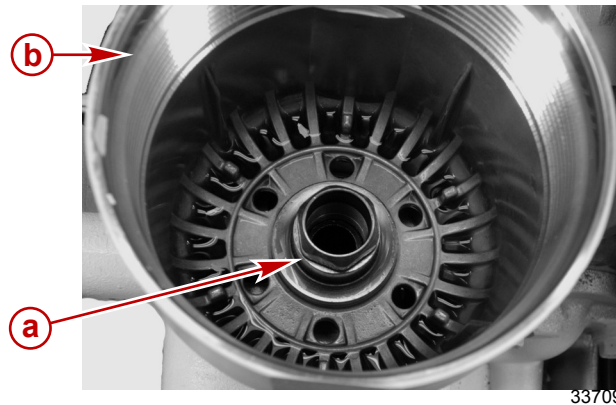
2. Remove the engine oil pressure and temperature sensor.
3. Remove the oil outlet pipe from the heat exchanger and oil cooler housing. Discard the gasket and O-rings.



- a** - Oil outlet pipe
- b** - Oil inlet pipe
- c** - Heat exchanger pipe gasket
- d** - Heat exchanger pipe O-rings
- e** - Oil cooler housing pipe O-rings

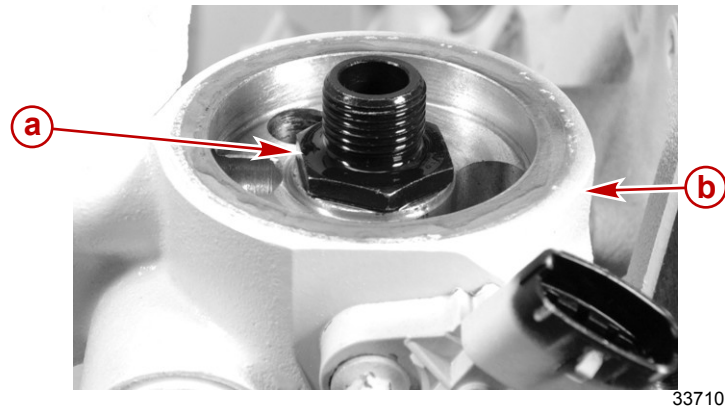
4. Remove the oil inlet pipe from the heat exchanger and oil cooler housing. Discard the gasket and O-rings.
5. Remove the oil filter housing cover and oil filter.

6. Remove the nut securing the oil filter housing to the oil feed pipe.



a - Nut
b - Oil filter housing

7. Remove the oil filter housing.
8. Remove the oil feed pipe securing the oil cooler housing to the engine block with an appropriately sized wrench.



a - Oil feed pipe
b - Oil cooler housing

9. Remove the oil cooler housing from the engine and discard the O-ring seal.



Loose oil feed pipe and cooler housing

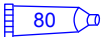
Cleaning And Inspection

1. Clean all sealing surfaces.
2. Inspect each part for cracks or other damage which would render it unserviceable.

Installation

IMPORTANT: Catch or contain any oil and coolant that leaks or spills during service.

1. Lubricate a new O-ring seal.

Tube Ref No.	Description	Where Used	Part No.
 80	SAE Engine Oil 30W	O-ring seal	Obtain Locally

2. Position the oil cooler housing with a new O-ring seal on the engine and start the oil feed pipe by hand.



Loose oil feed pipe and cooler housing

3. Install the oil feed pipe securing the oil cooler housing to the engine block with an appropriately sized wrench.

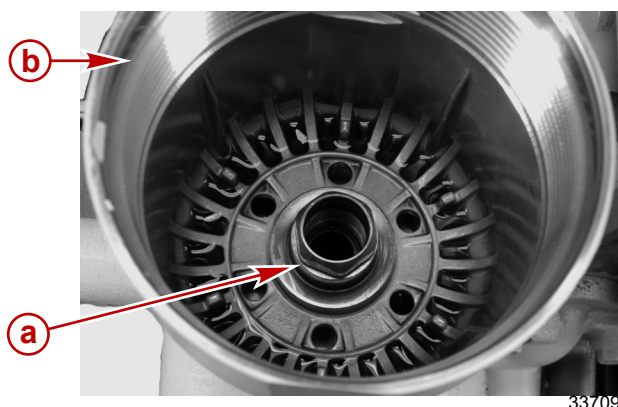


- a** - Oil feed pipe
b - Oil cooler housing

4. Tighten the oil feed pipe to specification.

Description	Nm	lb-in.	lb-ft
Oil feed pipe	60	–	44

5. Install the oil filter housing and secure to the oil feed pipe with its nut.

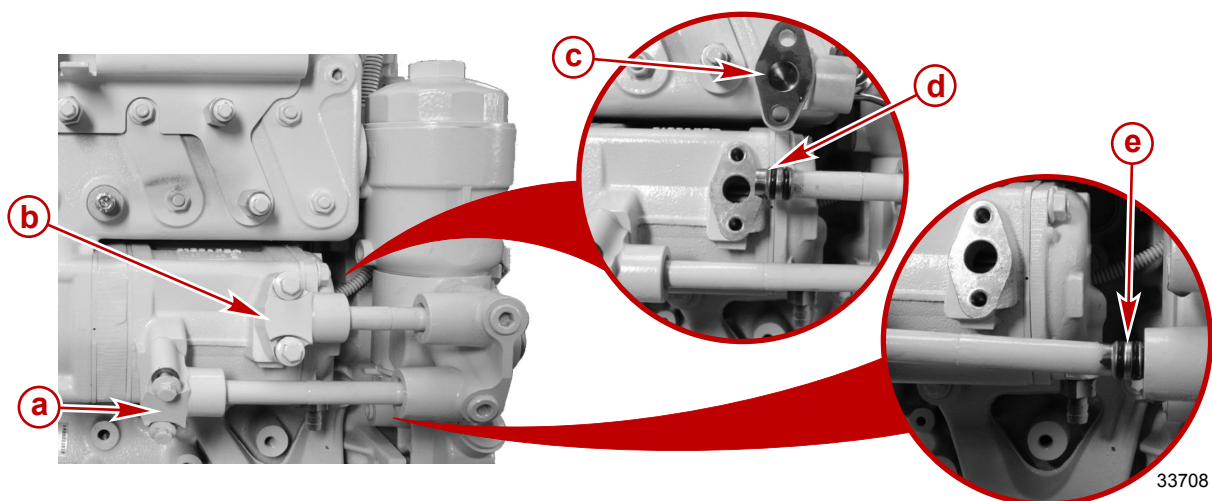


- a** - Nut
b - Oil filter housing

6. Tighten the oil feed pipe nut to specification.

Description	Nm	lb-in.	lb-ft
Oil feed pipe nut	60	–	44

7. Install the oil filter housing cover and oil filter. Refer to **Section 1B—Engine Oil**.
8. Install the oil inlet pipe to the heat exchanger and oil cooler housing. Use a new gasket and O-rings.

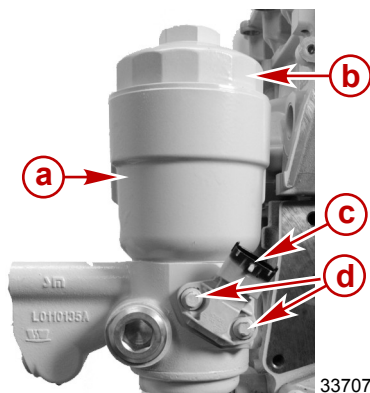


- a** - Oil outlet pipe
b - Oil inlet pipe
c - Heat exchanger pipe gasket
d - Heat exchanger pipe O-rings
e - Oil cooler housing pipe O-rings

9. Install the oil outlet pipe to the heat exchanger and oil cooler housing. Use a new gasket and O-rings.
10. Tighten the oil pipe to heat exchanger screws to specification.

Description	Nm	lb-in.	lb-ft
Screws	27	–	20

11. Install the engine oil pressure and temperature sensor.



- a** - Oil filter housing
- b** - Cover
- c** - Engine oil pressure and temperature sensor
- d** - Screw

12. Tighten the engine oil pressure and temperature sensor screws to specification.

Description	Nm	lb-in.	lb-ft
Screws	5.6	50	—

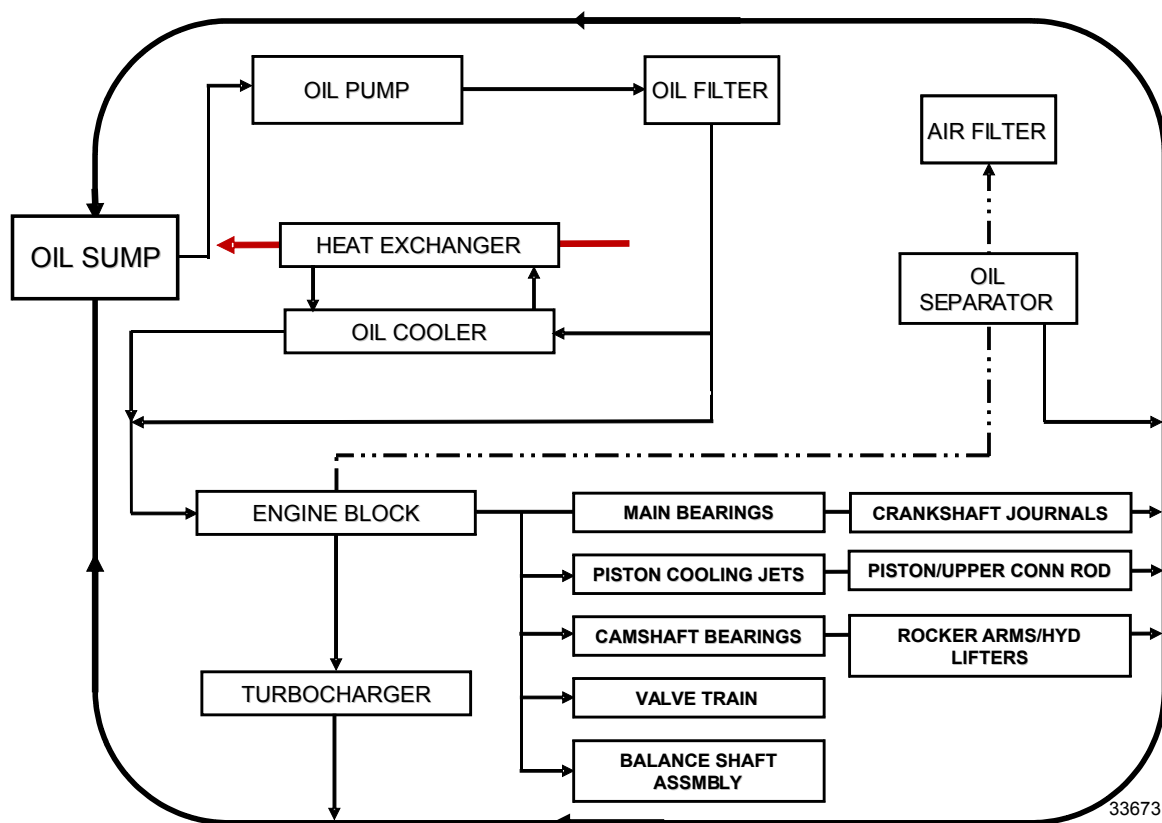
13. Connect the engine oil pressure and temperature sensor connector.

14. Check the engine oil level and fill as needed. Refer to **Section 1B—Engine Oil**.

15. Check the engine for leaks before returning to operation.

Oil Pump and Housing

Oil Flow Diagram

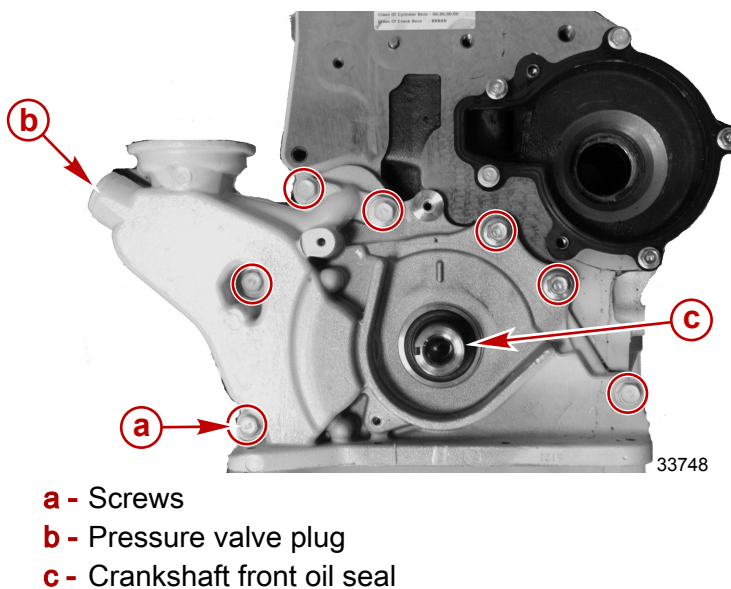


QSD 2.0 oil flow diagram

Removal

1. Drain the engine oil. Refer to **Section 1B—Engine Oil**.
2. Remove the accessory (if equipped) belt. See **Section 1B—Power Assisted Steering Pump Belt**.
3. Remove the serpentine drive belt. See **Section 1B—Serpentine Belt**.
4. Remove the timing belt cover. See **Section 3A—Timing Belt Cover**.
5. Remove the timing belt. See **Section 3A—Timing Belt**.
6. Remove the remaining time belt components and the rear timing belt cover. See **Section 3A—Timing Belt**.
7. Remove the crankshaft timing sprocket.
8. Remove the oil pan. See **Section 3A—Oil Pan, Oil Pickup, and Related Components**.
9. Remove the oil pickup. See **Section 3A—Oil Pan, Oil Pickup, and Related Components**.

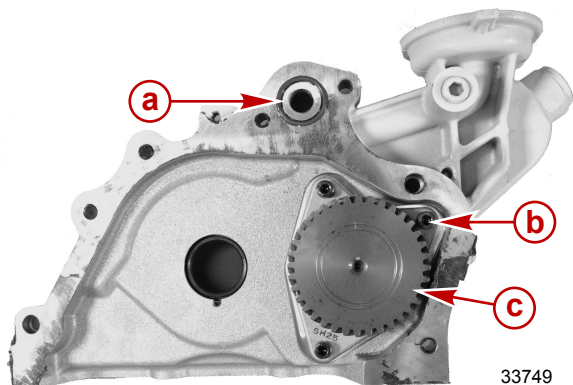
10. Remove the seven screws securing the engine oil pump housing to the engine block.



11. Remove the the engine oil pump housing from the cylinder block.

NOTE: The oil pump components are serviced as a kit and are not available separately.

12. Remove and discard the O-ring on the back of the oil pump housing.

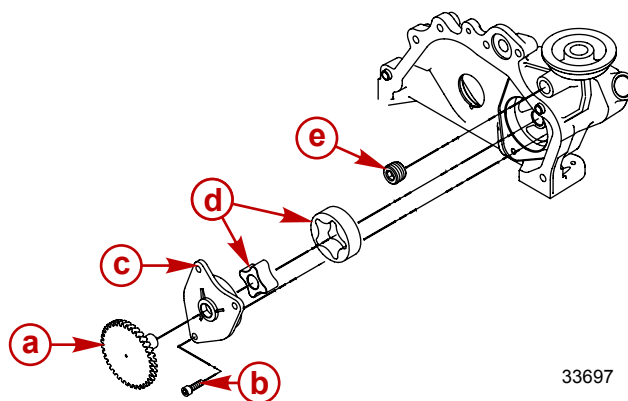


Back of engine oil pump housing

- a** - Engine oil pump housing
- b** - Plug
- c** - Rotor assembly
- d** - Gear

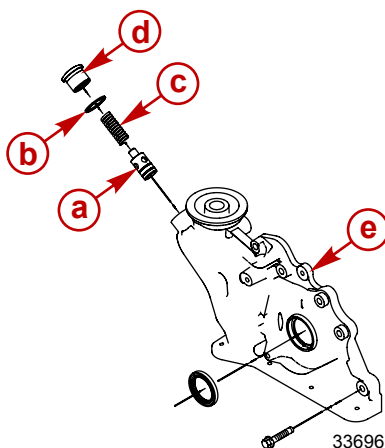
13. To remove the oil pump components:

- a. Remove the oil pump drive gear.



- a** - Drive gear
b - Screw
c - Rotor cover
d - Rotor assembly
e - Plug

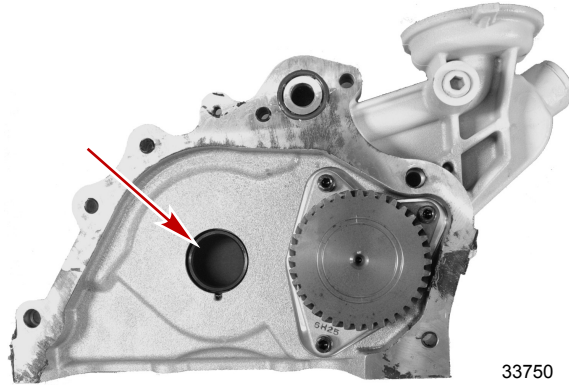
- b. Remove the three screws attaching the rotor cover to the oil pump housing.
 c. Remove the rotor cover.
 d. Remove the oil pump rotors.
14. To remove the oil pressure valve:
- a. Remove the oil pressure valve plug



- a** - Oil pressure valve
b - Sealing washer
c - Spring
d - Plug
e - Engine oil pump housing

- b. Remove and discard the sealing washer.
- NOTE:** A magnetic pickup tool can be used to extract the oil pressure spring and valve.
- c. Extract the spring.
 d. Extract the oil pressure valve.

15. Press out the crankshaft front oil seal from the back of the engine oil pump housing and discard.



Back of engine oil pump housing

Cleaning

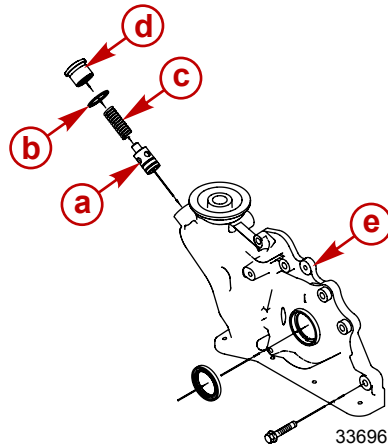
1. Disassemble and wash all parts in cleaning solvent.
2. Put on safety glasses and dry parts with compressed air.

Inspection

1. Clean all gasket sealing surfaces.
2. Inspect the oil pump components for varnish or deposit build up.
3. Inspect the oil pump shaft, rotors, and housing for excessive wear or damage.
4. Replace the oil pump assembly if excessive wear or damage is found.

Installation

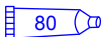
1. If service was required, install the oil pressure valve in to the engine oil pump housing:
 - a. Install the oil pressure valve.



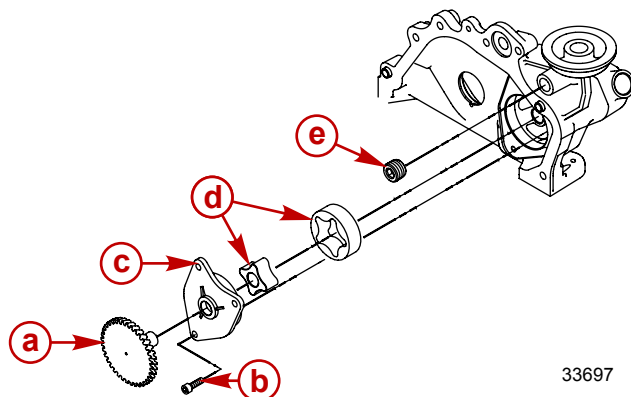
- a** - Oil pressure valve
- b** - Sealing washer
- c** - Spring
- d** - Plug
- e** - Engine oil pump housing

- b. Install the spring.
 - c. Install the oil pressure valve plug with a new sealing washer
2. If service was required, install the oil pump components in to the engine oil pump housing:

- a. Coat the oil pump rotors with engine oil.

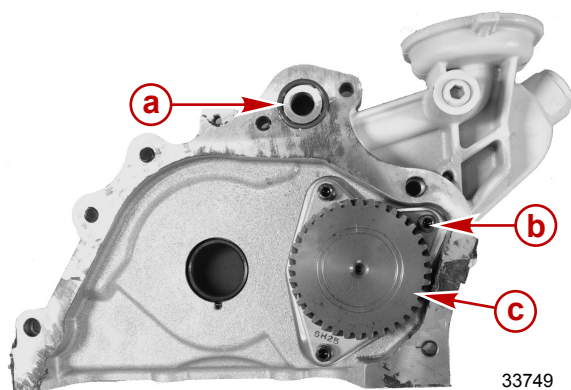
Tube Ref No.	Description	Where Used	Part No.
 80	SAE Engine Oil 30W	Oil pump rotors	Obtain Locally

- b. Install the oil pump rotor assembly.



- a** - Drive gear
b - Screw
c - Rotor cover
d - Rotor assembly
e - Plug

- c. Install the rotor cover.
d. Install the rotor cover and securely tighten the screws.
e. Install the oil pump drive gear.
3. Install a new O-ring in the back of the engine oil pump housing.

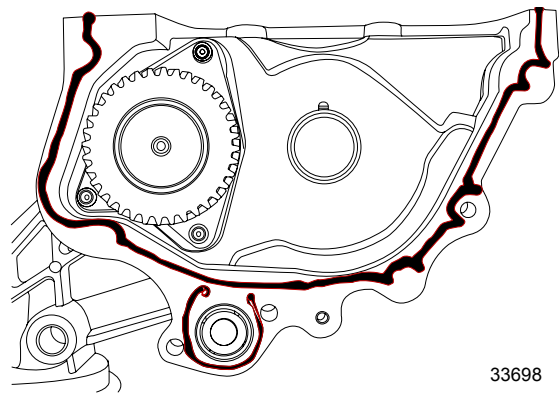


Back of engine oil pump housing


- a** - Engine oil pump housing
b - Plug
c - Rotor assembly
d - Gear

IMPORTANT: Do not allow any sealant to contaminate the oil pump rotor assembly.

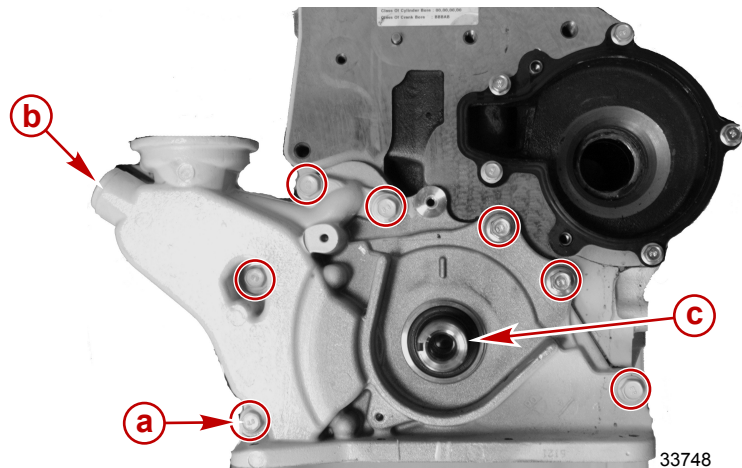
4. Apply sealant to the engine oil pump housing to block mating surface as indicated.



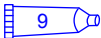
Sealant application

Tube Ref No.	Description	Where Used	Part No.
 128	Loctite 5900 Ultra Black RTV Silicone Sealant	Oil pump housing	92-809826

5. Apply sealant to the two lower oil pump housing screws and attach the the engine oil pump housing to the cylinder block.



- a** - Screws
- b** - Pressure valve plug
- c** - Crankshaft front oil seal

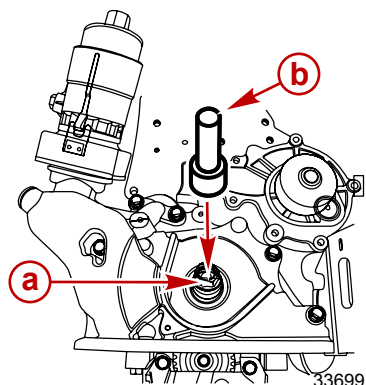
Tube Ref No.	Description	Where Used	Part No.
 9	Loctite 567 PST Pipe Sealant	Lower oil pump housing screws	92-809822

6. Install the remaining engine oil pump housing screws.

7. Tighten the engine oil pump housing screws to specification.

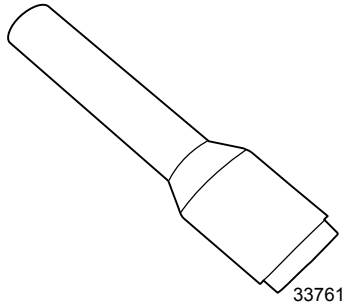
Description	Nm	lb-in.	lb-ft
Oil pump housing screw	24	–	18

8. Using the appropriate seal driver, install a new crankshaft front oil seal in the front of the oil pump housing.



a - Crankshaft front oil seal

b - Seal driver

Crankshaft front oil seal installer	Part Number
	87-915001

9. Install the oil pickup. See **Section 3A—Oil Pan, Oil Pickup, and Related Components**.
10. Install the oil pan. See **Section 3A—Oil Pan, Oil Pickup, and Related Components**.
11. Install the crankshaft timing sprocket.
12. Tighten the crankshaft timing sprocket screw to specification.

Description	Nm	lb-in.	lb-ft
Crankshaft timing sprocket screw	235	–	173

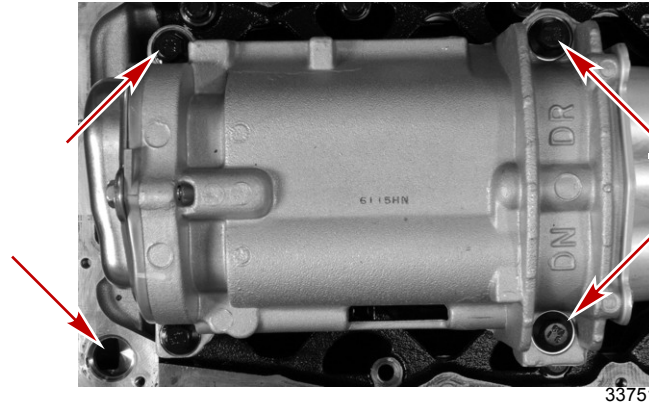
13. Install the remaining time belt components and the rear timing belt cover. See **Section 3A—Timing Belt**.
14. Install the timing belt. See **Section 3A—Timing Belt**.
15. Install the timing belt cover. See **Section 3A—Timing Belt Cover**.
16. Install the serpentine drive belt. **Section 1B—Serpentine Belt**.
17. Install the accessory (if equipped) belt. **Section 1B—Power Assisted Steering Pump Belt**.
18. Fill the engine oil. Refer to **Section 1B—Engine Oil**.

Balance Shaft Assembly

Removal

NOTE: The engine balance shaft assembly is serviced as a complete unit. It is not field serviceable.

1. Position the engine at cylinder number 1 TDC. See **Section 3A—Establishing TDC (Top Dead Center)**.
2. Remove the oil pan. See **Section 3A—Oil Pan, Oil Pickup, and Related Components**.
3. Remove the oil pickup. See **Section 3A—Oil Pan, Oil Pickup, and Related Components**.
4. Remove the four screws retaining the balance shaft assembly to the engine bed plate.



Balance shaft assembly screws

Cleaning

1. Wash the balance shaft assembly in cleaning solvent.
2. Remove and discard the O-rings on the oil supply tubes.
3. Wash the oil supply tubes in cleaning solvent.
4. Put on safety glasses and dry the components with compressed air.

Inspection

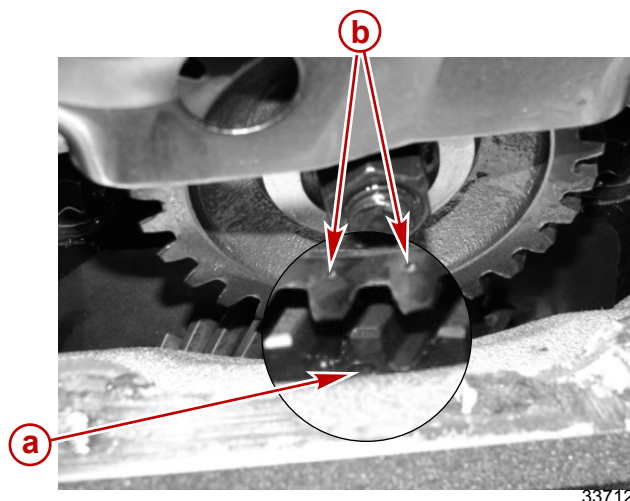
NOTE: *There are no individual replacement components for the balance shaft assembly. If worn, cracked, or damaged, the complete balance shaft assembly must be replaced.*

1. Inspect the gears on the crankshaft and balance shaft assembly for wear or damage.
2. Inspect the balance shaft assembly housing for cracks or damage.
3. Replace the crankshaft and balance shaft assembly if worn, cracked, or damaged.

Installation

1. Confirm that cylinder number 1 is at TDC and the crankshaft timing tool is still installed. See **Section 3A—Establishing TDC (Top Dead Center)**.

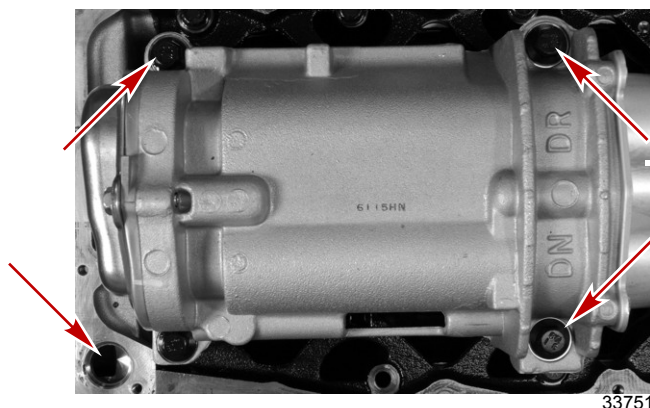
- Position the balance shaft assembly and align the balance shaft assembly and crankshaft gear timing marks. The marked tooth on the crankshaft gear should split the two marked teeth on the balance shaft assembly gear.



a - Crankshaft timing mark

b - Balance shaft assembly timing marks

- Install the four screws retaining balance shaft assembly to the engine bed plate.



Balance shaft assembly screws

- Tighten the balance shaft assembly screws to specification.

Description	Nm	lb-in.	lb-ft
Balance shaft assembly screw	55	–	46

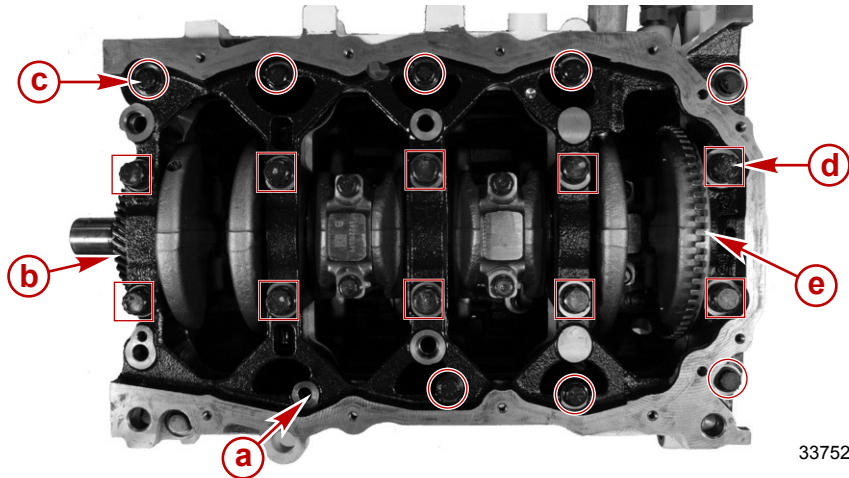
- Install the oil pickup. See **Section 3A—Oil Pan, Oil Pickup, and Related Components**.
- Install the oil pan. See **Section 3A—Oil Pan, Oil Pickup, and Related Components**.

Engine Bed Plate

Removal

- Position the engine at cylinder number 1 TDC. See **Section 3A—Establishing Top Dead Center**.
- Disconnect the wires attached to the engine ground screw threaded in to the bed plate.

3. Remove the oil pan. See **Section 3A—Oil Pan, Oil Pickup, and Related Components**.
4. Remove the oil pickup. See **Section 3A—Oil Pan, Oil Pickup, and Related Components**.
5. Remove the balance shaft assembly. See **Section 3A—Balance Shaft Assembly**.
6. Remove the screws retaining the engine bed plate to the cylinder block.



- a** - Screw installed with oil pickup
- b** - Crankshaft gear
- c** - Outer bed plate screw
- d** - Inner bed plate screw
- e** - CPS target wheel

Cleaning

1. Remove all residue gasket material from the engine bed plate and engine block.
2. Wash the engine bed plate in cleaning solvent.
3. Clean the engine bed plate screw holes.
4. Put on safety glasses and dry the components with compressed air.

Inspection

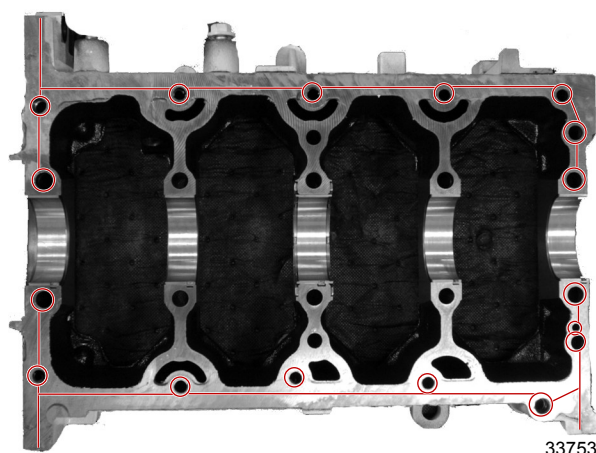
1. Inspect the engine bed plate and cylinder block sealing surfaces for damage.
2. Inspect the screw holes and threads for damage.
3. Replace or repair any damaged component.

Installation

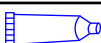
IMPORTANT: The crankshaft rear oil seal must be installed after the engine bed plate is installed and properly torqued.

1. Confirm that cylinder number 1 is still at TDC and that the crankshaft timing tool is properly installed. See **Section 3A—Establishing Top Dead Center**.

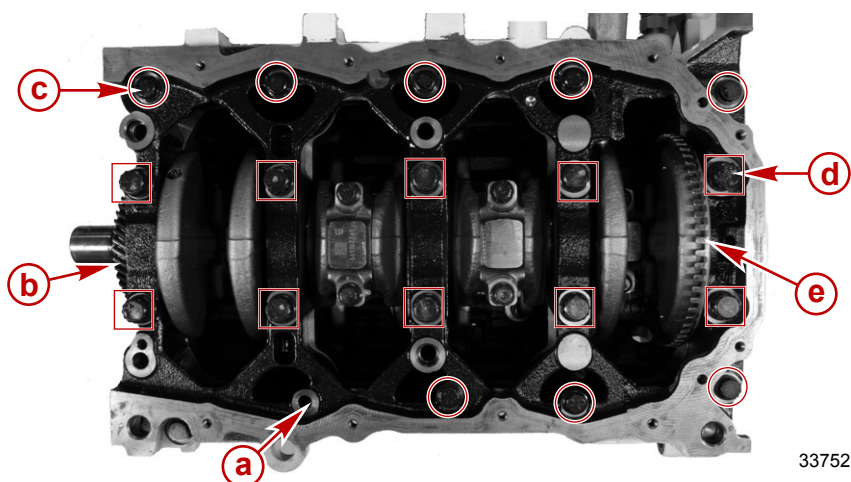
2. Apply sealant to the sealing surface of the engine bed plate.



Engine bed plate sealant application

Tube Ref No.	Description	Where Used	Part No.
	Hylomar 3000 (obtain locally)	Engine bed plate	Obtain Locally

3. Position the engine bed plate and install the screws retaining it to the cylinder block.



- a** - Screw installed with oil pickup
- b** - Crankshaft gear
- c** - Outer bed plate screw
- d** - Inner bed plate screw
- e** - CPS target wheel

4. Tighten the inner engine bed plate screws to specification.

Description		Nm	lb-in.	lb-ft
Inner engine bed plate screw	First	25	–	18
	Second	+ 45°		
	Final	+ 90°		

5. Tighten the outer engine bed plate screws to specification.

Description	Nm	lb-in.	lb-ft
Outer engine bed plate screw	35	–	26

6. Install the balance shaft assembly. See **Section 3A—Balance Shaft Assembly**.

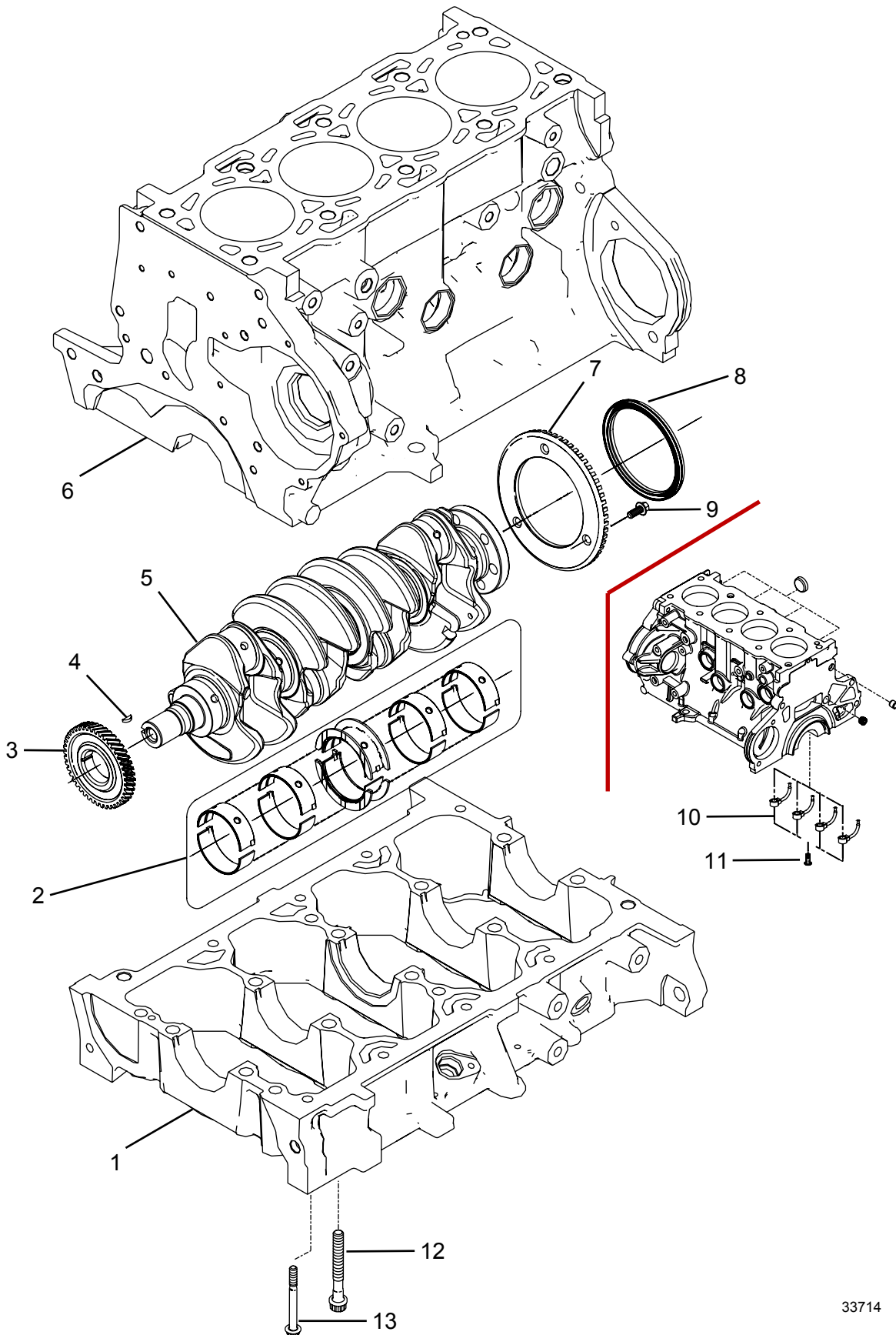
7. Install the oil pickup. See **Section 3A—Oil Pan, Oil Pickup, and Related Components**.
8. Install the oil pan. See **Section 3A—Oil Pan, Oil Pickup, and Related Components**.
9. Install the engine ground screw in the bed plate.
10. Tighten the engine ground screw to specification.

Description	Nm	lb-in.	lb-ft
Engine ground screw	25	–	18

Notes:

Crankshaft and Main Bearings

Exploded View—Crankshaft and Main Bearings



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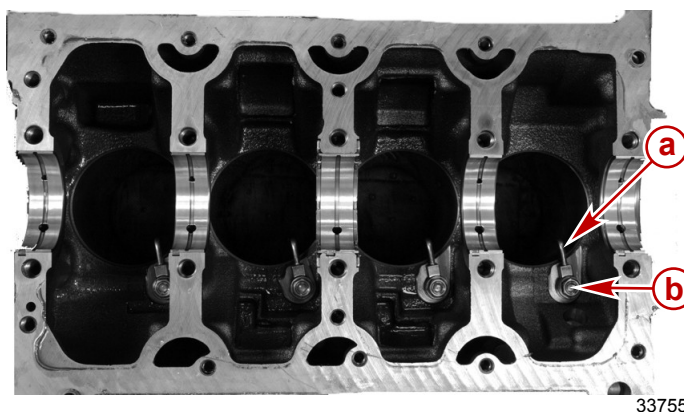
Exploded View—Crankshaft and Main Bearings

Ref. No.	Qty.	Description	Torque		
			Nm	lb-in.	lb-ft
1	1	Engine bed			
2	1	Crankshaft bearing set			
3	1	Gear			
4	1	Key			
5	1	Crankshaft			
6	1	Block			
7	1	CPS target wheel			
8	1	Rear main seal			
9	3	CPS target wheel bolt	12	106	–
10	4	Oil jet set			
11	4	Oil jet screw	23	–	18
12	10	Outer engine bed screw	35	–	26
13	10	Inner engine bed screw	First	25	–
			Second	+ 45°	
			Final	+ 90°	

Removal

IMPORTANT: If reusing any components label and store them so they are assembled in their original location.

1. Remove the starter. Refer to **Section 4A—Starter**.
2. Remove the rear engine mount brackets. See **Section 3A—Engine Mounts and Brackets**.
3. Remove the coupler or drive plate. See **Section 3A—Flywheel, Coupler Or Drive Plate, and Flywheel Housing**.
4. Remove the flywheel housing. See **Section 3A—Flywheel, Coupler Or Drive Plate, and Flywheel Housing**.
5. Remove the flywheel. See **Section 3A—Flywheel, Coupler Or Drive Plate, and Flywheel Housing**.
6. Position the engine at cylinder number 1 TDC. See **Section 3A—Establishing Top Dead Center**.
7. Disconnect the wires attached to the engine ground screw threaded in to the bed plate.
8. Remove the oil pump. See **Section 3A—Oil Pump**.
9. Remove the oil pan. See **Section 3A—Oil Pan, Oil Pickup, and Related Components**.
10. Remove the oil pickup. See **Section 3A—Oil Pan, Oil Pickup, and Related Components**.
11. Remove the balance shaft assembly. See **Section 3A—Balance Shaft Assembly**.
12. Remove the cylinder head. See **Section 3A—Cylinder head**.
13. Remove the pistons and connecting rods through the top of the block. See **Section 3A—Connecting Rods, Bearings, and Piston Assemblies**.
14. Remove the engine bed plate. See **Section 3A—Engine Bed Plate**.
15. Lift straight up and remove the crankshaft with the rear oil seal from the engine block.
16. Remove and discard the crankshaft rear oil seal.
17. Remove the oil jets.



- a** - Oil jet
b - Screw

Cleaning

CRANKSHAFT

1. Clean the crankshaft in cleaning solvent. Ensure that the oil passages are clear of all sludge and restrictions.
2. Put on safety glasses.
3. Clear the crankshaft oil passages with compressed air.
4. Dry the components with compressed air.

MAIN BEARINGS

1. Clean the main bearings in cleaning solvent.
2. Wipe the crankshaft bearings clean with a soft cloth. Do not scratch the crankshaft bearing surfaces.
3. Put on safety glasses and dry the components with compressed air.

Inspection

CRANKSHAFT

IMPORTANT: The crankshaft journal diameters must be measured in multiple locations approximately 90° apart. Average the resulting measurements for comparison to specification.

1. Measure and record the crankshaft main bearing and connecting rod bearing journal diameters with a micrometer and compare to specification.

Crankshaft	
Main journal outer diameter	60.002 – 60.020 mm (2.3623 – 2.3630 in..)
Connecting rod journal outer diameter	53.000 – 53.018 mm (2.0866 – 2.0873 in..)

2. Inspect the thrust journal surfaces for excessive wear or scoring.
3. Inspect the crankshaft for deep grooves, scratches, pitted surfaces, or uneven wear.
4. Inspect the crankshaft rear oil seal surface for scoring or damage.
5. Inspect the crankshaft oil passages for restrictions.
6. Inspect the crankshaft threaded bolt holes for damage or debris.
7. Inspect the crankshaft balancer keyway for damage.
8. After a seizure, overheating, or grinding, the crankshaft must be Magnafluxed to verify no surface cracks are present.
9. Crankshafts that do not meet specifications or are otherwise damaged must be replaced.

MAIN BEARINGS

1. Inspect the main bearings for any galling, scoring, or other damage.
2. Measure the main bearing installed oil clearance and compare to specification:

IMPORTANT: Follow the instructions provided with the Plastigauge.

- a. Trial fit and install the main bearings and crank shaft in the engine block using a piece of Plastigauge for each journal. See **Section 3A—Crankshaft and Main Bearings—Installation**.
- b. Remove the crankshaft and measure main bearing journal oil clearance and compare to specification. See **Section 3A—Crankshaft and Main Bearings—Removal**.

Crankshaft	
Main bearing journal oil clearance	0.024 – 0.042 mm (0.00094 – 0.00165 in..)

3. Bearings that do not meet specifications or are otherwise damaged must be replaced.
4. If the specified clearance cannot be achieved with the bearing sizes available replace the crankshaft and recheck.

CPS TARGET WHEEL RING

1. Inspect the CPS target wheel for missing teeth.
2. Inspect the CPS target wheel for cracks or rounding of screw holes.
3. Replace the CPS target wheel if worn or damaged.

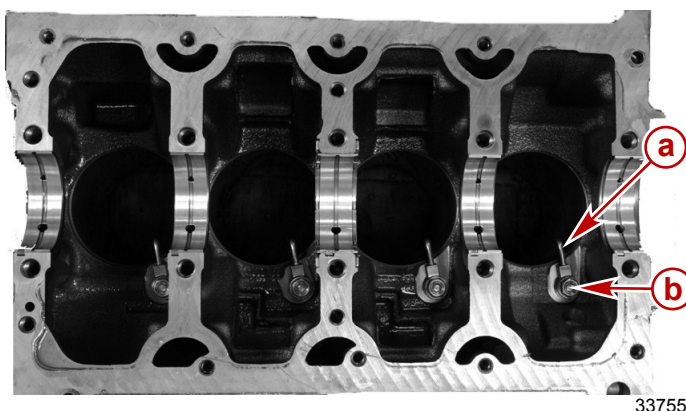
FLYWHEEL

1. Check the flywheel ring gear for worn and missing teeth. Replace if worn or damaged.
2. Clean the mating surfaces of the flywheel and crankshaft. The mating surfaces must be clean, bare metal.

Installation

IMPORTANT: If reusing any components they must be assembled in their original location.

1. Install the oil jets.



- a** - Oil jet
b - Screw


2. Tighten the oil jet screw to specification.

Description	Nm	lb-in.	lb-ft
Oil jet screw	23	–	17

3. If replacing the crankshaft, transfer the CPS target wheel and screws.
4. If replacing the crankshaft, tighten the CPS target wheel screws to specification.

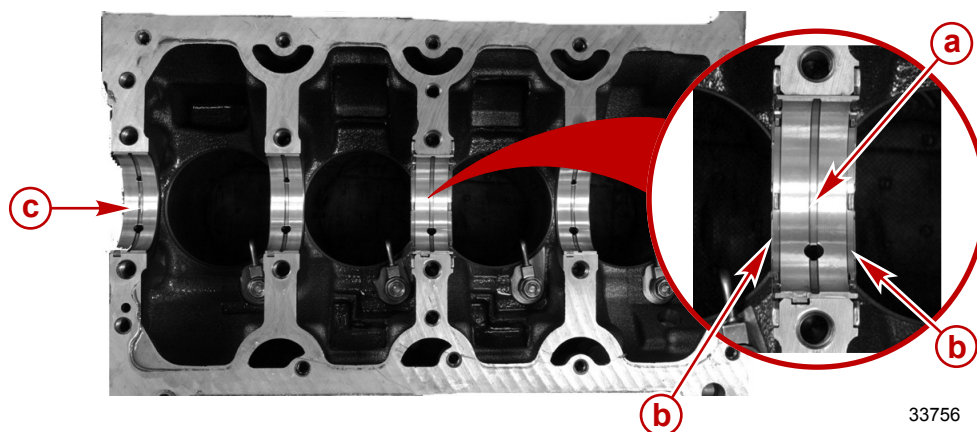
Description	Nm	lb-in.	lb-ft
CPS target wheel screw	12	106	–

5. Coat the crankshaft main bearings with engine oil.

Tube Ref No.	Description	Where Used	Part No.
 80	SAE Engine Oil 30W	Crankshaft main bearings	Obtain Locally

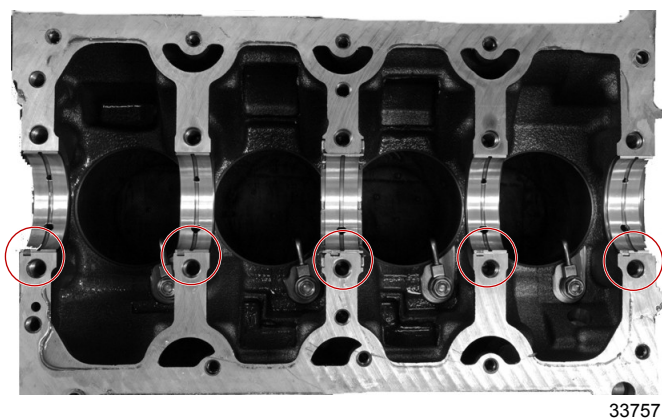
IMPORTANT: The flanged main bearing acts as a thrust control bearing and is installed in the center bearing journal.

6. Install the main bearing shells on their respective crankshaft journals.



- a** - Thrust bearing
- b** - Bearing thrust surface
- c** - Standard main bearing

7. Position the main bearing shells in the block with the bearing tab locked into the slot machined in the engine block.



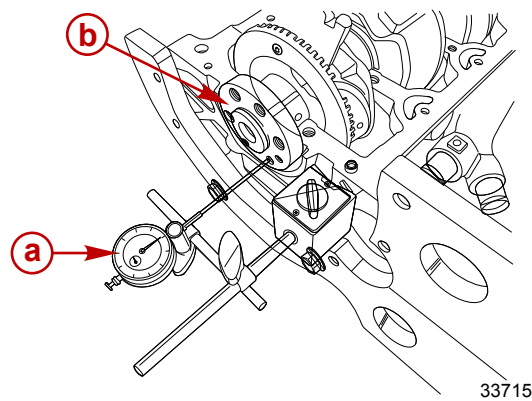
Proper main bearing shell orientation

8. Lower the crankshaft straight down in to the engine block.
9. Install the engine bed plate. See **Section 3A—Engine Bed Plate**.
10. Check crankshaft end play with a dial indicator.
 - a. Attach the Dial Indicator to the cylinder block to check the installed crankshaft end play (axial clearance). Take measurement at the crankshaft flywheel flange.

Dial Indicator	91-58222A1
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- b. Firmly force the crankshaft rearward. Record the measurement.
- c. Firmly force the crankshaft forward. Record the measurement.

d. Subtract the measurements to determine the crankshaft end play.



Measuring crankshaft end play

- a - Dial indicator
- b - Flywheel flange

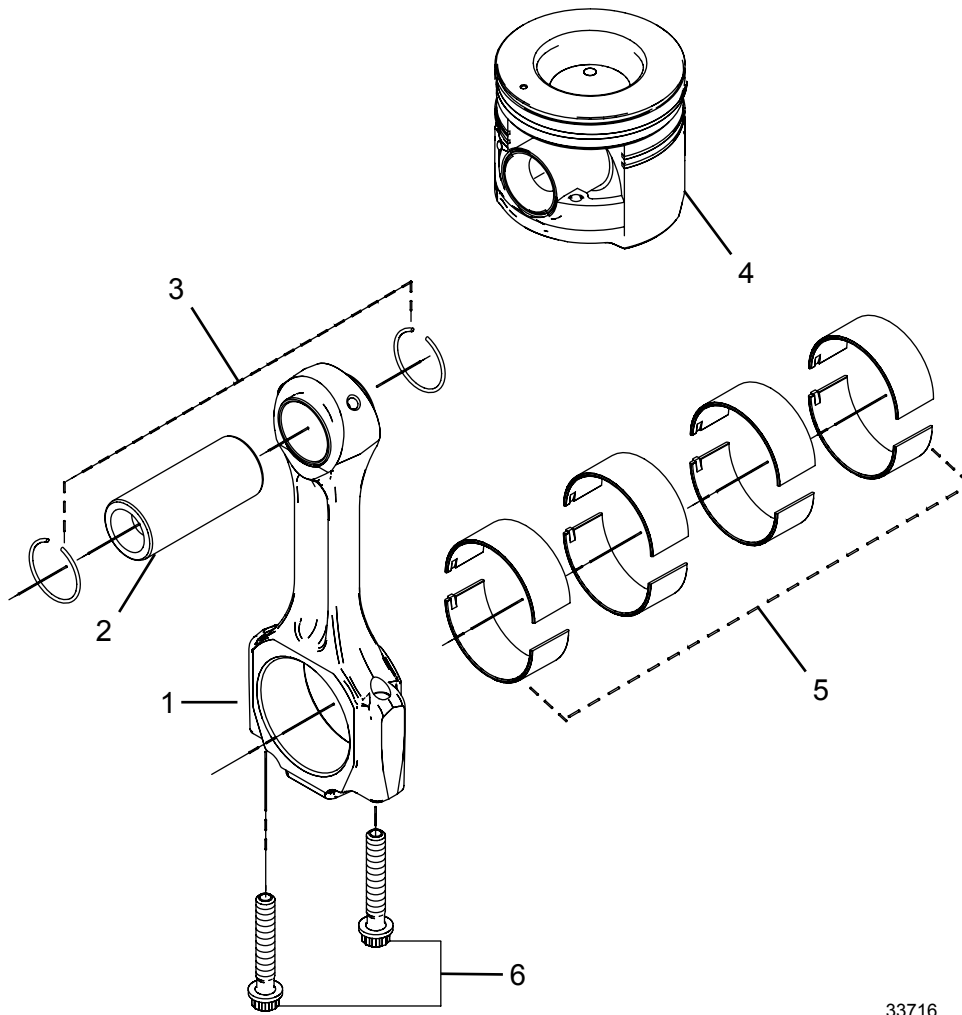
Crankshaft	
End play	0.10 - 0.32 mm (0.0039 - 0.0138 in.)

- e. If the end play (axial clearance) is incorrect, calculate the necessary size of center thrust bearing needed.
 - f. Repeat the steps until the proper end play (axial clearance) is reached.
11. Install the pistons and connecting rods through the top of the block. See **Section 3A—Connecting Rods, Bearings, and Piston Assemblies**.
 12. Install a new crankshaft rear oil seal. See **Section 3A—Crankshaft Rear Oil Seal**.
 13. Install the balance shaft assembly. See **Section 3A—Balance Shaft Assembly**.
 14. Install the oil pickup. See **Section 3A—Oil Pan, Oil Pickup, and Related Components**.
 15. Install the oil pan. See **Section 3A—Oil Pan, Oil Pickup, and Related Components**.
 16. Install the oil pump. See **Section 3A—Oil Pump**.
 17. Remove the cylinder head. See **Section 3A—Cylinder Head**.
 18. Position the engine at cylinder number 1 TDC. See **Section 3A—Establishing Top Dead Center**.
 19. Install the timing belt. See **Section 3A—Timing Belt**.
 20. Install the timing belt cover. See **Section 3A—Timing Belt Cover**.
 21. Install the flywheel. See **Section 3A—Flywheel, Coupler Or Drive Plate, and Flywheel Housing**.
 22. Install the coupler or drive plate. See **Section 3A—Flywheel, Coupler Or Drive Plate, and Flywheel Housing**.
 23. Install the flywheel housing. See **Section 3A—Flywheel, Coupler Or Drive Plate, and Flywheel Housing**.
 24. Install the starter. Refer to **Section 4A—Starter**.
 25. Install the rear engine mount brackets. See **Section 3A—Engine Mounts and Brackets**.
 26. Connect the wires attached to the engine ground screw and thread it in the bed plate.
 27. Tighten the engine ground screw to specification.

Description	Nm	lb-in.	lb-ft
CPS target wheel screw	25	–	18

Connecting Rod, Bearings, and Piston Assemblies

Exploded View—Connecting Rod, Bearings, and Piston Assemblies



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Exploded View—Connecting Rod, Bearings, and Piston Assemblies

Ref. No.	Qty.	Description	Torque		
			Nm	lb-in.	lb-ft
1	1	Connecting rod			
2	1	Piston pin			
3	2	Snap ring			
4	1	Piston			
5	1	Connecting rod bearing set			
6	2	Connecting rod screw	Refer to connecting rod installation procedure.		

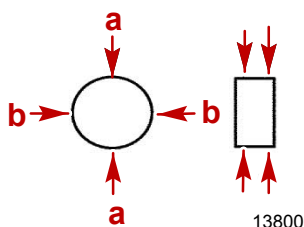
Checking the Connecting Rod Bearing Clearance—Engine Assembled

PREPARATION

1. Remove the oil pan. See **Section 3A—Oil Pan, Oil Pickup, and Related Components**.
2. Remove the oil pickup tube assembly. See **Section 3A—Oil Pan, Oil Pickup, and Related Components**.
3. Remove the balance shaft assembly. See **Section 3A—Balance Shaft Assembly**.
4. Turn the crankshaft to gain access to the connecting rod screws.
5. One cylinder at a time, remove the rod caps and inspect the bearings. See **Bearing Failure**.

CONNECTING ROD JOURNAL DIAMETER

1. Measure the crankshaft connecting rod journal with a micrometer for out of round, taper, or excessive wear. Measure journal diameters at points "a" and "b" on one side of the journal then repeat measurements on the opposite side of the journal.



Connecting Rod Journal	
Journal outside diameter	53.000–53.018 mm (2.0866–2.0873 in.)

2. Replace or recondition the crankshaft if any values are less than specified.

CONNECTING ROD BEARING CLEARANCE

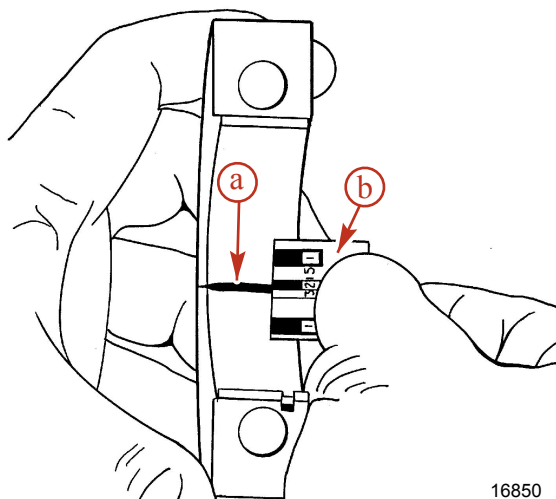
1. Ensure that the crankshaft, the connecting rod, the connecting rod cap, and the bearings are clean.
 2. Install the bearings onto the connecting rod and the connecting rod cap.
- IMPORTANT: Do not allow the crankshaft to move when installing the bearing cap.**
3. Place a piece of gauging plastic the full width of the crankshaft rod journal parallel to the crankshaft.
 4. Install the connecting rod cap and torque the connecting rod screw.

Description		Nm	lb-in.	lb-ft
Connecting rod screw	First pass	25	–	18
	Final pass (Angle Torque)	+ 90°		

IMPORTANT: Do not turn the crankshaft while the gauging plastic is in place.

5. Remove the connecting rod cap.
6. The flattened gauging plastic will adhere to either the connecting rod cap or crankshaft journal. Do not remove the gauging plastic.
7. Measure the width of the compressed gauging plastic at the widest point with the graduated scale on the gauging plastic envelope.

8. Compare the measurement to the specification for clearance.

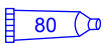


a - Compressed gauging plastic

b - Graduated scale

Connecting Rod Bearing	
Clearance	0.024–0.042 mm (0.00094–0.00165 in.)

9. If the clearance exceeds specifications, select new bearings of the correct size and recheck the clearance.
10. If the clearance is incorrect with the new bearings, recheck the crankshaft journal dimensions.
11. After obtaining the correct clearance, lubricate the crankshaft journal and connecting rod bearing surfaces and install the connecting rods.

Tube Ref No.	Description	Where Used	Part No.
 80	SAE Engine Oil 30W	Crankshaft journal and connecting rod bearing surfaces	Obtain Locally

12. Install all other components removed in the repair process.
13. Check for leaks when you start the engine.

Removal

1. Position the engine at cylinder number 1 TDC. See **Section 3A—Establishing Top Dead Center**.
2. Remove the cylinder head. See **Section 3A—Cylinder Head**.
3. Remove the oil pan. See **Section 3A—Oil Pan, Oil Pickup, and Related Components**.
4. Remove the oil pickup. See **Section 3A—Oil Pan, Oil Pickup, and Related Components**.
5. Remove the balance shaft assembly. See **Section 3A—Balance Shaft Assembly**.
6. Remove any ridge or combustion deposits from the top of the cylinder bore using a ridge reamer.
 - a. Install the Crankshaft Rotating (Barring) Tool and turn the crankshaft until the piston of the cylinder being serviced is at the bottom of the stroke.
 - b. Place a cloth on the top of the piston to collect the cuttings.

- c. Install the Cylinder Bore Ridge Reamer Tool according to the manufacturer and remove the ridge or combustion deposits.

Cylinder Bore Ridge Reamer Tool	Obtain Locally
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- d. Remove the Cylinder Bore Ridge Reamer Tool.
 - e. Turn the crankshaft until the piston is at top of its stroke.
 - f. Remove cloth and cuttings.
 - g. Repeat for each cylinder.
7. Turn the crankshaft to gain access to the connecting rod screws.
IMPORTANT: Each connecting rod assembly must be reassembled in its original location.
 8. Mark or identify each connecting rod assembly to ensure placement in the original cylinder number location during reassembly.
 9. Remove the connecting rod cap and rod bearings.
IMPORTANT: The connecting rod can damage the crankshaft journal, the cylinder bore, and the piston cooling jet. Ensure that no components are damaged during connecting rod removal.
 10. While protecting the crankshaft journal, cylinder bore, and piston cooling jets from damage, push the piston and connecting rod out of the cylinder.
IMPORTANT: The mating surfaces of the connecting rods and the connecting rod bearing caps form an individual fit and must not be interchanged or damaged under any circumstances. To avoid damage, do not lay connecting rods or connecting rod bearing caps on their mating surfaces.
 11. Retain the rod cap and bearings with the connecting rod and piston assembly. Do not mix the components.
 12. Remove the connecting rod bearings. Keep the bearings, with the original connecting rod and connecting rod cap, together as a matched set.

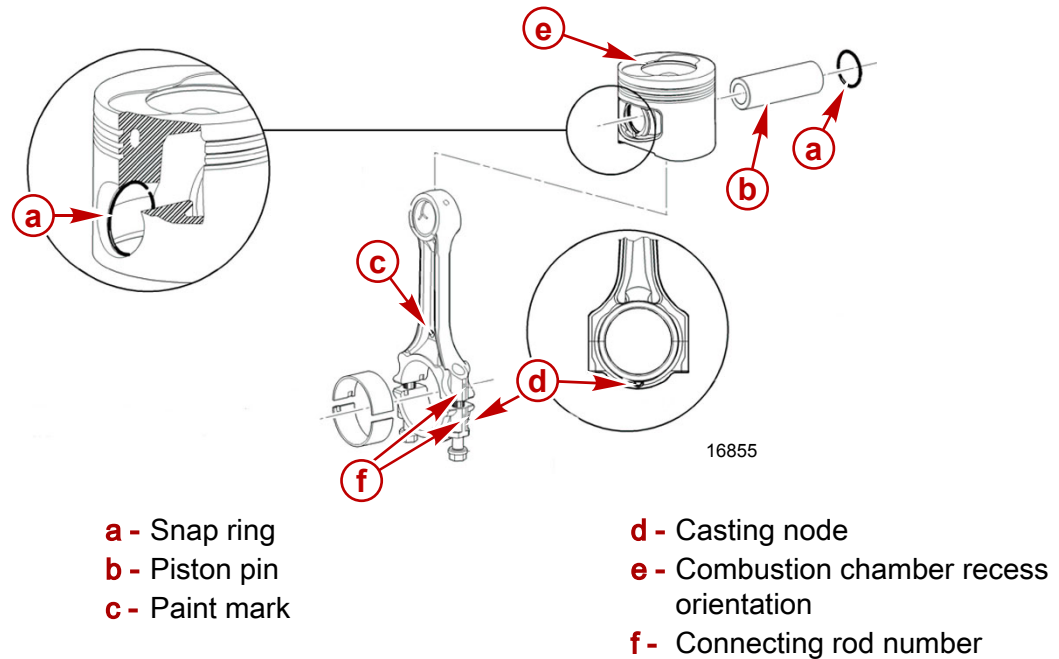
Disassembly

1. Clamp the connecting rod in a soft-jawed vise.
2. Use the Piston Ring Expander Tool to remove the first and second compression rings and the oil control ring with spring.

Piston Ring Expander Tool	91-24697
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3. Remove the snap rings that retain the piston pin. Push the piston pin out of the connecting rod and piston.

4. Note the orientation of the piston combustion chamber recess in relation to the paint mark, the casting node, and the connecting rod number.



Cleaning

CONNECTING RODS, PISTON PINS AND PISTON RINGS

1. Wash the components in cleaning solvent.
2. Put on safety glasses and dry the components with compressed air.

CONNECTING ROD BEARINGS

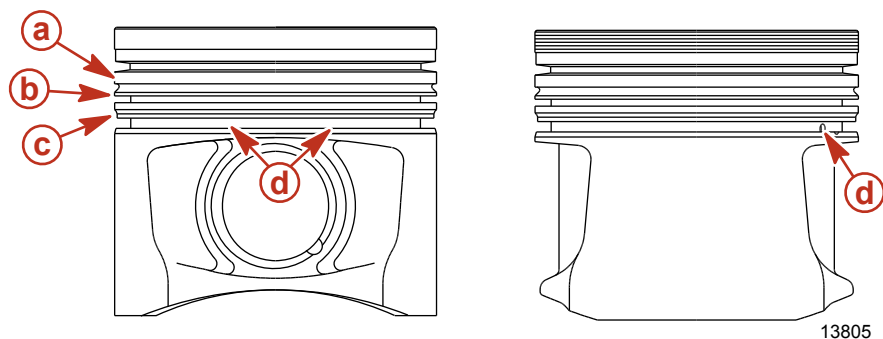
1. Wash the components in cleaning solvent.
2. Wipe the bearings clean with a soft cloth. Do not scratch the bearing contact surfaces.
3. Put on safety glasses and dry the components with compressed air.

PISTONS

IMPORTANT: Do not wire brush on any part of a piston.

1. Wash the components in cleaning solvent.
2. Clean varnish from the piston skirts and pins with a cleaning solvent.
3. Clean the ring grooves.

4. Clean the piston oil lubrication holes and slots.



a - First compression ring groove - (tapered)

b - Second compression ring groove

c - Oil control (lower) ring

d - Oil ring holes

5. Put on safety glasses and dry the components with compressed air.

Inspection

IMPORTANT: Measurements should be taken when the components are at room temperature.

CONNECTING ROD AND PISTON PIN

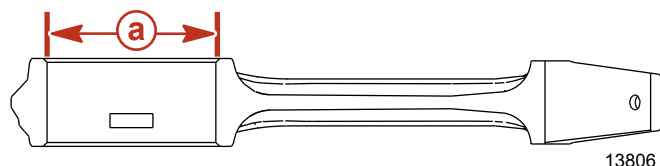
1. Check for twisted or bent connecting rods.
2. Inspect for nicks or cracks.
3. Inspect for damage to the bearing cap and bolt threads.
4. Replace damaged connecting rods.
5. Measure connecting rod width and compare to specification. Replace rods that do not meet specification.

Connecting Rod	
Width	29.900–27.950 mm (1.1772–1.1004 in.)

6. Compare the piston pin to specification:
 - a. Measure the piston pin diameter.
 - b. Measure the piston pin length.
 - c. Measure connecting rod piston pin journal inner diameter and subtract the piston pin outer diameter to determine journal clearance.

Piston Pin	
Diameter	27.993–27.998 mm (1.1021–1.1023 in.)
Length	66.800–67.000 mm (2.6299–2.6378 in.)
Journal clearance	0.102–0.307 mm (0.0040–0.0121 in.)

7. Use an inside dial indicator to measure the connecting rod crankshaft journal bore inside diameter, out of round, and taper.



a - Connecting rod crankshaft journal bore

Connecting Rod Crankshaft Journal	
Inner diameter	53.000–53.018 mm (2.0866–2.0873 in.)

- Replace the connecting rod if the measurements exceed the specifications.

CONNECTING ROD BEARING CLEARANCE - MICROMETER METHOD

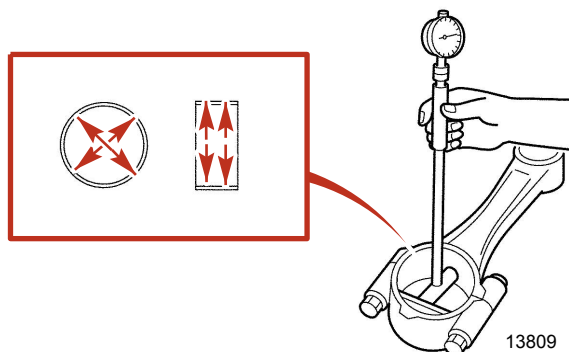
NOTE: The micrometer method is the preferred method of determining connecting rod bearing clearance.

- With the connecting rods removed from the engine, wipe both upper and lower connecting rod bearings clean.
- Install the upper and lower connecting rod bearings.
- Install the bearing cap. The bearing cap must be torqued to specification for proper reading.
- Torque the connecting rod screws.

Description		Nm	lb-in.	lb-ft
Connecting rod screw	First pass	25	–	18
	Final pass (Angle Torque)	+ 90°		

- Use an inside dial indicator to measure the connecting rod bearing inside diameter, out of round, and taper. Measure in several places approximately 90 degrees apart and average the measurements.

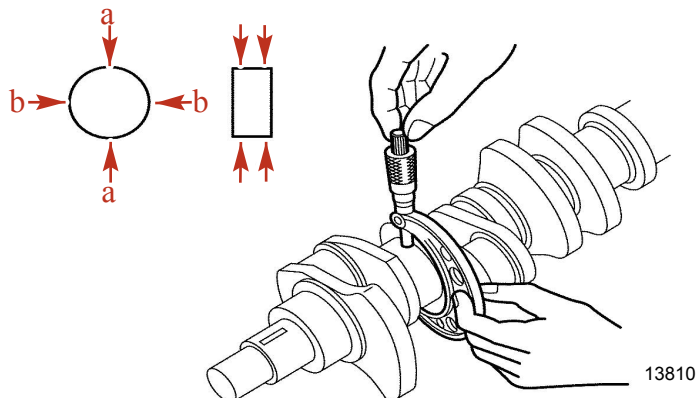
IMPORTANT: Do not measure the diameter close to the split line for the connecting rod and bearings. Bearings are eccentric and false readings could occur.



Measuring connecting rod bearing inside diameter

- Record the measurements for use later.
- Wipe the crankshaft connecting rod journal clean of oil.

8. Using a micrometer, measure the crankshaft connecting rod journal diameters at points "a" and "b" on one side of the journal then repeat measurements on opposite side of journal.



Connecting rod journal measurement - typical crankshaft shown

Crankshaft Connecting Rod Journal	
Outside diameter	50.008–50.026 mm (1.9688–1.9695 in.)

9. If journal diameters are not within specifications, replace or recondition the crankshaft.

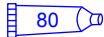
NOTICE

Inadequate clearance or interference between the bearing and its mating surface will result in rapid bearing wear and catastrophic component failure. Check all bearing clearances.

10. If journal diameters are within specifications, determine bearing clearance by subtracting the crankshaft connecting rod journal outside diameter from the inner diameter of the bearing recorded previously.

Connecting Rod Bearing	
Clearance	0.024–0.042 mm (0.0009–0.0017 in.)

11. If the clearance exceeds specifications, select a new bearing of the correct size and determine the clearance.
12. After obtaining the correct clearance, apply lubricant to the crankshaft journal. Apply lubricant to the bearing surface and install the connecting rod cap.

Tube Ref No.	Description	Where Used	Part No.
 80	SAE Engine Oil 30W	Crankshaft journal and bearing surface	Obtain Locally

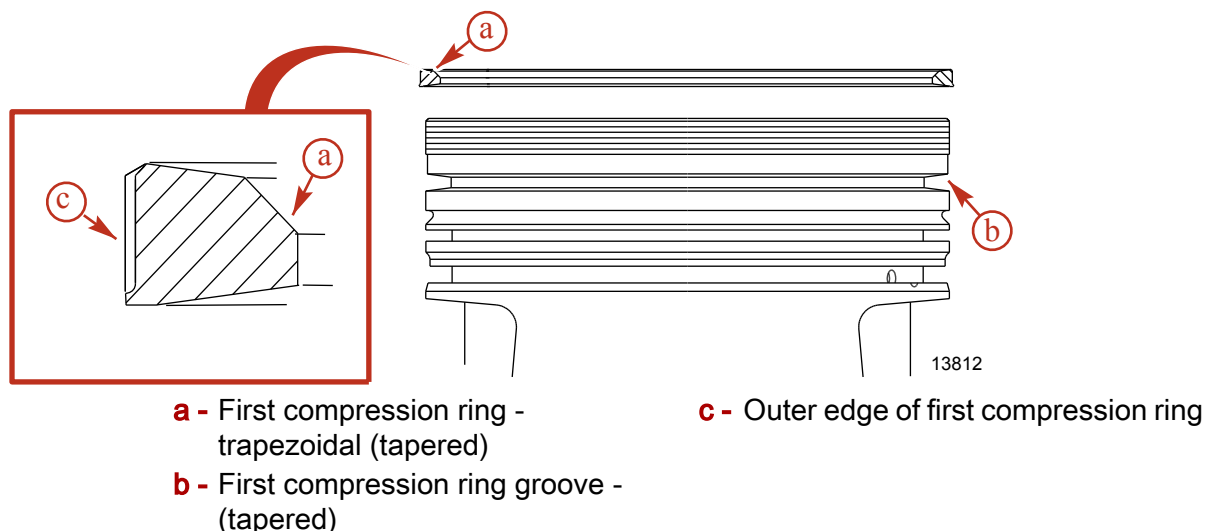
13. Torque the connecting rod screws.

Description		Nm	lb-in.	lb-ft
Connecting rod screw	First pass	25	–	18
	Final pass (Angle Torque)	+ 90°		

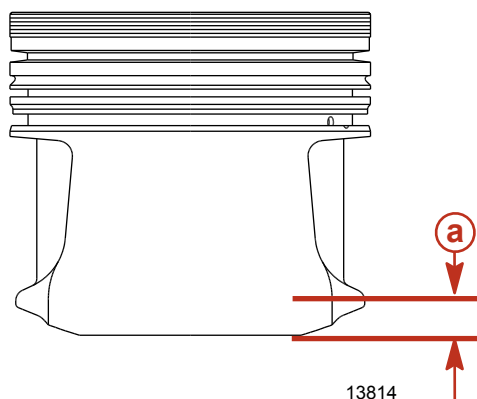
PISTONS AND RINGS

1. Inspect the piston for cracked ring lands, skirts or pin bosses, wavy worn ring lands, scuffed or damaged skirts, or eroded areas at the top of the piston. Replace pistons that are damaged or show signs of excessive wear.

NOTE: Do not mistake tapered or different ring design characteristics for unusual wear patterns. The first (upper) compression ring is trapezoidal (tapered). That is, it has a taper on both upper and lower surfaces. Correspondingly, the first compression ring groove is tapered on top and bottom. The second (scraper) compression ring and the oil control ring are more typical in design.



2. Measure the piston outer diameter 15 mm (19/32 in.) from the bottom and 90 degrees to the piston pin. Replace the piston if the measurement is less than specified.



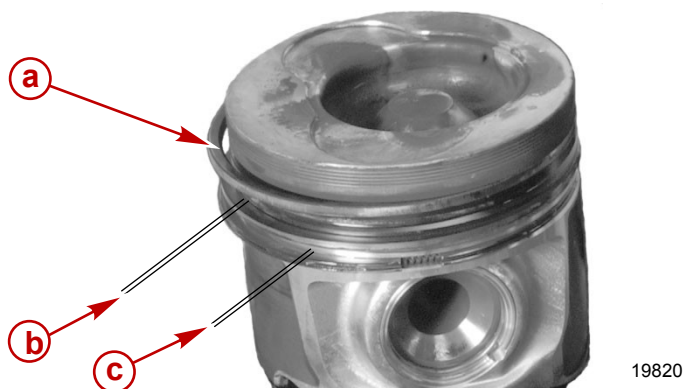
Piston	
Outer diameter	83.000 mm (3.2677 in.)

3. Inspect the piston ring grooves for nicks or burrs that might cause the rings to bind.
4. Except on the upper piston ring groove, insert the edge of the rings into their respective piston ring grooves. Roll the ring entirely around the groove to make sure that ring does not bind. If resistance or binding occurs at any point, determine the cause.
 - a. If binding is caused by a distorted ring, recheck with another ring.

IMPORTANT: When using a fine cut file, do not remove excess material. Verify with a feeler gauge and compare to specifications.

- b. If binding is caused by the ring groove, remove the material causing the binding by dressing the ring groove with a fine cut file.

5. Using a feeler gauge, measure the piston ring groove clearance of the serviceable, or new rings at several points around the piston. Replace the piston if the measured values exceed the specification.



Typical

- a** - First compression ring and groove **c** - Oil control ring and groove
b - Second compression ring and groove

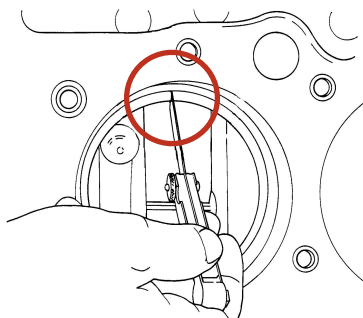
Piston Ring Groove		
Clearance	First compression	0.90 mm (0.0035 in.)
	Second compression	0.070–0.110 mm (0.0028–0.0043 in.)
	Oil control	0.030–0.070 mm (0.0012–0.0028 in.)

6. Check the piston ring end gap:

- a. Position the selected ring in the cylinder bore.

NOTE: The ring must be level (at right angles to the bore surface) for measurement. Push the ring 6 mm (1/4 in.) into the bore with the crown of the piston.

- b. Measure the gap between the ends of the ring with a feeler gauge as shown.



13815

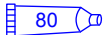
Measuring piston ring end gap

Piston Ring End Gap	
First compression	0.200–0.350 mm (0.0079–0.0138 in.)
Second compression	0.400–0.600 mm (0.0157–0.0236 in.)
Oil control	0.200–0.400 mm (0.0079–0.0157 in.)

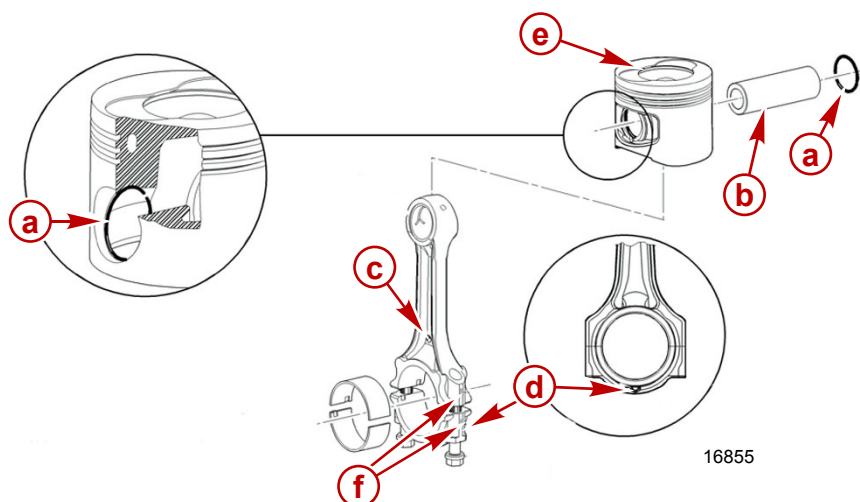
- c. If the gap between the ends of the piston ring is less than specified, remove the ring and try to fit another. Check the cylinder bore if the specification cannot be met with new rings. See **Cylinder Liners**.
- d. Fit each ring to the cylinder in which it will be installed.

Assembly

1. Lubricate the inside of the connecting rod bushing, piston pin bore, and piston pin.

Tube Ref No.	Description	Where Used	Part No.
 80	SAE Engine Oil 30W	Connecting rod bushing, piston pin bore, and piston pin	Obtain Locally

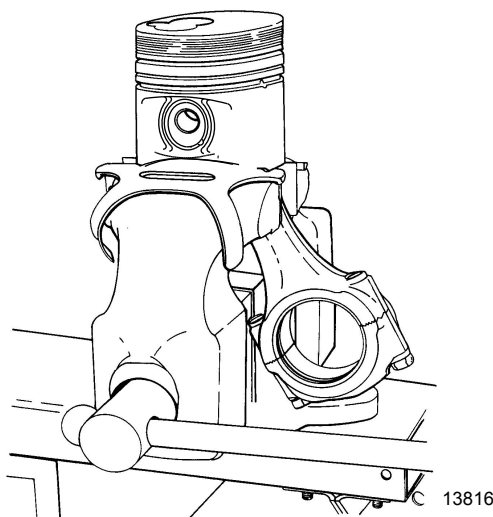
2. Assemble the piston to the connecting rod with the combustion chamber recess, the paint mark, the casting node, and the connecting rod number all oriented as noted during disassembly.
3. Insert the piston pin and install the snap ring.



Piston and connecting rod assembly orientation

- | | |
|-----------------------|--|
| a - Snap ring | d - Casting node |
| b - Piston pin | e - Combustion chamber recess orientation |
| c - Paint mark | f - Connecting rod number |

4. Clamp the connecting rod in a soft-jawed vise as shown.



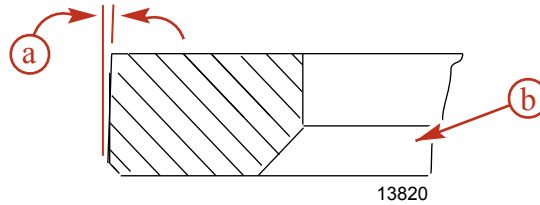
IMPORTANT: Always install rings with ring markings ("CTOP", "PIP" or a dot) facing the top of the piston.

5. Install the oil control ring spring in the lower piston groove.

6. Using the Piston Ring Expander Tool, install the oil control ring.

Piston Ring Expander	91-24697
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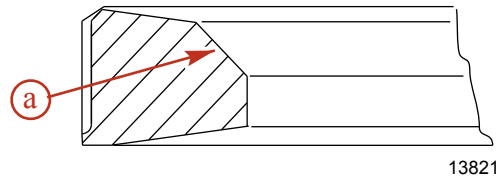
7. By hand, squeeze the ring into the groove to seat the spring. Check for binding.
 8. Using the tool, install the second compression ring in the center piston groove. The inner taper is toward the bottom of the piston.



Second compression ring

1 - Top tapered 2° + or - 30 minutes **2** - Inner taper

9. By hand, squeeze the ring into the groove and check for binding.
 10. Using the tool, install the first compression ring in the upper piston groove. The 45° inner taper is toward the top of the piston.



First compression ring

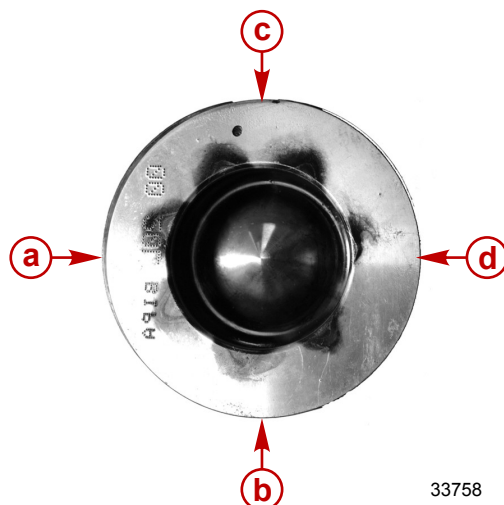
a - Inner taper

11. By hand, squeeze the ring into the groove. Check for binding.

Installation

1. If previously removed, install the crankshaft and engine bed plate. See **Section 3A—Crankshaft and Main Bearings**.
2. Position the piston rings before installing the pistons into the cylinders:
 - a. Position the piston so that the piston data stamping is on the left, the exhaust port side of the engine when installed.
 - b. First compression ring gap is 90° counter-clockwise from the piston data stamping on top of the piston.
 - c. Second compression ring gap is 90° clockwise from the piston data stamping on top of the piston.

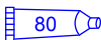
- d. Oil control ring gap is directly opposite the piston data stamping on top of the piston.



33758

- a** - Piston data stamping on the left
- b** - First compression ring gap
- c** - Second compression ring gap
- d** - Oil control ring gap

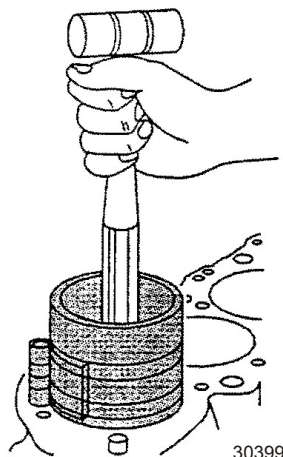
3. Lubricate the cylinder bores and piston rings with engine oil.

Tube Ref No.	Description	Where Used	Part No.
 80	SAE Engine Oil 30W	Cylinder bore and piston rings	Obtain Locally

4. Identify the cylinder from which each piston and connecting rod assembly was removed. Each assembly must be installed in the cylinder from which it was removed.
5. Turn the crankshaft to position the crank journal away from the cylinder so the connecting rod will not damage the journal during installation.
6. Make sure that the piston and connecting rod assembly are properly oriented when installed.

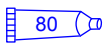
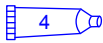
IMPORTANT: The connecting rod can damage the crankshaft journal, the cylinder bore, and the piston cooling jet. Ensure that no components are damaged during connecting rod installation.

7. Using a ring compressor, install the piston by tapping on the piston-top with a suitable device.



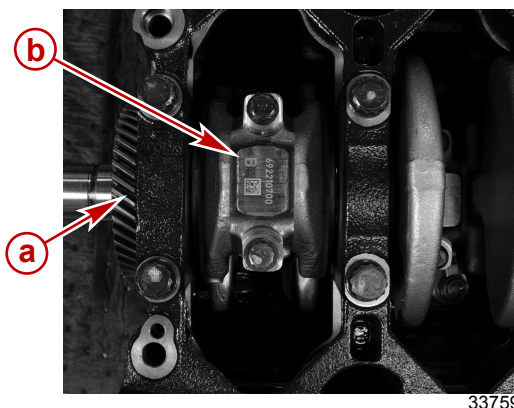
Piston Ring Compressor use

8. Insert the connecting rod bearings into the connecting rod and matching connecting rod cap. Lubricate the bearings and crankshaft journal with a lubricant mixture of 20% SAE 30W engine oil and 80% Needle Bearing Assembly Lubricant.

Tube Ref No.	Description	Where Used	Part No.
 80	SAE Engine Oil 30W	Connecting rod bearings and crankshaft journal	Obtain Locally
 4	Needle Bearing Assembly Lubricant	Connecting rod bearings and crankshaft journal	92-802868A 1

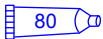
9. Align the connecting rod with the crankshaft journal and tap on the piston top until the connecting rod bearing contacts the journal. Do not scratch or nick the crankshaft journal.

IMPORTANT: The connecting rods are installed so that the data stamping on the small end of the rod faces the front of the engine.



- a** - Front of engine
b - Data stamping

10. Ensure that the matching marks on the connecting rod cap and the connecting rod are the same.
11. Apply lubricant to the crankshaft journal and connecting rod bearing surfaces.

Tube Ref No.	Description	Where Used	Part No.
 80	SAE Engine Oil 30W	Connecting rod crankshaft journal and rod bearing surfaces	Obtain Locally

12. Turn the crankshaft to gain access to the connecting rod screws.

IMPORTANT: Each connecting rod assembly must be reassembled in its original location.

13. Install the connecting rod cap.

14. Install and torque the connecting rod screws.

Description		Nm	lb-in.	lb-ft
Connecting rod screw	First pass	25	–	18
	Final pass (Angle Torque)	+ 90°		

15. Ensure that the connecting rod assembly and the crankshaft journal are not binding.

16. Check connecting rod end play with a feeler gauge. Connecting rods that do not meet specification for installed end play must be replaced.

Connecting Rod	
End play	0.10–0.35 mm (0.0039–0.0138 in.)

17. Install the remaining piston and connecting rod assemblies.

18. Position the engine at cylinder number 1 TDC. See **Section 3A—Establishing Top Dead Center**.

19. Install the cylinder head. See **Section 3A—Cylinder Head**.

20. Install the balance shaft assembly. See **Section 3A—Balance Shaft Assembly**.

21. Install the oil pickup. See **Section 3A—Oil Pan, Oil Pickup, and Related Components**.

22. Install the oil pan. See **Section 3A—Oil Pan, Oil Pickup, and Related Components**.

23. Complete the engine assembly, test engine operation, and check for leaks.

Crankshaft Rear Oil Seal

Removal

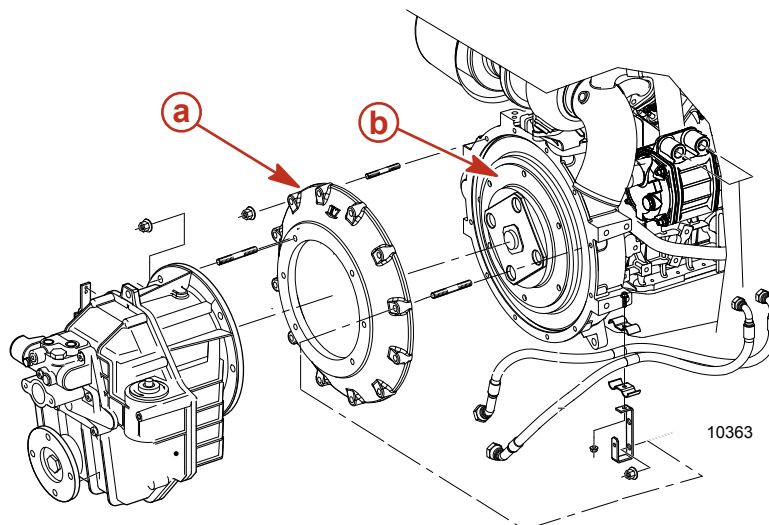
1. On Sterndrive Models:

- Remove the flywheel housing cover. See **Section 3A—Flywheel Housing**.
- Remove the coupler. See **Section 3A—Flywheel, Coupler Or Drive Plate, and Flywheel Housing**.

2. On Inboard Models:

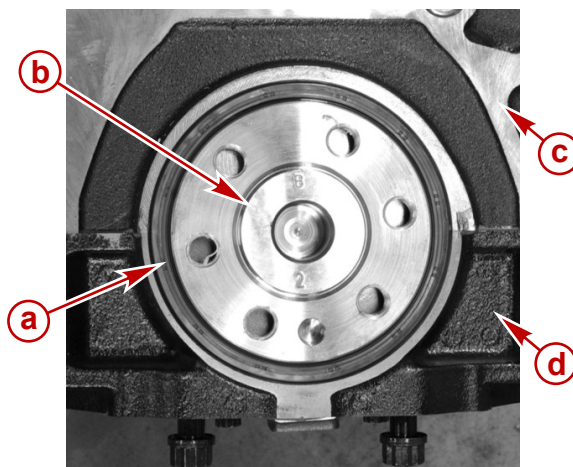
- Remove the transmission, if required.
- Remove the flywheel housing cover.

- c. Remove the drive plate.



- a** - Flywheel housing cover
b - Drive plate

3. Remove the flywheel from the crankshaft. See **Section 3A—Flywheel, Coupler Or Drive Plate, and Flywheel Housing**.
4. Pull the old crankshaft rear oil seal from the engine block with a seal puller.

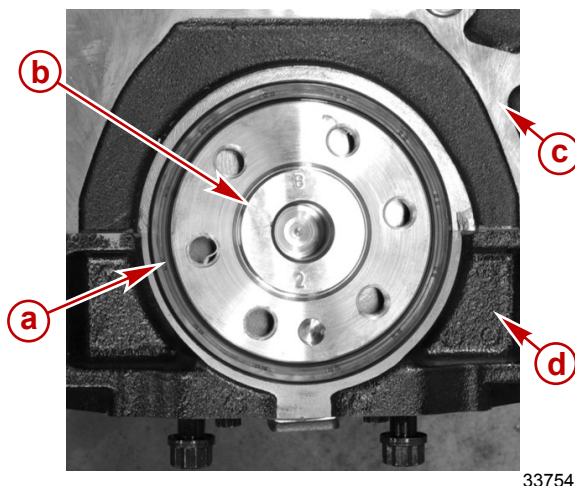


- a** - Oil seal
b - Crankshaft flange
c - Engine block
d - Bed plate

Installation

IMPORTANT: The crankshaft rear oil seal must be installed after the engine bed plate is installed and properly torqued.

1. Press the new rear oil seal into the bearing carrier using an appropriately sized seal installer. The seal will stop when seated.




- a** - Oil seal
- b** - Crankshaft flange
- c** - Engine block
- d** - Bed plate

2. Install the flywheel and flywheel screws.
3. Tighten the flywheel screws in a crosswise pattern to specification.

Description	Nm	lb-in.	lb-ft
Flywheel screw	105	–	77.4

4. Apply sealant to bolt threads and install the sterndrive coupler or inboard drive plate assembly.

Tube Ref No.	Description	Where Used	Part No.
 7	Loctite 271 Threadlocker	Sterndrive coupler or inboard drive plate bolt	92-809819

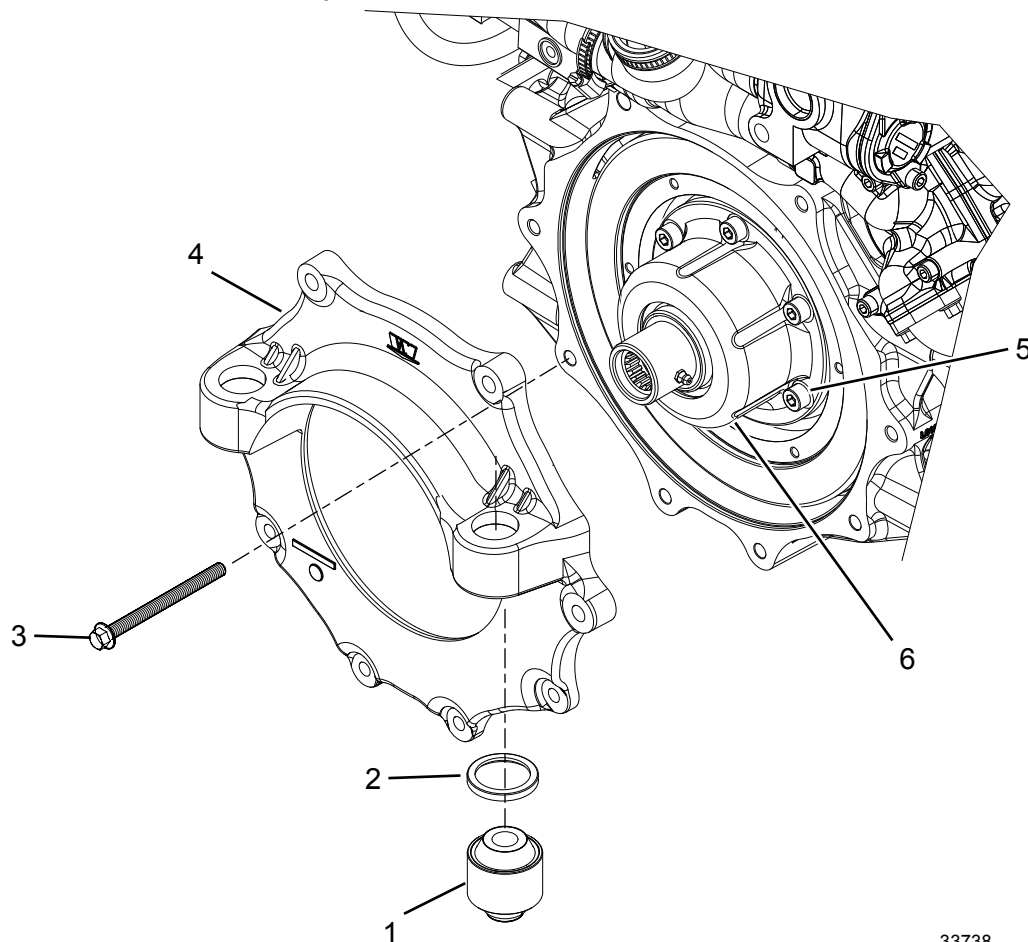
5. Tighten the sterndrive coupler or inboard drive plate bolts to specification.

Description	Nm	lb-in.	lb-ft
Sterndrive coupler bolt	47	–	35
Inboard drive plate bolt	47	–	35

6. Install the drive plate or coupler as required. See **Section 3A—Flywheel, Coupler Or Drive Plate, and Flywheel Housing**.
7. Install the flywheel housing cover and related components. See **Section 3A—Flywheel, Coupler or Drive Plate, and Flywheel Housing**.
8. Reconnect the sterndrive or transmission as applicable. Refer to the appropriate sterndrive or transmission service manual.
9. Install all other components removed.
10. Start the engine and check for leaks.

Flywheel, Coupler Or Drive Plate, and Flywheel Housing

Exploded View—Sterndrive Flywheel Cover and Coupler

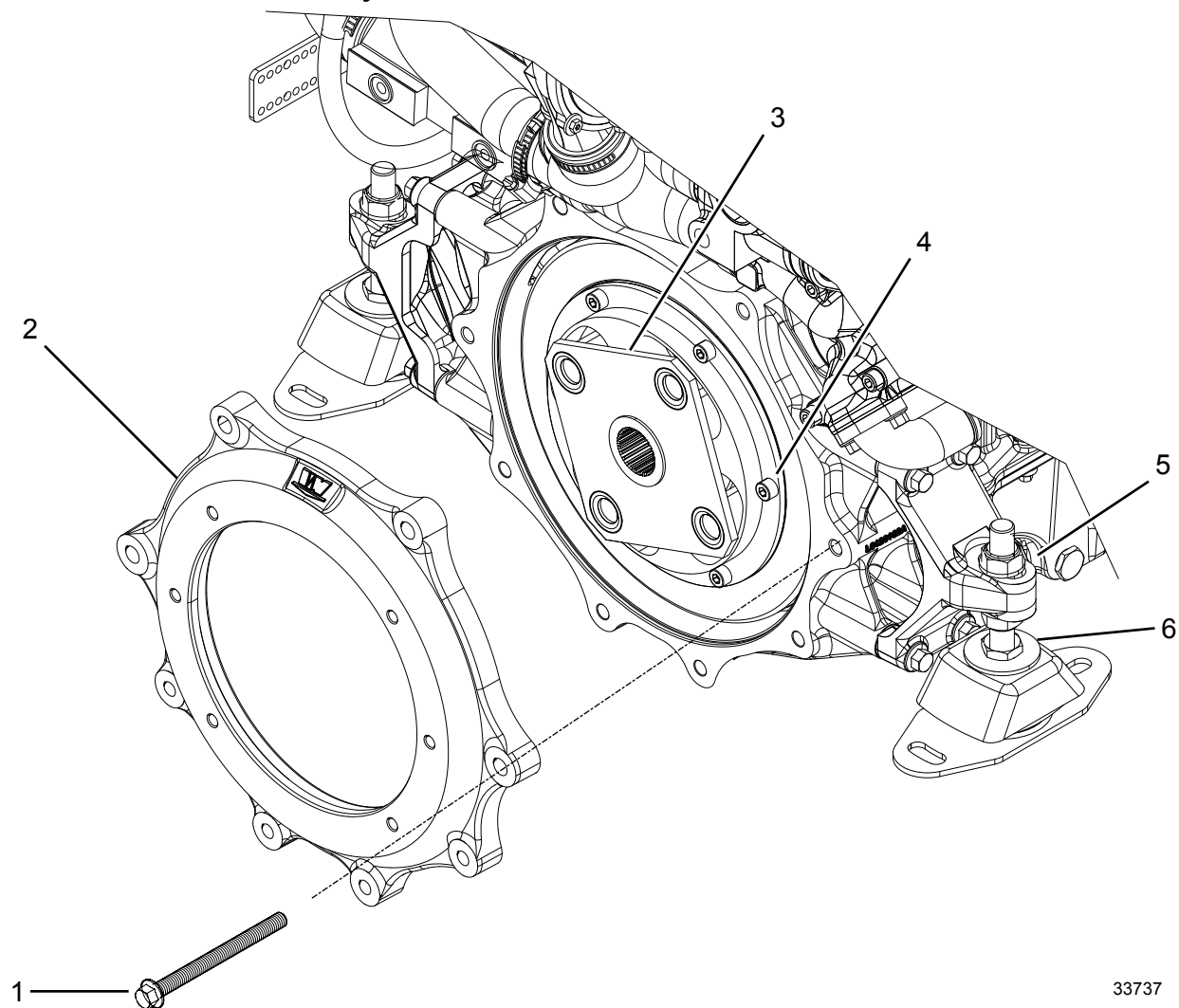


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Exploded View—Sterndrive Flywheel Cover and Coupler

Ref. No.	Qty.	Description	Torque		
			Nm	lb-in.	lb-ft
1	2	Bushing			
2	2	Washer			
3	8	Flywheel housing screw	47.1	–	34
4	1	Flywheel housing cover			
5	6	Coupler screw	47.1	–	34
6	1	Sterndrive Coupler			

Exploded View—Inboard Flywheel Cover and Drive Plate

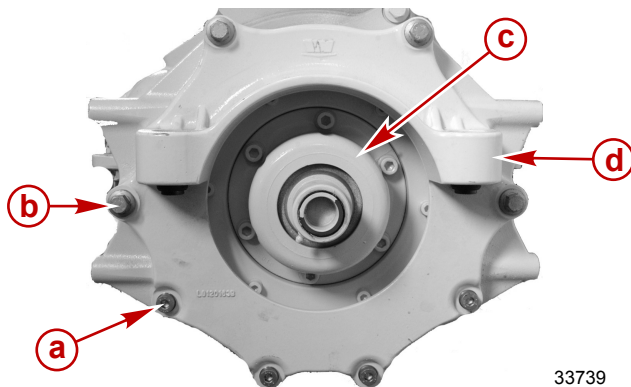


Exploded View—Inboard Flywheel Cover and Drive Plate

Ref. No.	Qty.	Description	Torque		
			Nm	lb. in.	lb. ft.
1	8	Flywheel housing screw	47.1	–	34
2	1	Flywheel housing cover			
3	1	Drive Plate			
4	6	Drive plate screw	47.1	–	34
5	2	Rear mount bracket			
6	2	Rear mount assembly			

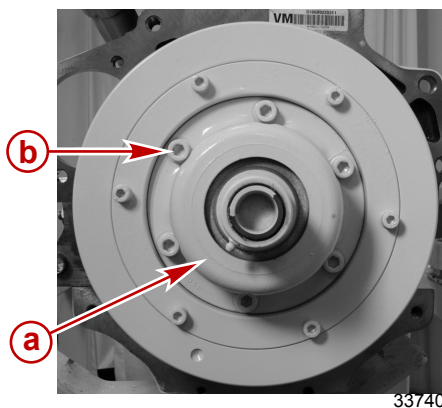
Removal

1. Remove the starter. Refer to **Section 4A—Starter**.
2. On Sterndrive Models:
 - a. Remove the flywheel housing cover.



- a** - Allen head screws
- b** - Flange screws
- c** - Coupler
- d** - Rear engine mount

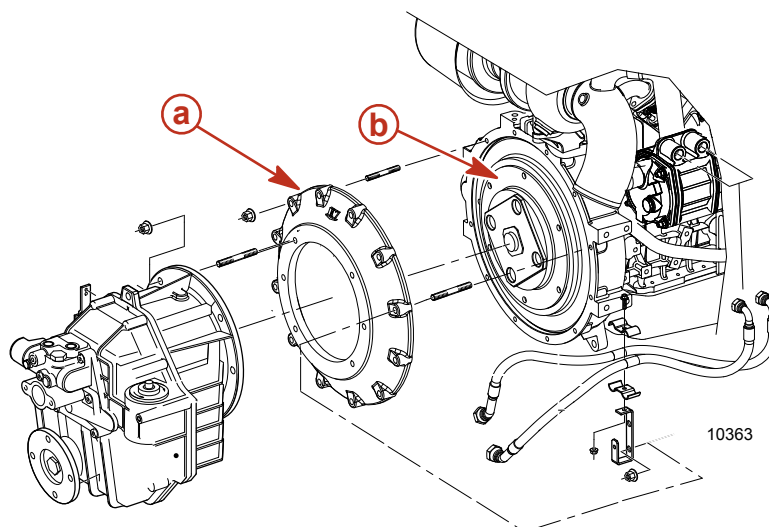
- b. Remove the coupler.



- a** - Coupler
- b** - Coupler screws

3. On Inboard Models:
 - a. Remove the transmission, if required.
 - b. Remove the flywheel housing cover.

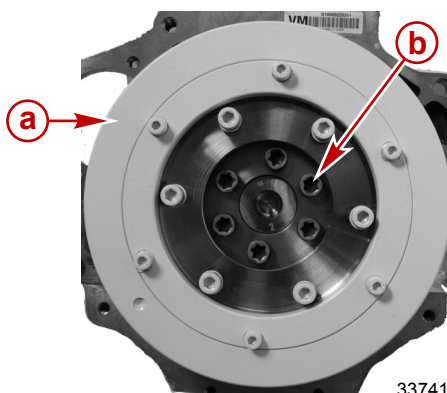
- c. Remove the drive plate.



Typical

- a** - Flywheel housing cover
b - Drive plate

4. Remove the flywheel bolts and the flywheel.



- a** - Flywheel
b - Flywheel bolts

Cleaning

1. Wash the flywheel housing cover, flywheel, and flywheel housing in cleaning solvent.
2. Put on safety glasses and dry the components with compressed air.
3. Clean the mating surfaces of the flywheel and crankshaft. Remove any burrs. Mating surfaces must be clean, bare metal.

Inspection

1. Inspect the rear mounts in the flywheel housing cover. Replace the rear mounts as a matched pair if damaged.
2. Inspect the flywheel housing cover and flywheel housing for cracks or damage.
3. Inspect the splines in the sterndrive coupler or the inboard drive plate for wear.
4. Clean the flywheel with a non-caustic solvent, then visually inspect the flywheel for cracks or heat checks which would make it unfit for further service.
5. Check the flywheel ring gear for worn and missing teeth.

6. Repair or replace worn or damaged components.

Repair

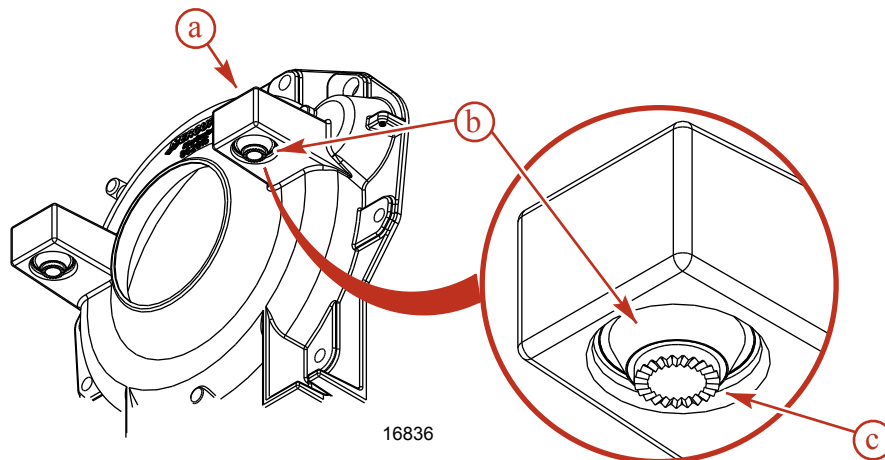
NOTE: The rear mounts pressed into the flywheel housing cover and the flywheel ring gear can be serviced. Replace the other components, such as the flywheel housing, coupler, and drive plate, if worn or damaged.

REAR MOUNTS

1. Replace the rear mounts in the sterndrive flywheel housing cover as follows:
 - a. With the flywheel housing cover in the upright position, remove the rear engine mounts and spacers using a suitable arbor and press.
 - b. Clean the flywheel housing cover rear mount bores.
 - c. Turn the flywheel housing cover upside down and insert the mount bushing inside the rear mount bore.

IMPORTANT: The yellow paint identifies the top of the mount bushing. The bottom has the knurled edge.

- d. Press the mount into the flywheel housing cover so that the painted end will be facing up and the knurled edge of the mount bottom will be facing down when installed on the engine.



Typical sterndrive flywheel housing cover, all similar

a - Painted end (not visible)

c - Knurled edge

b - Mount bottom

IMPORTANT: Because of the bottom knurled edge on these mounts, the double-wound lockwashers, if equipped, are no longer required.

FLYWHEEL RING GEAR

1. Heat the ring gear with a torch on the engine side of the ring gear.
2. Once heated, knock the ring gear off the flywheel. Do not strike the flywheel when removing the ring gear.

IMPORTANT: Some components are made of steel that has been heat treated to increase hardness. Applying excessive heat to the hardened steel will alter the hardness and make the steel weaker. Do not heat any portion of these hardened steel components, such as a flywheel ring gear, to a temperature higher than 278 °C (500 °F).

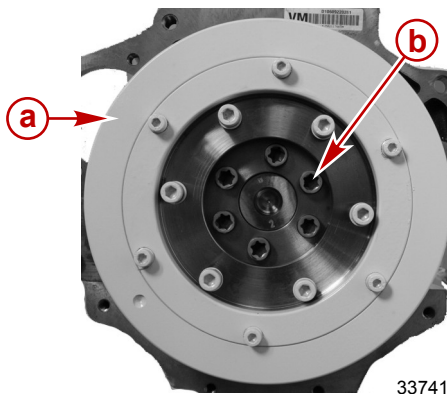
3. Heat the new ring gear for 20 minutes in an oven preheated to 127° C (260° F), or heat evenly until the gear expands enough to slip onto the flywheel. Do not overheat the ring gear.

IMPORTANT: The ring gear must be installed so the bevel on the teeth is toward the crankshaft side of the flywheel.

4. Install the ring gear. Ensure that the ring gear is seated properly against the flywheel shoulder.

Installation

1. Install the flywheel screws and the flywheel.

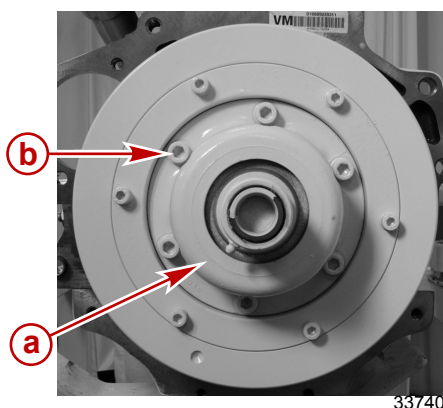


- a** - Flywheel
b - Flywheel bolts

2. Tighten the flywheel screws to specification.

Description	Nm	lb-in.	lb-ft
Flywheel screw	68.6	–	51

3. On Sterndrive Models:
 - a. Install the coupler.

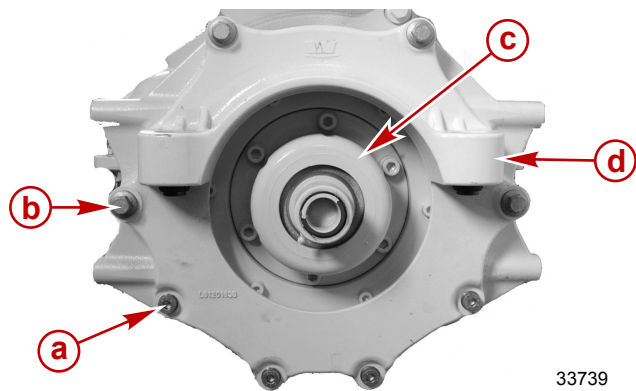


- a** - Coupler
b - Coupler screws

- b. Tighten the coupler screws to specification.

Description	Nm	lb-in.	lb-ft
Coupler screw	47.1	–	35

c. Install the flywheel housing cover.



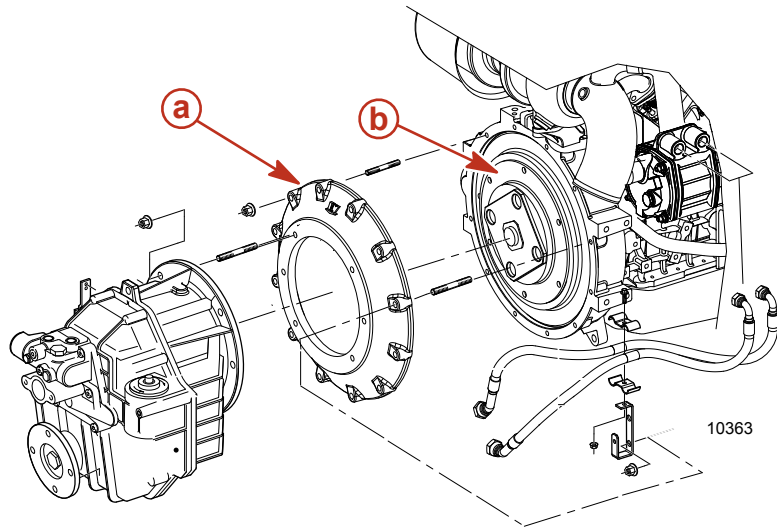
- a** - Allen head screws
- b** - Flange screws
- c** - Coupler
- d** - Rear engine mount

d. Tighten the flywheel housing screws to specification.

Description	Nm	lb-in.	lb-ft
Flywheel housing screw	47.1	–	35

4. On Inboard Models:

a. Install the drive plate.



- a** - Flywheel housing cover
- b** - Drive plate

b. Tighten the drive plate screws to specification.

Description	Nm	lb-in.	lb-ft
Drive plate	47.1	–	35

c. Install the flywheel housing cover.

d. Tighten the flywheel housing cover screws to specification.

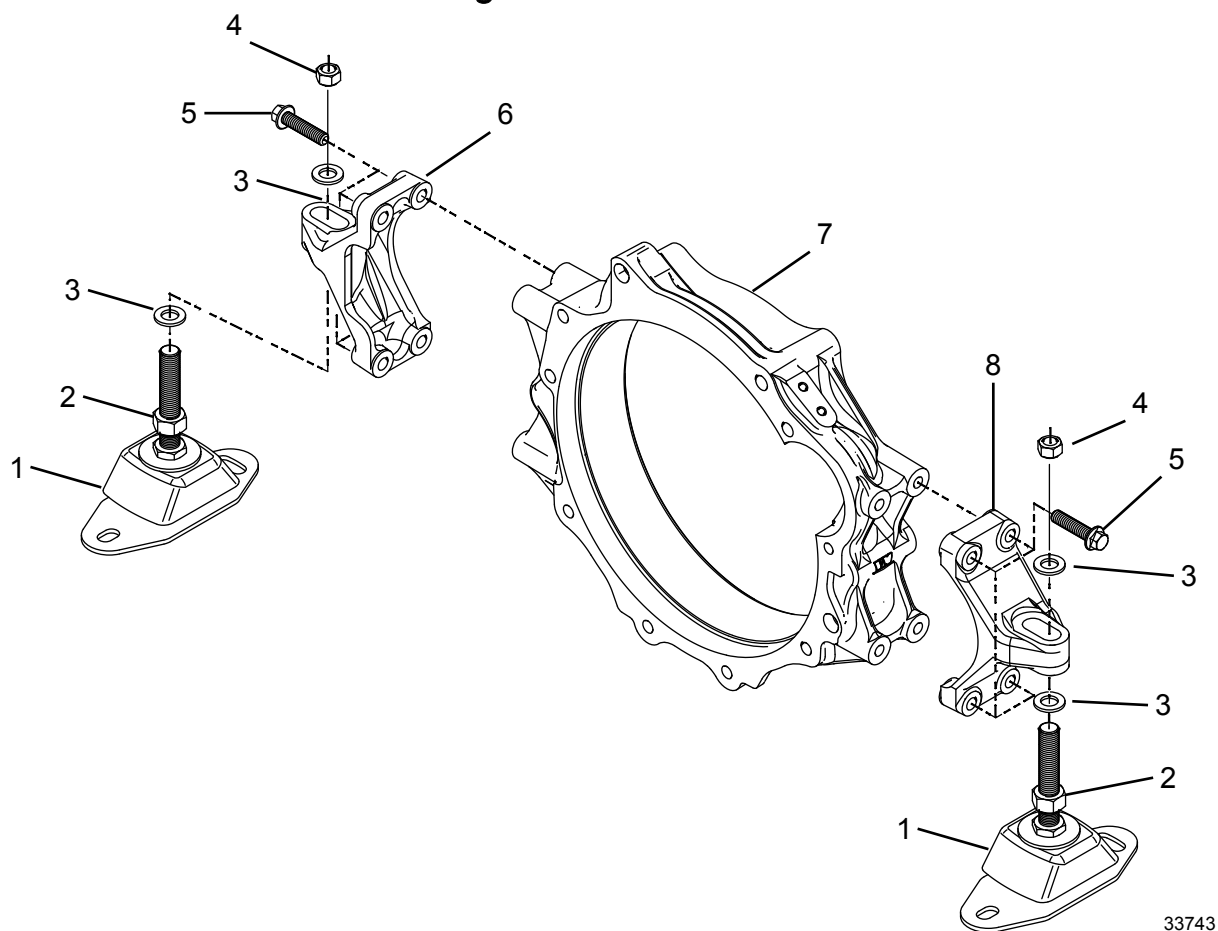
Description	Nm	lb-in.	lb-ft
Flywheel housing cover	47.1	–	35

- e. Install the transmission, if required.
- 5. Install the starter. Refer to **Section 4A—Starter**.

Exploded View—Front Engine Mounts and Brackets

Ref. No.	Qty.	Description	Torque		
			Nm	lb-in.	lb-ft
1	2	Engine mount			
2	6	Nut	47.1	–	35
3	4	Washer			
4	2	Locking (jam) nut	80	–	59
5	1	Port engine mount bracket			
6	1	Starboard engine mount bracket			
7	6	Stud			
8	2	Screw	63.7	–	47

Exploded View—Rear Inboard Engine Mounts and Brackets



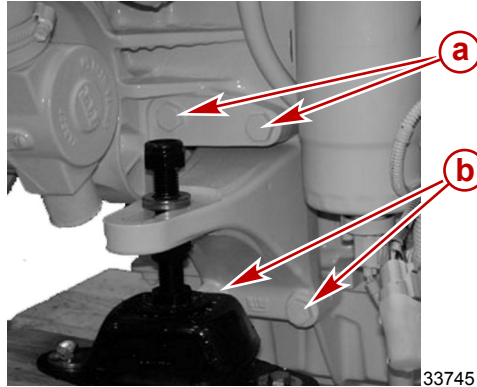
Exploded View—Rear Inboard Engine Mounts and Brackets

Ref. No.	Qty.	Description	Torque		
			Nm	lb-in.	lb-ft
1	2	Engine mount			
2	2	Adjusting nut			
3	4	Washer			
4	2	Locking (jam) nut	80	–	59
5	8	Screw	63.7	–	47
6	1	Starboard engine mount bracket			
7	1	Flywheel housing			
8	1	Port engine mount bracket			

Front Mounts

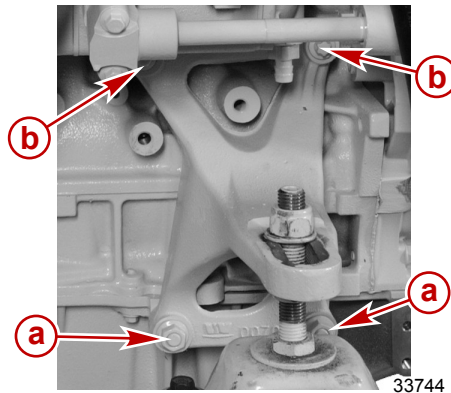
REMOVAL

1. Remove the front engine mount to engine bed fasteners and hardware.
2. Support the front part of the engine with a hoist, or put suitable blocks under the engine.
3. Remove the four engine mount bracket to cylinder block attaching screws from the port engine mount bracket.



- a** - Upper screws
b - Lower screws

4. Slide the mount bracket off the studs to remove.
5. Remove the two engine mount bracket to cylinder block attaching screws and two nuts from the starboard engine mount bracket.



- a** - Nut
b - Screw

6. Slide the mount bracket off the studs to remove.

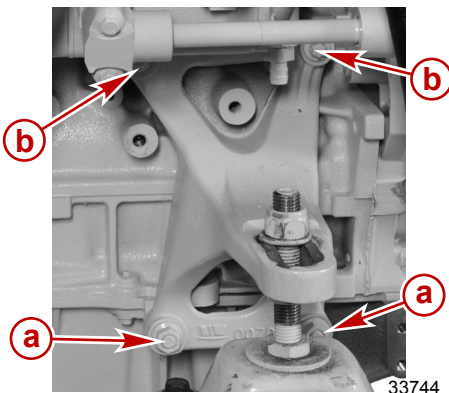
CLEANING AND INSPECTION

1. Except for rubber portions of the mounts, clean the components in cleaning solvent.
2. Put on safety glasses and dry the components with compressed air.
3. Inspect the mounts for cracks or damage.
4. Inspect the rubber portions of the mount for deterioration or wear.
5. Replace deteriorated, worn, cracked, or damaged components.

INSTALLATION

1. Slide the starboard mount bracket on the engine block studs.

2. Install the two engine mount bracket to cylinder block attaching screws and two nuts to the starboard engine mount bracket.

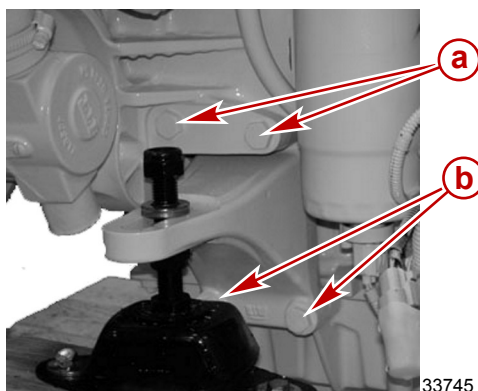


a - Nut
b - Screw

3. Tighten the engine mount bracket attaching nuts and screws to specification.

Description	Nm	lb-in.	lb-ft
Nut	47.1	–	35
Screw	63.7	–	47

4. Slide the port mount bracket on the engine block studs.
5. Install the four engine mount bracket to cylinder block attaching screws to the port engine mount bracket.



a - Upper screws
b - Lower screws

6. Tighten the engine mount bracket attaching screws to specification.

Description	Nm	lb-in.	lb-ft
Screws	47.1	–	35

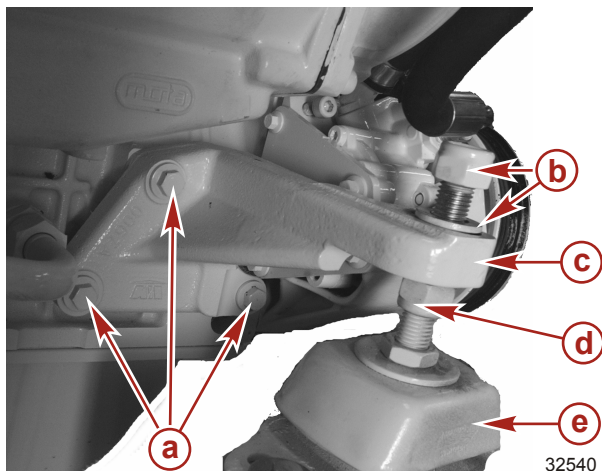
7. Lower the engine on to the mounts and check engine alignment. Refer to **Section 2A—Engine Installation**.
8. Install the front engine mount to engine bed fasteners and hardware.
9. Tighten the engine mount lock nut to specification.

Description	Nm	lb-in.	lb-ft
Nut	80	–	59

Rear Inboard Mounts

REMOVAL

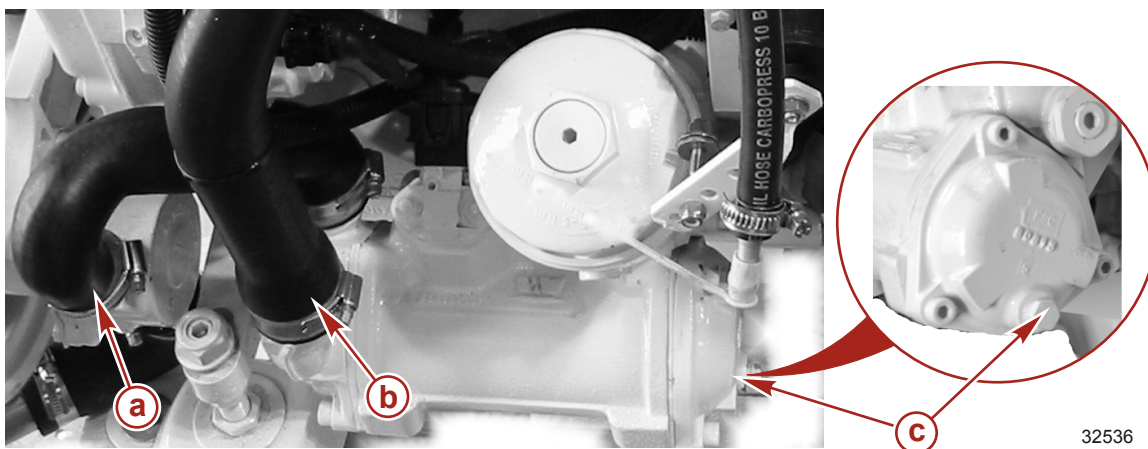
1. Remove the front engine mount to engine bed fasteners and hardware.
2. Support the front part of the engine with a hoist, or put suitable blocks under the engine.
3. Remove the three engine mount bracket to cylinder block attaching screws from the starboard engine mount bracket.



Starboard side shown, port attachment similar

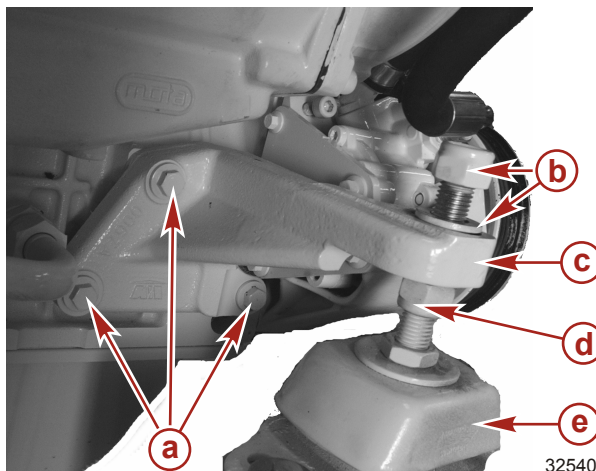
- a** - Engine mount attaching screws
- b** - Isolator to mount nut and lock washer
- c** - Engine mount bracket
- d** - Adjusting nut
- e** - Engine mount

4. If the boat is to remain in the water, close the seacock (if equipped) or disconnect and plug the seawater inlet hose.
5. Drain the seawater system.
6. Remove the two seawater hoses from the oil cooler to ease access to the port side engine mount bracket.



- a** - Seawater pump outlet hose
- b** - Oil cooler seawater outlet hose
- c** - Drain plug

7. Remove the three engine mount bracket to cylinder block attaching screws from the port engine mount bracket.



Port side shown, starboard attachment similar

- a** - Engine mount attaching screws
- b** - Isolator to mount nut and lock washer
- c** - Engine mount bracket
- d** - Adjusting nut
- e** - Engine mount

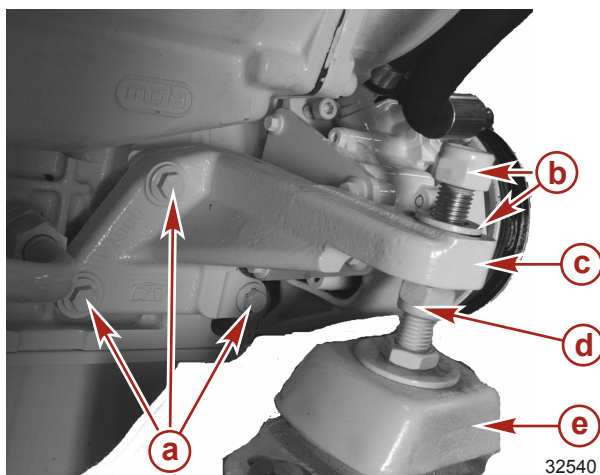
CLEANING AND INSPECTION

1. Except for rubber portions of the mounts, clean the components in cleaning solvent.
2. Put on safety glasses and dry the components with compressed air.
3. Inspect the mounts for cracks or damage.
4. Inspect the rubber portions of the mount for deterioration or wear.
5. Replace deteriorated, worn, cracked, or damaged components.

INSTALLATION

1. Install the starboard front mount bracket to the cylinder block.
2. Install the port front mount bracket to the cylinder block.

3. Torque the front mount bracket screws.

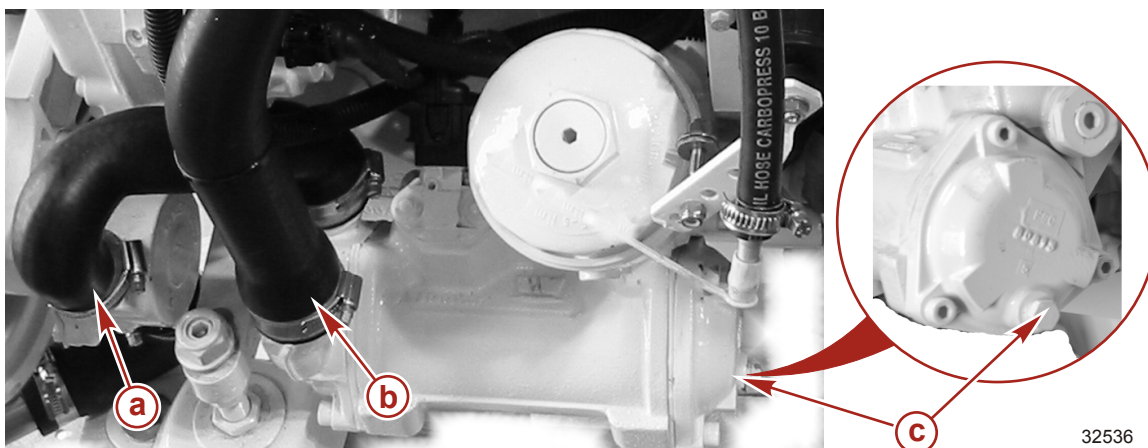


Port side shown, starboard attachment similar

- a** - Engine mount attaching screws
- b** - Isolator to mount nut and lock washer
- c** - Engine mount bracket
- d** - Adjusting nut
- e** - Engine mount

Description	Nm	lb. in.	lb. ft.
Front mount screw	78.5	—	58

4. Install the two seawater hoses on the oil cooler.



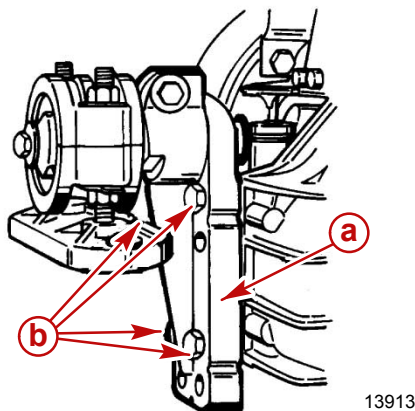
- a** - Seawater pump outlet hose
- b** - Oil cooler seawater outlet hose
- c** - Drain plug

5. Remove the engine's secondary support and lower the engine with a hoist.
6. Install the front engine mount to engine bed fasteners and hardware. Tighten securely.
7. Align the engine and drive. Adjust the mounts as needed. See **Section 2B—Engine Installation**.

V-drive Rear Engine Mounts

INSTALLATION POSITION

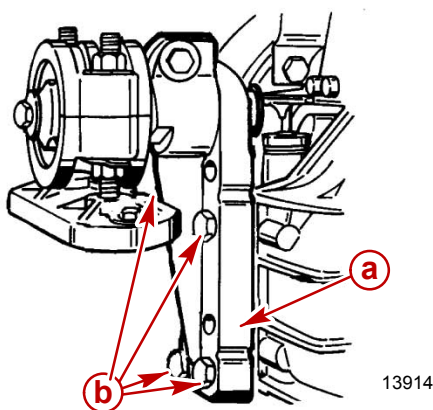
Depending on the installation angle, the inboard model rear mount bracket can be bolted to the transmission in the standard or alternate mount position as shown.



Standard Mount Position

a - Mount bracket

b - Bolts



Alternate Mount Position

a - Mount bracket

b - Bolts

REMOVAL

1. Remove the rear engine mount to engine bed fasteners and hardware.
2. Support the rear part of the engine or the transmission with a hoist, or put suitable blocks under the flywheel housing or transmission.
3. Remove the port and starboard rear mount brackets, with base and trunnion.

CLEANING AND INSPECTION

1. Except for rubber portions of the mount, clean the components in cleaning solvent.
2. Put on safety glasses and dry the components with compressed air.
3. Inspect the mounts for cracks or damage.
4. Inspect the rubber portions of the mount for deterioration or wear.
5. Replace deteriorated, worn, cracked, or damaged components.

INSTALLATION

1. Apply sealant to the threads of the rear mount bracket screws.

Tube Ref No.	Description	Where Used	Part No.
 51	Loctite 222 Threadlocker	Rear mount bracket screws	92-809818

2. Install the rear mount brackets in the standard or alternate mount position as required. Torque the rear mount bracket screws with lockwashers.

Description	Nm	lb. in.	lb. ft.
Rear mount bracket screw	75	–	55

3. Remove the suitable blocks under the flywheel housing or transmission and lower the rear part of the engine or the transmission with a hoist.
4. Install the four rear engine mount to engine bed fasteners and hardware. Tighten the fasteners securely.
5. Align the engine and drive. Adjust the mounts as needed. See **Section 2**.