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Illustrations and Description

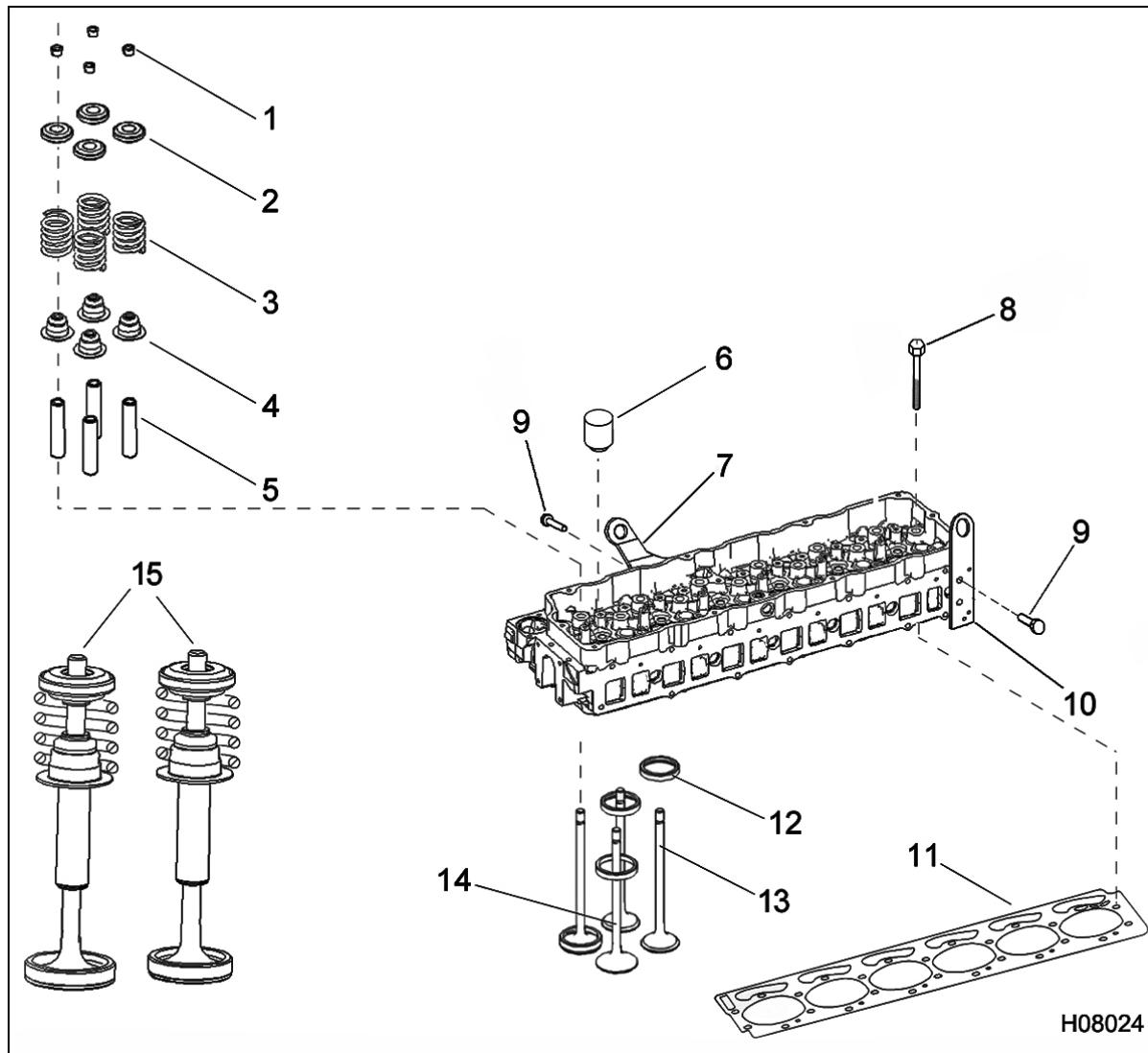


Figure 343 Cylinder head and valve train components

- | | | |
|------------------------------------|-----------------------------|----------------------------|
| 1. Valve spring retainer keys (24) | 6. Fuel injector sleeve (6) | 11. Cylinder head gasket |
| 2. Valve rotators or retainers | 7. Front lifting eye | 12. Valve seat insert (24) |
| 3. Valve springs (24) | 8. Cylinder head bolt, (26) | 13. Exhaust valve (12) |
| 4. Valve stem seals (24) | 9. M12 x 25 bolt (4) | 14. Intake valve (12) |
| 5. Valve guide inserts (24) | 10. Rear lifting eye | 15. Valve assemblies (24) |

MaxxForce™ DT, 9, and 10 cylinder heads are cast grey iron and feature four valves per cylinder. A single roller tappet camshaft transfers lifting force through a push rod, rocker arm, and onto a valve bridge where both intake or exhaust valves are opened

and closed simultaneously. Four valves per cylinder allows greater air volume to flow into and out of each cylinder than comparably sized engines using only two valves per cylinder.

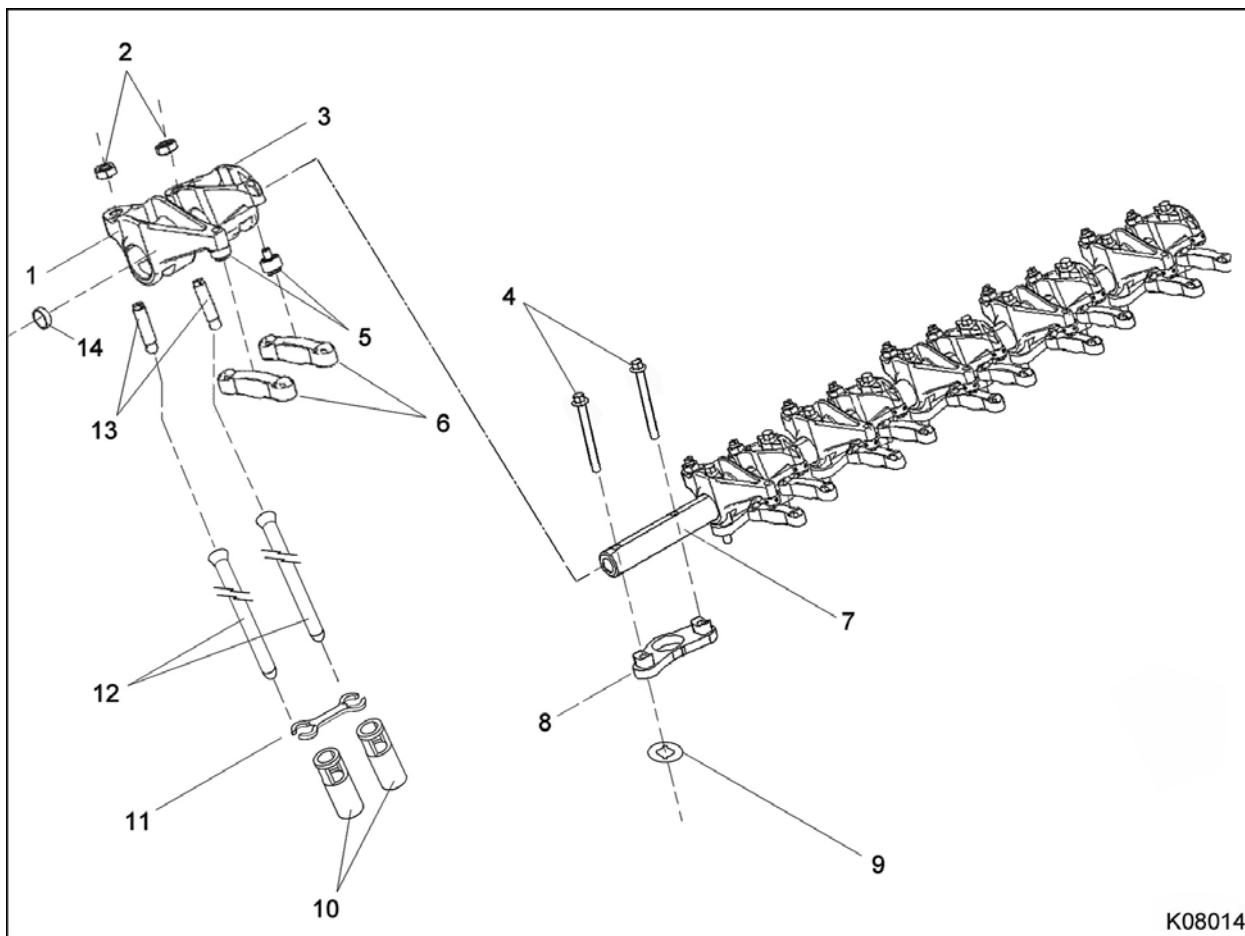


Figure 344 Valve train components

- | | | |
|--|---|--|
| 1. Intake rocker arm (6) | 6. Valve bridge (12) | 11. Roller tappet guide (6) |
| 2. Valve adjusting screw lock nut,
M10 (12) | 7. Rocker arm shaft | 12. Push rods (12) |
| 3. Exhaust rocker arm (6) | 8. Rocker shaft support (6) | 13. Valve lash adjuster screw, M10
(12) |
| 4. M8 x 60 shaft bolt (12) | 9. Support washer (assembly aid)
(6) | 14. Rocker shaft plug (2) |
| 5. Pivot foot assembly (12) | 10. Roller tappets (12) | |

Valve bridges, guides, springs, retainer keys, and valve stem seals are common between the intake and exhaust sides of the cylinder head. Rotators are always used on intake valves and can be used on exhaust valves. Some low horsepower engines have retainers on the exhaust valves.

New valve bridges can be installed on the intake or exhaust valves in either direction, and are also part of compression brake operation.

Valve guides and valve seats are replaceable.

Valve rotators allow valves to rotate for increased valve face life.

Valve stem seals are one piece and have a hardened washer for valve spring seating.

Phosphate coating is used on rocker arms for initial break-in and to extend life.

Pressurized oil is fed from the crankcase through the cylinder head at the cylinder 6 exhaust lower support. Oil then enters the rocker shaft and is distributed to the rocker arms.

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 transmission to park or neutral, set parking brake, and block wheels before doing diagnostic or service procedures.

⚠ WARNING: To prevent personal injury or death, allow engine to cool before working with components.

⚠ WARNING: To prevent personal injury or death, disconnect ground (-) cable from battery before doing service or diagnostic procedures.

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

⚠ 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 and filters according to applicable regulations. Never put engine fluids in the trash, on the ground, in sewers, or bodies of water.

Valve Lash Adjustment

The crankshaft is rotated twice during valve lash adjustment procedure.

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

If engine is equipped with a Diamond Logic® engine brake, corresponding engine brake actuator lash can be adjusted when piston 1 and 6 are at TDC compression.

NOTE: Engine brake lash adjustments are not required when adjusting valve lash.

1. Remove the valve cover (page 296) and EGR tube support bracket (page 124).
2. Turn the crankshaft in the direction of engine rotation to remove gear lash. Position piston 1 at TDC compression by observing cylinder 6 rocker arms in overlap as the vibration damper timing mark approaches the TDC mark on the front cover. Cylinder 6 exhaust valve will be closing (coming up) and the intake valve will be starting to open (going down).
3. If piston 1 is at TDC compression, see Chart 3 (page 294) and do steps 4, 5, and 6.

Chart 3

Valve and brake lash adjustments (inches) with piston 1 at TDC compression (Chart 3)											
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 0.019		Brake 0.019		Brake 0.019		Brake 0.019		Brake 0.019		Brake 0.019	

Valve and brake lash adjustments with piston 1 at TDC compression

Chart 4

Valve and brake lash adjustments (inches) with piston 6 at TDC compression (Chart 4)											
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 0.019		Brake 0.019		Brake 0.019		Brake 0.019		Brake 0.019		Brake 0.019	

Valve and brake lash adjustments with piston 6 at TDC compression

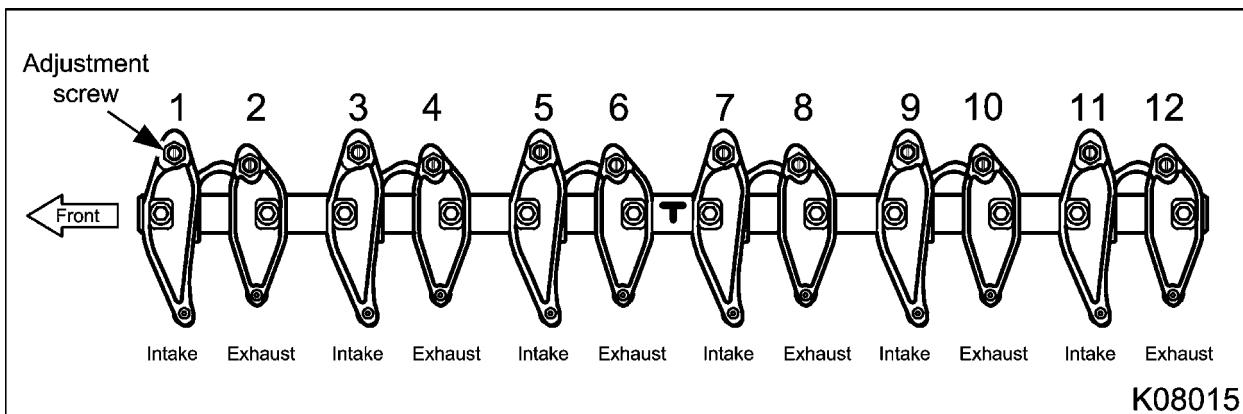


Figure 345 Valve lash adjustment

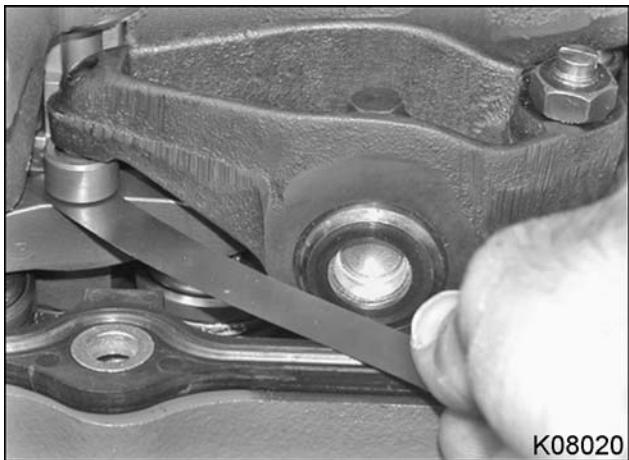


Figure 346 Valve lash measurement

4. Measure valve lash when the engine is cold. Put a 0.48 mm (0.019 in) feeler gauge (page 331) between the rocker arm pivot foot and the valve bridge. A light drag should be felt on the feeler gauge. If adjustment is required, loosen lock nut and turn valve adjustment screw until a light drag is felt.
5. Once valve lash is set, tighten valve adjustment screw lock nut to special torque (page 331) and remove feeler gauge. Recheck lash, a light drag should be felt on the feeler gauge. If drag is too tight or loose, repeat steps 4 and 5.
If engine is equipped with a Diamond Logic® engine brake, corresponding brake actuator lash can be adjusted before rotating crankshaft.
6. Turn crankshaft 360° in the direction of engine rotation to remove gear lash. Position piston 6 at TDC compression by observing cylinder 1 rocker arms in overlap as the vibration damper timing mark approaches the TDC mark on the front cover.
7. If piston 6 is at TDC compression, see Chart 4 (page 294) and do steps 4, 5, and 6.

Removal

Valve Cover

NOTE: If the valve cover is removed for any reason and engine is equipped with a Diamond Logic® engine brake, verify six brake piston locknuts are tight. If loose, check brake lash (page 186).

1. Disconnect the crankcase ventilation breather inlet tube (page 403) from the valve cover.

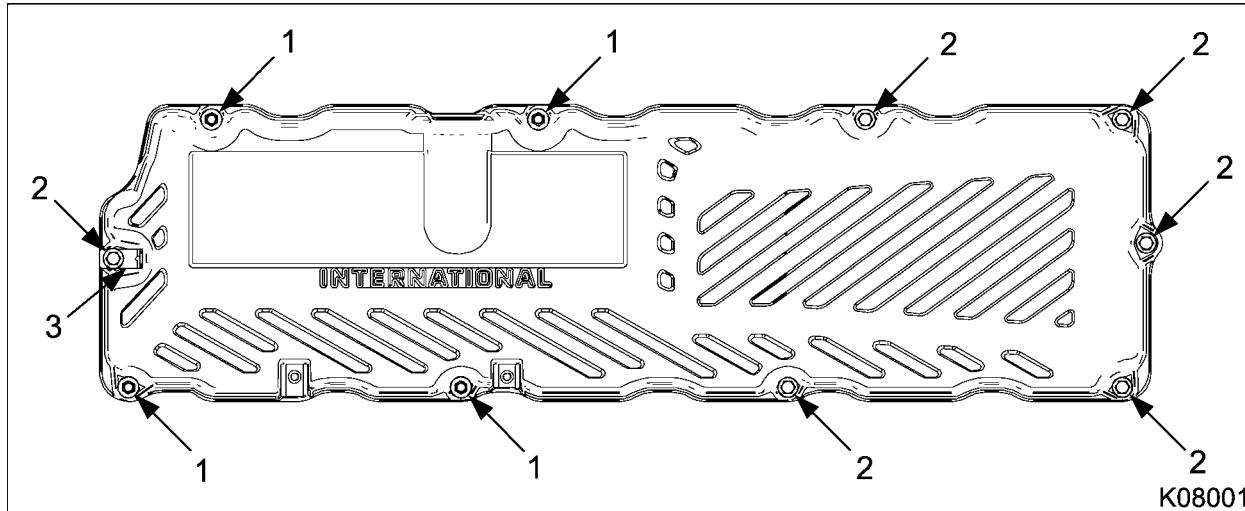
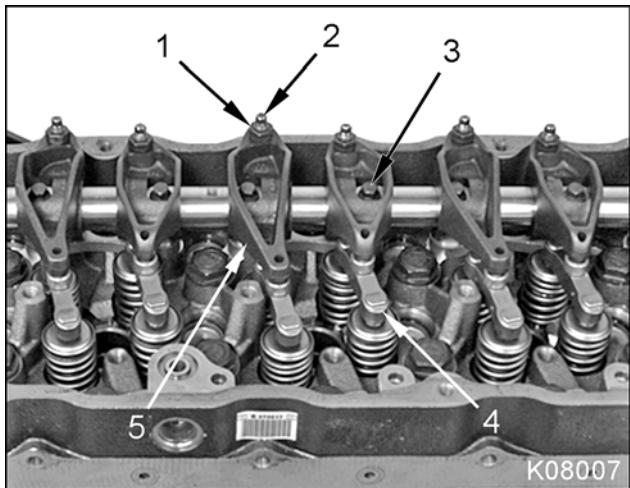


Figure 347 Valve cover

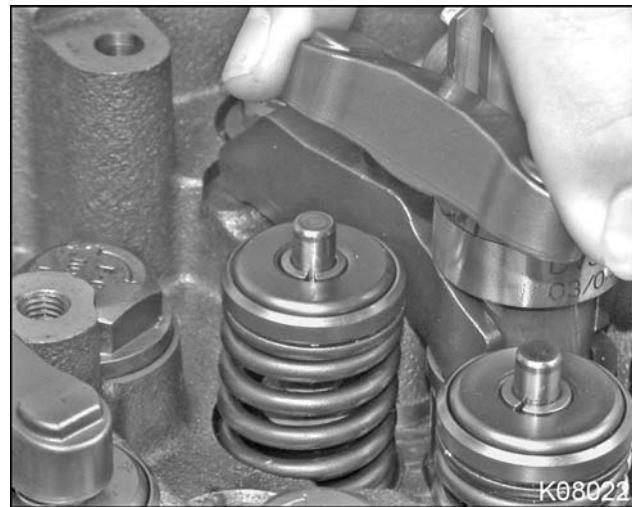
- | | | |
|---|---------------------|---|
| 1. M8 x 80 stud bolt (4) | 2. M8 x 80 bolt (6) | 3. Harness mounting bracket |
| | | 4. Lift valve cover off of cylinder head. |
| 2. Remove four M8 x 80 stud bolts. | | |
| 3. Remove six M8 x 80 bolts and harness mounting bracket. | | |

Rocker Arm Assembly**Figure 348** Valve train components

1. Valve adjusting screw lock nut (12)
2. Adjuster screw (12)
3. Rocker shaft bolt (12)
4. Valve bridge (12)
5. Rocker arm (12)

1. Loosen 12 adjuster screws and lock nuts. This will help prevent valve train damage and false torque readings during installation.
2. Loosen, but do not remove, 12 rocker shaft bolts.
3. Push down on rocker shaft bolts. This will latch support washers onto shaft bolts and keep rocker shaft supports from falling off.
4. Lift rocker arm shaft assembly up and off cylinder head.

NOTE: There are six support washers, one for each rocker shaft support, for assembly.

**Figure 349** Valve bridge removal

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

5. Mark all valve bridges for installation in original location and orientation.
6. Remove valve bridges.

NOTE: If required, measure camshaft lobe lift (page 300) before removing push rods or cylinder head.

Rocker Arms

CAUTION: To prevent engine damage, mark rocker arms and rocker shaft supports for installation in original locations.

1. Mark each rocker arm for installation in original location.
2. Remove 12 rocker shaft bolts.

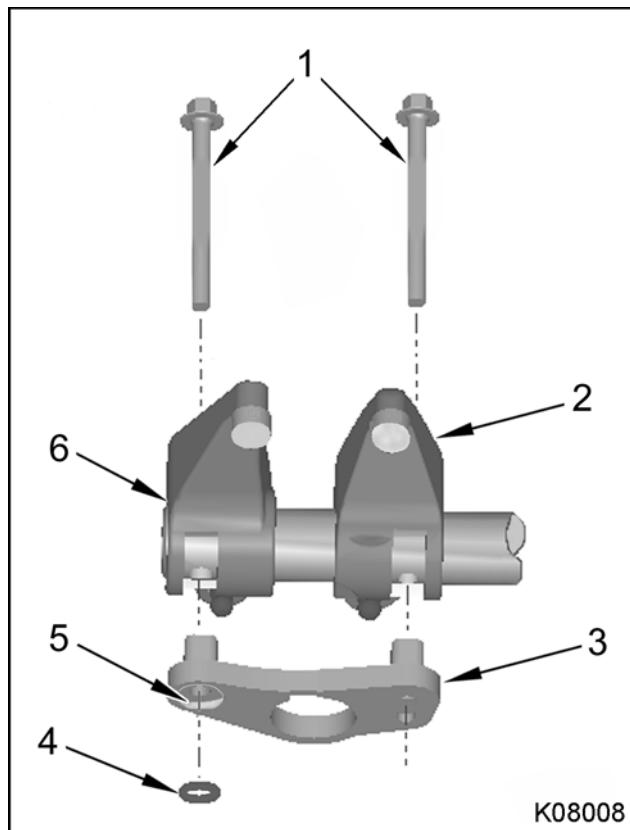


Figure 350 Rocker arm components

1. M8 x 60 shaft bolt
2. Exhaust rocker arm
3. Rocker arm shaft support
4. Support washer (assembly aid)
5. Machined recess
6. Intake rocker arm

3. Slide rocker arms off rocker arm shaft.
4. Remove and tag each push rod with cylinder number and valve association (intake or exhaust).

Cylinder Head

NOTE: If required, measure camshaft lobe lift (page 300) before removing push rods or cylinder head.

1. Drain engine coolant (page 58).
2. Remove the oil level gauge (page 404) and crankcase breather inlet tube (page 403).
3. Remove the fuel filter header assembly (page 164).
4. Remove the engine sensor wiring harness (page 84), injector wiring harness (page 86), intake air heater relay assembly (page 87), and UVC harness (page 90).
5. Remove the turbocharger oil supply tube (page 111) and VGT assembly (page 112).
6. Remove the EGR coolant supply tube (page 122), EGR tube assembly (page 123), coolant crossover tube and support bracket (page 124), exhaust side EGR cooler and bracket (page 125), EGR coolant return tube (page 126), EGR valve manifold assembly (page 127), EGR distribution tube (page 128), and intake side EGR cooler and bracket.
7. Remove the exhaust manifold (page 143), intake throttle assembly (page 144), EGR and inlet air mixer duct, and intake manifold (page 145).

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

8. Remove the high-pressure oil hose (page 165), high-pressure oil manifold (page 167), and fuel injectors (page 168).
9. Remove the water supply housing (page 249), water outlet tube, and fan drive assembly (page 251).

10. Remove 26 M15 x 180 cylinder head mounting bolts.

WARNING: To prevent personal injury or death, use a hoist rated for the weight of the cylinder head and follow the manufacturer's operation and safety instructions. Attach safety lifting hooks to the cylinder head lifting eyes.

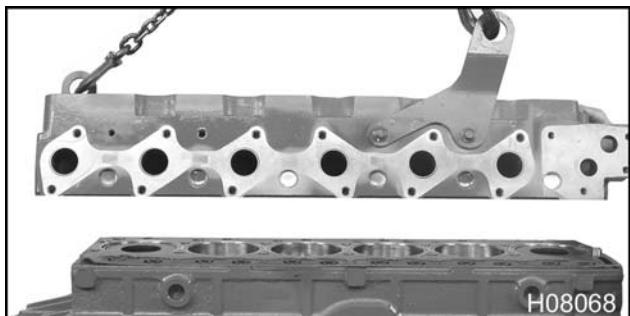


Figure 351 Cylinder head and crankcase

11. Attach appropriate hoist and lifting hooks to cylinder head lifting eyes.
12. Carefully lift cylinder head off crankcase.

NOTE: Place cylinder head on wood blocks to protect valves and bottom deck surface.

13. Place cylinder head on a workbench.
14. Remove four M12 x 25 bolts and both lifting eyes from cylinder head.



Figure 352 Cylinder head gasket

15. Remove cylinder head gasket from crankcase and discard.

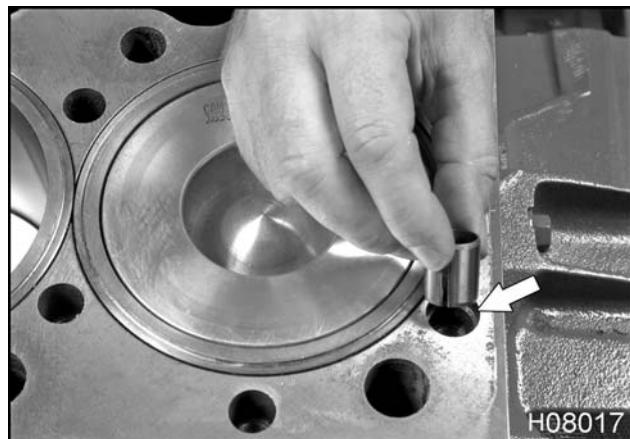


Figure 353 Cylinder head alignment dowels

16. Remove two cylinder head alignment dowels from the top of crankcase, if required.

Roller Tappets



Figure 354 Roller tappets and guide

Remove each roller tappet and guide from tappet bore and mark with cylinder number, valve association (intake or exhaust), and roller orientation.

Clean, Inspect, Measure, and Test

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

Measure Camshaft Lobe Lift

NOTE: If a complete engine overhaul is scheduled, camshaft wear can be accurately determined by measuring with a micrometer after the camshaft is removed. See Measure Camshaft Lobes and Journals (page 415). If this is not a complete engine overhaul, camshaft lobe lift can be measured using the following procedure.

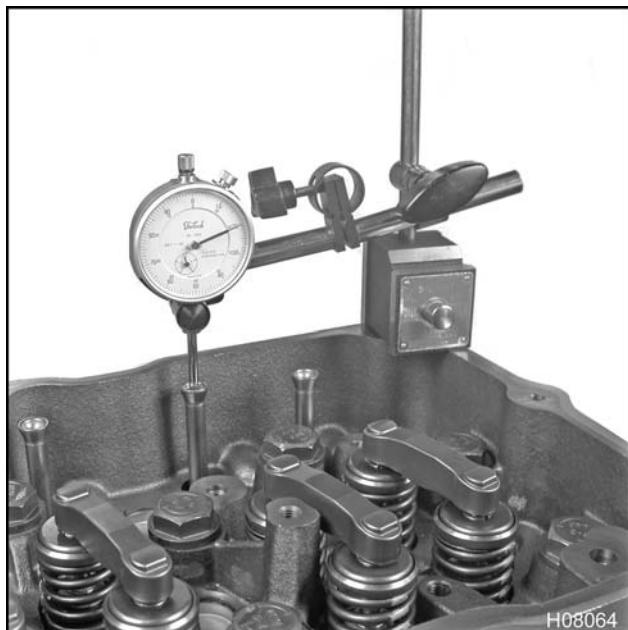


Figure 355 Dial indicator with magnetic base

1. Mount a dial indicator set (page 331) on the cylinder head.
2. Place dial indicator tip on top of push rod and rotate engine until push rod is at its lowest point of travel (base circle), then "zero" indicator.
3. Rotate the crankshaft and bring push rod to its highest point of travel. Record readings.
4. Repeat steps 2 and 3 for all twelve camshaft lobes.
5. Compare readings to camshaft lobe lift Specifications (page 329).

Clean Cylinder Head

CAUTION: To prevent engine damage, leave valves installed in cylinder head to protect valve seats during cleaning.

1. Remove deposits and gasket material from the cylinder head gasket surface using a rotary wire brush or sanding block with mineral spirits.
2. Clean all cylinder head mounting bolt holes using an appropriately sized brush.

CAUTION: To prevent engine damage, clean or repair dirty or damaged bolt threads which may cause binding and false torque readings.

3. Clean threads of all cylinder head mounting bolts.
4. Wash rocker arm assemblies, roller tappets, and push rods in a suitable solvent and dry thoroughly. Replace any bolts that have damaged threads.

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.

Cylinder Head Bolt Reusability Test

1. Spin Head Bolt Thread Gauge (page 331) on each cylinder head bolt across the entire length of threads.
2. If the thread gauge encounters any resistance on the threads, the bolt is considered stretched beyond limits and therefore cannot be reused.
3. Discard and replace any cylinder head bolt that fails the reusability test.

Clean and Inspect Push Rods

1. Clean push rods using a suitable solvent and dry using filtered compressed air.
2. Inspect push rods for wear at both ends. Replace if required.

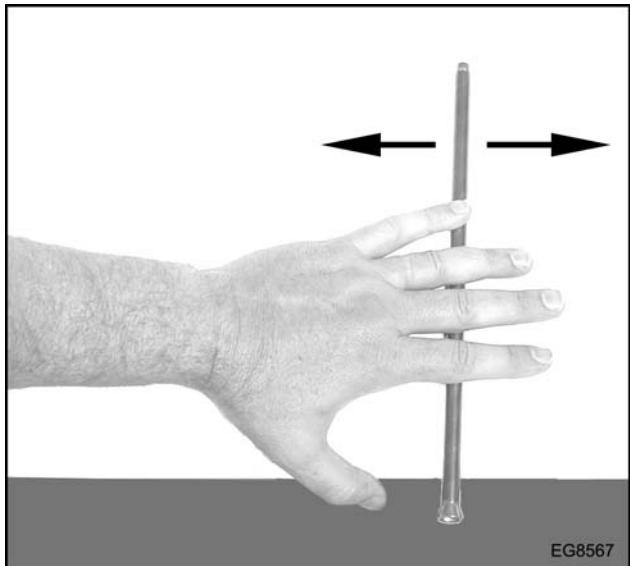


Figure 356 Inspect push rods for straightness

3. Inspect push rods for straightness by rolling on a flat surface with the cup end hanging over an edge.
4. Measure push rod runout with a feeler gauge (page 331) between the flat surface and push rod.
5. If Specifications (page 329) are exceeded, replace push rod.

Measure Rocker Shaft

CAUTION: To prevent engine damage, if replacing the rocker arm shaft, all rocker arms must be replaced. Reusing rocker arms on a new shaft will not allow proper break-in, causing premature failure.



Figure 357 Rocker arm shaft measurement

1. Inspect rocker shaft for scoring, pitting, and wear. Replace rocker arm shaft and all of the rocker arms if required.

NOTE: It is normal to see slight polishing at rocker arm contact areas.

2. Measure a non-contact area of the rocker arm shaft using an outside micrometer (page 331). This dimension will be used as a baseline for shaft diameter.
3. Measure each of the 12 rocker arm contact areas of the rocker arm shaft with a micrometer. If the difference between the baseline measurement and any of the contact area measurements is greater than 0.03 mm (0.001 in), replace the rocker shaft and all rocker arms.
4. Clean oil supply holes with a small wire or another suitable tool.
5. Inspect cup plugs at each end of the rocker arm shaft. Do not disturb the cup plugs unless they are damaged. If replacement is required, pry out plugs and press in new plugs.

Inspect and Measure Rocker Arms

1. Inspect rocker arms for scoring, pitting, or signs of excessive wear. If the bore has visible damage, replace the rocker arm. Inspect the lower half of the rocker arm, significant wear can occur at this location. If the phosphate coating is worn off the rocker arms, they may only be reused on the original rocker arm shaft in their original locations.

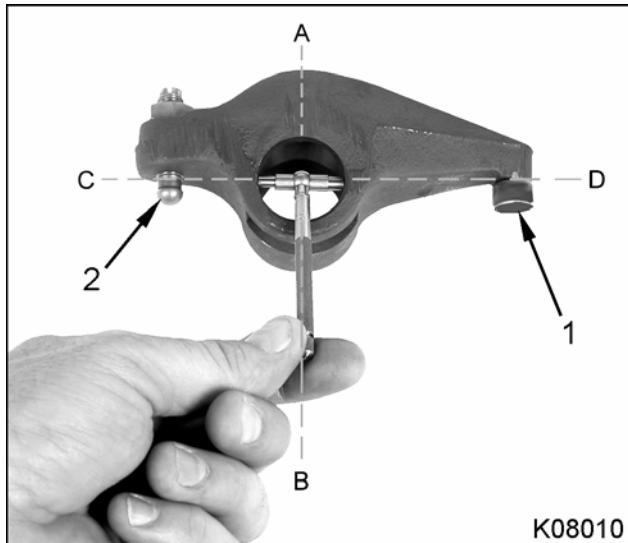


Figure 358 Rocker arm bore

1. Pivot foot assembly
2. Valve lash adjuster screw

NOTE: The black phosphate coating on rocker arms provides break-in lubricant between the rocker shaft and rocker arm bore. It is normal for the black phosphate coatings to wear off the bottom of the lever arm in the shaft and bore contact area. Rocker arms must be labeled and installed in their original locations to maintain proper wear patterns.

2. Use a telescoping gauge and outside micrometer (page 331) to measure rocker arm bore diameter at two locations. Measure diameter at A-B and C-D. If difference between diameters is greater than or equal to 0.03 mm (0.001 in), replace rocker arm.

3. Inspect twelve rocker arm pivot foot assemblies for scoring, pitting, or signs of excessive wear. Replace rocker arms if necessary.
4. Inspect valve lash adjuster screw for wear. Replace adjuster screw if excessively worn.

Measure Cylinder Head Warpage

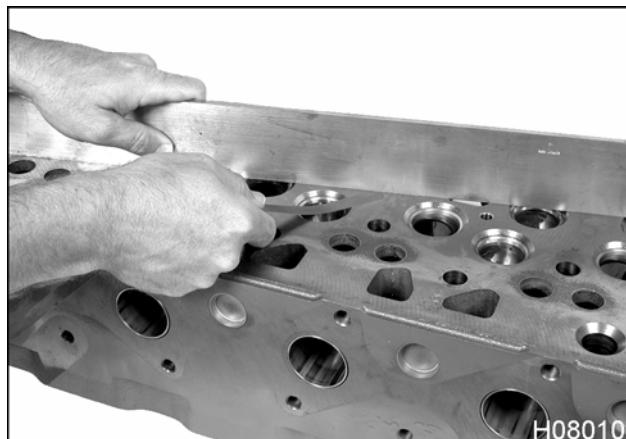


Figure 359 Cylinder head warpage measurement

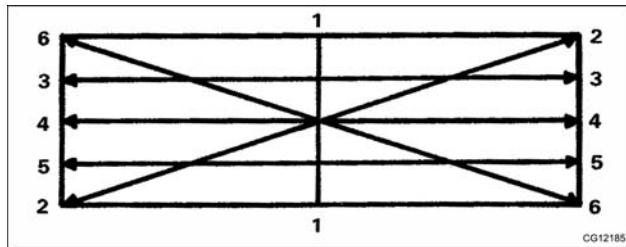


Figure 360 Cylinder head warpage measurement pattern

Use a straightedge and feeler gauge (page 331) to measure cylinder head gasket surface for warpage. If warpage exceeds cylinder head gasket surface flatness Specifications (page 329), measure cylinder head thickness.

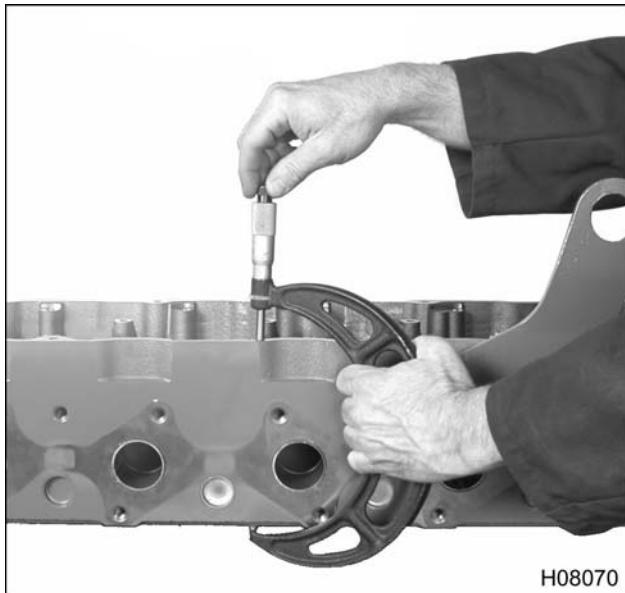
Measure Cylinder Head Thickness

Figure 361 Cylinder head thickness measurement

Use a 6 to 7 inch micrometer to measure cylinder head thickness at six locations (four corners and two center points). All Cylinder head thickness measurements must equal or exceed minimum Specification (page 329) after resurfacing. Replace cylinder head if under minimum specification.

Measure Valve Seat Leakage

NOTE: This test does not check condition of valve guides or valve stem-to-guide clearance.

1. Position cylinder head on wood blocks with gasket surface facing down.
2. Squirt mineral spirits in the intake and exhaust valve ports and wait 5 minutes.
3. Use an inspection mirror to inspect valve seat area for leakage of mineral spirits past valve seats.

NOTE: If leakage occurs, valves must be reconditioned.

Inspect Cylinder Head for Cracks

Figure 362 Spray cleaner on cylinder head

NOTE: Cylinder head crack inspection can be performed with or without valves installed.

1. Spray cleaner, from dye penetrant kit (page 331), on cylinder head gasket surface and wipe dry.

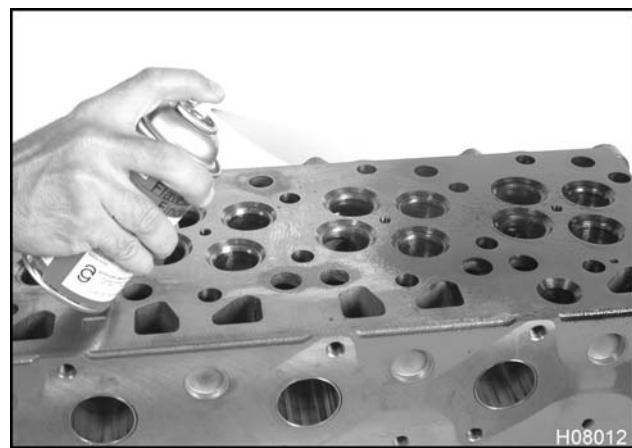


Figure 363 Spray dye penetrant on cylinder head

2. Spray dye penetrant, from dye penetrant kit, on cylinder head gasket surface. Leave dye penetrant on for 1 to 10 minutes.

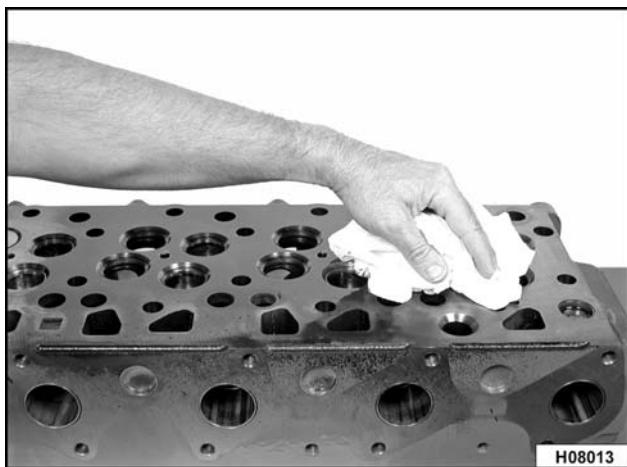


Figure 364 Wipe dye penetrant off cylinder head

3. Wipe off dye penetrant after 1 to 10 minutes. Dye will remain in any cracks in the cylinder head.



Figure 365 Spray developer on cylinder head

4. Spray developer, from dye penetrant kit, on cylinder head gasket surface. Allow developer to dry for 5 to 15 minutes.

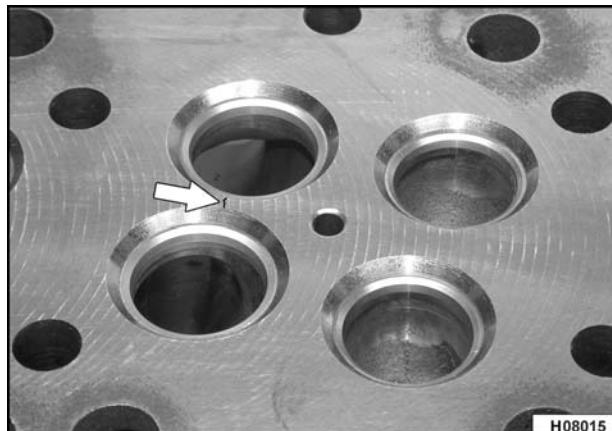


Figure 366 Crack in cylinder head

NOTE: Any cracks will show up as purple lines against the white developer. If any cracks are present, replace cylinder head.

Cylinder Head Pressure Test

NOTE: Pressure testing the cylinder head will reveal cracks in ports or sleeve leakage which can not be seen using dye penetrant.

1. Remove valves from cylinder head (page 306).
2. Install fuel injectors (page 171) in cylinder head injector bores.

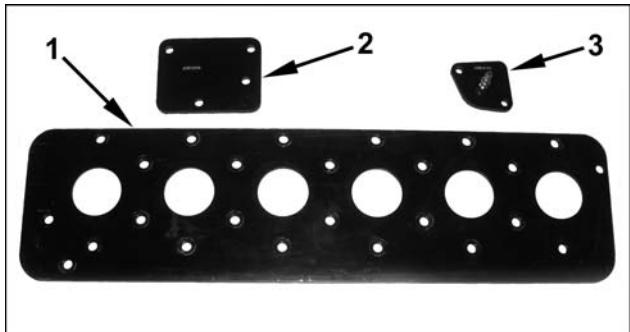


Figure 367 Cylinder head pressure test tools

1. Cylinder Head Test Plate
2. Water Supply Housing Pressure Adapter
3. Thermostat Opening Pressure Adapter

3. Pressure test cylinder head using Cylinder Head Test Plate, Water Supply Housing Pressure Adapter, Thermostat Opening Pressure Adapter, and a pressure regulator (page 331).

4. Attach Cylinder Head Test Plate to cylinder head gasket surface using mounting bolts and nuts supplied with kit.
5. Attach Water Supply Housing Pressure Adaptor to cylinder head and secure with mounting bolts.
6. Remove thermostat and fill cylinder head with hot water.
7. Attach Thermostat Opening Pressure Adapter to cylinder head and secure with mounting bolts.
8. Attach compressed air hose and pressure regulator to hose fitting on Thermostat Opening Pressure Adapter.
9. Apply 124 to 138 kPa (18 to 20 psi) air pressure and inspect cylinder head for leaks. Check the following:
 - Fuel injector nozzle sleeve areas
 - Valve ports
 - Upper deck
 - Lower deck

If leakage is observed from any fuel injector nozzle sleeves, replace injector sleeves and pressure test cylinder head again. If cylinder head leakage is observed replace the cylinder head.

Recondition

Remove Valves from Cylinder Head

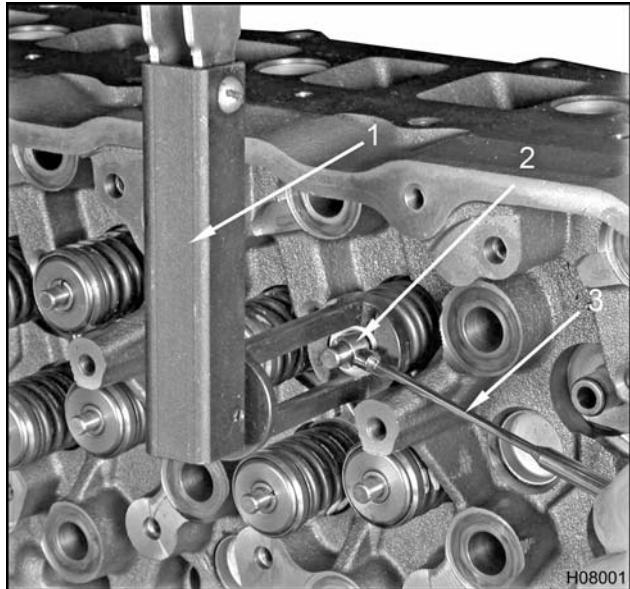


Figure 368 Valve spring retainer key removal

1. Valve Spring Compressor
2. Valve spring retainer key
3. Magnet



Figure 369 Valve rotator, spring, and valve stem seal

1. Valve stem seal
 2. Valve stem
 3. Valve rotator or retainer (typical)
 4. Valve spring
3. Release Valve Spring Compressor and remove valve rotator or retainer and valve spring.
 4. Remove and discard valve stem seal.
 5. Remove valve from the cylinder head.
 6. Repeat steps 1 through 5 for all 24 valves.

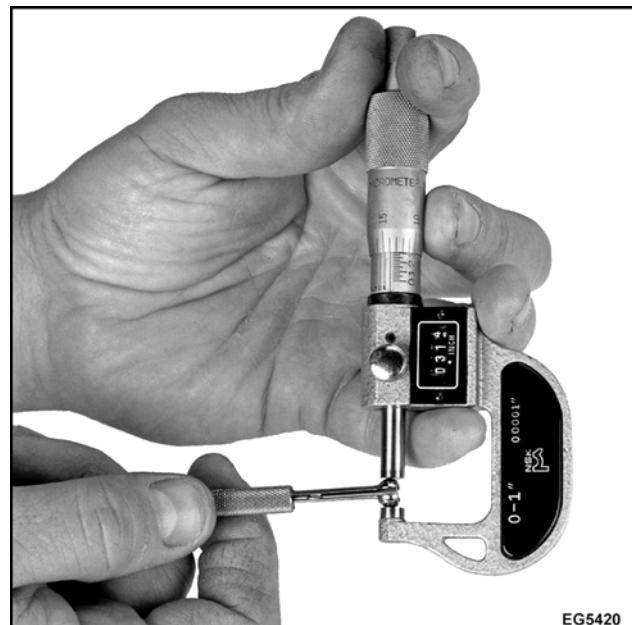


WARNING: To prevent personal injury or death, wear safety glasses when removing valves or valve spring retainer keys.

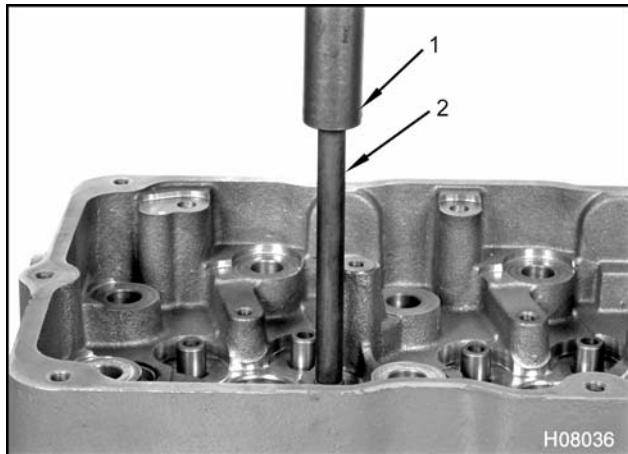
1. Install a Valve Spring Compressor (page 331) over the valve and compress the valve spring.
2. Use a magnet to remove valve spring retainer keys.

Inspect and Measure Valve Guides**Figure 370 Clean valve guides**

1. Clean valve guides with soap, water, and a nylon brush.
2. Position an inspection light at the bottom of valve guide bores. Inspect bores for burning or cracks. Replace any damaged valve guides.

**Figure 371 Measure valve guide with ball gauge****Figure 372 Measure Ball gauge with micrometer**

3. Measure inside diameter of each valve guide with a ball gauge or small hole gauge set and an outside micrometer (page 331).
If valve guide bore, taper, or out of round exceeds Specifications (page 329), replace the valve guide.
4. Measure valve guides within 0.64 mm (0.025 in) of each end and 90 degrees from crankshaft center line. Record measurements. Determine valve stem-to-guide running clearance after doing "Inspect and Measure Valves" procedure (page 309).

Replace Valve Guides**Figure 373 Press out valve guide insert**

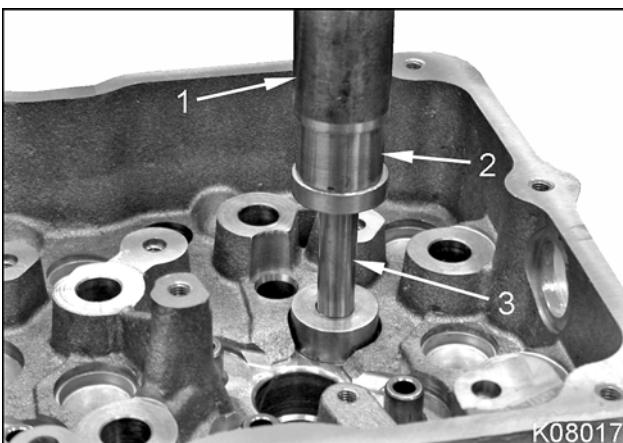
1. Press ram
2. Valve Guide Remover

NOTE: Replace Valve guides if damaged or out of specifications.

CAUTION: To prevent engine damage, do not use a hammer or other improper tool to remove or install valve guides.

1. Secure cylinder head on a press table with the gasket surface down.
2. Insert Valve Guide Remover (page 331) in the valve guide from the top side of the cylinder head.
3. Align Valve Guide Remover and valve guide to be replaced with center of press ram and press out valve guide insert.

NOTE: Chilling valve guide inserts may help installation.

**Figure 374 Press in valve guide insert**

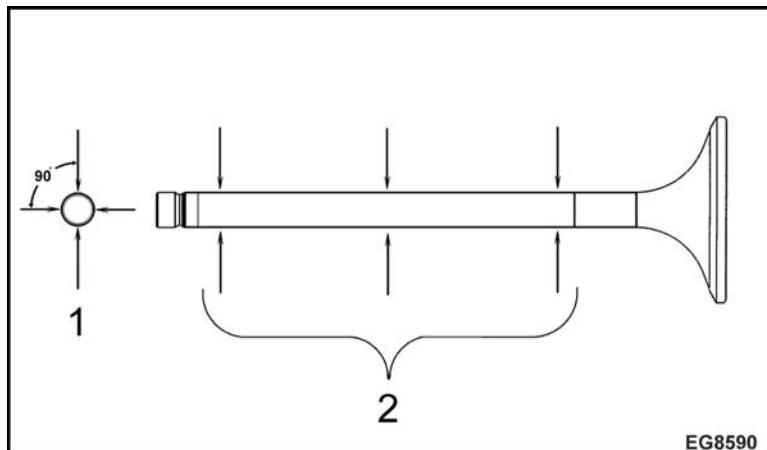
1. Press ram
2. Valve Guide Installer
3. Valve guide insert
4. Lubricate each new valve guide insert with clean engine oil.
5. Center valve guide insert and Valve Guide Installer (page 331) under press ram and install valve guide insert until installer bottoms out against cylinder head.

NOTE: Do not ream inside diameter of valve guide after installation. Service valve guides are finish reamed.

6. After installing valve guide insert, debur valve guide with Valve Guide Deburring Tool (page 331).

Inspect and Measure Valves

1. Remove carbon deposits from valve stems and valve heads.
2. Inspect each valve for burn marks, warpage, scuffing, and bending. Replace any damaged valves.
3. Inspect valve stem tip for scoring, pitting, or signs of excessive wear. Reface valve stem tip (page 311) or replace valve if required.

**Figure 375 Measure valve stem diameter**

1. Two measurements 90 degrees apart
2. Three valve stem diameter measurement locations
4. Measure valve stem diameter with a micrometer (page 331) at three locations. At each location, take two measurements 90 degrees apart. Average the two measurements from each location.
If the average of measurements at any of the three locations is not within valve stem diameter Specification (page 329), replace that valve.
5. Determine valve stem-to-guide running clearance using the valve stem diameter measurements above and valve guide inside diameter measurements (page 307). Subtract the average valve stem diameter from the average valve guide inside diameter.

NOTE: Valve Stem-to-guide Running Clearance = Valve Guide Inside Diameter – Valve Stem Diameter

6. Replace valve or valve guide if not within Specifications (page 329).

Reface Valves

Valve Face

NOTE: If valves are in good condition and within specifications, they may be refaced to specified angles.

CAUTION: To prevent engine damage, maintain minimum valve face margin across the entire valve face. An insufficient valve face margin will not allow proper heat dissipation, causing that valve to warp or break.



Figure 376 Grind valve face

NOTE: Make sure there is sufficient coolant in the valve grinding machine reservoir. Turn coolant pump on before grinding.

1. Dress the grinder cutting stone using the dressing stud attachment.

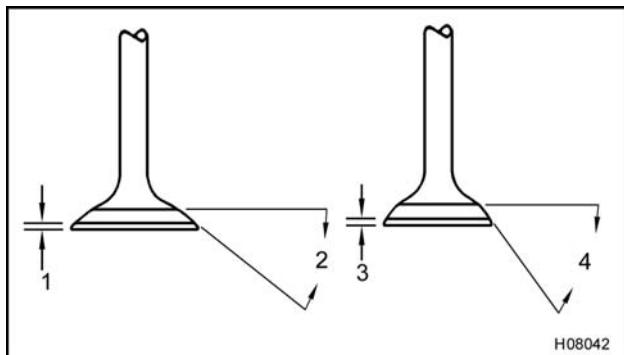


Figure 377 Valve face angles

1. Intake margin
2. Intake valve angle
3. Exhaust margin
4. Exhaust valve angle

NOTE: Intake valves and exhaust valves have different valve face margins.

2. Install valve in grinder and set grinder to specified intake or exhaust valve face angle (page 329).
3. Turn on coolant and grinder.

NOTE: Removal of too much material may reduce valve face margin below minimum specifications.

4. Grind valve face. Only remove the minimum amount of material necessary.

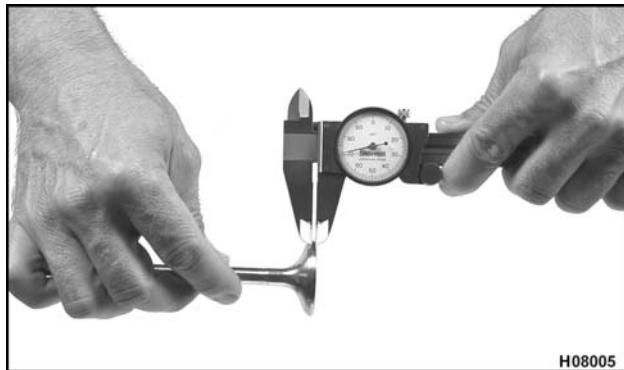


Figure 378 Valve face margin measurement

5. Measure valve face margin at four locations with a vernier caliper (page 331). If any measurements are less than minimum Specification (page 329), replace valve.

Reface Valve Stem Tip

CAUTION: To prevent engine damage, leave sufficient material on the tip of the valve stem so the valve bridge does not contact the valve retainer keys or valve rotator during operation. Maintain a minimum of 1.524 mm (0.060 in) gap between the valve bridge and valve spring retainer keys.

1. Dress the cutting stone using the dressing stud attachment on the grinder.

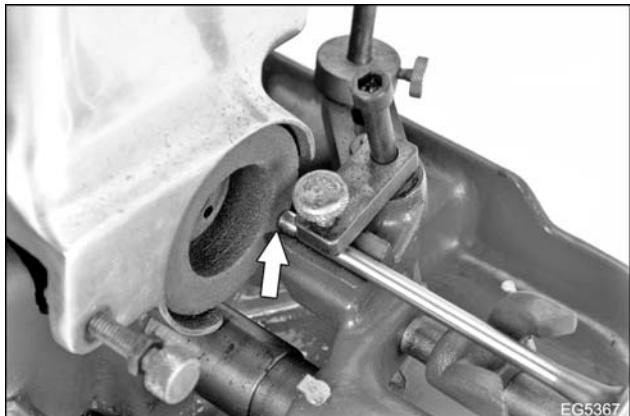


Figure 379 Valve stem grinding

2. Install valve in grinder so the tip of the valve stem is close to the grinding stone.
3. Briefly touch the tip of the valve stem to the grinding stone. Only remove the minimum amount of material necessary.

Inspect Valve Face-to-seat Contact



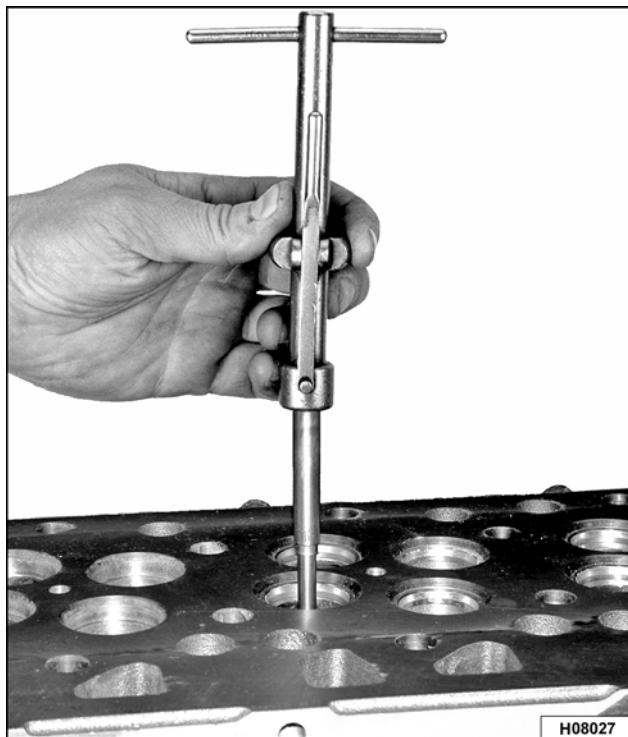
Figure 380 Apply marker paste to valve face

1. After refacing a valve, spread a thin film of marker paste (Prussian Blue™ or equivalent) on the valve face and insert the valve in the valve guide.

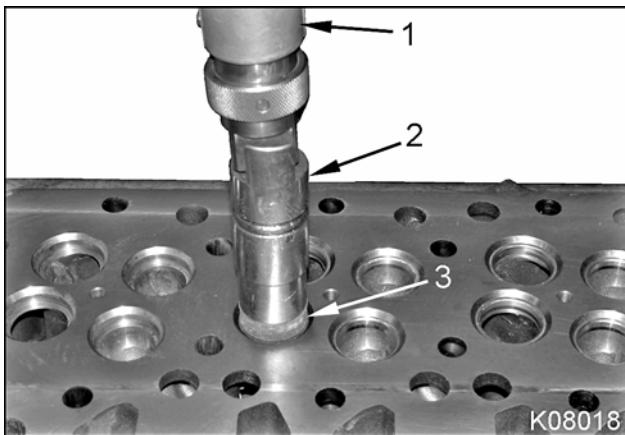


Figure 381 Turn valve on valve seat

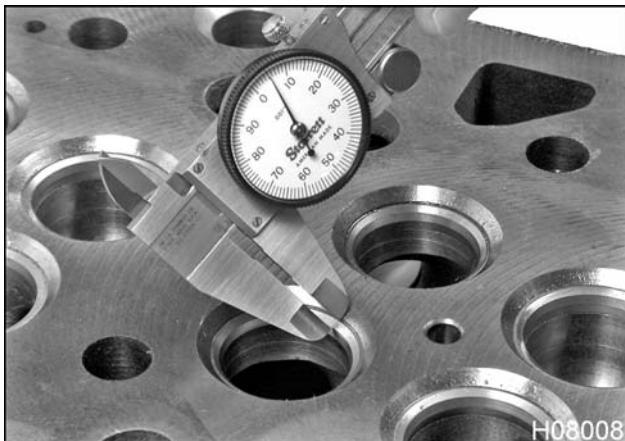
2. Apply pressure to the center of the valve head while turning valve 90 degrees on the valve seat.
3. Remove valve from cylinder head. Inspect impression on valve seat and valve face. Marker paste should appear around entire contact surface of valve seat and valve face.
4. Perform impression inspection several times to rule out any errors.
 - If marker paste contact impression is good, continue to Inspect Valve Springs (page 317).
 - If marker paste contact impression is not good, verify correct valve face angles and then continue to Resurface Valve Seats (page 312).

Resurface Valve Seats**Figure 382** Valve guide pilot

1. Lightly lubricate correct size grinding pilot from Valve Seat Grinder (page 331). Install grinding pilot in valve guide.
2. Choose correct angle valve seat grinding stone (page 331) and dress stone. See Specifications (page 329) for correct valve seat angle.
3. Install grinding stone over pilot.

**Figure 383** Grind valve seat

1. Motor and drive
2. Holder
3. Grindstone
4. Turn on grinding motor and gently apply pressure to the grindstone. Raise grinding stone frequently to prevent overheating. Grind valve seat to a smooth even finish, paying attention to achieving uniform width.

**Figure 384** Valve seat width measurement

5. Measure valve seat width using a vernier caliper (page 331). If valve seat width exceeds Specifications (page 329), the valve seat may be corrected by grinding with a 15 degree or smaller angle stone.



Figure 385 Measure valve recession

6. Install each valve in its valve guide. Use a depth micrometer (page 331) to measure valve recession and check Specification (page 329).
 - If valve recedes too far into head, install a new valve or replace valve seat. Reinspect valve face-to-seat contact (page 311).
 - If valve protrudes above cylinder head surface, regrind valve seat. After regrinding valve seat, check valve seat width again. Reinspect valve face-to-seat contact (page 311).

Replace Valve Seats

Remove

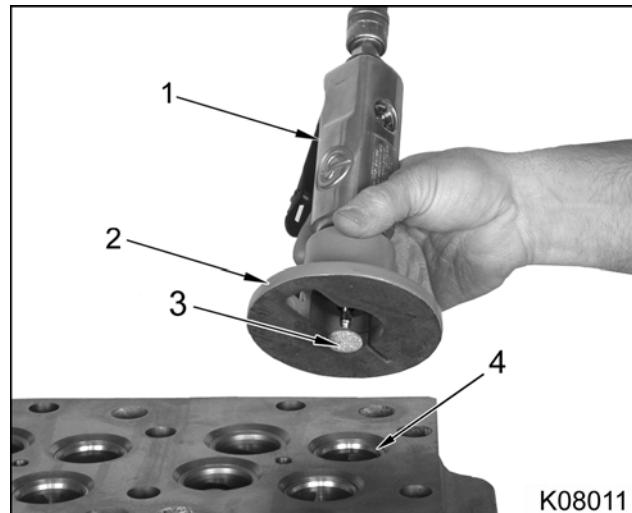


Figure 386 Valve seat groove grinder

1. Air motor
2. Grinding base
3. Grinding wheel
4. Valve seat insert

NOTE: Replace Valve seats if damaged or out of specifications.

1. Carefully grind a groove in valve seat insert using Valve Seat Extractor Kit (Universal) (page 331). Do not grind into cylinder head.

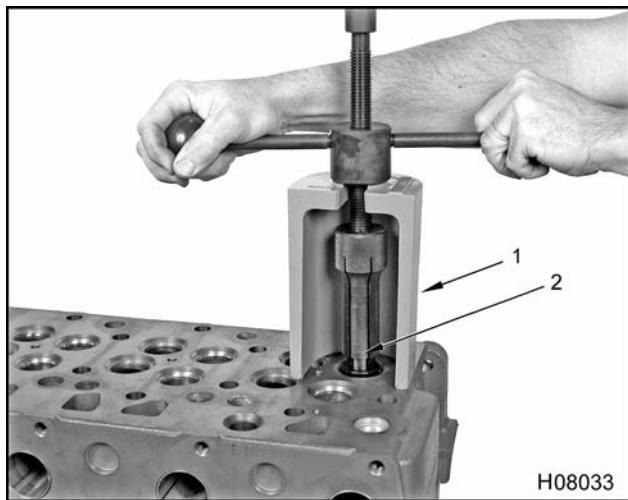


Figure 387 Remove valve seat insert

1. Lifting bridge
 2. Valve Seat Remover (collet)
-
2. Position appropriate size Valve Seat Remover (collet) (page 331) in valve seat.
 3. Expand collet by threading shaft into valve seat remover until tight inside valve seat. Turn T-handle on shaft to pull valve seat insert out of cylinder head.

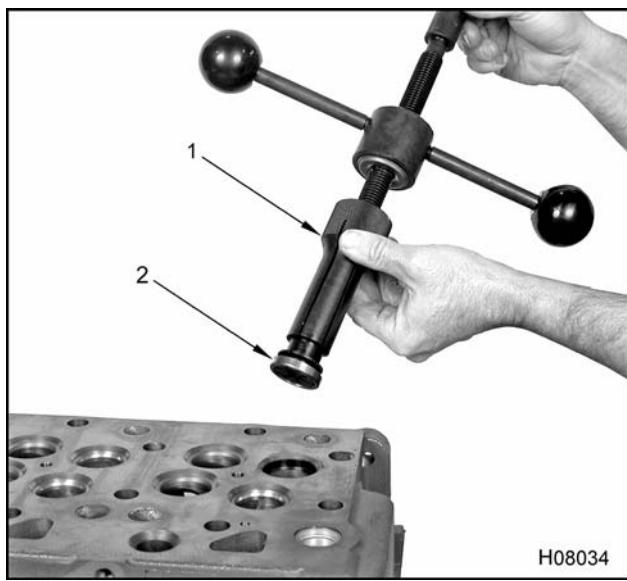
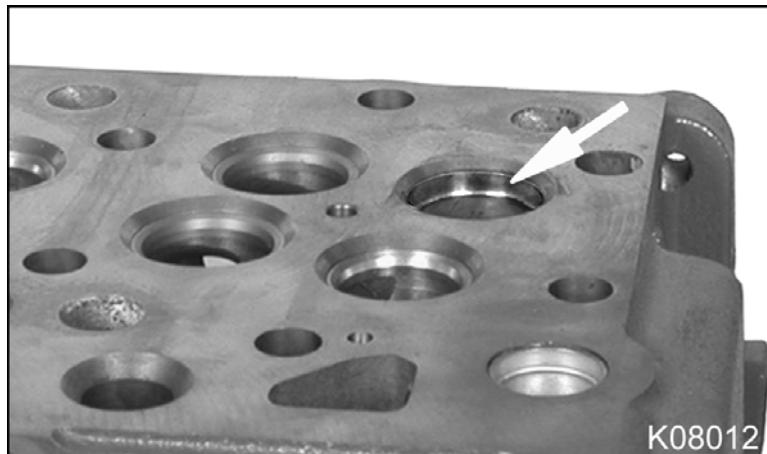


Figure 388 Remove valve seat insert

1. Collet
 2. Valve seat insert
-
4. Unlock collet by loosening threaded shaft and discard valve seat insert.

Install**Figure 389 Valve seat counterbore**

1. Measure valve seat counterbore diameter at two locations 90° apart, using an inside micrometer (page 331). Average the two measurements to determine the appropriate size valve seat insert to install.

CAUTION: To prevent engine damage, maintain proper diametral interference between valve seat insert outside diameter and valve seat counterbore diameter.

Valve Seat Insert Selection Chart

Available inserts (Intake and Exhaust)	Intake counterbore average diameter	Exhaust counterbore average diameter
Standard	40.120 to 40.170 mm (1.5795 to 1.5815 in)	37.478 to 37.528 mm (1.4755 to 1.4775 in)
Oversize - 0.05 mm (0.002 in)	40.170 to 40.221 mm (1.5815 to 1.5835 in)	37.529 to 37.579 mm (1.4775 to 1.4795 in)

2. Chill valve seat insert in a freezer for 30 minutes. This will slightly shrink insert and prevent the outer layer of metal from being shaved off during installation.

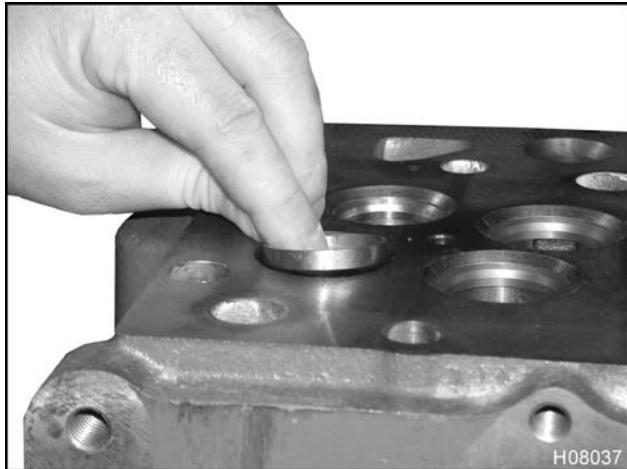


Figure 390 Valve seat insert

3. Align chilled valve seat insert over counterbore.



Figure 391 Valve seat insert installation

4. Carefully drive valve seat into place, until fully seated, using a hammer and Valve Seat Installer (page 331).
5. Grind new valve seats to Specified angles and widths (page 329).

Inspect Valve Springs

CAUTION: To prevent engine damage, do not grind valve springs or use a wire brush for cleaning. Disruption of spring surface may cause fatigue cracks and spring failure.

1. Clean valve springs in a suitable solvent.
2. Inspect valve springs for rust, cracks, and pitting. Replace any damaged valve springs.

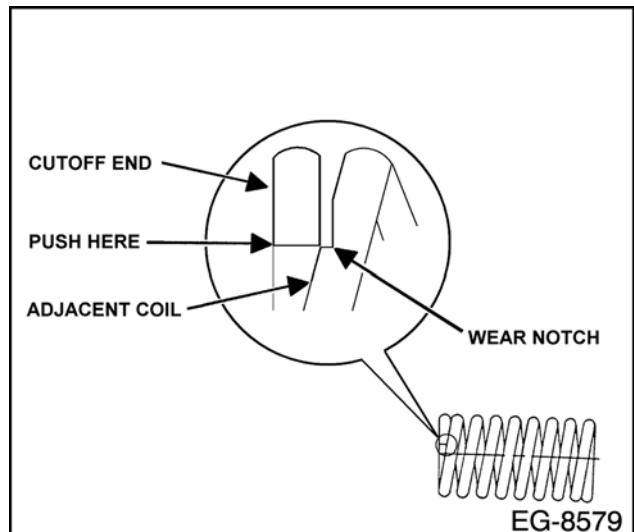


Figure 392 Inspect valve spring

3. Inspect both ends of each valve spring at contact points between the cutoff end of the last coil and the adjacent coil. If the cutoff end has worn a notch in the adjacent coil, replace the spring.

NOTE: Valve spring wear notches can also be detected by compressing the spring and listening for a clicking sound.

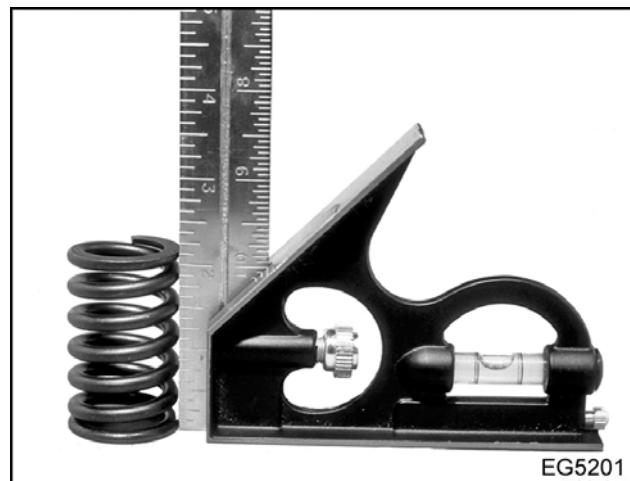


Figure 393 Measure perpendicularity and flatness of valve spring

NOTE: Valve springs that are not perpendicular to a flat surface put an unequal load on the valve stem, causing premature valve and valve guide wear.

4. Use a square to check flatness and perpendicularity of spring ends. If the end of any valve spring is not flat and square, replace spring.

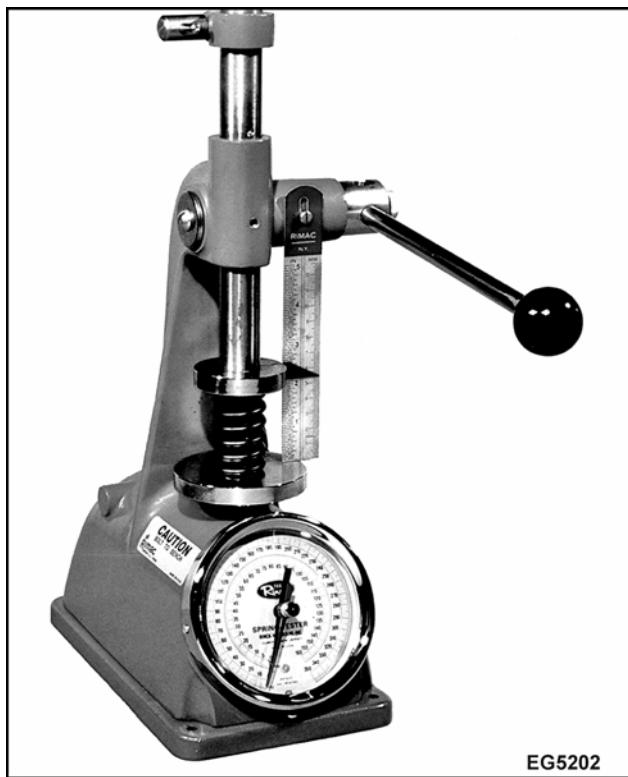


Figure 394 Measure valve spring tension

5. Use a Valve and Clutch Spring Tester (page 331) to measure valve spring tension. Measure the maximum and minimum lengths of the spring at appropriate test loads (valve closed and valve open). Replace any valve spring that does not meet Specifications (page 329).

Inspect Valve Rotators and Retainers

1. Clean all valve rotators and retainers in a suitable solvent.

CAUTION: To prevent engine damage, install rotators on intake valves.

NOTE: Some low horse power engines have retainers on the exhaust valves. Rotators must be used on intake valves and can be used on exhaust valves to extend valve life.

2. Inspect valve retainers and rotators for wear, deformation, cracking, or corrosion. Replace if damaged.

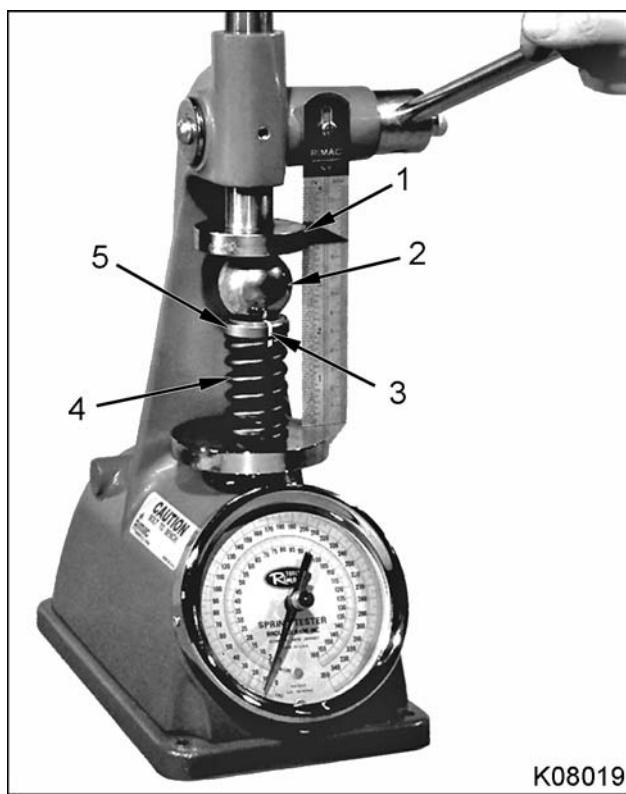


Figure 395 Inspect valve rotator

1. Ram
2. Steel ball bearing
3. Paint reference line
4. Spring
5. Valve rotator

CAUTION: To prevent engine damage, suitable protection must be placed between rotator and ram of Valve and Clutch Spring Tester.

3. Lubricate valve rotator with clean engine oil. Place valve spring and rotator in Valve and Clutch Spring Tester (page 331).
4. Place a ball bearing between the valve rotator and ram of the spring tester. The ball bearing must be large enough to prevent the ram from touching any part of the rotator.
5. Paint a reference line on the valve rotator and spring.
6. Compress valve spring rapidly with even pressure and observe the valve rotator as it turns. Replace any valve rotator that does not turn.

Inspect Valve Spring Retainer Keys

1. Clean all valve spring retainer keys with a suitable solvent.
2. Check the inside and outside of the valve spring retainer keys for wear. Replace any worn retainer keys.

Replace Fuel Injector Sleeves**Remove**

NOTE: Replace injector sleeves if damaged or excessively worn.

NOTE: If removing fuel injector sleeves with engine in-chassis, place a cup plug in injector bore before sleeve removal to prevent debris from entering cylinder.

1. Lubricate thread tap, part of Injector Sleeve Remover (page 331).
2. Insert thread tap in fuel injector sleeve.
3. Screw thread tap into fuel injector sleeve. Cut threads at least $\frac{3}{4}$ inch deep to accommodate fuel injector sleeve puller.

NOTE: Ensure fuel injector sleeve puller threads sufficiently into fuel injector sleeve.

4. Insert fuel injector sleeve puller (part of Injector Sleeve Remover) into fuel injector sleeve and tighten. Make sure puller tool is threaded all the way into fuel injector sleeve.

5. Install a slide hammer on puller tool and remove fuel injector sleeve from injector bore.

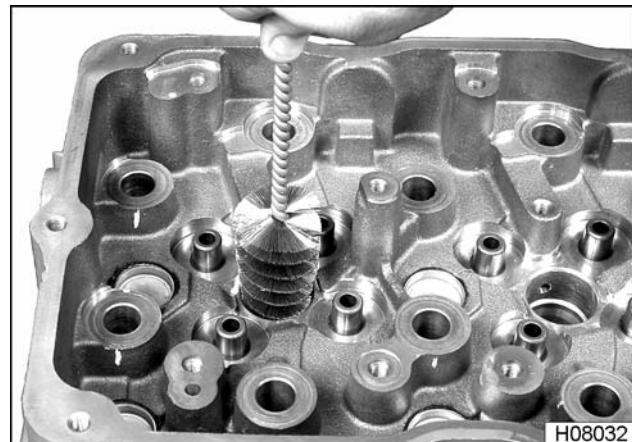


Figure 396 Clean fuel injector bore

6. Use a stiff wire brush from the Injector Sleeve Brush Set (set of 2) (page 331), clean deposits and hardened sealant from the fuel injector bore.
7. Insert a small stiff nylon brush tool into oil gallery for cleaning.

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

8. Use compressed air to clean out all fuel and oil galleries.

Install

1. Use an Injector Sleeve Installer (page 331) that does not have a bent pilot shaft or any nicks where the sleeve will seat.
2. Install a new fuel injector sleeve on the end of the Injector Sleeve Installer.

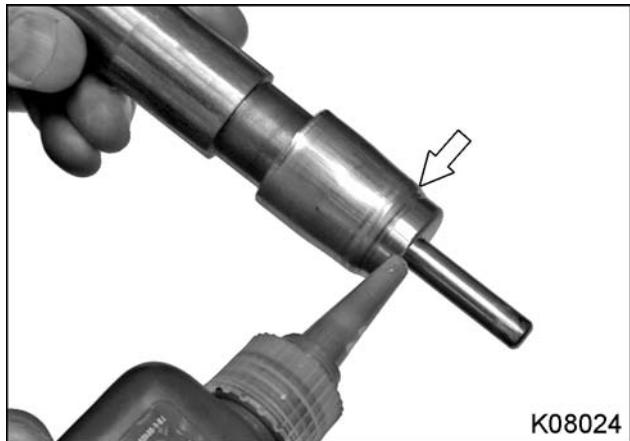


Figure 397 Apply sealant to fuel injector sleeve

3. Apply Loctite® 620 Retaining Compound (page 331) around outside bottom of injector sleeve and around beginning of taper at middle of sleeve.

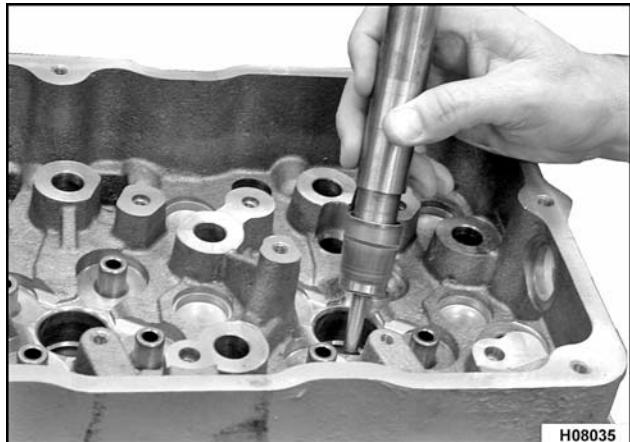


Figure 398 Fuel injector sleeve and injector bore

4. Insert fuel injector sleeve and Injector Sleeve Installer into injector bore.



Figure 399 Install fuel injector sleeve

5. Carefully drive fuel injector sleeve into injector bore with a hammer.
6. Clean fuel injector sleeve with a soft nylon brush.
7. Inspect inside surfaces of installed fuel injector sleeve. If nicked or scratched, replace sleeve again. Make sure Injector Sleeve Installer is not causing damage. Use a different Injector Sleeve Installer, if necessary.

Install Valves**Clean**

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

1. Clean valve faces and seats with a suitable solvent. Dry all components using filtered compressed air.
2. To clean valve guides, coat a brush with soap and water. Insert brush into each valve guide bore and rotate in one direction with an up and down motion. Dry valve guide bores using filtered compressed air.
3. Insert a large nylon brush in the rear of the fuel rail gallery to loosen dirt and deposits. Blow out debris using filtered compressed air.

Assemble

Figure 400 Valve stem seal, spring, and rotator

1. Valve stem seal
2. Valve stem
3. Valve rotator or retainer (typical)
4. Valve spring

1. Lubricate valve stem with clean engine oil and insert valve in valve guide.

2. Lubricate inside diameter of new valve stem seals with clean engine oil. Install seals over valve stems and valve guides. Make sure seals are completely seated against cylinder head spring pockets.

3. Install valve springs over valve stem seals.

CAUTION: To prevent engine damage, rotators must be installed on intake valves.

4. Install valve rotators on top of intake valve springs. Install valve rotators or retainers on top of exhaust valve springs.

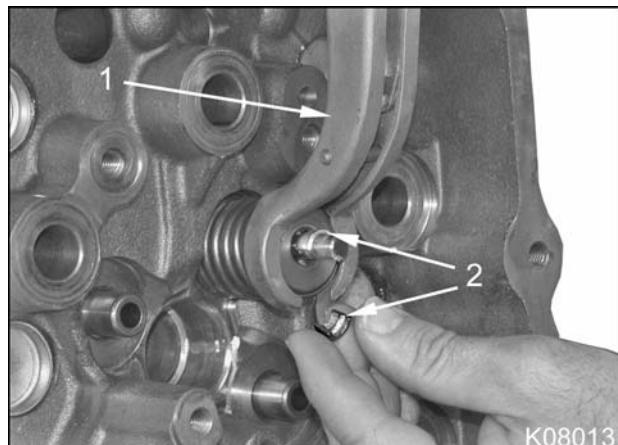


Figure 401 Valve Spring Compressor and retainer keys

1. Valve Spring Compressor
2. Valve spring retainer keys

⚠ WARNING: To prevent personal injury or death, wear safety glasses with side shields to protect eyes.

5. Install Valve Spring Compressor (page 331) over valve and compress valve spring.
6. Install valve spring retainer keys and release spring compressor.

Installation

Roller Tappets



Figure 402 Roller tappets and guide

1. Lubricate roller tappets with clean engine oil.
2. Install each roller tappet and guide into tappet bore. Install used roller tappets in their original locations, revolving in the same direction as before removal.

1. Install two lifting eyes with four M12 x 25 bolts onto cylinder head. Tighten bolts to standard torque (page 471).
2. Clean head bolt holes in crankcase with correct size tap. Clean and dry cylinder head gasket surfaces.

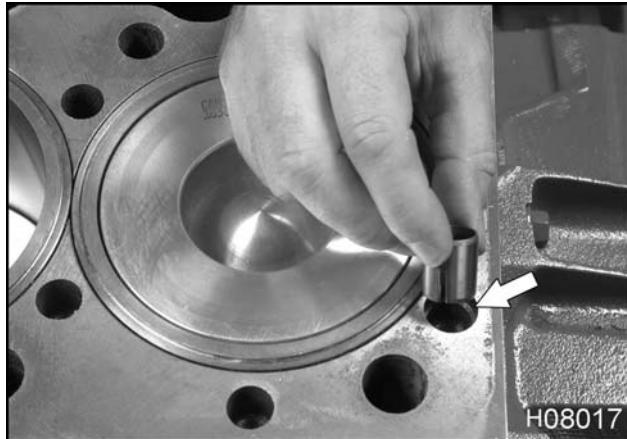


Figure 403 Cylinder head alignment dowel

3. Install or verify two alignment dowels are correctly installed in top of crankcase.

Cylinder Head

CAUTION: To prevent engine damage, Measure Cylinder Sleeve Protrusion (page 379) before installing cylinder head.

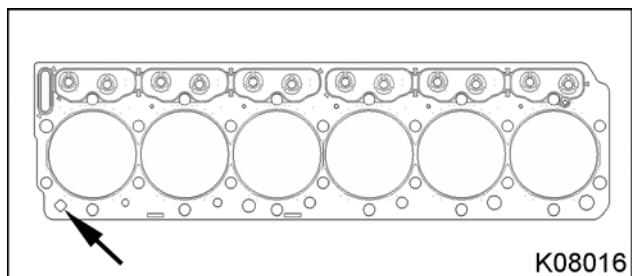


Figure 404 Cylinder head gasket diamond shape hole

NOTE: MaxxForce™ DT, 9, and 10 cylinder head gaskets have a diamond shaped hole which identify them from earlier model year gaskets.



Figure 405 Cylinder head gasket and alignment dowels

4. Install a new cylinder head gasket on crankcase, over alignment dowels.

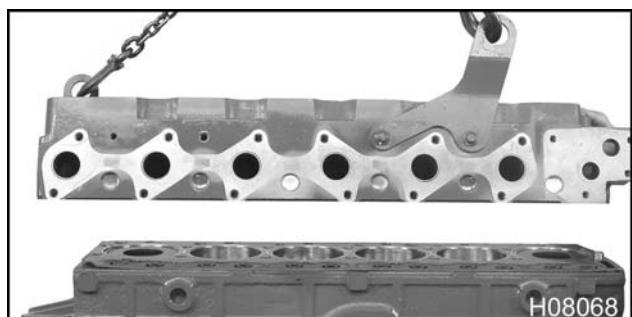


Figure 406 Cylinder head and crankcase



WARNING: To prevent personal injury or death, use a hoist rated for the weight of the cylinder head and follow the manufacturer's operation and safety instructions. Attach safety lifting hooks to the cylinder head lifting eyes.

5. Attach an appropriate hoist and lifting hooks to cylinder head lifting eyes.

CAUTION: To prevent engine damage, do not drop or slide cylinder head on head gasket.

6. Carefully lower cylinder head onto crankcase and align cylinder head alignment dowels in the crankcase with dowel holes in the cylinder head.

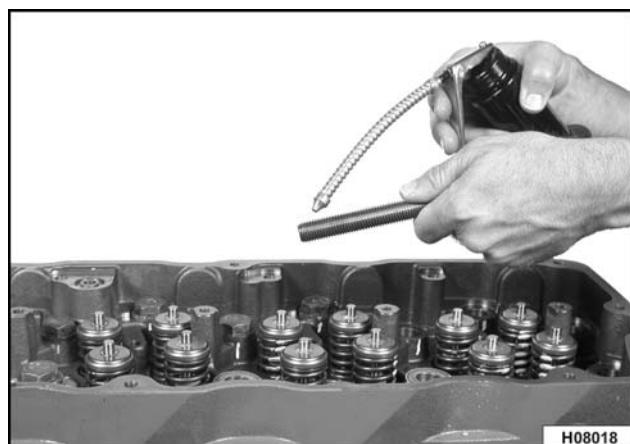
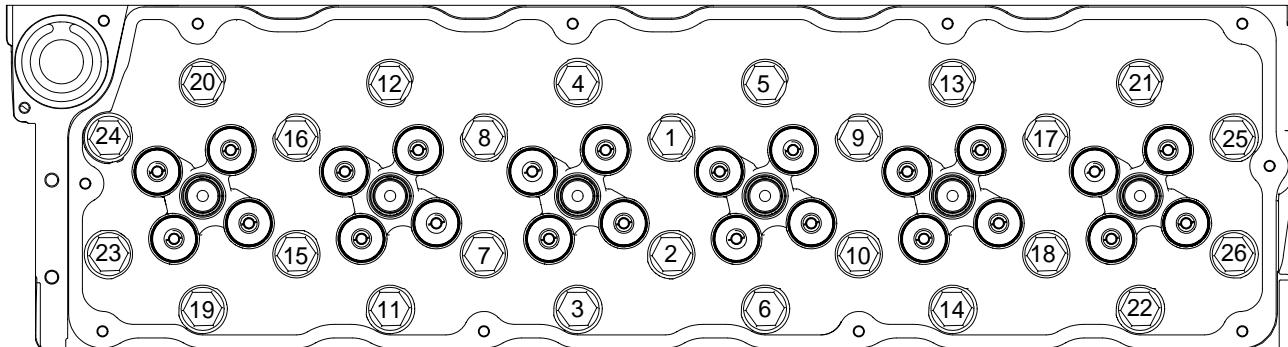


Figure 407 Cylinder head bolts

CAUTION: To prevent engine damage, do not reuse cylinder head bolts that have excessive stretch. Bolts that do not freely thread into the Head Bolt Thread Gauge (page 331) must be replaced. Excessively stretched bolts may break or give the wrong clamp load.

NOTE: Do not use chlorinated solvents on cylinder head bolts. Parts should be clean, dry, and free of chemicals other than engine oil.

7. Lightly lubricate threads and bolt flange of all cylinder head bolts with clean engine oil.
8. Install all cylinder head bolts finger tight.

Torque Procedure for Torque-to-yield Head Bolts

H08040

Figure 408 Cylinder head torque sequence A

1. Rotate crankshaft to TDC for Cylinder 1. Then rotate crankshaft 30 degrees past TDC.
2. Tighten each cylinder head bolt to 150 N·m (110 lbf·ft) in cylinder head torque sequence A.
3. Tighten each cylinder head bolt to 204 N·m (150 lbf·ft) in cylinder head torque sequence A.

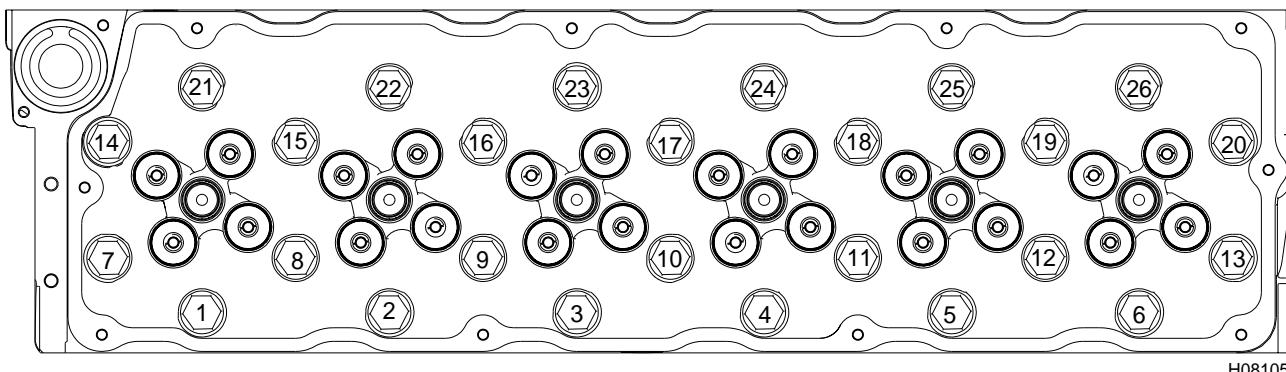


Figure 409 Cylinder head torque sequence B

4. Tighten each cylinder head bolt again to 204 N·m (150 lbf·ft) in cylinder head torque sequence B.

NOTE: It is necessary to torque cylinder head bolts twice at 204 N·m (150 lbf·ft) in order to obtain uniform head bolt torque.

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

5. Using a permanent marker, place a mark on each head bolt and put another mark on the head bolt socket (page 331) directly in line with the mark on each head bolt.
6. Put a mark on the cylinder head surface 90° clockwise from each head bolt mark.
7. Install head bolt socket on head bolt to be torqued and align mark on socket with the mark on the head bolt.
8. Torque-to-yield each cylinder head bolt by rotating bolt 90 degrees clockwise (1/4 turn) in cylinder head torque sequence B. The marks on the head bolt socket, head bolt, and cylinder head surface should be aligned.

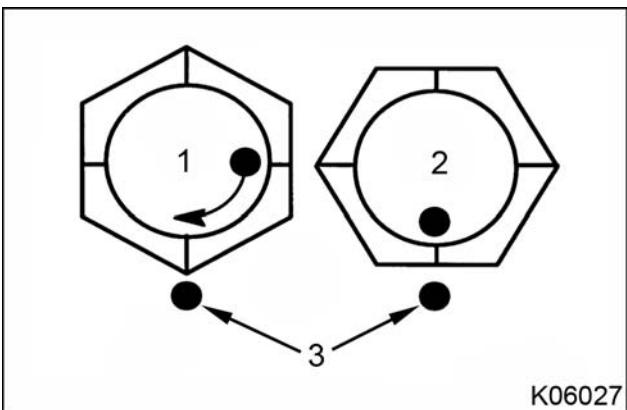


Figure 410 Head bolt torque-to-yield marking

1. Top of head bolt before Torque-to-Yield
2. Top of head bolt after Torque-to-Yield
3. Mark on cylinder head surface

Rocker Arms

NOTE: See Fuel System chapter for fuel injector installation (page 171).

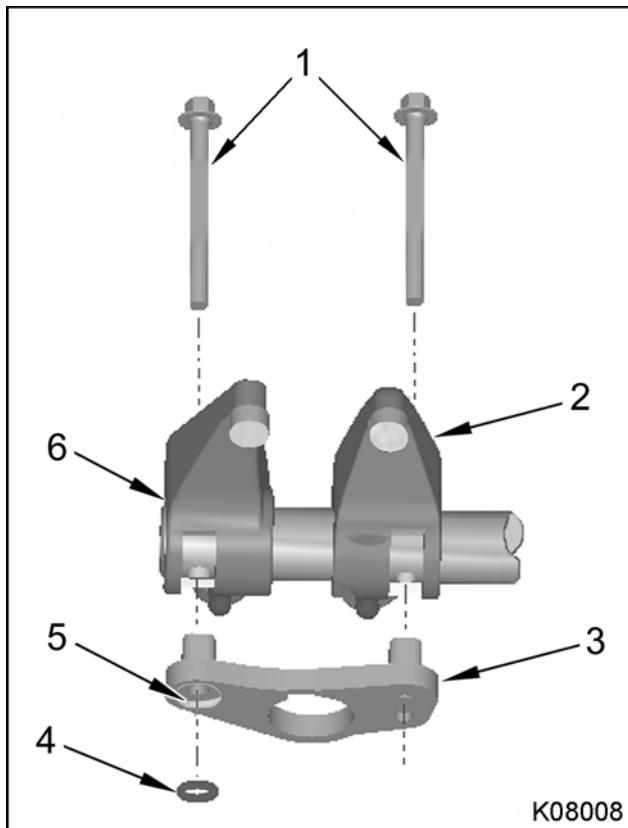


Figure 411 Rocker arm configuration

1. M8 x 60 shaft bolt
2. Exhaust rocker arm
3. Rocker arm shaft support
4. Support washer (assembly aid)
5. Machined recess
6. Intake rocker arm

1. Slide 12 rocker arms onto rocker shaft in order removed (rocker arms should have been marked during removal procedure).

NOTE: Ensure rocker arm shaft has big "T" stamp facing up (Figure 413).

2. Install twelve shaft bolts through rocker arm shaft and into rocker arm shaft supports.
3. Install a support washer (assembly aid) onto each intake rocker arm shaft bolt (recessed side of shaft support only).

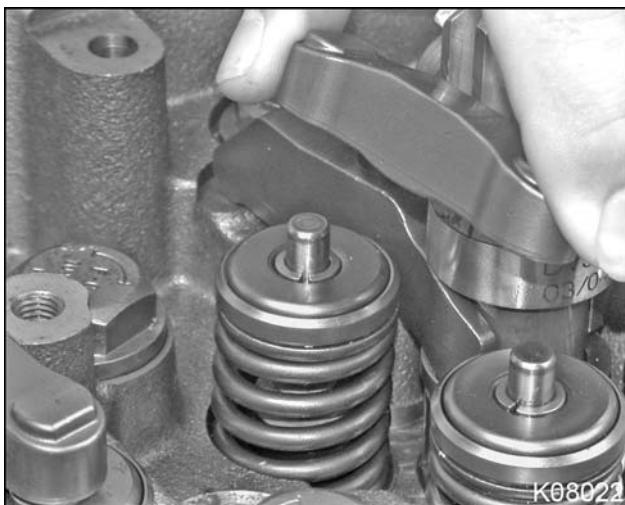
Rocker Arm Assembly

Figure 412 Valve bridge installation

1. Install valve bridges on each set of intake and exhaust valve stems. Used valve bridges must be reinstalled in their original location and orientation. (See marks from removal)

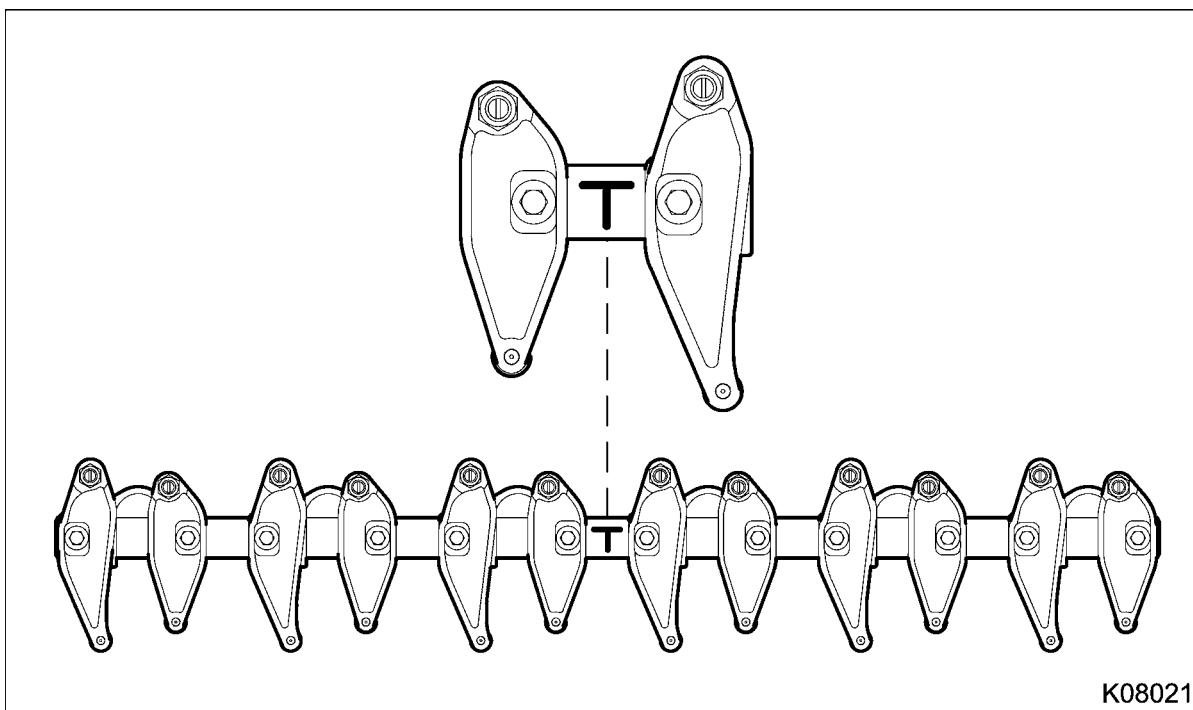


Figure 413 Rocker arm orientation and big "T" stamp

2. Install rocker arm shaft assembly with 12 shaft bolts and six shaft supports, onto cylinder head.
3. Align shaft bolts with cylinder head bolt holes and finger tighten bolts.

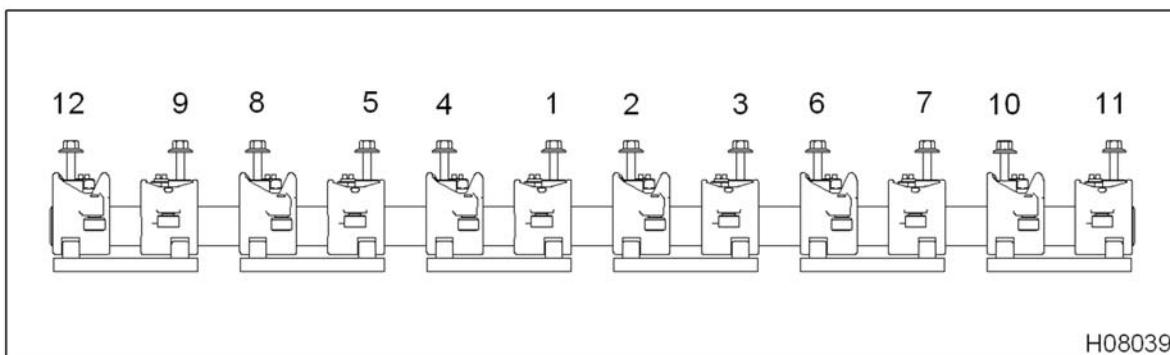


Figure 414 Rocker arm torque sequence

4. Tighten shaft bolts in two steps using rocker arm torque sequence (Figure 414).
 - a. Torque rocker arm shaft bolts in sequence to 27 N·m (20 lbf·ft).
 - b. Torque rocker arm shaft bolts in sequence to 37 N·m (27 lbf·ft).
5. Adjust valve lash (page 293) for all 12 rocker arms.

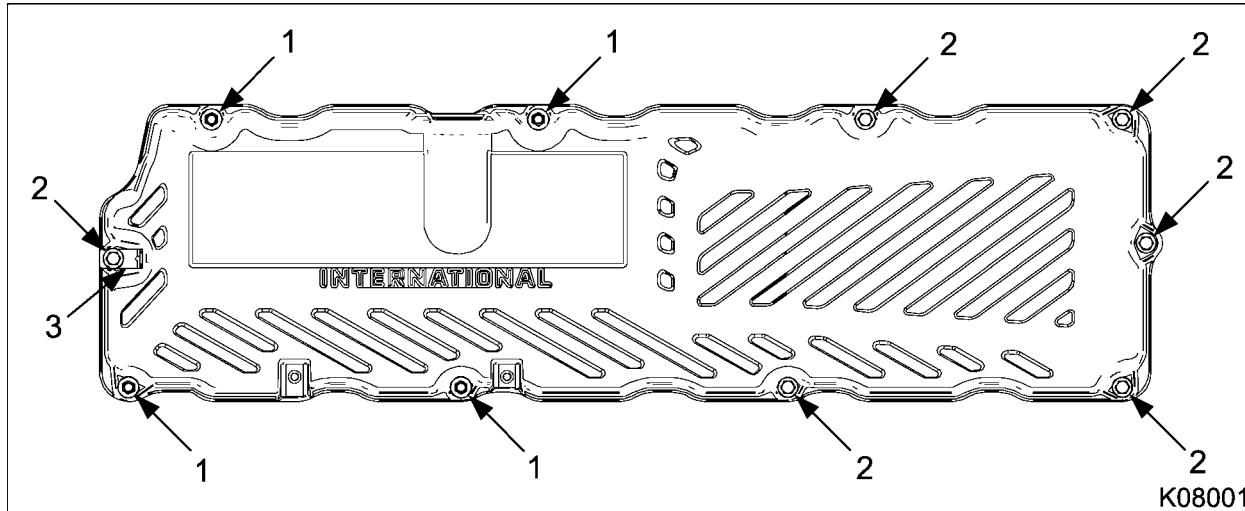
Read all safety instructions in the "Safety Information" section of this manual before doing any procedures.

Follow all warnings, cautions, and notes.

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Valve Cover

1. Install UVC harness valve cover gasket assembly (page 93) on the cylinder head.
2. Connect all sensor and injector connectors to the UVC harness valve cover gasket assembly.
3. Install valve cover onto cylinder head.

**Figure 415 Valve cover assembly**

- | | | |
|--------------------------|---------------------|-----------------------------|
| 1. M8 x 80 stud bolt (4) | 2. M8 x 80 bolt (6) | 3. Harness mounting bracket |
|--------------------------|---------------------|-----------------------------|
-
4. Install any harness mounting brackets removed to appropriate bolts.
 5. Install four M8 x 80 stud bolts finger tight.
 6. Install six M8 x 80 bolts finger tight.
 7. Tighten four bolts and six stud bolts to standard torque (page 471).

Specifications

Valve Specifications

Camshaft lobe lift	Intake: 6.68 mm (0.263 in) 0.254 mm (0.010 in) maximum wear limit Exhaust: 6.91 mm (0.272 in) 0.254 mm (0.010 in) maximum wear limit
Valve face angle	Intake: 59.75 to 60.00° Exhaust: 44.75 to 45.00°
Valve face margin (minimum)	Intake: 1.32 mm (0.052 in) Exhaust: 1.16 mm (0.046 in)
Valve face-to-valve stem runout (maximum)	0.038 mm (0.0015 in)
Valve lash (cold), intake and exhaust	0.48 mm (0.019 in)
Valve stem diameter (new condition)	Intake: 7.92861 ± 0.0089 mm (0.31215 ± 0.00035 in) Exhaust: 7.9083 ± 0.0089 mm (0.31135 ± 0.00035 in)
Valve stem straightness (maximum)	0.010 mm (0.0004 in)
Valve stem-to-guide running clearance (maximum)	Intake: 0.10 mm (0.004 in) Exhaust: 0.11 mm (0.005 in)
Intake valve head diameter	39.73 ± 0.13 mm (1.564 ± 0.005 in)
Exhaust valve head diameter	36.55 ± 0.13 mm (1.439 ± 0.005 in)

Valve Spring Specifications**Intake and Exhaust Valve Springs**

Free length	52.35 mm (2.061 in)
Solid height (maximum)	27.46 mm (1.081 in)
Valve closed test length @ 410.1 ± 24.5 N (92.2 ± 5.5 lbf) test load	40 mm (1.575 in)
Valve closed test length @ 764.2 ± 48.9 N (171.8 ± 11.0 lbf) test load	29.3 mm (1.155 in)

Cylinder Head and Valve Train Specifications

Cylinder head gasket surface flatness	0.10 mm (0.004 in.) per 229 mm (9.0 in)
Cylinder head thickness	New: 160.48 mm (6.318 in) Minimum: 159.97 mm (6.298 in)
Cylinder head valve guide bore diameter	14.308 ± 0.017 mm (0.5633 ± 0.0007 in)
Exhaust valve seat counterbore diameter	Standard: 37.503 ± 0.025 mm (1.4765 ± 0.0010 in) Oversize: 0.05 mm (0.002 in): 37.55 ± 0.03 mm (1.478 ± 0.001 in)
Exhaust valve seat insert outside diameter	Standard: 37.57 ± 0.01 mm (1.479 ± 0.0005 in) Oversize: 0.05 mm (0.002 in): 37.62 ± 0.01 mm (1.481 ± 0.0005 in)
Intake valve seat counterbore diameter	Standard: 40.145 ± 0.025 mm (1.5805 ± 0.0010 in) Oversize 0.05 mm (0.002 in): 40.195 ± 0.025 mm (1.5825 ± 0.0010 in)
Intake valve seat insert outside diameter	Standard: 40.21 ± 0.01 mm (1.583 ± 0.0005 in) Oversize 0.05 mm (0.002 in): 40.26 ± 0.01 mm (1.585 ± 0.0005 in)
Valve seat insert OD to valve seat counterbore diametral interference	0.025 to 0.102 mm (0.001 to 0.004 in)
Valve guide bore out-of-round (maximum)	0.005 mm (0.0002 in)
Valve guide bore taper (maximum)	0.013 mm (0.0005 in)
Valve guide height from cylinder head spring pocket	16.54 ± 0.25 mm (0.651 ± 0.010 in)
Valve guide inside diameter (installed)	7.98 to 8.00 mm (0.314 to 0.315 in)
Valve guide inside diameter (installed), maximum wear limit	Intake: 0.102 mm (0.004 in) Exhaust: 0.127 mm (0.005 in)
Valve guide interference fit dimension	0.043 mm (0.0017 in)
Valve guide outside diameter	14.351 ± 0.010 mm (0.5650 ± 0.0004 in)
Valve guide length (overall)	65.71 mm (2.587 in)

Cylinder Head and Valve Train Specifications (cont.)

Valve recession	Intake: 1.02 ± 0.13 mm (0.040 ± 0.005 in)
	Exhaust: 1.40 ± 0.13 mm (0.055 ± 0.005 in)
Valve seat angles	Intake: $59.75 - 60^\circ$
	Exhaust: $44.75 - 45^\circ$
Valve seat to valve guide bore concentricity (maximum)	0.076 mm (0.003 in)
Valve seat width	1.91 to 2.16 mm (0.075 to 0.085 in)
Push rod runout (maximum)	0.508 mm (0.020 in)

Special Torque

Cylinder head mounting bolts torque and sequence	(page 324)
Rocker arm bolts torque and sequence	(page 326)
Valve adjustment screw lock nut	27 N·m (20 lbf·ft)

Special Service Tools

Ball gauge	Obtain locally
Cylinder Head Test Plate	ZTSE4289A
Depth micrometer	Obtain locally
Dial indicator set	Obtain locally
Dye penetrant kit	Obtain locally
Feeler gauge	Obtain locally
Head bolt socket	Obtain locally
Head Bolt Bottoming Tap	ZTSE4671
Head Bolt Thread Gauge	ZTSE4667
Injector Sleeve Brush Set (set of 2)	ZTSE4304
Injector Sleeve Installer	ZTSE4642
Injector Sleeve Remover	ZTSE4643
Inside micrometer	Obtain locally
Loctite® 620 Retaining Compound	Obtain locally

Outside micrometer	Obtain locally
Pressure regulator	Obtain locally
Slide Hammer Puller Set	ZTSE1879
Small hole gauge set	Obtain locally
Square	Obtain locally
Straightedge	Obtain locally
Telescoping gauge	Obtain locally
Thermostat Opening Pressure Adapter	ZTSE4647
Valve and Clutch Spring Tester	ZTSE2241
Valve Guide Deburring Tool	ZTSE4393
Valve Guide Installer	ZTSE1943
Valve Guide Remover	ZTSE4377
Valve Seat Extractor Kit (Universal)	ZTSE1951C
Valve Seat Grinder	ZTSE1631A
Valve seat grinding stones 45° (exhaust)	Obtain locally
Valve seat grinding stones 60° (intake)	Obtain locally
Valve Seat Installer	ZTSE4641
Valve Seat Remover (collet)	ZTSE4640
Valve Spring Compressor	ZTSE1846
Valve Spring Compressor Jaws	ZTSE4652
Vernier caliper	Obtain locally
Water Supply Housing Pressure Adapter	ZTSE4648

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Exploded View and Description

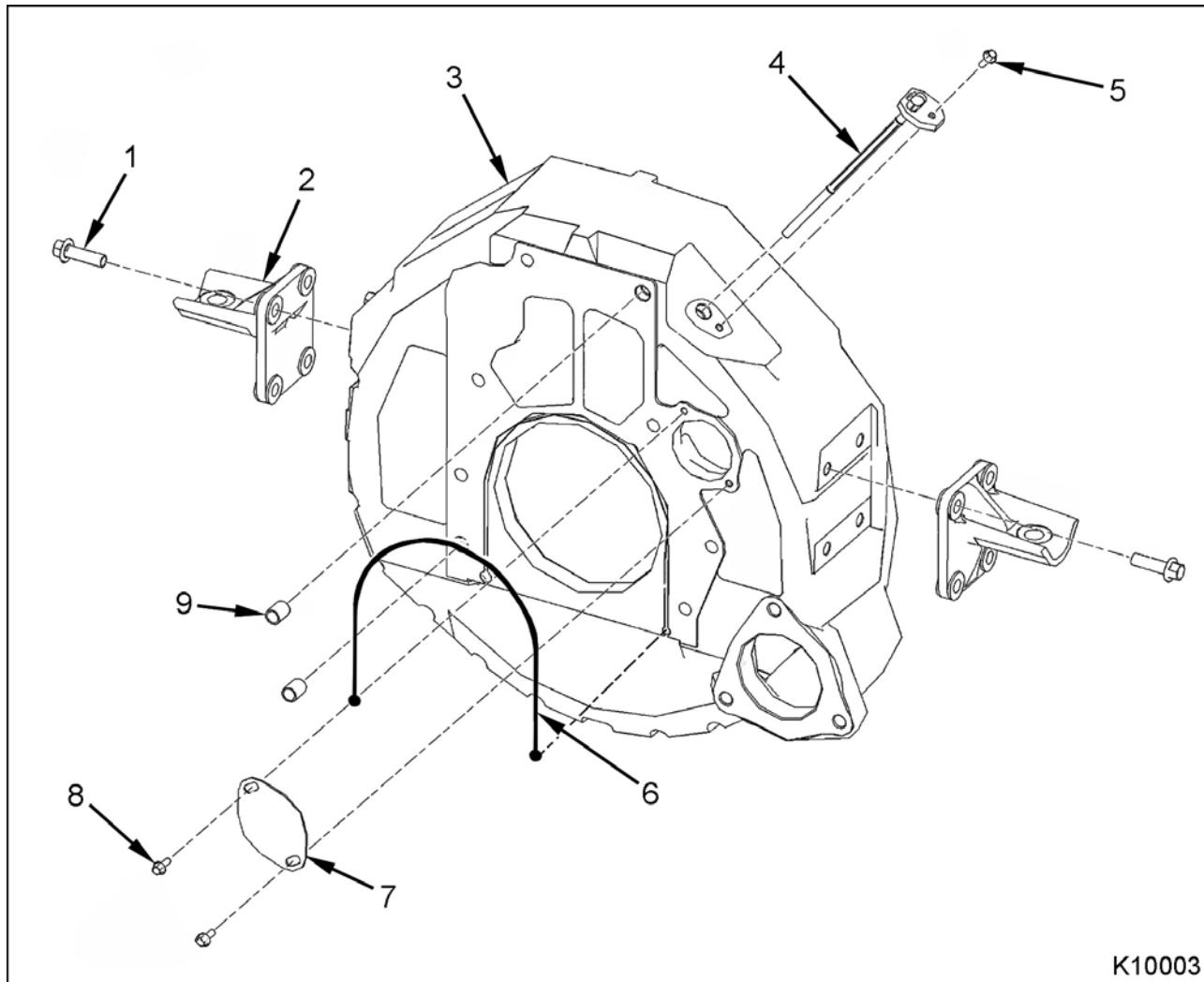


Figure 416 Flywheel housing and related parts (typical)

- | | | |
|--|--|---------------------|
| 1. M12 x 40 bolt (8) | 4. Crankshaft Position sensor
(CKP) | 7. Cover plate |
| 2. Rear engine mounting bracket
(2) | 5. M6 x 16 bolt | 8. M6 x 16 bolt (2) |
| 3. Flywheel housing | 6. Flywheel housing seal | 9. Hollow dowel (2) |

The flywheel housing assembly is bolted to the back of the crankcase and supports the transmission, starter motor, rear engine mounting brackets, and crankshaft position sensor. A flywheel and clutch assembly (manual transmission) or a flexplate and

torque converter assembly (automatic transmission) are housed inside the flywheel housing to transfer engine power to the transmission. Several flywheel housing, flywheel, and flexplate options are available to fit different applications.

All transmission applications are designed to attach to one of the following four flywheel housing assembly configurations:

Flywheel housing SAE #1

- Houses a flywheel or flexplate with a 148 tooth ring gear.
- SAE #1 transmission opening.
- SAE #1 starter motor location (will only work with a 148 tooth ring gear).
- Standard SAE #2 side mount locations.

Flywheel housing SAE #1A

- Houses a flywheel or flexplate with a 138 tooth ring gear.
- SAE #1 transmission opening.
- SAE #2 starter motor location (will only work with a 138 tooth ring gear).
- Standard SAE #2 side mount locations.

Flywheel housing SAE #2

- Houses a flywheel or flexplate with a 138 tooth ring gear.
- SAE #2 transmission opening.
- SAE #2 starter motor location (will only work with a 138 tooth ring gear).
- Standard SAE #2 side mount locations.

Flywheel housing (Bus) SAE #2

- Houses a flywheel or flexplate with a 138 tooth ring gear.
- SAE #2 starter motor location (will only work with a 138 tooth ring gear).
- High side mounts for bus.

Flywheel and Flexplate Applications

Manual Transmissions

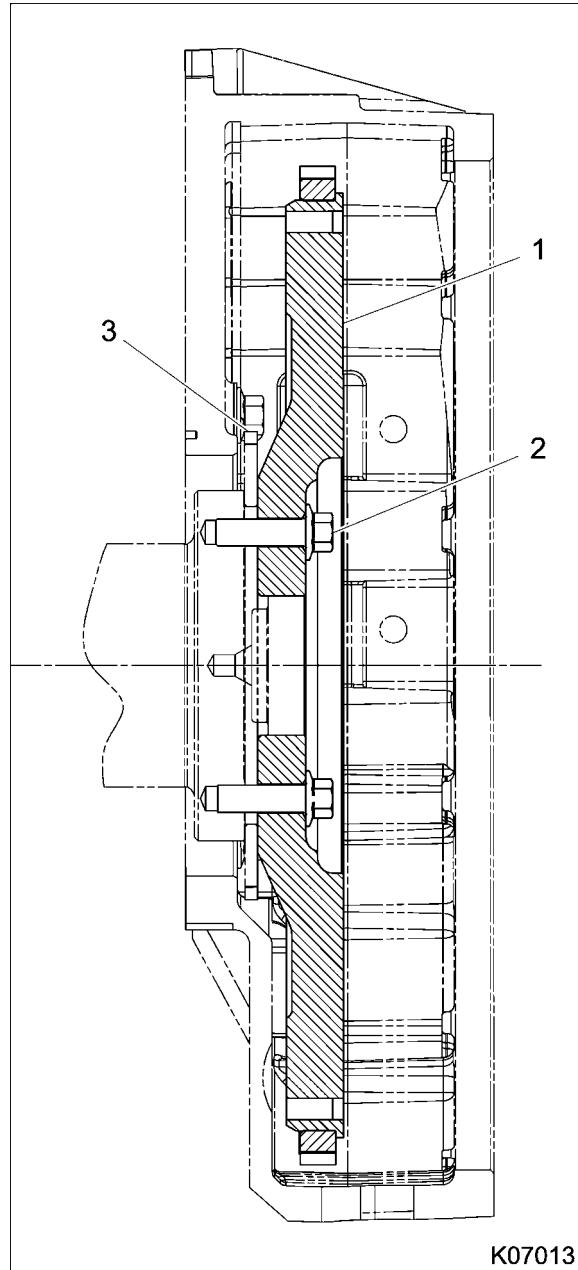


Figure 417 14 inch flywheel - for multiple plate clutch applications (800 lbf·ft and below)

1. Flywheel assembly
2. M12 x 40 bolt (12)
3. Crankshaft timing disk

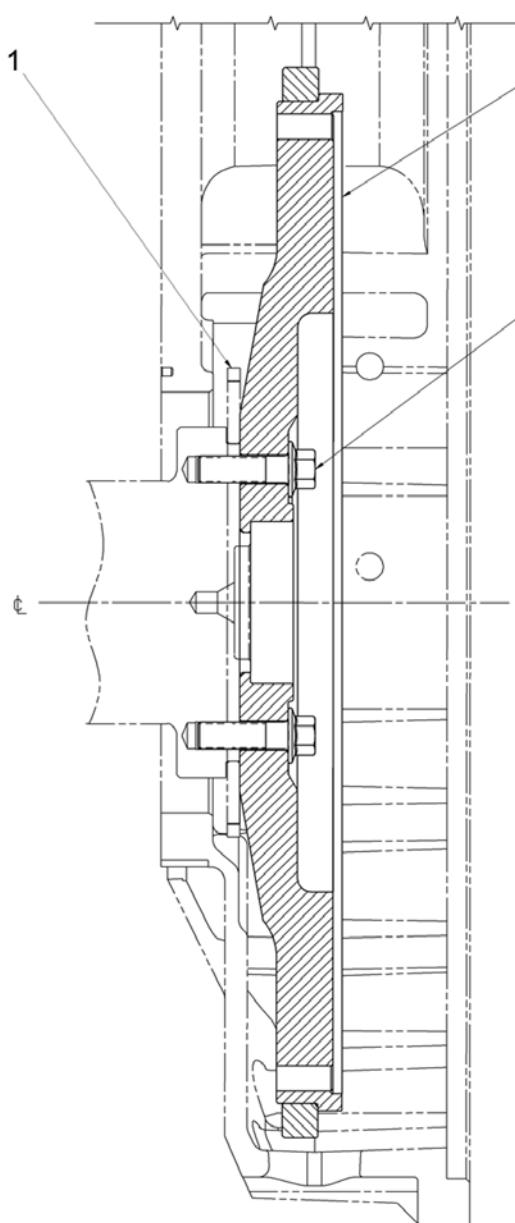


Figure 418 15.5 inch flywheel - for multiple plate clutch applications (800 lbf·ft and above)

1. Crankshaft timing disk
2. Flywheel assembly
3. M12 x 40 bolt (12)

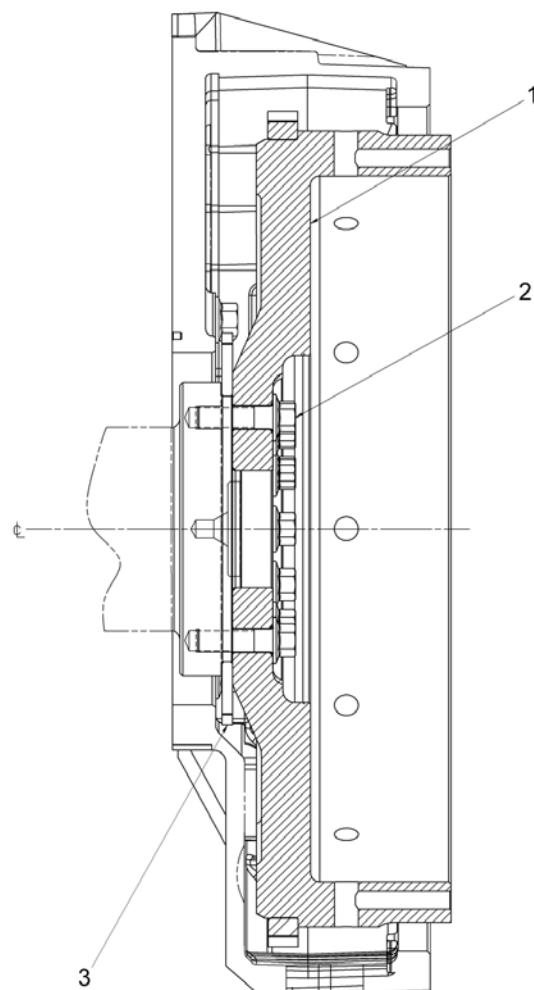


Figure 419 Pot type flywheel - for multiple plate clutch applications (800 lbf·ft and above)

1. Flywheel assembly
2. M12 x 40 bolt (12)
3. Crankshaft timing disk

Automatic Transmissions

NOTE: Side of reinforcement ring stamped with the part number or logo must face outward.

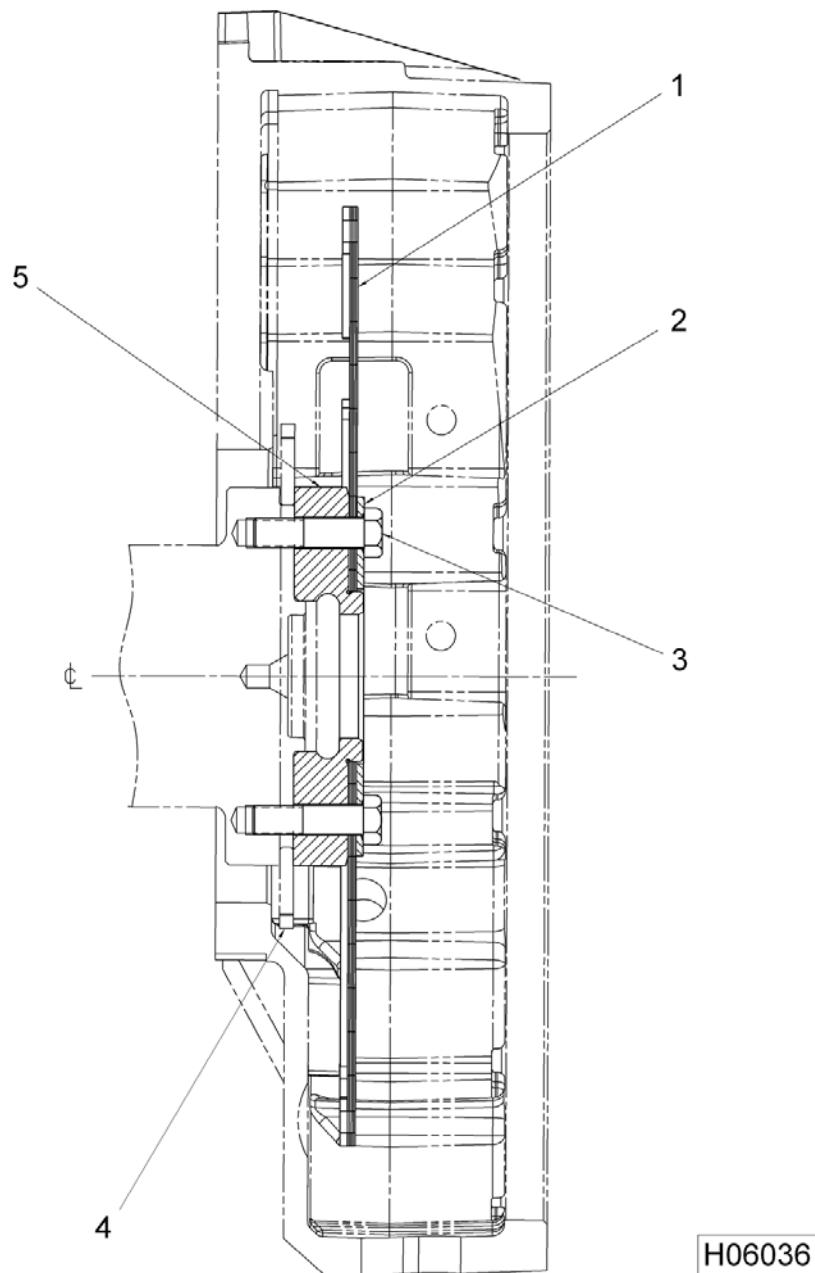


Figure 420 Application for Allison World Transmissions - MD-3060, MD-3560

- | | |
|--|---------------------------|
| 1. Flexplate assembly | 3. M12 x 45 bolt (12) |
| 2. Reinforcement ring (Allison transmissions only) | 4. Crankshaft timing disk |
| | 5. Hub crankshaft adaptor |

NOTE: Side of reinforcement ring stamped with the part number or logo must face outward.

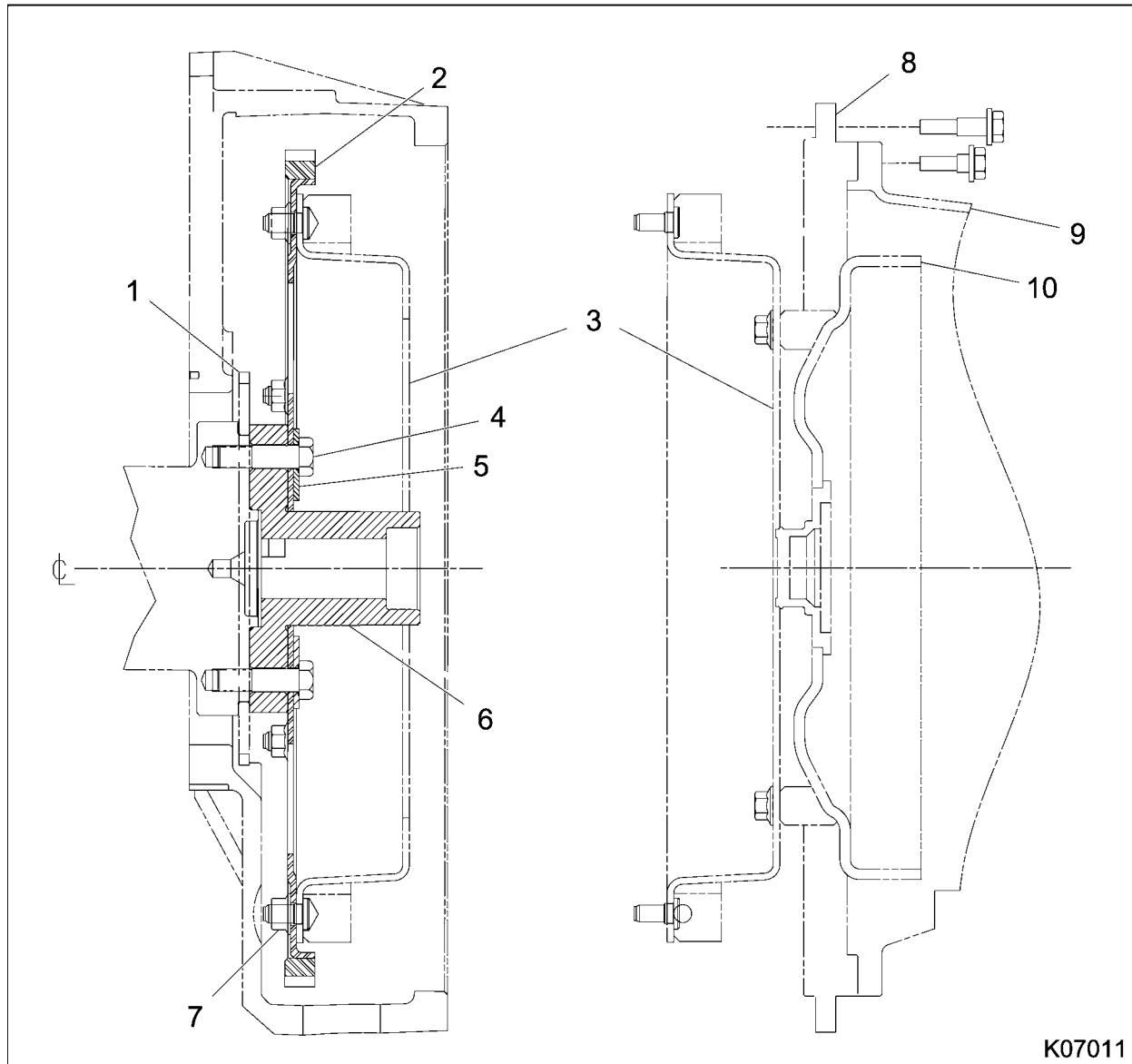


Figure 421 Application for Allison transmissions

- | | | |
|---|-----------------------|---|
| 1. Crankshaft timing disk | 4. M12 x 43 bolt (12) | 8. Converter adapter ring (SAE #2 to SAE #3 ring) |
| 2. Ring gear & flex plate assembly | 5. Reinforcement ring | 9. Transmission case |
| 3. Plate assembly, Allison AT transmissions | 6. Adapter hub, AT | 10. Torque converter assembly |
| | 7. M10 x 1.5 nut | |

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, disconnect ground (-) cable from battery before doing service or diagnostic procedures.



⚠ WARNING: To prevent personal injury or death, use a suitable lifting device to support the transmission assembly during removal and installation.



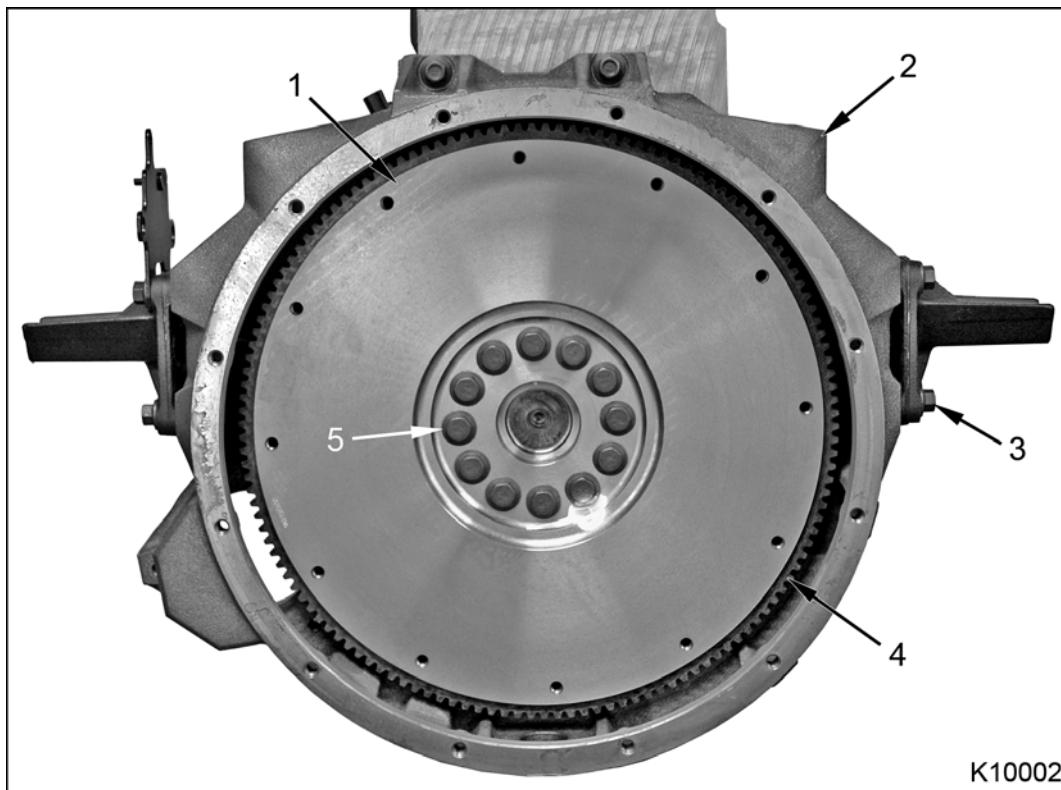
⚠ WARNING: To prevent personal injury or death, support engine (if in chassis) before removing any engine mounting bracket or flywheel housing bolts.



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

Flywheel Assembly

1. Disconnect the negative (ground) cable from the battery.
2. Disconnect the electrical cable and wires from the starter motor.
3. Remove bolts holding the starter motor to the flywheel housing and remove the starter.
4. Remove the transmission and clutch assembly.
(See transmission manufacturers service publications.)

**Figure 422 Flywheel and flywheel housing (typical)**

- | | | |
|---|---|--------------------------------|
| 1. Flywheel assembly (typical) | 3. M12 x 40 rear engine mount bolt
(8) | 5. M12 x 40 flywheel bolt (12) |
| 2. Flywheel housing assembly
(typical) | 4. Ring gear | |

NOTE: There are two flywheel options for manual transmissions: 138-tooth ring gear and 148-tooth ring gear. For 148-tooth flywheels, loosen the two lowest, rear most M12 x 40 rear engine mount bolts to provide clearance for flywheel removal.

5. Remove two M12 x 40 flywheel bolts, 180° from each other.

6. Install two guide pins (made locally) in place of the two flywheel bolts.
7. Remove remaining ten M12 x 40 flywheel bolts.
8. Carefully slide flywheel out of flywheel housing and off guide pins.
9. Remove guide pins.

Flexplate (Automatic Transmissions)

NOTE: Flexplate assemblies are available as fully assembled service part assemblies. Typically, there will be no need to disassemble flexplate assemblies.

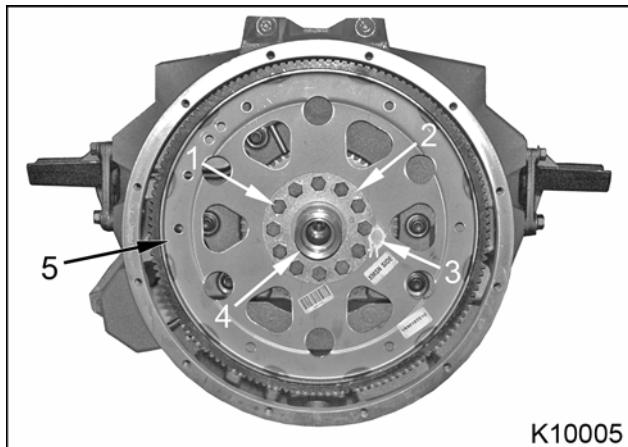
Allison 2000 Series Transmissions

Figure 423 Flexplate, reinforcement ring, and adaptor hub

1. M12 x 43 flexplate bolt (12)
2. Reinforcement ring
3. Paint marking index
4. AT adapter hub
5. Flexplate assembly

1. Remove transmission and torque converter assembly. (See transmission manufacturers service publications.)
2. Put a paint mark on the exposed face of the reinforcement ring and flexplate for proper installation orientation.
3. Remove two M12 x 43 flexplate bolts, 180° from each other.
4. Install two guide pins (made locally) in place of two flexplate bolts.
5. Remove remaining ten M12 x 43 bolts.
6. Slide reinforcement ring, flexplate, and adapter hub off guide pins.
7. Remove guide pins.

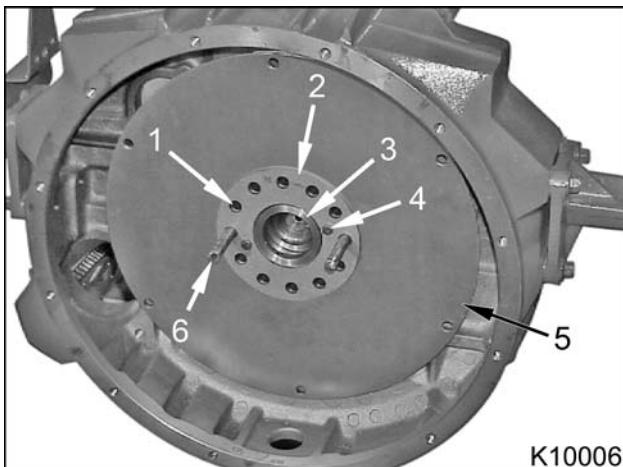
MD-3000 Series Transmissions

Figure 424 Flexplate, reinforcement ring, and guide pins

1. M12 x 45 flexplate bolt hole (12)
2. Reinforcement ring
3. Crankshaft hub adapter
4. M6 flexplate assembly bolt (2)
5. Flexplate assembly
6. Guide pin (2)

1. Remove transmission and torque converter assembly. (See transmission manufacturers service publications.)

CAUTION: To prevent engine or vehicle damage, do not remove two M6 flexplate assembly bolts.

 2. Remove two M12 x 45 flexplate bolts, 180° from each other.
 3. Install two guide pins (made locally) in place of two flexplate bolts.
 4. Remove remaining ten M12 x 45 flexplate bolts.
 5. Slide flexplate assembly off guide pins.
 6. Remove guide pins.

Crankshaft Timing Disk

CAUTION: To prevent engine damage, do not contact the rear oil seal with bolts threaded into the crankshaft timing disk for disk removal. Damage to the rear oil seal could occur resulting in oil leaks.

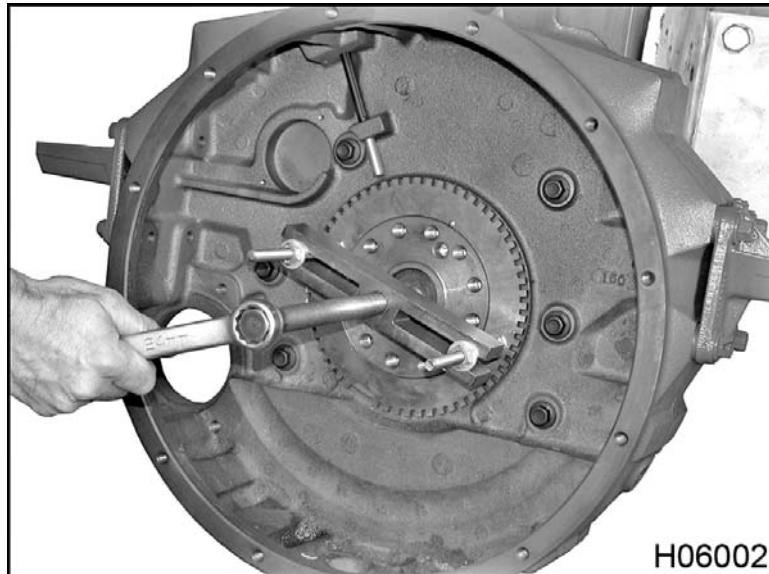
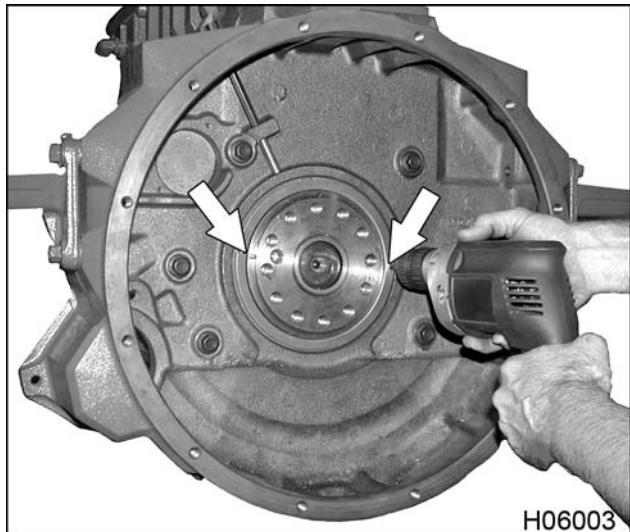


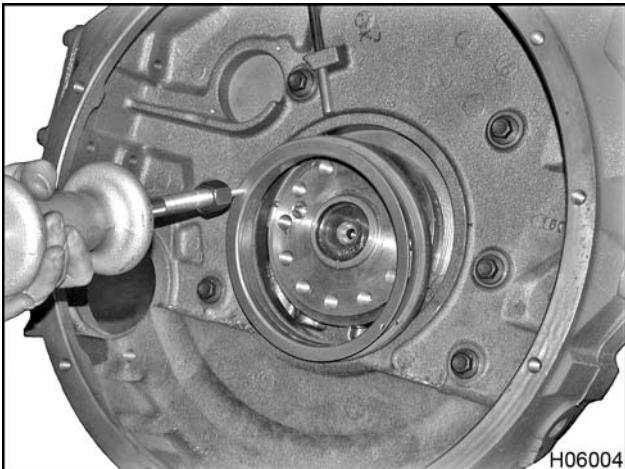
Figure 425 Crankshaft timing disk removal

1. Install two bolts and washers through H-bar puller (page 358) and into the crankshaft timing disk. Install bolt heads at equal lengths from the timing disk.
2. Tighten H-bar puller center shaft to pull timing disk off of the crankshaft.

Rear Oil Seal Assembly**Figure 426 Drill holes in rear oil seal assembly**

NOTE: Use an appropriate size drill bit to fit Slide Hammer Puller screw.

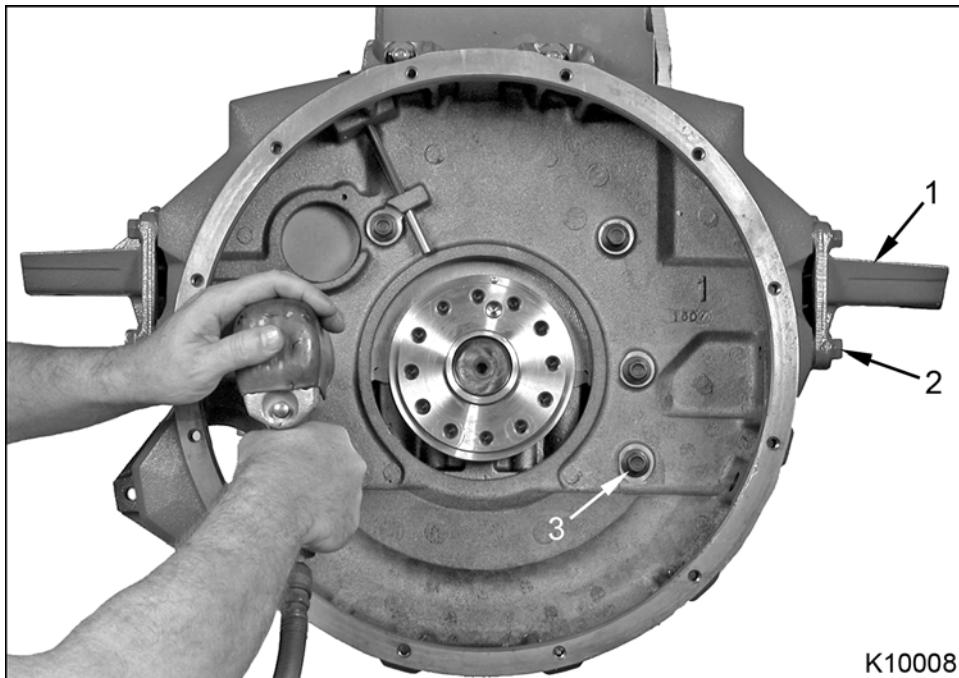
1. Carefully drill two holes approximately 180° from each other in the rear oil seal assembly.

**Figure 427 Rear oil seal assembly and slide hammer**

2. Screw Slide Hammer Puller Set (page 358) screw into holes drilled in the rear oil seal assembly.
3. Alternately pull each side of the rear oil seal out.
4. Remove and discard rear oil seal and wear sleeve.

Flywheel Housing

1. Remove the oil pan (page 233).

**Figure 428 Flywheel housing removal**

- | | | |
|--|---|---|
| 1. Rear engine mounting bracket
(2) | 2. M12 x 40 rear engine mount bolt
(8) | 3. M12 x 50 flywheel housing
mounting bolt (8) |
|--|---|---|

⚠ WARNING: To prevent personal injury or death, support engine (if in chassis) before removing any engine mounting bracket or flywheel housing bolts.

2. Properly support the engine and remove eight M12 x 40 rear engine mount bolts and two rear engine mounts.

3. Remove seven M12 x 50 flywheel housing mounting bolts.
4. Support the flywheel housing with help from an assistant.
5. Remove the final M12 x 50 flywheel housing bolt and remove flywheel housing from the crankcase.

⚠ WARNING: To prevent personal injury or death, get assistance to remove or install the flywheel housing.

Clean, Inspect, and Measure

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

Clean and Inspect

1. Clean flywheel or flexplate, flywheel housing, and rear engine mounting brackets with a non-caustic solvent and dry with filtered compressed air.
2. Inspect flywheel housing and rear engine mounting brackets for cracks and damage. Replace if required.
3. If equipped, inspect flexplate for cracks, damage, and warpage. Replace if required.
4. If equipped, inspect flywheel for cracks, heat checks, and extensive scoring. Replace or resurface as required.
5. Inspect ring gear for worn, chipped, or cracked teeth. If teeth are damaged, replace the ring gear.
6. Clean and inspect crankshaft and crankcase where flywheel and flywheel housing mount.

Measure Flywheel Housing Face Runout

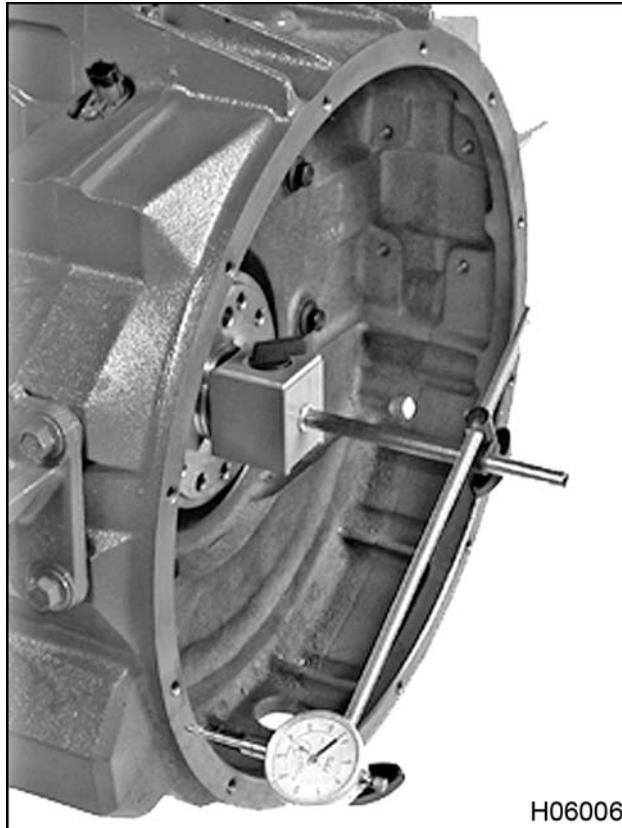


Figure 429 Flywheel housing face runout measurement

1. Push the crankshaft in by hand to bring crankshaft end play to zero.
2. Center the magnetic base of a dial indicator set (page 358) on the end of the crankshaft.
3. Place the dial indicator tip against the face of the flywheel housing.
4. Zero dial indicator.
5. Slowly rotate crankshaft 360 degrees while keeping crankshaft end play at zero and observe dial indicator measurements.
6. Compare the total dial indicator variation (highest – lowest reading) to flywheel housing face runout Specifications (page 357).

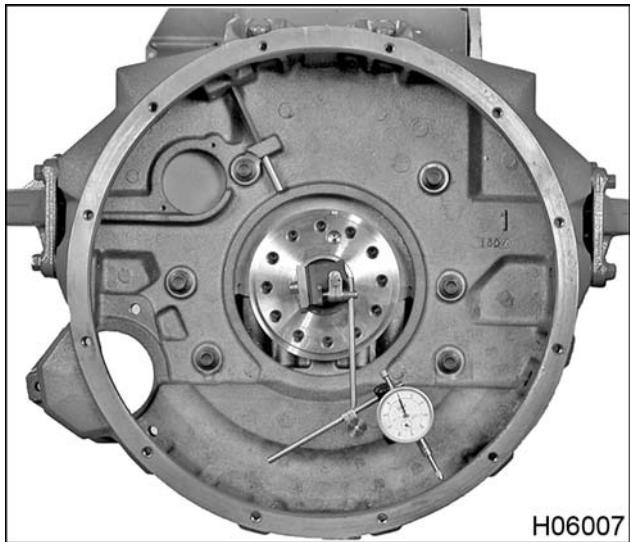
Measure Flywheel Housing Bore Concentricity

Figure 430 Flywheel housing bore concentricity measurement

1. Attach the magnetic base of a dial indicator set (page 358) on the end of the crankshaft.
2. Place the tip of the dial indicator against the flywheel housing bore.
3. Zero the dial indicator.
4. Slowly rotate the crankshaft 360 degrees and observe dial indicator measurements.
5. Compare the total dial indicator variation (highest – lowest reading) to flywheel housing bore concentricity Specification (page 357).

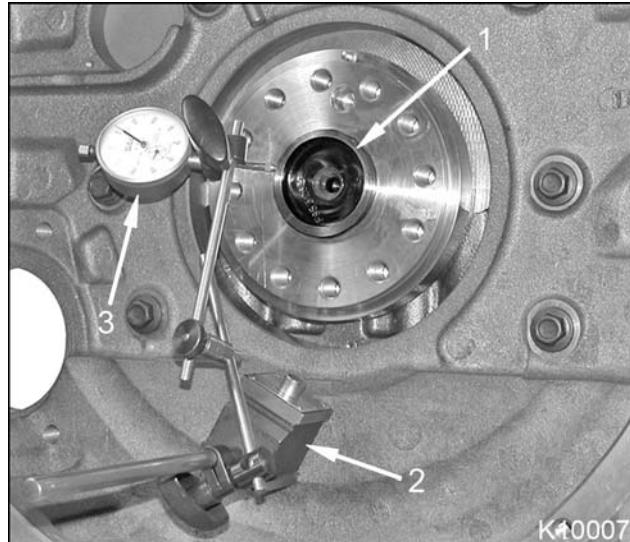
Measure Crankshaft Pilot Concentricity

Figure 431 Crankshaft pilot concentricity measurement

1. Crankshaft pilot
 2. Magnetic base
 3. Dial indicator
1. Attach the magnetic base of a dial indicator set (page 358) to the flywheel housing.
 2. Place dial indicator tip against the crankshaft pilot outer edge.
 3. Zero the dial indicator.
 4. Slowly rotate the crankshaft 360 degrees and observe dial indicator measurements.
 5. Compare the total dial indicator variation (highest – lowest reading) to crankshaft pilot concentricity Specification (page 357).

Measure Flywheel Surface Runout**Figure 432 Flywheel surface runout measurement**

1. Attach the magnetic base of a dial indicator set (page 358) to the face of the flywheel housing.
2. Place dial indicator tip against the face of the flywheel near the pressure plate mounting holes.
3. Zero the dial indicator.
4. Slowly rotate the crankshaft 360 degrees and observe dial indicator measurements.
5. Compare the total dial indicator variation (highest – lowest reading) to flywheel surface runout Specification (page 357).

Recondition

Resurface Flywheel

NOTE: Flywheels used with manual transmissions may be resurfaced to correct minor wear and scoring if flywheel is not cracked or damaged and meets minimum thickness specification (page 357).

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

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.

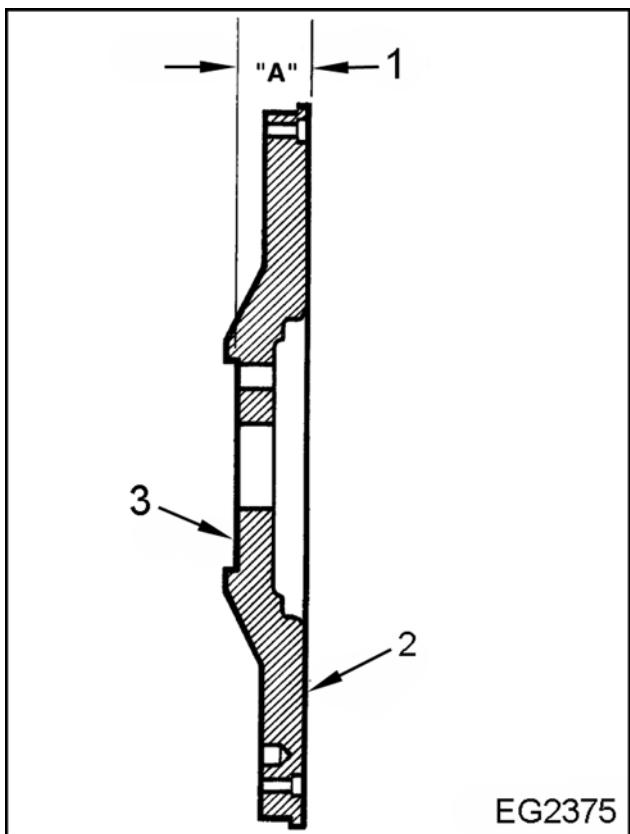


Figure 433 Flywheel surface dimension (typical)

1. Flywheel thickness (dimension "A")
2. Clutch disc mounting face
3. Crankshaft flange mounting face



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.
2. Measure flywheel thickness and compare to minimum required thickness Specification (page 357). 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.

Replace Flywheel Ring Gear



WARNING: To prevent personal injury or death, wear heat resistant gloves when handling heated components.

CAUTION: To prevent engine damage, do not heat ring gear higher than 278 °C (500 °F). Heating beyond this temperature will adversely affect the ring gear hardness.

1. Evenly heat ring gear with a torch to expand the gear for removal.
2. After the ring gear is heated, carefully knock the ring gear off the flywheel. Do not hit the flywheel when removing the ring gear.
3. Heat the new ring gear evenly until gear expands enough to slip onto the flywheel.
4. Make sure ring gear is properly seated against flywheel shoulder along the entire radius of the flywheel.

Installation

Flywheel Housing and Rear Engine Mounting Brackets

1. Install a new flywheel housing seal in the crankcase side of the flywheel housing.

NOTE: Verify two hollow dowels are installed in the crankcase side of the flywheel housing before installing the housing.

WARNING: To prevent personal injury or death, get assistance to remove or install the flywheel housing.

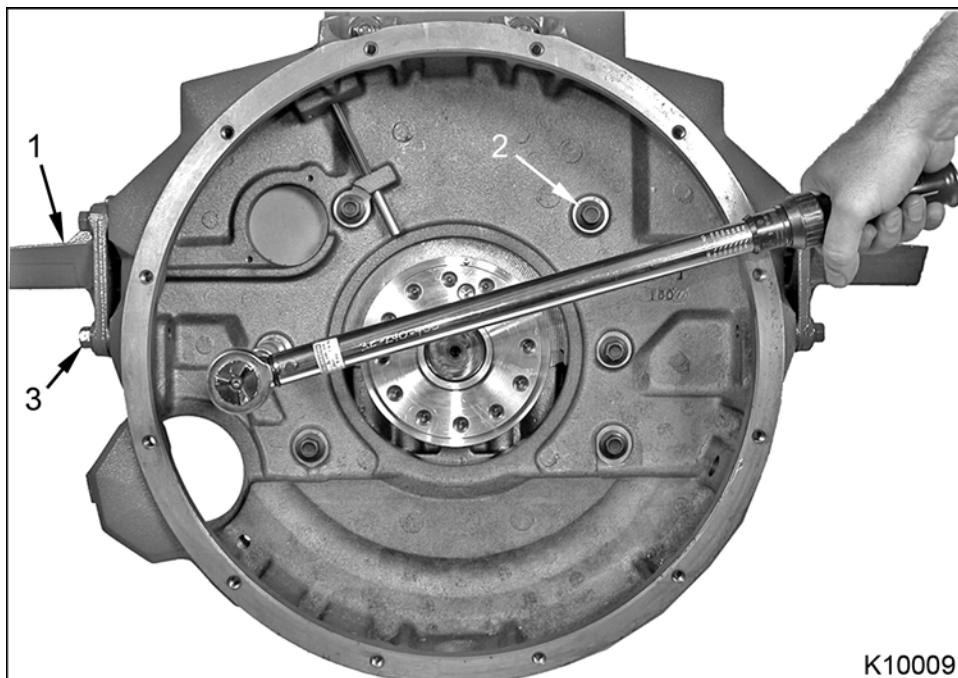


Figure 434 Flywheel housing installation

- | | | |
|--|--|---|
| 1. Rear engine mounting bracket
(2) | 2. M12 x 50 flywheel housing bolt
(8) | 3. M12 x 40 rear engine mount bolt
(8) |
|--|--|---|
- With help from an assistant, lift the flywheel housing into position and align two hollow dowels of the flywheel housing with dowel holes in the crankcase and install one M12 x 50 flywheel housing bolt finger tight.
 - Install seven remaining M12 x 50 flywheel housing bolts finger tight.
 - Tighten eight M12 x 50 flywheel housing bolts to standard torque (page 471).
 - With help from an assistant, lift the flywheel housing into position and align two hollow dowels of the flywheel housing with dowel holes in the crankcase and install one M12 x 50 flywheel housing bolt finger tight.
 - Install two rear engine mounting brackets and finger tighten eight M12 x 40 bolts.
 - Tighten eight M12 x 40 bracket bolts to standard torque.

NOTE: On engines with a 148-tooth ring gear, leave the lowest, rear most M12 x 40 mounting bracket bolt loose (2 or 3 threads) on each side of the flywheel housing (SAE #1A). This will provide clearance for installation of the flywheel and ring gear assembly.

Rear Oil Seal

Figure 435 Application of sealant to crankshaft wear sleeve area

1. Apply a 360° bead of Loctite® 569 Hydraulic Sealant (page 358) to the crankshaft where the rear oil seal wear sleeve will be positioned.

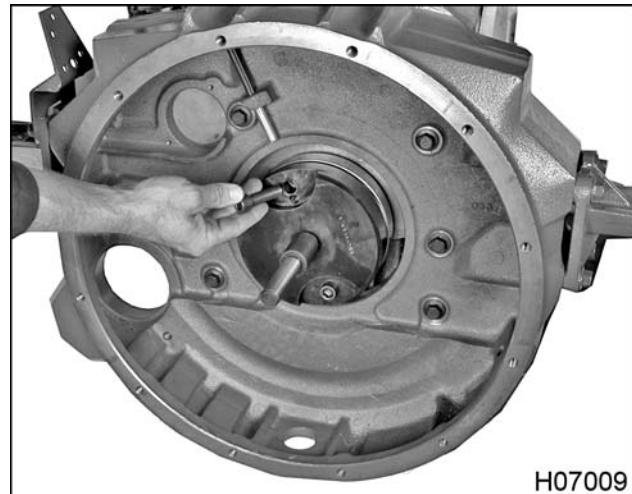


Figure 436 Rear Seal Installer base

2. Install base of Rear Seal Installer (page 358) on the crankshaft and tighten two bolts.

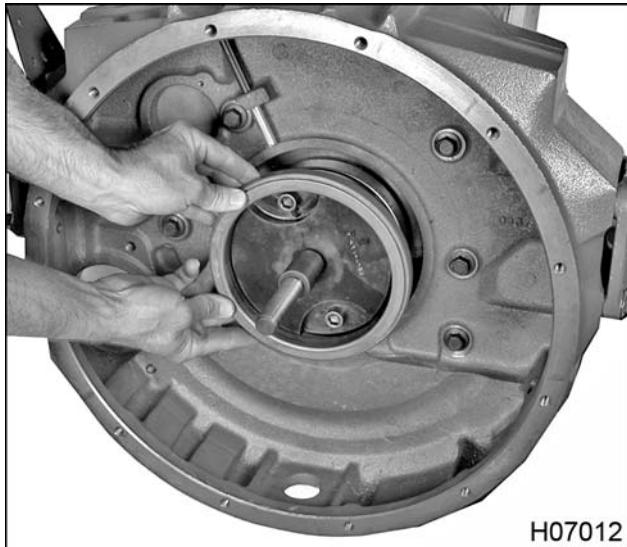


Figure 437 Rear oil seal installation on base

3. Turn steel face of rear oil seal outward (towards transmission) and install seal assembly on the Rear Seal Installer base.

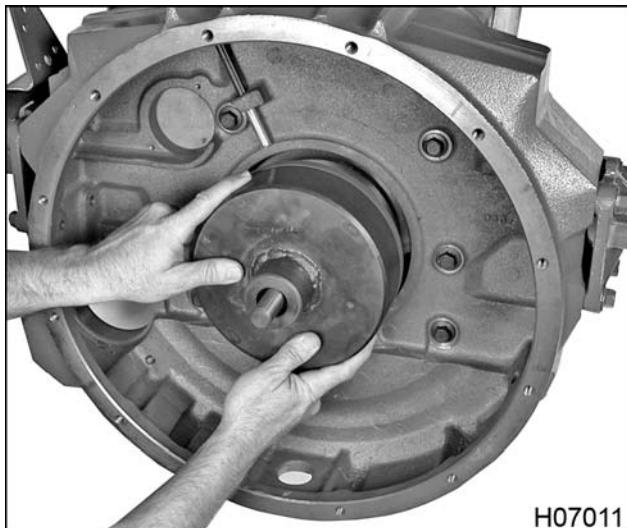


Figure 438 Rear Seal Installer installation onto base

4. Install Rear Seal Installer against steel face of rear oil seal and gently push into flywheel housing as far as possible, by hand.

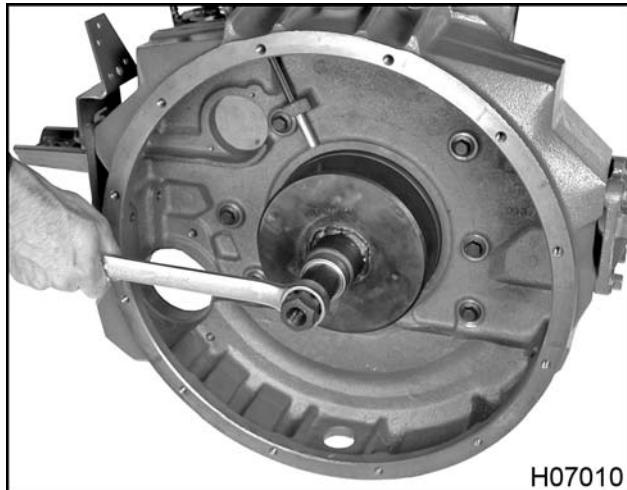


Figure 439 Rear oil seal installation

5. Install bearing, washer, and forcing nut on installer shaft.

CAUTION: To prevent engine damage, do not use air tools to tighten Rear Seal Installer nut.

6. Tighten forcing nut until rear oil seal installer bottoms out. Rear oil seal assembly will be placed at the correct depth.

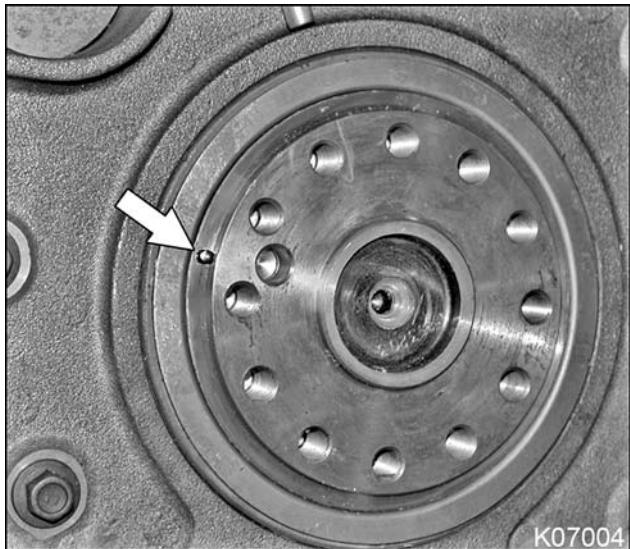
Crankshaft Timing Disk

Figure 440 Crankshaft timing disk alignment spring pin

CAUTION: To prevent engine damage, timing disk alignment spring pin must protrude out of the crankshaft.

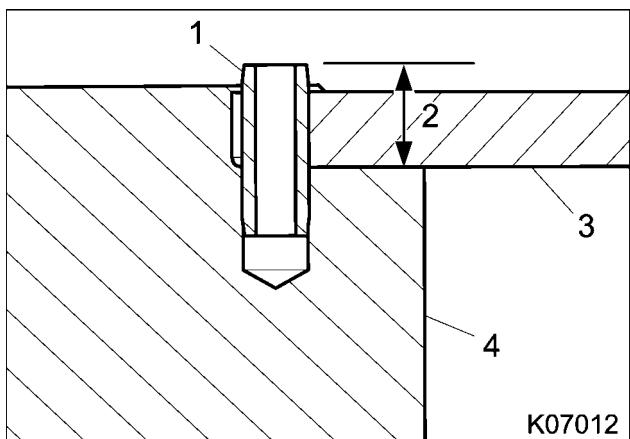


Figure 441 Crankshaft timing disk alignment spring pin (cut-away)

1. Slotted spring pin
2. 7.6 mm (0.30 in)
3. Crankshaft timing disk
4. Crankshaft

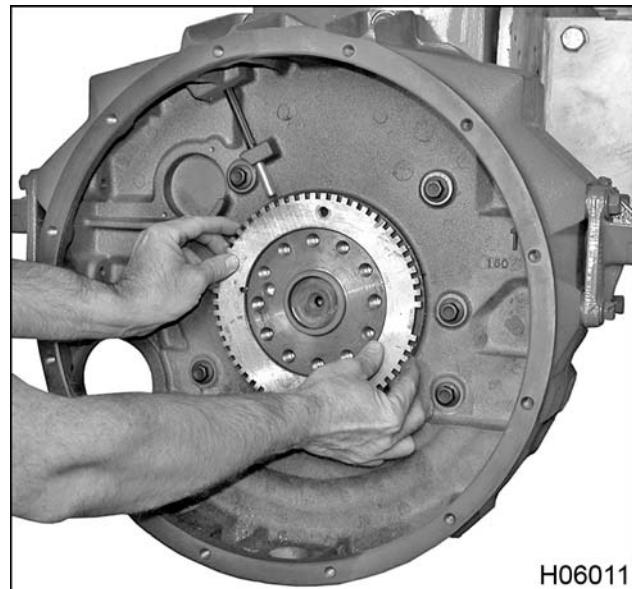
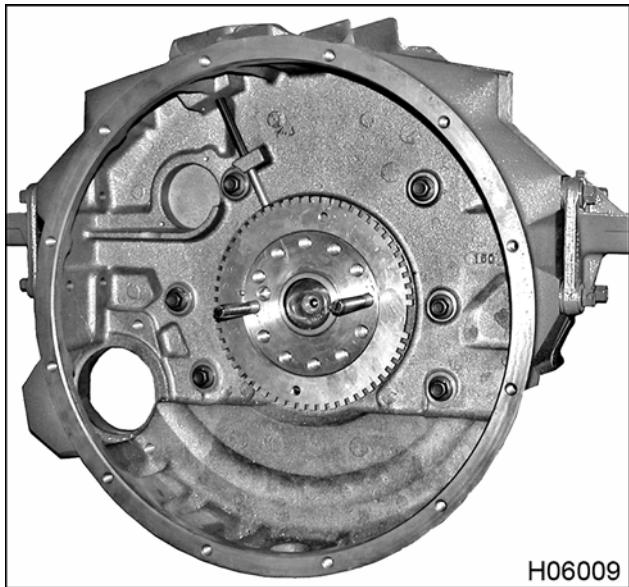


Figure 442 Crankshaft timing disk installation

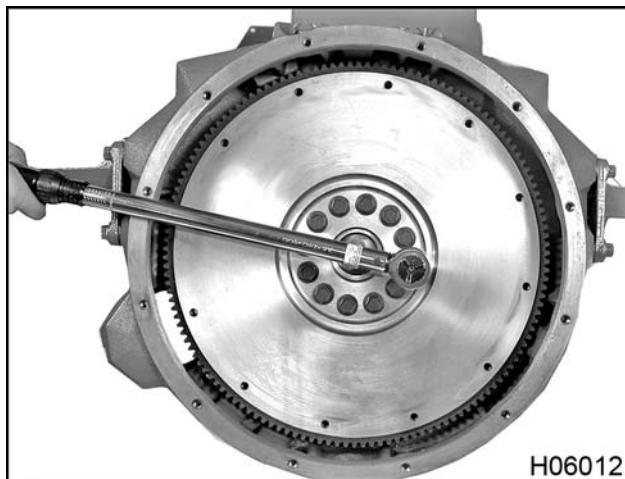
NOTE: Crankshaft timing disk can be installed with either side out.

1. Align index notch of the crankshaft timing disk with crankshaft timing disk alignment pin.
2. Use a rubber mallet to carefully tap the crankshaft timing disk onto the crankshaft. Tap evenly around the crankshaft timing disk to ensure a flush fit against the end of the crankshaft.

NOTE: Rear Seal Installer (page 358) can be used to press the crankshaft timing disk onto the crankshaft.

Flywheel Assembly**Figure 443 Guide pins for flywheel installation**

1. Install two guide pins (made locally) in the flywheel mounting bolt holes, 180° from each other.
2. Install flywheel over the guide pins.
3. Install ten M12 x 40 flywheel mounting bolts finger tight.
4. Remove two guide pins and install remaining two M12 x 40 flywheel mounting bolts finger tight.

**Figure 444 Flywheel mounting bolts (typical)**

5. Tighten flywheel mounting bolts to special torque (page 358).
6. Tighten two remaining rear engine mounting bracket bolts on manual transmission applications with 148-tooth ring gears to standard torque (page 471).
7. Measure Flywheel Surface Runout (page 348).

Flexplate (Automatic Transmissions)**Allison 2000 Series Transmissions**

CAUTION: To prevent engine damage, if the vehicle is being re-configured with an Allison 2000 Series transmission, make sure the correct flywheel housing is installed on the engine. Otherwise, there will be interference between the flexplate studs and the flywheel housing that will only be evident after the transmission has been installed.

1. Install two guide pins (made locally) in flexplate mounting bolt holes, 180° from each other.

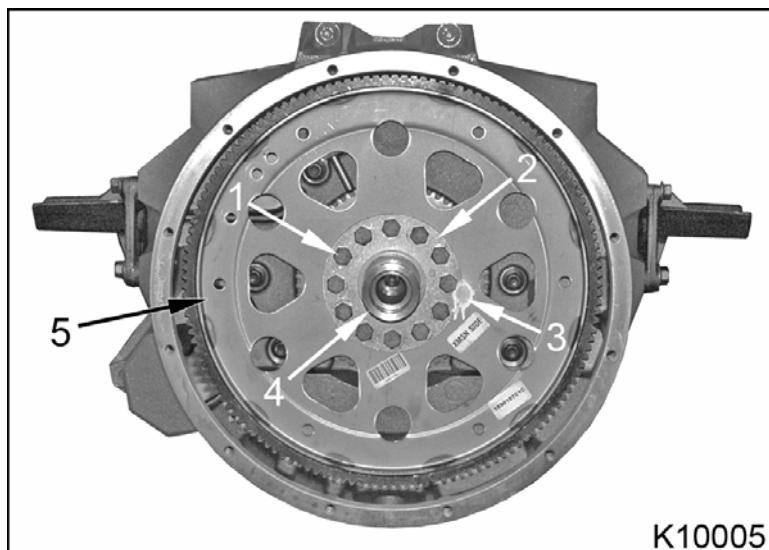
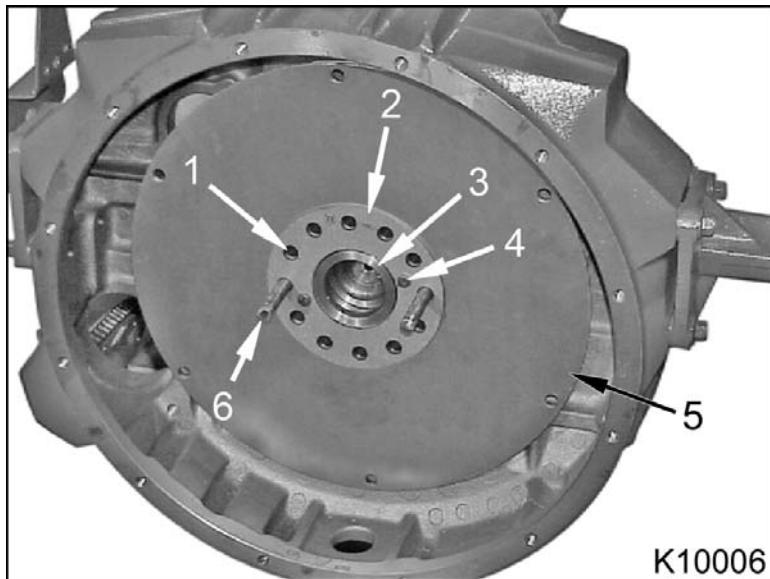


Figure 445 Adaptor hub, flexplate, and reinforcement ring

- | | | |
|---------------------------------|------------------------|-----------------------|
| 1. M12 x 43 flexplate bolt (12) | 3. Paint marking index | 5. Flexplate assembly |
| 2. Reinforcement ring | 4. AT adapter hub | |
-
2. Install AT adapter hub on guide pins.
 3. Install flexplate assembly on the guide pins.
 4. Install reinforcement ring on the guide pins with paint mark (or XMSN SIDE) facing outward.
 5. Install ten M12 x 43 flexplate bolts finger tight.
 6. Remove guide pins and install remaining two M12 x 43 flexplate bolts finger tight.
 7. Tighten twelve M12 x 43 flexplate bolts to special torque (page 358).
- NOTE:** When installed correctly, the ring gear of the flexplate is offset (not centered) toward the transmission.
- CAUTION:** To prevent engine damage, make sure the reinforcement ring is installed with the paint mark or XMSN SIDE facing outward (towards the transmission), otherwise, premature flexplate failure may occur.

MD-3000 Series World Transmissions**Figure 446 Flexplate assembly**

- | | | |
|--------------------------------------|-----------------------------------|-----------------------|
| 1. M12 x 45 flexplate bolt hole (12) | 3. Crankshaft hub adapter | 5. Flexplate assembly |
| 2. Reinforcement ring | 4. M6 flexplate assembly bolt (2) | 6. Guide pin (2) |

1. Install two guide pins (made locally) in flexplate mounting bolt holes, 180° from each other.

CAUTION: To prevent engine damage, make sure the paint mark, part number, or XMSN SIDE on the flexplate is facing outward (towards the transmission).

NOTE: The flexplate assembly is available as a complete assembled service part.

2. Install flexplate assembly over the guide pins.

NOTE: The following step applies to MD transmissions only.

3. Install reinforcement ring with part number or logo facing out (towards the transmission).

4. Install ten M12 x 45 flexplate bolts finger tight.

5. Remove guide pins and install remaining two M12 x 45 flexplate bolts finger tight.

6. Tighten M12 x 45 flexplate bolts to special torque (page 358).

NOTE: Flywheel and ring gear are part of the torque converter assembly.

Specifications

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

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

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.

Flywheel housing:

Flywheel housing bore concentricity	SAE # 1 = 0.30 mm (0.012 in)
	SAE # 2 = 0.28 mm (0.011 in)
Flywheel housing face runout	SAE # 1 = 0.30 mm (0.012 in)
	SAE # 2 = 0.28 mm (0.011 in)

Crankshaft pilot:

Crankshaft pilot concentricity	0.13 mm (0.005 in)
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Flywheel:

Flat flywheel surface runout maximum (measure at 17.8 cm (7 in) from center)	0.20 mm (0.008 in)
Pot flywheel surface runout maximum (measure at 16.5 cm (6.5 in) from center)	0.20 mm (0.008 in)
Pot flywheel clutch mounting surface runout maximum	0.30 mm (0.012 in)

Flywheel Resurfacing Specifications

Flat flywheel minimum thickness after resurfacing	36.32 mm (1.430 in)
Pot flywheel minimum thickness after resurfacing	39.37 mm (1.550 in)

NOTE: Requires measurement from crankshaft mounting surface of flywheel to clutch surface of flywheel.

Special Torque

Flywheel housing mounting bolts	108 N·m (80 lbf·ft)
M12 flexplate mounting bolts	136 N·m (100 lbf·ft)
M12 flywheel mounting bolts	136 N·m (100 lbf·ft)

Special Service Tools

Dial indicator set	Obtain locally
Guide pins	Obtain locally
H-bar puller	Obtain locally
Loctite® 569 Hydraulic Sealant	Obtain locally
Rear Seal Installer	ZTSE4637
Slide Hammer Puller Set	ZTSE1879