2012 ENGINE

Mechanical - Mazda 3, CX-7

ENGINE OVERHAUL SERVICE WARNING

WARNING:

- **Continuous exposure with USED engine oil has caused skin cancer in laboratory mice. Protect your skin by washing with soap and water immediately after this work.**

ENGINE MOUNTING/DISMOUNTING

1. Install the **SSTs** (arms) to the cylinder block holes as shown, and hand-tighten the bolts **(part No.: 9YA20-1003) or M10 x 1.5T length 90 mm {3.55 in}.**

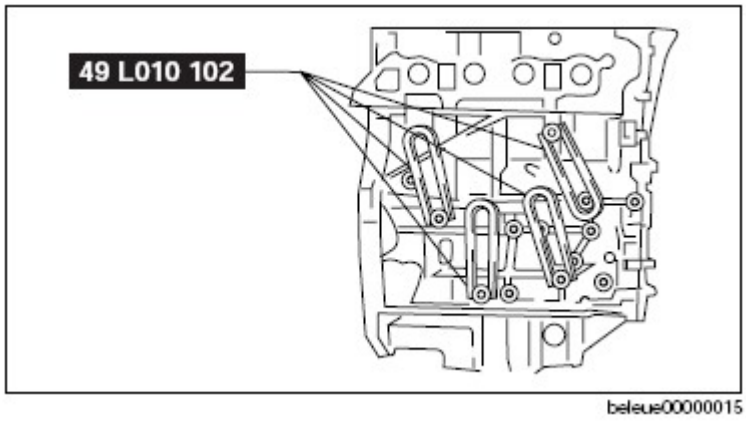


Fig. 1: Identifying SST (49 L010 102) On Cylinder Block

2. Assemble the **SSTs** (bolts, nuts and plate) to the specified positions.
3. Adjust the **SSTs** (bolts) so that less than **20 mm {0.79 in}** of thread is exposed.
4. Make the **SSTs** (arms and plate) parallel by adjusting the **SSTs** (bolts and nuts).

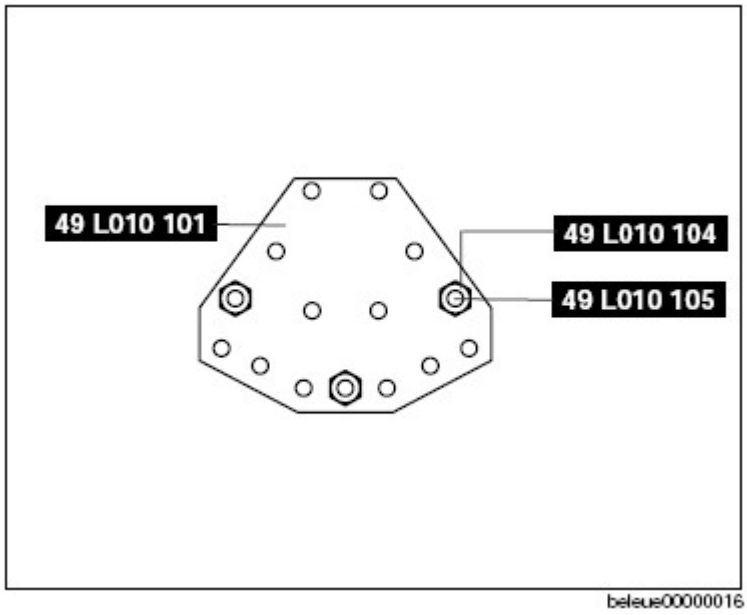


Fig. 2: Identifying SST (Bolts, Nuts And Plate) Positions

5. Tighten the **SSTs** (bolts and nuts) to affix the **SSTs** firmly.

WARNING:

- **Self-locking brake system of the engine stand may not be effective when the engine is held in an unbalanced position. This could lead to sudden, rapid movement of the engine and mounting stand handle and cause serious injury. Never keep the engine in an unbalanced position, and always hold the rotating handle firmly when turning the engine.**

6. Mount the engine on the **SST** (49 0107 680A).
7. Drain the engine oil into a container.
8. Install the oil pan drain plug.

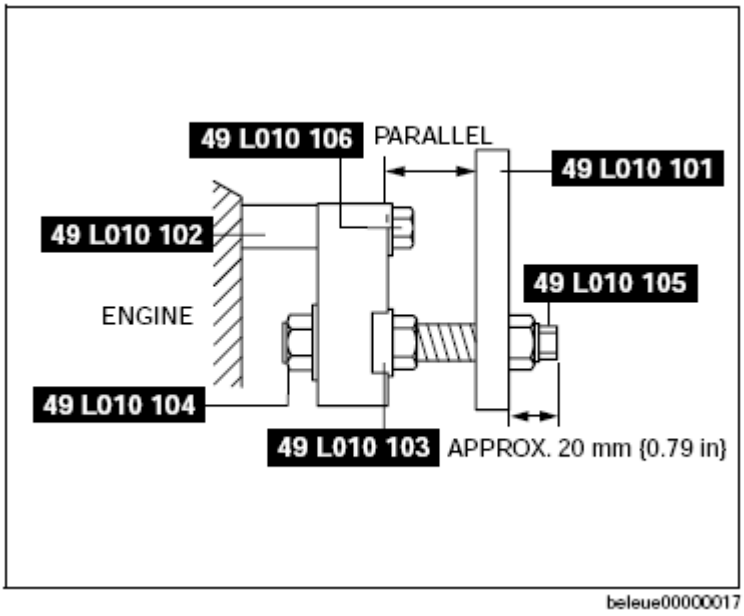


Fig. 3: Identifying SST Bolts And Nuts

1. Inspect the seal rubber of the oil pan drain plug and make sure there are no cracks or damage.
    - If necessary, replace the oil pan drain plug.
2. Clean the flange surface (seal rubber) on the oil pan drain plug, then install the oil pan drain plug.

    Tightening torque

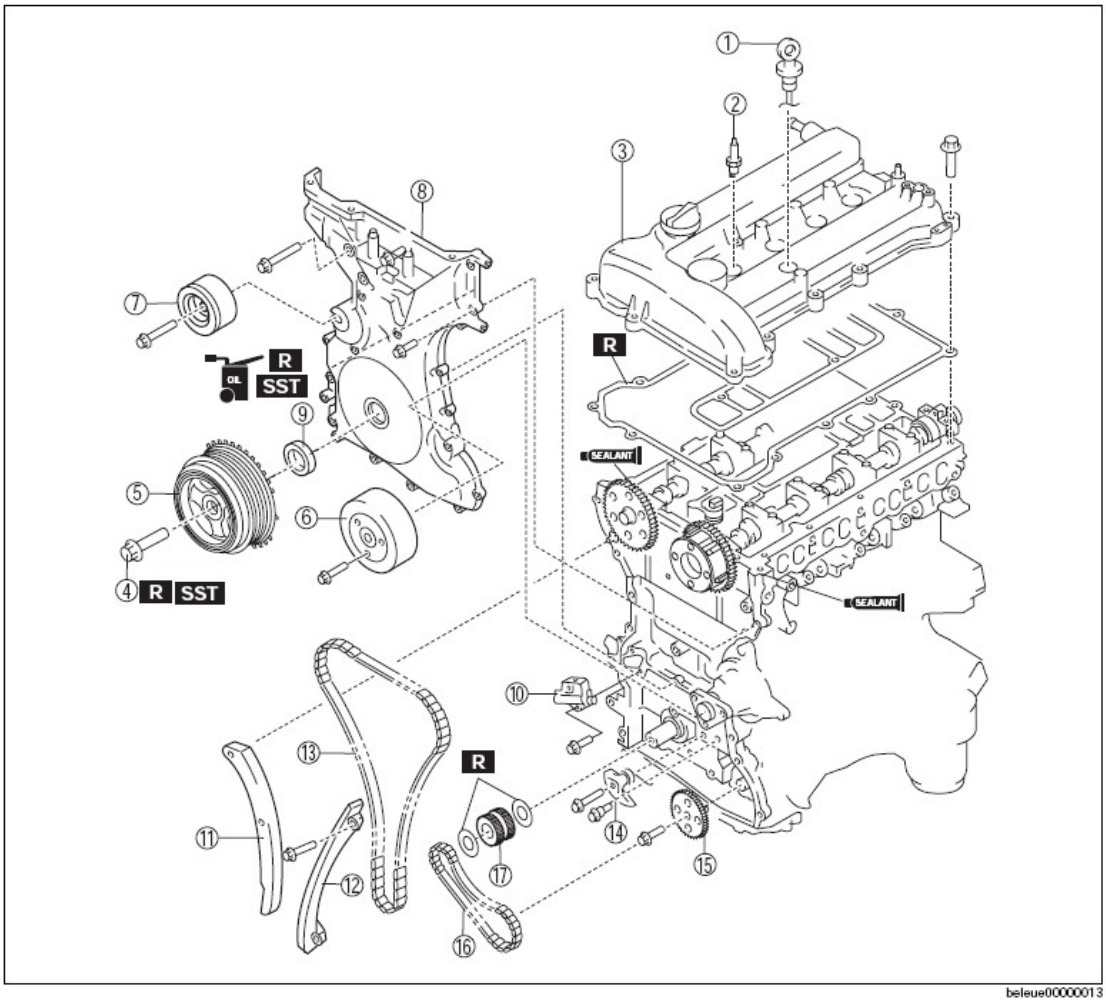
    25-30 N.m {2.6-3.0 kgf.m, 19-22 ft.lbf}

DISMOUNTING

- Dismount in the reverse order of mounting.

TIMING CHAIN DISASSEMBLY

1. Disassemble in the order indicated in the table.



1	Dipstick
2	Spark plug
3	Cylinder head cover
4	Crankshaft pulley lock bolt (See Crankshaft Pulley Lock Bolt Disassembly Note.)
5	Crankshaft pulley
6	Water pump pulley
7	Drive belt idler pulley
8	Engine front cover
9	Front oil seal (See Front Oil Seal Disassembly Note.)

10	Chain tensioner (See Chain Tensioner Disassembly Note.)
11	Tensioner arm
12	Chain guide
13	Timing chain
14	Oil pump chain tensioner
15	Oil pump sprocket (See Oil Pump Sprocket Disassembly Note.)
16	Oil pump chain
17	Crankshaft sprocket

Fig. 4: Identifying Timing Chain Disassemble Order

CRANKSHAFT PULLEY LOCK BOLT DISASSEMBLY NOTE

1. Install the SST to the ring gear to lock the crankshaft against rotation.

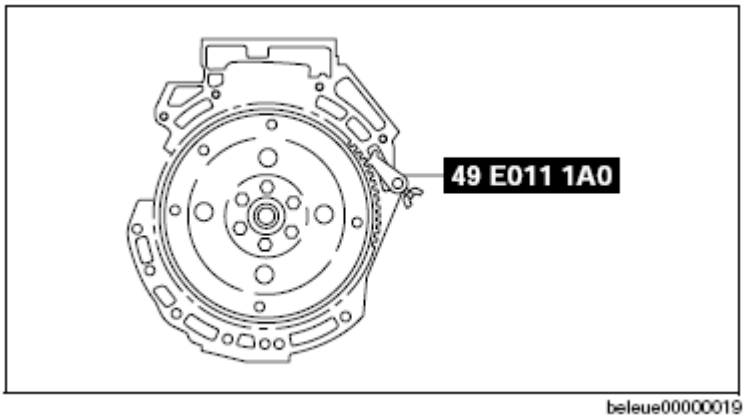


Fig. 5: Identifying SST (Crankshaft Pulley Lock)

FRONT OIL SEAL DISASSEMBLY NOTE

1. Remove the oil seal using a flat head screwdriver.

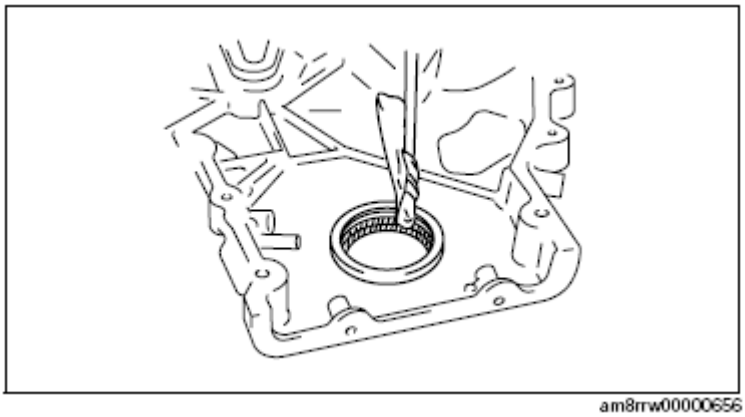


Fig. 6: Removing Oil Seal Using Flat Head Screwdriver

CHAIN TENSIONER DISASSEMBLY NOTE

1. Hold the chain tensioner ratchet lock mechanism away from the ratchet stem with a thin screwdriver.
2. Slowly press the tensioner piston.
3. Hold the chain tensioner piston with a **1.5 mm {0.06 in}** wire or paper clip.

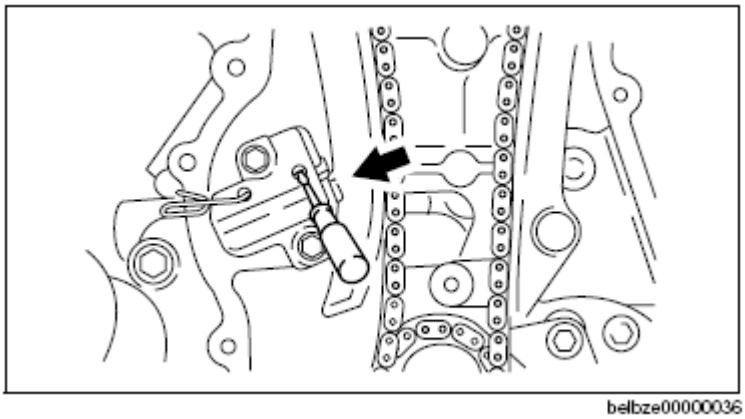


Fig. 7: Holding Chain Tensioner Ratchet Lock Mechanism Away From Ratchet Stem With Thin Screwdriver

OIL PUMP SPROCKET DISASSEMBLY NOTE

1. Temporarily install the crankshaft pulley and crankshaft pulley lock bolt to the crankshaft, and lock the oil pump against rotation as shown in figure.
2. Remove the oil pump sprocket, and then remove the crankshaft pulley and crankshaft pulley lock bolt.

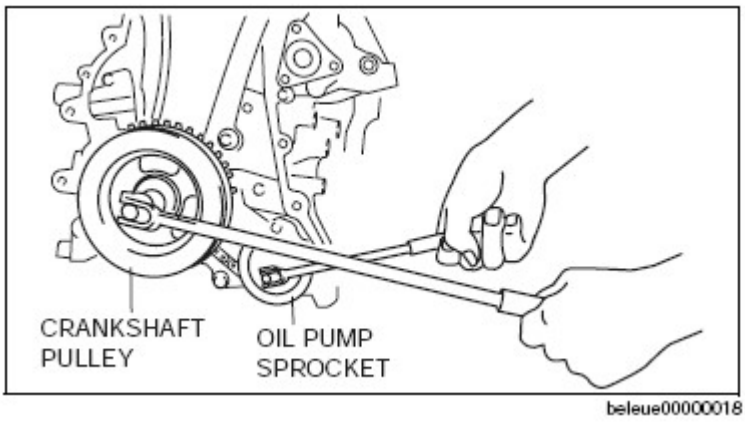
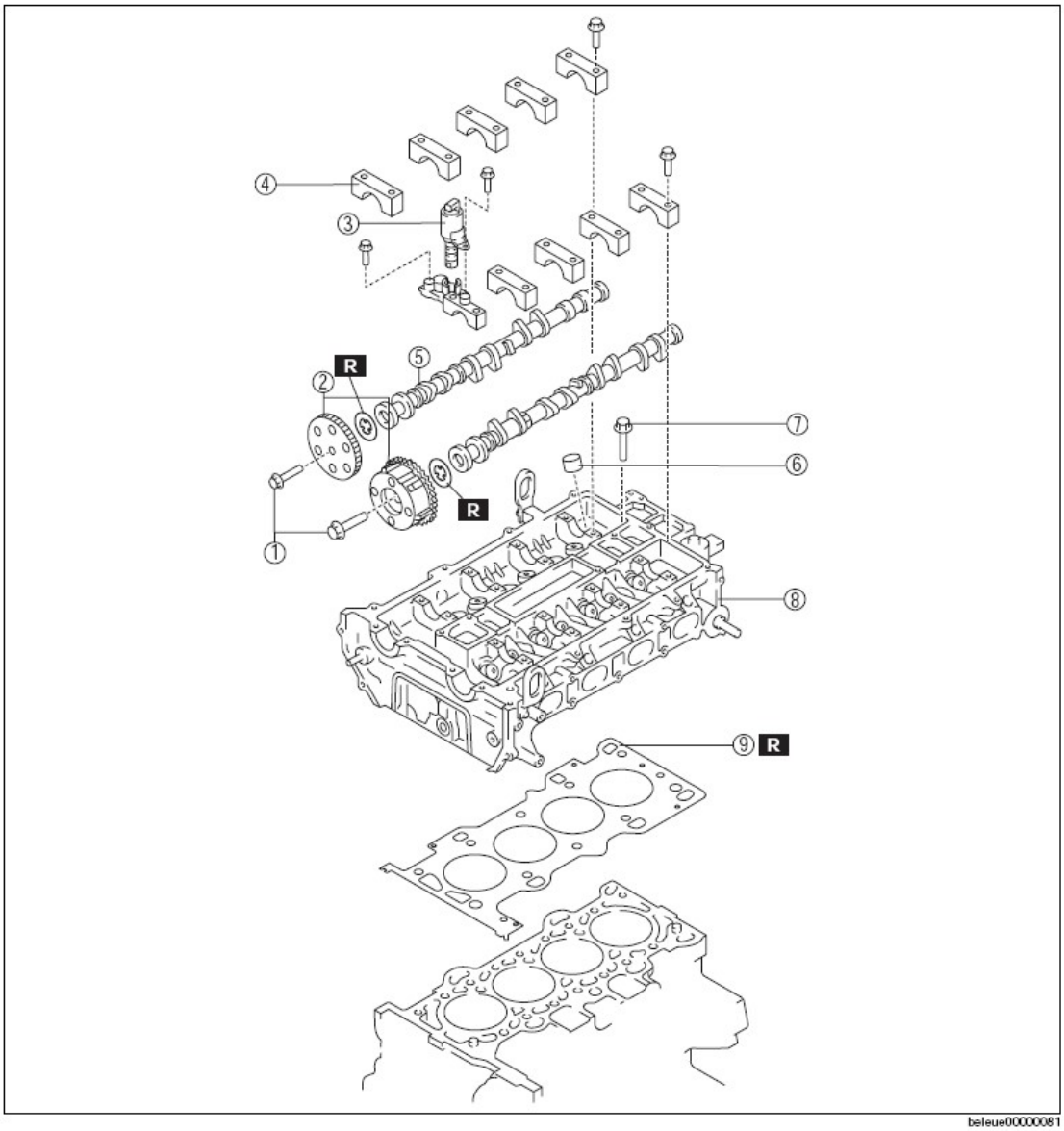


Fig. 8: Removing Crankshaft Pulley And Crankshaft Pulley Lock Bolt

CYLINDER HEAD DISASSEMBLY (I)

1. Disassemble in the order indicated in the table.



1	Camshaft sprocket lock bolt, variable valve timing actuator lock bolt (See Camshaft Sprocket Lock Bolt, Variable Valve Timing Actuator Lock Bolt Disassembly Note.)
2	Camshaft sprocket, variable valve timing actuator
3	OCV
4	Camshaft cap (See Camshaft Cap Disassembly Note.)
5	Camshaft

6	Tappet (See Tappet Disassembly Note.)
7	Cylinder head bolt (See Cylinder Head Bolt Disassembly Note.)
8	Cylinder head
9	Cylinder head gasket

Fig. 9: Identifying Cylinder Head Disassemble Order

CAMSHAFT SPROCKET LOCK BOLT, VARIABLE VALVE TIMING ACTUATOR LOCK BOLT DISASSEMBLY NOTE

1. Hold the camshaft by using a wrench on the cast hexagon as shown, and loosen the camshaft sprocket installation bolt or variable valve timing actuator installation bolt.

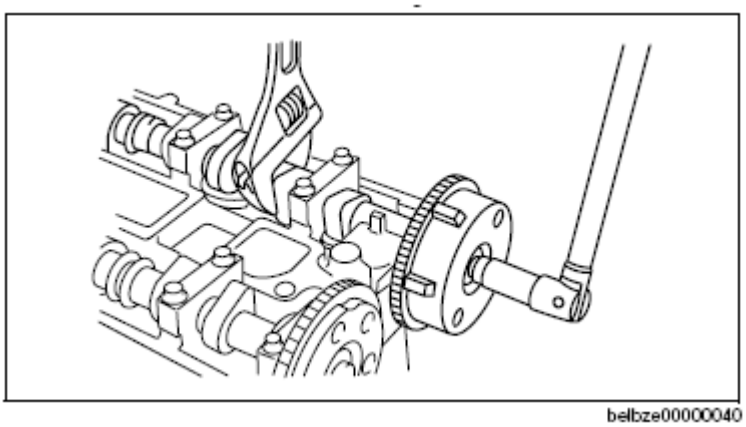


Fig. 10: Loosening Camshaft Sprocket Installation Bolt Or Variable Valve Timing Actuator Installation Bolt

CAMSHAFT CAP DISASSEMBLY NOTE

1. Before removing the camshaft caps, inspect the following:
   - Camshaft end play and camshaft journal oil clearance (See **CAMSHAFT INSPECTION**.)

NOTE:

- **The camshaft caps are numbered to make sure they are assembled in their original positions. When removed, keep the caps with the cylinder head they were removed from. Do not mix the caps.**

2. Loosen the camshaft caps bolts in 2-3 passes in the order shown in the figure.

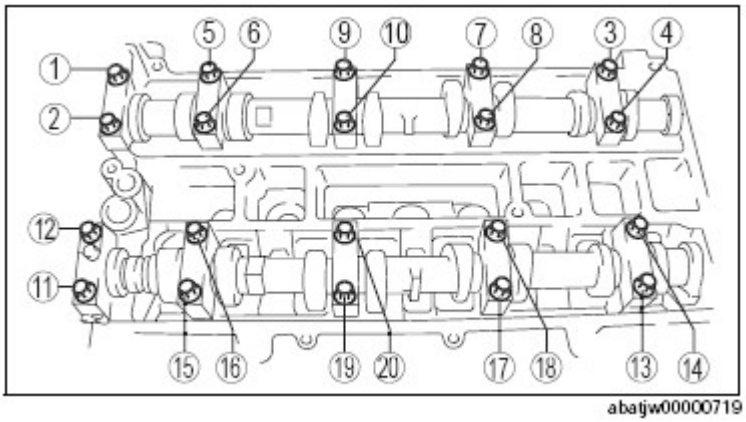


Fig. 11: Identifying Camshaft Caps Bolts Loosening Order

TAPPET DISASSEMBLY NOTE

NOTE:

- **The tappets are numbered to make sure they are assembled in their**

original positions. When removed, keep the tappets with the cylinder head they were removed from. Do not mix the tappets.

CYLINDER HEAD BOLT DISASSEMBLY NOTE

1. Loosen the cylinder head bolts in 2-3 passes in the order shown in the figure.

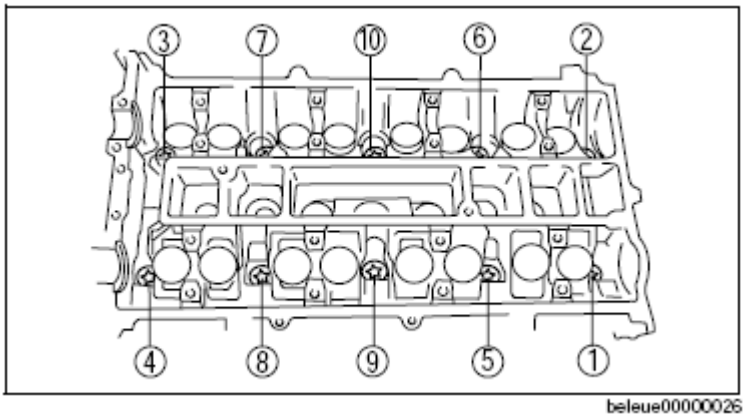
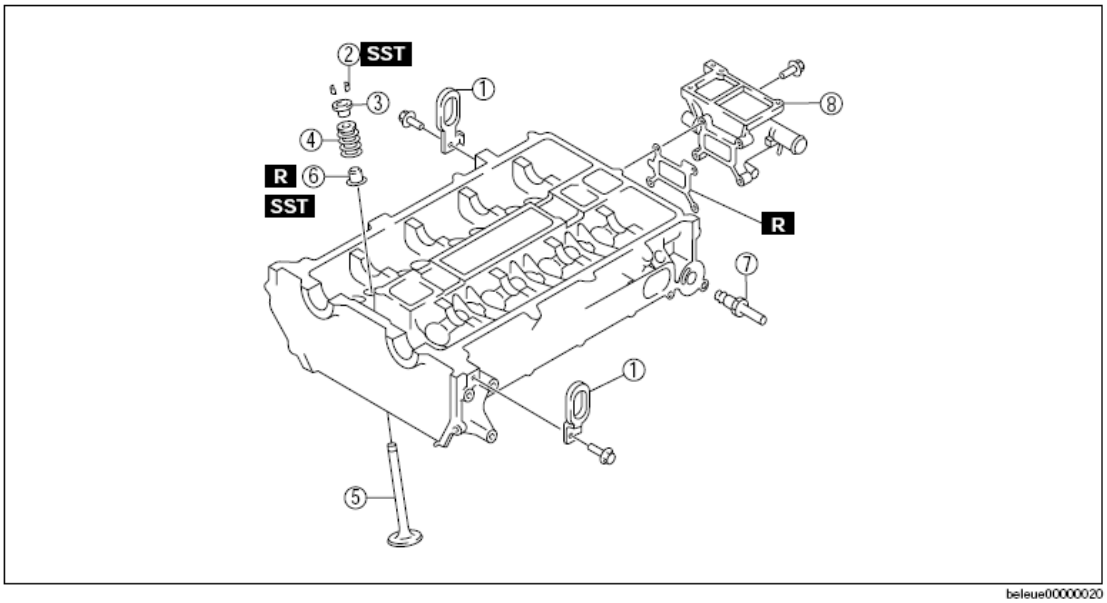


Fig. 12: Identifying Cylinder Head Bolts Loosening Order

CYLINDER HEAD DISASSEMBLY (II)

1. Disassemble in the order indicated in the table.



1	Engine hanger
2	Valve keeper (See Valve Keeper Disassembly Note.)
3	Upper valve spring seat
4	Valve spring

5	Valve
6	Valve seal (See Valve Seal Disassembly Note.)
7	EGR pipe
8	Water outlet case

Fig. 13: Identifying Cylinder Head Disassemble Order

VALVE KEEPER DISASSEMBLY NOTE

1. Remove the valve keeper using the **SSTs.**

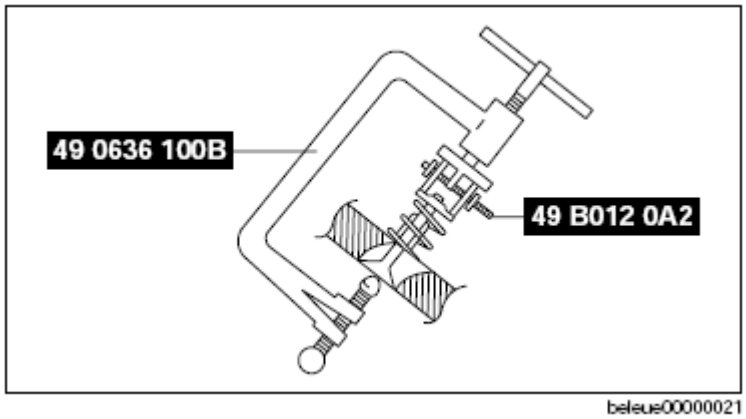


Fig. 14: Removing Valve Keeper Using SSTs

VALVE SEAL DISASSEMBLY NOTE

1. Remove the valve seal using the **SST.**

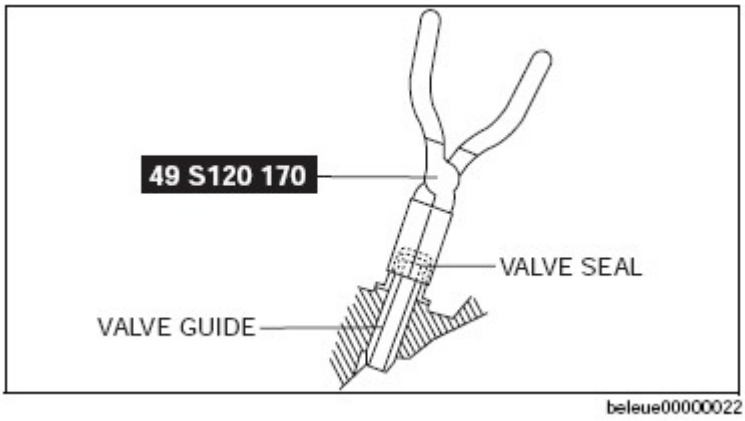
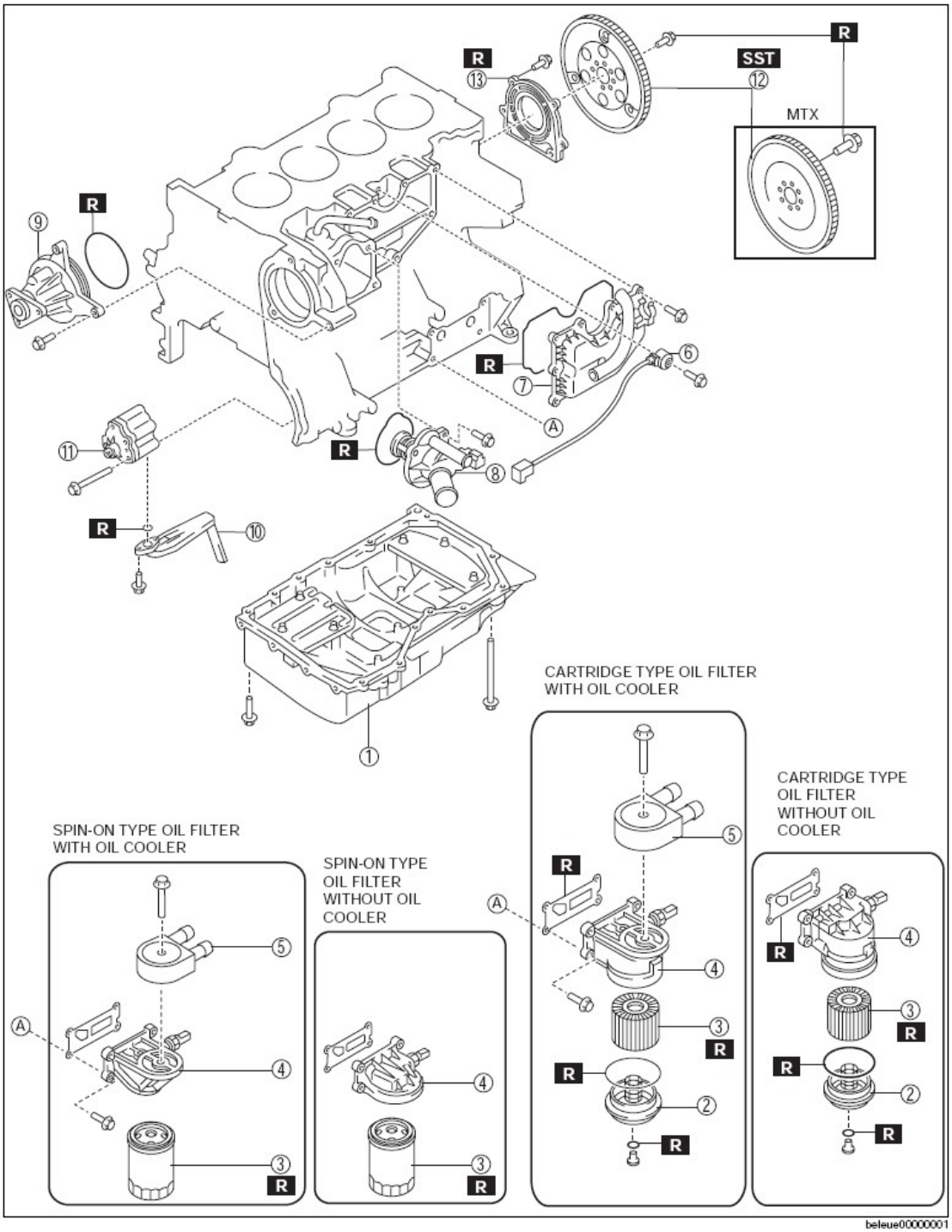


Fig. 15: Removing Valve Seal Using SST

CYLINDER BLOCK DISASSEMBLY (I)

1. Disassemble in the order indicated in the table.



1	Oil pan
2	Oil filter cover
3	Oil filter
4	Oil filter adapter
5	Oil cooler (If equipped)
6	KS
7	Oil separator
8	Thermostat

9	Water pump
10	Oil strainer
11	Oil pump
12	Flywheel (MTX), Drive plate (ATX) (See Drive Plate (ATX), Flywheel (MTX) Disassembly Note)
13	Rear oil seal

Fig. 16: Identifying Cylinder Block Disassemble Order

DRIVE PLATE (ATX), FLYWHEEL (MTX) DISASSEMBLY NOTE

1. Hold the crankshaft using the **SST** .
2. Remove the bolts in several passes.

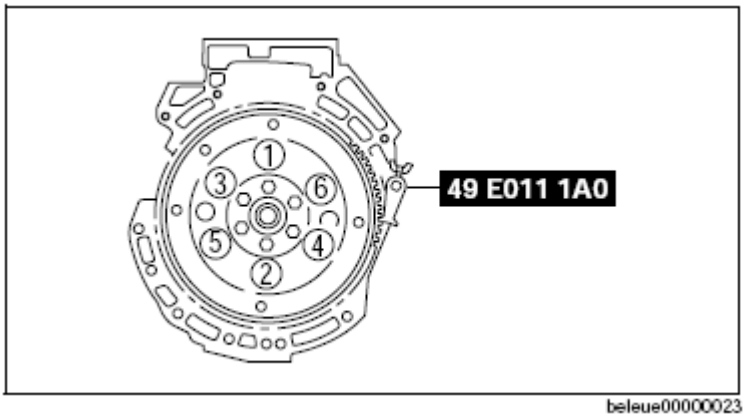


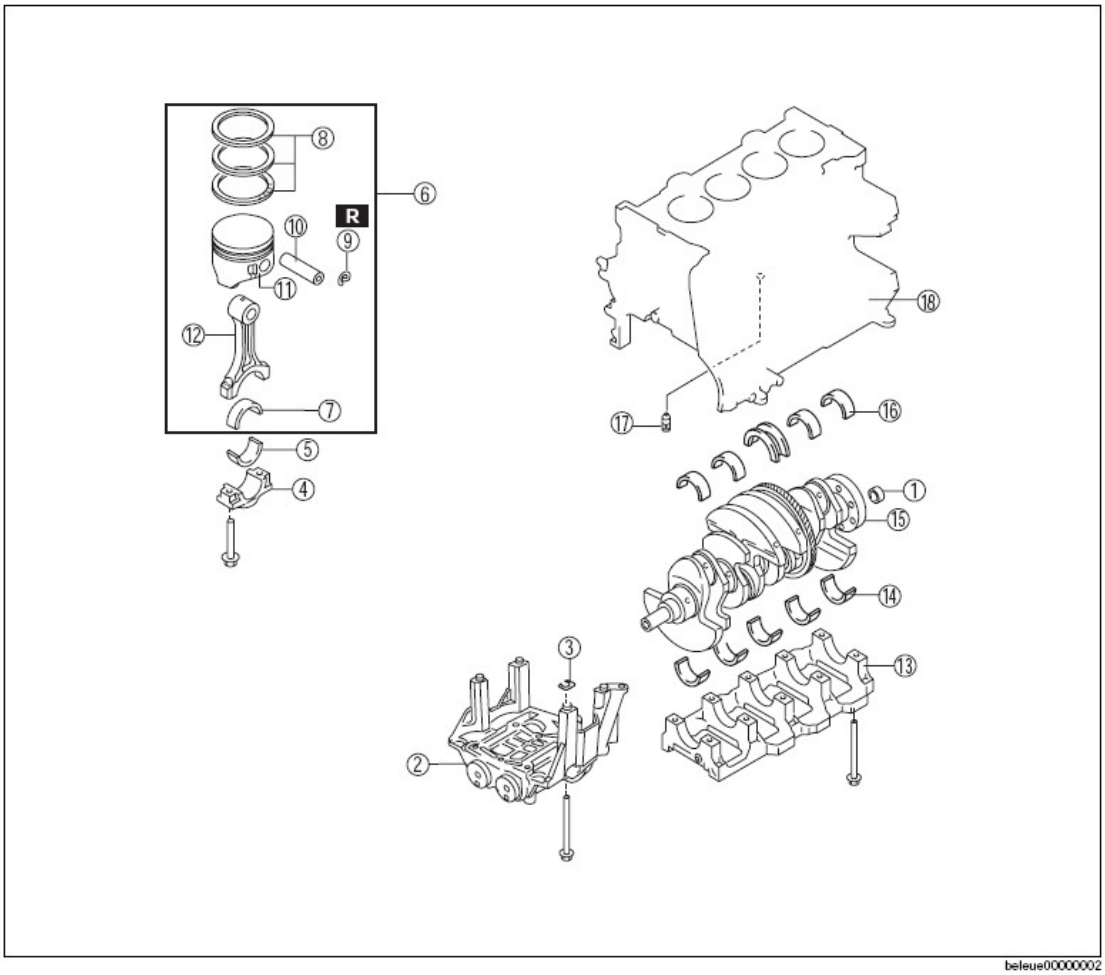
Fig. 17: Identifying Flywheel Bolt Removal Sequence

CYLINDER BLOCK DISASSEMBLY (II)

CAUTION:

- **Placing the crankshaft on a disassembly bench will cause the drive gear to contact the disassembly bench because the crankshaft drive gear is larger than the counterweight. This could result in the drive gear being scratched or damaged which could become a source of noise. Therefore, set wood blocks or similar object on the both sides of the crankshaft or place a thick clean rag under the drive gear so that the drive gear does not contact the disassembly bench directly.**

1. Disassemble in the order indicated in the table.



1	Pilot bearing (MTX) (See Pilot Bearing Disassembly Note.)
2	Balancer unit
3	Adjustment shim
4	Connecting rod cap (See Connecting Rod Cap Disassembly Note.)
5	Lower connecting rod bearing
6	Connecting rod, piston component
7	Upper connecting rod bearing
8	Piston ring

9	Snap ring
10	Piston pin
11	Piston
12	Connecting rod
13	Main bearing cap (See Main Bearing Cap Disassembly Note.)
14	Lower main bearing, thrust bearing
15	Crankshaft
16	Upper main bearing, thrust bearing
18	Cylinder block
17	Oil jet valve

Fig. 18: Identifying Cylinder Block Disassemble Order

PILOT BEARING DISASSEMBLY NOTE

NOTE:

- **Only remove the pilot bearing if there is a malfunction in the pilot bearing or when replacing the crankshaft.**

1. Use the **SST** to remove the pilot bearing.

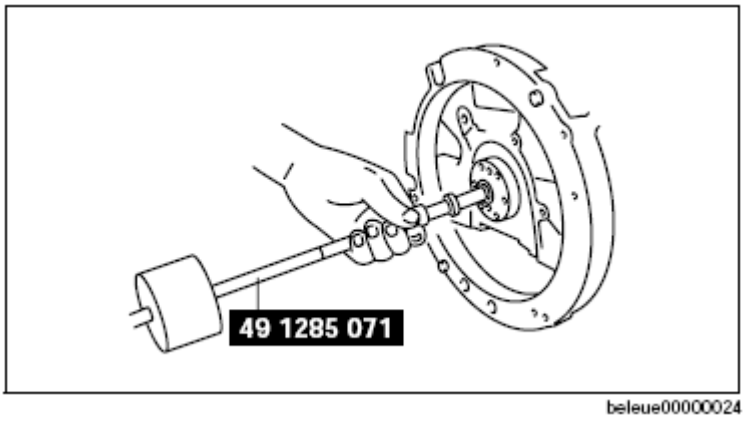


Fig. 19: Removing Pilot Bearing Using SST

CONNECTING ROD CAP DISASSEMBLY NOTE

NOTE:

- **Determine the position of each removed connecting rod cap.**

1. Before removing the connecting rod cap, inspect the connecting rod side clearance. (See **CONNECTING ROD INSPECTION**.)
2. Remove the connecting rod bolt from the connecting rod cap by tapping the bolt with a plastic hammer.

MAIN BEARING CAP DISASSEMBLY NOTE

1. Before removing the main bearing cap, inspect the crankshaft end play. (See **CRANKSHAFT INSPECTION**.)
2. Loosen the main bearing cap bolts in two or three steps in the order shown in the figure.

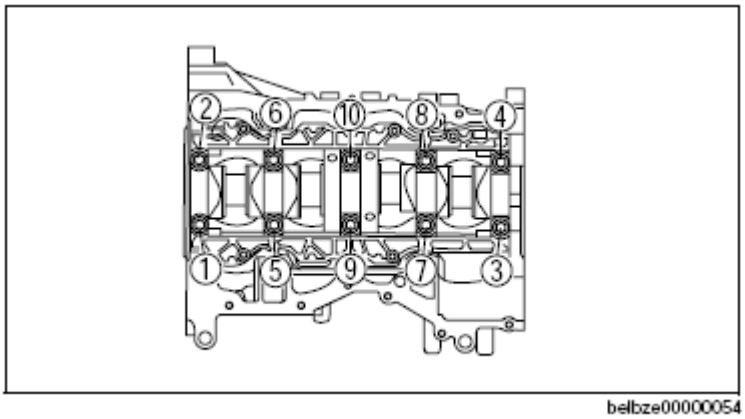


Fig. 20: Identifying Main Bearing Cap Bolts Loosening Sequence

CYLINDER HEAD INSPECTION

1. Perform color contrast penetrate examination on the cylinder head surface.

- Replace the cylinder head if necessary.

2. Inspect for the following and repair or replace if necessary.
    1. Sunken valve seats
    2. Excessive camshaft oil clearance and end play
3. Measure the cylinder head for distortion in six directions as shown in the figure.
    - If it exceeds the maximum specification, replace the cylinder head.

Maximum distortion, head gasket side

0.10 mm {0.004 in}

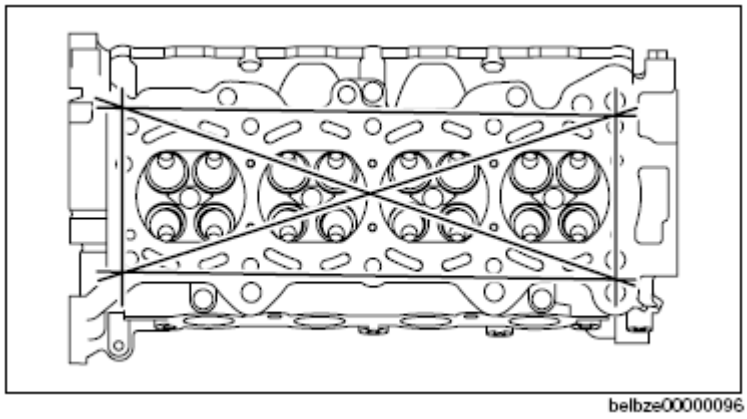


Fig. 21: Measuring Cylinder Head For Distortion In Six Directions

4. Measure the manifold contact surface distortion as shown in the figure.
    - If it exceeds the maximum specification, grind the surface or replace the cylinder head.

Maximum distortion, manifold side

0.10 mm {0.0039 in}

Maximum cutting length, manifold side

0.15 mm {0.0059 in}

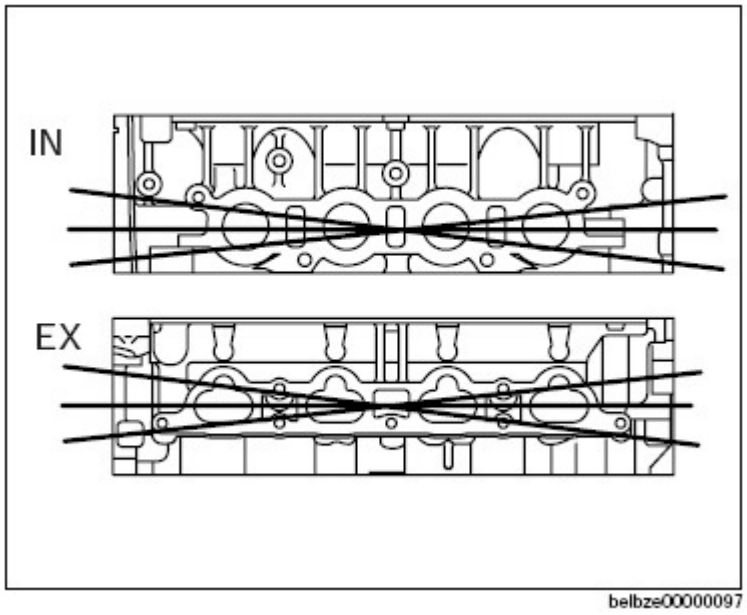


Fig. 22: Measuring Manifold Contact Surface Distortion

VALVE SEAT INSPECTION/REPAIR

1. Measure the contact width of the valve face and the valve seat using the valve lapping compound.
   - If it is not within the specification, resurface the valve seat using the 45° valve seat cutter.

   Standard valve seat contact width

   0.99-1.84 mm {0.039-0.072 in}

2. Verify that the valve seating position is at the center of the valve face.
   1. If the seating position is too inner side, correct the valve seat using a **70°** (IN) or **65°** (EX) cutter, and a **45°** cutter.

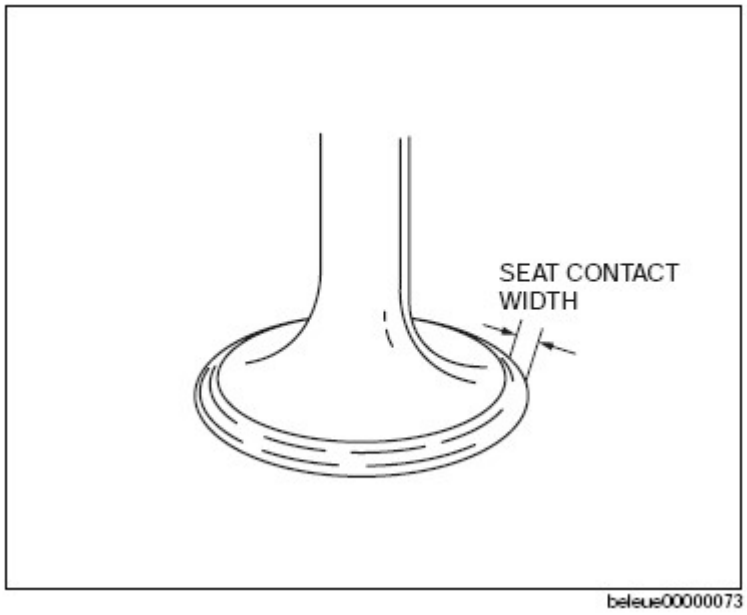


Fig. 23: Checking Valve Seat Contact Width

2. If the seating position is too out side, correct the valve seat using a **30°** (IN) or **0°** (EX) cutter, and a **45°** cutter.

Valve seat angle

45°

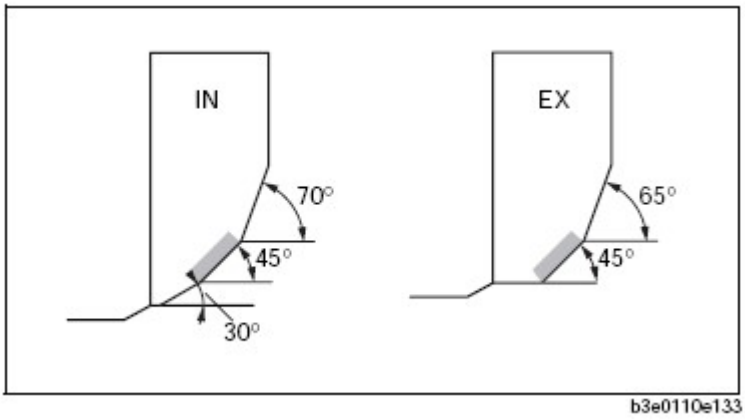


Fig. 24: Checking Valve Seat Angle

3. Inspect the sinking of the valve seat. Measure the protruding length (dimension L) of the valve stem.
   - If not specified, replace the valve.
     - If not as specified, replace the cylinder head.

Standard valve seat sinkage amount

(Dimension L)

IN: 40.64-42.24 mm {1.601-1.662 in}

EX: 40.50-41.30 mm {1.60-1.65 in}

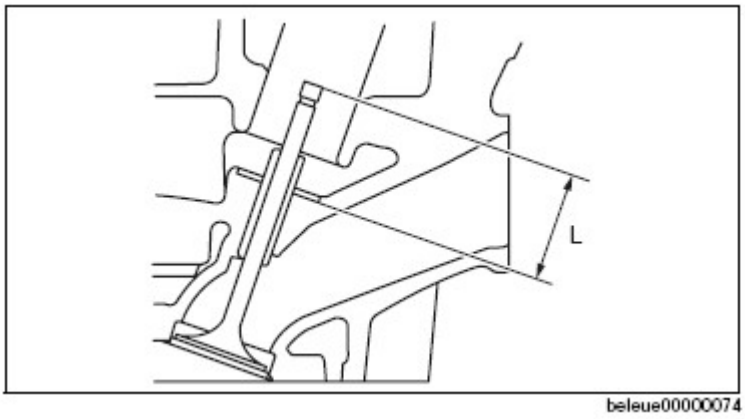


Fig. 25: Measuring Protruding Length (Dimension L) Of Valve Stem

VALVE, VALVE GUIDE INSPECTION

1. Measure the valve head margin thickness using a vernier caliper.
    - If it is less than the specification, replace the valve.

    Minimum valve head margin thickness

    IN: 1.65 mm {0.0650 in}

    EX: 1.85 mm {0.0728 in}

2. Measure the length of each valve. Replace the valve if necessary.
    - If it is less than the specification, replace the valve.

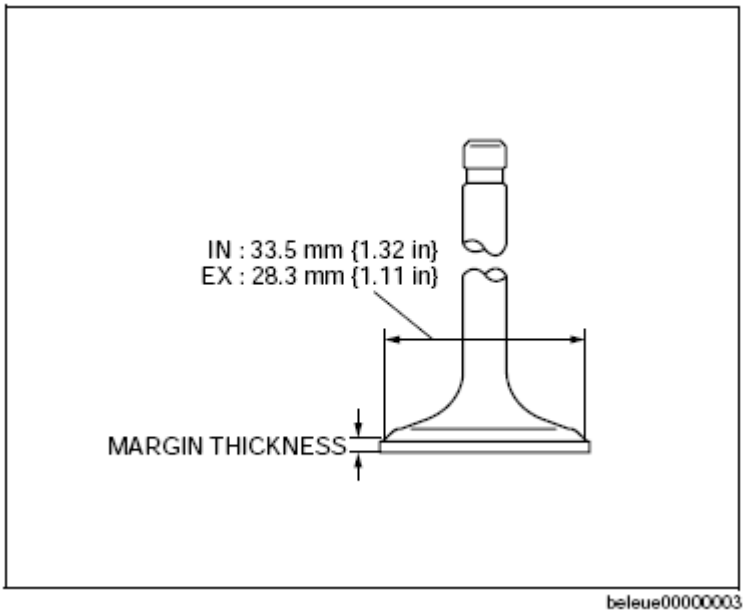


Fig. 26: Checking Valve Head Margin Thickness

Standard valve length (Dimension L)

IN: 102.99-103.79 mm {4.0548-4.0862 in}

EX: 104.25-105.05 mm {4.1044-4.1358 in}

Minimum valve length (Dimension L)

IN: 102.99 mm {4.0548 in}

EX: 104.25 mm {4.1044 in}

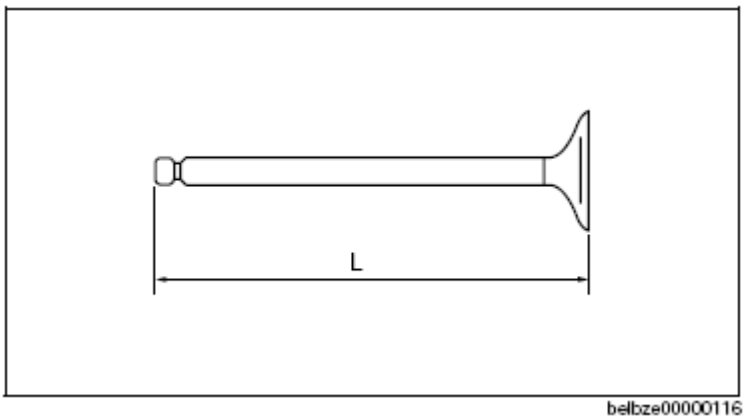


Fig. 27: Measuring Valve Length (Dimension L)

3. Measure the stem diameter of each valve in X and Y directions at the three points (A, B, and C) as

indicated in the figure.

- If it exceeds the specification, replace the valve.

Standard valve stem diameter

IN: 5.470-5.485 mm {0.2154-0.2159 in}

EX: 5.465-5.480 mm {0.2152-0.2157 in}

Minimum valve stem diameter

IN: 5.470 mm {0.2154 in}

EX: 5.465 mm {0.2152 in}

4. Measure the inner diameter of each valve guide in X and Y directions at the three points (A, B, and C) as indicated in the figure.

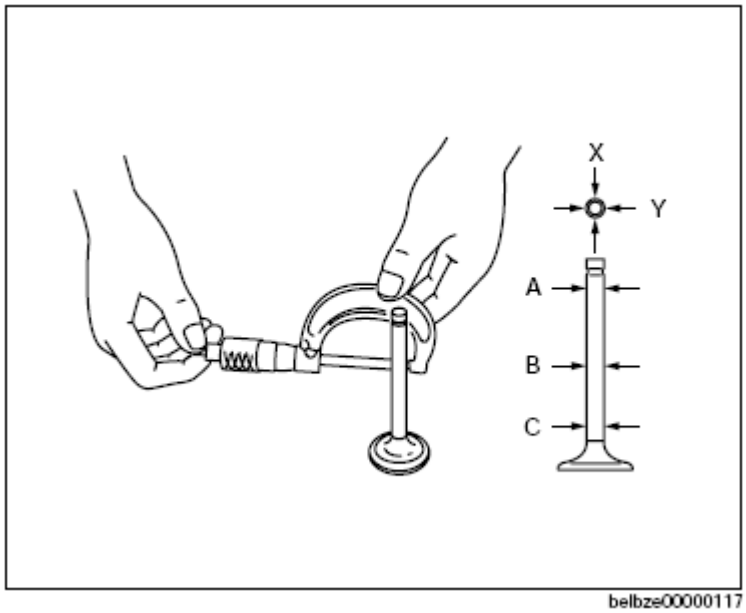


Fig. 28: Measuring Stem Diameter Of Each Valve In X And Y Directions At Three Points (A, B, And C)

- If not as specified, replace the valve guide.

Standard valve guide inner diameter

5.509-5.539 mm {0.2169-0.2180 in}

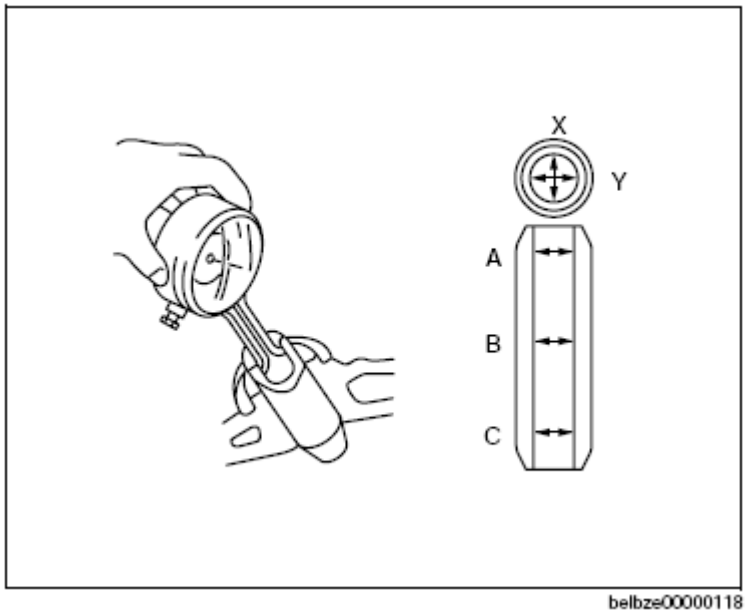


Fig. 29: Measuring Inner Diameter Of Each Valve Guide In X And Y Directions At Three Points (A, B, And C)

5. Calculate the valve stem to guide clearance by subtracting the outer diameter of the valve stem from the inner diameter of the corresponding valve guide.
   - If it exceeds the specification, replace the valve and/or the valve guide.

Standard clearance between valve stem and guide

IN: 0.024-0.069 mm {0.0010-0.0027 in}

EX: 0.029-0.074 mm {0.0012-0.0029 in}

Maximum clearance between valve stem and guide

0.10 mm {0.004 in}

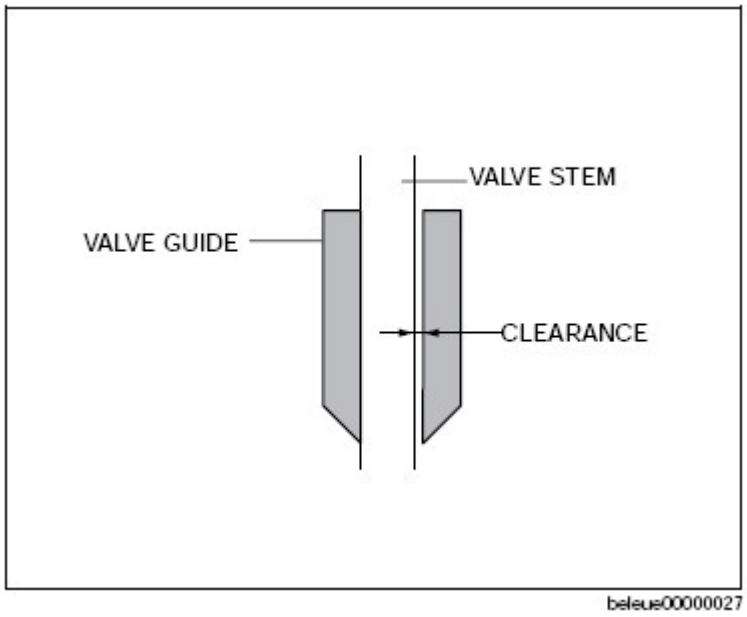


Fig. 30: Inspecting Clearance Between Valve Stem And Guide

6. Measure the protrusion height (dimension A) of each valve guide without lower valve spring seat using the vernier caliper.
   - If not within the specification, replace the valve guide.

Standard valve guide projection height

12.2-12.8 mm {0.481-0.503 in}

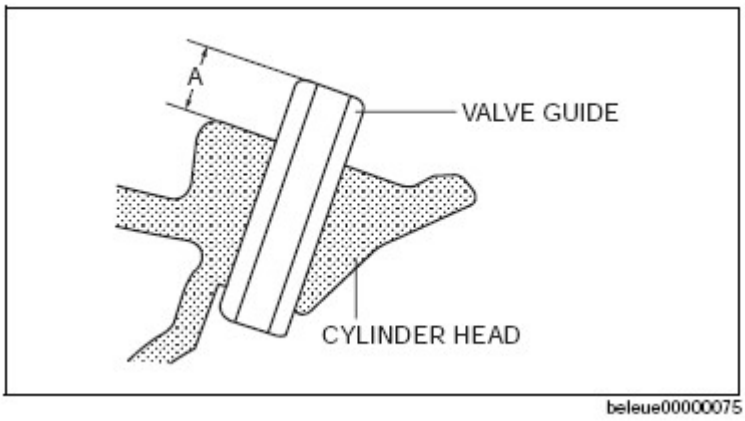


Fig. 31: Measuring Protrusion Height (Dimension A) Of Valve Guide Without Lower Valve Spring Seat

VALVE GUIDE REPLACEMENT

VALVE GUIDE REMOVAL

1. Remove the valve guide from the combustion chamber side using the **SST** .

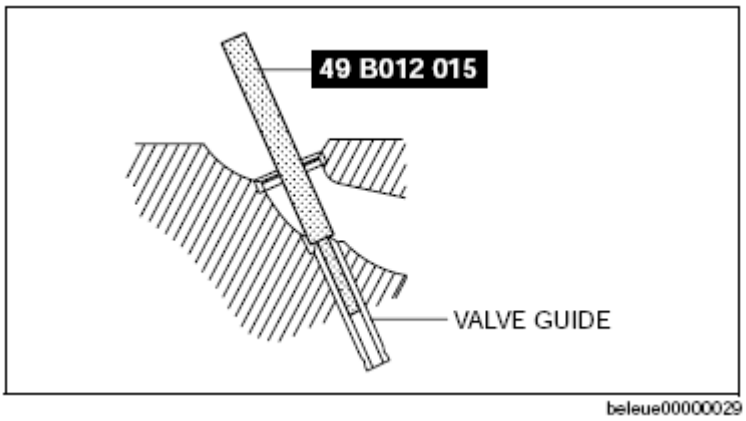


Fig. 32: Removing Valve Guide From Combustion Chamber Side Using SST

VALVE GUIDE INSTALLATION

1. Assemble the **SSTs** so that depth L is as specified.

   Standard valve guide projection height

   12.2-12.8 mm {0.481-0.503 in}

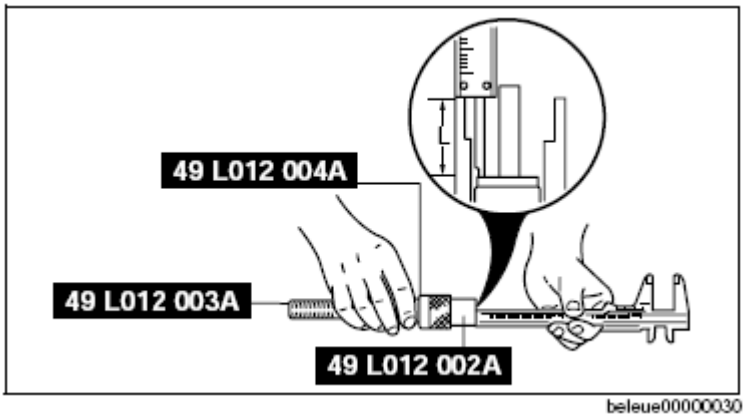


Fig. 33: Measuring Valve Guide Projection Height

2. Tap the valve guide in from the cam side using the **SSTs** assembled in Step 1.

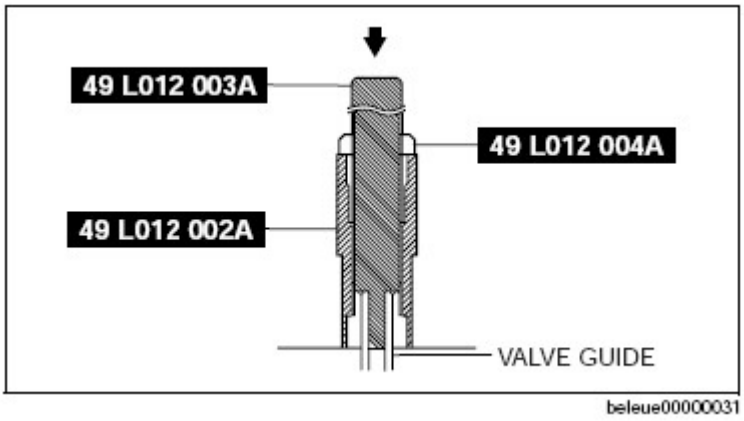


Fig. 34: Tapping Valve Guide In From Cam Side Using SSTs

3. Verify that the valve guide protrusion height (dimension A) is within the specification using the vernier caliper.

   Standard valve guide projection height

   12.2-12.8 mm {0.481-0.503 in}

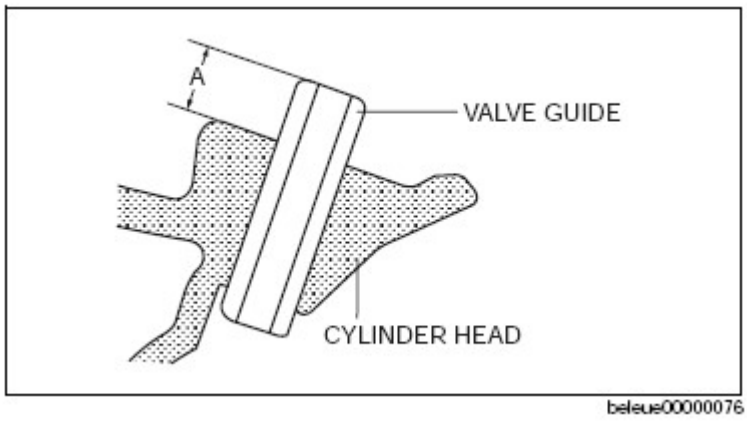


Fig. 35: Measuring Valve Guide Projection Height

VALVE SPRING INSPECTION

1. Apply pressing force to the pressure spring and inspect the spring height.
   - If it is less than the specification, replace the valve spring.

   Valve spring installation height

   28.68 mm {1.129 in} (390 N {39.8 kgf, 87.7 lbf})

2. Measure the out-of-square of the valve spring, using a square, as shown in the figure.

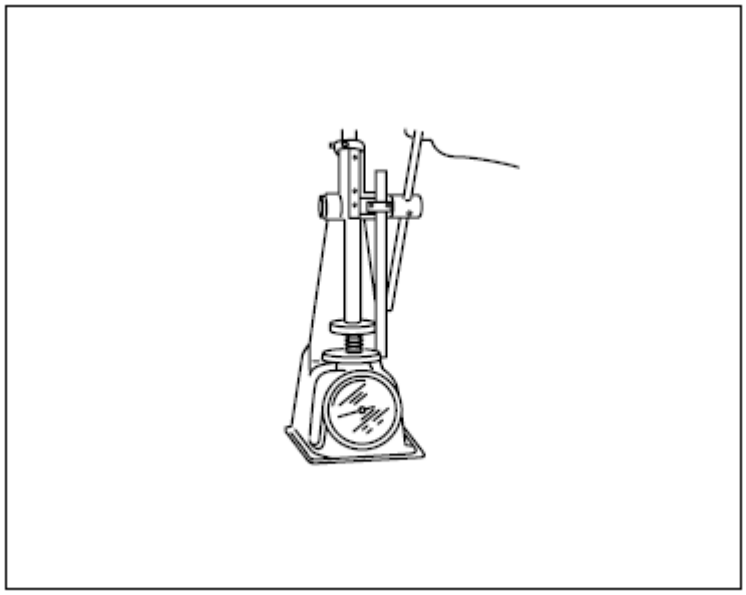


Fig. 36: Measuring Out-Of-Square Of Valve Spring Using Square

1. Rotate the valve spring one full turn and measure "A" at the point where the gap is the largest.
    - If it exceeds the specification, replace the valve spring.

Maximum valve spring off-square

3.41 mm {0.134} (2°)

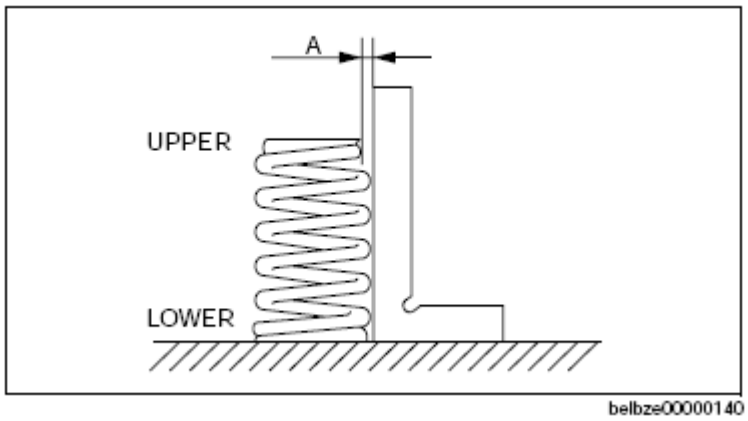


Fig. 37: Measuring Valve Spring Off-Square

TAPPET INSPECTION

1. Measure the tappet hole inner diameter in X and Y directions at the two points (A and B) shown in the figure.

Standard tappet bore diameter

31.000-31.030 mm {1.2205-1.2216 in}

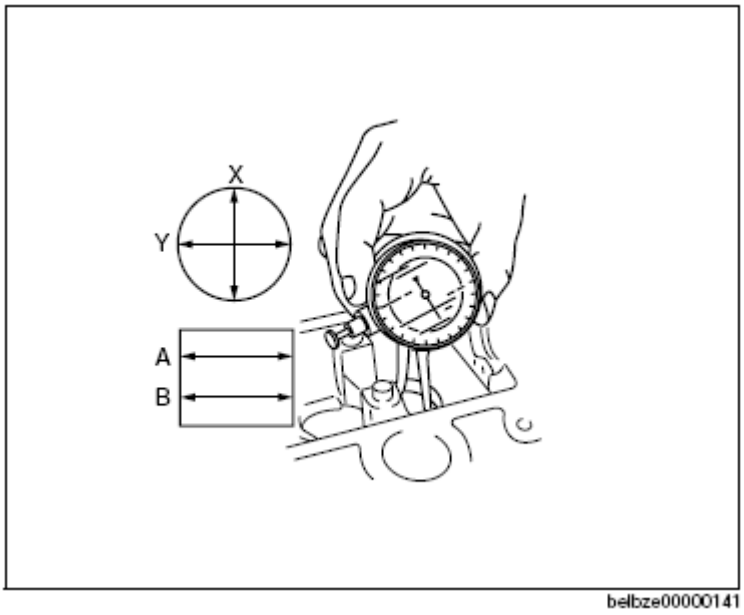


Fig. 38: Measuring Tappet Hole Inner Diameter In X And Y Directions At Two Points (A And B)

2. Measure the tappet body outer diameter in X and Y directions at the two points (A and B) shown in the figure.

   Standard tappet body outer diameter

   30.970-30.980 mm {1.2193-1.2196 in}

3. Subtract the tappet body outer diameter from the tappet hole inner diameter.
   - If it exceeds the specification, replace the tappet or cylinder head.

   Standard clearance between tappet and tappet bore

   0.02-0.06 mm {0.001-0.002 in}

   Maximum clearance between tappet and tappet bore

   0.15 mm {0.0059 in}

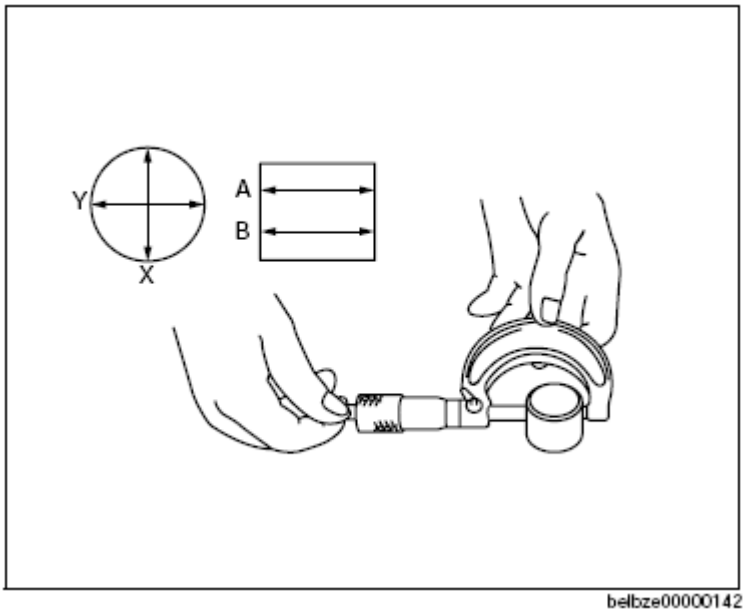


Fig. 39: Measuring Tappet Body Outer Diameter In X And Y Directions At Two Points (A And B)

VARIABLE VALVE TIMING ACTUATOR INSPECTION

CAUTION:
- **Variable valve timing actuator cannot be disassembled because it is a precision unit.**

1. Confirm that the groove of the rotor and notch of the cover at the variable valve timing actuator are aligned and fixed.
   - If the notch and the groove are not aligned, rotate the rotor toward the valve timing retard position by hand until they are in place.
   - If the rotor and cover are not fixed even though their notch and groove are aligned, replace the variable valve timing actuator.

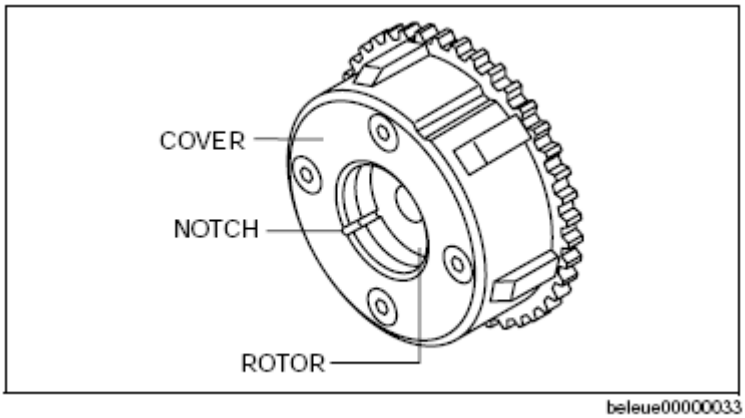


Fig. 40: Inspecting Variable Valve Timing Actuator

OIL CONTROL VALVE (OCV) INSPECTION

COIL RESISTANCE INSPECTION

1. Measure the resistance between terminals A and B using an ohmmeter.
   - If not as specified, replace the OCV.

   OCV coil resistance

   6.9-7.9 ohms [20 °C {68 °F}]

2. Connect the OCV connector.

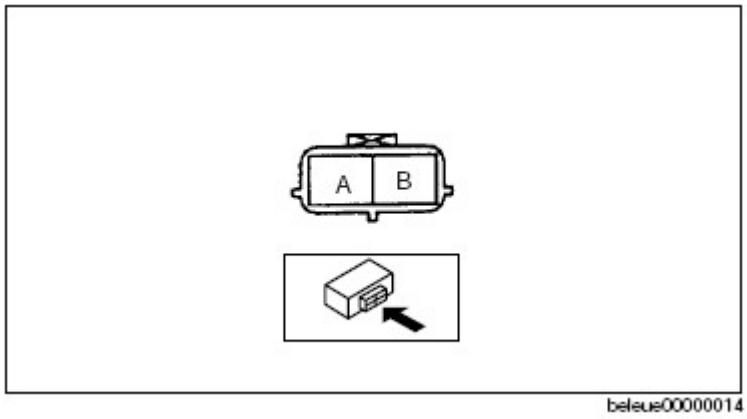


Fig. 41: Identifying OCV Connector Terminals

SPOOL VALVE OPERATION INSPECTION

1. Verify that the spool valve in the OCV is in the maximum valve timing retard position as indicated in the figure.
   - If it exceeds the specification, replace the OCV.
2. Verify that the battery is fully charged.
   - If it is less than specification, recharge the battery.
3. Apply battery positive voltage between the OCV terminals and verify that the spool valve operates and moves to the maximum valve timing advance position.
   - If it exceeds the specification, replace the OCV.

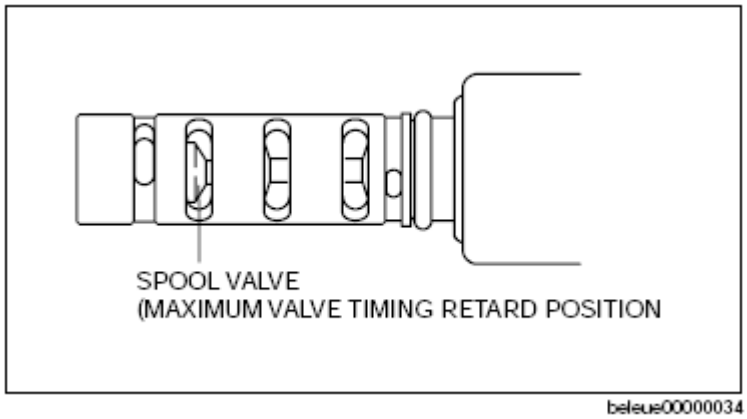


Fig. 42: Inspecting Spool Valve In OCV Is In Maximum Valve Timing Retard Position

NOTE:

- **When applying battery positive voltage between the OCV terminals, the connection can be either of the following:**
  - **Positive battery cable to terminal A, negative battery cable to terminal B**
  - **Positive battery cable to terminal B, negative battery cable to terminal A**

4. Stop applying battery positive voltage and verify that the spool valve returns to the maximum valve timing retard position.
   - If it exceed the specification, replace the OCV.

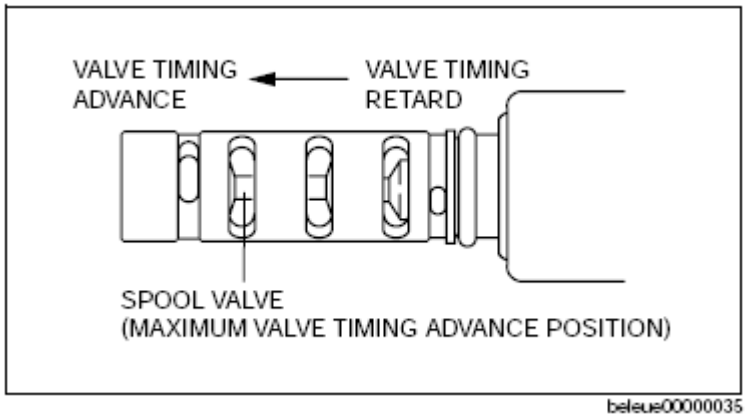


Fig. 43: Inspecting Spool Valve Returns To Maximum Valve Timing Retard Position

CAMSHAFT INSPECTION

1. Set the No.1 and No.5 journals on V-blocks.
2. Measure the camshaft runout.
   - If it exceeds the specification, replace the camshaft.

Maximum camshaft runout

0.03 mm {0.0012 in}

3. Measure the cam lobe height at the two points as shown in the figure.
   - If it is less than the specification, replace the camshaft.

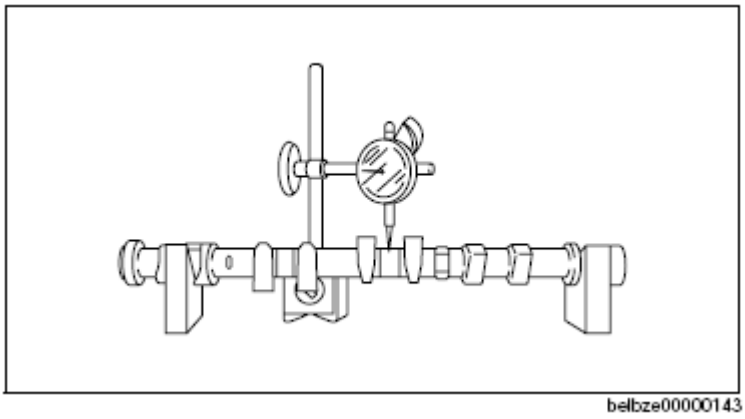


Fig. 44: Measuring Camshaft Runout

Camshaft standard height

IN: 42.44 mm {1.671 in}

EX: 41.18 mm {1.621 in}

Camshaft minimum height

IN: 42.33 mm {1.666 in}

EX: 41.06 mm {1.616 in}

4. Measure the journal diameters in X and Y directions at the two points (A and B) as indicated in the figure.
   - If it is less than the specification, replace the camshaft.

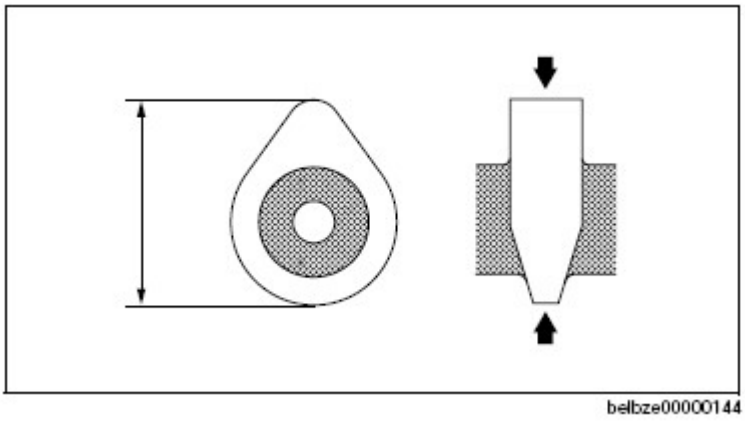


Fig. 45: Measuring Cam Lobe Height At Two Points

Camshaft journal standard diameter

24.96-24.98 mm {0.9827-0.9834 in}

Camshaft journal minimum diameter

24.95 mm {0.9822 in}

5. Remove the tappet.

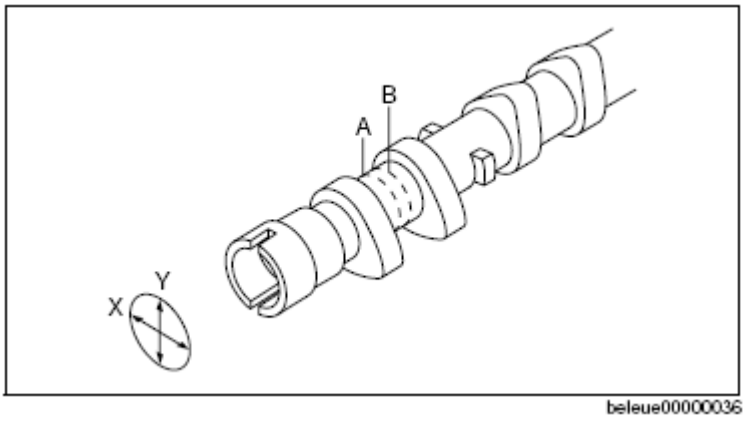


Fig. 46: Measuring Journal Diameters In X And Y Directions At Two Points (A And B)

6. Position a plastigauge atop the journals in the axial direction.
7. Install the camshaft cap. (See **CYLINDER HEAD ASSEMBLY (II)**.)
8. Remove the camshaft cap. (See **CYLINDER HEAD DISASSEMBLY (I)**.)
9. Measure the oil clearance.
    - If it exceeds the specification, replace the cylinder head.

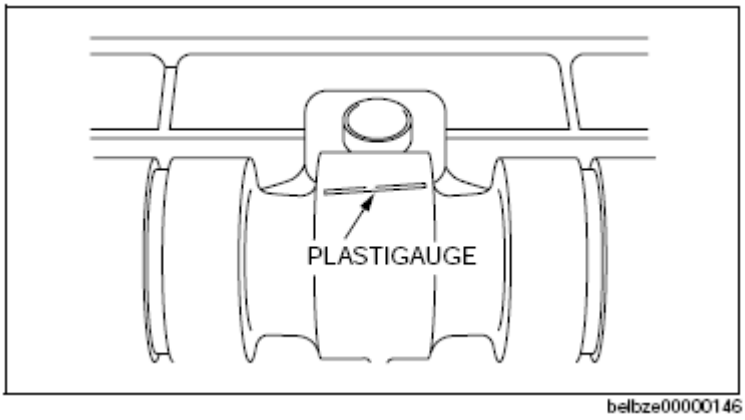


Fig. 47: Positioning Plastigauge Atop Journals In Axial Direction

Camshaft journal standard oil clearance

0.04-0.08 mm {0.002-0.003 in}

Camshaft journal maximum oil clearance

0.09 mm {0.003 in}

10. Install the camshaft cap. (See **CYLINDER HEAD ASSEMBLY (II)**.)
11. Measure the camshaft end play.
    - If it exceeds the specification, replace the cylinder head or camshaft.

Camshaft standard end play

0.09-0.24 mm {0.004-0.009 in}

Camshaft maximum end play

0.25 mm {0.0098 in}

12. Remove the camshaft cap. (See **CYLINDER HEAD DISASSEMBLY (I)**.)

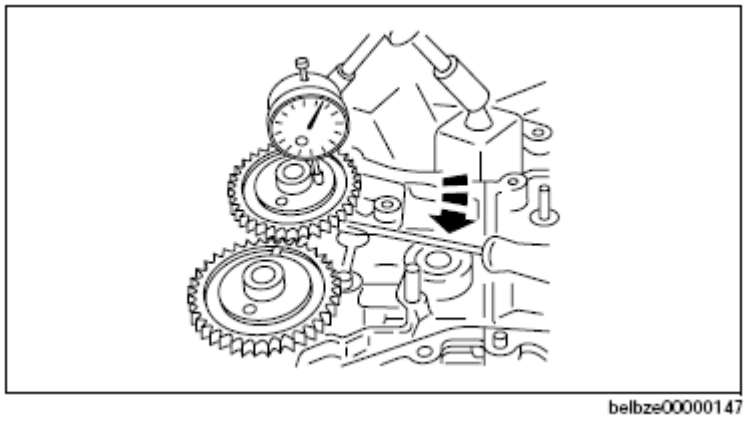


Fig. 48: Measuring Camshaft End Play

CYLINDER BLOCK INSPECTION

1. Measure the distortion of the cylinder block top surface in six directions as indicated in the figure.
   - If it exceeds the maximum, replace the cylinder block.

   Maximum distortion, head gasket side

   0.10 mm {0.0039 in}

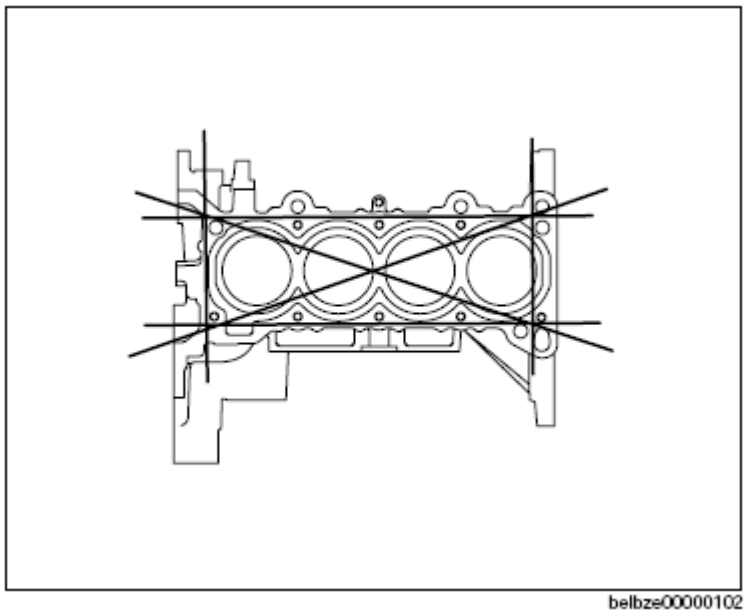


Fig. 49: Measuring Distortion Of Cylinder Block Top Surface In Six Directions

2. Measure the cylinder bores in X and Y directions at **42 mm {1.65 in}** below the top surface.
   - If not within the specification, replace the cylinder block.

Maximum bore inner diameter

89.000-89.030 mm {3.5040-3.5051 in}

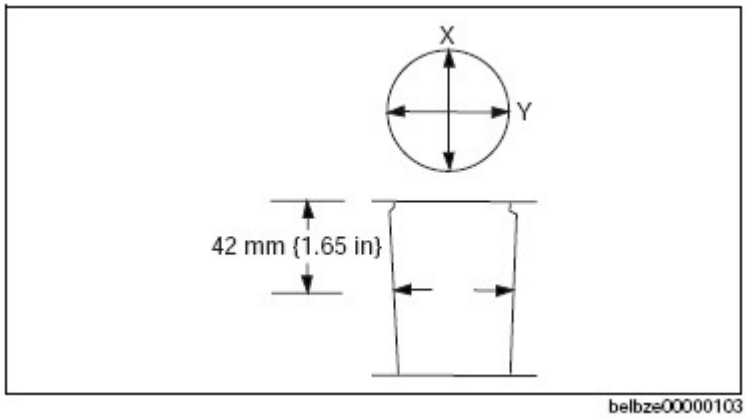


Fig. 50: Measuring Cylinder Bores In X And Y Directions At 42 mm (1.65 in) Below Top Surface

OIL JET VALVE INSPECTION

1. Apply compressed air to oil jet valve A and verify that air passes through oil jet valve B.
   - If air does not flow, replace the oil jet valve.

Air pressure

280 kPa {2.86 kgf/cm^2 , 40.7 psi} or more

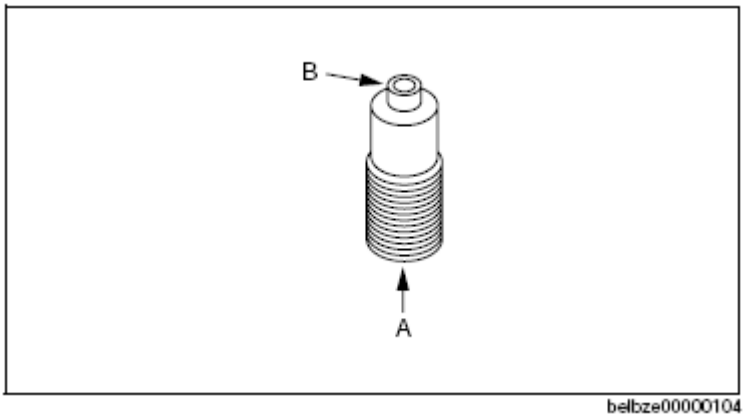


Fig. 51: Inspecting Oil Jet Valve

PISTON INSPECTION

1. Measure the outer diameter of each piston at right angle 90° to the piston pin, 10.0 mm {0.40 in} above the bottom of the piston.

- If not within the specification, replace the piston, piston pin and snap ring as a single unit.

Standard piston outer diameter

88.965-88.995 mm {3.5026-3.5037 in}

2. Measure the piston-to-cylinder clearance.
   - If not within the specification, replace the piston, piston pin and snap ring as a single unit.

Standard clearance between piston and cylinder

0.025-0.045 mm {0.0010-0.0017 in}

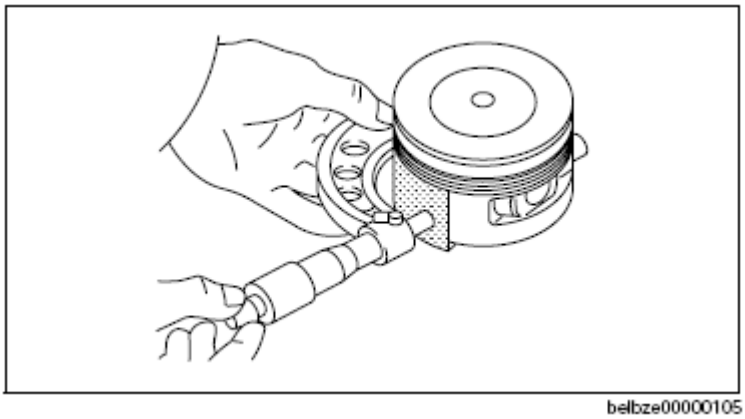


Fig. 52: Measuring Outer Diameter Of Each Piston At Right Angle 90° To Piston Pin, 10.0 mm (0.40 in) Above Bottom Of Piston

Maximum clearance between piston and cylinder

0.11 mm {0.0043 in}

3. Measure the piston ring-to-ring groove clearance around the entire circumference.
   - If it exceeds the specification, replace the piston ring.

Standard clearance between piston ring and ring groove

Top: 0.04-0.08 mm {0.002-0.003 in}

Second: 0.03-0.07 mm {0.0012-0.0027 in}

Oil: 0.06-0.15 mm {0.003-0.005 in}

Maximum clearance between piston ring and ring groove

Top: 0.17 mm {0.0066 in}

Second, Oil: 0.15 mm {0.0059 in}

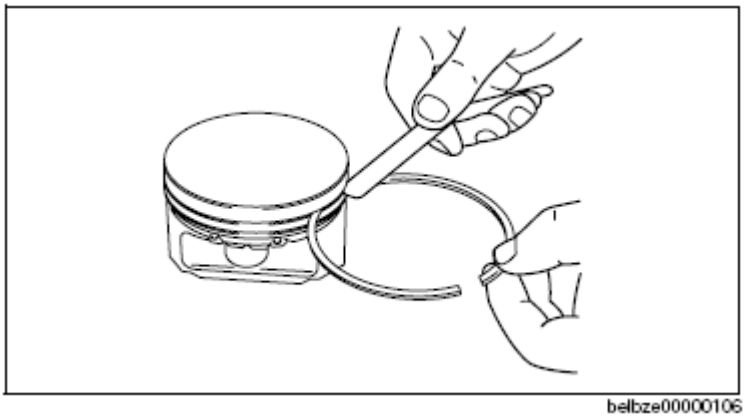


Fig. 53: Measuring Piston Ring-To-Ring Groove Clearance Around Entire Circumference

4. Insert the piston ring into the cylinder by hand and use the piston to push it to the bottom of the ring travel.
5. Measure each piston ring end gap with a feeler gauge.
   - If it exceeds the specification, replace the piston ring.

Standard piston ring end gap

Top: 0.16-0.26 mm {0.0063-0.010 in}

Second: 0.31-0.46 mm {0.013-0.018 in}

Oil (rail): 0.15-0.40 mm {0.006-0.015 in}

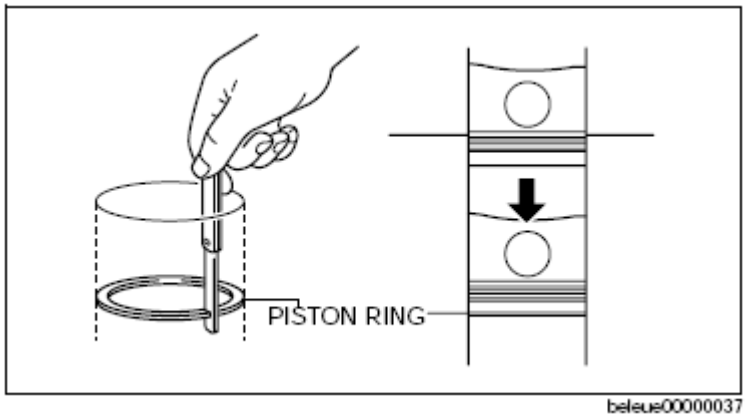


Fig. 54: Measuring Piston Ring End Gap

Maximum piston ring end gap

1.0 mm {0.039 in}

PISTON AND CONNECTING ROD INSPECTION

1. Check the oscillation torque as shown in the figure. Verify that the large end drops under its own weight with no resistance.
    - If the piston shakes heavily or unsmoothly, disassemble the piston and connecting rod, replace the piston and snap ring, piston pin, then inspect the inner diameter of the connecting rod at the small end. (See **CONNECTING ROD INSPECTION**.)

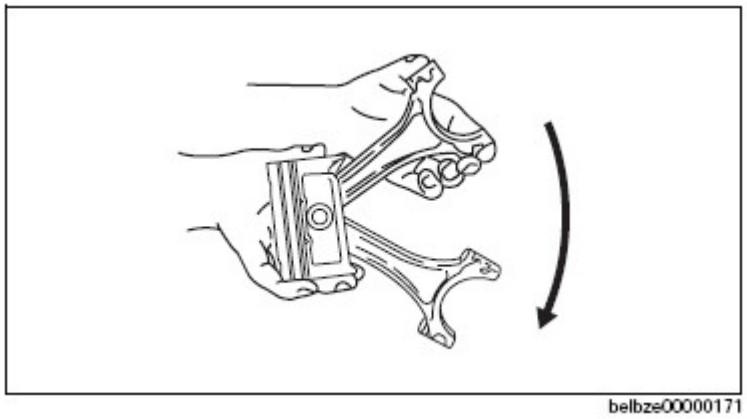


Fig. 55: Inspecting Piston And Connecting Rod

CONNECTING ROD INSPECTION

1. Install the connecting rod cap. (See **CYLINDER BLOCK ASSEMBLY (I)**.)
2. Measure the connecting rod large end side clearance.
    - If it exceeds the specification, replace the piston, piston pin, snap ring and connecting rod.

Connecting rod large end standard side clearance

0.14-0.36 mm {0.006-0.014 in}

Connecting rod large end maximum side clearance

0.435 mm {0.0171 in}

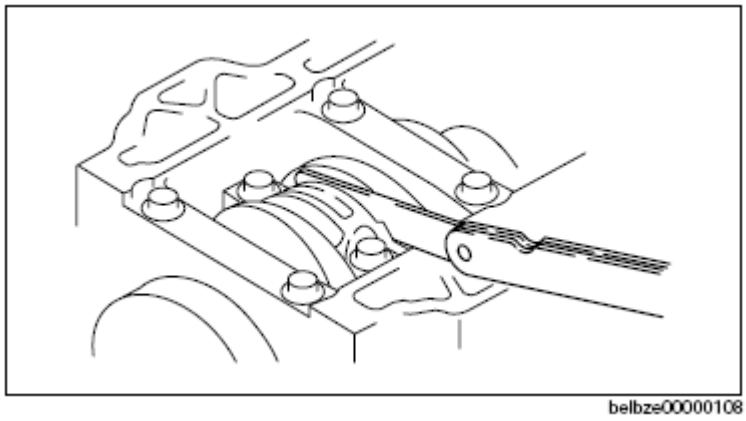


Fig. 56: Measuring Connecting Rod Large End Side Clearance

3. Remove the connecting rod cap.
4. Position plastigauge atop the journals in the axial direction.
5. Install the connecting rod bearing and connecting rod cap. (See **CYLINDER BLOCK ASSEMBLY (I)**.)
6. Remove the connecting rod cap.
7. Measure the connecting rod oil clearance.
    - If it exceeds the specification, replace the connecting rod bearing or grind the crank pin and use oversize bearings so that the specified clearance is obtained.

Standard bearing oil clearance at the large end of connecting rod

0.026-0.052 mm {0.0011-0.0020 in}

Maximum bearing oil clearance at the large end of connecting rod

0.1 mm {0.003 in}

Connecting rod bearing size

STD: 1.497-1.521 mm {0.05894-0.05988 in}

OS 0.25: 1.622-1.628 mm {0.06386-0.06409 in}

OS 0.50: 1.747-1.753 mm {0.06878-0.06901 in}

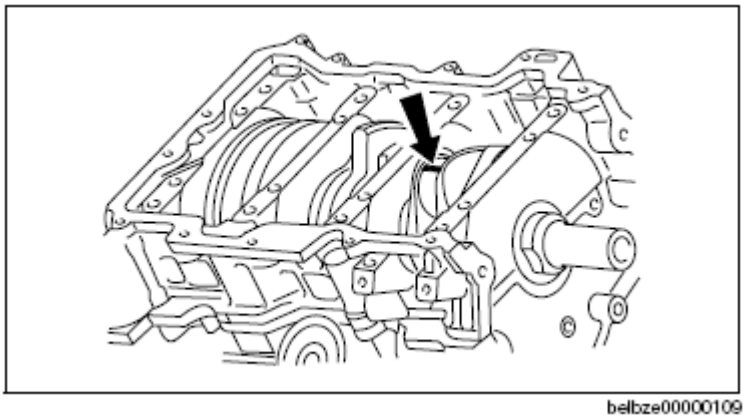


Fig. 57: Measuring Connecting Rod Oil Clearance

8. Measure the connecting rod small end using a caliper gauge.
   - If not exceeds the specification, replace the connecting rod.

   Standard connecting rod small end inner diameter

   20.010-20.021 mm {0.78780-0.78822 in}

9. Calculate the clearance between the connecting rod small end inner diameter and the new piston pin outer diameter.
   - If not exceeds the specification, replace the connecting rod.

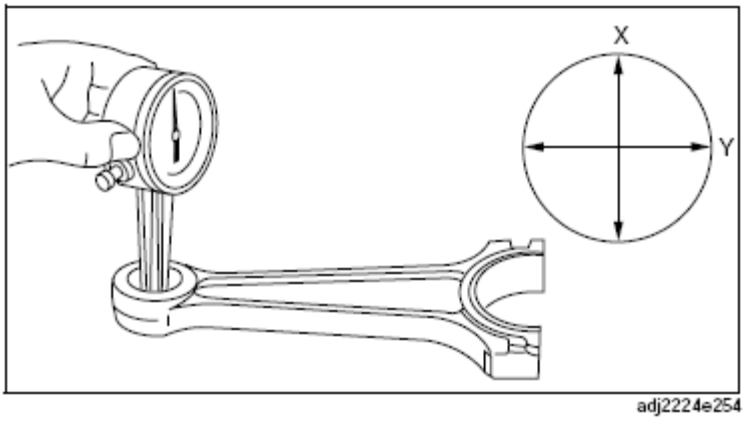


Fig. 58: Measuring Connecting Rod Small End Using Caliper Gauge

Standard clearance between connecting rod small end inner diameter and piston pin outer diameter

0.010-0.026 mm {0.0004-0.0010 in}

CRANKSHAFT INSPECTION

1. Install the main bearing cap. (See **CYLINDER BLOCK ASSEMBLY (I)**.)
2. Measure the crankshaft end play.
   - If it exceeds the specification, replace the thrust bearing or crankshaft so that the specified end play is obtained.

   Crankshaft standard end play

   0.22-0.45 mm {0.009-0.017 in}

   Crankshaft maximum end play

   0.55 mm {0.022 in}

3. Remove the main bearing cap. (See **CYLINDER BLOCK DISASSEMBLY (II)**.)

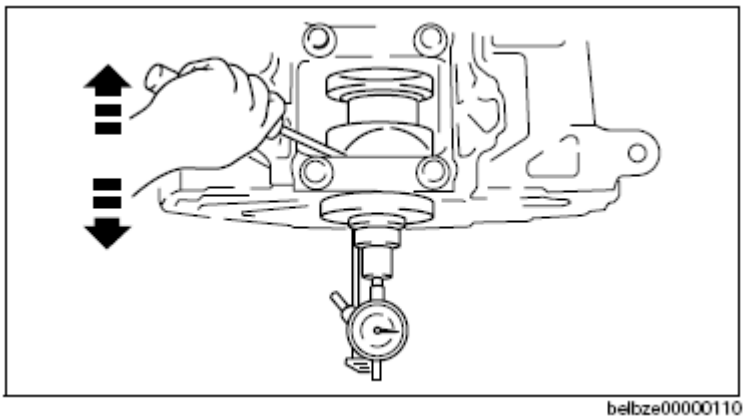


Fig. 59: Measuring Crankshaft End Play

4. Measure the crankshaft runout.
   - If it exceeds the specification, replace the crankshaft.

   Maximum main journal runout

   0.05 mm {0.001 in}

5. Measure the journal diameter in X and Y directions at the two points (A and B) as indicated in the figure.
   - If it exceeds the specification, replace the crankshaft or grind the journal and install the undersize bearing.

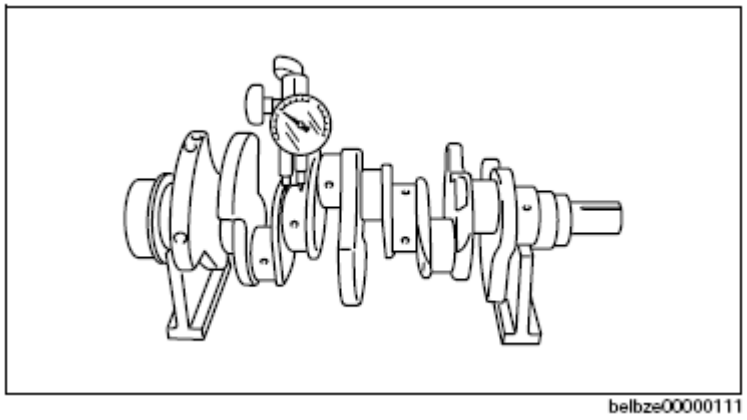


Fig. 60: Measuring Crankshaft Runout

Main journal diameter

STD: 51.980-52.000 mm {2.0465-2.0472 in}

US 0.25: 51.730-51.750 mm {2.0367-2.0374 in}

Maximum main journal off-round

0.005 mm {0.0001 in}

Crank pin diameter

STD: 51.980-52.000 mm {2.0465-2.0472 in}

US 0.25: 51.730-51.750 mm {2.0367-2.0374 in}

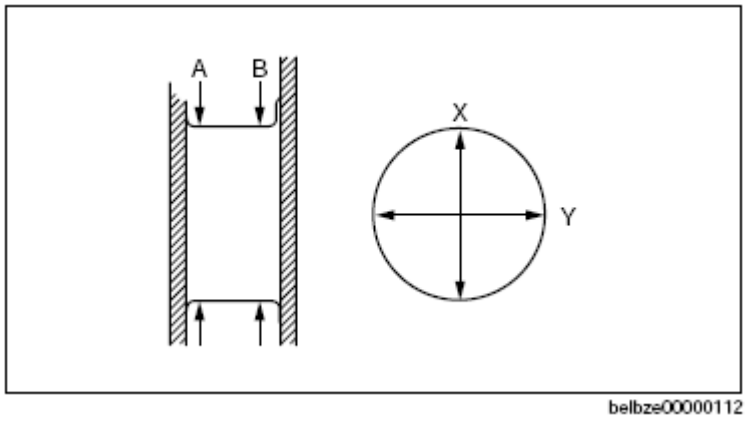


Fig. 61: Measuring Journal Diameter In X And Y Directions At Two Points (A And B)

Maximum crank pin off-round

0.005 mm {0.0001 in}

6. Install the main bearing caps and crankshaft. (See **CYLINDER BLOCK ASSEMBLY (I)**.)
7. Position a plastigauge atop the journals in the axial direction.
8. Install the main bearing caps and cylinder block. (See **CYLINDER BLOCK ASSEMBLY (I)**.)
9. Remove the main bearing caps. (See **CYLINDER BLOCK DISASSEMBLY (II)**.)
10. Measure the main journal oil clearance.
    - If it exceeds the specification, replace the main bearing using the main bearing selection table or grind the main journal and install the oversize bearings so that the specified oil clearance is obtained.

Main journal standard oil clearance

0.016-0.046 mm {0.0007-0.0018 in}

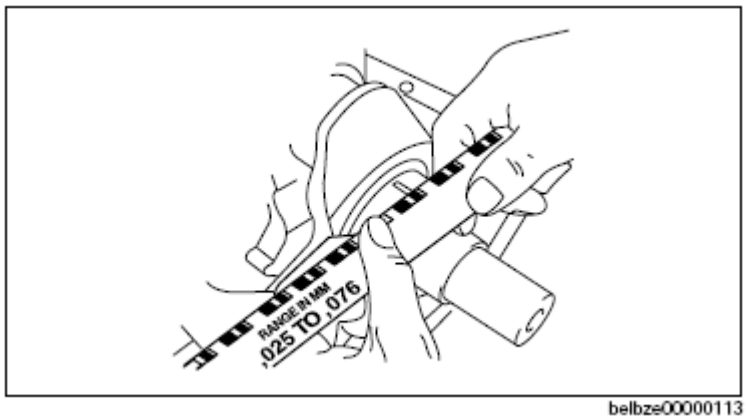
Main journal maximum oil clearance

0.10 mm {0.0039 in}

Main bearing size

STD: 2.501-2.529 mm {0.09847-0.09956 in}

OS0.25: 2.623-2.630 mm {0.1033-0.1035 in}



belbze00000113

Fig. 62: Measuring Main Journal Oil Clearance

PILOT BEARING INSPECTION

1. Without removing the pilot bearing, turn the bearing while applying force in the axial direction.
    - If there is any malfunction, replace the pilot bearing.

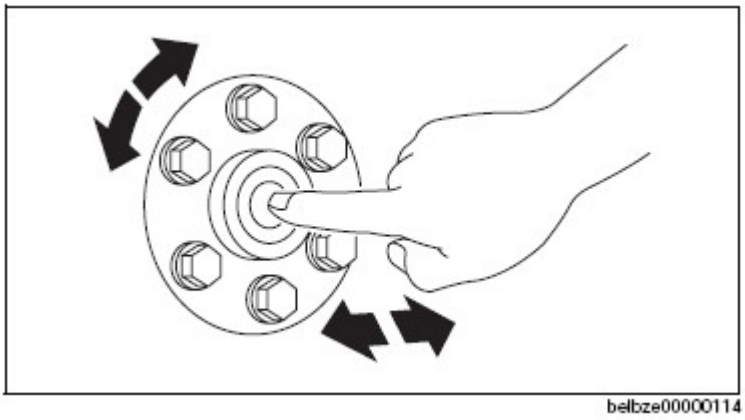


Fig. 63: Inspecting Pilot Bearing

BOLT INSPECTION

1. Measure the length of each bolt.
   - If it exceeds the specification, replace the bolt.

   Cylinder head bolt length

   Standard: 145.2-145.8 mm {5.717-5.740 in}

   Maximum: 146.5 mm {5.768 in}

   Connecting rod bolt length

   Standard: 43.7-44.3 mm {1.73-1.74 in}

   Maximum: 45.0 mm {1.77 in}

   Main bearing cap bolt length

   Standard: 104.0-104.6 mm {4.095-4.118 in}

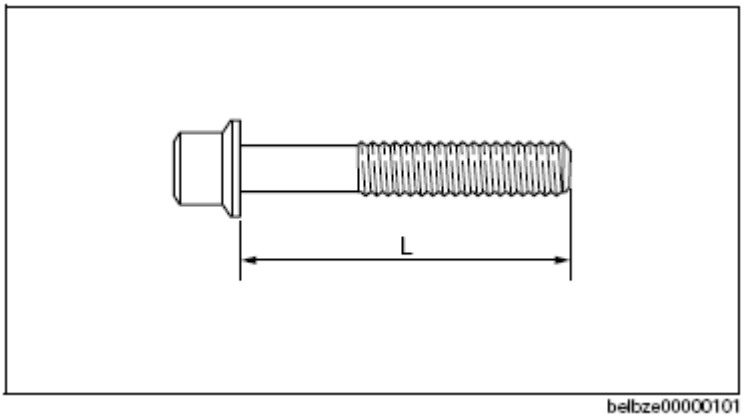


Fig. 64: Measuring Length Of Bolt

VALVE CLEARANCE INSPECTION

1. Measure the valve clearance as follows.
    1. Turn the crankshaft clockwise so that the No.1 piston is at TDC of the compression stroke.
    2. Measure the valve clearance at A in the figure.
        - If the valve clearance exceeds the standard, replace the tappet. (See **VALVE CLEARANCE ADJUSTMENT**.)

    NOTE:
    - **Make sure to note the measured values for choosing the suitable replacement tappets.**

    Standard valve clearance [when cold]

    IN: 0.22-0.28 mm {0.009-0.011 in}

    EX: 0.27-0.33 mm {0.011-0.012 in}

    3. Turn the crankshaft **360°** clockwise so that the No.4 piston is at TDC of the compression stroke.
    4. Measure the valve clearance at B in the figure.
        - If the valve clearance exceeds the standard, replace the tappet. (See **VALVE CLEARANCE ADJUSTMENT**.)

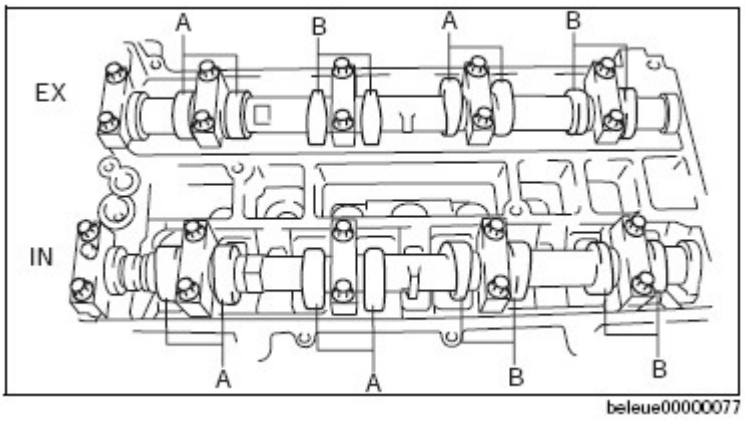


Fig. 65: Identifying Valve Clearance Measuring Locations (A And B)

NOTE:

- **Make sure to note the measured values for choosing the suitable replacement tappets.**

Standard valve clearance [when cold]

IN: 0.22-0.28 mm {0.009-0.011 in}

EX: 0.27-0.33 mm {0.011-0.012 in}

VALVE CLEARANCE ADJUSTMENT

1. Remove the engine front cover lower blind plug.

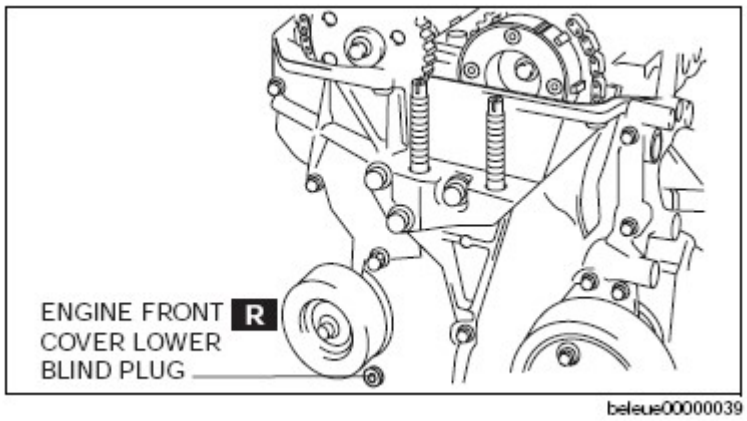


Fig. 66: Identifying Engine Front Cover Lower Blind Plug

2. Remove the engine front cover upper blind plug.

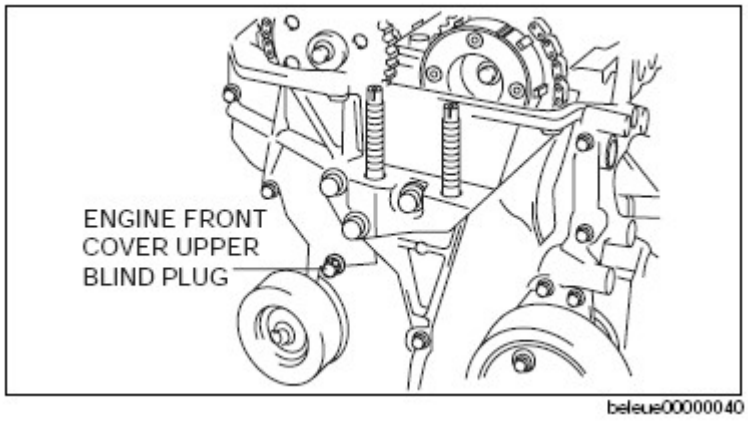


Fig. 67: Identifying Engine Front Cover Upper Blind Plug

3. Remove the cylinder block lower blind plug, and install the **SST** .
4. Rotate the crankshaft in the direction of the engine rotation so that the No.1 piston is at TDC of the compression stroke. (Until the counterweight contacts **SST** and stops.)
5. Loosen the timing chain using the following procedure:

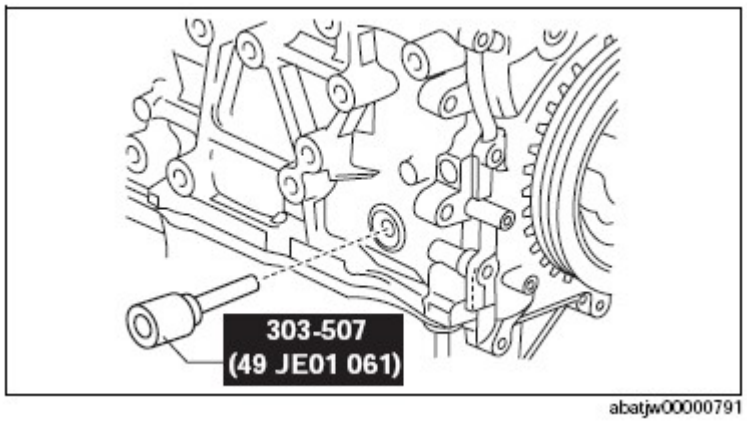


Fig. 68: Identifying SST (303-507)

1. Insert a suitable bolt **(M6 X 1.0, length 25-35 mm {0.99-1.3 in})** into the engine front cover upper blind plug and tighten it until it contacts the chain tensioner arm, and then rotate it back one turn. (Set the bolt slightly away from the chain tensioner arm so that it does not contact it.)

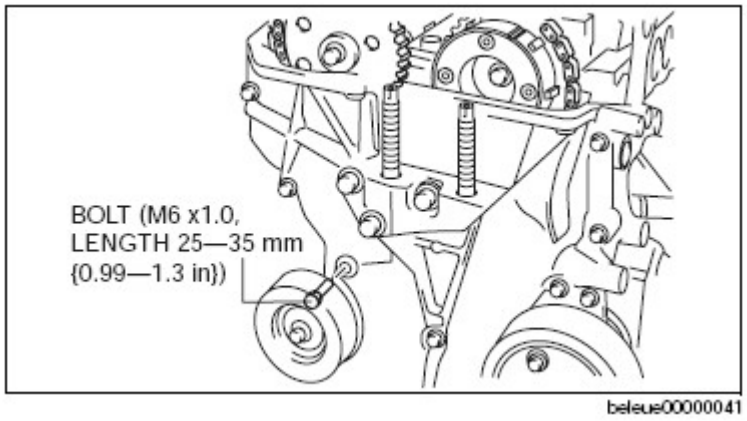


Fig. 69: Inserting Suitable Bolt (M6 X 1.0, Length 25-35 mm [0.99-1.3 in]) Into Engine Front Cover Upper Blind Plug

2. Using the cast hexagon on the exhaust camshaft, apply force counterclockwise to facilitate unlocking the chain tensioner ratchet.
3. Using a Hex bit socket **(2.5 mm {0.098 in})** or T15 Torx bit socket, unlock the chain tensioner ratchet so that it can be lifted up.

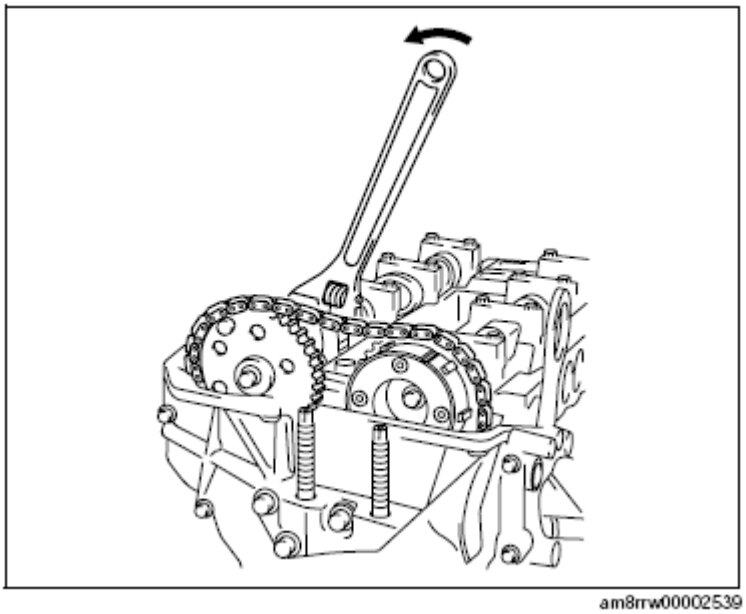


Fig. 70: Applying Force Counterclockwise To Facilitate Unlocking Chain Tensioner Ratchet

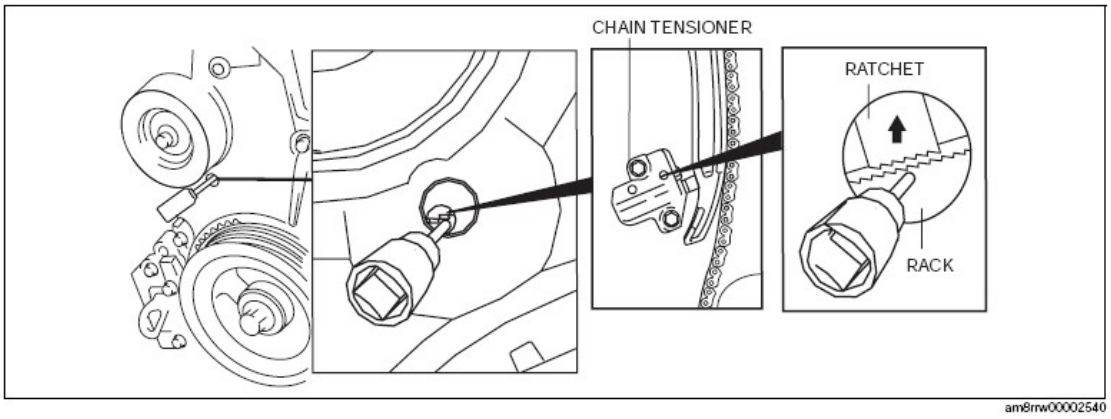


Fig. 71: Unlocking Chain Tensioner Ratchet

4. Using the cast hexagon on the exhaust camshaft, apply force in the direction of the engine rotation to increase tension on the chain.

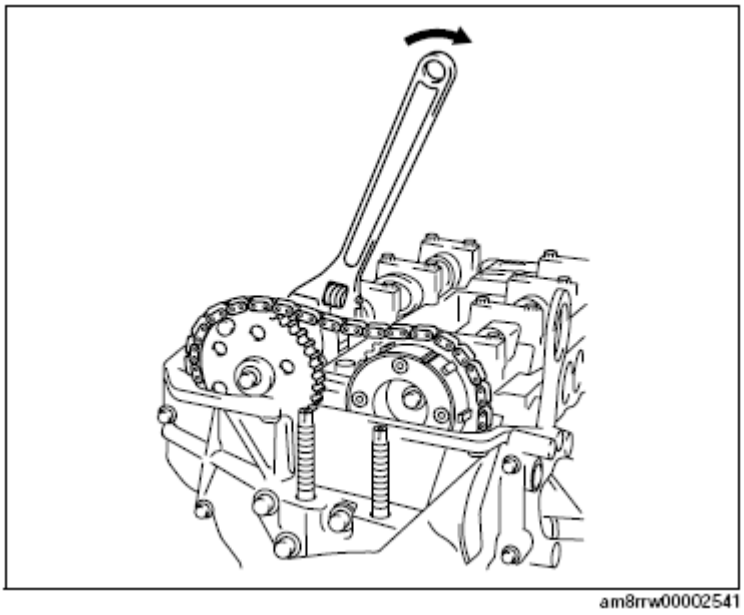


Fig. 72: Applying Force In Direction Of Engine Rotation To Increase Tension On Chain

NOTE:

- **The chain tensioner rack is compressed using the chain tension generated by applying force to the exhaust camshaft in the direction of the engine rotation.**

NOTE:

- **The racket has not been unlocked if the bolt cannot be pressed in approx. 5 mm {0.2 in}.**

5. Screw in the bolt set in Step 1 approx. 5 mm {0.2 in} and secure the tensioner arm with the rack compressed.

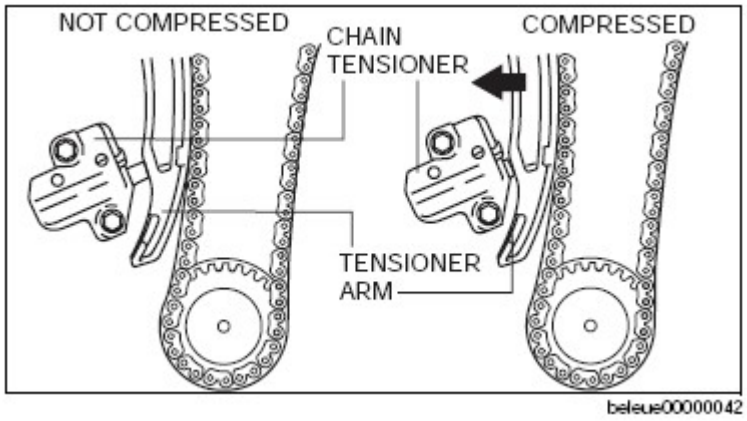


Fig. 73: Applying Force To Exhaust Camshaft In Direction Of Engine Rotation

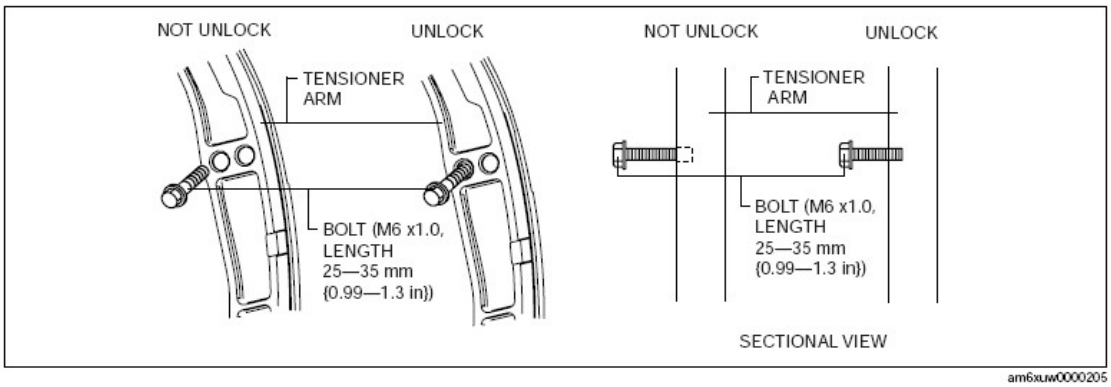


Fig. 74: Securing Tensioner Arm With Rack Compressed

- If the tensioner arm cannot be secured, return the bolt to its original position and repeat the procedure from Step 3.

6. Fix the exhaust camshaft using a wrench on the cast hexagon, and loosen the camshaft sprocket installation bolt.

CAUTION:
- **Perform the work carefully so that the washer does not drop out.**

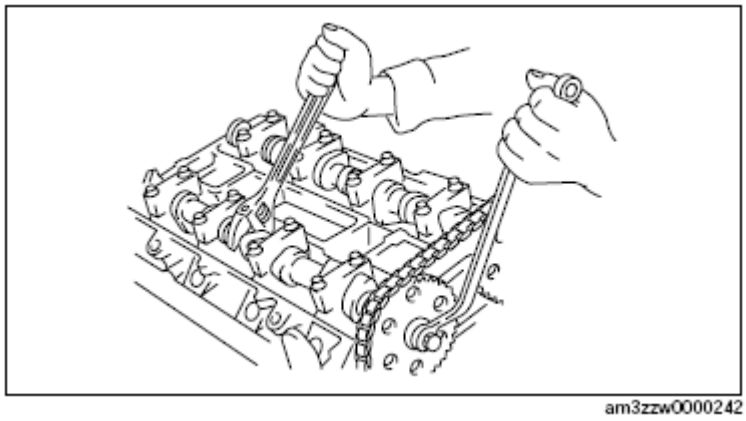


Fig. 75: Holding Camshaft Sprocket On Cast Hexagon

7. Remove the exhaust camshaft sprocket installation bolt, exhaust camshaft sprocket, and washer as a single unit.

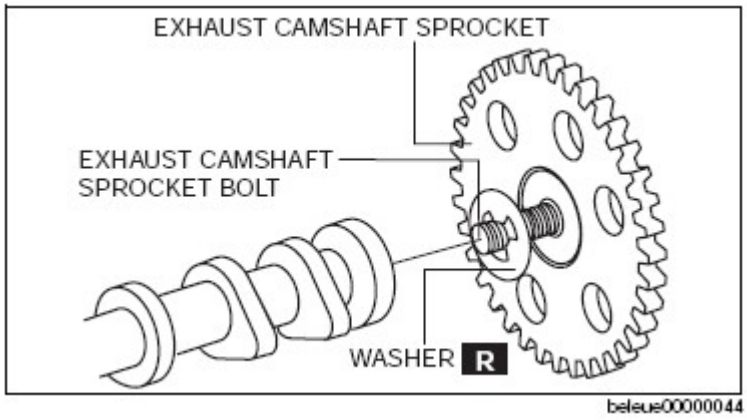


Fig. 76: Removing Exhaust Camshaft Sprocket Installation Bolt, Exhaust Camshaft Sprocket, And Washer

8. Remove the OCV.

NOTE:

- **The camshaft caps are to be kept ordered for correct reassembly in their original positions. Do not mix the caps.**

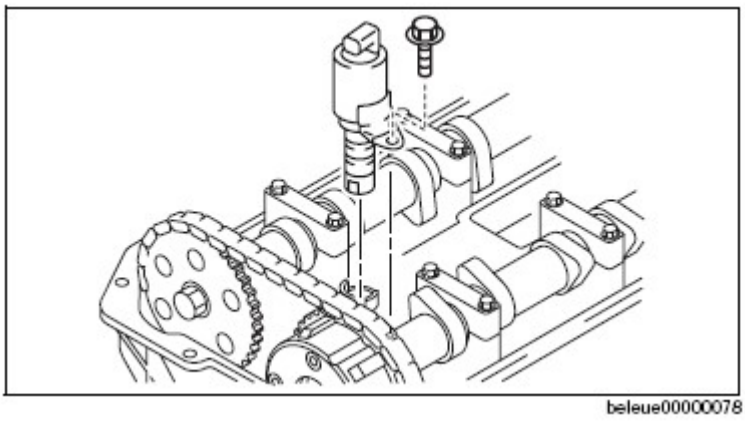


Fig. 77: Identifying OCV

9. Loosen the camshaft cap bolts in two or three steps in the order shown in the figure and remove the camshaft cap.

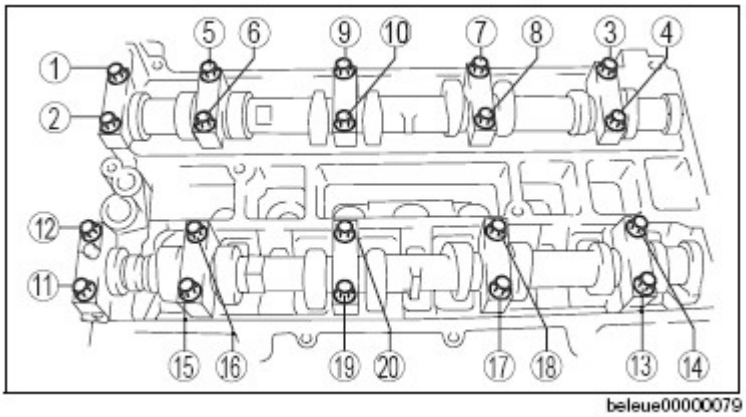


Fig. 78: Identifying Camshaft Cap Bolt Loosening Order

10. Remove the camshafts for the intake and exhaust sides.
11. Remove the tappet.
12. Install an appropriate tappet based on the results of the valve clearance inspection.

    Selected tappet = Removed tappet thickness + Measured valve clearance - Standard valve clearance

    Standard valve clearance [Engine cold]

    IN: 0.22-0.28 mm {0.009-0.011 in}

    EX: 0.27-0.33 mm {0.011-0.012 in}

13. Verify that No.1 cylinder is at TDC of the compression stroke. (Position counterweight contacts **SST** .)
14. Apply the gear oil (SAE No.90 or equivalent) to each journal of the cylinder head as shown in the figure.

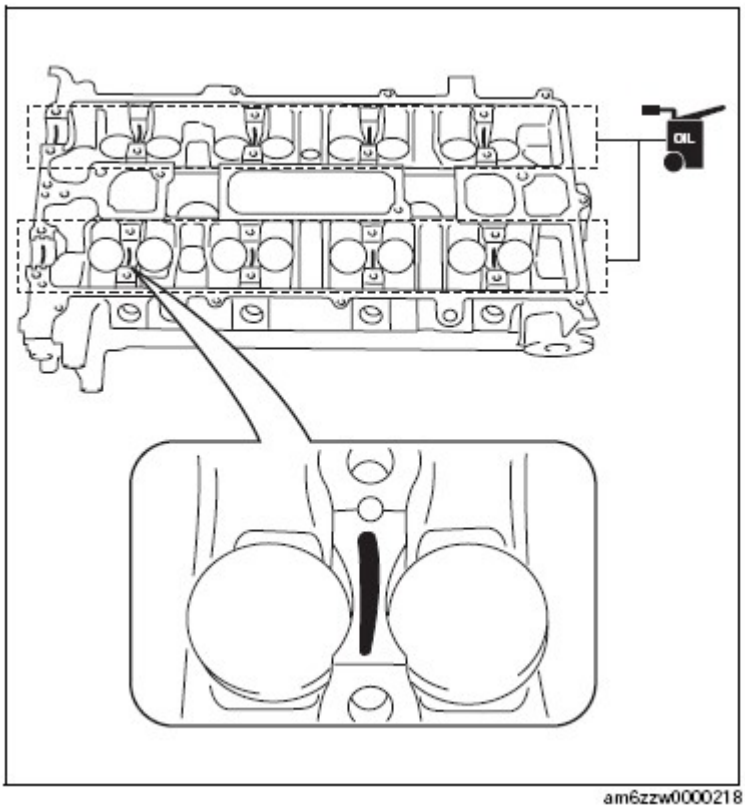


Fig. 79: Applying Gear Oil (SAE No.90 Or Equivalent) To Each Journal Of Cylinder Head

15. Install the camshaft with No.1 cylinder aligned with the TDC position.
16. Apply the gear oil (SAE No.90 or equivalent) to each journal of the camshaft as shown in the figure.
17. Temporarily tighten the camshaft cap bolts evenly in 2-3 steps.

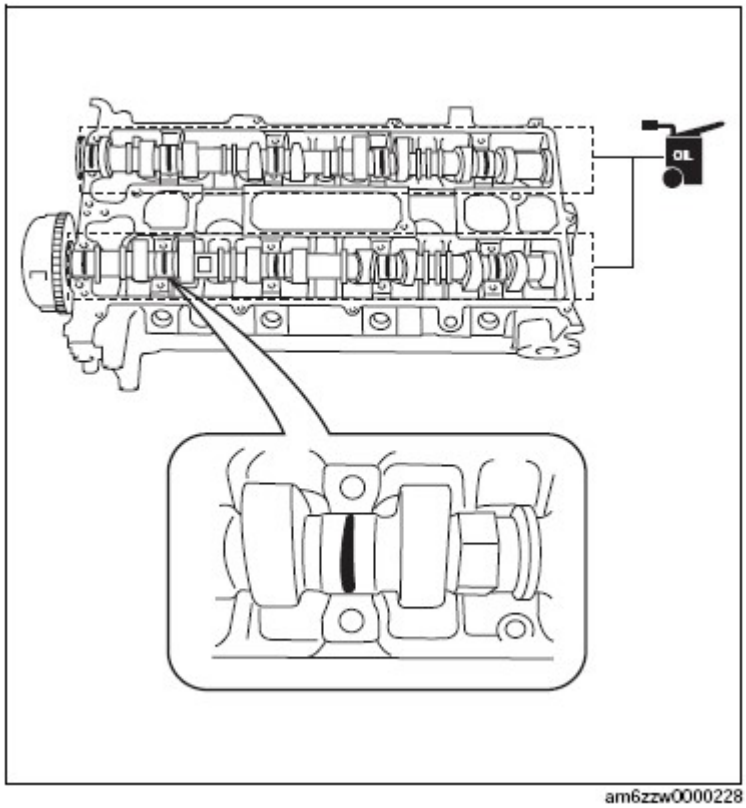


Fig. 80: Applying Gear Oil (SAE No.90 Or Equivalent) To Each Journal Of Camshaft

18. Tighten the camshaft cap bolts in the order shown in the following two steps.

Tightening procedure

1. **5.0-9.0 N.m {51-91 kgf.cm, 45-79 in.lbf}**
2. **14-17 N.m {1.5-1.7 kgf.m, 11-12 ft.lbf}**

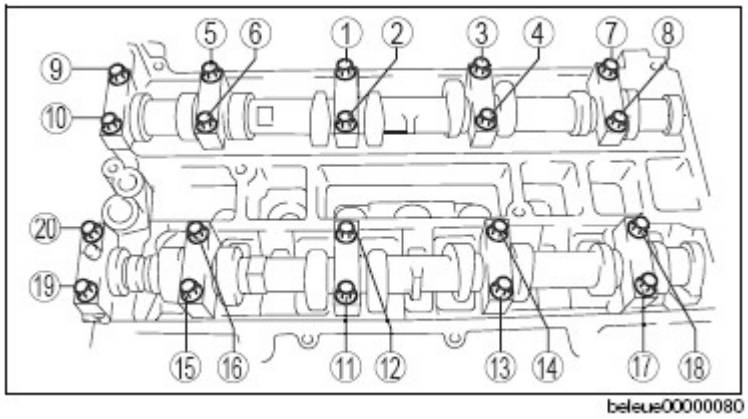


Fig. 81: Identifying Camshaft Cap Bolt Tightening Order

19. Install the OCV.

Tightening torque

8-11 N.m {82-112 kgf.cm, 71-97 in.lbf}

CAUTION:
- **Install a washer to the fourth or fifth thread of the exhaust camshaft sprocket bolt being careful not to drop the washer.**
- **Do not tighten the camshaft sprocket installation bolt at this stage. Verify the valve timing before performing the bolt tightening.**

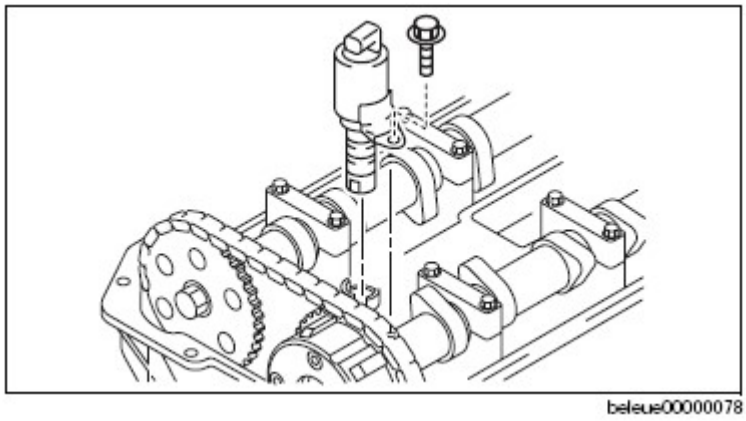


Fig. 82: Identifying OCV

20. Install the exhaust camshaft sprocket installation bolt, exhaust camshaft sprocket, and a new washer as a single unit.

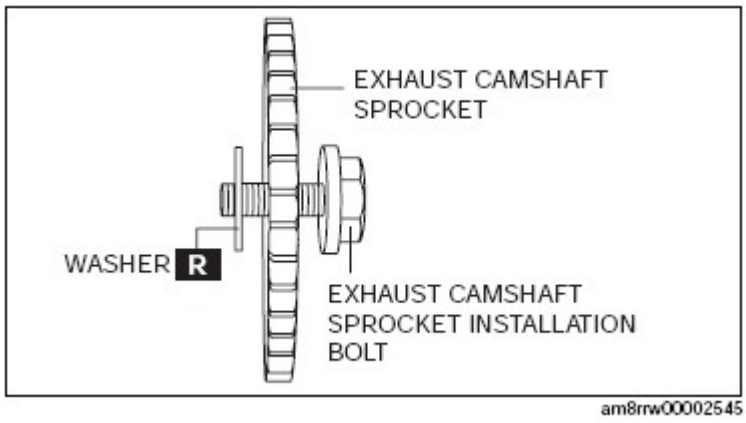


Fig. 83: Identifying Exhaust Camshaft Sprocket Installation Bolt, Exhaust Camshaft Sprocket, And Washer

21. Install the **SST** on the camshaft as shown in the figure.

22. Remove the installation bolt for the engine front cover upper blind plug **(M6 X 1.0 length 25-35mm {1.0-1.3 in})** , and apply tension to the timing chain.
23. Fix the exhaust camshaft using a wrench on the cast hexagon, and tighten the sprocket installation bolt.
24. Remove the **SST** from the camshaft.
25. Remove the **SST** installed in the cylinder block lower blind plug hole.

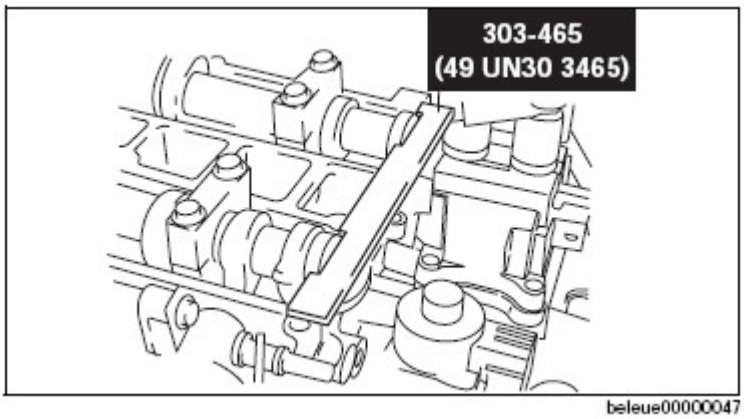


Fig. 84: Installing SST (303-465) On Camshaft

26. Rotate the crankshaft clockwise two turns and inspect the valve timing.
    - If not aligned, repeat the procedure from 21.
27. Install the cylinder block lower blind plug.

Tightening torque

18-22 N.m {1.9-2.2 kgf.m, 14-16 ft.lbf}

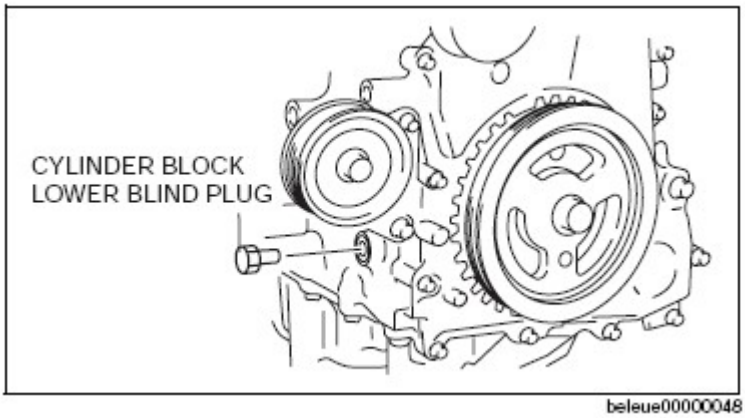


Fig. 85: Identifying Cylinder Block Lower Blind Plug

28. Apply the silicone sealant and install the engine front cover upper blind plug.

Tightening torque

8.0-11.5 N.m {82-117 kgf.cm, 71-101 in.lbf}

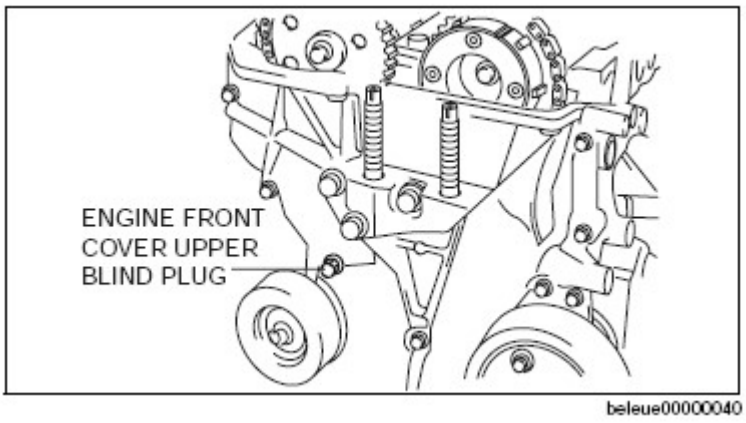


Fig. 86: Identifying Engine Front Cover Upper Blind Plug

29. Install a new engine front cover lower blind plug.

Tightening torque

10-14 N.m {102-142 kgf.cm, 89-123 in.lbf}

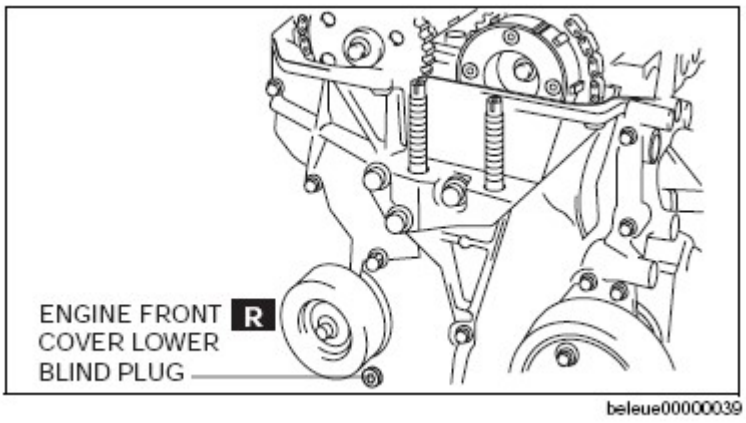
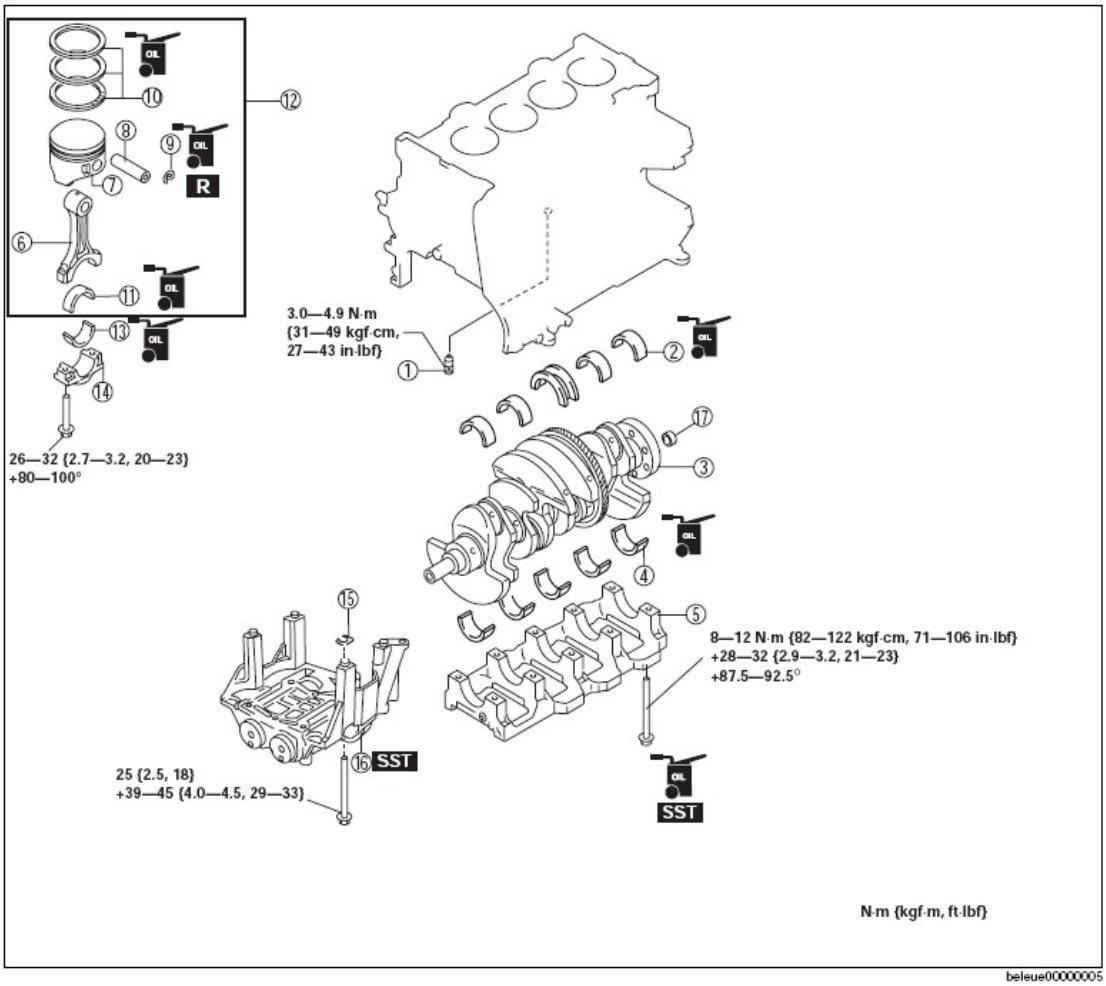


Fig. 87: Identifying Engine Front Cover Lower Blind Plug

CYLINDER BLOCK ASSEMBLY (I)

1. Assemble in the order indicated in the table.



1	Oil jet valve
2	Upper main bearing, thrust bearing
3	Crankshaft
4	Lower main bearing, thrust bearing
5	Main bearing cap (See Main Bearing Cap Assembly Note)
6	Connecting rod
7	Piston
8	Piston pin
9	Snap ring
10	Piston ring (See Piston Ring Assembly Note)
11	Upper connecting rod bearing (See Connecting Rod Bearing Assembly Note)

12	Connecting rod, piston component (See Piston Assembly Note)
13	Lower connecting rod bearing (See Connecting Rod Bearing Assembly Note)
14	Connecting rod cap (See Connecting Rod Cap Assembly Note)
15	Adjustment shim (See Balancer Unit Assembly Note)
16	Balancer unit (See Balancer Unit Assembly Note)
17	Pilot bearing (MTX) (See Pilot Bearing Assembly Note.)

Fig. 88: Identifying Cylinder Block Assembling Order

MAIN BEARING CAP ASSEMBLY NOTE

1. Install the main bearing caps in the order indicated in the figure, using the **SST (49 D032 316)** .

   Tightening torque

1. **8-12 N.m {82-122 kgf.cm, 71-106 in.lbf}**
2. **28-32 N.m {2.9-3.2 kgf.m, 21-23 ft.lbf}**
3. **87.5-92.5°**

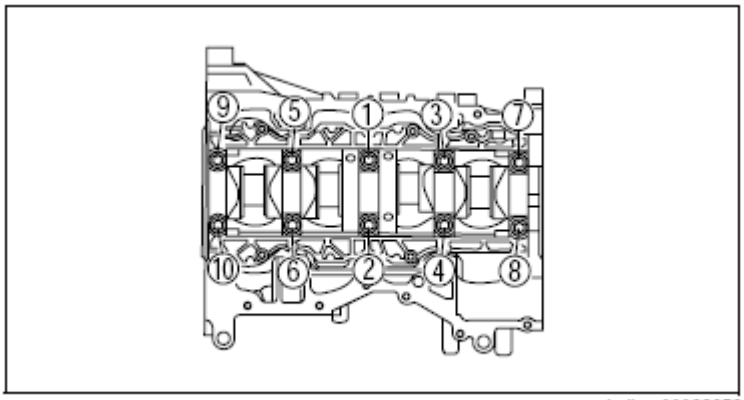


Fig. 89: Identifying Main Bearing Caps Installing Order

PISTON RING ASSEMBLY NOTE

1. Install the two oil control ring segments and spacer.
2. Verify that the second ring is installed with scraper face side downward.
3. Verify that the top ring is installed with chamfered face side inner of upper.

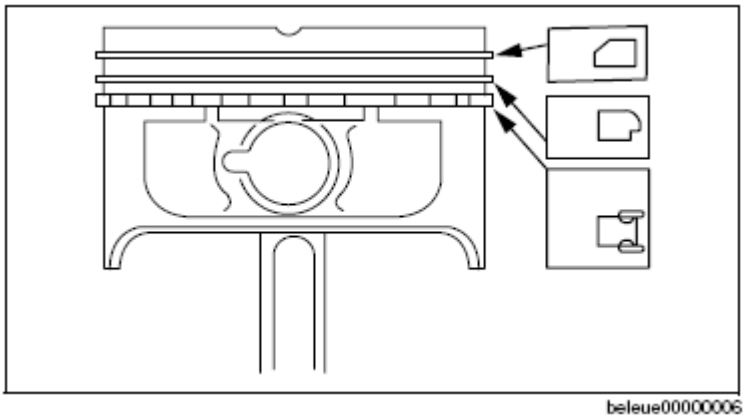


Fig. 90: Identifying Piston Ring Assembly

4. Position the end gap of each ring as indicated in the figure.

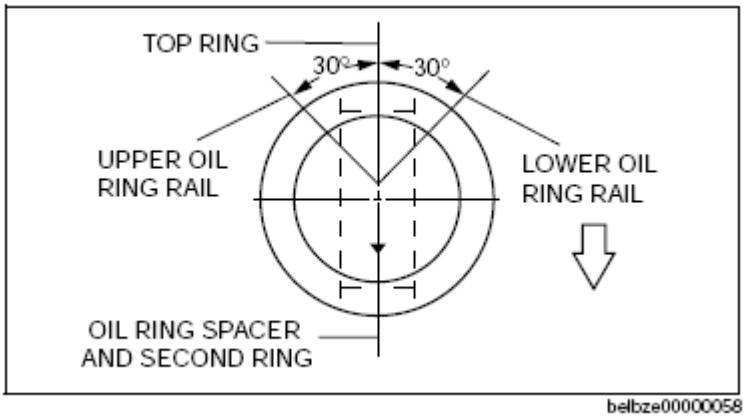


Fig. 91: Identifying Piston Rings End Gap Position

CONNECTING ROD BEARING ASSEMBLY NOTE

1. Install the connecting rod bearing to the connecting rod and connecting rod caps, as shown in the figure.

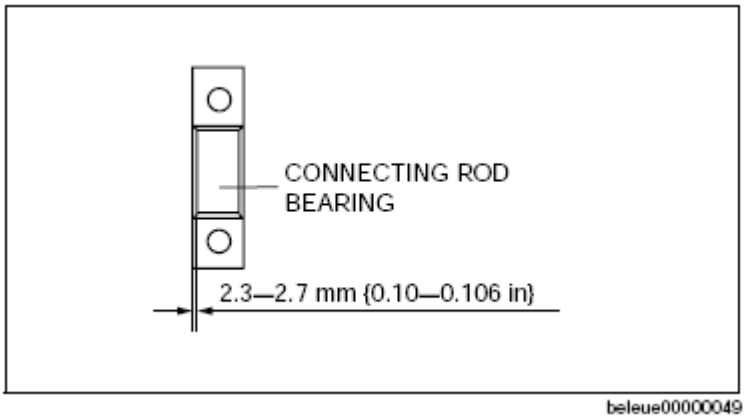


Fig. 92: Installing Connecting Rod Bearing To Connecting Rod And Connecting Rod Caps

PISTON ASSEMBLY NOTE

1. Insert the piston and connecting rod into the cylinder with the arrow mark to front of the engine.

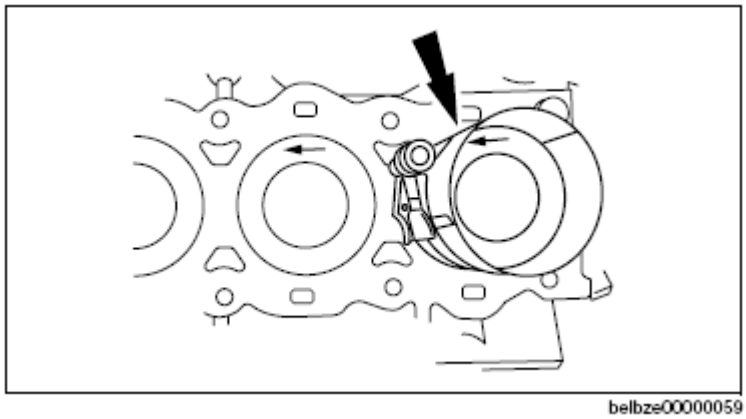


Fig. 93: Inserting Piston And Connecting Rod Into Cylinder With Arrow Mark To Front Of Engine

CONNECTING ROD CAP ASSEMBLY NOTE

1. Tighten the connecting rod bolts in two steps using the **SST (49 D032 316).**

   Tightening torque

   1. **26-32 N.m {2.7-3.2 kgf.m, 20-23 ft.lbf}**
   2. **80-100°**

BALANCER UNIT ASSEMBLY NOTE

CAUTION:
- **The balancer unit cannot be disassembled due to the precision interior construction of the balancer unit.**

1. Visually inspect the balancer unit gear for damage and verify that the shaft rotates smoothly.
   - If there is any malfunction, replace the balancer unit.
2. Remove the cylinder block lower blind plug and install the SST.
3. Rotate the crankshaft in the direction of engine rotation so that the No. 1 cylinder is at top dead center (TDC). (Until the counterweight contacts the SST and stops.)

NOTE:
- **If the cylinder block, crankshaft, crankshaft main bearing, and balancer unit are not replaced, use the adjustment shim as it is. In this case, go to Step 12.**

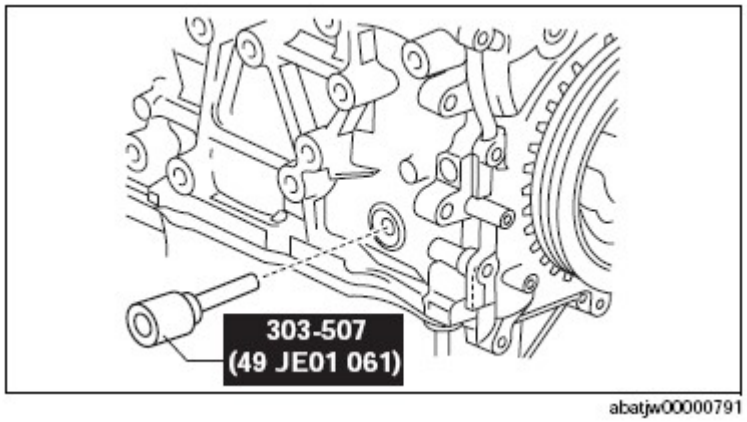


Fig. 94: Identifying SST (303-507)

4. Assemble the master shims (No. 50) to the shim seating face of the balancer unit at the angles shown in the figure.

CAUTION:
- **Engage the gears slowly and place the balancer unit on the cylinder block while being careful not to contact the balancer unit gear strongly with the crankshaft drive gear and damage it.**

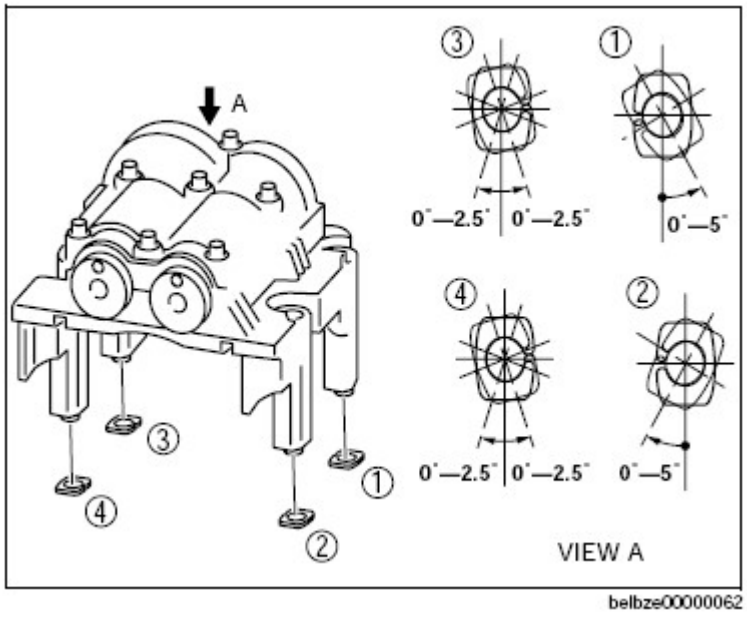


Fig. 95: Assembling Master Shims (No. 50) To Shim Seating Face Of Balancer Unit At Angles

5. With the balancer unit marks at the exact top center positions, assemble the balancer unit to the cylinder block and tighten the bolts in a crisscross pattern in two steps.

Tightening torque

1. **25 N.m {2.5 kgf.m, 18 ft.lbf}**
2. **39-45 N.m {4.0-4.5 kgf.m, 29-33 ft.lbf}**

6. Remove the SST installed in Step 2.
7. Measure the gear backlash using the following procedure.

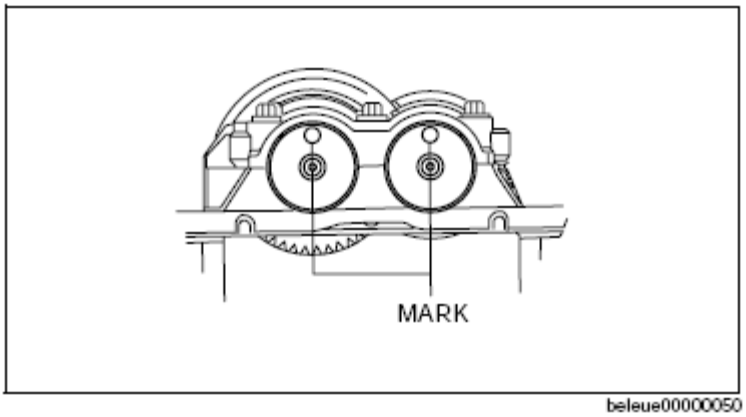


Fig. 96: Identifying Balancer Unit Marks At Exact Top Center Positions

1. Place the ATDC marks **10 °, 30 °, 100 °, 190 °, 210 °, 280 °** on the rear side of the crankshaft to indicate the angles.
2. Insert a flathead screwdriver into the crankshaft No.1 counterweight area and set both the rotation and the thrust direction with the flathead screwdriver, using a prying action, as shown in the figure for accurate measurement of the backlash.

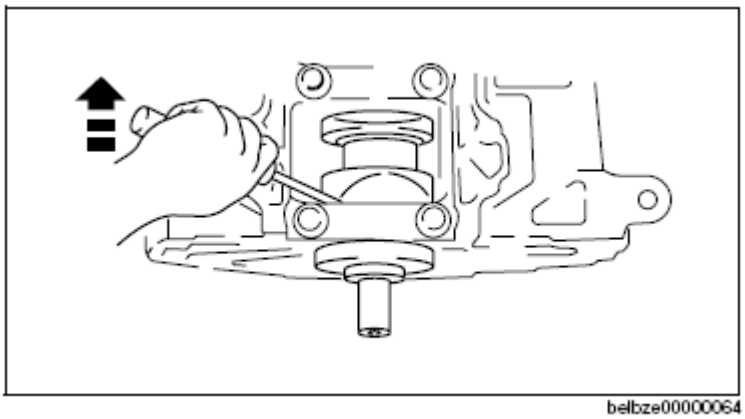


Fig. 97: Inserting Flathead Screwdriver Into Crankshaft No.1 Counterweight Area

3. Set the SST and a dial gauge as shown in the figure.
4. Rotate the driven gear to the left and right so that the crankshaft drive gear and balancer unit gear contact each other lightly.
5. When measuring the backlash, rotate the crankshaft one full rotation and measure the backlash at 6 locations (A to F) as shown in the figure.

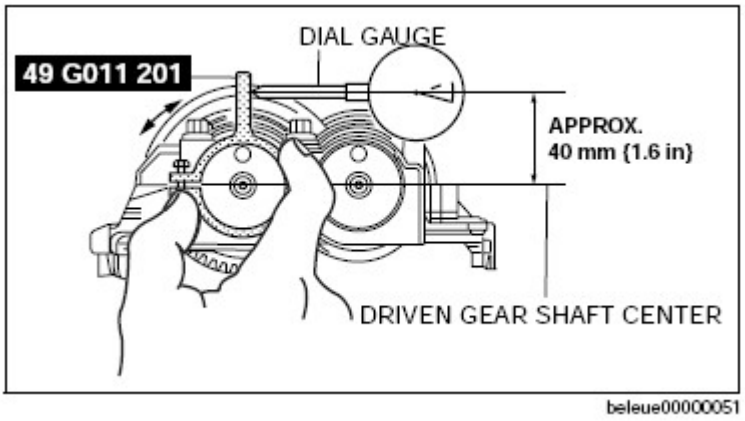


Fig. 98: Setting SST (49 G011 201) And Dial Gauge

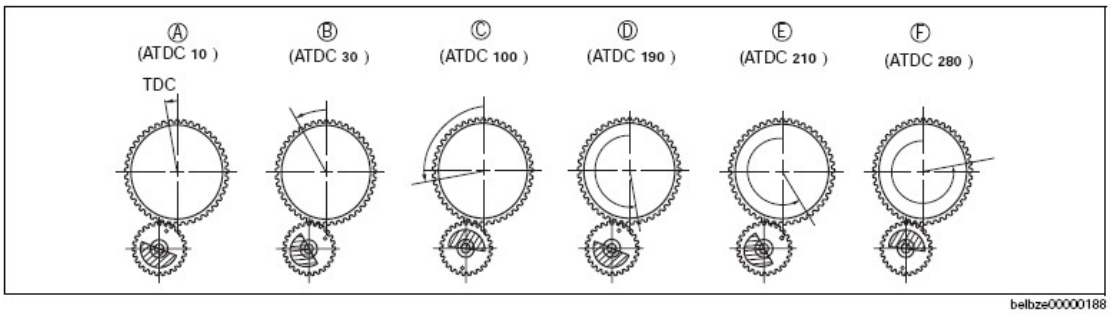


Fig. 99: Identifying Crankshaft Backlash Measuring Locations (A To F)

8. Select the adjustment shim from the selection table based on the measured minimum value of the backlash.

ADJUSTMENT SHIM SELECTION

Measured backlash mm {in}	Selection shim (No.)	Shim thickness mm {in}
0.267-0.273 {0.01051- 0.01074}	15	1.15 {0.0452}
0.260-0.266 {0.01023- 0.01047}	16	1.16 {0.0456}
0.253-0.259 {0.00996- 0.01019}	17	1.17 {0.0460}
0.246-0.252 {0.00968- 0.00992}	18	1.18 {0.0464}
0.239-0.245 {0.00940- 0.00964}	19	1.19 {0.0468}
0.232-0.238 {0.00913- 0.00937}	20	1.20 {0.0472}
0.225-0.231 {0.00885- 0.00909}	21	1.21 {0.0476}
0.218-0.224 {0.00858- 0.00881}	22	1.22 {0.0480}
0.211-0.217 {0.00830- 0.00854}	23	1.23 {0.0484}
0.204-0.210 {0.00803- 0.00826}	24	1.24 {0.0488}
0.197-0.203 {0.00775- 0.00799}	25	1.25 {0.492}
0.190-0.196 {0.00748- 0.00771}	26	1.26 {0.496}
0.183-0.189 {0.00720- 0.00744}	27	1.27 {0.499}
0.176-0.182 {0.00692- 0.00716}	28	1.28 {0.503}

0.169-0.175 {0.00665- 0.00688}	29	1.29 {0.507}
0.162-0.168 {0.00637- 0.00661}	30	1.30 {0.511}
0.155-0.161 {0.00610- 0.00633}	31	1.31 {0.515}
0.148-0.154 {0.00582- 0.00606}	32	1.32 {0.519}
0.141-0.147 {0.00555- 0.00578}	33	1.33 {0.523}
0.134-0.140 {0.00527- 0.00551}	34	1.34 {0.527}
0.127-0.133 {0.00500- 0.00523}	35	1.35 {0.0531}
0.120-0.126 {0.00472- 0.00496}	36	1.36 {0.0535}
0.113-0.119 {0.00444- 0.00468}	37	1.37 {0.0539}
0.106-0.112 {0.00417- 0.00440}	38	1.38{0.0543}
0.099-0.105 {0.00389- 0.00413}	39	1.39 {0.0547}
0.092-0.098 {0.00362- 0.00385}	40	1.40 {0.0551}
0.085-0.091 {0.00334- 0.00358}	41	1.41 {0.0555}
0.078-0.084 {0.00307- 0.00330}	42	1.42 {0.0559}
0.071-0.077 {0.00279- 0.00303}	43	1.43 {0.0562}
0.064-0.070 {0.00251- 0.00275}	44	1.44 {0.0566}
0.057-0.063 {0.00224- 0.00248}	45	1.45 {0.0570}
0.050-0.056 {0.00196- 0.00220}	46	1.46 {0.0574}
0.043-0.049 {0.00169- 0.00192}	47	1.47 {0.0578}
0.036-0.042 {0.00141- 0.00165}	48	1.48 {0.0582}
0.029-0.035 {0.00114- 0.00137}	49	1.49 {0.0586}
0.022-0.028 {0.000866- 0.00110}	50 (master shim)	1.50 {0.0590}
0.015-0.021 {0.00059- 0.000826}	51	1.51 {0.0594}
0.008-0.014 {0.000314- 0.000551}	52	1.52 {0.0598}
0.001-0.007 {0.00003- 0.000275}	53	1.53 {0.0602}
0.000-0.000 {0.000-0.000}	54	1.54 {0.0606}

9. Verify that the No. 1 cylinder is at TDC.
    - If not aligned, perform Steps 2-3.
10. Remove the master shim from the balancer unit and assemble the selected adjustment shim at the angles shown in the figure.
11. Perform Steps 5-7.
12. Verify that the measured backlash is within the specified range.
    - If the backlash exceeds the maximum specification, replace the adjustment shim and repeat Steps 4-12.

Measured backlash maximum

0.01-0.10 mm {0.001-0.003 In}

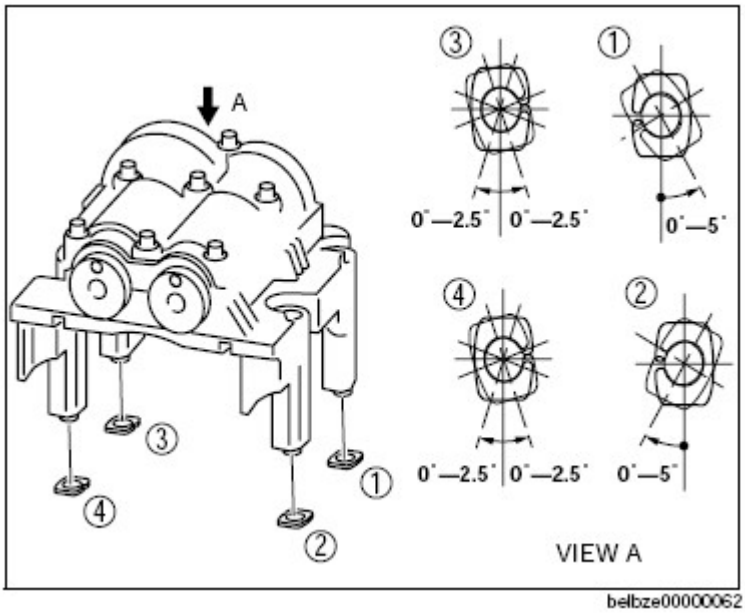


Fig. 100: Assembling Selected Adjustment Shim At Angles

PILOT BEARING ASSEMBLY NOTE

1. Assemble the pilot bearing using the corresponding 20 mm {0.79 in} side of a Snap-on brand millimeter size bushing driver set A160M adapter A160M7 (20-22 mm {0.79-0.86 in}).

   Substitution

   A160M7 (20 mm {0.79 in})

   Outer diameter: 21 mm {0.83 in}

   Inner diameter: 19 mm {0.75 in}

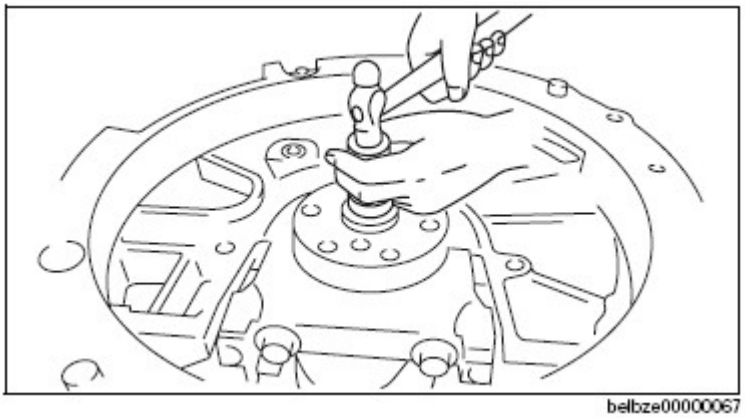


Fig. 101: Assembling Pilot Bearing

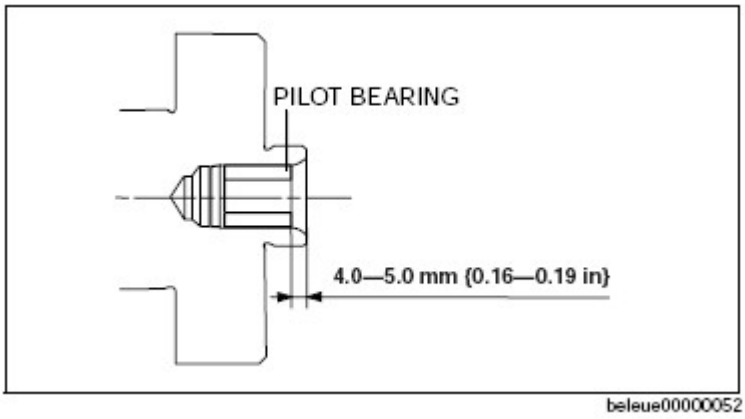
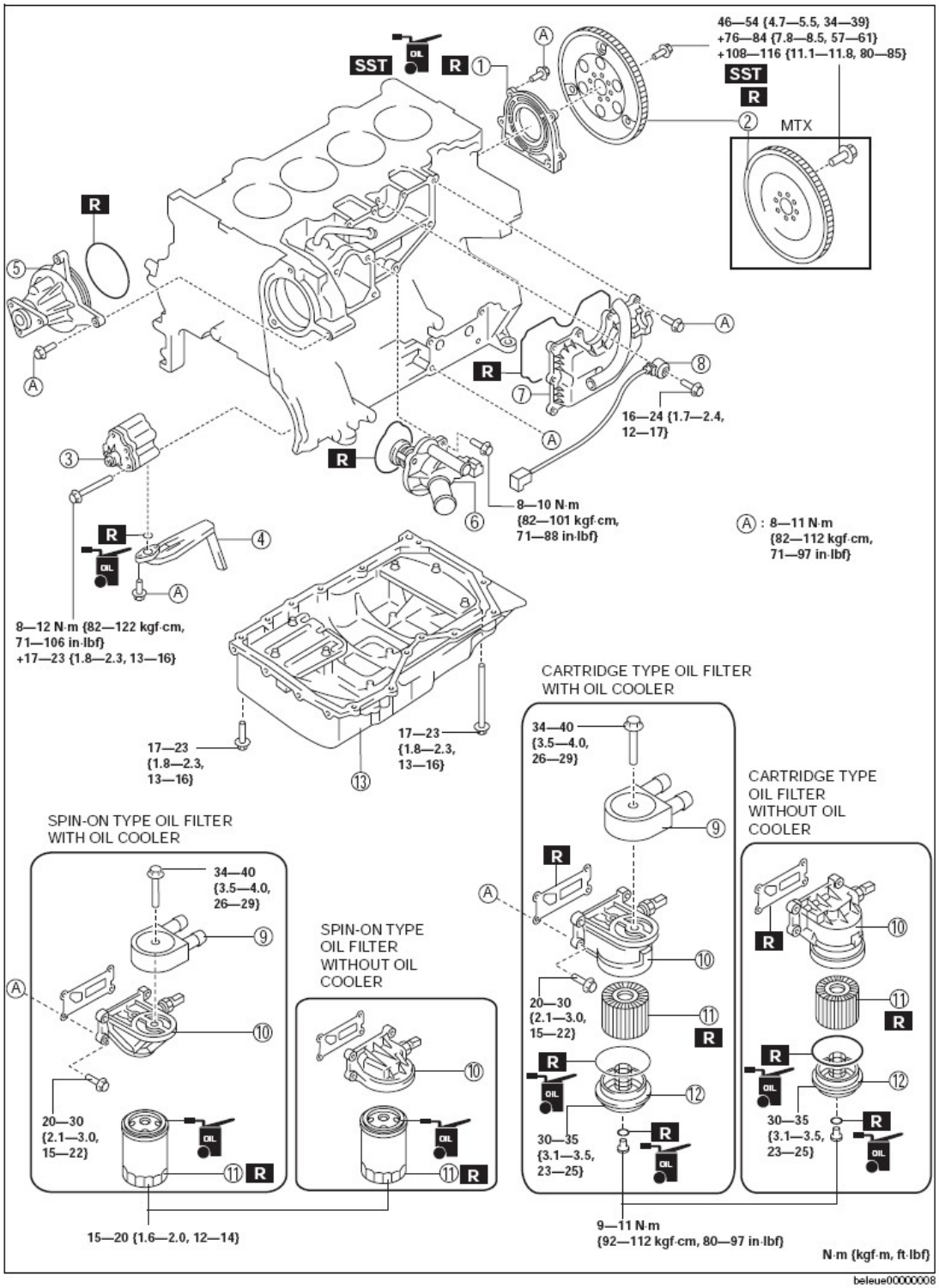


Fig. 102: Identifying Pilot Bearing Installation Dimensions

CYLINDER BLOCK ASSEMBLY (II)

1. Assemble in the order indicated in the table.



1	Rear oil seal (See Rear Oil Seal Assembly Note)
2	Flywheel (MTX), Drive plate (ATX) (See Drive Plate (ATX), Flywheel (MTX) Assembly Note)
3	Oil pump
4	Oil strainer

7	Oil separator
8	KS
9	Oil cooler
10	Oil filter adapter
11	Oil filter
12	Oil filter cover

Fig. 103: Identifying Cylinder Block Assemble Order

REAR OIL SEAL ASSEMBLY NOTE

1. Apply clean engine oil to the new oil seal lip.
2. Install the **SST** to the non-woven fabric side of the rear oil seal.

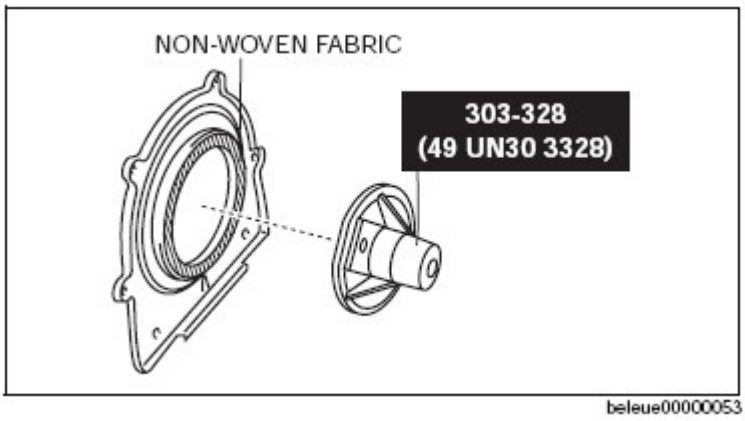


Fig. 104: Installing SST (303-328) To Non-Woven Fabric Side Of Rear Oil Seal

3. From the back side of the rear oil seal, verify that there is no damage or separation in the lip area of the rear oil seal.
4. Install the rear oil seal to the engine.

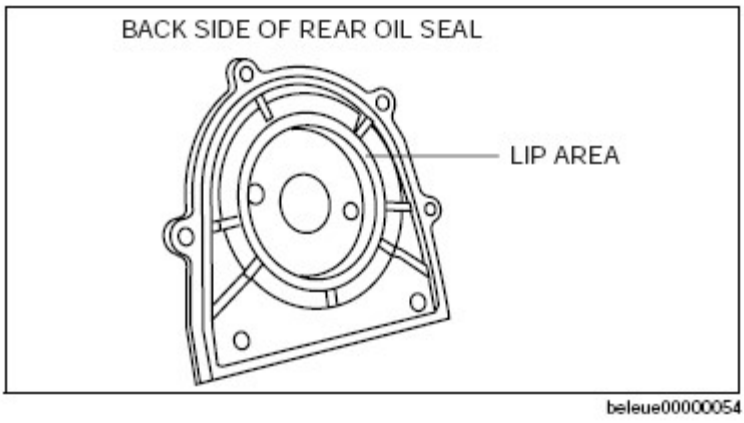


Fig. 105: Inspecting Lip Area Of Rear Oil Seal

5. Tighten the rear oil seal bolts in the order as shown in the figure. (Except TRIBUTE (L.H.D.) Face-lifted model.)

Tightening torque

8-11 N.m {82-112 kgf.cm, 71-97 in.lbf}

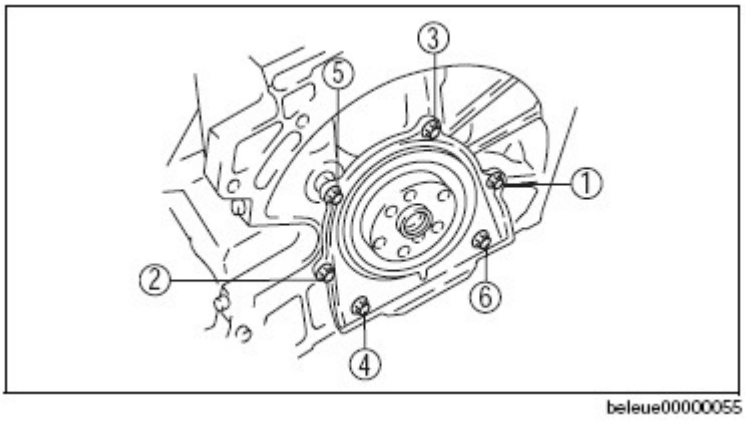


Fig. 106: Identifying Rear Oil Seal Bolt Tightening Order

DRIVE PLATE (ATX), FLYWHEEL (MTX) ASSEMBLY NOTE

1. Hold the crankshaft using the **SST** .
2. Tighten the bolts in the 3 steps in the figure.

Tightening torque

1. **46-54 N.m {4.7-5.5 kgf.m, 34-39 ft.lbf}**
2. **76-84 N.m {7.8-8.5 kgf.m, 57-61 ft.lbf}**
3. **108-116 N.m {11.1-11.8 kgf.m, 80-85 ft.lbf}**

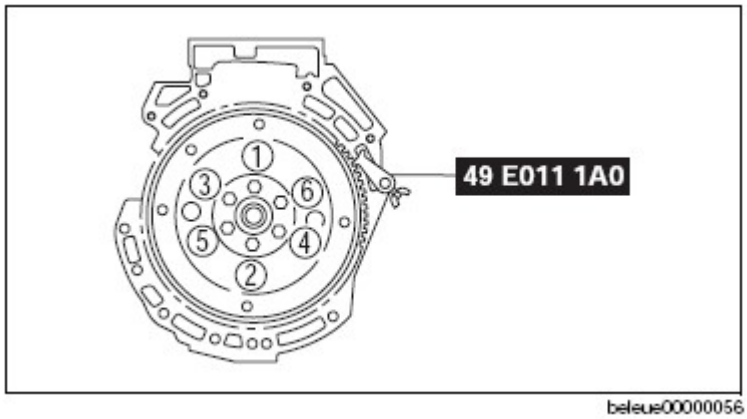


Fig. 107: Identifying Flywheel Bolts Tightening Sequence

OIL PAN ASSEMBLY NOTE

1. Apply a continuous bead of silicone sealant to the oil pan as indicated in the figure.

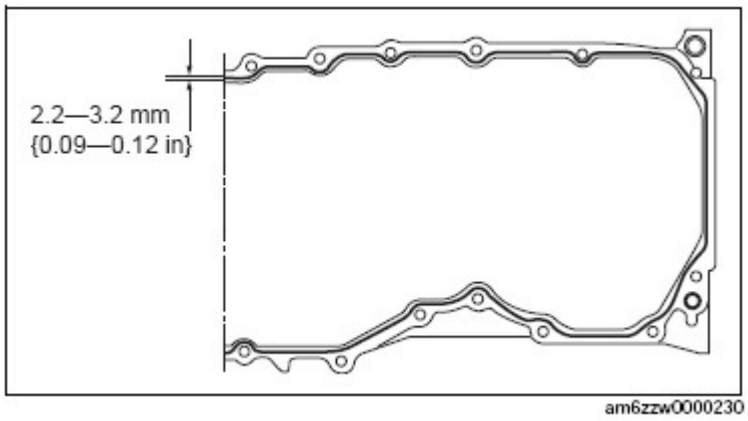


Fig. 108: Applying Continuous Bead Of Silicone Sealant To Oil Pan

2. Use a square ruler to unite the oil pan and the cylinder block junction side on the engine front cover side.

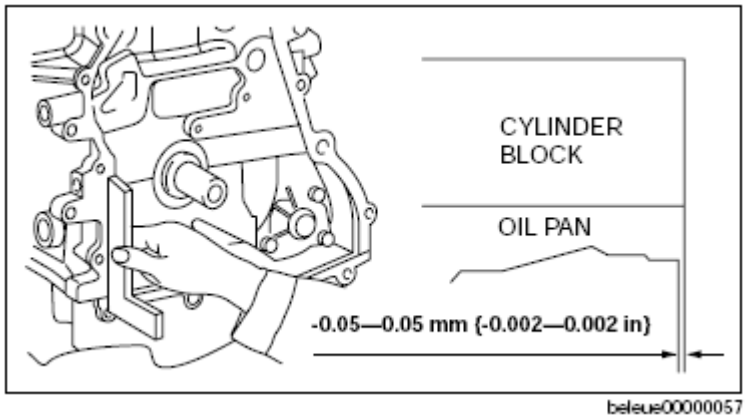


Fig. 109: Assemblying Oil Pan And Cylinder Block Junction Side On Engine Front Cover Side Using Square Ruler

3. Tighten the rear oil pan bolts in the order as shown in the figure.

Tightening torque

17-23 N.m {1.8-2.3 kgf.m, 13-16 ft.lbf}

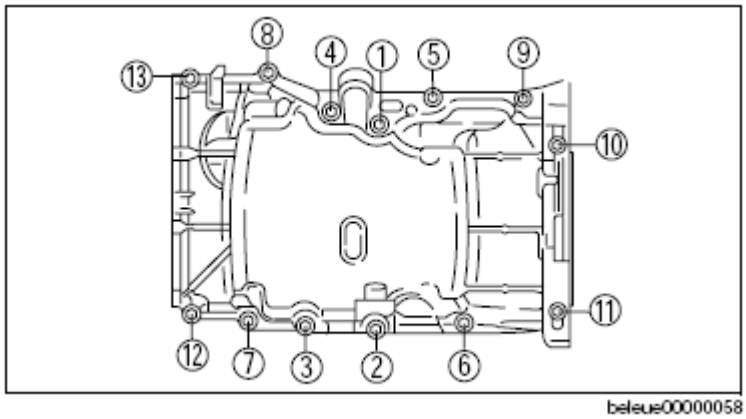
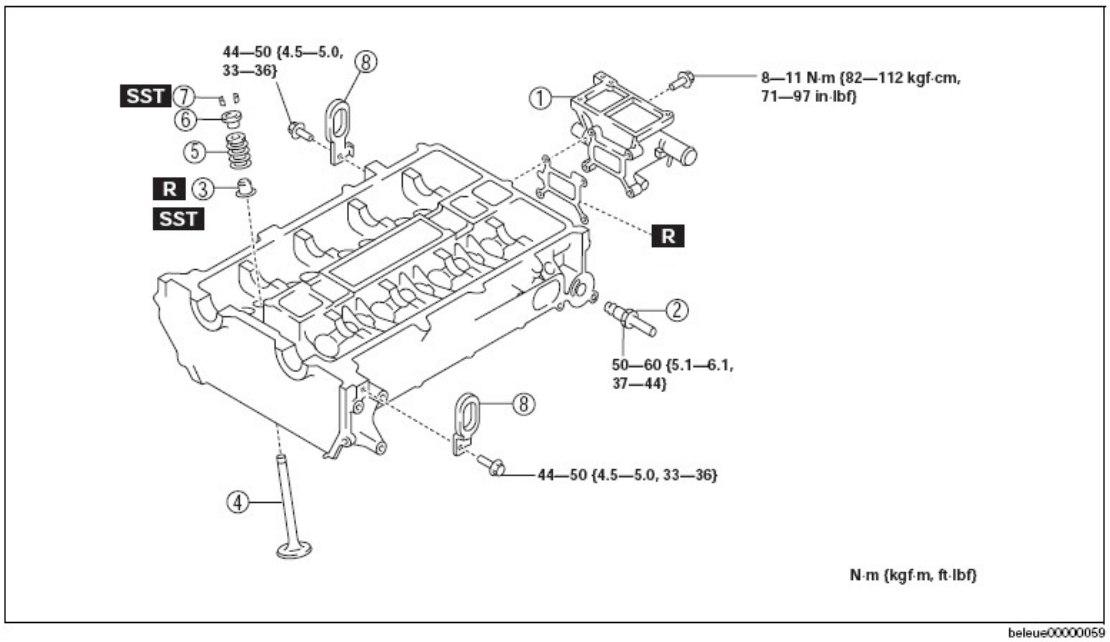


Fig. 110: Identifying Rear Oil Pan Bolt Tightening Order

CYLINDER HEAD ASSEMBLY (I)

1. Assemble in the order indicated in the table.



1	Water outlet case	5	Valve spring
2	EGR pipe	6	Upper valve spring seat
3	Valve seal (See Valve Seal Assembly Note)	7	Valve keeper (See Valve Keeper Assembly Note)
4	Valve	8	Engine hanger

Fig. 111: Identifying Cylinder Head Assemblying Order

VALVE SEAL ASSEMBLY NOTE

1. Press the valve seal onto the valve guide by hand.

2. Lightly tap the **SST** using a plastic hammer.

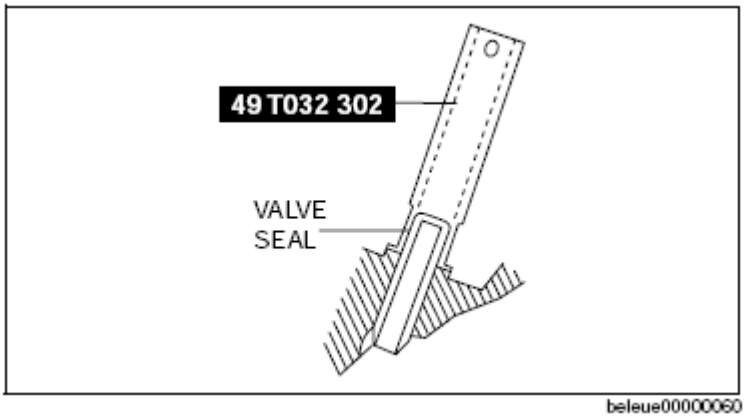


Fig. 112: Tapping SST Using Plastic Hammer

VALVE KEEPER ASSEMBLY NOTE

1. Install the valve keeper using the **SSTs** .

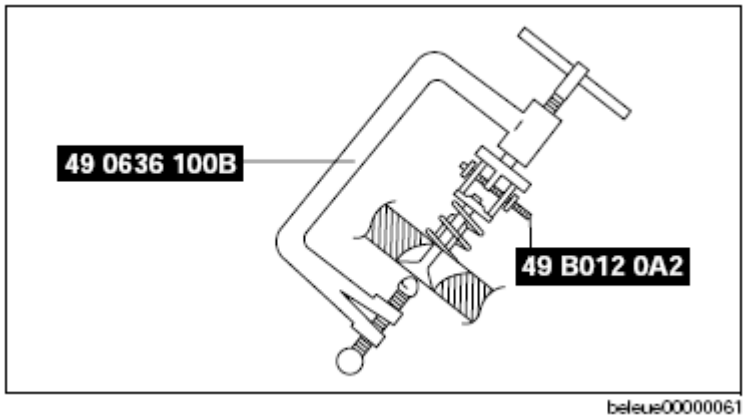
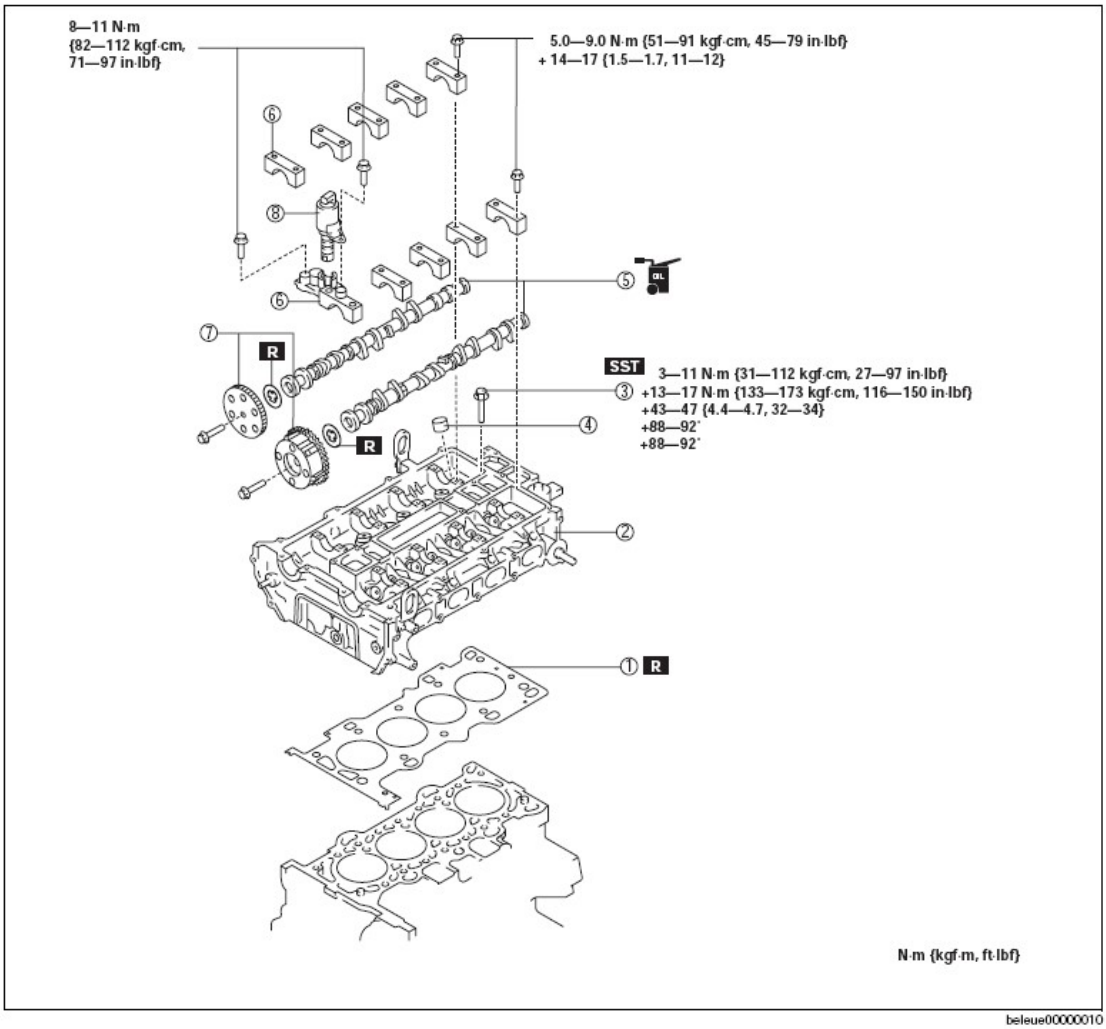


Fig. 113: Installing Valve Keeper Using SSTs

CYLINDER HEAD ASSEMBLY (II)

1. Assemble in the order indicated in the table.



1	Cylinder head gasket
2	Cylinder head
3	Cylinder head bolt (See Cylinder Head Bolt Assembly Note)
7	Camshaft sprocket, variable valve timing actuator (See Camshaft Sprocket, Variable Valve Timing Actuator Assembly Note)

4	Tappet
5	Camshaft (See Camshaft Assembly Note)
6	Camshaft cap
8	OCV

Fig. 114: Identifying Cylinder Head Assemblying Order

CYLINDER HEAD BOLT ASSEMBLY NOTE

1. Tighten the cylinder head bolts in the order indicated in the figure in 5 steps. However, use the **SST (49 D32 316)** in Steps 4 and 5.

Tightening torque

1. **3-11 N.m {31-112 kgf.cm, 27-97 in.lbf}**
2. **13-17 N.m {133-173 kgf.cm, 116-150 in.lbf}**
3. **43-47 N.m {4.4-4.7 kgf.m, 32-34 ft.lbf}**

4. **88-92°**
5. **88-92°**

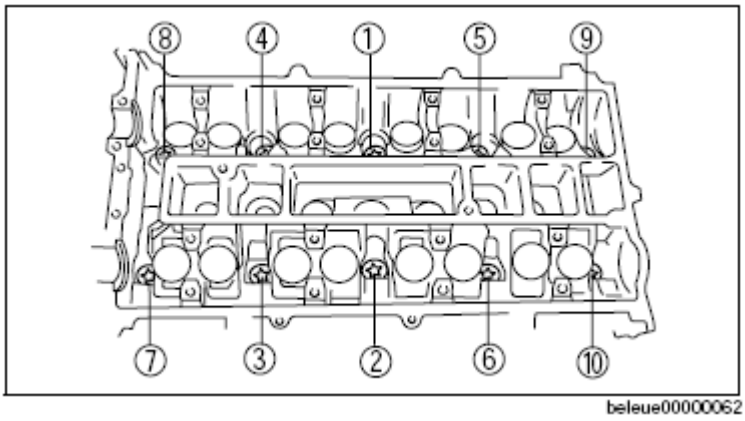


Fig. 115: Identifying Cylinder Head Bolt Tightening Order

CAMSHAFT ASSEMBLY NOTE

1. Apply the gear oil (SAE No.90 or equivalent) to each journal of the cylinder head as shown in the figure.
2. Set the cam position of No.1 cylinder at the top dead center (TDC) and install the camshaft.

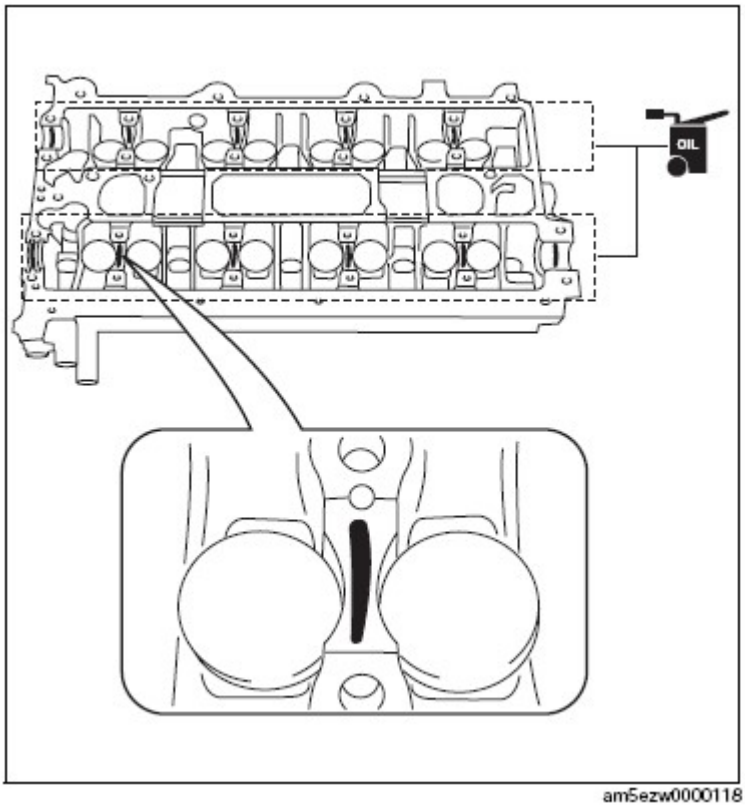


Fig. 116: Applying Gear Oil (SAE No.90 Or Equivalent) To Each Journal Of Cylinder Head

3. Apply the gear oil (SAE No.90 or equivalent) to each journal of the camshaft as shown in the figure.
4. Temporarily tighten the camshaft cap bolts evenly in 2-3 steps.
5. Tighten the camshaft cap bolts in the order shown with the following two steps.

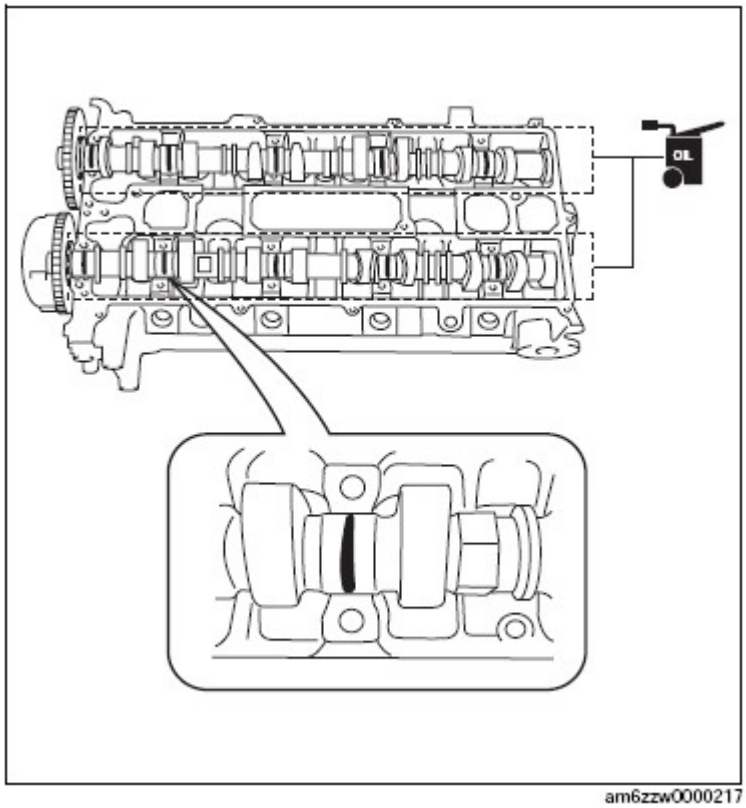


Fig. 117: Applying Gear Oil (SAE No.90 Or Equivalent) To Each Journal Of Camshaft

Tighten torque

1. **5.0-9.0 N.m {51-91 kgf.cm, 45-79 in.lbf}**
2. **14-17 N.m {1.5-1.7 kgf.m, 11-12 ft.lbf}**

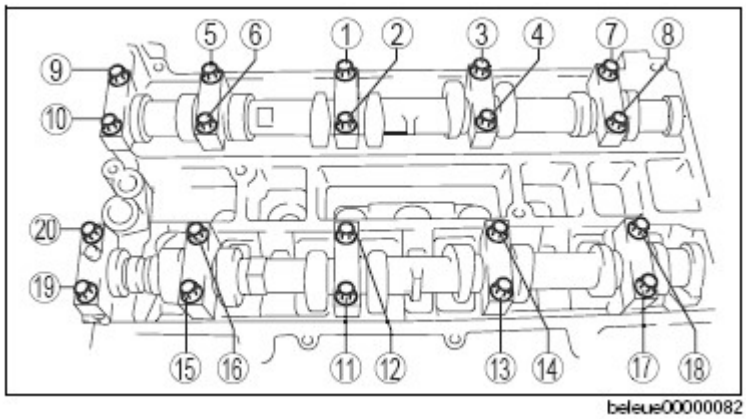


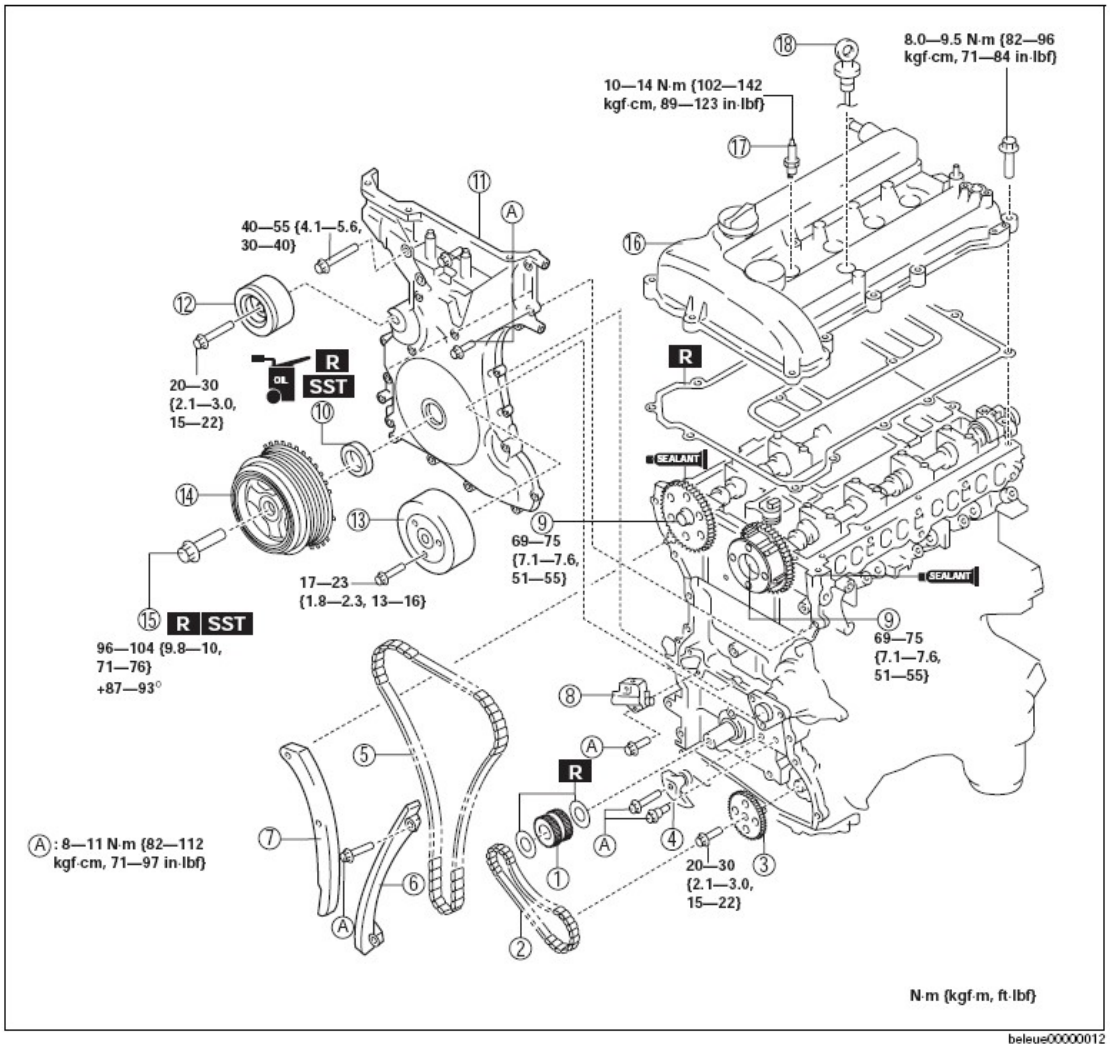
Fig. 118: Identifying Camshaft Cap Bolt Tightening Order

CAMSHAFT SPROCKET, VARIABLE VALVE TIMING ACTUATOR ASSEMBLY NOTE

1. Temporarily tighten the camshaft sprocket or variable valve timing actuator installation bolts by hand until the timing chain is installed.
2. Fully tighten the camshaft sprocket or variable valve timing actuator installation bolts after timing chain installation.

TIMING CHAIN ASSEMBLY

1. Assemble in the order indicated in the table.



1	Crankshaft sprocket
2	Oil pump chain
3	Oil pump sprocket (See Oil Pump Sprocket Assembly Note.)
4	Oil pump chain tensioner
5	Timing chain (See Timing Chain Assembly Note.)
6	Chain guide
7	Tensioner arm
8	Chain tensioner
9	Camshaft sprocket, variable valve timing actuator (See Camshaft Sprocket, Variable Valve Timing Actuator Assembly Note.)
10	Front oil seal (See Front Oil Seal Assembly Note.)

11	Engine front cover (See Engine Front Cover Assembly Note.)
12	Drive belt idler pulley
13	Water pump pulley
14	Crankshaft pulley
15	Crankshaft pulley lock bolt (See Crankshaft Pulley Lock Bolt Assembly Note.)
16	Cylinder head cover (See Cylinder Head Cover Assembly Note)
17	Spark plug
18	Oil level gauge

Fig. 119: Identifying Timing Chain Assembling Order

OIL PUMP SPROCKET ASSEMBLY NOTE

1. Temporarily install the crankshaft pulley and crankshaft pulley lock bolt to the crankshaft, and lock the oil pump against rotation as shown in figure.

2. Install the oil pump sprocket, and then remove the crankshaft pulley and crankshaft pulley lock bolt.

   Tightening torque

   20-30 N.m {2.1-3.0 kgf.m, 15-22 ft.lbf}

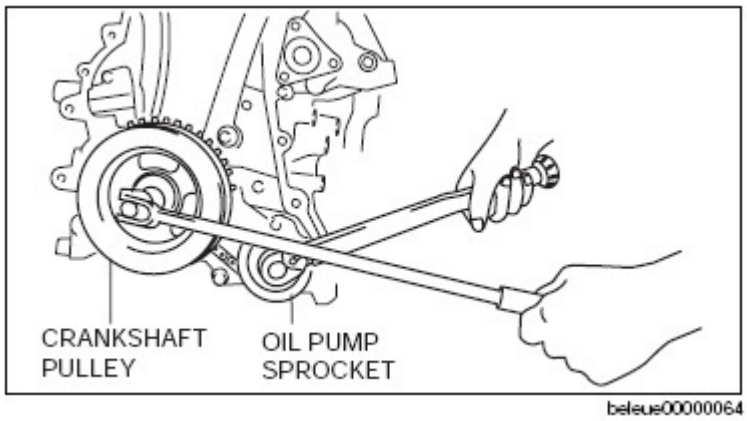


Fig. 120: Tightening Crankshaft Pulley Lock Bolt

TIMING CHAIN ASSEMBLY NOTE

1. Install the **SST** to the camshaft, then align the No. 1 camshaft position with the TDC.
2. Remove the cylinder block lower blind plug.

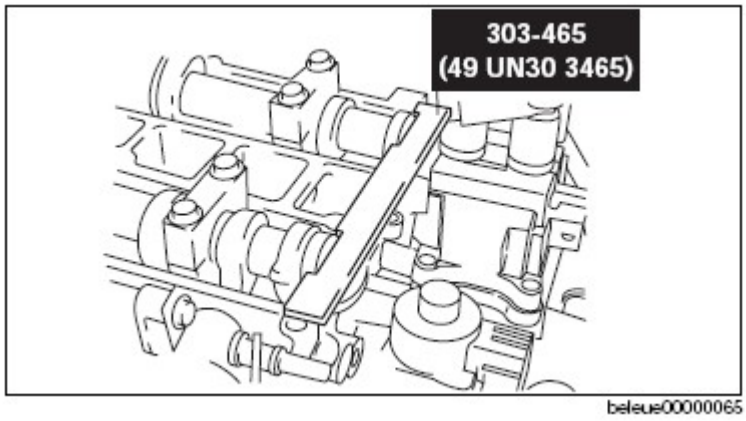


Fig. 121: Installing SST To Camshaft

3. Install the **SST** as shown in the figure.
4. Turn the crankshaft clockwise so that the crankshaft is in the No.1 cylinder TDC position.
5. Install the timing chain.

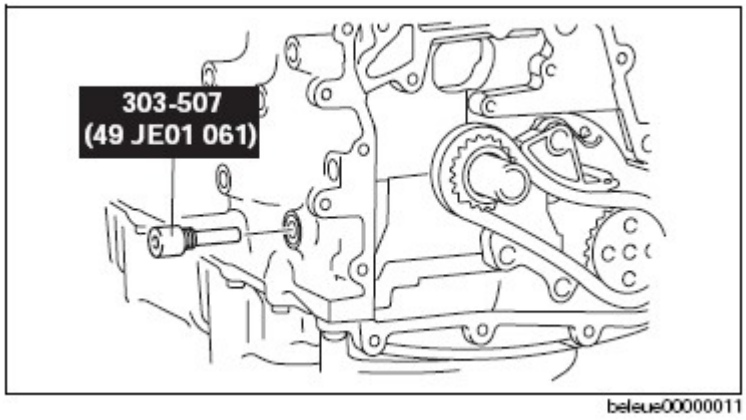


Fig. 122: Identifying SST (303-507)

6. Install the chain tensioner and remove the retaining wire.

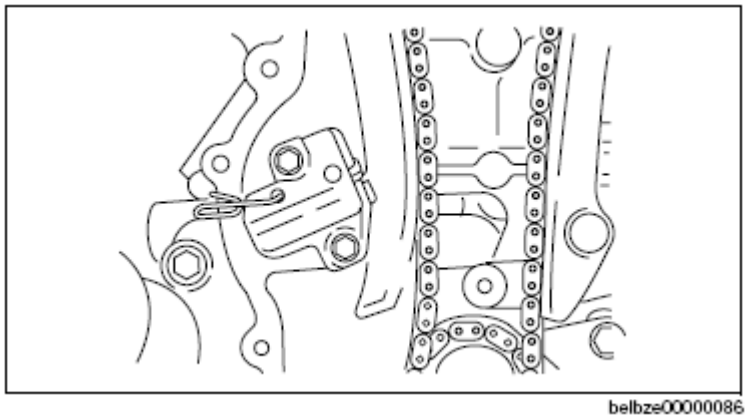


Fig. 123: Identifying Chain Tensioner And Retaining Wire

CAMSHAFT SPROCKET, VARIABLE VALVE TIMING ACTUATOR ASSEMBLY NOTE

1. Hold the camshaft using a suitable wrench on the cast hexagon as shown in the figure.
2. Tighten the camshaft sprocket lock bolt.

Tightening torque

69-75 N.m {7.1-7.6 kgf.m, 51-55 ft.lbf}

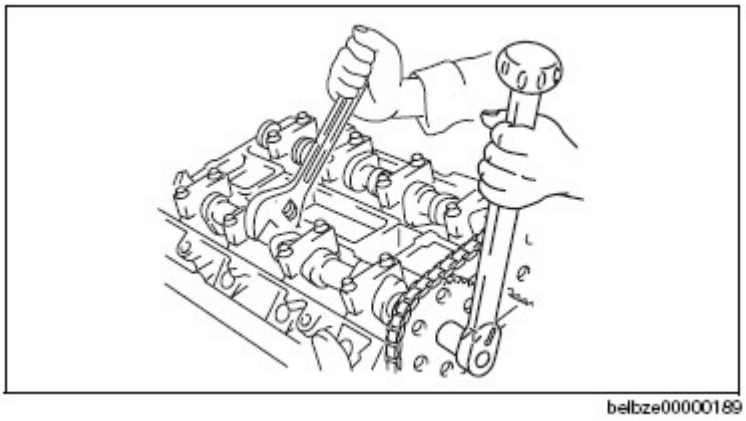


Fig. 124: Tightening Camshaft Sprocket Lock Bolt

FRONT OIL SEAL ASSEMBLY NOTE

1. Apply clean engine oil to the oil seal.
2. Push the oil seal slightly in by hand.
3. Compress the oil seal using the **SST** and a hammer.

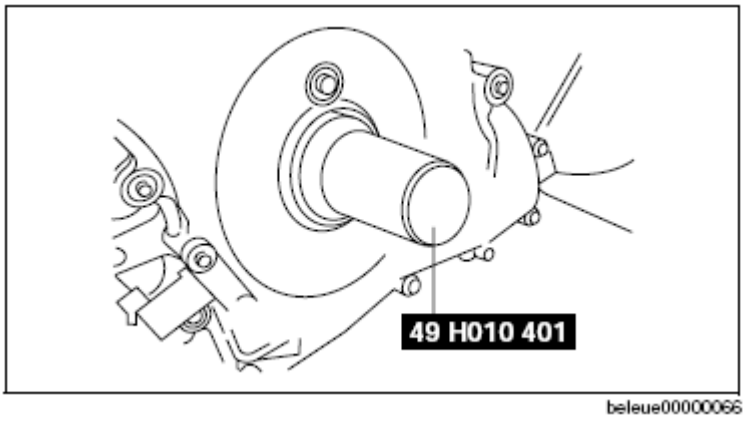


Fig. 125: Compressing Oil Seal Using SST (49 H010 401)

Front oil seal press-in amount

0-0.5 mm {0-0.019 in}

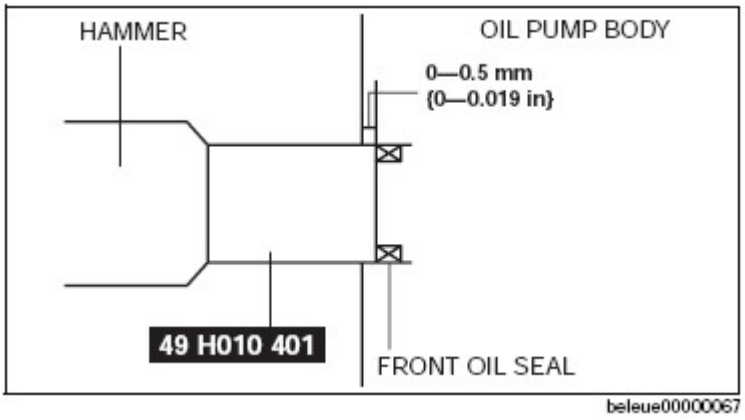


Fig. 126: Identifying Front Oil Seal Press-In Amount

ENGINE FRONT COVER ASSEMBLY NOTE

CAUTION:
- **Install the engine front cover within 10 minutes of applying the silicone sealant.**

1. Apply silicone sealant to the engine front cover as shown.

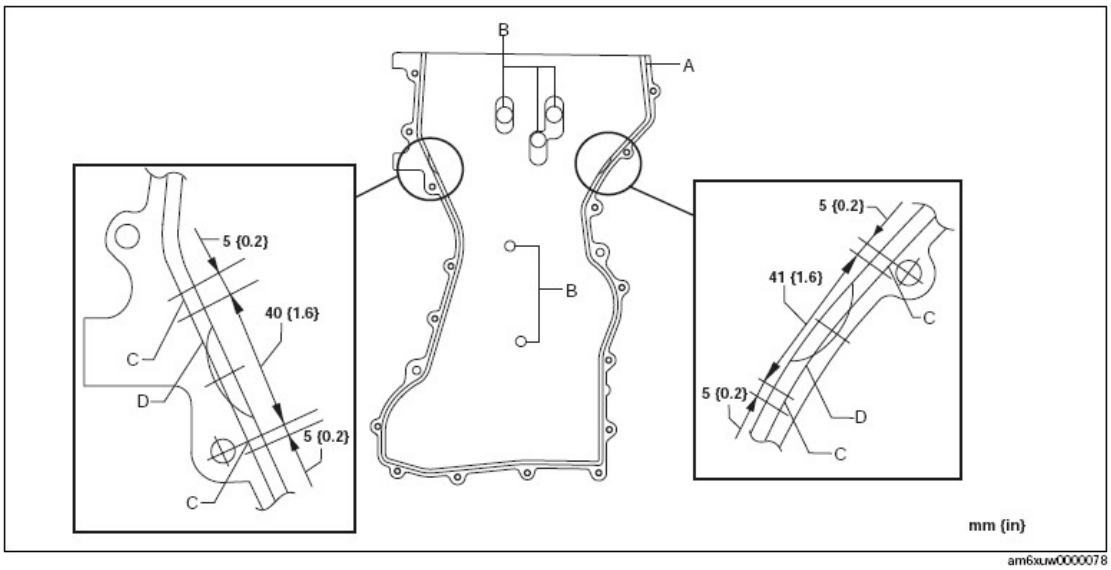


Fig. 127: Applying Silicone Sealant To Engine Front Cover

Thickness

A. **2.2-3.2 mm {0.09-0.12 in}**
B. **1.5-2.5 mm {0.06-0.098 in}**
C. **2.2-4.3 mm {0.09-0.16 in}**
D. **3.3-4.3 mm {0.13-0.16 in}**

2. Install the cylinder head cover bolts in the order as shown in the figure.

No.	Tightening torque
1-18	8.0-11.5 N.m {81.6-117.2 kgf.cm, 70.9- 101.7 in.lbf}
19-22	40-55 N.m {4.1-5.6 kgf.m, 30-40 ft.lbf}

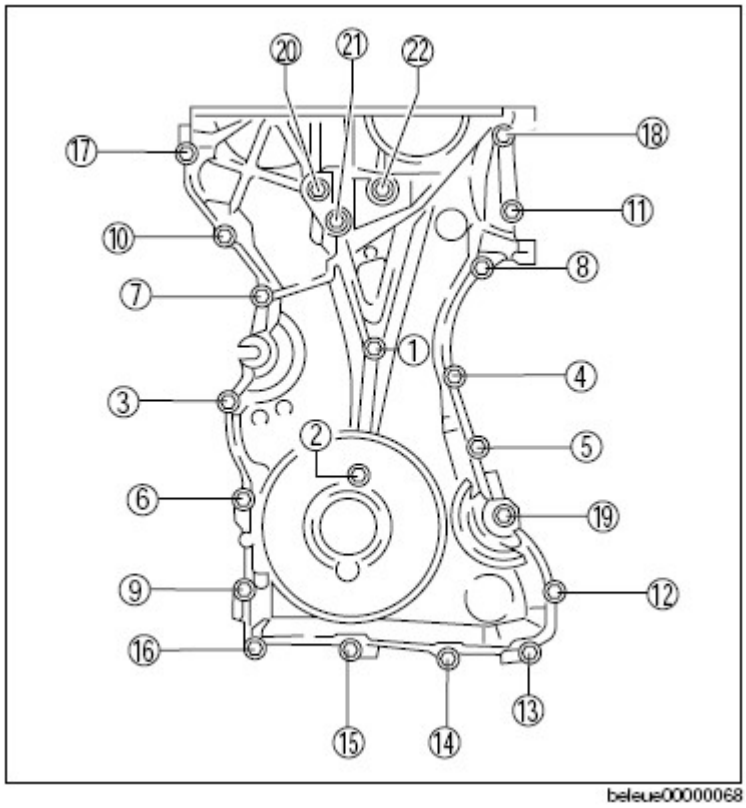


Fig. 128: Identifying Cylinder Head Cover Bolts Installation Order

CRANKSHAFT PULLEY LOCK BOLT ASSEMBLY NOTE

1. Install the **SST** to the camshaft as shown in the figure.
2. Verify that No.1 cylinder is at TDC of the compression stroke. (Position counterweight contacts **SST** .)

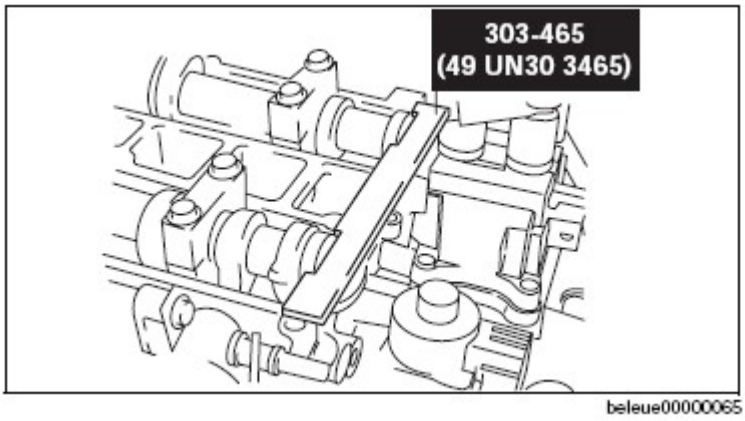


Fig. 129: Installing SST To Camshaft

3. To position the crankshaft pulley, temporarily tighten it and, using a suitable bolt **(M6 X 1.0)** , fix the crankshaft pulley to the engine front cover.

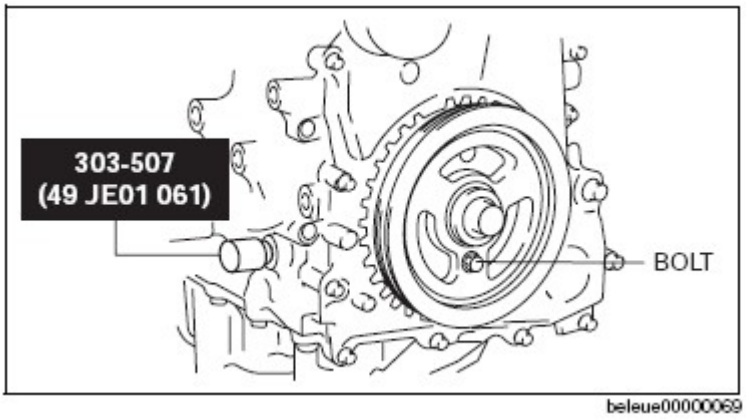


Fig. 130: Identifying SST (303-507) And Bolt (M6 X 1.0)

4. Install the **SST** to the ring gear to lock the crankshaft against rotation.
5. Tighten the crankshaft pulley lock bolt in the order shown in the following two steps using the SST (49 D032 316).

Tightening procedure

1. **96-104 N.m {9.8-10 kgf.m, 71-76 ft.lbf}**
2. **87-93°**

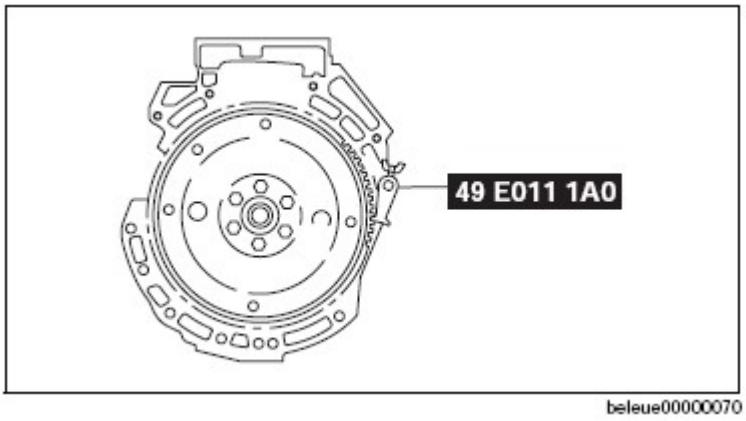


Fig. 131: Identifying SST On Ring Gear To Lock Crankshaft Against Rotation

6. Remove the bolt **(M6 X 1.0)** installed to the crankshaft pulley.
7. Remove the **SST** from the camshaft.
8. Remove the **SST** from the cylinder block lower blind plug hole.
9. Remove the **SST** from the ring gear.
10. Rotate the crankshaft clockwise two turns and inspect the valve timing.
    - If not aligned, loosen the crankshaft pulley lock bolt and repeat from Step 1.
11. Install the cylinder block lower blind plug.

Tightening torque

18-22 N.m {1.9-2.2 kgf.m, 14-16 ft.lbf}

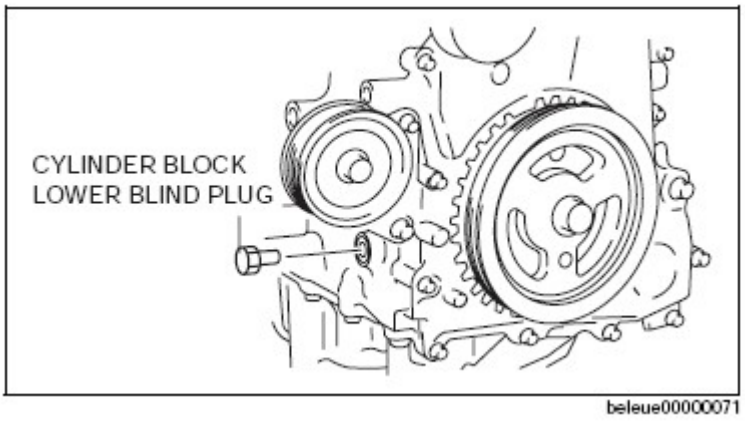


Fig. 132: Identifying Cylinder Block Lower Blind Plug

CYLINDER HEAD COVER ASSEMBLY NOTE

CAUTION:
- **Install the cylinder head cover within 10 min of applying the silicone sealant.**

1. Apply silicone sealant to the mating faces as shown in the figure.

   Thickness

   4.0-6.0 mm {0.16-0.23 in}

2. Install the cylinder head cover with a new gasket.

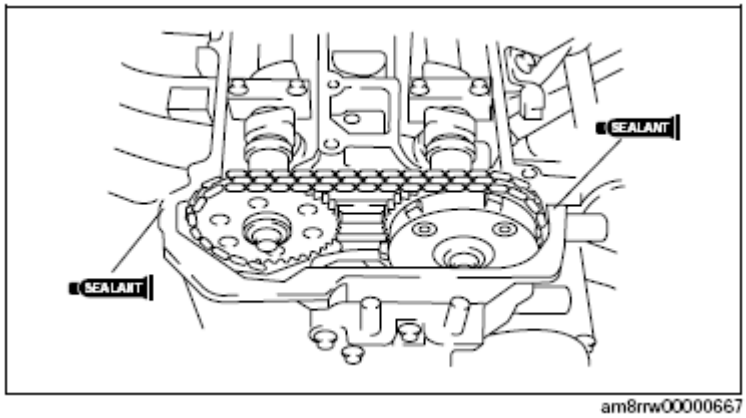


Fig. 133: Applying Silicone Sealant To Mating Faces Of Cylinder Head Cover

3. Tighten the bolts in the order shown in the figure.

   Tightening torque

   8.0 -9.5 N.m {82-96 kgf.cm, 71-84 in.lbf}

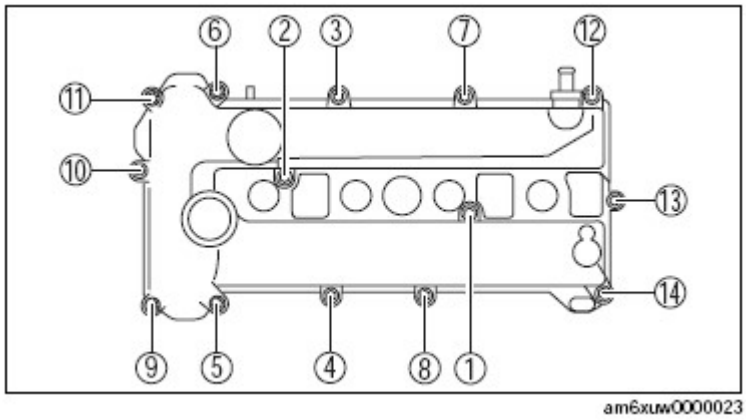


Fig. 134: Identifying Cylinder Head Cover Bolt Tightening Order

