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Component

Component Exploded View

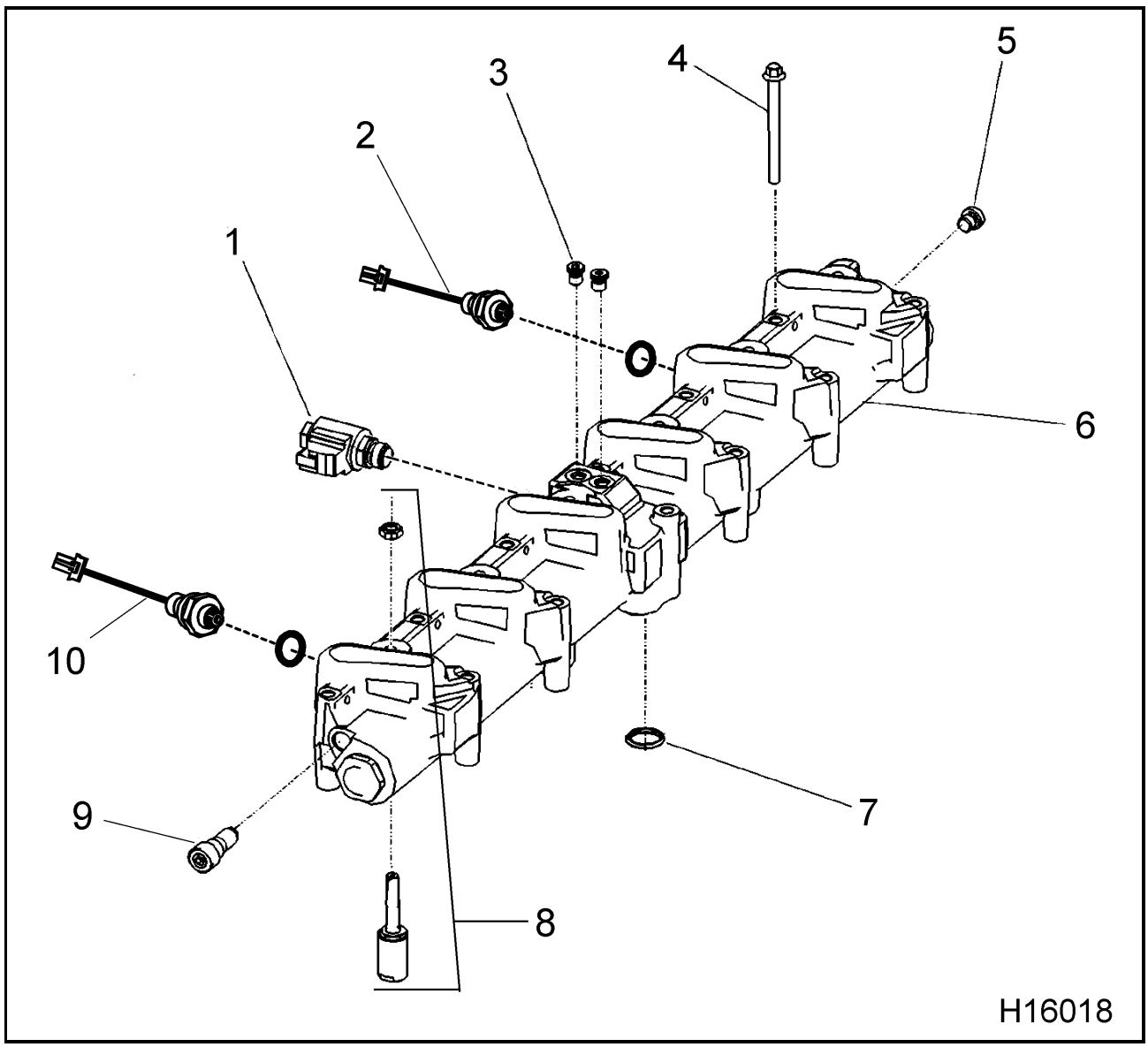

Figure 576 High-pressure oil manifold / engine brake

1. Brake shutoff valve assembly
2. Injection Control Pressure (ICP) sensor with O-ring
3. Plug, M10 (3)
4. Brake housing bolt, M8 x 90 (12)
5. Plug assembly, M12 (2)
6. Engine brake housing
7. High-pressure oil supply to rail O-ring
8. Brake actuator piston assembly
9. Oil pressure relief valve
10. Brake Control Pressure (BCP) sensor with O-ring

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Removal

Brake Assembly

WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, read all safety instructions in the "Safety Information" section of this manual.

WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, make sure the transmission is in neutral, parking brake is set, and wheels are blocked before doing diagnostic or service procedures on engine or vehicle.

NOTE: For information regarding the removal or installation of adjacent components, refer to the following service procedures located in other sections of this manual:

- Valve cover

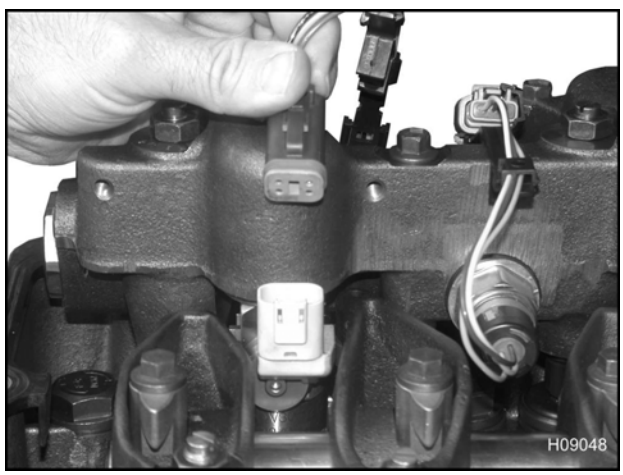

Figure 577 Injector electrical connector

1. Unclip and disconnect each injector electrical connector from the brake housing and valve cover gasket and place aside.

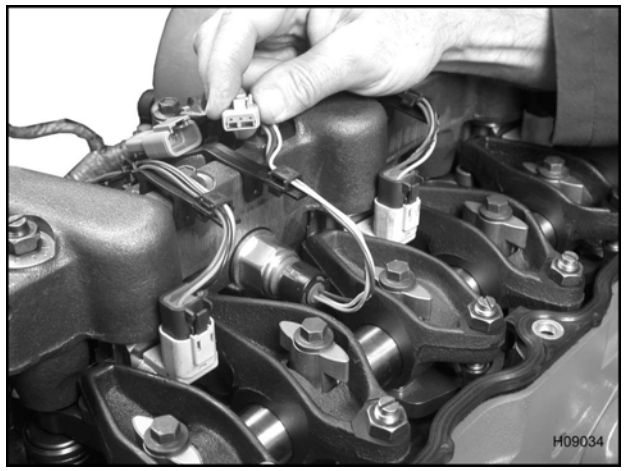

Figure 578 Injection Control Pressure (ICP) sensor electrical connector

2. Unclip and disconnect the Injection Control Pressure (ICP) sensor electrical connector from brake housing and valve cover gasket (rear).

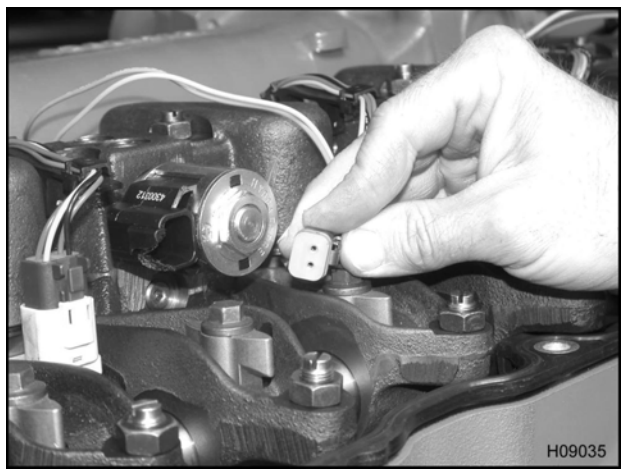

Figure 579 Brake shutoff valve assembly electrical connector

3. Unclip and disconnect brake shutoff valve electrical connector from brake housing and valve cover gasket.

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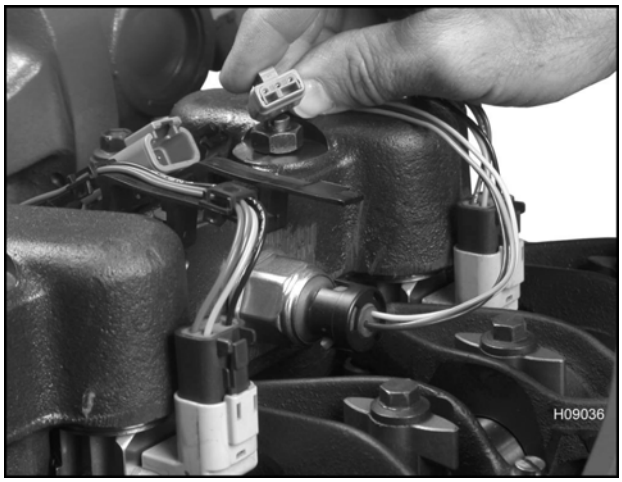

Figure 580 Brake Control Pressure (BCP) sensor electrical connector

4. Unclip and disconnect Brake Control Pressure (BCP) sensor electrical connector from brake housing and valve cover gasket (front).

NOTE: The ICP and BCP sensors are identical and share the same part number.

5. Loosen all brake housing bolts (M8 x 90) in a circular pattern beginning from either end.

WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, have an assistant help remove or install the engine brake assembly when working within the chassis.

6. Remove all bolts and lift brake assembly straight up just enough to drain as much oil out of brake assembly before lifting it away from cylinder head.
7. Prior to disassembly, clean outside of brake assembly using appropriate solvent .

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Reconditioning

Brake Assembly Components

NOTE: If for any reason the valve cover is removed, verify the six brake piston locknuts are tight. If found loose, verify and reset brake lash as required.

NOTE: When the high-pressure oil manifold equipped with a brake is removed for reasons other than cylinder head reconditioning, inspect the contact surfaces which include brake actuator piston face and top of valve bridge at six locations. Inspect for evidence of pitting and material transfer deformation. Replace as necessary. Polished surfaces are acceptable.

The following items are available as service parts as required after diagnostic testing. See engine diagnostic manual for further information about appropriate tests.

A. Brake shutoff valve assembly
B. ICP sensor with O-ring
C. BCP sensor with O-ring
D. Plug, M10 (3)
E. Brake housing bolt, M8 x 90 (12)
F. Plug assembly, M12 (2)
G. High-pressure supply to rail O-ring
H. Oil pressure relief valve
I. Brake actuator piston assembly

Brake Shutoff Valve Replacement

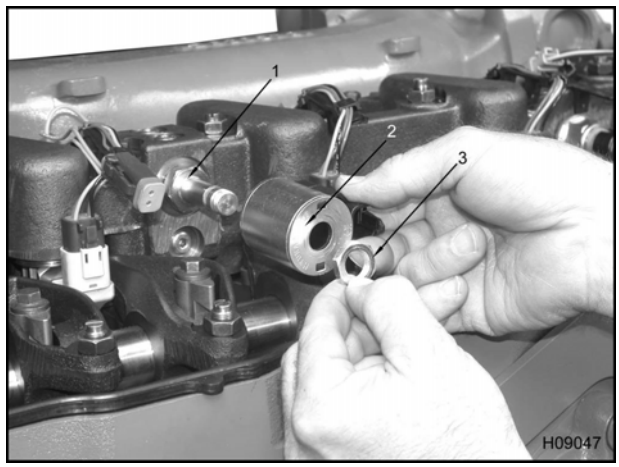

Figure 581 Brake shutoff valve assembly

1. Brake shutoff valve
2. Solenoid
3. Tinnermann nut

1. Remove the tinnermann nut and solenoid.

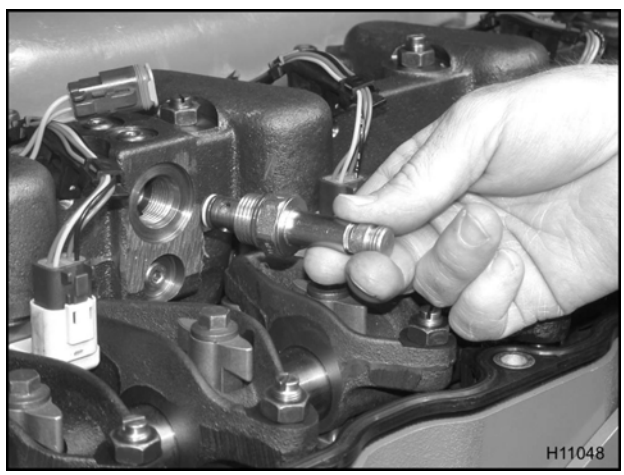

Figure 582 Brake shutoff valve

2. Remove the shutoff valve.
3. Install the new shutoff valve. Move valve in and out against spring tension to check for any binding. Lubricate the O-ring seals with clean engine oil
4. Place the solenoid over the brake shutoff valve.
5. Install the tinnermann nut and torque to the special torque value (Table 53).

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BCP Sensor Replacement

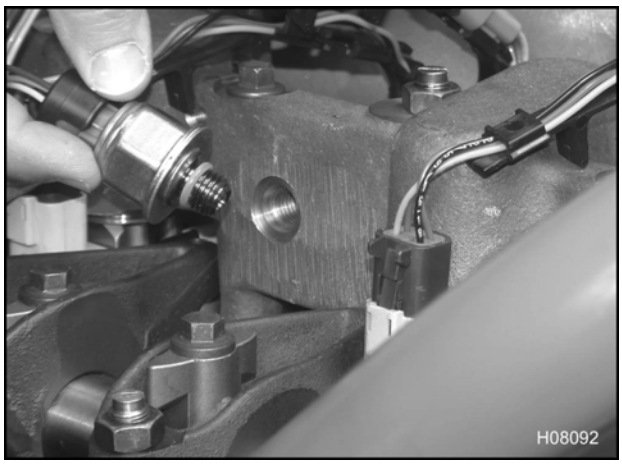

Figure 583 BCP sensor with O-ring

Replace BCP sensor with new O-ring. Tighten sensor to the special torque value (Table 53) .

ICP Sensor Replacement

Figure 584 ICP sensor with O-ring

Replace ICP sensor with new O-ring. Tighten sensor to the special torque value (Table 53).

M10 Plug Replacement

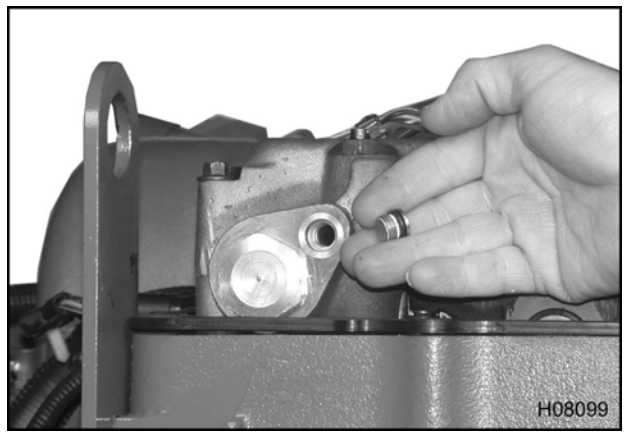

Figure 585 Plug, M10 (3)

Replace plugs with new O-ring seals as required to eliminate any leakage.

M12 End Plug Replacement

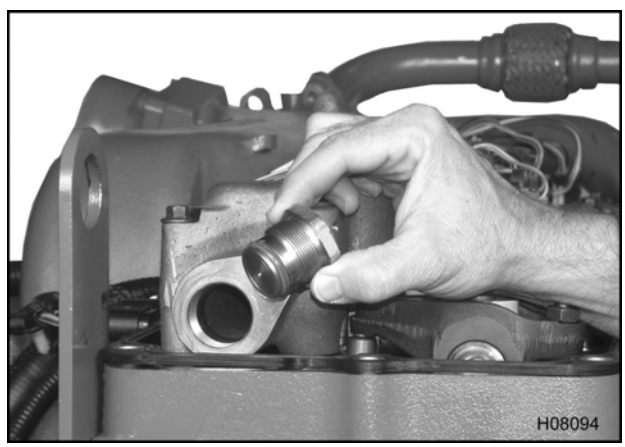

Figure 586 End plug, M12

Replace plug with new O-ring seal as required to eliminate any leakage. Tighten to the special torque value (Table 53).

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Oil Pressure Relief Valve Replacement

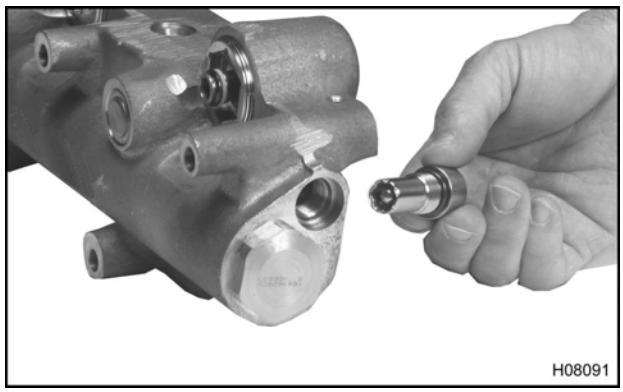

Figure 587 Oil pressure relief valve

1. Replace oil pressure relief valve with a new O-ring seal and tighten to the special torque value (Table 53).

Brake Actuator Piston Assembly Replacement

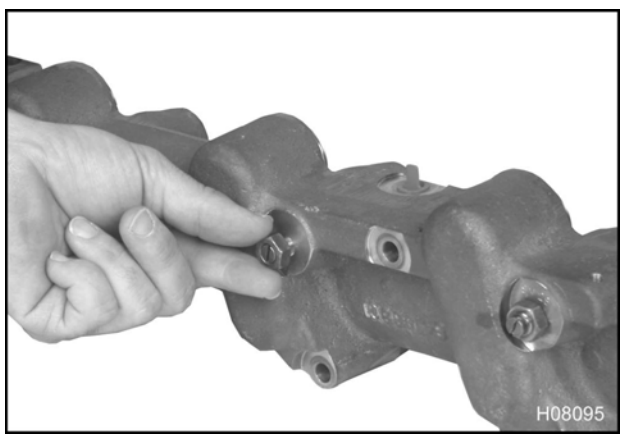

Figure 588 Brake actuator lash locknut

1. Remove the lash locknut.

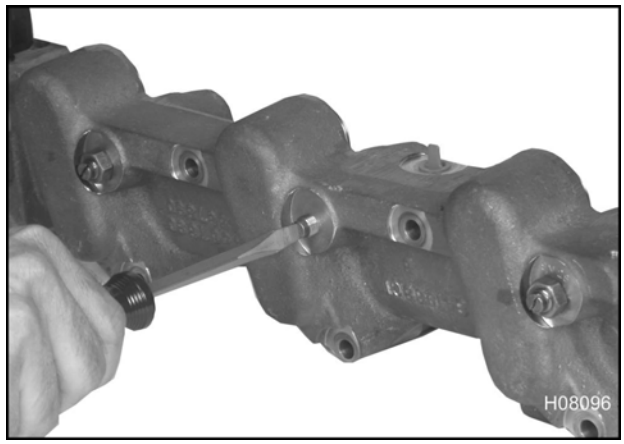

Figure 589 Removing the brake actuator piston

2. Use a screwdriver to turn out the piston assembly from the high-pressure oil manifold housing.

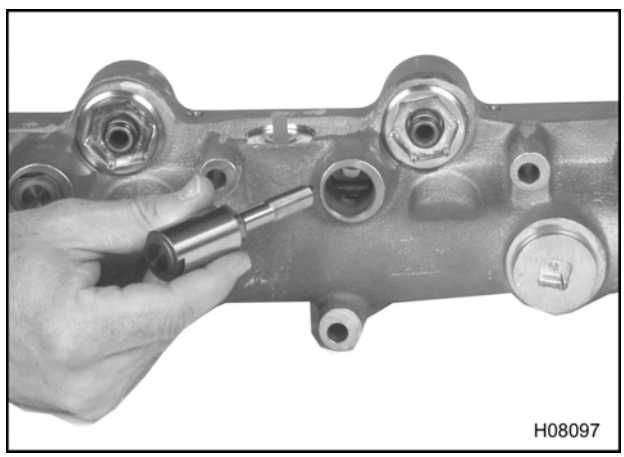

Figure 590 Brake actuator piston assembly

3. Reverse the steps to install the new piston assembly. There are no seals associated with this assembly.
4. Final lash adjustments will be made after brake assembly is installed onto cylinder head.

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Installation

Brake Assembly

WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, make certain that the parking brake is set, wheels are blocked, and transmission is in neutral before cranking engine.

NOTE: The seal and backup ring for the high-pressure oil manifold and brake assembly oil inlet adapters may be the same color. The larger diameter ring must be installed first and then the smaller seal can be installed.

1. Back off all valve lash adjustments. This must be done to eliminate the possibility of additional forces on the brake assembly when torqing mounting bolts.

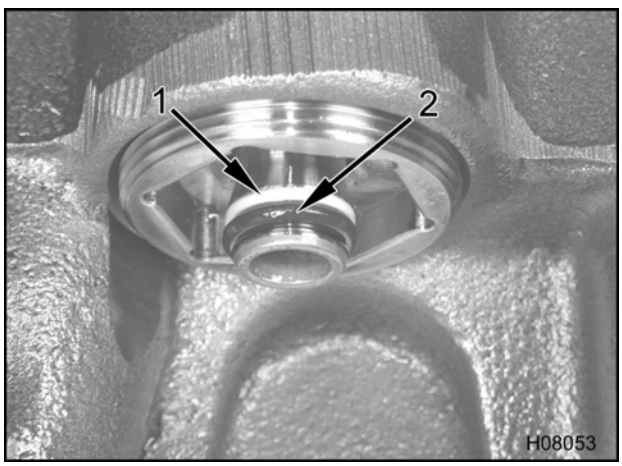

Figure 591 High-pressure oil manifold and brake assembly oil inlet adapter seal

1. Backup ring
2. Seal

2. Coat six new injector oil inlet seals with clean engine oil and install onto high-pressure oil manifold and brake assembly oil inlet adapters.

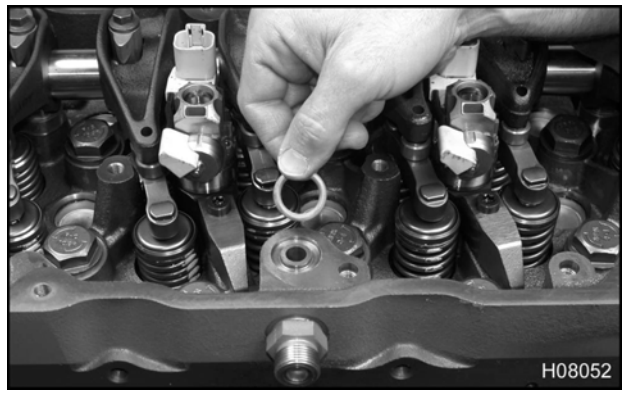

Figure 592 High-pressure oil manifold and brake assembly O-ring

3. Coat new oil inlet O-ring with clean engine oil and install onto cylinder head oil inlet recess.

WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, have an assistant help remove or install the engine brake assembly when working within the chassis due to its heavy weight and limited accessibility.

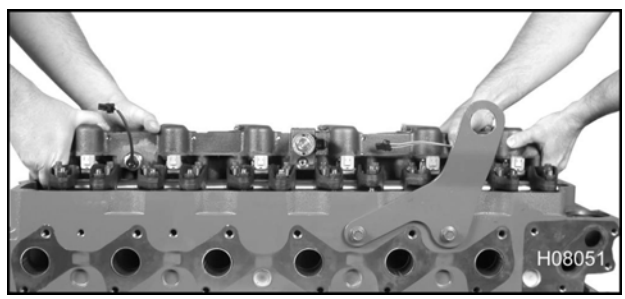

Figure 593 Installing the high-pressure oil manifold and brake assembly

4. Lift assembly up and place onto engine. Align high-pressure oil manifold oil inlet adapters with injector inlets.

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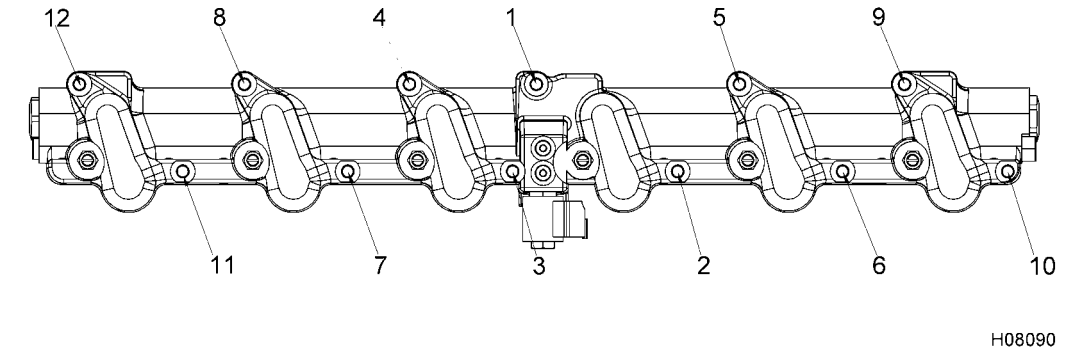

Figure 594 Engine brake bolt torque sequence

5. Install and hand tighten all brake housing bolts (M8 x 90). Torque bolts to the special torque value (Table 53) in a circular pattern, beginning from the center.

NOTE: Air trapped within the engine brake rail will be purged automatically during the cranking and start-up phase.

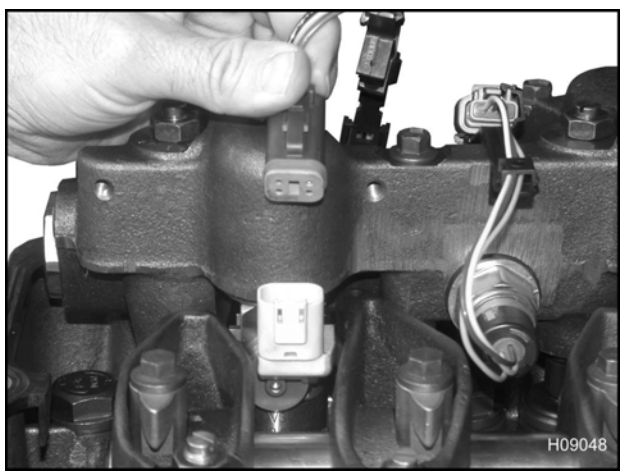

Figure 595 Injector electrical connector

6. Connect each valve cover gasket pass-through connector to its respective injector and clip harness onto the brake housing.

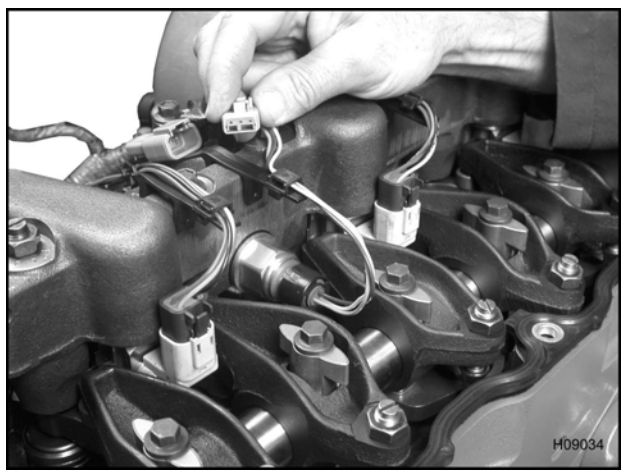

Figure 596 Injection Control Pressure (ICP) sensor electrical connector

7. Connect Injection Control Pressure (ICP) sensor electrical connector to valve cover gasket pass-through connector (rear) and clip harness to brake housing.

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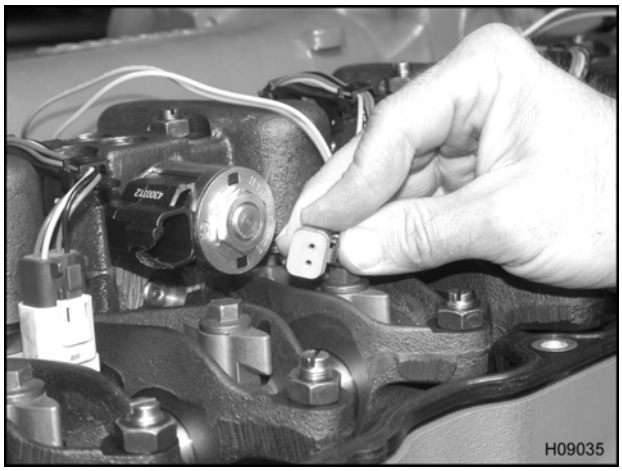

Figure 597 Brake shutoff valve assembly electrical connector

8. Connect brake shutoff valve electrical connector to valve cover gasket pass-through connector and clip harness to brake housing.
9. Connect the Brake Control Pressure (BCP) sensor electrical connector to the valve cover gasket pass-through connector.

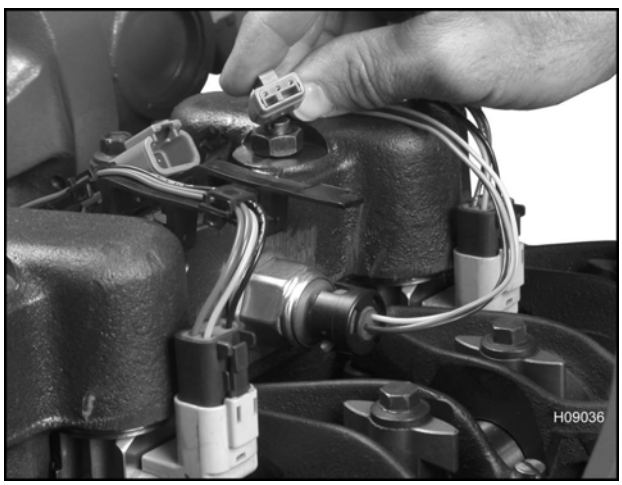

Figure 598 Brake Control Pressure (BCP) sensor electrical connector

10. Connect the Injection Control Pressure (ICP) sensor electrical connector to the valve cover gasket pass-through connector.

Engine Brake Actuator Lash

During the procedure to adjust brake lash, the crankshaft is rotated two times:

- Three actuators are adjusted when piston 1 is at Top Dead Center (TDC) compression.
- Three actuators are adjusted when piston 6 is at Top Dead Center (TDC) compression.

Corresponding intake and exhaust valve lash can be adjusted before and after rotating the crankshaft. See “Procedure for Valve Lash” (See Adjusting Valve Lash, page 132) .

Adjusting Brake Lash

1. Remove valve cover (See Valve Cover, page 104).
2. Turn crankshaft in the direction of engine rotation to remove gear lash from gear train and align the timing mark on the damper pulley with the TDC mark on the front cover.
3. Confirm that piston 1 is at TDC compression by turning push rods by hand to verify that valves are closed.
   - If push rods are loose and turn easily, piston 1 is at TDC compression and valves are closed. If piston 1 is at TDC, see (Figure 599) and do steps 4, 5 and 6.
   - If push rods will not turn easily, piston 6 is at TDC compression. Confirm that valves are closed by making sure that push rods for cylinder 6 are loose and turn easily. If piston 6 is at TDC, see (Figure 600) and do steps 4, 5 and 6.

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Valve and brake lash adjustments (Inches) with piston 1 at TDC compression											
Cylinder 1		Cylinder 2		Cylinder 3		Cylinder 4		Cylinder 5		Cylinder 6	
Intake 1	Exhaust 2	Intake 3	Exhaust 4	Intake 5	Exhaust 6	Intake 7	Exhaust 8	Intake 9	Exhaust 10	Intake 11	Exhaust 12
0.019	0.019	0.019			0.019	0.019			0.019		
Brake				Brake				Brake			
0.019				0.019				0.019			

H08044

Figure 599 Valve and brake lash adjustments with piston 1 at TDC compression

Valve and brake lash adjustments (Inches) with piston 6 at TDC compression											
Cylinder 1		Cylinder 2		Cylinder 3		Cylinder 4		Cylinder 5		Cylinder 6	
Intake 1	Exhaust 2	Intake 3	Exhaust 4	Intake 5	Exhaust 6	Intake 7	Exhaust 8	Intake 9	Exhaust 10	Intake 11	Exhaust 12
			0.019	0.019			0.019	0.019		0.019	0.019
		Brake				Brake				Brake	
		0.019				0.019				0.019	

H08045

Figure 600 Valve and brake lash adjustments with piston 6 at TDC compression

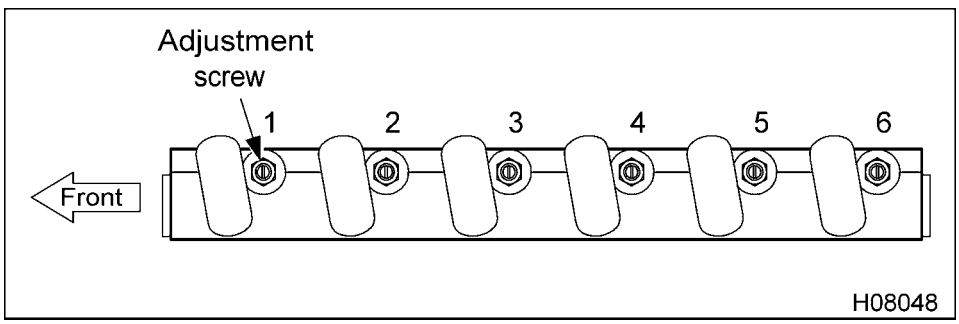

Figure 601 Brake lash adjustment

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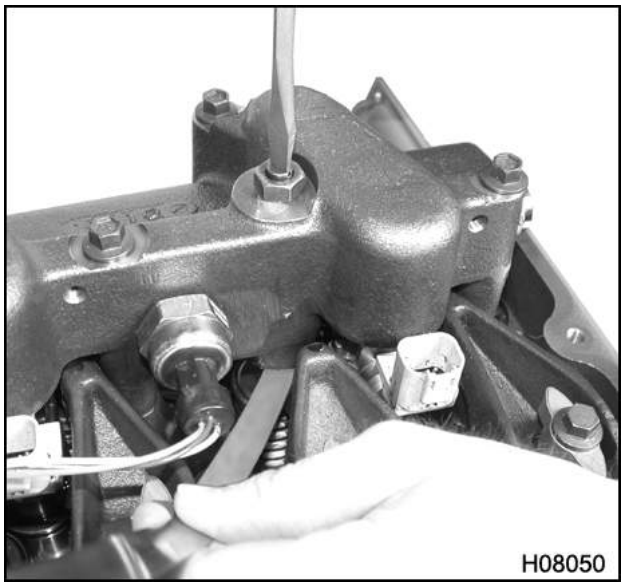

Figure 602 Feeler gauge between the valve bridge and brake actuator

4. Check brake lash when cold with a (0.019 in) feeler gauge between the pivot foot and valve bridge. If adjustment is required, loosen the locknut and turn the actuator adjustment screw until a light drag is felt.
5. Once brake lash is set, tighten the locknut to the special torque value (Table 53) and remove the feeler gauge. Recheck for light drag on feeler gauge. If drag is too tight or loose, repeat steps 4 and 5.
6. Turn crankshaft 360° in the direction of engine rotation to remove gear lash from gear train and realign the timing mark on the damper pulley with the TDC mark on the front cover.
   - If first adjustments were with piston 1 at TDC compression, cylinder 6 should be at TDC compression. Confirm that valves are closed by making sure that push rods for cylinder 6 are loose and turn easily. If piston 6 is at TDC compression, see (Figure 600) and do steps 4 and 5.
   - If first adjustments were with Piston 6 at TDC compression, cylinder 1 should be at TDC compression. Confirm that valves are closed by making sure that push rods for cylinder 1 are loose and turn easily. If piston 1 is at TDC compression, see (Figure 599) and do steps 4 and 5.

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Valve Cover

1. Install valve cover gasket.
2. Connect the ICP, BCP, and brake shutoff valve electrical connectors to the valve cover gasket.
3. Install valve cover onto cylinder head.

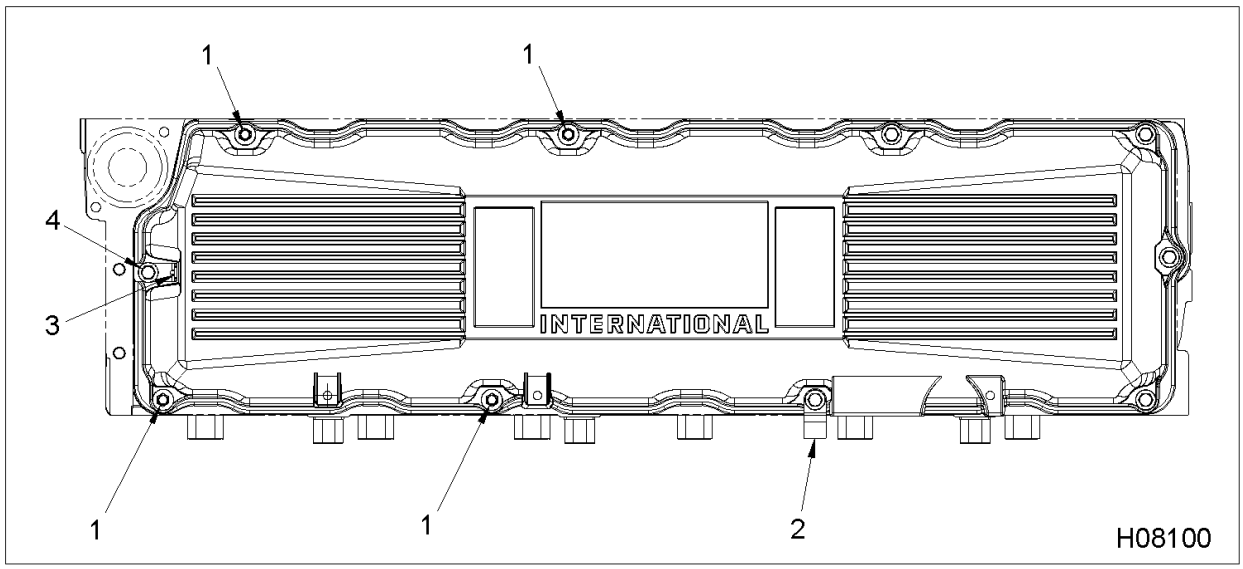

Figure 603 Valve cover assembly detail

1. Bolt / stud, M8 x 80 / 19 (4)
2. Extension bracket
3. Valve cover harness mounting bracket
4. Bolt, M8 x 80 (6)

4. Install four valve cover bolt / studs (M8 x 80 / 19) finger tight.
5. Install six valve cover bolts (M8 x 80) finger tight.
6. Tighten all bolts and studs to the standard torque value (See General Torque Guidelines, page 409).
7. Add any necessary brackets to the appropriate studs.
8. Connect crankcase ventilation piping (See Crankcase Ventilation System, page 248).
9. Add coolant (if cylinder head was removed in chassis).

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SPECIFICATIONS

Table 52 Engine Brake Specifications

Brake actuator lash (cold)	0.48 mm (0.019 in)
Engine exhaust valve lash (cold)	Refer to (See Adjusting Valve Lash, page 132)

Special Torque

Table 53 Engine Brake Special Torques

Brake Control Pressure (BCP) sensor	20-30 N·m (15-22 lbf·ft)
Brake housing bolts (M8 x 90)	27 N·m (20 lbf·ft)
Brake piston adjustment locknut	27 N·m (20 lbf·ft)
Brake shutoff solenoid tinnermann nut	7-11 N·m (5-8 lbf·lb)
Brake shutoff valve	34 N·m (25 lbf·ft)
Injection Control Pressure (ICP) sensor	20-30 N·m (15-22 lbf·ft)
Oil pressure relief valve	41-48 N·m (30-35 lbf·ft)
Rail end plug assembly	204 N·m (150 lbf·ft)

SPECIAL SERVICE TOOLS

Table 54 Engine Brake Special Service Tools

Feeler gauge (long)	Obtain locally

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Description

The air compressor and power steering pump assemblies are optional components on International® engines. They can be configured individually or together depending on vehicle application requirements.

Air for braking is supplied by an air compressor mounted on the lower left side of the engine. It is gear driven from the lower idler gear located within the front engine cover.

- Lubrication of the compressor is provided by a hose connected at the engine oil pressure sensor port with oil draining back to the crankcase through an elbow at the bottom of the compressor.
- Filtered air is furnished through an air hose connected to the air cleaner assembly, and compressed into a supply tank. When the air supply tank is full, compressed air is simply vented to the atmosphere.
- Coolant to the compressor is supplied and returned through two hoses to ports located on the left side of the engine crankcase.

The power steering pump assembly is mounted in one of two following configurations:

A. **Without** an air compressor, the power steering pump is mounted onto the front cover and is driven by the lower idler gear that would normally drive the air compressor.

B. **With** an air compressor, the power steering pump is mounted to the air compressor. The compressor is driven by the lower idler gear and power is transferred through the compressor crankshaft to drive the power steering pump.

NOTE: For component service procedures other than removal and installation refer to the **International Service Information Solutions - ISIS®** and then select manufacturer from suppliers tab.

Removal

WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, read all safety instructions in the "Safety Information" section of this manual.

WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, make sure the transmission is in neutral, parking brake is set, and wheels are blocked before doing diagnostic or service procedures on engine or vehicle.

NOTE: Air compressor and power steering pump may be removed as an assembly depending on servicing circumstances.

Air Compressor

WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, do the following before removing the air compressor because of its heavy weight and possibly high temperature. Wait until the air compressor cools down. Also, it is advised to have two people remove the air compressor and power steering pump combination from the engine, especially in chassis.

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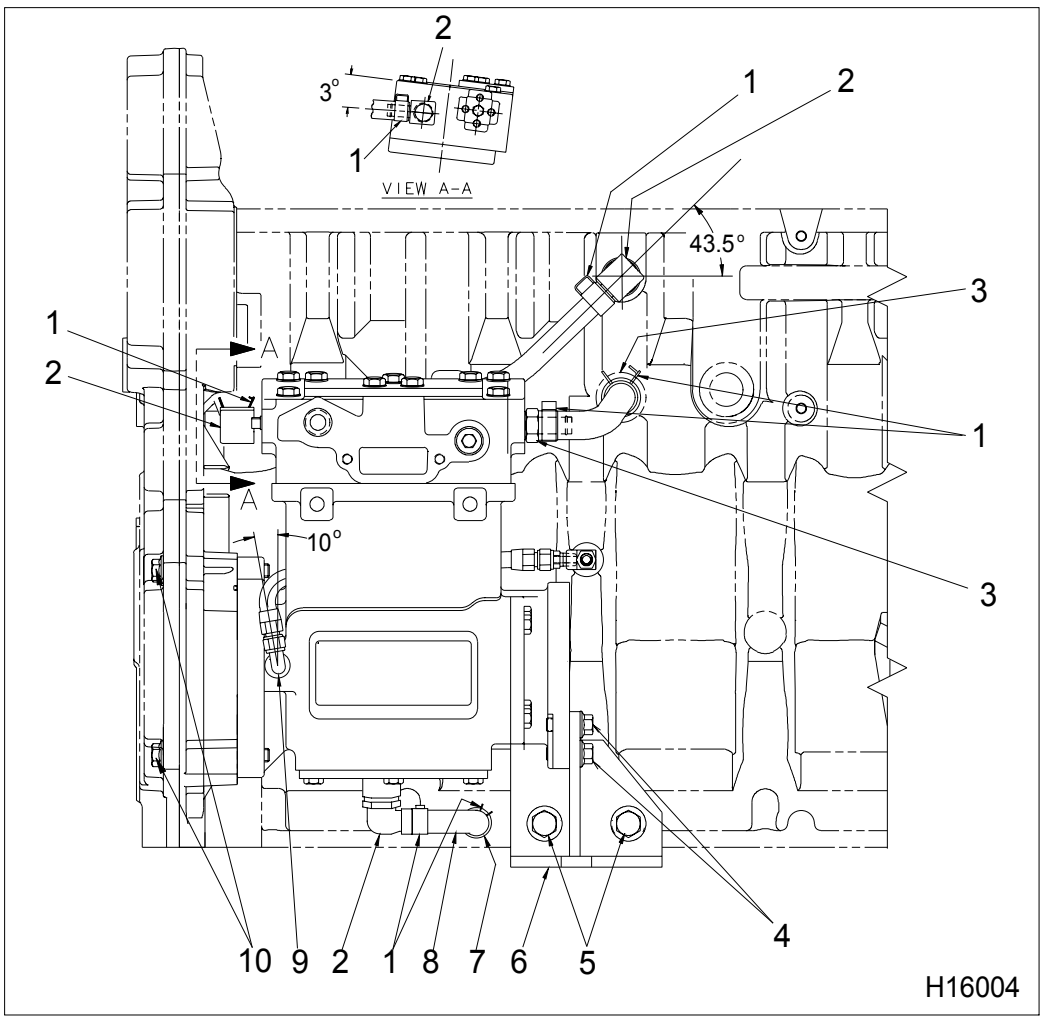

Figure 604 Air compressor mounting and connections

1. Hose clamps (6)
2. Elbow assembly, M18 (3)
3. Connector assembly, M18 (2)
4. Support bracket bolts (to compressor), M10 x 25 (2)
5. Support bracket bolts (to crankcase), M12 x 25 (2)
6. Air compressor support bracket assembly
7. Fitting (NPTF), ⅜ x ½
8. Drain hose elbow
9. Elbow assembly, M10 (oil supply)
10. Air compressor mounting bolts, M12 x 80 (2)

1. Place a coolant drain pan beneath air compressor bracket.
2. Loosen the coolant outlet hose clamp (from crankcase).
3. Loosen the coolant inlet hose clamp (to crankcase).
4. Remove hose ends from both crankcase fittings. Cap and plug open fittings and hose ends to keep clean.
5. Disconnect oil supply line at air compressor. Cap line and fitting.
6. Disconnect oil drain hose elbow and clamps.
7. Remove two bolts (M12 x 80) and nuts (M12) securing compressor to front cover.
8. Support weight of air compressor and remove two air compressor support bracket bolts (M12 x 25). Lift air compressor and bracket assembly from engine.

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9. Place air compressor and bracket onto work bench.
10. Remove and discard air compressor gasket.
11. Remove remaining two bracket bolts attached to air compressor (M10 x 25) (Figure 604).

Power Steering Pump

1. Disconnect the high-pressure hose at power steering pump.
2. Disconnect the low-pressure hose at power steering pump.
3. Cap oil lines to eliminate contamination.
4. Depending on application, do either the following:
   - For applications with power steering pump attached to the rear of air compressor, remove two bolts (M10 x 35).
   - For applications with power steering pump attached to rear of the front cover, remove two bolts (M12 x 90 and nuts).
5. Remove gasket and discard.

Installation

Air Compressor

WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, do not attempt to install the air compressor alone. It is advised to have two people install the air compressor onto the engine.

1. On work bench, loosely install air compressor support bracket assembly (Figure 604) to the air compressor with two bolts (M10 x 25). Thread finger tight but do not tighten.
2. Apply a small amount of assembly grease to the O-ring and install into groove on front cover.
3. Install the air compressor and support bracket assembly onto front cover with two bolts (M12 x 80). Tighten, but do not torque.
4. Loosely install two bolts (M12 x 25) through air compressor bracket into crankcase.
5. Torque all air compressor bolts in the following order:

   CAUTION: To avoid engine damage, do not over torque the air compressor mounting bolts. Over torquing bolts will result in a fractured front cover.

   a. Torque two compressor to front cover bolts (M12 x 80) to the standard torque value (See General Torque Guidelines, page 409).
   b. Torque two compressor to bracket assembly bolts (M12 x 25) to the special torque value (Table 55).
   c. Torque two bracket assembly to crankcase bolts (M12 x 10) to the special torque value (Table 55).
6. Uncap coolant hoses and install onto elbow assembly (M18) and connector assembly (M18) fittings with hose clamps.

NOTE: If these fittings were removed from the crankcase or air compressor for any reason, they will require standard torque values (See General Torque Guidelines, page 409) and need to be oriented to the correct angle (Figure 604) upon installation.

7. Remove caps and install oil supply hose to elbow assembly (M10) (Figure 604). Tighten oil supply line fitting.
8. Install oil drain hose elbow and clamps.

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Power Steering Pump With Air Compressor

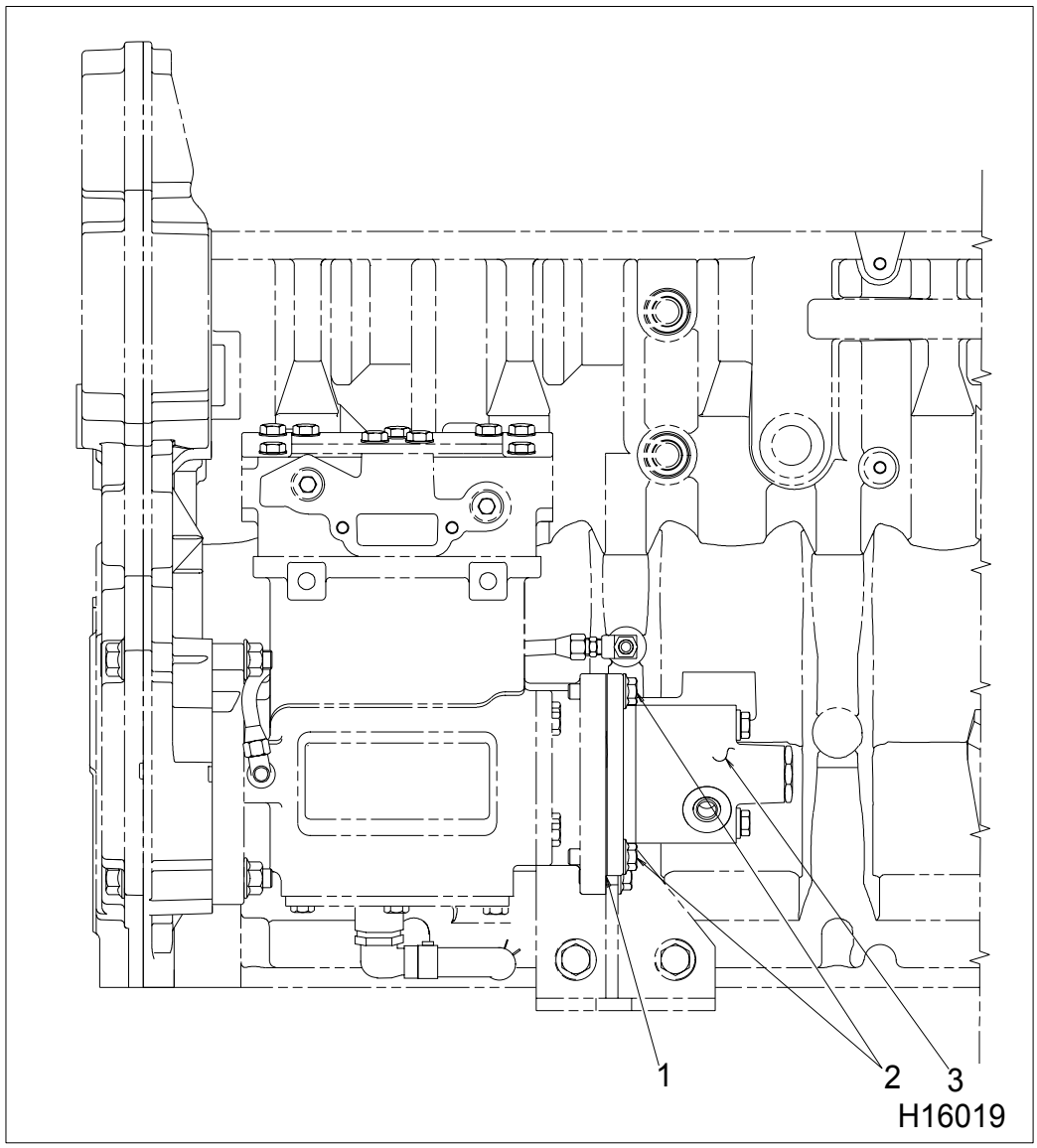

Figure 605 Power steering pump with air compressor

1. Power steering pump gasket
2. Hex flange bolt, M10 x 35
3. Power steering pump assembly

1. Apply a small amount of assembly grease to the O-ring and install into groove on backside of compressor.
2. Install two power steering pump mounting bolts (M10 x 35) and tighten to the special torque value (Table 55).
3. Install low-pressure hose.
4. Install high-pressure hose.

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Power Steering Pump Without Air Compressor

NOTE: The following steps are only for applications that are not equipped with an air compressor.

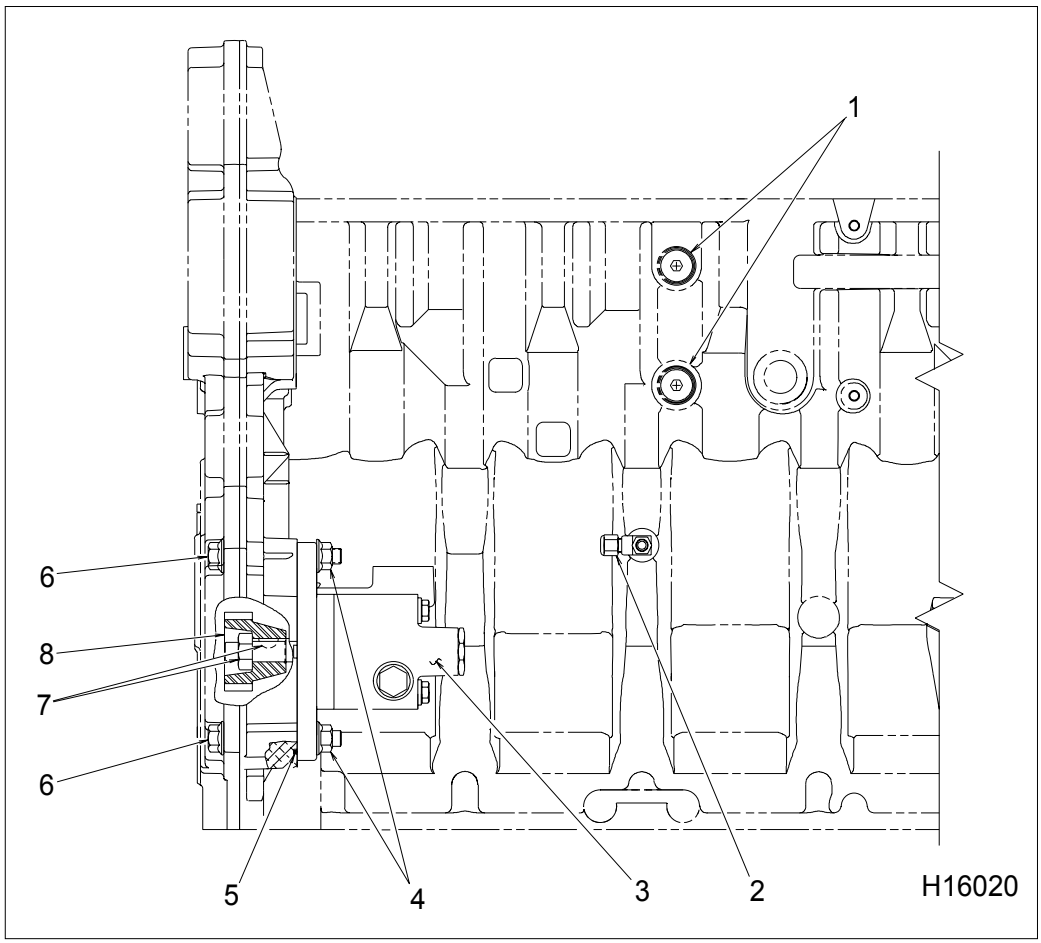

Figure 606 Power steering pump without air compressor

1. Plug assembly, M18 (standard torque) (See General Torque Guidelines, page 409)
2. Cap
3. Power steering pump assembly
4. Nut, M12
5. O-ring gasket
6. Bolt, M12 x 90
7. Power steering pump gear nut and shaft key (supplied with pump)
8. Drive gear (supplied with pump)

1. Apply a small amount of assembly grease to the O-ring and install into groove on front cover.
2. Install two power steering pump mounting bolts (M10 x 90) and nuts (M10) and tighten to the standard torque value (See General Torque Guidelines, page 409).
3. Install power steering low-pressure hose.
4. Install power steering high-pressure hose.

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Special Torques

Table 55 TF 550 and TF 750 Air Compressor and Power Steering Pump Special Torques

Air compressor gear nut	150 N·m (110 lbf·ft)
Bracket bolt to air compressor, M10 x 25	67 N·m (49 lbf·ft)
Bracket bolt to crankcase, M12 x 25	115 N·m (85 lbf·ft)
Elbow assembly, M10	15-16 N·m (132-141lbf·in)
Elbow fitting assembly, M18	48 N·m (35 lbf·ft)
Hose connector assembly, M18	48 N·m (35 lbf·ft)
Power steering mounting bolts, M10 x 35	57 N·m (42 lbf·ft)
Power steering pump drive nut	90 N·m (66 lbf·ft)

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