

**ENGINE SECTION 2**

This service manual has been prepared to provide SUBARU service personnel with the necessary information and data for the correct maintenance and repair of SUBARU vehicles.

This manual includes the procedures for maintenance, disassembling, reassembling, inspection and adjustment of components and diagnostics for guidance of experienced mechanics.

Please peruse and utilize this manual fully to ensure complete repair work for satisfying our customers by keeping their vehicle in optimum condition. When replacement of parts during repair work is needed, be sure to use SUBARU genuine parts.

All information, illustration and specifications contained in this manual are based on the latest product information available at the time of publication approval.

**FUEL INJECTION (FUEL SYSTEMS) FU(H6DO)**

**EMISSION CONTROL  
(AUX. EMISSION CONTROL DEVICES) EC(H6DO)**

**INTAKE (INDUCTION) IN(H6DO)**

**MECHANICAL ME(H6DO)**

**EXHAUST EX(H6DO)**

**COOLING CO(H6DO)**

**LUBRICATION LU(H6DO)**

**SPEED CONTROL SYSTEMS SP(H6DO)**

**IGNITION IG(H6DO)**

**STARTING/CHARGING SYSTEMS SC(H6DO)**

**ENGINE (DIAGNOSTICS) EN(H6DO)**



# MECHANICAL

# *ME(H6DO)*

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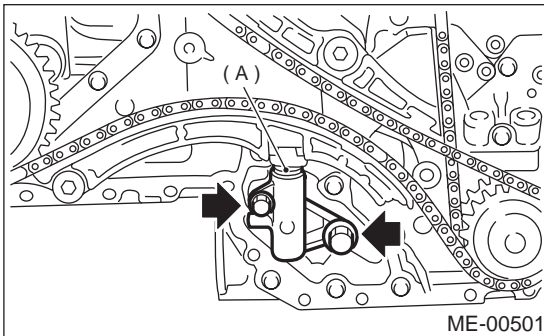
## 12. Timing Chain Assembly

### A: REMOVAL

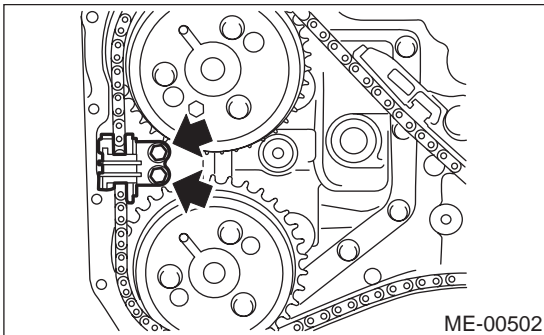
- 1) Remove crankshaft pulley. <Ref. to ME(H6DO)-38, REMOVAL, Crankshaft Pulley.>
- 2) Remove front chain cover. <Ref. to ME(H6DO)-39, REMOVAL, Front Chain Cover.>
- 3) Remove chain tensioner (RH).

**NOTE:**

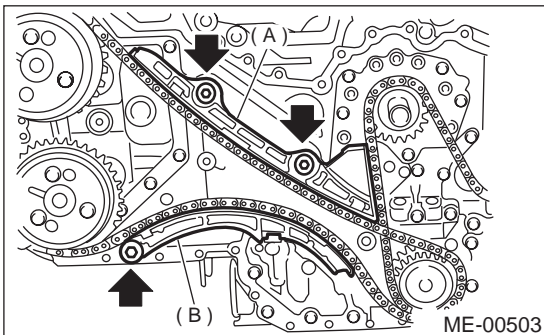
Make sure plunger (A) does not come out.



- 4) Remove chain guide. (Right-hand between cams)



- 5) Remove chain guide (RH).
- 6) Remove chain tensioner lever (RH).



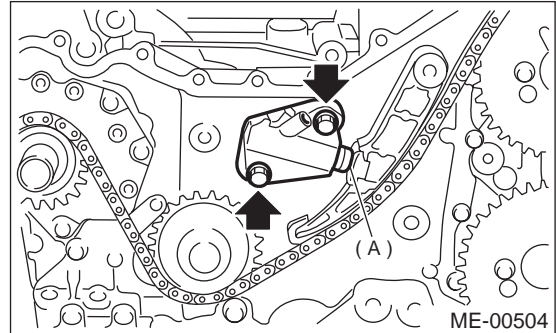
- (A) Chain guide (RH)
- (B) Chain tensioner lever (RH)

- 7) Remove timing chain (RH).

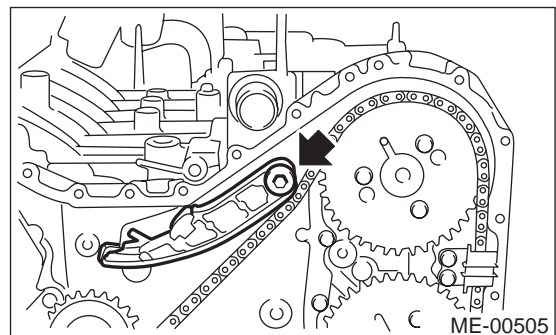
- 8) Remove chain tensioner (LH).

**NOTE:**

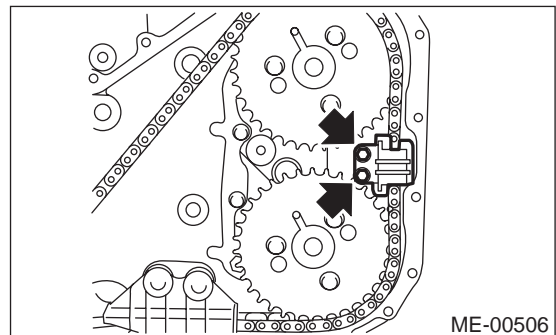
Make sure plunger (A) does not come out.



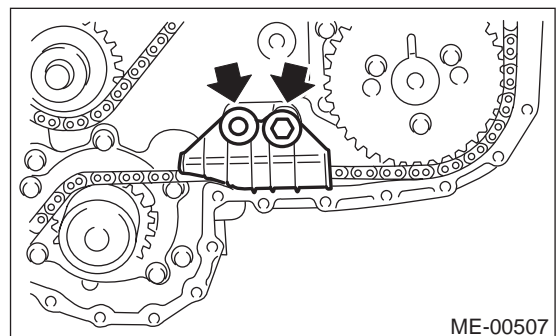
- 9) Remove chain tensioner lever (LH).



- Remove chain guide. (Left-hand between cams)



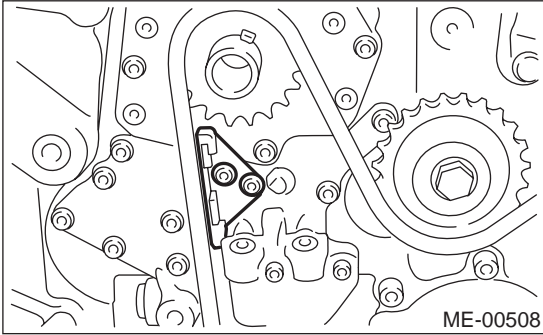
- 10) Remove chain guide (LH).



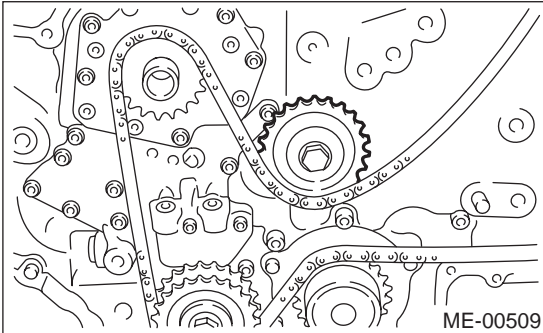
# TIMING CHAIN ASSEMBLY

## MECHANICAL

### 11) Remove chain guide. (Center)

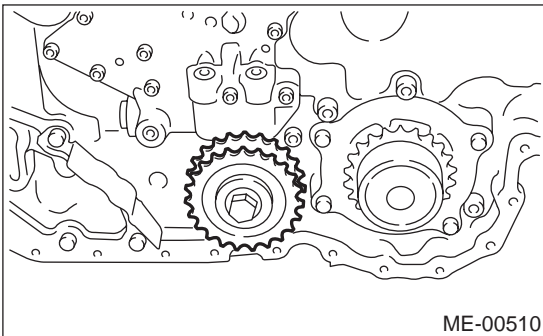


### 12) Remove idler sprocket. (Upper)



### 13) Remove timing chain (LH).

### 14) Remove idler sprocket. (Lower)



## B: INSTALLATION

### NOTE:

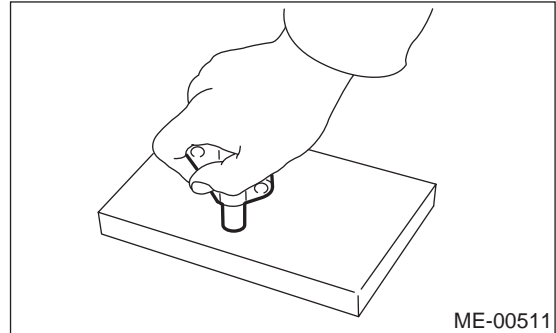
- During installation, be careful to prevent foreign objects from attaching to or mixing with assembled components.
- Apply engine oil to chain guide, chain tensioner lever, and idler sprocket during installation.

#### 1) Preparation for installation of chain tensioner.

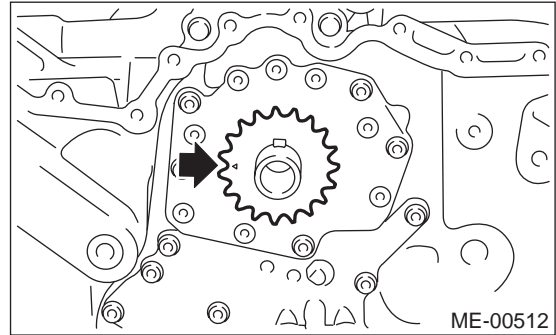
- (1) Put the screw, spring, pin and tension rod into the tensioner body.
- (2) While pressing tensioner onto rubber mat, twist it left and right to shorten tension rod. Then set a thin pin into the holes between tension rod and tensioner body to hold it.

### NOTE:

Carry out the work on rubber mat or other nonslip material.

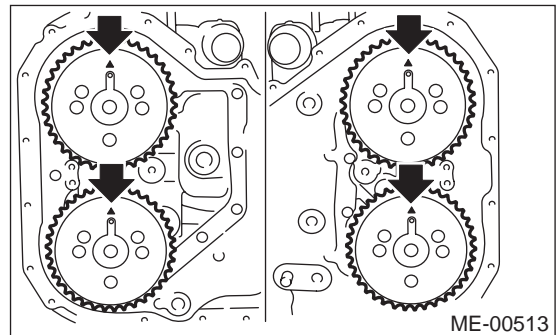


- 2) Using ST, align "top mark" on crankshaft sprocket at 9 o'clock position as shown in the figure.  
ST 18252AA000 CRANKSHAFT SOCKET



- 3) Using ST, align four key grooves on camshaft sprocket at 12 o'clock position as shown in the figure.

ST 18231AA000 CAMSHAFT SPROCKET WRENCH



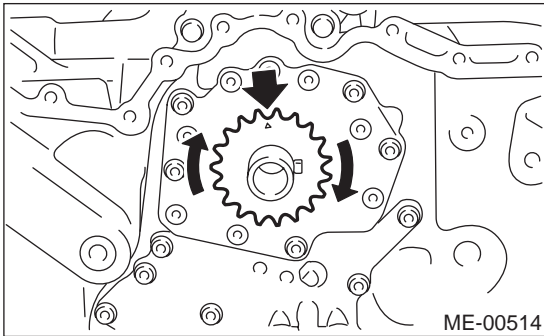
# TIMING CHAIN ASSEMBLY

MECHANICAL

4) Rotate crankshaft sprocket clockwise to align "top mark" at 12 o'clock position as shown in the figure. (Piston # 1 is at TDC.)

**NOTE:**

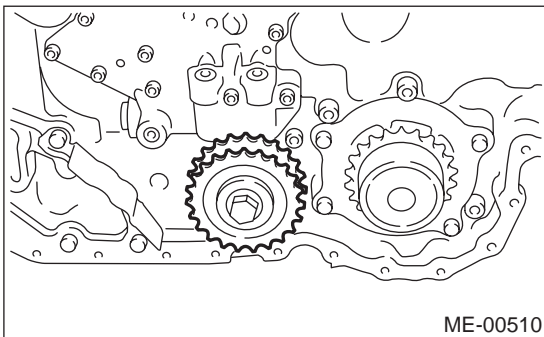
Do not rotate crankshaft and camshaft sprockets until timing chain is completely routed.



5) Install the idler sprocket. (Lower)

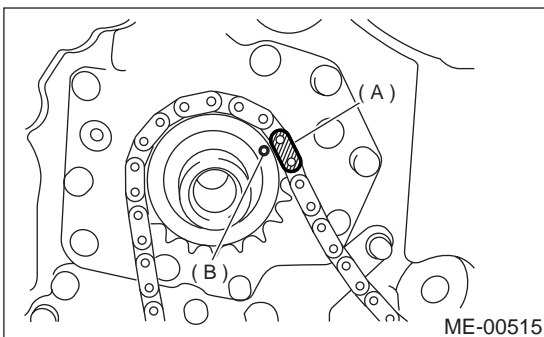
**Tightening torque:**

**69 N·m (7.0 kgf-m, 50.6 ft-lb)**



6) Install timing chain LH.

(1) Align the timing mark (B) on crankshaft sprocket with the matching mark (A) on timing chain LH.

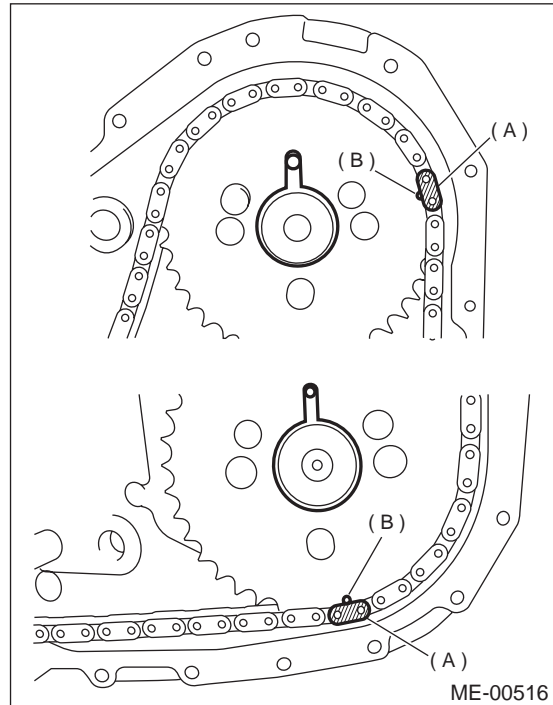


- (A) Gold
- (B) Mark

(2) Route timing chain LH on idler sprocket (Lower), water pump, exhaust cam sprocket, and intake cam sprocket in order.

**NOTE:**

Make sure that matching marks on the timing chain (A) and camshaft sprocket (B) are aligned the same way as the one on crankshaft sprocket.

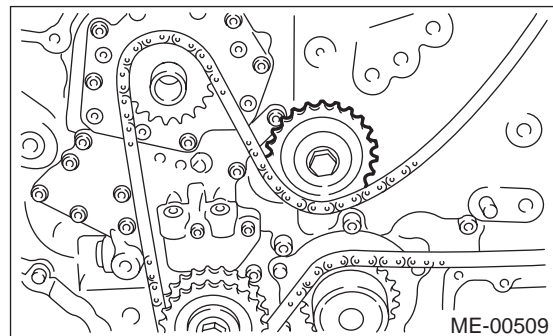


- (A) Dark blue
- (B) Mark

(3) Install chain idler. (Upper)

**Tightening torque:**

**69 N·m (7.0 kgf-m, 50.6 ft-lb)**



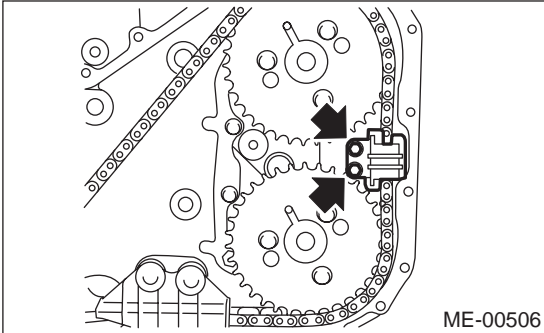
# TIMING CHAIN ASSEMBLY

## MECHANICAL

- (4) Install chain guide. (Left-hand between cams)

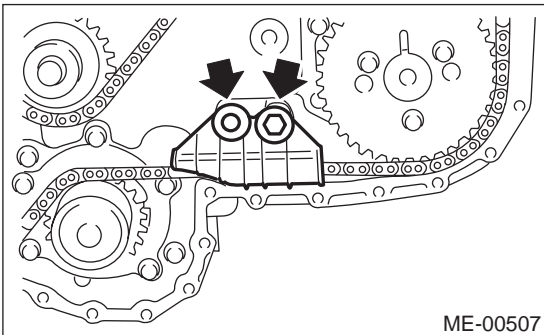
**Tightening torque:**  
**6.3N·m (0.64 kgf-m, 4.6 ft-lb)**

**NOTE:**  
Replace mounting bolt with a new one.



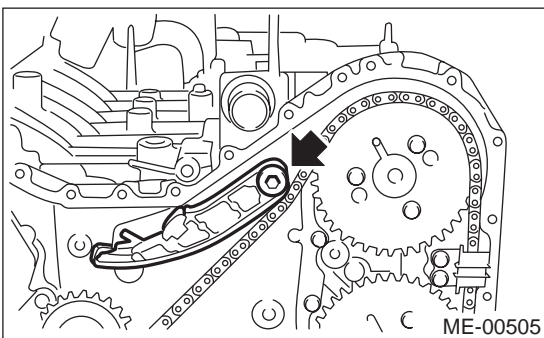
- (5) Install chain guide (LH).

**Tightening torque:**  
**16 N·m (1.6 kgf-m, 11.6 ft-lb)**



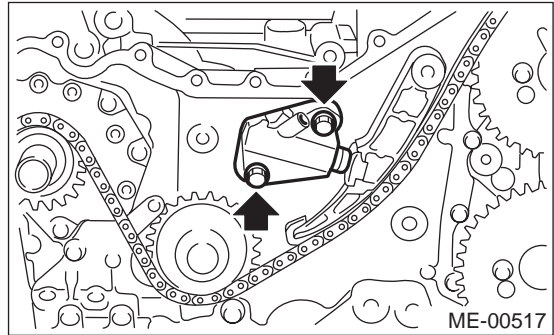
- (6) Install chain tensioner lever LH.

**Tightening torque:**  
**16 N·m (1.6 kgf-m, 11.6 ft-lb)**



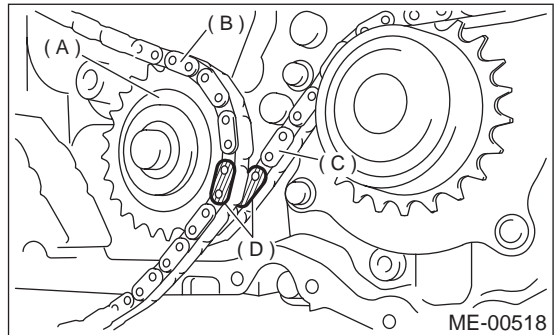
- (7) Install chain tensioner LH.

**Tightening torque:**  
**16 N·m (1.6 kgf-m, 11.6 ft-lb)**



- 7) Install timing chain RH.

- (1) On idler sprocket (Lower) , align matching marks on timing chains LH and RH.



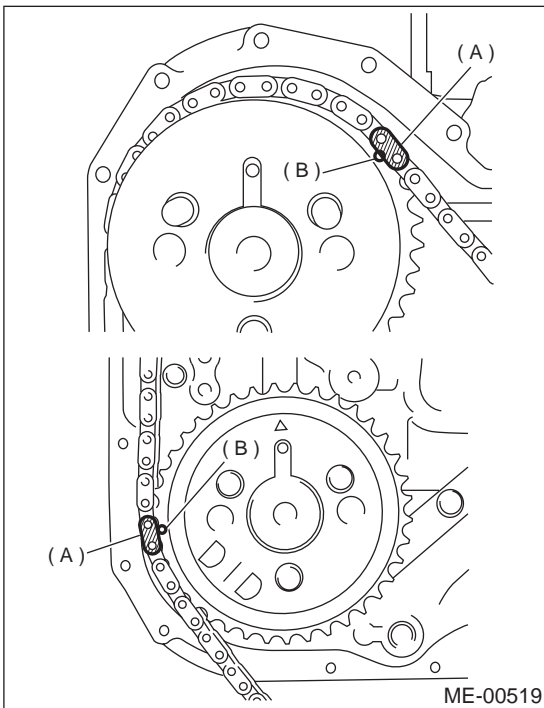
- (A) Lower idler sprocket  
(B) Timing chain RH  
(C) Timing chain LH  
(D) Dark gray

- (2) Route timing chain RH on intake cam sprocket and then exhaust cam sprocket.

**NOTE:**

Make sure that matching marks on the timing chain (A) and camshaft sprocket (B) are aligned the same way as the one on crankshaft sprocket.

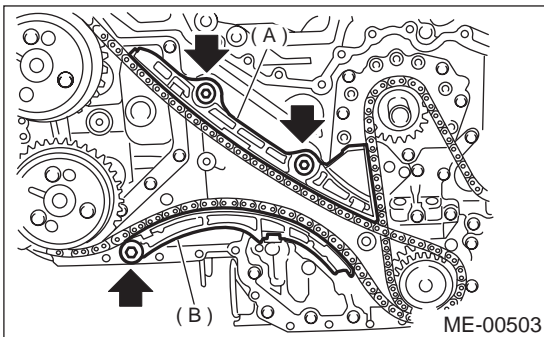




- (A) Gold
- (B) Mark

- (3) Install chain guide (RH).
- (4) Install chain tensioner lever (RH).

**Tightening torque:**  
**16 N·m (1.6 kgf-m, 11.6 ft-lb)**

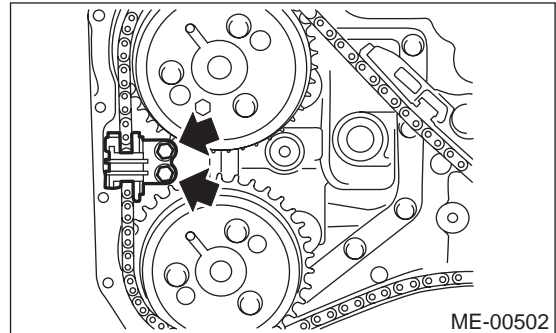


- (A) Chain guide (RH)
- (B) Chain tensioner lever (RH)

- (5) Install timing chain guide RH No. 1.

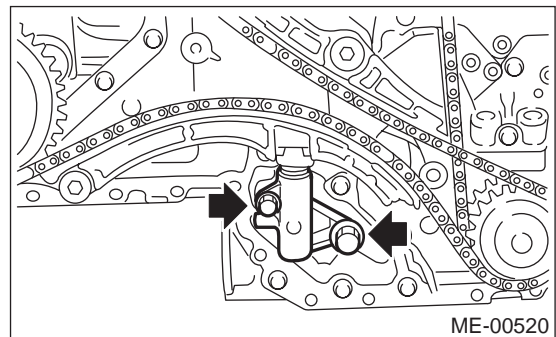
**Tightening torque:**  
**6.3 N·m (0.64 kgf-m, 4.6 ft-lb)**

**NOTE:**  
 Replace mounting bolt with a new one.



- (6) Install the chain tensioner (RH).

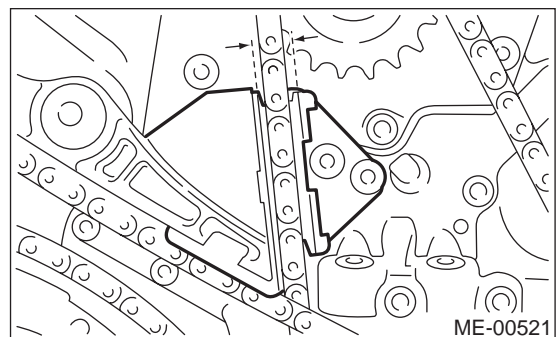
**Tightening torque:**  
**16 N·m (1.6 kgf-m, 11.6 ft-lb)**



- (7) Adjust the clearance between chain guide (RH) and chain guide (Center) to the range between 8.4 mm (0.331 in) to 8.6 mm (0.339 in). And install chain guide (Center).

**Tightening torque:**  
**7.8 N·m (0.8 kgf-m, 5.8 ft-lb)**

**NOTE:**  
 Replace mounting bolt with a new one.



- (8) After checking the matching marks on each sprocket and corresponding timing chain are aligned, pull stopper pin out of chain tensioner.

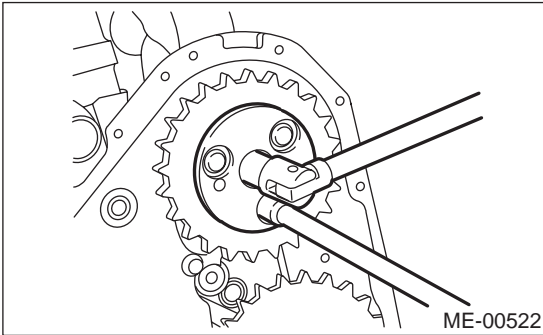


## 13. Camshaft Sprocket

### A: REMOVAL

- 1) Remove crankshaft pulley. <Ref. to ME(H6DO)-38, REMOVAL, Crankshaft Pulley.>
- 2) Remove front chain cover. <Ref. to ME(H6DO)-39, REMOVAL, Front Chain Cover.>
- 3) Remove timing chain assembly. <Ref. to ME(H6DO)-41, REMOVAL, Timing Chain Assembly.>
- 4) Remove camshaft sprocket. To lock camshaft, use ST.

ST 18231AA000 CAMSHAFT SPROCKET WRENCH



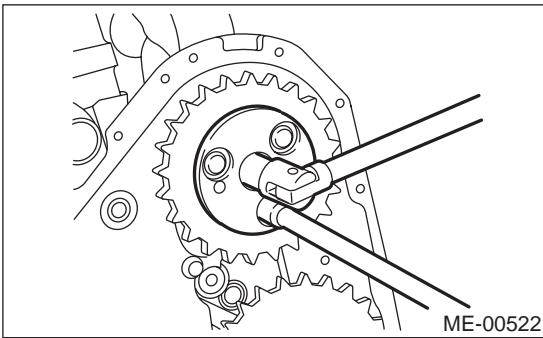
### B: INSTALLATION

- 1) Install camshaft sprocket. To lock camshaft, use ST.

ST 18231AA000 CAMSHAFT SPROCKET WRENCH

#### **Tightening torque:**

**13 N·m (1.0 kgf-m, 7.2 ft-lb)**



- 2) Install timing chain assembly. <Ref. to ME(H6DO)-42, INSTALLATION, Timing Chain Assembly.>
- 3) Install front chain cover. <Ref. to ME(H6DO)-39, INSTALLATION, Front Chain Cover.>
- 4) Install crankshaft pulley. <Ref. to ME(H6DO)-38, INSTALLATION, Crankshaft Pulley.>

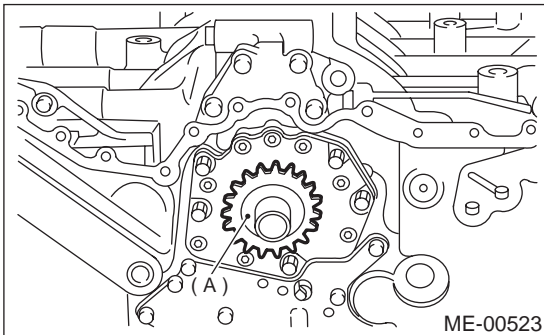
### C: INSPECTION

- 1) Check sprocket teeth for abnormal wear and scratches.
- 2) Make sure there is no free play between sprocket and key.

## 14.Crankshaft Sprocket

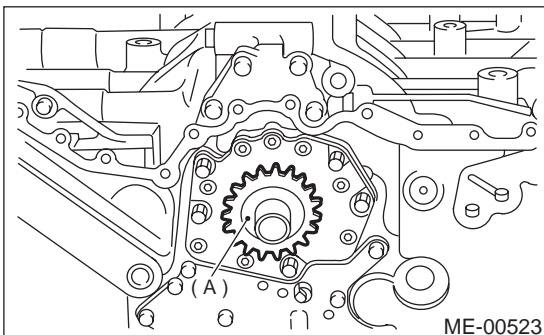
### A: REMOVAL

- 1) Remove crankshaft pulley. <Ref. to ME(H6DO)-38, REMOVAL, Crankshaft Pulley.>
- 2) Remove front chain cover. <Ref. to ME(H6DO)-39, REMOVAL, Front Chain Cover.>
- 3) Remove timing chain assembly. <Ref. to ME(H6DO)-41, REMOVAL, Timing Chain Assembly.>
- 4) Remove camshaft sprocket. <Ref. to ME(H6DO)-46, REMOVAL, Camshaft Sprocket.>
- 5) Remove crankshaft sprocket (A).



### B: INSTALLATION

- 1) Install crankshaft sprocket (A).



- 2) Install camshaft sprocket. <Ref. to ME(H6DO)-46, INSTALLATION, Camshaft Sprocket.>
- 3) Install timing chain assembly. <Ref. to ME(H6DO)-42, INSTALLATION, Timing Chain Assembly.>
- 4) Install front chain cover. <Ref. to ME(H6DO)-39, INSTALLATION, Front Chain Cover.>
- 5) Install crankshaft pulley. <Ref. to ME(H6DO)-38, INSTALLATION, Crankshaft Pulley.>

### C: INSPECTION

- 1) Check sprocket teeth for abnormal wear and scratches.
- 2) Make sure there is no free play between sprocket and key.

# REAR CHAIN COVER

MECHANICAL

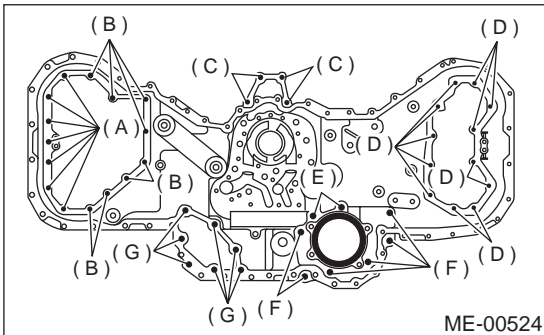
## 15.Rear Chain Cover

### A: REMOVAL

- 1) Remove crankshaft pulley. <Ref. to ME(H6DO)-38, REMOVAL, Crankshaft Pulley.>
- 2) Remove front chain cover. <Ref. to ME(H6DO)-39, REMOVAL, Front Chain Cover.>
- 3) Remove timing chain. <Ref. to ME(H6DO)-41, REMOVAL, Timing Chain Assembly.>
- 4) Remove camshaft sprocket. <Ref. to ME(H6DO)-46, REMOVAL, Camshaft Sprocket.>
- 5) Remove crankshaft sprocket.
- 6) Remove oil pump. <Ref. to LU(H6DO)-11, REMOVAL, Oil Pump.>
- 7) Remove oil pump relief valve. <Ref. to LU(H6DO)-13, REMOVAL, Oil Pump Relief Valve.>
- 8) Remove water pump. <Ref. to CO(H6DO)-24, REMOVAL, Water Pump.>
- 9) Remove rear chain cover.

#### NOTE:

There are seven different types of mounting bolts. Sort them into separate containers to avoid confusion at installation.



#### Bolt dimension:

- (A) 6 × 14
- (B) 6 × 18 (Silver)
- (C) 6 × 30
- (D) 6 × 18
- (E) 6 × 40
- (F) 6 × 30
- (G) 6 × 22

### B: INSTALLATION

- 1) Remove old fluid gasket on the matching surface, and degrease it.
- 2) Apply fluid gasket to the mating surface of rear chain cover.

#### Fluid gasket:

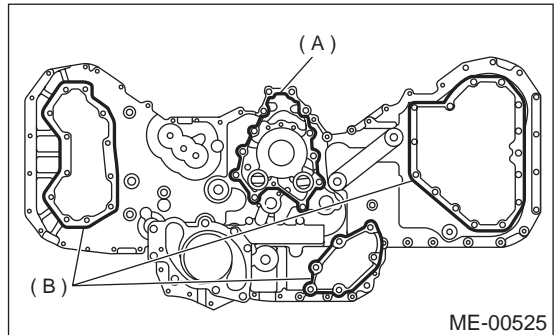
**THREE BOND 1280B**

**Part No.: K0877YA018**

#### Fluid gasket application diameter:

**(A) 1.0±0.5 mm (0.039±0.020 in)**

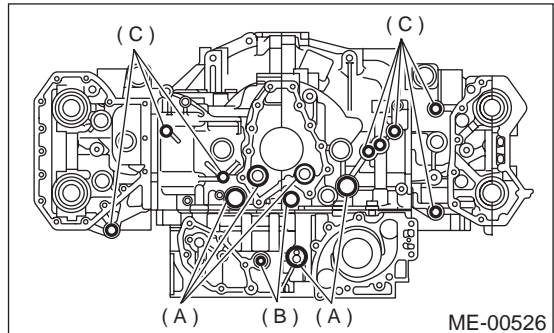
**(B) 3.0±1.0 mm (0.118±0.039 in)**



- 3) Install O-ring.

#### NOTE:

Do not reuse the O-ring.

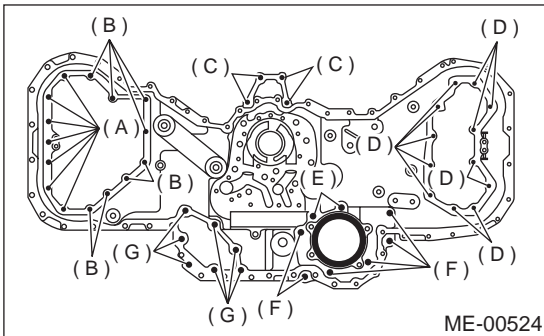


- (A) O-ring (Large)
- (B) O-ring (Medium)
- (C) O-ring (Small)

4) Temporarily tighten rear chain cover.

**NOTE:**

- Do not confuse the mounting positions of the bolts.
- Replace mounting bolts (G) with new ones.



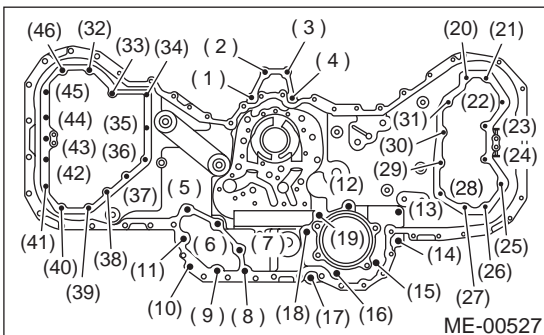
**Bolt dimension:**

- (A) 6 × 14
- (B) 6 × 18 (Silver)
- (C) 6 × 30
- (D) 6 × 18
- (E) 8 × 40
- (F) 8 × 30
- (G) 6 × 22

5) Tighten the bolts in the numerical sequence shown in figure.

**Tightening torque:**

(1) to (11)	9 N·m (0.9 kgf-m, 6.5 ft-lb)
(12) to (19)	20 N·m (2.0 kgf-m, 14 ft-lb)
(20) to (31)	9 N·m (0.9 kgf-m, 6.5 ft-lb)
(32) to (39)	12 N·m (1.2 kgf-m, 8.7 ft-lb)
(40) to (46)	9 N·m (0.9 kgf-m, 6.5 ft-lb)

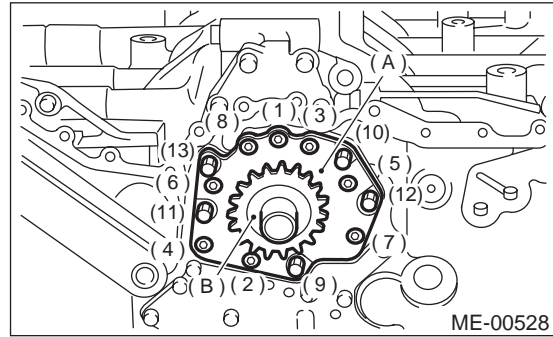


6) Install water pump. <Ref. to CO(H6DO)-24, REMOVAL, Water Pump.>

7) Install oil pump relief valve. <Ref. to LU(H6DO)-13, INSTALLATION, Oil Pump Relief Valve.>

8) Install oil pump. <Ref. to LU(H6DO)-11, INSTALLATION, Oil Pump.>

9) Install crankshaft sprocket.



10) Install camshaft sprocket. <Ref. to ME(H6DO)-46, INSTALLATION, Camshaft Sprocket.>

11) Install timing chain. <Ref. to ME(H6DO)-42, INSTALLATION, Timing Chain Assembly.>

12) Install front chain cover. <Ref. to ME(H6DO)-39, INSTALLATION, Front Chain Cover.>

13) Install crankshaft pulley. <Ref. to ME(H6DO)-38, INSTALLATION, Crankshaft Pulley.>

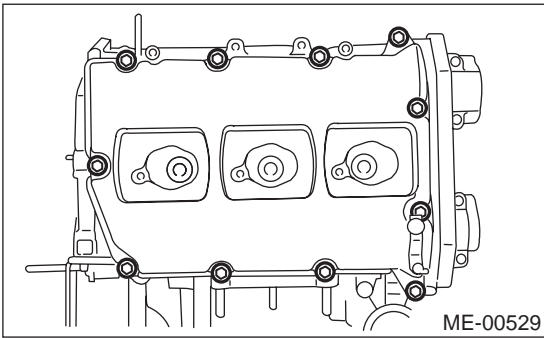
# CAMSHAFT

MECHANICAL

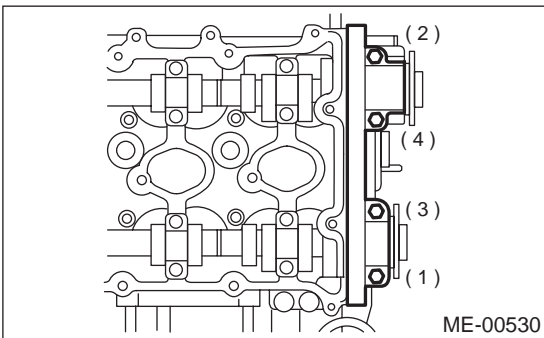
## 16. Camshaft

### A: REMOVAL

- 1) Remove crankshaft pulley. <Ref. to ME(H6DO)-38, REMOVAL, Crankshaft Pulley.>
- 2) Remove front chain cover. <Ref. to ME(H6DO)-39, REMOVAL, Front Chain Cover.>
- 3) Remove timing chain assembly. <Ref. to ME(H6DO)-41, REMOVAL, Timing Chain Assembly.>
- 4) Remove camshaft sprockets. <Ref. to ME(H6DO)-46, REMOVAL, Camshaft Sprocket.>
- 5) Remove crankshaft sprocket. <Ref. to ME(H6DO)-47, REMOVAL, Crankshaft Sprocket.>
- 6) Remove rear chain cover. <Ref. to ME(H6DO)-48, REMOVAL, Rear Chain Cover.>
- 7) Remove rocker cover (RH).

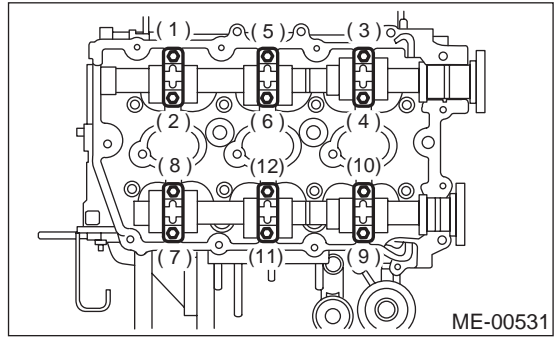


- 8) Loosen front camshaft cap bolts equally, a little at a time in numerical sequence shown in the figure (RH).



- 9) Remove camshaft cap and intake camshaft (RH).

- 10) Loosen camshaft cap bolts equally, a little at a time in the numerical sequence shown in the figure.

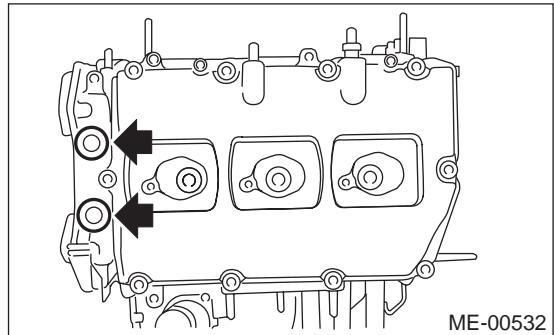


- 11) Remove camshaft cap and exhaust camshaft (RH).

### CAUTION:

Arrange camshaft caps in order so that they can be installed in their original position.

- 12) Remove plug (LH).



- 13) Similarly, remove left-hand camshafts and related parts.

### B: INSTALLATION

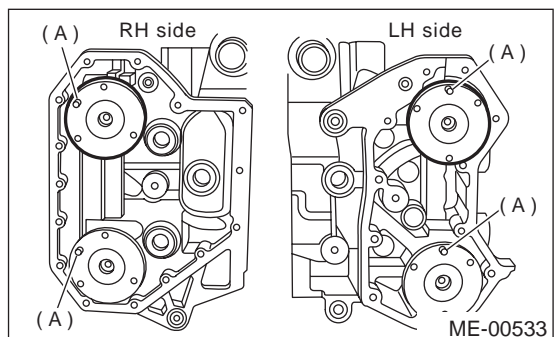
- 1) Apply a coat of engine oil to camshaft journals and install camshaft.

### NOTE:

When installing camshaft, adjust camshaft front flange knock pin (A) position as follows:

LH side: 12 o'clock

RH side: 10 o'clock



- 2) Install camshaft cap.
  - (1) Apply fluid packing sparingly to back of front camshaft cap shown in the figure.

**CAUTION:**

Do not apply fluid gasket excessively. Failure to do so may cause excess fluid gasket to come out and flow toward camshaft journal, resulting burning stuck of engine.

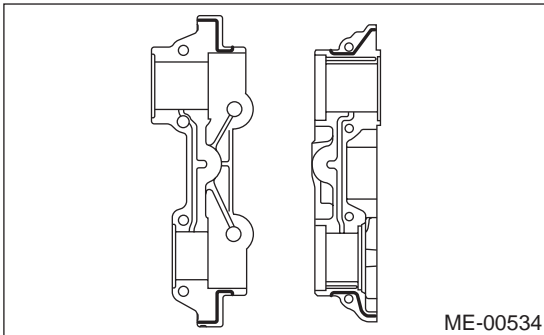
**Fluid gasket:**

**THREE BOND 1280B**

**Part No.: K0877YA018**

**Fluid gasket application diameter:**

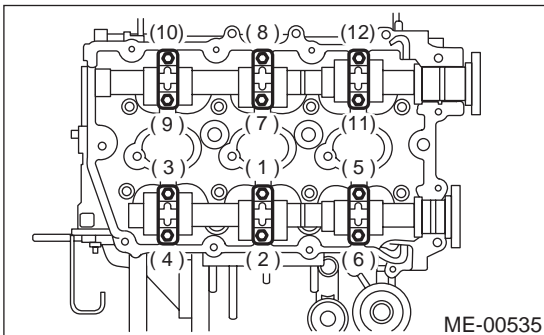
**2.0±0.5 mm (0.079±0.020 in)**



- (2) Apply engine oil to cap bearing surface and install cap on camshaft.
- (3) Tighten the camshaft cap bolts in the numerical sequence shown in the figure.

**Tightening torque:**

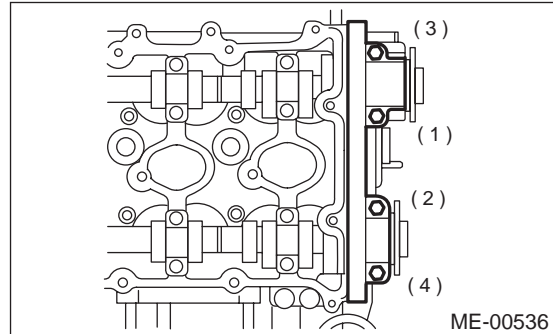
**16 N·m (1.6 kgf·m, 11.6 ft·lb)**



- (4) Tighten the front camshaft cap bolts in the numerical sequence shown in the figure.

**Tightening torque:**

**9.8 N·m (1.0 kgf·m, 7.2 ft·lb)**



- 3) Install rocker cover.

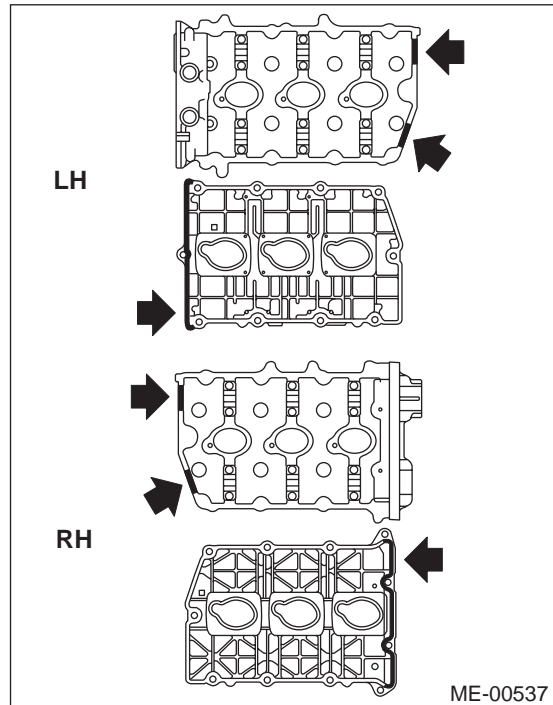
- (1) Apply fluid gasket sparingly to matching surface of cylinder heads and rocker covers shown in the figure.

**CAUTION:**

Do not apply fluid gasket excessively. Doing so may cause excess fluid gasket to come out and flow toward camshaft journal, resulting burning stuck of engine.

**Fluid gasket:**

**THREE BOND 1280B**





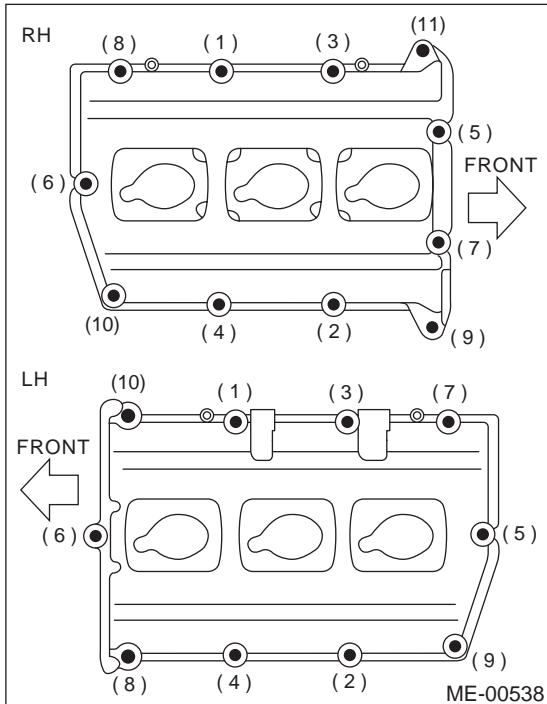
# CAMSHAFT

## MECHANICAL

(2) Tighten the rocker cover bolts in the numerical order shown in the figure.

### Tightening torque:

**6.4 N·m (0.64 kgf-m, 4.6 ft-lb)**



4) Install rear chain cover. <Ref. to ME(H6DO)-48, INSTALLATION, Rear Chain Cover.>

5) Install crankshaft sprocket. <Ref. to ME(H6DO)-47, INSTALLATION, Crankshaft Sprocket.>

6) Install camshaft sprockets. <Ref. to ME(H6DO)-46, INSTALLATION, Camshaft Sprocket.>

7) Install timing chain assembly. <Ref. to ME(H6DO)-42, INSTALLATION, Timing Chain Assembly.>

8) Install front chain cover. <Ref. to ME(H6DO)-39, INSTALLATION, Front Chain Cover.>

9) Install crankshaft pulley. <Ref. to ME(H6DO)-38, INSTALLATION, Crankshaft Pulley.>

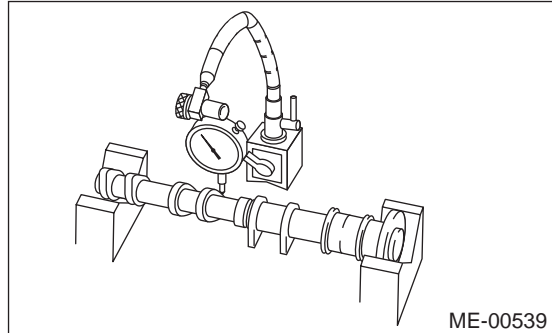
## C: INSPECTION

### 1. CAMSHAFT

1) Measure the bend, and repair or replace if necessary.

#### Limit:

**0.020 mm (0.0008 in)**



2) Check journal for damage and wear. Replace if faulty.

3) Measure outside diameter of camshaft journal. If the journal diameter is not as specified, check the oil clearance.

	Camshaft journal	
	Front	Center, rear
Standard	37.946 — 37.963 mm (1.4939 — 1.4946 in)	27.946 — 27.963 mm (1.1002 — 1.1009 in)

4) Measurement of the camshaft journal oil clearance

(1) Clean the bearing caps and camshaft journals.

(2) Place the camshafts on the cylinder head.

(3) Place plastigauge across each of the camshaft journals.

(4) Install the bearing caps.

#### NOTE:

Do not turn the camshaft.

(5) Remove the bearing caps.



(6) Measure the widest point of the plastigauge on each journal.

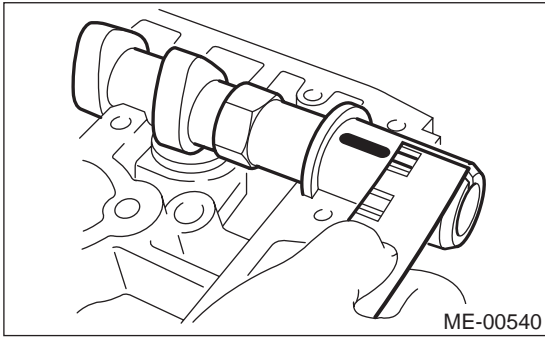
If the oil clearance exceeds the limit, replace the camshaft. If necessary, replace the camshaft caps and cylinder head as a set.

**Standard oil clearance:**

**0.037 — 0.072 mm (0.0015 — 0.0028 in)**

**Limit:**

**0.10 mm (0.0039 in)**



(7) Completely remove the plastigauge.

5) Check cam face condition; remove minor faults by grinding with oil stone. Measure the cam height H; replace if the limit has been exceeded.

**Cam height: H**

**Standard:**

**Intake:**

**45.75 — 45.85 mm (1.8012 — 1.8051 in)**

**Exhaust:**

**45.25 — 45.35 mm (1.7815 — 1.7854 in)**

**Limit:**

**Intake:**

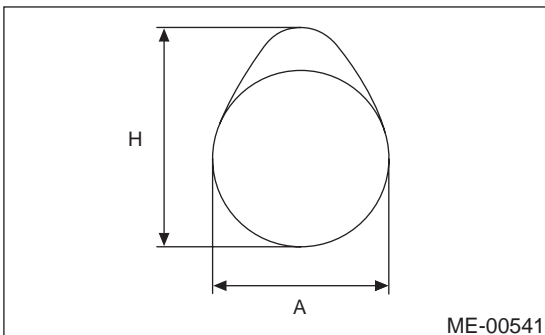
**45.65 mm (1.7972 in)**

**Exhaust:**

**45.15 mm (1.7776 in)**

**Cam base circle diameter A:**

**36.0 mm (1.4173 in)**



6) Measure the thrust clearance of camshaft with dial gauge. If the clearance exceeds the limit, replace caps and cylinder head as a set. If necessary replace camshaft.

**Standard:**

**Intake:**

**0.075 — 0.135 mm (0.0030 — 0.0053 in)**

**Exhaust:**

**0.048 — 0.108 mm (0.0019 — 0.0043 in)**

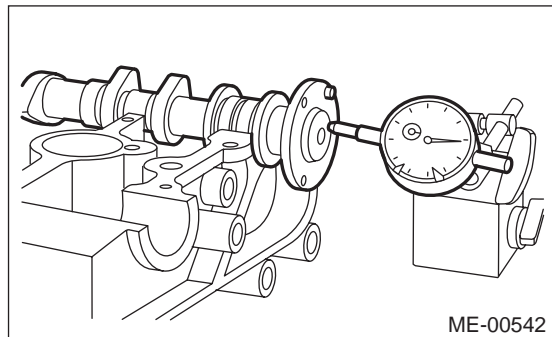
**Limit:**

**Intake:**

**0.155 mm (0.0061 in)**

**Exhaust:**

**0.130 mm (0.0051 in)**



# CYLINDER HEAD ASSEMBLY

MECHANICAL

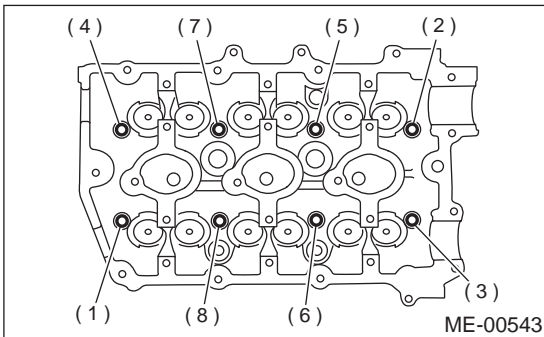
## 17. Cylinder Head Assembly

### A: REMOVAL

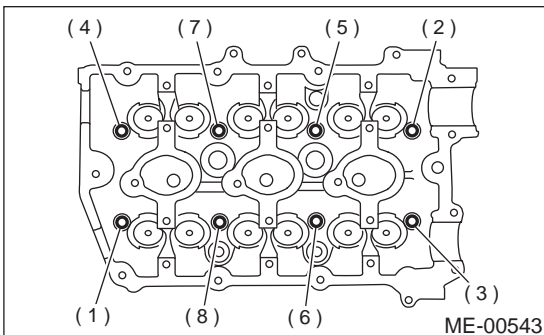
- 1) Remove crankshaft pulley. <Ref. to ME(H6DO)-38, REMOVAL, Crankshaft Pulley.>
- 2) Remove front chain cover. <Ref. to ME(H6DO)-39, REMOVAL, Front Chain Cover.>
- 3) Remove timing chain assembly. <Ref. to ME(H6DO)-41, REMOVAL, Timing Chain Assembly.>
- 4) Remove camshaft sprockets. <Ref. to ME(H6DO)-46, REMOVAL, Camshaft Sprocket.>
- 5) Remove crankshaft sprocket. <Ref. to ME(H6DO)-47, REMOVAL, Crankshaft Sprocket.>
- 6) Remove rear chain cover. <Ref. to ME(H6DO)-48, REMOVAL, Rear Chain Cover.>
- 7) Remove camshafts. <Ref. to ME(H6DO)-50, REMOVAL, Camshaft.>
- 8) Remove cylinder head bolts in numerical sequence shown in figure.

#### NOTE:

Leave bolts (2) and (4) engaged by three or four threads to prevent cylinder head from falling.



- 9) Tap cylinder head with a plastic hammer to separate it from cylinder block.
- 10) Remove bolts (2) and (4) to remove cylinder head.



- 11) Remove cylinder head gasket.

#### NOTE:

Do not scratch the mating surface of cylinder head and cylinder block.

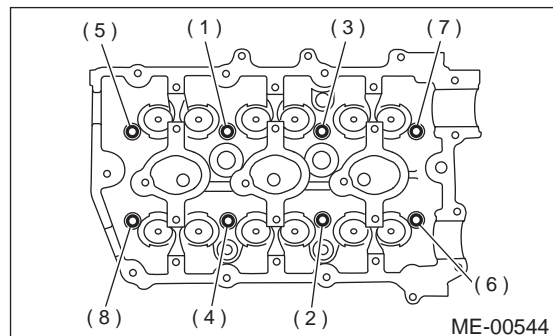
- 12) Similarly, remove right side cylinder head.

### B: INSTALLATION

- 1) Install cylinder head and gaskets on cylinder block.

#### NOTE:

- Use new cylinder head gaskets.
  - Be careful not to scratch the mating surface of cylinder block and oil pump.
- 2) Tighten cylinder head bolts.
    - (1) Coat the washers and threaded parts of the cylinder head bolts with engine oil.
    - (2) Install the cylinder head on the cylinder block and tighten the bolts in the numerical order shown in the figure to a tightening torque of 20 N·m (2.0 kgf·m, 14 ft·lb).
    - (3) Tighten the bolts in the numerical order shown in the figure to a tightening torque of 50 N·m (5.1 kgf·m, 37 ft·lb).
    - (4) Loosen all the bolts in 2 stages, 180° at a time, in the reverse order of tightening.
    - (5) Tighten the bolts in the numerical order shown in the figure to a tightening torque of 25 N·m (2.5 kgf·m, 18 ft·lb).
    - (6) Tighten the bolts in the numerical order shown in the figure to a tightening torque of 25 N·m (2.5 kgf·m, 18 ft·lb).
    - (7) Tighten all the bolts 90° in the numerical order shown in the figure.
    - (8) Tighten the (1) to (4) bolts 90° again in the numerical order shown in the figure.
    - (9) Tighten the (5) to (8) bolts 45° again in the numerical order shown in the figure.



- 3) Install camshafts. <Ref. to ME(H6DO)-50, INSTALLATION, Camshaft.>
- 4) Install rear chain cover. <Ref. to ME(H6DO)-48, INSTALLATION, Rear Chain Cover.>
- 5) Install crankshaft sprocket. <Ref. to ME(H6DO)-47, INSTALLATION, Crankshaft Sprocket.>
- 6) Install camshaft sprockets. <Ref. to ME(H6DO)-46, INSTALLATION, Camshaft Sprocket.>
- 7) Install timing chain assembly. <Ref. to ME(H6DO)-42, INSTALLATION, Timing Chain Assembly.>
- 8) Install front chain cover. <Ref. to ME(H6DO)-39, INSTALLATION, Front Chain Cover.>

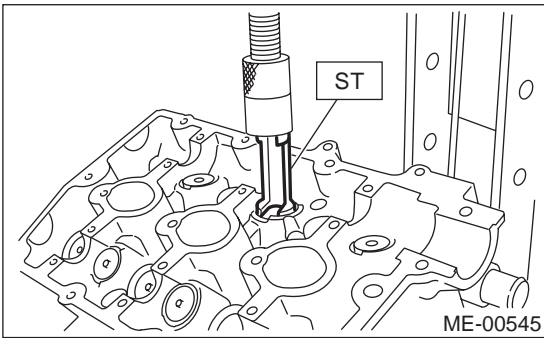
9) Install crankshaft pulley. <Ref. to ME(H6DO)-38, INSTALLATION, Crankshaft Pulley.>

## C: DISASSEMBLY

- 1) Place cylinder head on ST.  
ST 18250AA000 CYLINDER HEAD TABLE
- 2) Remove valve shims and valve lifters.
- 3) Set ST on valve spring retainer. Compress valve spring and remove the valve spring retainer key. Remove each valve and valve spring.  
ST 499718000 VALVE SPRING REMOVER

### NOTE:

- For correct re-installation, keep removed parts in order in their original positions.
- Mark each valve to prevent confusion.
- Use extreme care not to damage the lips of the intake valve oil seals and exhaust valve stem seals.



## D: ASSEMBLY

- 1) Installation of valve spring and valve
  - (1) Place cylinder head on ST.  
ST 18250AA000 CYLINDER HEAD TABLE
  - (2) Coat stem of each valve with engine oil and insert valve into valve guide.

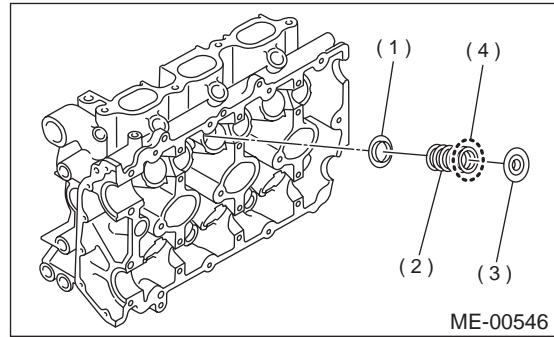
### NOTE:

When inserting valve into valve guide, use special care not to damage the stem seal lip.

- (3) Install valve spring and retainer.

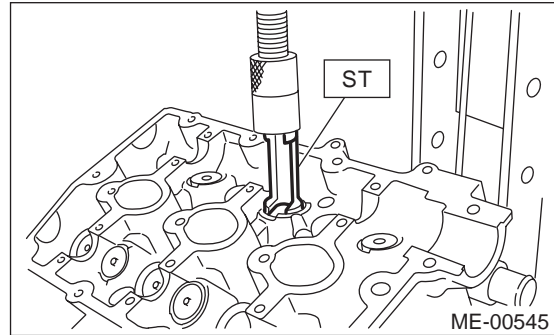
### NOTE:

- Be sure to install the valve springs with their close-coiled end facing the seat on the cylinder head.
- Install valve spring with the painted surface facing the retainer side.



- (1) Seat
- (2) Valve spring
- (3) Retainer
- (4) Painted face

- (4) Set ST on valve spring.  
ST 499718000 VALVE SPRING REMOVER



- (5) Compress valve spring and fit valve spring retainer key.
- (6) After installing, tap valve spring retainers lightly with wooden hammer for better seating.
- 2) Apply oil to the surface of the valve lifter and valve shim.
- 3) Install valve lifter and valve shim.

# CYLINDER HEAD ASSEMBLY

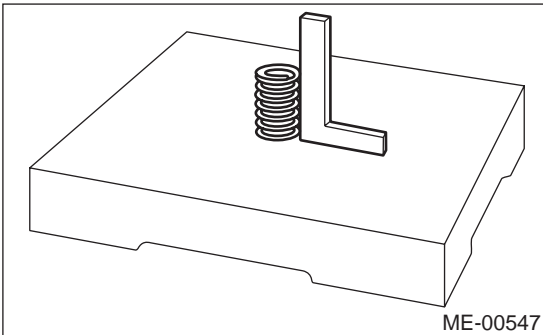
MECHANICAL

## E: INSPECTION

### 1. VALVE SPRING

- 1) Check valve springs for damage, free length, and tension. Replace valve spring if it is not to the specifications presented below.
- 2) To measure the squareness of the valve spring, stand the spring on a surface plate and measure its deflection at the top using a try square.

Free length	46.79 mm (1.8421 in)
Squareness	2.5°, 2.0 mm (0.079 in)



### 2. INTAKE AND EXHAUST VALVE STEM SEAL

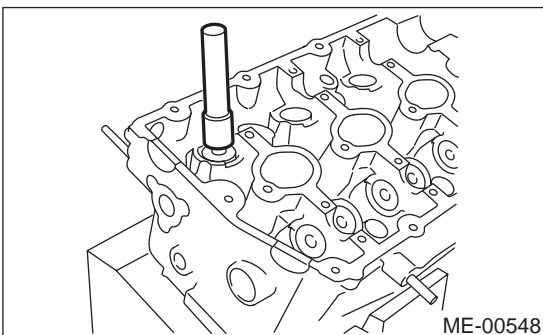
Replace oil seal with new one, if lip is damaged or spring out of place, or when the surfaces of intake valve and valve seat are reconditioned or intake valve guide is replaced. Use pliers to pinch and remove oil seal from valve.

- 1) Place cylinder head on ST1.
- 2) Press-fit oil seal to the specified dimension indicated in the figure using ST2.

#### NOTE:

- Apply engine oil to stem seal before press-fitting.
- When press-fitting stem seal, do not use hammer or strike in.

ST1 18250AA000 CYLINDER HEAD TABLE  
ST2 498857100 VALVE OIL SEAL GUIDE

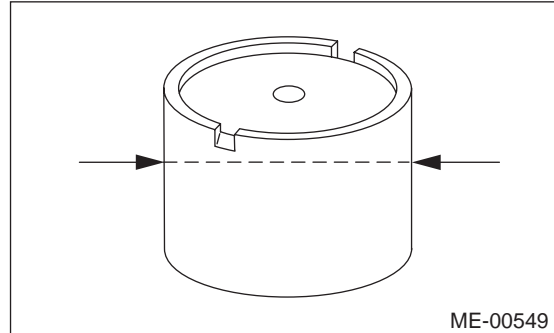


### 3. VALVE LIFTER

- 1) Check valve lifter visually.
- 2) Measure outer diameter of valve lifter.

#### Outer diameter:

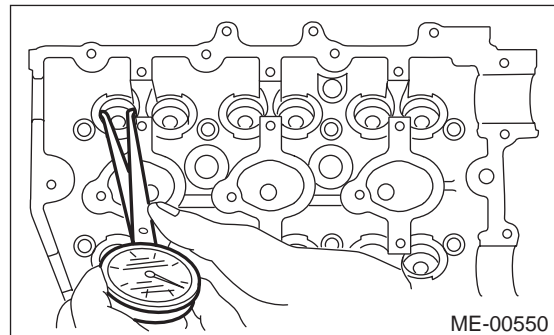
**33.959 — 33.975 mm (1.3370 — 1.3376 in)**



- 3) Measure inner diameter of valve lifter mating part on cylinder head.

#### Inner diameter:

**34.006 — 34.016 mm (1.3388 — 1.3392 in)**



#### NOTE:

If difference between outer diameter of valve lifter and inner diameter of valve lifter mating part is over the limit, replace cylinder head.

#### Standard:

**0.019 — 0.057 mm (0.0007 — 0.0022 in)**

#### Limit:

**0.100 mm (0.0039 in)**

## F: ADJUSTMENT

### 1. CYLINDER HEAD

1) Make sure that no crack or other damage exists. In addition to visual inspection, inspect important areas by means of red lead check.

Also make sure that gasket installing surface shows no trace of gas and water leaks.

2) Place cylinder head on ST.

ST 18250AA000 CYLINDER HEAD TABLE

3) Measure the warping of the cylinder head surface that mates with crankcase using a straight edge and thickness gauge.

If the warping exceeds 0.05 mm (0.0020 in), re-grind the surface with a surface grinder.

**Warping limit:**

**0.05 mm (0.0020 in)**

**Grinding limit:**

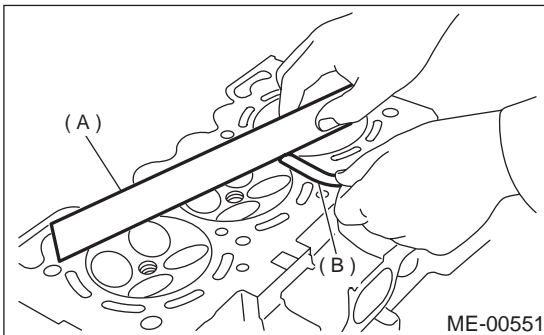
**0.1 mm (0.004 in)**

**Standard height of cylinder head:**

**124 mm (4.88 in)**

**NOTE:**

Uneven torque for the cylinder head bolts can cause warping. When reassembling, pay special attention to the torque so as to tighten evenly.



- (A) Straight edge
- (B) Thickness gauge

### 2. VALVE SEAT

Inspect intake and exhaust valve seats, and correct the contact surfaces with valve seat cutter if they are defective or when valve guides are replaced.

**Valve seat width: *W***

**Intake**

**Standard**

**1.0 mm (0.039 in)**

**Limit**

**1.7 mm (0.067 in)**

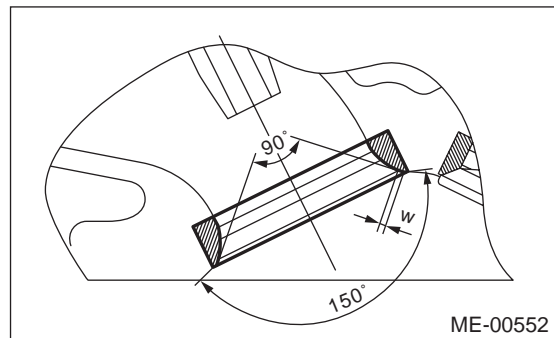
**Exhaust**

**Standard**

**1.5 mm (0.059 in)**

**Limit**

**2.2 mm (0.087 in)**



### 3. VALVE GUIDE

1) Check the clearance between valve guide and stem. The clearance can be checked by measuring the outside diameter of valve stem and the inside diameter of valve guide with outside and inside micrometers respectively.

**Clearance between the valve guide and valve stem:**

**Standard**

**Intake**

**0.030 — 0.057 mm (0.0012 — 0.0022 in)**

**Exhaust**

**0.040 — 0.067 mm (0.0016 — 0.0026 in)**

**Limit**

**0.15 mm (0.0059 in)**

# CYLINDER HEAD ASSEMBLY

## MECHANICAL

2) If the clearance between valve guide and stem exceeds the limit, replace valve guide or valve itself whichever shows greater amount of wear. See following procedure for valve guide replacement.

### Valve guide inner diameter:

**5.500 — 5.512 mm (0.2165 — 0.2170 in)**

### Valve stem outer diameter:

#### Intake

**5.455 — 5.470 mm (0.2148 — 0.2154 in)**

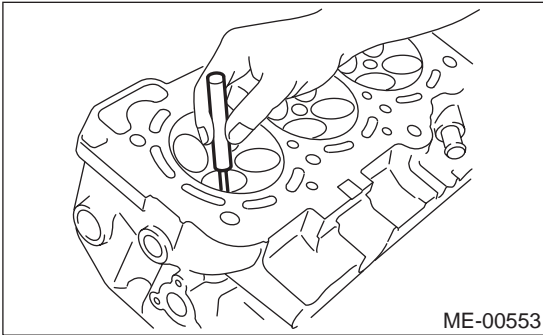
#### Exhaust

**5.455 — 5.460 mm (0.2148 — 0.2150 in)**

(1) Place cylinder head on ST1 with the combustion chamber upward so that valve guides enter the holes in ST1.

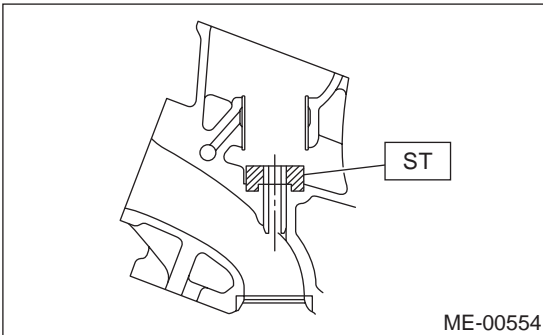
(2) Insert ST2 into valve guide and press it down to remove valve guide.

ST1 18250AA000 CYLINDER HEAD TABLE  
ST2 499765700 VALVE GUIDE REMOVER



(3) Turn cylinder head upside down and place ST as shown in the figure.

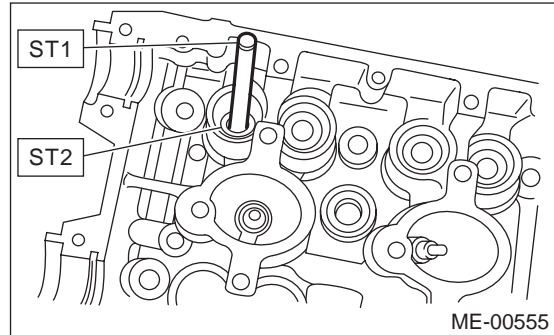
ST 18251AA000 VALVE GUIDE ADJUSTER



(4) Before installing new valve guide, make sure that neither scratches nor damages exist on the inside surface of the valve guide holes in cylinder head.

(5) Put new valve guide in cylinder, and insert ST1 into valve guide. Press in until the valve guide upper end is flush with the upper surface of ST2.

ST1 499765700 VALVE GUIDE REMOVER  
ST2 18251AA000 VALVE GUIDE ADJUSTER



(6) Check the valve guide protrusion.

### Valve guide protrusion: L

**12.3 — 12.7 mm (0.484 — 0.500 in)**

(7) Ream the inside of valve guide with ST. Gently rotate the reamer clockwise while pressing it lightly into valve guide, and return it also rotating clockwise. After reaming, clean valve guide to remove chips.

ST 499765900 VALVE GUIDE REAMER

### NOTE:

- Apply engine oil to the reamer when reaming.
- If the inner surface of the valve guide is torn, the edge of the reamer should be slightly ground with an oil stone.
- If the inner surface of the valve guide becomes lustrous and the reamer does not chips, use a new reamer or remedy the reamer.

(8) Recheck the contact condition between valve and valve seat after replacing valve guide.



#### 4. INTAKE AND EXHAUST VALVE

1) Inspect the flange and stem of valve, and replace if damaged, worn, or deformed, or if "H" is less than the specified limit.

**H:**

##### **Intake**

**Standard**

1.0 mm (0.039 in)

**Limit**

0.8 mm (0.031 in)

##### **Exhaust**

**Standard**

1.2 mm (0.047 in)

**Limit**

0.8 mm (0.031 in)

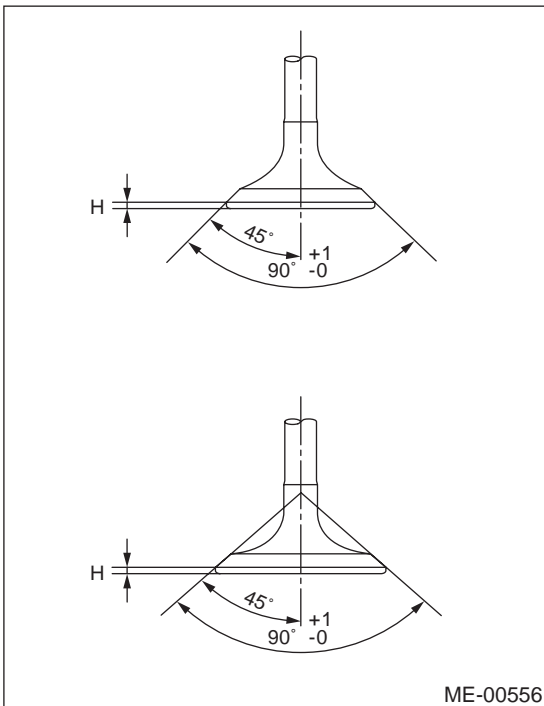
##### **Valve overall length:**

**Intake**

103.5 mm (4.075 in)

**Exhaust**

103.2 mm (4.063 in)



2) Put a small amount of grinding compound on the seat surface and lap the valve and seat surface. Install a new intake valve oil seal after lapping.



# CYLINDER BLOCK

MECHANICAL

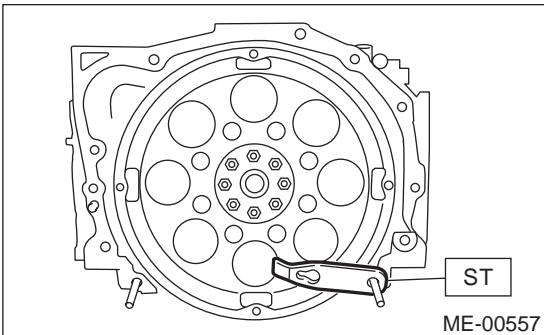
## 18. Cylinder Block

### A: REMOVAL

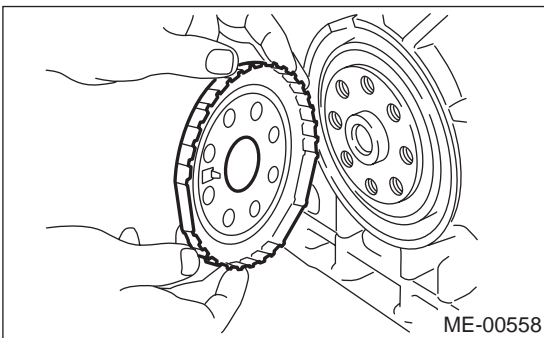
- 1) Remove crankshaft pulley. <Ref. to ME(H6DO)-38, REMOVAL, Crankshaft Pulley.>
- 2) Remove front chain cover. <Ref. to ME(H6DO)-39, REMOVAL, Front Chain Cover.>
- 3) Remove timing chain assembly. <Ref. to ME(H6DO)-41, REMOVAL, Timing Chain Assembly.>
- 4) Remove camshaft sprockets. <Ref. to ME(H6DO)-46, REMOVAL, Camshaft Sprocket.>
- 5) Remove crankshaft sprocket. <Ref. to ME(H6DO)-47, REMOVAL, Crankshaft Sprocket.>
- 6) Remove rear chain cover. <Ref. to ME(H6DO)-48, REMOVAL, Rear Chain Cover.>
- 7) Remove camshafts. <Ref. to ME(H6DO)-50, REMOVAL, Camshaft.>
- 8) Remove cylinder head assembly. <Ref. to ME(H6DO)-54, REMOVAL, Cylinder Head Assembly.>
- 9) Remove drive plate.

Using ST, lock crankshaft.

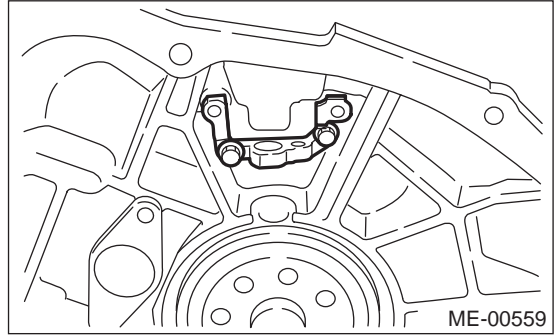
ST 498497100 CRANKSHAFT STOPPER



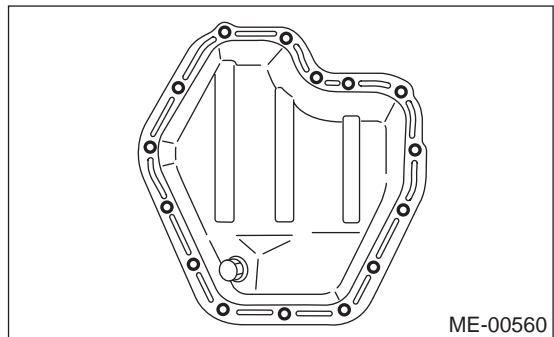
- 10) Remove crankshaft position sensor plate.



- 11) Remove crankshaft position sensor bracket.



- 12) Rotate engine until oil pan comes to the top.
- 13) Remove bolts which secure lower oil pan to upper oil pan.

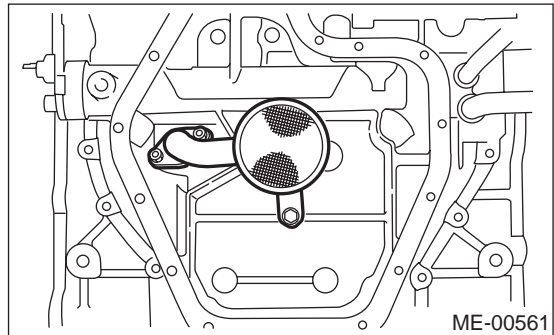


- 14) Insert an oil pan cutter blade between cylinder block-to-oil pan clearance and remove oil pan.

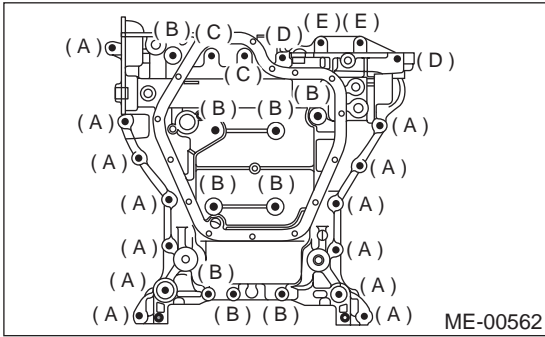
### CAUTION:

Do not use a screwdriver or similar tool in place of oil pan cutter.

- 15) Remove oil strainer.



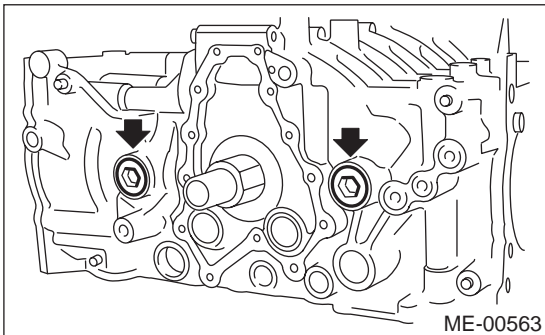
16) Remove bolts which secure upper oil pan to cylinder block.



**Bolt dimension:**

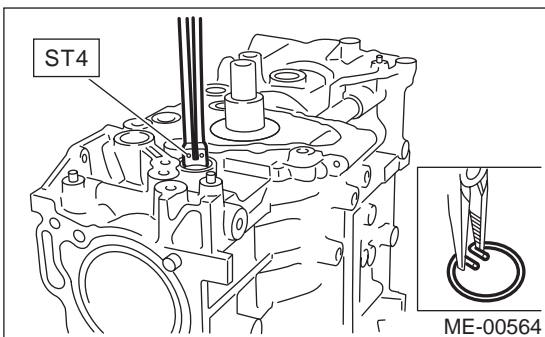
- (A) 8 × 40
- (B) 8 × 65
- (C) 8 × 85
- (D) 8 × 130
- (E) 8 × 24

17) Remove service hole cover and service hole plugs using hexagon wrench.



18) Rotate crankshaft to bring #1 and #2 pistons to bottom dead center position, then remove piston circlip through service hole of #1 and #2 cylinders by using ST.

ST 18233AA000 PISTON PIN CIRCLIP PLIER

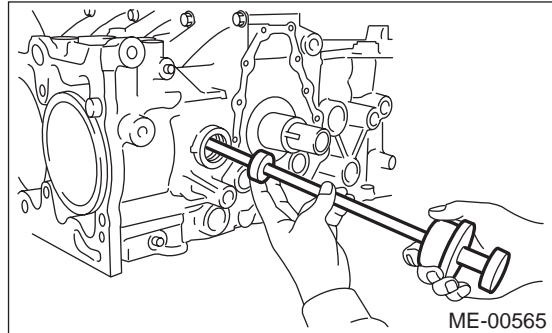


19) Draw out piston pin from #1 and #2 pistons by using ST.

ST 499097500 PISTON PIN REMOVER

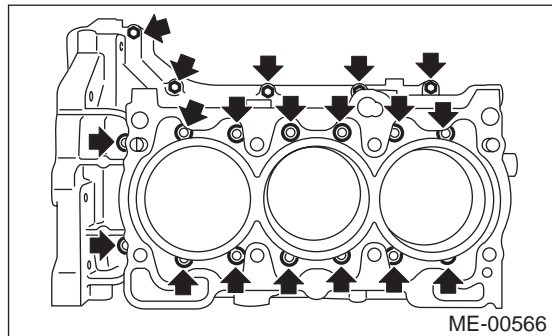
**NOTE:**

Be careful not to confuse original combination of piston, piston pin and cylinder.



20) Similarly remove piston pins from #3, #4, #5 and #6 pistons.

21) Remove bolts which connect cylinder block.



22) Separate left-hand and right-hand cylinder blocks.

**NOTE:**

When separating cylinder block, do not allow the connecting rod to fall and damage the cylinder block.

23) Remove rear oil seal.

24) Remove crankshaft together with connecting rod.

25) Remove crankshaft bearings from cylinder block using hammer handle.

**NOTE:**

Do not confuse combination of crankshaft bearings. Press bearing at the end opposite to locking lip.

26) Draw out each piston from cylinder block using wooden bar or hammer handle.

**NOTE:**

Do not confuse combination of piston, piston pin and cylinder.

# CYLINDER BLOCK

## MECHANICAL

### B: INSTALLATION

1) Install ST to cylinder block, then install crankshaft bearing.

ST 18232AA000 ENGINE STAND

#### NOTE:

Remove oil in the mating surface of bearing and cylinder block before installation. Also apply a coat of engine oil to crankshaft pins.

2) Position crankshaft and connecting rod on the #2, #4 and #6 cylinder.

3) Apply fluid gasket to the mating surface of #1, #3 and #5 cylinder block.

#### Fluid gasket:

**THREE BOND 1215B or equivalent**

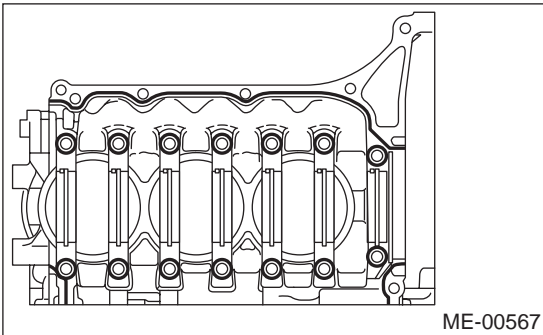
**Part No.: 004403007**

#### NOTE:

Do not allow fluid gasket to jut into O-ring grooves, oil passages, bearing grooves, etc.

#### Fluid gasket application diameter:

**1.0±0.2 mm (0.039±0.008 in)**

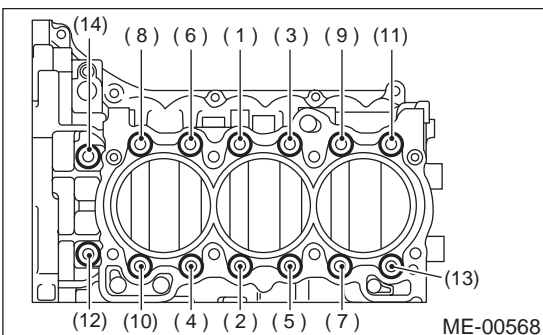


4) Apply engine oil to washers and threads of cylinder block connecting bolts. Tighten the bolts following the steps below.

(1) Tighten all the bolts in the numerical order shown in the figure.

#### Tightening torque:

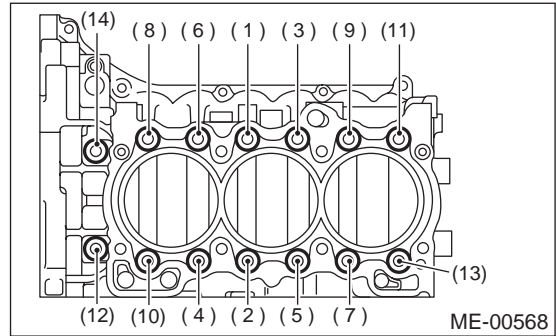
(1) to (11)	25 N·m (2.5 kgf-m, 18 ft-lb)
(12)	20 N·m (2.0 kgf-m, 14 ft-lb)
(13)	25 N·m (2.5 kgf-m, 18 ft-lb)
(14)	20 N·m (2.0 kgf-m, 14 ft-lb)



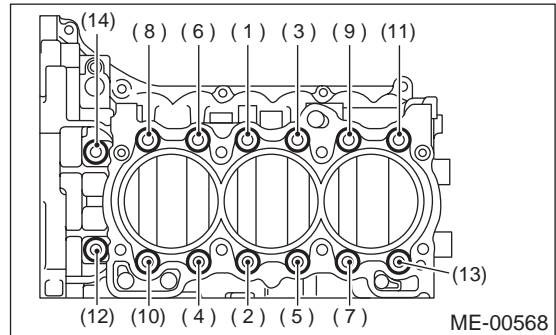
(2) Tighten all the bolts again in the order shown in the figure.

#### Tightening torque:

(1) to (11)	25 N·m (2.5 kgf-m, 18 ft-lb)
(12)	20 N·m (2.0 kgf-m, 14 ft-lb)
(13)	25 N·m (2.5 kgf-m, 18 ft-lb)
(14)	20 N·m (2.0 kgf-m, 14 ft-lb)



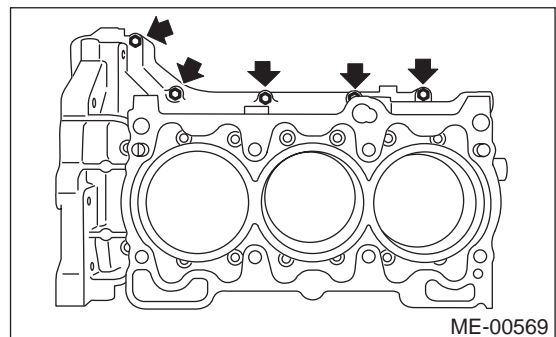
5) Tighten all the bolts by 90° in the order shown in the figure.



6) Install upper bolts on cylinder block.

#### Tightening torque:

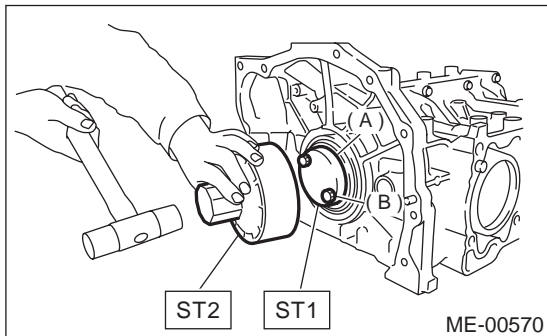
**25 N·m (2.5 kgf-m, 18 ft-lb)**



7) Install rear oil seal using ST1 and ST2.

ST1 499597100 CRANKSHAFT OIL SEAL GUIDE

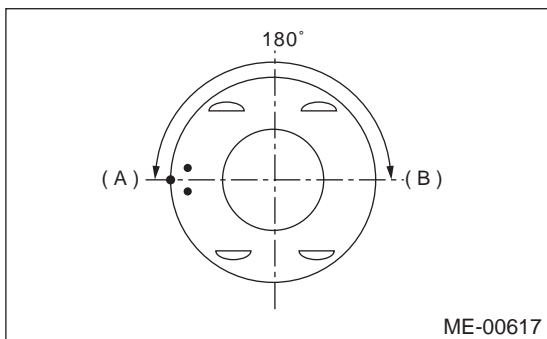
ST2 499587200 CRANKSHAFT OIL SEAL INSTALLER



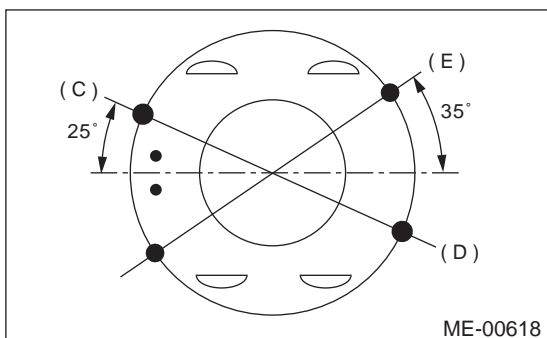
- (A) Rear oil seal
- (B) Drive plate attaching bolt

8) Positioning of piston ring.

- (1) Position the top ring gap at (A) in the figure.
- (2) Position the second ring gap at (B) in the figure.



- (3) Position the upper rail gap at (C) in the figure.
- (4) Position the expander gap at (D) in the figure.
- (5) Position the lower rail gap at (E) in the figure.



NOTE:

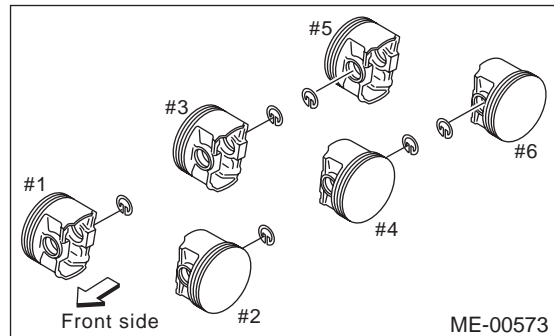
- Ensure ring gaps do not face the same direction.
- Ensure ring gaps are not within the piston skirt area.

(6) Install circlip.

Install circlips in piston holes located opposite service holes in cylinder block, when positioning all pistons in the corresponding cylinders.

NOTE:

Use new circlips.



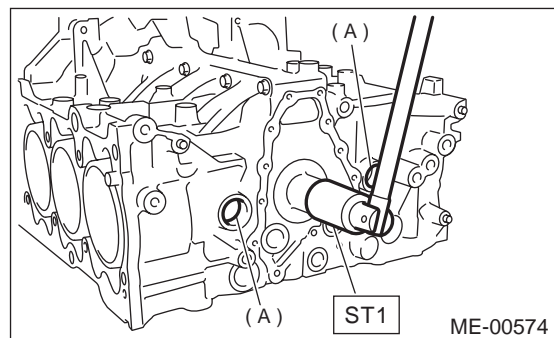
9) Installing piston.

NOTE:

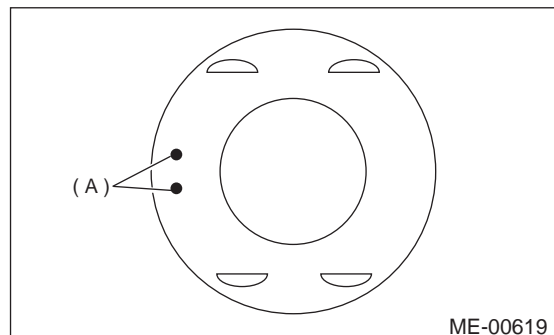
Install piston and piston pin to the same cylinder they were installed before overhaul.

- (1) Using ST1, rotate crankshaft until each small end of connecting rods #3 and #4 is aligned over service hole (A).

ST1 18252AA000 CRANKSHAFT SOCKET



- (2) Apply a coat of engine oil to piston and cylinders.
- (3) Install pistons with their front marks (A) facing the front of engine.

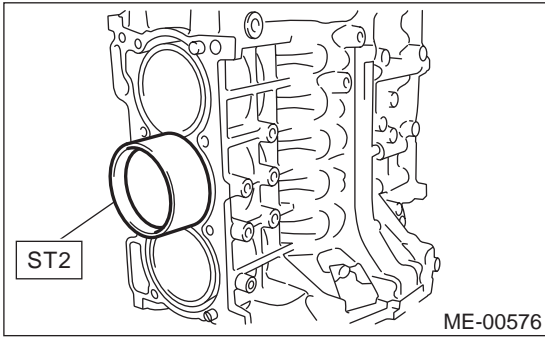


(4) Insert pistons in their cylinders using ST2.

# CYLINDER BLOCK

MECHANICAL

## ST2 18254AA000 PISTON GUIDE

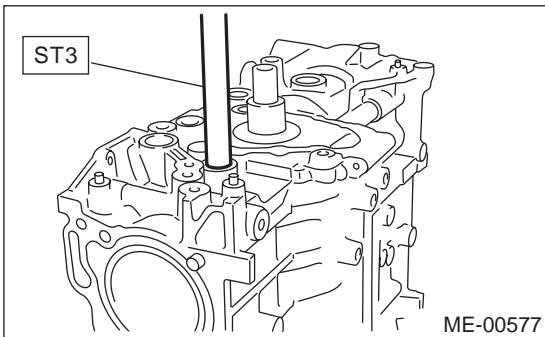


### 10) Installing piston pin.

- (1) Apply a coat of engine oil to ST3.

## ST3 18253AA000 PISTON PIN GUIDE

- (2) Insert ST3 into service hole to align piston pin hole with connecting rod small end.



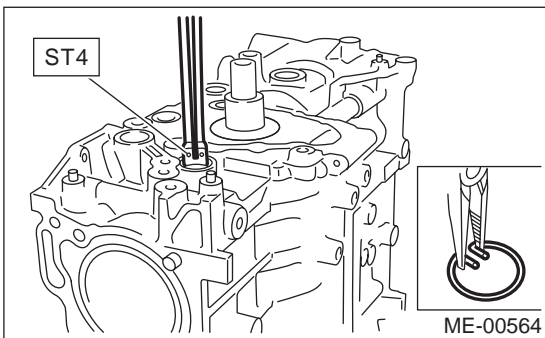
- (3) Apply a coat of engine oil to piston pin and insert piston pin into piston and connecting rod small end through service hole.

- (4) Using ST4, install circlip.

## ST4 18233AA000 PISTON PIN CIRCLIP PLIER

### NOTE:

Use a new circlip.



- 11) Repeat the same steps for pistons #1 and #2, #5 and #6.

- 12) Install service hole plug and cover.

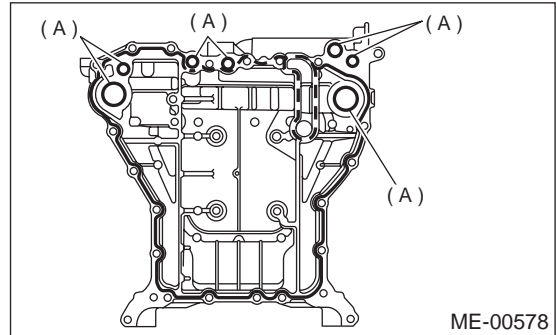
- 13) Apply fluid gasket to mating surface of upper oil pan.

- 14) Install O-ring.

### Fluid gasket:

**THREE BOND 1280B**

**Part No.: K0877YA018**

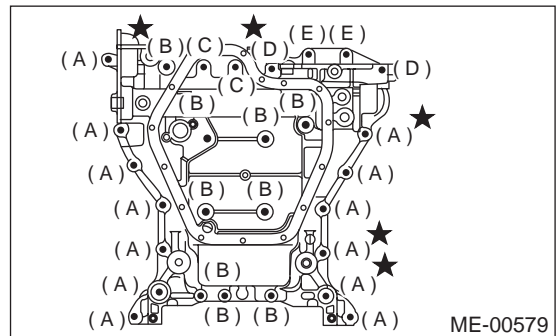


- (A) O-ring

- 15) Temporarily tighten the upper oil pan.

### NOTE:

Do not confuse the mounting positions of the bolts.



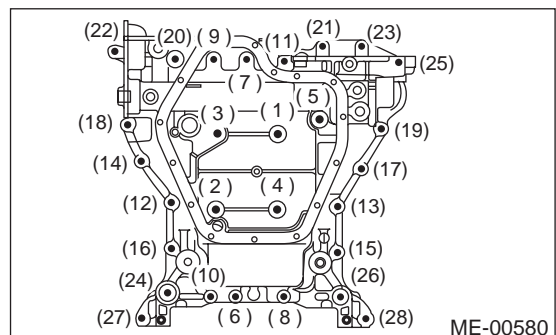
### Bolt dimension:

- (A) 8 × 40
- (B) 8 × 65
- (C) 8 × 85
- (D) 8 × 130
- (E) 8 × 20

- 16) Tighten the upper oil pan mounting bolts in the numerical sequence shown in the figure.

### Tightening torque:

**18 N·m (1.8 kgf·m, 13.0 ft·lb)**

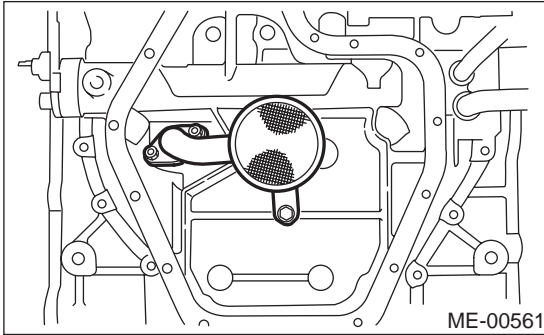




17) Install oil strainer.

NOTE:

Use a new O-ring.



18) Apply fluid gasket to mating surface of lower oil pan.

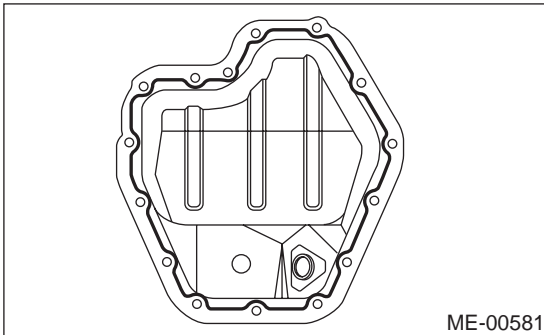
**Fluid gasket:**

**THREE BOND 1280B**

**Part No.: K0877YA018**

**Fluid gasket application diameter:**

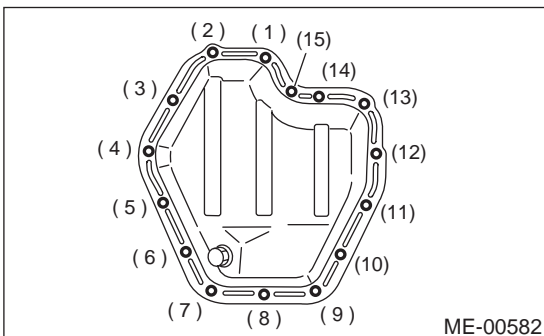
**5.0±1.0 mm (0.097±0.039 in)**



19) Tighten the lower oil pan mounting bolts in the numerical sequence shown in the figure.

**Tightening torque:**

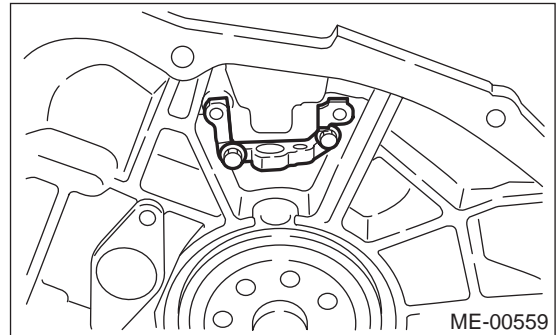
**6.4 N·m (0.65 kgf·m, 4.7 ft·lb)**



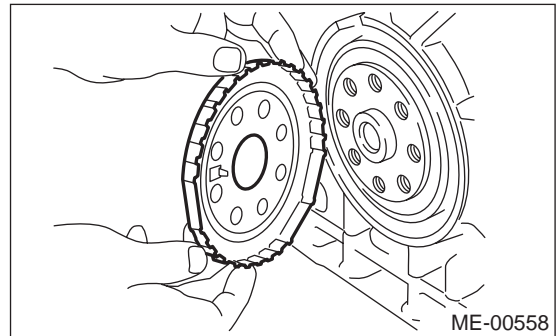
20) Install crankshaft position sensor bracket.

**Tightening torque:**

**6.4 N·m (0.65 kgf·m, 4.7 ft·lb)**



21) Install crankshaft position sensor plate.



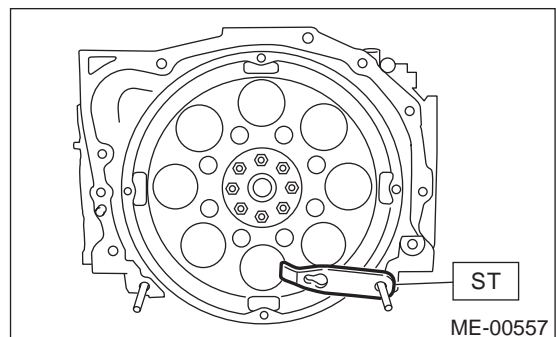
22) Install drive plate.

Using ST, lock crankshaft.

ST 498497100 CRANKSHAFT STOPPER

**Tightening torque:**

**81 N·m (8.3 kgf·m, 60 ft·lb)**



23) Install cylinder head assembly. <Ref. to ME(H6DO)-54, INSTALLATION, Cylinder Head Assembly.>

24) Install camshafts. <Ref. to ME(H6DO)-50, INSTALLATION, Camshaft.>

25) Install rear chain cover. <Ref. to ME(H6DO)-48, INSTALLATION, Rear Chain Cover.>

26) Install crankshaft sprocket. <Ref. to ME(H6DO)-47, INSTALLATION, Crankshaft Sprocket.>

27) Install camshaft sprockets. <Ref. to ME(H6DO)-46, INSTALLATION, Camshaft Sprocket.>

# CYLINDER BLOCK

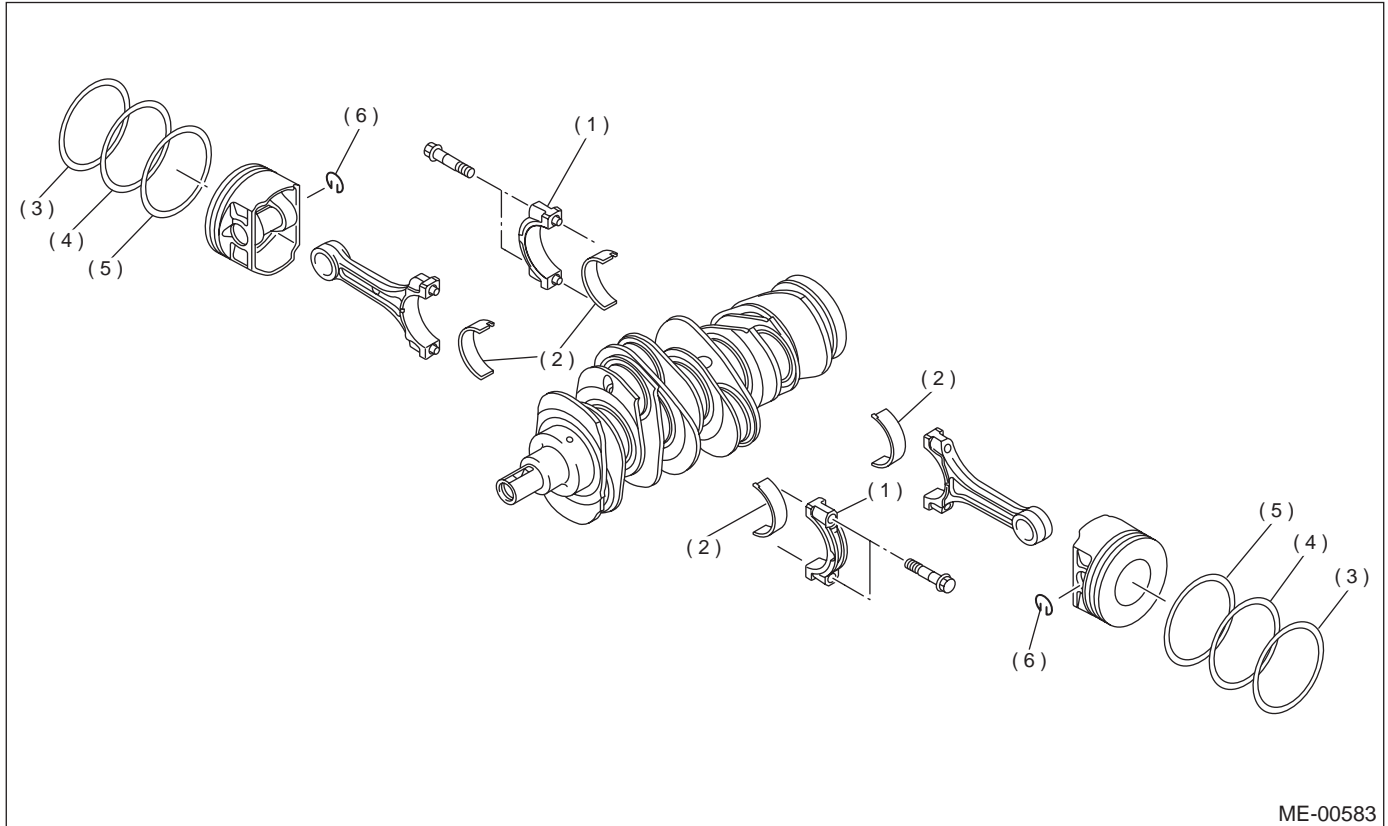
## MECHANICAL

28) Install timing chain assembly. <Ref. to ME(H6DO)-42, INSTALLATION, Timing Chain Assembly.>

29) Install front chain cover. <Ref. to ME(H6DO)-39, INSTALLATION, Front Chain Cover.>

30) Install crankshaft pulley. <Ref. to ME(H6DO)-38, INSTALLATION, Crankshaft Pulley.>

## C: DISASSEMBLY



(1) Connecting rod cap

(3) Top ring

(5) Oil ring

(2) Connecting rod bearing

(4) Second ring

(6) Circlip

1) Remove connecting rod cap.

2) Remove connecting rod bearing.

### NOTE:

Arrange removed connecting rod, connecting rod cap and bearing in order to prevent confusion.

3) Remove piston rings using the piston ring expander.

4) Remove the oil ring by hand.

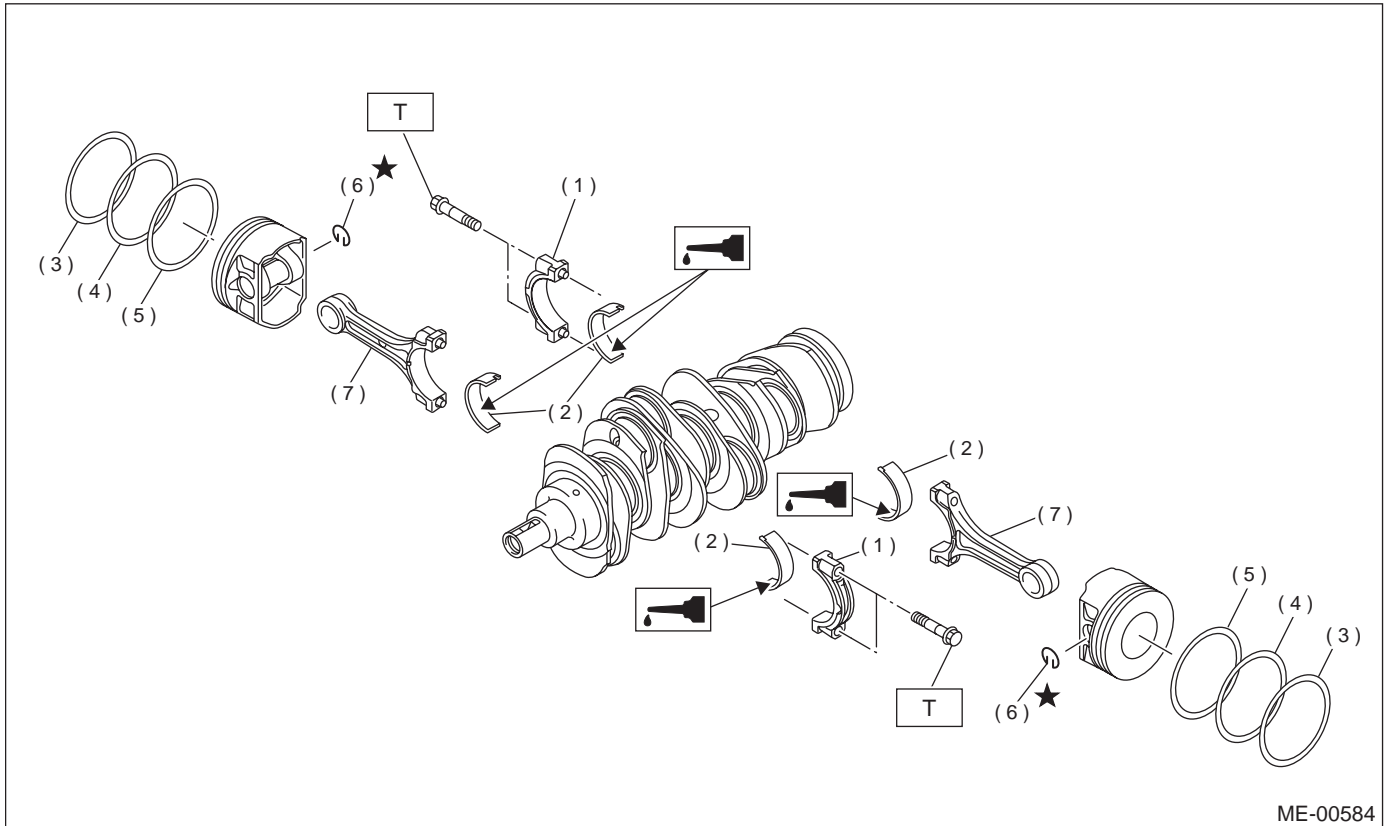
### NOTE:

Arrange the removed piston rings in good order to prevent confusion.

5) Remove circlip.



## D: ASSEMBLY



ME-00584

- |                            |                    |
|----------------------------|--------------------|
| (1) Connecting rod cap     | (5) Oil ring       |
| (2) Connecting rod bearing | (6) Circlip        |
| (3) Top ring               | (7) Connecting rod |
| (4) Second ring            |                    |

**Tightening torque: N·m (kgf·m, ft·lb)**  
**T: 53 (5.4, 39)**

1) Install connecting rod bearings on connecting rods and connecting rod caps.

**CAUTION:**

**Apply oil to the surfaces of the connecting rod bearings.**

2) Install connecting rod on crankshaft.

**CAUTION:**

**Position each connecting rod with the side marked facing forward.**

3) Install connecting rod cap with connecting rod nut.

Ensure the arrow on connecting rod cap faces the front during installation.

**CAUTION:**

- Each connecting rod has its own mating cap. Make sure that they are assembled correctly by checking their matching number.
- When tightening the connecting rod nuts, apply oil on the threads.

4) Installation of piston rings and oil ring

## E: INSPECTION

### 1. CYLINDER BLOCK

1) Visually check for cracks and damage. Especially, inspect important parts by means of red lead check.

2) Check the oil passages for clogging.

3) Inspect crankcase surface that mates with cylinder head for warping by using a straight edge, and correct by grinding if necessary.

**Warping limit:**

**0.05 mm (0.0020 in)**

**Grinding limit:**

**0.1 mm (0.004 in)**

**Standard height of cylinder block:**

**202 mm (7.95 in)**

# CYLINDER BLOCK

MECHANICAL

## 2. CYLINDER AND PISTON

1) The cylinder bore size is stamped on the cylinder block's front upper surface.

NOTE:

Measurement should be performed at a temperature 20°C (68°F).

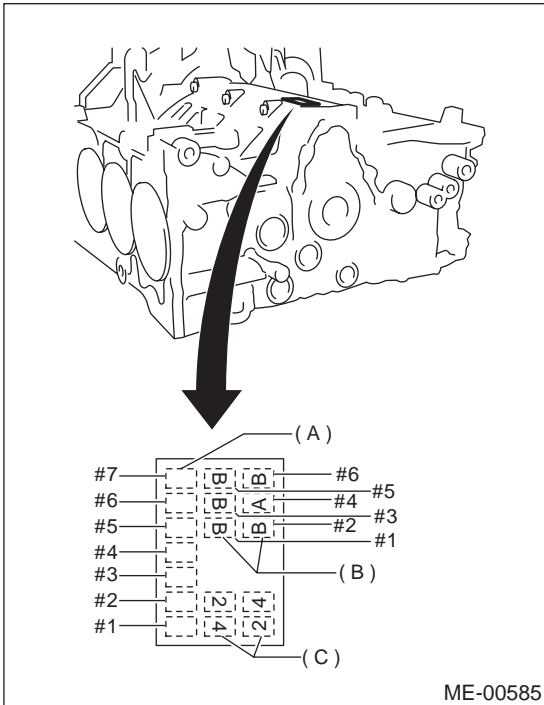
NOTE:

Standard sized pistons are classified into two grades, "A" and "B". These grades should be used as a guide line in selecting a standard piston.

**Standard diameter:**

**A: 89.205 — 89.215 mm (3.5120 — 3.5124 in)**

**B: 89.195 — 89.205 mm (3.5116 — 3.5120 in)**



- (A) Main journal size mark
- (B) Cylinder bore size mark
- (C) Cylinder block RH-LH combination mark

2) How to measure the inner diameter of each cylinder

Measure the inner diameter of each cylinder in both the thrust and piston pin directions at the heights shown in the figure, using a cylinder bore gauge.

**CAUTION:**

Measurement should be performed at a temperature 20°C (68°F).

**Taper:**

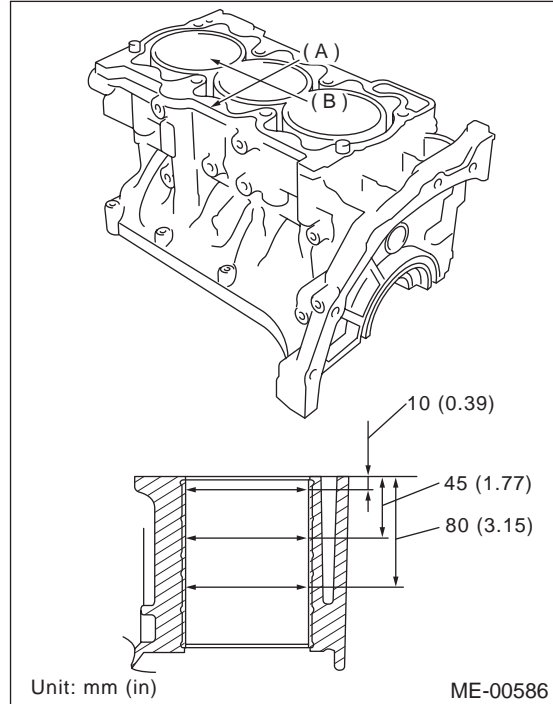
**Limit**

**0.050 mm (0.0020 in)**

**Out-of-roundness:**

**Limit**

**0.050 mm (0.0020 in)**



- (A) Thrust direction
- (B) Piston pin direction

3) When piston is to be replaced due to general or cylinder wear, determine a suitable sized piston by measuring the piston clearance.

4) How to measure the outer diameter of each piston

Measure the outer diameter of each piston at the height shown in the figure. (Thrust direction)

**CAUTION:**

Measurement should be performed at a temperature of 20°C (68°F).

**Piston grade point H:**  
39.0 mm (1.535 in)

**Piston outer diameter:**  
**Standard**

**A: 89.185 — 89.195 mm**  
(3.5112 — 3.5116 in)

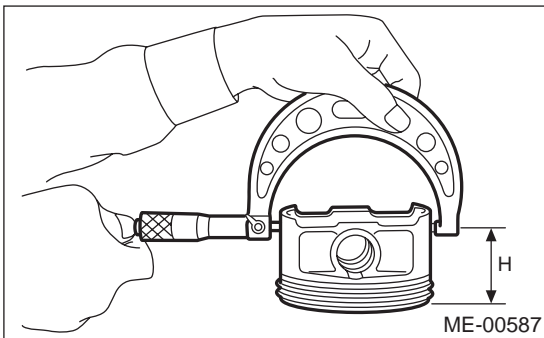
**B: 89.175 — 89.185 mm**  
(3.5108 — 3.5112 in)

**0.25 mm (0.0098 in) oversize**

**89.425 — 89.435 mm**  
(3.5207 — 3.5211 in)

**0.50 mm (0.0197 in) oversize**

**89.675 — 89.685 mm**  
(3.5305 — 3.5309 in)



5) Calculate the clearance between cylinder and piston.

**CAUTION:**

Measurement should be performed at a temperature of 20°C (68°F).

**Cylinder to piston clearance at 20°C (68°F):**

**Standard**

**0.010 — 0.030 mm (0.0004 — 0.0012 in)**

**Limit**

**0.050 mm (0.0020 in)**

6) Boring and honing

(1) If the value of taper, out-of-roundness, or cylinder-to-piston clearance measured exceeds the specified limit or if there is any damage on the cylinder wall, rebore it to use an oversize piston.

**NOTE:**

When any of the cylinders needs reboring, all other cylinders must be bored at the same time, and use oversize pistons. Do not perform boring on one cyl-

inder only, nor use an oversize piston for one cylinder only.

(2) If the cylinder inner diameter exceeds the limit after boring and honing, replace the crankcase.

**NOTE:**

Immediately after reboring, the cylinder diameter may differ from its real diameter due to temperature rise. Thus, pay attention to this when measuring the cylinder diameter.

**Limit of cylinder enlarging (boring):**  
**0.5 mm (0.020 in)**

### 3. PISTON AND PISTON PIN

1) Check pistons and piston pins for damage, cracks, and wear and the piston ring grooves for wear and damage. Replace if defective.

2) Measure the piston-to-cylinder clearance at each cylinder. <Ref. to ME(H6DO)-68, CYLINDER AND PISTON, INSPECTION, Cylinder Block.> If any of the clearances is not to specification, replace the piston or bore the cylinder to use an oversize piston.

3) Make sure that piston pin can be inserted into the piston pin hole with a thumb at 20°C (68°F). Replace if defective.

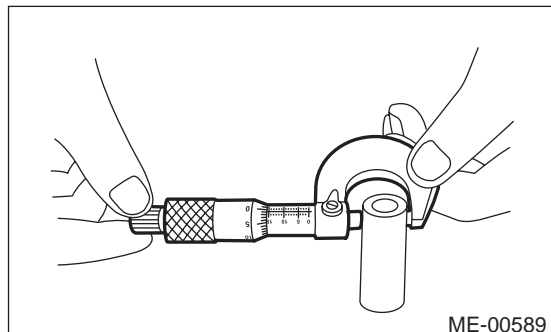
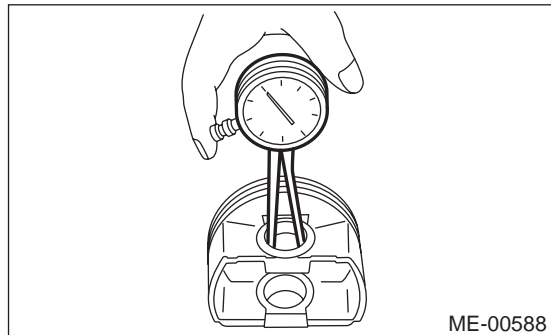
**Standard clearance between piston pin and hole in piston:**

**Standard**

**0.004 — 0.008 mm (0.0002 — 0.0003 in)**

**Limit**

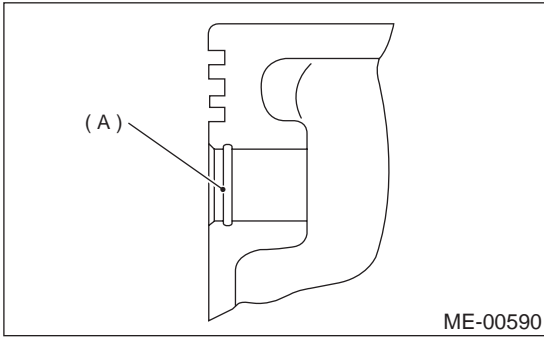
**0.020 mm (0.0008 in)**



# CYLINDER BLOCK

## MECHANICAL

4) Check circlip installation groove on the piston for burr. If necessary, remove burr (A) from the groove so that piston pin can lightly move.



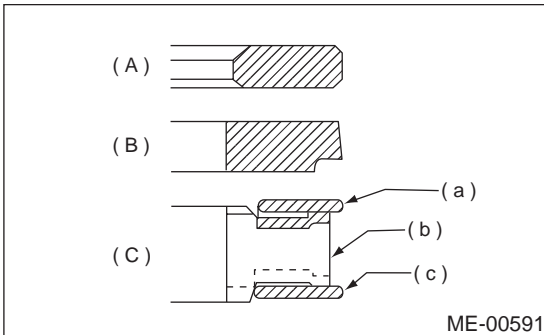
5) Check piston pin circlip for distortion, cracks and wear.

### 4. PISTON RING

1) If piston ring is broken, damaged, or worn, or if its tension is insufficient, or when the piston is replaced, replace piston ring with a new one of the same size as the piston.

#### CAUTION:

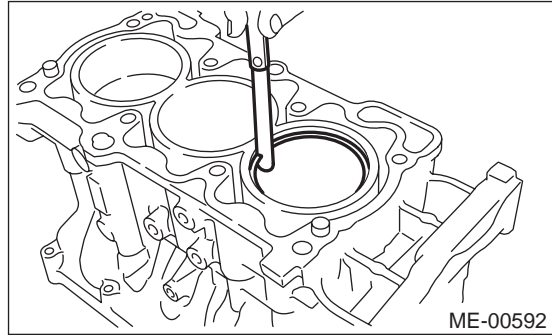
- Marks are shown on the end of the top and second rings. When installing the rings to the piston, face this mark upward.
- The oil ring is a combined ring consisting of two rails and a spacer in between. When installing, be careful to assemble correctly.



- (A) Top ring
- (B) Second ring
- (C) Oil ring
- (a) Upper rail
- (b) Expander
- (c) Lower rail

2) Squarely place piston ring and oil ring in cylinder, and measure the piston ring gap with a thickness gauge.

		Unit: mm (in)	
		Standard	Limit
Piston ring gap	Top ring	0.20 — 0.35 (0.0079 — 0.0138)	1.0 (0.039)
	Second ring	0.35 — 0.50 (0.0138 — 0.0197)	1.0 (0.039)
	Oil ring rail	0.20 — 0.60 (0.0079 — 0.0236)	1.5 (0.059)

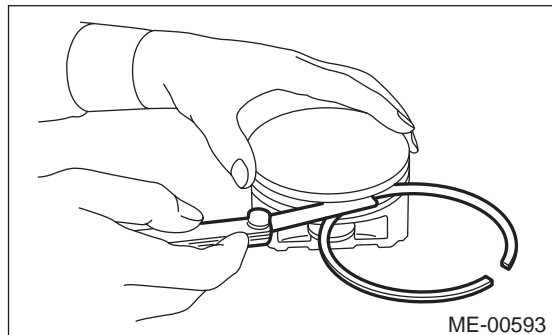


3) Measure the clearance between piston ring and piston ring groove with a thickness gauge.

#### CAUTION:

Before measuring the clearance, clean the piston ring groove and piston ring.

		Unit: mm (in)	
		Standard	Limit
Clearance between piston ring and piston ring groove	Top ring	0.040 — 0.080 (0.0016 — 0.0031)	0.15 (0.0059)
	Second ring	0.030 — 0.070 (0.0012 — 0.0028)	0.15 (0.0059)
Clearance between oil ring and oil ring groove		0.065 — 0.155 (0.0026 — 0.0061)	—

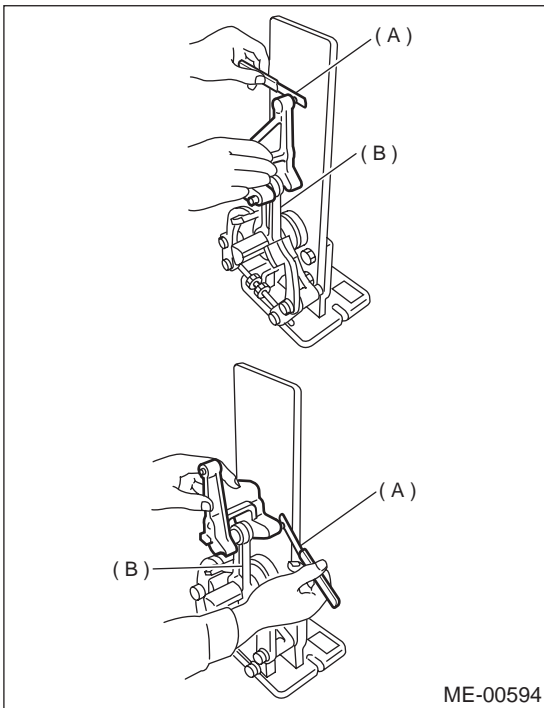


## 5. CONNECTING ROD

- 1) Replace connecting rod, if the large or small end thrust surface is damaged.
- 2) Check for bend or twist using a connecting rod aligner. Replace connecting rod if the bend or twist exceeds the limit.

**Limit of bend or twist per 100 mm (3.94 in) in length:**

**0.10 mm (0.0039 in)**



- (A) Thickness gauge  
(B) Connecting rod

- 3) Install connecting rod fitted with bearing to crankshaft and measure the side clearance (thrust clearance). Replace connecting rod if the side clearance exceeds the specified limit.

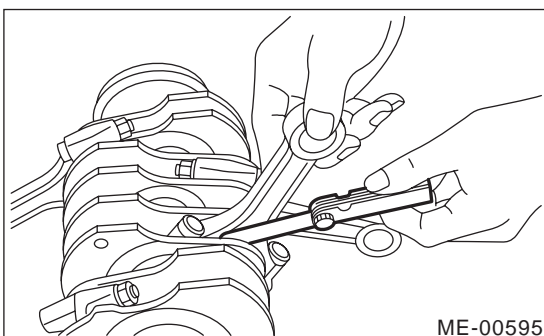
**Connecting rod side clearance:**

**Standard**

**0.070 — 0.330 mm (0.0028 — 0.0130 in)**

**Limit**

**0.4 mm (0.016 in)**



- 4) Inspect connecting rod bearing for scar, peeling, seizure, melting, wear, etc.

- 5) Measure the oil clearance on individual connecting rod bearings by means of plastigauge. If any oil clearance is not within specification, replace the defective bearing with a new one of standard size or undersize as necessary. (See the table below.)

**Connecting rod oil clearance:**

**Standard**

**0.020 — 0.046 mm (0.0008 — 0.0018 in)**

**Limit**

**0.050 mm (0.0020 in)**

Unit: mm (in)		
Bearing	Bearing size (Thickness at center)	Outer diameter of crank pin
Standard	1.490 — 1.502 (0.0587 — 0.0591)	51.984 — 52.000 (2.0466 — 2.0472)
0.03 (0.0012) undersize	1.510 — 1.513 (0.0594 — 0.0596)	51.954 — 51.970 (2.0454 — 2.0461)
0.05 (0.0020) undersize	1.520 — 1.523 (0.0598 — 0.0600)	51.934 — 51.950 (2.0446 — 2.0453)
0.25 (0.0098) undersize	1.620 — 1.623 (0.0638 — 0.0639)	51.734 — 51.750 (2.0368 — 2.0374)

# CYLINDER BLOCK

## MECHANICAL

6) Inspect bushing at connecting rod small end, and replace if worn or damaged. Also measure the piston pin clearance at the connecting rod small end.

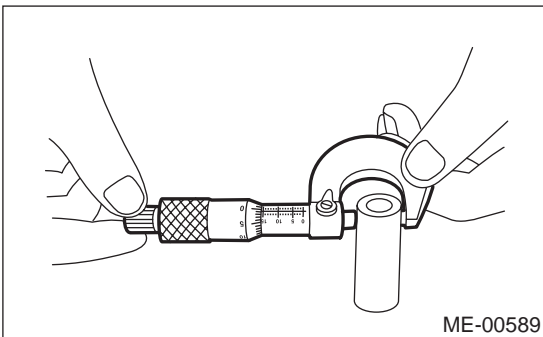
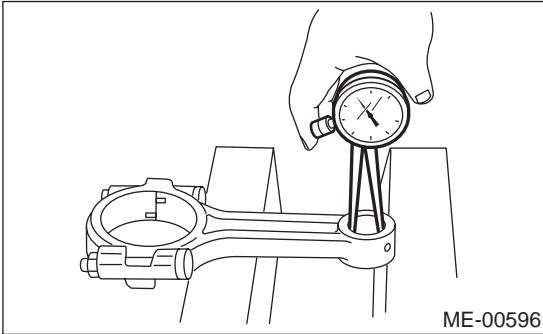
### **Clearance between piston pin and bushing:**

#### **Standard**

**0 — 0.022 mm (0 — 0.0009 in)**

#### **Limit**

**0.030 mm (0.0012 in)**

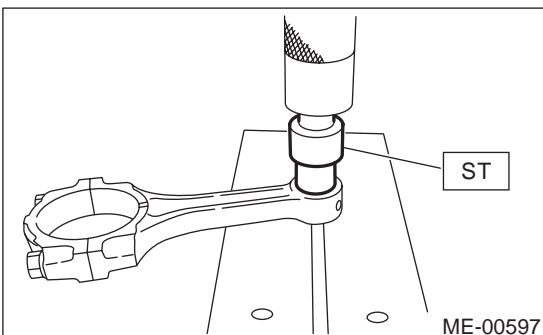


7) Replacement procedure is as follows.

(1) Remove bushing from connecting rod with ST and press.

(2) Press bushing with ST after applying oil on the periphery of bushing.

ST 18350AA000 CONNECTING ROD BUSHING REMOVER AND INSTALLER



(3) Make two 3 mm (0.12 in) holes in bushing. Ream the inside of bushing.

(4) After completion of reaming, clean bushing to remove chips.

## 6. CRANKSHAFT AND CRANKSHAFT BEARING

1) Clean crankshaft completely and check for cracks by means of red lead check etc., and replace if defective.

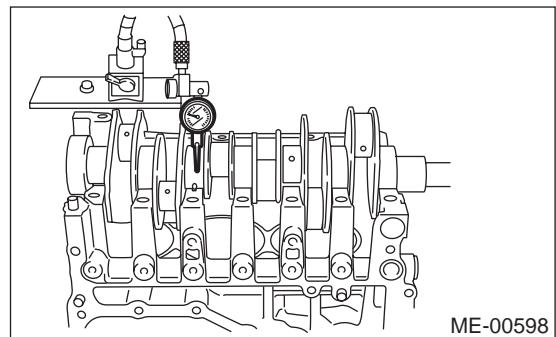
2) Measure the crankshaft bend, and correct or replace if it exceeds the limit.

### **NOTE:**

If a suitable V-block is not available, install #1 and #5 crankshaft bearing on cylinder block, position crankshaft on these bearings and measure crankshaft bend using a dial gauge.

### **Crankshaft bend limit:**

**0.035 mm (0.0014 in)**



3) Inspect the crank journal and crank pin for wear. If they are not within the specifications, replace bearing with a suitable (undersize) one, and replace or recondition crankshaft as necessary. When grinding crank journal or crank pin, finish them to the specified dimensions according to the undersize bearing to be used.

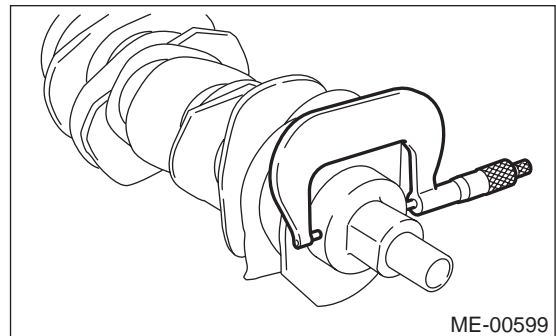
### **Crank pin and crank journal:**

#### **Out-of-roundness**

**0.020 mm (0.0008 in) or less**

#### **Grinding limit**

**0.250 mm (0.0098 in)**





# CYLINDER BLOCK

MECHANICAL

		Crank journal diameter		Crank pin diameter
		#1, #3, #5, #7	#2, #4, #6	
Standard	Journal O.D.	63.992 — 64.008 (2.5194 — 2.5200)		51.984 — 52.000 (2.0466 — 2.0472)
	Bearing size (Thickness at center)	1.992 — 2.005 (0.0784 — 0.0789)	1.996 — 2.000 (0.0786 — 0.0787)	1.490 — 1.502 (0.0587 — 0.0591)
0.03 (0.0012) undersize	Journal O.D.	63.962 — 63.978 (2.5182 — 2.5188)		51.954 — 51.970 (2.0454 — 2.0461)
	Bearing size (Thickness at center)	2.017 — 2.020 (0.0794 — 0.0795)	2.019 — 2.020 (0.0795 — 0.0795)	1.510 — 1.513 (0.0594 — 0.0596)
0.05 (0.0020) undersize	Journal O.D.	63.942 — 63.958 (2.5174 — 2.5180)		51.934 — 51.950 (2.0446 — 2.0453)
	Bearing size (Thickness at center)	2.027 — 2.030 (0.0798 — 0.0799)	2.029 — 2.032 (0.0799 — 0.0800)	1.520 — 1.523 (0.0598 — 0.0600)
0.25 (0.0098) undersize	Journal O.D.	63.742 — 63.758 (2.5095 — 2.5102)		51.734 — 51.750 (2.0368 — 2.0374)
	Bearing size (Thickness at center)	2.127 — 2.130 (0.0837 — 0.0839)	2.129 — 2.132 (0.0838 — 0.0839)	1.620 — 1.623 (0.0638 — 0.0639)

O.D. ... Outer Diameter

4) Measure the thrust clearance of crankshaft at center bearing. If the clearance exceeds the limit, replace bearing.

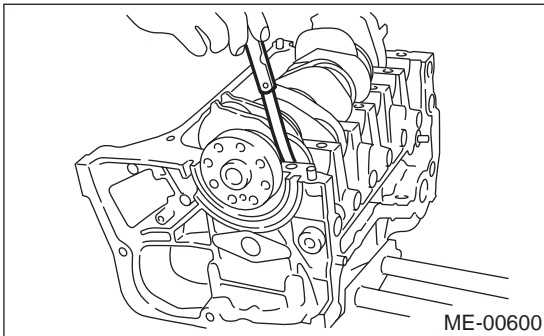
**Crankshaft thrust clearance:**

**Standard**

**0.030 — 0.115 mm (0.0012 — 0.0045 in)**

**Limit**

**0.25 mm (0.0098 in)**



5) Inspect individual crankshaft bearings for signs of flaking, seizure, melting, and wear.

6) Measure the oil clearance on each crankshaft bearing by means of plastigauge. If the measurement is not within the specification, replace defective bearing with an undersize one, and replace or recondition crankshaft as necessary.

		Unit: mm (in)
Crankshaft oil clearance		
Standard	0.010 — 0.030 (0.0004 — 0.0012)	
Limit	0.050 (0.0020)	

# ENGINE TROUBLE IN GENERAL

MECHANICAL

## 19.Engine Trouble in General

### A: INSPECTION

NOTE:

“RANK” shown in the chart refer to the possibility of reason for the trouble in order (“Very often” to “Rarely”)

A — Very often

B — Sometimes

C — Rarely

TROUBLE	PROBLEM PARTS, ETC.	POSSIBLE CAUSE	RANK
1. Engine will not start.			
1) Starter does not turn.	• Starter	• Defective battery-to-starter harness	B
		• Defective starter switch	C
		• Defective inhibitor switch or neutral switch	C
		• Defective starter	B
	• Battery	• Poor terminal connection	A
		• Run-down battery	A
		• Defective charging system	B
	• Friction	• Seizure of crankshaft and connecting rod bearing	C
		• Seized camshaft	C
• Seized or stuck piston and cylinder		C	
2) Initial combustion does not occur.	• Starter	• Defective starter	C
	• Engine control system <Ref. to EN(H6DO)-2, Basic Diagnostic Procedure.>		A
	• Fuel line	• Defective fuel pump and relay	A
		• Lack of or insufficient fuel	B
	• Chain	• Defective	B
		• Defective timing	B
	• Compression	• Incorrect valve clearance	C
		• Loosened spark plugs or defective gasket	C
		• Loosened cylinder head bolts or defective gasket	C
		• Improper valve seating	C
		• Defective valve stem	C
		• Worn or broken valve spring	B
		• Worn or stuck piston rings, cylinder and piston	C
		• Incorrect valve timing	B
	• Improper engine oil (low viscosity)	B	
3) Initial combustion occur.	• Engine control system <Ref. to EN(H6DO)-2, Basic Diagnostic Procedure.>		A
	• Intake system	• Defective intake manifold gasket	B
		• Defective throttle body gasket	B
	• Fuel line	• Defective fuel pump and relay	C
		• Clogged fuel line	C
		• Lack of or insufficient fuel	B
	• Chain	• Defective	B
		• Defective timing	B
	• Compression	• Incorrect valve clearance	C
		• Loosened spark plugs or defective gasket	C
		• Loosened cylinder head bolts or defective gasket	C
		• Improper valve seating	C
		• Defective valve stem	C
		• Worn or broken valve spring	B
		• Worn or stuck piston rings, cylinder and piston	C
• Incorrect valve timing		B	
• Improper engine oil (low viscosity)	B		

# ENGINE TROUBLE IN GENERAL

MECHANICAL

TROUBLE	PROBLEM PARTS, ETC.	POSSIBLE CAUSE	RANK
4) Engine stalls after initial combustion.	• Engine control system <Ref. to EN(H6DO)-2, Basic Diagnostic Procedure.>		A
	• Intake system	• Loosened or cracked intake duct	B
		• Loosened or cracked PCV hose	C
		• Loosened or cracked vacuum hose	C
		• Defective intake manifold gasket	B
		• Defective throttle body gasket	B
		• Dirty air cleaner element	C
	• Fuel line	• Clogged fuel line	C
		• Lack of or insufficient fuel	B
	• Chain	• Defective	B
		• Defective timing	B
	• Compression	• Incorrect valve clearance	C
		• Loosened spark plugs or defective gasket	C
		• Loosened cylinder head bolts or defective gasket	C
		• Improper valve seating	C
		• Defective valve stem	C
		• Worn or broken valve spring	B
• Worn or stuck piston rings, cylinder and piston		C	
• Incorrect valve timing		B	
• Improper engine oil (low viscosity)		B	
2. Rough idle and engine stall	• Engine control system <Ref. to EN(H6DO)-2, Basic Diagnostic Procedure.>		A
	• Intake system	• Loosened or cracked intake duct	A
		• Loosened or cracked PCV hose	A
		• Loosened or cracked vacuum hose	A
		• Defective intake manifold gasket	B
		• Defective throttle body gasket	B
		• Defective PCV valve	C
		• Loosened oil filter cap	B
		• Dirty air cleaner element	C
	• Fuel line	• Defective fuel pump and relay	C
		• Clogged fuel line	C
		• Lack of or insufficient fuel	B
	• Chain	• Defective timing	C
	• Compression	• Incorrect valve clearance	B
		• Loosened spark plugs or defective gasket	B
		• Loosened cylinder head bolts or defective gasket	B
		• Improper valve seating	B
		• Defective valve stem	C
		• Worn or broken valve spring	B
		• Worn or stuck piston rings, cylinder and piston	B
		• Incorrect valve timing	A
		• Improper engine oil (low viscosity)	B
	• Lubrication system	• Incorrect oil pressure	B
		• Defective rocker cover gasket	C
	• Cooling system	• Overheating	C
	• Others	• Malfunction of evaporative emission control system	A
		• Stuck or damaged throttle valve	B
		• Accelerator cable out of adjustment	C

# ENGINE TROUBLE IN GENERAL

MECHANICAL

TROUBLE	PROBLEM PARTS, ETC.	POSSIBLE CAUSE	RANK
3. Low output, hesitation and poor acceleration	• Engine control system <Ref. to EN(H6DO)-2, Basic Diagnostic Procedure.>		A
	• Intake system	• Loosened or cracked intake duct	A
		• Loosened or cracked PCV hose	A
		• Loosened or cracked vacuum hose	B
		• Defective intake manifold gasket	B
		• Defective throttle body gasket	B
		• Defective PCV valve	B
		• Loosened oil filler cap	B
		• Dirty air cleaner element	A
	• Fuel line	• Defective fuel pump and relay	B
		• Clogged fuel line	B
		• Lack of or insufficient fuel	C
	• Chain	• Defective timing	B
	• Compression	• Incorrect valve clearance	B
		• Loosened spark plugs or defective gasket	B
		• Loosened cylinder head bolts or defective gasket	B
		• Improper valve seating	B
		• Defective valve stem	C
		• Worn or broken valve spring	B
		• Worn or stuck piston rings, cylinder and piston	C
• Incorrect valve timing		A	
• Improper engine oil (low viscosity)	B		
• Lubrication system	• Incorrect oil pressure	B	
• Cooling system	• Overheating	C	
	• Over cooling	C	
• Others	• Malfunction of evaporative emission control system	A	
4. Surging	• Engine control system <Ref. to EN(H6DO)-2, Basic Diagnostic Procedure.>		A
	• Intake system	• Loosened or cracked intake duct	A
		• Loosened or cracked PCV hose	A
		• Loosened or cracked vacuum hose	A
		• Defective intake manifold gasket	B
		• Defective throttle body gasket	B
		• Defective PCV valve	B
		• Loosened oil filler cap	B
		• Dirty air cleaner element	B
	• Fuel line	• Defective fuel pump and relay	B
		• Clogged fuel line	B
		• Lack of or insufficient fuel	C
	• Chain	• Defective timing	B
	• Compression	• Incorrect valve clearance	B
		• Loosened spark plugs or defective gasket	C
		• Loosened cylinder head bolts or defective gasket	C
		• Improper valve seating	C
		• Defective valve stem	C
		• Worn or broken valve spring	C
		• Worn or stuck piston rings, cylinder and piston	C
• Incorrect valve timing		A	
• Improper engine oil (low viscosity)	B		
• Cooling system	• Overheating	B	
• Others	• Malfunction of evaporative emission control system	C	

# ENGINE TROUBLE IN GENERAL

MECHANICAL

TROUBLE	PROBLEM PARTS, ETC.	POSSIBLE CAUSE	RANK
5. Engine does not return to idle.	• Engine control system <Ref. to EN(H6DO)-2, Basic Diagnostic Procedure.>		A
	• Intake system	• Loosened or cracked vacuum hose	A
	• Others	• Stuck or damaged throttle valve	A
		• Accelerator cable out of adjustment	B
6. Dieseling (Run-on)	• Engine control system <Ref. to EN(H6DO)-2, Basic Diagnostic Procedure.>		A
	• Cooling system	• Overheating	B
	• Others	• Malfunction of evaporative emission control system	B
7. After burning in exhaust system	• Engine control system <Ref. to EN(H6DO)-2, Basic Diagnostic Procedure.>		A
	• Intake system	• Loosened or cracked intake duct	C
		• Loosened or cracked PCV hose	C
		• Loosened or cracked vacuum hose	B
		• Defective PCV valve	B
		• Loosened oil filler cap	C
	• Chain	• Defective timing	B
	• Compression	• Incorrect valve clearance	B
		• Loosened spark plugs or defective gasket	C
		• Loosened cylinder head bolts or defective gasket	C
		• Improper valve seating	B
		• Defective valve stem	C
		• Worn or broken valve spring	C
		• Worn or stuck piston rings, cylinder and piston	C
		• Incorrect valve timing	A
• Lubrication system	• Incorrect oil pressure	C	
• Cooling system	• Over cooling	C	
• Others	• Malfunction of evaporative emission control system	C	
8. Knocking	• Engine control system <Ref. to EN(H6DO)-2, Basic Diagnostic Procedure.>		A
	• Intake system	• Loosened oil filter cap	B
	• Chain	• Defective timing	B
	• Compression	• Incorrect valve clearance	C
		• Incorrect valve timing	B
	• Cooling system	• Overheating	A
9. Excessive engine oil consumption	• Intake system	• Loosened or cracked PCV hose	A
		• Defective PCV valve	B
		• Loosened oil filler cap	C
	• Compression	• Defective valve stem	A
		• Worn or stuck piston rings, cylinder and piston	A
	• Lubrication system	• Loosened oil pump attaching bolts and defective gasket	B
		• Defective oil filter seal	B
		• Defective crankshaft oil seal	B
		• Defective rocker cover gasket	B
		• Loosened oil drain plug or defective gasket	B
	• Loosened oil pan fitting bolts or defective oil pan	B	

# ENGINE TROUBLE IN GENERAL

## MECHANICAL

TROUBLE	PROBLEM PARTS, ETC.	POSSIBLE CAUSE	RANK	
10. Excessive fuel consumption	• Engine control system <Ref. to EN(H6DO)-2, Basic Diagnostic Procedure.>		A	
	• Intake system	• Dirty air cleaner element	A	
	• Chain	• Defective timing	B	
	• Compression	• Incorrect valve clearance		B
		• Loosened spark plugs or defective gasket		C
		• Loosened cylinder head bolts or defective gasket		C
		• Improper valve seating		B
		• Defective valve stem		C
		• Worn or broken valve spring		C
		• Worn or stuck piston rings, cylinder and piston		B
		• Incorrect valve timing		B
	• Lubrication system	• Incorrect oil pressure	C	
	• Cooling system	• Over cooling	C	
• Others	• Accelerator cable out of adjustment	B		



## 20.Engine Noise

### A: INSPECTION

Type of sound	Condition	Possible cause
Regular clicking sound	Sound increases as engine speed increases.	<ul style="list-style-type: none"> <li>Valve mechanism is defective.</li> <li>Incorrect valve clearance</li> <li>Worn camshaft</li> <li>Broken valve spring</li> </ul>
Heavy and dull clank	Oil pressure is low.	<ul style="list-style-type: none"> <li>Worn crankshaft main bearing</li> <li>Worn connecting rod bearing (big end)</li> </ul>
	Oil pressure is normal.	<ul style="list-style-type: none"> <li>Loose flywheel mounting bolts</li> <li>Damaged engine mounting</li> </ul>
High-pitched clank (Spark knock)	Sound is noticeable when accelerating with an overload.	<ul style="list-style-type: none"> <li>Ignition timing advanced</li> <li>Accumulation of carbon inside combustion chamber</li> <li>Wrong spark plug</li> <li>Improper gasoline</li> </ul>
Clank when engine speed is medium (1,000 to 2,000 rpm).	Sound is reduced when fuel injector connector of noisy cylinder is disconnected. (NOTE*)	<ul style="list-style-type: none"> <li>Worn crankshaft main bearing</li> <li>Worn bearing at crankshaft end of connecting rod</li> </ul>
Knocking sound when engine is operating under idling speed and engine is warm	Sound is reduced when fuel injector connector of noisy cylinder is disconnected. (NOTE*)	<ul style="list-style-type: none"> <li>Worn cylinder liner and piston ring</li> <li>Broken or stuck piston ring</li> <li>Worn piston pin and hole at piston end of connecting rod</li> </ul>
	Sound is not reduced if each fuel injector connector is disconnected in turn. (NOTE*)	<ul style="list-style-type: none"> <li>Unusually worn valve lifter</li> <li>Worn cam gear</li> <li>Worn camshaft journal bore in crankcase</li> </ul>
Squeaky sound	—	<ul style="list-style-type: none"> <li>Insufficient generator lubrication</li> </ul>
Rubbing sound	—	<ul style="list-style-type: none"> <li>Defective generator brush and rotor contact</li> </ul>
Gear scream when starting engine	—	<ul style="list-style-type: none"> <li>Defective ignition starter switch</li> <li>Worn gear and starter pinion</li> </ul>
Sound like polishing glass with a dry cloth	—	<ul style="list-style-type: none"> <li>Loose drive belt</li> <li>Defective water pump shaft</li> </ul>
Hissing sound	—	<ul style="list-style-type: none"> <li>Loss of compression</li> <li>Air leakage in air intake system, hoses, connections or manifolds</li> </ul>
Timing chain noise	—	<ul style="list-style-type: none"> <li>Loose timing chain</li> <li>Chain contacting case/adjacent part</li> </ul>
Valve tappet noise	—	<ul style="list-style-type: none"> <li>Incorrect valve clearance</li> </ul>

**NOTE\*:**

When disconnecting fuel injector connector, Malfunction Indicator Light (CHECK ENGINE light) illuminates and trouble code is stored in ECM memory.

Therefore, carry out the CLEAR MEMORY MODE <Ref. to EN(H6DO)-54, Clear Memory Mode.> and INSPECTION MODE <Ref. to EN(H6DO)-47, Inspection Mode.> after connecting fuel injector connector.

# ENGINE NOISE

MECHANICAL

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**MEMO:**