Table of Contents

Exploded Views.....283

Removal.....291
- **Pulley (High Mount Fan)**.....291
- **Tensioner Bracket (High Mount Fan)**.....291
- **High Mount Fan Drive**.....292
- **Coolant Elbow and Thermostat Elements**.....292
- **Automatic Belt Tensioner and Cable Roller (Typical)**.....293
- **Water Pump Pulley**.....294
- **Drive Housing Pulley**.....294
- **Vibration Damper (Typical)**.....294
- **Drive Housing Radial Shaft Seal**.....295
- **Drive Housing**.....295
- **Coolant Control Valve (CCV)**.....295
- **Thermostat Housing Assembly**.....296
- **Water Pump**.....297
- **Distributor Case**.....297
- **Front Crankcase Cover Radial Shaft Seal**.....297
- **Front Crankcase Cover** 298

Cleaning, Inspection, and Testing.....299

Installation.....300
- **Front Crankcase Cover**.....300
- **Front Crankcase Cover Radial Shaft Seal**.....300
- **Distributor Case**.....301
- **Water Pump**.....301
- **Thermostat Housing Assembly**.....301
- **Coolant Control Valve (CCV)**.....302
- **Drive Housing**.....303
- **Drive Housing Radial Shaft Seal**.....303
- **Vibration Damper (Typical)**.....303
- **Drive Housing Pulley**.....304
- **Water Pump Pulley**.....304
- **Automatic Belt Tensioner and Cable Roller (Typical)**.....305
- **Coolant Elbow and Thermostat Element**.....305
- **High Mount Fan Drive**.....306
- **Tensioner Bracket (High Mount Fan)**.....307
- **Pulley (High Mount Fan)**.....307

Special Torque.....308

Special Service Tools.....309

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Exploded Views

Figure 486 High mount fan drive system and vibration damper

1. Air clutch fan drive
2. Tensioner bracket
3. M8 x 30 hex bolt (3)
4. M10 x 35 hex bolt (9)
5. Vibration damper
6. Fan drive pulley (in place of hub for high mount fan application)
7. Hub for vibration damper (in place of pulley for low mount fan application)
8. M16 x 85 cylinder screw (8)
9. Tensioner
10. M10 x 70 countersunk screw
11. Pulley assembly
12. Shoulder bolt
13. M10 x 65 hex bolt
14. M10 x 150 hex bolt (5)

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Figure 487 Accessory drive system (typical)

1. Pulley (water pump)
2. Cable roller (2)
3. Automatic belt tensioner
4. Pulley (drive housing)
5. Washer
6. M8 x 20 hex bolt (3)
7. M12 x 30 hex bolt
8. M10 x 70 countersunk screw
9. M12 x 55 hex bolt (2)
10. M8 x 12 hex bolt (3)

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Figure 488 Drive housing

1. Drive housing
2. M12 x 90 hex bolt (4)
3. Radial shaft seal

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Figure 489 Thermostat elements and coolant elbow

1. M8 x 130 hex bolt (2) (M8 x 70 with high mount fan only)
2. Bracket (with low mount fan only)
3. Bushing (2) (with low mount fan only)
4. Coolant elbow (to radiator)
5. 60 x 4 O-ring (2)
6. Thermostat element (2)
7. Gasket (2)
8. M8 x 70 hex bolt

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Figure 490 Water pump and Coolant Control Valve (CCV)

1. Coolant pipe low temperature radiator (LTR) supply
2. Water pump gasket
3. Water pump
4. M8 x 40 hex bolt (7)
5. M8 x 130 hex bolt (2)
6. O-ring
7. CCV
8. M8 x 60 hex bolt (2)

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Figure 491 Thermostat housing assembly

1. M8 x 145 hex bolt (4)
2. Coolant elbow (to EGR module)
3. Gasket
4. Thermostat housing assembly
5. Gasket
6. DMR40/DMR32 extension tube (2)
7. M8 x 60 hex bolt
8. M8 x 75 hex bolt
9. M8 x 30 hex bolt
10. DMR62 extension tube

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Figure 492 Distributor case (typical)

1. M8 x 110 bolt (5)
2. Distributor case
3. Gasket
4. M14 x 1.5 drain plug
5. M8 x 150 bolt (2)

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Figure 493 Front crankcase cover (typical)

1. Cover
2. Front cover gasket
3. M12 x 70 hex bolt (2)
4. M8 x 25 hex bolt (13)
5. M14 x 30 hex bolt (2)
6. Radial shaft seal
7. M8 x 40 hex bolt (2)

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Removal

WARNING: To prevent personal injury or death, read all safety instructions in the "Safety Information" section of this manual.

WARNING: To prevent personal injury or death, shift transmission to park or neutral, set parking brake, and block wheels before doing diagnostic or service procedures.

WARNING: To prevent personal injury or death, make sure the engine has cooled before removing components.

WARNING: To prevent personal injury or death, do not let engine fluids stay on your skin. Clean skin and nails using hand cleaner and wash with soap and water. Wash or discard clothing and rags contaminated with engine fluids.

GOVERNMENT REGULATION: Engine fluids (oil, fuel, and coolant) may be a threat to the environment. Recycle or dispose of engine fluids according to applicable regulations. Never put engine fluids in the trash, on the ground, in sewers or bodies of water.

NOTE: Refer to the following service sections for information on removal of components prior to this section.

- Engine Electrical
- Fuel System
- Exhaust Gas Recirculation (EGR) System

Pulley (High Mount Fan)

Figure 494 Pulley assembly

1. Shoulder bolt
2. Pulley assembly

1. Remove shoulder bolt and pulley assembly.

Tensioner Bracket (High Mount Fan)

Figure 495 Tensioner

1. Tensioner
2. M10 x 70 countersunk screw

1. Remove M10 x 70 countersunk screw and tensioner.

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Figure 496 Tensioner bracket

1. M8 x 30 hex bolt (3)
2. Tensioner bracket

2. Remove three M8 x 30 hex bolts and tensioner bracket.

High Mount Fan Drive

Figure 497 Air clutch fan drive

1. Air clutch fan drive
2. M10 x 150 hex bolt (5)
3. M10 x 65 hex bolt

1. Disconnect air line from back of air clutch fan drive.
2. Remove five M10 x 150 and M10 x 65 hex bolts and air clutch fan drive.
3. Discard all hex bolts.

Coolant Elbow and Thermostat Elements

Figure 498 Coolant elbow (to radiator)

1. M8 x 70 hex bolt
2. M8 x 130 hex bolt (2) (M8 x 70 with high mount fan only)
3. Bracket (with low mount fan only)
4. Coolant elbow
5. Bushing (2) (with low mount fan only)

1. Remove coolant elbow hex bolts as follows:
   a. If equipped with low mount fan, remove M8 x 70 and two M8 x 130 hex bolts, bracket and two bushings.
   b. If equipped with high mount fan, remove three M8 x 70 hex bolts.
2. Remove coolant elbow.

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Figure 499 Thermostat elements

1. Thermostat housing assembly
2. 60 x 4 O-ring (2)
3. Thermostat element (2)
4. Ball valves (part of thermostat elements)

3. Remove and discard two 60 x 4 O-rings.
4. Remove two thermostat elements and gaskets from thermostat housing assembly. Discard gaskets.

Automatic Belt Tensioner and Cable Roller (Typical)

Figure 500 Automatic belt tensioner and cable roller

1. Cable roller (2)
2. M12 x 55 hex bolt (2)
3. M10 x 70 countersunk screw
4. Automatic belt tensioner

1. Remove two M12 x 55 hex bolts and cable rollers.

CAUTION: To prevent engine damage, do not twist the belt tensioner; damage to the locating pin may occur, resulting in improper alignment of the belt tensioner.

2. Remove M10 x 70 countersunk screw and automatic belt tensioner.

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Water Pump Pulley

Figure 501 Water pump pulley

1. Water pump
2. Pulley
3. M8 x 12 hex bolt (3)

1. Remove three M8 x 12 hex bolts and water pump pulley.

Drive Housing Pulley

Figure 502 Drive housing pulley

1. M8 x 20 hex bolt (3)
2. Pulley
3. M12 x 30 hex bolt
4. Washer

1. Remove M12 x 30 and three M8 x 20 hex bolts. Clean any sealer off of bolt threads.
2. Remove washer from drive housing pulley and clean sealer off of washer.

Figure 503 Drive housing pulley

1. Pulley
2. Drive housing shaft

3. Remove pulley from drive housing shaft. Clean any sealer from drive housing shaft and pulley.

Vibration Damper (Typical)

Figure 504 Vibration damper (without fan drive pulley)

1. M16 x 85 cylinder screw (8)
2. Vibration damper

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WARNING: To prevent personal injury or death, support the vibration damper when removing bolts. The damper can easily slide off the end of the crankshaft.

NOTE: If equipped with high mount fan, remove pulley and vibration damper together. If equipped with vibration damper hub, remove hub and vibration damper together.

1. Remove eight M16 x 85 cylinder screws.
2. Remove vibration damper with hub or pulley as an assembly.
3. For vibration damper replacement only, remove hub or fan drive pulley by removing nine M10 x 35 hex bolts.

Drive Housing Radial Shaft Seal

Figure 505 Drive housing radial shaft seal

1. Slide hammer
2. Radial shaft seal

1. With an awl and hammer, punch two holes 180° apart in radial shaft seal.
2. Thread a slide hammer (page 309) with correct size screw into one of the two holes.
3. Slide hammer until one side of seal begins to pull out of drive housing. Move slide hammer to other hole and repeat until radial shaft seal is completely removed.

Drive Housing

Figure 506 Drive housing

1. Drive housing
2. M12 x 90 hex bolt (4)

1. Remove four M12 x 90 drive housing hex bolts.
2. Remove drive housing off crankcase dowels.
3. Clean all RTV from sealing surfaces.

Coolant Control Valve (CCV)

Figure 507 Coolant Control Valve (CCV)

1. Coolant pipe low temperature radiator (LTR) supply
2. Clamp
3. CCV
4. M8 x 60 hex bolt (2)

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1. Release clamp and remove coolant pipe LTR supply.
2. Remove two M8 x 60 hex bolts and CCV with O-ring.

Thermostat Housing Assembly

Figure 508 Coolant elbow (to Exhaust Gas Recirculation (EGR) module)

1. Coolant elbow
2. M8 x 145 hex bolt (4)
3. M8 x 30 hex bolt

CAUTION: To prevent engine damage, do not remove extension tubes by grabbing sealing surface.

1. Remove DMR62 extension tube from coolant elbow. Inspect extension tube for damage, replace as needed.
2. Remove four M8 x 145 hex bolts and M8 x 30 hex bolt.
3. Remove coolant elbow (EGR module) and discard gasket.

Figure 509 Thermostat housing assembly

1. Thermostat housing assembly
2. M8 x 75 hex bolt
3. M8 x 60 hex bolt

4. Remove M8 x 75 and M8 x 60 hex bolts.
5. Remove thermostat housing assembly and discard gasket.

Figure 510 Thermostat housing assembly

1. DMR40/DMR32 extension tube
2. Thermostat housing assembly

CAUTION: To prevent engine damage, do not remove extension tubes by grabbing sealing surface.

6. Remove two DMR40/DMR32 extension tubes from thermostat housing assembly. Inspect extension tubes for damage, replace as needed.

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Water Pump

Figure 511 Water pump

1. Water pump
2. M8 x 130 hex bolt (2)
3. M8 x 40 hex bolt (7)

NOTE: If the oil module was removed previously, the second M8 x 130 bolt will already have been removed.

1. Remove one or two M8 x 130 hex bolts and seven M8 x 40 hex bolts.

CAUTION: To prevent engine damage, do not drop water pump impeller or hit impeller with hard objects.

2. Remove water pump and discard water pump gasket.

Distributor Case

Figure 512 Distributor case

1. Distributor case
2. M8 x 110 hex bolt (5)
3. M8 x 150 hex bolt (2)

1. Remove two M8 x 150 and five M8 x 110 hex bolts.
2. Remove distributor case and discard gasket.

Front Crankcase Cover Radial Shaft Seal

Figure 513 Radial shaft seal

1. Radial shaft seal
2. Slide hammer

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WARNING: To prevent personal injury or death, wear safety glasses with side shields when doing the following procedure.

1. With an awl and hammer, punch two holes 180° apart in front oil seal.
2. Thread a slide hammer (page 309) with correct size screw in one of the two holes.
3. Slide hammer until one side of seal begins to pull out of cover. Move slide hammer to other hole and repeat until front oil seal is removed completely.

Front Crankcase Cover

Figure 514 Front crankcase cover bolts (typical)

1. Cover
2. M12 x 70 hex bolt (2)
3. M8 x 40 hex bolt (2)
4. M8 x 25 hex bolt (13)
5. M14 x 30 hex bolt (2)

1. Remove two M8 x 40 hex bolts, two M14 x 30 hex bolts, two M12 x 70 hex bolts and 13 M8 x 25 hex bolts.
2. Remove cover and front cover gasket from crankcase dowels. Discard front cover gasket.

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Cleaning, Inspection, and Testing

WARNING: To prevent personal injury or death, wear safety glasses with side shields. Limit compressed air pressure to 207 kPa (30 psi).

1. Clean distributor case, water pump, coolant elbows, thermostat housing, front engine mount, and front crankcase cover with a suitable non-caustic solvent.
2. Blow parts dry using filtered compressed air.
3. Clean coolant and oil seal mating surfaces on the crankcase, cylinder head, distributor case, water pump, coolant elbow, thermostat housing, and front crankcase cover.
4. Inspect distributor case, coolant elbow, vibration damper, and front crankcase cover, for damage, contamination, or excessive wear. Replace parts if required.
5. Inspect automatic belt tensioner and pulley to make sure tensioner arm and pulley are properly in line with the fan drive belt and not coming apart. Make sure tensioner arm is not binding and pulley bearing is not loose. Replace belt tensioner if required.
6. Inspect cable rollers to make sure pulleys are properly in line with the fan drive belt and not coming apart. Replace cable rollers if required.
7. Inspect thermostat elements. If thermostat elements are stuck open, damaged, cracked, or not opening properly replace thermostat elements.
8. Inspect water pump. Wiggle water pump hub and shaft. If water pump bearing has excess play, replace water pump. Inspect water pump housing for coolant leaks. Replace water pump if leaking.

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Installation

Front Crankcase Cover

Figure 515 Front crankcase cover bolts (typical)

1. Cover
2. M12 x 70 hex bolt (2)
3. M8 x 40 hex bolt (2)
4. M8 x 25 hex bolt (13)
5. M14 x 30 hex bolt (2)

1. Position a new front cover gasket on crankcase dowels.
2. Install cover on crankcase dowels.
3. Install two M8 x 40 hex bolts, two M14 x 30 hex bolts, two M12 x 70 hex bolts and 13 M8 x 25 hex bolts. Tighten hex bolts to special torque (page 308).

Front Crankcase Cover Radial Shaft Seal

Figure 516 Radial shaft seal

1. Cover
2. Front Crankshaft Seal Installer

CAUTION: To avoid damage to the radial shaft seal, do not touch inner seal lip, allow oil or grease on any part of the seal during installation.

1. Using Front Crankshaft Seal Installer (page 309), install new radial shaft seal into cover.
   a. Install inner hub of tool to crankshaft flange. Use two bolts provided with tool.
   b. Install radial shaft seal to inner hub of tool.
   c. Install pressing hub and nut and tighten to install radial shaft seal. When tool bottoms out, seal is fully installed.

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Distributor Case

Figure 517 Distributor case

1. Distributor case
2. M8 x 110 hex bolt (5)
3. M8 x 150 hex bolt (2)

1. Install new gasket and distributor case.
2. Install two M8 x 150 hex bolts and five M8 x 110 hex bolts. Tighten hex bolts to special torque (page 308).

Water Pump

Figure 518 Water pump

1. Water pump
2. M8 x 130 hex bolt (2)
3. M8 x 40 bolt (7)

NOTE: If the oil module was removed previously, the second M8 x 130 bolt will not be installed at this time.

1. Install new water pump gasket and water pump.
2. Install one or two M8 x 130 bolts and seven M8 x 40 hex bolts. Tighten hex bolts to special torque (page 308).

Thermostat Housing Assembly

Figure 519 Thermostat housing assembly

1. DMR40/DMR32 extension tube
2. Thermostat housing assembly

1. Lubricate sealing surfaces of two DMR40/DMR32 extension tubes with P-80® Rubber Lubricant or equivalent (page 309) and install into thermostat housing assembly.

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Figure 520 Thermostat housing assembly

1. Thermostat housing assembly
2. M8 x 75 hex bolt
3. M8 x 60 hex bolt

2. Install new gasket and thermostat housing assembly.
3. Install M8 x 75 and M8 x 60 hex bolts. Do not tighten hex bolts until coolant elbow is installed.

Figure 521 Coolant elbow (to Exhaust Gas Recirculation (EGR) module)

1. Coolant elbow
2. M8 x 145 hex bolt (4)
3. M8 x 30 hex bolt

4. Install new gasket and coolant elbow.
5. Install four M8 x 145 hex bolts and M8 x 30 hex bolt. Tighten hex bolts to special torque (page 308).
6. Tighten M8 x 75 and M8 x 60 thermostat housing assembly hex bolts to special torque (page 308).
7. Lubricate sealing surfaces of DMR62 extension tube with P-80® Rubber Lubricant or equivalent (page 309) and install into coolant elbow.

Coolant Control Valve (CCV)

Figure 522 Coolant control valve (CCV)

1. Coolant pipe low temperature radiator (LTR) supply
2. Clamp
3. CCV
4. M8 x 60 hex bolt (2)

1. Inspect O-ring for damage and replace as needed.
2. Install CCV and two M8 x 60 hex bolts. Tighten hex bolts to special torque (page 308).
3. Install coolant pipe LTR supply and release clamp.

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Drive Housing

Figure 523 Drive housing

1. Drive housing
2. M12 x 90 hex bolt (4)

CAUTION: To prevent engine damage, apply Liquid Gasket and component within 5 minutes of application to inhibit the formation of a skin and ensure a leak proof joint.

1. Apply Liquid Gasket (RTV) (page 309) to joining surfaces of drive housing and crankcase.
2. Install drive housing on crankcase dowels.
3. Install four M12 x 90 drive housing hex bolts. Tighten hex bolts to special torque (page 308).

Drive Housing Radial Shaft Seal

Figure 524 Drive housing radial shaft seal

1. Fan Hub/High Pressure Drive Seal Installer
2. Drive housing

1. Using Fan Hub/High Pressure Drive Seal Installer (page 309), drive new radial shaft seal into drive housing. Seal is fully installed when tool bottoms out on housing.

Vibration Damper (Typical)

Figure 525 Vibration damper (without fan drive pulley)

1. M16 x 85 cylinder screw (8)
2. Vibration damper

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NOTE: Install hub or pulley and vibration damper together as an assembly.

1. If previously disassembled, assemble vibration damper hub or fan drive pulley to vibration damper with nine M10 x 35 hex bolts. Tighten hex bolts to special torque (page 308).
2. Install vibration damper with hub or pulley as an assembly.
3. Install eight M16 x 85 cylinder screws. Using a crisscross pattern, tighten cylinder screws as follows.
   a. Tighten cylinder screws to 150 N·m (111 lbf·ft).
   b. Turn cylinder screws an additional 90°.

Drive Housing Pulley

Figure 526 Drive housing pulley

1. Pulley
2. Drive housing shaft

1. Apply Loctite® 5900 sealant or equivalent (page 309) to drive housing shaft.
2. Install pulley onto drive housing shaft.

Figure 527 Drive housing pulley

1. M8 x 20 hex bolt (3)
2. Pulley
3. M12 x 30 hex bolt
4. Washer

3. Apply Loctite® 5900 sealant or equivalent (page 309) to washer. Install washer to pulley.
4. Install M12 x 30 and three M8 x 20 hex bolts. Tighten hex bolts to special torque (page 308).

Water Pump Pulley

Figure 528 Water pump pulley

1. Water pump
2. Pulley
3. M8 x 12 hex bolt (3)

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1. Install water pump pulley and three M8 x 12 hex bolts. Tighten hex bolts to special torque (page 308).

Automatic Belt Tensioner and Cable Roller (Typical)

Figure 529 Automatic belt tensioner and cable roller (typical)

1. Cable roller (2)
2. M12 x 55 hex bolt (2)
3. M10 x 70 countersunk screw
4. Automatic belt tensioner

CAUTION: To prevent engine damage, do not twist the belt tensioner; damage to the locating pin may occur, resulting in improper alignment of the belt tensioner.

1. Install automatic belt tensioner and M10 x 70 countersunk screw. Make sure locating pin is placed into locating hole. Tighten countersunk screw to special torque (page 308).
2. Install two cable rollers and two M12 x 55 hex bolts. Tighten hex bolts to special torque (page 308).

Coolant Elbow and Thermostat Element

Figure 530 Thermostat elements

1. Thermostat housing assembly
2. 60 x 4 O-ring (2)
3. Thermostat element (2)
4. Ball valves (part of thermostat elements)

1. Install two new gaskets and two thermostat elements into thermostat housing assembly with ball valves at 12 o'clock position.
2. Install two new 60 x 4 O-rings.

Figure 531 Coolant elbow (to radiator)

1. M8 x 70 hex bolt
2. M8 x 130 hex bolt (2)
3. Bracket (with low mount fan only)
4. Coolant elbow
5. Bushing (2) (with low mount fan only)

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3. Install coolant elbow.
4. If equipped with low mount fan, install bracket and two bushings.
5. Install coolant elbow hex bolts as follows:
   a. If equipped with low mount fan, install one M8 x 70 hex bolt and two M8 x 130 hex bolts. Tighten coolant elbow hex bolts to special torque (page 308).
   b. If equipped with high mount fan, install three M8 x 70 bolts. Tighten coolant elbow hex bolts to special torque (page 308).

High Mount Fan Drive

Figure 532 Air clutch fan drive

1. Air clutch fan drive
2. M10 x 150 hex bolt (5)
3. M10 x 65 hex bolt

CAUTION: To prevent engine damage, do not use chlorinated solvents on bolts or crankcase tapped holes. Parts should be clean, dry, and free of any chemicals other than engine oil.

1. Clean thread holes of air clutch fan drive.

Figure 533 Tensioner bracket tightening sequence

2. Install air clutch fan drive and five new M10 x 150 and one new M10 x 65 hex bolt with engine oil applied to threads.
3. Tighten hex bolts using sequence indicated above as follows.
   a. Tighten six hex bolts to 27 N·m (20 lbf·ft).
   b. Re-tighten six hex bolts to 27 N·m (20 lbf·ft).
   c. Turn five M10 x 150 hex bolts an additional 90° in sequence.
   d. Tighten M10 x 65 hex bolt to 45 N·m (33 lbf·ft).
4. Connect air line to back of air clutch fan drive.

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Tensioner Bracket (High Mount Fan)

Figure 534 Tensioner bracket

1. Tensioner bracket
2. M8 x 30 hex bolt (3)

1. Install tensioner bracket and three M8 x 30 hex bolt. Tighten hex bolts to standard torque (page 455).

Figure 535 High mount fan tensioner

1. Tensioner
2. M10 x 70 countersunk screw

2. Install tensioner and M10 x 70 countersunk screw. Make sure locating pin is placed into locating hole. Tighten countersunk screw to special torque (page 308).

Pulley (High Mount Fan)

Figure 536 Pulley assembly

1. Shoulder bolt
2. Pulley assembly

1. Install pulley assembly and shoulder bolt. Tighten shoulder bolt to special torque (page 308).

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Special Torque

Table 24 Front Cover, High Mount Fan Drive, Cooling System, Related Components

Air clutch fan drive hex bolts	See tightening steps in procedure
Automatic belt tensioner countersunk screw	47 N·m (35 lbf·ft)
Cable roller hex bolts	60 N·m (44 lbf·ft)
Coolant Control Valve (CCV) hex bolts	31 N·m (23 lbf·ft)
Coolant elbow (to Exhaust Gas Recirculation (EGR) module) hex bolts	35 N·m (26 lbf·ft)
Coolant elbow (to radiator) hex bolts	35 N·m (26 lbf·ft)
Distributor case hex bolts	35 N·m (26 lbf·ft)
Drive housing hex bolts	115 N·m (85 lbf·ft)
High mount fan bracket	See tightening steps in procedure
High mount fan tensioner countersunk screw	47 N·m (35 lbf·ft)
Hub and pulley hex bolts to vibration damper	45 N·m (33 lbf·ft)
High mount fan pulley assembly shoulder bolt	62 N·m (45 lbf·ft)
M8 x 20 drive housing pulley hex bolts	35 N·m (26 lbf·ft)
M8 x 25 front crankcase cover hex bolts	35 N·m (26 lbf·ft)
M8 x 40 front crankcase cover hex bolts	35 N·m (26 lbf·ft)
M12 x 30 drive housing pulley hex bolt	115 N·m (85 lbf·ft)
M12 x 70 front crankcase cover hex bolts	115 N·m (85 lbf·ft)
M14 x 30 front crankcase cover hex bolts	115 N·m (85 lbf·ft)
Thermostat housing assembly hex bolts	35 N·m (26 lbf·ft)
Water pump hex bolts	35 N·m (26 lbf·ft)
Water pump pulley hex bolts	35 N·m (26 lbf·ft)
Vibration damper cylinder screws	See tightening steps in procedure

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Special Service Tools

Table 25 Front Cover, High Mount Fan Drive, Cooling System, Related Components

Description	Tool Number
Fan Hub High Pressure Drive Seal Installer	ZTSE4776
Front Crankshaft Seal Installer	ZTSE4873
Liquid Gasket (RTV)	Obtain locally
Loctite® 5900 Sealant or equivalent	Obtain locally
P-80® Rubber Lubricant or equivalent	Obtain locally
Slide Hammer	Obtain locally

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Table of Contents

Exploded Views.....313

Periodic Service.....318
- **Valve Lash Adjustment**.....318

Removal.....322
- **Valve Cover**.....323
- **Fuel Injectors**.....324
- **Counterpiece**.....327
- **Rocker Gear**.....327
- **Camshaft**.....328
- **Fuel Injector Harness**.....331
- **Cylinder Head**.....332
- **Cylinder Intermediate Gear**.....334

Cleaning, Inspection, and Testing.....335
- **Cylinder Head and Crankcase Components**.....335
- **Camshaft Bearings**.....335
- **Fuel Injector Bore**.....335
- **Fuel Injector Harness**.....335
- **Valves Leak Test**.....336

Installation.....338
- **Cylinder Intermediate Gear**.....338
- **Cylinder Head**.....338
- **Fuel Injector Harness**.....341
- **Camshaft**.....342
- **Rocker Gear**.....345
- **Counterpiece**.....346
- **Fuel Injectors**.....346
- **Valve Cover**.....350

Specifications.....352

Special Torque.....352

Special Service Tools.....353

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Exploded Views

Figure 537 Valve cover

1. Screw with damper element (18)
2. Valve cover
3. Valve cover gasket

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Figure 538 Injector harness and fuel injectors

1. M8 x 50 hex bolt (6)
2. Injector harness
3. M6 x 16 hex bolt (4)
4. Pressure pipe nut (6)
5. Pressure pipe neck (6)
6. O-ring
7. Sealing washer (6)
8. O-ring (6)
9. Injector (6)
10. Thrust washer (6)
11. Pressure flange (6)
12. Retaining washer (6)

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Figure 539 Rocker gears and valve bridges

1. M12 x 60 cylinder screw (12)
2. Rocker gear (6)
3. M10 x 60 hex bolt (12)
4. Counterpiece (6)
5. Valve bridge (exhaust) (6)
6. Valve bridge (intake) (6)
7. Rocker bearing block (6)

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Figure 540 Camshaft and intermediate gear

1. M8 x 35 hex bolt (14)
2. Cylinder head bearing cap (7)
3. 4 mm dowel pin (14)
4. Bearing shell (14)
5. Camshaft
6. 6 mm dowel pin
7. Cylinder intermediate gear
8. Small gear stud
9. M8 x 30 cylinder screw (3)
10. Cover
11. Camshaft pulse wheel
12. M8 x 30 hex bolt (3)
13. Camshaft gear

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Figure 541 Cylinder head

1. Lifting eye
2. M18 x 246 collar bolt (26)
3. Cylinder head
4. Cylinder head gasket
5. 8 mm dowel pin (2)
6. M12 x 25 hex bolt (2)

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Periodic Service

WARNING: To prevent personal injury or death, read all safety instructions in the "Safety Information" section of this manual.

WARNING: To prevent personal injury or death, shift the transmission to park or neutral, set the parking brake, and block the wheels before doing diagnostic or service procedures.

WARNING: To prevent personal injury or death, make sure the engine has cooled before removing components.

WARNING: To prevent personal injury or death, remove the ground cable from the negative terminal of the main battery before disconnecting or connecting electrical components. Always connect the ground cable last.

WARNING: To prevent personal injury or death, do not let engine fluids stay on your skin. Clean skin and nails using hand cleaner and wash with soap and water. Wash or discard clothing and rags contaminated with engine fluids.

GOVERNMENT REGULATION: Engine fluids (oil, fuel, and coolant) may be a threat to the environment. Recycle or dispose of engine fluids according to applicable regulations. Never put engine fluids in the trash, on the ground, in sewers or bodies of water.

GOVERNMENT REGULATION: Dispose of fuel according to applicable regulations in a correct container clearly marked DIESEL FUEL.

Valve Lash Adjustment

1. Remove Valve Cover (page 323).
2. If previously removed, install Drive Housing (page 303).

Figure 542 Pulley bolts (drive housing)

1. Pulley (drive housing)
2. M8 x 20 hex bolt (3)

NOTE: Do not remove center bolt and pulley.

3. Remove three M8 x 20 hex bolts from drive housing pulley.

Figure 543 Engine Rotating Tool

1. Engine Rotating Tool
2. M8 x 25 hex bolt (3) (part of Engine Rotating Tool)

CAUTION: To prevent engine damage, install the Engine Rotating Tool using only the M8 x 25 bolts included with the tool.

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4. Install Engine Rotating Tool (page 353) and three M8 x 25 hex bolts. Tighten hex bolts to standard torque (page 455).

Figure 544 Rotating engine

5. Facing front of engine, turn Engine Rotating Tool in clockwise direction with a suitable 1/2 inch drive handle.

Figure 545 Camshaft timing mark

1. Camshaft gear
2. Timing mark

NOTE: When timing mark is aligned with cylinder head surface, piston 1 is at Top Dead Center (TDC), and intake and exhaust valves are in overlap at cylinder 6. Valve overlap is when both exhaust and intake valves are open at the same time, and occurs as the exhaust valve finishes closing and the intake valve starts opening.

6. Continue rotating engine until timing mark on camshaft gear is aligned with cylinder head surface on left side of camshaft gear. This puts piston 1 at TDC.

Figure 546 Flywheel housing timing index

1. Flywheel housing timing index
2. Flywheel timing mark

7. Remove sealing cap from lower side of flywheel housing and verify timing mark on flywheel is aligned with flywheel housing timing index.
   - If timing mark on flywheel is out of alignment, then the timing has slipped due to big intermediate gear slippage. Install a new big intermediate gear. See Oil Pump, Low Mount Fan Drive and Timing Gears section (page 391) for procedure to replace big intermediate gear.
   - If timing mark on flywheel is aligned with flywheel housing timing index, continue to next step.

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Figure 547 Intake valve lash adjustment (typical)

1. Adjusting screw
2. M10 hexagon nut
3. Valve bridge (intake)

8. Adjust intake valve lash for the cylinder with piston at TDC as follows:
   a. Loosen intake valve lash adjustment M10 hexagon nut.
   b. Insert a 0.5 mm (0.019 in) feeler gauge (page 353) between intake valve bridge and adjusting screw, and tighten adjusting screw until a slight drag on feeler gauge is felt.
   c. Hold adjusting screw in position and tighten intake valve lash adjustment M10 hexagon nut to special torque (page 352).

Figure 548 Exhaust valve and retarder lash adjustment (typical)

1. Adjusting screw (exhaust valve)
2. M10 hexagon nut
3. M14 hexagon nut
4. Valve bridge (exhaust)
5. Counterpiece
6. Adjusting screw (counterpiece)

9. Adjust counterpiece and exhaust valve lash for the cylinder with piston at TDC as follows:
   a. Loosen counterpiece adjustment M14 hexagon nut and back out counterpiece adjusting screw until it no longer contacts valve bridge.
   b. Push valve bridge down onto exhaust valves several times to push oil out from piston inside exhaust valve bridge.
   c. Loosen exhaust valve lash adjustment M10 hexagon nut. Back out exhaust valve lash adjusting screw until a 0.8 mm (0.0314 in) feeler gauge (page 353) can be inserted between exhaust valve bridge and exhaust valve lash adjusting screw.
   d. Tighten exhaust valve lash adjusting screw until it grips the feeler gauge. Turning resistance increases while adjusting screw is tightened due to retarder piston spring inside exhaust valve bridge being compressed.
   e. Tighten exhaust valve lash adjustment M10 hexagon nut to special torque (page 352).

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f. Insert a 0.6 mm (0.0236 in) feeler gauge between counterpiece adjusting screw and valve bridge. Tighten counterpiece adjusting screw until it grips the feeler gauge.

g. Tighten counterpiece adjustment M14 hexagon nut to special torque (page 352).

NOTE: Use intake and exhaust valve overlap as a guide to determine what cylinder is at TDC.

10. Facing front of engine, rotate engine in clockwise direction one cylinder at a time, and adjust lash on all other intake, counterpiece, and exhaust valves, as indicated in Chart 1 below.

Chart 1

Valves in overlap at cylinder	6	2	4	1	5	3
Adjust valves at cylinder (piston at TDC)	1	5	3	6	2	4

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Removal

NOTE: Refer to the following service sections for information on removal of components prior to this section.

- Engine Electrical
- Turbochargers
- Air Compressor and Power Steering Pump
- Fuel System
- Oil Cooler, Filter Housing, and Crankcase Ventilation
- Exhaust Gas Recirculation (EGR) System
- Air Inlet Duct and Exhaust Manifolds
- Front Cover, High Mount Fan Drive, Cooling System, and Related Components

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Valve Cover

Figure 549 Valve Cover

1. Screw with damper element (18)
2. Valve cover

CAUTION: To prevent engine damage, do not use air tools to remove or install valve cover.

NOTE: The valve cover screws can only be removed from valve cover as assemblies with the damper elements. The screws and damper elements should only be completely removed from cover if replacing the valve cover gasket.

1. Release 18 screws with damper elements from cylinder head. Do not completely remove screws from valve cover at this time.
2. Remove valve cover.

NOTE: Valve cover gasket can be reused and does not require removal from valve cover unless damaged.

3. Inspect valve cover gasket for damage. If damaged, continue with steps 4 and 5.

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Figure 550 Valve cover gasket

1. Valve cover gasket
2. Screw with damper element (18)
3. Valve cover

4. Completely remove 18 screws with damper elements from valve cover to release valve cover gasket.
5. Discard valve cover gasket.

Fuel Injectors

CAUTION: To prevent engine damage, remove injectors before removing cylinder head.

CAUTION: To prevent engine damage, do not use power tools.

CAUTION: To prevent engine damage, install new injector O-ring and sealing washer before installing injector.

Figure 551 Fuel injector connections (typical)

1. Injector harness nuts (12)
2. Injector harness

NOTE: The injector harness nuts are part of the injector harness and cannot be separated.

1. Loosen 12 injector harness nuts and position injector harness aside.

Figure 552 Pressure pipe neck (typical)

1. Pressure pipe nut (6)
2. Pressure pipe neck (6)

2. Remove six pressure pipe nuts.
3. Remove and discard six pressure pipe necks.

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4. Cover cylinder head pressure pipe neck bores with appropriate size plugs from Disposable Air and Fuel Caps (page 353).

Figure 553 Pressure flange hex bolt (typical)

1. M8 x 50 hex bolt (6) and retaining washer (6)
2. Pressure flange (6)

5. Remove six M8 x 50 pressure flange hex bolts and six retaining washers.

Figure 554 Injector puller

1. Clamping sleeve
2. Extractor plate
3. Extractor
4. Knurled nut
5. Extractor nut
6. Plate column (2)
7. Plate column nuts (2)

6. Use Injector Puller (page 353) to remove injectors.

Figure 555 Injector extractor (typical)

1. Extractor (part of Injector Puller)
2. Injector

7. Install extractor on injector.

Figure 556 Clamping sleeve (typical)

1. Extractor (part of Injector Puller)
2. Clamping sleeve (part of Injector Puller)

8. Slide clamping sleeve over extractor.

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Figure 557 Extractor plate and plate columns (typical)

1. Extractor plate (part of Injector Puller)
2. Plate column (2) (part of Injector Puller)

9. Position two plate columns on two opposite cylinder head bolts, and slide extractor plate over extractor and plate columns.
10. Install and finger tighten plate column nuts on plate columns.

Figure 558 Extractor nut (typical)

1. Knurled nut (part of Injector Puller)
2. Extractor nut (part of Injector Puller)

11. Install knurled nut and extractor nut on injector with the extractor nut backed out.
12. Hold knurled nut and tighten extractor nut to remove injector with sealing washer and pressure flange.

NOTE: Make sure that no sealing washer remains in the injector bore after the injector is removed.

13. Cover cylinder head injector bore with appropriate size plugs from Disposable Air and Fuel Caps (page 353).

Figure 559 Injector seals (typical)

1. Injector
2. O-ring
3. Sealing washer

14. Using a small hand tool, remove and discard sealing washer. Wipe injector nozzle with a lint free cloth. Do not remove O-ring at this time.

CAUTION: To prevent engine damage, do not clean fuel injectors with solvents or brake cleaner.

15. Clean injector tip with Fuel Injector Tip Cleaning Brush (page 353).
16. Insert injector into Fuel Injector Cup (page 353), and place in Fuel Injector Rack Holder (page 353).

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Figure 560 Thrust washer (typical)

17. Remove six thrust washers from cylinder head.

Counterpiece

Figure 561 Counterpiece bolts (typical)

1. M10 x 60 hex bolt (12)
2. Counterpiece (6)

1. Remove 12 M10 x 60 hex bolts.
2. Remove six counterpieces from cylinder head.

Rocker Gear

CAUTION: To prevent engine damage, use permanent markers to identify internal components and their orientation. Do not use paint or temporary markers.

Figure 562 Rocker gear (typical)

1. M12 x 60 cylinder screw (12)
2. Rocker gear (6)

1. Mark rocker gears 1 through 6 so they can be installed in their original cylinder location.
2. Remove 12 M12 x 60 cylinder screws.
3. Remove six rocker gears.

Figure 563 Rocker bearing block (typical)

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4. Mark rocker bearing blocks 1 through 6 so they can be installed in their original cylinder location.
5. Remove six rocker bearing blocks.

Figure 564 Valve bridges (typical)

1. Valve bridge (exhaust) (6)
2. Valve bridge (intake) (6)
3. Counterpiece end

6. Mark valve bridges so they can be installed in their original location and orientation.
7. Remove 12 valve bridges.

Camshaft

CAUTION: To prevent engine damage, use permanent markers to identify internal components and their orientation. Do not use paint or temporary markers.

Figure 565 Camshaft end play check

1. Check camshaft end play as follows:
   a. Mount dial indicator with magnetic base (page 353) on cylinder head with indicator tip on end of camshaft as shown.
   b. Move camshaft toward rear of engine and zero the dial indicator.
   c. Move camshaft back and forth while reading dial indicator. Compare dial indicator reading with specifications (page 352).
   d. If end play exceeds specified limits, install a new camshaft.

Figure 566 Camshaft timing mark

1. Camshaft gear
2. Timing mark

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2. Rotate engine until timing mark on camshaft gear is aligned with cylinder head surface.

Figure 567 Flywheel housing timing index

1. Flywheel housing timing index
2. Flywheel timing mark

3. Remove sealing cap from lower side of flywheel housing and verify timing mark on flywheel is aligned with flywheel housing timing index.
   - If timing mark on flywheel is out of alignment, then the timing has slipped due to big intermediate gear slippage. Install a new big intermediate gear. See Oil Pump, Low Mount Fan Drive and Timing Gears section (page 391) for procedures to replace big intermediate gear.
   - If timing mark on flywheel is aligned with flywheel housing timing index, continue to next step.

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Figure 568 Camshaft bearing bolts

1. M8 x 35 hex bolt (14)
2. Cylinder head bearing cap (7)

4. Remove 14 M8 x 35 hex bolts.
5. Remove seven cylinder head bearing caps. Mark each cylinder head bearing cap number and orientation.

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Figure 569 Cylinder head bearing cap and bearing (typical)

1. Cylinder head bearing cap
2. 4 mm dowel pin (2)
3. Bearing shell

6. Remove seven bearing shells from cylinder head bearing caps. Mark each bearing shell with cylinder head bearing cap number and orientation.
7. If damaged, remove 14 – 4 mm dowel pins from seven cylinder head bearing caps.
8. Remove camshaft.
9. Remove seven lower bearing shells from cylinder head. Mark each bearing shell with cylinder head bearing cap number and orientation.

Figure 570 Camshaft gear and camshaft pulse wheel

1. 6 mm dowel pin
2. Camshaft gear
3. Camshaft pulse wheel
4. M8 x 30 hex bolt (3)

10. Remove three M8 x 30 hex bolts.
11. Remove camshaft pulse wheel and camshaft gear.
12. If damaged, remove 6 mm dowel pin from camshaft.

Fuel Injector Harness

Figure 571 Injector harness bolts

1. M6 x 16 hex bolt (4)
2. Injector harness

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1. Remove four M6 x 16 hex bolts.
2. Remove injector harness.
3. If damaged, remove and discard O-ring from injector harness flange.

Cylinder Head

CAUTION: To prevent engine damage, remove injectors before removing cylinder head.

Figure 572 Cylinder Head Lifting Bracket

1. Cylinder head lifting bracket
2. M8 x 20 class 10.9 bolt (4)

1. Position Cylinder Head Lifting Bracket (page 353) on rear end of cylinder head.
2. Install four M8 x 20 class 10.9 bolts (page 353). Tighten bolts to standard torque (page 455).

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Figure 573 Cylinder head bolts

3. Use Head Bolt Torx Socket (page 353), and working in a circular pattern, loosen, remove, and discard 26 M18 x 246 collar bolts. Begin with the outer bolts and move inward.

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Figure 574 Cylinder head removal

4. Lift cylinder head using a suitable lifting device.

CAUTION: To prevent engine damage, do not scratch gasket surface of cylinder head.

CAUTION: To prevent engine damage, carefully set cylinder head on blocks to protect the cylinder intermediate gear.

5. Place cylinder head on a clean non-metallic surface.
6. Remove four M8 x 20 class 10.9 bolts and Cylinder Head Lifting Bracket (page 353).
7. Remove and discard cylinder head gasket.

Figure 575 8 mm dowel pin (2)

8. If damaged, remove two 8 mm dowel pins.

Cylinder Intermediate Gear

Figure 576 Cover removal

1. Use a punch to knock in bottom of cover. Remove and discard cover.

Figure 577 Cylinder intermediate gear

1. Small gear stud
2. Cylinder intermediate gear
3. M8 x 30 cylinder screw (3)

2. Remove three M8 x 30 cylinder screws, small gear stud, and cylinder intermediate gear.

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Cleaning, Inspection, and Testing

Cylinder Head and Crankcase Components

WARNING: To prevent personal injury or death, wear safety glasses with side shields. Limit compressed air pressure to 207 kPa (30 psi).

CAUTION: To prevent engine damage, do not use chlorinated solvents on bolts or crankcase tapped holes. Parts should be clean, dry, and free of any chemicals other than engine oil.

CAUTION: To prevent engine damage, do not scratch gasket surface of cylinder head.

1. Use a scraper and wire brush to remove deposits and gasket material from valve heads and gasket surface.
2. Use a suitable solvent to remove dirt, grease, and deposits from removed parts.
3. Clean all bolt holes. Make sure gasket surfaces, and oil return passages are clean. Clean all surfaces and ports with steam, and then dry with filtered compressed air.
4. Clean all bolts (except head bolts) with a suitable solvent and dry thoroughly. New head bolts must be installed.

CAUTION: To prevent engine damage, clean and dry threads in crankcase bolt holes with filtered compressed air. Dirt or oil in holes may cause binding and incorrect torque readings.

Figure 578 Head bolt bottoming tap

5. Clean cylinder head bolt holes in crankcase with Head Bolt Bottoming Tap (page 353).
6. Clean out debris with filtered compressed air.

Camshaft Bearings

1. With camshaft removed, install previously marked bearing shells and cylinder head bearing caps. Tighten M8 x 35 hex bolts to special torque (page 352).

Figure 579 Camshaft bearing check

2. Use a telescoping gauge set (page 353) and a 1-2 inch micrometer (page 353) to measure camshaft bearing inside diameter. If inside diameter does not meet specifications (page 352), install new camshaft bearings.

Fuel Injector Bore

1. Use Injector Sleeve Brushes (page 353) in injector bore to remove deposits.

WARNING: To prevent personal injury or death, wear safety glasses with side shields. Limit compressed air pressure to 207 kPa (30 psi).

2. Use filtered compressed air to clean out debris from injector bores.

Fuel Injector Harness

Inspect injector wire harness for kinked wires or terminals. Replace harness if kinks are found. Kinked

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wires can result in oil leak between the harness protective foam covering and the wires.

Valves Leak Test

NOTE: Position wooden blocks so the view of all the valves seats is not restricted.

1. Position cylinder head on wooden blocks with cylinder head gasket surface facing down.

Figure 580 Air inlet duct

1. M8 x 90 hex bolt (2)
2. Air inlet duct
3. M8 x 50 hex bolt

2. Apply Loctite® 5900 sealant or equivalent (page 353) to joining surfaces of air inlet duct and cylinder head.
3. Install air inlet duct.
4. Install M8 x 50 hex bolt and two M8 x 90 hex bolts. Tighten hex bolts to special torque (page 352).
5. Spray mineral spirits into exhaust ports.
6. Pour mineral spirits into air inlet duct until intake manifold inside cylinder head is filled.

Figure 581 Leak inspection

1. Inspection mirror
2. Reflection of valve
3. Flashlight

NOTE: Valve seats must not leak. If valve seats leak, install a new cylinder head. Cylinder head replacement is not required if the cylinder head passes the mineral spirits test.

7. Wait five minutes. Use an inspection mirror to inspect valve seat area for leakage of mineral spirits. If there is no leakage of mineral spirits through the intake or exhaust valves, the cylinder head is acceptable for reinstallation.

Figure 582 Air inlet duct

1. M8 x 90 hex bolt (2)
2. Air inlet duct
3. M8 x 50 hex bolt

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8. Position a suitable container under air inlet duct to catch mineral spirits and loosen M8 x 50 hex bolt and two M8 x 90 hex bolts.
9. Remove air inlet duct.
10. Lift rear end of cylinder head to drain all remaining mineral spirits out of the intake manifold.

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Installation

Cylinder Intermediate Gear

Figure 583 Cylinder intermediate gear

1. Small gear stud
2. Cylinder intermediate gear
3. M8 x 30 cylinder screw (3)

1. Install small gear stud and cylinder intermediate gear.
2. Install three M8 x 30 cylinder screws. Tighten cylinder screws to special torque (page 352).
3. Clean cylinder head mating surfaces for cylinder intermediate gear access cover.
4. Apply Loctite® 262™ Threadlocker (page 353) to the outside edge of new cylinder intermediate gear access cover.

Figure 584 Cover installation

5. Drive new cover into the hole using a bearing installer (page 353) approximately 6mm (0.25 in) smaller in diameter than the cover.
6. Recess cover 2.3 mm (0.9 in) below the machined surface.

Cylinder Head

Figure 585 8 mm dowel pin (2)

1. If previously removed, install two 8 mm dowel pins on crankcase.

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WARNING: To prevent personal injury or death, wear safety glasses with side shields to protect eyes. Limit compressed air pressure to 207 kPa (30 psi).

CAUTION: To prevent engine damage, do not use chlorinated solvents on bolts or crankcase tapped holes. Parts should be clean, dry, and free of any chemicals other than engine oil.

CAUTION: To prevent engine damage, clean and blow dry threads in the crankcase bolt holes with filtered compressed air. Dirt or oil in holes may cause binding or an incorrect torque reading.

CAUTION: To prevent engine damage, remove debris from cylinder head. If debris is not removed, a faulty seal between the cylinder head and gasket will cause oil, coolant, and compression leaks. Do not apply sealant to head gasket surfaces.

CAUTION: To prevent engine damage, install a new cylinder head gasket with part number facing up.

2. Install a new cylinder head gasket on crankcase, over dowel pins.

Figure 586 Cylinder Head Lifting Bracket

1. Cylinder Head Lifting Bracket
2. M8 x 20 class 10.9 bolt (4)

3. Position Cylinder Head Lifting Bracket (page 353) on rear end of cylinder head.
4. Install four M8 x 20 class 10.9 bolts (page 353). Tighten bolts to standard torque (page 455).

Figure 587 Cylinder head installation

CAUTION: To prevent engine damage, do not drop or slide cylinder head on cylinder head gasket. This will damage the cylinder head gasket, dowel pins, and the cylinder intermediate gear.

5. Lower cylinder head on crankcase.

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Figure 588 Cylinder head bolts

CAUTION: To prevent engine damage, install new head bolts. Lightly lubricate new bolt threads and mating surfaces of bolt flanges with clean engine oil. Too much oil will cause hydrostatic lock and give incorrect torque reading.

6. Install 26 new lightly lubricated M18 x 246 collar bolts. Do not tighten bolts at this time.
7. Remove four M8 x 20 class 10.9 bolts and Cylinder Head Lifting Bracket (page 353).

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Figure 589 Cylinder head bolts tightening sequence

CAUTION: To prevent engine damage, use only permanent ink markers to identify bolt torque orientation.

CAUTION: To prevent engine damage, use a torque wrench to tighten cylinder head bolts; do not use an impact wrench.

NOTE: For proper cylinder head surface seating and sealing, follow the correct tightening sequence.

8. Use Head Bolt Torx Socket (page 353) to tighten the M18 x 246 collar bolts in sequence indicated above as follows:
    1. Hand tighten collar bolts.
    2. Tighten collar bolts numbered 1 through 26 to 10 N·m (89 lbf·in) in numerical sequence.
    3. Tighten collar bolts numbered 1 through 26 to 150 N·m (111 lbf·ft) in numerical sequence.
    4. Tighten collar bolts numbered 1 through 26 to 300 N·m (221 lbf·ft) in numerical sequence.
    5. Rotate collar bolts numbered 1 through 26 an additional 90° (1/4 turn) clockwise in numerical sequence.
    6. Rotate collar bolts numbered 1 through 26 an additional 90° (1/4 turn) clockwise in numerical sequence for second time.
    7. Rotate collar bolts numbered 1 through 26 an additional 90° (1/4 turn) clockwise in numerical sequence for third time.

Fuel Injector Harness

1. If necessary, install a new O-ring on injector harness flange.

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Figure 590 Injector harness bolts

1. M6 x 16 hex bolt (4)
2. Injector harness

2. Lightly lubricate O-ring on injector harness flange with clean engine oil.
3. Install injector harness and four M6 x 16 hex bolts.
4. Tighten hex bolts to standard torque (page 455).

Camshaft

Figure 591 Camshaft gear and camshaft pulse wheel

1. 6 mm dowel pin
2. Camshaft gear
3. Camshaft pulse wheel
4. M8 x 30 hex bolt (3)

1. If previously removed, install 6 mm dowel pin into camshaft.
2. Align camshaft gear with dowel pin and install on camshaft.
3. Align camshaft pulse wheel with dowel pin and install on camshaft.
4. Install and finger tighten three M8 x 30 hex bolts.

Figure 592 Camshaft lower bearing shell (typical)

NOTE: If original camshaft bearing shells are installed, make sure to place them as previously marked in their original location and orientation.

5. Install seven new or previously marked camshaft lower bearing shells on cylinder head. Make sure oil holes in bearings are aligned with oil holes in cylinder head bearing support.
6. Rotate crankshaft so that cylinder number 1 is positioned at Top Dead Center (TDC).

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Figure 593 Flywheel housing timing index

1. Flywheel housing timing index
2. Flywheel timing mark

7. Verify timing mark on flywheel is aligned with flywheel housing timing index at bottom of flywheel housing.

Figure 594 Camshaft timing mark

1. Camshaft gear
2. Timing mark

8. Lower camshaft on cylinder head and make sure timing mark on camshaft gear is aligned with cylinder head surface.

Figure 595 Cylinder head bearing cap and bearing (typical)

1. Cylinder head bearing cap
2. 4 mm dowel pin (2)
3. Bearing shell

NOTE: Make sure that each bearing cap has the two dowel pins installed.

9. If previously removed, install 14 – 4 mm dowel pins into seven bearing caps.

NOTE: If original bearing shells are installed, make sure they are placed as previously marked in their original location and orientation.

10. Install seven new or previously marked bearing shells on cylinder head bearing caps.

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Figure 596 Camshaft bearing bolts

1. M8 x 35 hex bolt (14)
2. Cylinder head bearing cap (7)

11. Install seven previously marked cylinder head bearing caps with bearing shells in their original location and orientation.
12. Install 14 M8 x 35 hex bolts. Tighten hex bolts to special torque (page 352).

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Figure 597 Camshaft gear bolts tightening

1. Camshaft gear
2. M8 x 30 hex bolt (3)

13. Tighten three M8 x 30 hex bolts to 15 N·m (133 lbf·in).
14. Tighten three M8 x 30 hex bolts an additional 90° (1/4 turn).

Rocker Gear

Figure 598 Valve bridges (typical)

1. Valve bridge (exhaust) (6)
2. Valve bridge (intake) (6)
3. Counterpiece end

NOTE: If original valve bridges are installed, make sure they are placed as previously marked in their original location.

1. Place six exhaust valve bridges on exhaust valves with counterpiece end oriented toward exhaust manifold and milled end toward camshaft.

Figure 599 Intake valve bridge orientation (typical)

1. Camshaft side
2. Exhaust manifold side

2. Place six intake valve bridges on intake valves with milled end oriented toward camshaft.

Figure 600 Rocker bearing block (typical)

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NOTE: If original rocker bearing blocks are installed, make sure they are placed as previously marked in their original location.

3. Install six rocker bearing blocks.

Figure 601 Rocker gear (typical)

1. M12 x 60 cylinder screw (12)
2. Rocker gear (6)

NOTE: If original rocker gears are installed, make sure they are placed as previously marked in their original location.

4. Install six rocker gears.
5. Install 12 M12 x 60 cylinder screws. Tighten cylinder screws to special torque (page 352).

Counterpiece

Figure 602 Counterpiece bolts (typical)

1. M10 x 60 hex bolt (12)
2. Counterpiece (6)

1. Place six counterpieces on cylinder head.
2. Install 12 M10 x 60 hex bolts. Tighten hex bolts to special torque (page 352).
3. Adjust counterpiece, exhaust, and intake valves lash. See Valve Lash Adjustment (page 318).

Fuel Injectors

CAUTION: To prevent engine damage, remove protective plugs and cups only before immediate installation of components.

CAUTION: To prevent engine damage, do not use power tools.

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Figure 603 Thrust washer (typical)

1. Install six thrust washers on cylinder head.

Figure 604 Injector seals (typical)

1. Injector
2. O-ring
3. Sealing washer

CAUTION: To prevent engine damage, install new injector O-ring and sealing washer before installing injector.

2. Install a new sealing washer onto injector tip.
3. Install a new O-ring. Lubricate O-ring with clean engine oil.

Figure 605 Injector and pressure flange orientation (typical)

1. Pressure flange
2. Injector inlet opening

4. Slide injector into pressure flange with injector inlet opening on opposite side of pressure flange.

Figure 606 Injector and pressure flange installation (typical)

1. Pressure flange
2. Injector

CAUTION: To prevent engine damage, align injector and pressure flange correctly with cylinder head; do not twist injector when inserting injector into cylinder head.

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NOTE: Make sure that injector bore in cylinder head is clean and no old sealing washer remains inside the bore.

5. Install injector by lowering injector and pressure flange as one unit into injector bore.
6. Using Injector Installer (page 353), firmly press injector and pressure flange and make sure injector is fully seated into cylinder head.

Figure 607 Pressure pipe neck alignment (typical)

1. Cylinder head notch
2. Locating ball

CAUTION: To prevent engine damage, install new pressure pipe.

7. Align locating ball on pressure pipe neck with notch in cylinder head, and install six new pressure pipe necks.

Figure 608 Pressure flange hex bolt (typical)

1. M8 x 50 hex bolt (6) and retaining washer (6)
2. Pressure flange

8. Install six M8 x 50 pressure flange hex bolts and six retaining washers.
9. Pre-tighten M8 x 50 hex bolts to 2 N·m (18 lbf·in).

Figure 609 Pressure pipe neck (typical)

1. Pressure pipe nut (6)
2. Pressure pipe neck (6)

10. Install six pressure pipe nuts. Tighten pressure pipe nuts to initial torque of 10 N·m (89 lbf·in).
11. Tighten six M8 x 50 pressure flange hex bolts to 25 N·m (18 lbf·ft).

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12. Tighten six M8 x 50 pressure flange hex bolts an additional 90° (1/4 turn).
13. Tighten six pressure pipe nuts to 20 N·m (177 lbf·in).
14. Tighten six pressure pipe nuts an additional 60° (1/6 turn).

Figure 610 Injector connections (typical)

1. Injector harness nuts (12)
2. Injector harness

CAUTION: To prevent engine damage, hold injector harness terminals to prevent twisting or turning while tightening the injector harness nuts. Kinked harness terminals can result in an oil leak path between the protective cover and the wire.

CAUTION: To prevent engine damage, use a torque wrench to tighten injector harness nuts to 1.5 Nm (13 lbf in).

15. Connect injector harness to injectors. Make sure harness terminals are in straight alignment with harness. Hold terminals stationary to avoid twisting, and tighten nuts to special torque (page 352).

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Valve Cover

Figure 611 Valve cover gasket

1. Valve cover gasket
2. Screw with damper element (18)
3. Valve cover

1. If necessary, install a new valve cover gasket.
2. If previously removed, install 18 screws with damper element on valve cover and through valve cover gasket.

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Figure 612 Valve Cover

1. Screw with damper element (18)
2. Valve cover

CAUTION: To prevent engine damage, do not use air tools to remove or install valve cover.

3. Place valve cover on cylinder head.
4. Tighten 18 screws with damper elements to special torque (page 352).

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Specifications

Table 26 Cylinder Head, Camshaft and Valve Train

Camshaft	
Camshaft end play	0.25 – 0.85 mm (0.0098 – 0.0334 in)
Camshaft bearing inside diameter	39.925 – 39.950 mm (1.57185 – 1.57283 in)
Valve Lash Adjustment	
Intake valve clearance	0.5 mm (0.0196 in)
Exhaust valve clearance	0.8 mm (0.0314 in)
Counterpiece clearance	0.6 mm (0.0236 in)
Cylinder Intermediate Gear Access Cover	
Cover recess	2.3 mm (0.9 in)

Special Torque

Table 27 Cylinder Head, Camshaft and Valve Train

Air inlet duct hex bolts	15 N·m (11 lbf·ft)
Cylinder head bearing cap hex bolt	35 N·m (26 lbf·ft)
Camshaft gear hex bolts	See tightening steps in procedure
Cylinder head collar bolts	See tightening steps in procedure
Cylinder intermediate gear cylinder screws	30 N·m (22 lbf·ft)
Counterpiece adjustment M14 hexagon nuts	45 N·m (33 lbf·ft)
Counterpiece hex bolts	75 N·m (55 lbf·ft)
Exhaust valve lash adjustment M10 hexagon nuts	45 N·m (33 lbf·ft)
Injector harness nuts	1.5 N·m (13 lbf·in)
Injector pressure flange hex bolts	See tightening steps in procedure
Intake valve lash adjustment M10 hexagon nuts	45 N·m (33 lbf·ft)
Pressure pipe nuts	See tightening steps in procedure
Rocker gear cylinder screws	105 N·m (77 lbf·ft)
Valve cover screw with damper elements	11 N·m (97 lbf·in)

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Special Service Tools

Table 28 Cylinder Head, Camshaft and Valve Train

Description	Tool Number
1–2 inch Micrometer	Obtain locally
Bearing Installer	Obtain locally
Cylinder Head Lifting Bracket	ZTSE4869
Dial Indicator with Magnetic Base	Obtain locally
Disposable Air and Fuel Caps	ZTSE4891
Engine Rotating Tool	ZTSE4786
Feeler Gauge	Obtain locally
Fuel Injector Tip Cleaning Brush	ZTSE4301
Fuel Injector Rack Holder	ZTSE4299B
Fuel Injector Cups	ZTSE4892
Head Bolt Bottoming Tap	ZTSE4855
Head Bolt Torx Socket	ZTSE4835
Injector Installer	ZTSE4777
Injector Puller	ZTSE4770
Injector Sleeve Brushes	ZTSE4751
Loctite® 262™ Threadlocker	Obtain locally
Loctite® 5900 sealant or equivalent	Obtain locally
M8 x 20 class 10.9 bolts	Obtain locally
Telescoping Gauge Set	Obtain locally

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Table of Contents

Exploded View.....357

Removal.....358
- **Preliminary Checks**.....358
  - **Flywheel Assembly (Manual Transmission)**.....358
  - **Flywheel Surface Runout**.....358
- **Pilot Bearing**.....359
- **Flywheel (Manual Transmission)**.....359
- **Radial Shaft Seal**.....359
- **Lifting Eyes**.....360
- **Flywheel housing**.....360

Cleaning.....361
- **All Components**.....361

Preliminary Checks.....361
- **Flywheel Assembly (Manual Transmission)**.....361

Recondition.....361
- **Flywheel**.....361

Installation.....363
- **Flywheel Housing**.....363
- **Lifting Eyes**.....363
- **Radial Shaft Seal**.....364
- **Flywheel Assembly (Manual Transmission)**.....364
- **Pilot Bearing (Flywheel)**.....365

Specifications.....366

Special Torque.....366

Special Service Tools.....366

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Exploded View

Figure 613 Flywheel housing and flywheel

1. Radial shaft seal
2. M10 x 30 hex bolt (12)
3. M10 x 40 hex bolt (3)
4. Flywheel housing
5. Plug
6. Sealing cap
7. Tapping screw (2)
8. Plug
9. Flywheel
10. Pilot bearing
11. 12KT flywheel bolt (10)
12. M16 x 150 hex bolt (4)
13. Lifting eye (2)

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Removal

WARNING: To prevent personal injury or death, read all safety instructions in the "Safety Information" section of this manual.

WARNING: To prevent personal injury or death, shift transmission to park or neutral, set parking brake, and block wheels before doing diagnostic or service procedures.

WARNING: To prevent personal injury or death, make sure the engine has cooled before removing components.

WARNING: To prevent personal injury or death, do not let engine fluids stay on your skin. Clean skin and nails using hand cleaner and wash with soap and water. Wash or discard clothing and rags contaminated with engine fluids.

GOVERNMENT REGULATION: Engine fluids (oil, fuel, and coolant) may be a threat to the environment. Recycle or dispose of engine fluids according to applicable regulations. Never put engine fluids in the trash, on the ground, in sewers or bodies of water.

NOTE: Refer to the following service sections for information on removal of components prior to this section.

- Aftertreatment System

Preliminary Checks

Flywheel Assembly (Manual Transmission)

1. Inspect flywheel for cracks around webbing and bolt holes.
2. Inspect flywheel for heat cracks and extensive scoring.
3. Inspect all ring gear teeth for starter pinion damage.
4. Replace flywheel if necessary.

Flywheel Surface Runout

CAUTION: To prevent engine damage, check runout of flywheel surface for correct alignment of engine to transmission. Failure to ensure correct bore concentricity and face runout may reduce life of clutch or transmission.

Figure 614 Flywheel surface runout

1. Dial indicator with magnetic base
2. Flywheel

1. Attach dial indicator with magnetic base (page 366) to surface of lifting eye. Place indicator tip against flywheel.

NOTE: Keep crankshaft end play at zero and rotate in same direction for all measurements.

2. Push the flywheel inward to eliminate crankshaft end play, set dial indicator zero.
3. While pushing inward on the flywheel to eliminate crankshaft end play effects, slowly rotate crankshaft one complete revolution. Verify reading is within specification (page 366).

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Pilot Bearing

Figure 615 Pilot bearing removal

1. Slide hammer
2. Blind hole puller

1. Using a slide hammer (page 366), install blind hole puller (page 366), into pilot bearing.
2. Remove pilot bearing.

Flywheel (Manual Transmission)

Figure 616 Flywheel removal

1. 12KT flywheel bolt (10)
2. Flywheel

1. Remove and discard two 12KT flywheel bolts at approximately 3 o'clock and 9 o'clock position.
2. Install two guide pins (make locally) into crankshaft flange.
3. Remove and discard remaining eight flywheel bolts.
4. Slide flywheel off guide pins and out of flywheel housing.
5. Remove guide pins from crankshaft timing gear.

Radial Shaft Seal

WARNING: To prevent personal injury or death, wear safety glasses with side shields when doing the following procedure.

Figure 617 Radial shaft seal removal

1. Slide hammer
2. Radial shaft seal

1. With an awl and hammer, punch two holes 180° apart in radial shaft seal.
2. Thread a slide hammer (page 366) with correct size screw into one of the two holes.
3. Slide hammer until one side of seal begins to pull out of flywheel housing. Move slide hammer to other hole and repeat until radial shaft seal is completely removed.

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Lifting Eyes

Figure 618 Lifting eye

1. M16 x 150 hex bolt (4)
2. Lifting eye (2)

1. Remove four M16 x 150 hex bolts.
2. Remove two lifting eyes.

Flywheel housing

WARNING: To prevent personal injury or death, get help when removing or installing the flywheel housing

Figure 619 Bracket for turbo exhaust pipe

1. Bracket for turbo exhaust pipe
2. M8 x 16 bolt

1. Remove M8 x 16 bolt and bracket for turbo exhaust pipe from flywheel housing.

Figure 620 Flywheel housing

1. M10 x 30 hex bolt (12)
2. M10 x 40 hex bolt (3)
3. Flywheel housing

2. Remove 12 M10 x 30 and three M10 x 40 hex bolts from flywheel housing.
3. Use a thin gasket scraper to separate sealant between flywheel housing and crankcase.

WARNING: To prevent personal injury or death, get help when removing or installing the flywheel housing.

4. Remove flywheel housing with aid of an assistant.

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Cleaning

All Components

1. Clean foreign material from gasket surfaces of crankcase and flywheel housing. Use a scraper or wire brush to remove sealant from gasket surfaces.
2. Gasket surfaces must be oil-free for good adhesion of liquid gasket during assembly. Use a commercially available, non-caustic brake cleaner to clean gasket surfaces of crankcase and flywheel housing.

WARNING: To prevent personal injury or death, wear safety glasses with side shields. Limit compressed air pressure to 207 kPa (30 psi).

3. Wash flywheel and flywheel housing. Dry all with filtered compressed air.
4. Wash crankshaft timing gear, with a stiff brush and suitable solvent. Dry all with filtered compressed air.

Preliminary Checks

Flywheel Assembly (Manual Transmission)

1. Inspect flywheel for cracks around webbing and bolt holes.
2. Inspect flywheel for heat cracks and extensive scoring.
3. Inspect all ring gear teeth for starter pinion damage.
4. Replace flywheel if necessary.

Recondition

Flywheel

NOTE: Flywheels used with manual transmissions may be resurfaced to correct minor wear and scoring. If flywheel meets the following requirements it can be resurfaced.

WARNING: To prevent personal injury or death, do not machine flywheel beyond minimum thickness specified for flywheel resurfacing.

Figure 621 Flywheel surface dimension (typical)

1. Flywheel thickness (dimension “A”)
2. Clutch disc mounting face
3. Crankshaft timing gear face

NOTE: Flywheel resurfacing information is provided for guidance only. International Truck and Engine Corporation assumes no responsibility either for the results of any work performed in accordance with this information or for the ability of service personnel to detect cracks.

WARNING: To prevent personal injury or death, carefully examine flywheel for any cracks or heat checks before and after resurfacing. Cracks in the flywheel can cause it to separate. If there are any questions, do not reuse the flywheel.

1. Check flywheel for cracks and damage. Replace flywheel if required.

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2. Using 1–2 inch micrometer (page 366), measure flywheel thickness and compare to minimum required thickness specification (dimension “A”) (page 366). Discard flywheel if below minimum thickness specification or if flywheel will be below minimum thickness after resurfacing.
3. Resurface flywheel. See Flywheel Resurfacing Machine operators manual for instructions on flywheel resurfacing procedure.
4. Check flywheel for cracks and damage after resurfacing. Replace flywheel if required.
5. Measure flywheel thickness after resurfacing and compare to minimum required thickness specification. Discard flywheel if below minimum thickness specification.

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Installation

Flywheel Housing

Figure 622 Flywheel housing

1. M10 x 30 hex bolt (12)
2. M10 x 40 hex bolt (3)
3. Flywheel housing

CAUTION: To prevent engine damage, apply Liquid Gasket and component within 5 minutes of application to inhibit the formation of a skin and ensure a leak proof joint.

1. Verify flywheel housing alignment dowels are installed into the crankcase and are not damaged. Replace as necessary.
2. Apply Loctite 5900 or equivalent (page 366) to joining surfaces of flywheel housing and crankcase.

WARNING: To prevent personal injury or death, get help when removing or installing the crankcase rear cover.

3. Install flywheel housing to crankcase with aid of an assistant.
4. Install 12 M10 x 30 and three M10 x 40 flywheel housing hex bolts. Tighten bolts to special torque (page 366).

Figure 623 Bracket for turbo exhaust pipe

1. Bracket for turbo exhaust pipe
2. M8 x 16 bolt

5. Install M8 x 16 bolt and bracket for turbo exhaust pipe to flywheel housing. Tighten bolt to standard torque (page 455).

Lifting Eyes

Figure 624 Lifting eyes

1. M16 x 150 hex bolt (4)
2. Lifting eye (2)

1. Install two lifting eyes.
2. Install four M16 x 150 lifting eyes hex bolts. Tighten hex bolts to special torque (page 366).

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Radial Shaft Seal

Figure 625 Radial shaft seal installation

1. Rear Oil Seal Installer
2. Radial shaft seal

CAUTION: To avoid damage to the radial shaft seal, do not touch inner seal lip, allow oil or grease on any part of the seal during installation.

1. Using Rear Oil Seal Installer (page 366), install radial shaft seal into flywheel housing.
   a. Install inner hub of tool to crankshaft flange. Use two bolts provided with tool.
   b. Install radial shaft seal to inner hub of tool.
   c. Install pressing hub and nut and tighten to install radial shaft seal. When tool bottoms out, seal is fully installed.

Flywheel Assembly (Manual Transmission)

Figure 626 Flywheel installation

1. 12KT flywheel bolt (10)
2. Flywheel

WARNING: To prevent personal injury or death, inspect flywheel for cracks or heat checks after resurfacing. Do not install flywheel if damaged or questionable. Flywheel resurfacing information is provided for guidance only. INTERNATIONAL does not assume responsibility for work done by service personnel.

1. Install two guide pins (made locally) into crankshaft flange at approximately 3 o'clock and 9 o'clock position.
2. Align crankshaft timing gear pin hole in flywheel assembly with crankshaft timing gear pin and slide flywheel onto guide pins.

CAUTION: To prevent engine damage, always install new flywheel mounting bolts.

CAUTION: To prevent engine damage, do not use anti-seize compounds or grease on new flywheel or flexplate mounting bolts.

3. Loosely install eight new 12KT flywheel bolts to secure flywheel assembly to crankshaft flange.
4. Remove both guide pins and loosely install two remaining new 12KT flywheel bolts.

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Figure 627 Flywheel tightening sequence

NOTE: For proper flywheel installation, follow the correct tightening sequence while keeping the crankshaft from turning.

5. Tighten 12KT flywheel bolts using sequence indicated above as follows:
   a. Tighten 12KT flywheel bolts to 110 N·m (81 lbf·ft).
   b. Turn 12KT flywheel bolts 90°.
   c. Turn 12KT flywheel bolts an additional 90°.

Pilot Bearing (Flywheel)

Figure 628 Pilot bearing installation

1. Pilot bearing
2. Dial caliper

1. Place pilot bearing in flywheel bore.
2. Using Pilot Bearing Installation Tool (page 366), install pilot bearing into flywheel. When tool bottoms out, pilot bearing is fully installed.

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Specifications

Table 29 Flywheel and Flywheel Housing

Flywheel minimum thickness (dimension “A”)	46 mm (1.811 in)
Flywheel maximum surface runout	0.20 mm (0.0079 in)

Special Torque

Table 30 Flywheel and Flywheel Housing

12KT flywheel bolts	See tightening steps in procedure.
Flywheel housing hex bolts	75 N·m (55 lbf·ft)
Lifting eye hex bolts	180 N·m (133 lbf·ft)

Special Service Tools

Table 31 Flywheel and Flywheel Housing

Description	Tool Number
1–2 Inch Micrometer	Obtain locally
Blind Hole Puller	Obtain locally
Pilot Bearing Installation Tool	ZTSE4898
Brake Cleaner (non-caustic)	Obtain locally
Dial Indicator with Magnetic Base	Obtain locally
Loctite 5900 or Equivalent	Obtain locally
Rear Oil Seal Installer	ZTSE4875
Slide Hammer	Obtain locally

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