

# 2013 Subaru Forester X

2013 ENGINE Engine Mechanical (H4DO) - Forester

## 2013 ENGINE

### Engine Mechanical (H4DO) - Forester

## GENERAL DESCRIPTION

## SPECIFICATION

|                       |                                                                                                                      |  |                                |                                                                           |                                      |                           |
|-----------------------|----------------------------------------------------------------------------------------------------------------------|--|--------------------------------|---------------------------------------------------------------------------|--------------------------------------|---------------------------|
| Engine                | Model                                                                                                                |  |                                | 2.5 L                                                                     |                                      |                           |
|                       | Cylinder arrangement                                                                                                 |  |                                | Horizontally opposed, liquid cooled, 4-cylinder, 4-stroke gasoline engine |                                      |                           |
|                       | Valve system mechanism                                                                                               |  |                                | Chain driven, double overhead camshaft, 4-valve/cylinder                  |                                      |                           |
|                       | Bore x Stroke                                                                                                        |  | mm (in)                        | 94.0 x 90.0 (3.70 x 3.54)                                                 |                                      |                           |
|                       | Displacement                                                                                                         |  | cm <sup>3</sup> (cu in)        | 2, 498 (152.43)                                                           |                                      |                           |
|                       | Compression ratio                                                                                                    |  |                                | 10                                                                        |                                      |                           |
|                       | Compression pressure (at 200 - 300 rpm)                                                                              |  | kPa (kg/cm <sup>2</sup> , psi) | Standard                                                                  | 1, 050 - 1, 400 (11 - 14, 152 - 203) |                           |
|                       | Number of piston rings                                                                                               |  |                                | Pressure ring: 2, Oil ring: 1                                             |                                      |                           |
|                       | Intake valve timing                                                                                                  |  | Open                           | Max. retard                                                               | ATDC 12°                             |                           |
|                       |                                                                                                                      |  |                                | Min. advance                                                              | BTDC 43°                             |                           |
|                       |                                                                                                                      |  | Close                          | Max. retard                                                               | ABDC 76°                             |                           |
|                       |                                                                                                                      |  |                                | Min. advance                                                              | ABDC 21°                             |                           |
|                       | Exhaust valve timing                                                                                                 |  | Open                           |                                                                           | BBDC 37°                             |                           |
|                       |                                                                                                                      |  | Close                          |                                                                           | ATDC 11°                             |                           |
|                       | Cam clearance                                                                                                        |  | mm (in)                        | Intake                                                                    | Standard                             | 0.13±0.03 (0.0051±0.0012) |
|                       |                                                                                                                      |  |                                | Exhaust                                                                   | Standard                             | 0.24±0.03 (0.0094±0.0012) |
|                       | Idling speed (Select lever is in "P" or "N" range on AT model; Gear shift lever is in neutral position on MT model.) |  | rpm                            | No load                                                                   | Standard                             | AT model: 675±100         |
|                       |                                                                                                                      |  |                                | A/C ON                                                                    | Standard                             | MT model: 650±100         |
|                       | Ignition order                                                                                                       |  | 800 - 850±100                  |                                                                           |                                      |                           |
|                       | Ignition timing                                                                                                      |  | BTDC/rpm                       |                                                                           | Standard                             | 1 --> 3 --> 2 --> 4       |
| AT model: 16°±10°/675 |                                                                                                                      |  |                                |                                                                           |                                      |                           |
|                       |                                                                                                                      |  |                                |                                                                           | MT model: 16°±10°/650                |                           |

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|                  |                                                    |                     |              |          |                                                         |                                   |
|------------------|----------------------------------------------------|---------------------|--------------|----------|---------------------------------------------------------|-----------------------------------|
| Camshaft         | Bending limit                                      |                     |              | mm (in)  | 0.020 (0.00079)                                         |                                   |
|                  | Cam lobe height                                    | mm (in)             | Intake       | Standard | 40.77 - 40.87 (1.605 - 1.609)                           |                                   |
|                  |                                                    |                     | Exhaust      | Standard | 40.15 - 40.25 (1.581 - 1.585)                           |                                   |
|                  | Cam base circle diameter                           |                     |              | mm (in)  | Standard                                                | 34.0 (1.339)                      |
|                  | Journal O.D.                                       |                     |              | mm (in)  | Standard                                                | 25.946 - 25.963 (1.0215 - 1.0222) |
|                  | Oil clearance                                      |                     |              | mm (in)  | Standard                                                | 0.037 - 0.072 (0.0015 - 0.0028)   |
| Thrust clearance |                                                    |                     | mm (in)      | Standard | 0.068 - 0.116 (0.0027 - 0.0047)                         |                                   |
| Cylinder head    | Warping limit (Mating surface with cylinder block) |                     |              | mm (in)  | 0.035 (0.0014)                                          |                                   |
|                  | Grinding limit                                     |                     |              | mm (in)  | 0.1 (0.004)                                             |                                   |
|                  | Standard height                                    |                     |              | mm (in)  | 98.5 (3.878)                                            |                                   |
| Valve seat       | Seating angle between valve and valve seat         |                     |              |          | 90°                                                     |                                   |
|                  | Contacting width between valve and valve seat      | mm (in)             | Intake       | Standard | 0.8 - 1.6 (0.031 - 0.063)                               |                                   |
|                  |                                                    |                     | Exhaust      | Standard | 1.1 - 1.7 (0.043 - 0.067)                               |                                   |
| Valve guide      | Clearance between the valve guide and valve stem   | mm (in)             | Intake       | Standard | 0.030 - 0.057 (0.0012 - 0.0022)                         |                                   |
|                  |                                                    |                     | Exhaust      | Standard | 0.040 - 0.067 (0.0016 - 0.0026)                         |                                   |
|                  | Inside diameter                                    |                     |              | mm (in)  | Standard                                                | 5.500 - 5.512 (0.2165 - 0.2170)   |
|                  | Valve stem outer diameters                         | mm (in)             | Intake       | Standard | 5.455 - 5.470 (0.2148 - 0.2154)                         |                                   |
|                  |                                                    |                     | Exhaust      | Standard | 5.445 - 5.460 (0.2144 - 0.2150)                         |                                   |
|                  | Valve guide protrusion amount                      |                     |              | mm (in)  | Standard                                                | 11.4 - 11.8 (0.449 - 0.465)       |
| Valve            | Head edge thickness                                | mm (in)             | Intake       | Standard | 0.8 - 1.2 (0.031 - 0.047)                               |                                   |
|                  |                                                    |                     | Exhaust      | Standard | 1.0 - 1.4 (0.039 - 0.055)                               |                                   |
|                  | Overall length                                     | mm (in)             | Intake       |          | 103.3 (4.067)                                           |                                   |
| Exhaust          |                                                    |                     | 94.1 (3.705) |          |                                                         |                                   |
| Valve spring     | Free length                                        |                     |              | mm (in)  | Standard                                                | 41.06 (1.617)                     |
|                  | Tension/spring height                              | N (kgf, lb)/mm (in) | Set          | Standard | 182 - 210 (18.56 - 21.41, 40.92 - 47.22)/33.0 (1.299)   |                                   |
|                  |                                                    |                     | Lift         | Standard | 552 - 610 (56.29 - 62.20, 124.11 - 137.15)/22.0 (0.866) |                                   |
|                  |                                                    |                     |              |          |                                                         | 2.5°, 1.8 mm (0.071 in) or        |

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|                                                            |                                                     |                                                   |          |                                   |                                 |
|------------------------------------------------------------|-----------------------------------------------------|---------------------------------------------------|----------|-----------------------------------|---------------------------------|
|                                                            | Squareness                                          |                                                   | Standard | less                              |                                 |
| Valve shim                                                 | Inside diameter                                     |                                                   | mm (in)  | Standard                          | 5.500 - 5.560 (0.2165 - 0.2189) |
|                                                            | Valve stem end outer diameters                      | mm (in)                                           | Intake   | Standard                          | 5.455 - 5.470 (0.2148 - 0.2154) |
|                                                            |                                                     |                                                   | Exhaust  | Standard                          | 5.445 - 5.460 (0.2144 - 0.2150) |
|                                                            | Clearance between the valve shim and valve stem end | mm (in)                                           | Intake   | Standard                          | 0.030 - 0.105 (0.0012 - 0.0041) |
|                                                            |                                                     |                                                   | Exhaust  | Standard                          | 0.040 - 0.115 (0.0016 - 0.0045) |
|                                                            | Cylinder block                                      | Warping limit (Mating surface with cylinder head) |          | mm (in)                           |                                 |
| Grinding limit                                             |                                                     | mm (in)                                           |          | 0.1 (0.004)                       |                                 |
| Standard height                                            |                                                     | mm (in)                                           |          | 205.0 (8.07)                      |                                 |
| Cylindricity                                               |                                                     | mm (in)                                           | Limit    |                                   | 0.015 (0.0006)                  |
| Out-of-roundness                                           |                                                     | mm (in)                                           | Limit    |                                   | 0.010 (0.0004)                  |
| Clearance between cylinder liner and piston at 20°C (68°F) |                                                     | mm (in)                                           | Standard | 0.015 - 0.035 (0.00059 - 0.00138) |                                 |
| Inner diameter of cylinder liner boring limit (diameter)   |                                                     | mm (in)                                           |          | To 94.505 (3.7207)                |                                 |
| <b>NOTE:</b>                                               |                                                     |                                                   |          |                                   |                                 |
| <b>OS: Oversize US: Undersize</b>                          |                                                     |                                                   |          |                                   |                                 |

|            |                                                  |         |                  |          |                                                                    |
|------------|--------------------------------------------------|---------|------------------|----------|--------------------------------------------------------------------|
| Piston     | Piston grade point                               |         |                  | mm (in)  | 13.3 (0.52)                                                        |
|            | Outer diameter                                   | mm (in) | Standard         | A        | 93.980 - 93.990 (3.7000 - 3.7004)                                  |
|            |                                                  |         |                  | B        | 93.970 - 93.980 (3.6996 - 3.7000)                                  |
|            |                                                  |         | 0.25 (0.0098) OS |          | 94.220 - 94.240 (3.7094 - 3.7102)                                  |
|            |                                                  |         | 0.50 (0.0197) OS |          | 94.470 - 94.490 (3.7193 - 3.7201)                                  |
| Piston pin | Degree of fit                                    |         |                  |          | Piston pin must be fitted into position with thumb at 20°C (68°F). |
|            | Clearance between piston pin hole and piston pin |         | mm (in)          | Standard | 0.004 - 0.008 (0.0002 - 0.0003)                                    |
|            | Piston ring gap                                  | mm (in) | Top ring         | Standard | 0.20 - 0.30 (0.0079 - 0.0118)                                      |
|            |                                                  |         | Second ring      | Standard | 0.30 - 0.45 (0.0118 - 0.0177)                                      |
|            |                                                  |         |                  |          | 0.20 - 0.50 (0.0079 -                                              |

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|                                           |                                                         |                       |                  |                  |                                 |                                   |
|-------------------------------------------|---------------------------------------------------------|-----------------------|------------------|------------------|---------------------------------|-----------------------------------|
| Piston ring                               |                                                         |                       | Oil ring         | Standard         | 0.0197)                         |                                   |
|                                           | Clearance between piston ring and piston ring groove    | mm (in)               | Top ring         | Standard         | 0.040 - 0.080 (0.0016 - 0.0031) |                                   |
|                                           |                                                         |                       | Second ring      | Standard         | 0.030 - 0.070 (0.0012 - 0.0028) |                                   |
| Connecting rod and connecting rod bearing | Bend or twist per 100 mm (3.94 in) in length            |                       | mm (in)          | Limit            | 0.10 (0.0039)                   |                                   |
|                                           | Thrust clearance                                        |                       | mm (in)          | Standard         | 0.070 - 0.330 (0.0028 - 0.0130) |                                   |
|                                           | Oil clearance                                           |                       | mm (in)          | Standard         | 0.017 - 0.047 (0.0007 - 0.0019) |                                   |
|                                           | Bearing size (Thickness at center)                      | mm (in)               | Standard         |                  | 1.492 - 1.508 (0.0587 - 0.0594) |                                   |
|                                           |                                                         |                       | 0.03 (0.0012) US |                  | 1.511 - 1.515 (0.0595 - 0.0596) |                                   |
|                                           |                                                         |                       | 0.05 (0.0020) US |                  | 1.521 - 1.525 (0.0599 - 0.0600) |                                   |
|                                           |                                                         |                       | 0.25 (0.0098) US |                  | 1.621 - 1.625 (0.0638 - 0.0640) |                                   |
| Connecting rod bushing                    | Clearance between piston pin and connecting rod bushing |                       | mm (in)          | Standard         | 0.004 - 0.026 (0.0002 - 0.0010) |                                   |
| Crankshaft and                            | Bending limit                                           |                       |                  | mm (in)          |                                 | 0.035 (0.0014)                    |
|                                           | Crank pin                                               | Cylindricity          | mm (in)          | Limit            | 0.006 (0.0002)                  |                                   |
|                                           |                                                         | Out-of-roundness      | mm (in)          | Limit            | 0.005 (0.0002)                  |                                   |
|                                           |                                                         | Grinding limit (dia.) |                  | mm (in)          |                                 | To 47.726 (1.8790)                |
|                                           | Crank journal                                           | Cylindricity          | mm (in)          | Limit            | 0.006 (0.0002)                  |                                   |
|                                           |                                                         | Out-of-roundness      | mm (in)          | Limit            | 0.005 (0.0002)                  |                                   |
|                                           |                                                         | Grinding limit (dia.) |                  | mm (in)          |                                 | To 67.735 (2.6667)                |
|                                           | Crank pin outer diameter                                |                       | mm (in)          | Standard         |                                 | 47.976 - 48.000 (1.8888 - 1.8898) |
|                                           |                                                         |                       |                  | 0.03 (0.0012) US |                                 | 47.946 - 47.970 (1.8876 - 1.8886) |
|                                           |                                                         |                       |                  | 0.05 (0.0020) US |                                 | 47.926 - 47.950 (1.8868 - 1.8878) |
|                                           |                                                         |                       |                  | 0.25 (0.0098) US |                                 | 47.726 - 47.750 (1.8790 - 1.8799) |
|                                           |                                                         |                       |                  | Standard         |                                 | 67.985 - 68.009 (2.6766 - 2.6775) |
|                                           |                                                         |                       |                  | 0.03 (0.0012) US |                                 | 67.955 - 67.979 (2.6754 - 2.6763) |
|                                           |                                                         |                       |                  |                  |                                 |                                   |

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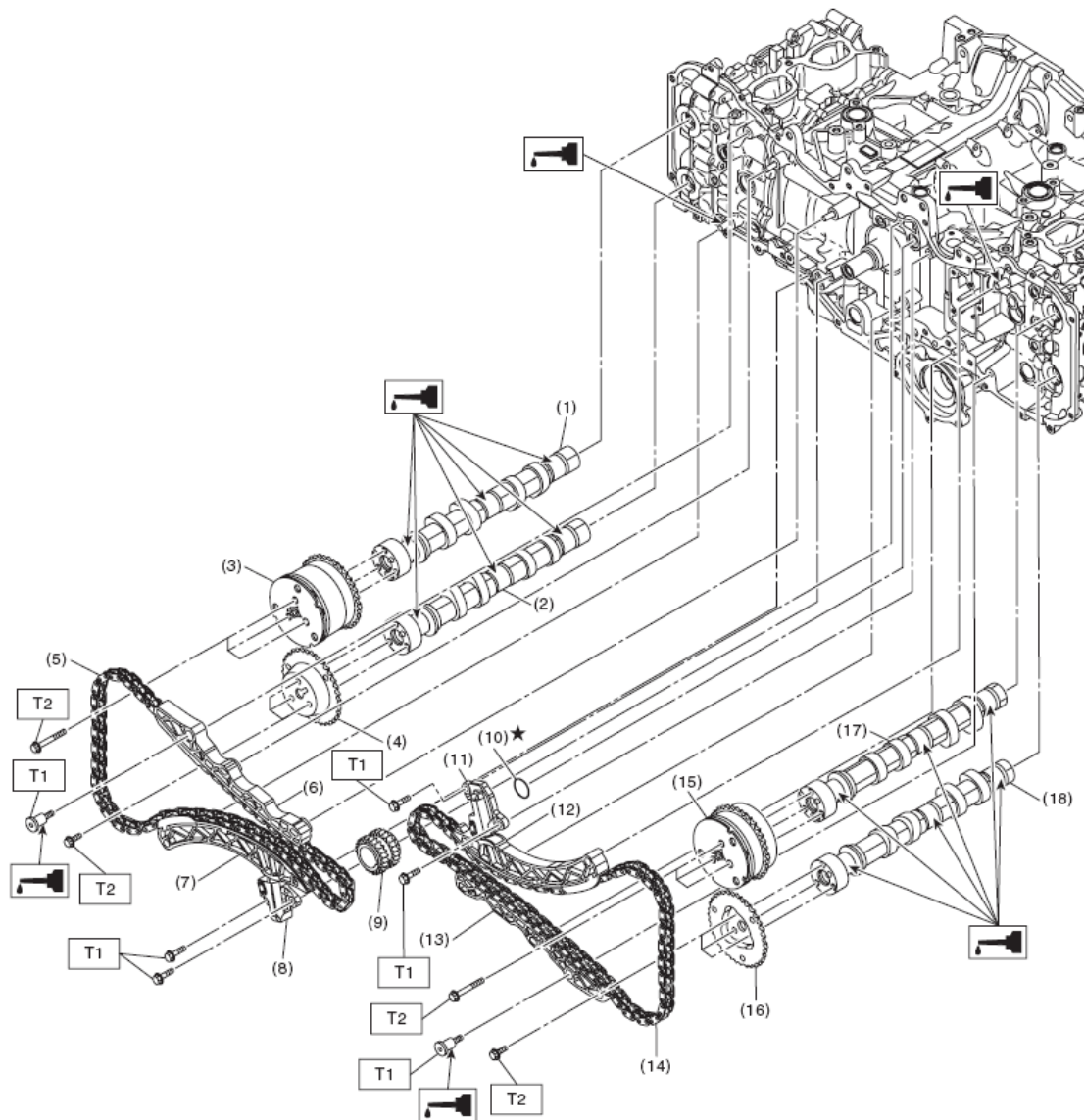
|                    |                                               |                |                  |                                   |
|--------------------|-----------------------------------------------|----------------|------------------|-----------------------------------|
| crankshaft bearing | Crank journal outer diameter    mm (in)       |                | 0.05 (0.0020) US | 67.935 - 67.959 (2.6746 - 2.6755) |
|                    |                                               |                | 0.25 (0.0098) US | 67.735 - 67.759 (2.6667 - 2.6677) |
|                    | Bearing size (Thickness at center)    mm (in) | #1, #2, #3, #4 | Standard         | 2.495 - 2.513 (0.0982 - 0.0989)   |
|                    |                                               |                | 0.03 (0.0012) US | 2.519 - 2.522 (0.0992 - 0.0993)   |
|                    |                                               |                | 0.05 (0.0020) US | 2.529 - 2.532 (0.0996 - 0.0997)   |
|                    |                                               |                | 0.25 (0.0098) US | 2.629 - 2.632 (0.1035 - 0.1036)   |
|                    |                                               | #5             | Standard         | 2.493 - 2.511 (0.0981 - 0.0989)   |
|                    |                                               |                | 0.03 (0.0012) US | 2.517 - 2.520 (0.0991 - 0.0992)   |
|                    |                                               |                | 0.05 (0.0020) US | 2.527 - 2.530 (0.0995 - 0.0996)   |
|                    |                                               |                | 0.25 (0.0098) US | 2.627 - 2.630 (0.1034 - 0.1035)   |
|                    | Thrust clearance    mm (in)                   |                | Standard         | 0.130 - 0.308 (0.00512 - 0.01213) |
|                    | Oil clearance    mm (in)                      |                | Standard         | 0.013 - 0.031 (0.00051 - 0.00122) |

### NOTE:

OS: Oversize US: Undersize

## COMPONENT

### TIMING CHAIN



ME-05439

- |                              |                               |                              |
|------------------------------|-------------------------------|------------------------------|
| (1) Intake camshaft RH       | (9) Crank sprocket            | (16) Exhaust cam sprocket LH |
| (2) Exhaust camshaft RH      | (10) O-ring                   | (17) Intake camshaft LH      |
| (3) Intake cam sprocket RH   | (11) Chain tensioner LH       | (18) Exhaust camshaft LH     |
| (4) Exhaust cam sprocket RH  | (12) Chain tensioner lever LH |                              |
| (5) Timing chain RH          | (13) Chain guide              |                              |
| (6) Chain guide              | (14) Timing chain LH          |                              |
| (7) Chain tensioner lever RH | (15) Intake cam sprocket LH   |                              |
| (8) Chain tensioner RH       |                               |                              |

**Fig. 1: Exploded View Of Timing Chain With Torque Specifications**  
 Courtesy of SUBARU OF AMERICA, INC.

**Tightening torque: N.m (kgf-m, ft-lb)**

**T1: 6.4 (0.7, 4.7)**

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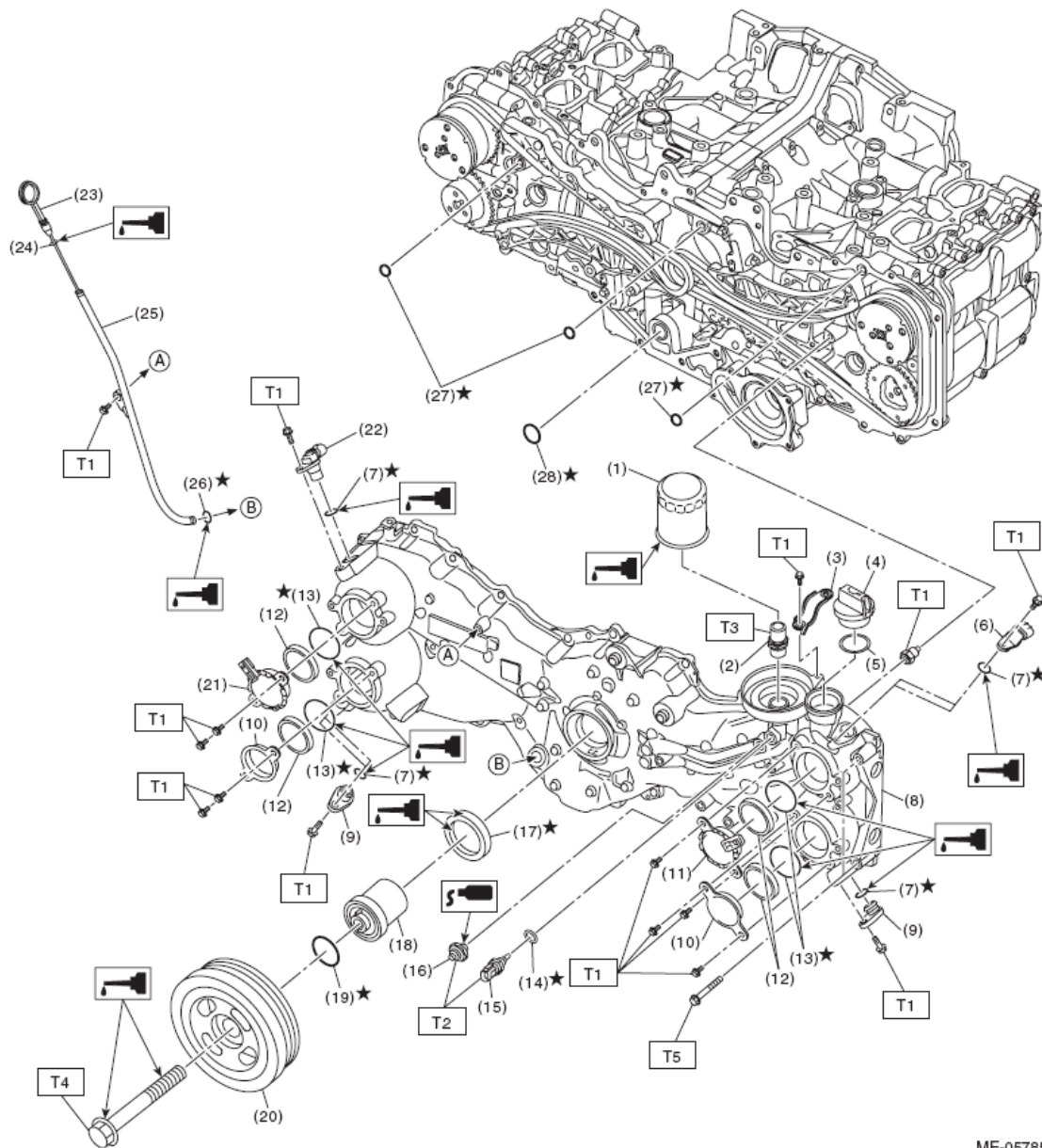
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***T2: 18 (1.8, 13.3)***

### **CHAIN COVER**

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ME-05785

- |                                 |                                    |                            |
|---------------------------------|------------------------------------|----------------------------|
| (1) Oil filter                  | (13) O-ring                        | (25) Oil level gauge guide |
| (2) Oil pump union              | (14) Gasket                        | (26) O-ring                |
| (3) Generator cord stay         | (15) Engine oil temperature sensor | (27) O-ring                |
| (4) Oil filler cap              | (16) Oil pressure switch           | (28) O-ring                |
| (5) Gasket                      | (17) Front oil seal                |                            |
| (6) Camshaft position sensor LH | (18) Crank pulley boss             |                            |
| (7) O-ring                      | (19) O-ring                        |                            |
| (8) Chain cover                 | (20) Crank pulley                  |                            |
| (9) Sensor cover                | (21) Oil control solenoid RH       |                            |
| (10) Actuator cover             | (22) Camshaft position sensor RH   |                            |
| (11) Oil control solenoid LH    | (23) Oil level gauge               |                            |
| (12) Back-up ring               | (24) O-ring                        |                            |

**Fig. 2: Exploded View Of Chain Cover With Torque Specifications**

Courtesy of SUBARU OF AMERICA, INC.

*Tightening torque: N.m (kgf-m, ft-lb)*

*T1: 6.4 (0.7, 4.7)*

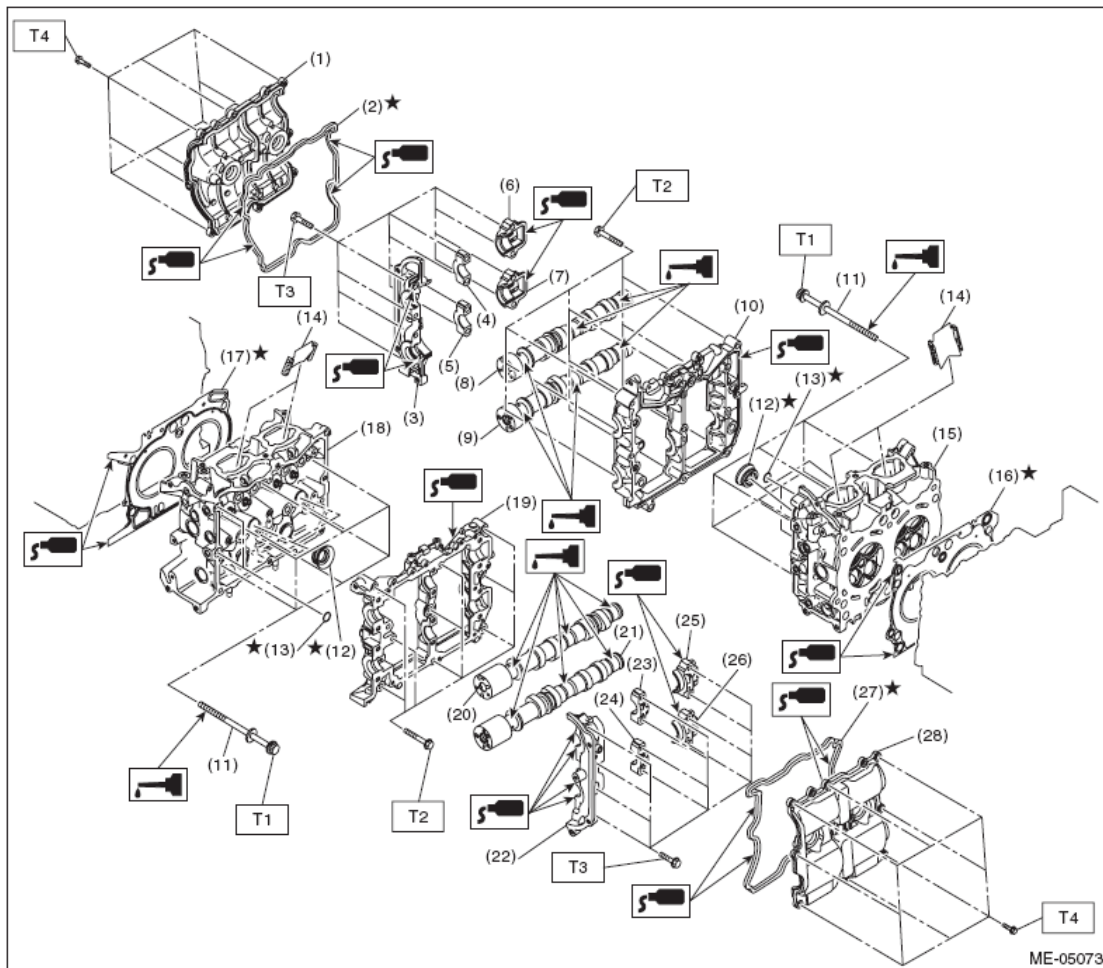
*T2: 18 (1.8, 13.3)*

*T3: 45 (4.6, 33.2)*

*T4: < Refer to INSTALLATION, Crank Pulley. >*

*T5: < Refer to INSTALLATION, Chain Cover. >*

**CYLINDER HEAD AND CAMSHAFT**



- |                                    |                                    |                                     |
|------------------------------------|------------------------------------|-------------------------------------|
| (1) Rocker cover RH                | (13) O-ring                        | (24) Exhaust center camshaft cap LH |
| (2) Rocker cover gasket RH         | (14) Cylinder head plate           | (25) Intake rear camshaft cap LH    |
| (3) Front camshaft cap RH          | (15) Cylinder head RH              | (26) Exhaust rear camshaft cap LH   |
| (4) Intake center camshaft cap RH  | (16) Cylinder head gasket RH       | (27) Rocker cover gasket LH         |
| (5) Exhaust center camshaft cap RH | (17) Cylinder head gasket LH       | (28) Rocker cover LH                |
| (6) Intake camshaft cap RH         | (18) Cylinder head LH              |                                     |
| (7) Exhaust rear camshaft cap RH   | (19) Cam carrier LH                |                                     |
| (8) Intake camshaft RH             | (20) Intake camshaft LH            |                                     |
|                                    |                                    |                                     |
| (9) Exhaust camshaft RH            | (21) Exhaust camshaft LH           |                                     |
| (10) Cam carrier RH                | (22) Front camshaft cap LH         |                                     |
| (11) Cylinder head bolt            | (23) Intake center camshaft cap LH |                                     |
| (12) Spark plug pipe gasket        |                                    |                                     |

**Fig. 3: Exploded View Of Cylinder Head And Camshaft With Torque Specifications**  
 Courtesy of SUBARU OF AMERICA, INC.

**Tightening torque: N.m (kgf-m, ft-lb)**

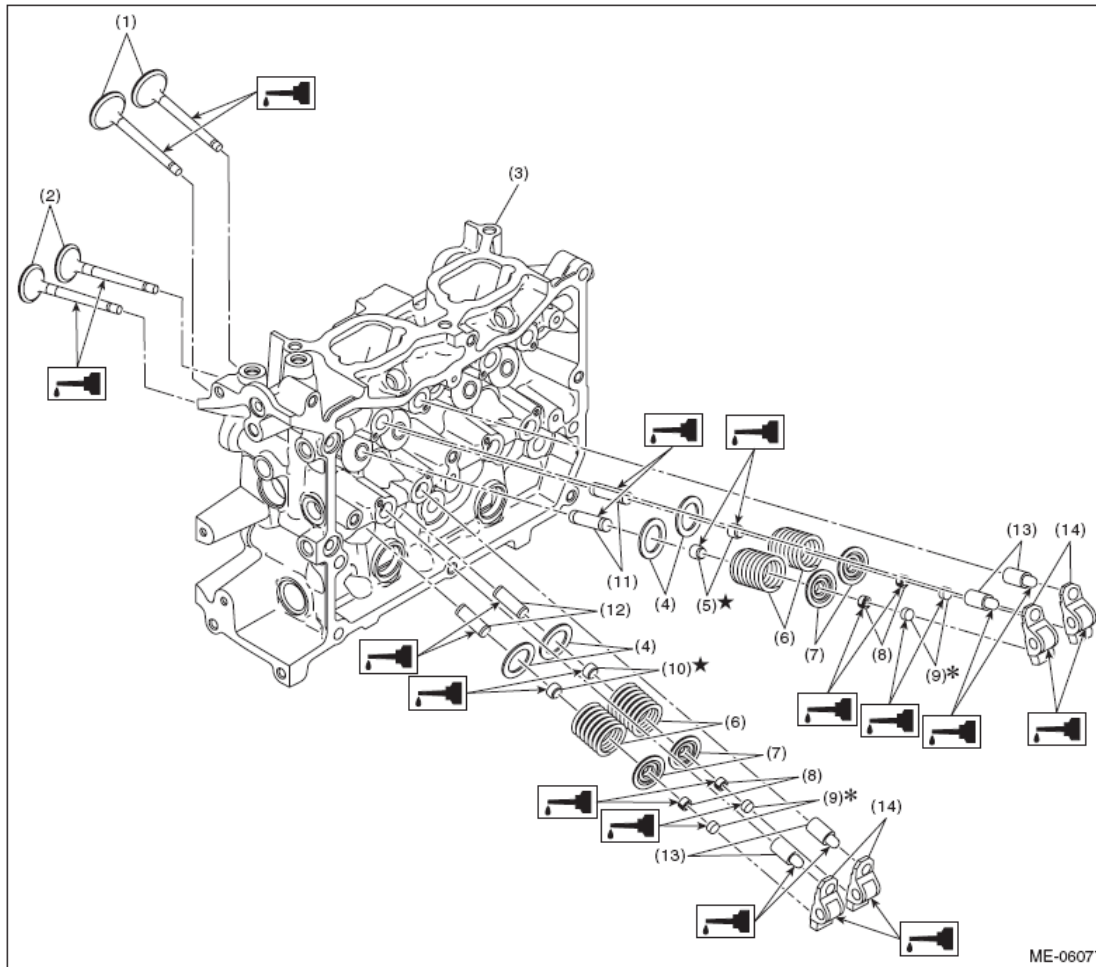
**T1: < Refer to INSTALLATION, Cylinder Head. >**

**T2:** < Refer to INSTALLATION, Cam Carrier. >

**T3:** < Refer to ASSEMBLY, Cam Carrier. >

**T4:** < Refer to INSTALLATION, Rocker Cover. >

### CYLINDER HEAD AND VALVE ASSEMBLY



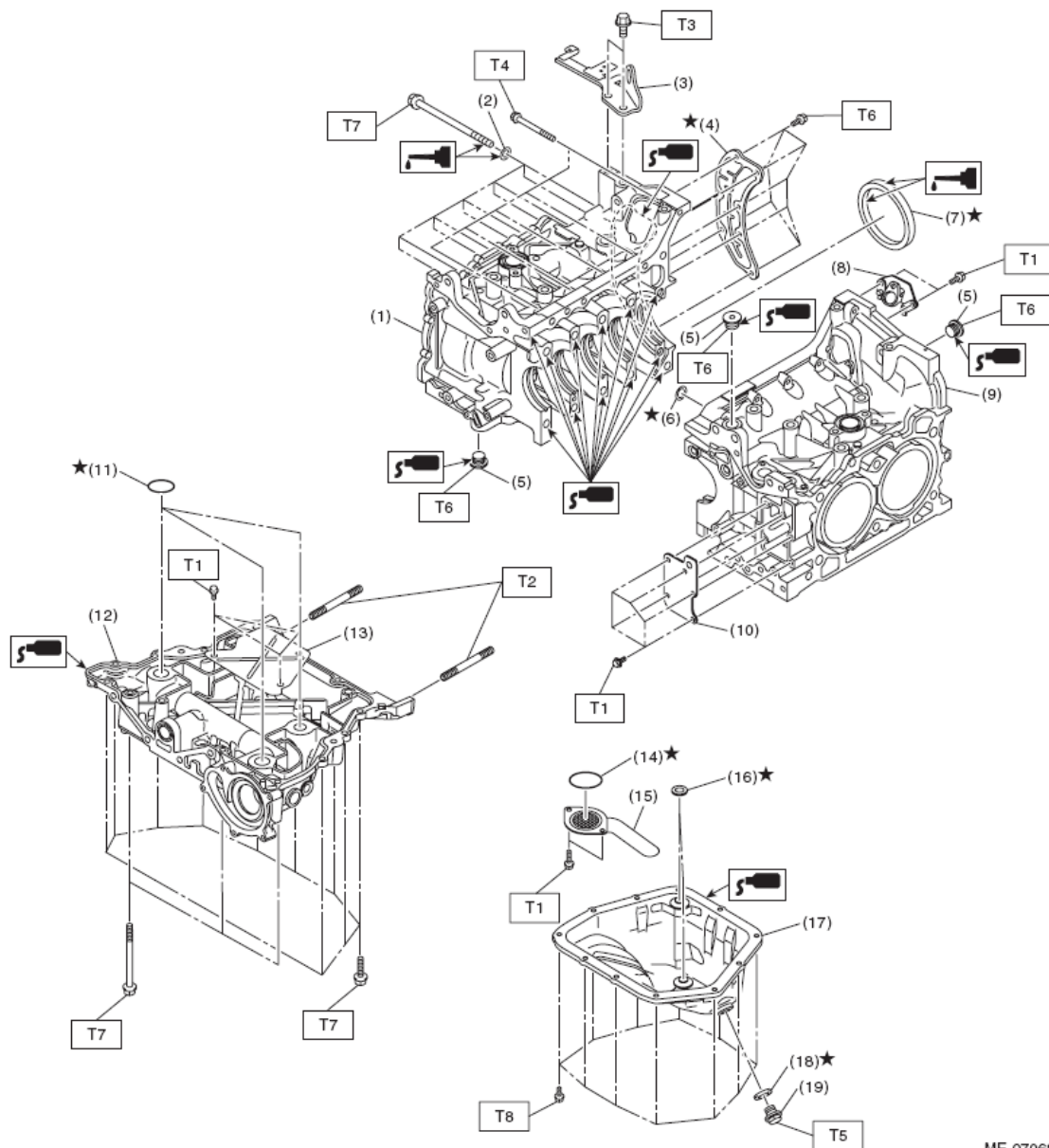
- |                           |                             |                              |
|---------------------------|-----------------------------|------------------------------|
| (1) Exhaust valve         | (6) Valve spring            | (11) Intake valve guide      |
| (2) Intake valve          | (7) Valve spring retainer   | (12) Exhaust valve guide     |
| (3) Cylinder head         | (8) Valve collet            | (13) Roller rocker arm pivot |
| (4) Valve spring seat     | (9) Valve shim              | (14) Roller rocker arm       |
| (5) Intake valve oil seal | (10) Exhaust valve oil seal |                              |

**Fig. 4: Exploded View Of Cylinder Head And Valve Assembly**  
Courtesy of SUBARU OF AMERICA, INC.

### CYLINDER BLOCK

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ME-07068

- |                                       |                        |
|---------------------------------------|------------------------|
| (1) Cylinder block RH                 | (11) O-ring            |
| (2) Washer                            | (12) Oil pan upper     |
| (3) Engine rear hanger                | (13) Baffle plate      |
| (4) Oil separator cover               | (14) O-ring            |
| (5) Main gallery plug                 | (15) Oil strainer      |
| (6) O-ring                            | (16) Oil pan seal ring |
| (7) Rear oil seal                     | (17) Oil pan           |
| (8) Crankshaft position sensor holder | (18) Drain plug gasket |
| (9) Cylinder block LH                 | (19) Drain plug        |
| (10) Cylinder block plate             |                        |

**Fig. 5: Exploded View Of Cylinder Block With Torque Specifications**

Courtesy of SUBARU OF AMERICA, INC.

*Tightening torque: N.m (kgf-m, ft-lb)*

*T1: 6.4 (0.7, 4.7)*

*T2: 10 (1.0, 7.4)*

*T3: 21 (2.1, 15.5)*

*T4: 25 (2.5, 18.4)*

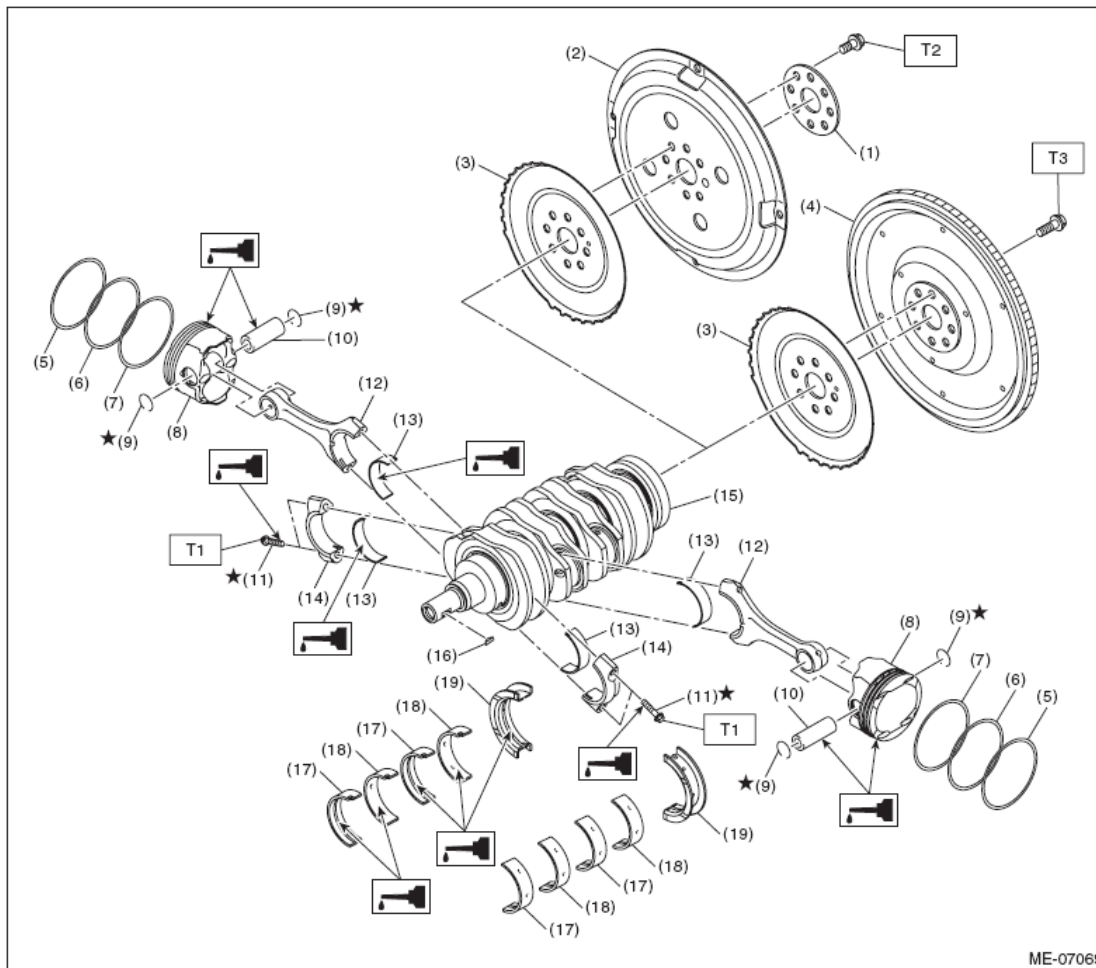
*T5: 41.7 (4.3, 30.8)*

*T6: < Refer to CYLINDER BLOCK, ASSEMBLY, Cylinder Block. >*

*T7: < Refer to INSTALLATION, Cylinder Block. >*

*T8: < Refer to OIL PAN, INSTALLATION, Oil Pan and Strainer. >*

**CRANKSHAFT AND PISTON**



ME-07069

- |                                      |                              |                                |
|--------------------------------------|------------------------------|--------------------------------|
| (1) Reinforcement (AT model)         | (9) Circlip                  | (17) Crankshaft bearing #1, #3 |
| (2) Drive plate (AT model)           | (10) Piston pin              | (18) Crankshaft bearing #2, #4 |
| (3) Crankshaft position sensor plate | (11) Connecting rod cap bolt | (19) Crankshaft bearing #5     |
| (4) Flywheel (MT model)              | (12) Connecting rod          |                                |
| (5) Top ring                         | (13) Connecting rod bearing  |                                |
| (6) Second ring                      | (14) Connecting rod cap      |                                |
| (7) Oil ring                         | (15) Crankshaft              |                                |
| (8) Piston                           | (16) Woodruff key            |                                |

**Fig. 6: Exploded View Of Crankshaft And Piston With Torque Specifications**  
**Courtesy of SUBARU OF AMERICA, INC.**

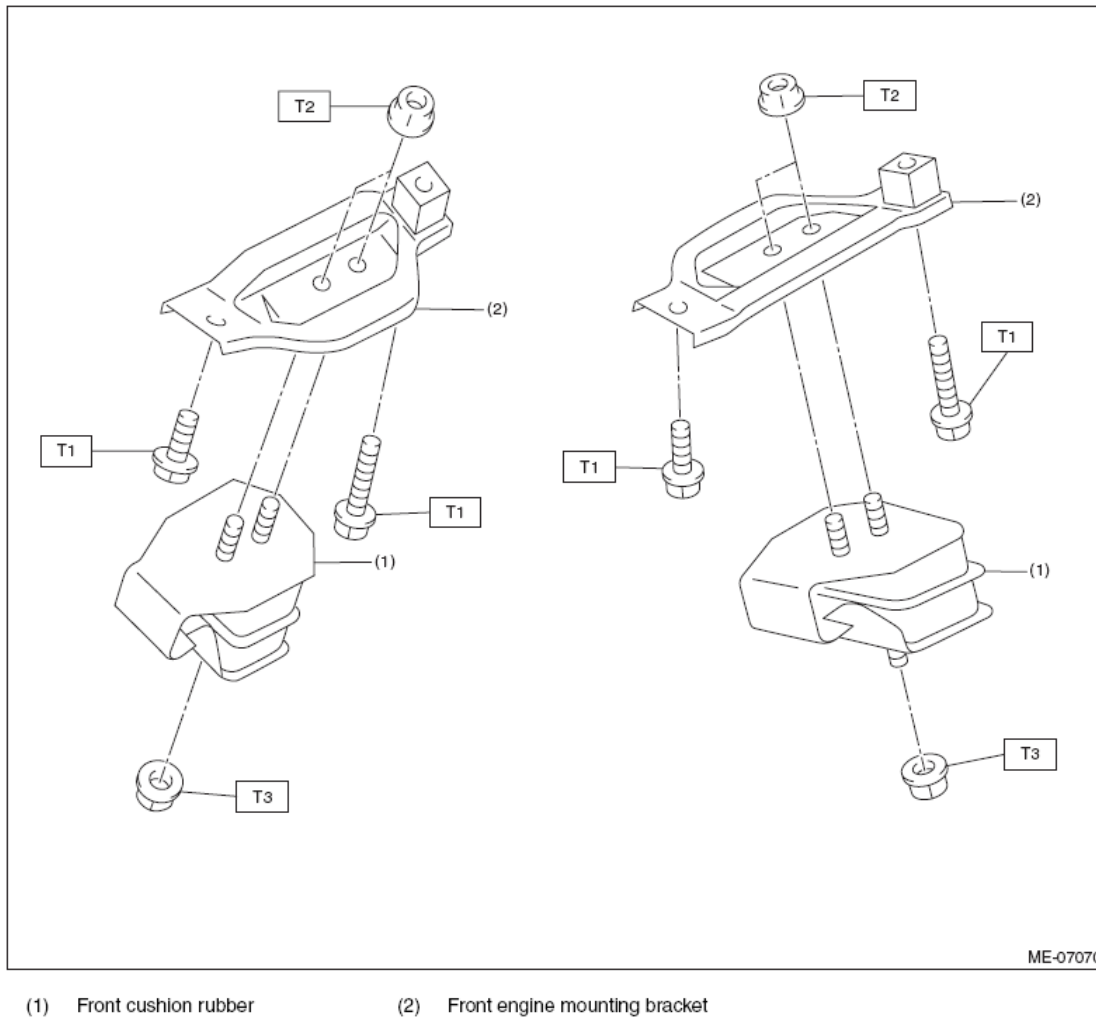
**Tightening torque: N.m (kgf-m, ft-lb)**

**T1: < Refer to INSTALLATION, Cylinder Block. >**

**T2: < Refer to INSTALLATION, Drive Plate. >**

**T3: < Refer to INSTALLATION, Flywheel. >**

## ENGINE MOUNTING



**Fig. 7: Identifying Front Cushion Rubber, Front Engine Mounting Bracket And Bolts With Torque Specifications**

Courtesy of SUBARU OF AMERICA, INC.

**Tightening torque: N.m (kgf-m, ft-lb)**

**T1: 35 (3.6, 25.8)**

**T2: 42 (4.3, 31.0)**

**T3: 45 (4.6, 33.2)**

## CAUTION

- Prior to starting work, pay special attention to the following:
  1. Always wear work clothes, a safety cap, protective shoes. Additionally, wear a helmet, protective

goggles, etc. if necessary.

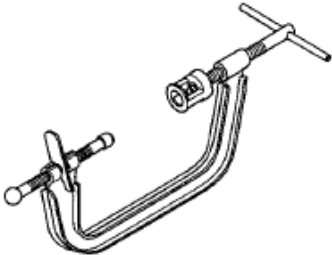
2. Protect the vehicle using a seat cover, fender cover, etc.

3. Prepare the service tools, clean cloth, containers to catch grease and oil, etc.

- Vehicle components are extremely hot immediately after driving. Be wary of receiving burns from heated parts.
- When performing a repair, identify the cause of trouble and avoid unnecessary removal, disassembly and replacement.
- Before disconnecting connectors of sensors or units, be sure to disconnect the ground cable from battery.
- Always use the jack-up point when the shop jacks or rigid racks are used to support the vehicle.
- Remove or install the engine in an area where chain hoists, lifting devices, etc. are available for ready use. When lifting up the vehicle, make sure to support the vehicle at the jack-up points.
- Be careful not to let any oil or grease contact the clutch disc or flywheel.
- Remove contamination including dirt and corrosion before removal, installation, disassembly or assembly.
- Keep the removed parts in order and protect them from dust and dirt.
- All removed parts, if to be reused, should be reinstalled in the original positions with attention to the correct directions, etc.
- Rotating parts and sliding parts such as piston, bearing and gear should be coated with oil when being assembled.
- Bolts, nuts and washers should be replaced with new parts as required.
- Be sure to tighten the fasteners including bolts and nuts to the specified torque.

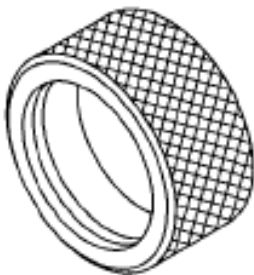
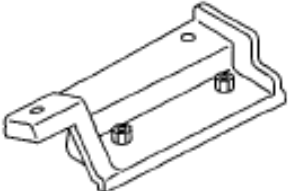
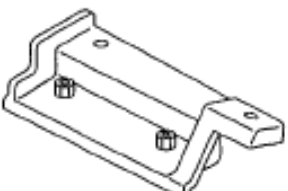
## PREPARATION TOOL

### SPECIAL TOOL

| ILLUSTRATION                                                                                               | TOOL NUMBER   | DESCRIPTION          | REMARKS                                           |
|------------------------------------------------------------------------------------------------------------|---------------|----------------------|---------------------------------------------------|
|  <p>ST0920287002000</p> | 0920287002000 | REMOVER AND REPLACER | Used for removing and installing valve spring.    |
|                                                                                                            | 398437700     | OIL SEAL INSTALLER   | Used for installing the front oil seal of engine. |

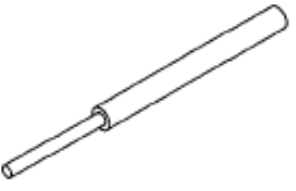
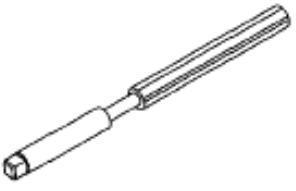
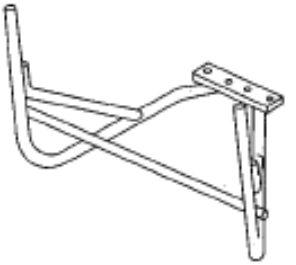
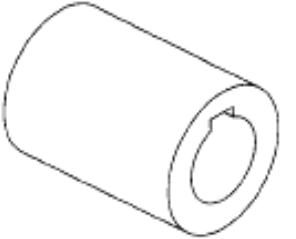
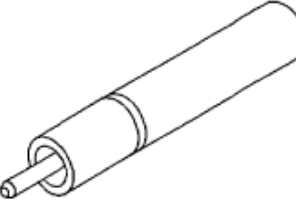
## 2013 Subaru Forester X

2013 ENGINE Engine Mechanical (H4DO) - Forester

|                                                                                                         |           |                                   |                                                                                                                                                                                    |
|---------------------------------------------------------------------------------------------------------|-----------|-----------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  <p>ST-398437700</p>   |           |                                   |                                                                                                                                                                                    |
|  <p>ST-498277200</p>   | 498277200 | STOPPER SET                       | Used for preventing the torque converter from falling when removing and installing the engine.                                                                                     |
|  <p>ST-498457000</p> | 498457000 | ENGINE STAND ADAPTER RH           | <ul style="list-style-type: none"> <li>• Used for disassembling and assembling engine.</li> <li>• Used together with ENGINE STAND (499817100) and ADAPTER (18362AA020).</li> </ul> |
|  <p>ST-498457100</p> | 498457100 | ENGINE STAND ADAPTER LH           | <ul style="list-style-type: none"> <li>• Used for disassembling and assembling engine.</li> <li>• Used together with ENGINE STAND (499817100) and ADAPTER (18362AA020).</li> </ul> |
|                                                                                                         | 499765700 | VALVE GUIDE REMOVER AND INSTALLER | Used for removing and installing valve guide.                                                                                                                                      |

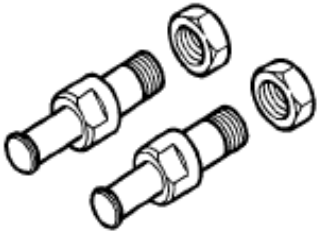
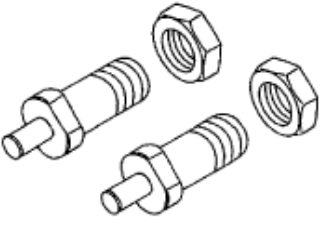
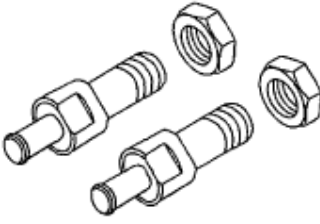
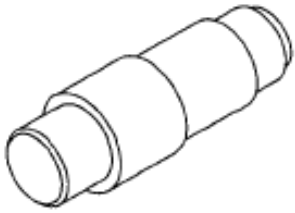
## 2013 Subaru Forester X

2013 ENGINE Engine Mechanical (H4DO) - Forester

|                                                                                                         |            |                      |                                                                                                                                                                                                               |
|---------------------------------------------------------------------------------------------------------|------------|----------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  <p>ST-499765700</p>   |            |                      |                                                                                                                                                                                                               |
|  <p>ST-499765900</p>   | 499765900  | VALVE GUIDE REAMER   | Used for reaming valve guides.                                                                                                                                                                                |
|  <p>ST-499817100</p>  | 499817100  | ENGINE STAND         | <ul style="list-style-type: none"> <li>• Used for disassembling and assembling engine.</li> <li>• Used together with ADAPTER (18362AA020), ENGINE STAND ADAPTER RH (498457000) and LH (498457100).</li> </ul> |
|  <p>ST18252AA000</p> | 18252AA000 | CRANKSHAFT SOCKET    | Used for rotating crankshaft.                                                                                                                                                                                 |
|  <p>ST18261AA010</p> | 18261AA010 | VALVE OIL SEAL GUIDE | Used for press-fitting of intake valve guide stem seals and exhaust valve guide stem seals.                                                                                                                   |
|                                                                                                         |            |                      |                                                                                                                                                                                                               |

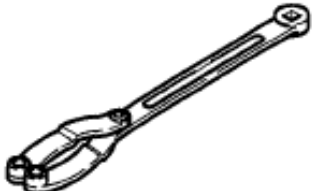
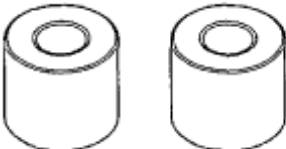
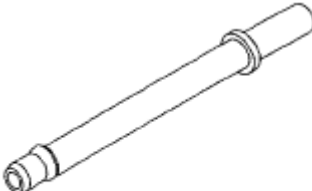
## 2013 Subaru Forester X

2013 ENGINE Engine Mechanical (H4DO) - Forester

|                                                                                                         |            |                                                       |                                                                                                                                                                                           |
|---------------------------------------------------------------------------------------------------------|------------|-------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  <p>ST18270AA020</p>   | 18270AA020 | SOCKET                                                | Used for removing and installing connecting rod.                                                                                                                                          |
|  <p>ST18334AA000</p>   | 18334AA000 | PULLEY WRENCH<br>PIN SET                              | <ul style="list-style-type: none"> <li>• Used for removing and installing the crank pulley.</li> <li>• Used together with PULLEY WRENCH (18355AA000).</li> </ul>                          |
|  <p>ST18334AA020</p>  | 18334AA020 | PULLEY WRENCH<br>PIN SET                              | <ul style="list-style-type: none"> <li>• Used for removing and installing exhaust cam sprocket LH.</li> <li>• Used together with PULLEY WRENCH (18355AA000).</li> </ul>                   |
|  <p>ST18334AA030</p> | 18334AA030 | PULLEY WRENCH<br>PIN SET                              | <ul style="list-style-type: none"> <li>• Used for removing and installing water pump pulley and intake cam sprocket.</li> <li>• Used together with PULLEY WRENCH (18355AA000).</li> </ul> |
|  <p>ST18350AA000</p> | 18350AA000 | CONNECTING ROD<br>BUSHING<br>REMOVER AND<br>INSTALLER | Used for removing and installing the connecting rod bushing at connecting rod small end.                                                                                                  |
|                                                                                                         |            |                                                       | <ul style="list-style-type: none"> <li>• Used for removing and</li> </ul>                                                                                                                 |

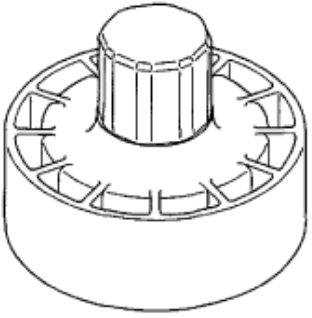
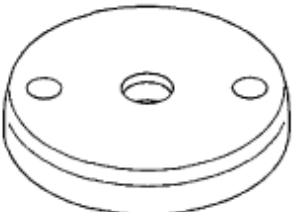
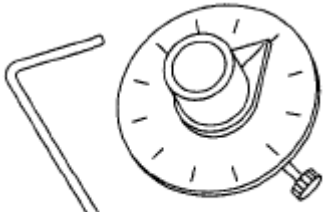
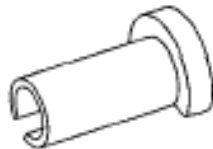
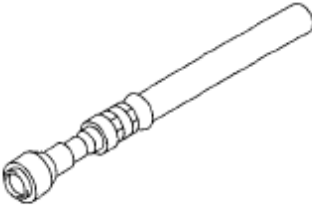
# 2013 Subaru Forester X

2013 ENGINE Engine Mechanical (H4DO) - Forester

|                                                                                                         |            |                   |                                                                                                                                                                                                                                                                                                                                                                                                            |
|---------------------------------------------------------------------------------------------------------|------------|-------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  <p>ST18353AA000</p>   | 18353AA000 | CLAMP PLIERS      | <p>installing the PCV hose.</p> <ul style="list-style-type: none"> <li>This tool is made by the French company CAILLAU. (code) 54.0.000.205</li> </ul> <p>To make it easier to obtain, it has been provided with a tool number.</p>                                                                                                                                                                        |
|  <p>ST18355AA000</p>   | 18355AA000 | PULLEY WRENCH     | <ul style="list-style-type: none"> <li>Used for installing and removing the water pump pulley.</li> <li>Used for removing and installing the crank pulley.</li> <li>Used for removing and installing intake cam sprocket and exhaust cam sprocket LH.</li> <li>Used together with PULLEY WRENCH PIN SET (18334AA030), PULLEY WRENCH PIN SET (18334AA000) or PULLEY WRENCH PIN SET (18334AA020).</li> </ul> |
|  <p>ST18362AA020</p> | 18362AA020 | ADAPTER           | <ul style="list-style-type: none"> <li>Used for disassembling and assembling engine.</li> <li>Used together with STAND (499817100), ENGINE STAND ADAPTER RH (498457000) and LH (498457100).</li> <li>Bolt used: M10 x 50 (SUBARU genuine Part No.: 010410500)</li> </ul>                                                                                                                                   |
|  <p>ST18471AA000</p> | 18471AA000 | FUEL PIPE ADAPTER | <p>Used for inspecting the fuel pressure.</p>                                                                                                                                                                                                                                                                                                                                                              |
|                                                                                                         |            |                   |                                                                                                                                                                                                                                                                                                                                                                                                            |

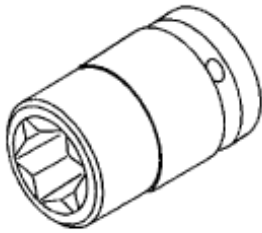
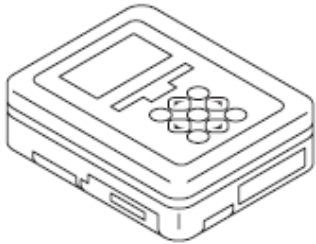
## 2013 Subaru Forester X

2013 ENGINE Engine Mechanical (H4DO) - Forester

|                                                                                                         |            |                         |                                                                                                                                                                     |
|---------------------------------------------------------------------------------------------------------|------------|-------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  <p>ST18657AA030</p>   | 18657AA030 | OIL SEAL INSTALLER      | <ul style="list-style-type: none"> <li>• Used for installing the rear oil seal of engine.</li> <li>• Used together with OIL SEAL GUIDE (18671AA020).</li> </ul>     |
|  <p>ST18671AA020</p>   | 18671AA020 | OIL SEAL GUIDE          | <ul style="list-style-type: none"> <li>• Used for installing the rear oil seal of engine.</li> <li>• Used together with OIL SEAL INSTALLER (18657AA030).</li> </ul> |
|  <p>ST18854AA000</p>  | 18854AA000 | ANGLE GAUGE             | Used for angle tightening.                                                                                                                                          |
|  <p>ST42099AE000</p> | 42099AE000 | QUICK CONNECTOR RELEASE | Used for removing the quick connector.                                                                                                                              |
|  <p>ST42075AG690</p> | 42075AG690 | FUEL HOSE               | <p>Used for inspecting the fuel pressure.</p> <p><b>NOTE:</b><br/>This is the SUBARU genuine part.</p>                                                              |

## 2013 Subaru Forester X

2013 ENGINE Engine Mechanical (H4DO) - Forester

|                                                                                                   |            |                               |                                                                                |
|---------------------------------------------------------------------------------------------------|------------|-------------------------------|--------------------------------------------------------------------------------|
| <br>ST18270KA010 | 18270KA010 | SOCKET                        | Used for installing and removing intake cam sprocket and exhaust cam sprocket. |
| <br>ST1B022XU0   | 1B022XU0   | SUBARU SELECT MONITOR III KIT | Used for various inspections.                                                  |

### GENERAL TOOL

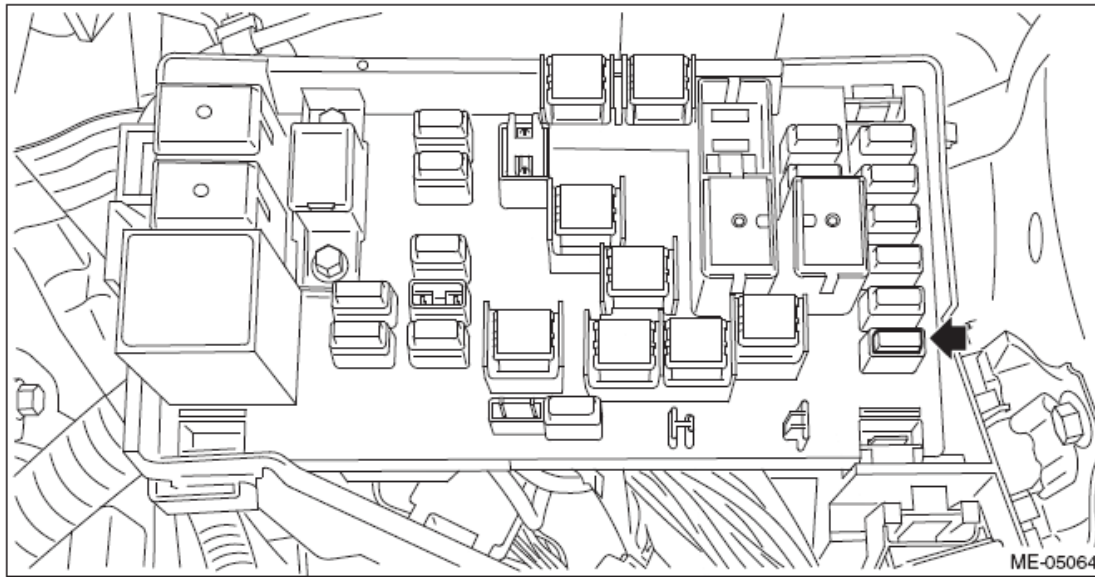
| TOOL NAME              | REMARKS                                                 |
|------------------------|---------------------------------------------------------|
| Compression gauge      | Used for measuring compression.                         |
| Vacuum gauge           | Used for measuring intake manifold vacuum.              |
| Oil pressure gauge     | Used for measuring engine oil pressure.                 |
| Fuel pressure gauge    | Used for measuring fuel pressure.                       |
| Piston ring compressor | Used for installing the piston into the cylinder block. |
| Thickness gauge        | Used for various inspections.                           |

## COMPRESSION

### INSPECTION

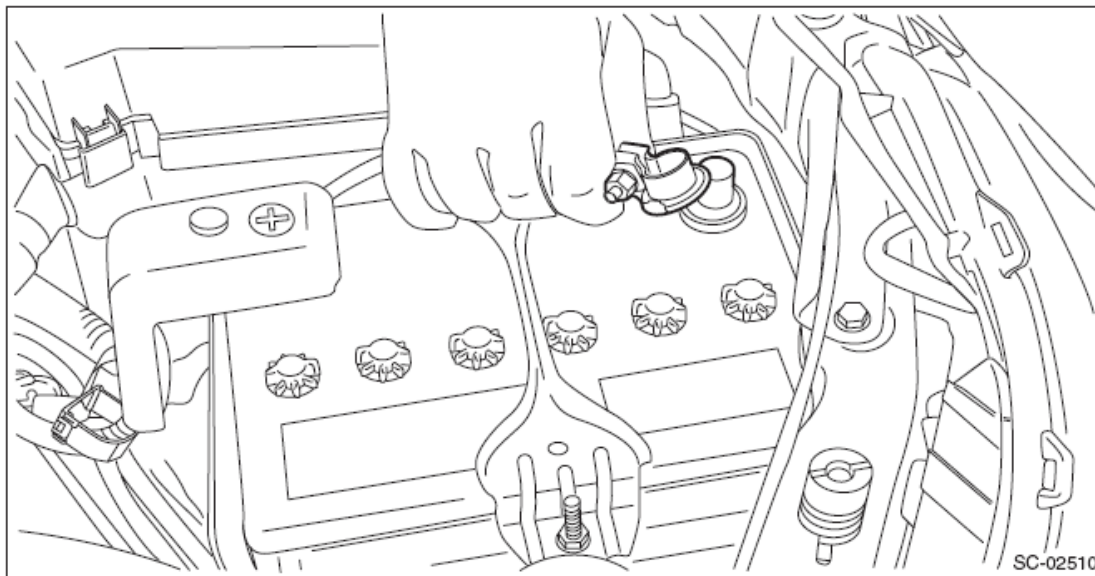
**CAUTION:** After warming-up, engine becomes very hot. Be careful not to burn yourself during measurement.

1. After warming-up the engine, turn the ignition switch to OFF.
2. Make sure that the battery is fully charged.
3. Check the starter motor for satisfactory performance and operation.
4. Remove the fuse of fuel pump from main fuse box.



**Fig. 8: Locating Fuel Pump Fuse**  
Courtesy of SUBARU OF AMERICA, INC.

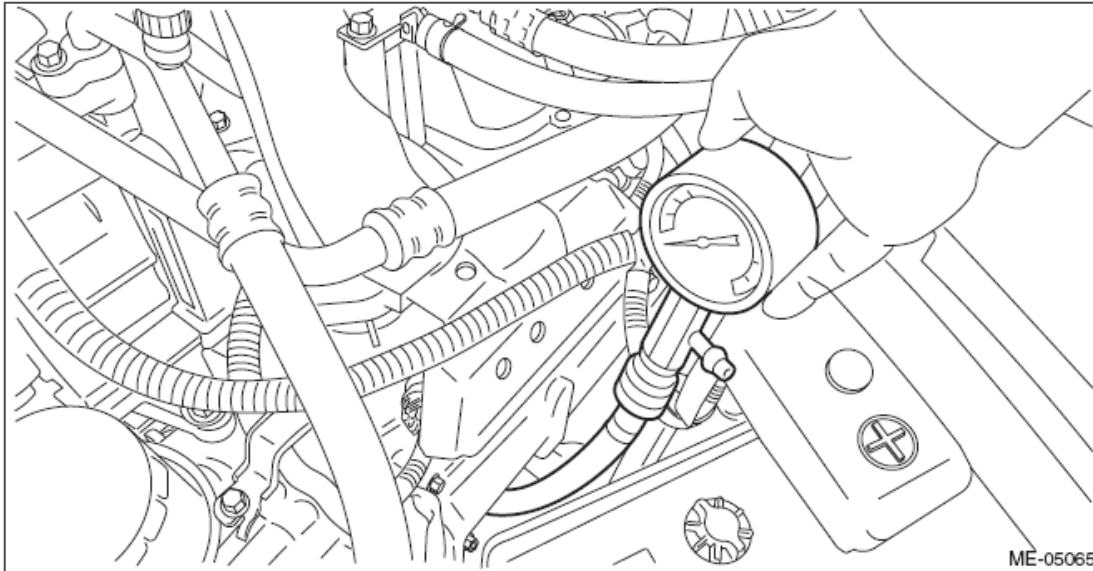
5. Start the engine and run it until it stalls.
6. After the engine stalls, crank it for five more seconds.
7. Turn the ignition switch to OFF.
8. Remove all spark plugs. < Refer to **REMOVAL** , Spark Plug. >
9. Connect the battery ground terminal.



**Fig. 9: Connecting/Disconnecting Battery Ground Terminal**  
Courtesy of SUBARU OF AMERICA, INC.

10. Install the compression gauge to the spark plug hole.

**NOTE:** When using a screw-in type compression gauge, the screw should be less than 25 mm (0.98 in) long.



**Fig. 10: Installing Compression Gauge To Spark Plug Hole**  
Courtesy of SUBARU OF AMERICA, INC.

11. Turn the ignition switch to ON.
12. Fully open the throttle valve.
13. Crank the engine by starter motor and read the value when the needle of the compression gauge becomes stable.

**NOTE:**

- Perform at least two measurements per cylinder, and make sure that the values are correct.
- If the compression pressure is out of standard, check or adjust the pistons, valves and cylinders.

*Compression (fully open throttle):*

*Standard*

*1, 050 - 1, 400 kPa (11 - 14 kgf/cm<sup>2</sup> , 152 - 203 psi)*

*Difference between cylinders*

*100 kPa (1 kgf/cm<sup>2</sup> , 14 psi) or less*

14. After inspection, install the related parts in the reverse order of removal.

## IDLE SPEED

### INSPECTION

1. Before checking the idle speed, check the following item:
  1. Check the air cleaner element is free from clogging, ignition timing is correct, spark plugs are in good condition, and hoses are connected properly.
  2. Check the malfunction indicator light does not illuminate.
2. Warm up the engine.
3. Read the engine idle speed using Subaru Select Monitor. < Refer to **READ CURRENT DATA FOR ENGINE (NORMAL MODE)** , OPERATION, Subaru Select Monitor. >

#### NOTE:

- Idle speed cannot be adjusted manually, because the idle speed is automatically adjusted.
- If idle speed is out of standard, refer to the General Diagnosis Table under "Engine Control System". < Refer to **BASIC DIAGNOSTIC PROCEDURE** . >

1. Check the idle speed when no-loaded. (Headlight, heater fan, rear defroster, radiator fan, A/C and etc. are OFF)

*Idling speed (At no load; Select lever is in "P" or "N" range on AT model; Gear shift lever is in neutral position on MT model.):*

#### *Standard*

*675±100 rpm (AT model)*

*650±100 rpm (MT model)*

2. Check the idle speed when loaded. (Turn the A/C switch to ON and operate the compressor for at least one minute before measurement.)

*Idling speed (With A/C ON; Select lever is in "P" or "N" range on AT model; Gear shift lever is in neutral position on MT model.):*

#### *Standard*

*800 - 850±100 rpm*

## IGNITION TIMING

### INSPECTION

**CAUTION: After warming-up, engine becomes very hot. Be careful not to burn yourself at measurement.**

1. Before checking the ignition timing, check the following item:
  1. Check the air cleaner element is free from clogging, spark plugs are in good condition, and hoses are connected properly.
  2. Check the malfunction indicator light does not illuminate.
2. Warm up the engine.
3. Read the ignition timing using Subaru Select Monitor. < Refer to **READ CURRENT DATA FOR ENGINE (NORMAL MODE)** , OPERATION, Subaru Select Monitor. >

**NOTE:** If ignition timing is out of standard, check the ignition control system. Refer to "Engine Control System". < Refer to **BASIC DIAGNOSTIC PROCEDURE** . >

*Ignition timing [BTDC/rpm]:*

*Standard*

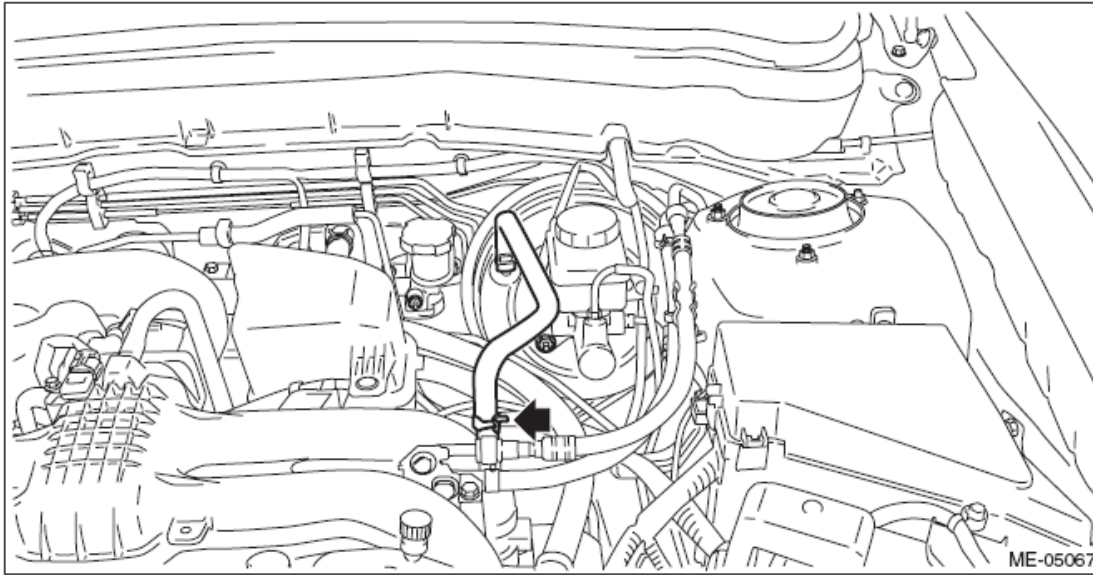
*16°±10°/675 (AT model)*

*16°±10°/650 (MT model)*

## **INTAKE MANIFOLD VACUUM**

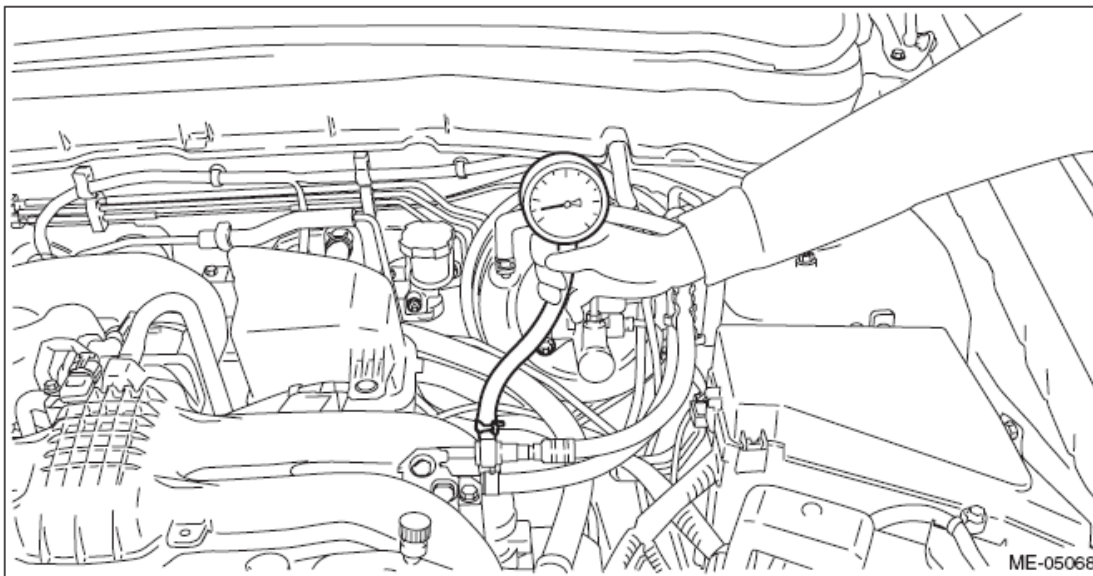
### **INSPECTION**

1. Warm up the engine.
2. Disconnect the brake booster vacuum hose from the intake manifold.



**Fig. 11: Locating Intake Manifold Brake Booster Vacuum Hose Mounting Clip**  
Courtesy of SUBARU OF AMERICA, INC.

3. Connect the vacuum gauge to the intake manifold.



**Fig. 12: Connecting Vacuum Gauge To Intake Manifold**  
Courtesy of SUBARU OF AMERICA, INC.

4. Keep the engine at idle speed and read the vacuum gauge indication.

**NOTE:** Condition of engine inside can be diagnosed by observing the behavior of the vacuum gauge needle as described in table below.

**Intake manifold vacuum (at idling, A/C OFF):**

**Standard**

**-60.0 kPa (-450 mmHg, -17.72 inHg) or more**

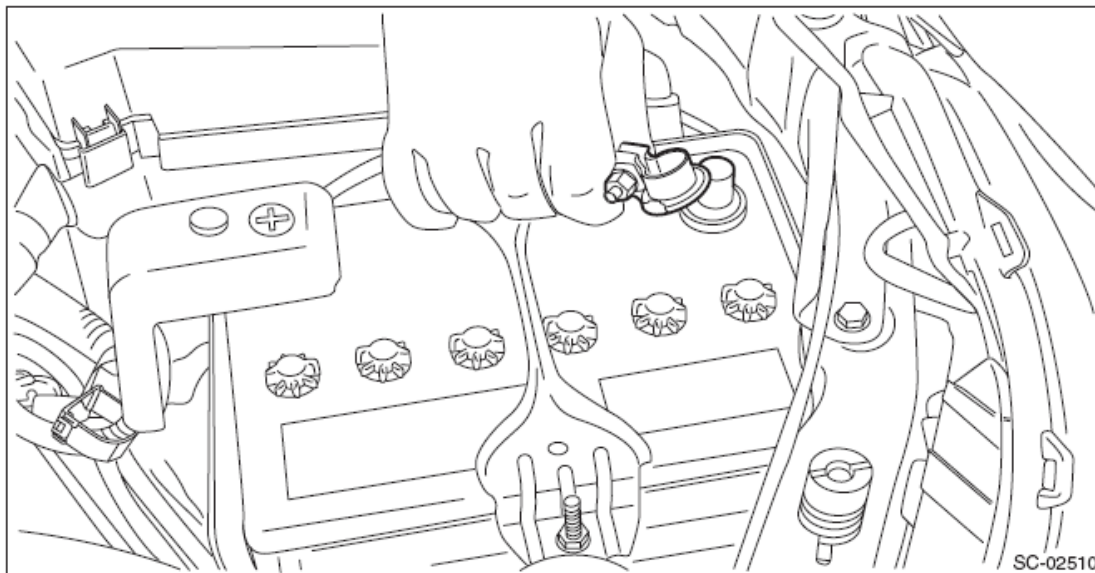
| Diagnosis of engine condition by inspection of intake manifold vacuum                                                                                   |                                                                               |
|---------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------|
| Vacuum gauge needle behavior                                                                                                                            | Possible engine condition                                                     |
| 1. Needle is steady but lower than standard value. This tendency becomes more evident as engine temperature rises.                                      | Leakage around intake manifold gasket, disconnection or damage of vacuum hose |
| 2. Needle intermittently drops to position lower than standard value.                                                                                   | Leakage around cylinder                                                       |
| 3. Needle drops suddenly and intermittently from standard value.                                                                                        | Sticky valve                                                                  |
| 4. When engine speed is gradually increased, needle begins to vibrate rapidly at certain speed, and then vibration increases as engine speed increases. | Weak or broken valve springs                                                  |
| 5. Needle vibrates above and below standard value in narrow range.                                                                                      | Defective ignition system                                                     |

5. After inspection, install the related parts in the reverse order of removal.

## ENGINE OIL PRESSURE

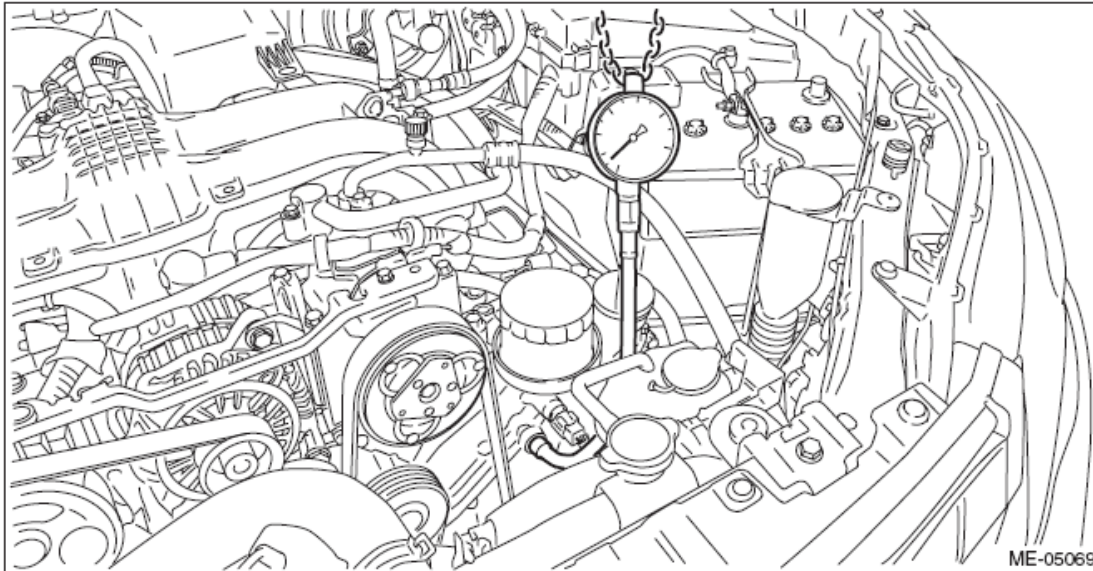
### INSPECTION

1. Disconnect the ground cable from battery.



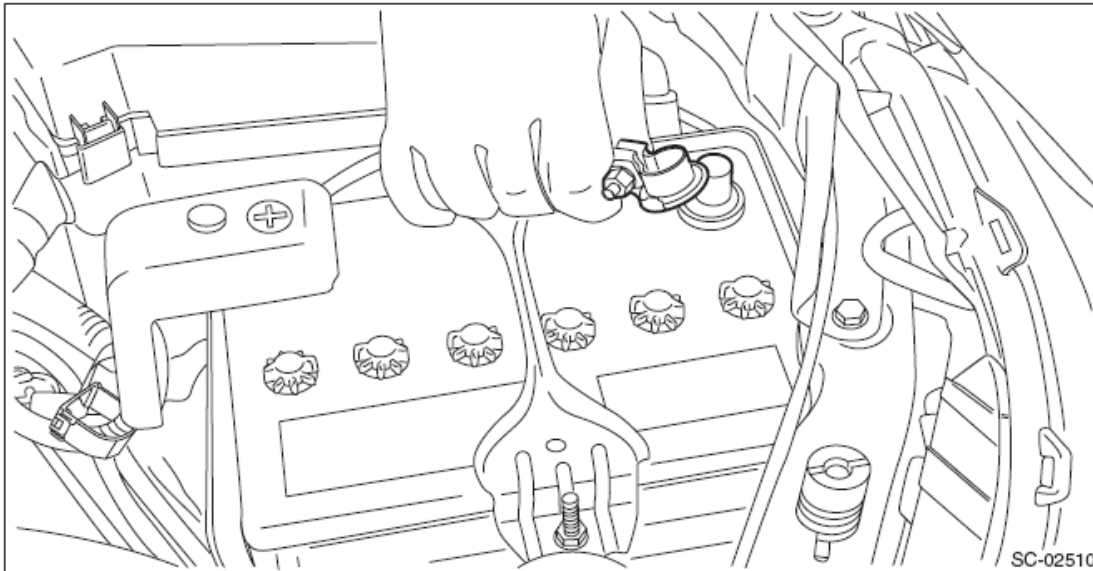
**Fig. 13: Connecting/Disconnecting Battery Ground Terminal**  
Courtesy of SUBARU OF AMERICA, INC.

2. Remove the oil pressure switch. < Refer to **REMOVAL** , Oil Pressure Switch. >
3. Install the oil pressure gauge to the chain cover.



**Fig. 14: Installing Oil Pressure Gauge To Chain Cover**  
Courtesy of SUBARU OF AMERICA, INC.

4. Connect the battery ground terminal.



**Fig. 15: Connecting/Disconnecting Battery Ground Terminal**  
Courtesy of SUBARU OF AMERICA, INC.

5. Start the engine, and check the oil pressure.

**NOTE:**

- Standard value is based on an engine oil temperature of 80°C (176°F).
- If the oil pressure is out of specification, check oil pump, oil filter and lubrication line. < Refer to INSPECTION , Engine Lubrication System Trouble in General. >
- If the oil pressure warning light is ON and oil pressure is within standard, check the oil pressure switch. < Refer to INSPECTION , Engine Lubrication System Trouble in General. >

*Engine oil pressure:**Standard*

50 kPa (0.5 kgf/cm<sup>2</sup> , 7 psi) or more (at 600 rpm)

350 kPa (3.6 kgf/cm<sup>2</sup> , 51 psi) or more (at 6, 000 rpm)

6. After inspection, install the related parts in the reverse order of removal.

## FUEL PRESSURE

### INSPECTION

**CAUTION:**

- Before removing the fuel pressure gauge, release the fuel pressure.
- Be careful not to spill fuel.
- Catch the fuel from hoses using a container or cloth.

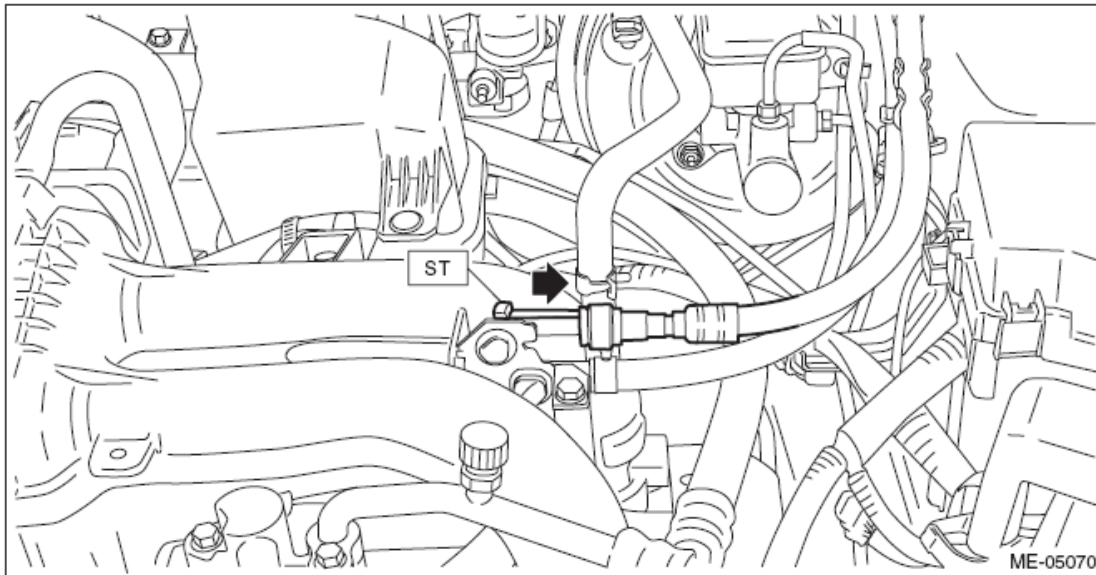
1. Release the fuel pressure. < Refer to RELEASING OF FUEL PRESSURE , PROCEDURE, Fuel. >
2. Open the fuel filler lid and remove the fuel filler cap.
3. Disconnect the fuel delivery hose from the fuel delivery pipe, and connect the fuel pressure gauge.

**CAUTION:**

- Be careful not to spill fuel.
- Catch the fuel from hoses using a container or cloth.

1. Attach ST to the fuel delivery pipe and push ST in the direction of arrow mark to disconnect the quick connector of the fuel delivery hose.

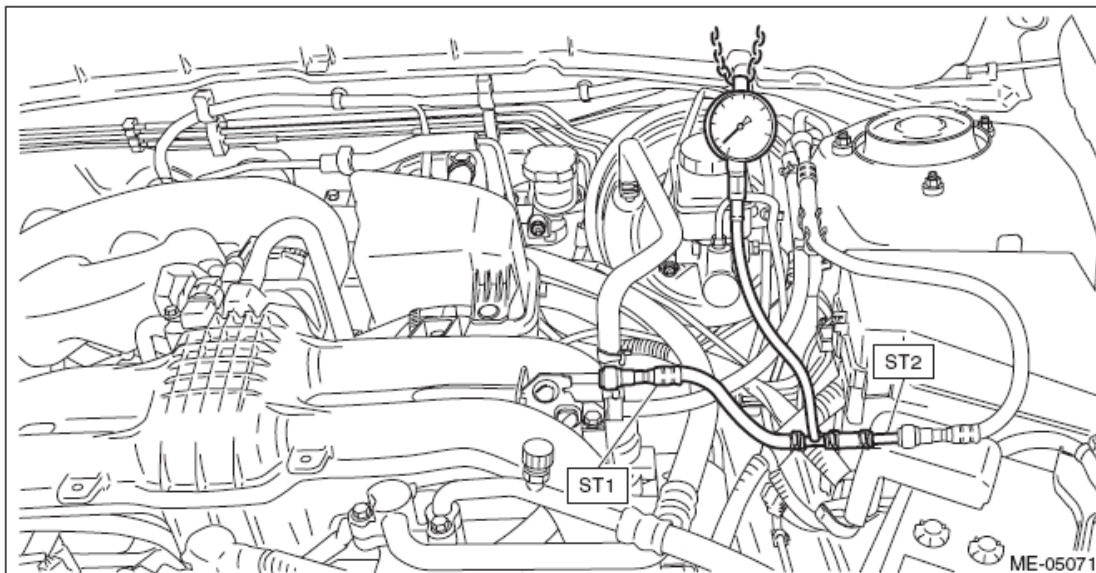
ST 42099AE000 QUICK CONNECTOR RELEASE



**Fig. 16: Disconnecting Fuel Delivery Hose Quick Connector**  
Courtesy of SUBARU OF AMERICA, INC.

2. Connect the fuel pressure gauge with ST1 and ST2.

**NOTE:**      **ST1 is a SUBARU genuine part.**  
                 **ST1 42075AG690 FUEL HOSE**  
                 **ST2 18471AA000 FUEL PIPE ADAPTER**



**Fig. 17: Connecting Fuel Pressure Gauge Using ST1 And ST2**  
Courtesy of SUBARU OF AMERICA, INC.

4. Start the engine.

5. Check the fuel pressure after warming up the engine.

**NOTE:**

- The fuel pressure gauge registers 10 to 20 kPa (0.1 to 0.2 kgf/cm<sup>2</sup> , 1 to 3 psi) higher than standard values during high-altitude operations.
- Check or replace the fuel pump and fuel delivery line if the fuel pressure is out of the standard.

*Fuel pressure:**Standard*

*340 - 400 kPa (3.5 - 4.1 kgf/cm<sup>2</sup> , 49 - 58 psi)*

6. After inspection, install the related parts in the reverse order of removal.

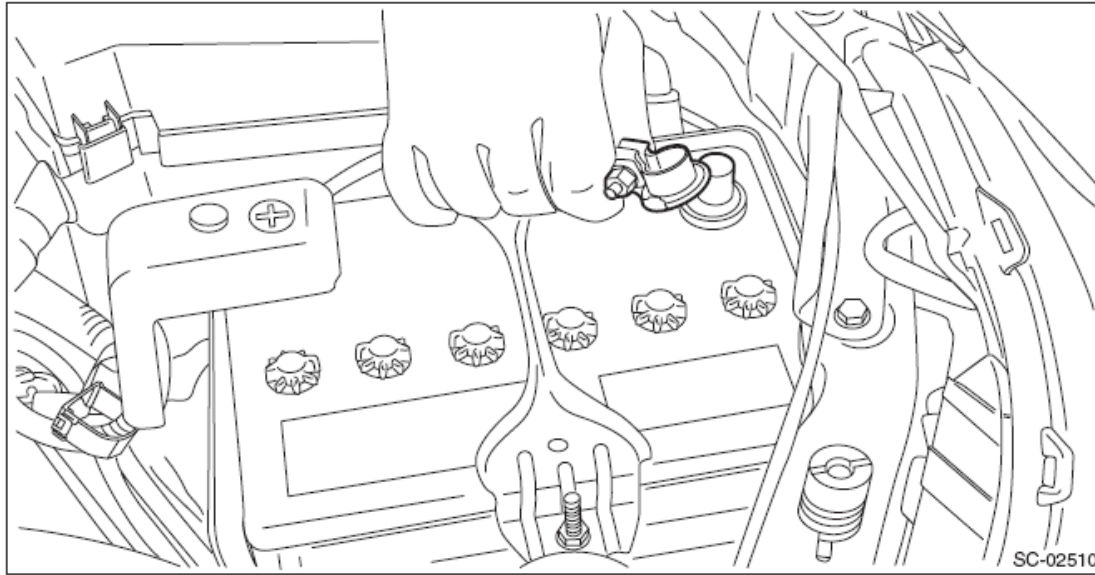
**CAM CLEARANCE****INSPECTION****WHEN TIMING CHAIN ASSEMBLY IS NOT REMOVED**

**CAUTION:** When working on the vehicle, if engine oil is spilt onto the exhaust pipe, wipe it off with cloth to avoid emission of smoke or causing a fire.

**NOTE:**

- Inspection of cam clearance should be performed while engine is cold.
- If the engine is removed from vehicle, performing the step 1) and 2) is not necessary.

1. Disconnect the ground cable from battery.



**Fig. 18: Connecting/Disconnecting Battery Ground Terminal**  
 Courtesy of SUBARU OF AMERICA, INC.

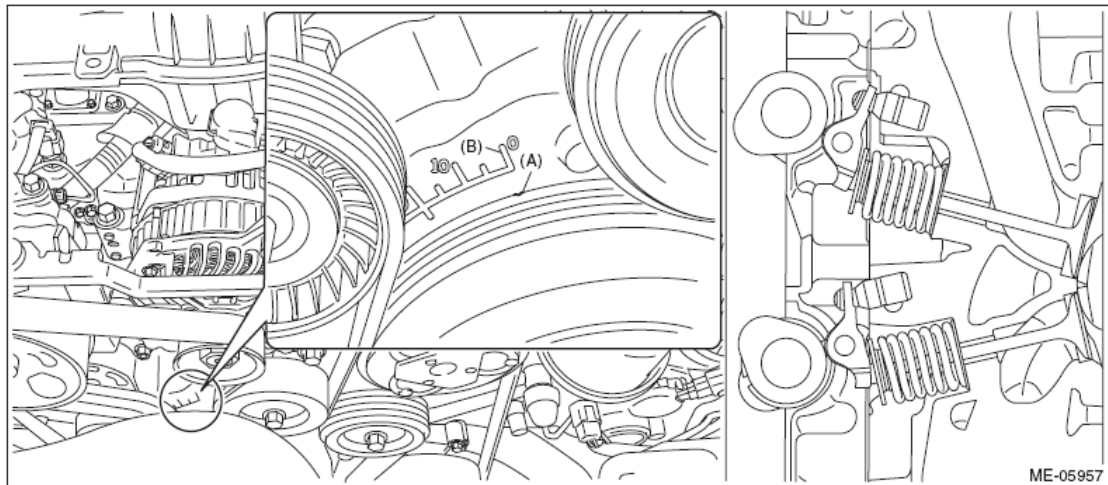
2. Remove the air intake duct (rear). < Refer to **REMOVAL** , Air Intake Duct. >
3. When inspecting #1 and #3 cylinders
  1. Remove the rocker cover RH. < Refer to **ROCKER COVER RH**, REMOVAL, Rocker Cover. >

**NOTE:** When working on the vehicle, place a suitable container under the vehicle.

2. Set #1 cylinder piston to top dead center of compression stroke by rotating the crank pulley clockwise using the socket wrench.

**NOTE:** When the timing mark (A) on crank pulley is aligned to the 0° in timing gauge (B) on chain cover as shown in the figure, the #1 cylinder piston is located at TDC of compression stroke if the intake camshaft and exhaust camshaft does not depress the #1 cylinder intake side roller rocker arm (intake valve) and exhaust side roller rocker arm (exhaust valve). If roller rocker arm (valve) is depressed, turn the crank pulley by 360° in order to make #1 cylinder piston at TDC of compression stroke.

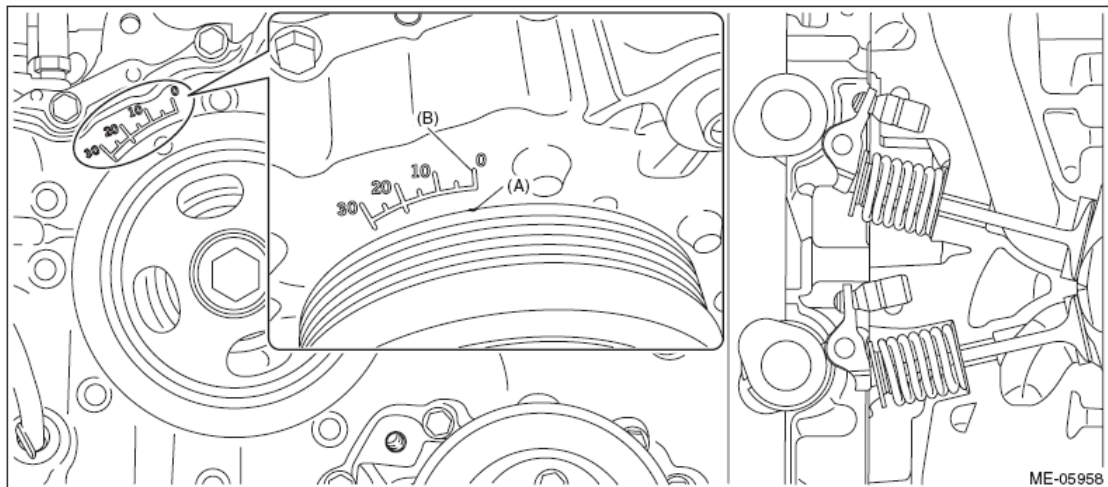
- When working on the vehicle



**Fig. 19: Identifying Timing Mark On Crank Pulley And Chain Cover (When Working On Vehicle)**

Courtesy of SUBARU OF AMERICA, INC.

- When working on the engine unit only



**Fig. 20: Identifying Timing Mark On Crank Pulley And Chain Cover (When Working On Engine Unit Only)**

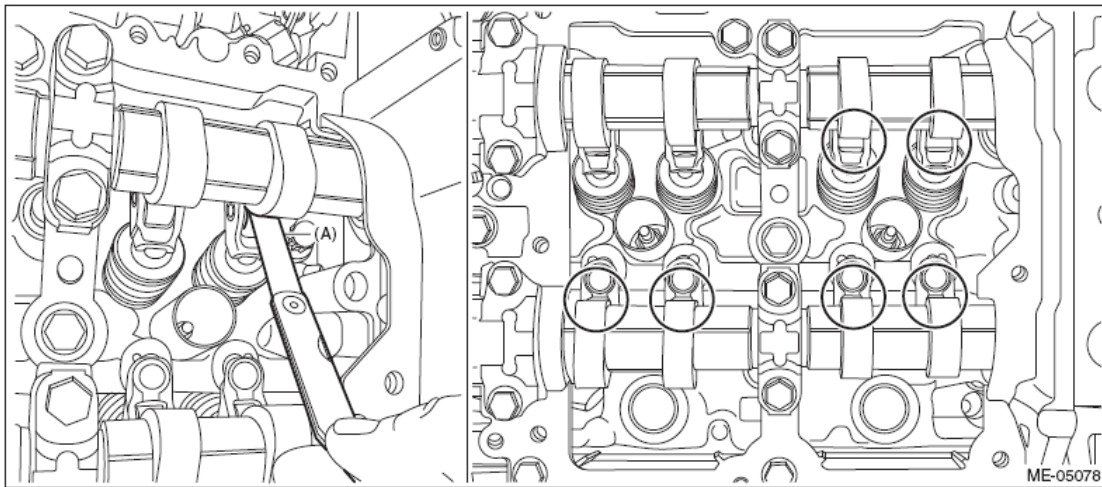
Courtesy of SUBARU OF AMERICA, INC.

3. Check the cam clearance for #1 cylinder intake, #1 cylinder exhaust and #3 cylinder exhaust.

**NOTE:**

- Measure the roller surface of cam base circle and roller rocker arm using thickness gauge (A).
- If the measured value is out of standard, take notes of the value in order to adjust the cam clearance later on.

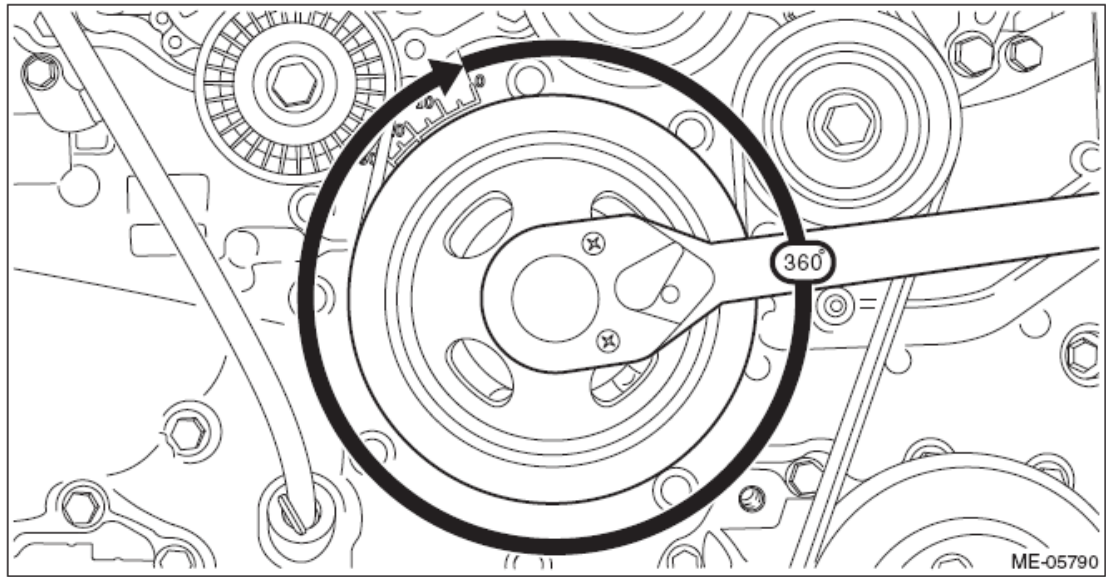
*Cam clearance:*

***Intake******Standard******0.13±0.03 mm (0.0051±0.0012 in)******Exhaust******Standard******0.24±0.03 mm (0.0094±0.0012 in)***

**Fig. 21: Measuring Roller Surface Of Cam Base Circle And Roller Rocker Arm Using Thickness Gauge**

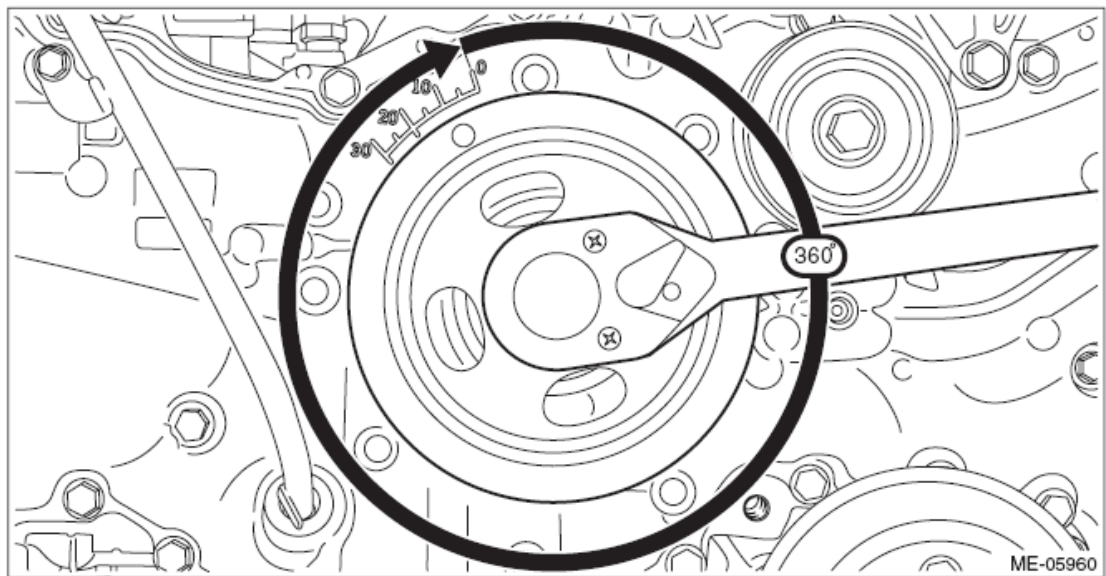
**Courtesy of SUBARU OF AMERICA, INC.**

4. Turn the crank pulley by 360°.
  - When working on the vehicle



**Fig. 22: Turning Crank Pulley (When Working On Vehicle)**  
Courtesy of SUBARU OF AMERICA, INC.

- When working on the engine unit only



**Fig. 23: Turning Crank Pulley (When Working On Engine Unit Only)**  
Courtesy of SUBARU OF AMERICA, INC.

5. Check the clearance of #3 cylinder intake.

**NOTE:**

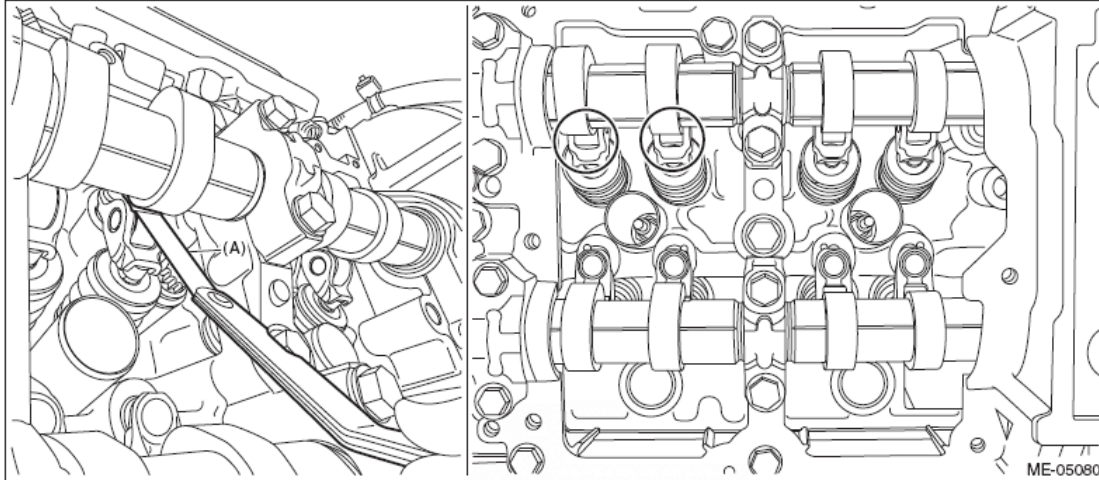
- Measure the roller surface of cam base circle and roller rocker arm using thickness gauge (A).
- If the measured value is out of standard, take notes of the value

in order to adjust the cam clearance later on.

*Cam clearance:*

*Standard*

*0.13±0.03 mm (0.0051±0.0012 in)*



**Fig. 24: Measuring Roller Surface Of Cam Base Circle And Roller Rocker Arm Using Thickness Gauge**  
Courtesy of SUBARU OF AMERICA, INC.

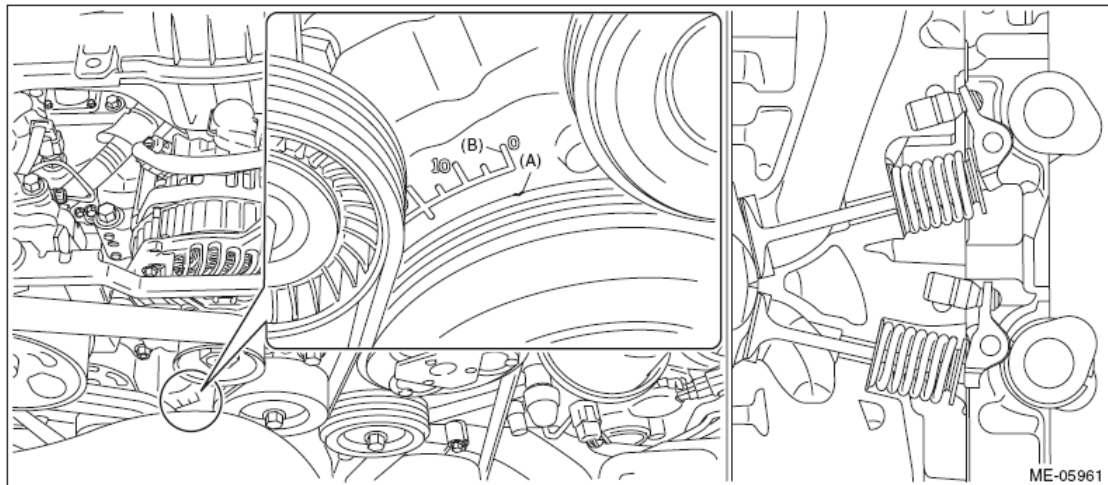
4. When inspecting #2 and #4 cylinders
  1. Remove the rocker cover LH. < Refer to **ROCKER COVER LH, REMOVAL**, Rocker Cover. >

**NOTE:** When working on the vehicle, place a suitable container under the vehicle.

2. Set #2 cylinder piston to top dead center of compression stroke by rotating the crank pulley clockwise using the socket wrench.

**NOTE:** When the timing mark (A) on crank pulley is aligned to the 0° in timing gauge (B) on chain cover as shown in the figure, the #2 cylinder piston is located at TDC of compression stroke if the intake camshaft and exhaust camshaft does not depress the #2 cylinder intake side roller rocker arm (intake valve) and exhaust side roller rocker arm (exhaust valve). If roller rocker arm (valve) is depressed, turn the crank pulley by 360° in order to make #2 cylinder piston at TDC of compression stroke.

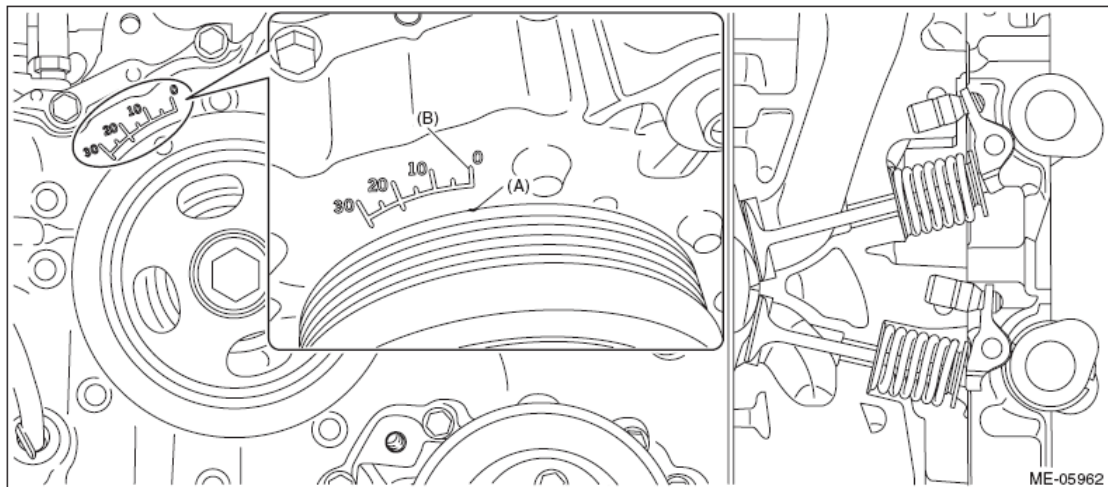
- When working on the vehicle



**Fig. 25: Identifying Timing Mark On Crank Pulley And Chain Cover (When Working On Vehicle)**

Courtesy of SUBARU OF AMERICA, INC.

- When working on the engine unit only



**Fig. 26: Identifying Timing Mark On Crank Pulley And Chain Cover (When Working On Engine Unit Only)**

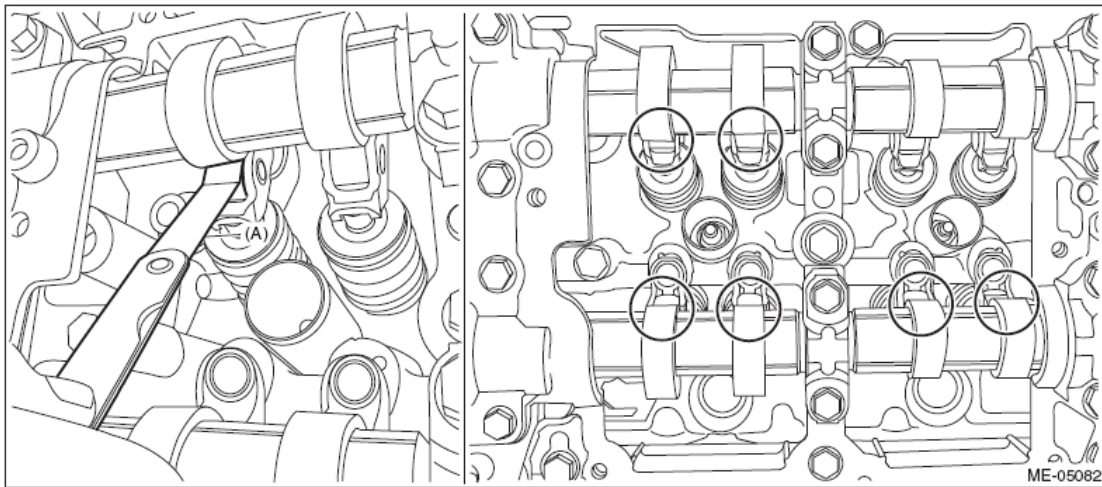
Courtesy of SUBARU OF AMERICA, INC.

3. Check the cam clearance for #2 cylinder intake, #2 cylinder exhaust and #4 cylinder exhaust.

**NOTE:**

- Measure the roller surface of cam base circle and roller rocker arm using thickness gauge (A).
- If the measured value is out of standard, take notes of the value in order to adjust the cam clearance later on.

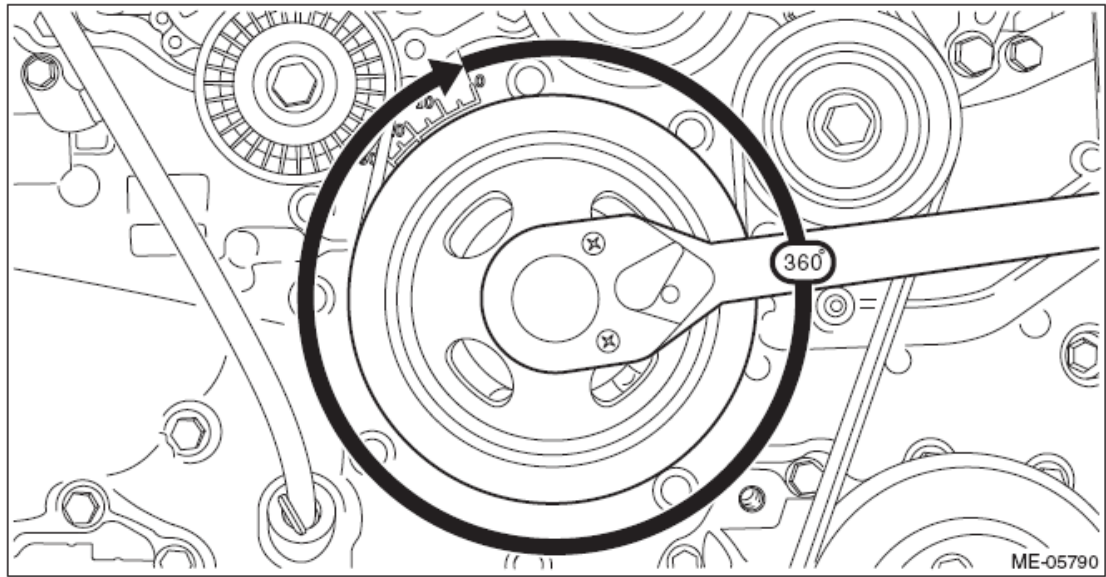
*Cam clearance:*

***Intake******Standard******0.13±0.03 mm (0.0051±0.0012 in)******Exhaust******Standard******0.24±0.03 mm (0.0094±0.0012 in)***

**Fig. 27: Measuring Roller Surface Of Cam Base Circle And Roller Rocker Arm Using Thickness Gauge**

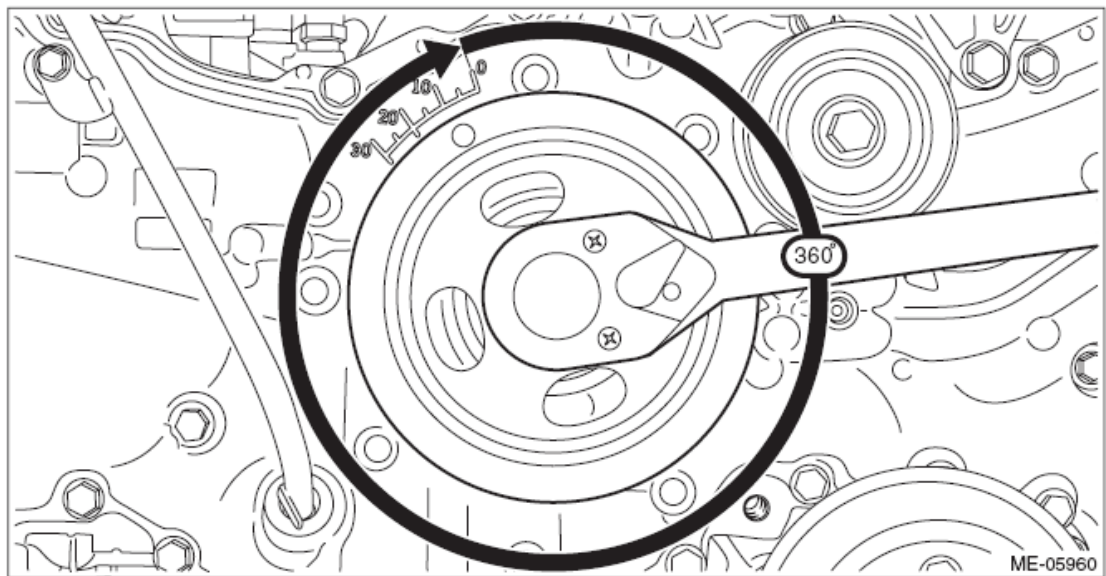
**Courtesy of SUBARU OF AMERICA, INC.**

4. Turn the crank pulley by 360°.
  - When working on the vehicle



**Fig. 28: Turning Crank Pulley (When Working On Vehicle)**  
Courtesy of SUBARU OF AMERICA, INC.

- When working on the engine unit only



**Fig. 29: Turning Crank Pulley (When Working On Engine Unit Only)**  
Courtesy of SUBARU OF AMERICA, INC.

5. Check the clearance of #4 cylinder intake.

**NOTE:**

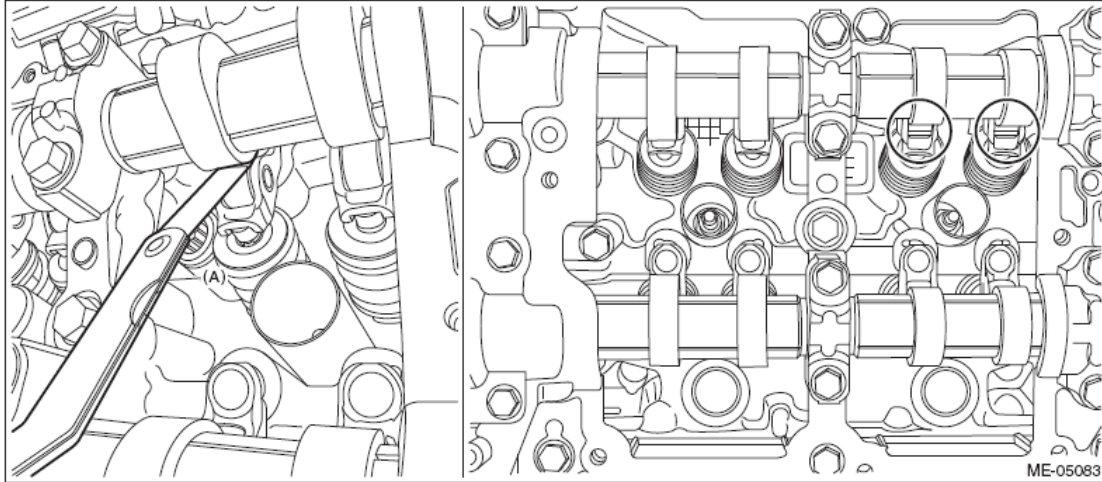
- Measure the roller surface of cam base circle and roller rocker arm using thickness gauge (A).
- If the measured value is out of standard, take notes of the value

in order to adjust the cam clearance later on.

*Cam clearance:*

*Standard*

*0.13±0.03 mm (0.0051±0.0012 in)*



**Fig. 30: Measuring Roller Surface Of Cam Base Circle And Roller Rocker Arm Using Thickness Gauge**  
Courtesy of SUBARU OF AMERICA, INC.

5. If necessary, adjust the cam clearance. < Refer to **ADJUSTMENT**, Cam Clearance. >
6. After inspection, install the related parts in the reverse order of removal.

#### WHEN TIMING CHAIN ASSEMBLY IS REMOVED

**NOTE:** Inspection of cam clearance should be performed while engine is cold.

1. When inspecting #1 and #3 cylinders
  1. Remove the rocker cover RH. < Refer to **ROCKER COVER RH**, REMOVAL, Rocker Cover. >

**NOTE:** When working on the vehicle, place a suitable container under the vehicle.

2. Check the #1 and #3 cylinder cam clearance.

**CAUTION:** Intake and exhaust camshafts can be independently rotated with the timing chain removed. When the intake valve and exhaust valve lift at the same time, the valve heads contact each other and valve stem may bend. Do not turn it to the outside of

range of zero lift (cam base circle position) (in range where it can be turned lightly by hand).

**NOTE:**

- For cam clearance inspection, adjust the cam base circle position so that the thickness gauge (A) can be inserted easily by hand turning the camshaft (cam sprocket) to be measured.
- Measure the roller surface of cam base circle and roller rocker arm using thickness gauge (A).
- If the measured value is out of standard, take notes of the value in order to adjust the cam clearance later on.

*Cam clearance:*

*Intake*

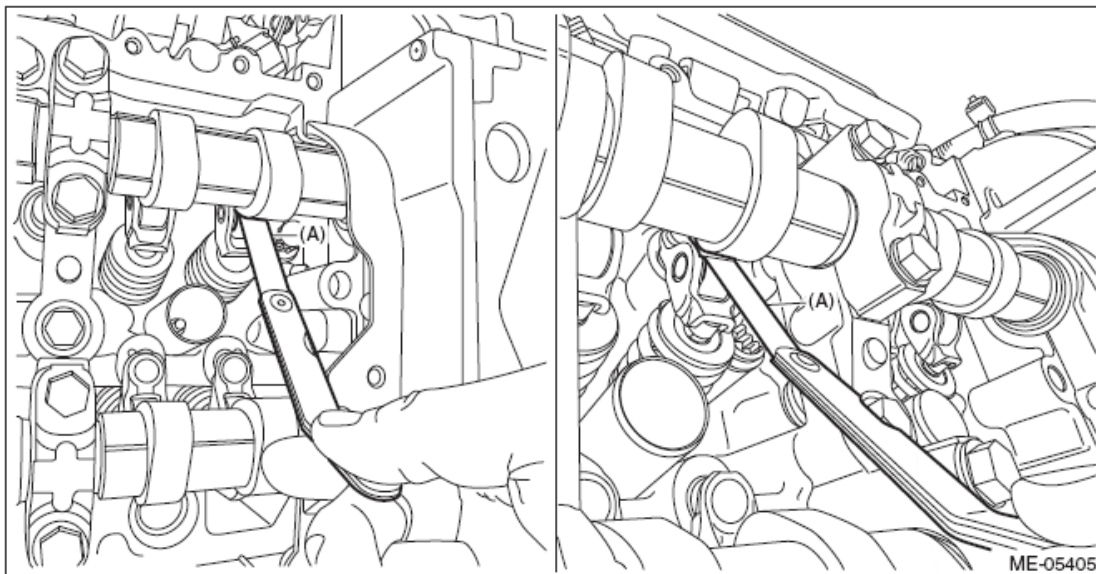
*Standard*

$0.13 \pm 0.03 \text{ mm}$  ( $0.0051 \pm 0.0012 \text{ in}$ )

*Exhaust*

*Standard*

$0.24 \pm 0.03 \text{ mm}$  ( $0.0094 \pm 0.0012 \text{ in}$ )



**Fig. 31: Measuring Roller Surface Of Cam Base Circle And Roller Rocker Arm Using Thickness Gauge**

Courtesy of SUBARU OF AMERICA, INC.

## 2. When inspecting #2 and #4 cylinders

1. Remove the rocker cover LH. < Refer to **ROCKER COVER LH**, REMOVAL, Rocker Cover. >

**NOTE:** When working on the vehicle, place a suitable container under the vehicle.

2. Check the #2 and #4 cylinder cam clearance.

**CAUTION:** Intake and exhaust camshafts can be independently rotated with the timing chain removed. When the intake valve and exhaust valve lift at the same time, the valve heads contact each other and valve stem may bend. Do not turn it to the outside of range of zero lift (cam base circle position) (in range where it can be turned lightly by hand).

- NOTE:**
- For cam clearance inspection, adjust the cam base circle position so that the thickness gauge (A) can be inserted easily by hand turning the camshaft (cam sprocket) to be measured.
  - Measure the roller surface of cam base circle and roller rocker arm using thickness gauge (A).
  - If the measured value is out of standard, take notes of the value in order to adjust the cam clearance later on.

*Cam clearance:*

*Intake*

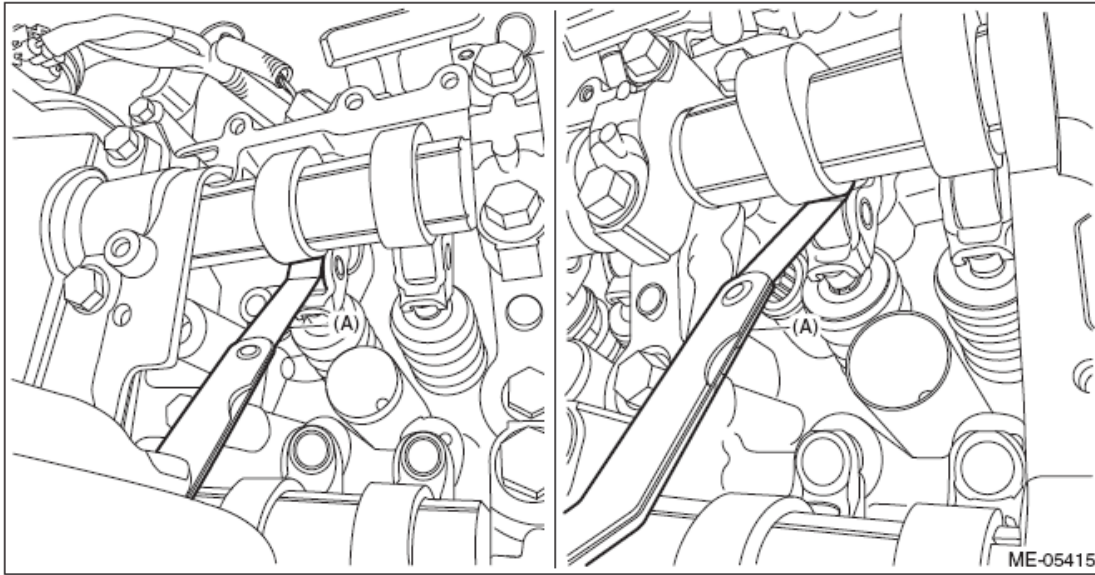
*Standard*

*0.13±0.03 mm (0.0051±0.0012 in)*

*Exhaust*

*Standard*

*0.24±0.03 mm (0.0094±0.0012 in)*



**Fig. 32: Measuring Roller Surface Of Cam Base Circle And Roller Rocker Arm Using Thickness Gauge**

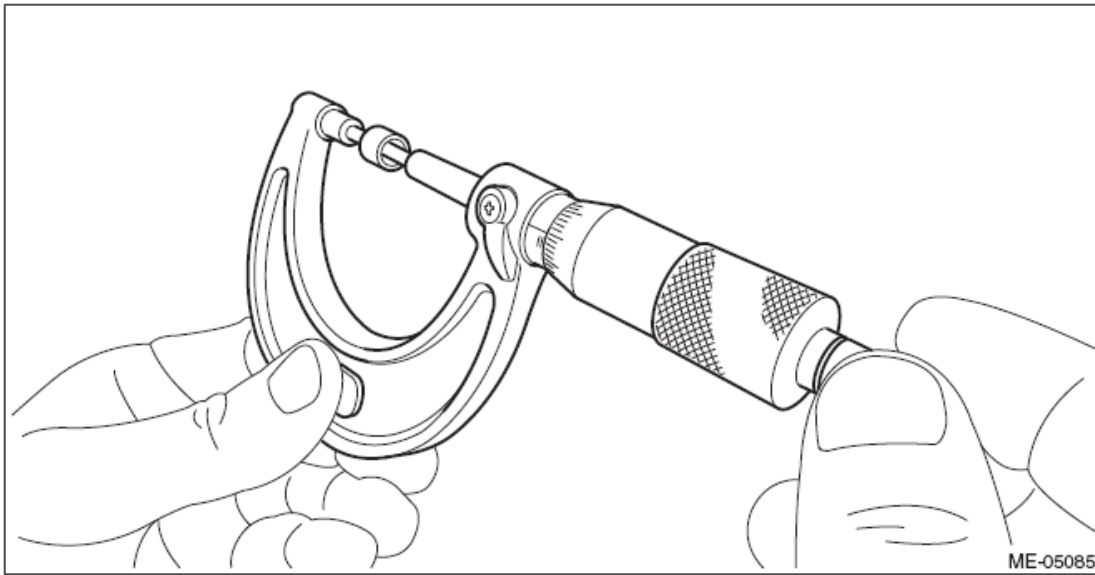
Courtesy of SUBARU OF AMERICA, INC.

3. If necessary, adjust the cam clearance. < Refer to **ADJUSTMENT**, Cam Clearance. >
4. After inspection, install the related parts in the reverse order of removal.

## ADJUSTMENT

1. Remove the engine from the vehicle. < Refer to **REMOVAL**, Engine Assembly. >
2. Remove the chain cover. < Refer to **REMOVAL**, Chain Cover. >
3. When adjusting #1 and #3 cylinders
  1. Remove the timing chain RH. < Refer to **TIMING CHAIN RH**, REMOVAL, Timing Chain Assembly. >
  2. Remove the cam carrier RH. < Refer to **CAM CARRIER RH**, REMOVAL, Cam Carrier. >
  3. Measure the thickness of valve shim using micrometer.

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



**Fig. 33: Measuring Thickness Of Valve Shim Using Micrometer**  
 Courtesy of SUBARU OF AMERICA, INC.

4. Select a valve shim of suitable thickness using the measured cam clearance and valve shim thickness.

**NOTE:** Use a new valve shim.

|                                                                       |
|-----------------------------------------------------------------------|
| Intake side: $S = T + 1.54 \times (V - 0.13 \text{ mm (0.0051 in)})$  |
| Exhaust side: $S = T + 1.69 \times (V - 0.24 \text{ mm (0.0094 in)})$ |
| S: Valve shim thickness required                                      |
| V: Measured cam clearance                                             |
| T: Current valve shim thickness                                       |

5. Install the cam carrier RH. < Refer to **CAM CARRIER RH, INSTALLATION**, Cam Carrier. >
6. Check all the cam clearance of RH side at this time. If the cam clearance is not within the standard value, repeat the procedure over again from step 2).

**NOTE:** When the removing/installing of cam carrier RH has been performed, cam clearance may be outside the standard value. Checking of all cam clearance of RH side is necessary. Refer to **INSPECTION of "Cam Clearance"** for the cam clearance inspection. < Refer to **WHEN TIMING CHAIN ASSEMBLY IS REMOVED, INSPECTION**, Cam Clearance. >

*Cam clearance:*

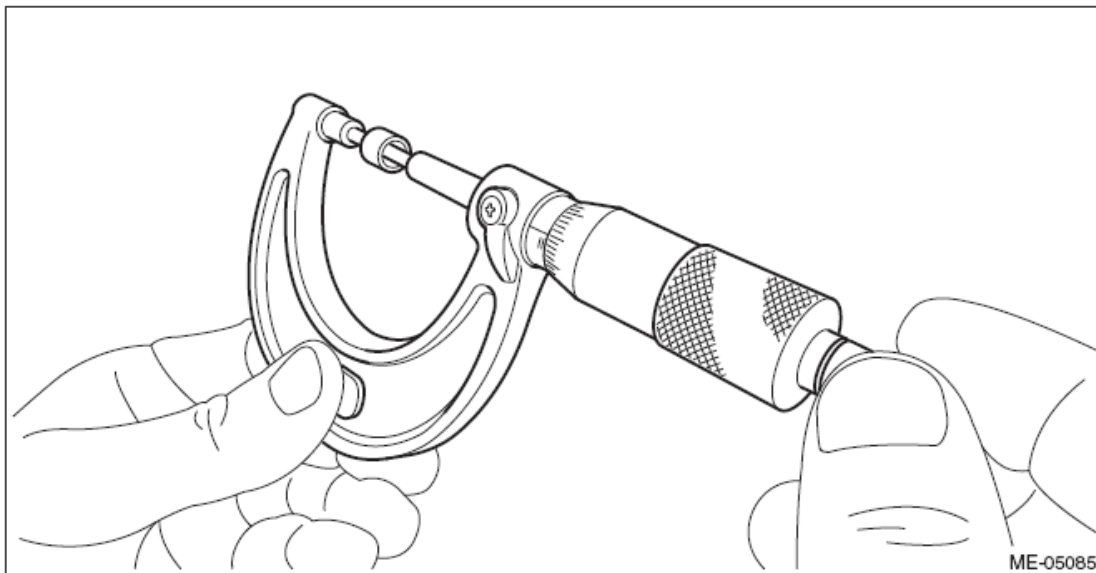
*Intake*

**Standard** **$0.13 \pm 0.03 \text{ mm}$  ( $0.0051 \pm 0.0012 \text{ in}$ )****Exhaust****Standard** **$0.24 \pm 0.03 \text{ mm}$  ( $0.0094 \pm 0.0012 \text{ in}$ )**

## 4. When adjusting #2 and #4 cylinders

1. Remove the timing chain LH. < Refer to **TIMING CHAIN LH**, REMOVAL, Timing Chain Assembly. >
2. Remove the cam carrier LH. < Refer to **CAM CARRIER LH**, REMOVAL, Cam Carrier. >
3. Measure the thickness of valve shim using micrometer.

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



**Fig. 34: Measuring Thickness Of Valve Shim Using Micrometer**  
Courtesy of SUBARU OF AMERICA, INC.

4. Select a valve shim of suitable thickness using the measured cam clearance and valve shim thickness.

**NOTE:** Use a new valve shim.

|                                                                       |
|-----------------------------------------------------------------------|
| Intake side: $S = T + 1.54 \times (V - 0.13 \text{ mm (0.0051 in)})$  |
| Exhaust side: $S = T + 1.69 \times (V - 0.24 \text{ mm (0.0094 in)})$ |
| S: Valve shim thickness required                                      |

V: Measured cam clearance  
T: Current valve shim thickness

5. Install the cam carrier LH. < Refer to **CAM CARRIER LH**, INSTALLATION, Cam Carrier. >
6. Check all the cam clearance of LH side at this time. If the cam clearance is not within the standard value, repeat the procedure over again from step 2).

**NOTE:** When the removing/installing of cam carrier LH has been performed, cam clearance may be outside the standard value. Checking of all cam clearance of LH side is necessary. Refer to INSPECTION of "Cam Clearance" for the cam clearance inspection. < Refer to **WHEN TIMING CHAIN ASSEMBLY IS REMOVED**, INSPECTION, Cam Clearance. >

*Cam clearance:*

*Intake*

*Standard*

*0.13±0.03 mm (0.0051±0.0012 in)*

*Exhaust*

*Standard*

*0.24±0.03 mm (0.0094±0.0012 in)*

5. After adjustment, install the related parts in the reverse order of removal.

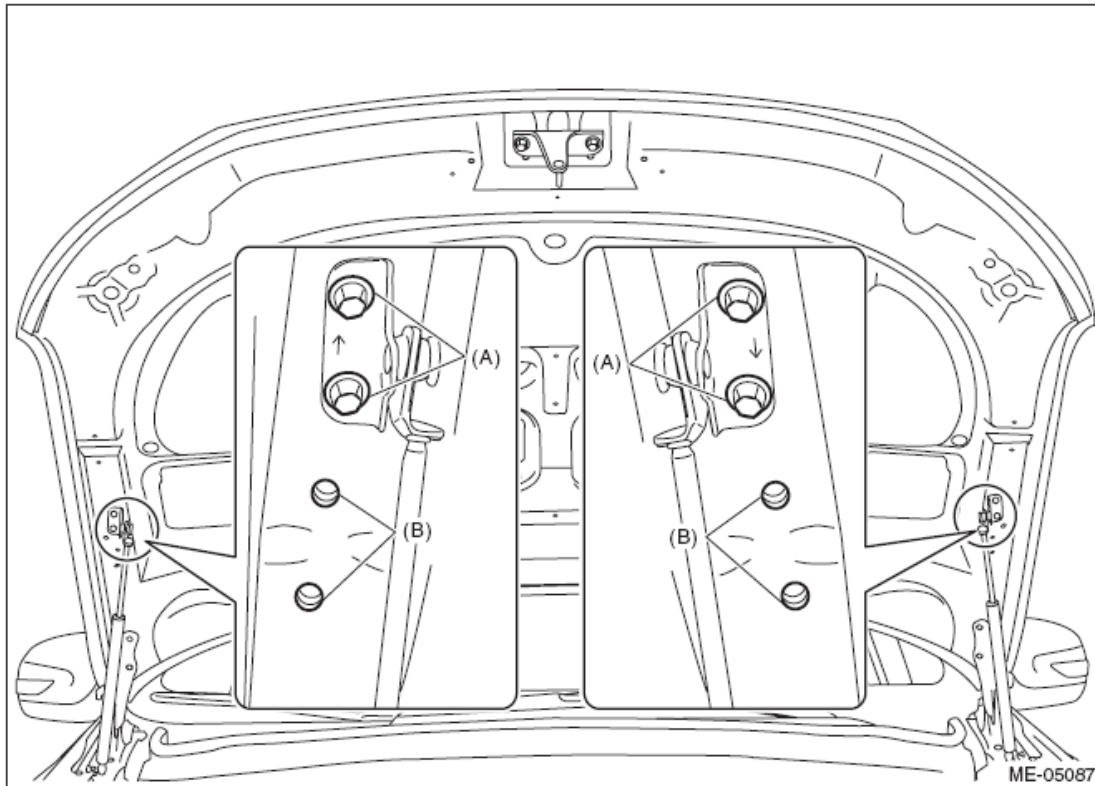
## ENGINE ASSEMBLY

### REMOVAL

1. Change the bolt installation position from (A) to (B), then open the front hood completely.

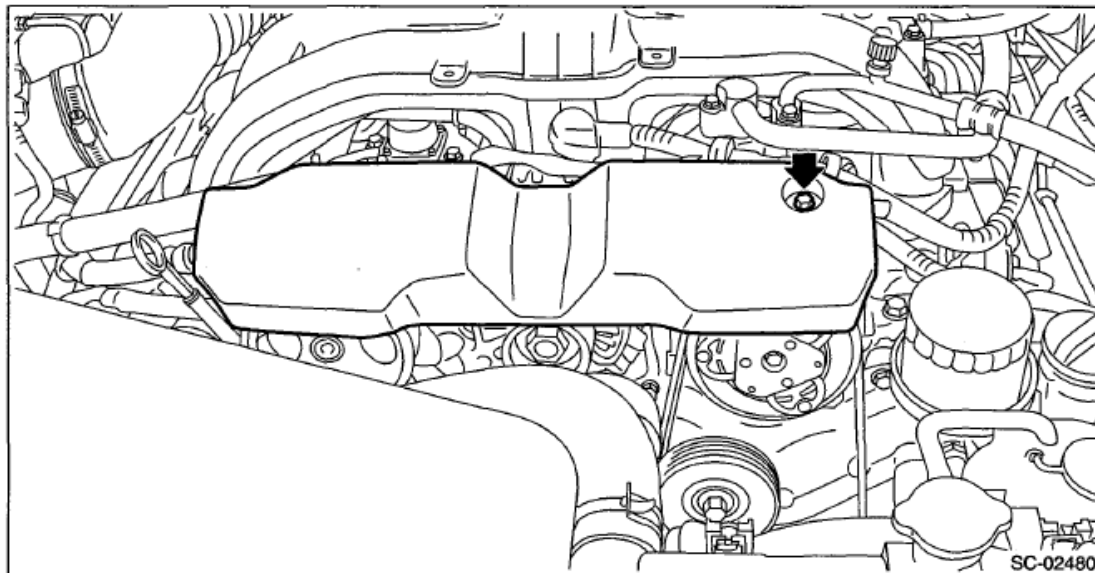
***Tightening torque:***

***7.5 N.m (0.8 kgf-m, 5.5 ft-lb)***



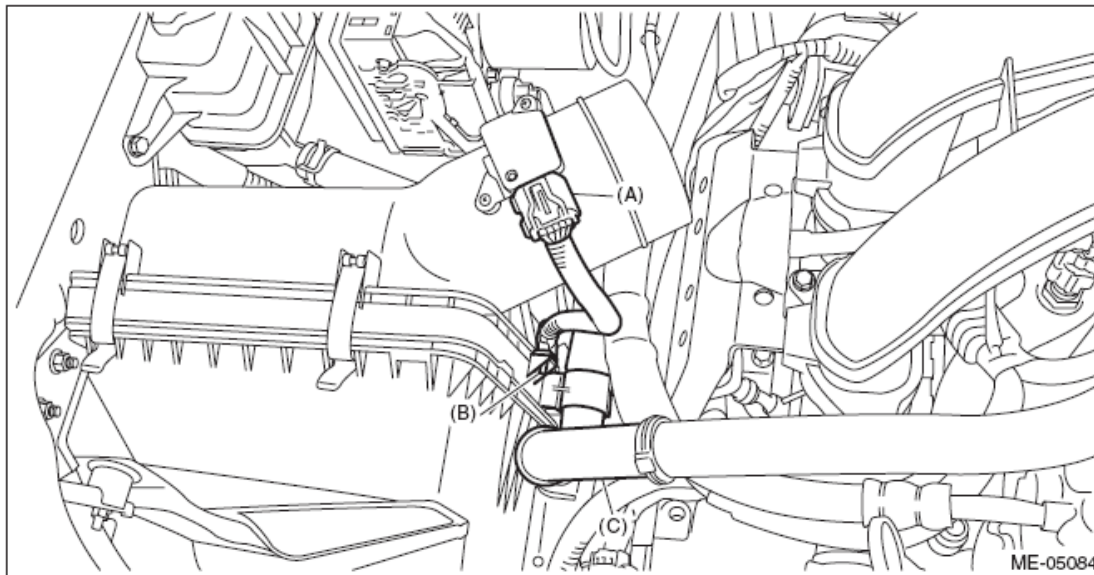
**Fig. 35: Identifying Front Hood Bolt Installation Positions**  
Courtesy of SUBARU OF AMERICA, INC.

2. Remove the V-belt covers.



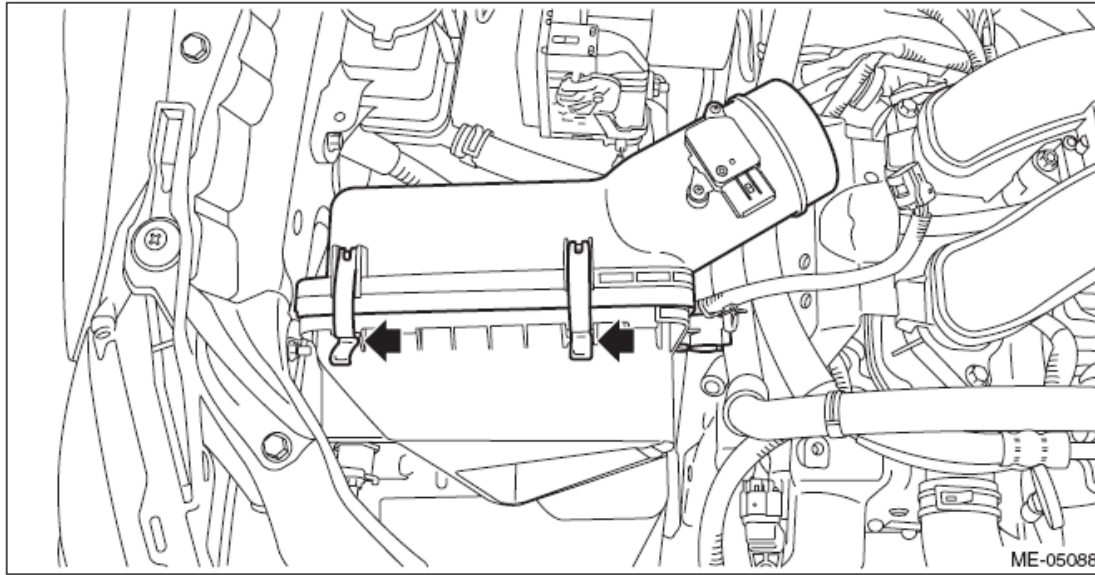
**Fig. 36: Locating V-Belt Cover Mounting Bolt**  
Courtesy of SUBARU OF AMERICA, INC.

3. Collect the refrigerant from A/C system. < Refer to **REFRIGERANT RECOVERY PROCEDURE** . >
4. Release the fuel pressure. < Refer to **RELEASING OF FUEL PRESSURE** , PROCEDURE, Fuel. >
5. Remove the battery. < Refer to **REMOVAL** , Battery. >
6. Remove the air intake duct (rear). < Refer to **REMOVAL** , Air Intake Duct. >
7. Remove the air intake boot. < Refer to **REMOVAL** , Air Intake Boot. >
8. Disconnect the connector (A) from the mass air flow and intake air temperature sensor, and remove the clip (B) which holds the mass air flow and intake air temperature sensor harness.
9. Remove the suction hose (C) from the air cleaner case (rear).



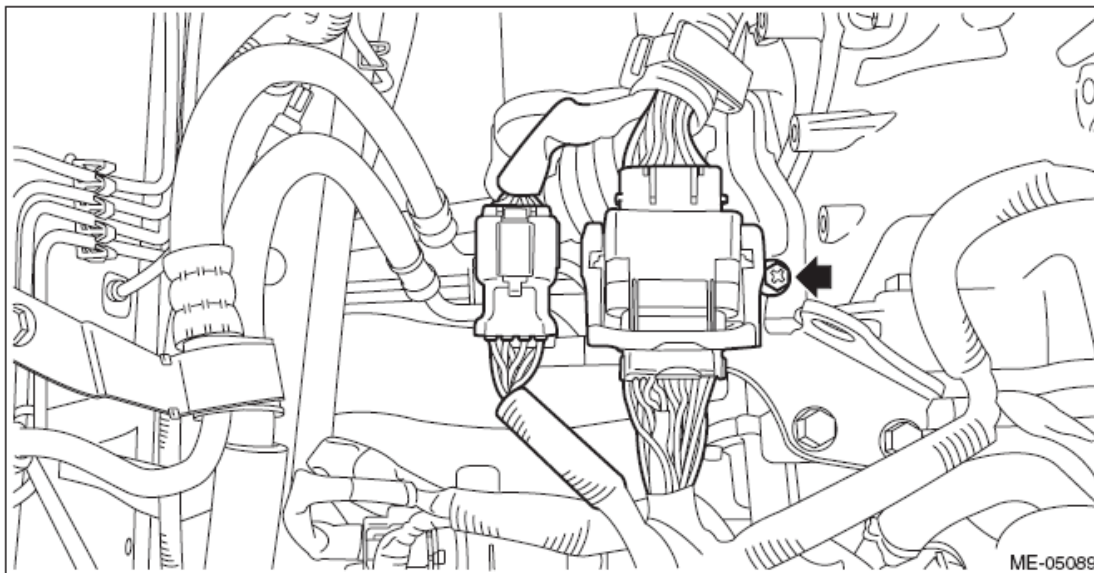
**Fig. 37: Identifying Mass Air Flow Connector And Air Cleaner Case Suction Hose**  
Courtesy of SUBARU OF AMERICA, INC.

10. Remove the air cleaner case (rear).



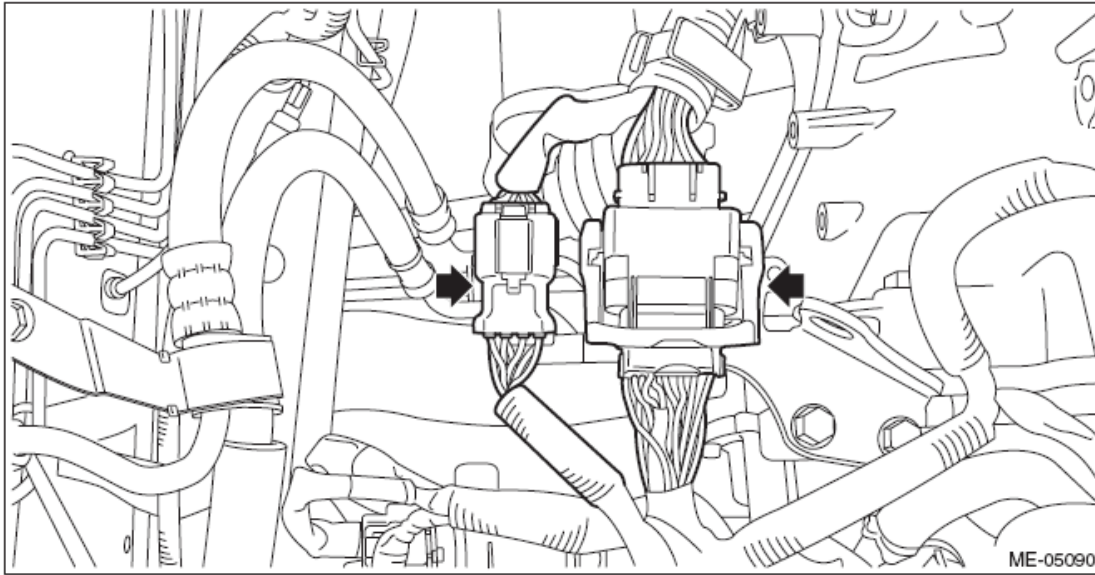
**Fig. 38: Locating Rear Air Cleaner Case Clamps**  
Courtesy of SUBARU OF AMERICA, INC.

11. Remove the radiator. < Refer to **REMOVAL** , Radiator. >
12. Disconnect the engine harness connector.
  1. Remove the bolt securing the bulkhead harness connector bracket.



**Fig. 39: Locating Bulkhead Harness Connector Bracket Mounting Bolt**  
Courtesy of SUBARU OF AMERICA, INC.

2. Disconnect the bulkhead harness connector from the engine harness connector (black) and engine harness connector (brown).



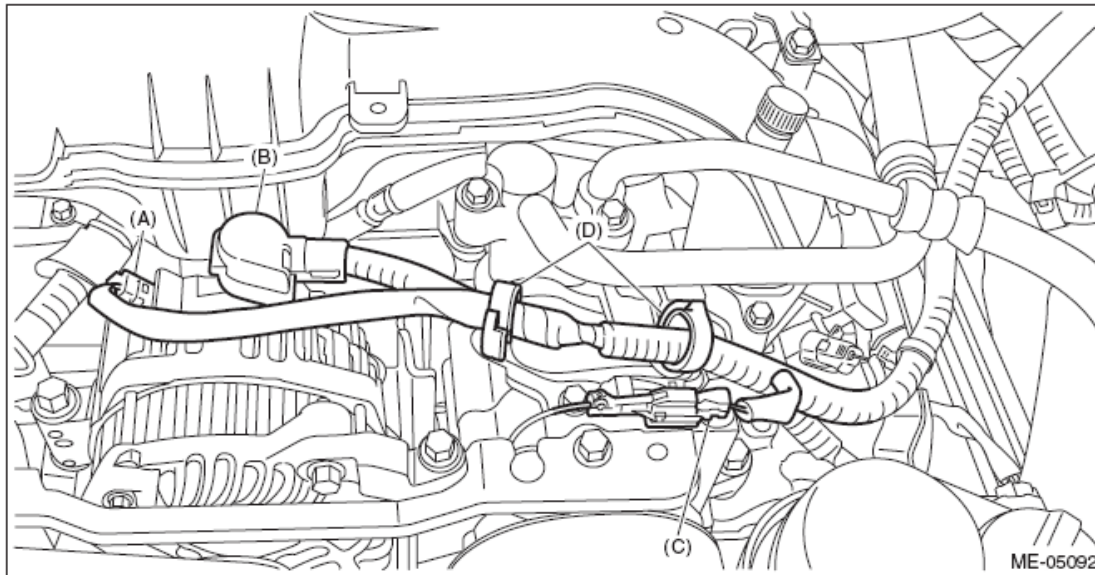
**Fig. 40: Locating Bulkhead And Engine Harness Connectors**  
Courtesy of SUBARU OF AMERICA, INC.

13. Remove the bolts which secure the generator cord stay to the chain cover.



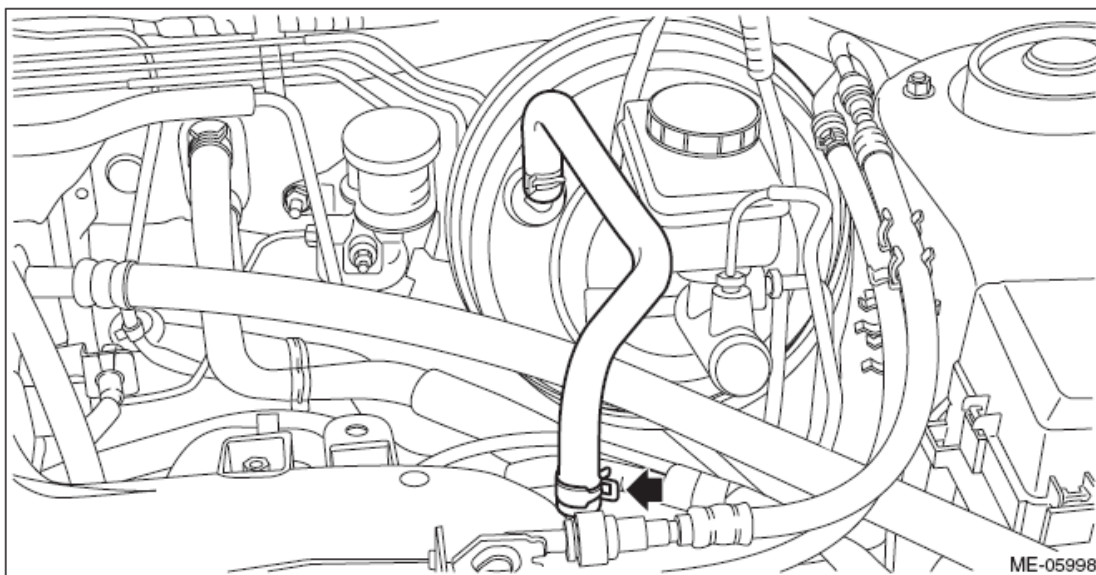
**Fig. 41: Locating Generator Cord Stay Bolt**  
Courtesy of SUBARU OF AMERICA, INC.

14. Disconnect connector (A) and terminal (B) from the generator, and disconnect connector (C) from A/C compressor.
15. Remove the generator cord from the clip (D) and move the generator cord to the left side wheel apron.



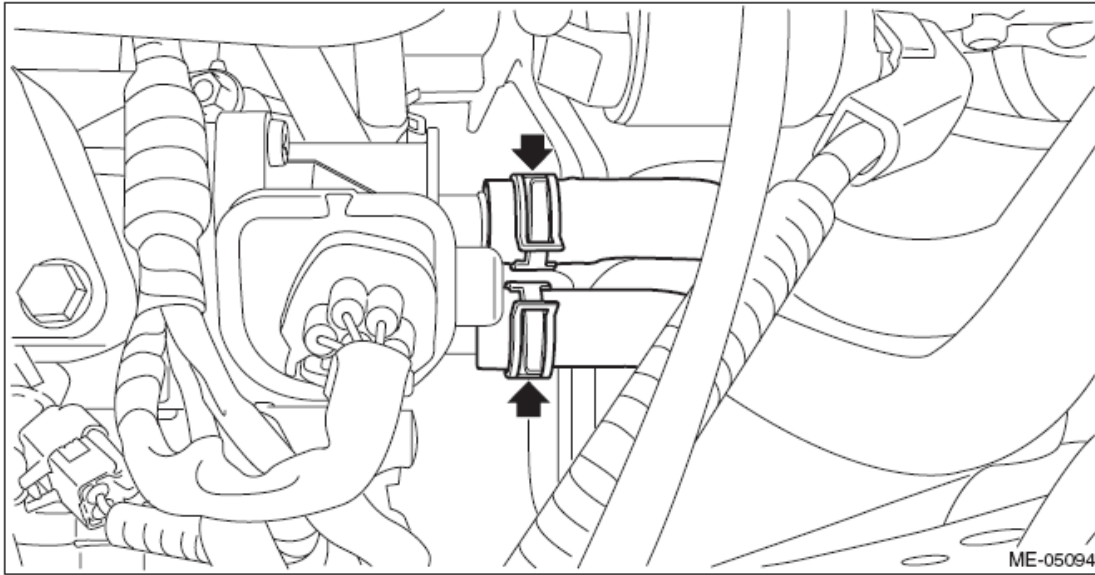
**Fig. 42: Identifying A/C Compressor And Generator Connector, Terminal And Clip**  
Courtesy of SUBARU OF AMERICA, INC.

16. Disconnect the following hoses.
  1. A/C pressure hose < Refer to **REMOVAL** , Hose and Pipe. >
  2. Brake booster vacuum hose



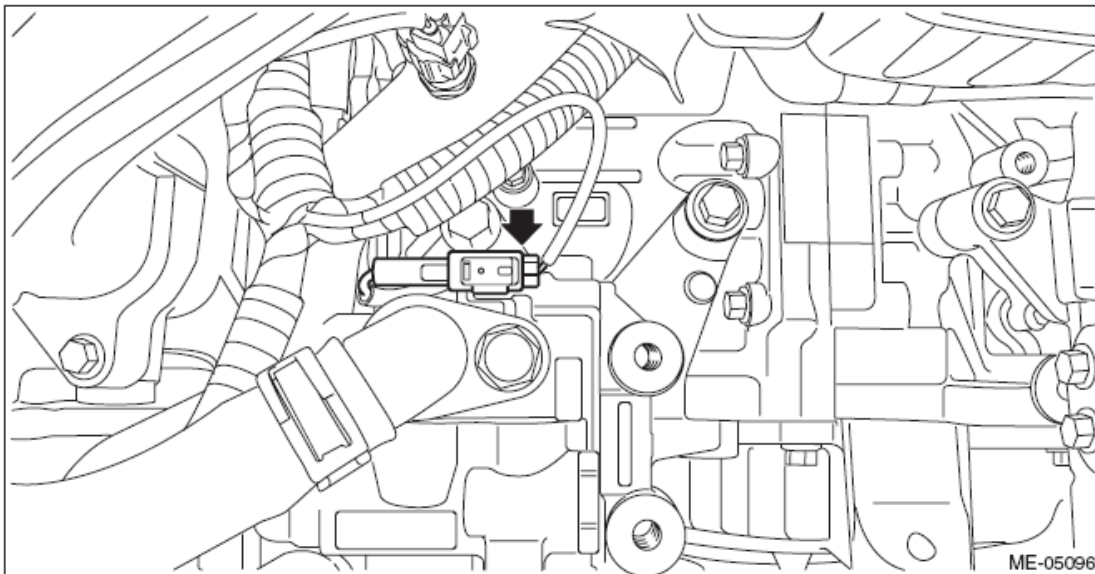
**Fig. 43: Locating Brake Booster Vacuum Hose Clip**  
Courtesy of SUBARU OF AMERICA, INC.

3. Heater inlet hose and heater outlet hose



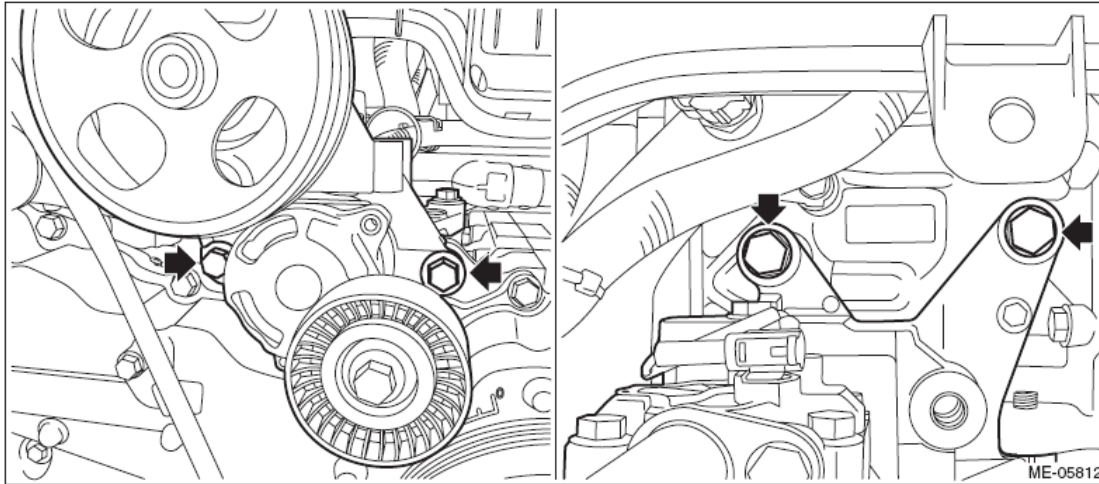
**Fig. 44: Locating Heater Inlet, Outlet Hose Clips**  
Courtesy of SUBARU OF AMERICA, INC.

17. Remove the power steering pump.
  1. Remove the V-belts. < Refer to **REMOVAL**, V-belt. >
  2. Remove the generator. < Refer to **REMOVAL**, Generator. >
  3. Disconnect the connector from power steering pump switch.



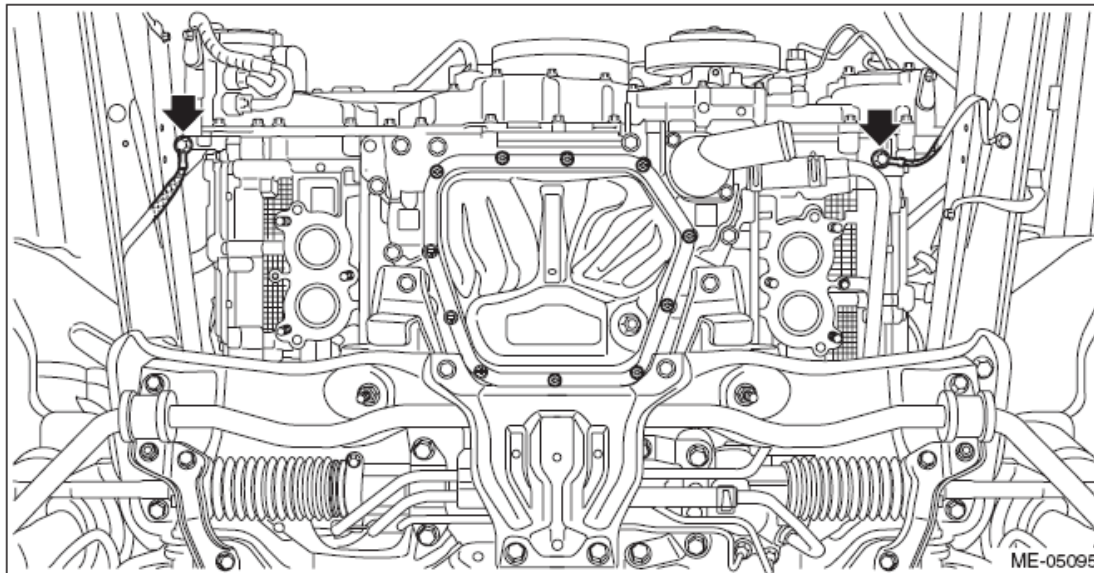
**Fig. 45: Locating Power Steering Pump Switch Connector**  
Courtesy of SUBARU OF AMERICA, INC.

4. Remove the power steering pump from the engine.



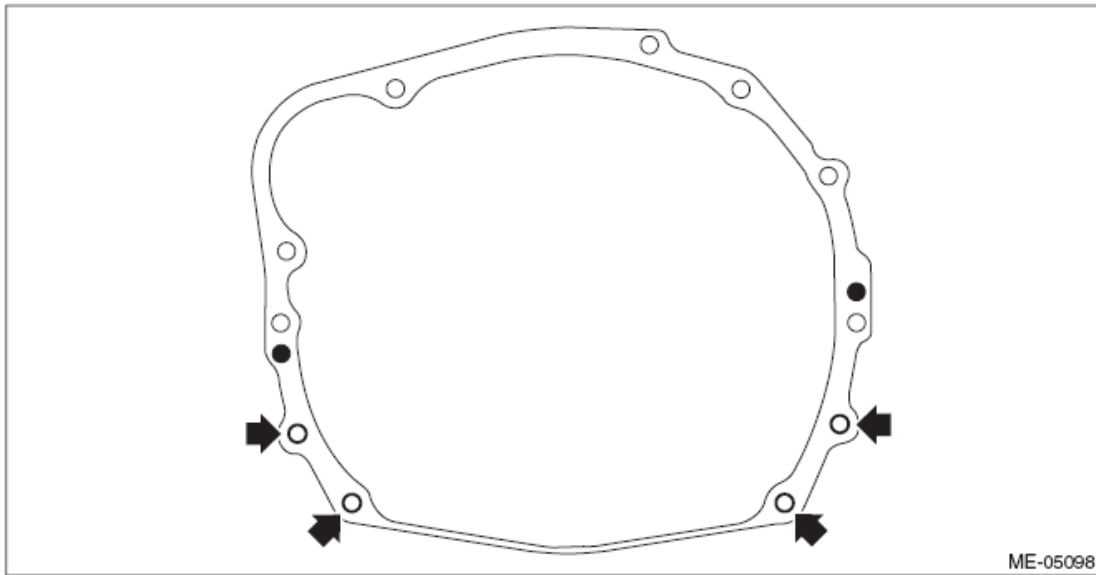
**Fig. 46: Locating Engine Power Steering Pump Mounting Bolts**  
Courtesy of SUBARU OF AMERICA, INC.

5. Place the power steering pump on the right side wheel apron.
18. Lift up the vehicle.
19. Remove the front exhaust pipe. < Refer to **REMOVAL** , Front Exhaust Pipe. >
20. Disconnect the ground cable on the engine side.



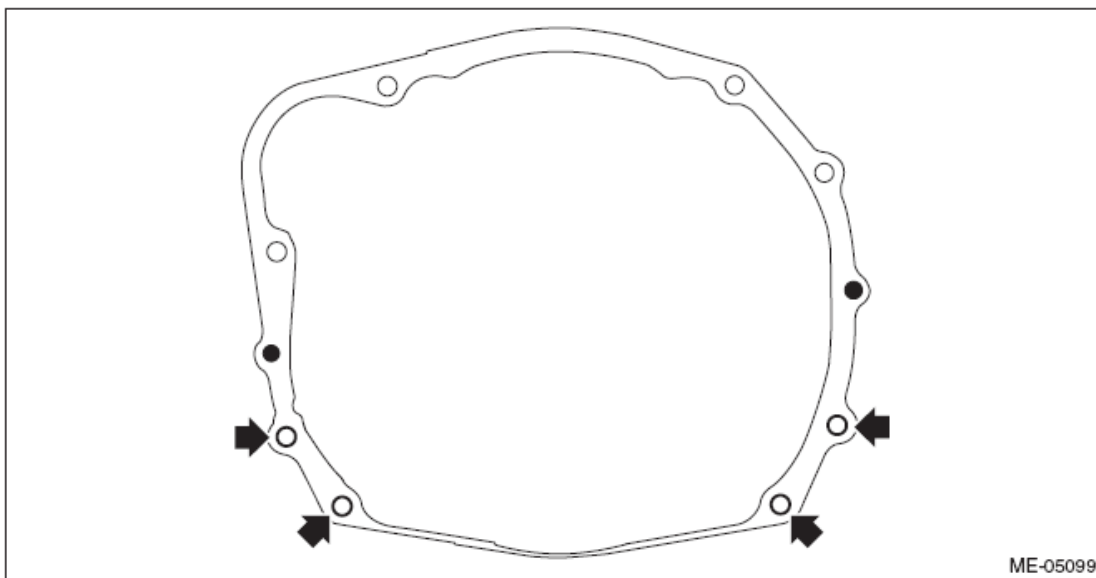
**Fig. 47: Locating Ground Cable Bolts**  
Courtesy of SUBARU OF AMERICA, INC.

21. Remove the bolts and nuts which hold the lower side of transmission to the engine.
  - AT model



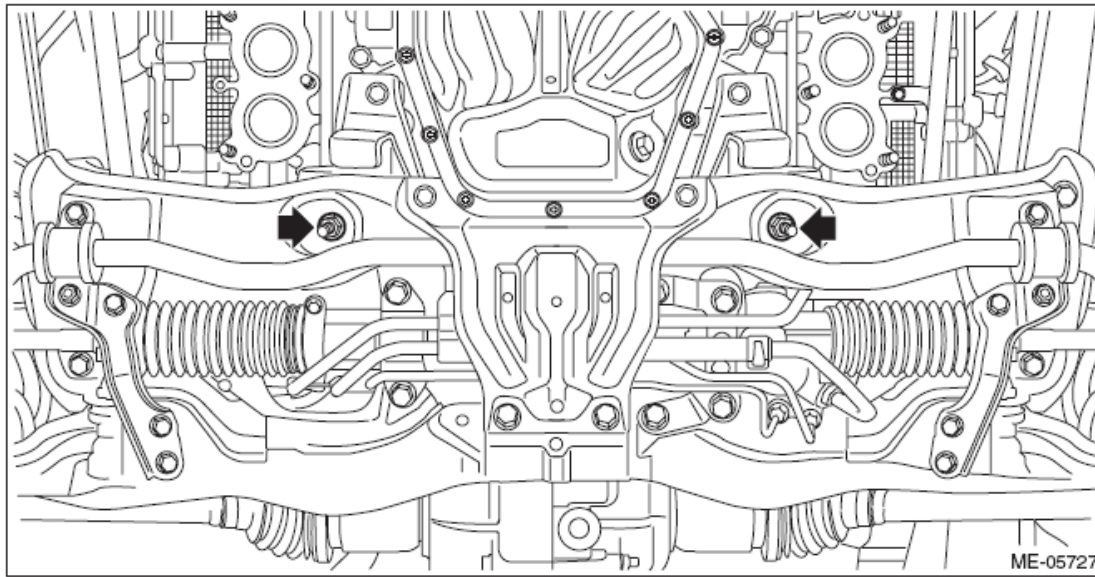
**Fig. 48: Locating Lower Side Of Transmission Gasket Bolts And Nuts (AT Model)**  
 Courtesy of SUBARU OF AMERICA, INC.

- MT model



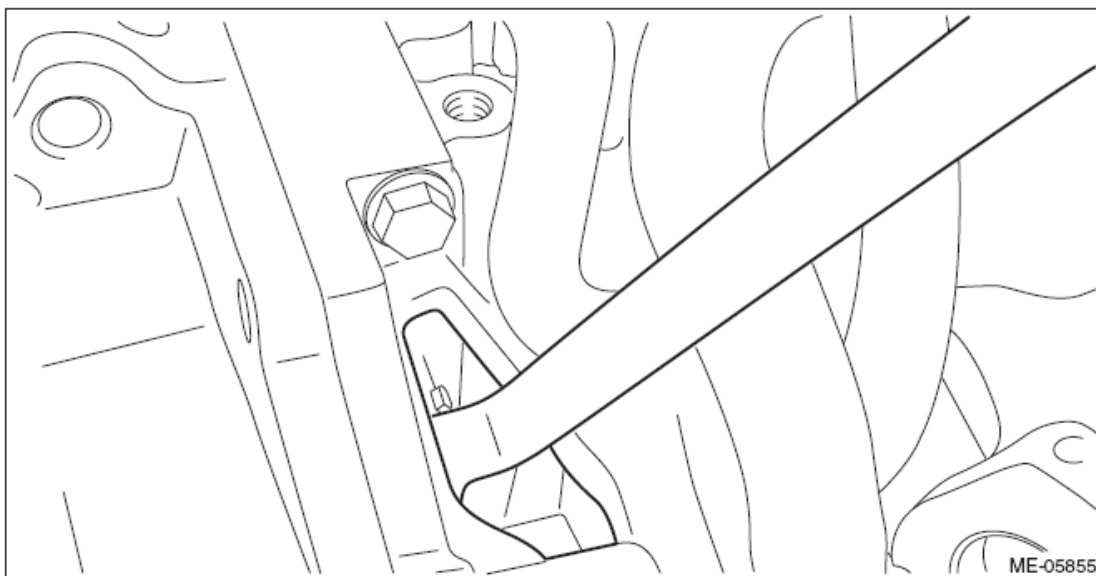
**Fig. 49: Locating Lower Side Of Transmission Gasket Bolts And Nuts (MT Model)**  
 Courtesy of SUBARU OF AMERICA, INC.

22. Remove the nuts which secure the engine mounting to the front crossmember.



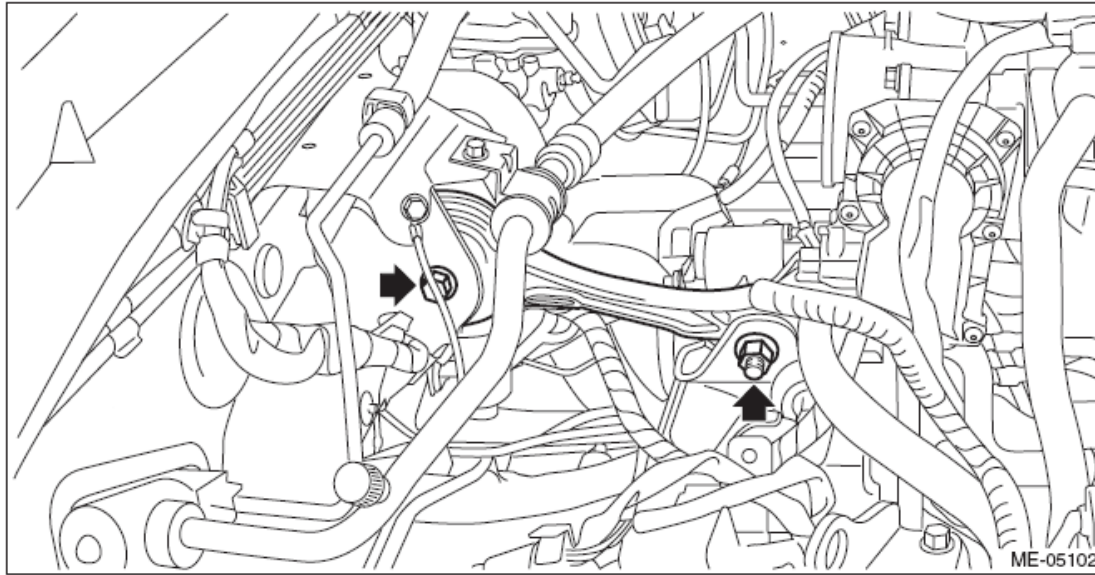
**Fig. 50: Locating Engine Mount To Front Crossmember Mounting Bolts**  
Courtesy of SUBARU OF AMERICA, INC.

23. Separate the torque converter clutch from the drive plate. (AT model)
  1. Lower the vehicle.
  2. Remove the service hole plug.
  3. Insert the wrench into the crank pulley bolt and rotate the crank pulley to remove the bolts which hold torque converter clutch to drive plate.



**Fig. 51: Removing/Installing Torque Converter Clutch (AT Model)**  
Courtesy of SUBARU OF AMERICA, INC.

24. Remove the pitching stopper.



**Fig. 52: Locating Pitching Stopper Mounting Bolt**  
Courtesy of SUBARU OF AMERICA, INC.

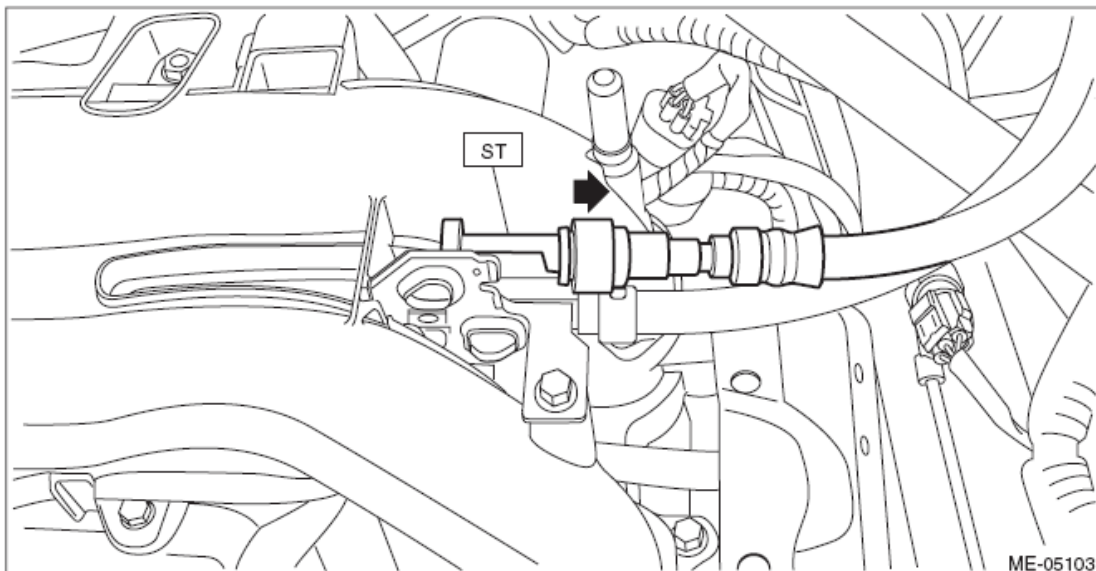
25. Disconnect the fuel delivery hose and evaporation hose.

**CAUTION:**

- Be careful not to spill fuel.
- Catch the fuel from hoses using a container or cloth.

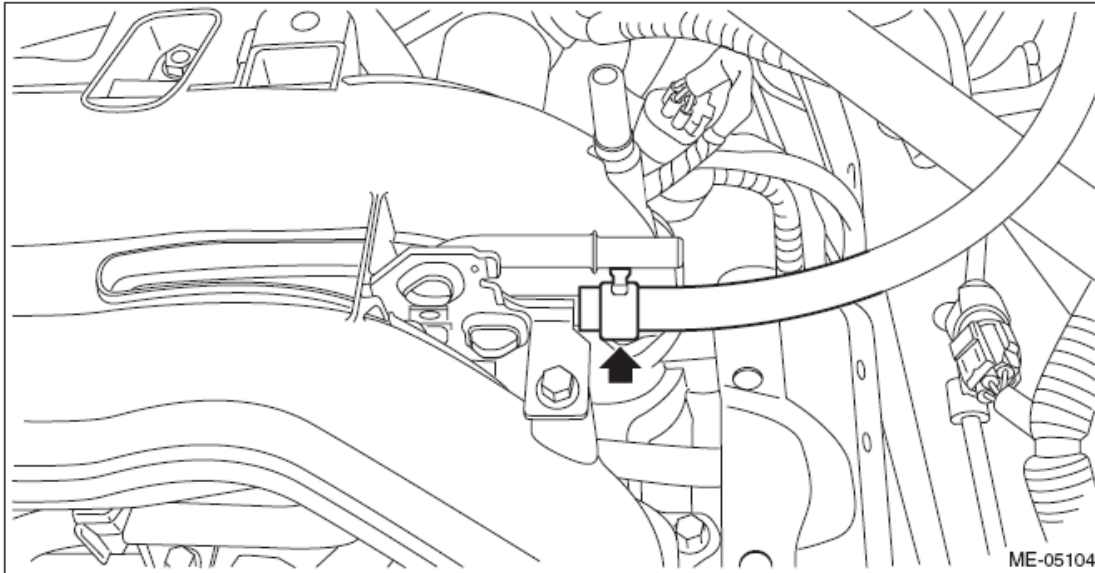
1. Attach ST to the fuel delivery pipe and push ST in the direction of arrow mark to disconnect the quick connector of the fuel delivery hose.

ST 42099AE000 QUICK CONNECTOR RELEASE



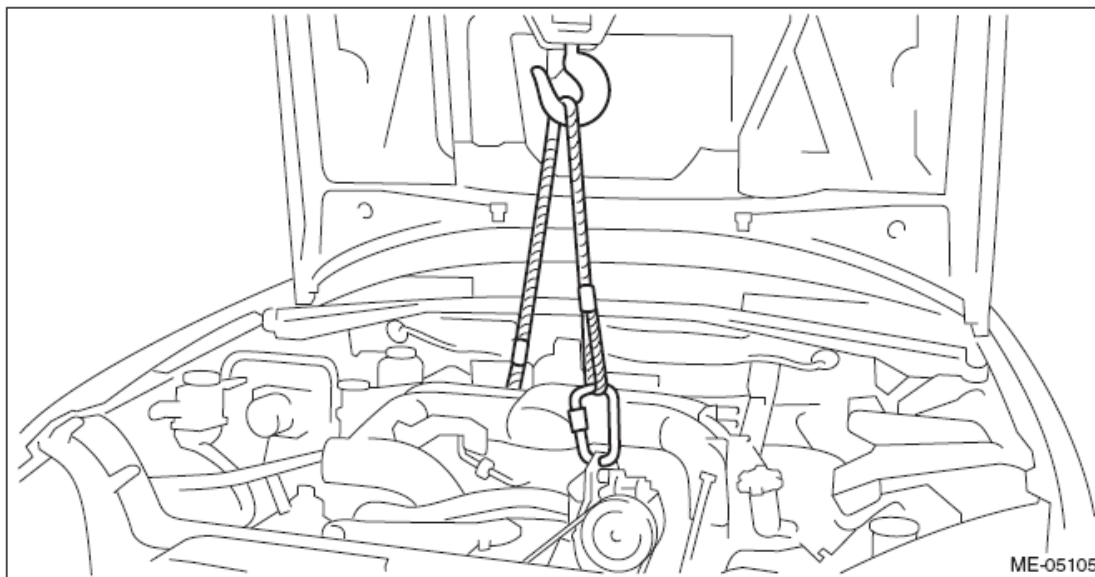
**Fig. 53: Pushing ST In Quick Connector Of Fuel Delivery Hose**  
Courtesy of SUBARU OF AMERICA, INC.

2. Remove the clip and disconnect the evaporation hose from the evaporation pipe.



**Fig. 54: Locating Evaporation Hose Clip**  
Courtesy of SUBARU OF AMERICA, INC.

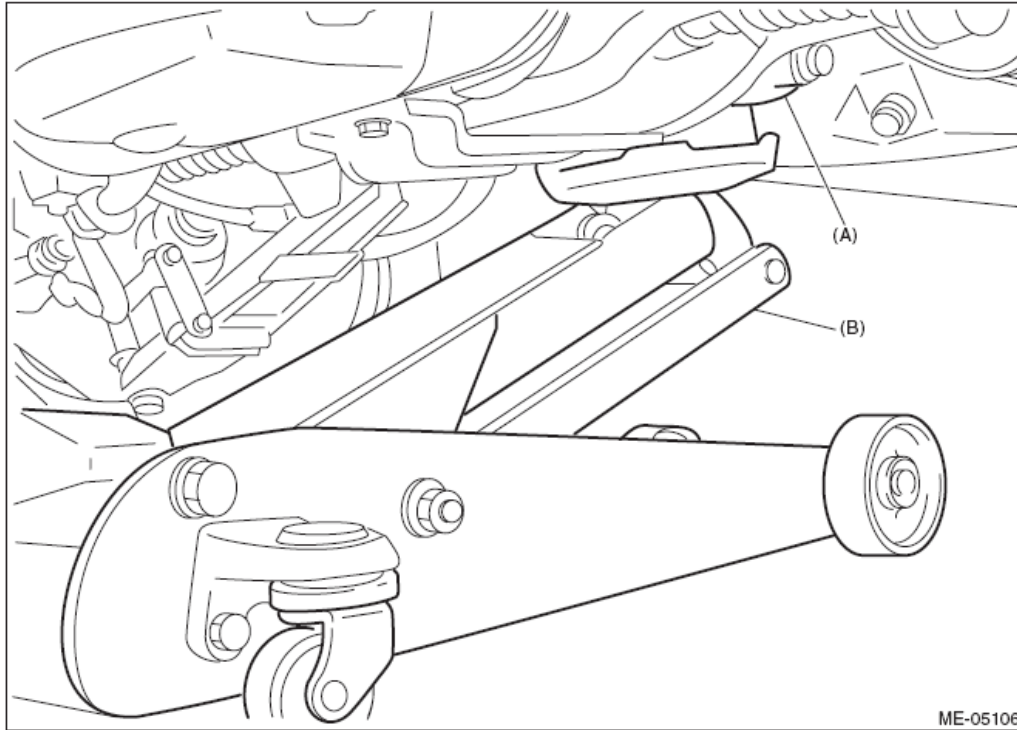
26. Support the engine with a lifting device and wire ropes.



**Fig. 55: Lifting Engine Using Wire Ropes**  
Courtesy of SUBARU OF AMERICA, INC.

27. Support the transmission with a garage jack.

**CAUTION:** Be sure to perform this procedure to prevent the transmission from lowering by its own weight.



(A) Transmission

(B) Garage jack

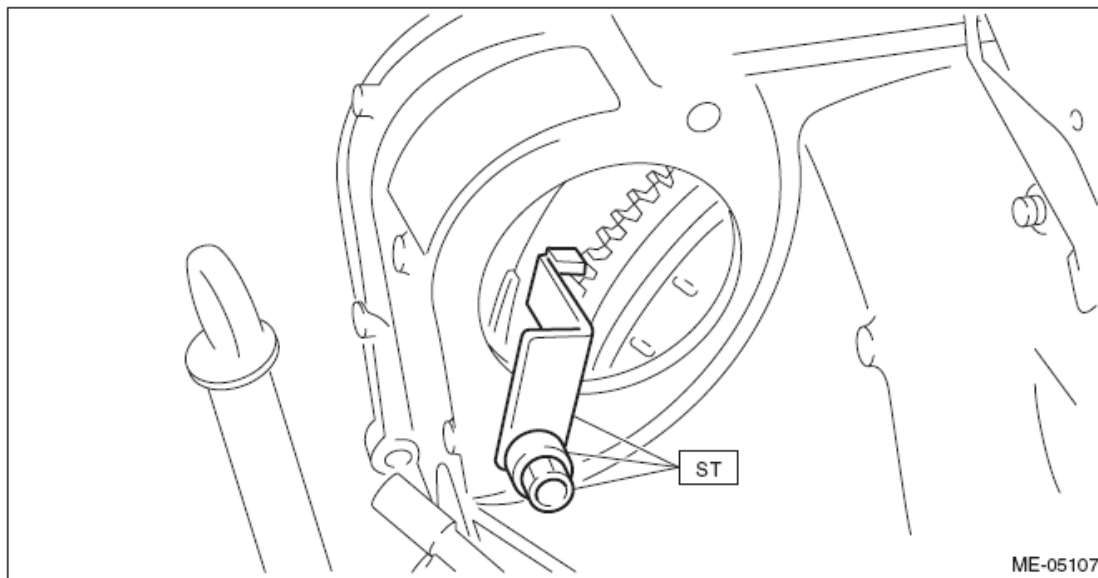
**Fig. 56: Supporting Transmission Using Garage Jack**  
 Courtesy of SUBARU OF AMERICA, INC.

28. Separate the engine and transmission.

**CAUTION:** Before removing the engine away from transmission, check to be sure no work has been overlooked.

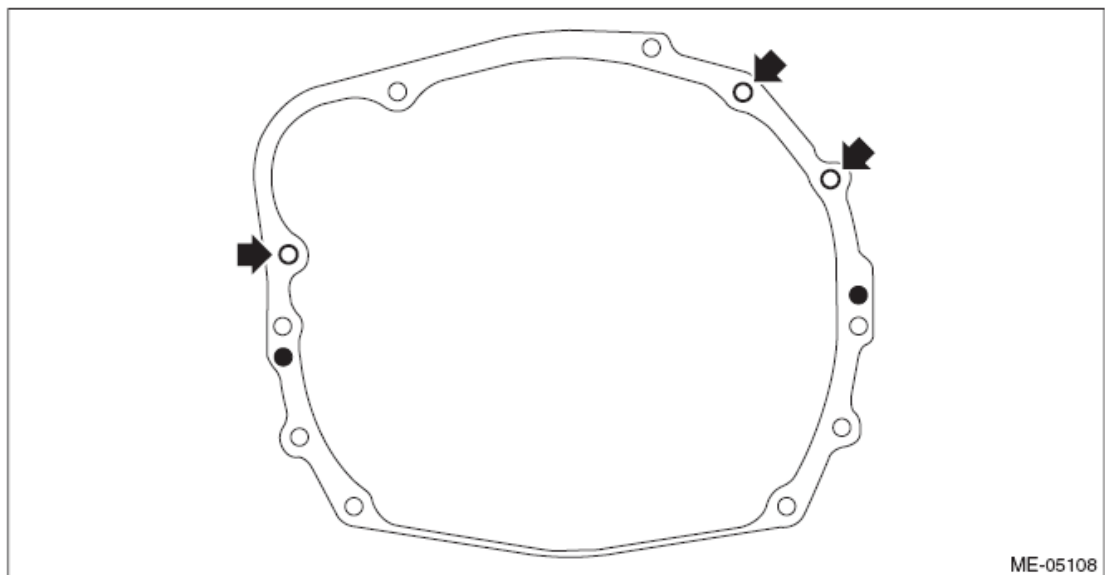
1. Remove the starter. < Refer to **REMOVAL** , Starter. >
2. Attach the ST to the torque converter clutch case. (AT model)

ST 498277200 STOPPER SET



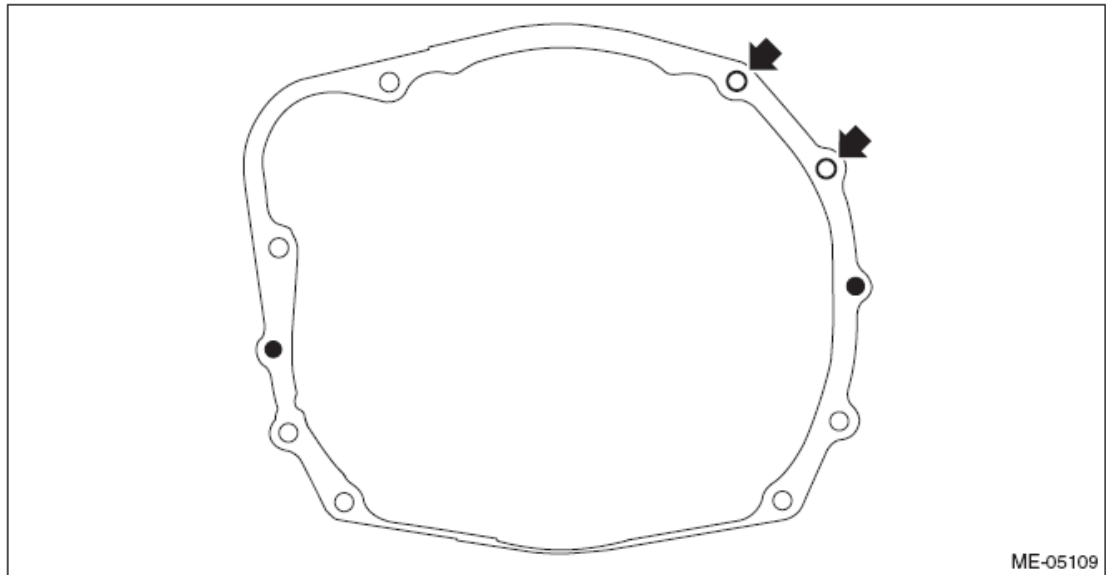
**Fig. 57: Attaching ST To Torque Converter Clutch Case (AT Model)**  
 Courtesy of SUBARU OF AMERICA, INC.

3. Remove the bolts which hold the upper side of the transmission to the engine.
  - AT model



**Fig. 58: Locating Upper Side Of Transmission Gasket Bolts (AT Model)**  
 Courtesy of SUBARU OF AMERICA, INC.

- MT model



**Fig. 59: Locating Upper Side Of Transmission Gasket Bolts (MT Model)**  
Courtesy of SUBARU OF AMERICA, INC.

29. Remove the engine from the vehicle.

**NOTE:** Be careful not to damage adjacent parts or body panels with crank pulley, oil level gauge, etc.

1. Slightly raise the engine.
  2. Raise the transmission with garage jack.
  3. Move the engine horizontally until main shaft is withdrawn from clutch cover. (MT model)
  4. Slowly move the engine away from engine compartment.
30. Remove the engine mounting from the engine.

## INSTALLATION

1. Install the engine mounting onto the engine.

***Tightening torque:***

***35 N.m (3.6 kgf-m, 25.8 ft-lb)***

2. Apply a small amount of grease to splines of main shaft. (MT model)

***Grease:***

***NICHIMOLY N-130 or equivalent***

3. Position the engine in engine compartment and align it with transmission.

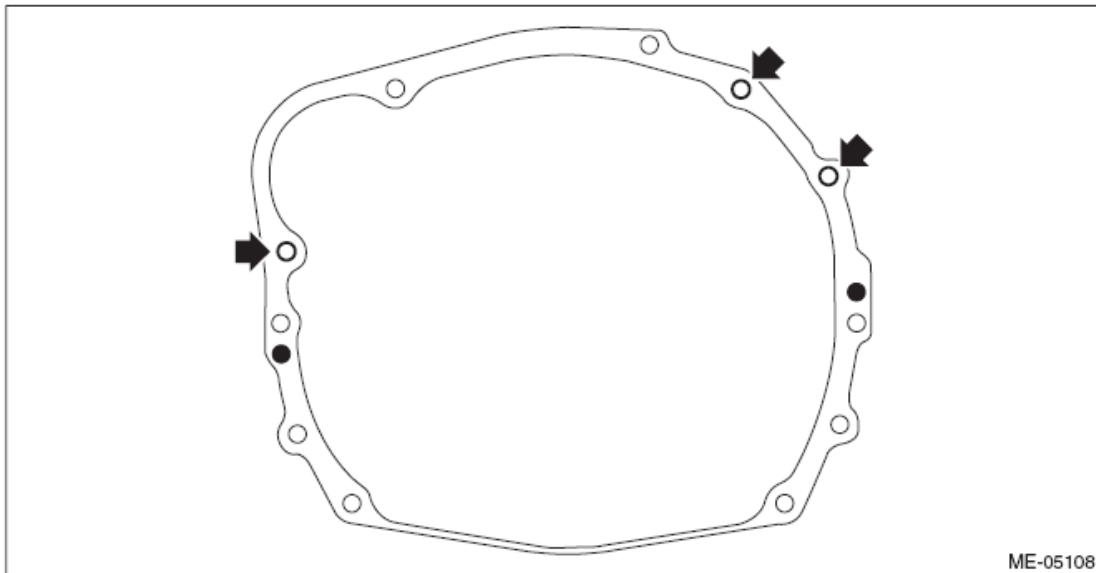
**NOTE:** Be careful not to damage adjacent parts or body panels with crank pulley, oil level gauge, etc.

4. Tighten the bolts which hold upper side of transmission to engine.

***Tightening torque:***

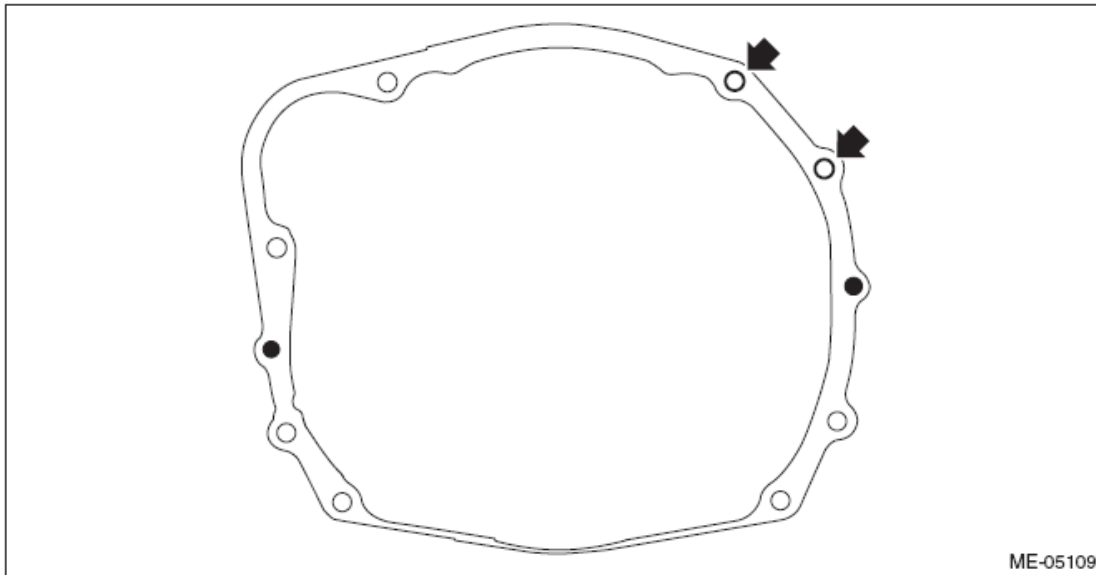
***50 N.m (5.1 kgf-m, 36.9 ft-lb)***

- AT model



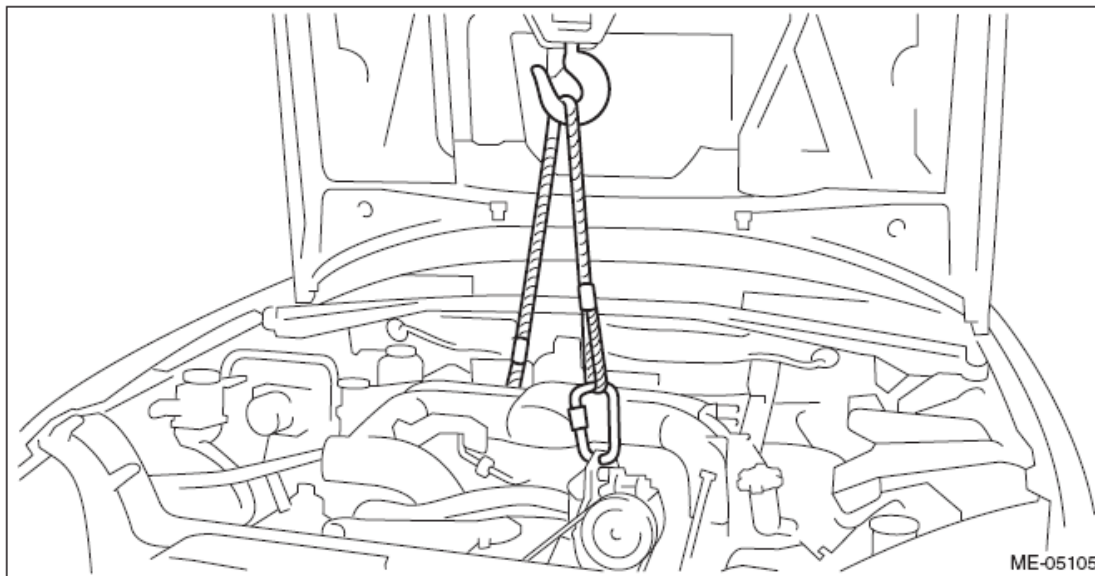
**Fig. 60: Locating Upper Side Of Transmission Gasket Bolts (AT Model)**  
Courtesy of SUBARU OF AMERICA, INC.

- MT model



**Fig. 61: Locating Upper Side Of Transmission Gasket Bolts (MT Model)**  
Courtesy of SUBARU OF AMERICA, INC.

5. Remove the lifting device and wire ropes.



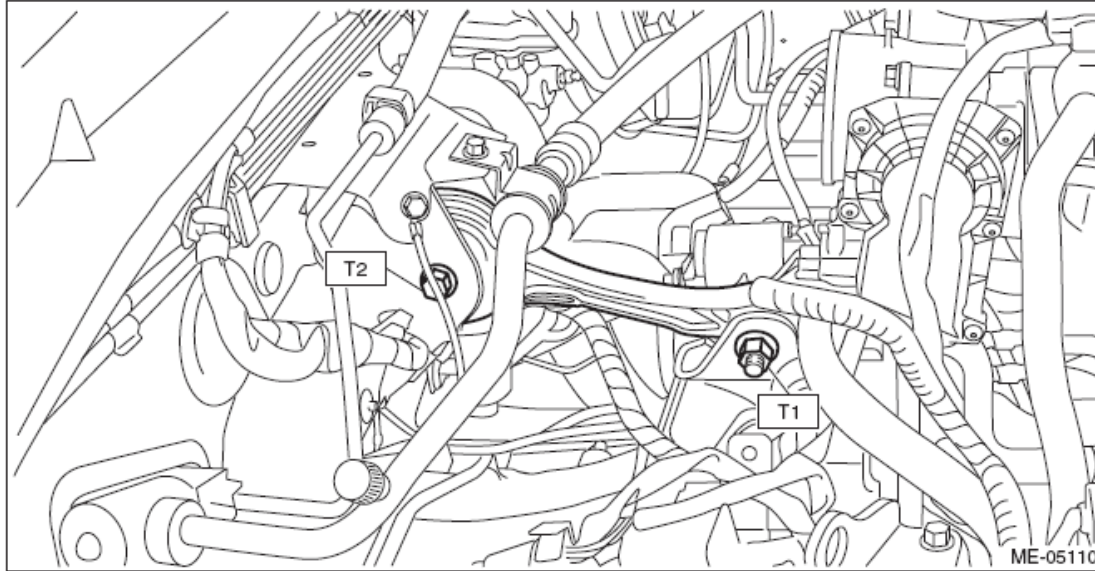
**Fig. 62: Lifting Engine Using Wire Ropes**  
Courtesy of SUBARU OF AMERICA, INC.

6. Remove the garage jack.
7. Install the pitching stopper.

***Tightening torque:***

***T1: 50 N.m (5.1 kgf-m, 36.9 ft-lb)***

***T2: 58 N.m (5.9 kgf-m, 42.8 ft-lb)***

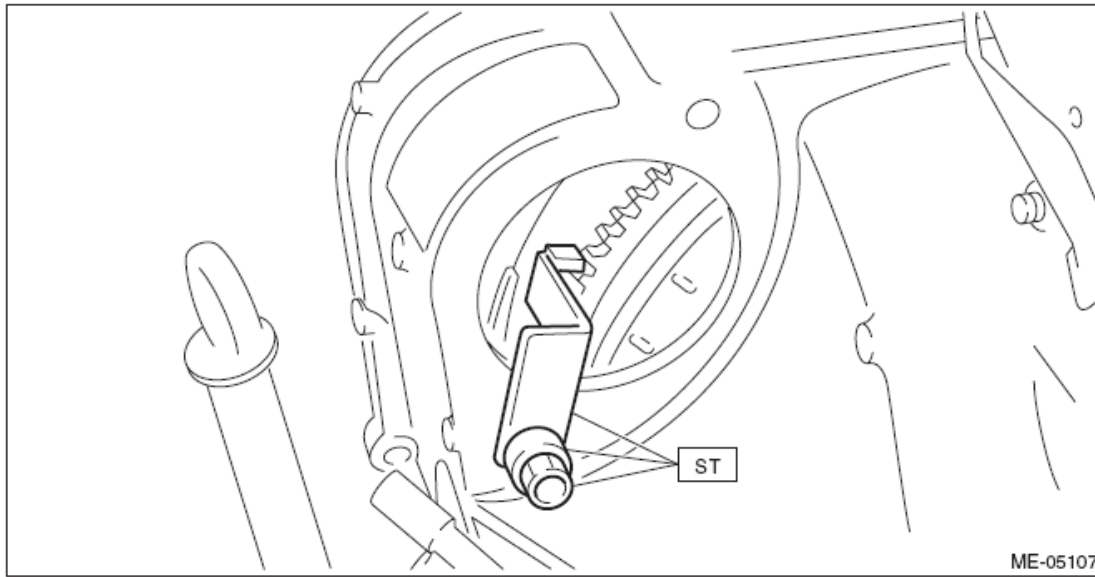


**Fig. 63: Installing Pitching Stopper With Torque Specifications**  
**Courtesy of SUBARU OF AMERICA, INC.**

8. Remove the ST from torque converter clutch case. (AT model)

**NOTE:**        **Be careful not to drop the ST into the torque converter clutch case when removing the ST.**

ST 498277200 STOPPER SET



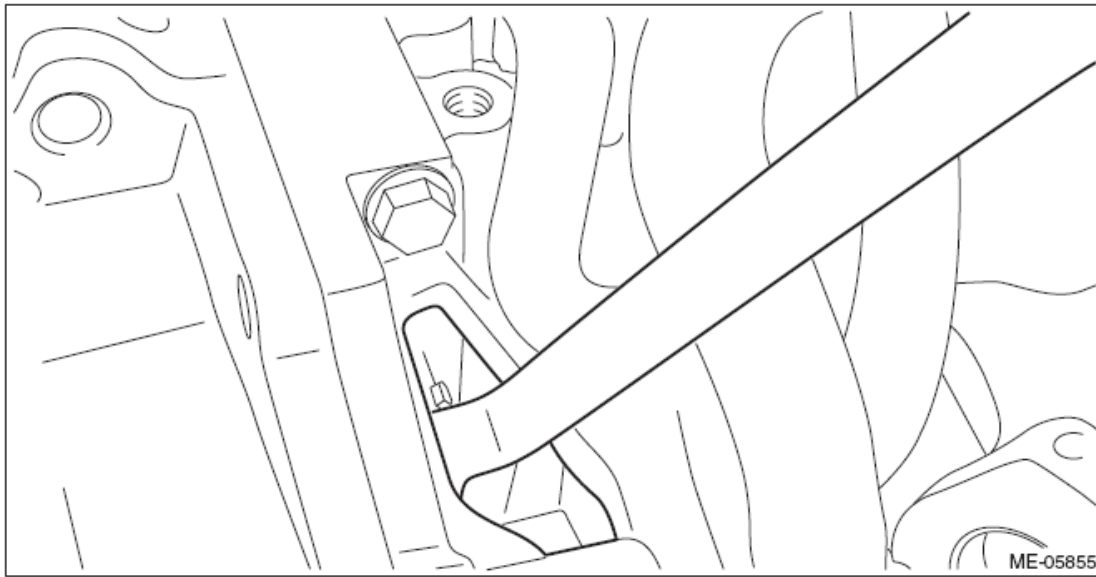
**Fig. 64: Removing ST From Torque Converter Clutch Case (AT Model)**  
Courtesy of SUBARU OF AMERICA, INC.

9. Install the starter. < Refer to **INSTALLATION** , Starter. >
10. Install the torque converter clutch to drive plate. (AT model)
  1. Insert the wrench into the crank pulley bolt and rotate the crank pulley to install the bolts which hold torque converter clutch to drive plate.

**NOTE:** Be careful not to drop bolts into the torque converter clutch case.

***Tightening torque:***

***25 N.m (2.5 kgf-m, 18.4 ft-lb)***

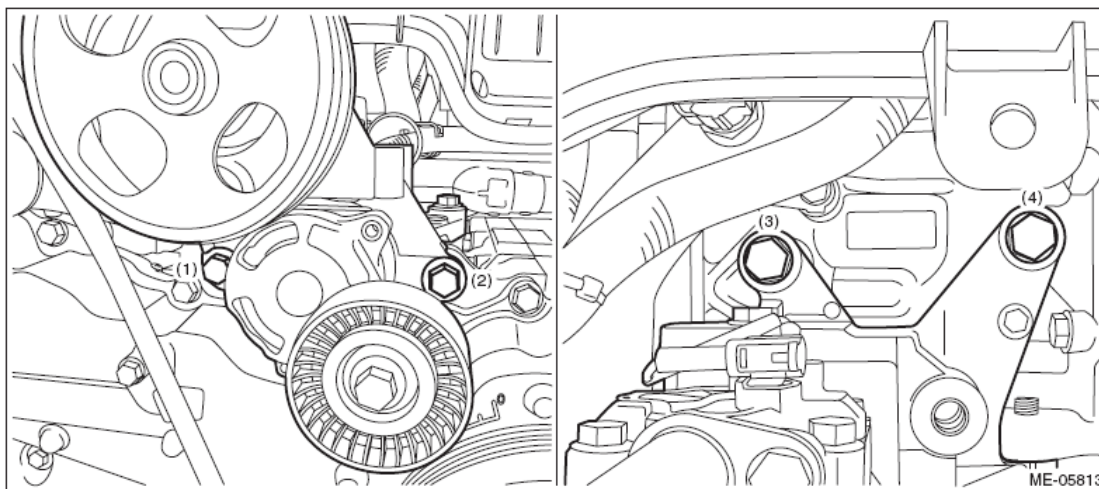


**Fig. 65: Removing/Installing Torque Converter Clutch (AT Model)**  
Courtesy of SUBARU OF AMERICA, INC.

2. Fit the plug to service hole.
11. Install the power steering pump.
  1. Set the power steering pump to the engine, and tighten the bolts in numerical order as shown in the figure.

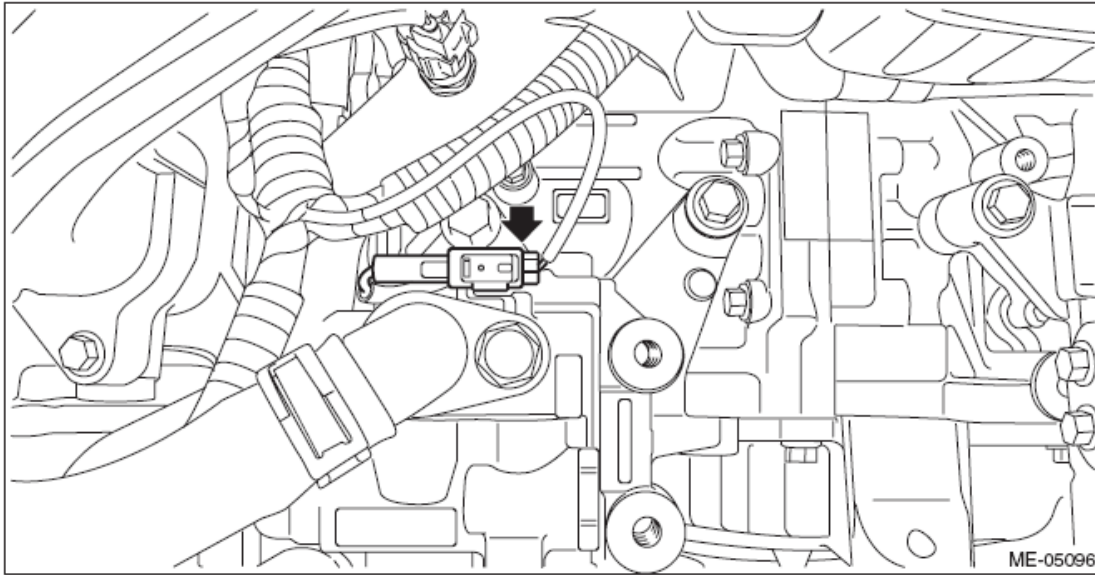
***Tightening torque:***

***36 N.m (3.7 kgf-m, 26.6 ft-lb)***



**Fig. 66: Locating Power Steering Pump Bolts With Tightening Sequence**  
Courtesy of SUBARU OF AMERICA, INC.

2. Connect the connector to the power steering pump switch.



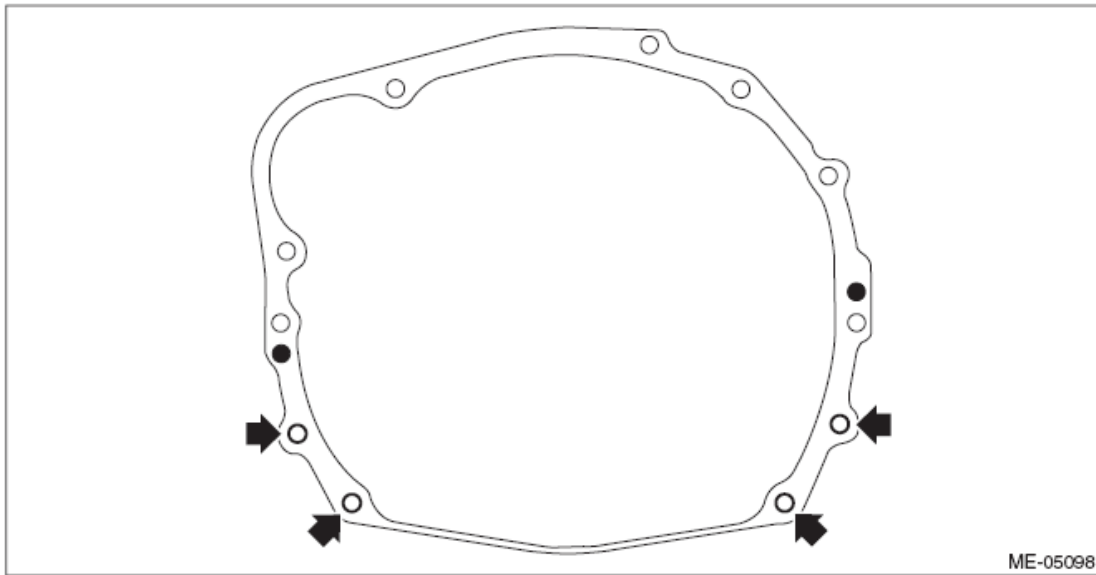
**Fig. 67: Locating Power Steering Pump Switch Connector**  
Courtesy of SUBARU OF AMERICA, INC.

3. Install the generator. < Refer to **INSTALLATION** , Generator. >
4. Install the V-belts. < Refer to **INSTALLATION**, V-belt. >
12. Lift up the vehicle.
13. Install the bolts and nuts which hold lower side of the transmission to engine.

***Tightening torque:***

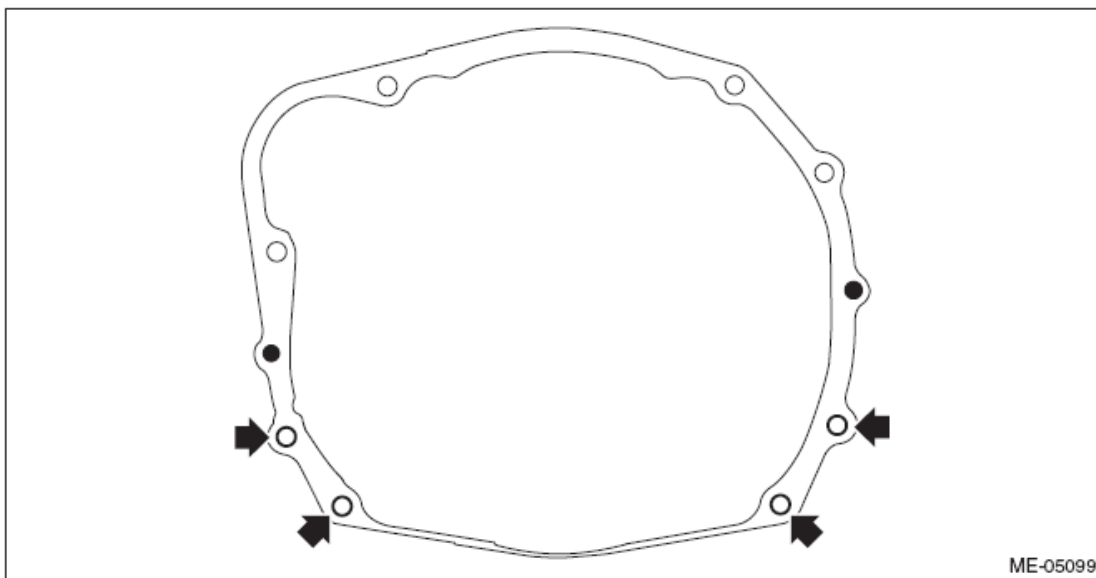
***50 N.m (5.1 kgf-m, 36.9 ft-lb)***

- AT model



**Fig. 68: Locating Transmission To Engine Mounting Bolts And Nuts (AT Model)**  
Courtesy of SUBARU OF AMERICA, INC.

- MT model

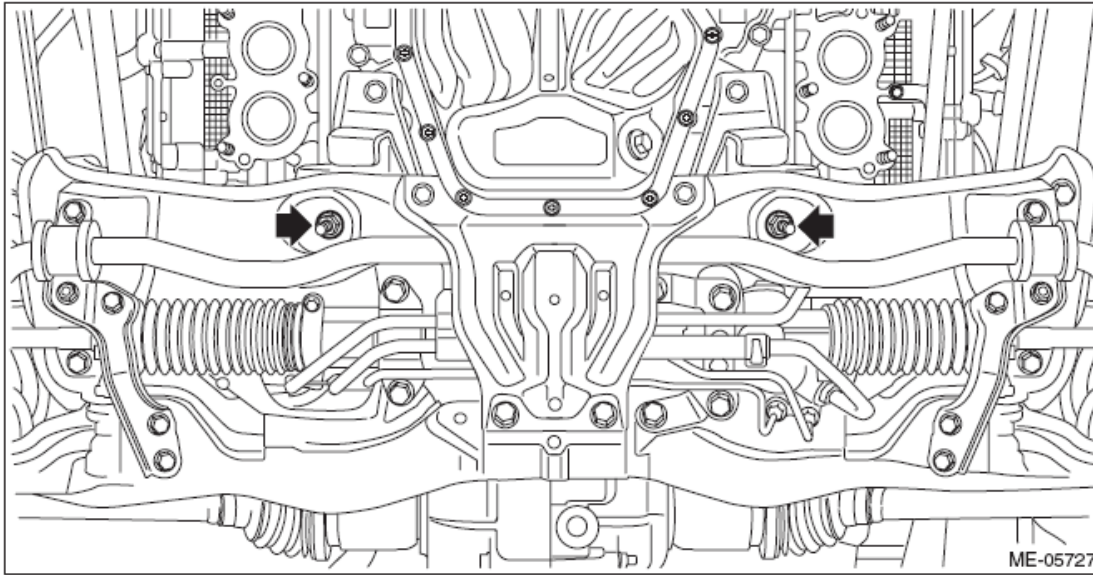


**Fig. 69: Locating Transmission To Engine Mounting Bolts And Nuts (MT Model)**  
Courtesy of SUBARU OF AMERICA, INC.

14. Install the nuts which hold the engine mounting to the crossmember.

***Tightening torque:***

***45 N.m (4.6 kgf-m, 33.2 ft-lb)***

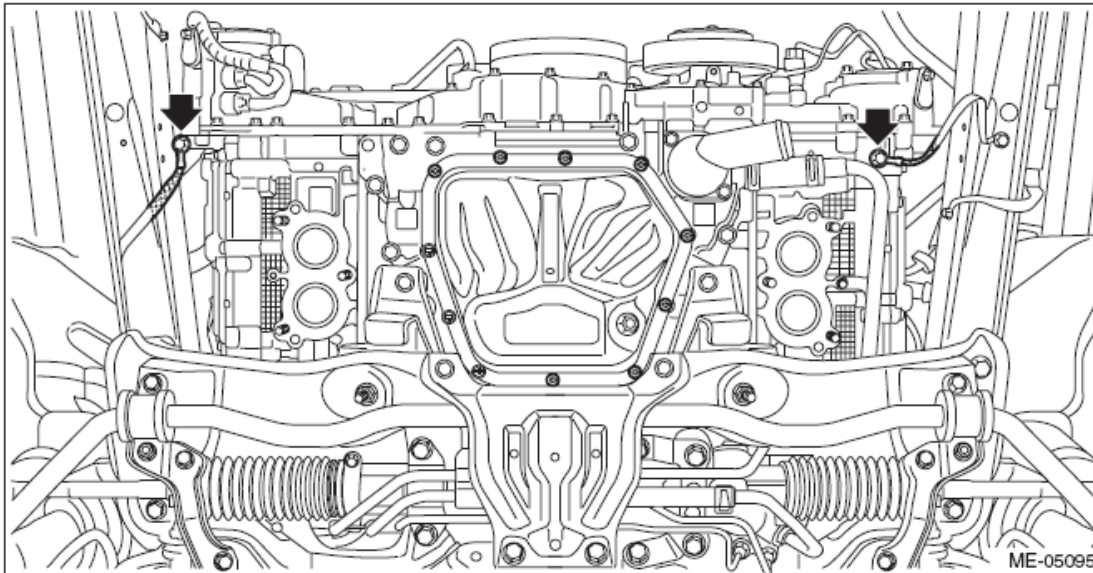


**Fig. 70: Locating Engine Mounting To Front Crossmember Mounting Nuts**  
Courtesy of SUBARU OF AMERICA, INC.

15. Connect the ground cable.

***Tightening torque:***

***7.5 N.m (0.8 kgf-m, 5.5 ft-lb)***



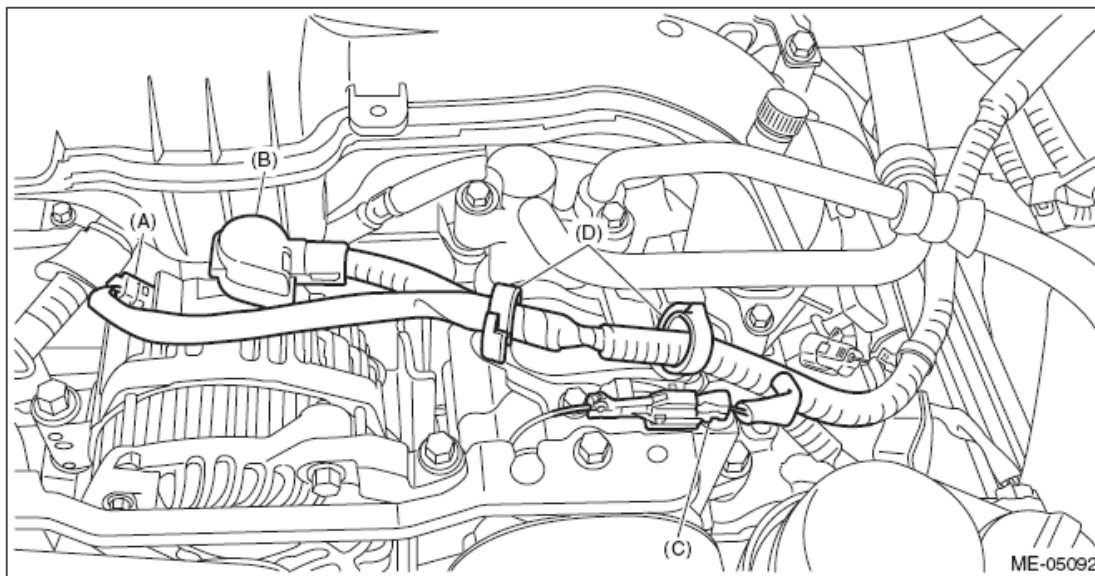
**Fig. 71: Locating Ground Cable Bolts**  
Courtesy of SUBARU OF AMERICA, INC.

16. Install the front exhaust pipe. < Refer to **INSTALLATION** , Front Exhaust Pipe. >

17. Lower the vehicle.
18. Connect the following hoses.
  1. Fuel delivery hose and evaporation hose
  2. Heater inlet hose and heater outlet hose
  3. Brake booster vacuum hose
  4. A/C pressure hose < Refer to **INSTALLATION** , Hose and Pipe. >
19. Place the generator code and install the generator cord to the clip (D).
20. Connect connector (A) and terminal (B) to the generator, and connect connector (C) to A/C compressor.

***Tightening torque:***

***15 N.m (1.5 kgf-m, 11.1 ft-lb)***



**Fig. 72: Identifying Clip, A/C Compressor Connector, Generator Connector And Terminal**  
 Courtesy of SUBARU OF AMERICA, INC.

21. Install the generator cord stay to the chain cover.

**NOTE:** Install the generator cord stay so that the folded end (A) touches at the chain cover boss.

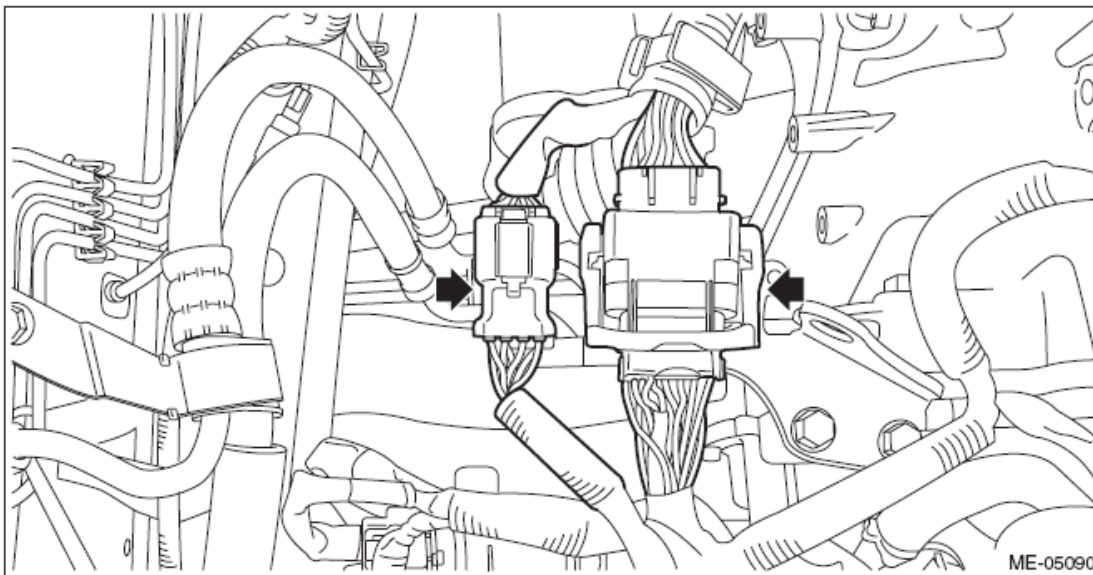
***Tightening torque:***

***6.4 N.m (0.7 kgf-m, 4.7 ft-lb)***



**Fig. 73: Locating Chain Cover Generator Cord Stay Mounting Bolt**  
Courtesy of SUBARU OF AMERICA, INC.

22. Connect the engine harness connector.
  1. Connect the bulkhead harness connector to the engine harness connector (black) and engine harness connector (brown).

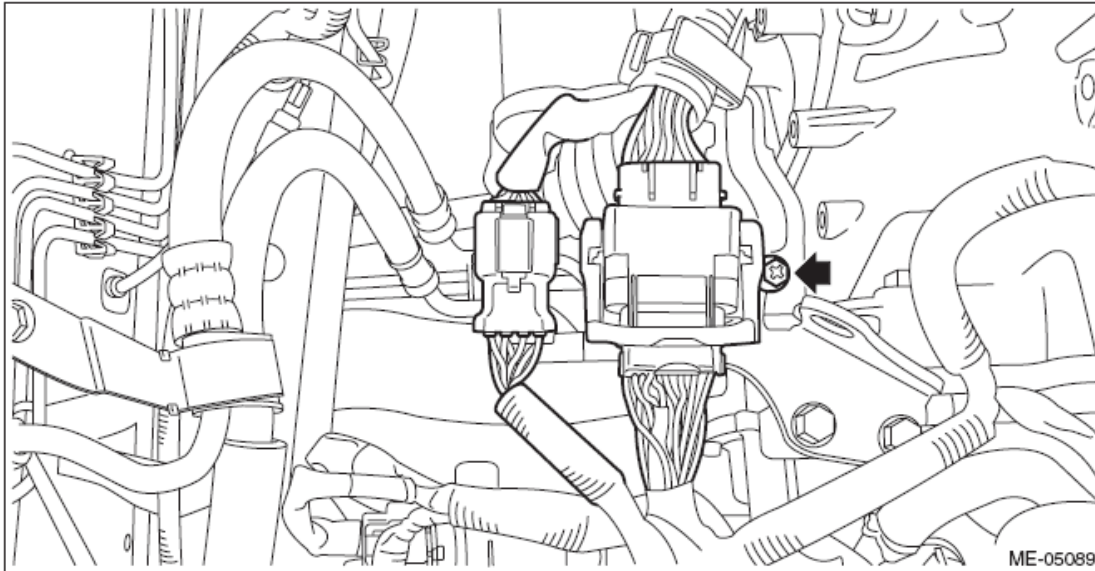


**Fig. 74: Locating Bulkhead And Engine Harness Connectors**  
Courtesy of SUBARU OF AMERICA, INC.

2. Install the bolt which secures the bulkhead harness connector bracket.

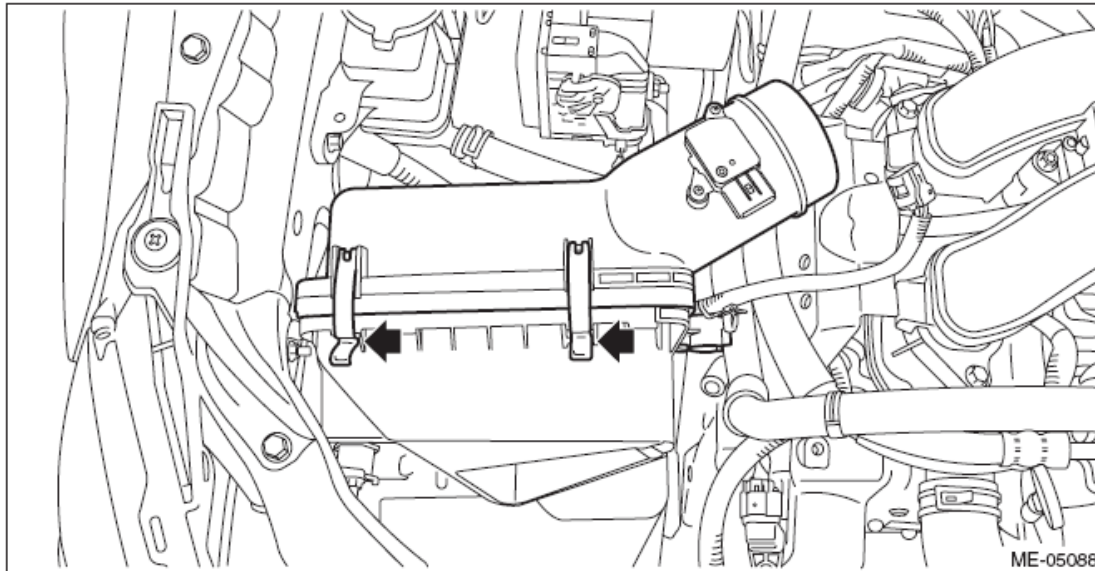
***Tightening torque:***

**7.5 N.m (0.8 kgf-m, 5.5 ft-lb)**



**Fig. 75: Locating Bulkhead Harness Connector Bracket Bolt**  
Courtesy of SUBARU OF AMERICA, INC.

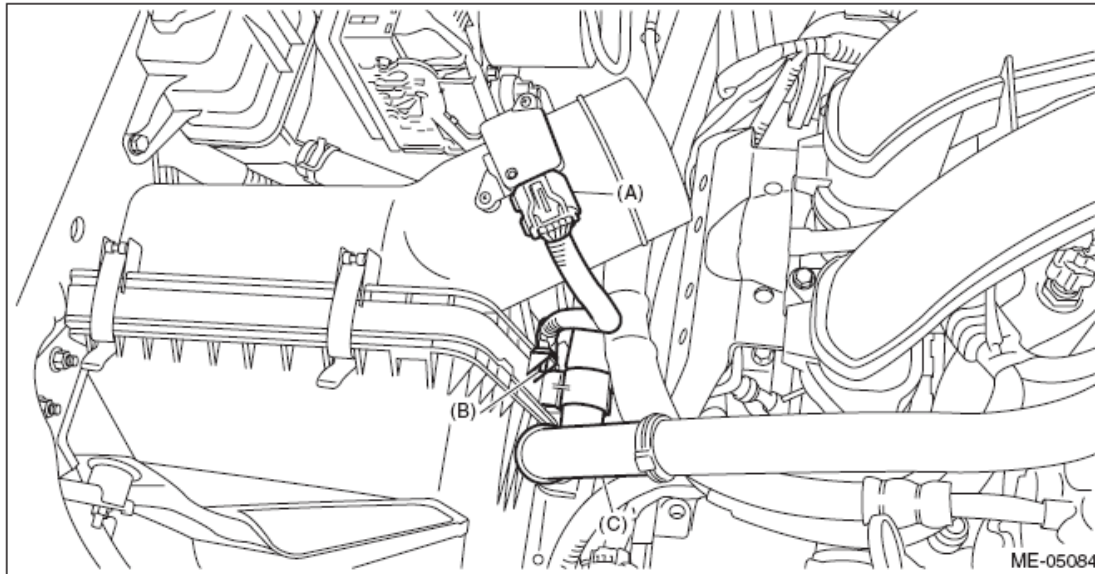
23. Install the radiator. < Refer to **INSTALLATION** , Radiator. >
24. Install the air intake case (rear).



**Fig. 76: Locating Rear Air Cleaner Case Clamps**  
Courtesy of SUBARU OF AMERICA, INC.

25. Install the clip (B) which secures the air flow and intake air temperature sensor harness, and connect the connector (A) to the air flow and intake air temperature sensor.

26. Install the suction hose (C) to the air cleaner case (rear).

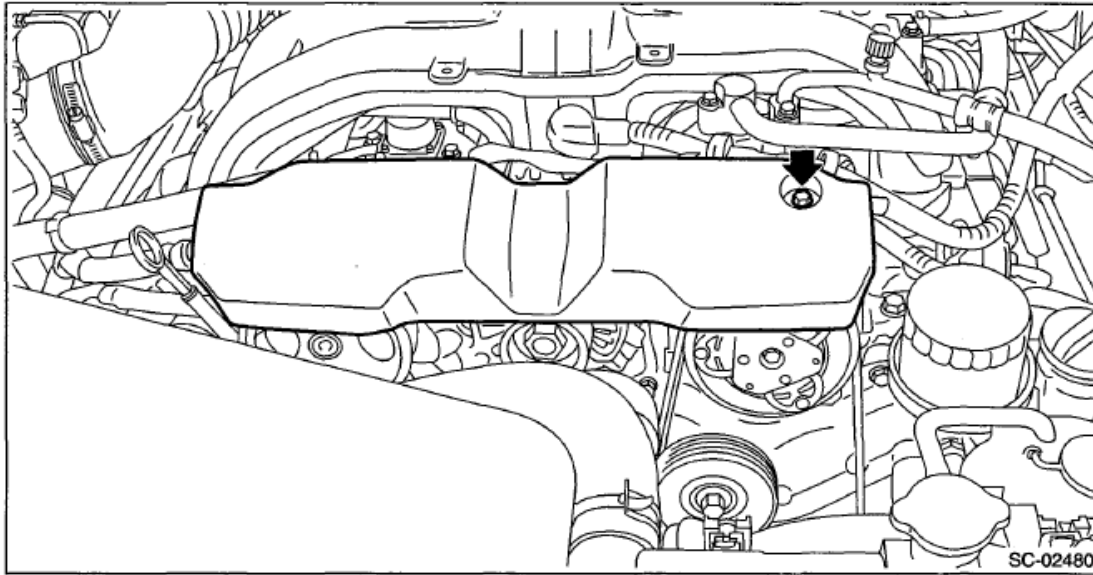


**Fig. 77: Mass Air Flow And Intake Air Temperature Sensor Connector, Clip And Suction Hose**  
Courtesy of SUBARU OF AMERICA, INC.

27. Install the air intake boot. < Refer to **INSTALLATION** , Air Intake Boot. >  
28. Install the air intake duct (rear). < Refer to **INSTALLATION** , Air Intake Duct. >  
29. Install the battery. < Refer to **INSTALLATION** , Battery. >  
30. Fill engine coolant. < Refer to **FILLING OF ENGINE COOLANT** , REPLACEMENT, Engine Coolant. >  
31. Check the ATF level and replenish it if necessary. (AT model) < Refer to **INSPECTION** , Automatic Transmission Fluid. >  
32. Charge the A/C system with refrigerant. < Refer to **PROCEDURE** , Refrigerant Charging Procedure. >  
33. Install the V-belt cover.

***Tightening torque:***

***13 N.m (1.3 kgf-m, 9.6 ft-lb)***

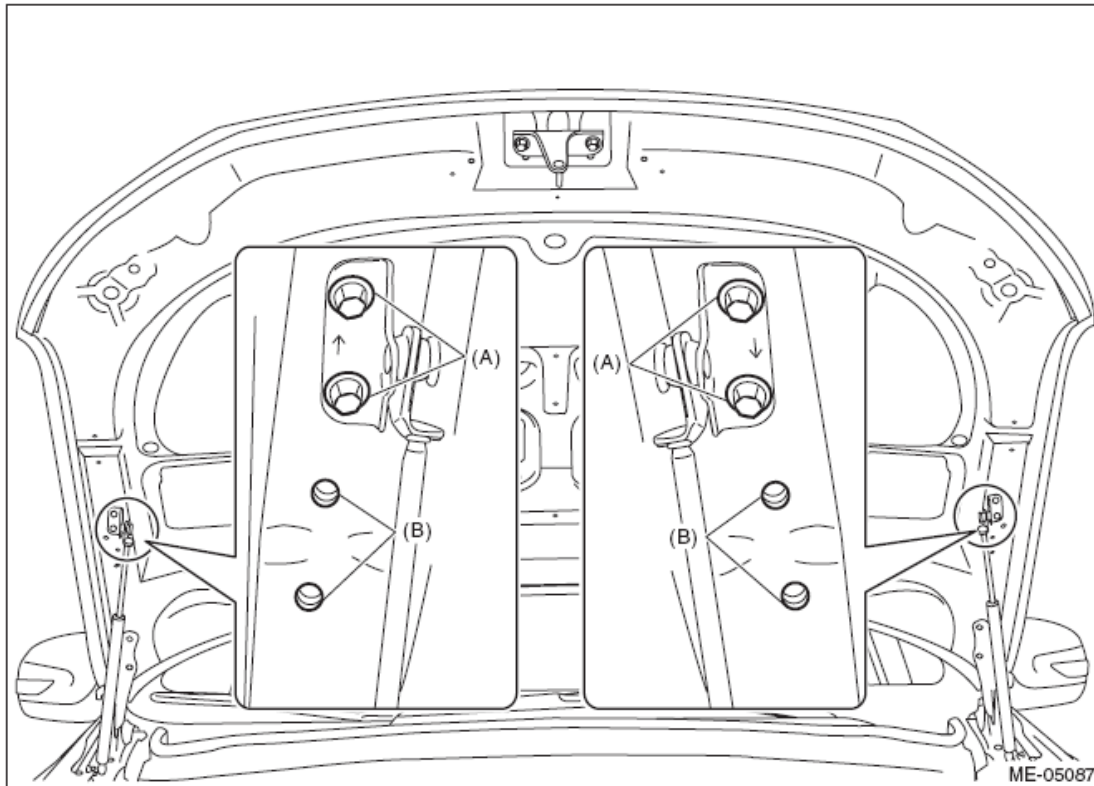


**Fig. 78: Locating V-Belt Cover Bolt**  
Courtesy of SUBARU OF AMERICA, INC.

34. Change the bolt installation position from (B) to (A), then close the front hood.

***Tightening torque:***

***7.5 N.m (0.8 kgf-m, 5.5 ft-lb)***



**Fig. 79: Identifying Front Hood Bolt Installation Positions**  
 Courtesy of SUBARU OF AMERICA, INC.

## INSPECTION

1. Check that pipes, hoses, connectors and clamps are installed firmly.
2. Check the engine coolant is at specified level.
3. Check that the ATF is at specified level. (AT model)
4. Start the engine and check for exhaust gas, engine coolant, leaks of fuel, etc. Also check for noise and vibrations.

## ENGINE MOUNTING

### REMOVAL

1. Remove the engine from the vehicle. < Refer to **REMOVAL**, Engine Assembly. >
2. Remove the engine mounting from the engine.

### INSTALLATION

Install in the reverse order of removal.

***Tightening torque:***

**35 N.m (3.6 kgf-m, 25.8 ft-lb)**

## INSPECTION

Make sure that there are no cracks or other damages.

## PREPARATION FOR OVERHAUL

### PROCEDURE

1. After removing the engine from vehicle body, attach the ST to the engine as shown in the figure.

**NOTE:** When using a commercially sold engine stand, follow the instructions of engine stand used.

*Tightening torque:*

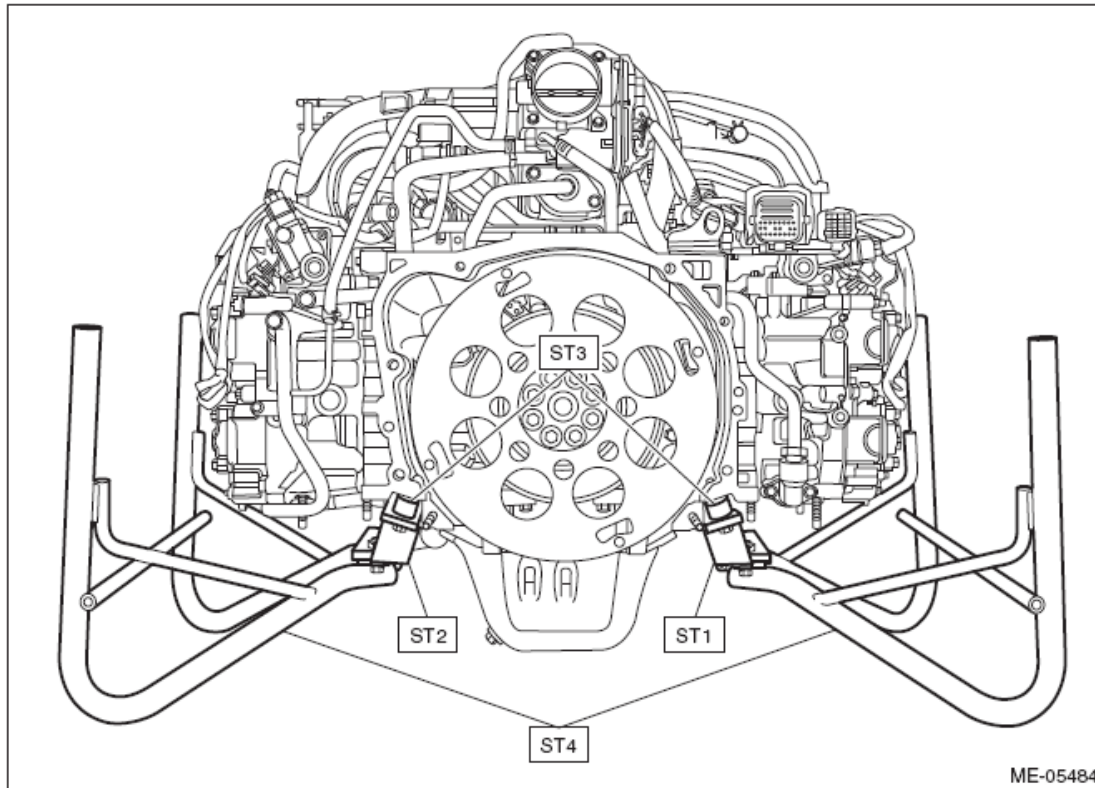
**35 N.m (3.6 kgf-m, 25.8 ft-lb)**

ST1 498457000 ENGINE STAND ADAPTER RH

ST2 498457100 ENGINE STAND ADAPTER LH

ST3 18362AA020 ADAPTER

ST4 499817100 ENGINE STAND



**Fig. 80: Attaching ST To Engine**  
Courtesy of SUBARU OF AMERICA, INC.

2. In this service information the procedures described under each index are all connected and stated in order. The procedure for overhauling of the engine will be completed when you go through all steps in the process.

Therefore, in this service information, to conduct the particular procedure within the flow of information, you need to go back and conduct the procedure described previously in order to do that particular procedure.

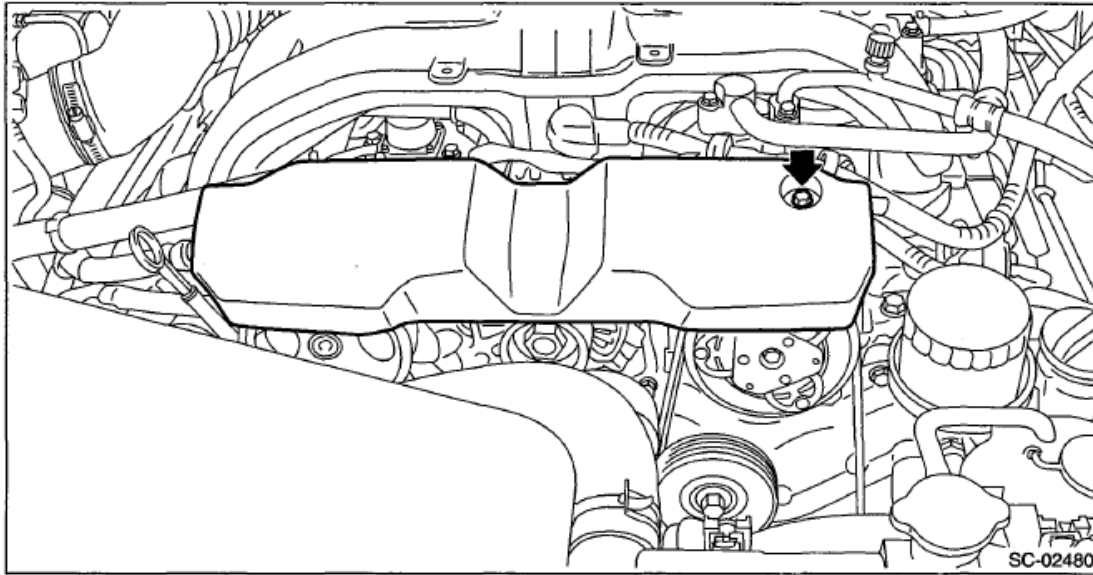
## V-BELT

### REMOVAL

**NOTE:** When replacing a single part, perform the work with the engine assembly installed to body.

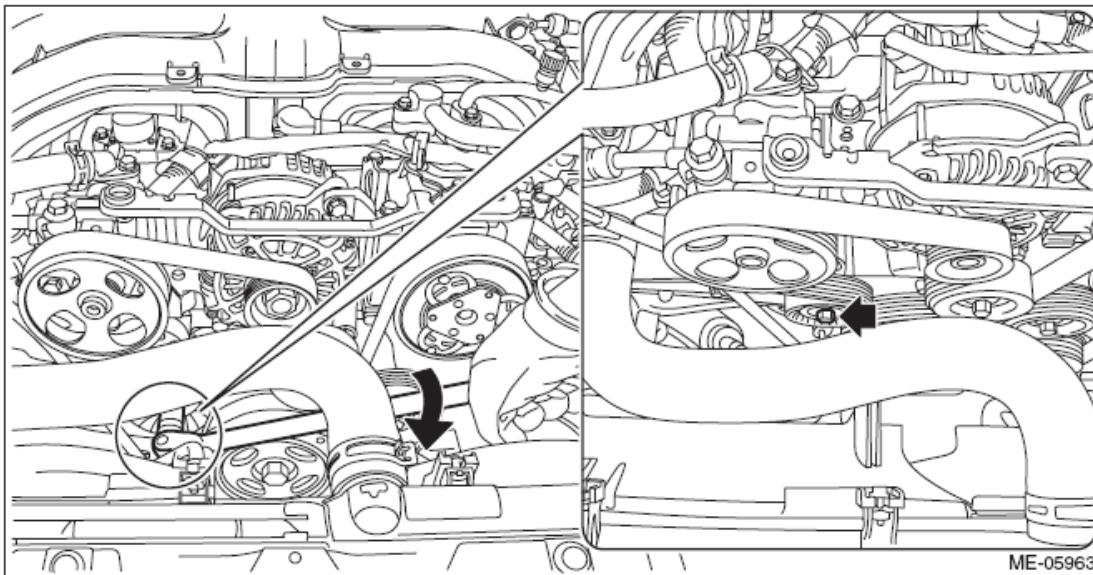
### V-BELT

1. Remove the V-belt covers.



**Fig. 81: Locating V-Belt Cover Bolt**  
Courtesy of SUBARU OF AMERICA, INC.

2. Remove the air intake duct (rear). < Refer to **REMOVAL** , Air Intake Duct. >
3. Attach the tool to the V-belt tensioner assembly, and rotate the tool clockwise to loosen and remove the V-belt.

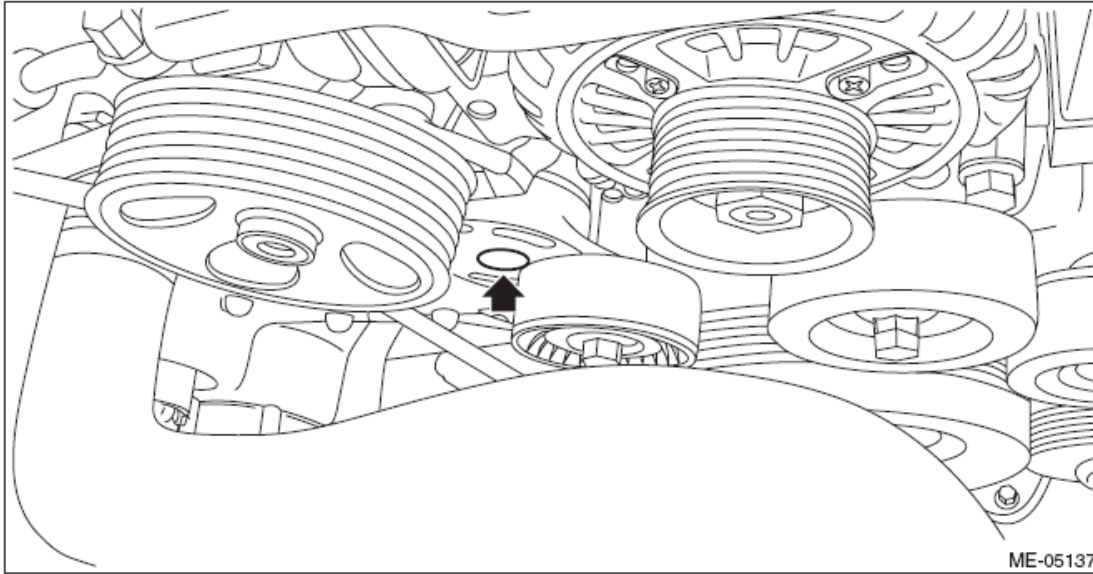


**Fig. 82: Removing V-Belt Using Tool**  
Courtesy of SUBARU OF AMERICA, INC.

#### V-BELT TENSIONER ASSEMBLY AND IDLER PULLEY

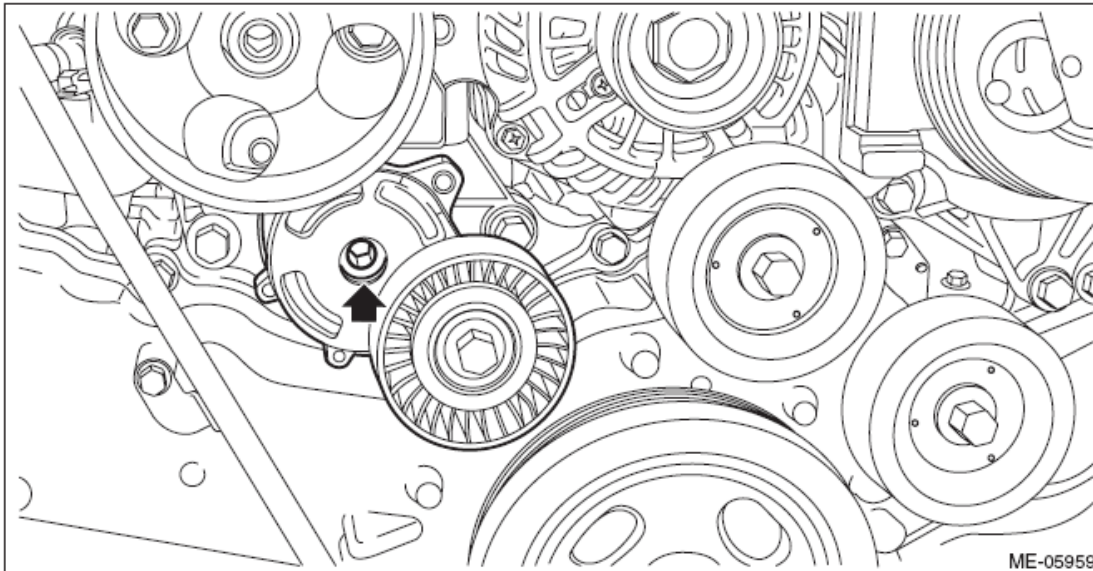
1. Remove the V-belts. < Refer to **V-BELT**, REMOVAL, V-belt. >

2. Remove the cap from V-belt tensioner assembly.



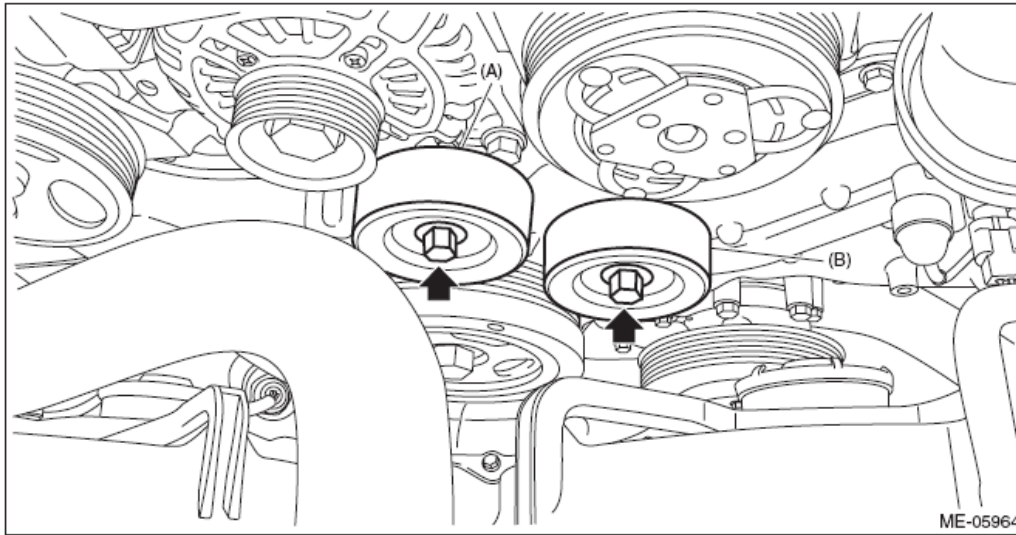
**Fig. 83: Locating V-Belt Tensioner Assembly Cap**  
Courtesy of SUBARU OF AMERICA, INC.

3. Remove the bolt securing the V-belt tensioner assembly to the power steering pump bracket, and remove the V-belt tensioner assembly.



**Fig. 84: Locating V-Belt Tensioner Assembly Bolt**  
Courtesy of SUBARU OF AMERICA, INC.

4. Remove the bolts which secure the idler pulley to the chain cover, and remove the idler pulley.



(A) Idler pulley A

(B) Idler pulley B

**Fig. 85: Identifying Idler Pulley Mounting Bolts (A And B)****Courtesy of SUBARU OF AMERICA, INC.**

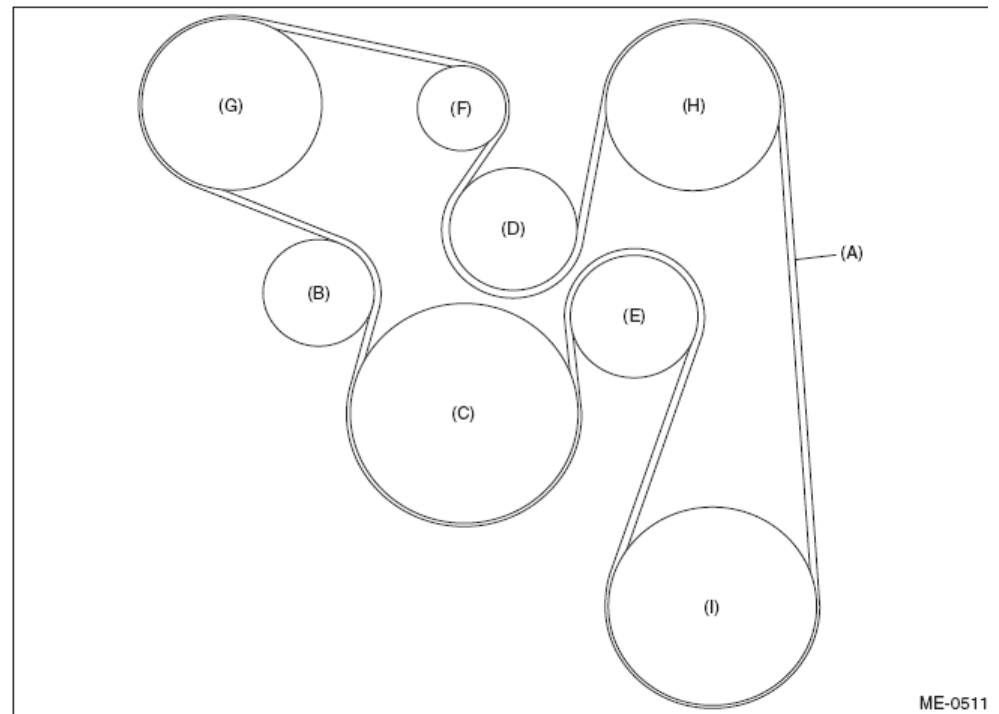
## INSTALLATION

### V-BELT

Install in the reverse order of removal.

#### **CAUTION:**

- When reusing the V-belt, wipe off dust and water with cloth.
- Do not use the V-belt if there is any oil, grease or coolant on the belt.
- Be careful not to rub the V-belt end surface with bare hands; exposed core may cause injury.
- Wipe off any dust, oil and water on the groove of each pulley with cloth.



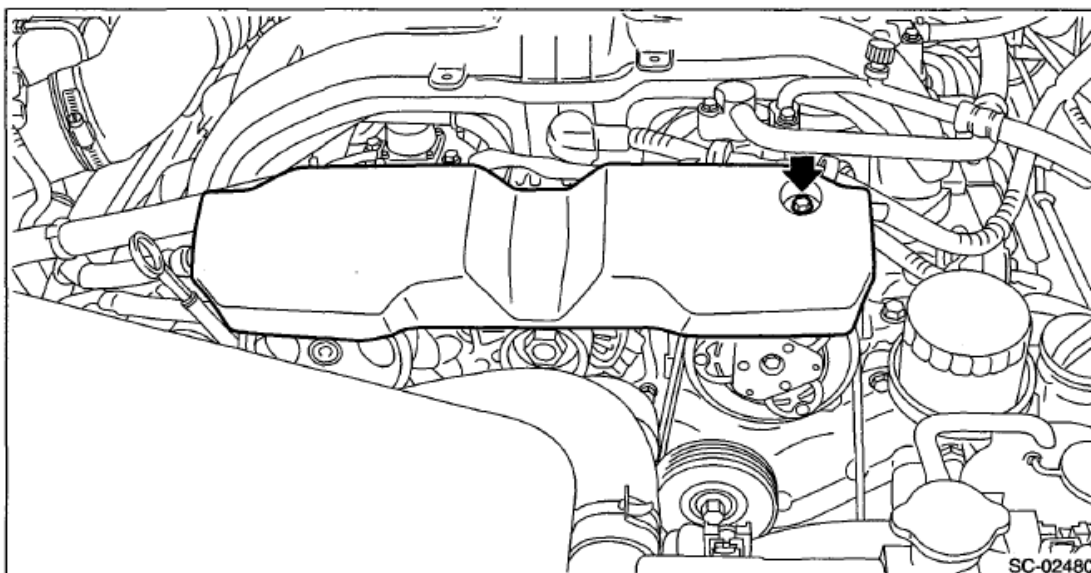
ME-0511

- |                           |                      |                                |
|---------------------------|----------------------|--------------------------------|
| (A) V-belt                | (D) Idler pulley A   | (G) Power steering pump pulley |
| (B) V-belt tensioner ASSY | (E) Idler pulley B   | (H) A/C compressor pulley      |
| (C) Crank pulley          | (F) Generator pulley | (I) Water pump pulley          |

**Fig. 86: V-Belt Routing Diagram**  
**Courtesy of SUBARU OF AMERICA, INC.**

### *Tightening torque:*

**13 N.m (1.3 kgf-m, 9.6 ft-lb)**



SC-02480

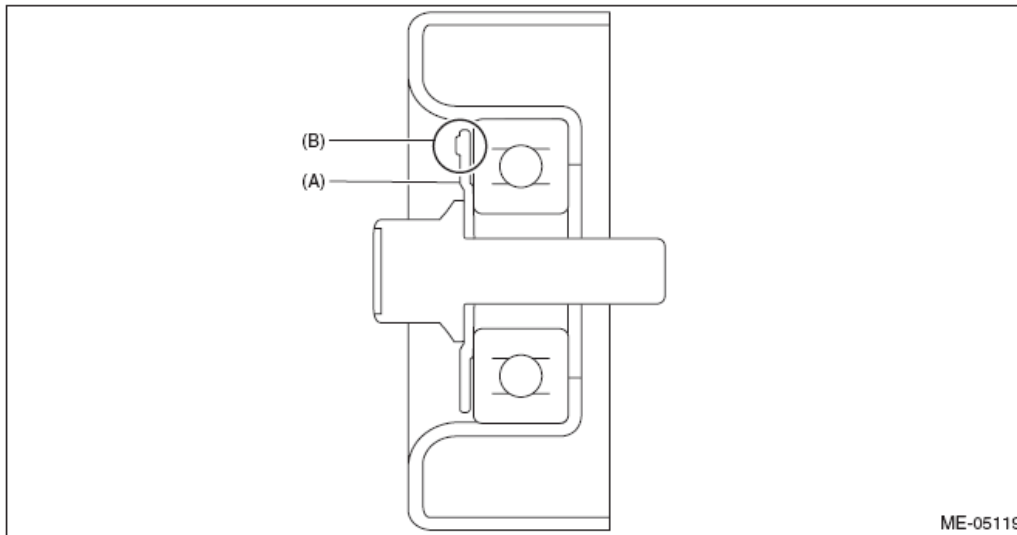
**Fig. 87: Locating V-Belt Cover Bolt**

Courtesy of SUBARU OF AMERICA, INC.

**V-BELT TENSIONER ASSEMBLY AND IDLER PULLEY**

1. Install the idler pulley to the chain cover.

**NOTE:** When installing the idler pulley, be careful of the idler pulley cover direction.



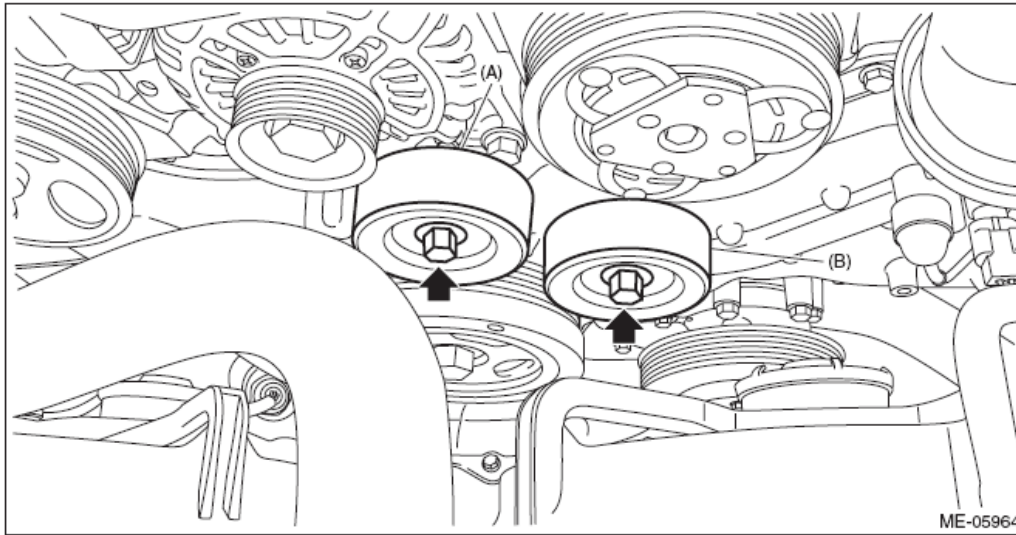
(A) Idler pulley cover

(B) Protrusion (3 places)

**Fig. 88: Identifying Protrusion And Idler Pulley Cover**

Courtesy of SUBARU OF AMERICA, INC.

*Tightening torque:***36 N.m (3.7 kgf-m, 26.6 ft-lb)**



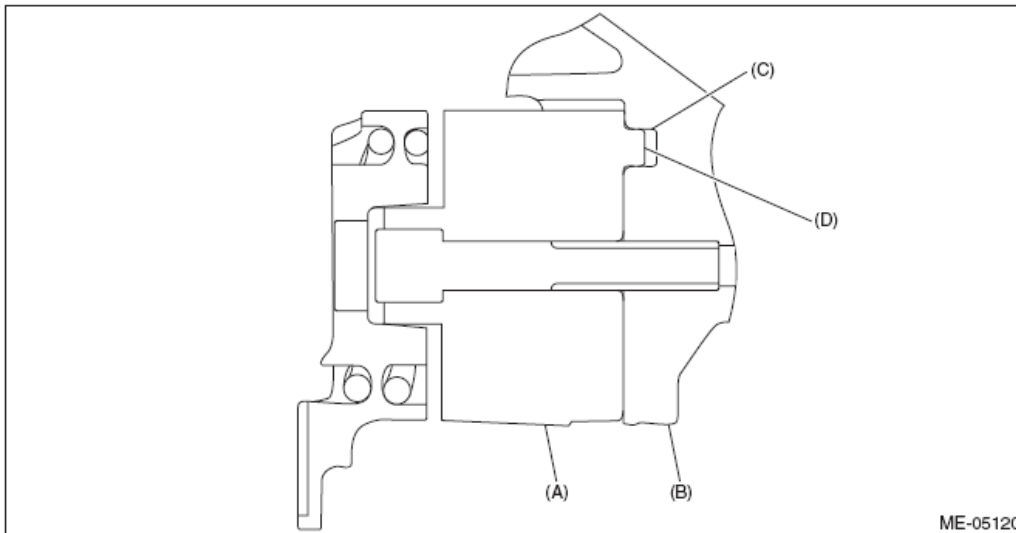
(A) Idler pulley A

(B) Idler pulley B

**Fig. 89: Identifying Idler Pulley Mounting Bolts (A And B)**  
Courtesy of SUBARU OF AMERICA, INC.

2. Install the V-belt tensioner assembly onto the power steering pump bracket.

**NOTE:** When installing the V-belt tensioner assembly, insert the protrusion of V-belt tensioner assembly into the hole at the power steering pump bracket to prevent rotating.

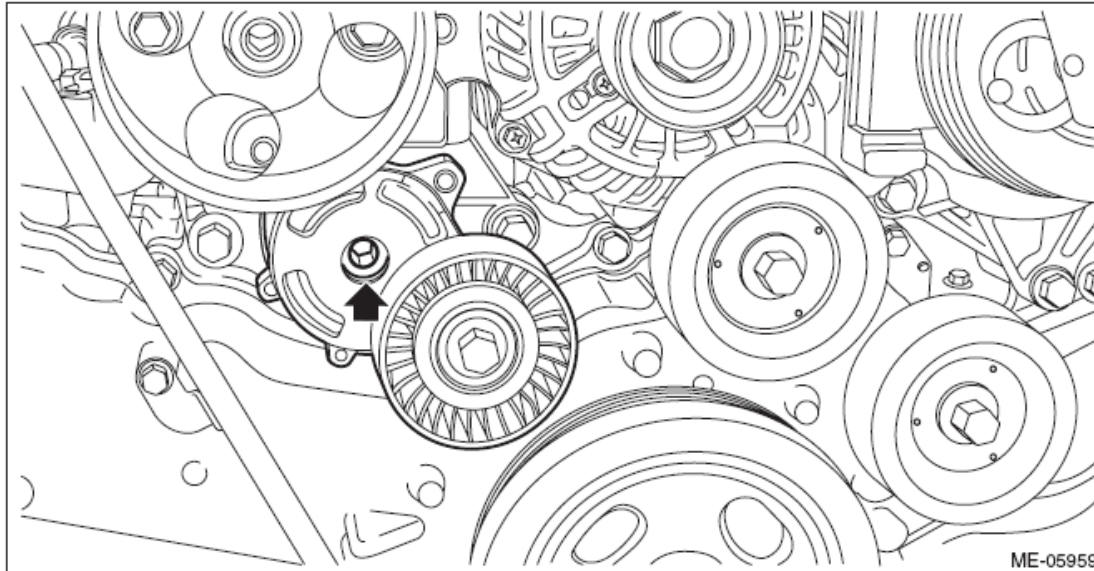


(A) V-belt tensioner ASSY  
(B) Power steering bracket

(C) Hole to prevent rotation

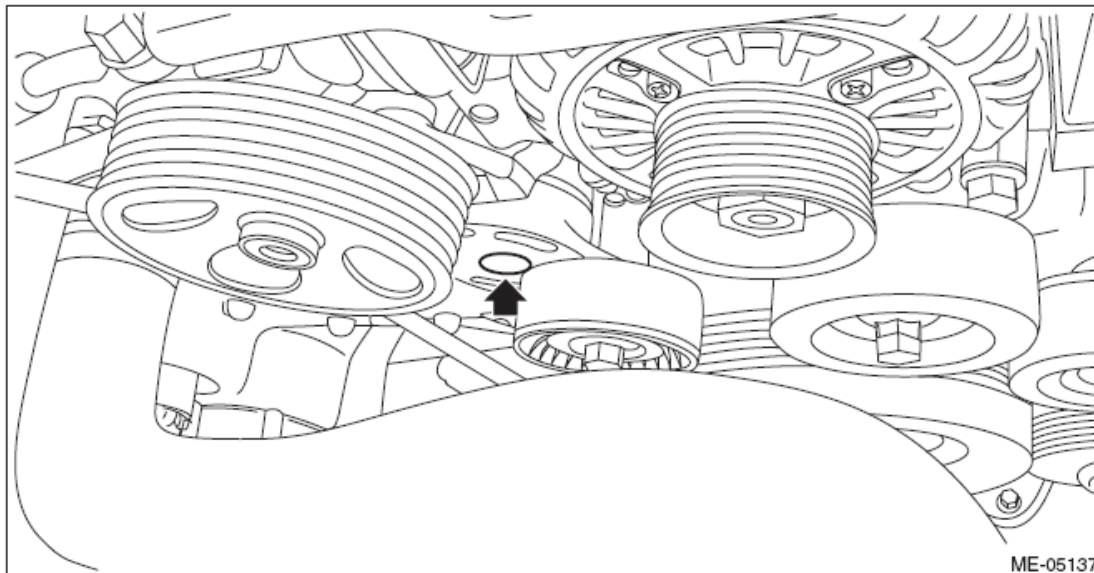
(D) Protrusion portion

**Fig. 90: Identifying V-Belt Tensioner Assembly, Hole, Protrusion Portion And Power Steering Bracket**  
Courtesy of SUBARU OF AMERICA, INC.

***Tightening torque:******25 N.m (2.5 kgf-m, 18.4 ft-lb)***

**Fig. 91: Locating V-Belt Tensioner Assembly Bolt**  
Courtesy of SUBARU OF AMERICA, INC.

3. Install the cap to the V-belt tensioner assembly.

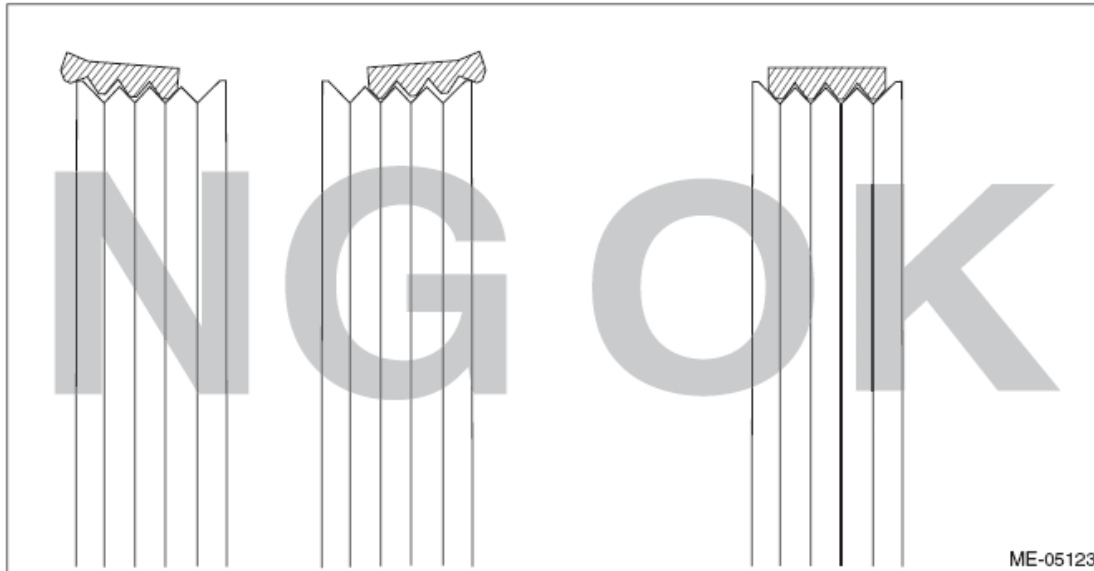


**Fig. 92: Locating V-Belt Tensioner Assembly Cap**  
Courtesy of SUBARU OF AMERICA, INC.

4. Install the V-belts. < Refer to **V-BELT**, INSTALLATION, V-belt. >

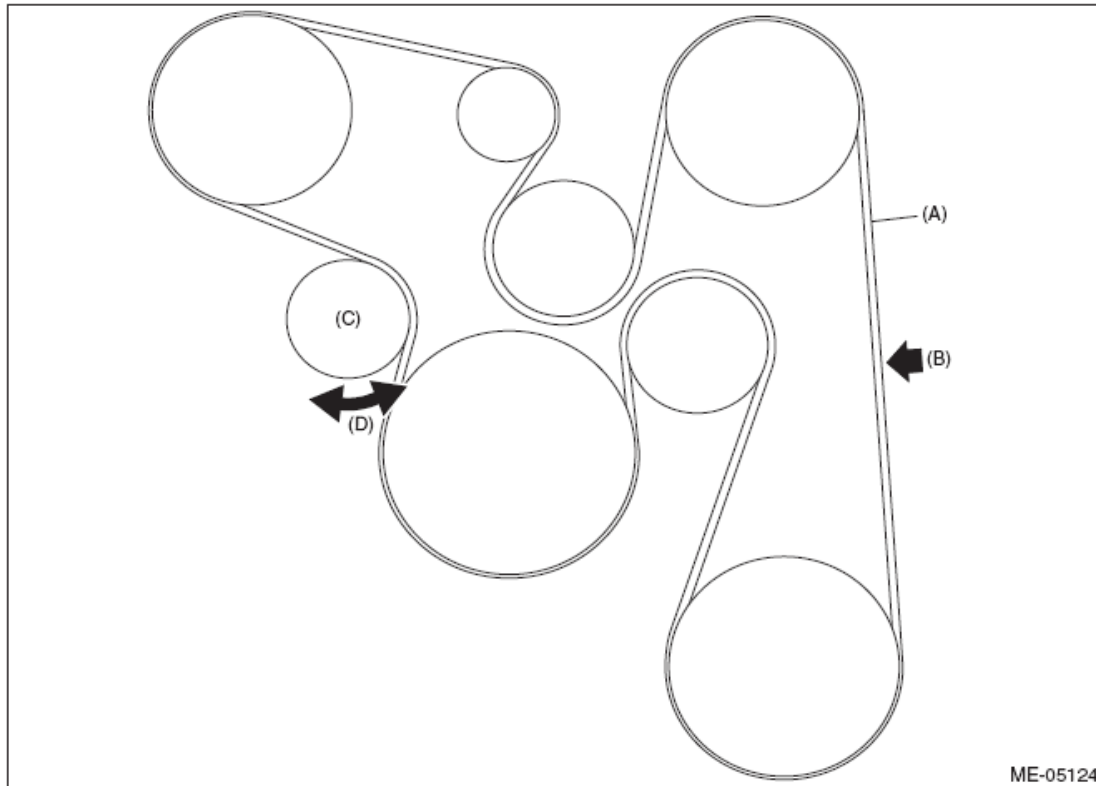
**INSPECTION**

1. Check the V-belt for cracks, tear or wear.
2. Check the V-belt tensioner assembly and idler pulley for deformation, cracks or other damages.
3. Check that the V-belt ribs are securely placed on the rib grooves for each pulleys.



**Fig. 93: Identifying Proper And Improper Condition Of V-Belt**  
Courtesy of SUBARU OF AMERICA, INC.

4. Check that the V-belt tensioner assembly (C) moves in the direction of arrow (D), when the V-belt (A) is pushed and released by the area indicated by the arrow (B).



**Fig. 94: Checking V-Belt Tensioner Assembly**  
Courtesy of SUBARU OF AMERICA, INC.

## CRANK PULLEY

### REMOVAL

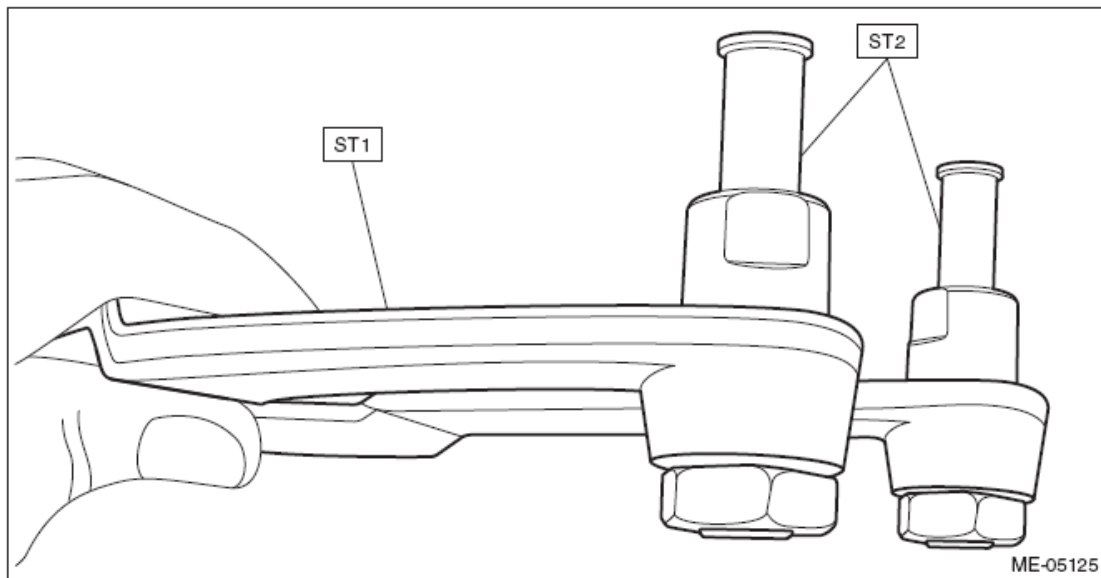
**NOTE:** When replacing a single part, perform the work with the engine assembly installed to body.

1. Remove the V-belts. < Refer to **REMOVAL**, V-belt. >
2. Remove the radiator sub fan and fan motor. < Refer to **REMOVAL**, Radiator Sub Fan and Fan Motor. >
3. Use the ST to lock the crank pulley, and remove the crank pulley bolt.

**NOTE:** To prevent damaging ST1, attach the ST2 onto the ST1 as shown.

ST1 18355AA000 PULLEY WRENCH

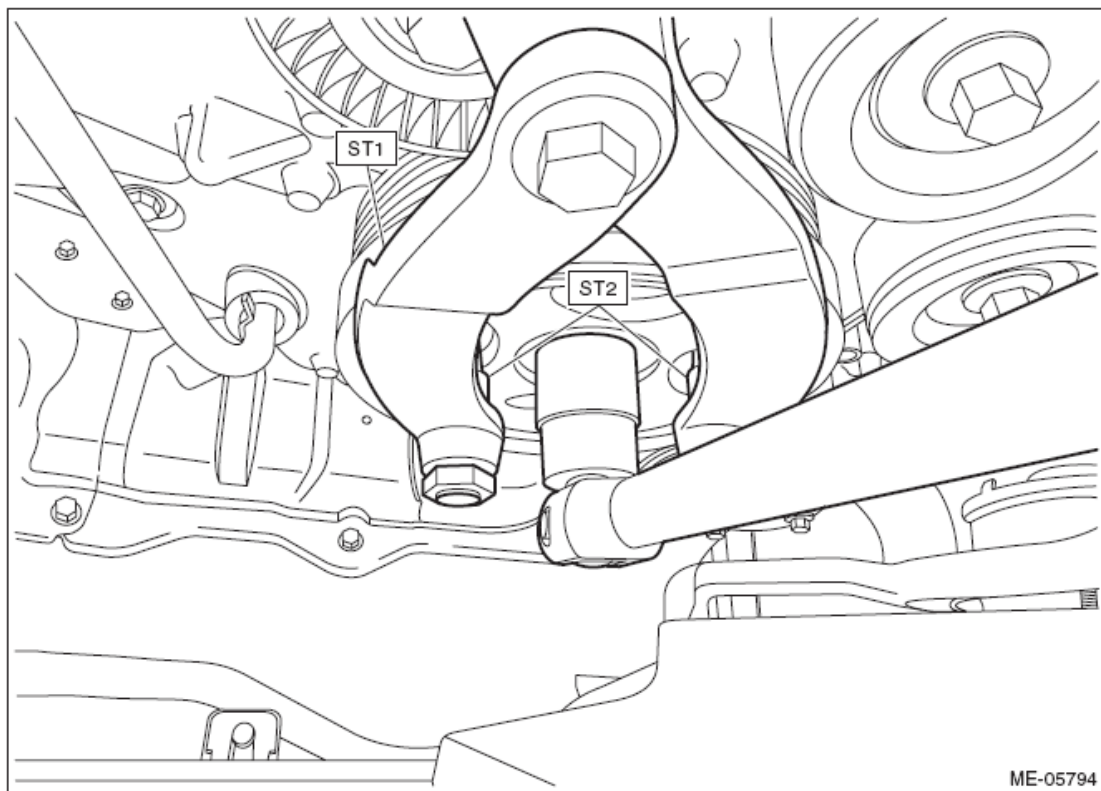
ST2 18334AA000 PULLEY WRENCH PIN SET



**Fig. 95: Connecting Pulley Wrench Pin Set On Pulley Wrench**  
Courtesy of SUBARU OF AMERICA, INC.

ST1 18355AA000 PULLEY WRENCH

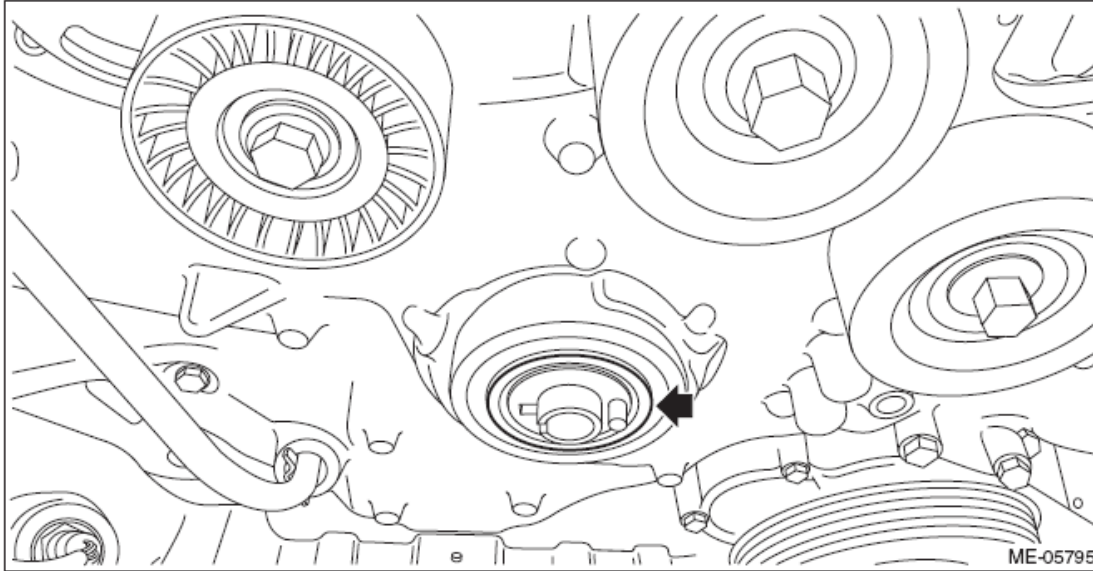
ST2 18334AA000 PULLEY WRENCH PIN SET



**Fig. 96: Removing Crank Pulley Bolt Using Tools**

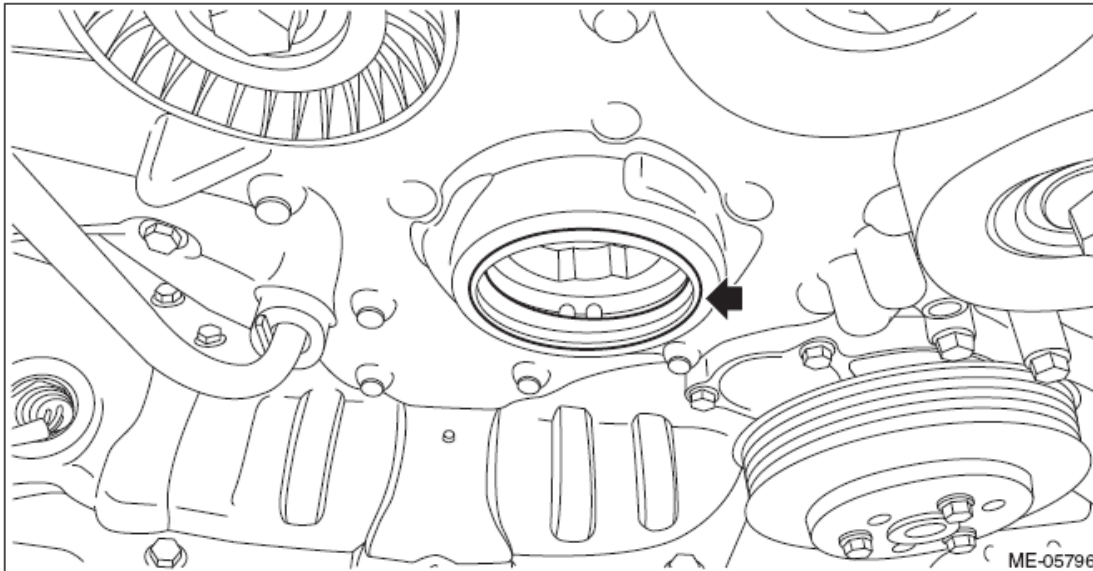
Courtesy of SUBARU OF AMERICA, INC.

4. Remove the crank pulley and remove the crank pulley boss.



**Fig. 97: Locating Crank Pulley Boss**  
Courtesy of SUBARU OF AMERICA, INC.

5. Remove the front oil seal.



**Fig. 98: Locating Front Oil Seal**  
Courtesy of SUBARU OF AMERICA, INC.

## INSTALLATION

# METHOD WITHOUT ANGLE GAUGE

1. Apply a light coat of engine oil to the front oil seal inner periphery and outer periphery, and install the front oil seal using ST.

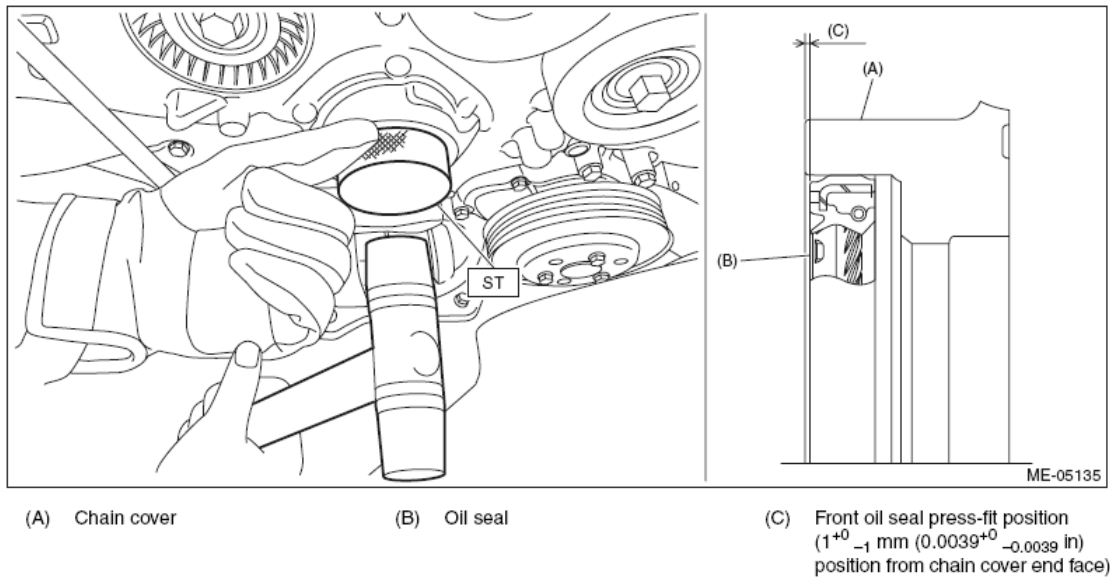
## NOTE:

- Use a new front oil seal.
- When tapping the front oil seal in, protect the radiator fin with cardboards etc. so as not to damage the radiator fin by the plastic hammer.

ST 398437700 OIL SEAL INSTALLER

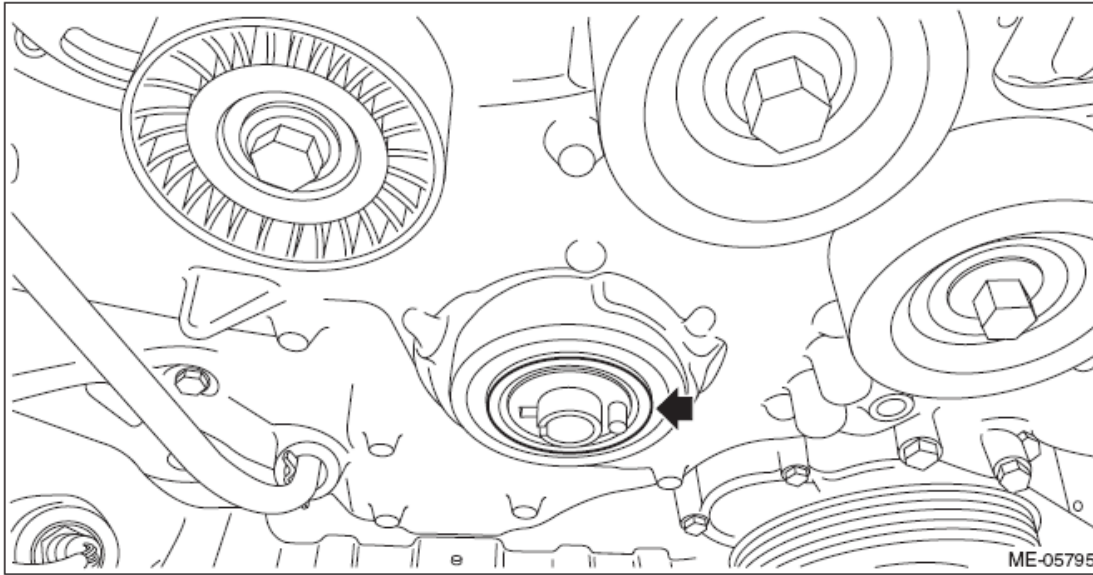
*Front oil seal press-fit position:*

*$1^{+0}_{-1}$  mm ( $0.0039^{+0}_{-0.0039}$  in) position from chain cover end face*



**Fig. 99: Installing Front Oil Seal Using Oil Seal Installer**  
 Courtesy of SUBARU OF AMERICA, INC.

2. Clean the crankshaft thread using compressed air.
3. Install the crank pulley boss.

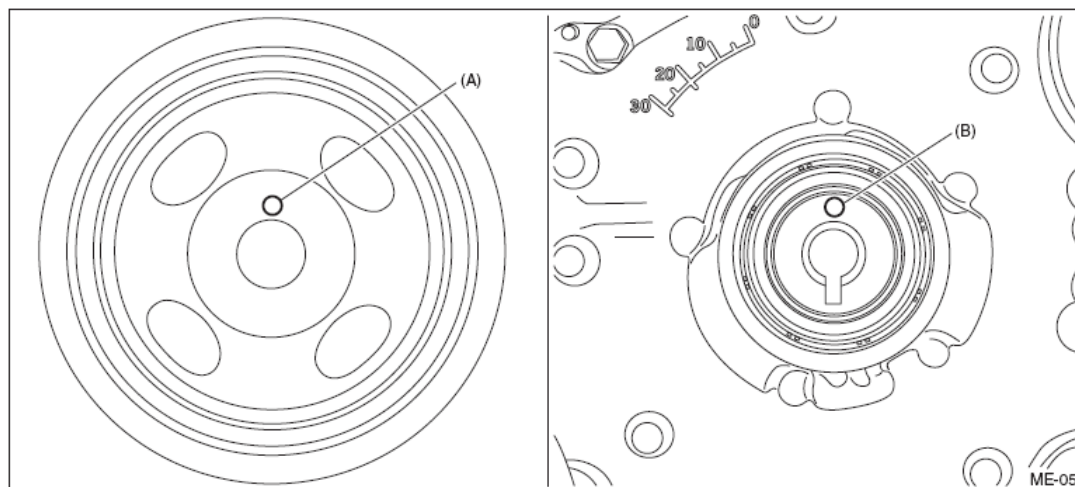


**Fig. 100: Locating Crank Pulley Boss**  
Courtesy of SUBARU OF AMERICA, INC.

4. Apply engine oil to the crank pulley bolt seat and thread.
5. Install the crank pulley.
  1. Install the crank pulley to the crank pulley boss.

**NOTE:**

- Use new O-rings.
- Install the crank pulley by aligning the crank pulley knock hole (A) and crank pulley boss knock pin (B).



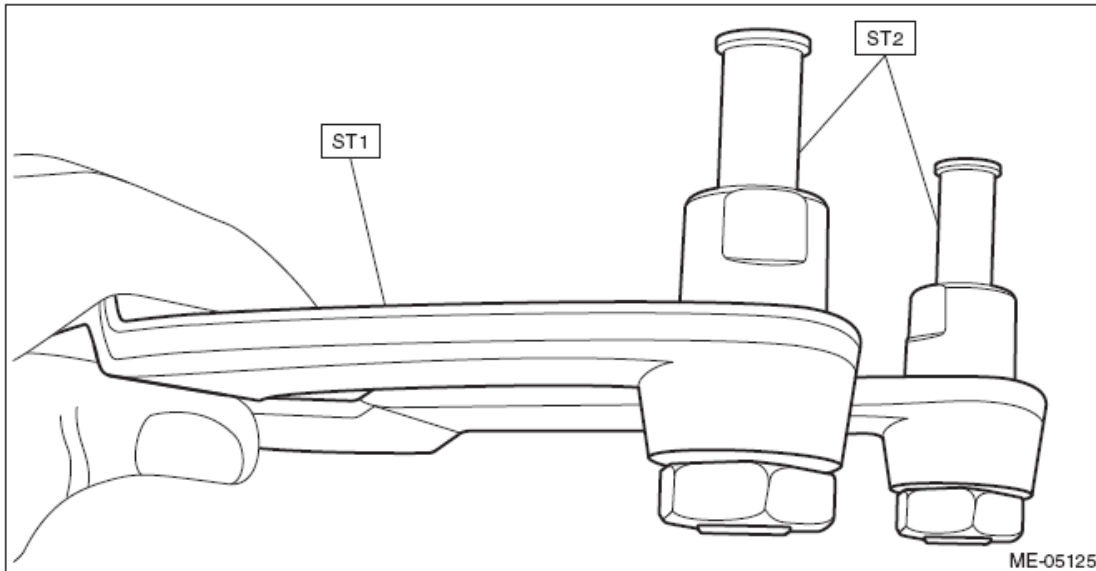
**Fig. 101: Identifying Alignment Marks On Crank Pulley Knock Hole And Crank Knock Pin**  
Courtesy of SUBARU OF AMERICA, INC.

2. Use the ST to lock the crank pulley, and temporarily tighten the crank pulley bolt.

**NOTE:** To prevent damaging ST1, attach the ST2 onto the ST1 as shown.

ST1 18355AA000 PULLEY WRENCH

ST2 18334AA000 PULLEY WRENCH PIN SET



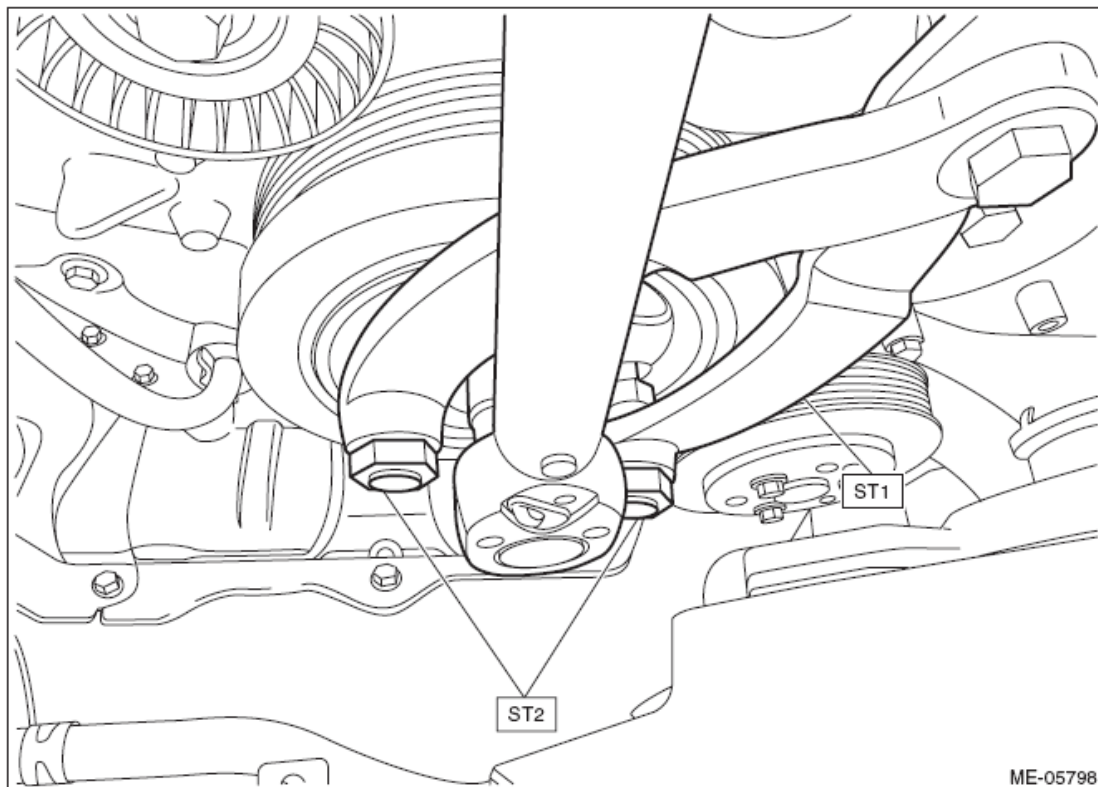
**Fig. 102: Connecting Pulley Wrench Pin Set On Pulley Wrench**  
Courtesy of SUBARU OF AMERICA, INC.

ST1 18355AA000 PULLEY WRENCH

ST2 18334AA000 PULLEY WRENCH PIN SET

***Tightening torque:***

***60 N.m (6.1 kgf-m, 44.3 ft-lb)***



**Fig. 103: Tightening Crank Pulley Bolt Using ST**  
Courtesy of SUBARU OF AMERICA, INC.

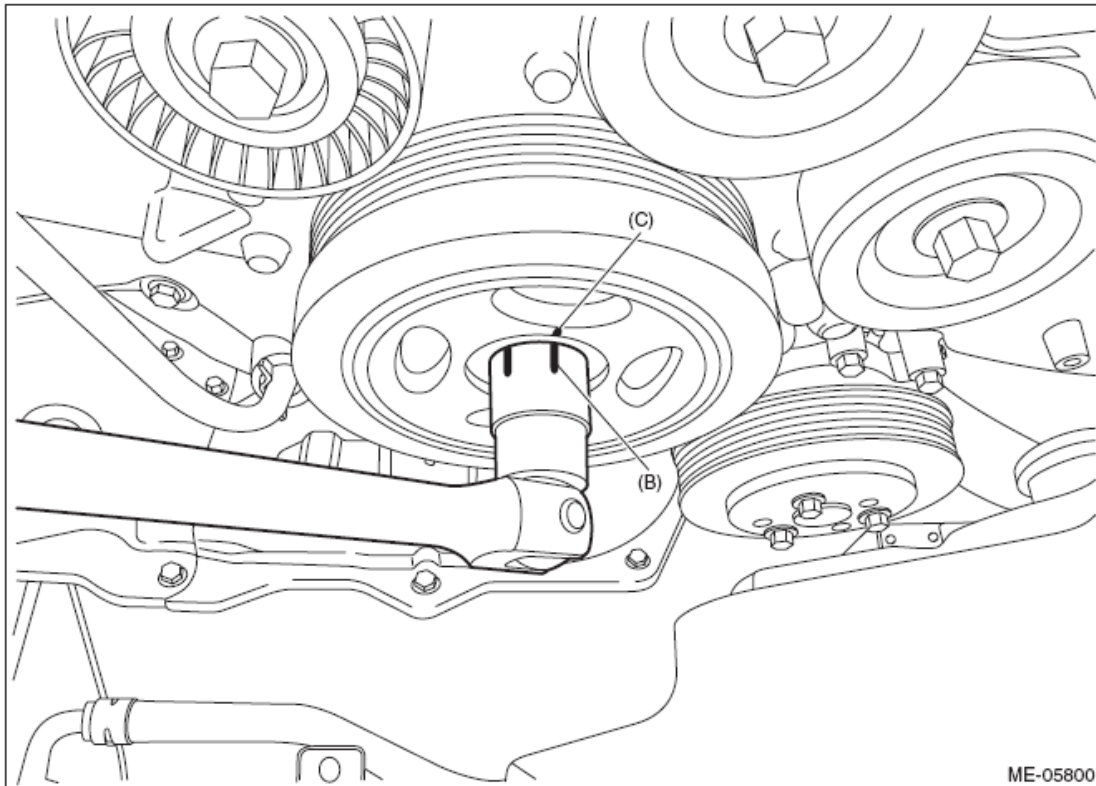
3. Draw reference lines (A) and (B) using a marker to set the socket to the crank pulley bolt as shown in the figure.

**NOTE:** Set the socket onto the crank pulley bolt so that reference lines (A) and (B) is visible.



Courtesy of SUBARU OF AMERICA, INC.

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**Fig. 105: Drawing End Line On Crank Pulley Using Marker**  
Courtesy of SUBARU OF AMERICA, INC.

5. Use the ST to lock the crank pulley, and tighten the crank pulley bolt to the angle where reference line (A) and end line (C) are aligned.

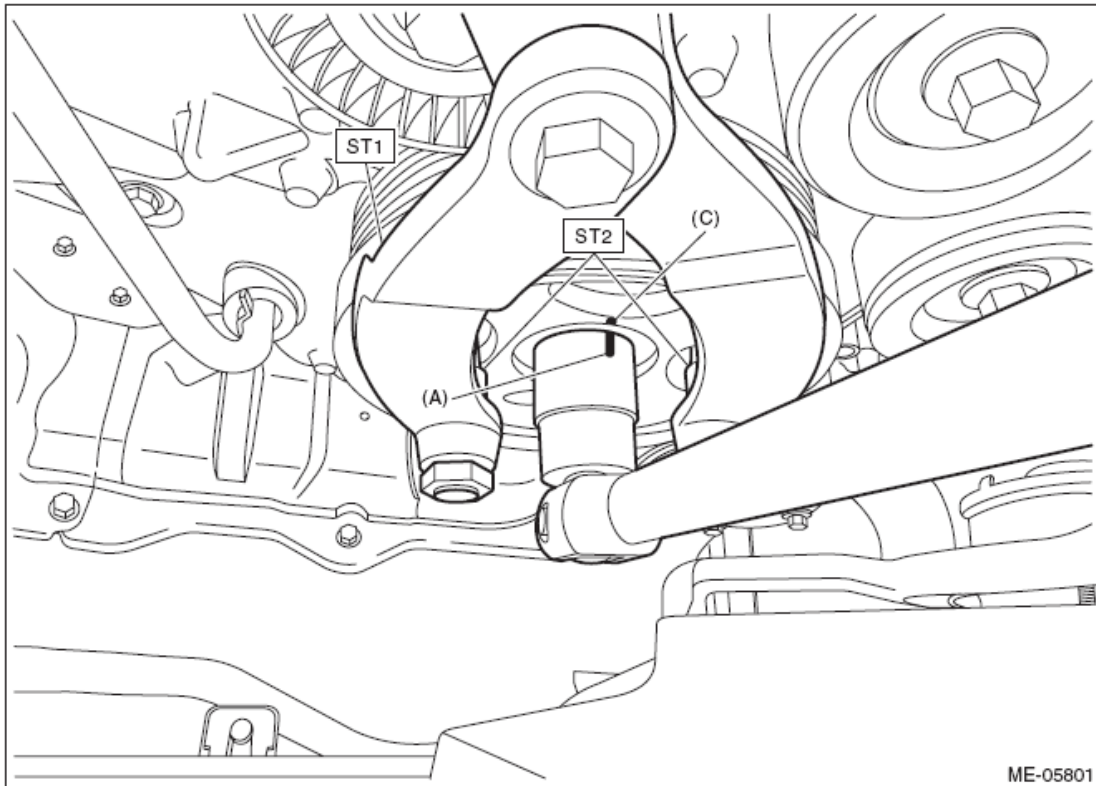
**NOTE:** It should be approx. 60° when reference line (A) and end line (C) are aligned.

ST1 18355AA000 PULLEY WRENCH

ST2 18334AA000 PULLEY WRENCH PIN SET

***Tightening angle:***

***60°±5°***



**Fig. 106: Tightening Crank Pulley Bolt**  
Courtesy of SUBARU OF AMERICA, INC.

6. Install the radiator sub fan and fan motor. < Refer to **INSTALLATION** , Radiator Sub Fan and Fan Motor. >
7. Install the V-belts. < Refer to **INSTALLATION**, V-belt. >

#### METHOD WITH ANGLE GAUGE

1. Apply a light coat of engine oil to the front oil seal inner periphery and outer periphery, and install the front oil seal using ST.

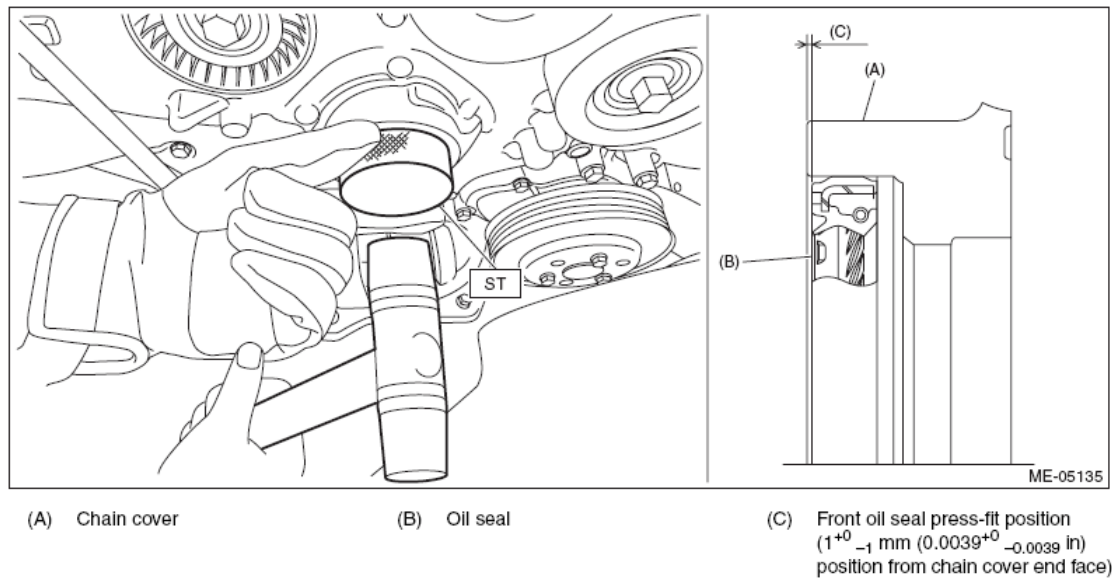
#### NOTE:

- Use a new front oil seal.
- When tapping the front oil seal in, protect the radiator fin with cardboards etc. so as not to damage the radiator fin by the plastic hammer.

ST 398437700 OIL SEAL INSTALLER

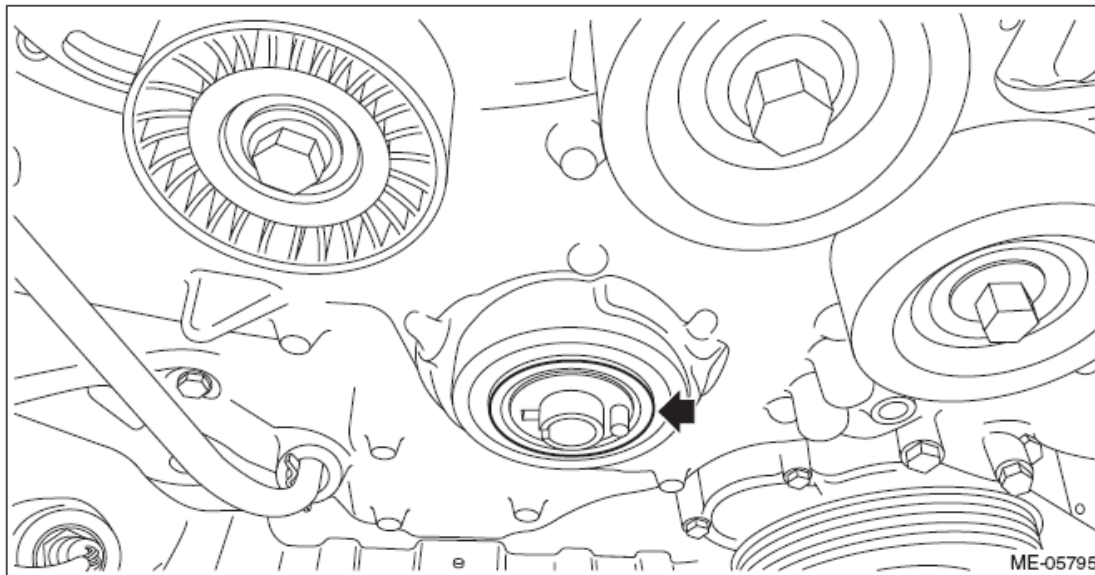
*Front oil seal press-fit position:*

$1^{+0}_{-1}$  mm ( $0.0039^{+0}_{-0.0039}$  in) position from chain cover end face



**Fig. 107: Installing Front Oil Seal Using Oil Seal Installer**  
 Courtesy of SUBARU OF AMERICA, INC.

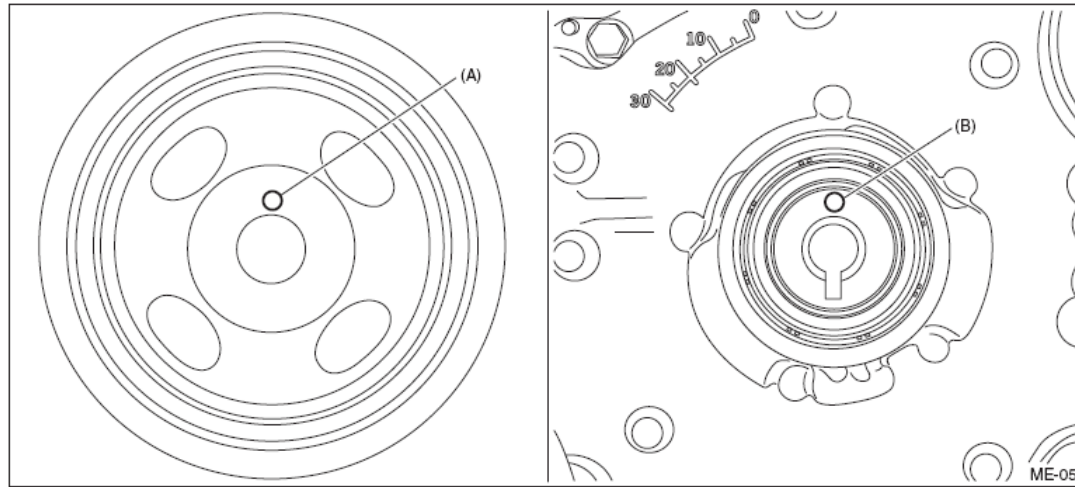
2. Clean the crankshaft thread using compressed air.
3. Install the crank pulley boss.



**Fig. 108: Locating Crank Pulley Boss**  
 Courtesy of SUBARU OF AMERICA, INC.

4. Apply engine oil to the crank pulley bolt seat and thread.
5. Install the crank pulley.
  1. Install the crank pulley to the crank pulley boss.

- NOTE:**
- Use new O-rings.
  - Install the crank pulley by aligning the crank pulley knock hole (A) and crank pulley boss knock pin (B).



**Fig. 109: Identifying Alignment Marks On Crank Pulley Knock Hole And Crank Knock Pin**

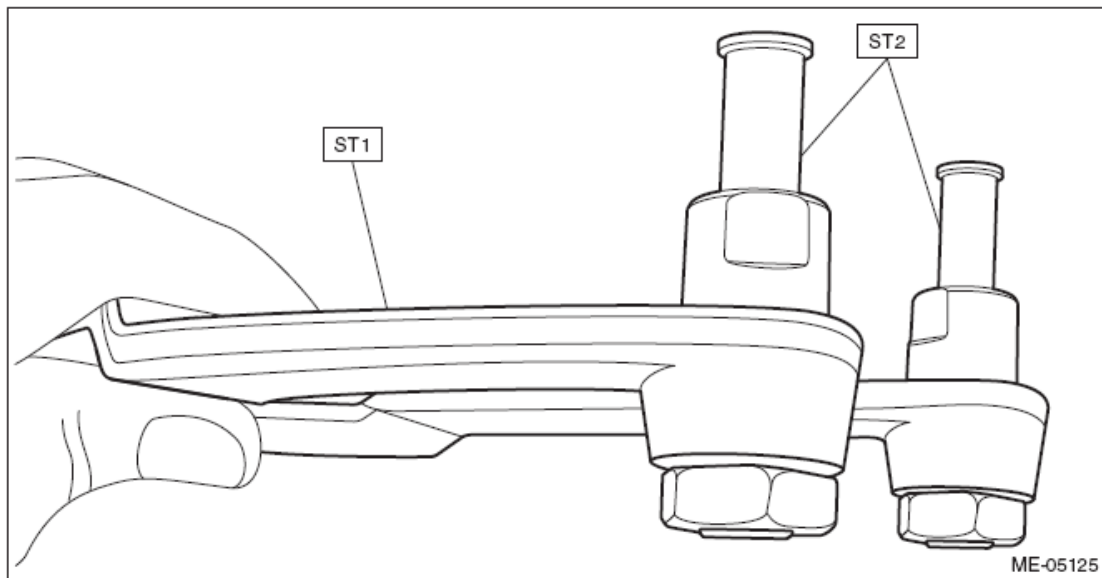
Courtesy of SUBARU OF AMERICA, INC.

2. Use the ST to lock the crank pulley, and temporarily tighten the crank pulley bolt.

**NOTE:** To prevent damaging ST1, attach the ST2 onto the ST1 as shown.

ST1 18355AA000 PULLEY WRENCH

ST2 18334AA000 PULLEY WRENCH PIN SET



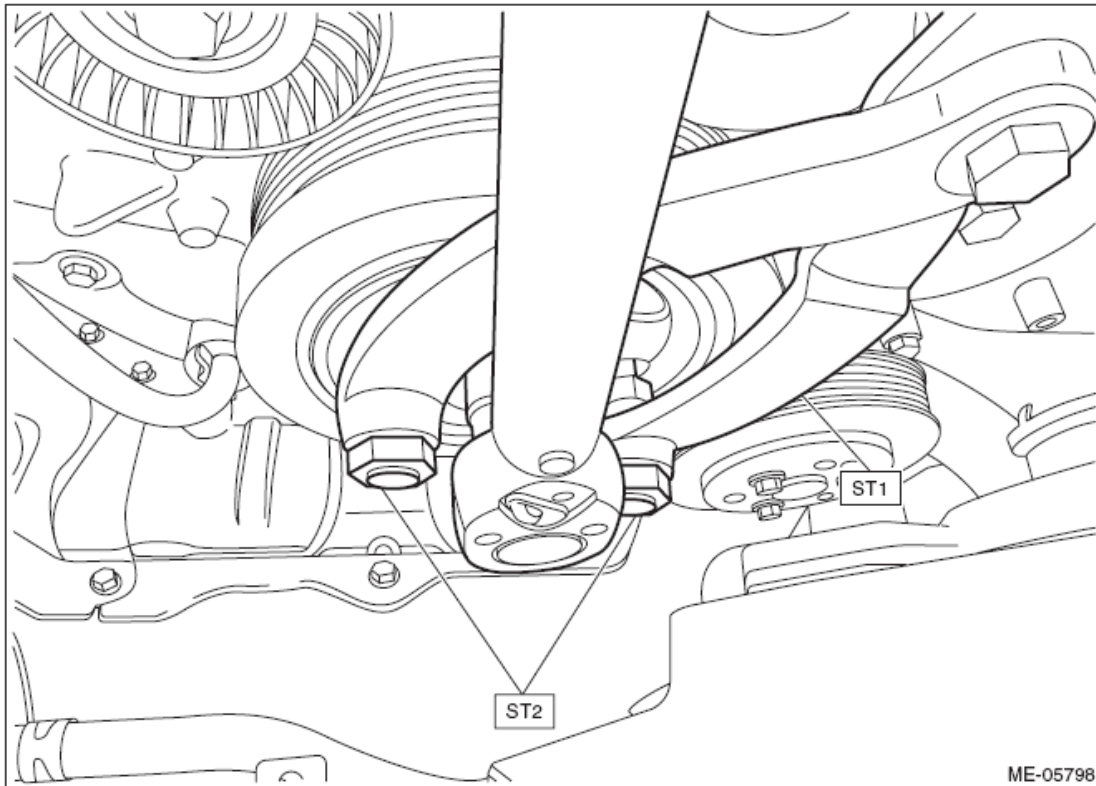
**Fig. 110: Connecting Pulley Wrench Pin Set On Pulley Wrench**  
Courtesy of SUBARU OF AMERICA, INC.

ST1 18355AA000 PULLEY WRENCH

ST2 18334AA000 PULLEY WRENCH PIN SET

***Tightening torque:***

***60 N.m (6.1 kgf-m, 44.3 ft-lb)***



**Fig. 111: Tightening Crank Pulley Bolt Using ST**  
**Courtesy of SUBARU OF AMERICA, INC.**

3. Set the ST2, use the ST1 to lock the crank pulley, and tighten the crank pulley bolt to the specified angle.

**NOTE:**        **Attach the magnet used for securing the ST3 (ANGLE GAUGE) to ST1.**

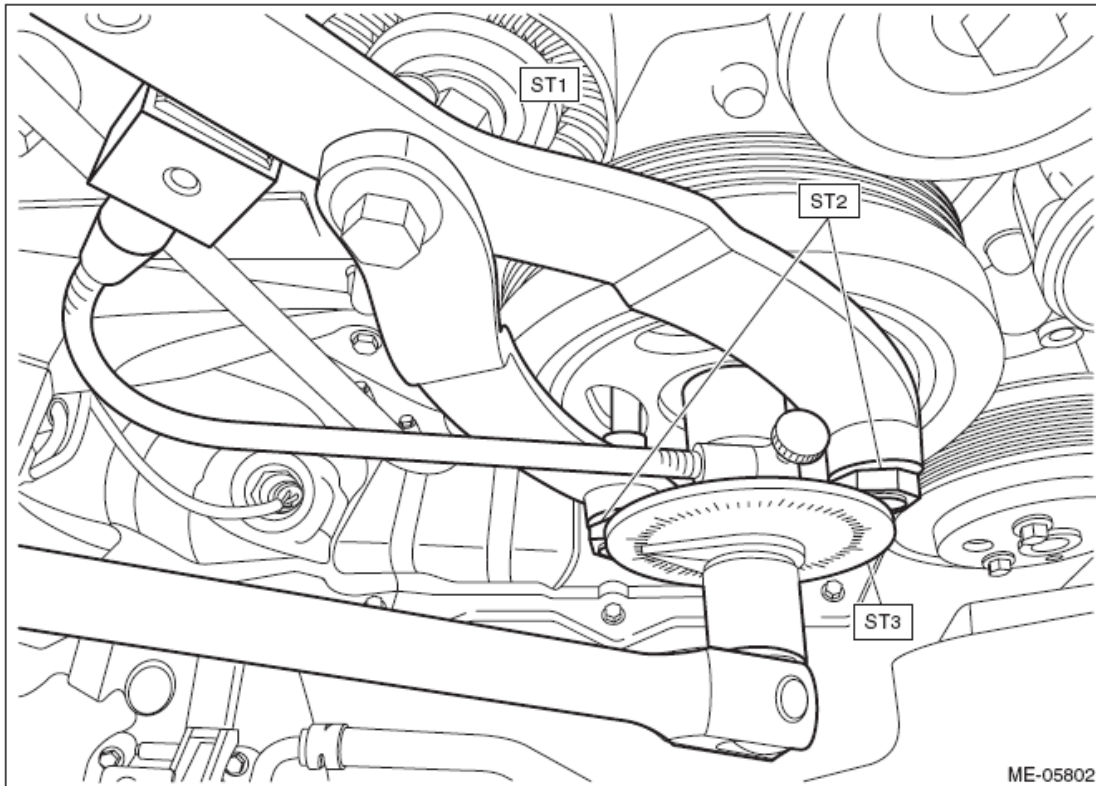
ST1 18355AA000 PULLEY WRENCH

ST2 18334AA000 PULLEY WRENCH PIN SET

ST3 18854AA000 ANGLE GAUGE

***Tightening angle:***

***60°±5°***



**Fig. 112: Tightening Crank Pulley Bolt**  
Courtesy of SUBARU OF AMERICA, INC.

6. Install the radiator sub fan and fan motor. < Refer to **INSTALLATION** , Radiator Sub Fan and Fan Motor. >
7. Install the V-belts. < Refer to **INSTALLATION**, V-belt. >

## INSPECTION

1. Check that the crank pulley has no deformation, cracks or other damages.
2. Inspect for oil leakage from the front oil seal. If there is an oil leak, replace the front oil seal with a new one. < Refer to **REMOVAL**, Crank Pulley. >

## CHAIN COVER

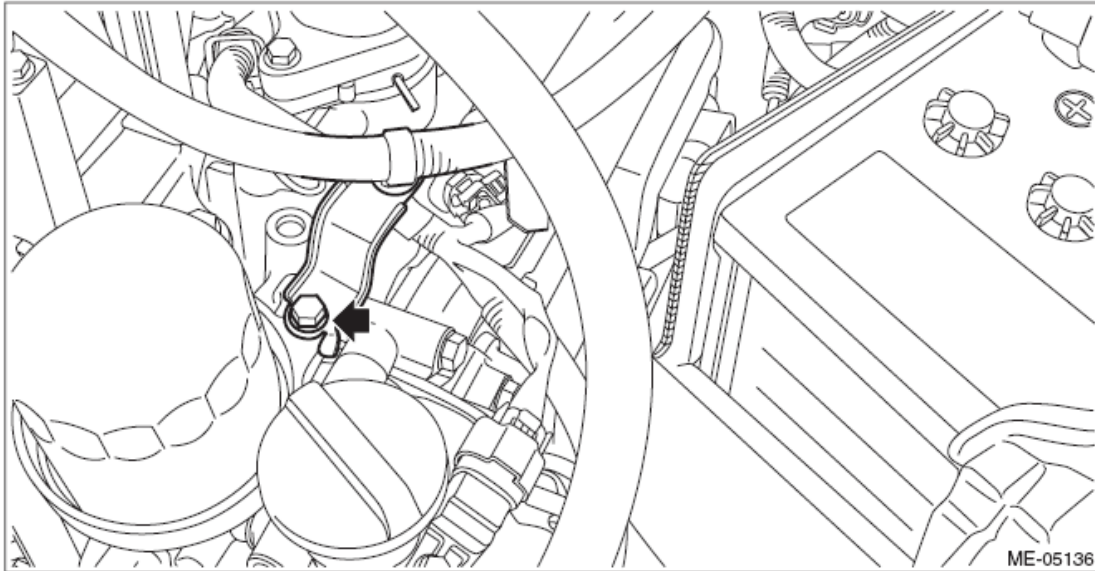
### REMOVAL

**NOTE:** When replacing a single part, perform the work with the engine assembly installed to body.

1. When working on the vehicle

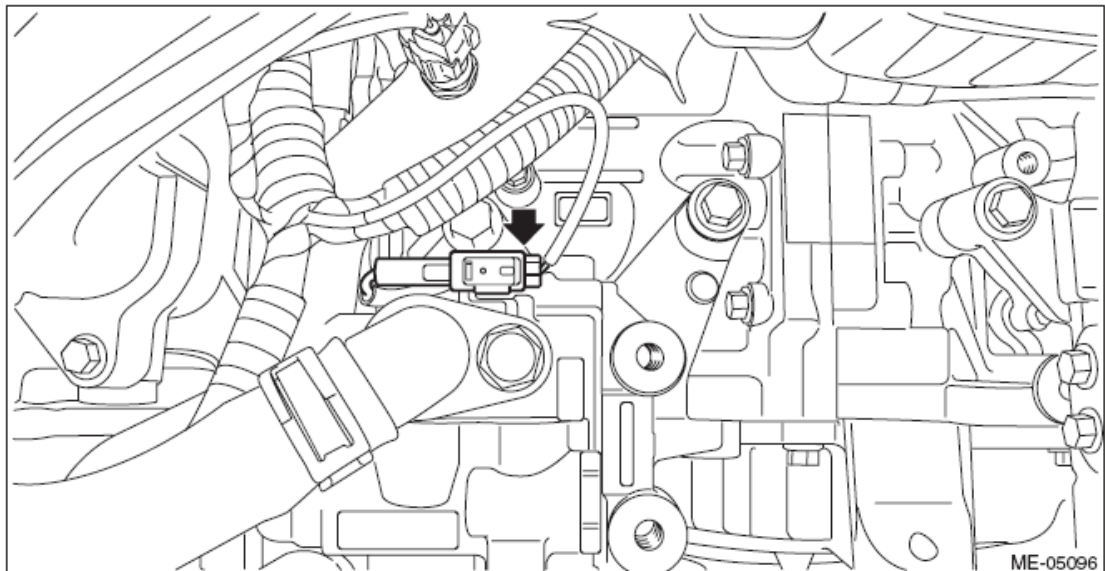
**NOTE:** When working on the vehicle, perform the following steps also.

1. Remove the radiator. < Refer to **REMOVAL** , Radiator. >
2. Remove the front exhaust pipe. < Refer to **REMOVAL** , Front Exhaust Pipe. >
3. Remove the bolts which secure the generator cord stay to the chain cover.



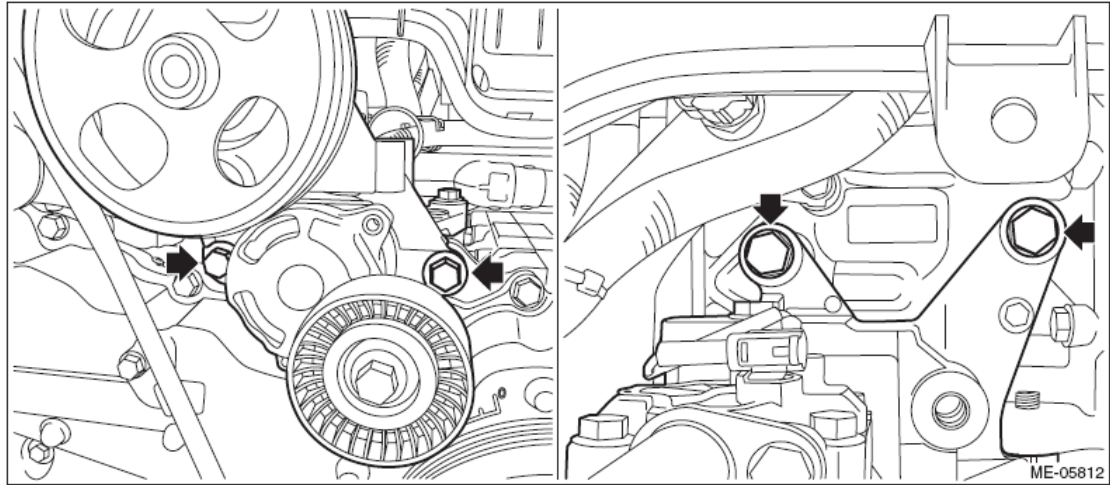
**Fig. 113: Locating Generator Cord Stay Bolt**  
Courtesy of SUBARU OF AMERICA, INC.

4. Remove the power steering pump.
  1. Remove the V-belts. < Refer to **REMOVAL** , V-belt. >
  2. Remove the generator. < Refer to **REMOVAL** , Generator. >
  3. Disconnect the connector from the power steering pump switch.



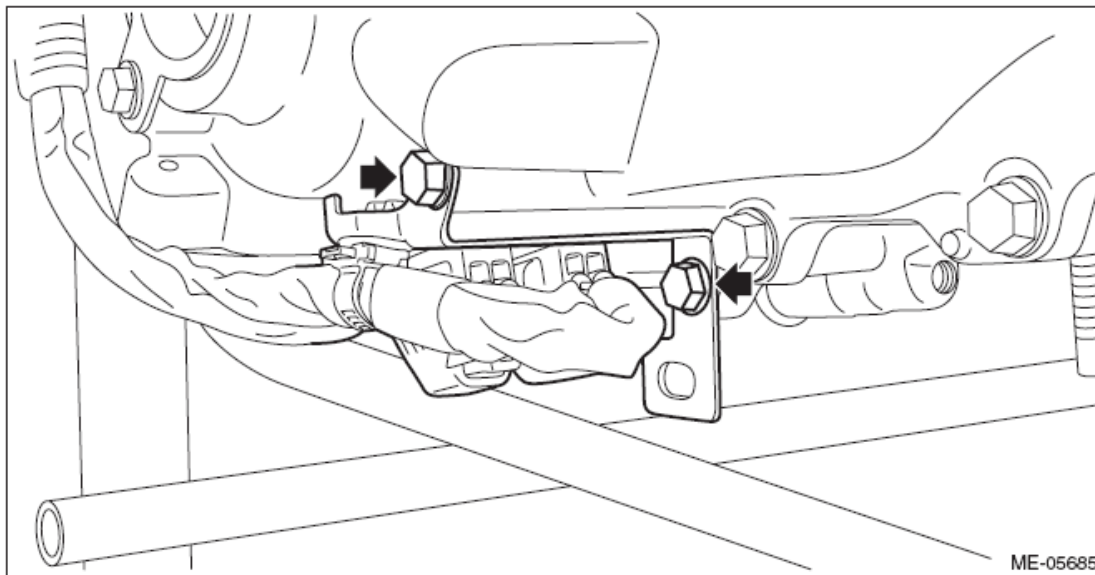
**Fig. 114: Locating Power Steering Pump Switch Connector**  
Courtesy of SUBARU OF AMERICA, INC.

4. Remove the power steering pump from the engine.



**Fig. 115: Locating Engine Power Steering Pump Mounting Bolts**  
Courtesy of SUBARU OF AMERICA, INC.

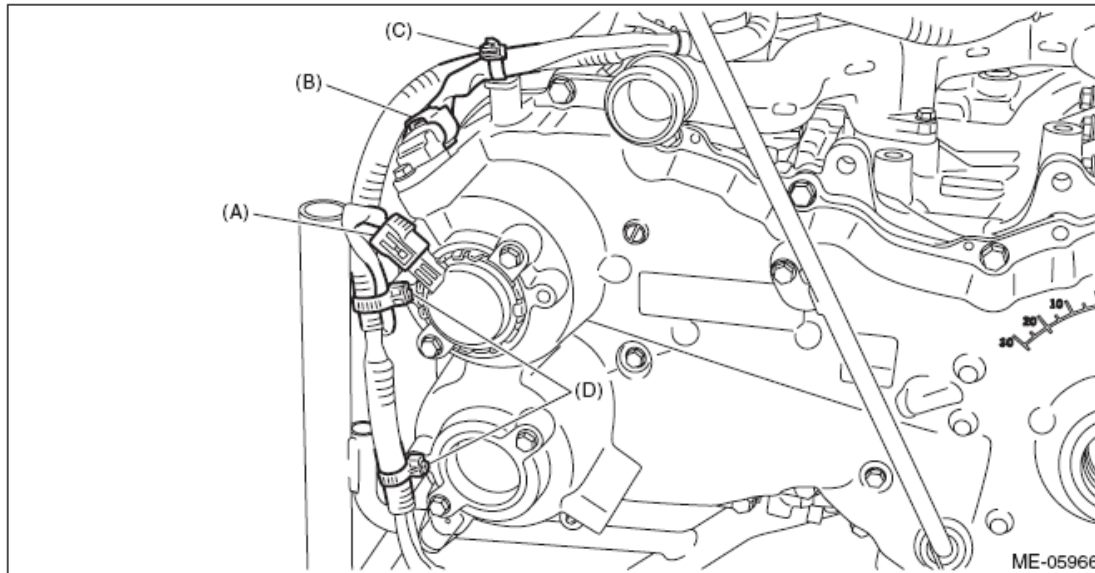
5. Place the power steering pump on the right side wheel apron.
2. Drain the engine oil. < Refer to **REPLACEMENT** , Engine Oil. >
3. Remove the water pump pulley. < Refer to **WATER PUMP** , REMOVAL, Water Pump. >
4. Remove the crank pulley. < Refer to **REMOVAL**, Crank Pulley. >
5. Remove the engine harness stay from the chain cover.



**Fig. 116: Locating Engine Harness Stay Mounting Bolts**

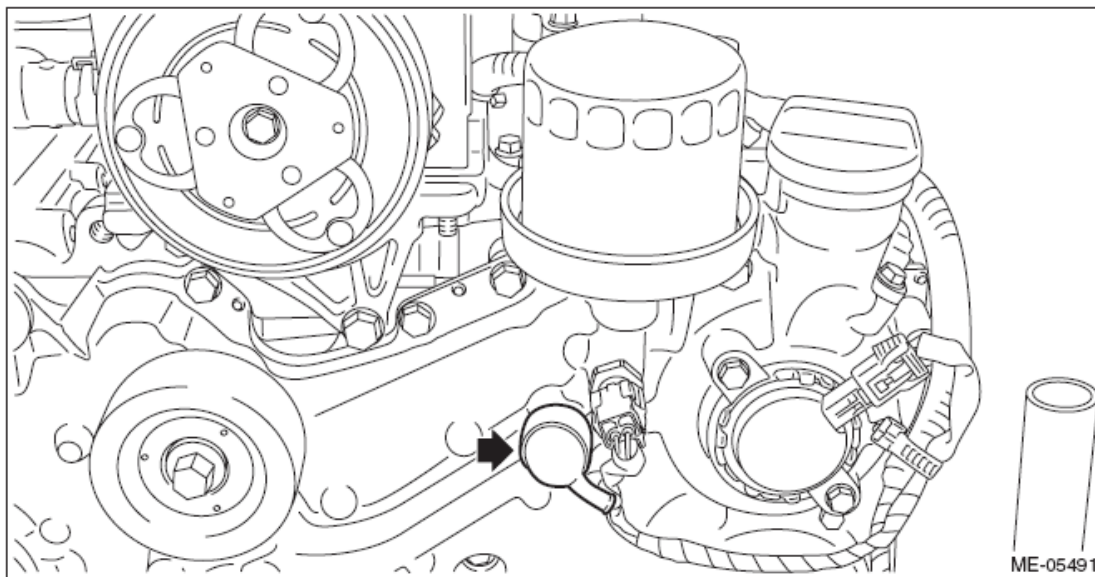
Courtesy of SUBARU OF AMERICA, INC.

6. Disconnect the connector (A) from the oil control solenoid RH, and the connector (B) from the camshaft position sensor RH, and remove the clip (C) and clip (D) which secure the engine harness.



**Fig. 117: Identifying Camshaft Position Sensor And Oil Control Solenoid Connectors And Clips**  
Courtesy of SUBARU OF AMERICA, INC.

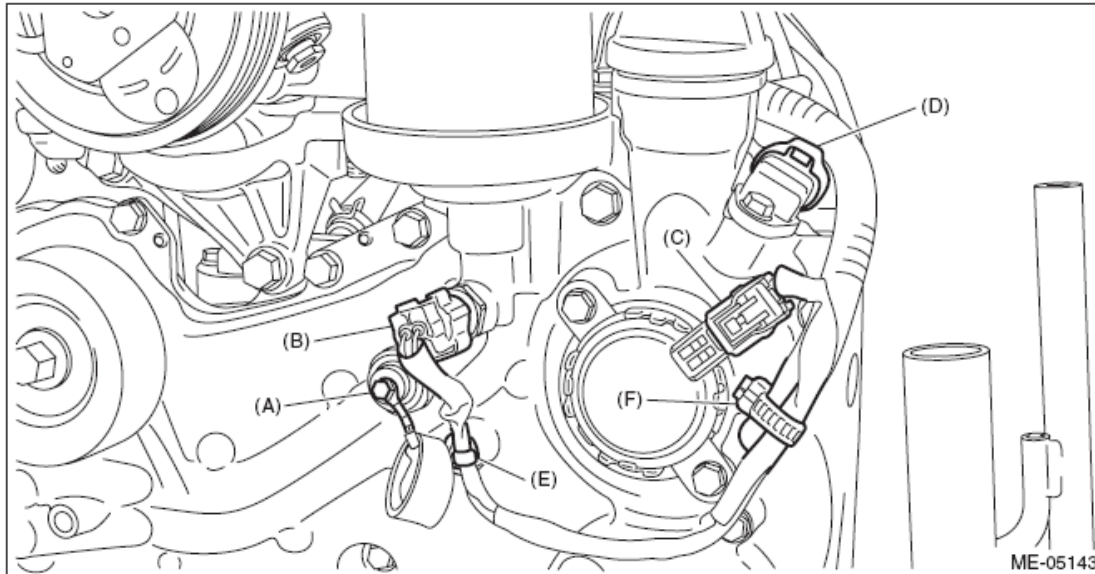
7. Remove the rubber cap from the oil pressure switch.



**Fig. 118: Locating Oil Pressure Switch Rubber Cap**  
Courtesy of SUBARU OF AMERICA, INC.

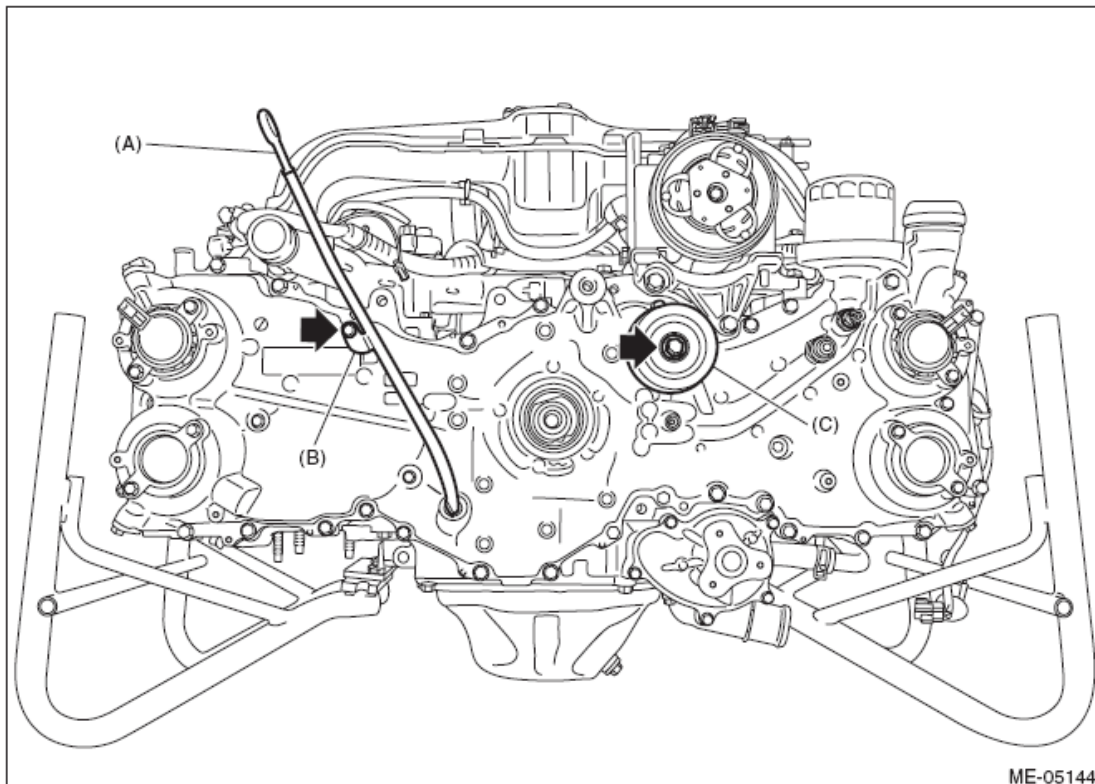
8. Disconnect the terminal (A) from the oil pressure switch, and connector (B) from the engine oil

temperature sensor, and connector (C) from the oil control solenoid LH, and connector (D) from the camshaft position sensor LH, and remove the clip (E) and clip (F) which secure the engine harness.



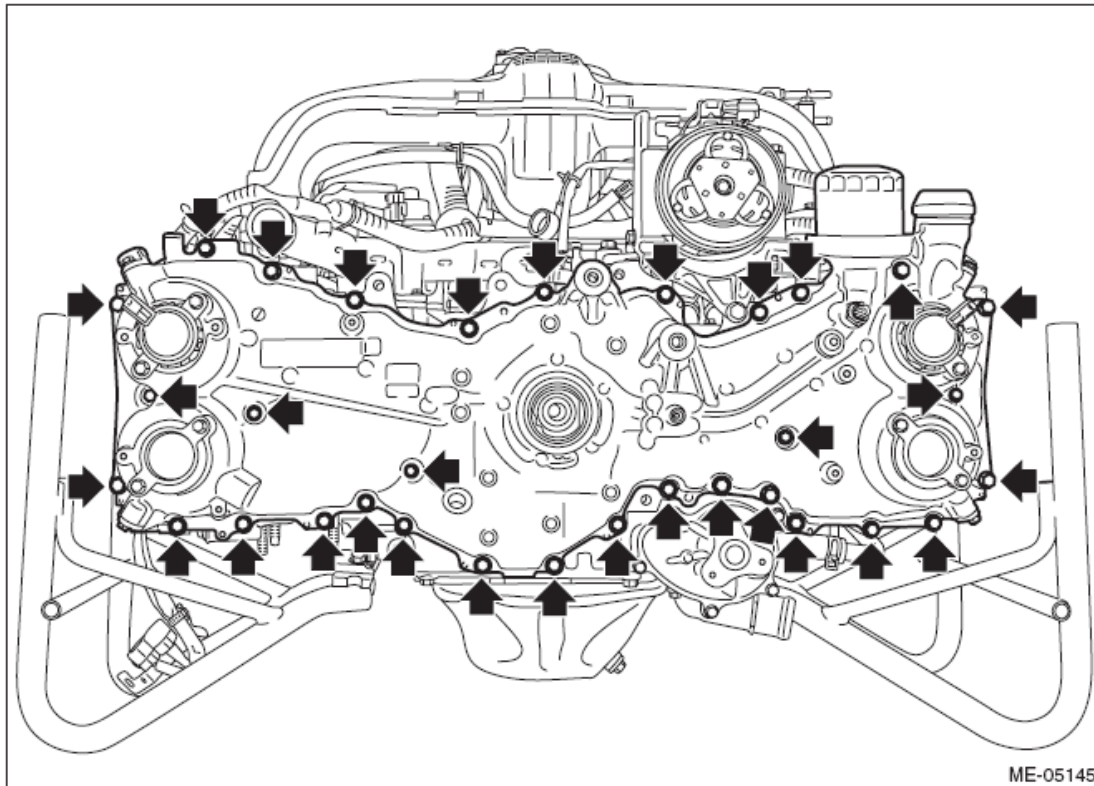
**Fig. 119: Identifying Oil Pressure Switch And Oil Control Solenoid Connectors, And Clip**  
 Courtesy of SUBARU OF AMERICA, INC.

9. Pull out the oil level gauge (A), and remove the oil level gauge guide (B) and idler pulley (C).



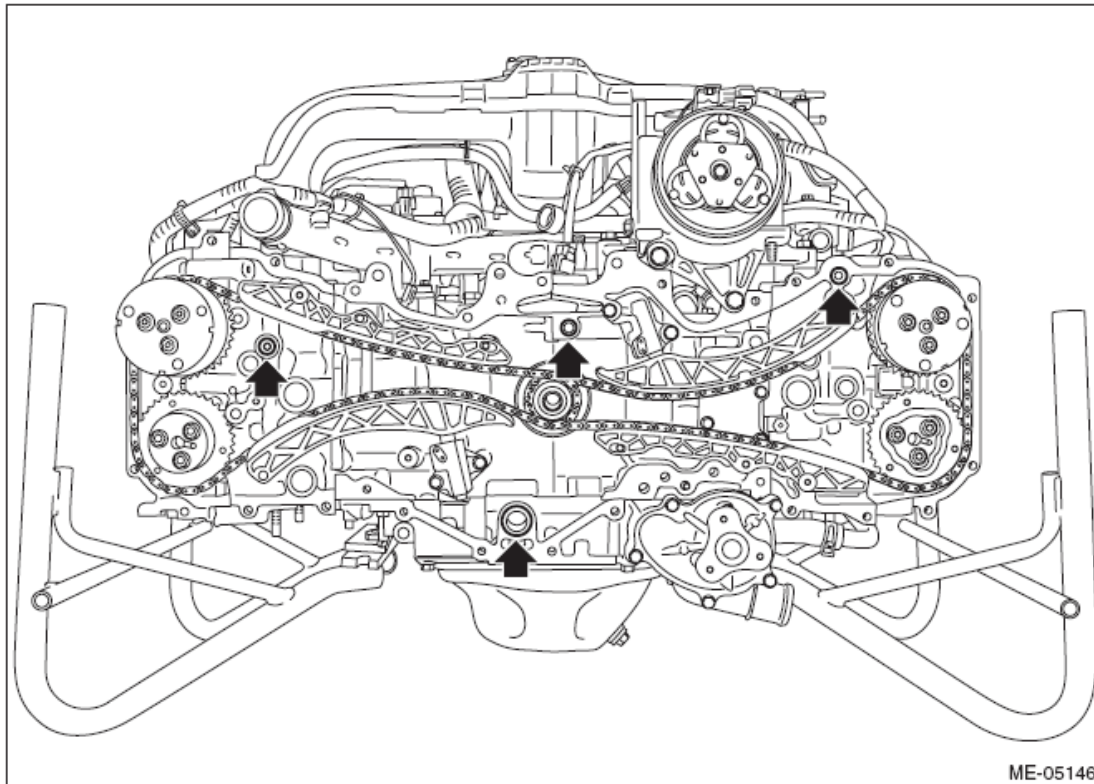
**Fig. 120: Locating Oil Level Gauge Guide And Idler Pulley Mounting Bolts**  
Courtesy of SUBARU OF AMERICA, INC.

10. Remove the chain cover.



**Fig. 121: Locating Chain Cover Mounting Bolts**  
Courtesy of SUBARU OF AMERICA, INC.

11. Remove the O-rings from cylinder head RH, cylinder head LH, cylinder block LH and oil pan upper.



**Fig. 122: Removing/Installing Cylinder Head And Block O-Rings**  
Courtesy of SUBARU OF AMERICA, INC.

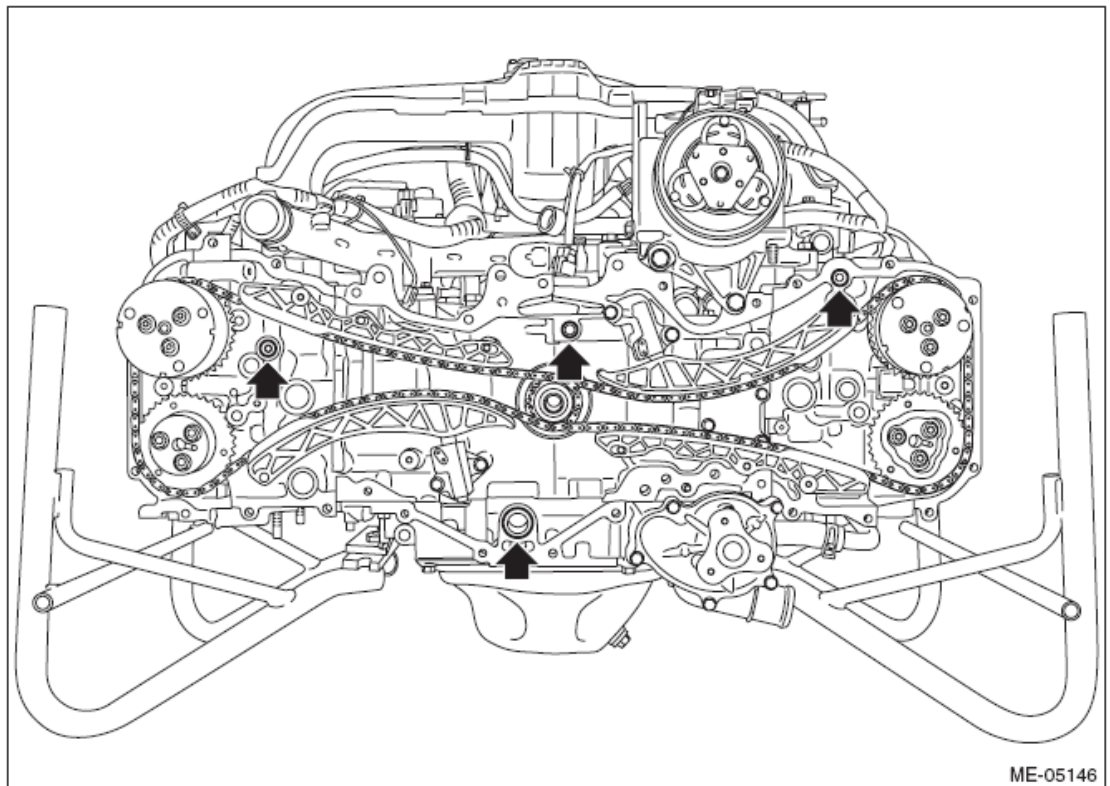
12. Remove the liquid gasket from the chain cover and engine unit.

## INSTALLATION

1. Install the O-rings to cylinder head RH, cylinder head LH, cylinder block LH and oil pan upper.

### NOTE:

- Use new O-rings.
- Apply a coat of engine oil to the O-rings.

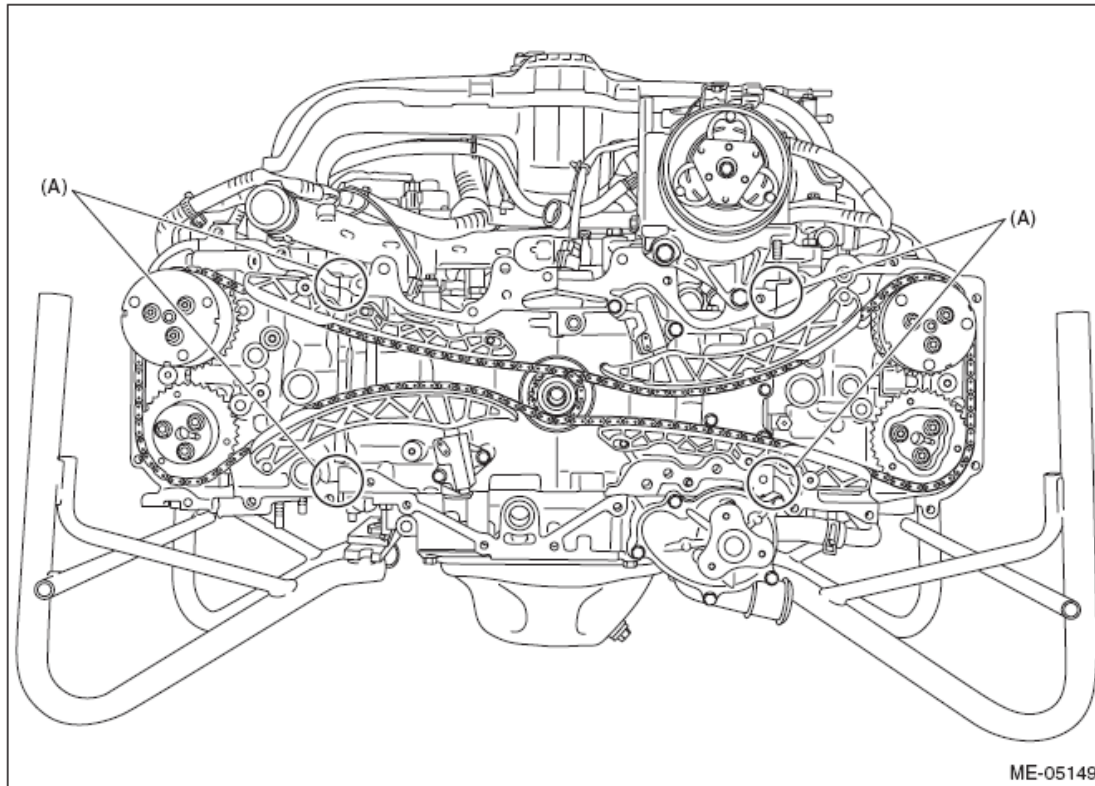


**Fig. 123: Removing/Installing Cylinder Head And Block O-Rings**  
**Courtesy of SUBARU OF AMERICA, INC.**

2. Apply liquid gasket if there are gaps between cylinder head and cylinder block (A) as shown.

***Liquid gasket:***

***THREE BOND 1217G (Part No. K0877Y0100) or equivalent***



**Fig. 124: Applying Liquid Gasket On Gaps Between Cylinder Head And Cylinder Block**  
Courtesy of SUBARU OF AMERICA, INC.

3. Apply liquid gasket to the chain cover mating surface and center boss (5 places) as shown in the figure.

**NOTE:**

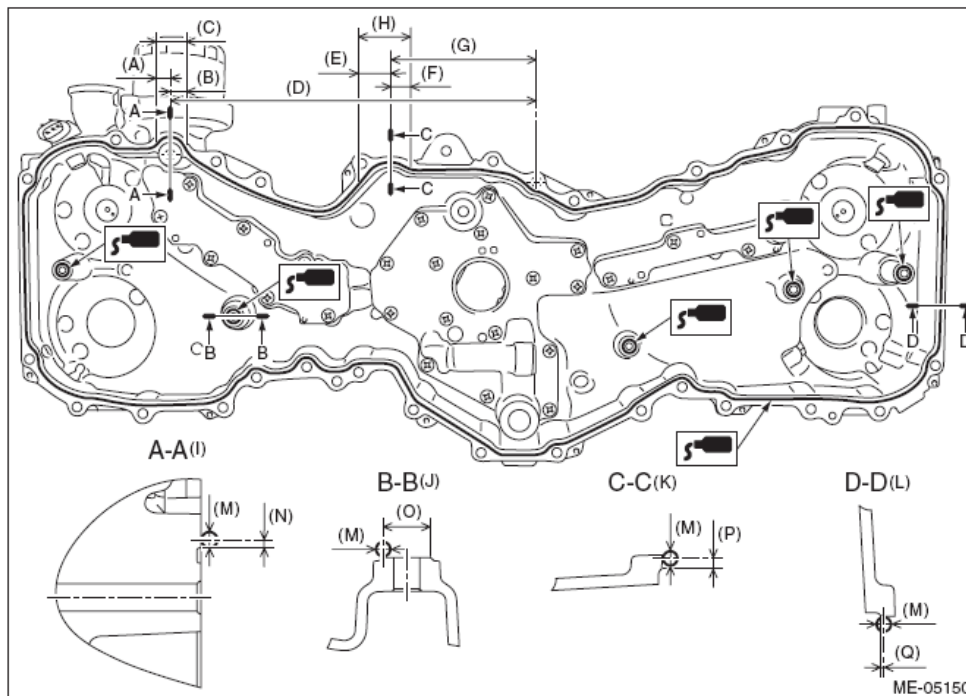
- Before applying liquid gasket, degrease the old liquid gasket seal surface of the engine and chain cover.
- Install within 5 min. after applying liquid gasket.

**Liquid gasket:**

**THREE BOND 1217G (Part No. K0877Y0100) or equivalent**

**Liquid gasket applying diameter:**

**$4 \pm 0.5 \text{ mm}$  ( $0.1575 \pm 0.0197 \text{ in}$ )**



|                           |                                                                                       |                                                  |
|---------------------------|---------------------------------------------------------------------------------------|--------------------------------------------------|
| (A) 14.5 mm (0.5709 in)   | (G) 127 mm (5.0000 in)                                                                | (M) $\phi 4 \pm 0.5$ mm (0.1575 $\pm$ 0.0197 in) |
| (B) 17.5 mm (0.6890 in)   | (H) Range B                                                                           | (N) 2 mm (0.0787 in)                             |
| (C) Range A               | (I) Liquid gasket applying position of mating surfaces of range A                     | (O) $\phi 12$ mm (0.4724 in)                     |
| (D) 316.2 mm (12.4488 in) | (J) Liquid gasket applying position of center boss (5 places)                         | (P) 2.5 mm (0.0984 in)                           |
| (E) 24.5 mm (0.9646 in)   | (K) Liquid gasket applying position of mating surfaces of range B                     | (Q) 0.5 mm (0.0197 in)                           |
| (F) 18.5 mm (0.7283 in)   | (L) Liquid gasket applying position of mating surfaces other than range A and range B |                                                  |

**Fig. 125: Identifying Liquid Gasket Applying Areas On Chain Cover Mating Surface And Center Boss**

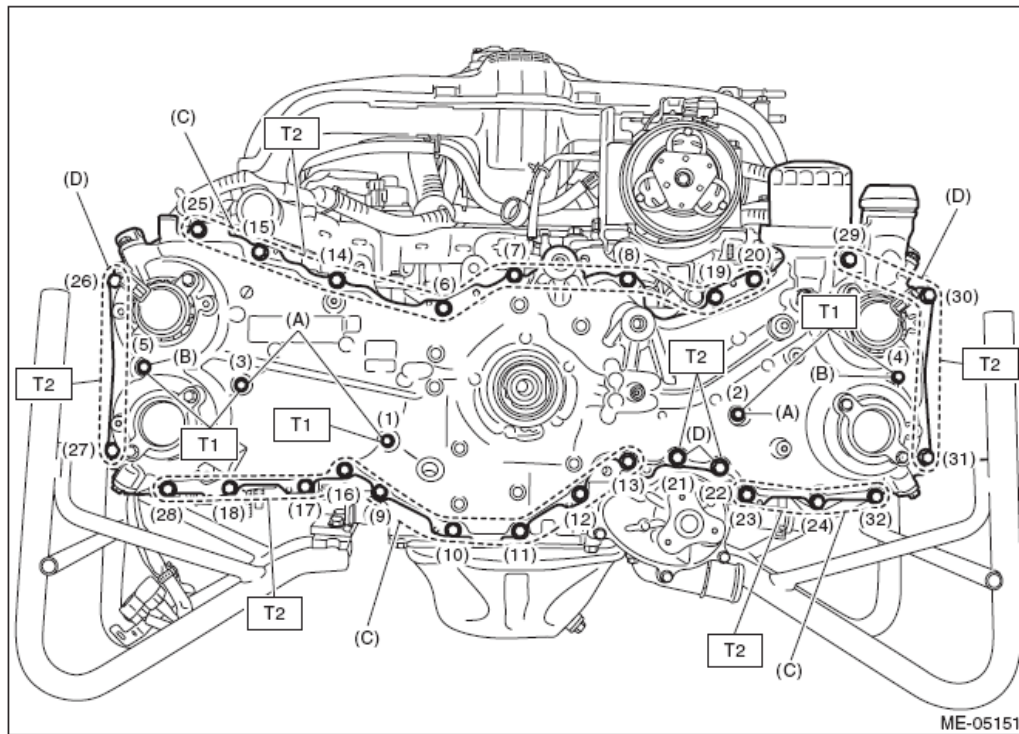
Courtesy of SUBARU OF AMERICA, INC.

- Set the chain cover, and tighten the bolts in numerical order as shown in the figure.

**Tightening torque:**

**T1: 10 N.m (1.0 kgf-m, 7.4 ft-lb)**

**T2: 25 N.m (2.5 kgf-m, 18.4 ft-lb)**



(A) M6 × 20  
(B) M6 × 50

(C) M8 × 25

(D) M8 × 60

**Fig. 126: Identifying Tightening Sequence Of Chain Cover Mounting Bolts**  
Courtesy of SUBARU OF AMERICA, INC.

5. Install the idler pulley (C) and oil level gauge guide (B), and insert the oil level gauge (A).

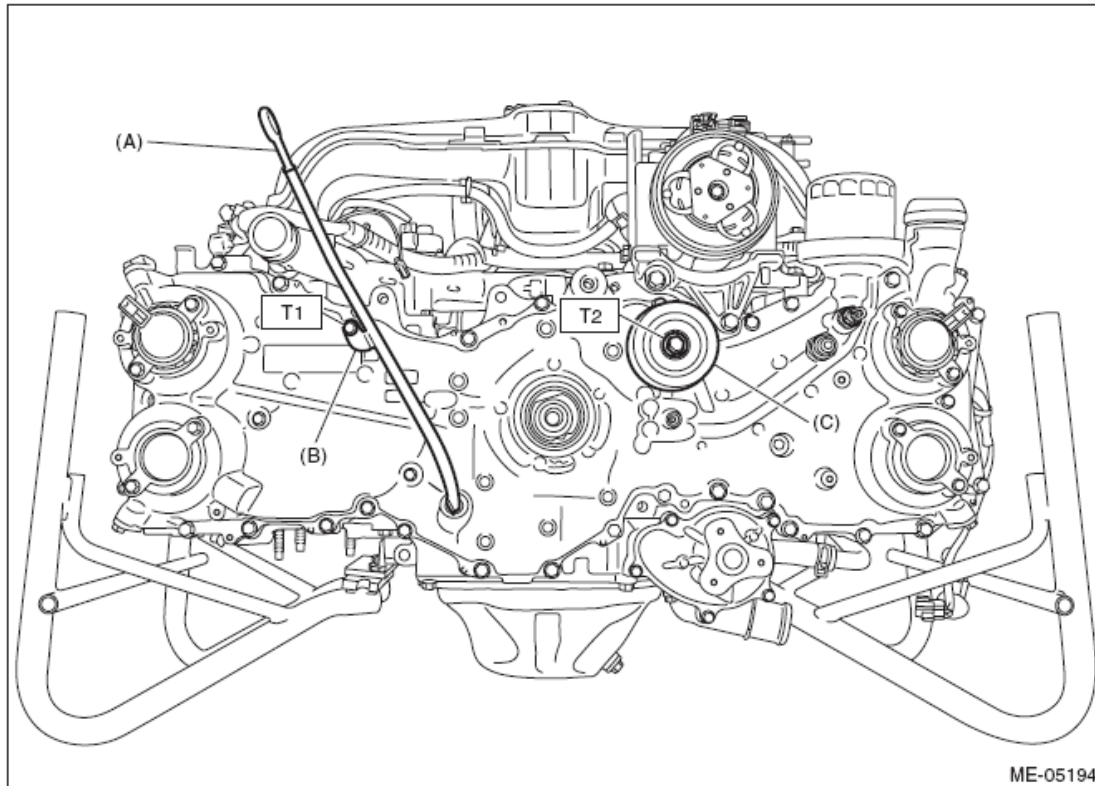
**NOTE:**

- Use a new O-ring to the oil level gauge guide.
- Apply a light coat of engine oil to the O-rings of the oil level gauge guide and the oil level gauge.

**Tightening torque:**

**T1: 6.4 N.m (0.7 kgf-m, 4.7 ft-lb)**

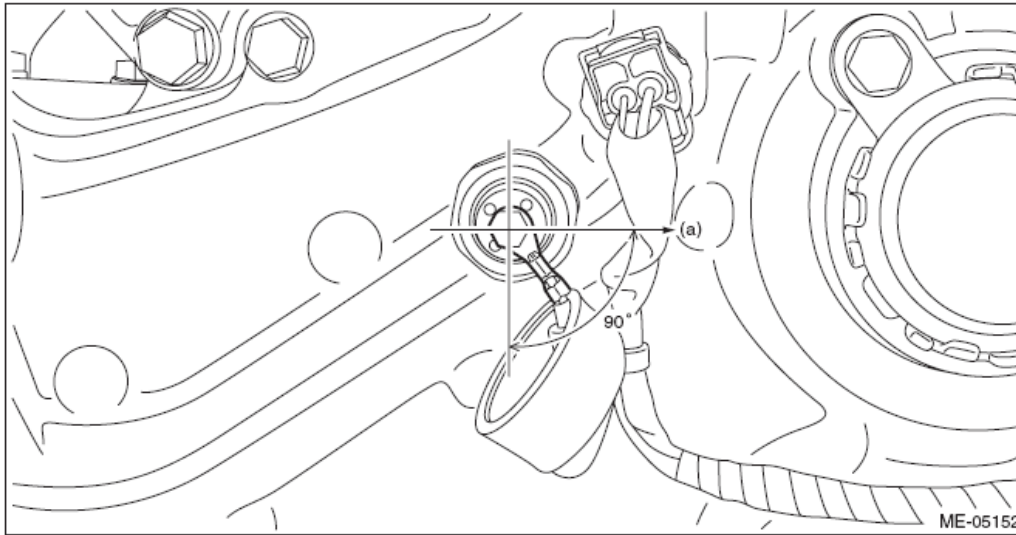
**T2: 36 N.m (3.7 kgf-m, 26.6 ft-lb)**



**Fig. 127: Locating Oil Level Gauge Guide And Idler Pulley Bolts With Torque Specifications**  
**Courtesy of SUBARU OF AMERICA, INC.**

6. Connect the terminal (A) to the oil pressure switch, and connector (B) to the engine oil temperature sensor, and connector (C) to the oil control solenoid LH, and connector (D) to the camshaft position sensor LH, and secure the engine harness with clip (E) and clip (F).

**NOTE:**      **The oil pressure switch harness must be positioned toward the left lower side of the vehicle within the range of 90°.**

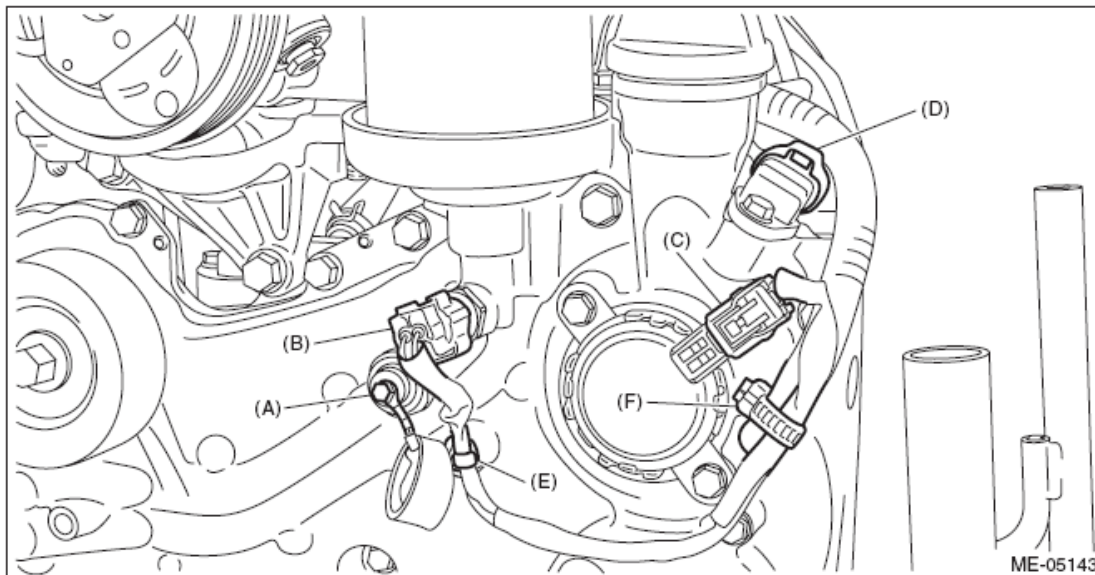


(a) Left side of vehicle

**Fig. 128: Positioning Of Oil Pressure Switch Harness From Vehicle Left Side**  
Courtesy of SUBARU OF AMERICA, INC.

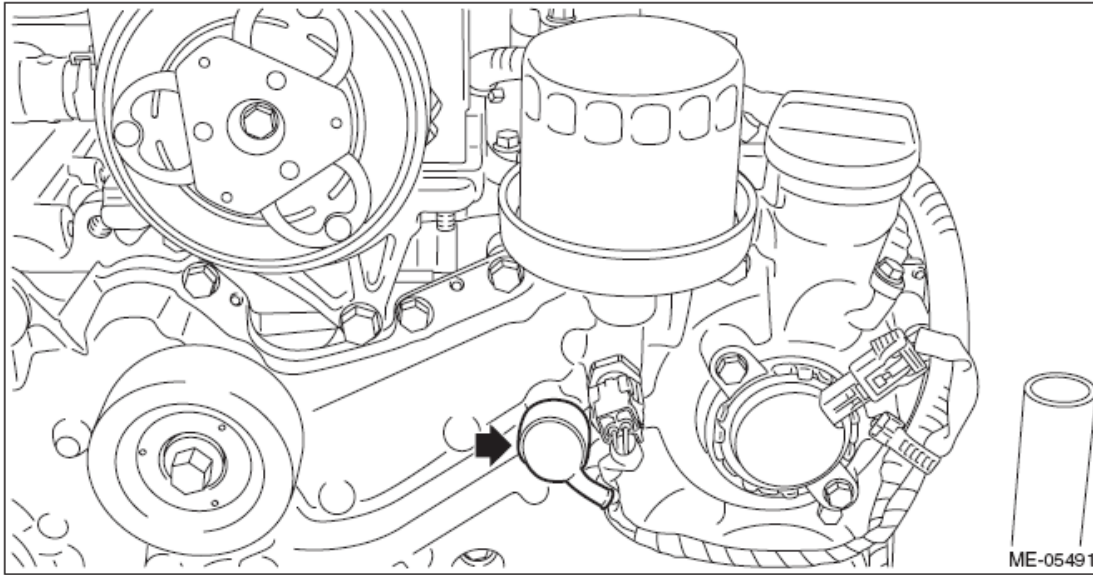
***Tightening torque:***

***1.5 N.m (0.2 kgf-m, 1.1 ft-lb)***



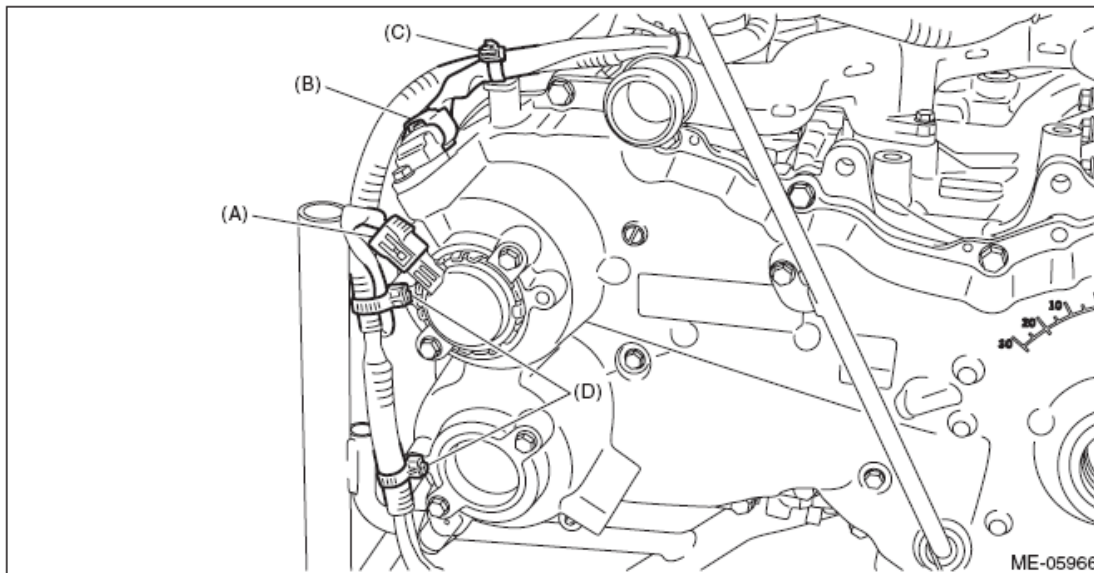
**Fig. 129: Identifying Oil Pressure Switch And Oil Control Solenoid, Connectors And Clips**  
Courtesy of SUBARU OF AMERICA, INC.

7. Attach the rubber cap to the oil pressure switch.



**Fig. 130: Locating Oil Level Switch Rubber Cap**  
Courtesy of SUBARU OF AMERICA, INC.

8. Connect the connector (A) to the oil control solenoid RH, and the connector (B) to the camshaft position sensor RH, and secure the engine harness with clip (C) and clip (D).

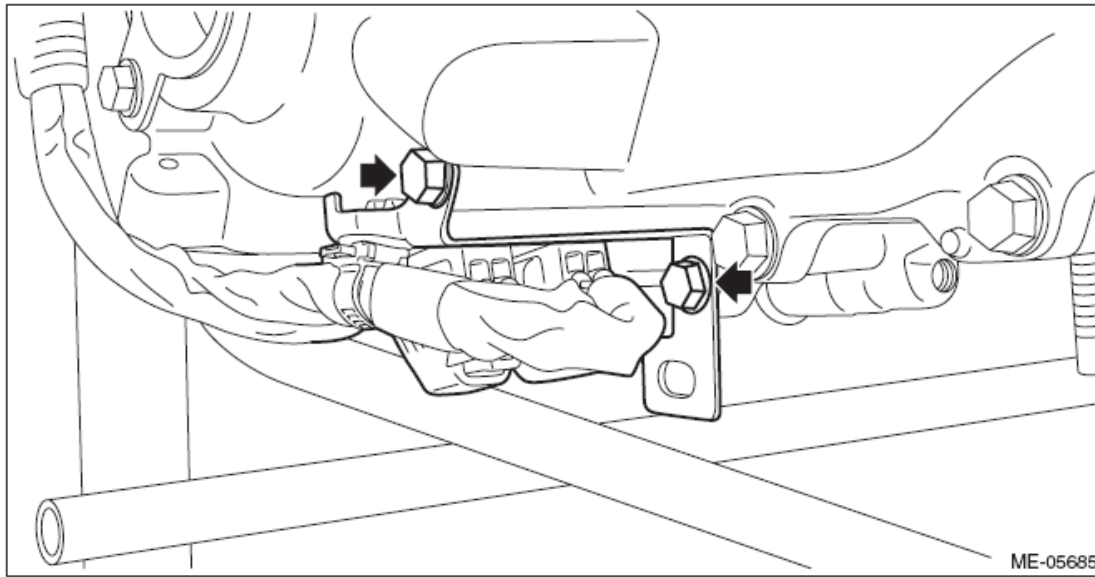


**Fig. 131: Identifying Camshaft Position Sensor And Oil Control Solenoid Connectors And Clips**  
Courtesy of SUBARU OF AMERICA, INC.

9. Install the engine harness stay to the chain cover.

**Tightening torque:**

**6.4 N.m (0.7 kgf-m, 4.7 ft-lb)**



**Fig. 132: Locating Engine Harness Stay Mounting Bolts**  
Courtesy of SUBARU OF AMERICA, INC.

10. Install the crank pulley. < Refer to **INSTALLATION**, Crank Pulley. >
11. Install the water pump pulley. < Refer to **WATER PUMP**, INSTALLATION, Water Pump. >
12. Fill engine oil. < Refer to **REPLACEMENT**, Engine Oil. >
13. When working on the vehicle

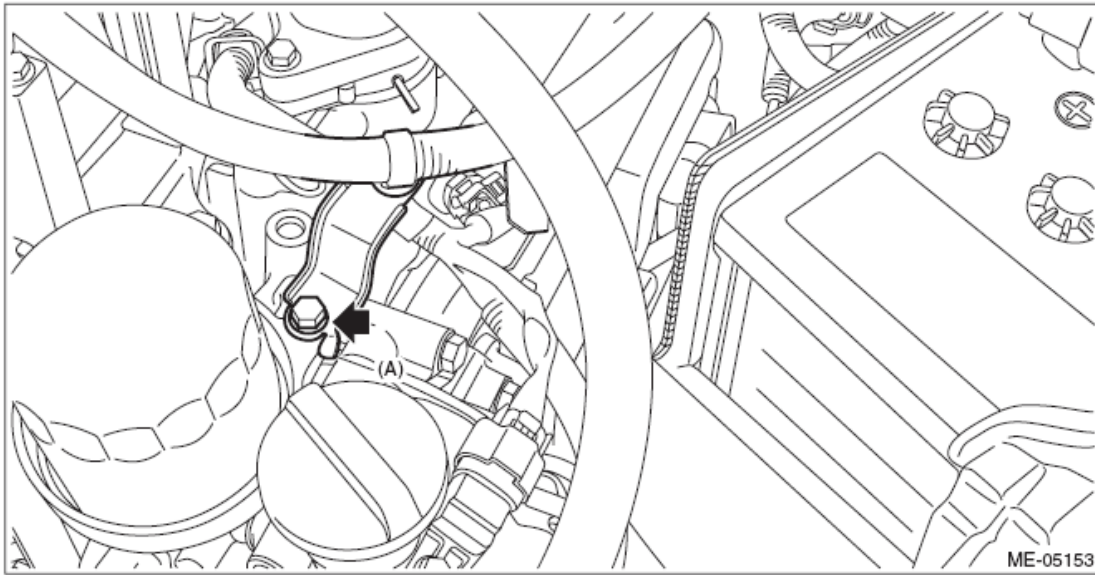
**NOTE:** When working on the vehicle, perform the following steps also.

1. Install the radiator. < Refer to **INSTALLATION**, Radiator. >
2. Install the front exhaust pipe. < Refer to **INSTALLATION**, Front Exhaust Pipe. >
3. Install the generator cord stay to the chain cover.

**NOTE:** Install the generator cord stay so that the folded end (A) touches at the chain cover boss.

**Tightening torque:**

**6.4 N.m (0.7 kgf-m, 4.7 ft-lb)**

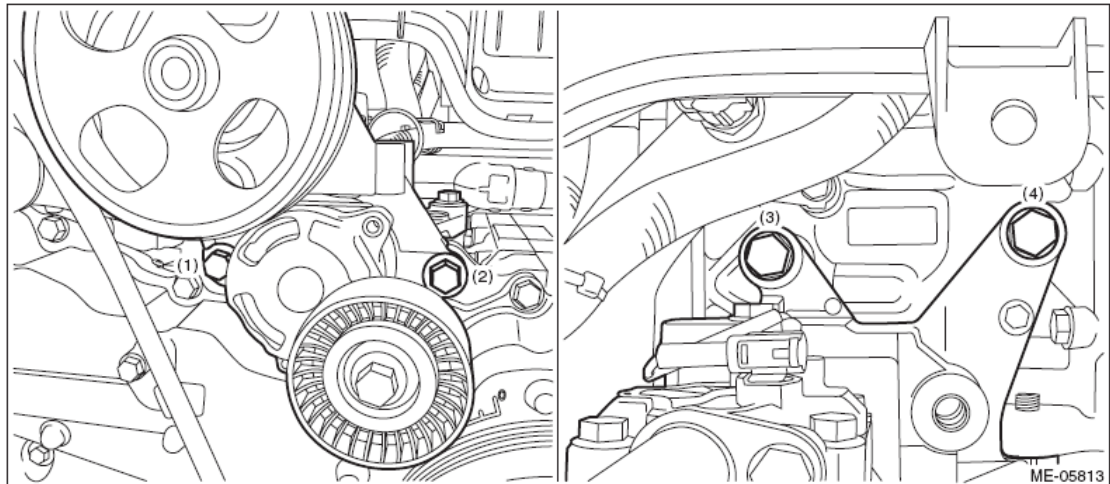


**Fig. 133: Locating Generator Cord Stay Mounting Bolts**  
Courtesy of SUBARU OF AMERICA, INC.

4. Install the power steering pump.
  1. Set the power steering pump to the engine, and tighten the bolts in numerical order as shown in the figure.

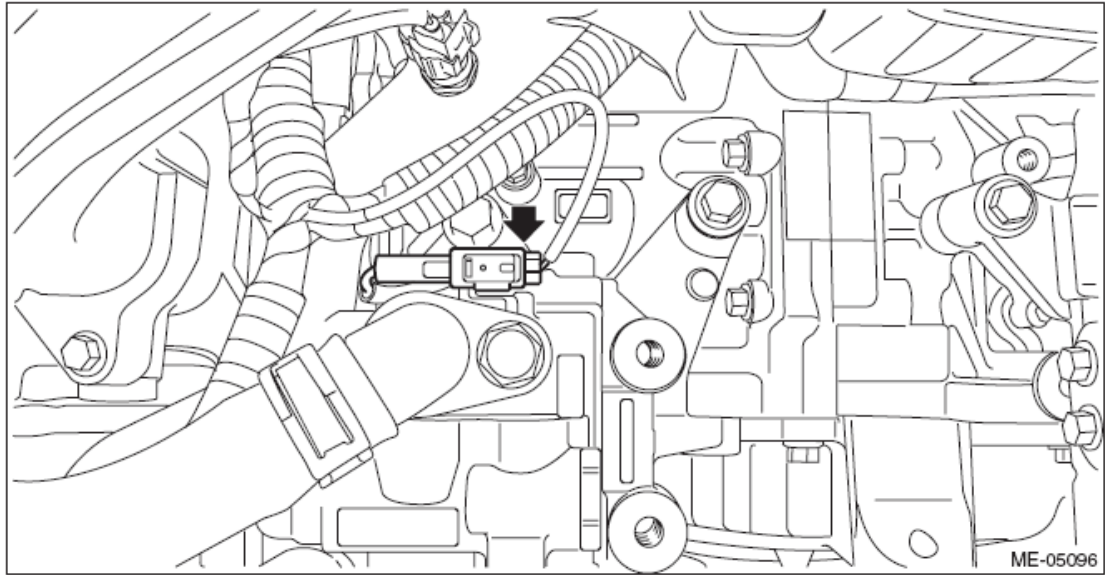
***Tightening torque:***

***36 N.m (3.7 kgf-m, 26.6 ft-lb)***



**Fig. 134: Power Steering Pump Bolts Tightening Sequence**  
Courtesy of SUBARU OF AMERICA, INC.

2. Connect the connector to the power steering pump switch.

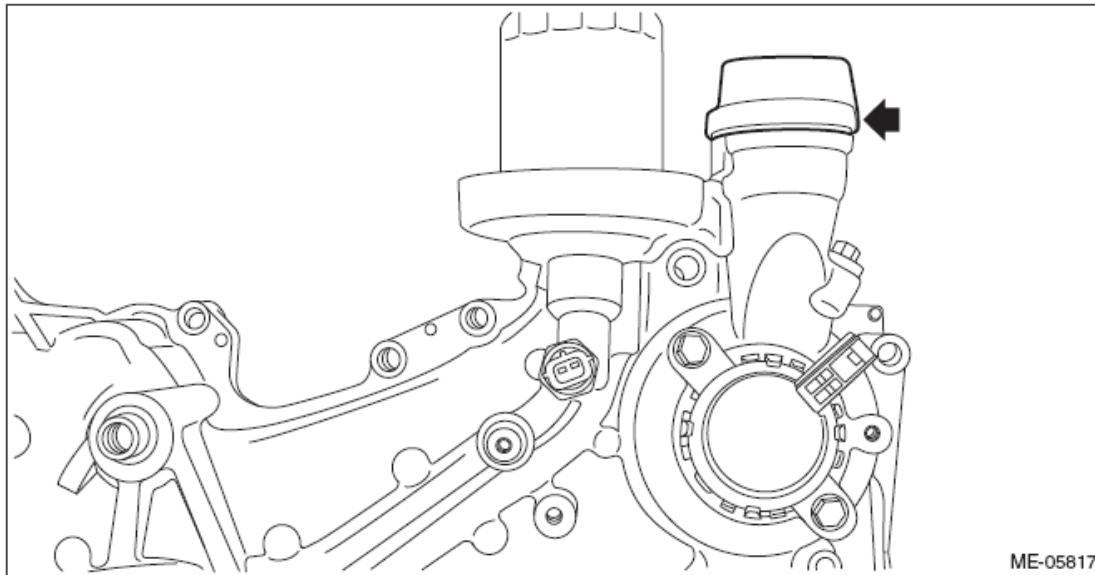


**Fig. 135: Locating Power Steering Pump Switch Connector**  
Courtesy of SUBARU OF AMERICA, INC.

3. Install the generator. < Refer to **INSTALLATION** , Generator. >
4. Install the V-belts. < Refer to **INSTALLATION**, V-belt. >

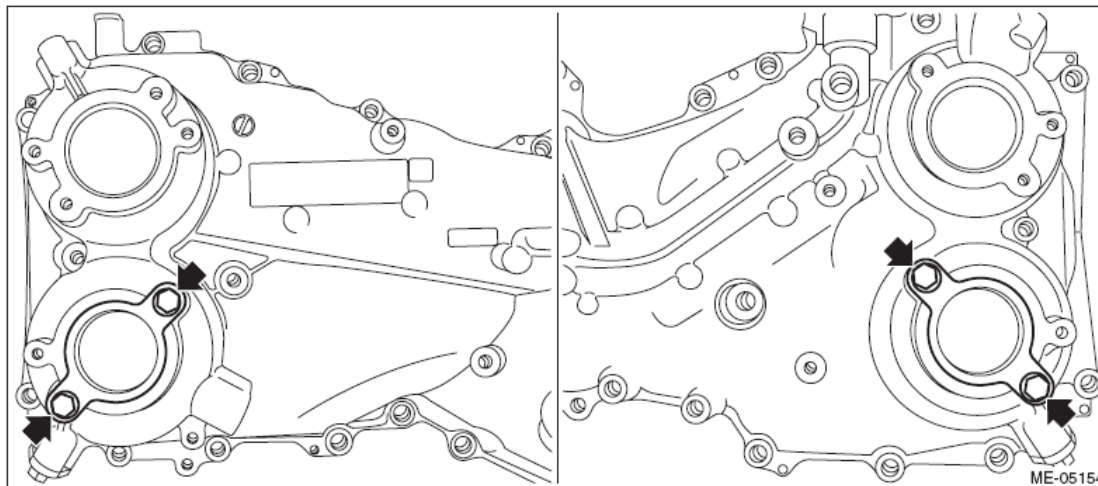
## **DISASSEMBLY**

1. Remove the oil filler cap.
2. Remove the engine oil filter and the oil pump union. < Refer to **REMOVAL** , Engine Oil Filter. >
3. Remove the oil pressure switch. < Refer to **REMOVAL** , Oil Pressure Switch. >
4. Remove the engine oil temperature sensor. < Refer to **REMOVAL** , Engine Oil Temperature Sensor. >
5. Remove the oil control solenoid. < Refer to **REMOVAL** , Oil Control Solenoid. >



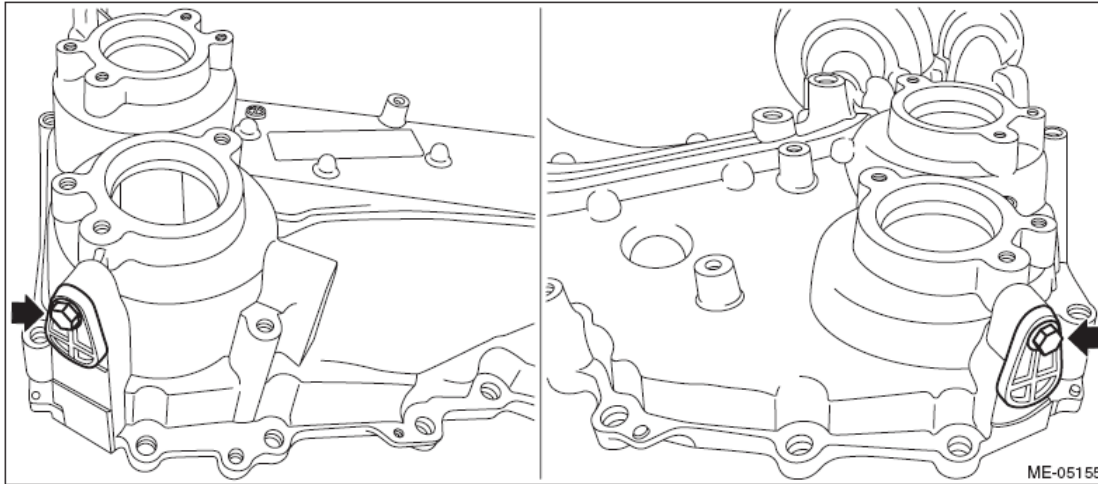
**Fig. 136: Locating Oil Filler Cap**  
 Courtesy of SUBARU OF AMERICA, INC.

6. Remove the camshaft position sensor. < Refer to **REMOVAL** , Camshaft Position Sensor. >
7. Remove the actuator cover from chain cover.



**Fig. 137: Locating Actuator Cover Bolts**  
 Courtesy of SUBARU OF AMERICA, INC.

8. Remove the sensor cover from chain cover.



**Fig. 138: Locating Sensor Cover Bolts**  
Courtesy of SUBARU OF AMERICA, INC.

#### ASSEMBLY

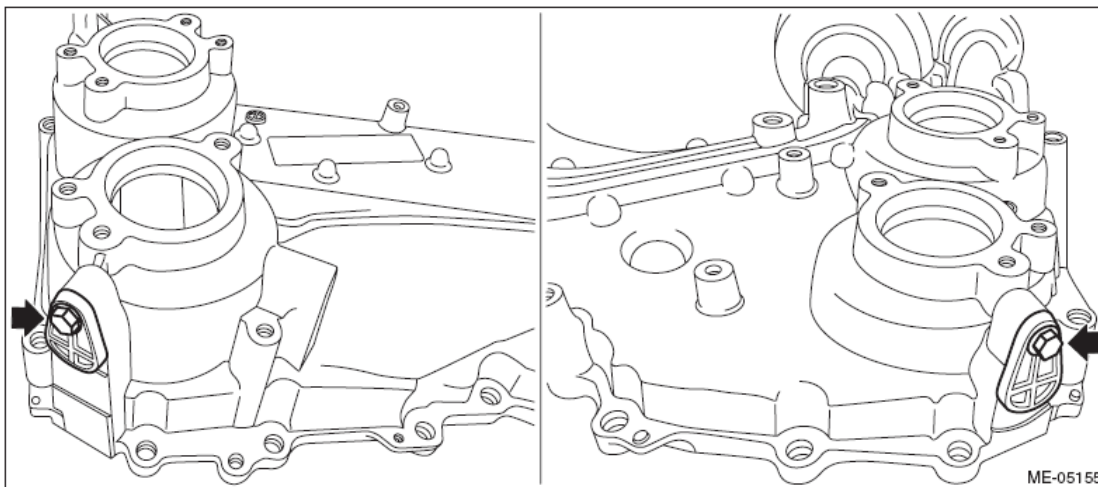
1. Install the sensor cover to the chain cover.

**NOTE:**

- Use new O-rings.
- Apply a coat of engine oil to the O-rings.

***Tightening torque:***

***6.4 N.m (0.7 kgf-m, 4.7 ft-lb)***



**Fig. 139: Locating Sensor Cover Bolts**  
Courtesy of SUBARU OF AMERICA, INC.

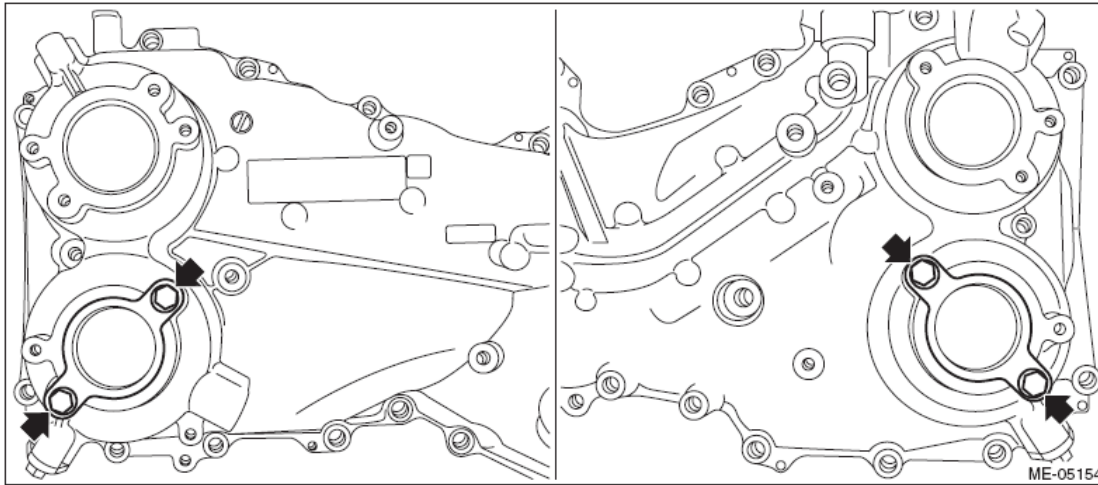
2. Install the actuator cover to chain cover.

**NOTE:**

- Use new O-rings.
- Apply a coat of engine oil to the O-rings.

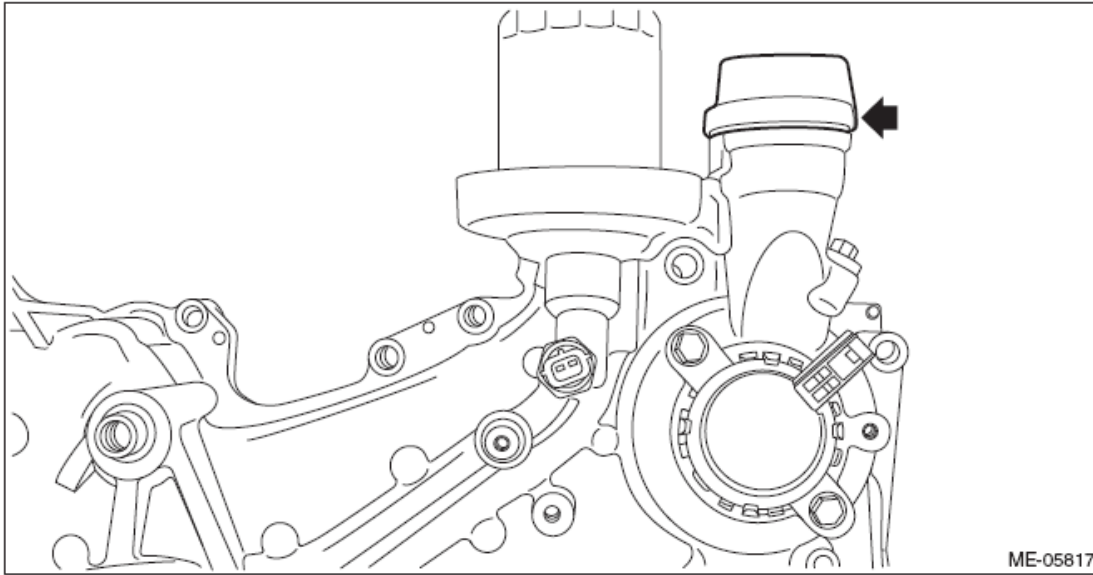
***Tightening torque:***

***6.4 N.m (0.7 kgf-m, 4.7 ft-lb)***



**Fig. 140: Locating Actuator Cover Bolts**  
Courtesy of SUBARU OF AMERICA, INC.

3. Install the camshaft position sensor. < Refer to **INSTALLATION** , Camshaft Position Sensor. >
4. Install the oil control solenoid. < Refer to **INSTALLATION** , Oil Control Solenoid. >
5. Install the engine oil temperature sensor. < Refer to **INSTALLATION** , Engine Oil Temperature Sensor. >
6. Install the oil pressure switch. < Refer to **INSTALLATION** , Oil Pressure Switch. >
7. Install the engine oil filter and the oil pump union. < Refer to **INSTALLATION** , Engine Oil Filter. >
8. Install the oil filler cap.



**Fig. 141: Locating Oil Filler Cap**  
Courtesy of SUBARU OF AMERICA, INC.

## INSPECTION

Check that the chain cover does not have deformation, cracks and any other damage.

## TIMING CHAIN ASSEMBLY

### REMOVAL

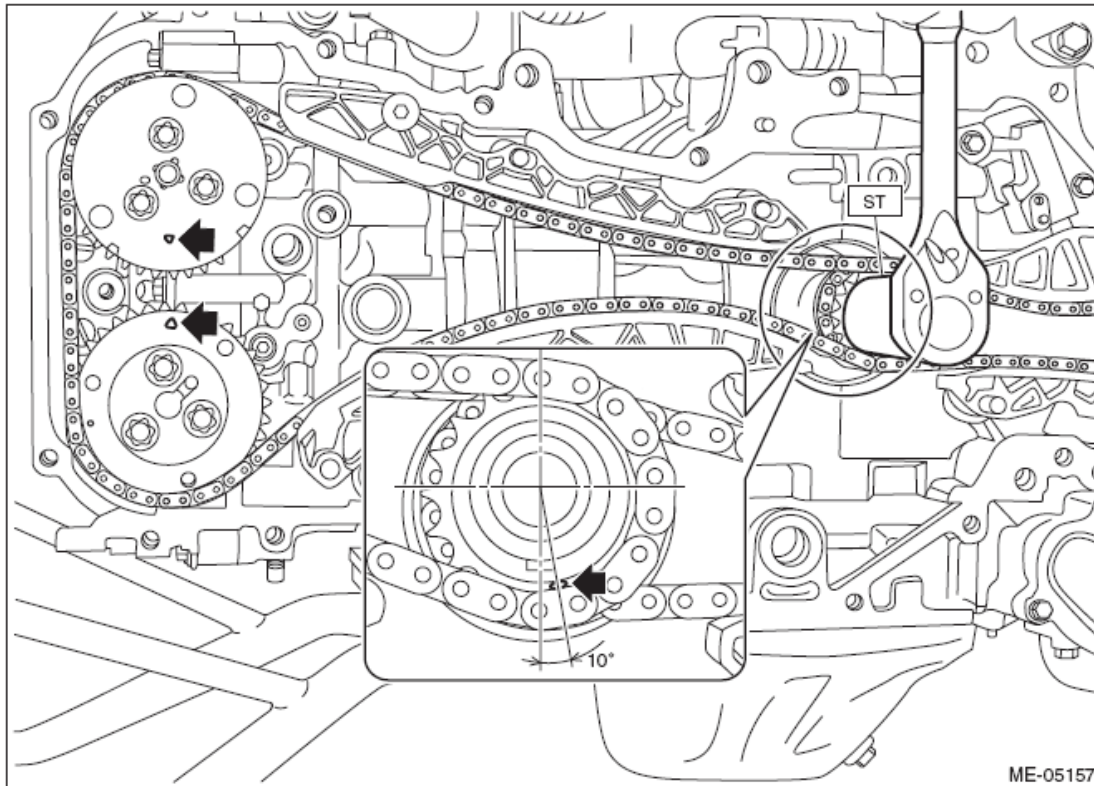
#### TIMING CHAIN RH

**NOTE:** When replacing a single part, perform the work with the engine assembly installed to body.

1. Remove the chain cover. < Refer to **REMOVAL**, Chain Cover. >
2. Using ST and by turning the crankshaft, align the alignment marks of crank sprocket, intake cam sprocket RH and exhaust cam sprocket RH to the positions as shown in the figure.

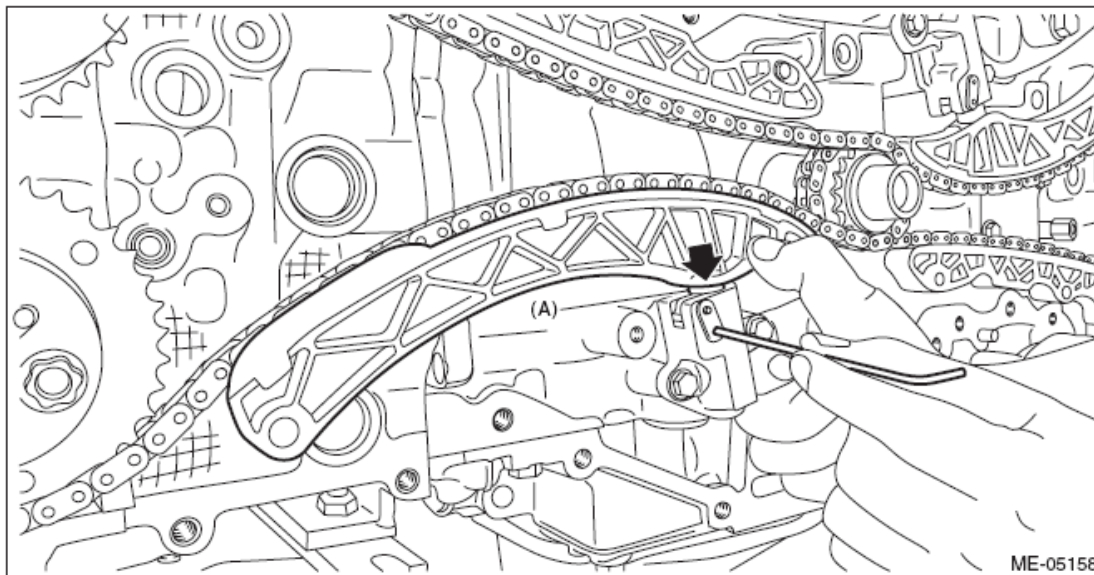
**NOTE:** If the alignment marks are aligned to the positions as shown in the figure, the crankshaft key is located at six o'clock position.

ST 18252AA000 CRANKSHAFT SOCKET



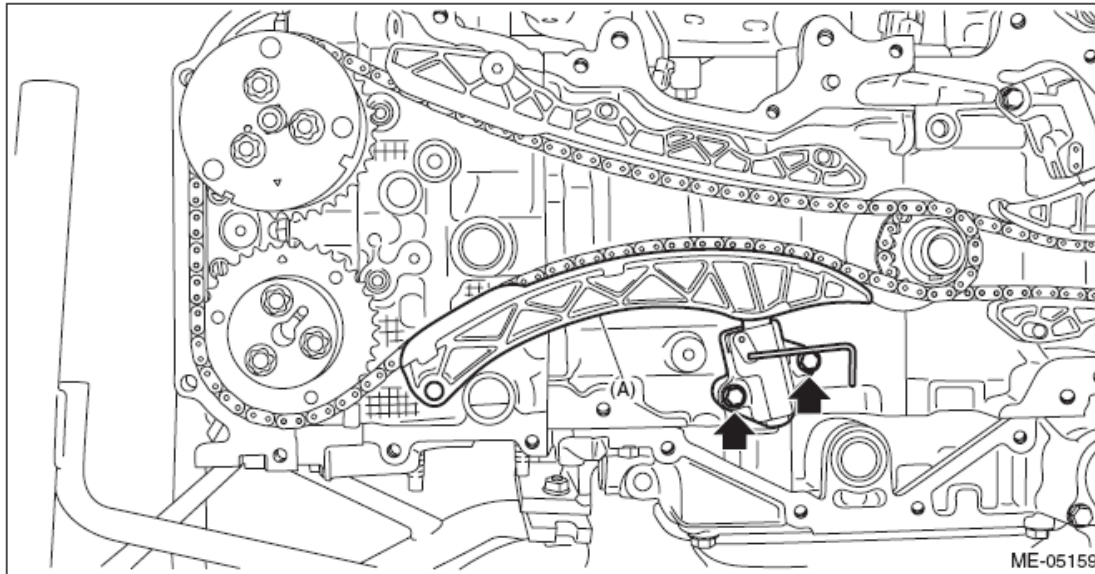
**Fig. 142: Aligning Crankshaft Using Crankshaft Socket**  
Courtesy of SUBARU OF AMERICA, INC.

3. Push down the chain lever tensioner RH, and with a 2.5 mm (0.98 in) dia. stopper pin or a 2.5 mm (0.98 in) dia. hex wrench inserted into the stopper pin hole in the chain tensioner RH, secure the plunger (A).



**Fig. 143: Inserting Hex Wrench Into Stopper Pin Hole**  
Courtesy of SUBARU OF AMERICA, INC.

4. Remove the chain tensioner RH, and remove the chain tensioner lever RH (A).



**Fig. 144: Locating Chain Tensioner RH And Chain Tensioner Lever RH Bolts**  
Courtesy of SUBARU OF AMERICA, INC.

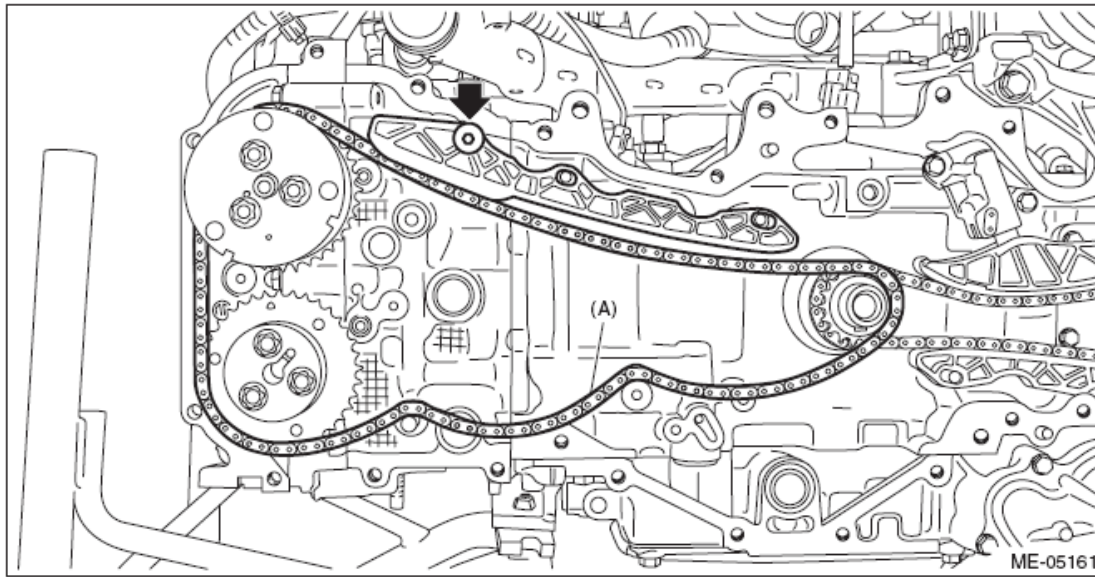
5. Remove the chain guide RH, and remove the timing chain RH (A).

**CAUTION:**

- If the timing chain RH is not installed, the intake camshaft RH and exhaust camshaft RH are kept at zero-lift position. All cams on the camshaft are not pressing down the roller rocker arm (intake valve and exhaust valve). (Under this condition, all valves remain unlifted.)
- Intake camshaft RH and exhaust camshaft RH can be independently rotated with the timing chain RH removed. When the intake valve and exhaust valve lift at the same time, the valve heads contact each other and valve stem may bend. Do not turn it to the outside of range of zero-lift (in range where it can be turned lightly by hand).

**NOTE:**

To avoid mixing with LH side, keep the removed part in order.

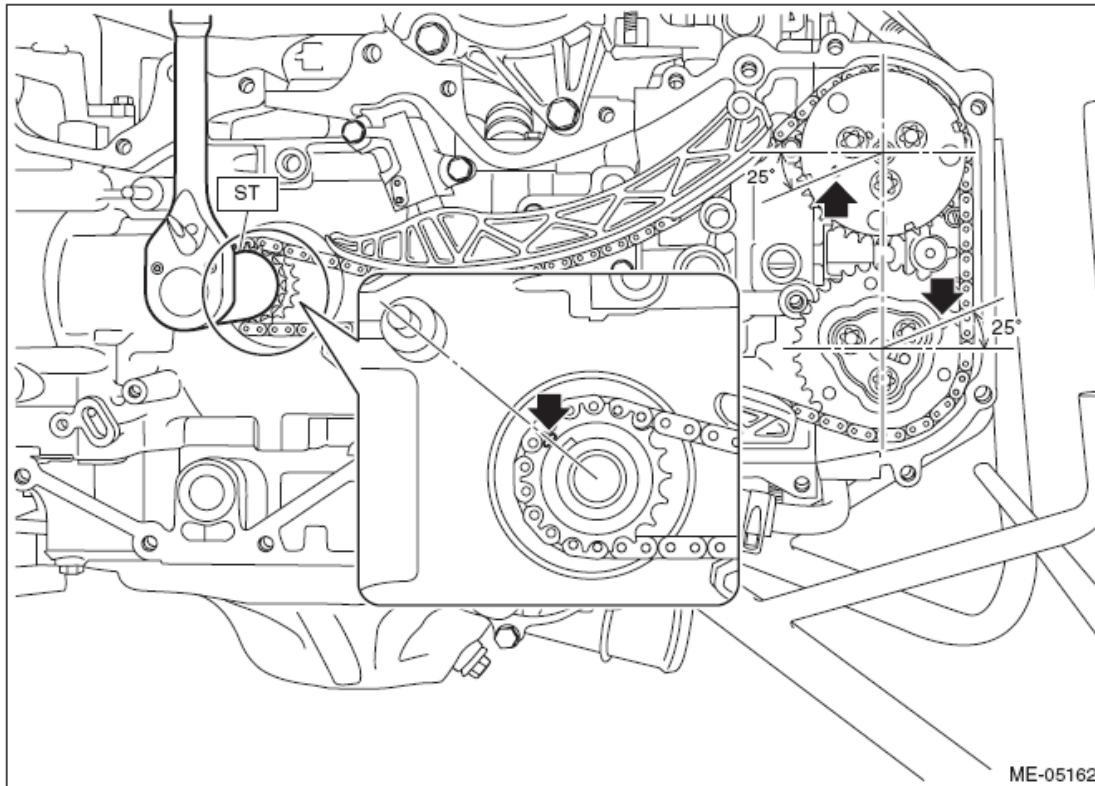


**Fig. 145: Locating Timing Chain LH Chain Guide Mounting Bolt**  
Courtesy of SUBARU OF AMERICA, INC.

#### **TIMING CHAIN LH**

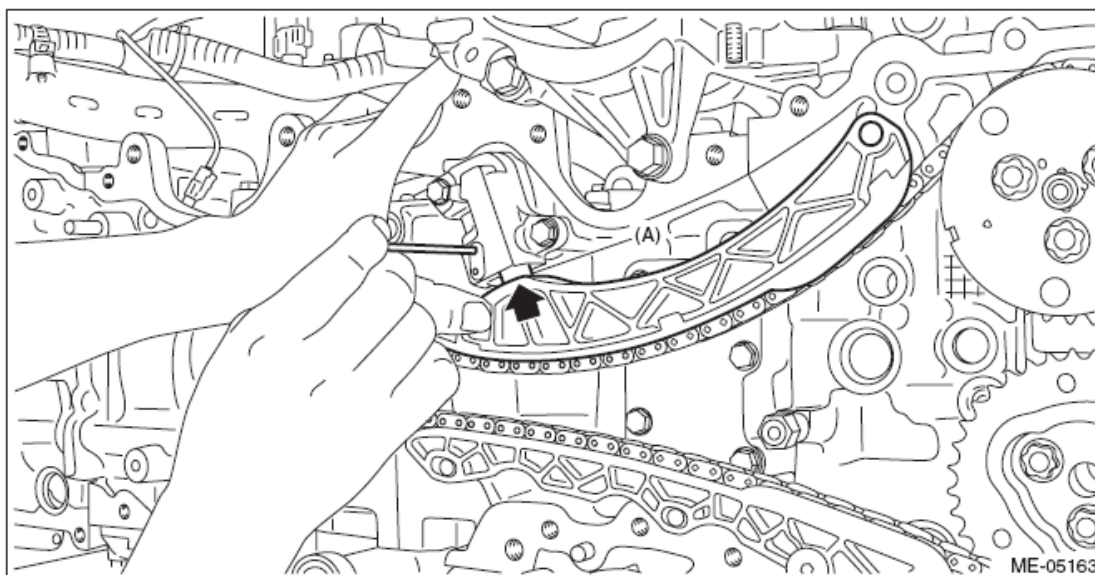
1. Remove the timing chain RH. < Refer to **TIMING CHAIN RH**, REMOVAL, Timing Chain Assembly.  
>
2. Using ST and by turning the crankshaft, align the alignment marks of crankshaft key, intake cam sprocket LH and exhaust cam sprocket LH to the positions as shown in the figure.

ST 18252AA000 CRANKSHAFT SOCKET



**Fig. 146: Aligning Alignment Marks Of Crankshaft Key, Intake And Exhaust Cam Sprocket LH Using Tool**  
 Courtesy of SUBARU OF AMERICA, INC.

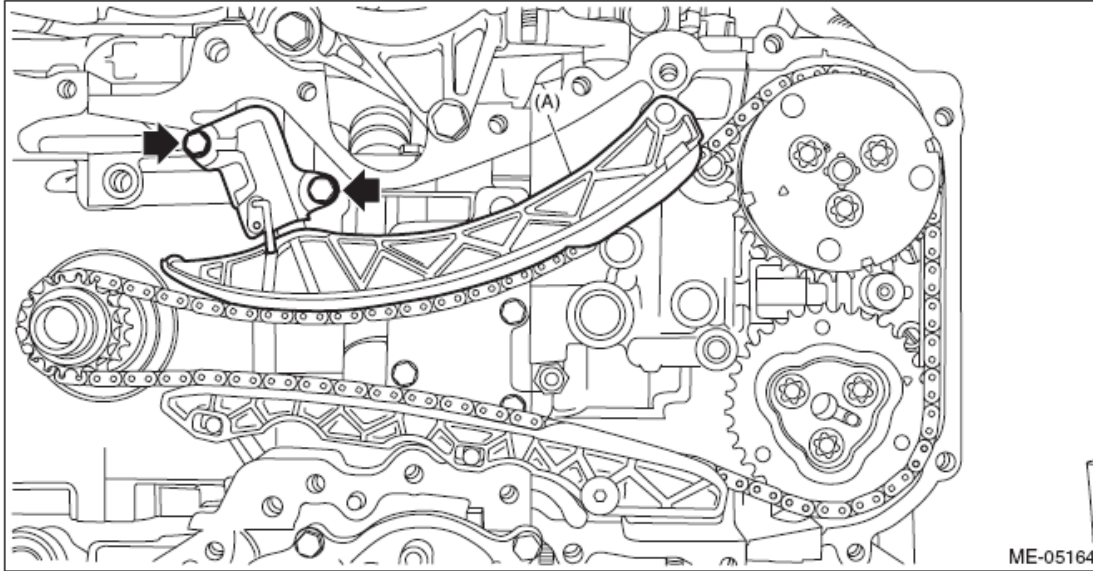
3. Push down the chain lever tensioner LH, and with a 2.5 mm (0.98 in) dia. stopper pin or a 2.5 mm (0.98 in) dia. hex wrench inserted into the stopper pin hole in the chain tensioner LH, secure the plunger (A).



**Fig. 147: Inserting Hex Wrench Into Stopper Pin Hole**

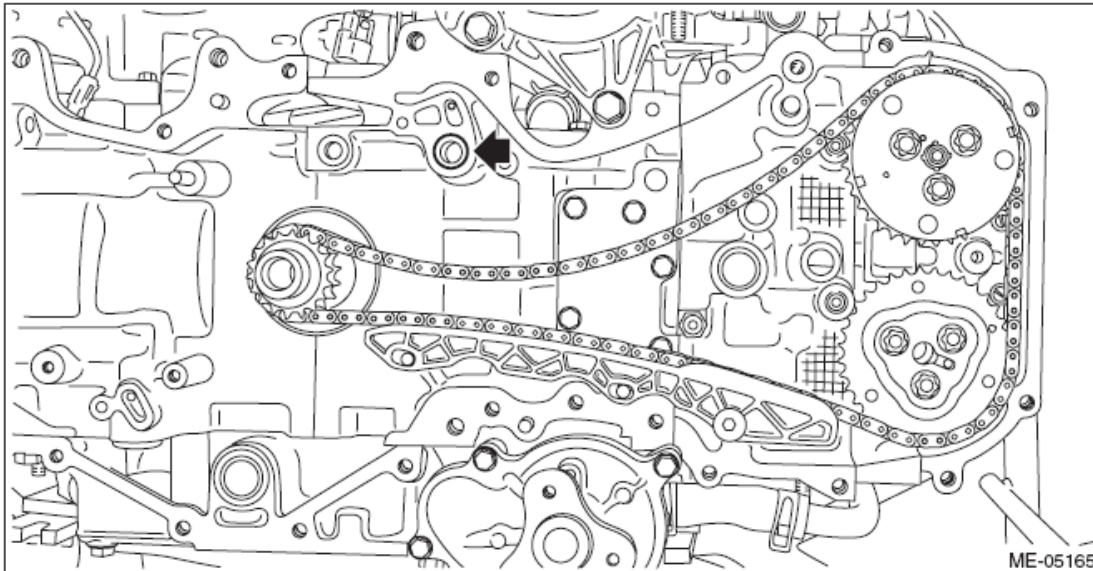
Courtesy of SUBARU OF AMERICA, INC.

4. Remove the chain tensioner LH, and remove the chain tensioner lever LH (A).



**Fig. 148: Locating Chain Tensioner Lever LH Mounting Bolts**  
Courtesy of SUBARU OF AMERICA, INC.

5. Remove the O-ring from the cylinder block LH.



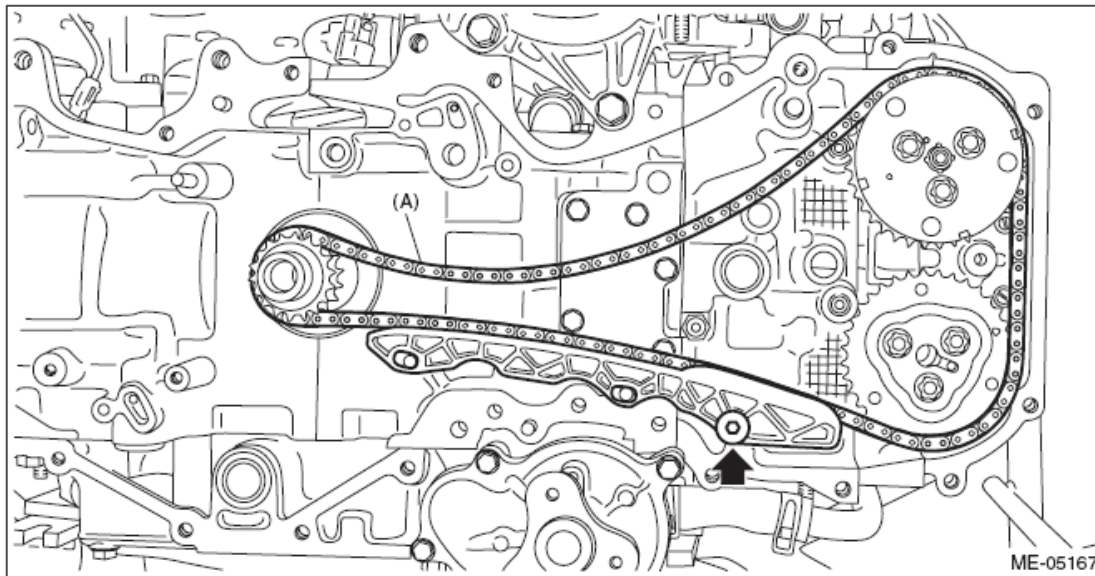
**Fig. 149: Locating Cylinder Block LH O-Ring**  
Courtesy of SUBARU OF AMERICA, INC.

6. Remove the chain guide LH, and remove the timing chain LH (A).

**CAUTION:**

- If the timing chain LH is not installed, the exhaust camshaft LH is kept at zero-lift position. All cams on the exhaust camshaft LH are not pressing down the roller rocker arm (exhaust valve). (Under this condition, exhaust valves remain unlifted.)
- Intake camshaft LH is kept at lift position. All cams on the intake camshaft LH are pressing down the roller rocker arm (intake valve). (Under this condition, intake valves remain lifted.)
- Intake camshaft LH and exhaust camshaft RH can be independently rotated with the timing chain LH removed. When the exhaust camshaft LH is turned, the valve heads contact each other and valve stem may bend as described in above. Do not turn the exhaust camshaft LH to the outside of range of zero-lift (in range where it can be turned lightly by hand).
- #1 piston and #4 piston are located near TDC. If the intake camshaft LH is turned, the valve and the piston may contact and valve stem may bend. Do not turn the intake camshaft LH at this time.

**NOTE:** To avoid mixing with RH side, keep the removed part in order.



**Fig. 150: Locating Chain Guide LH**  
Courtesy of SUBARU OF AMERICA, INC.

7. Using ST and by turning the crankshaft approximately 200° clockwise, align the alignment marks of crank sprocket to the positions as shown in the figure.

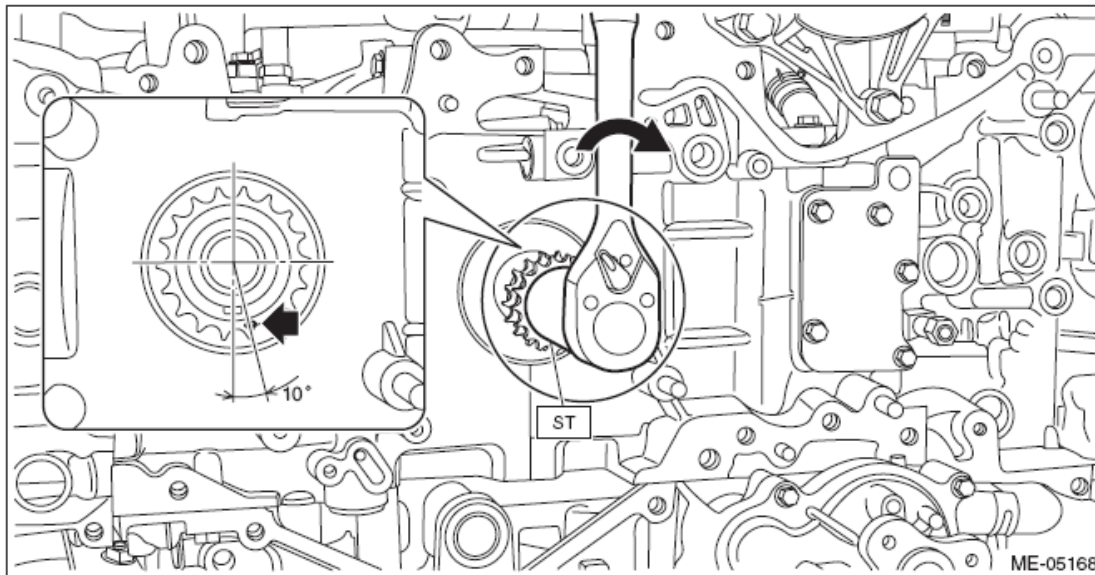
**CAUTION:**

- This procedure is required to prevent the valve and piston contacting with each other, by moving the all pistons to the

middle of the cylinders.

- **Never turn counterclockwise because the valve and piston may contact. Counterclockwise turn is allowed only when adjusting precisely the alignment marks, after turning the crank sprocket alignment mark clockwise near the position as shown in the figure.**

ST 18252AA000 CRANKSHAFT SOCKET



**Fig. 151: Identifying Crankshaft Turning Angle**

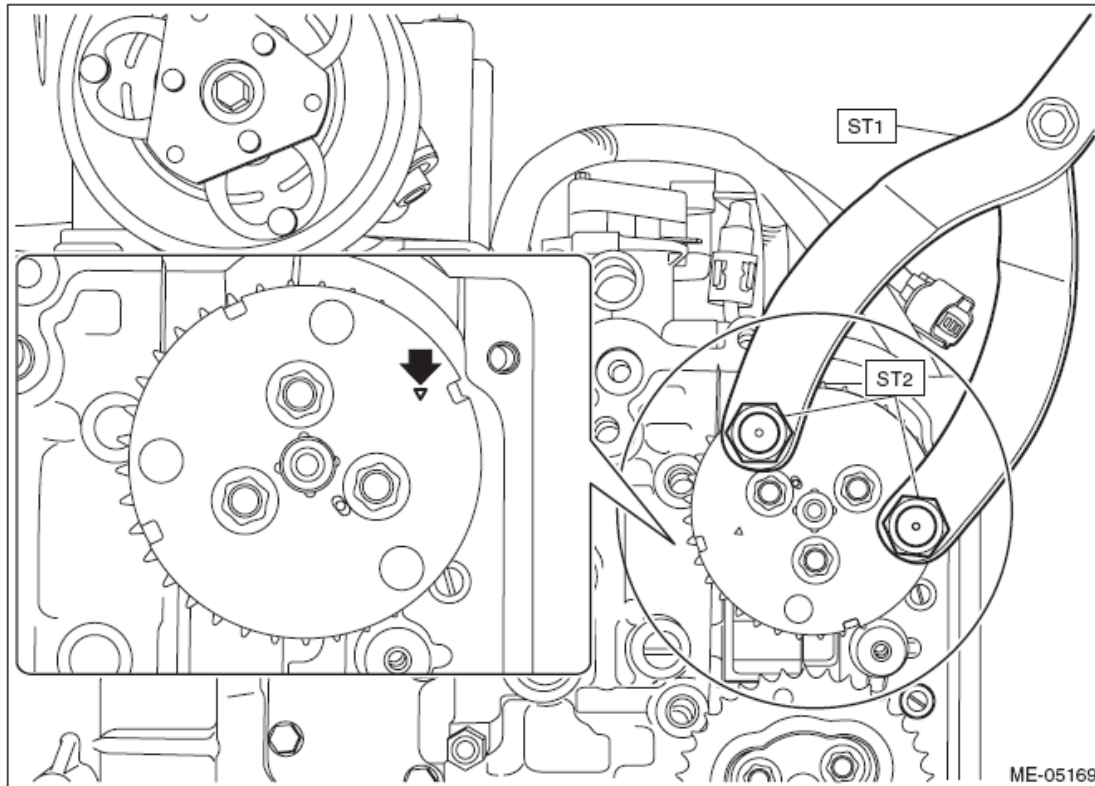
Courtesy of SUBARU OF AMERICA, INC.

8. Using ST and by turning the intake cam sprocket LH approximately 180°, align the alignment marks of intake cam sprocket LH to the positions (zero-lift position) as shown in the figure.

**CAUTION:** After this work, when the intake valve and exhaust valve lift at the same time, the valve heads contact each other and valve stem may bend. Do not turn the intake camshaft LH and exhaust camshaft LH to the outside of range of zero-lift (in range where it can be turned lightly by hand).

ST1 18355AA000 PULLEY WRENCH

ST2 18334AA030 PULLEY WRENCH PIN SET



**Fig. 152: Aligning Alignment Marks Of Intake Cam Sprocket LH To Zero-Lift Position Using ST**  
 Courtesy of SUBARU OF AMERICA, INC.

## INSTALLATION

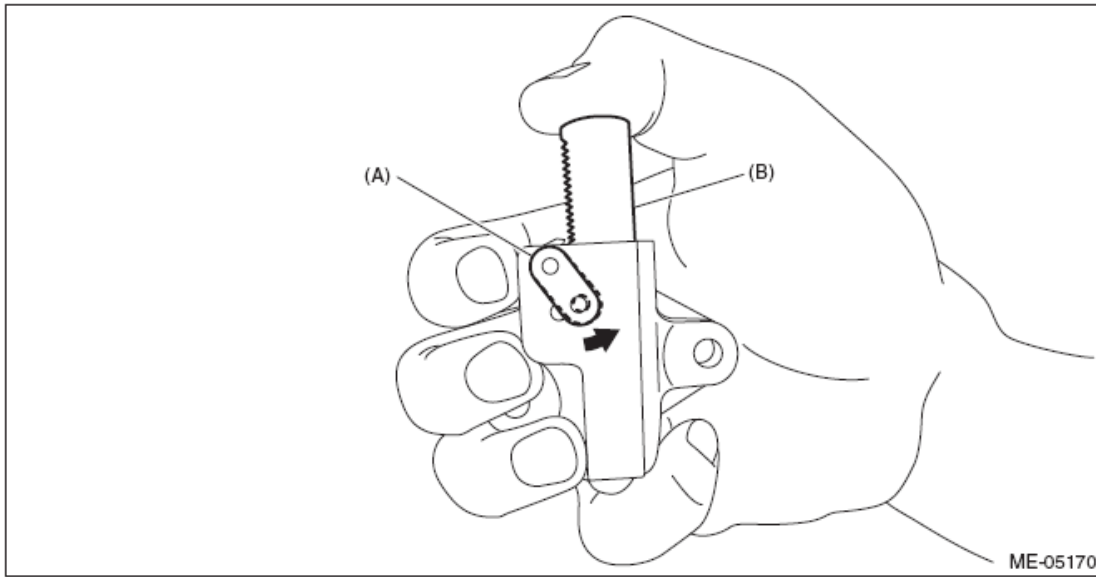
**CAUTION:** Before installing the timing chain RH, install the timing chain LH.

### TIMING CHAIN RH

#### NOTE:

- Be careful that the foreign matter is not into or onto the assembled component during installation.
- Apply engine oil to all component parts of the timing chain.

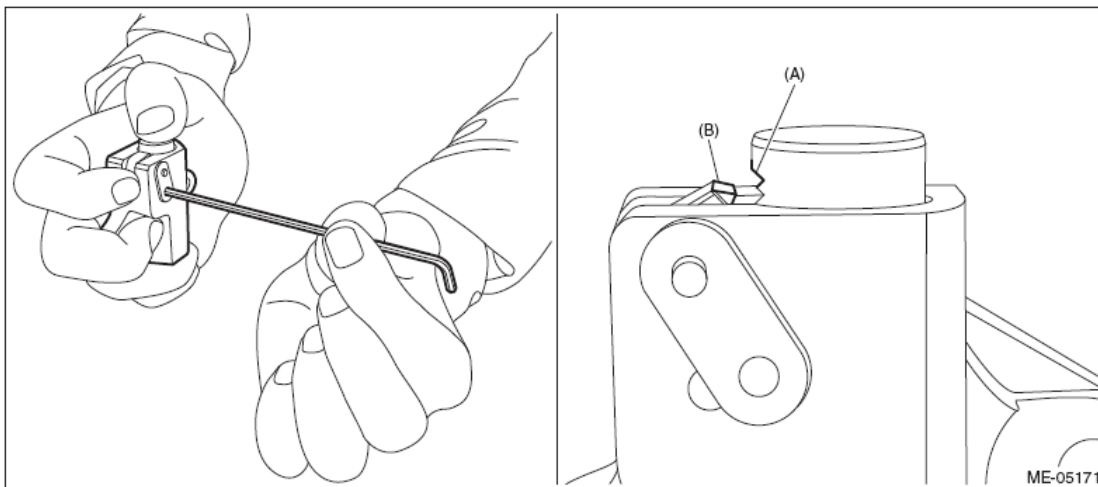
1. Install timing chain LH. < Refer to **TIMING CHAIN LH**, INSTALLATION, Timing Chain Assembly. >
2. Prepare to attach the chain tensioner RH.
  1. Move the link plate (A) in the direction of arrow to press in the plunger (B).



**Fig. 153: Pressing Link Plate Plunger**  
 Courtesy of SUBARU OF AMERICA, INC.

2. With a 2.5 mm (0.98 in) dia. stopper pin or a 2.5 mm (0.98 in) (nominal) dia. hex wrench inserted into the stopper pin hole, secure the plunger.

**NOTE:** If the stopper pin hole on the link plate and the stopper pin hole on the chain tensioner are not aligned, check that the first notch of plunger rack (A) is engaged with the stopper tooth (B). If not engaged, retract the plunger a little so that the first notch of plunger rack (A) is engaged with the stopper tooth (B).



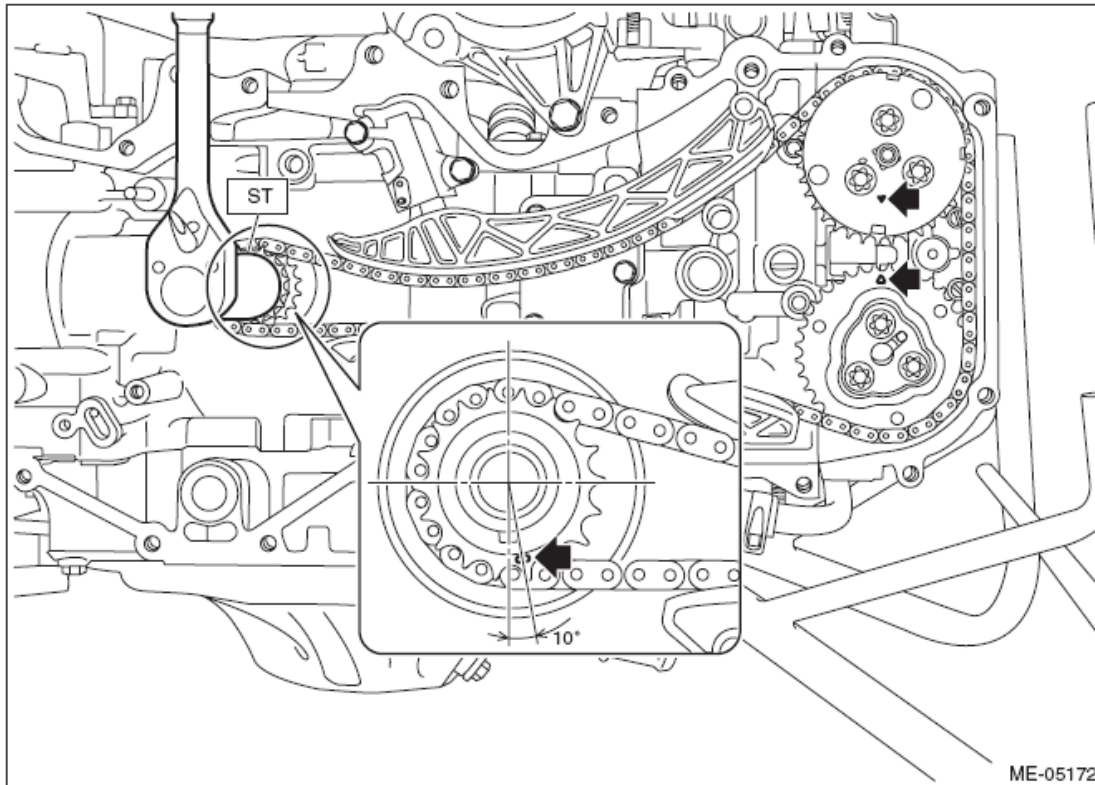
**Fig. 154: Inserting Hex Wrench Into Stopper Pin Hole**  
 Courtesy of SUBARU OF AMERICA, INC.

3. Using ST and by turning the crankshaft, align the alignment marks of crank sprocket, intake cam sprocket

LH and exhaust cam sprocket LH to the positions as shown in the figure.

**NOTE:** If the alignment marks are aligned to the positions as shown in the figure, the crankshaft key is located at six o'clock position.

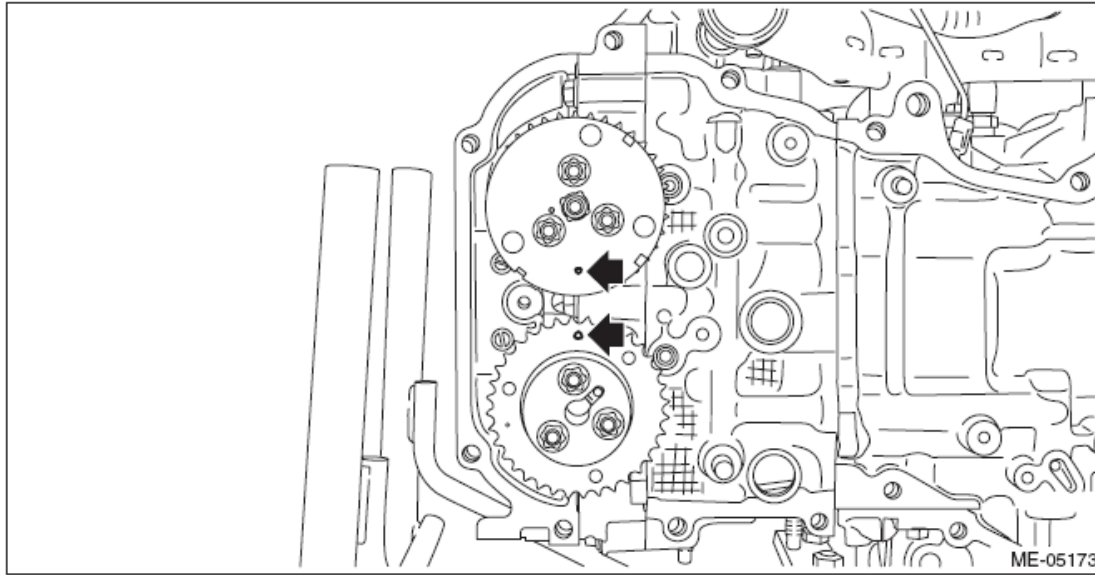
ST 18252AA000 CRANKSHAFT SOCKET



**Fig. 155: Aligning Alignment Marks Of Crank Sprocket, Intake Cam Sprocket LH And Exhaust Cam Sprocket LH Using Crankshaft Socket**  
Courtesy of SUBARU OF AMERICA, INC.

4. Align the alignment marks of intake cam sprocket RH and exhaust cam sprocket RH to the positions as shown in the figure.

**CAUTION:** To prevent valve damage, turn the intake cam sprocket RH and exhaust cam sprocket RH only within the range of zero-lift (in range where it can be turned lightly by hand).

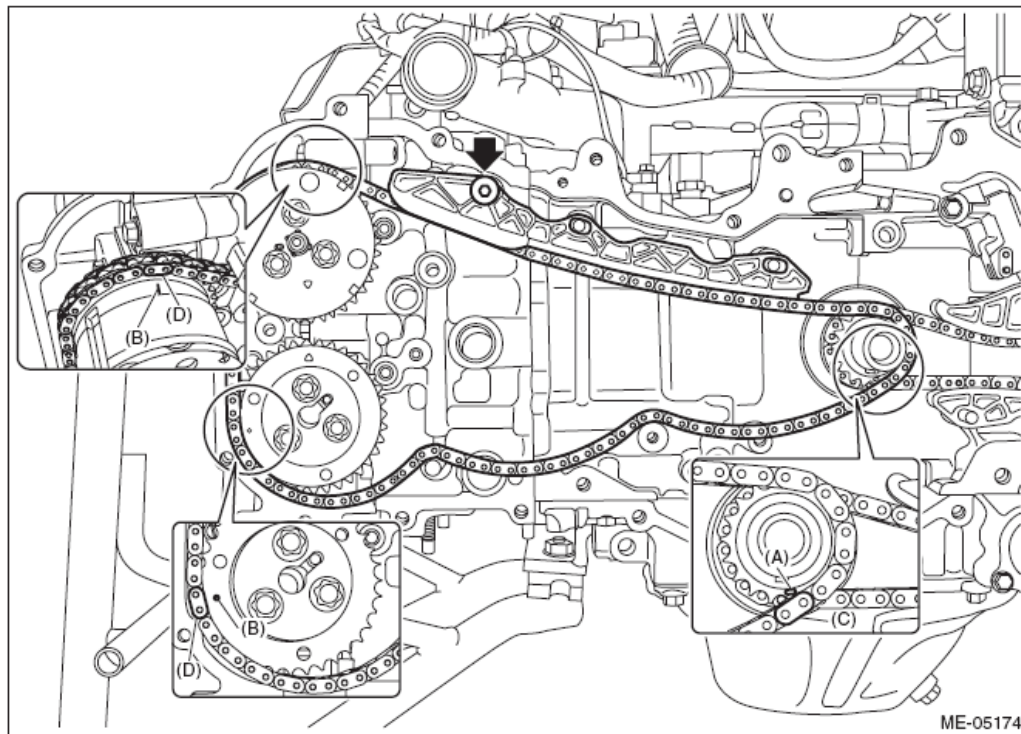


**Fig. 156: Identifying Alignment Marks On Intake And Exhaust Cam Sprocket RH**  
Courtesy of SUBARU OF AMERICA, INC.

5. Install the timing chain RH and the timing chain guide RH.
  1. Match the timing chain mark (yellow) to the alignment mark of the crank sprocket.
  2. Match the timing chain mark (orange) to the timing mark position of the intake cam sprocket RH.
  3. Match the timing chain mark (orange) to the timing mark position of the exhaust cam sprocket RH.
  4. Install the timing chain guide RH.

***Tightening torque:***

***6.4 N.m (0.7 kgf-m, 4.7 ft-lb)***



(A) Alignment mark  
(B) Timing mark

(C) Yellow

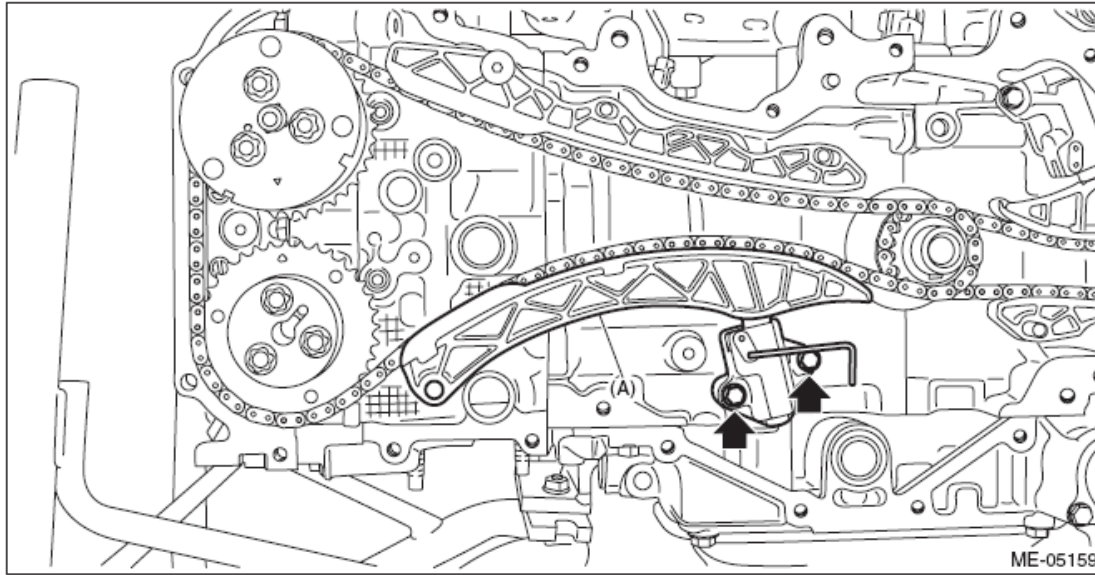
(D) Orange

**Fig. 157: Locating Timing Chain Guide RH**  
Courtesy of SUBARU OF AMERICA, INC.

6. Install the chain tensioner lever RH (A) and chain tensioner RH.

***Tightening torque:***

***6.4 N.m (0.7 kgf-m, 4.7 ft-lb)***

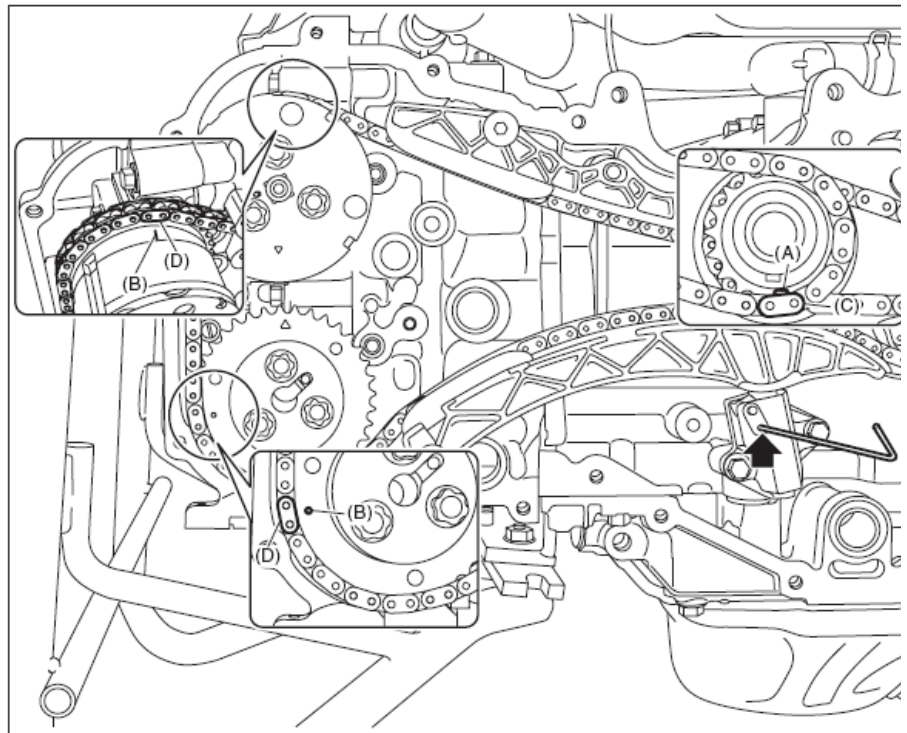


**Fig. 158: Locating Chain Tensioner RH And Chain Tensioner Lever RH Bolts**  
Courtesy of SUBARU OF AMERICA, INC.

7. Pull out the stopper pin from the chain tensioner RH.

**CAUTION:** Confirm the following before pulling out the stopper pin.

- Matching of the timing chain mark (yellow) to the alignment mark crank sprocket.
- Matching of the timing chain mark (orange) to the timing mark po the intake cam sprocket RH.
- Matching of the timing chain mark (orange) to the timing mark po the exhaust cam sprocket RH.



(A) Alignment mark

(C) Yellow

(D) Orange

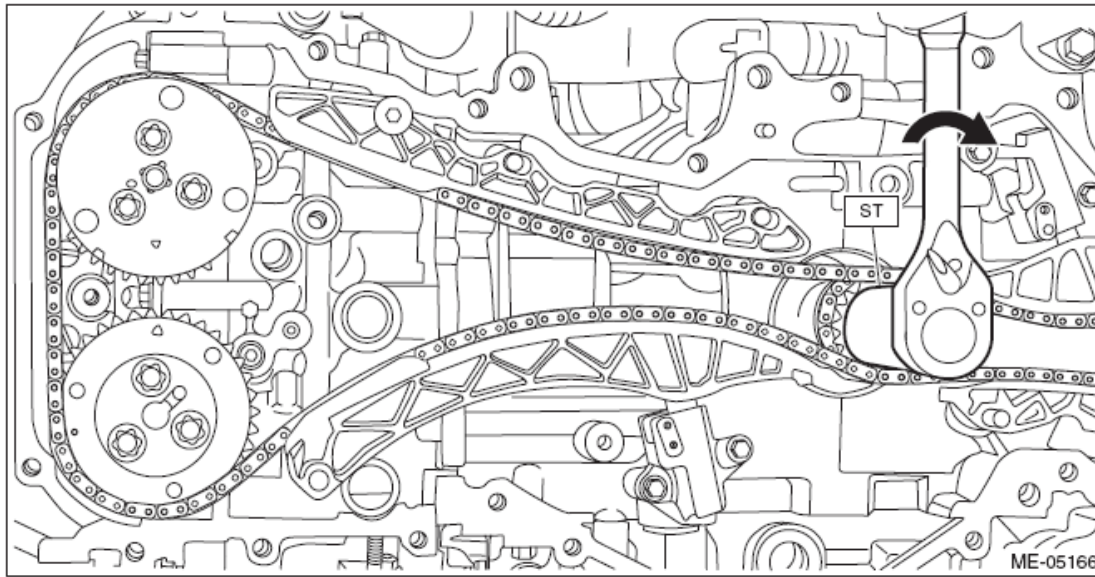
(B) Timing mark

**Fig. 159: Pulling Out Stopper Pin From Chain Tensioner RH**  
**Courtesy of SUBARU OF AMERICA, INC.**

8. Using the ST, turn the crankshaft clockwise, and make sure that there are no abnormal conditions.

**CAUTION: Always make sure to perform this confirmation.**

ST 18252AA000 CRANKSHAFT SOCKET



**Fig. 160: Turning Crankshaft Clockwise Using Crankshaft Socket**  
 Courtesy of SUBARU OF AMERICA, INC.

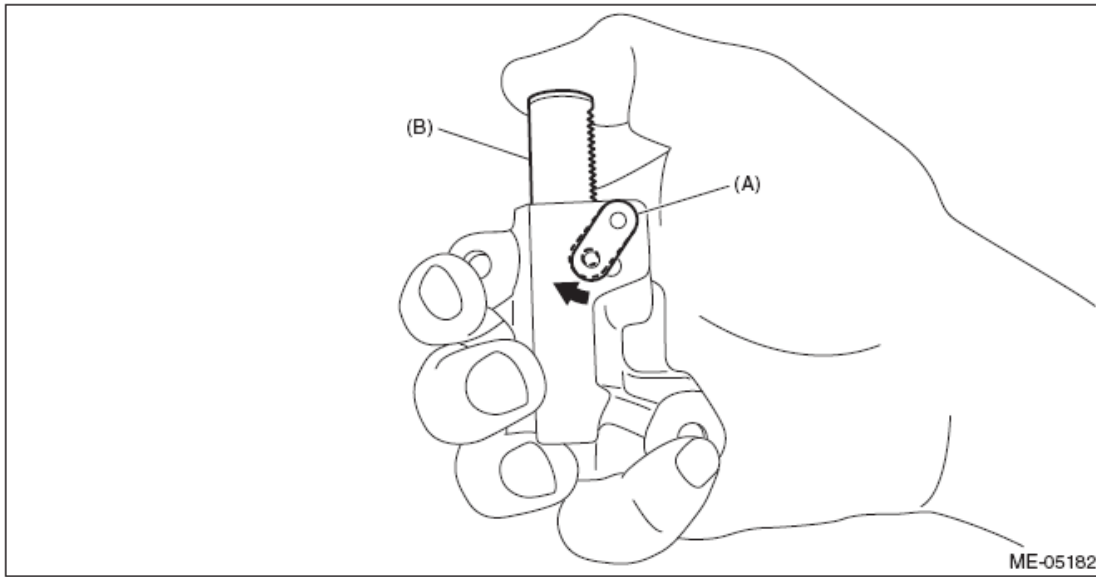
9. Install the chain cover. < Refer to **INSTALLATION**, Chain Cover. >

#### **TIMING CHAIN LH**

##### **NOTE:**

- Be careful that the foreign matter is not into or onto the assembled component during installation.
- Apply engine oil to all component parts of the timing chain.

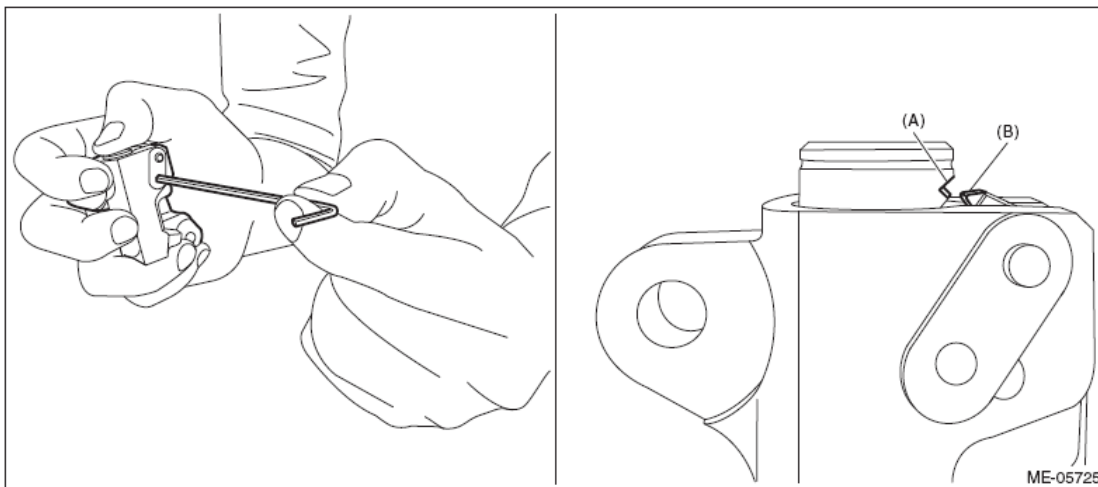
1. Prepare to attach the chain tensioner LH.
  1. Move the link plate (A) in the direction of arrow to press in the plunger (B).



**Fig. 161: Pressing Link Plate Plunger**  
Courtesy of SUBARU OF AMERICA, INC.

2. With a 2.5 mm (0.98 in) dia. stopper pin or a 2.5 mm (0.98 in) (nominal) dia. hex wrench inserted into the stopper pin hole, secure the plunger.

**NOTE:** If the stopper pin hole on the link plate and the stopper pin hole on the chain tensioner are not aligned, check that the first notch of plunger rack (A) is engaged with the stopper tooth (B). If not engaged, retract the plunger a little so that the first notch of plunger rack (A) is engaged with the stopper tooth (B).



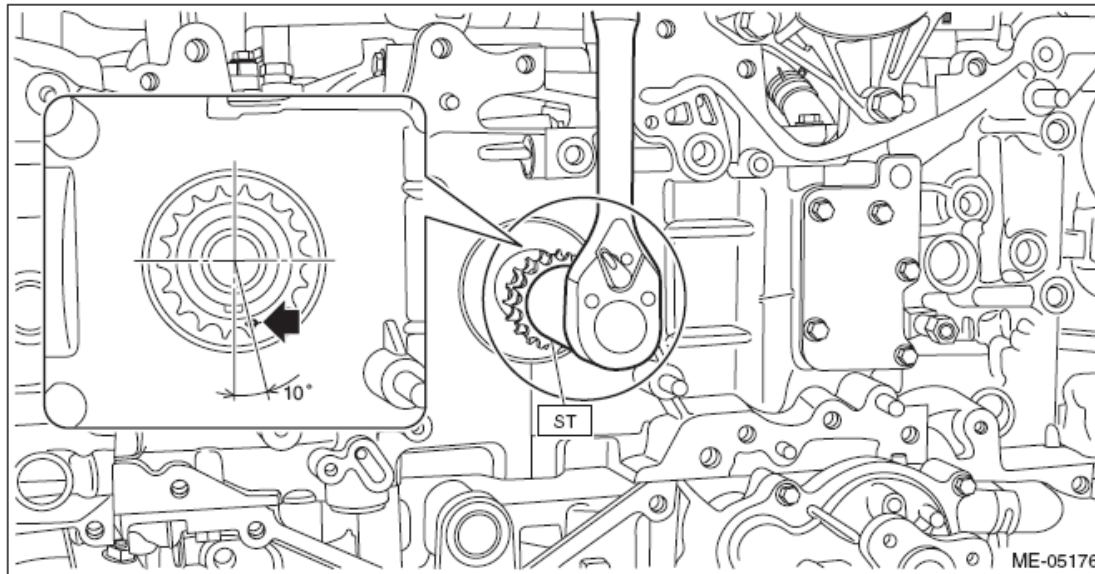
**Fig. 162: Inserting Hex Wrench Into Stopper Pin Hole**  
Courtesy of SUBARU OF AMERICA, INC.

2. Check that the crank sprocket is located at the position shown in the figure. If not aligned, using ST turn

the crankshaft to align the crank sprocket alignment mark to the position shown in the figure.

**NOTE:** This procedure is required to prevent the valve and piston contacting with each other in the next step.

ST 18252AA000 CRANKSHAFT SOCKET



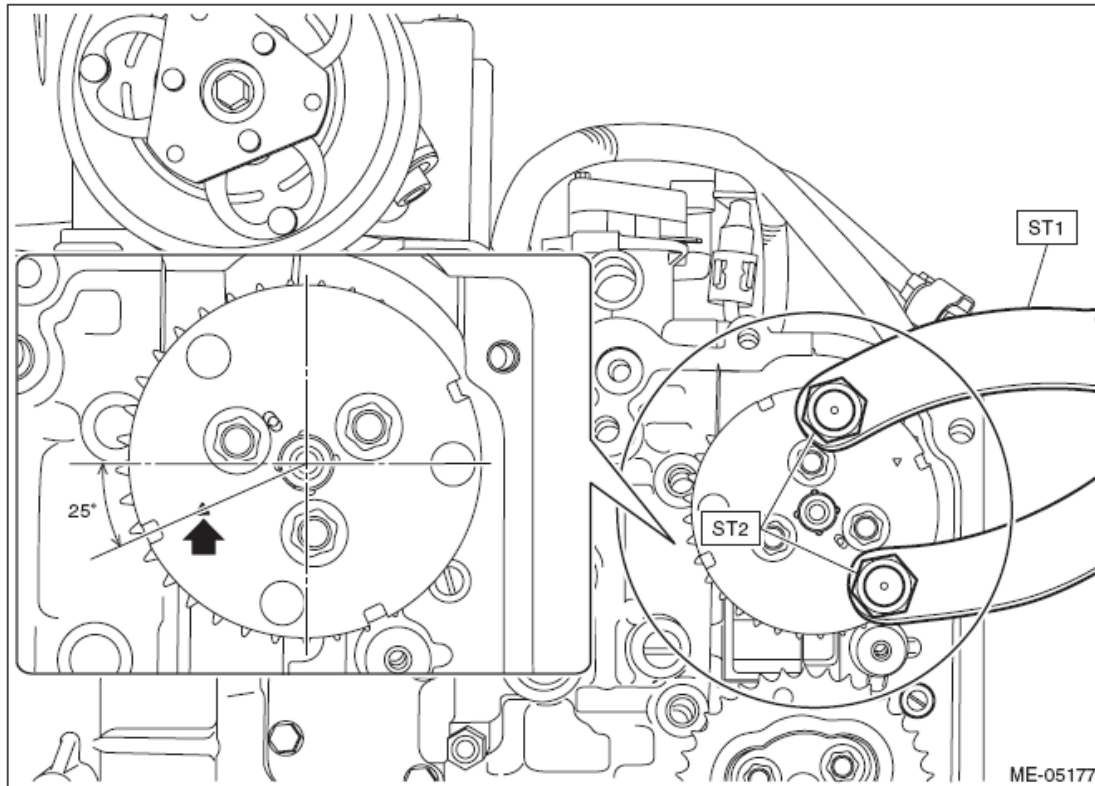
**Fig. 163: Aligning Crank Sprocket Alignment Mark Using Crankshaft Socket**  
Courtesy of SUBARU OF AMERICA, INC.

3. Using ST and by turning the intake cam sprocket LH, align the alignment marks to the positions as shown in the figure.

**CAUTION:** When the intake valve and exhaust valve lift at the same time, the valve heads contact each other and valve stem may bend. Do not turn the exhaust camshaft LH.

ST1 18355AA000 PULLEY WRENCH

ST2 18334AA030 PULLEY WRENCH PIN SET

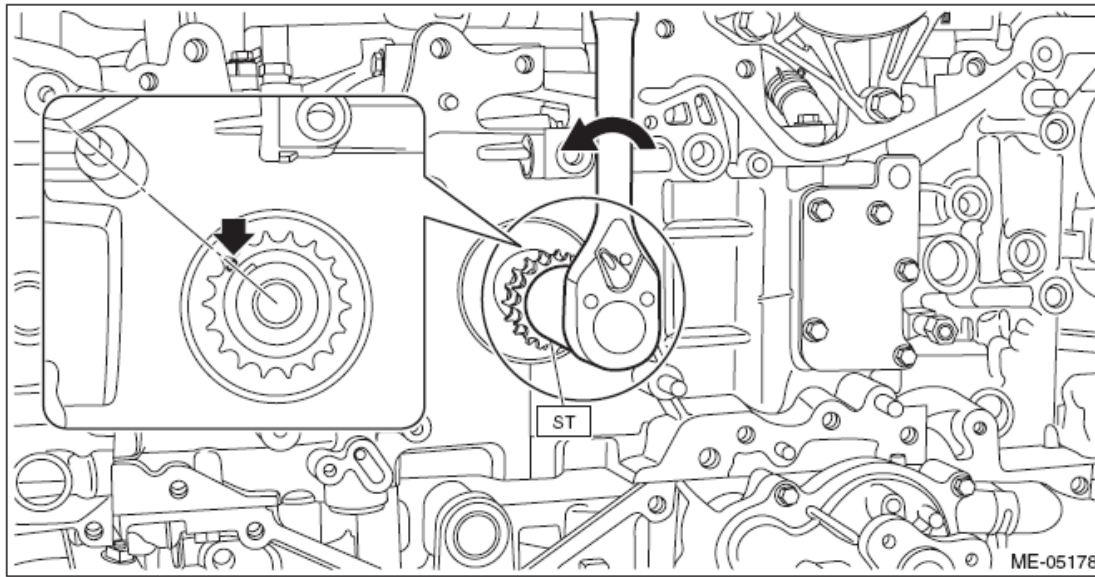


**Fig. 164: Identifying Intake Cam Sprocket LH Turning Angle**  
Courtesy of SUBARU OF AMERICA, INC.

4. Using ST and by turning the crankshaft approximately 200° counterclockwise, align the alignment marks of crankshaft key to the positions as shown in the figure.

**CAUTION:** Never turn clockwise because the valve and piston may contact. Clockwise turn is allowed only when adjusting the key position precisely, after turning the crankshaft counterclockwise to bring the key near the position as shown in the figure.

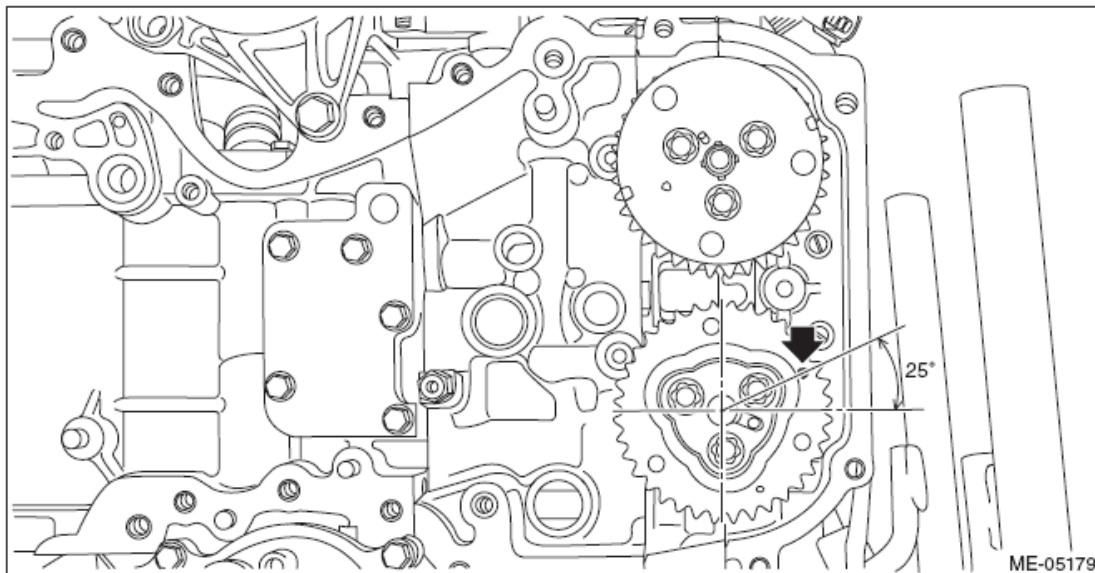
ST 18252AA000 CRANKSHAFT SOCKET



**Fig. 165: Turning Crankshaft To Counterclockwise Using Crankshaft Socket**  
Courtesy of SUBARU OF AMERICA, INC.

5. Align the alignment mark of exhaust cam sprocket LH to the position shown in the figure.

**CAUTION:** To prevent valve damage, turn the exhaust cam sprocket LH only within the range of zero-lift (in range where it can be turned lightly by hand).



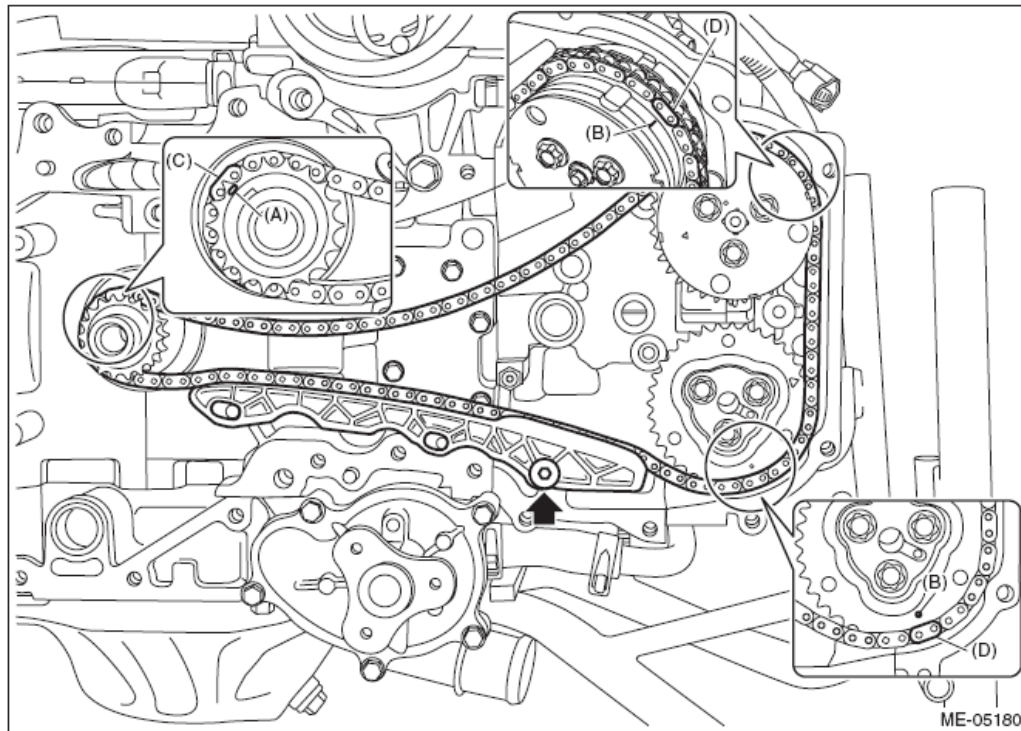
**Fig. 166: Aligning Alignment Mark Of Exhaust Cam Sprocket LH**  
Courtesy of SUBARU OF AMERICA, INC.

6. Install the timing chain LH and the timing chain guide LH.

1. Match the timing chain mark (yellow) to the alignment mark of the crank sprocket.
2. Match the timing chain mark (orange) to the timing mark position of the intake cam sprocket LH.
3. Match the timing chain mark (orange) to the timing mark position of the exhaust cam sprocket LH.
4. Install timing chain guide LH.

***Tightening torque:***

**6.4 N.m (0.7 kgf-m, 4.7 ft-lb)**



(A) Alignment mark  
(B) Timing mark

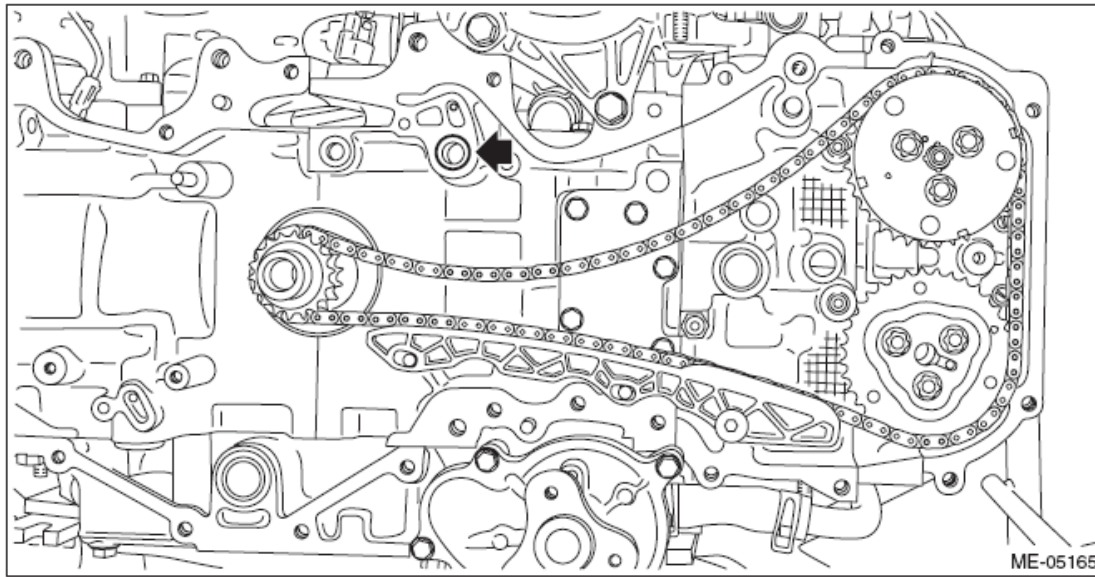
(C) Yellow

(D) Orange

**Fig. 167: Locating Timing Chain Guide LH**  
Courtesy of SUBARU OF AMERICA, INC.

7. Install O-rings to the cylinder block LH.

**NOTE: Use new O-rings.**

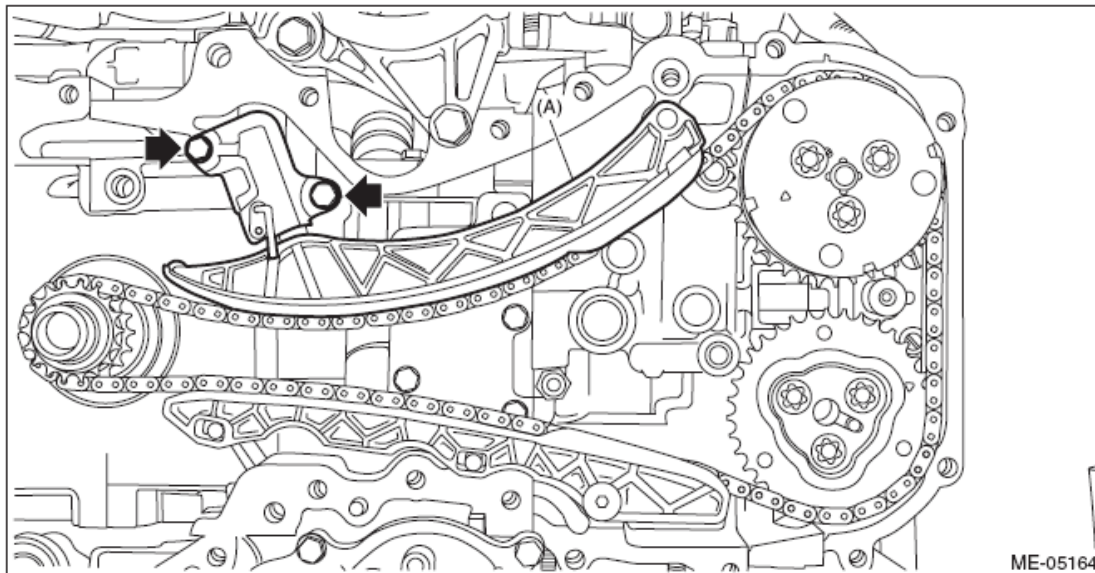


**Fig. 168: Locating Cylinder Block LH O-Ring**  
Courtesy of SUBARU OF AMERICA, INC.

8. Install the chain tensioner lever LH (A) and chain tensioner LH.

***Tightening torque:***

***6.4 N.m (0.7 kgf-m, 4.7 ft-lb)***

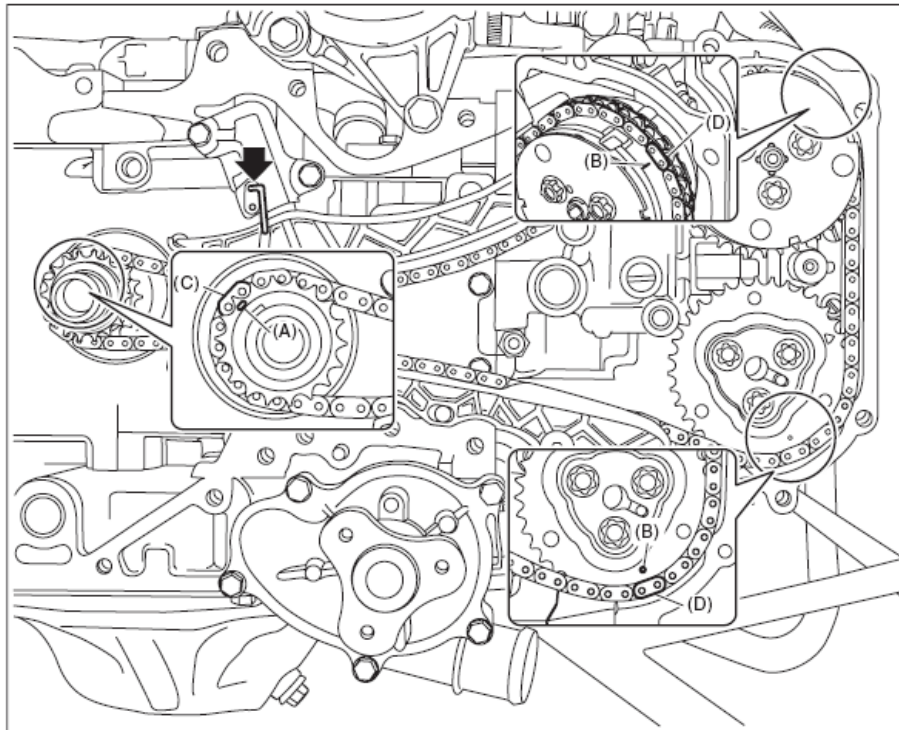


**Fig. 169: Locating Chain Tensioner LH And Chain Tensioner Lever LH Bolts**  
Courtesy of SUBARU OF AMERICA, INC.

9. Pull out the stopper pin from the chain tensioner LH.

**CAUTION:** Confirm the following before pulling out the stopper pin.

- Matching of the timing chain mark (yellow) to the alignment mark crank sprocket.
- Matching of the timing chain mark (orange) to the timing mark on the intake cam sprocket LH.
- Matching of the timing chain mark (orange) to the timing mark on the exhaust cam sprocket LH.



(A) Alignment mark  
(B) Timing mark

(C) Yellow

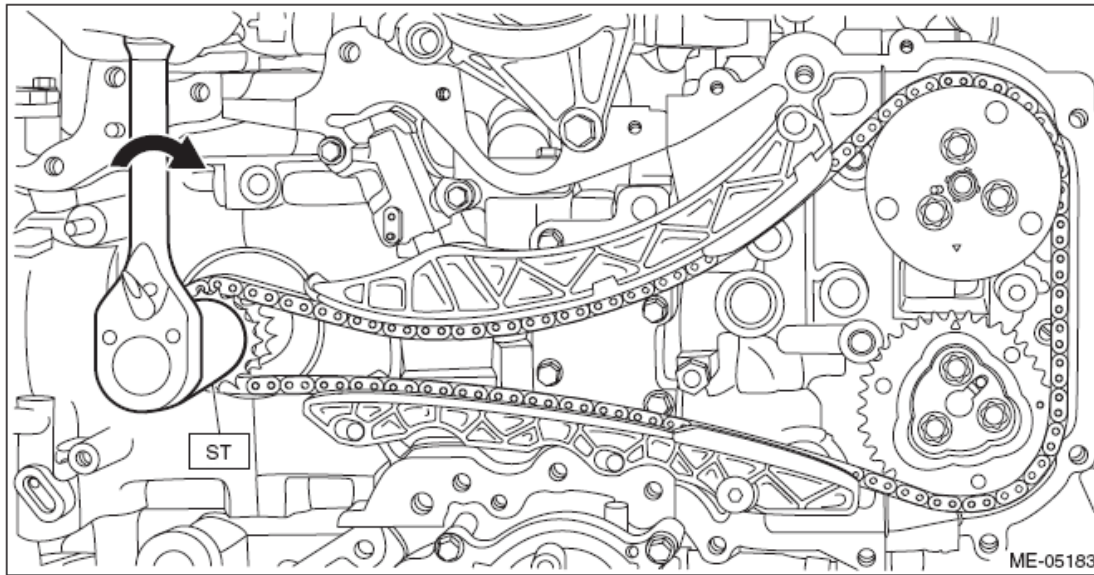
(D) Orange

**Fig. 170: Removing Stopper Pin From Chain Tensioner LH**  
Courtesy of SUBARU OF AMERICA, INC.

10. Using the ST, turn the crankshaft clockwise, and make sure that there are no abnormal conditions.

**CAUTION:** Always make sure to perform this confirmation.

ST 18252AA000 CRANKSHAFT SOCKET



**Fig. 171: Turning Crankshaft Clockwise Using Crankshaft Socket**  
 Courtesy of SUBARU OF AMERICA, INC.

11. Install the timing chain RH. < Refer to **TIMING CHAIN RH**, INSTALLATION, Timing Chain Assembly. >

## INSPECTION

1. Check the timing chain, chain guide, chain tensioner lever and chain tensioner for deformation, cracks or other damages.
2. Check the chain guide and chain tensioner lever for abnormal wear.

## CAM SPROCKET

### REMOVAL

#### CAM SPROCKET RH

**NOTE:** When replacing a single part, perform the work with the engine assembly installed to body.

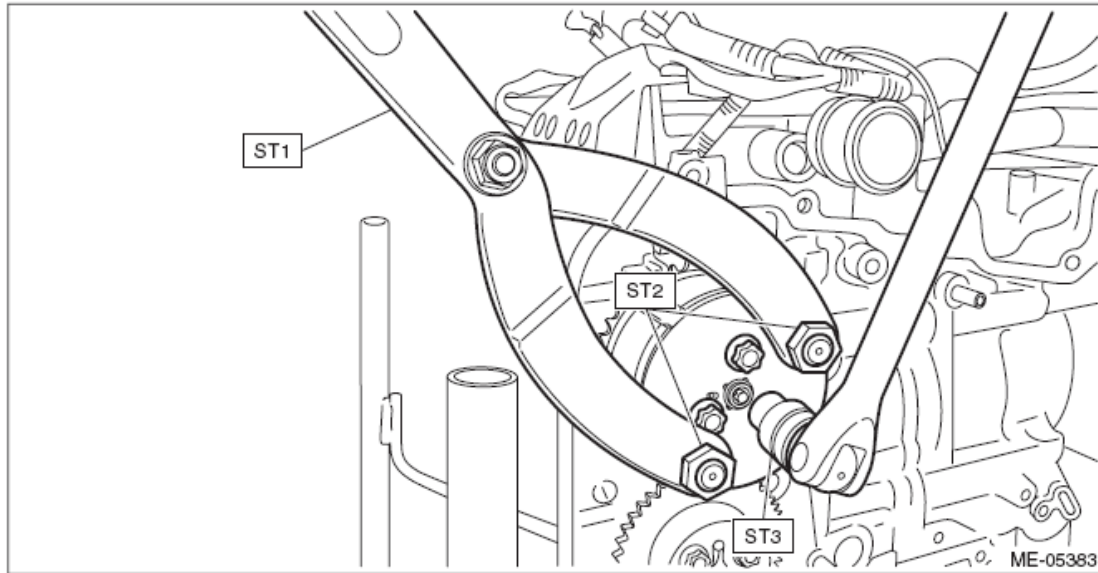
- **Intake cam sprocket RH**

1. Remove the chain cover. < Refer to **REMOVAL**, Chain Cover. >
2. Remove the timing chain RH. < Refer to **TIMING CHAIN RH**, REMOVAL, Timing Chain Assembly. >
3. Hold the intake cam sprocket RH using the ST1 and ST2, and remove the bolts using the ST3.

ST1 18355AA000 PULLEY WRENCH

ST2 18334AA030 PULLEY WRENCH PIN SET

ST3 18270KA010 SOCKET



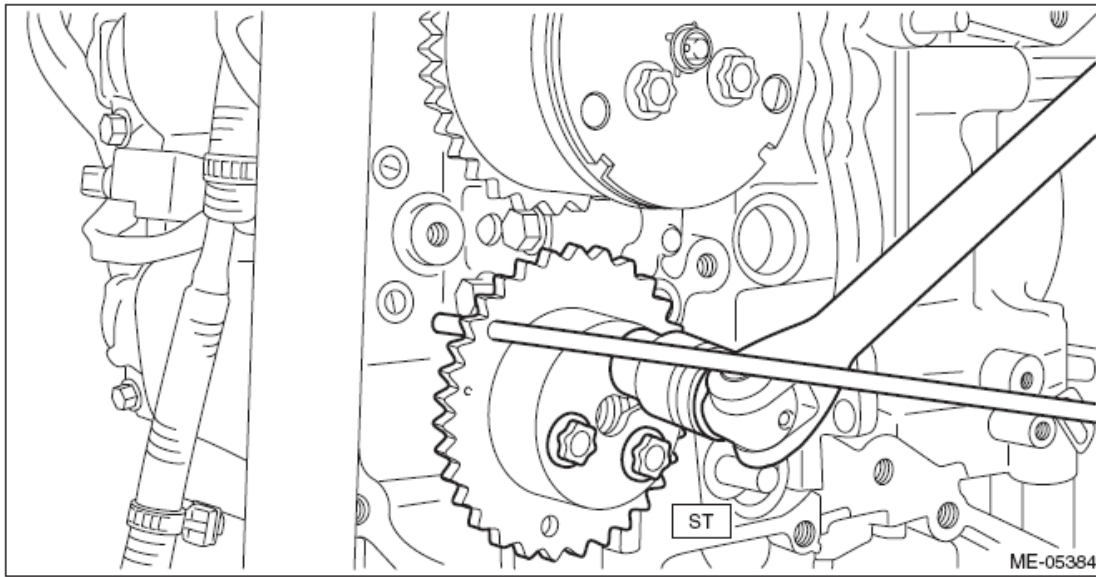
**Fig. 172: Removing Intake Cam Sprocket RH Mounting Bolt Using Tools**  
Courtesy of SUBARU OF AMERICA, INC.

4. Remove the intake cam sprocket RH.

• **Exhaust cam sprocket RH**

1. Remove the chain cover. < Refer to **REMOVAL**, Chain Cover. >
2. Remove the timing chain RH. < Refer to **TIMING CHAIN RH**, REMOVAL, Timing Chain Assembly. >
3. Hold the exhaust cam sprocket RH by inserting the 6 mm (0.236 in) dia. steel rod into the exhaust cam sprocket RH hole as shown in the figure, and remove the bolts using the ST.

ST 18270KA010 SOCKET



**Fig. 173: Inserting Steel Rod Into Exhaust Cam Sprocket RH Hole**  
 Courtesy of SUBARU OF AMERICA, INC.

4. Remove the exhaust cam sprocket RH.

#### CAM SPROCKET LH

**NOTE:** When replacing a single part, perform the work with the engine assembly installed to body.

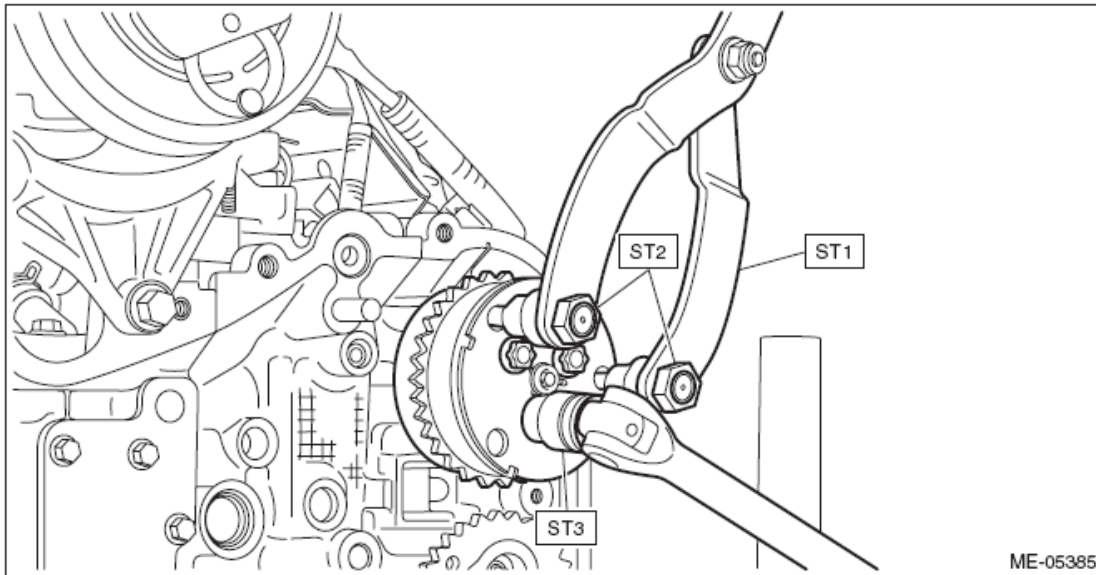
##### • Intake cam sprocket LH

1. Remove the chain cover. < Refer to **REMOVAL**, Chain Cover. >
2. Remove the timing chain LH. < Refer to **TIMING CHAIN LH**, REMOVAL, Timing Chain Assembly. >
3. Hold the intake cam sprocket LH using the ST1 and ST2, and remove the bolts using the ST3.

ST1 18355AA000 PULLEY WRENCH

ST2 18334AA030 PULLEY WRENCH PIN SET

ST3 18270KA010 SOCKET



**Fig. 174: Removing Intake Cam Sprocket LH Mounting Bolt Using Tools**  
 Courtesy of SUBARU OF AMERICA, INC.

4. Remove the intake cam sprocket LH.

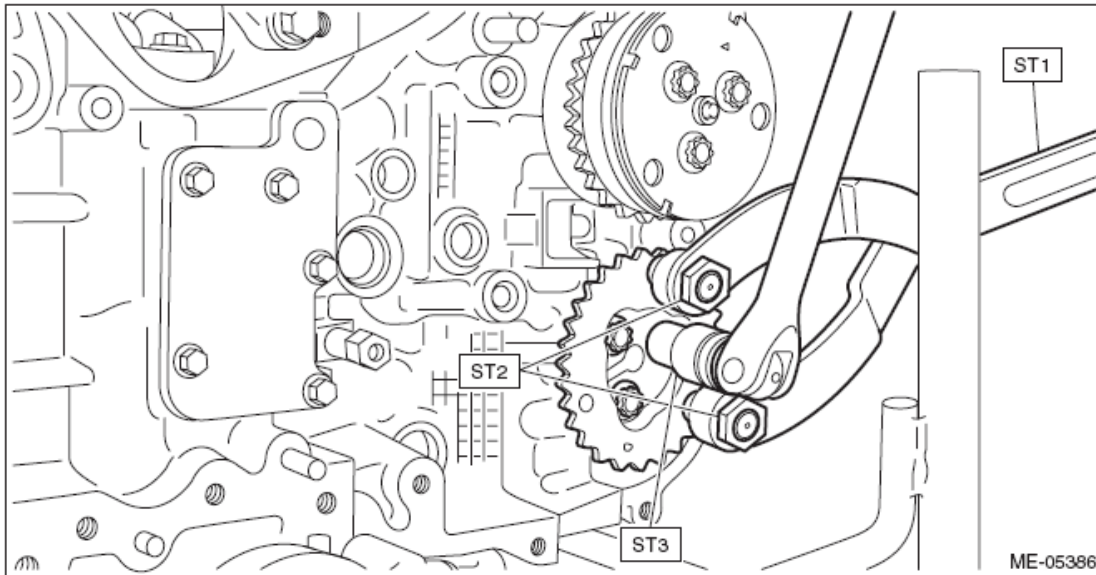
• **Exhaust cam sprocket LH**

1. Remove the chain cover. < Refer to **REMOVAL**, Chain Cover. >
2. Remove the timing chain LH. < Refer to **TIMING CHAIN LH**, REMOVAL, Timing Chain Assembly. >
3. Hold the exhaust cam sprocket LH using the ST1 and ST2, and remove the bolts using the ST3.

ST1 18355AA000 PULLEY WRENCH

ST2 18334AA020 PULLEY WRENCH PIN SET

ST3 18270KA010 SOCKET



**Fig. 175: Removing Exhaust Cam Sprocket LH Mounting Bolt Using Tools**  
Courtesy of SUBARU OF AMERICA, INC.

4. Remove the exhaust cam sprocket LH.

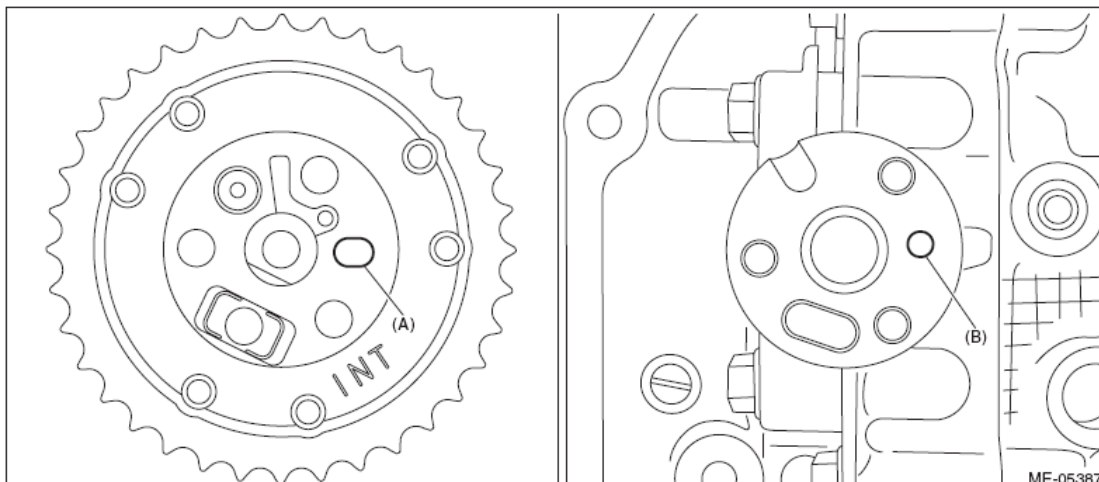
## INSTALLATION

### CAM SPROCKET RH

- Intake cam sprocket RH

1. Install the intake cam sprocket RH by aligning the knock hole (A) of intake cam sprocket RH and the knock pin (B) of intake camshaft RH.

**NOTE:** Before installation, check that there is no foreign matter on the intake cam sprocket RH and intake camshaft RH.



**Fig. 176: Identifying Intake Cam Sprocket RH Knock Hole And Knock Pin**  
Courtesy of SUBARU OF AMERICA, INC.

2. Hold the intake cam sprocket RH using the ST1 and ST2, and install the bolts using the ST3.

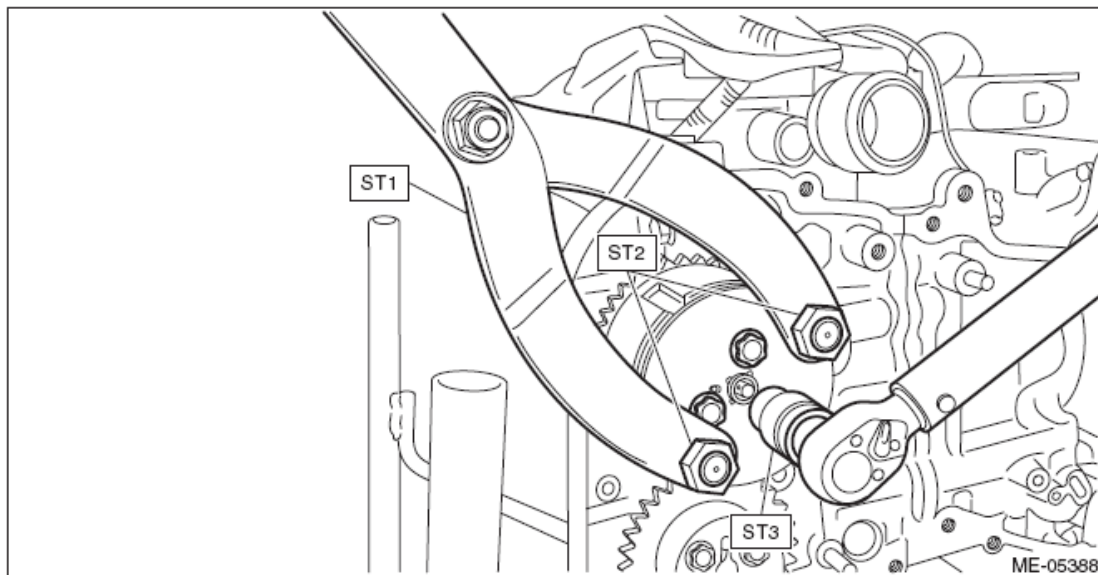
ST1 18355AA000 PULLEY WRENCH

ST2 18334AA030 PULLEY WRENCH PIN SET

ST3 18270KA010 SOCKET

***Tightening torque:***

***18 N.m (1.8 kgf-m, 13.3 ft-lb)***



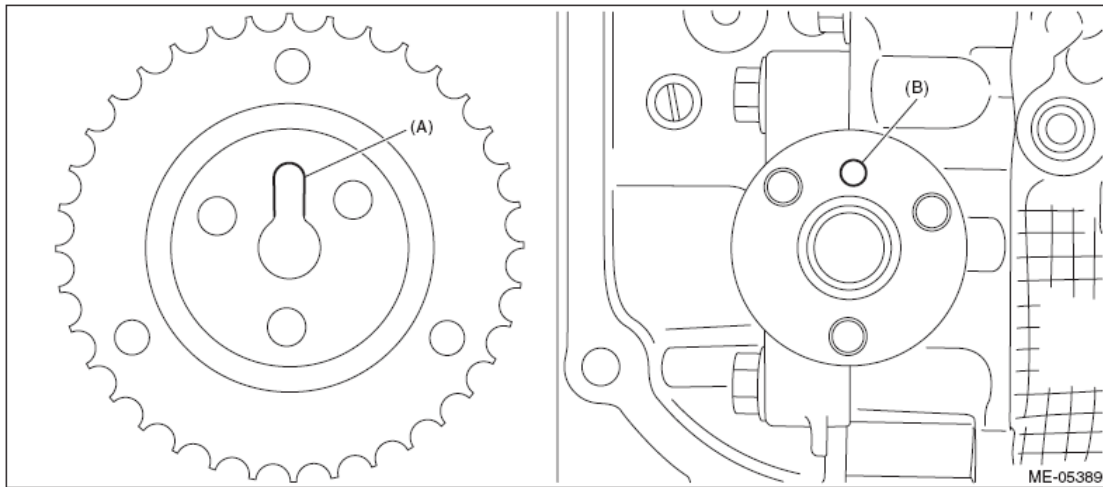
**Fig. 177: Installing Intake Cam Sprocket RH Mounting Bolt Using Tools**  
Courtesy of SUBARU OF AMERICA, INC.

3. Install the timing chain RH. < Refer to **TIMING CHAIN RH**, INSTALLATION, Timing Chain Assembly. >
4. Install the chain cover. < Refer to **INSTALLATION**, Chain Cover. >

• **Exhaust cam sprocket RH**

1. Install the exhaust cam sprocket RH by aligning the knock hole (A) of exhaust cam sprocket RH and the knock pin (B) of exhaust camshaft RH.

**NOTE:** Before installation, check that there is no foreign matter on the exhaust cam sprocket RH and exhaust camshaft RH.



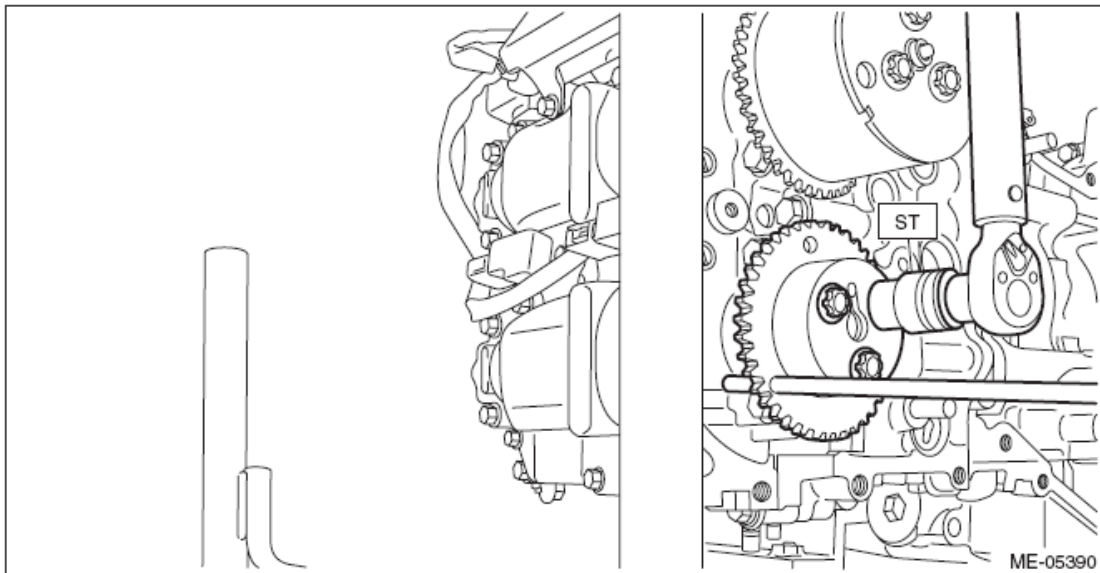
**Fig. 178: Identifying Exhaust Cam Sprocket RH Knock Hole And Knock Pin**  
Courtesy of SUBARU OF AMERICA, INC.

2. Hold the exhaust cam sprocket RH by inserting the 6 mm (0.236 in) dia. steel rod into the exhaust cam sprocket RH hole as shown in the figure, and install the bolts using the ST.

ST 18270KA010 SOCKET

*Tightening torque:*

**18 N.m (1.8 kgf-m, 13.3 ft-lb)**



**Fig. 179: Inserting Steel Rod Into Exhaust Cam Sprocket RH Hole**  
Courtesy of SUBARU OF AMERICA, INC.

3. Install the timing chain RH. < Refer to **TIMING CHAIN RH, INSTALLATION**, Timing Chain

Assembly. >

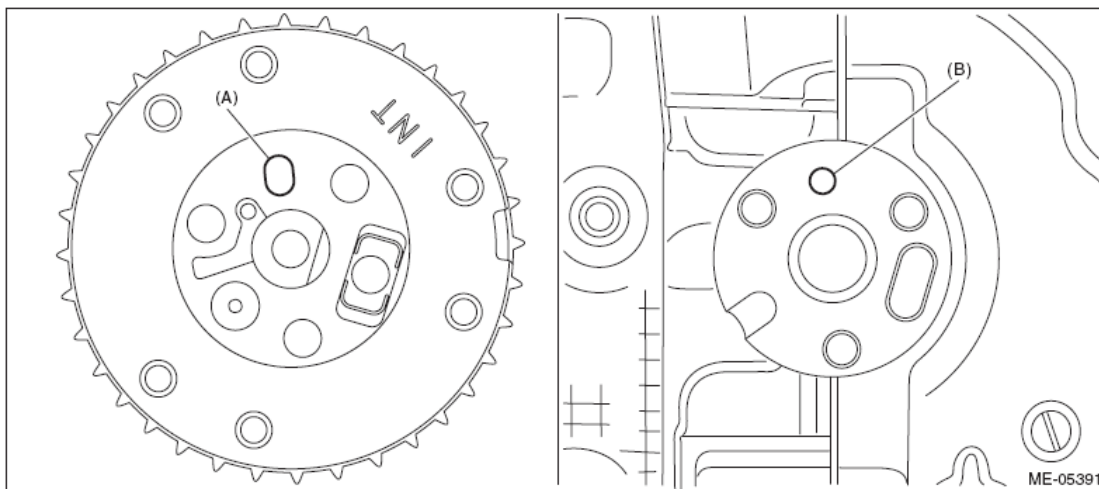
4. Install the chain cover. < Refer to **INSTALLATION**, Chain Cover. >

#### CAM SPROCKET LH

- **Intake cam sprocket LH**

1. Install the intake cam sprocket LH by aligning the knock hole (A) of intake cam sprocket LH and the knock pin (B) of intake camshaft LH.

**NOTE:** Before installation, check that there is no foreign matter on the intake cam sprocket LH and intake camshaft LH.



**Fig. 180: Identifying Intake Cam Sprocket LH Knock Hole And Knock Pin**  
Courtesy of SUBARU OF AMERICA, INC.

2. Hold the intake cam sprocket LH using the ST1 and ST2, and install the bolts using the ST3.

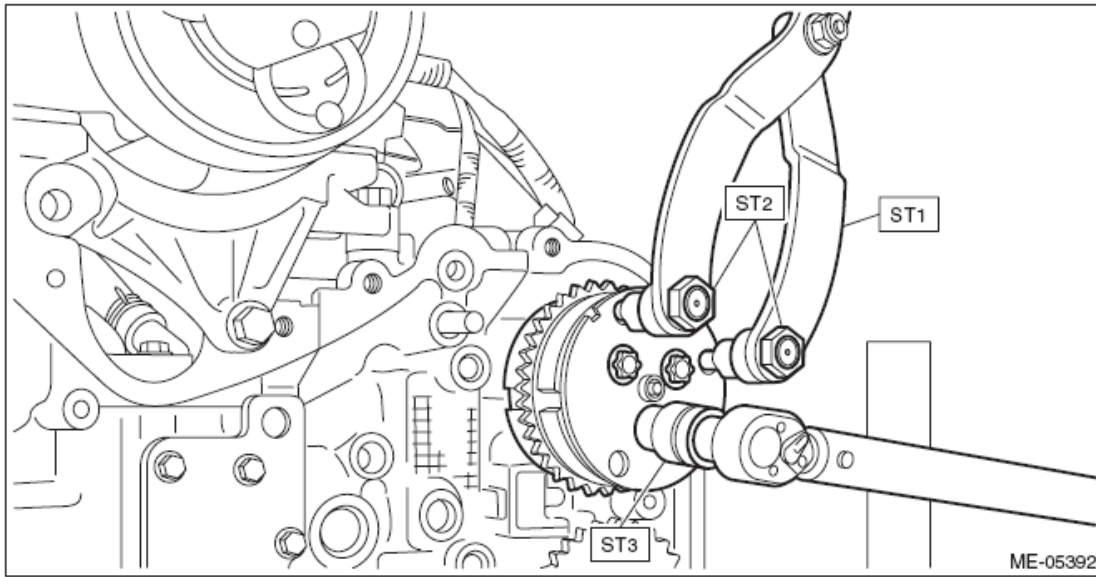
ST1 18355AA000 PULLEY WRENCH

ST2 18334AA030 PULLEY WRENCH PIN SET

ST3 18270KA010 SOCKET

**Tightening torque:**

**18 N.m (1.8 kgf-m, 13.3 ft-lb)**



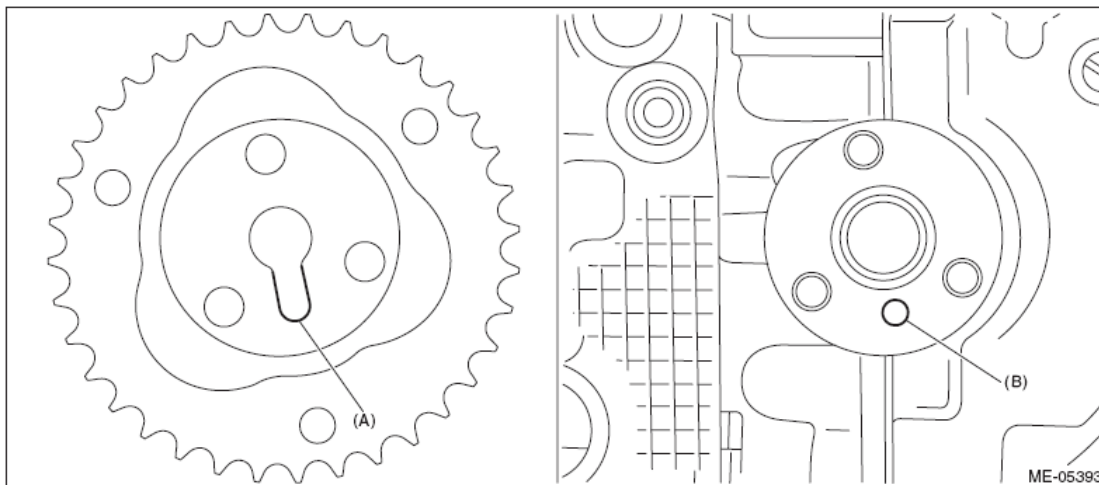
**Fig. 181: Installing Intake Cam Sprocket LH Bolts**  
Courtesy of SUBARU OF AMERICA, INC.

3. Install timing chain LH. < Refer to **TIMING CHAIN LH**, INSTALLATION, Timing Chain Assembly. >
4. Install the chain cover. < Refer to **INSTALLATION**, Chain Cover. >

• **Exhaust cam sprocket LH**

1. Install the exhaust cam sprocket LH by aligning the knock hole (A) of exhaust cam sprocket LH and the knock pin (B) of exhaust camshaft LH.

**NOTE:** Before installation, check that there is no foreign matter on the exhaust cam sprocket LH and exhaust camshaft LH.



**Fig. 182: Identifying Exhaust Cam Sprocket LH Knock Hole And Knock Pin**  
Courtesy of SUBARU OF AMERICA, INC.

2. Hold the exhaust cam sprocket LH using the ST1 and ST2, and install the bolts using the ST3.

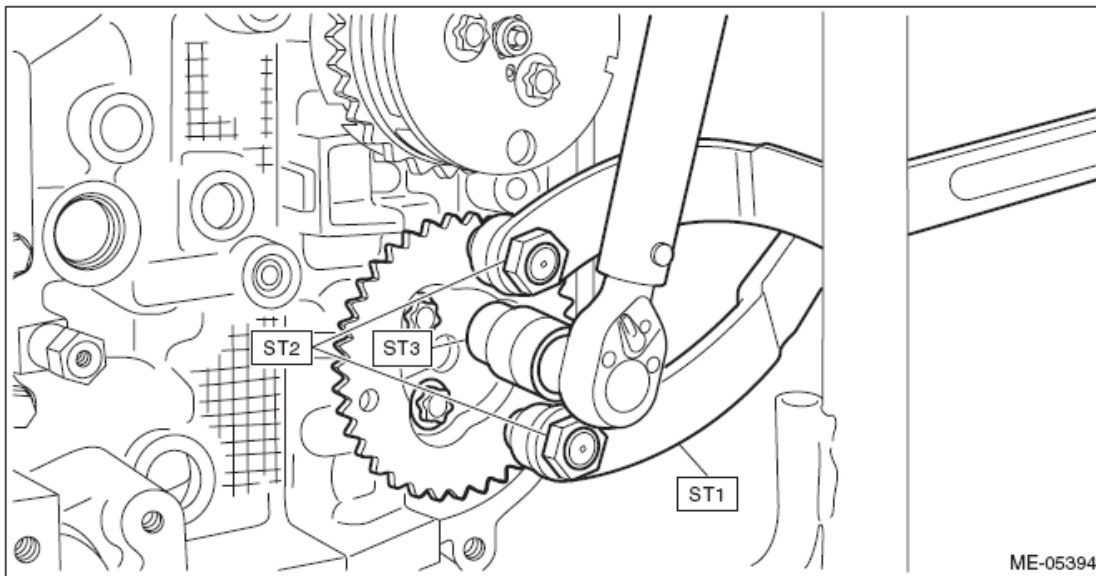
ST1 18355AA000 PULLEY WRENCH

ST2 18334AA020 PULLEY WRENCH PIN SET

ST3 18270KA010 SOCKET

***Tightening torque:***

***18 N.m (1.8 kgf-m, 13.3 ft-lb)***



**Fig. 183: Installing Exhaust Cam Sprocket LH Bolts Using ST**  
Courtesy of SUBARU OF AMERICA, INC.

3. Install timing chain LH. < Refer to TIMING CHAIN LH, INSTALLATION, Timing Chain Assembly. >
4. Install the chain cover. < Refer to INSTALLATION, Chain Cover. >

## INSPECTION

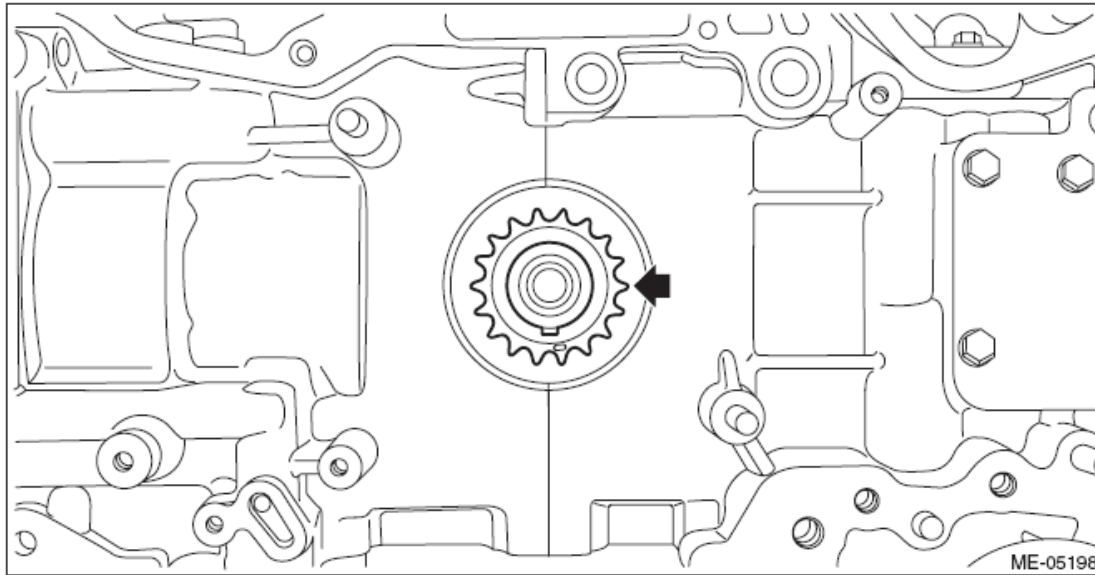
Check the cam sprocket teeth for abnormal wear and scratches.

## CRANK SPROCKET

### REMOVAL

**NOTE:** When replacing a single part, perform the work with the engine assembly installed to body.

1. Remove the chain cover. < Refer to **REMOVAL**, Chain Cover. >
2. Remove the timing chain. < Refer to **REMOVAL**, Timing Chain Assembly. >
3. Remove the crank sprocket.

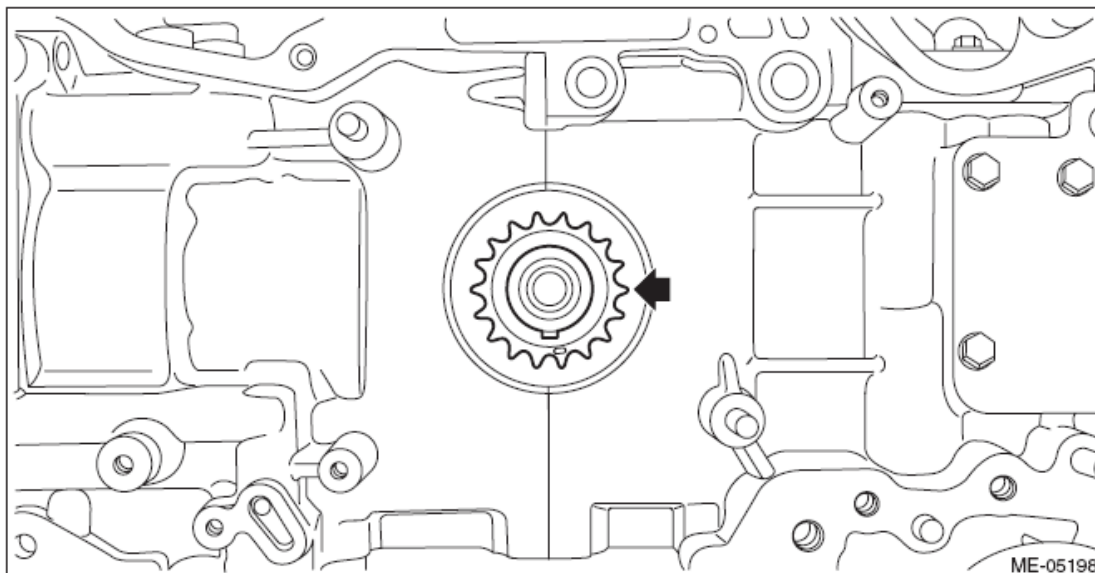


**Fig. 184: Locating Crank Sprocket**  
Courtesy of SUBARU OF AMERICA, INC.

## INSTALLATION

1. Install the crank sprocket.

**NOTE:** The direction of installation is not specified for the crank sprocket.



**Fig. 185: Locating Crank Sprocket****Courtesy of SUBARU OF AMERICA, INC.**

2. Install the timing chain. < Refer to **INSTALLATION**, Timing Chain Assembly. >
3. Install the chain cover. < Refer to **INSTALLATION**, Chain Cover. >

**INSPECTION**

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

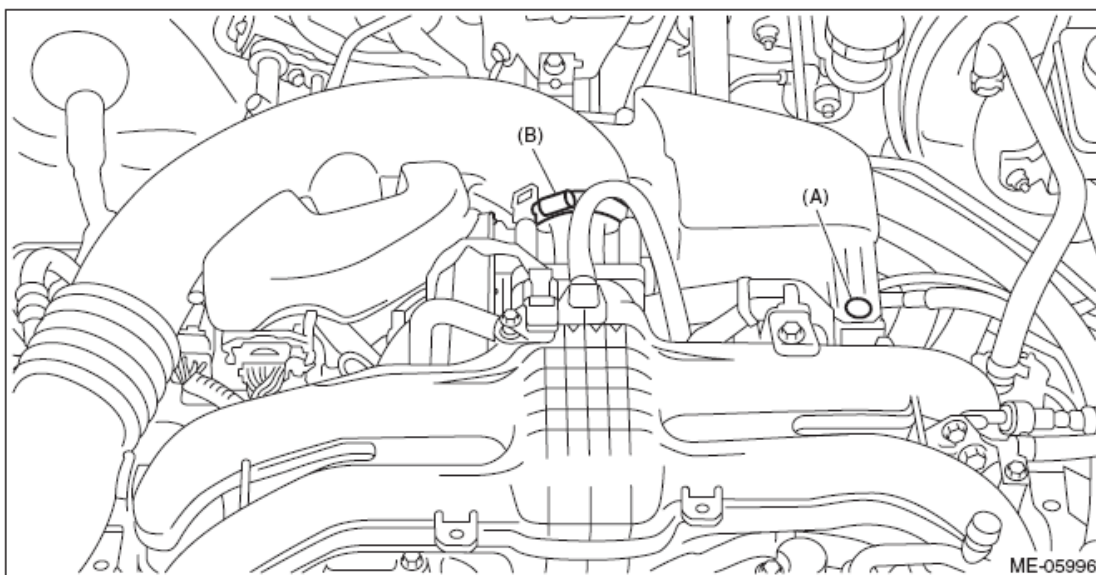
**ROCKER COVER****REMOVAL****ROCKER COVER RH**

**NOTE:** When replacing a single part, perform the work with the engine assembly installed to body.

1. When working on the vehicle

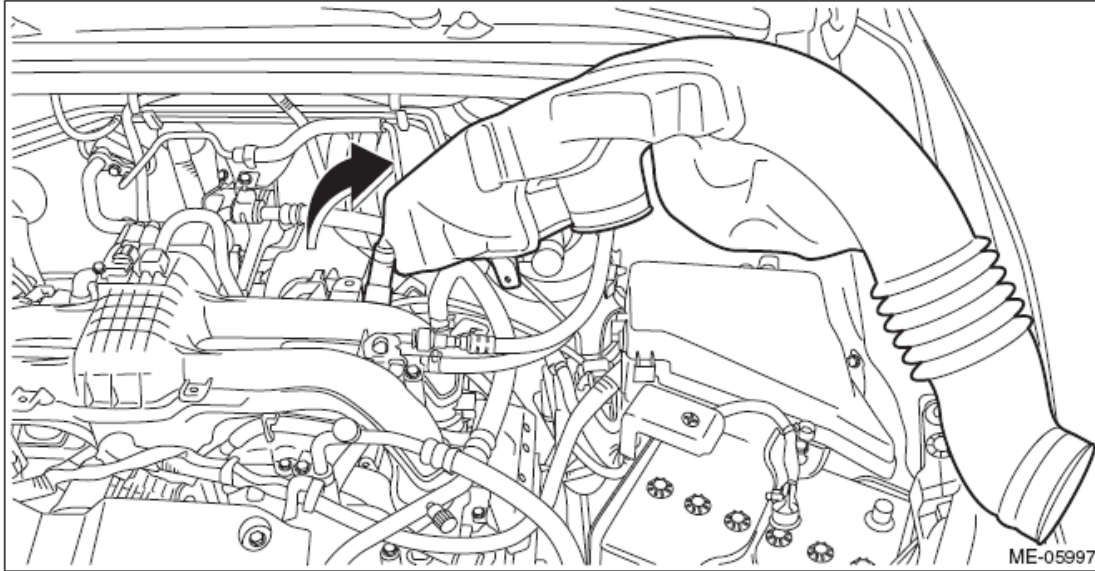
**NOTE:** When working on the vehicle, perform the following steps also.

1. Remove the air cleaner case. < Refer to **REMOVAL** , Air Cleaner Case. >
2. Remove the clip (A) from the air intake boot, and loosen the clamp (B) securing the air intake boot to the throttle body.

**Fig. 186: Identifying Air Intake Boot Clip And Clamp**

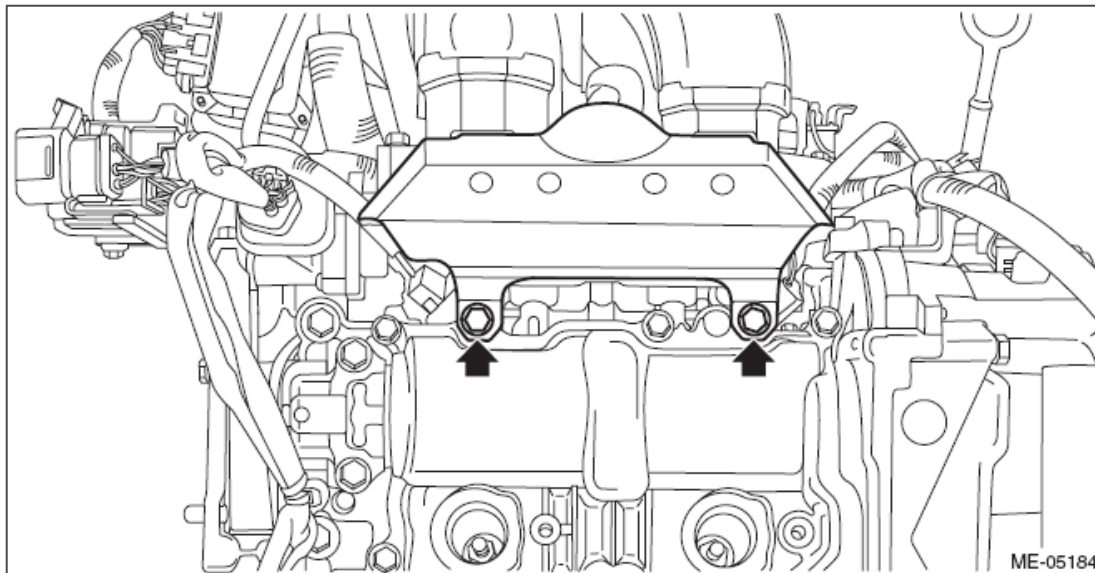
Courtesy of SUBARU OF AMERICA, INC.

3. Remove the air intake boot from the throttle body, and move it to the left side wheel apron.



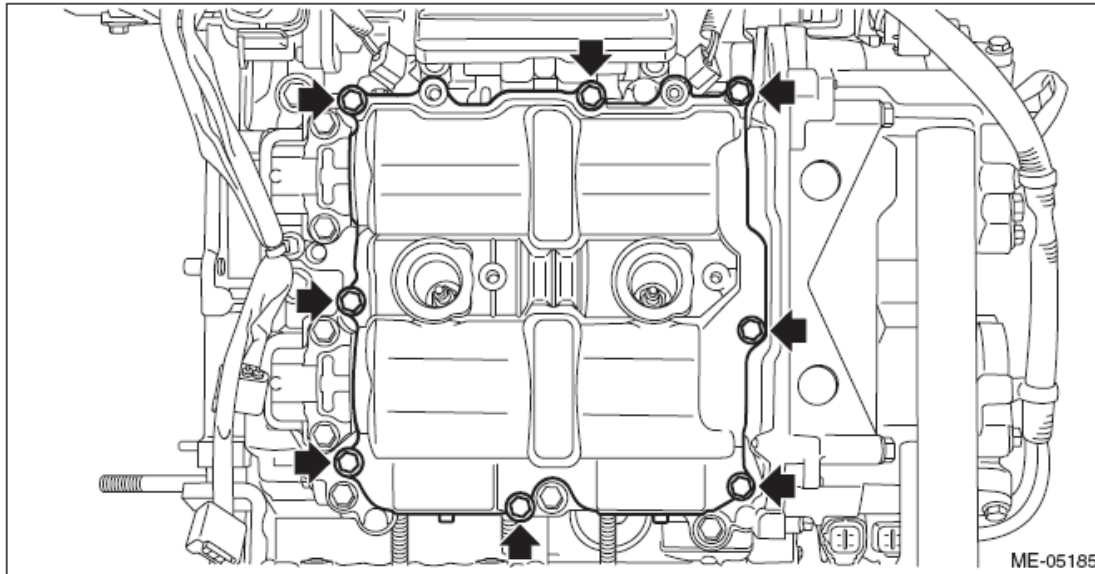
**Fig. 187: Removing Air Intake Boot From Throttle Body**  
Courtesy of SUBARU OF AMERICA, INC.

4. Remove the front exhaust pipe. < Refer to **REMOVAL** , Front Exhaust Pipe. >
2. Remove the #1 ignition coil and the #3 ignition coil. < Refer to **REMOVAL** , Ignition Coil. >
3. Remove the intake manifold protector RH.



**Fig. 188: Locating Intake Manifold Protector RH Mounting Bolts**  
Courtesy of SUBARU OF AMERICA, INC.

4. Remove the rocker cover RH.

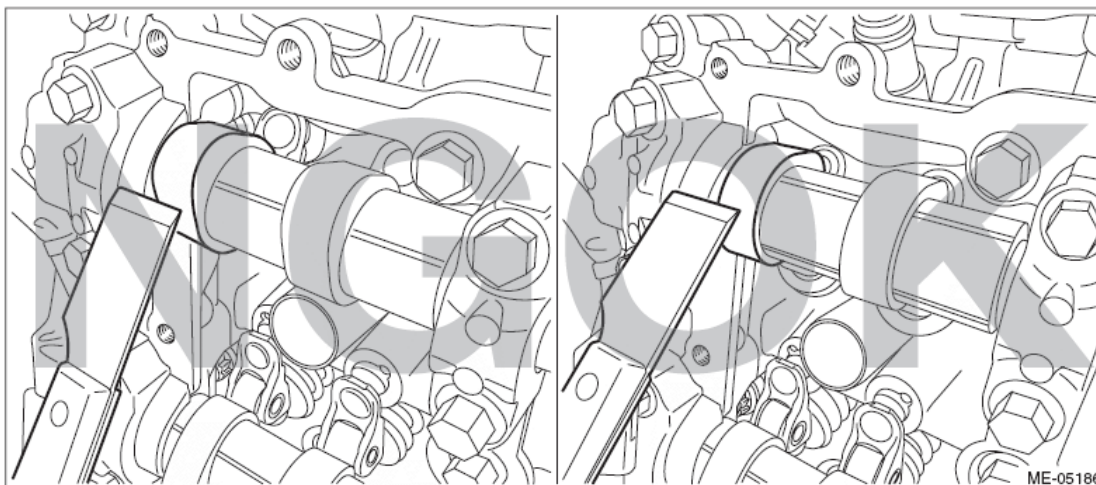


**Fig. 189: Locating Rocker Cover RH Bolts**  
Courtesy of SUBARU OF AMERICA, INC.

5. Remove the rocker cover gasket RH, #1 spark plug pipe gasket and #3 spark plug pipe gasket, and remove the liquid gasket.

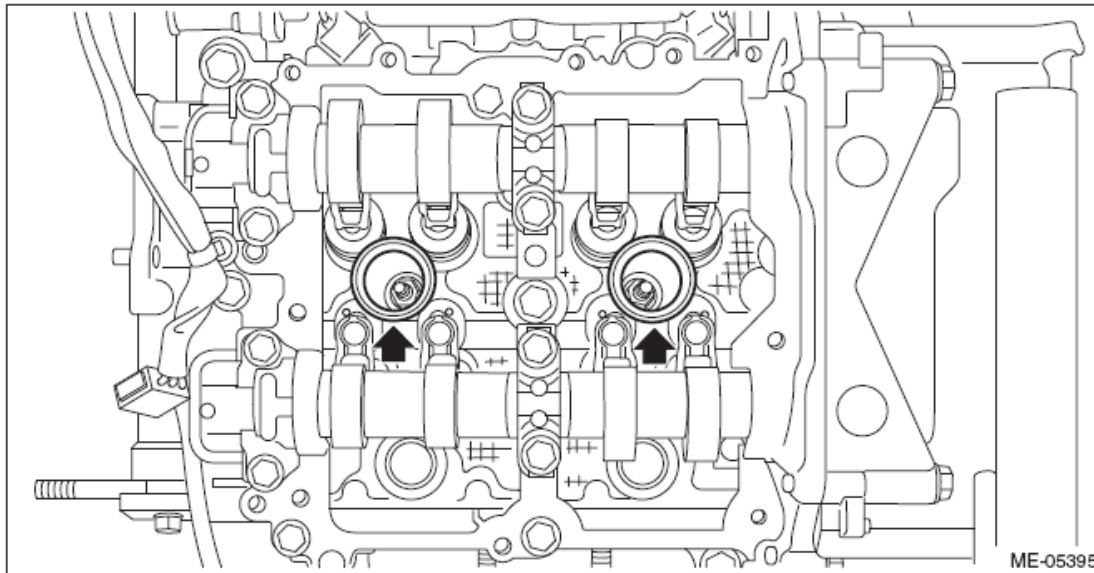
**CAUTION:**

- When removing the liquid gasket from engine unit using scraper, use special care not to damage the cam lobe of camshaft RH.
- If the cam lobe of camshaft RH interferes, turn the crankshaft to the position where the scraper does not touch.



**Fig. 190: Identifying Correct And Incorrect Method Of Removing Liquid Gasket**

Courtesy of SUBARU OF AMERICA, INC.



**Fig. 191: Locating Spark Plug Pipe Gaskets**  
Courtesy of SUBARU OF AMERICA, INC.

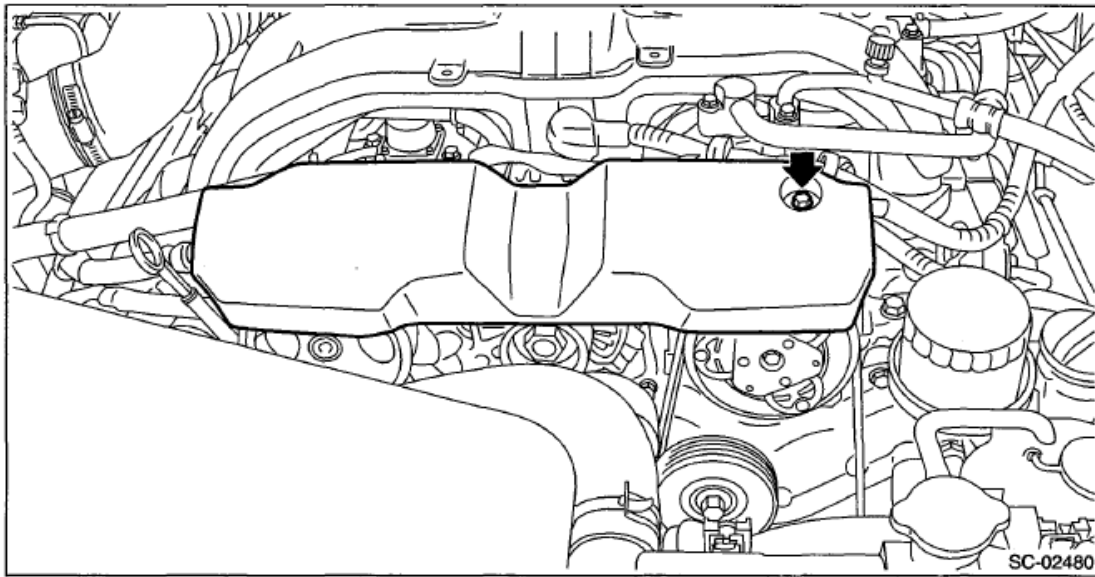
#### ROCKER COVER LH

**NOTE:** When replacing a single part, perform the work with the engine assembly installed to body.

1. When working on the vehicle

**NOTE:** When working on the vehicle, perform the following steps also.

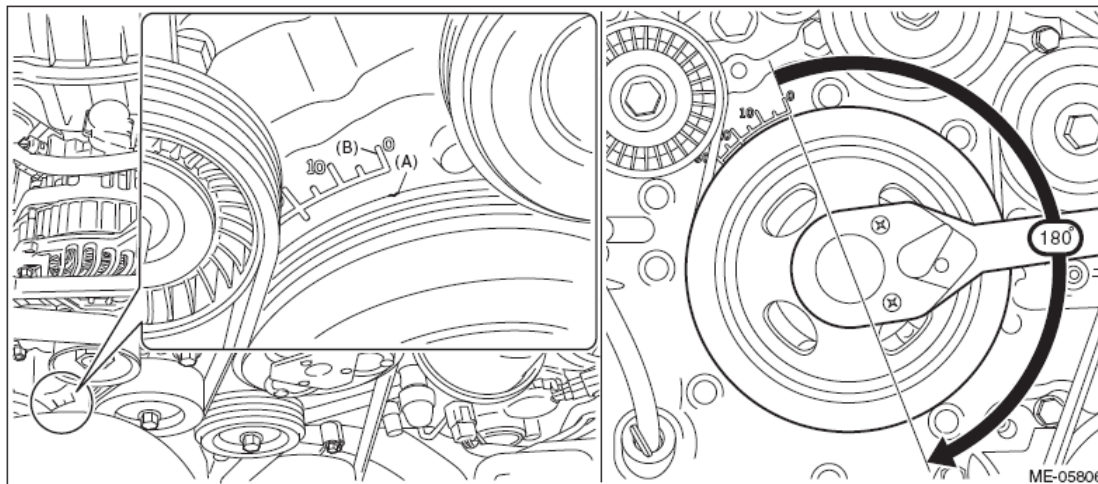
1. Remove the battery. < Refer to **REMOVAL** , Battery. >
2. Remove the V-belt covers.



**Fig. 192: Locating V-Belt Cover Mounting Bolt**  
 Courtesy of SUBARU OF AMERICA, INC.

3. Remove the air intake duct. < Refer to **REMOVAL** , Air Intake Duct. >
4. Align the timing mark (A) of crank pulley to the timing gauge (B) 0° of chain cover as shown in the figure, and turn the crankshaft by 180° clockwise from that position.

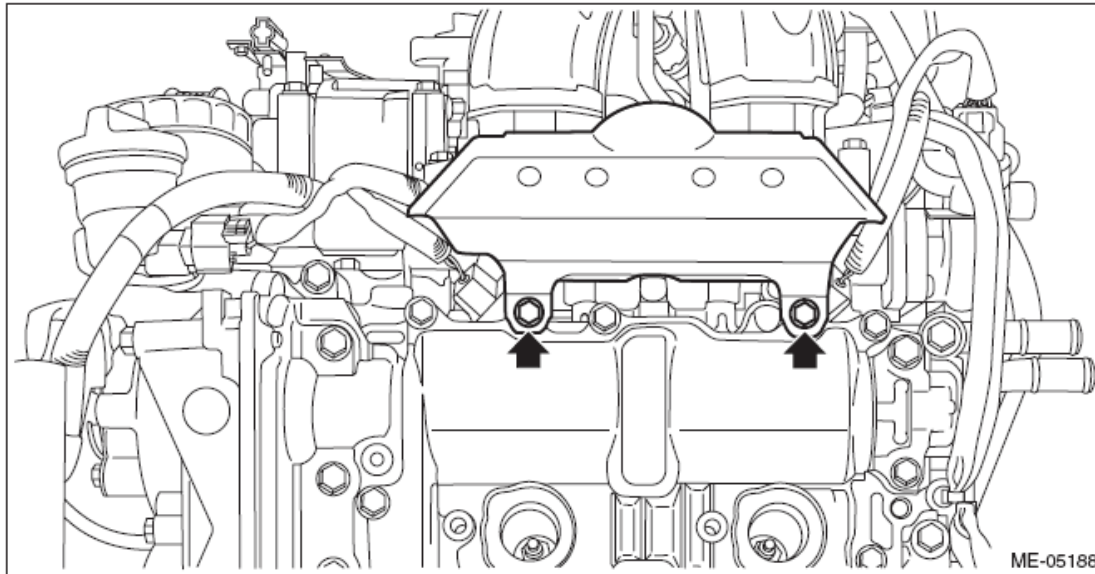
**NOTE:** This procedure is required to prevent the rocker cover LH and the cam lobe of camshaft LH contacting with each other when removing the rocker cover LH.



**Fig. 193: Turning Crankshaft By 180 Degrees Clockwise**  
 Courtesy of SUBARU OF AMERICA, INC.

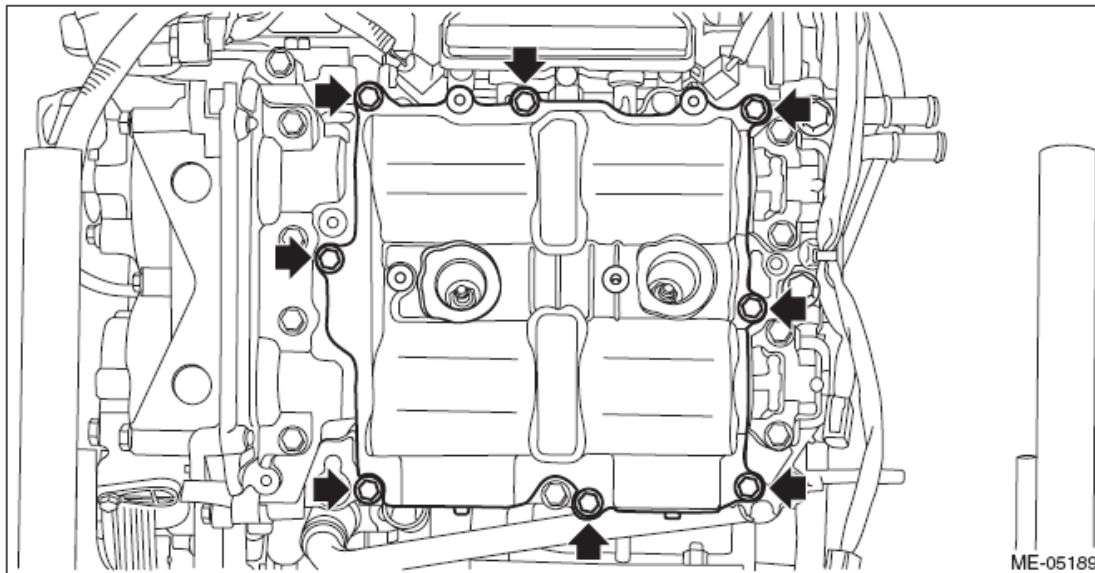
2. Remove the #2 ignition coil and the #4 ignition coil. < Refer to **REMOVAL** , Ignition Coil. >

3. Remove the intake manifold protector LH.



**Fig. 194: Locating Intake Manifold Protector LH Mounting Bolts**  
Courtesy of SUBARU OF AMERICA, INC.

4. Remove the rocker cover LH.

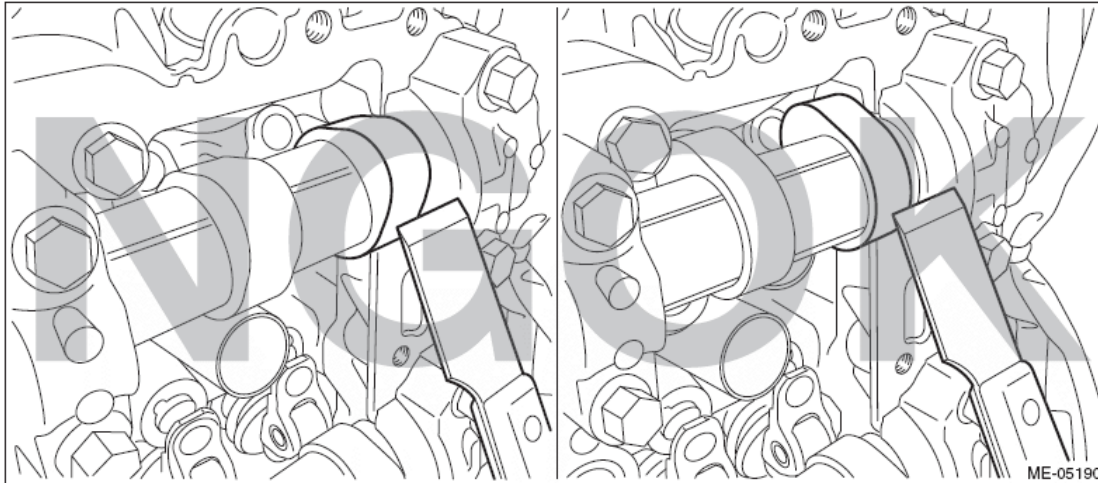


**Fig. 195: Locating Rocker Cover LH Mounting Bolts**  
Courtesy of SUBARU OF AMERICA, INC.

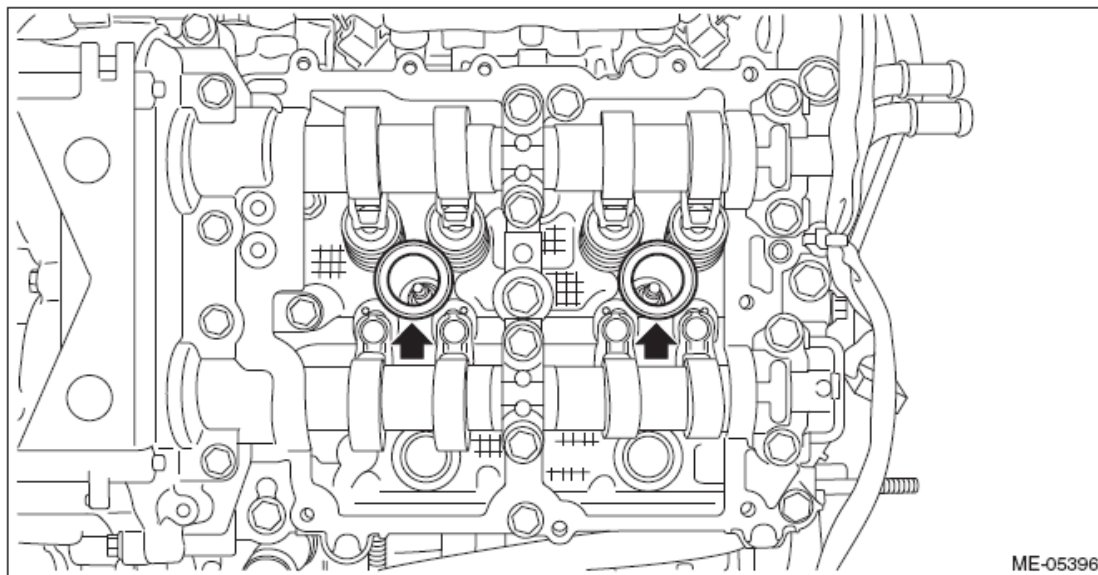
5. Remove the rocker cover gasket LH, #2 spark plug pipe gasket and #4 spark plug pipe gasket, and remove the liquid gasket.

**CAUTION:**

- When removing the liquid gasket from engine unit using scraper, use special care not to damage the cam lobe of camshaft LH.
- If the cam lobe of camshaft LH interferes, turn the crankshaft to the position where the scraper does not touch.



**Fig. 196: Identifying Correct And Incorrect Method Of Removing Liquid Gasket**  
Courtesy of SUBARU OF AMERICA, INC.



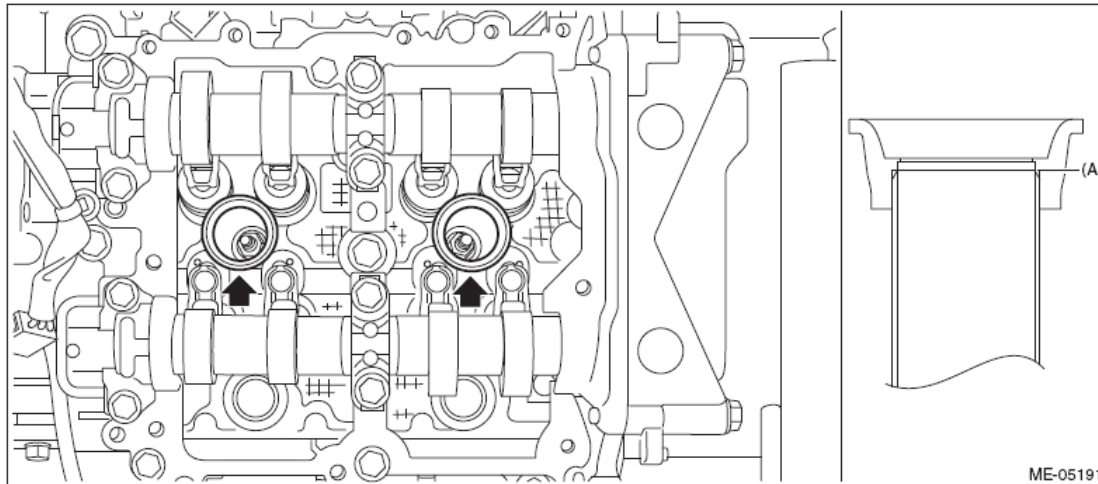
**Fig. 197: Locating Spark Plug Pipe Gaskets**  
Courtesy of SUBARU OF AMERICA, INC.

**INSTALLATION****ROCKER COVER RH**

1. Install the #1 spark plug pipe gasket and #3 spark plug pipe gasket to the #1 spark plug pipe and #3 spark plug pipe.

**NOTE:**

- Use a new #1 spark plug pipe gasket and #3 spark plug pipe gasket.
- Apply a light coat of engine oil to the #1 spark plug pipe gasket and #3 spark plug pipe gasket, and insert them onto the spark plug pipe edge (A).



**Fig. 198: Locating Spark Plug Pipe Gaskets**  
Courtesy of SUBARU OF AMERICA, INC.

2. Install the rocker cover gasket RH to the rocker cover RH.

**NOTE:** Use a new rocker cover gasket RH.

3. Apply liquid gasket to the mating surface of rocker cover RH as shown in the figure.

**NOTE:**

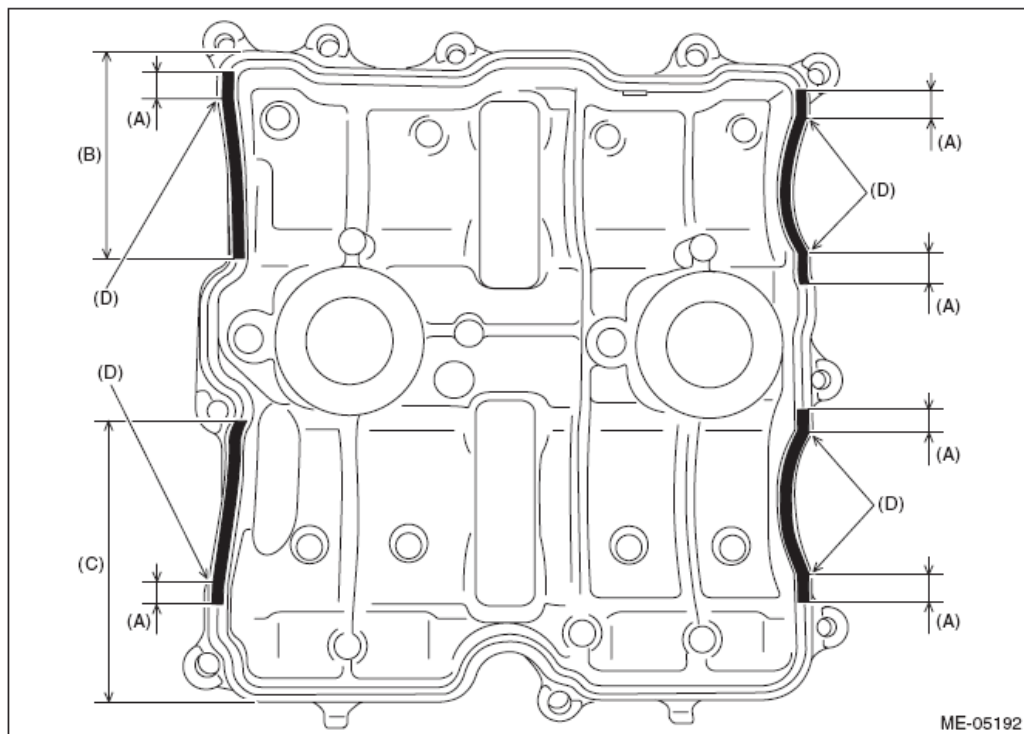
- Before applying liquid gasket, remove oil from liquid gasket seal surface of the engine.
- Be careful not to allow liquid gasket to be squeezed out from rocker cover RH.
- Install within 5 min. after applying liquid gasket.

**Liquid gasket:**

**THREE BOND 1217G (Part No. K0877Y0100) or equivalent**

**Liquid gasket applying diameter:**

**3.5±0.5 mm (0.1378±0.0197 in)**



(A) 10 mm (0.394 in) or more

(B) 68 mm (2.677 in) or more

(C) 89 mm (3.504 in) or more

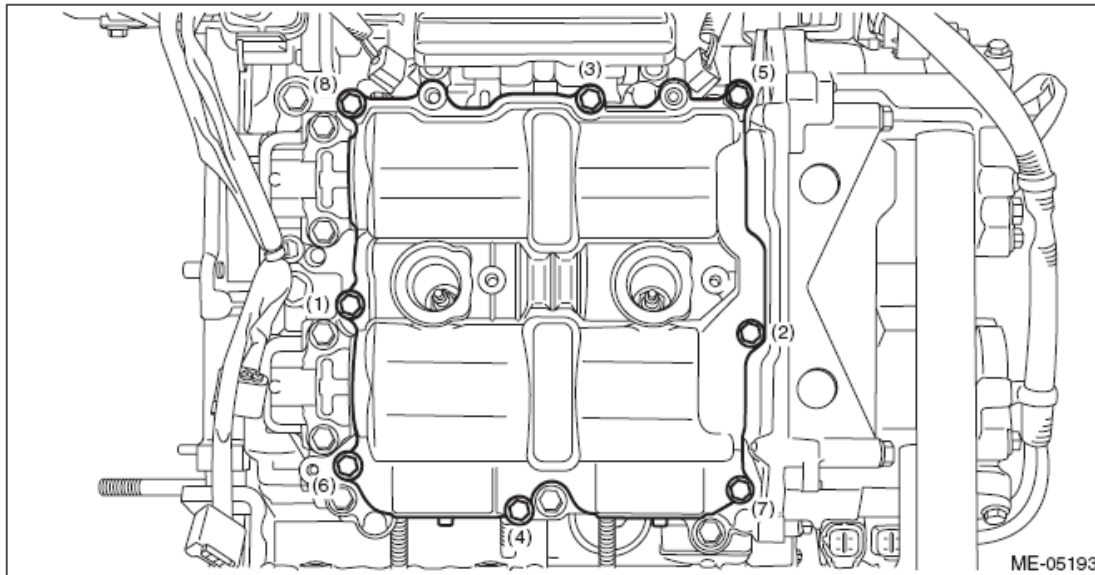
(D) Arch starting point

**Fig. 199: Identifying Liquid Gasket Applying Areas On Mating Surface Of Rocker Cover RH**  
Courtesy of SUBARU OF AMERICA, INC.

4. Set the rocker cover RH, and tighten the bolts in numerical order as shown in the figure.

***Tightening torque:***

***6.4 N.m (0.7 kgf-m, 4.7 ft-lb)***

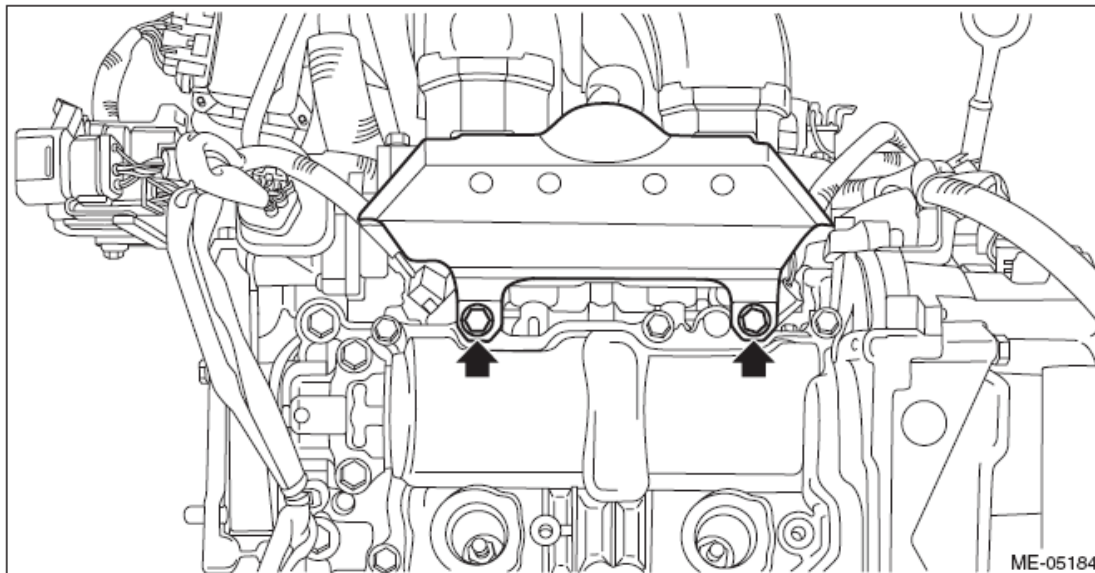


**Fig. 200: Identifying Rocker Cover RH Bolts Tightening Sequence**  
Courtesy of SUBARU OF AMERICA, INC.

5. Install the intake manifold protector RH.

***Tightening torque:***

***6.4 N.m (0.7 kgf-m, 4.7 ft-lb)***



**Fig. 201: Locating Intake Manifold Protector RH Bolts**  
Courtesy of SUBARU OF AMERICA, INC.

6. Install the #1 ignition coil and the #3 ignition coil. < Refer to **INSTALLATION** , Ignition Coil. >

7. When working on the vehicle

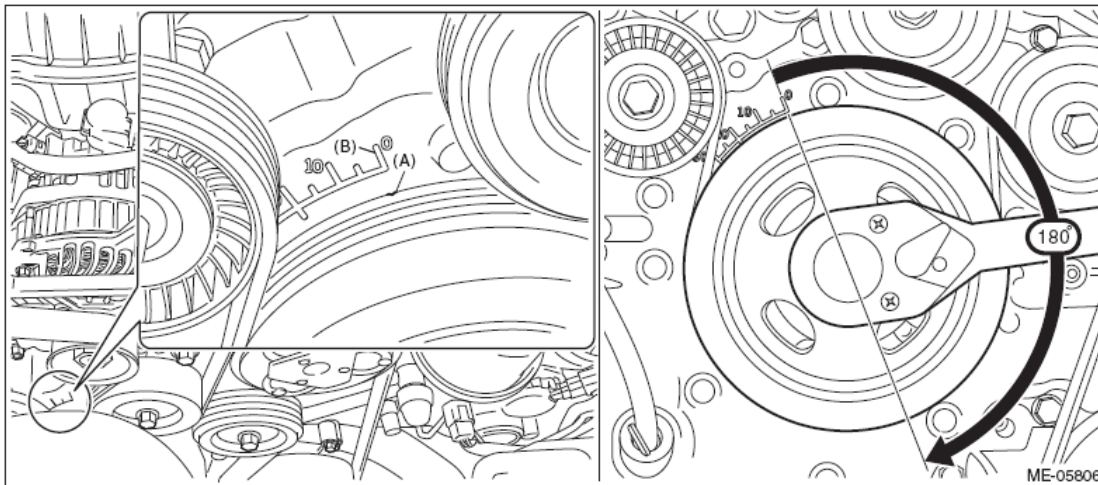
1. Install the front exhaust pipe. < Refer to **INSTALLATION** , Front Exhaust Pipe. >
2. Install the air intake boot. < Refer to **INSTALLATION** , Air Intake Boot. >
3. Install the air cleaner case. < Refer to **INSTALLATION** , Air Cleaner Case. >

**ROCKER COVER LH**

1. Align the timing mark (A) of crank pulley to the timing gauge (B) of chain cover as shown in the figure, and turn the crankshaft by 180° clockwise from that position.

**NOTE:**

- This procedure is required only when working on the vehicle.
- This procedure is required to prevent the rocker cover LH and the cam lobe of camshaft LH contacting with each other when installing the rocker cover LH.

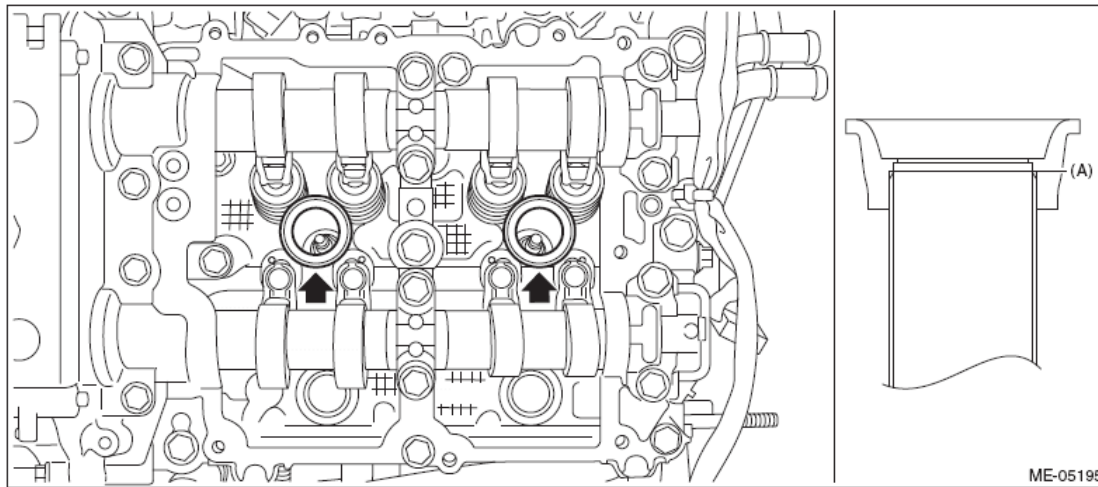


**Fig. 202: Aligning Timing Mark Of Crank Pulley To Timing Gauge Of Chain Cover**  
 Courtesy of SUBARU OF AMERICA, INC.

2. Install the #2 spark plug pipe gasket and #4 spark plug pipe gasket to the #2 spark plug pipe and #4 spark plug pipe.

**NOTE:**

- Use a new #2 spark plug pipe gasket and #4 spark plug pipe gasket.
- Apply a light coat of engine oil to the #2 spark plug pipe gasket and #4 spark plug pipe gasket, and insert them onto the spark plug pipe edge (A).



**Fig. 203: Locating Spark Plug Pipe Gaskets**  
 Courtesy of SUBARU OF AMERICA, INC.

3. Install the rocker cover gasket LH to the rocker cover LH.

**NOTE:** Use a new rocker cover gasket LH.

4. Apply liquid gasket to the mating surface of rocker cover LH as shown in the figure.

**NOTE:**

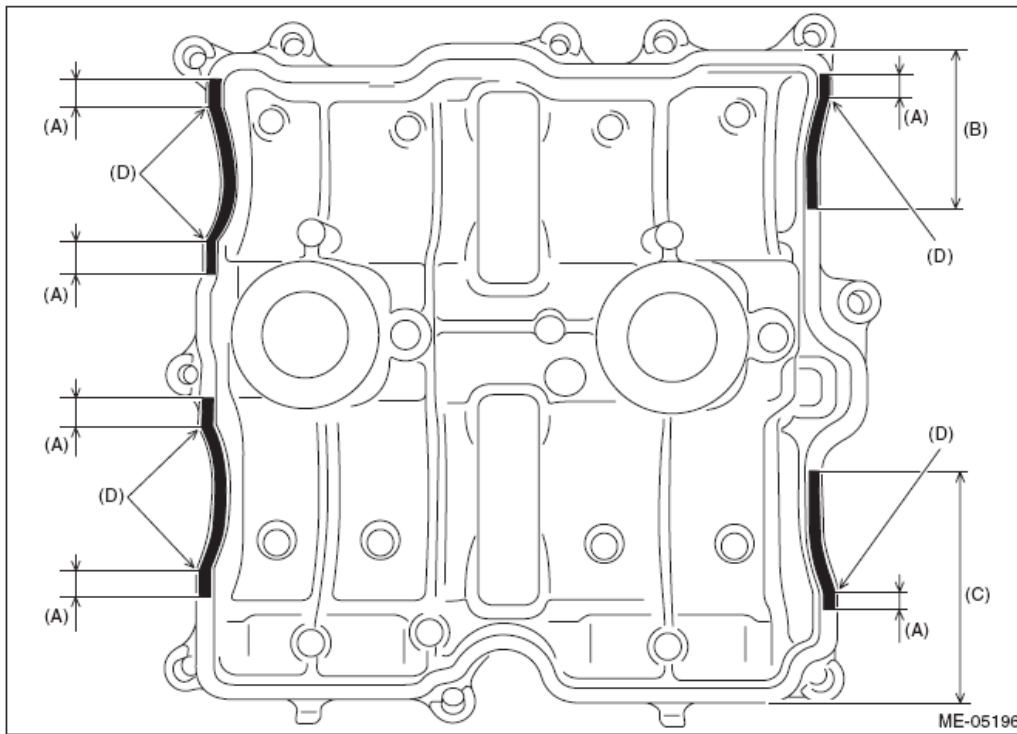
- Before applying liquid gasket, degrease the old liquid gasket seal surface of the engine.
- Be careful not to allow liquid gasket to be squeezed out from rocker cover LH.
- Install within 5 min. after applying liquid gasket.

**Liquid gasket:**

**THREE BOND 1217G (Part No. K0877Y0100) or equivalent**

**Liquid gasket applying diameter:**

**3.5±0.5 mm (0.1378±0.0197 in)**



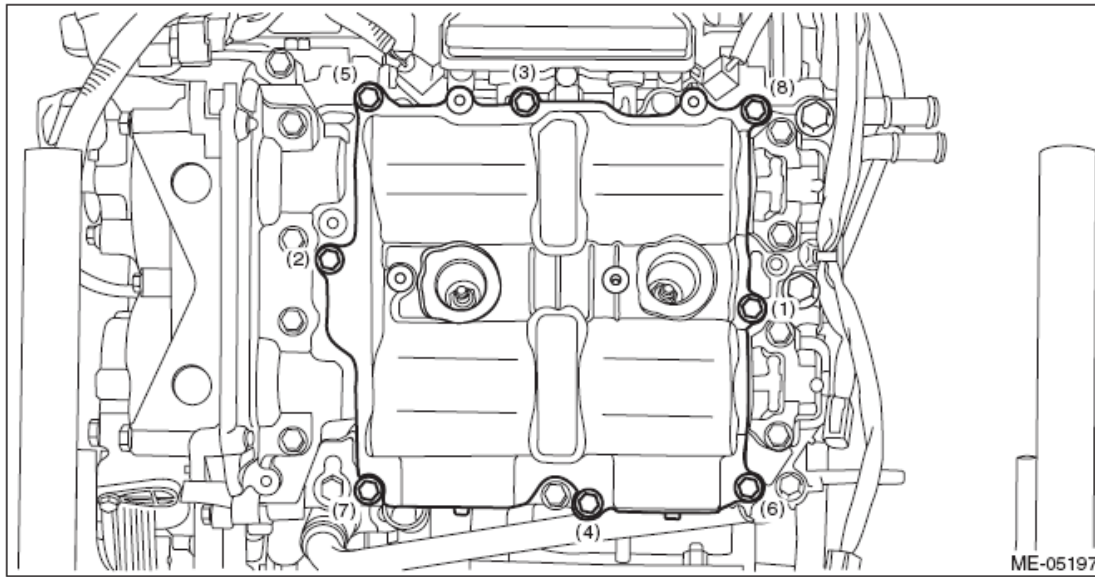
- (A) 10 mm (0.394 in) or more  
 (B) 51 mm (2.008 in) or more  
 (C) 73 mm (2.874 in) or more  
 (D) Arch starting point

**Fig. 204: Identifying Liquid Gasket Applying Areas On Mating Surface Of Rocker Cover LH**  
 Courtesy of SUBARU OF AMERICA, INC.

5. Set the rocker cover LH, and tighten the bolts in numerical order as shown in the figure.

***Tightening torque:***

***6.4 N.m (0.7 kgf-m, 4.7 ft-lb)***

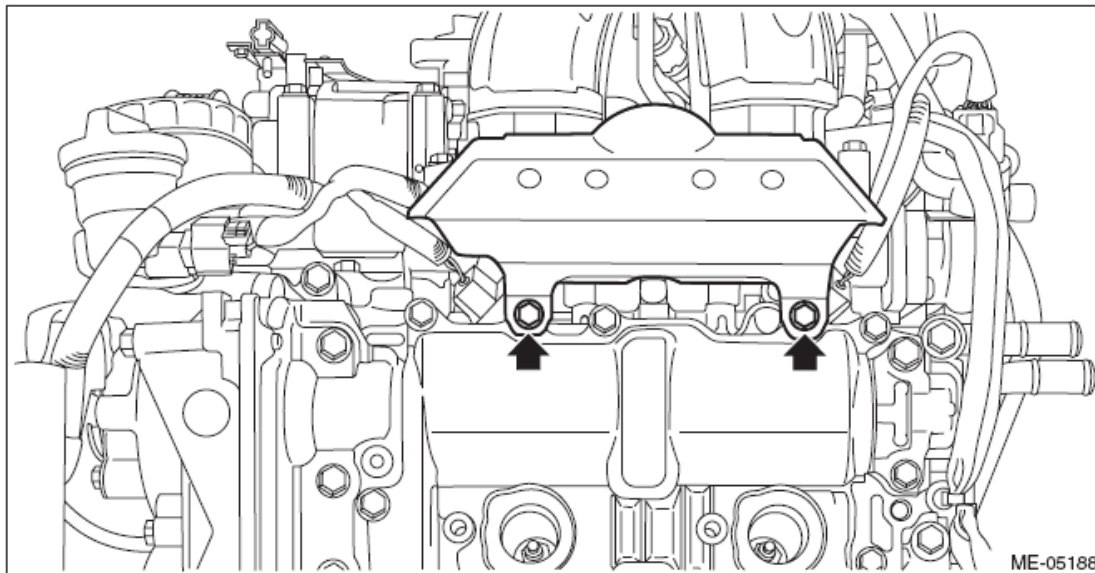


**Fig. 205: Identifying Rocker Cover LH Bolts Tightening Sequence**  
Courtesy of SUBARU OF AMERICA, INC.

6. Install the intake manifold protector LH.

***Tightening torque:***

***6.4 N.m (0.7 kgf-m, 4.7 ft-lb)***



**Fig. 206: Locating Intake Manifold Protector LH Bolts**  
Courtesy of SUBARU OF AMERICA, INC.

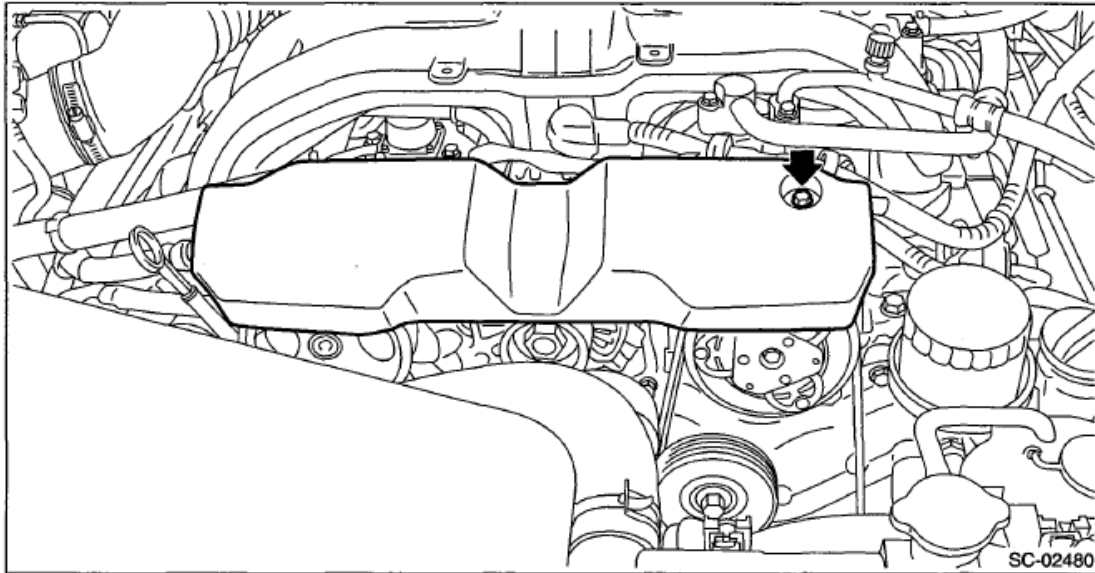
7. Install the #2 ignition coil and the #4 ignition coil. < Refer to **INSTALLATION** , Ignition Coil. >

8. When working on the vehicle

1. Install the air intake duct. < Refer to **INSTALLATION** , Air Intake Duct. >
2. Install the V-belt cover.

***Tightening torque:***

***13 N.m (1.3 kgf-m, 9.6 ft-lb)***



**Fig. 207: Locating V-Belt Cover Bolt**  
Courtesy of SUBARU OF AMERICA, INC.

3. Install the battery. < Refer to **INSTALLATION** , Battery. >

## INSPECTION

Check that the rocker cover does not have deformation, cracks and any other damage.

## CAMSHAFT

### REMOVAL

#### CAMSHAFT RH

The camshaft RH and cam carrier are designed as removing as a unit. Refer to "Cam Carrier" for removal procedures of camshaft RH. < Refer to **CAM CARRIER RH**, REMOVAL, Cam Carrier. > < Refer to **CAM CARRIER RH**, DISASSEMBLY, Cam Carrier. >

#### CAMSHAFT LH

The camshaft LH and cam carrier are designed as removing as a unit. Refer to "Cam Carrier" for removal

procedures of camshaft LH. < Refer to **CAM CARRIER LH**, REMOVAL, Cam Carrier. > < Refer to **CAM CARRIER LH**, DISASSEMBLY, Cam Carrier. >

## INSTALLATION

### CAMSHAFT RH

The camshaft RH and cam carrier are designed as installing as a unit. Refer to "Cam Carrier" for installation procedures of camshaft RH. < Refer to **CAM CARRIER RH**, ASSEMBLY, Cam Carrier. > < Refer to **CAM CARRIER RH**, INSTALLATION, Cam Carrier. >

### CAMSHAFT LH

The camshaft LH and cam carrier are designed as installing as a unit. Refer to "Cam Carrier" for installation procedures of camshaft LH. < Refer to **CAM CARRIER LH**, ASSEMBLY, Cam Carrier. > < Refer to **CAM CARRIER LH**, INSTALLATION, Cam Carrier. >

## CAM CARRIER

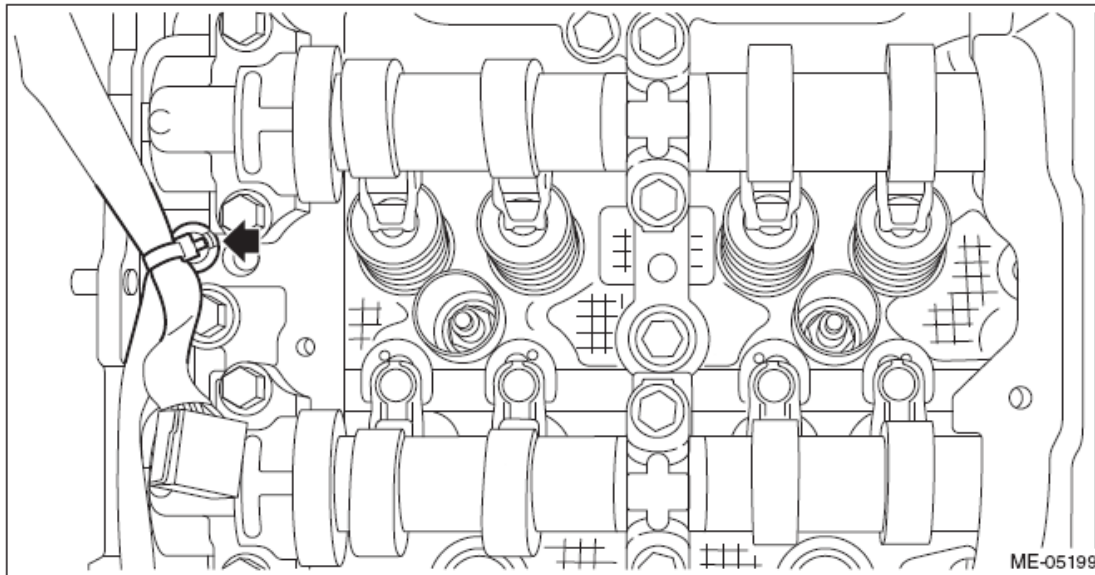
### REMOVAL

#### CAM CARRIER RH

1. Remove the engine from the vehicle. < Refer to **REMOVAL**, Engine Assembly. >
2. Remove the chain cover. < Refer to **REMOVAL**, Chain Cover. >
3. Remove the timing chain RH. < Refer to **TIMING CHAIN RH**, REMOVAL, Timing Chain Assembly. >
4. Remove the cam sprocket RH. < Refer to **CAM SPROCKET RH**, REMOVAL, Cam Sprocket. >

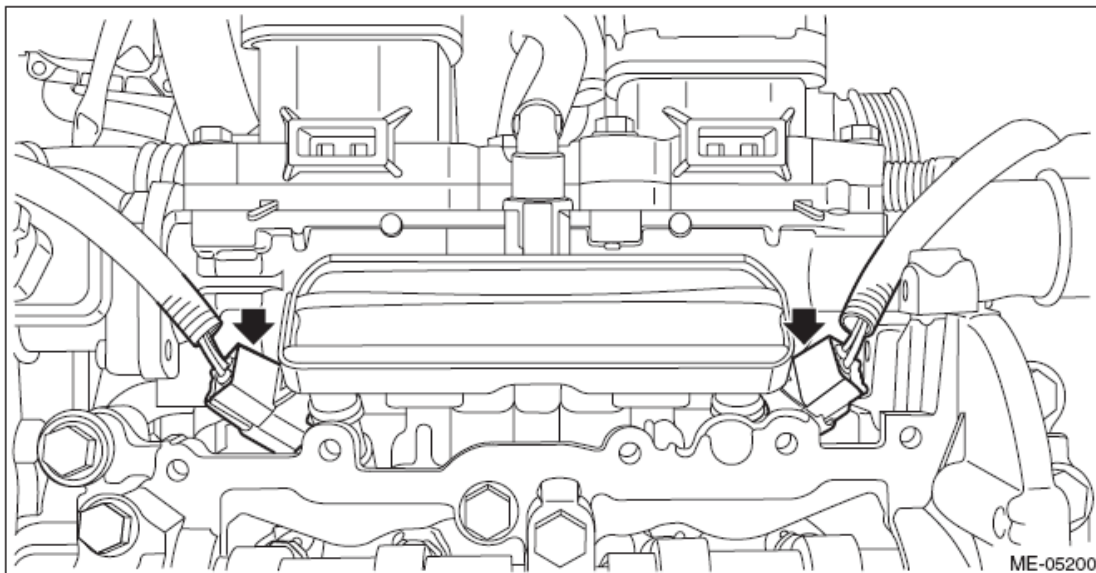
**NOTE:** This procedure is required only when disassembling the cam carrier RH.

5. Remove the rocker cover RH. < Refer to **ROCKER COVER RH**, REMOVAL, Rocker Cover. >
6. Remove the clip holding the engine harness from cam carrier RH.



**Fig. 208: Locating Cam Carrier RH Engine Harness Clip**  
Courtesy of SUBARU OF AMERICA, INC.

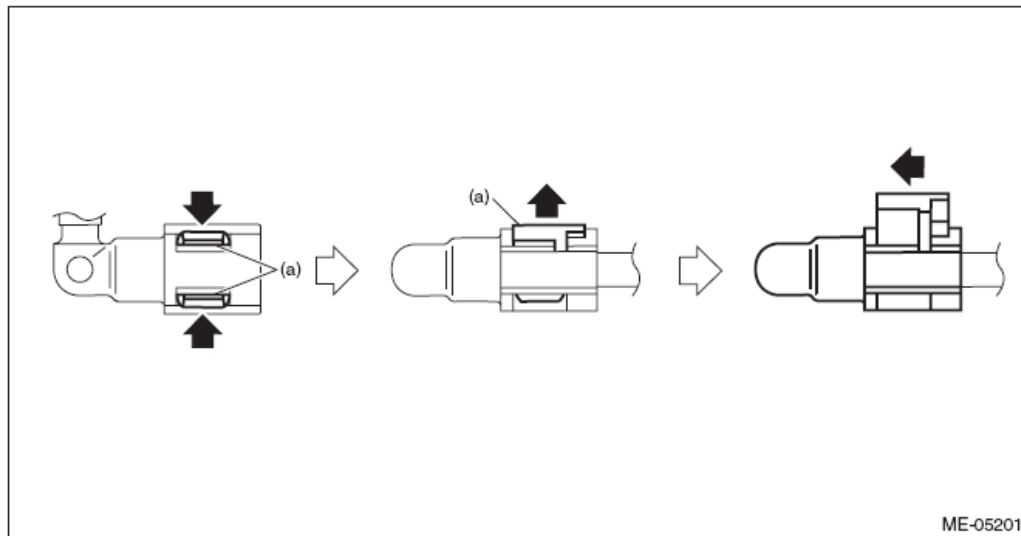
7. Remove the fuel pipe RH and the fuel injector RH.
  1. Disconnect the connector from fuel injector RH.



**Fig. 209: Locating Fuel Injector RH Connectors**  
Courtesy of SUBARU OF AMERICA, INC.

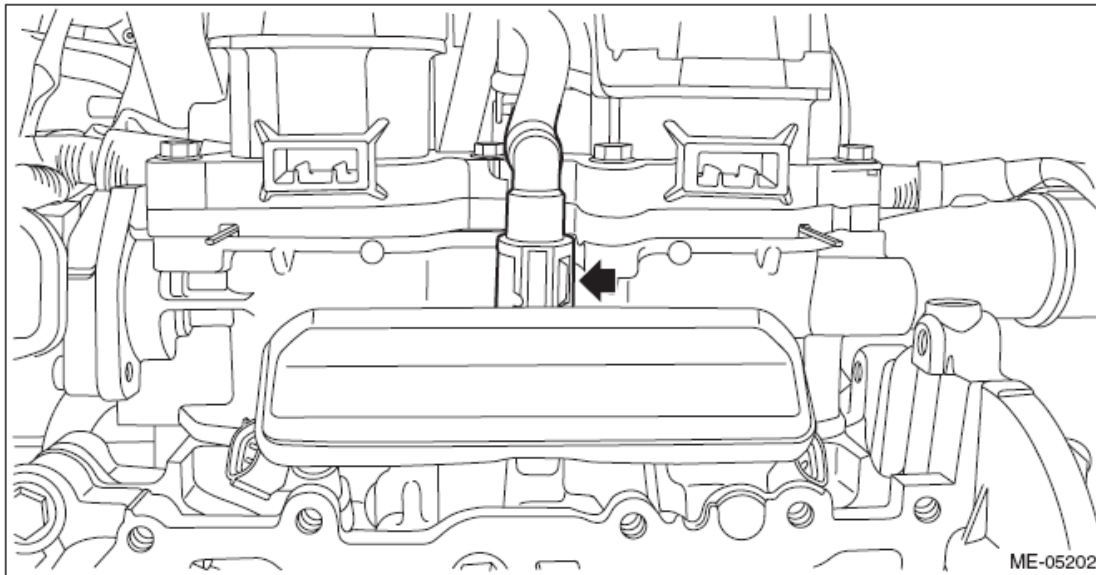
2. Disconnect the quick connector from fuel pipe RH.

**NOTE:**        **Disconnect the quick connector as shown in the figure.**



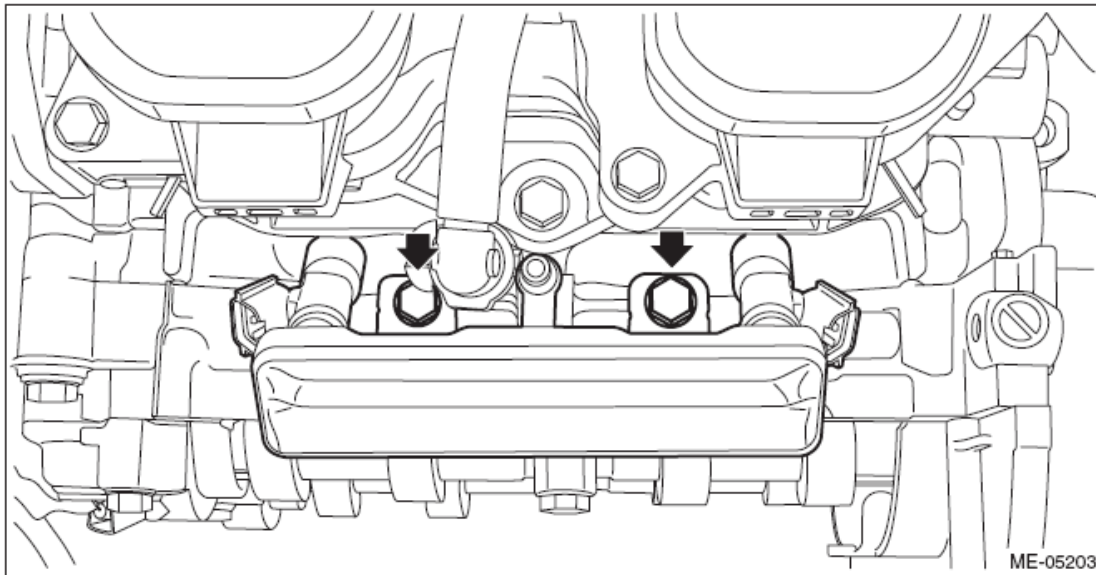
(a) Slider

**Fig. 210: Disconnecting Quick Connector From Fuel Pipe RH**  
Courtesy of SUBARU OF AMERICA, INC.



**Fig. 211: Locating Fuel Pipe RH Quick Connector**  
Courtesy of SUBARU OF AMERICA, INC.

3. Remove the bolts securing the fuel pipe RH, and remove the fuel pipe RH and the fuel injector RH.



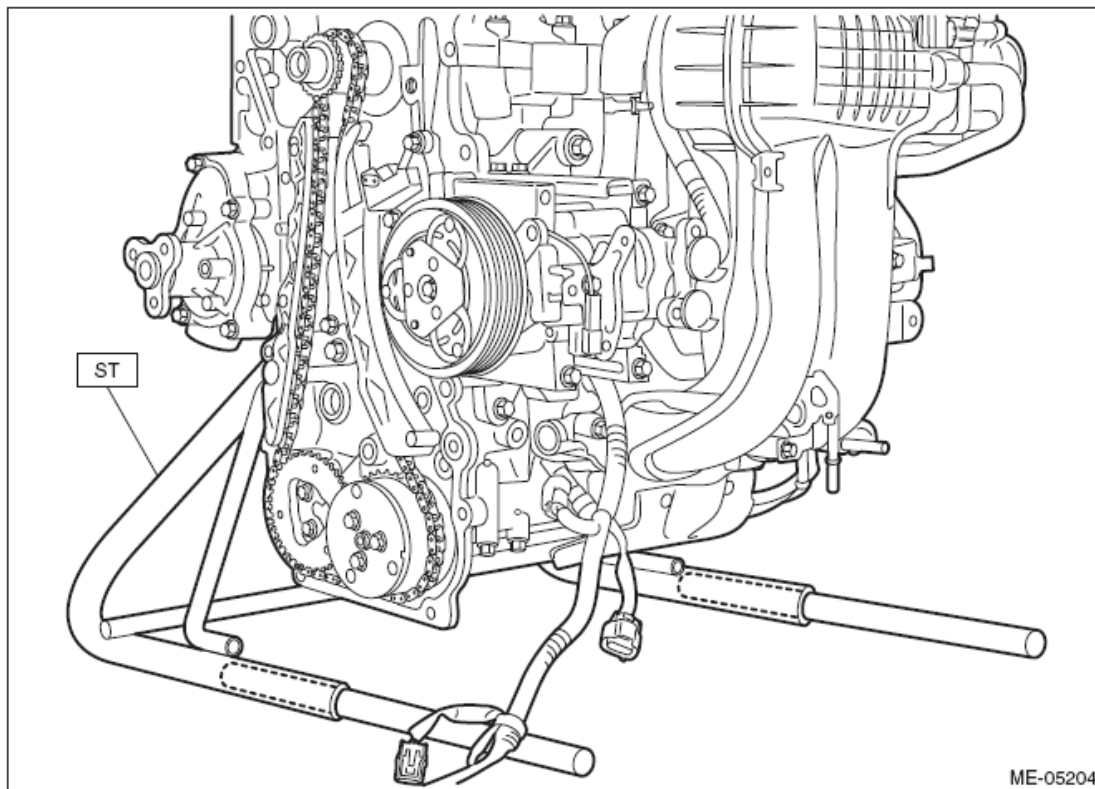
**Fig. 212: Locating Fuel Pipe RH Mounting Bolts**  
Courtesy of SUBARU OF AMERICA, INC.

8. Insert the steel rods into ST, and set the engine so that the camshaft RH is facing up.

**CAUTION:**

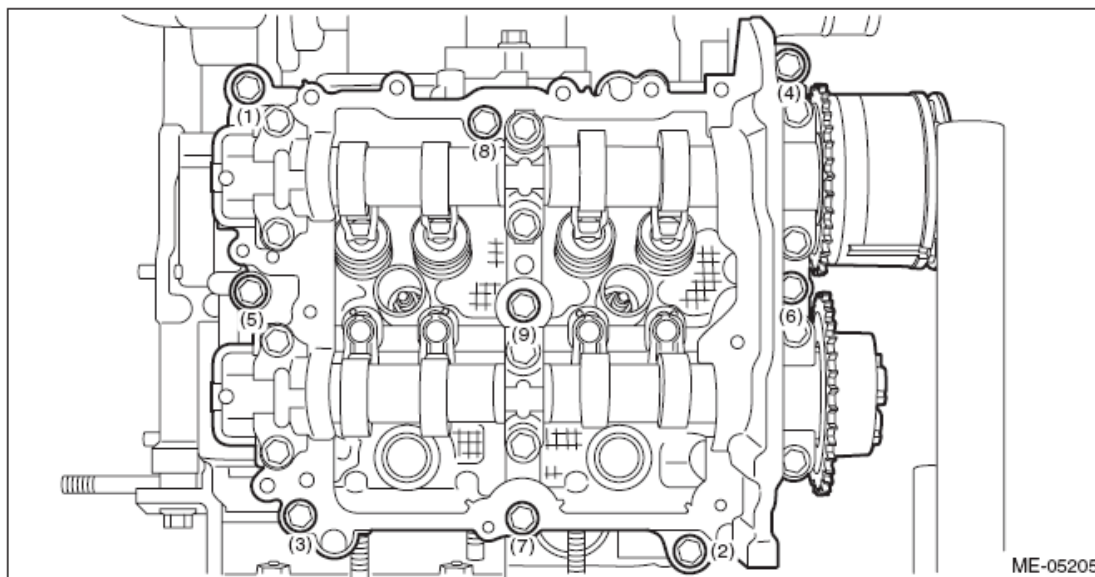
- If the engine is standing on one side without inserting the steel rod into ST, engine may lose balance and fall down. Be sure to insert the steel rod into ST to extend the length.
- Use the steel rod with enough strength.
- Be careful not to pinch the engine harness with ST.

ST 499817100 ENGINE STAND



**Fig. 213: Inserting Steel Rods Into ST**  
 Courtesy of SUBARU OF AMERICA, INC.

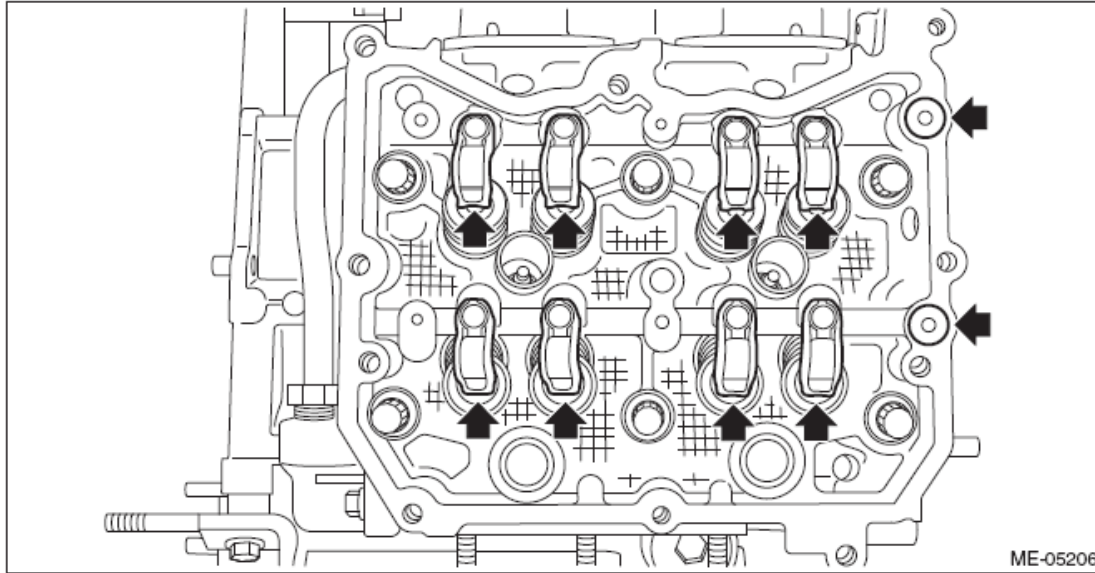
9. Loosen the bolts holding the cam carrier RH equally, a little at a time in numerical sequence as shown in the figure and remove the cam carrier RH.



**Fig. 214: Identifying Loosening Sequence Of Cam Carrier RH Mounting Bolts**  
 Courtesy of SUBARU OF AMERICA, INC.

10. Remove the O-ring and the roller rocker arm from cylinder head RH.

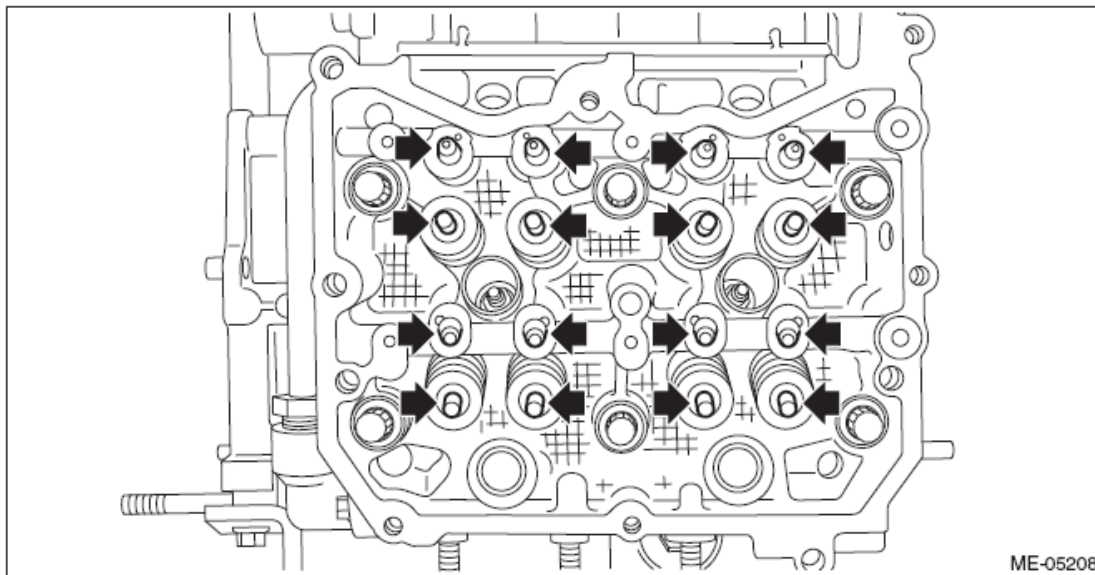
**NOTE:** Be careful not to confuse the roller rocker arms.



**Fig. 215: Locating Cylinder Head RH O-Ring And Roller Rocker Arms**  
Courtesy of SUBARU OF AMERICA, INC.

11. Remove the valve shim and the roller rocker arm pivot from cylinder head RH.

**NOTE:** Be careful not to confuse the valve shim and the roller rocker arm pivot.



**Fig. 216: Locating Cylinder Head RH Valve Shim And Roller Rocker Arm Pivot**  
Courtesy of SUBARU OF AMERICA, INC.

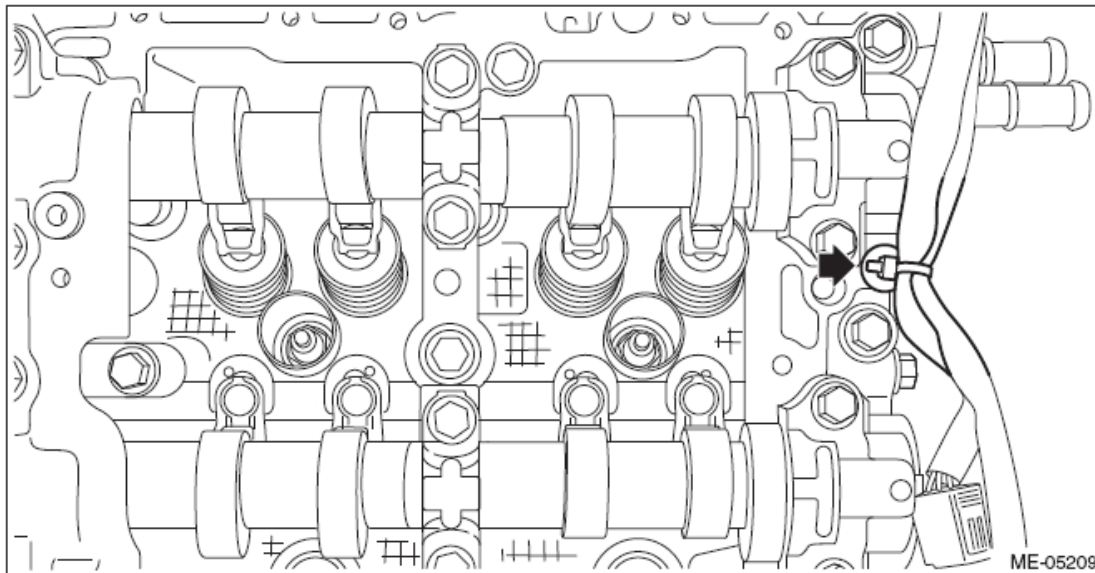
12. Remove the liquid gasket from cam carrier RH and cylinder head RH.

#### CAM CARRIER LH

1. Remove the engine from the vehicle. < Refer to **REMOVAL**, Engine Assembly. >
2. Remove the chain cover. < Refer to **REMOVAL**, Chain Cover. >
3. Remove the timing chain LH. < Refer to **TIMING CHAIN LH**, REMOVAL, Timing Chain Assembly. >
4. Remove the cam sprocket LH. < Refer to **CAM SPROCKET LH**, REMOVAL, Cam Sprocket. >

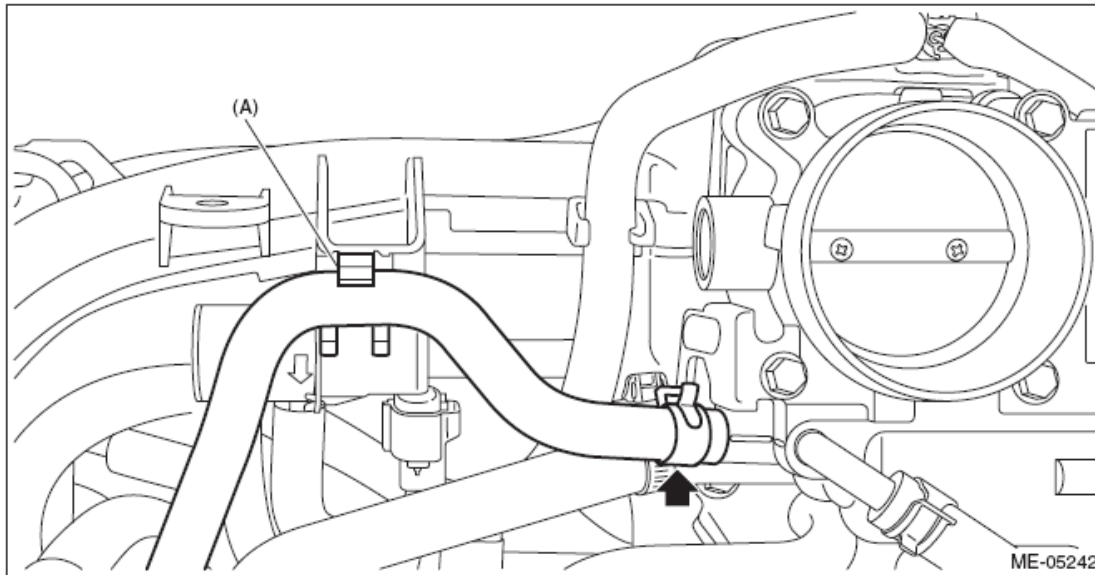
**NOTE:** This procedure is required only when disassembling the cam carrier LH.

5. Remove the rocker cover LH. < Refer to **ROCKER COVER LH**, REMOVAL, Rocker Cover. >
6. Remove the clip holding the engine harness from cam carrier LH.



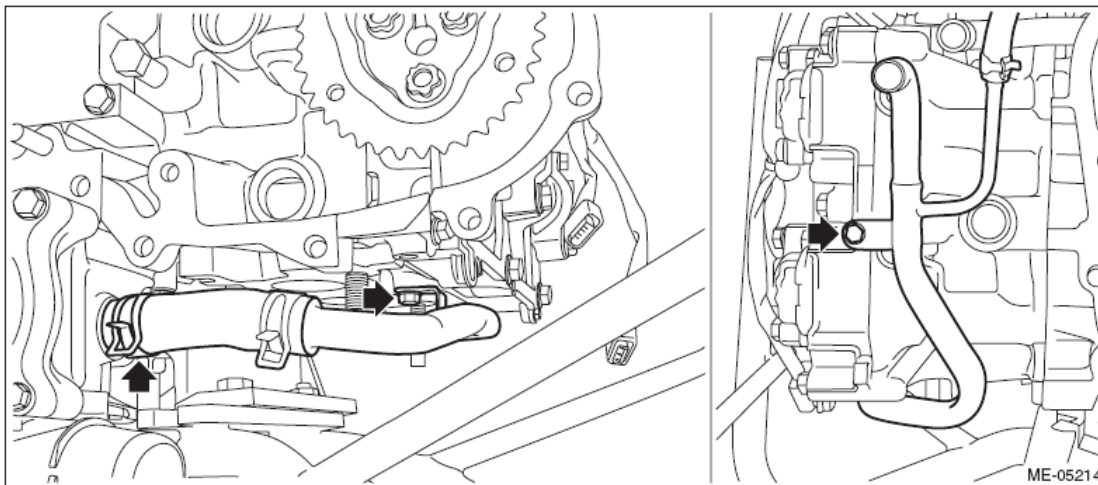
**Fig. 217: Locating Cam Carrier LH Engine Harness Clip**  
Courtesy of SUBARU OF AMERICA, INC.

7. Remove the preheater hose from intake manifold clip (A), and disconnect the preheater hose from throttle body.



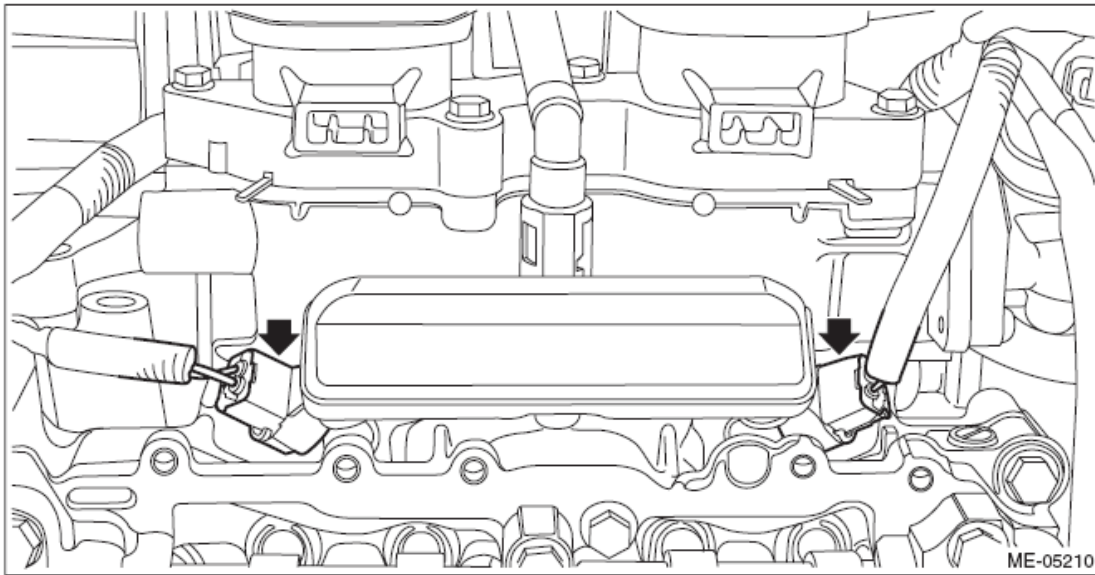
**Fig. 218: Locating Intake Manifold Preheater Hose Clip**  
 Courtesy of SUBARU OF AMERICA, INC.

8. Disconnect the water pipe hose from oil pan upper, and remove the water pipe assembly.



**Fig. 219: Locating Water Pipe Hose Clamp And Bolts**  
 Courtesy of SUBARU OF AMERICA, INC.

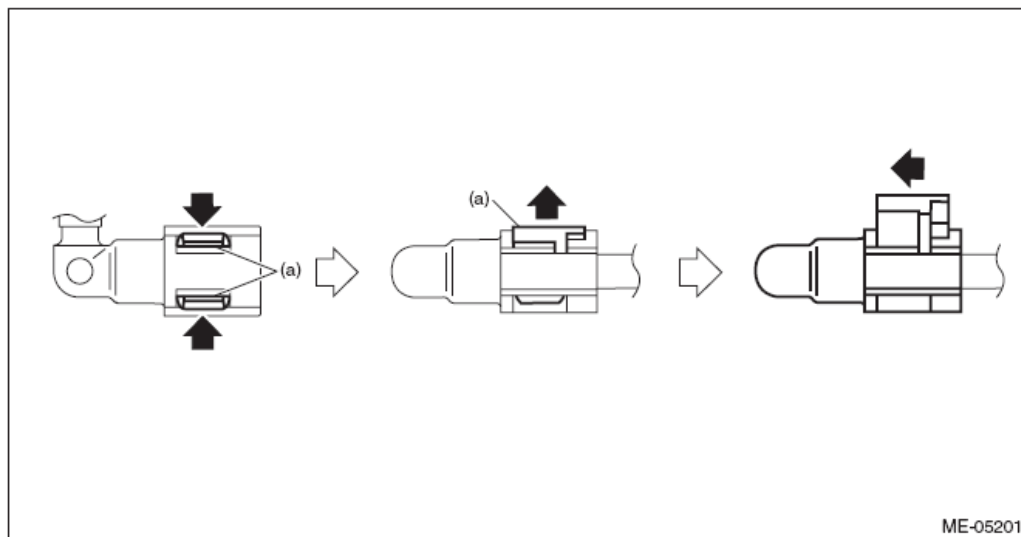
9. Remove the fuel pipe LH and the fuel injector LH.
  1. Disconnect the connector from fuel injector LH.



**Fig. 220: Locating Fuel Injector LH Connectors**  
Courtesy of SUBARU OF AMERICA, INC.

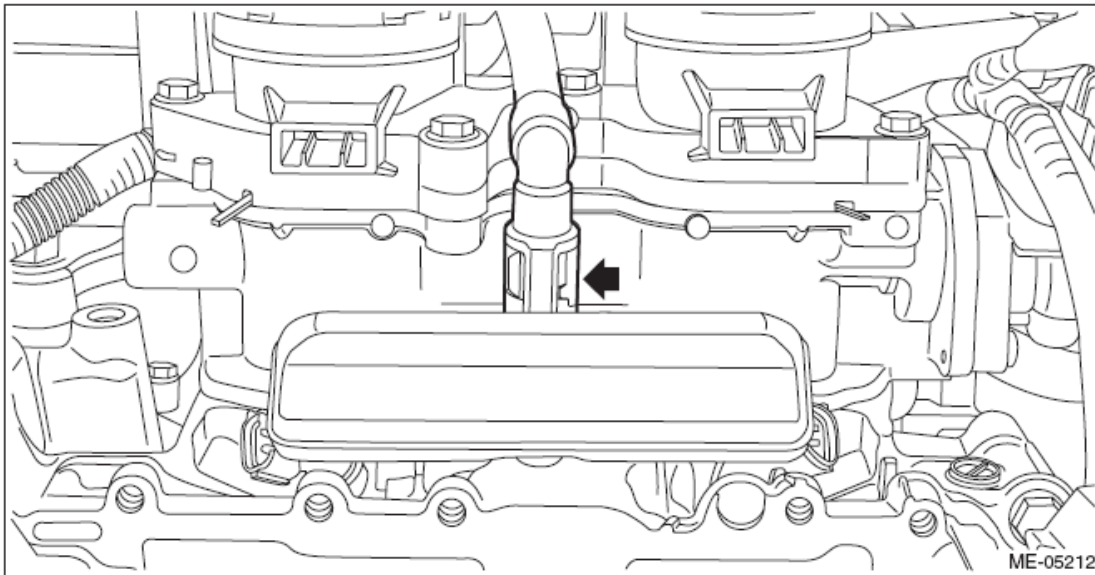
2. Disconnect the quick connector from fuel pipe LH.

**NOTE:** Disconnect the quick connector as shown in the figure.



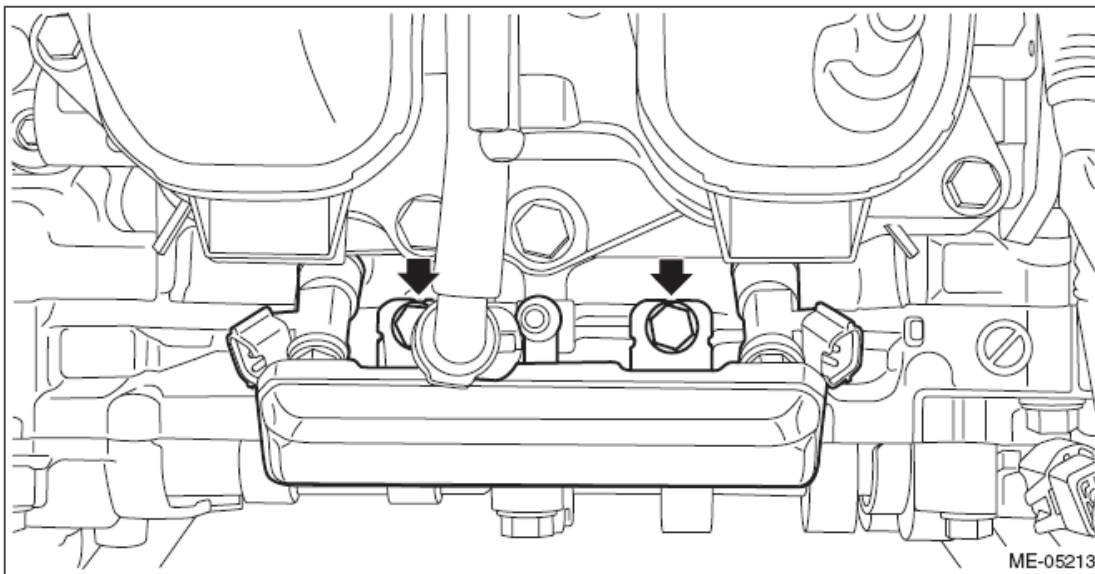
(a) Slider

**Fig. 221: Disconnecting Quick Connector From Fuel Pipe LH**  
Courtesy of SUBARU OF AMERICA, INC.



**Fig. 222: Locating Quick Connector**  
Courtesy of SUBARU OF AMERICA, INC.

3. Remove the bolts securing the fuel pipe LH, and remove the fuel pipe LH and the fuel injector LH.



**Fig. 223: Locating Fuel Pipe LH Bolts**  
Courtesy of SUBARU OF AMERICA, INC.

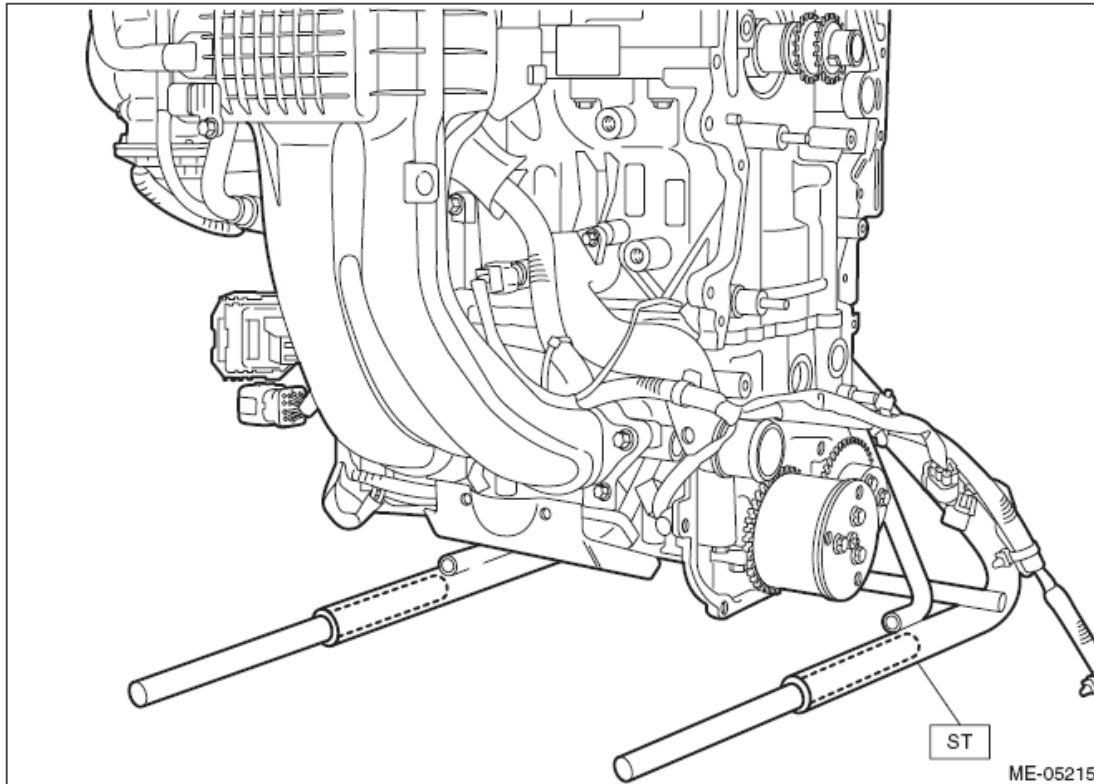
10. Insert the steel rods into ST, and set the engine so that the camshaft LH is facing up.

**CAUTION:**

- If the engine is standing on one side without inserting the steel rod into ST, engine may lose balance and fall down. Be sure to insert the steel rod into ST to extend the length.

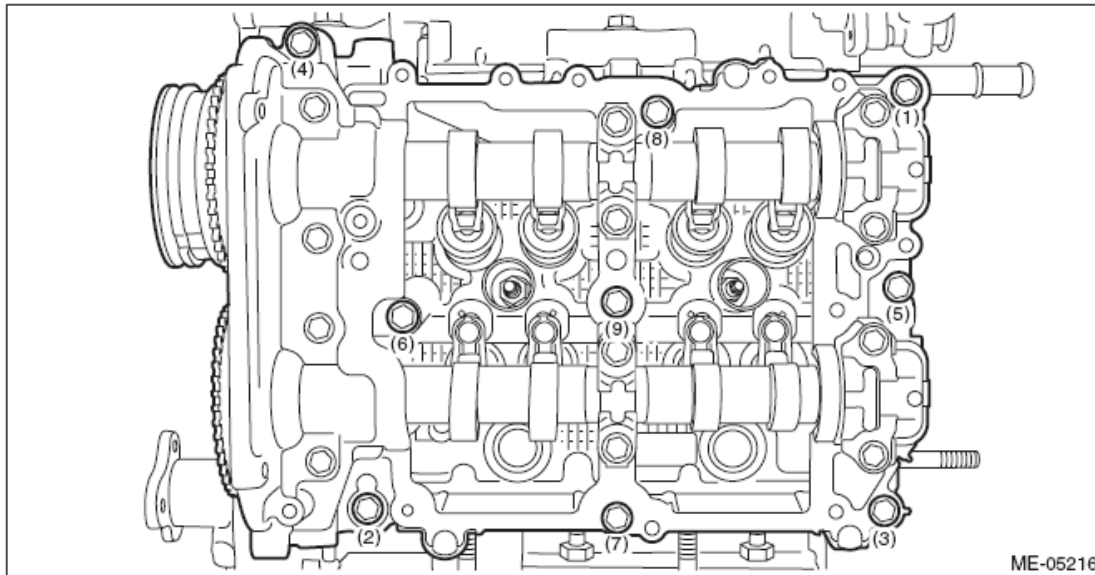
- Use the steel rod with enough strength.
- Be careful not to pinch the engine harness with ST.

ST 499817100 ENGINE STAND



**Fig. 224: Inserting Steel Rods Into Engine Stand**  
Courtesy of SUBARU OF AMERICA, INC.

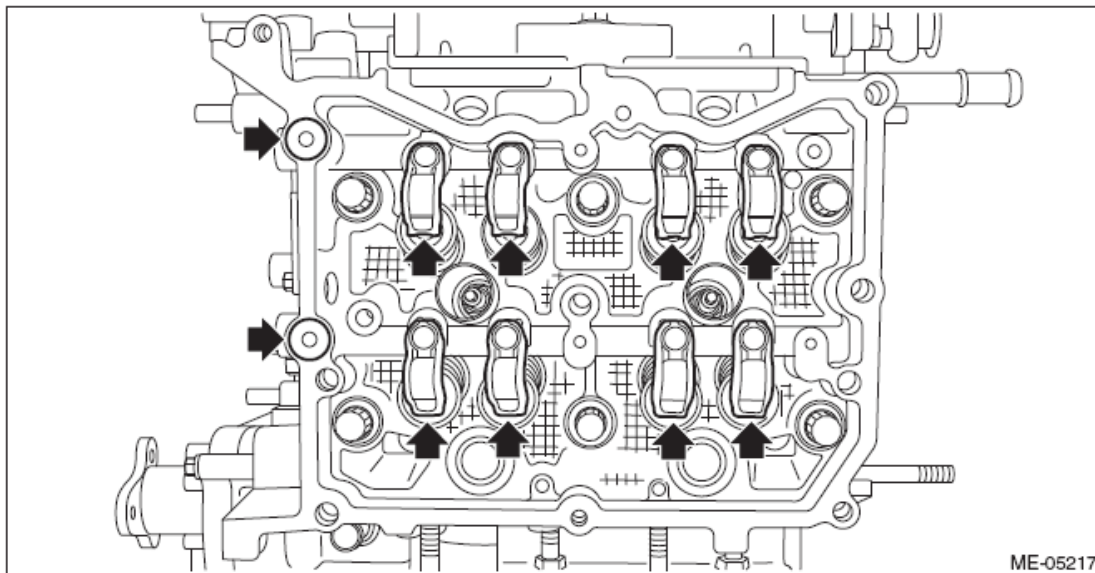
11. Loosen the bolts holding the cam carrier LH equally, a little at a time in numerical sequence as shown in the figure and remove the cam carrier LH.



**Fig. 225: Identifying Loosening Sequence Of Cam Carrier LH Bolts**  
Courtesy of SUBARU OF AMERICA, INC.

12. Remove the O-ring and the roller rocker arm from cylinder head LH.

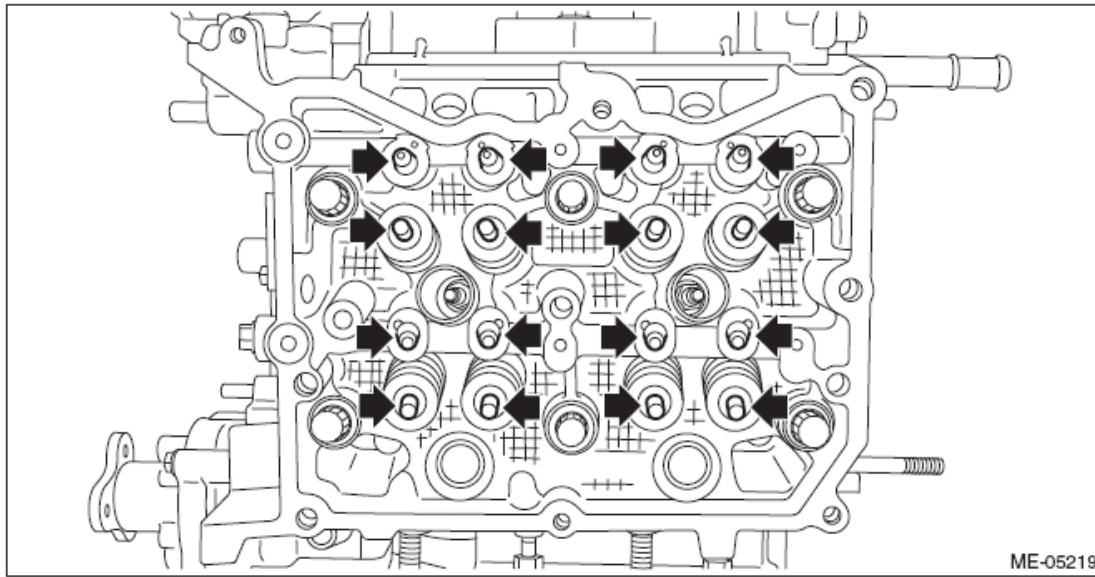
**NOTE:** Be careful not to confuse the roller rocker arms.



**Fig. 226: Locating O-Ring And Roller Rocker Arm From Cylinder Head LH**  
Courtesy of SUBARU OF AMERICA, INC.

13. Remove the valve shim and the roller rocker arm pivot from cylinder head LH.

**NOTE:** Be careful not to confuse the valve shim and the roller rocker arm pivot.



**Fig. 227: Locating Valve Shim And Roller Rocker Arm Pivot Of Cylinder Head LH**  
Courtesy of SUBARU OF AMERICA, INC.

14. Remove the liquid gasket from cam carrier LH and cylinder head LH.

## INSTALLATION

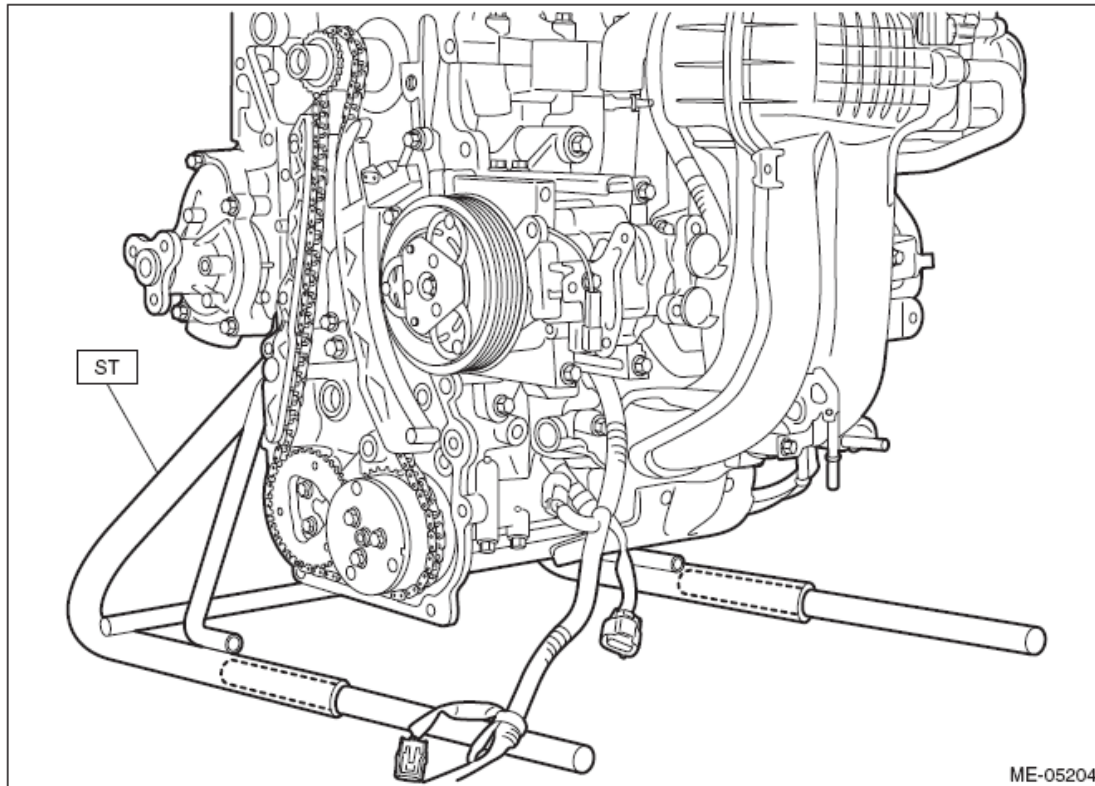
### CAM CARRIER RH

1. Insert the steel rods into ST, and set the engine so that the camshaft RH is facing up.

#### CAUTION:

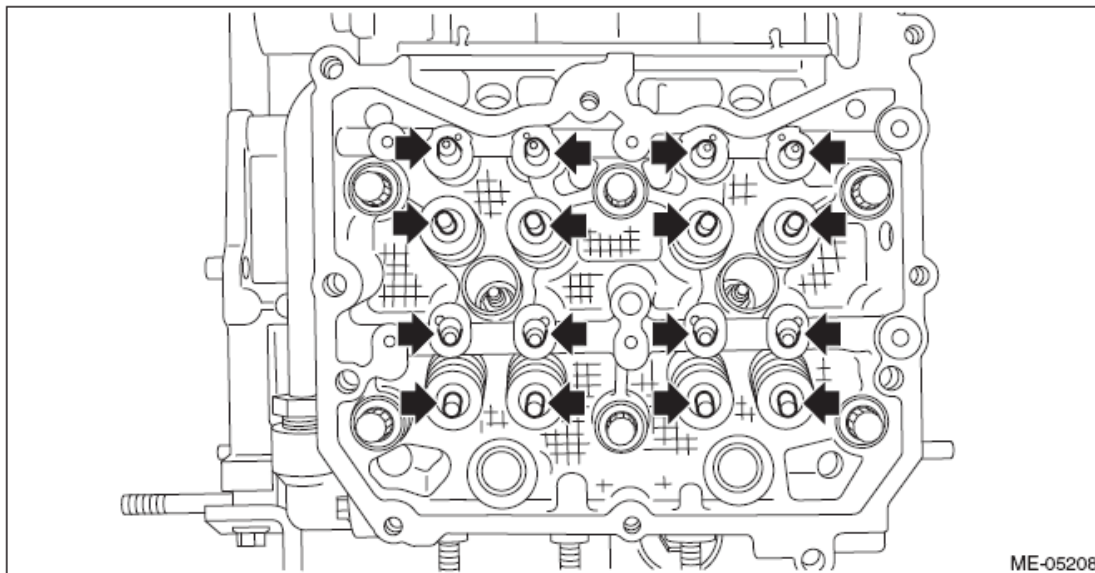
- If the engine is standing on one side without inserting the steel rod into ST, engine may lose balance and fall down. Be sure to insert the steel rod into ST to extend the length.
- Use the steel rod with enough strength.
- Be careful not to pinch the engine harness with ST.

ST 499817100 ENGINE STAND



**Fig. 228: Inserting Steel Rods Into ST**  
Courtesy of SUBARU OF AMERICA, INC.

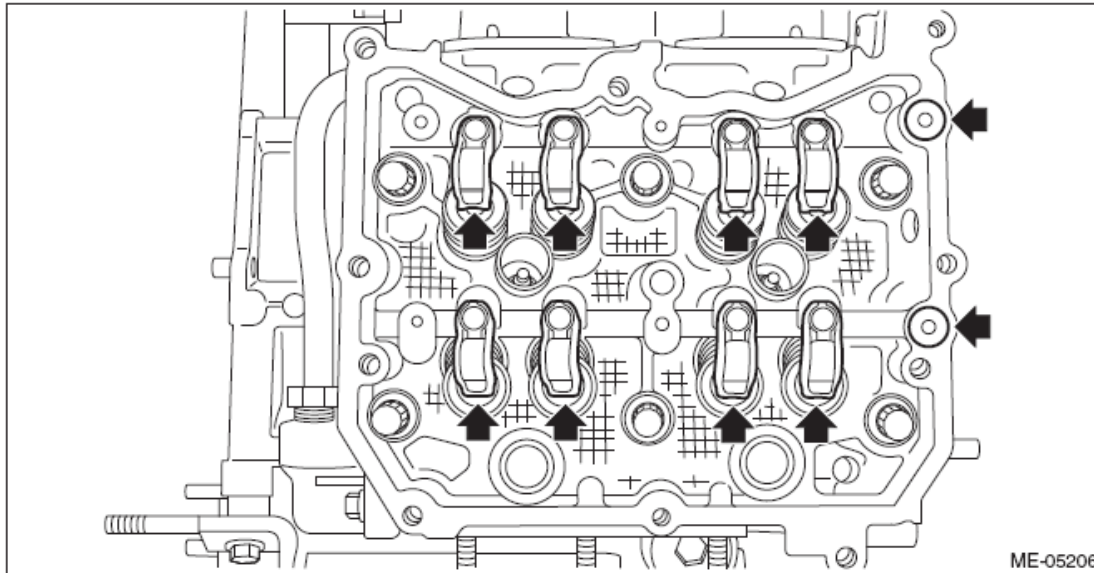
2. Apply engine oil to the valve shim and the roller rocker arm pivot, and install the valve shim and the roller rocker arm pivot to the cylinder head RH.



**Fig. 229: Locating Valve Shim And Roller Rocker Arm Pivot Of Cylinder Head RH**  
Courtesy of SUBARU OF AMERICA, INC.

3. Apply engine oil to the O-ring and the roller rocker arm, and install the O-ring and the roller rocker arm to the cylinder head RH.

**NOTE:** Use new O-rings.



**Fig. 230: Locating O-Ring And Roller Rocker Arm Of Cylinder Head RH**  
Courtesy of SUBARU OF AMERICA, INC.

4. Apply liquid gasket to the mating surface of cam carrier RH as shown in the figure.

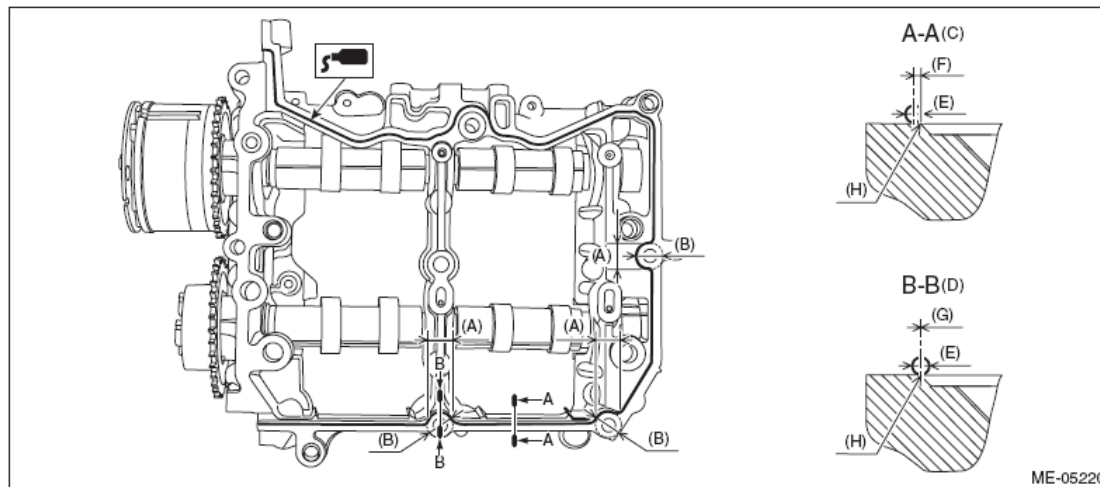
- NOTE:**
- Before applying liquid gasket, degrease the old liquid gasket seal surface of the cylinder head RH and cam carrier RH.
  - Install within 5 min. after applying liquid gasket.

*Liquid gasket:*

**THREE BOND 1217G (Part No. 0877Y0100) or equivalent**

*Liquid gasket applying diameter:*

**3.0±0.5 mm (0.1181±0.0197 in)**

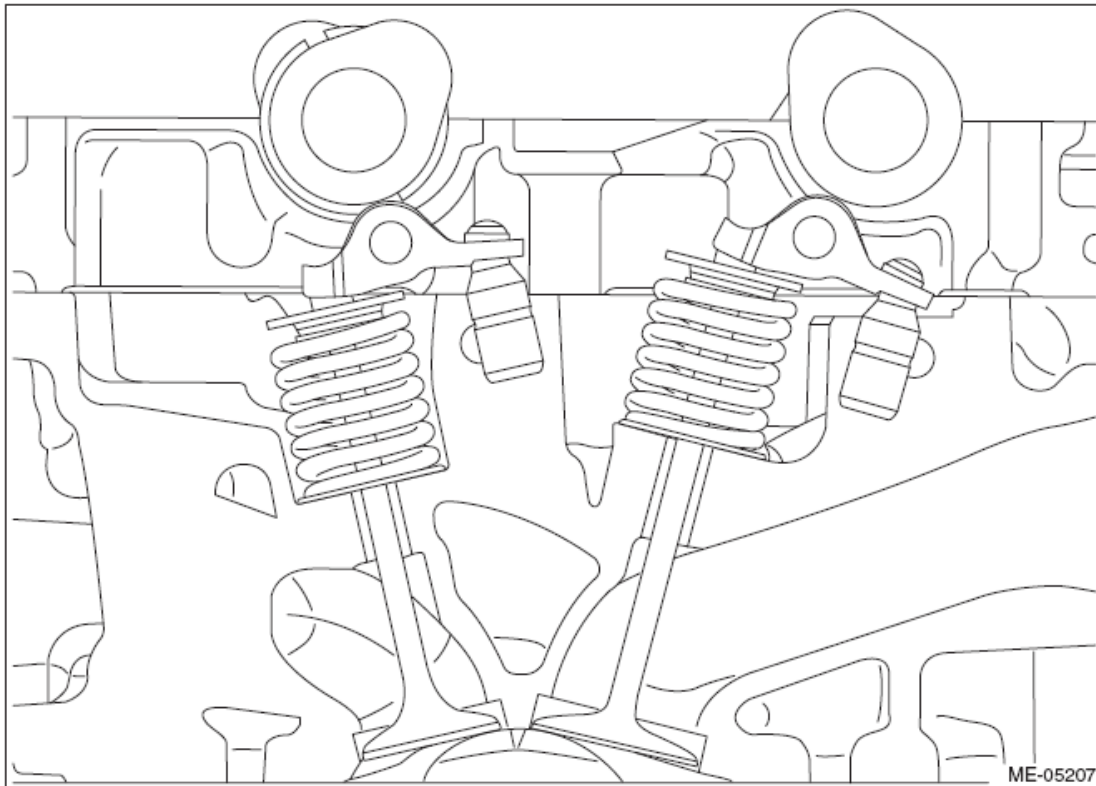


- |                                                                           |                                                                      |                                                          |
|---------------------------------------------------------------------------|----------------------------------------------------------------------|----------------------------------------------------------|
| (A) Range A                                                               | (D) Liquid gasket applying position of mating surfaces of range A    | (G) $0 \pm 0.5 \text{ mm}$ ( $0 \pm 0.0197 \text{ in}$ ) |
| (B) $\phi 18 \text{ mm}$ ( $0.7087 \text{ in}$ )                          | (E) $\phi 3.0 \pm 0.5 \text{ mm}$ ( $0.1181 \pm 0.0197 \text{ in}$ ) | (H) Chamfer edge                                         |
| (C) Liquid gasket applying position of mating surfaces other than range A | (F) $1 \text{ mm}$ ( $0.0394 \text{ in}$ ) or less                   |                                                          |

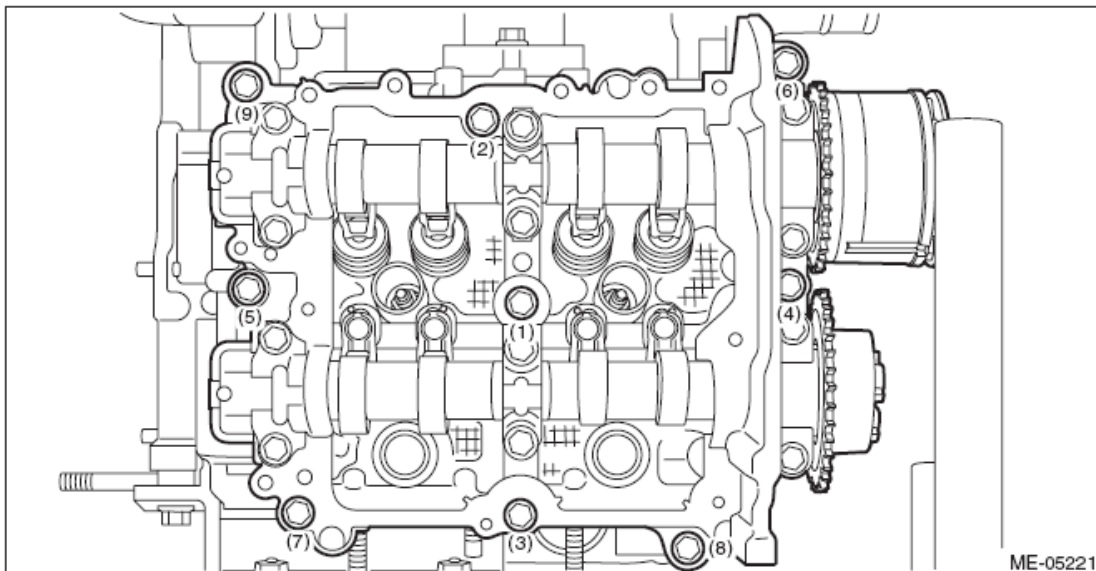
**Fig. 231: Identifying Liquid Gasket Applying Area On Mating Surface Of Cam Carrier RH**  
 Courtesy of SUBARU OF AMERICA, INC.

5. Install the cam carrier RH to the cylinder head RH.
  1. Mount the cam carrier RH, then tighten all bolts with a torque of  $18 \text{ N.m}$  ( $1.8 \text{ kgf-m}$ ,  $13.3 \text{ ft-lb}$ ) in numerical order as shown in the figure.

**NOTE:** Set the intake camshaft RH and the exhaust camshaft RH to the zero-lift position.

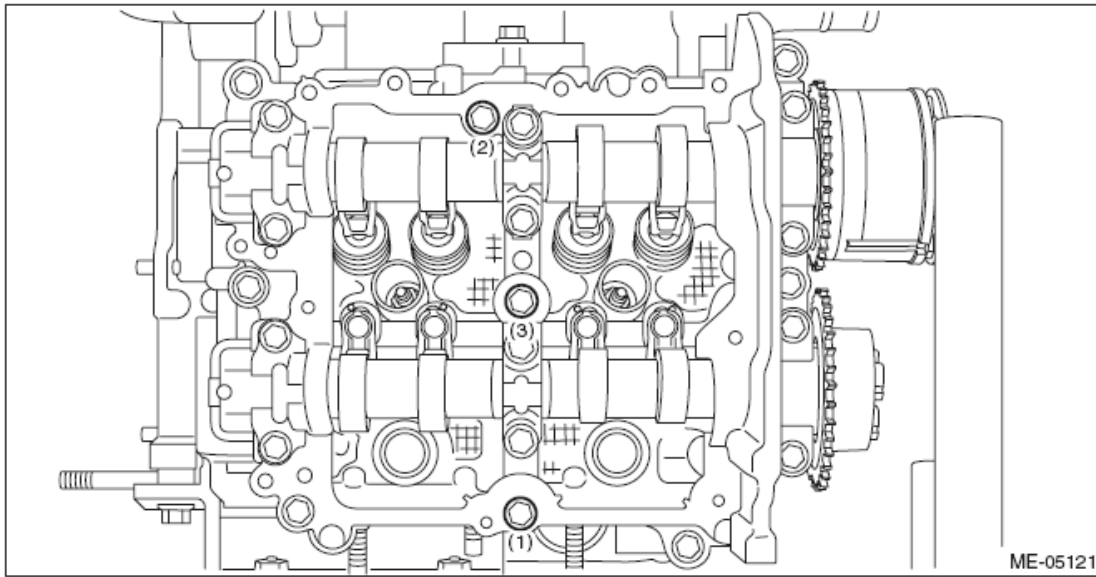


**Fig. 232: Identifying Cam Carrier RH**  
Courtesy of SUBARU OF AMERICA, INC.



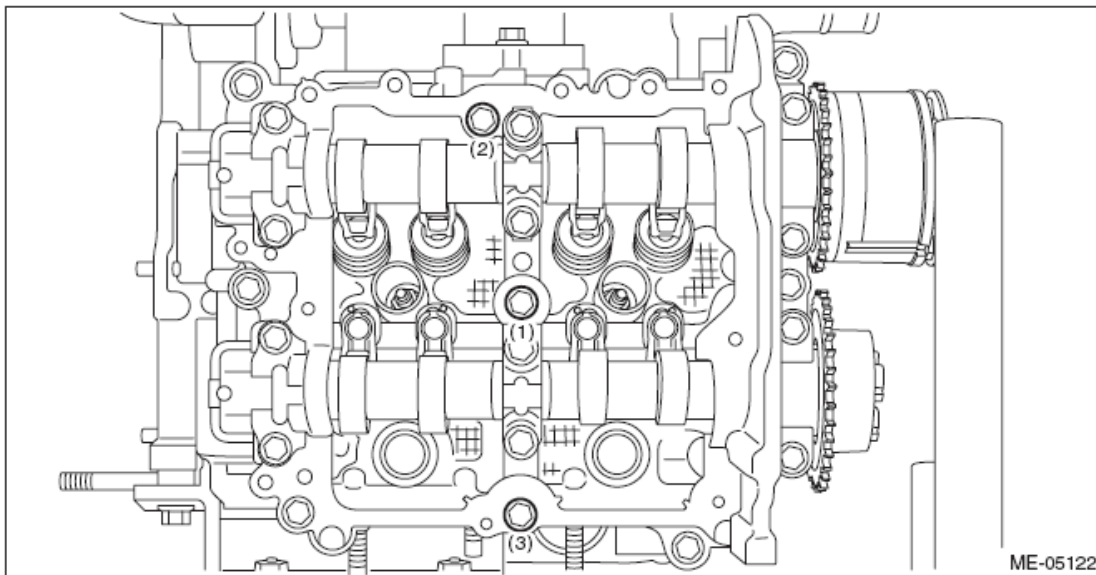
**Fig. 233: Identifying Cam Carrier RH Bolts Tightening Sequence**  
Courtesy of SUBARU OF AMERICA, INC.

2. Loosen the bolts (3 places) by 180° in numerical order as shown in the figure.



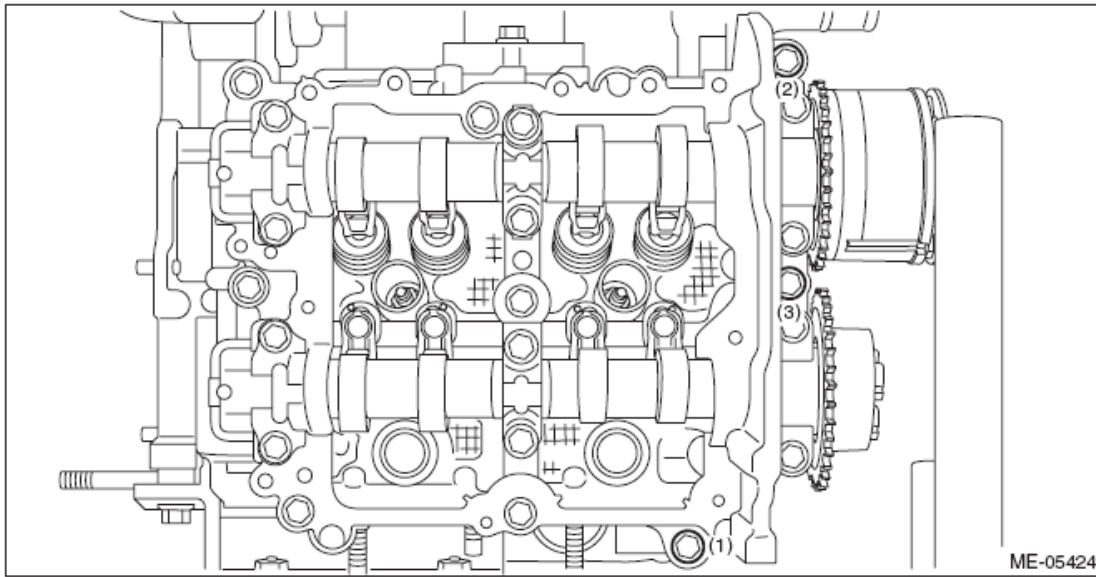
**Fig. 234: Identifying Cam Carrier RH Bolts Loosening Sequence**  
Courtesy of SUBARU OF AMERICA, INC.

3. Tighten the bolts (3 places) with a torque of 18 N.m (1.8 kgf-m, 13.3 ft-lb) in numerical order as shown in the figure.



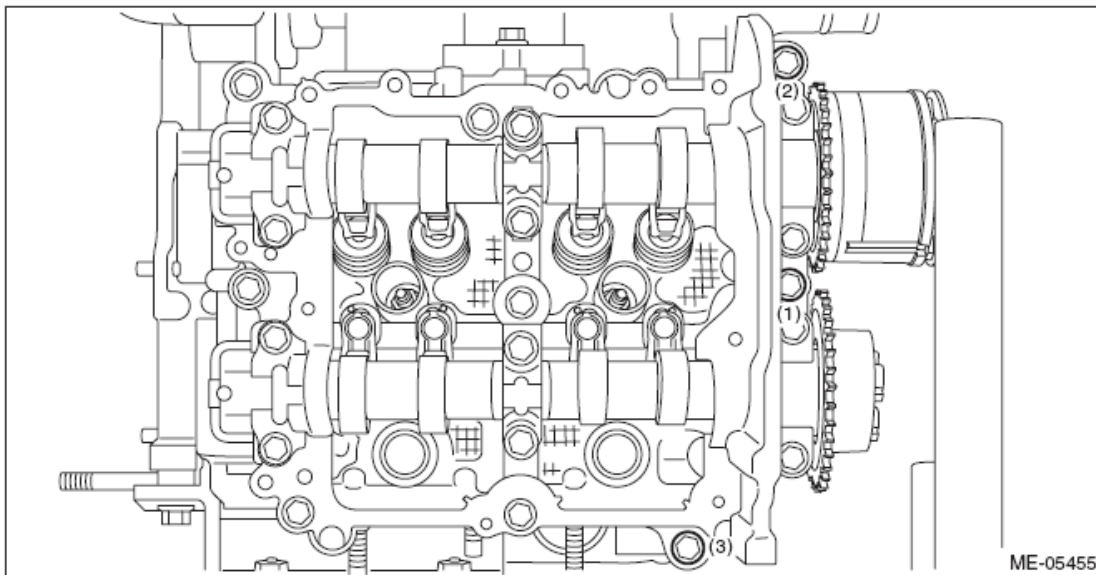
**Fig. 235: Identifying Cam Carrier RH Bolts Tightening Sequence**  
Courtesy of SUBARU OF AMERICA, INC.

4. Loosen the bolts (3 places) by 180° in numerical order as shown in the figure.



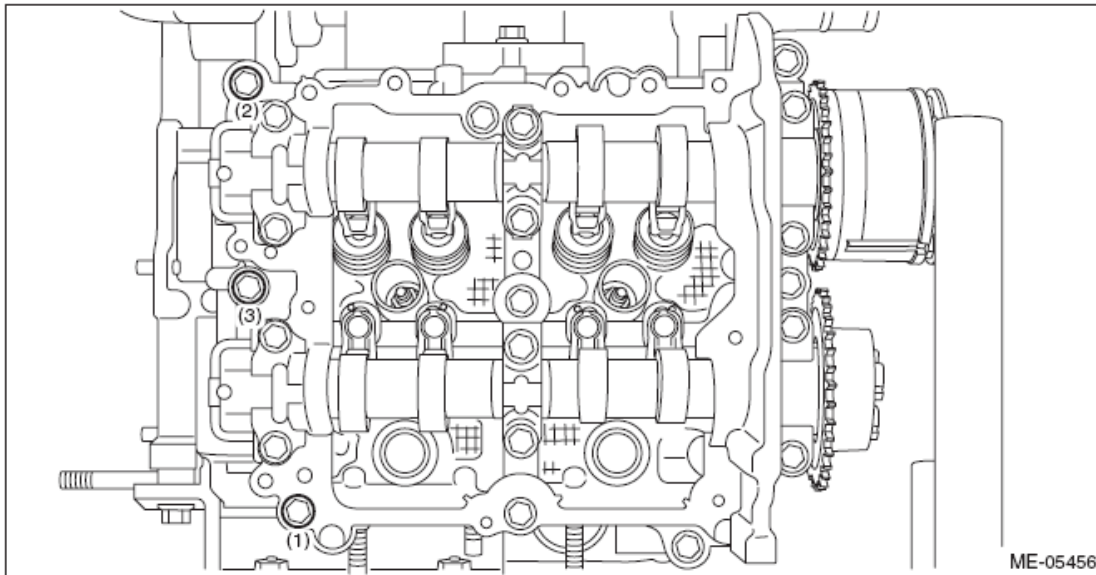
**Fig. 236: Identifying Cam Carrier RH Bolts Loosening Sequence**  
Courtesy of SUBARU OF AMERICA, INC.

5. Tighten the bolts (3 places) with a torque of 18 N.m (1.8 kgf-m, 13.3 ft-lb) in numerical order as shown in the figure.



**Fig. 237: Identifying Cam Carrier RH Bolts Tightening Sequence**  
Courtesy of SUBARU OF AMERICA, INC.

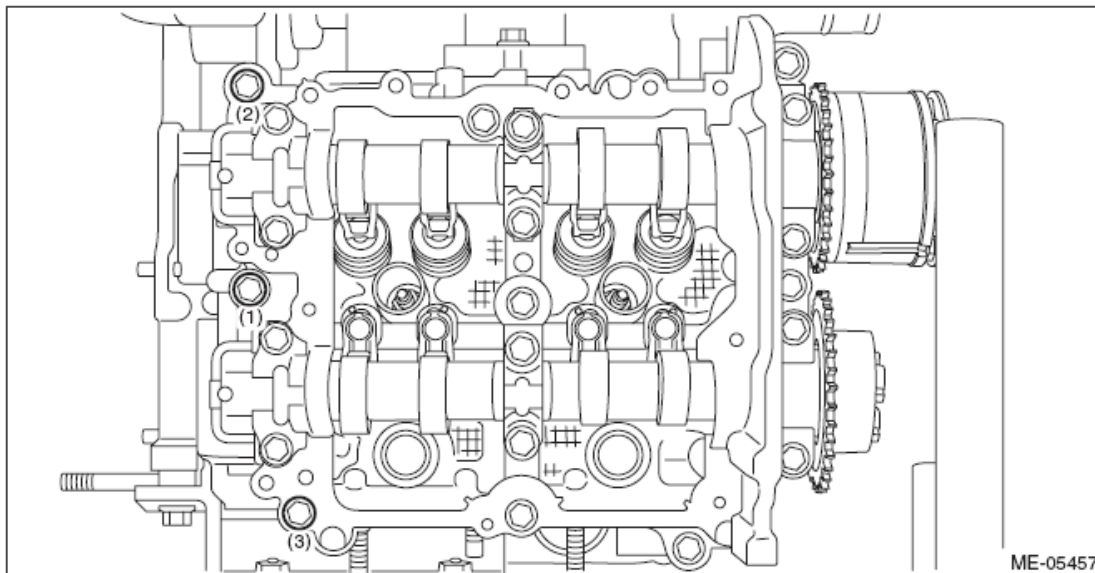
6. Loosen the bolts (3 places) by 180° in numerical order as shown in the figure.



**Fig. 238: Identifying Cam Carrier RH Bolts Loosening Sequence**  
Courtesy of SUBARU OF AMERICA, INC.

7. Tighten the bolts (3 places) with a torque of 18 N.m (1.8 kgf-m, 13.3 ft-lb) in numerical order as shown in the figure.

**NOTE:** After tightening, if the liquid gasket is squeezed out onto the seal surface of the chain cover, completely remove any squeezed-out liquid gasket.



**Fig. 239: Identifying Cam Carrier RH Bolts Tightening Sequence**  
Courtesy of SUBARU OF AMERICA, INC.

6. Set the part so that the intake manifold is on the upper side.

7. Install the cam sprocket RH. < Refer to **CAM SPROCKET RH**, INSTALLATION, Cam Sprocket. >

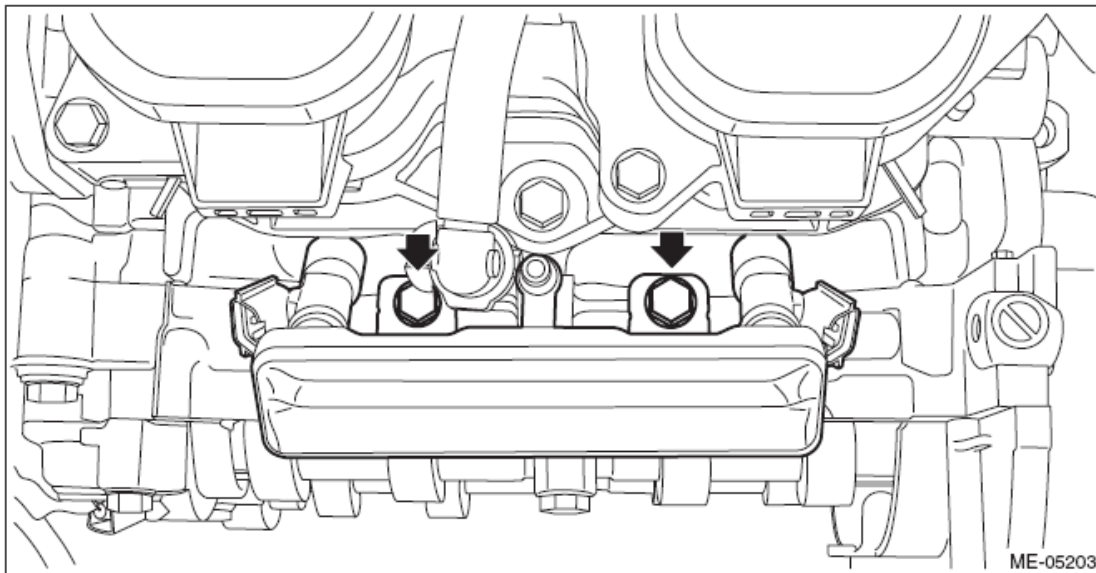
**NOTE:** This procedure is required only when the cam carrier RH is removed for disassembly.

8. Check the cam clearance. < Refer to **WHEN TIMING CHAIN ASSEMBLY IS REMOVED**, INSPECTION, Cam Clearance. >
9. Install the timing chain RH. < Refer to **TIMING CHAIN RH**, INSTALLATION, Timing Chain Assembly. >
10. Install the fuel pipe RH and the fuel injector RH.
  1. Install the fuel pipe RH and the fuel injector RH, and install the bolts which secure the fuel pipe RH.

**NOTE:** Use new O-rings, rubbers and seal rings.

*Tightening torque:*

**6.4 N.m (0.7 kgf-m, 4.7 ft-lb)**



**Fig. 240: Locating Fuel Pipe RH And Fuel Injector RH Bolts**  
Courtesy of SUBARU OF AMERICA, INC.

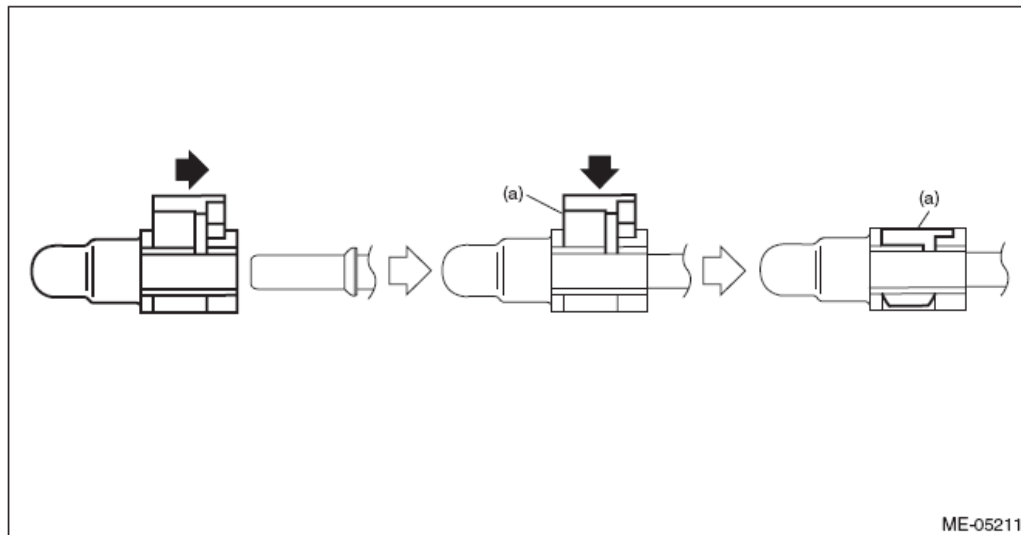
2. Connect the quick connector to the fuel pipe RH.

**CAUTION:**

- Check that there is no damage or dust on the quick connector. If necessary, clean the seal surface of the pipe.
- When connecting the quick connector, make sure to insert the pipe all the way in before locking the slider.

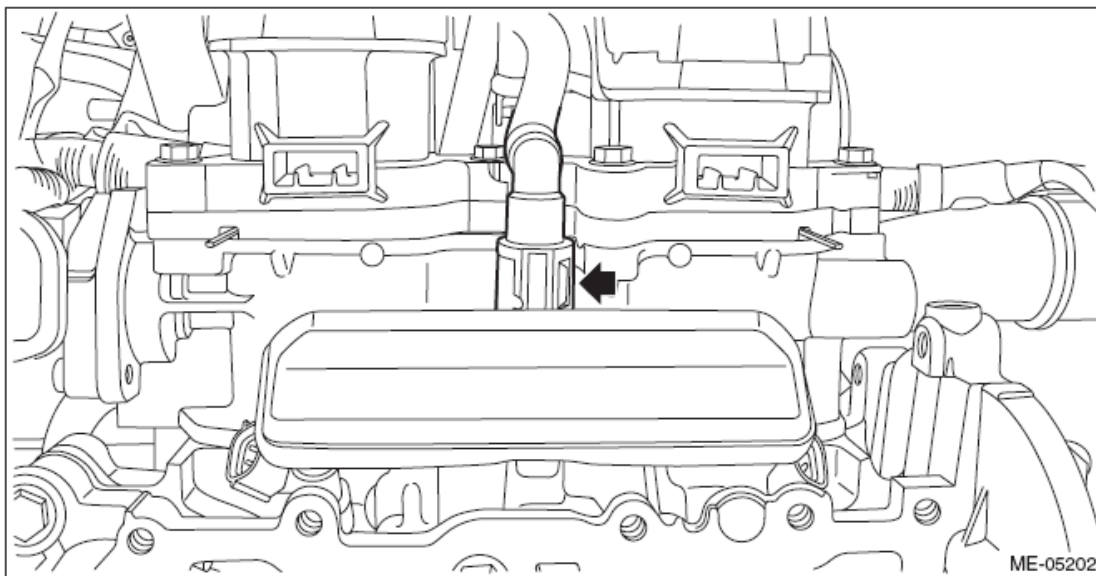
- When it is difficult to lock the slider, check that the pipe is fully inserted.
- Make sure that the quick connector is securely connected.

**NOTE:** Connect the quick connector as shown in the figure.



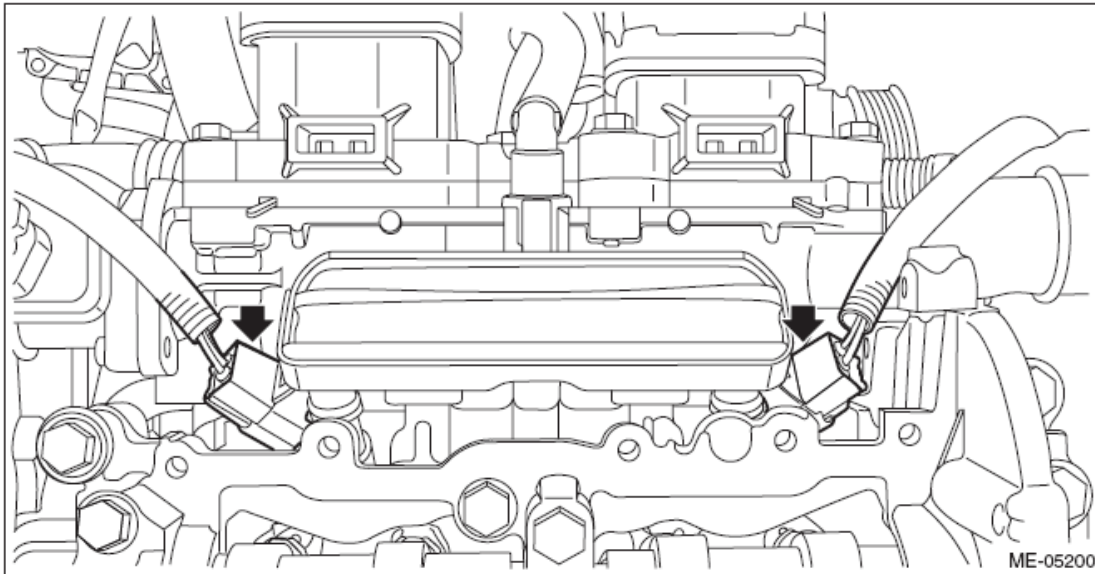
(a) Slider

**Fig. 241: Connecting Quick Connector To Fuel Pipe RH**  
Courtesy of SUBARU OF AMERICA, INC.



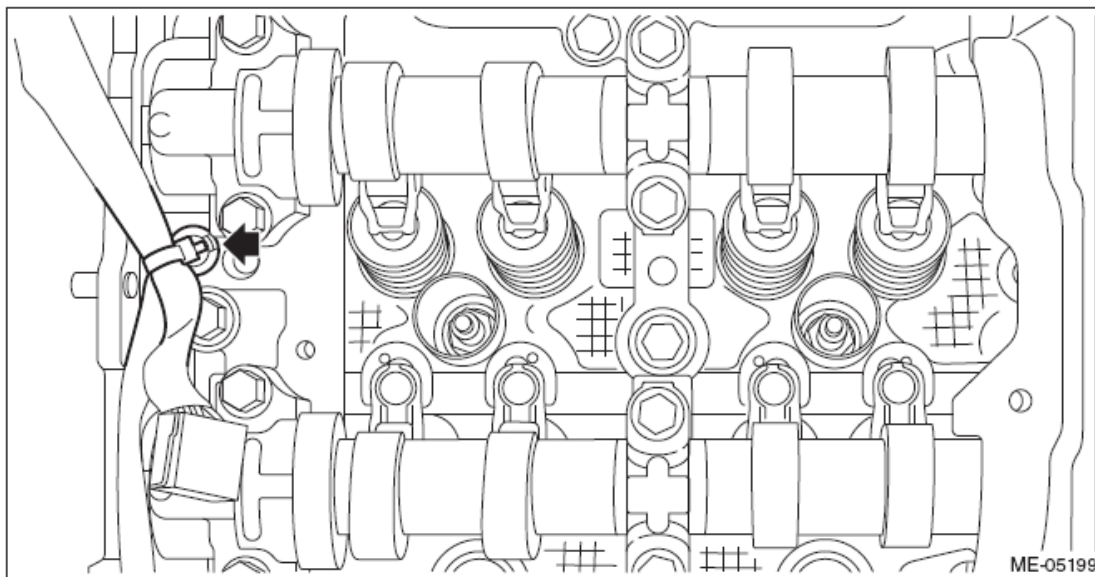
**Fig. 242: Locating Quick Connector**  
Courtesy of SUBARU OF AMERICA, INC.

3. Connect the connectors to the fuel injector RH.



**Fig. 243: Locating Fuel Injector RH Connectors**  
Courtesy of SUBARU OF AMERICA, INC.

11. Secure the engine harness to the cam carrier RH with a clip.



**Fig. 244: Locating Cam Carrier RH Engine Harness Clip**  
Courtesy of SUBARU OF AMERICA, INC.

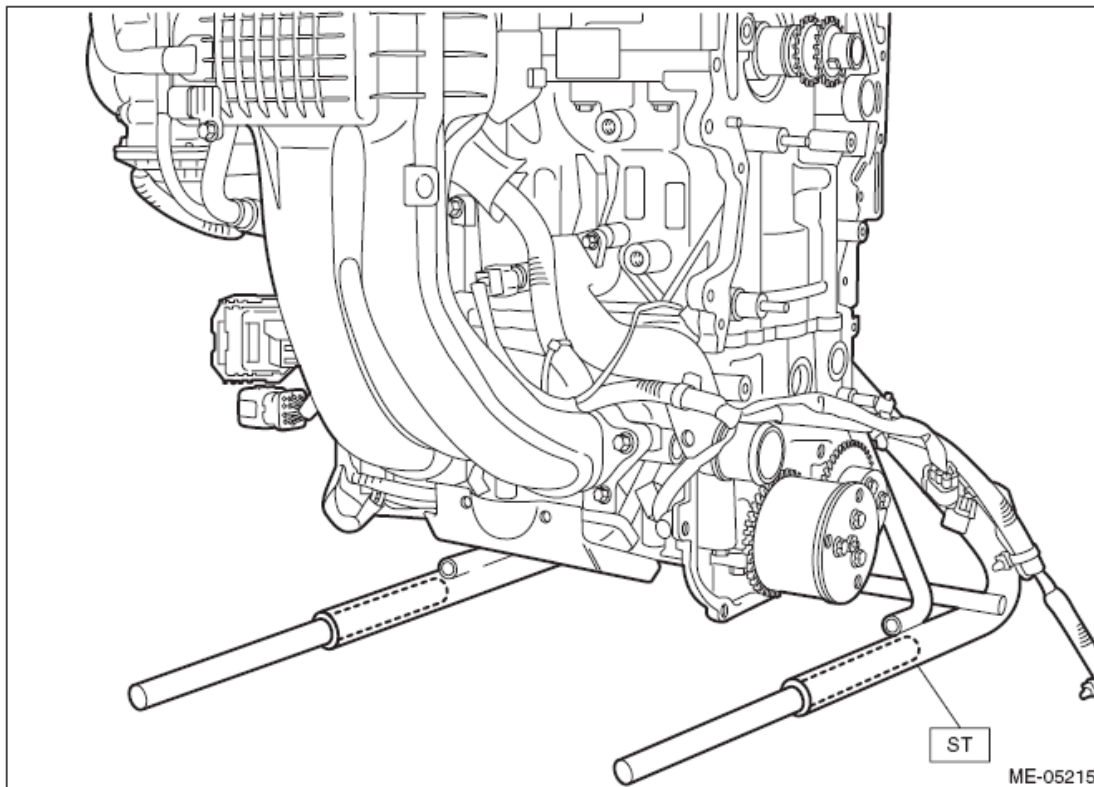
12. Install the rocker cover RH. < Refer to **ROCKER COVER RH**, INSTALLATION, Rocker Cover. >
13. Install the chain cover. < Refer to **INSTALLATION**, Chain Cover. >
14. Install the engine to the vehicle. < Refer to **INSTALLATION**, Engine Assembly. >

**CAM CARRIER LH**

1. Insert the steel rods into ST, and set the engine so that the camshaft LH is facing up.

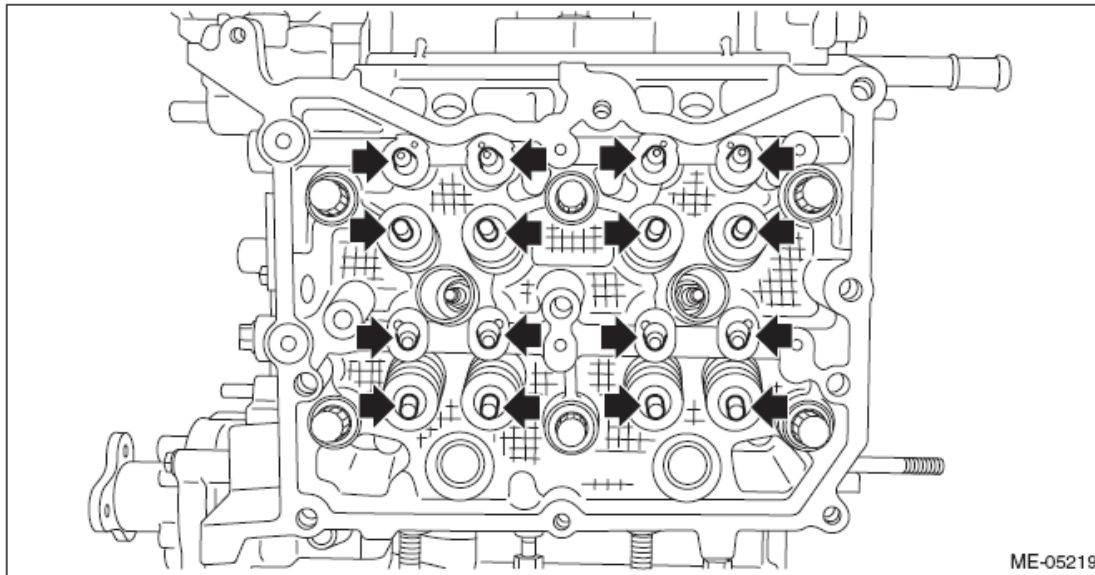
**CAUTION:**

- If the engine is standing on one side without inserting the steel rod into ST, engine may lose balance and fall down. Be sure to insert the steel rod into ST to extend the length.
- Use the steel rod with enough strength.
- Be careful not to pinch the engine harness with ST.

**ST 499817100 ENGINE STAND**

**Fig. 245: Inserting Steel Rods Into Engine Stand**  
Courtesy of SUBARU OF AMERICA, INC.

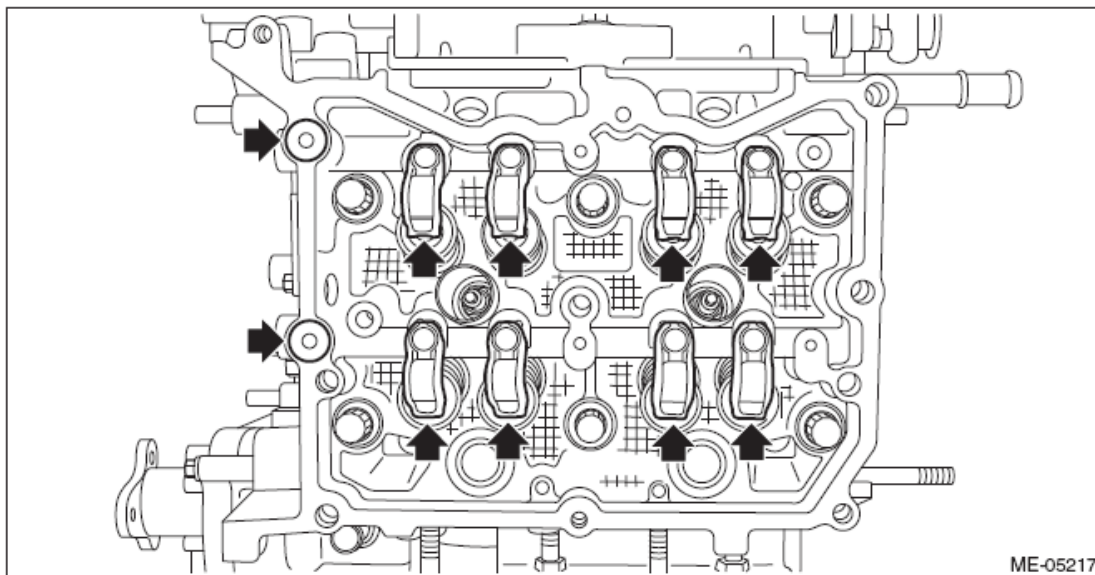
2. Apply engine oil to the valve shim and the roller rocker arm pivot, and install the valve shim and the roller rocker arm pivot to the cylinder head LH.



**Fig. 246: Locating Valve Shim And Roller Rocker Arm Pivot Of Cylinder Head LH**  
Courtesy of SUBARU OF AMERICA, INC.

3. Apply engine oil to the O-ring and the roller rocker arm, and install the O-ring and the roller rocker arm to the cylinder head LH.

**NOTE:** Use new O-rings.



**Fig. 247: Locating O-Ring And Roller Rocker Arm From Cylinder Head LH**  
Courtesy of SUBARU OF AMERICA, INC.

4. Apply liquid gasket to the mating surface of cam carrier LH as shown in the figure.

**NOTE:**

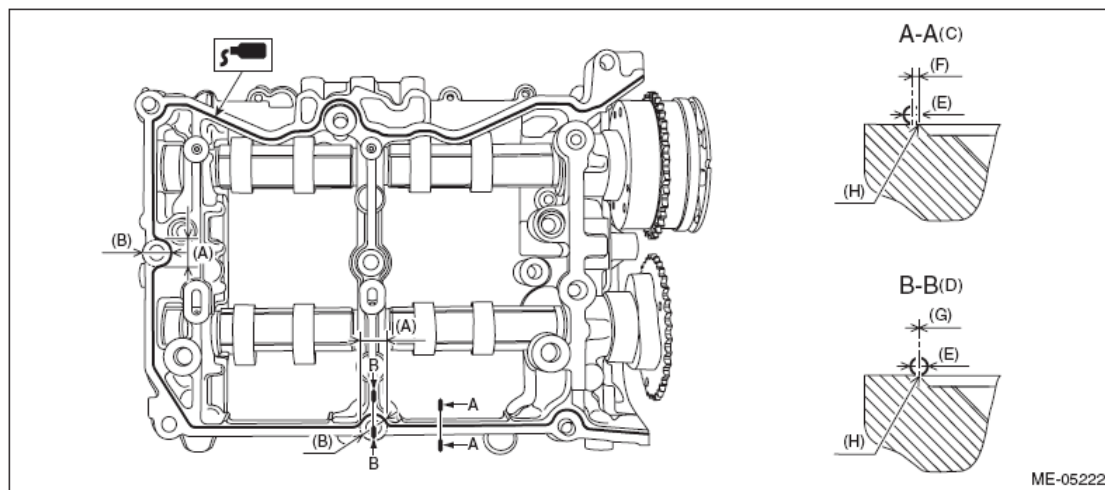
- Before applying liquid gasket, degrease the old liquid gasket seal surface of the cylinder head LH and cam carrier LH.
- Install within 5 min. after applying liquid gasket.

**Liquid gasket:**

**THREE BOND 1217G (Part No. 0877Y0100) or equivalent**

**Liquid gasket applying diameter:**

**3.0±0.5 mm (0.1181±0.0197 in)**



- |                                                                           |                                                                   |                            |
|---------------------------------------------------------------------------|-------------------------------------------------------------------|----------------------------|
| (A) Range A                                                               | (D) Liquid gasket applying position of mating surfaces of range A | (G) 0±0.5 mm (0±0.0197 in) |
| (B) $\phi 18$ mm (0.7087 in)                                              | (E) $\phi 3.0 \pm 0.5$ mm (0.1181±0.0197 in)                      | (H) Chamfer edge           |
| (C) Liquid gasket applying position of mating surfaces other than range A | (F) 1 mm (0.0394 in) or less                                      |                            |

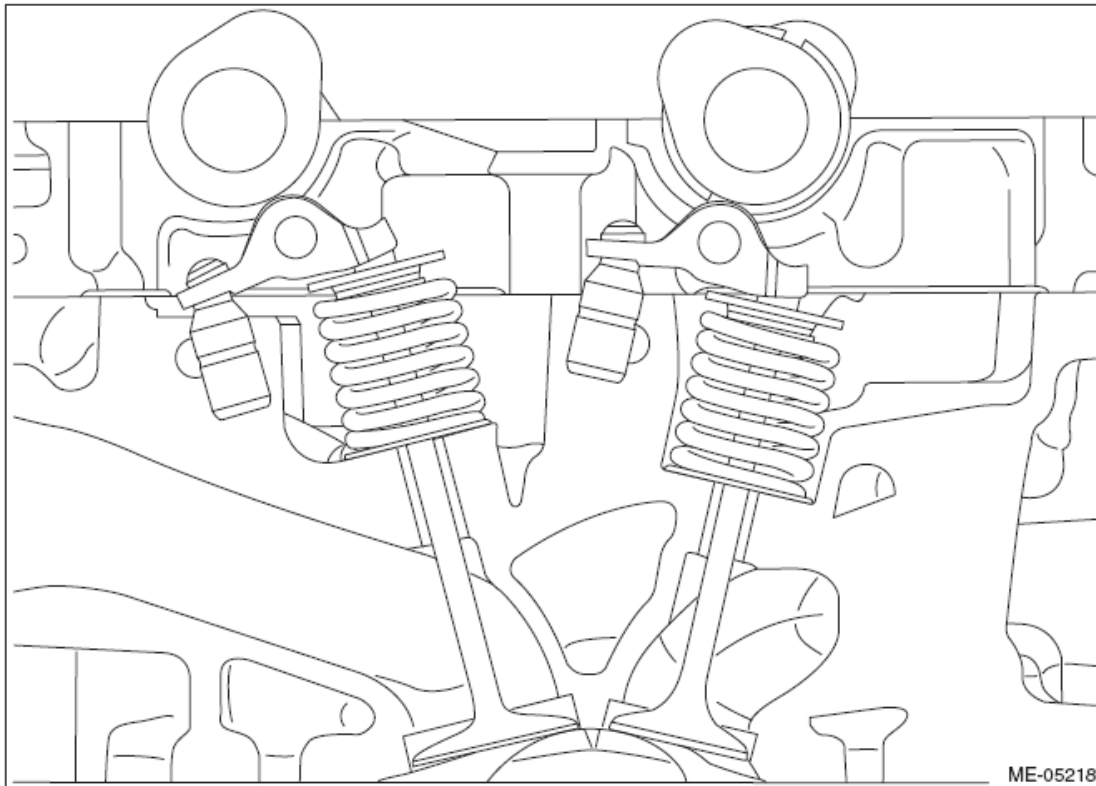
**Fig. 248: Identifying Liquid Gasket Applying Area On Mating Surface Of Cam Carrier LH**  
**Courtesy of SUBARU OF AMERICA, INC.**

**5. Install the cam carrier LH to the cylinder head LH.**

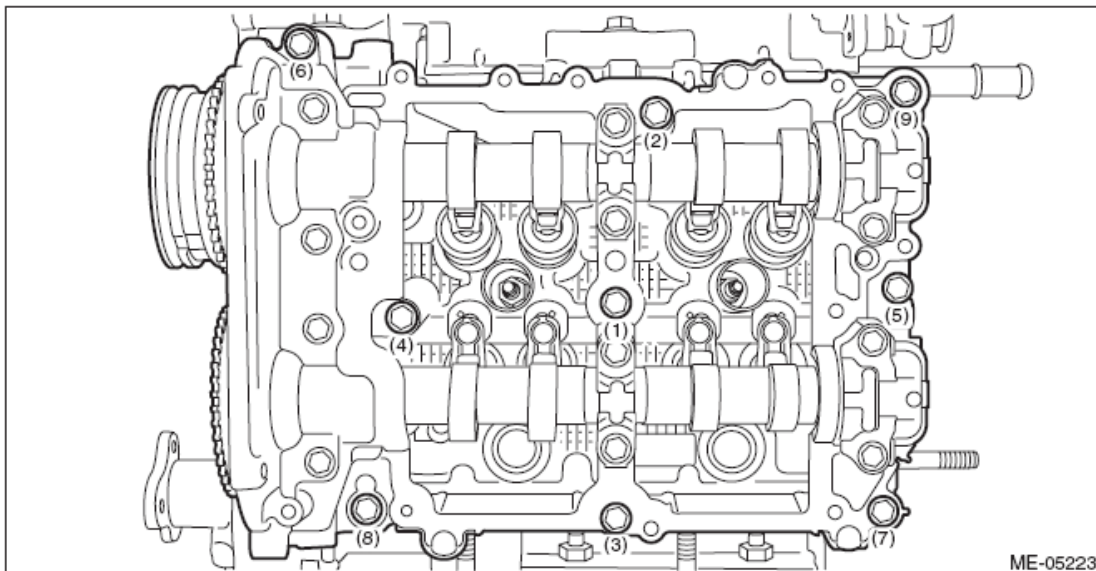
1. Mount the cam carrier LH, then tighten all bolts with a torque of 18 N.m (1.8 kgf-m, 13.3 ft-lb) in numerical order as shown in the figure.

**NOTE:**

**Set the intake camshaft LH and the exhaust camshaft LH to the zero-lift position.**

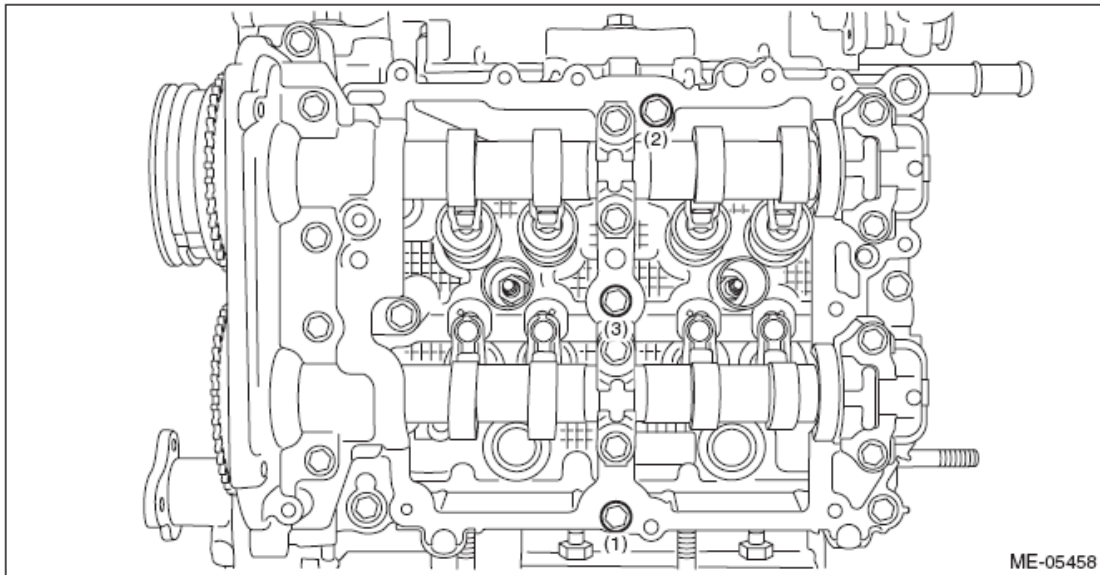


**Fig. 249: Identifying Cam Carrier LH**  
 Courtesy of SUBARU OF AMERICA, INC.



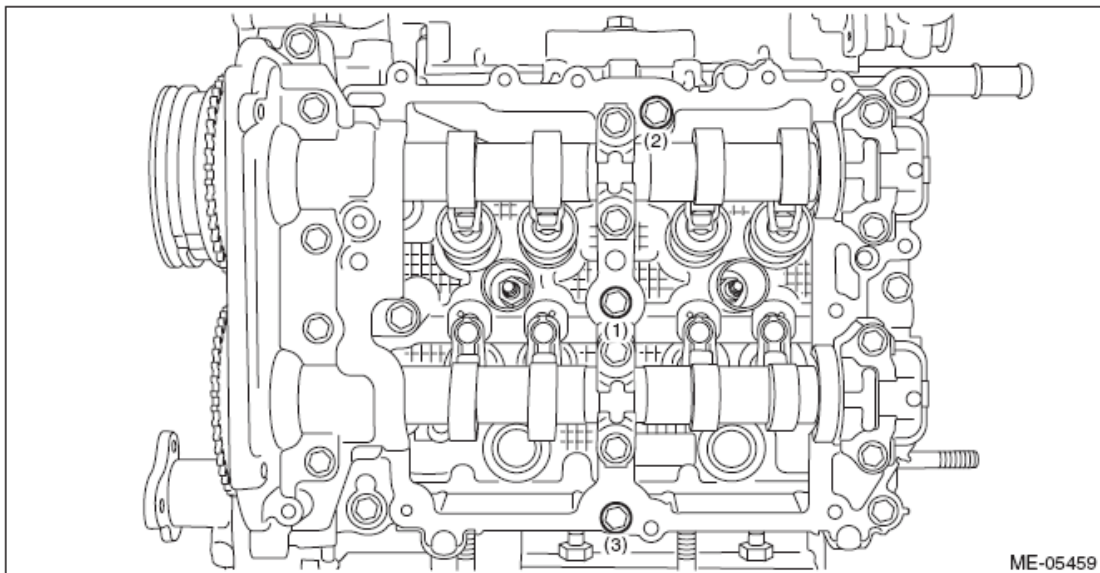
**Fig. 250: Identifying Cam Carrier LH Bolts Tightening Sequence**  
 Courtesy of SUBARU OF AMERICA, INC.

2. Loosen the bolts (3 places) by 180° in numerical order as shown in the figure.



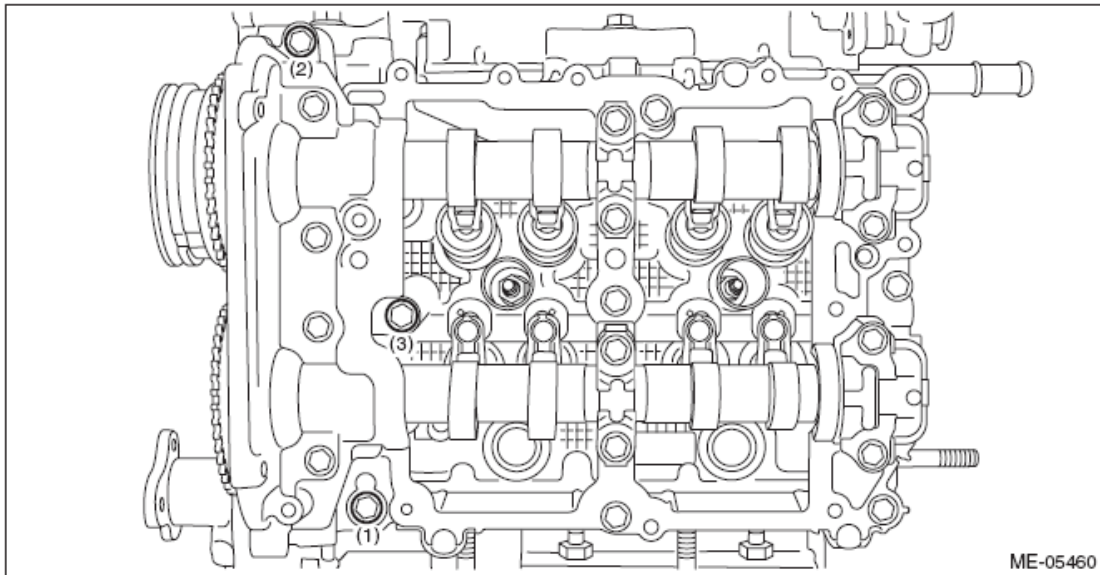
**Fig. 251: Identifying Cam Carrier LH Bolts Loosening Sequence**  
Courtesy of SUBARU OF AMERICA, INC.

3. Tighten the bolts (3 places) with a torque of 18 N.m (1.8 kgf-m, 13.3 ft-lb) in numerical order as shown in the figure.



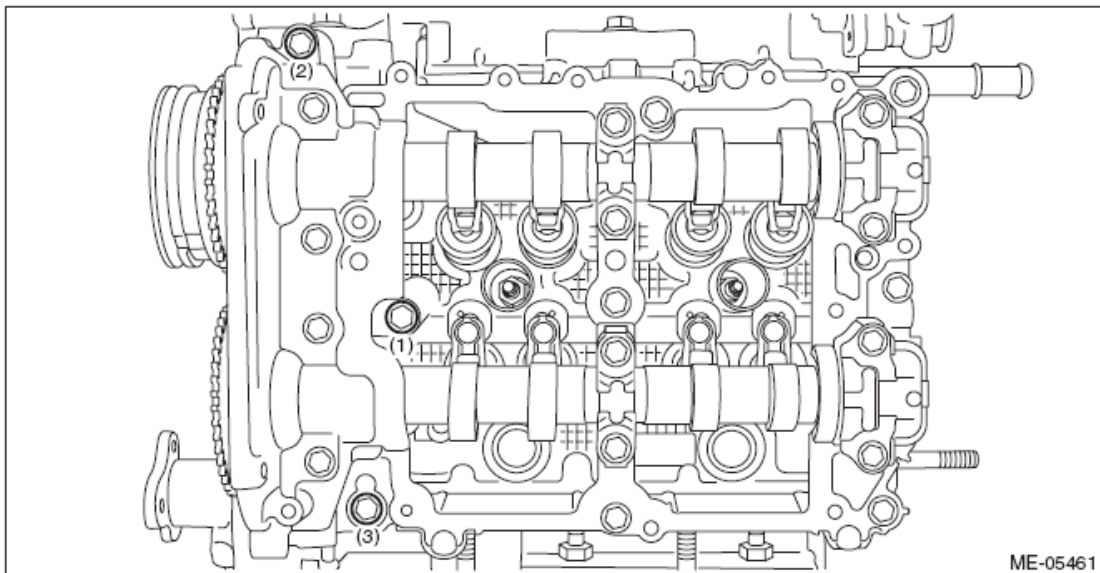
**Fig. 252: Identifying Tightening Sequence Of Cam Carrier LH Mounting Bolts**  
Courtesy of SUBARU OF AMERICA, INC.

4. Loosen the bolts (3 places) by 180° in numerical order as shown in the figure.



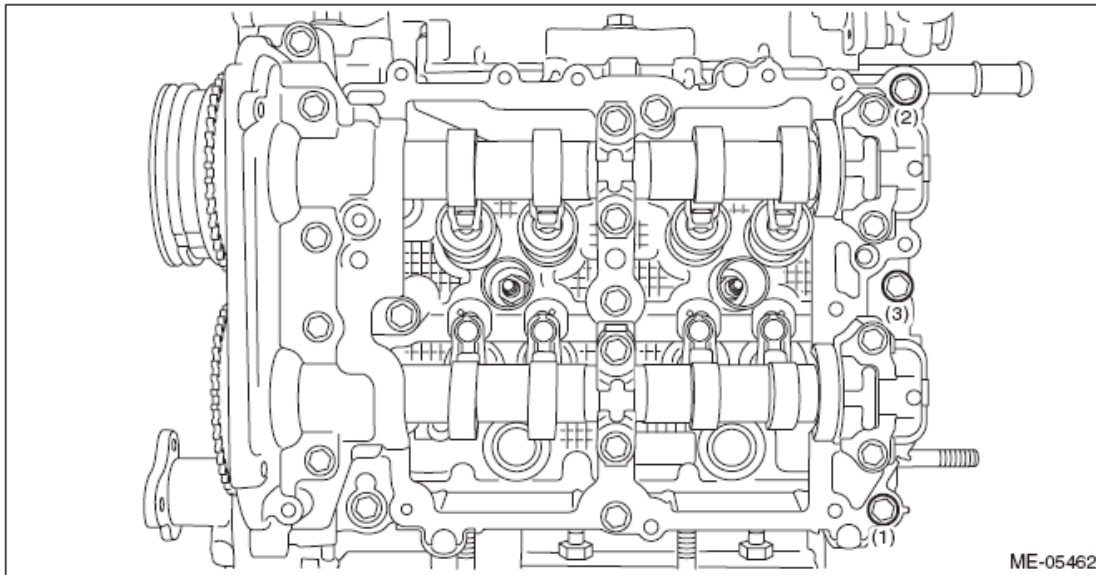
**Fig. 253: Identifying Cam Carrier LH Bolts Loosening Sequence**  
Courtesy of SUBARU OF AMERICA, INC.

5. Tighten the bolts (3 places) with a torque of 18 N.m (1.8 kgf-m, 13.3 ft-lb) in numerical order as shown in the figure.



**Fig. 254: Identifying Tightening Sequence Of Cam Carrier LH Mounting Bolts**  
Courtesy of SUBARU OF AMERICA, INC.

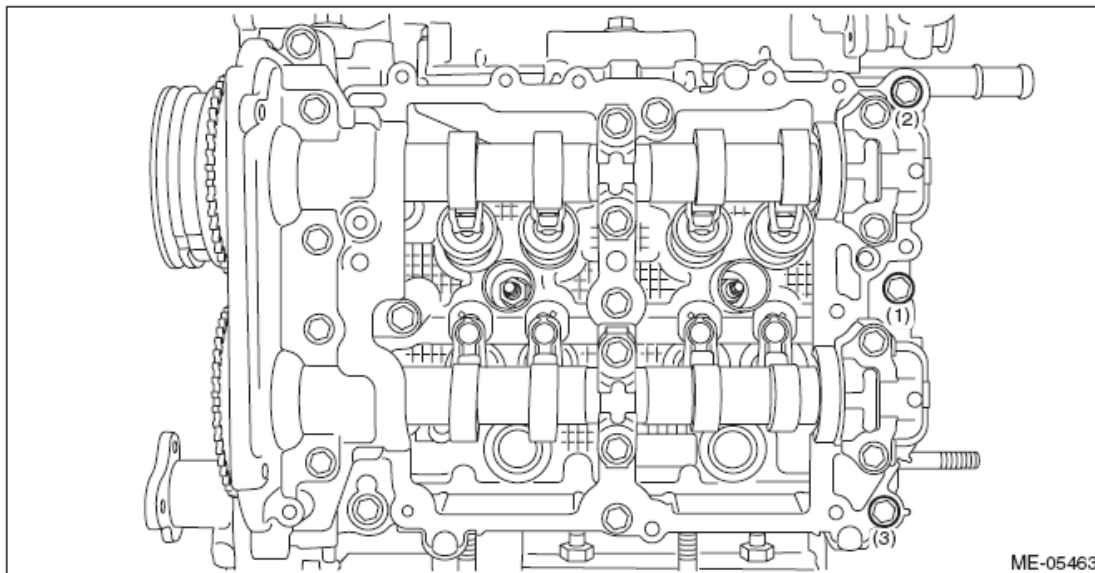
6. Loosen the bolts (3 places) by 180° in numerical order as shown in the figure.



**Fig. 255: Identifying Loosening Sequence Of Cam Carrier LH Mounting Bolts**  
Courtesy of SUBARU OF AMERICA, INC.

7. Tighten the bolts (3 places) with a torque of 18 N.m (1.8 kgf-m, 13.3 ft-lb) in numerical order as shown in the figure.

**NOTE:** After tightening, if the liquid gasket is squeezed out onto the seal surface of the chain cover, completely remove any squeezed-out liquid gasket.



**Fig. 256: Identifying Tightening Sequence Of Cam Carrier LH Mounting Bolts**  
Courtesy of SUBARU OF AMERICA, INC.

6. Set the part so that the intake manifold is on the upper side.

7. Install the cam sprocket LH. < Refer to **CAM SPROCKET LH**, INSTALLATION, Cam Sprocket. >

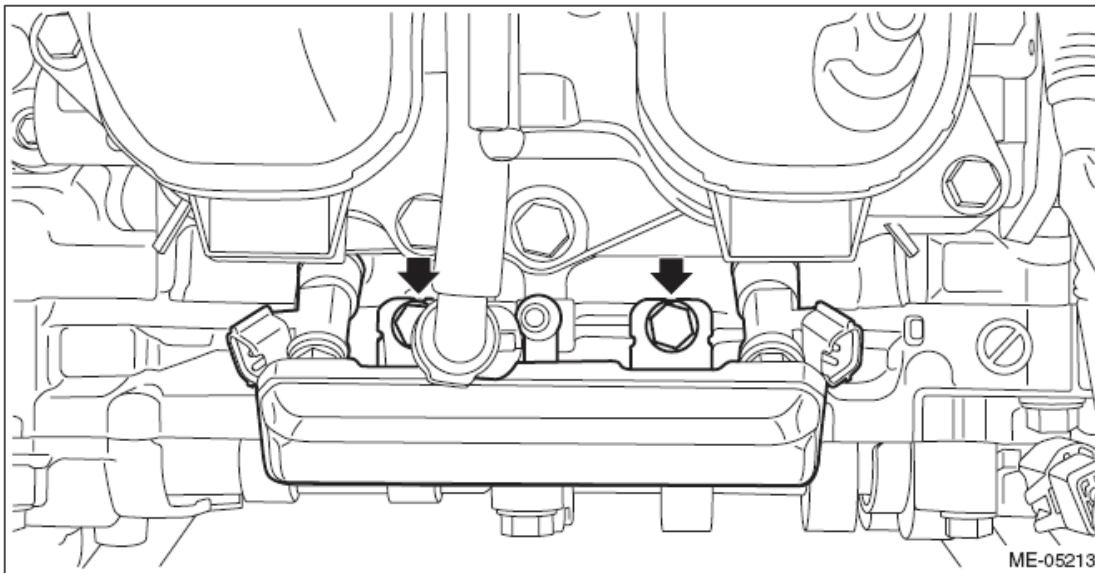
**NOTE:** This procedure is required only when the cam carrier LH is removed for disassembly.

8. Check the cam clearance. < Refer to **WHEN TIMING CHAIN ASSEMBLY IS REMOVED**, INSPECTION, Cam Clearance. >
9. Install timing chain LH. < Refer to **TIMING CHAIN LH**, INSTALLATION, Timing Chain Assembly. >
10. Install the fuel pipe LH and the fuel injector LH.
1. Install the fuel pipe LH and the fuel injector LH, and install the bolts which secure the fuel pipe LH.

**NOTE:** Use new O-rings, rubbers and seal rings.

*Tightening torque:*

**6.4 N.m (0.7 kgf-m, 4.7 ft-lb)**



**Fig. 257: Locating Fuel Pipe LH Mounting Bolts**  
Courtesy of SUBARU OF AMERICA, INC.

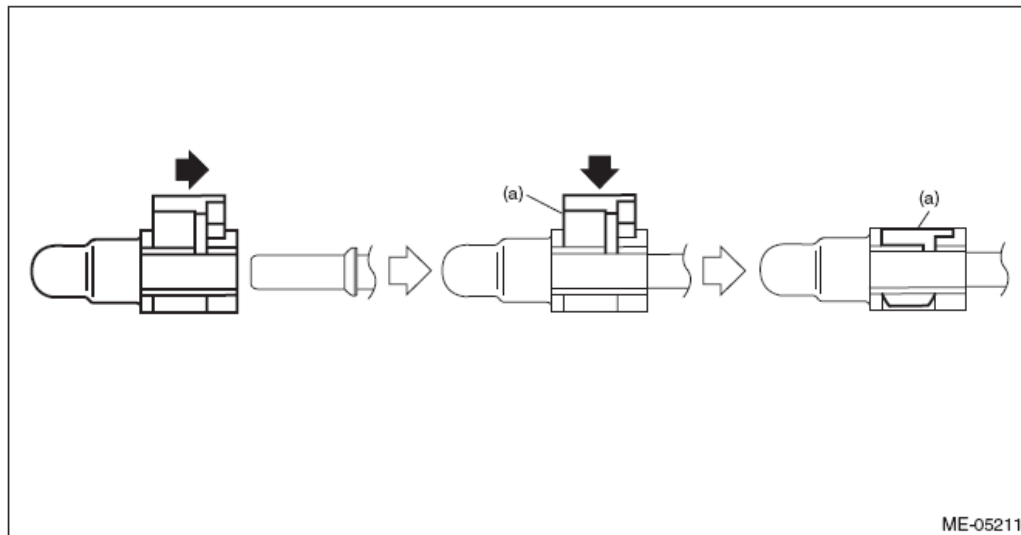
2. Connect the quick connector to the fuel pipe LH.

**CAUTION:**

- Check that there is no damage or dust on the quick connector. If necessary, clean the seal surface of the pipe.
- When connecting the quick connector, make sure to insert the pipe all the way in before locking the slider.

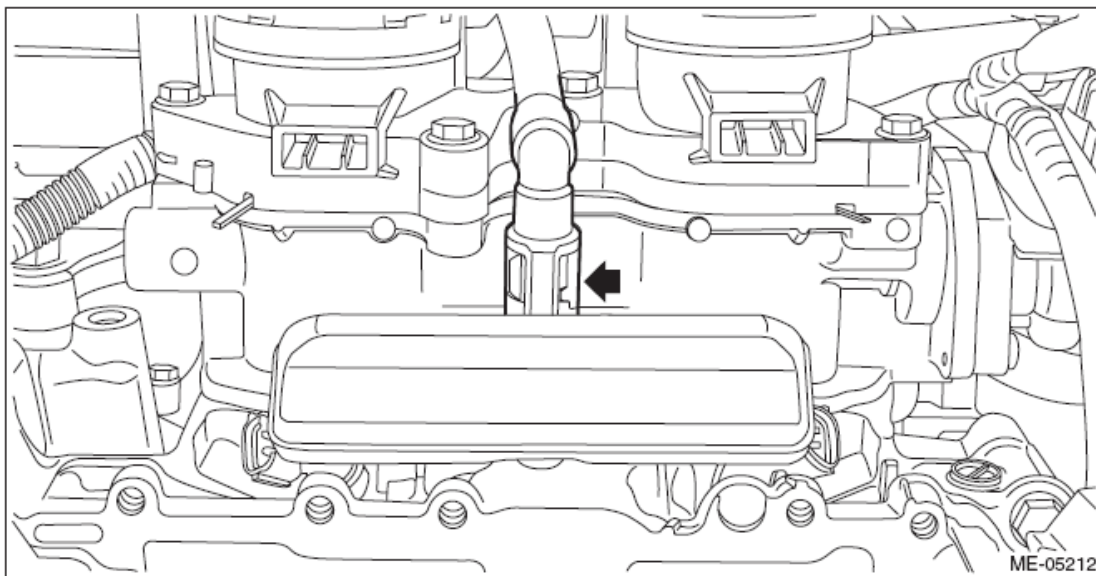
- When it is difficult to lock the slider, check that the pipe is fully inserted.
- Make sure that the quick connector is securely connected.

**NOTE:** Connect the quick connector as shown in the figure.



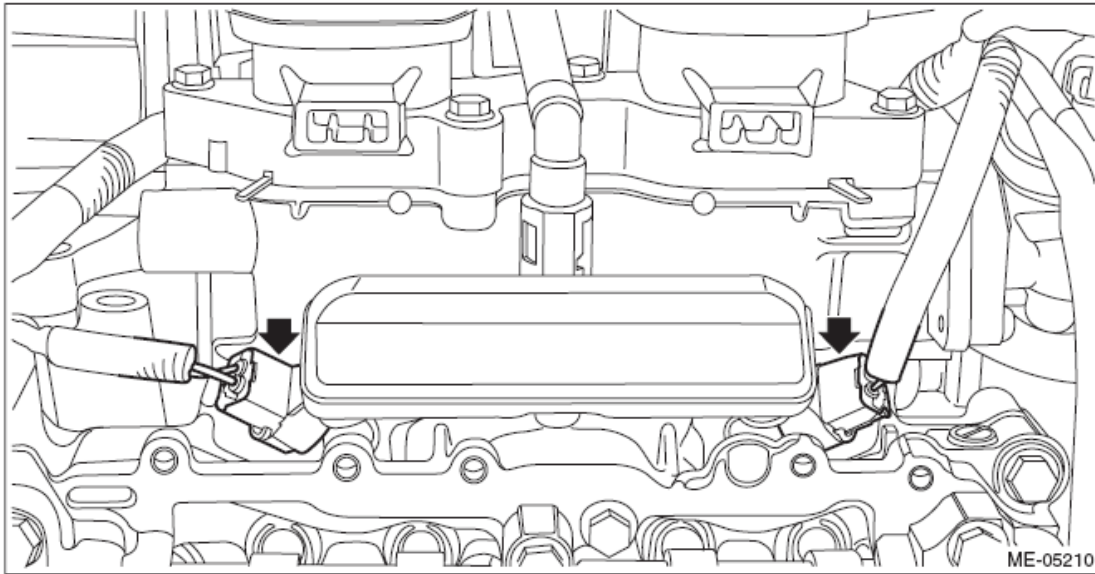
(a) Slider

**Fig. 258: Connecting Quick Connector To Fuel Pipe LH**  
Courtesy of SUBARU OF AMERICA, INC.



**Fig. 259: Locating Quick Connector**  
Courtesy of SUBARU OF AMERICA, INC.

3. Connect the connectors to the fuel injector LH.

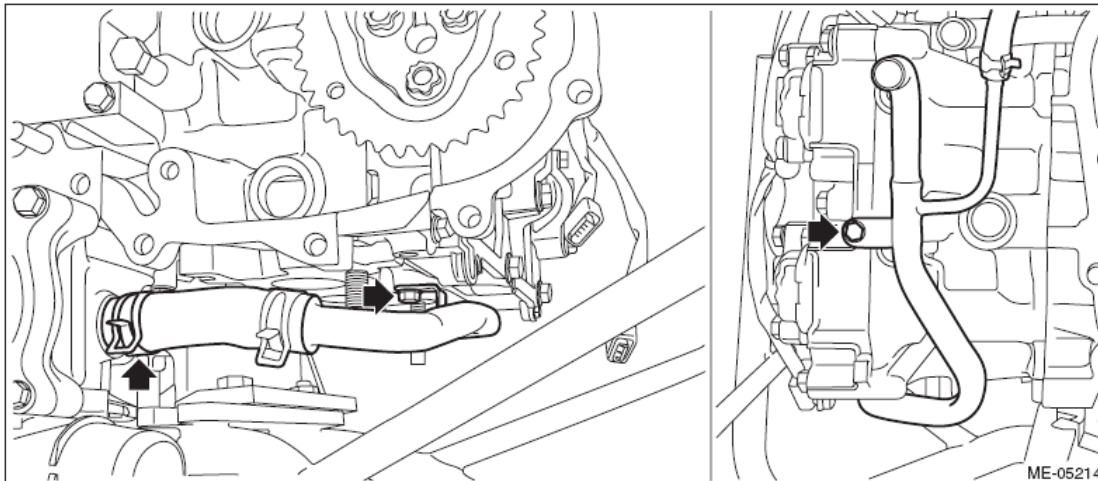


**Fig. 260: Locating Fuel Injector LH Connectors**  
Courtesy of SUBARU OF AMERICA, INC.

11. Connect the water pipe hose to oil pan upper, and install the water pipe assembly.

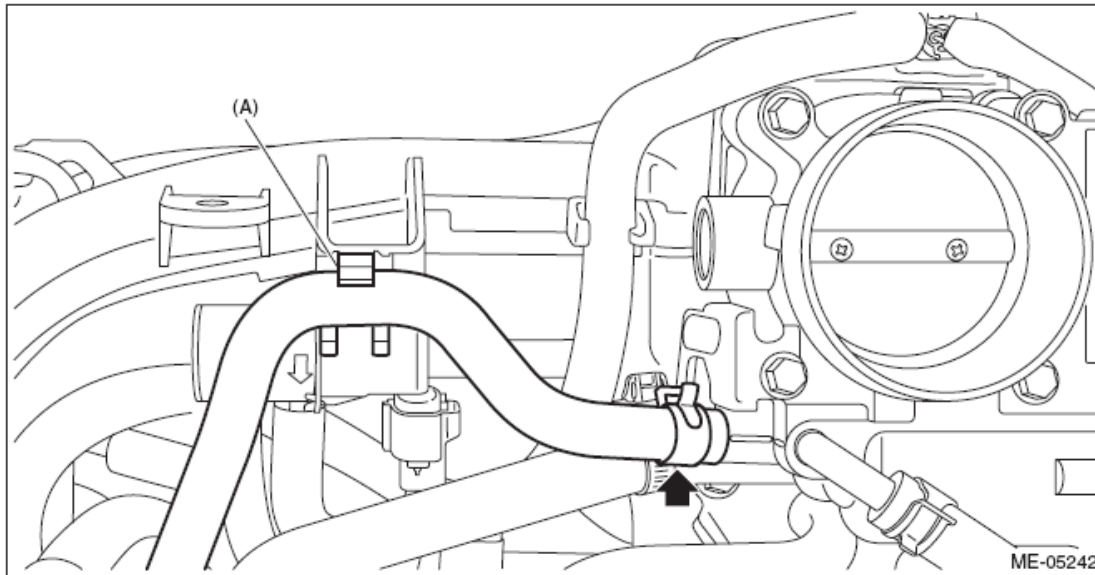
***Tightening torque:***

***6.4 N.m (0.7 kgf-m, 4.7 ft-lb)***



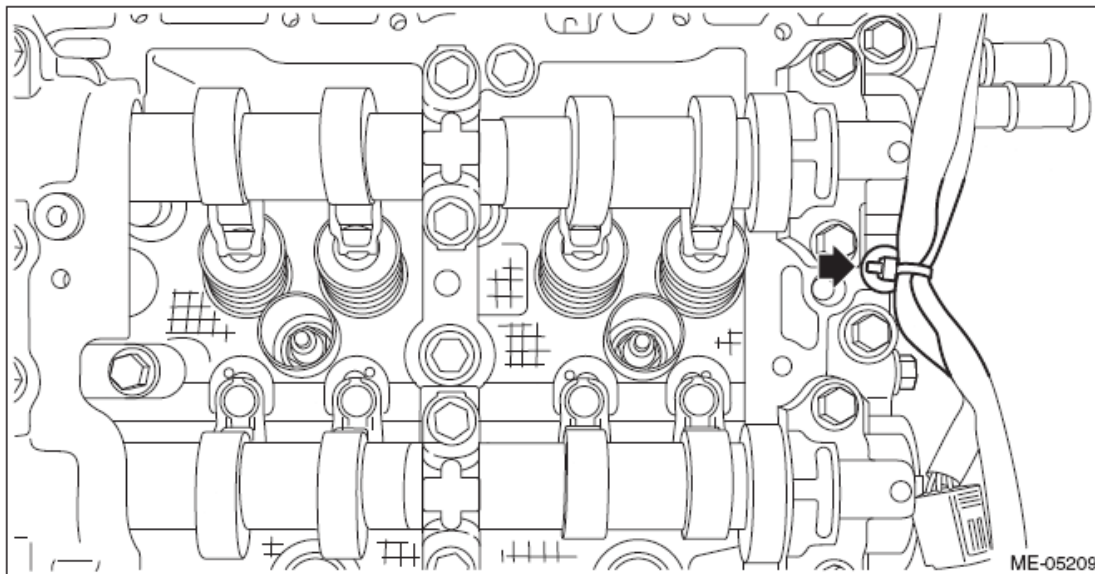
**Fig. 261: Locating Water Pipe Hose Clamp And Bolts**  
Courtesy of SUBARU OF AMERICA, INC.

12. Connect the preheater hose to throttle body and install the preheater hose to intake manifold clip (A).



**Fig. 262: Locating Intake Manifold Preheater Hose Clip**  
 Courtesy of SUBARU OF AMERICA, INC.

13. Secure the engine harness to the cam carrier LH with a clip.



**Fig. 263: Locating Cam Carrier LH Engine Harness Clip**  
 Courtesy of SUBARU OF AMERICA, INC.

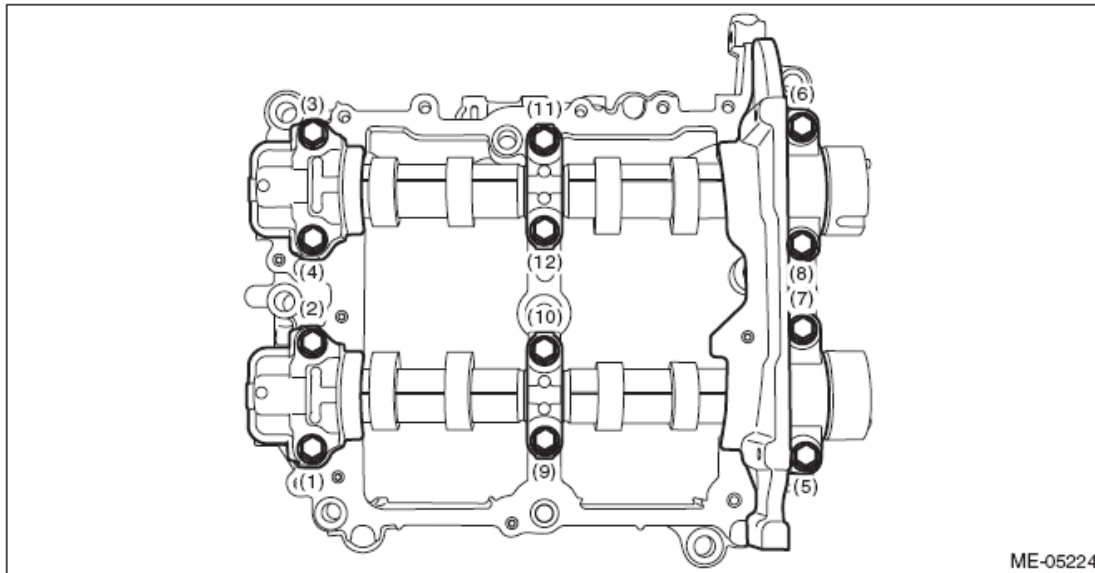
14. Install the rocker cover LH. < Refer to **ROCKER COVER LH**, INSTALLATION, Rocker Cover. >
15. Install the chain cover. < Refer to **INSTALLATION**, Chain Cover. >
16. Install the engine to the vehicle. < Refer to **INSTALLATION**, Engine Assembly. >

## DISASSEMBLY

**CAM CARRIER RH**

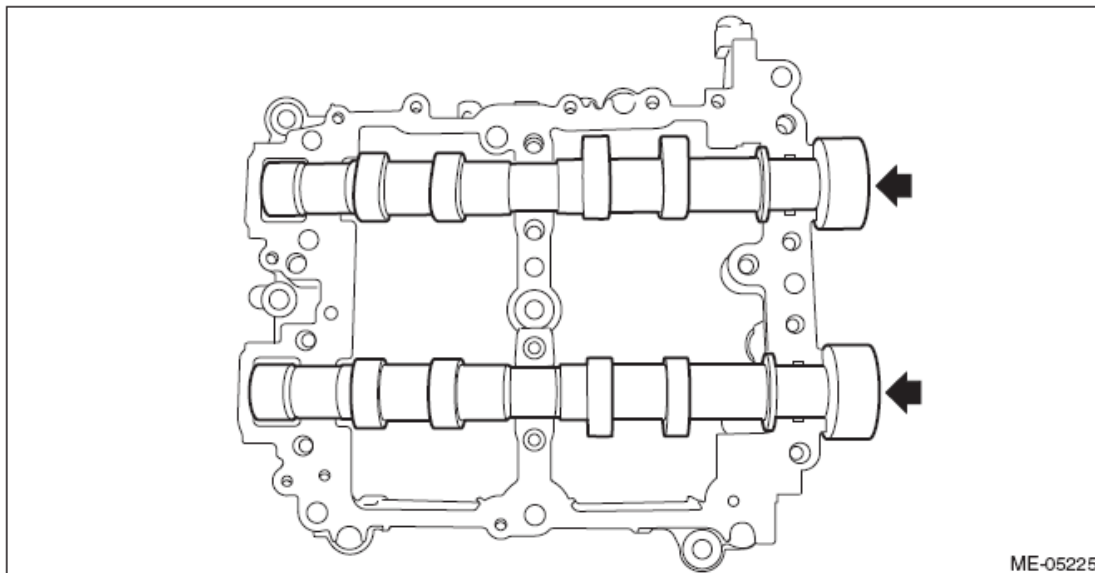
1. Loosen the bolts (front camshaft cap RH, intake center camshaft cap RH, intake rear camshaft cap RH, exhaust center camshaft cap RH, and exhaust rear camshaft cap RH) equally, a little at a time in numerical sequence as shown in the figure, and remove each camshaft cap.

**NOTE:** Arrange camshaft caps in order so that they can be installed in their original positions.



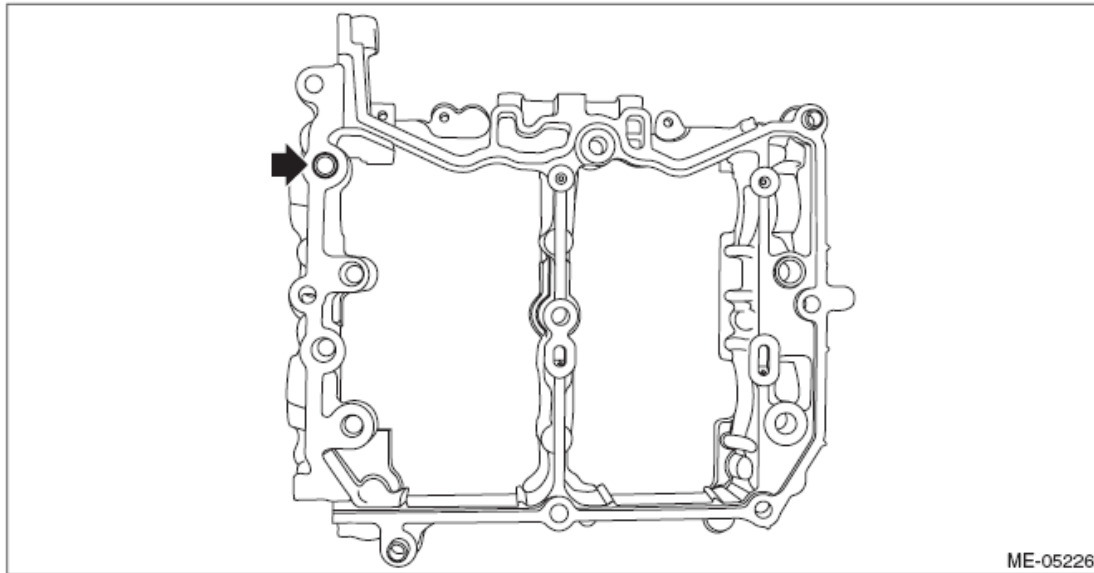
**Fig. 264: Identifying Loosening Sequence Of Cam Carrier RH Mounting Bolts**  
Courtesy of SUBARU OF AMERICA, INC.

2. Remove the intake camshaft RH and the exhaust camshaft RH from cam carrier RH.



**Fig. 265: Locating Intake And Exhaust Camshaft RH**  
Courtesy of SUBARU OF AMERICA, INC.

3. Remove the filter from cam carrier RH.



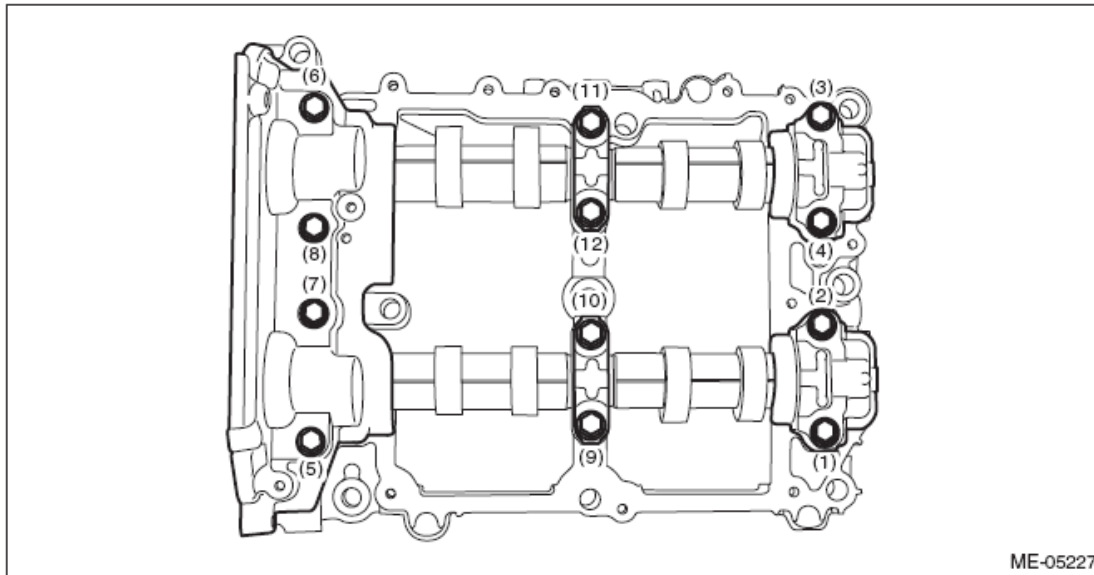
**Fig. 266: Locating Filter From Cam Carrier RH**  
Courtesy of SUBARU OF AMERICA, INC.

4. Remove the liquid gasket from cam carrier RH and front camshaft cap RH, intake rear camshaft cap RH and exhaust rear camshaft cap RH.

#### **CAM CARRIER LH**

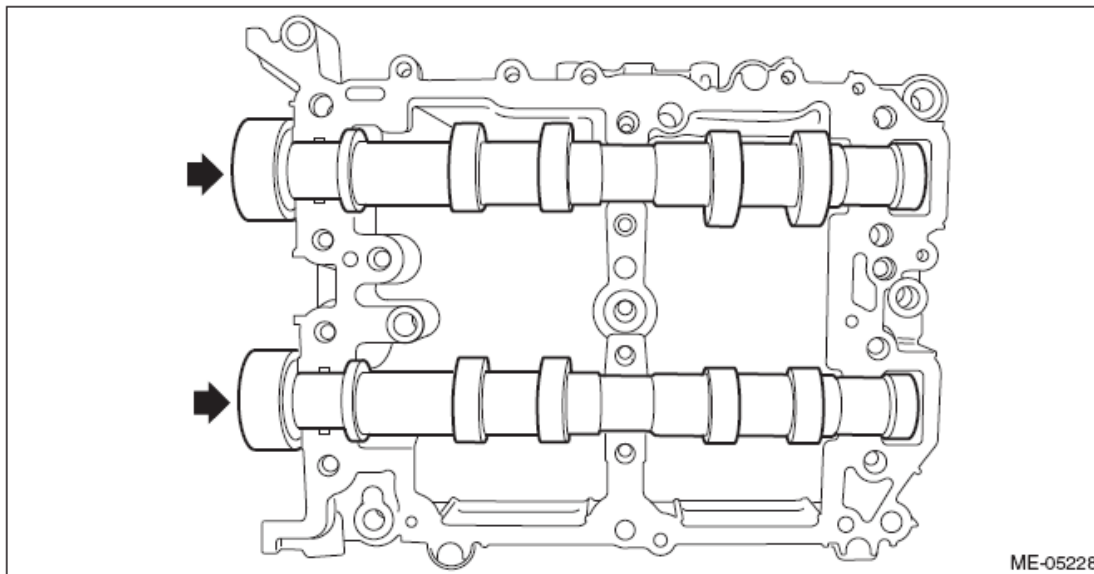
1. Loosen the bolts (front camshaft cap LH, intake center camshaft cap LH, intake rear camshaft cap LH, exhaust center camshaft cap LH and exhaust rear camshaft cap LH) equally, a little at a time in numerical sequence as shown in the figure, and remove each camshaft cap.

**NOTE:**        **Arrange camshaft caps in order so that they can be installed in their original positions.**



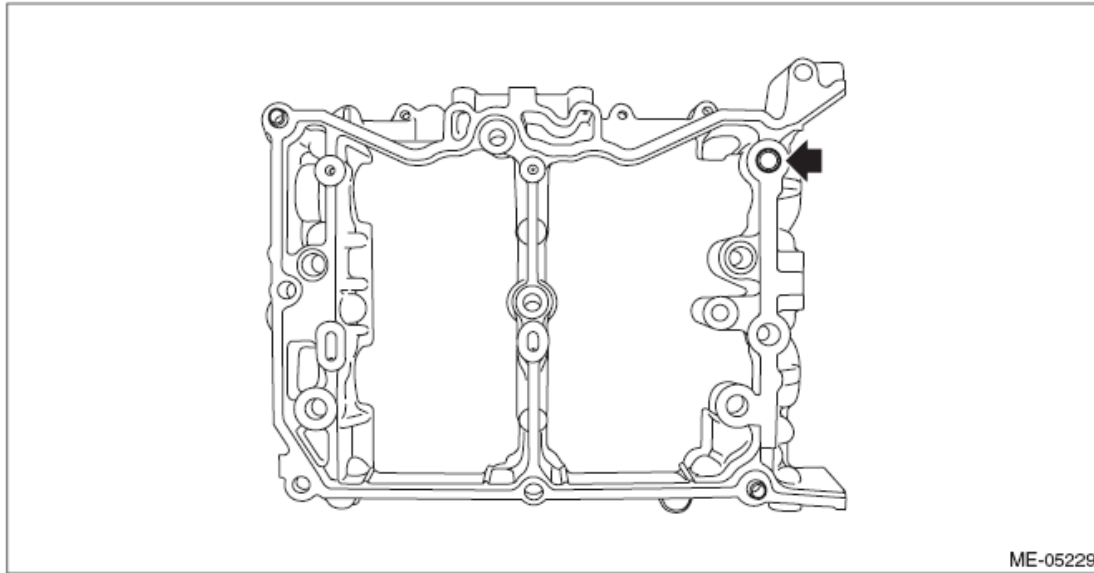
**Fig. 267: Identifying Loosening Sequence Of Cam Carrier LH Mounting Bolts**  
Courtesy of SUBARU OF AMERICA, INC.

2. Remove the intake camshaft LH and the exhaust camshaft LH from cam carrier LH.



**Fig. 268: Locating Intake And Exhaust Camshaft LH**  
Courtesy of SUBARU OF AMERICA, INC.

3. Remove the filter from cam carrier LH.



**Fig. 269: Locating Filter Bolt Of Cam Carrier LH**  
 Courtesy of SUBARU OF AMERICA, INC.

4. Remove the liquid gasket from cam carrier LH and front camshaft cap LH, intake rear camshaft cap LH and exhaust rear camshaft cap LH.

## ASSEMBLY

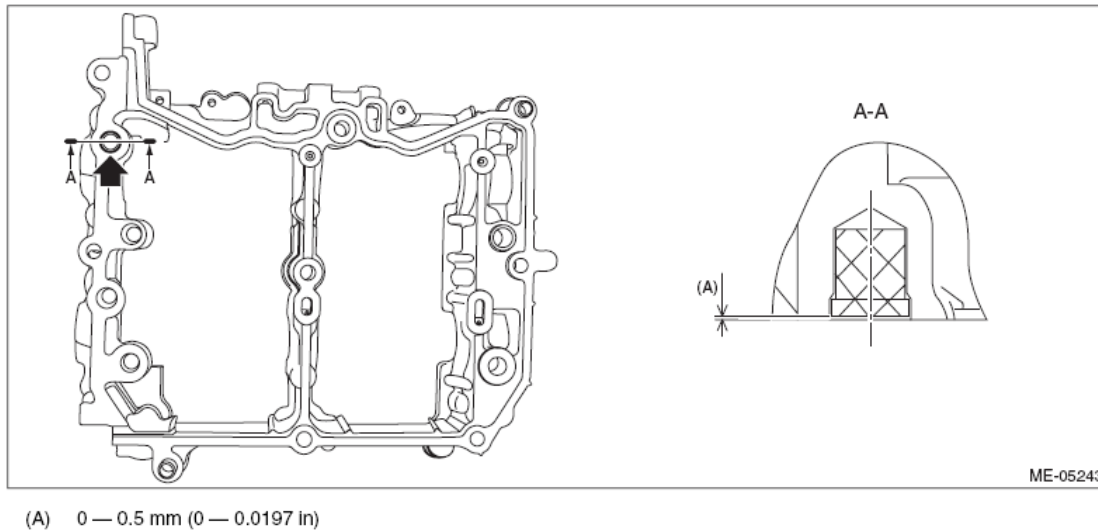
### CAM CARRIER RH

1. Install the filter to the cam carrier RH.

**NOTE:** Use a new filter.

*Filter insert position:*

*Cam carrier RH end face  $0^{+0}_{-0.5} \text{ mm}$  ( $^{+0}_{-0.0197} \text{ in}$ ) position*



**Fig. 270: Locating Filter Installation Position On Cam Carrier RH**  
 Courtesy of SUBARU OF AMERICA, INC.

2. Set the intake camshaft RH and the exhaust camshaft RH to the cam carrier RH.

**NOTE:** Apply engine oil to the journals of cam carrier RH before setting the intake camshaft RH and exhaust camshaft RH.

3. Install the front camshaft cap RH, intake center camshaft cap RH, intake rear camshaft cap RH, exhaust center camshaft cap RH and exhaust rear camshaft cap RH.
  1. Apply liquid gasket to the mating surface of front camshaft cap RH, intake rear camshaft cap RH and exhaust rear camshaft cap RH as shown in the figure.

**CAUTION:**

- Do not apply liquid gasket excessively. Applying excessively may cause excess gasket to flow toward cam journal, resulting in engine seizure.
- Do not apply liquid gasket excessively to the intake center camshaft cap RH and exhaust center camshaft cap RH.

**NOTE:**

- Before applying liquid gasket, degrease the old liquid gasket seal surface of the front camshaft cap RH, intake rear camshaft cap RH, exhaust rear camshaft cap RH, and cam carrier RH.
- Install within 5 min. after applying liquid gasket.

*Liquid gasket:*

*THREE BOND 1217G (Part No. 0877Y0100) or equivalent*

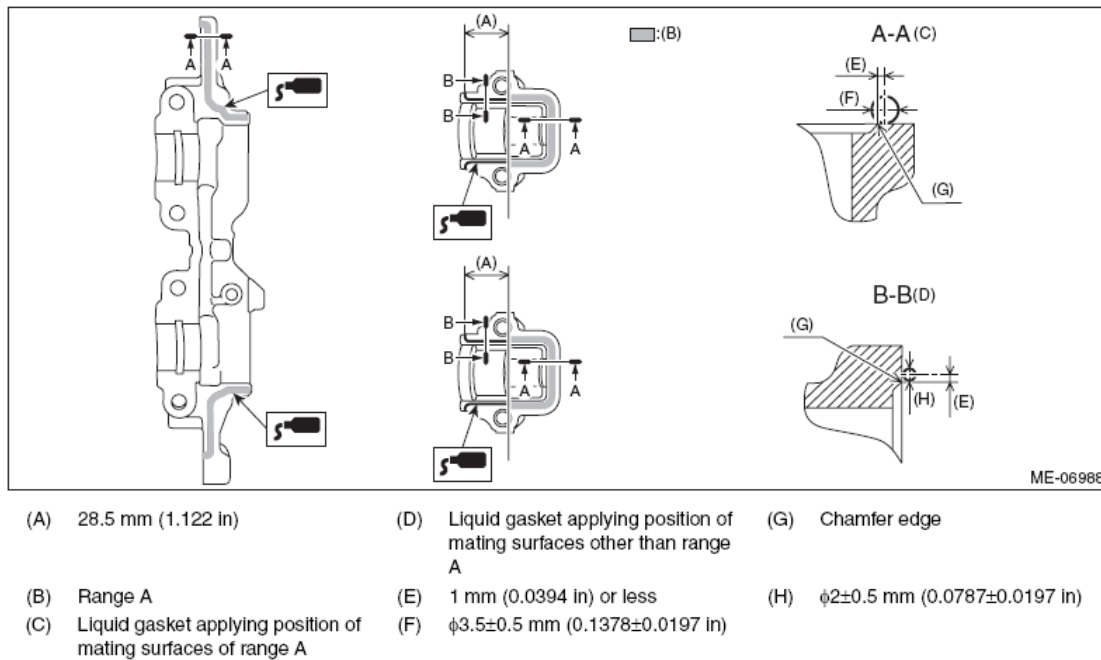
*Liquid gasket applying diameter:*

***Mating surfaces other than range A***

***2±0.5 mm (0.0787±0.0197 in)***

***Mating surfaces of range A***

***3.5±0.5 mm (0.1378±0.0197 in)***



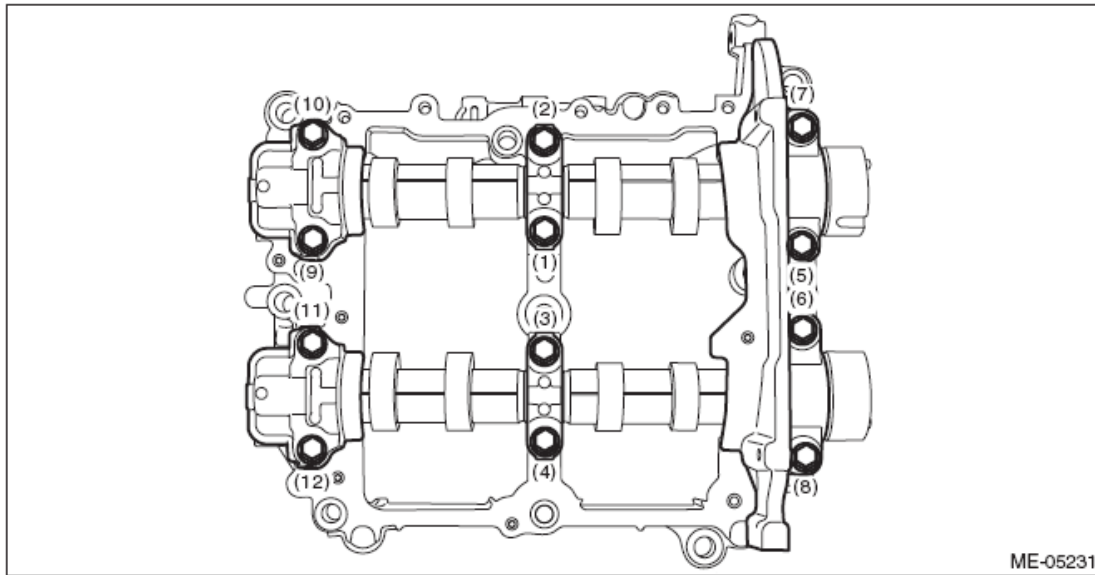
**Fig. 271: Identifying Liquid Gasket Applying Areas On Front Camshaft Cap RH Mating Surface**

**Courtesy of SUBARU OF AMERICA, INC.**

2. Apply engine oil to the journals of each camshaft cap before setting the camshaft cap.
3. Tighten the bolts which secure front camshaft cap RH, intake center camshaft cap RH, intake rear camshaft cap RH, exhaust center camshaft cap RH and exhaust rear camshaft cap RH in numerical order as shown in the figure.

***Tightening torque:***

***18 N.m (1.8 kgf-m, 13.3 ft-lb)***



**Fig. 272: Identifying Tightening Sequence Of Camshaft Cap Mounting Bolts**  
Courtesy of SUBARU OF AMERICA, INC.

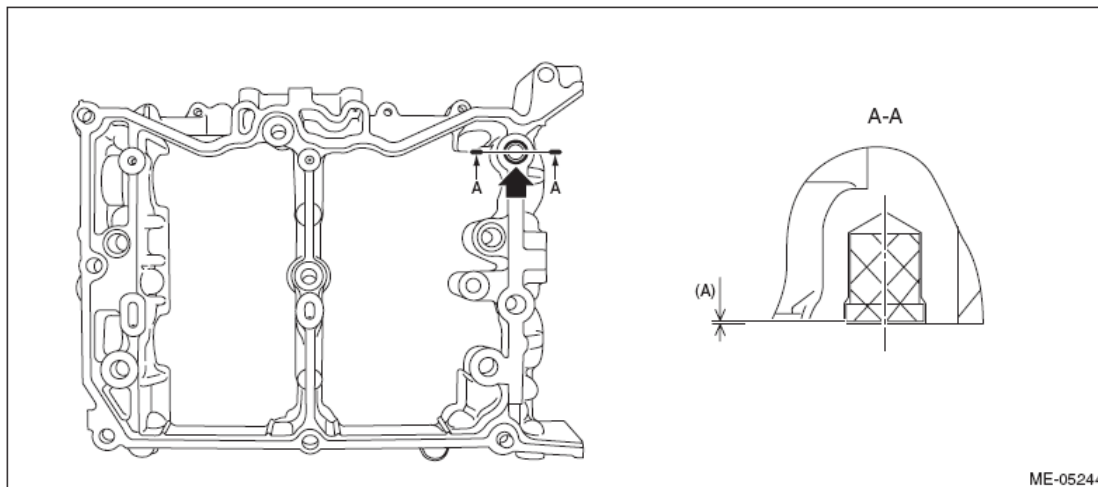
#### CAM CARRIER LH

1. Install the filter to the cam carrier LH.

**NOTE:** Use a new filter.

*Filter insert position:*

*Cam carrier LH end face  $0^{+0}_{-0.5}$  mm ( $^{+0}_{-0.0197}$  in) position*



(A)  $0 - 0.5$  mm ( $0 - 0.0197$  in)

**Fig. 273: Locating Filter Installation Position On Cam Carrier LH**

Courtesy of SUBARU OF AMERICA, INC.

2. Set the intake camshaft LH and the exhaust camshaft LH to the cam carrier LH.

**NOTE:** Apply engine oil to the journals of cam carrier LH before setting the intake camshaft LH and exhaust camshaft LH.

3. Install the front camshaft cap LH, intake center camshaft cap LH, intake rear camshaft cap LH, exhaust center camshaft cap LH and exhaust rear camshaft cap LH.

1. Apply liquid gasket to the mating surface of front camshaft cap LH, intake rear camshaft cap LH and exhaust rear camshaft cap LH as shown in the figure.

**CAUTION:**

- Do not apply liquid gasket excessively. Applying excessively may cause excess gasket to flow toward cam journal, resulting in engine seizure.
- Do not apply liquid gasket excessively to the intake center camshaft cap LH and exhaust center camshaft cap LH.

**NOTE:**

- Before applying liquid gasket, degrease the old liquid gasket seal surface of the front camshaft cap LH, intake rear camshaft cap LH, exhaust rear camshaft cap LH, and cam carrier LH.
- Install within 5 min. after applying liquid gasket.

*Liquid gasket:*

*THREE BOND 1217G (Part No. 0877Y0100) or equivalent*

*Liquid gasket applying diameter:*

*Mating surfaces other than ranges A and B*

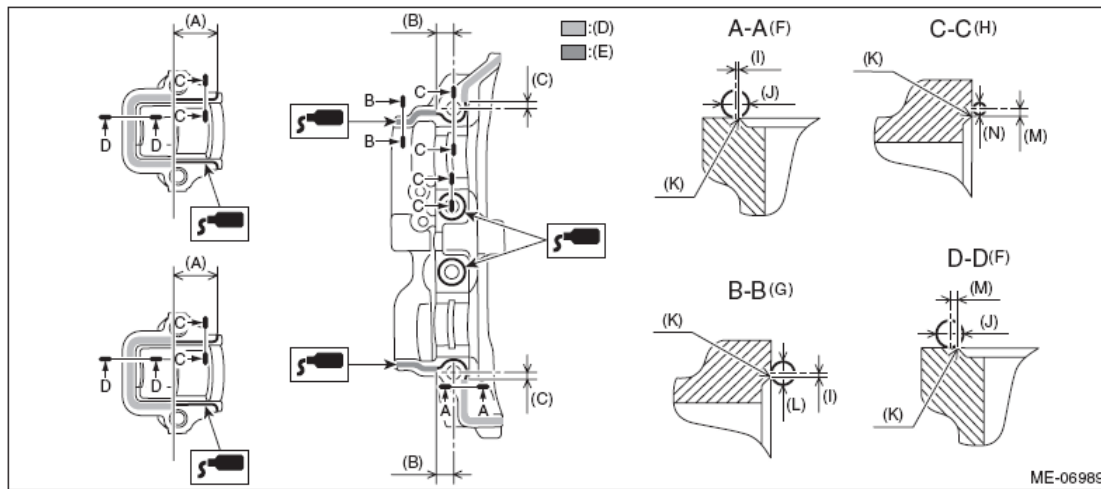
*2±0.5 mm (0.0787±0.0197 in)*

*Mating surfaces of range A*

*3.5±0.5 mm (0.1378±0.0197 in)*

*Mating surfaces of range B*

*3<sup>+0.5</sup><sub>0</sub> mm (0.1181<sup>+0.0197</sup><sub>0</sub> in)*



|                         |                                                                                       |                                                  |
|-------------------------|---------------------------------------------------------------------------------------|--------------------------------------------------|
| (A) 28.5 mm (1.122 in)  | (F) Liquid gasket applying position of mating surfaces of range A                     | (K) Chamfer edge                                 |
| (B) 11.6 mm (0.4567 in) | (G) Liquid gasket applying position of mating surfaces of range B                     | (L) $\phi 3^{+0.5}_0$ mm ( $+0.0197_0$ in)       |
| (C) 5.1 mm (0.2008 in)  | (H) Liquid gasket applying position of mating surfaces other than range A and range B | (M) 1 mm (0.0394 in) or less                     |
| (D) Range A             | (I) 0.5 mm (0.0197 in)                                                                | (N) $\phi 2 \pm 0.5$ mm (0.0787 $\pm$ 0.0197 in) |
| (E) Range B             | (J) $\phi 3.5 \pm 0.5$ mm (0.1378 $\pm$ 0.0197 in)                                    |                                                  |

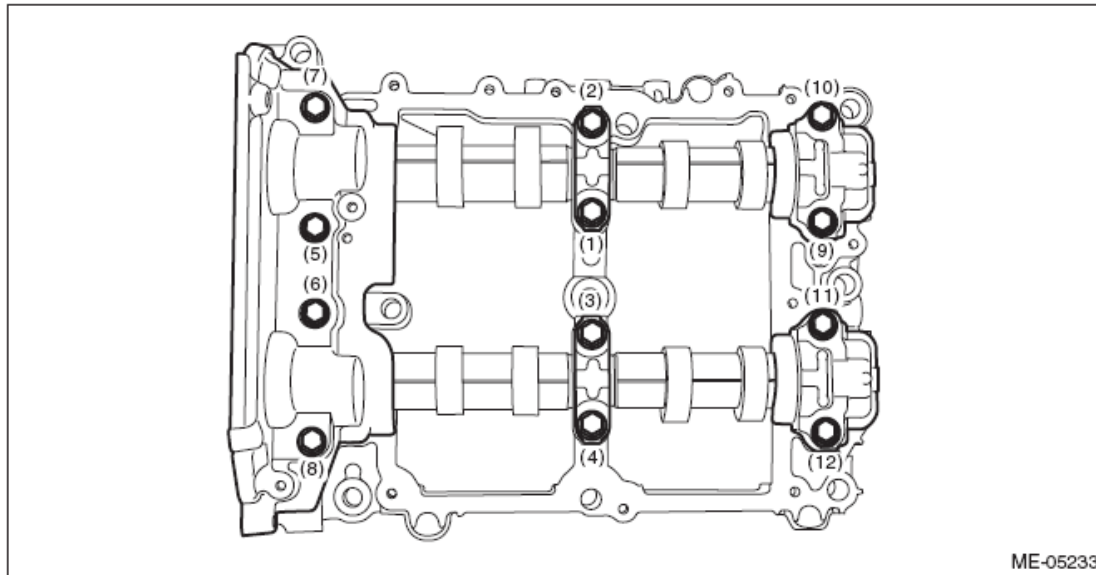
**Fig. 274: Identifying Liquid Gasket Applying Areas On Mating Surface Of Front Camshaft Cap LH**

Courtesy of SUBARU OF AMERICA, INC.

2. Apply engine oil to the journals of each camshaft cap before setting the camshaft cap.
3. Tighten the bolts which secure front camshaft cap LH, intake center camshaft cap LH, intake rear camshaft cap LH, exhaust center camshaft cap LH and exhaust rear camshaft cap LH in numerical order as shown in the figure.

### ***Tightening torque:***

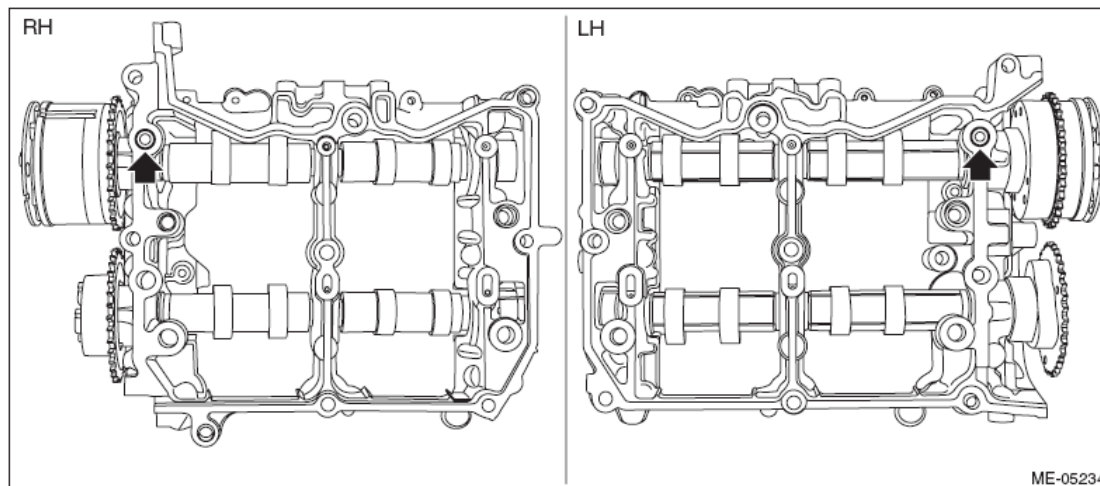
***18 N.m (1.8 kgf-m, 13.3 ft-lb)***



**Fig. 275: Identifying Camshaft Cap LH Bolts Tightening Sequence**  
Courtesy of SUBARU OF AMERICA, INC.

## INSPECTION

1. Visually check the cam carrier filter, and if clogging is found, replace with a new part.



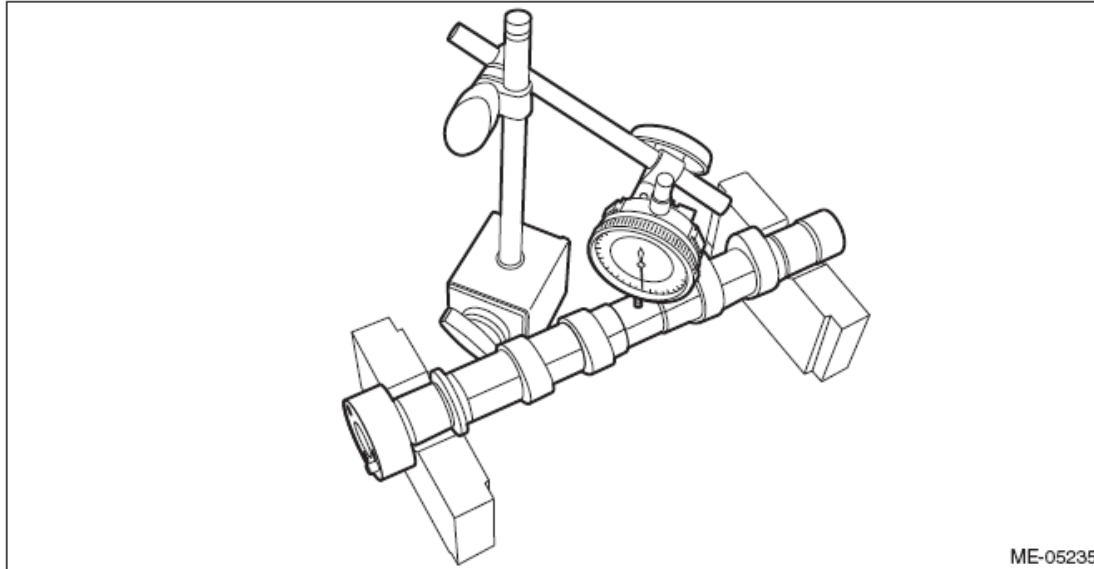
**Fig. 276: Locating Cam Carrier Filter**  
Courtesy of SUBARU OF AMERICA, INC.

2. Check the camshaft journals for damage and wear. Replace the camshaft if faulty.
3. Check the cam face condition of camshaft, and remove the minor faults by grinding with oil stone. Replace the camshaft if uneven wear is found.
4. Using a dial gauge, check the camshaft bend. If it exceeds the limit, replace the camshaft.

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

*Camshaft bend limit:*

*0.020 mm (0.00079 in)*



**Fig. 277: Measuring Camshaft Bend Using Dial Gauge**  
Courtesy of SUBARU OF AMERICA, INC.

5. Check the cam lobe height "H" and cam base circle diameter "A" of camshaft using micrometer. If it is not within the standard, replace the camshaft.

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

*Cam lobe height H:*

*Intake*

*Standard*

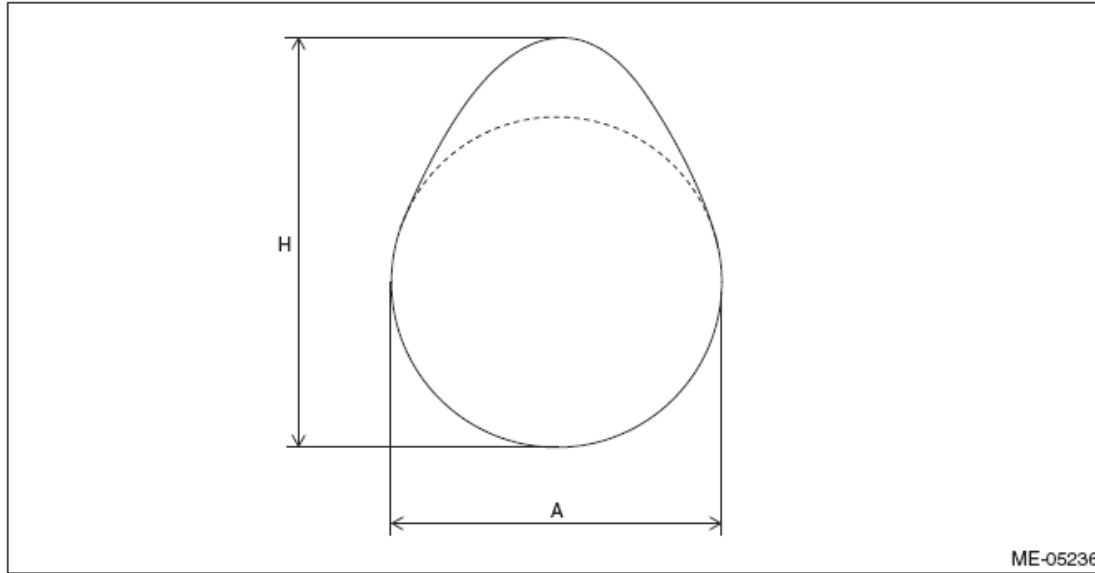
*40.77 - 40.87 mm (1.606 - 1.609 in)*

*Exhaust*

*Standard*

*40.15 - 40.25 mm (1.581 - 1.585 in)*

*Cam base circle diameter A:*

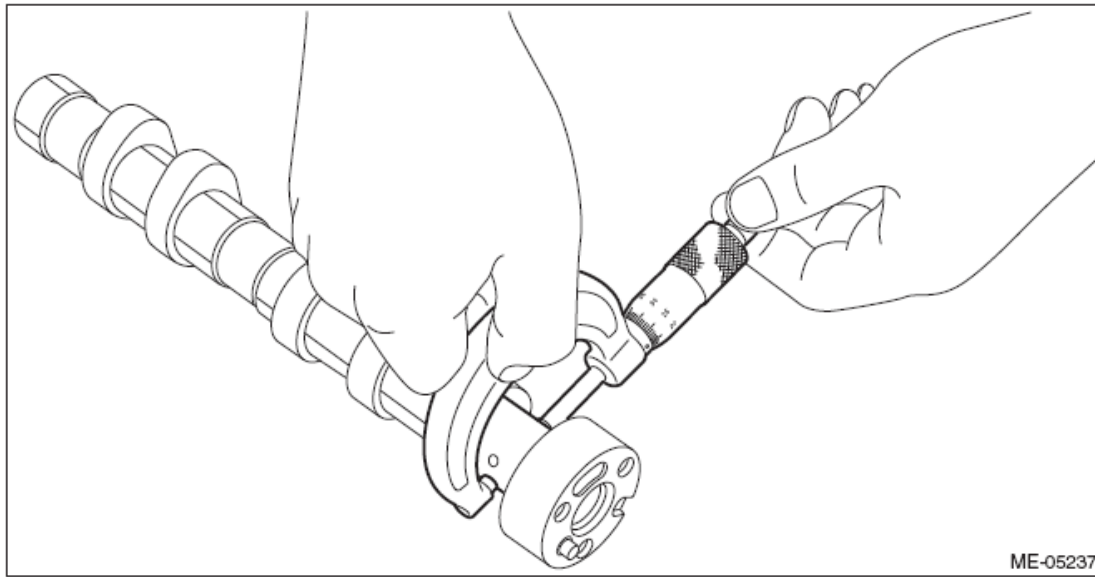
**Standard****34.0 mm (1.339 in)**

**Fig. 278: Identifying Camshaft Cam Lobe Overall Height And Base Circle Diameter**  
Courtesy of SUBARU OF AMERICA, INC.

6. Check the camshaft journal outer diameter using micrometer. If it is not within the standard, check the oil clearance. Refer to step 7) for inspection procedure of oil clearance.

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

**Camshaft journal O.D.:****Standard****25.946 - 25.963 mm (1.0215 - 1.0222 in)**



**Fig. 279: Measuring Camshaft Journal Outer Diameter Using Micrometer**  
Courtesy of SUBARU OF AMERICA, INC.

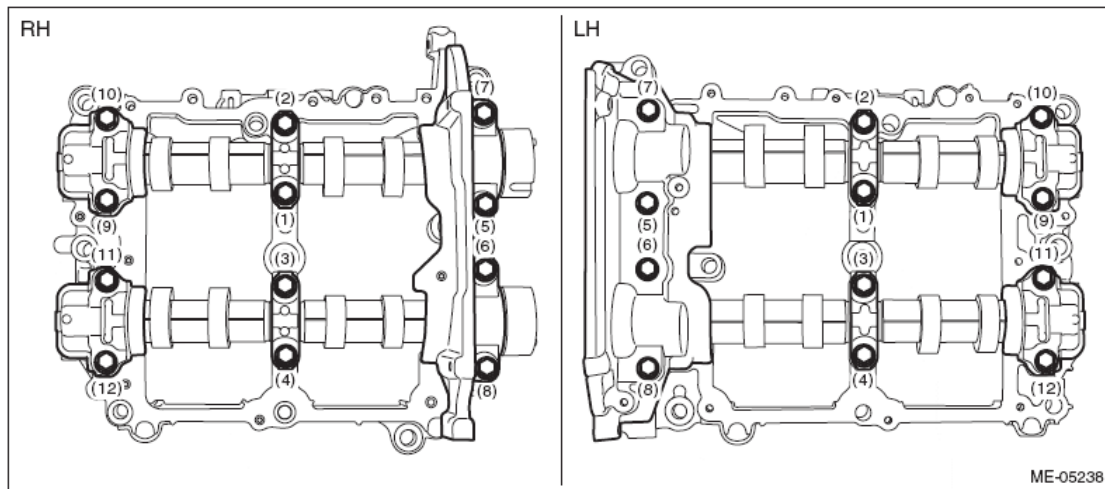
7. Check the oil clearance of camshaft journals using plastigauge.

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

1. Remove the liquid gasket from cam carrier and front camshaft cap, intake rear camshaft cap and exhaust rear camshaft cap.
2. Clean each camshaft cap and cam carrier journals.
3. Set the camshaft to the cam carrier.
4. Place a plastigauge across the camshaft journals of each camshaft and set the camshaft caps.
5. Tighten the bolts which secure front camshaft cap, intake center camshaft cap, intake rear camshaft cap, exhaust center camshaft cap and exhaust rear camshaft cap in numerical order as shown in the figure.

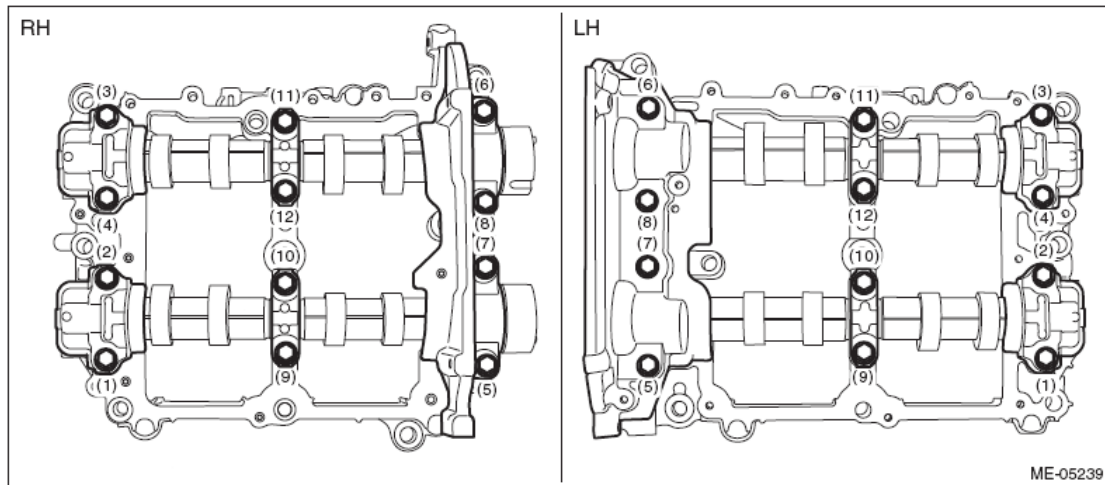
***Tightening torque:***

***18 N.m (1.8 kgf-m, 13.3 ft-lb)***



**Fig. 280: Identifying Camshaft Caps Bolts Tightening Sequence**  
Courtesy of SUBARU OF AMERICA, INC.

6. Loosen the bolts (front camshaft cap, intake center camshaft cap, intake rear camshaft cap, exhaust center camshaft cap and exhaust rear camshaft cap) equally, a little at a time in numerical sequence as shown in the figure, and remove each camshaft cap.



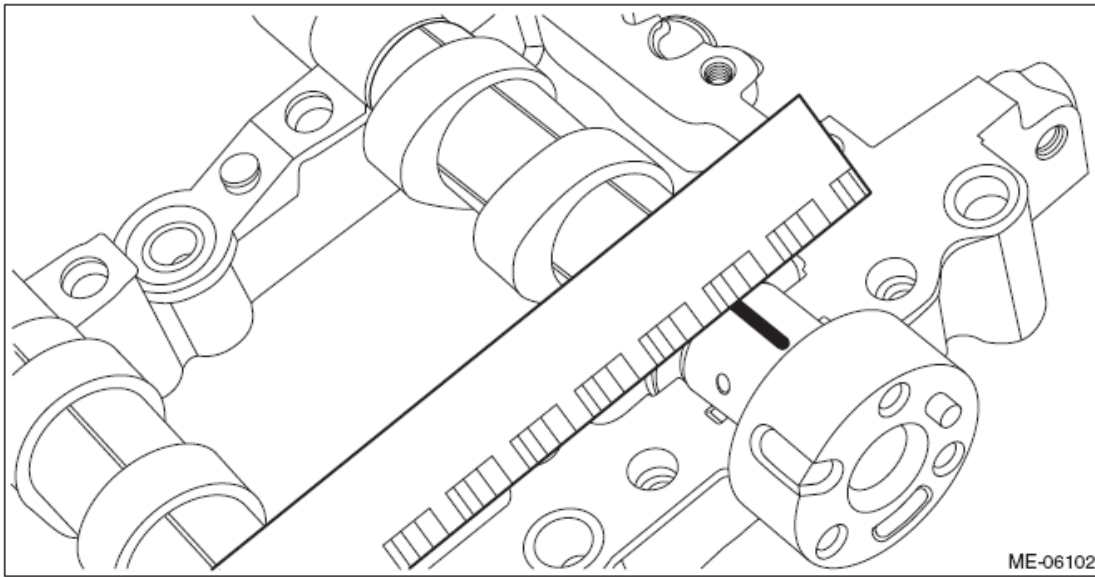
**Fig. 281: Identifying Camshaft Caps Bolts Loosening Sequence**  
Courtesy of SUBARU OF AMERICA, INC.

7. Measure the widest point of the plastigauge on each journal. If it is not within the standard, replace the camshaft. If necessary, replace each camshaft cap and cam carrier as a set.

**Oil clearance of camshaft journals:**

**Standard**

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



**Fig. 282: Measuring Camshaft Oil Clearance Using Plastigauge**  
Courtesy of SUBARU OF AMERICA, INC.

8. Completely remove the plastigauge.
8. Using a dial gauge, check the thrust clearance. If it is not within the standard or if uneven wear is found, replace each camshaft cap and cam carrier as a set. If necessary replace the camshaft.

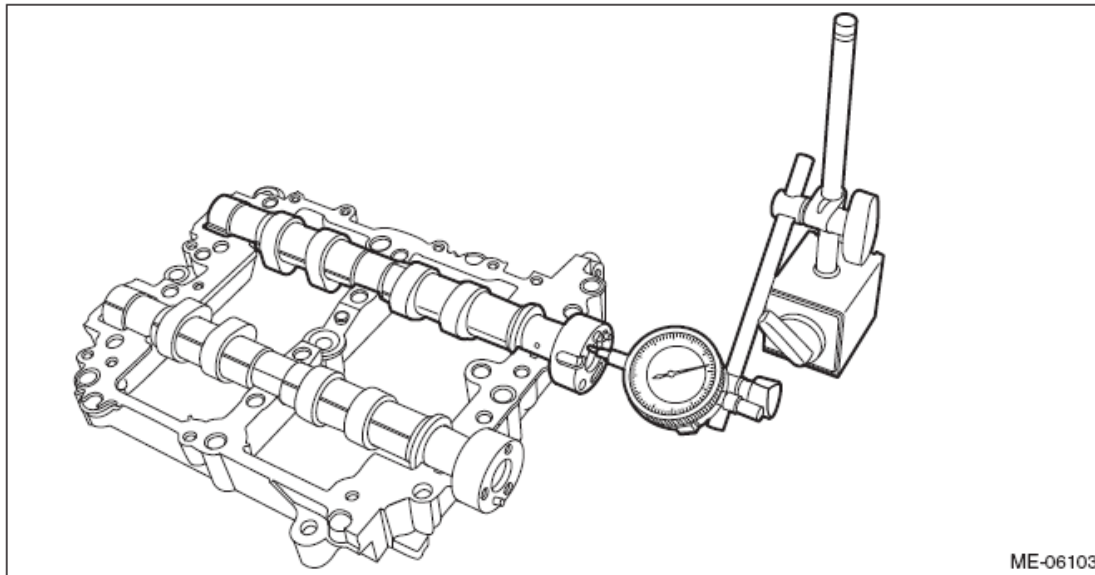
**NOTE:**

- **Measurement should be performed at a temperature of 20°C (68°F).**
- **Set the dial gauge at end surface of camshaft.**

*Camshaft thrust clearance:*

*Standard*

*0.068 - 0.116 mm (0.0027 - 0.0047 in)*



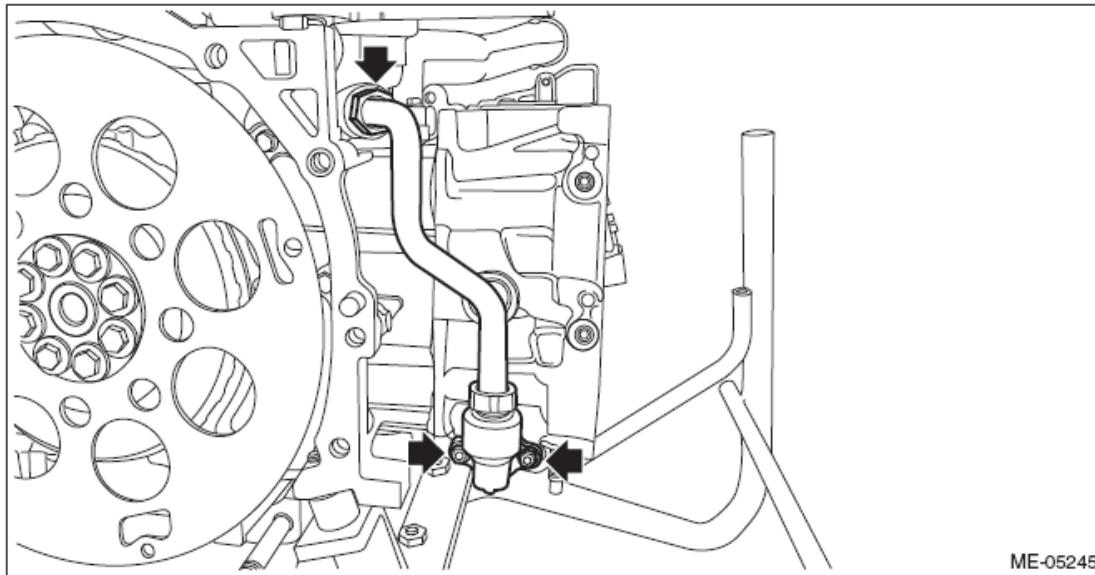
**Fig. 283: Measuring Camshaft Thrust Clearance Using Dial Gauge**  
Courtesy of SUBARU OF AMERICA, INC.

## CYLINDER HEAD

### REMOVAL

#### CYLINDER HEAD RH

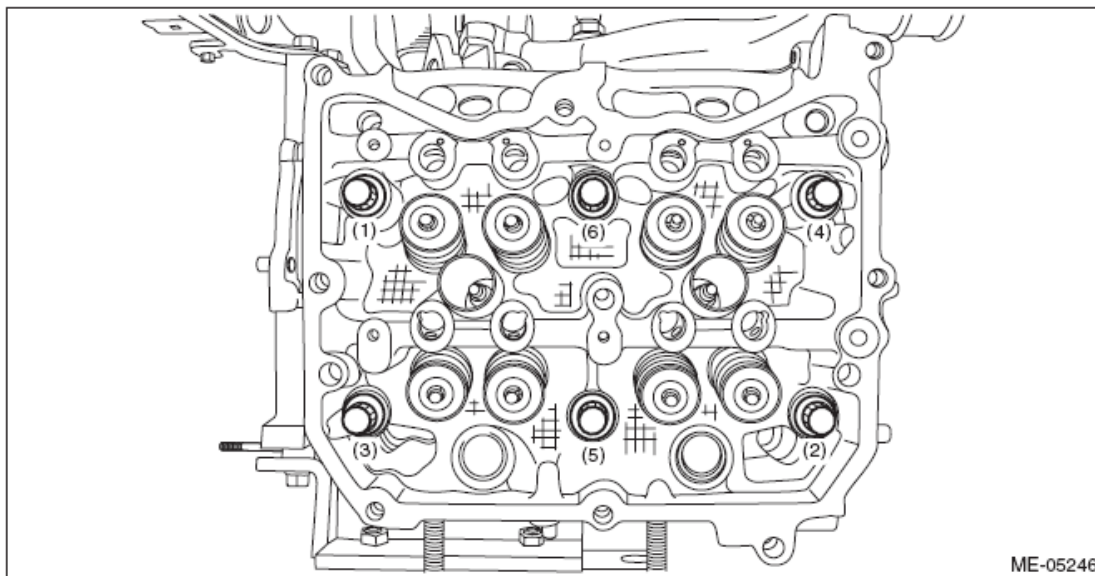
1. Remove the engine from the vehicle. < Refer to **REMOVAL**, Engine Assembly. >
2. Remove the intake manifold. < Refer to **REMOVAL**, Intake Manifold. >
3. Remove the tumble generator valve assembly RH. < Refer to **REMOVAL**, Tumble Generator Valve Assembly. >
4. Remove the chain cover. < Refer to **REMOVAL**, Chain Cover. >
5. Remove the rocker cover RH. < Refer to **ROCKER COVER RH**, REMOVAL, Rocker Cover. >
6. Remove the cam carrier RH. < Refer to **CAM CARRIER RH**, REMOVAL, Cam Carrier. >
7. Remove the EGR pipe assembly from the water pipe assembly and the cylinder block RH.



**Fig. 284: Locating EGR Pipe Assembly With Bolts**  
Courtesy of SUBARU OF AMERICA, INC.

8. Loosen the bolts holding the cylinder head RH equally, a little at a time in numerical sequence as shown in the figure, and while leaving the cylinder head bolts (1) and (4) engaged by three or four threads, remove the other cylinder head bolts.

**NOTE:** Leaving the cylinder head bolts (1) and (4) engaged by three or four threads prevents the cylinder head RH from falling.



**Fig. 285: Identifying Loosening Sequence Of Cylinder Head RH Mounting Bolts**  
Courtesy of SUBARU OF AMERICA, INC.

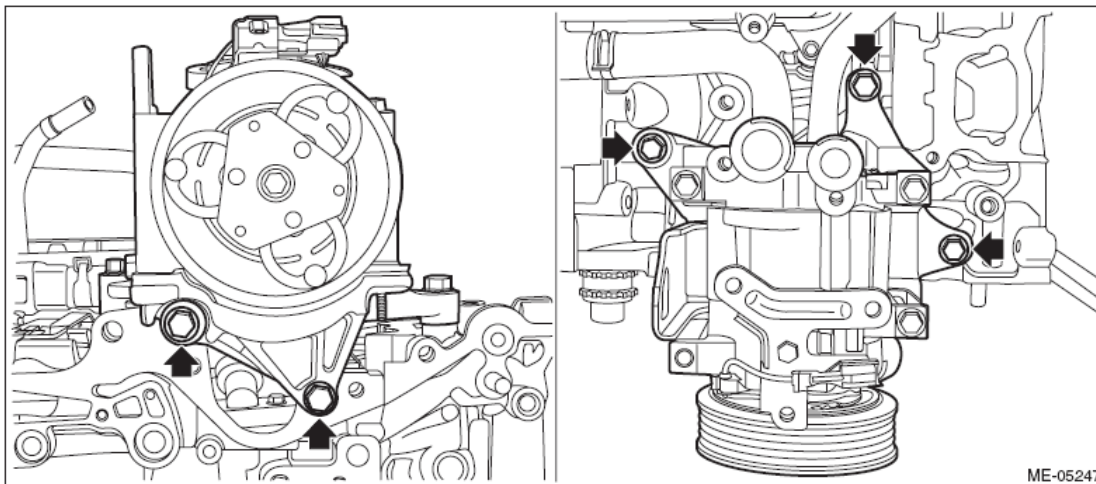
9. While tapping the cylinder head RH with a plastic hammer, separate it from cylinder block RH.
10. Remove the bolts (1) and (4) to remove cylinder head RH.
11. Remove the cylinder head gasket RH.

**CAUTION: Be careful not to scratch the mating surface of cylinder head and cylinder block.**

12. Remove the liquid gasket from cylinder head RH and cam carrier RH.

#### CYLINDER HEAD LH

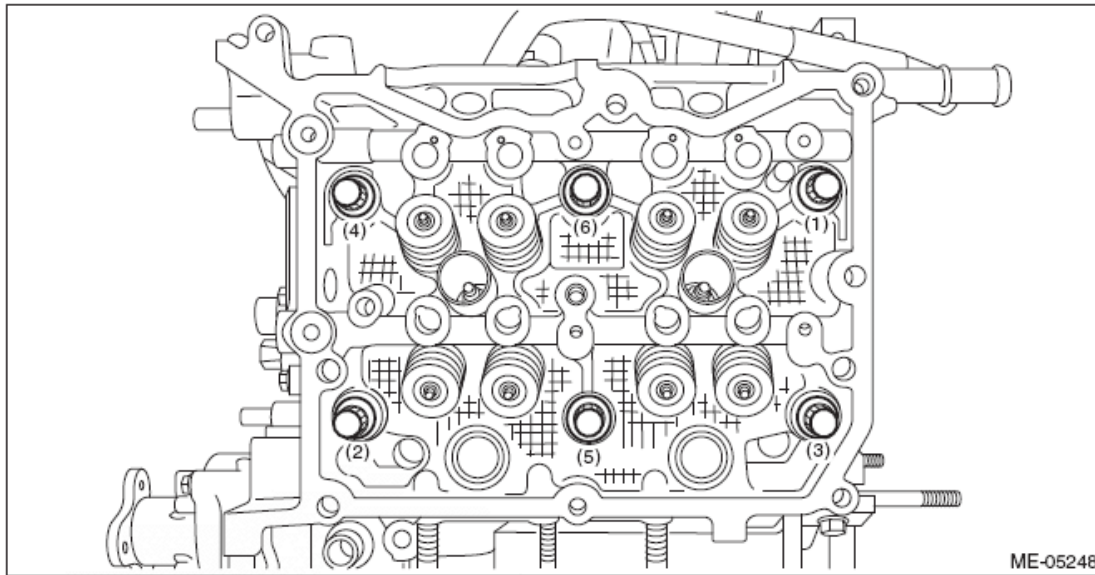
1. Remove the engine from the vehicle. < Refer to **REMOVAL**, Engine Assembly. >
2. Remove the intake manifold. < Refer to **REMOVAL**, Intake Manifold. >
3. Remove the tumble generator valve assembly LH. < Refer to **REMOVAL**, Tumble Generator Valve Assembly. >
4. Remove the chain cover. < Refer to **REMOVAL**, Chain Cover. >
5. Remove the rocker cover LH. < Refer to **ROCKER COVER LH**, REMOVAL, Rocker Cover. >
6. Remove the cam carrier LH. < Refer to **CAM CARRIER LH**, REMOVAL, Cam Carrier. >
7. Remove the bolt securing the A/C compressor bracket to the cylinder head LH, and remove the A/C compressor bracket.



**Fig. 286: Locating A/C Compressor Bracket To Cylinder Head LH Mounting Bolts**  
**Courtesy of SUBARU OF AMERICA, INC.**

8. Loosen the bolts holding the cylinder head LH equally, a little at a time in numerical sequence as shown in the figure, and while leaving the cylinder head bolts (1) and (4) engaged by three or four threads, remove the other cylinder head bolts.

**NOTE: Leaving the cylinder head bolts (1) and (4) engaged by three or four threads prevents the cylinder head LH from falling.**



**Fig. 287: Identifying Loosening Sequence Of Cylinder Head Mounting Bolts**  
 Courtesy of SUBARU OF AMERICA, INC.

9. While tapping the cylinder head LH with a plastic hammer, separate it from cylinder block LH.
10. Remove the cylinder head bolts (1) and (4) to remove cylinder head LH.
11. Remove the cylinder head gasket LH.

**CAUTION: Be careful not to scratch the mating surface of cylinder head and cylinder block.**

12. Remove the liquid gasket from cylinder head LH and cam carrier LH.

## INSTALLATION

### CYLINDER HEAD RH

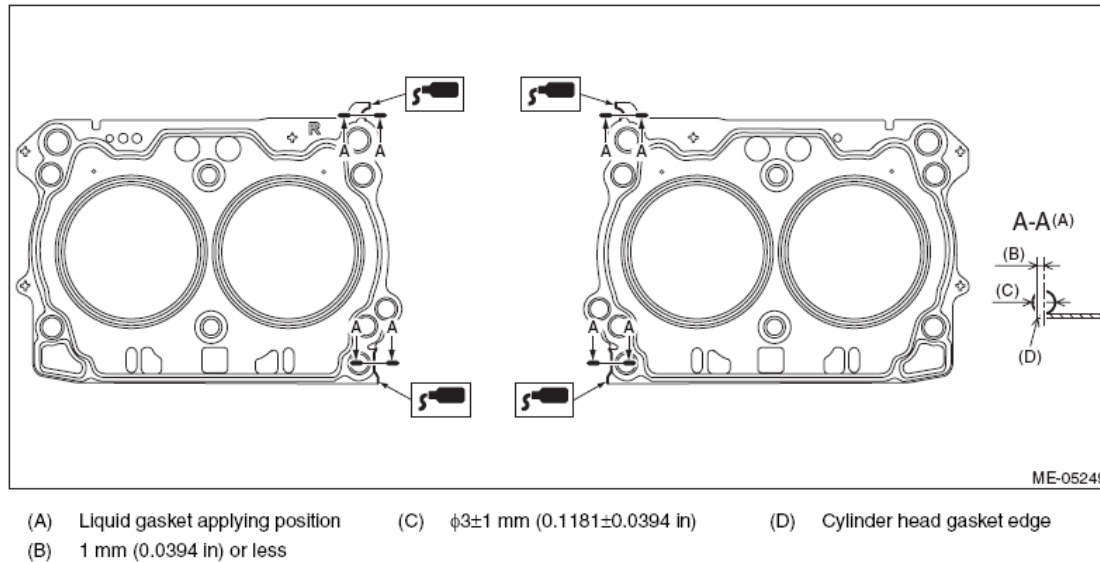
1. Clean the bolt holes in the cylinder block RH.

**CAUTION: To avoid erroneous tightening of the bolts, clean out the bolt holes sufficiently by blowing with compressed air to eliminate engine coolant etc.**

2. Apply liquid gasket to both sides of the cylinder head gasket RH as shown in the figure.

#### NOTE:

- Use a new cylinder head gasket RH.
- Before applying liquid gasket, degrease the mating surface of cylinder blocks RH and cylinder head RH.
- Install within 5 min. after applying liquid gasket.

**Liquid gasket:****THREE BOND 1217G (Part No. 0877Y0100) or equivalent****Liquid gasket applying diameter:** **$3\pm1$  mm ( $0.1181\pm0.0394$  in)**

**Fig. 288: Identifying Liquid Gasket Applying Area On Both Sides Of Cylinder Head Gasket RH**  
 Courtesy of SUBARU OF AMERICA, INC.

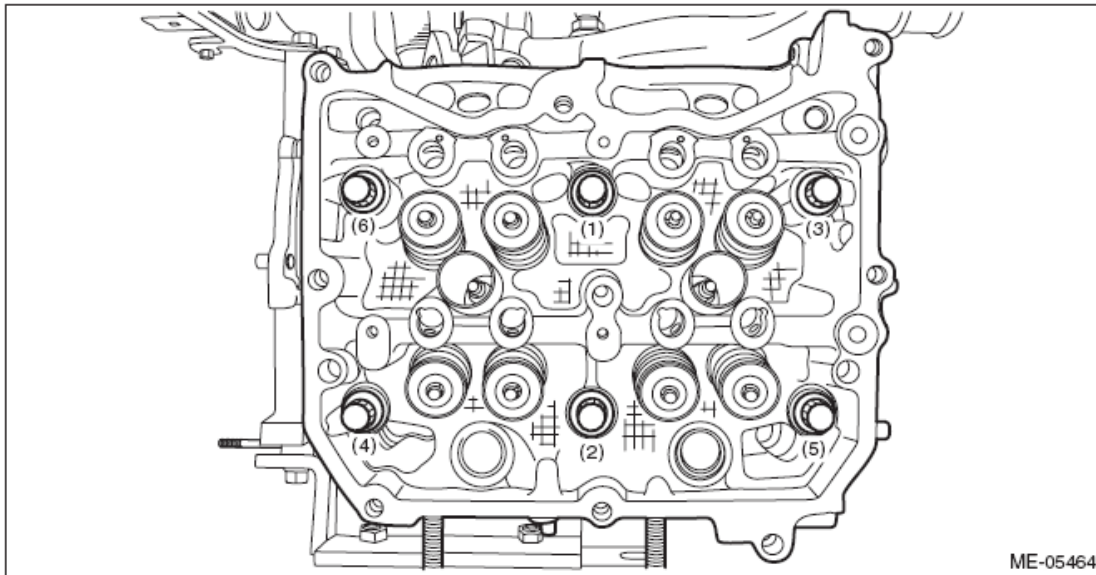
3. Attach the cylinder head gasket RH.

**NOTE:** Check that liquid gasket RH is squeezed out from the cylinder head gasket.

4. Install the cylinder head RH to the cylinder block RH.

**CAUTION:** Be careful not to scratch the mating surface of cylinder head RH and cylinder block RH.

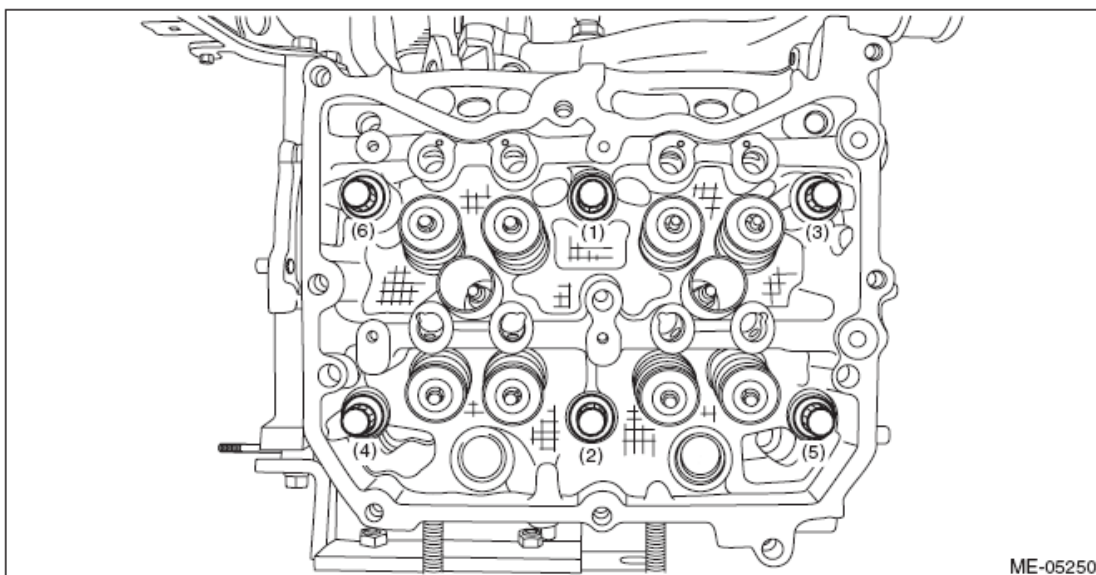
1. Clean the cylinder head bolt threads and apply sufficient engine oil to the washer and cylinder head bolts threads.
2. Mount the cylinder head RH onto the cylinder block RH, and tighten all bolts with a torque of 29 N.m (3.0 kgf-m, 21.4 ft-lb) in numerical order as shown in the figure.



**Fig. 289: Identifying Tightening Sequence Of Cylinder Head RH Bolts**  
Courtesy of SUBARU OF AMERICA, INC.

3. Tighten all cylinder head bolts further with a torque of 100 N.m (10.2 kgf-m, 73.8 ft-lb) in numerical order as shown in the figure.

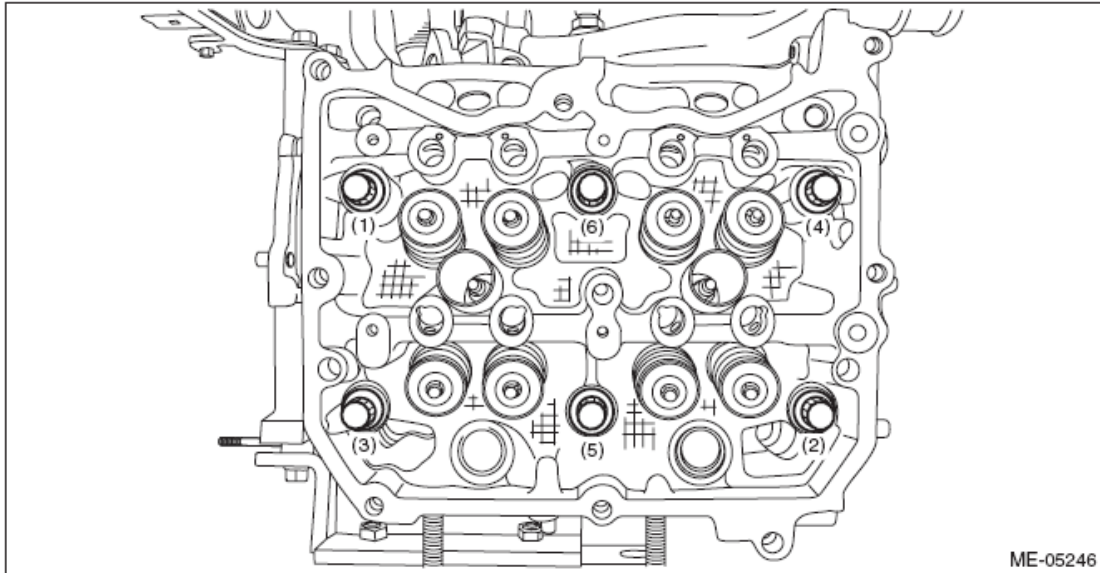
**CAUTION:** If the bolt makes stick-slip sound during tightening, repeat the procedure from step 1). In that case, the cylinder head gasket RH can be reused. But it is necessary to remove liquid gasket completely from cylinder block RH, cylinder head RH and cylinder head gasket RH and re-apply to them.



**Fig. 290: Identifying Tightening Sequence Of Cylinder Head Bolts**

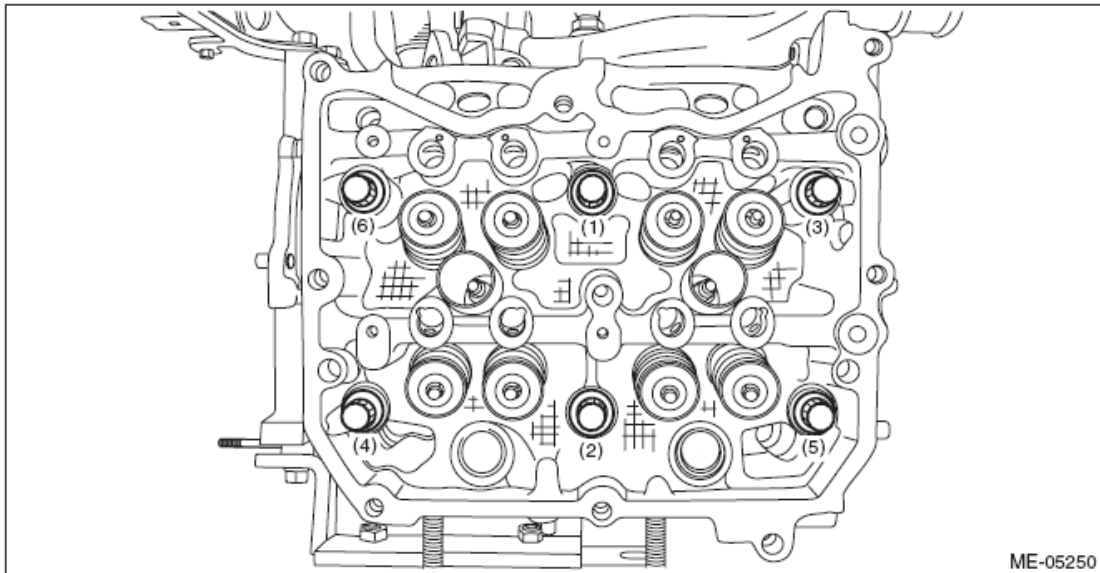
Courtesy of SUBARU OF AMERICA, INC.

4. Loosen all cylinder head bolts 180° in numerical order as shown in the figure, and then loosen all cylinder head bolts 180° further in numerical order as shown in the figure.



**Fig. 291: Identifying Loosening Sequence Of Cylinder Head RH Bolts**  
Courtesy of SUBARU OF AMERICA, INC.

5. Tighten all cylinder head bolts with a torque of 42 N.m (4.3 kgf-m, 31.0 ft-lb) in numerical order as shown in the figure.



**Fig. 292: Identifying Tightening Sequence Of Cylinder Head Mounting Bolts**  
Courtesy of SUBARU OF AMERICA, INC.

6. Using ST2, tighten all cylinder head bolts with specified angle in numerical order as shown in the figure.

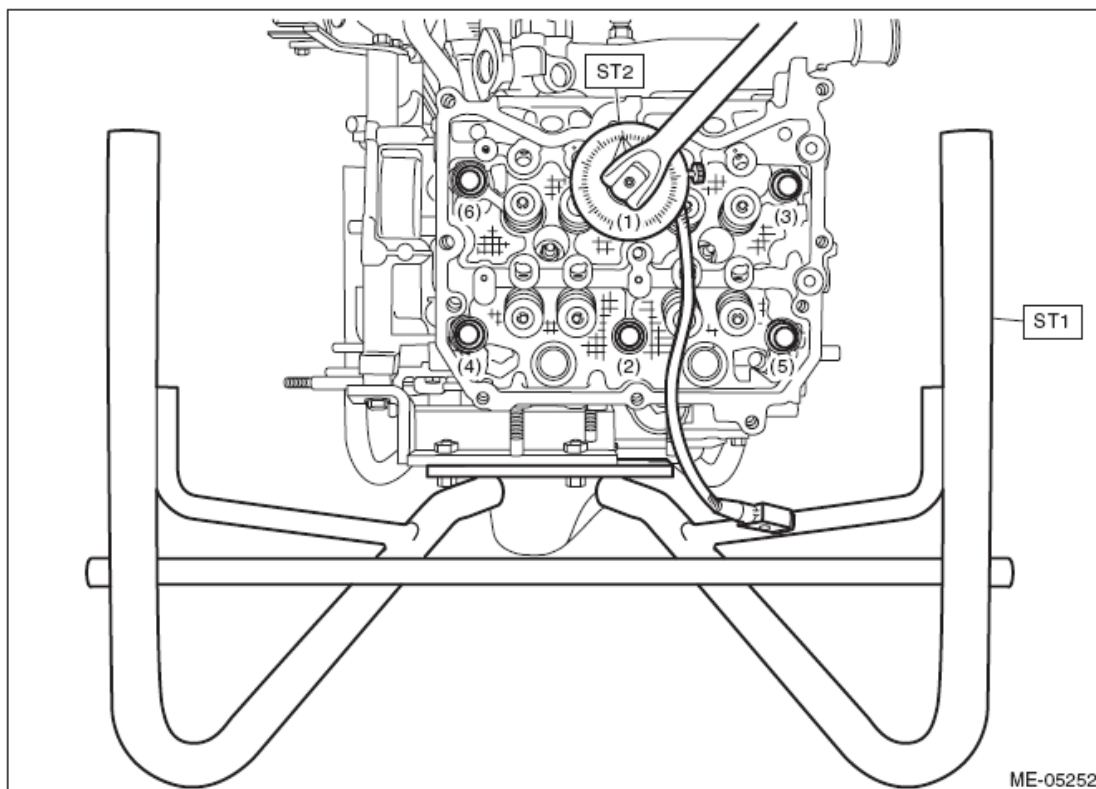
**NOTE:** Attach the magnet used for securing the ST2 (ANGLE GAUGE) to ST1.

ST1 499817100 ENGINE STAND

ST2 18854AA000 ANGLE GAUGE

***Tightening angle:***

***80°±2°***



**Fig. 293: Tightening Cylinder Head Bolts Using Angle Gauge**  
Courtesy of SUBARU OF AMERICA, INC.

7. Using ST2, tighten the cylinder head bolts (2 places) with specified angle in numerical order as shown in the figure.

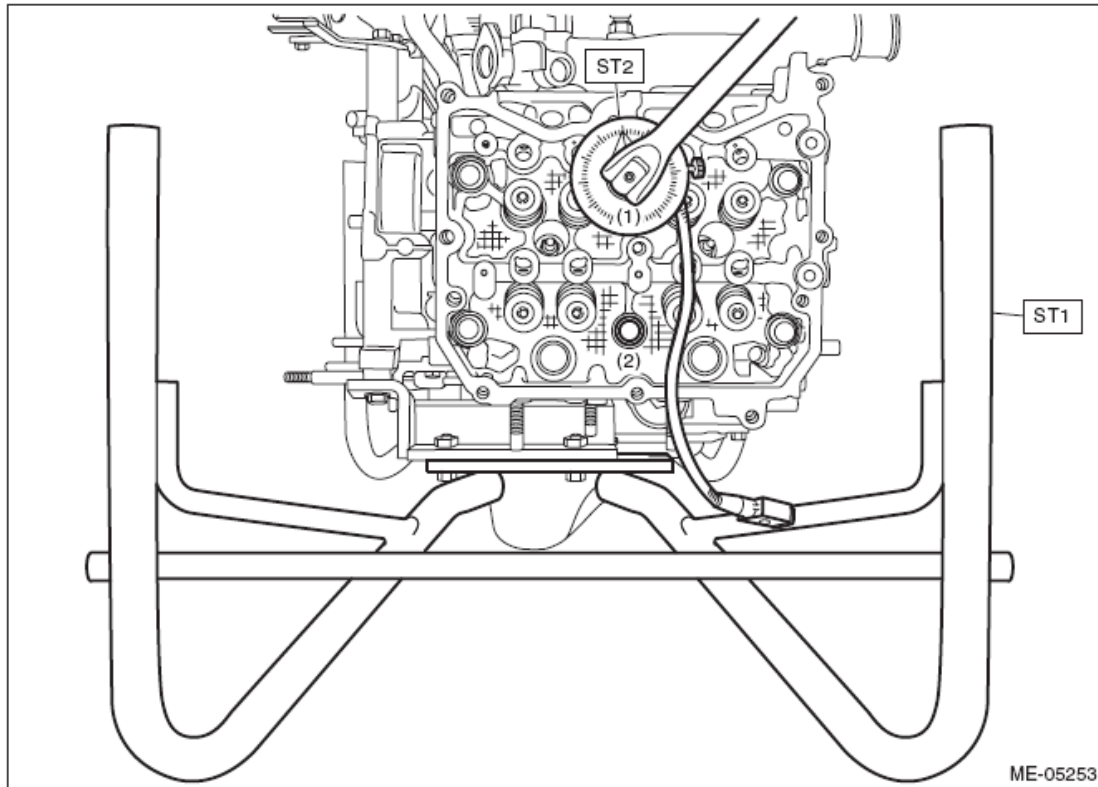
**NOTE:** Attach the magnet used for securing the ST2 (ANGLE GAUGE) to ST1.

ST1 499817100 ENGINE STAND

ST2 18854AA000 ANGLE GAUGE

***Tightening angle:***

$75^{\circ} \pm 2^{\circ}$



**Fig. 294: Tightening Cylinder Head Bolts Using Angle Gauge**  
Courtesy of SUBARU OF AMERICA, INC.

8. Using ST2, tighten the cylinder head bolts (4 places) with specified angle in numerical order as shown in the figure.

**NOTE:**

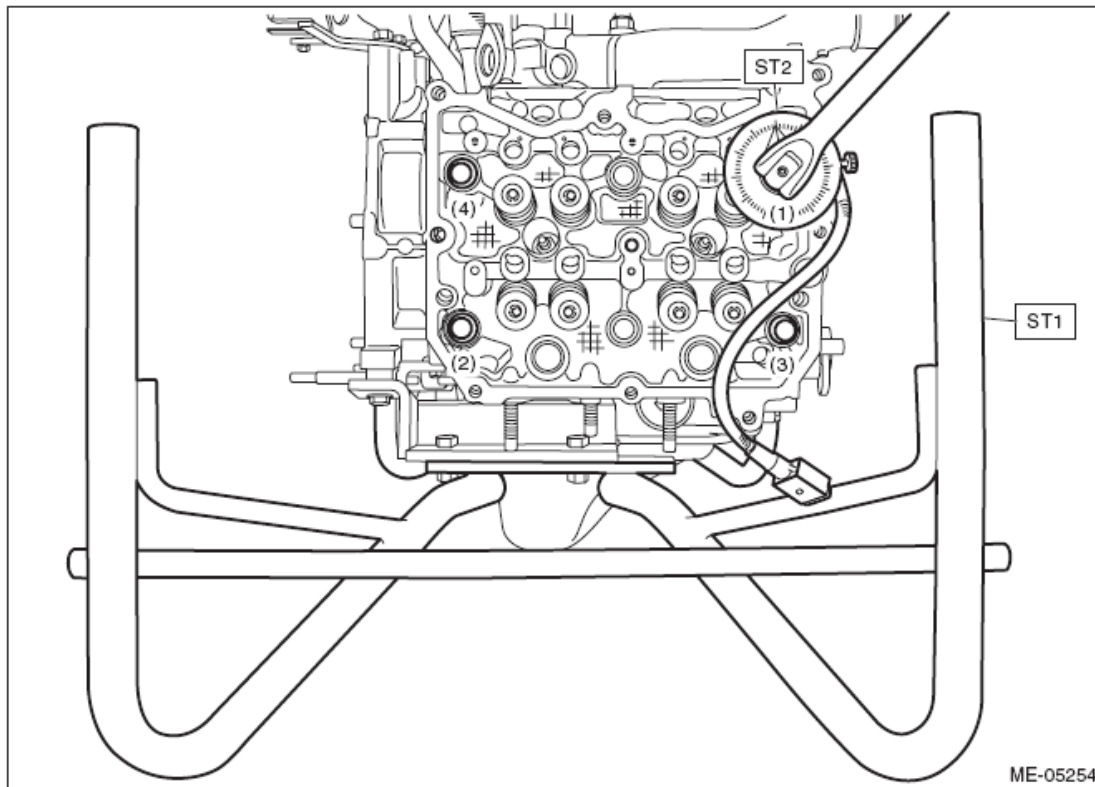
- After tightening, if the liquid gasket is squeezed out onto the seal surface of the chain cover, completely remove any squeezed-out liquid gasket.
- Attach the magnet used for securing the ST2 (ANGLE GAUGE) to ST1.

ST1 499817100 ENGINE STAND

ST2 18854AA000 ANGLE GAUGE

***Tightening angle:***

$30^{\circ} \pm 2^{\circ}$



**Fig. 295: Tightening Cylinder Head Bolts Using Angle Gauge**  
Courtesy of SUBARU OF AMERICA, INC.

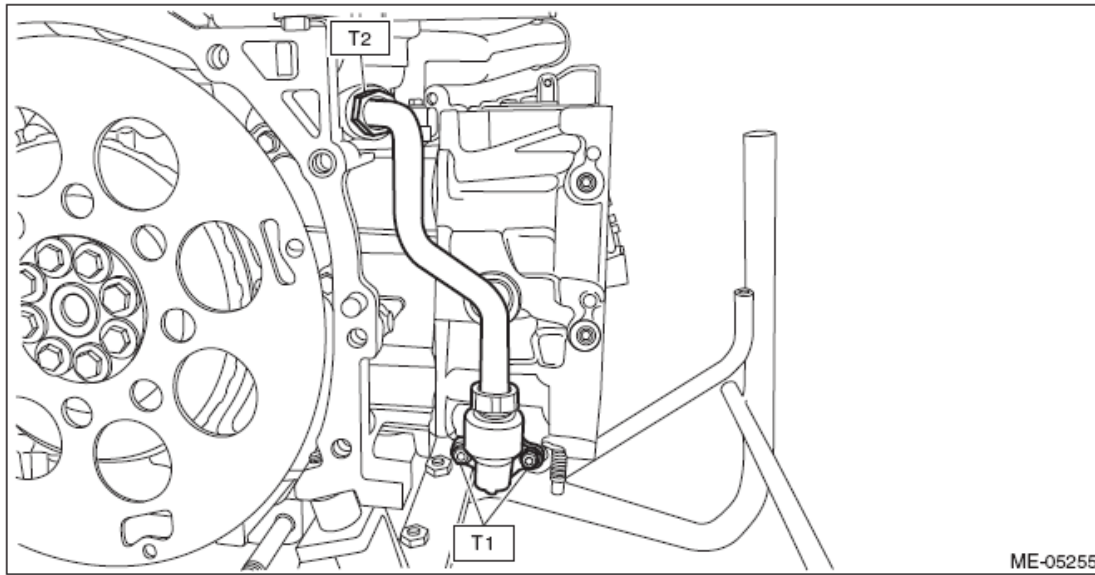
5. Install the EGR pipe assembly to the water pipe assembly and the cylinder block RH.

**NOTE:** Use a new gasket.

*Tightening torque:*

**T1: 6.4 N.m (0.7 kgf-m, 4.7 ft-lb)**

**T2: 51 N.m (5.2 kgf-m, 37.6 ft-lb)**



**Fig. 296: Locating EGR Pipe Assembly Mounting Bolts With Torque Specifications**  
 Courtesy of SUBARU OF AMERICA, INC.

6. Install the cam carrier RH. < Refer to **CAM CARRIER RH**, INSTALLATION, Cam Carrier. >
7. Install the rocker cover RH. < Refer to **ROCKER COVER RH**, INSTALLATION, Rocker Cover. >
8. Install the chain cover. < Refer to **INSTALLATION**, Chain Cover. >
9. Install the tumble generator valve assembly RH. < Refer to **INSTALLATION**, Tumble Generator Valve Assembly. >
10. Install the intake manifold. < Refer to **INSTALLATION**, Intake Manifold. >
11. Install the engine to the vehicle. < Refer to **INSTALLATION**, Engine Assembly. >

#### CYLINDER HEAD LH

1. Clean the bolt holes in the cylinder block LH.

**CAUTION:** To avoid erroneous tightening of the bolts, clean out the bolt holes sufficiently by blowing with compressed air to eliminate engine coolant etc.

2. Apply liquid gasket to both sides of the cylinder head gasket LH as shown in the figure.

**NOTE:**

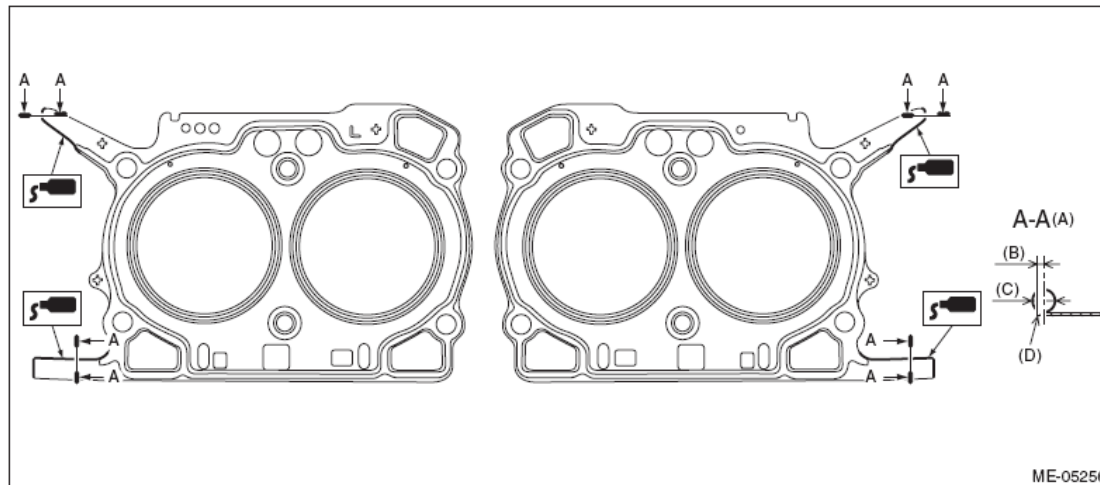
- Use a new cylinder head gasket LH.
- Before applying liquid gasket, degrease the mating surface of cylinder blocks LH and cylinder head LH.
- Install within 5 min. after applying liquid gasket.

*Liquid gasket:*

**THREE BOND 1217G (Part No. 0877Y0100) or equivalent**

**Liquid gasket applying diameter:**

**$3\pm1$  mm ( $0.1181\pm0.0394$  in)**



(A) Liquid gasket applying position

(C)  $\phi 3\pm1$  mm ( $0.1181\pm0.0394$  in)

(D) Cylinder head gasket edge

(B) 1 mm (0.0394 in) or less

**Fig. 297: Identifying Liquid Gasket Applying Area On Both Sides Of Cylinder Head Gasket LH**  
**Courtesy of SUBARU OF AMERICA, INC.**

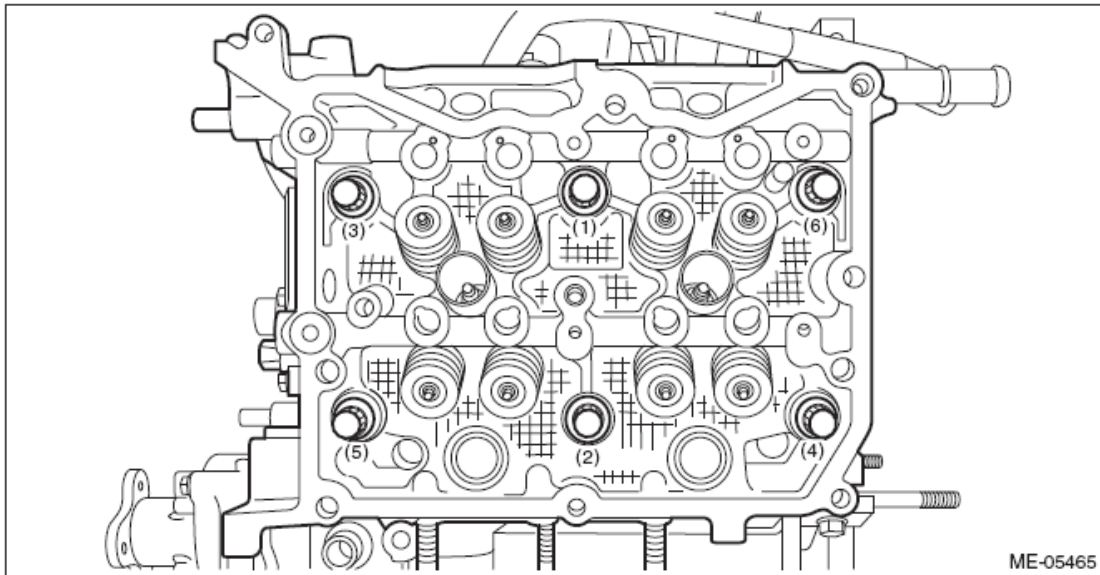
3. Attach the cylinder head gasket LH.

**NOTE:** Check that liquid gasket is squeezed out from the cylinder head gasket LH.

4. Install the cylinder head LH to the cylinder block LH.

**CAUTION:** Be careful not to scratch the mating surface of cylinder head LH and cylinder block LH.

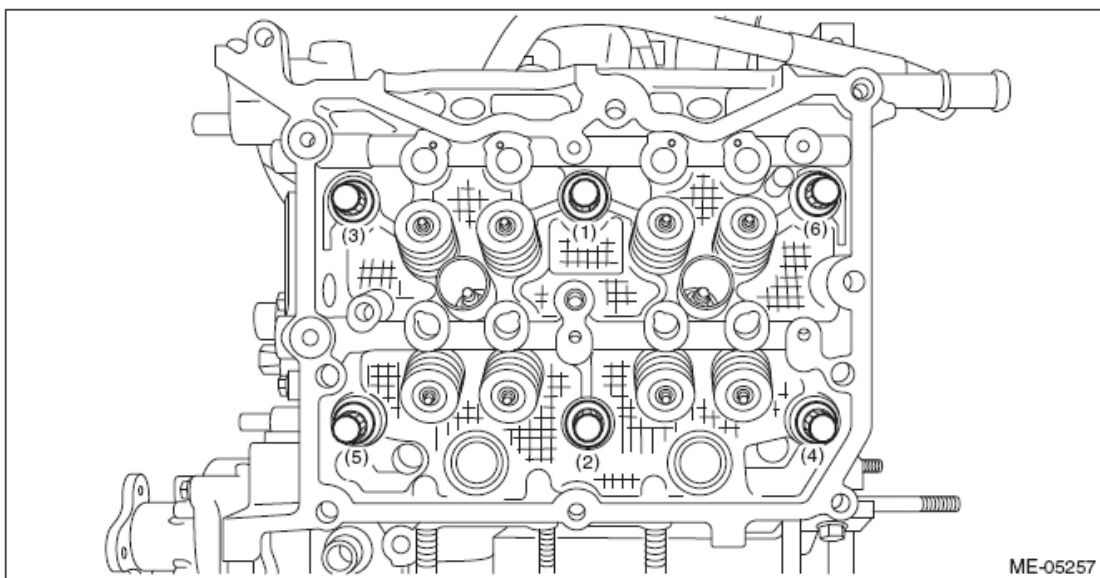
1. Clean the cylinder head bolt threads and apply sufficient engine oil to the washer and cylinder head bolts threads.
2. Mount the cylinder head LH onto the cylinder block LH, then tighten all bolts with a torque of 29 N.m (3.0 kgf-m, 21.4 ft-lb) in numerical order as shown in the figure.



**Fig. 298: Identifying Cylinder Head LH Bolts Tightening Sequence**  
 Courtesy of SUBARU OF AMERICA, INC.

3. Tighten all cylinder head bolts further with a torque of 100 N.m (10.2 kgf-m, 73.8 ft-lb) in numerical order as shown in the figure.

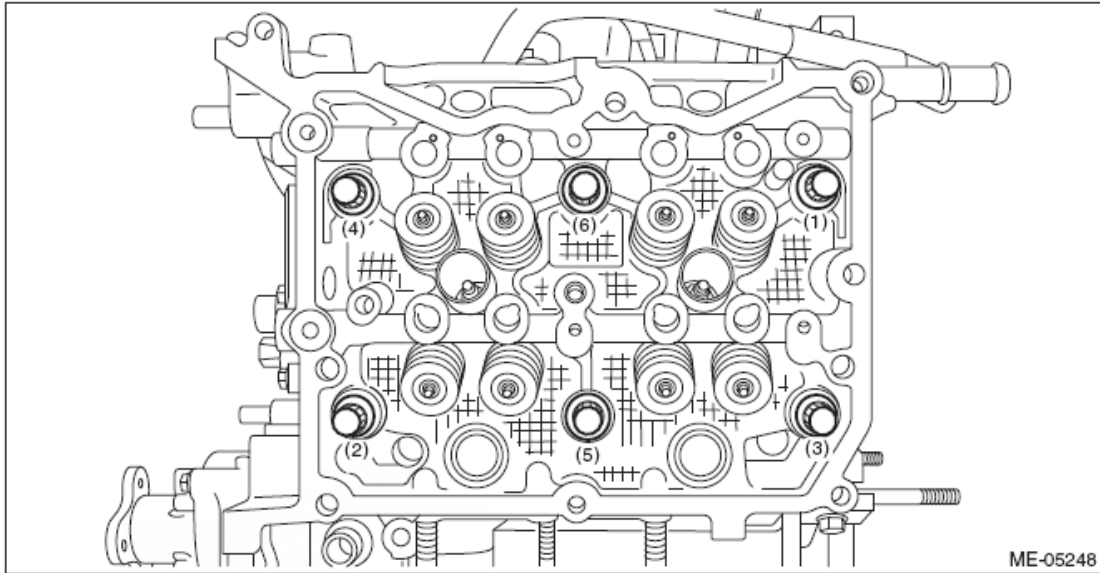
**CAUTION:** If the bolt makes stick-slip sound during tightening, repeat the procedure from step 1). In that case, the cylinder head gasket LH can be reused. But it is necessary to remove liquid gasket completely from cylinder block LH, cylinder head LH and cylinder head gasket LH and re-apply to them.



**Fig. 299: Identifying Cylinder Head Bolts Tightening Sequence**

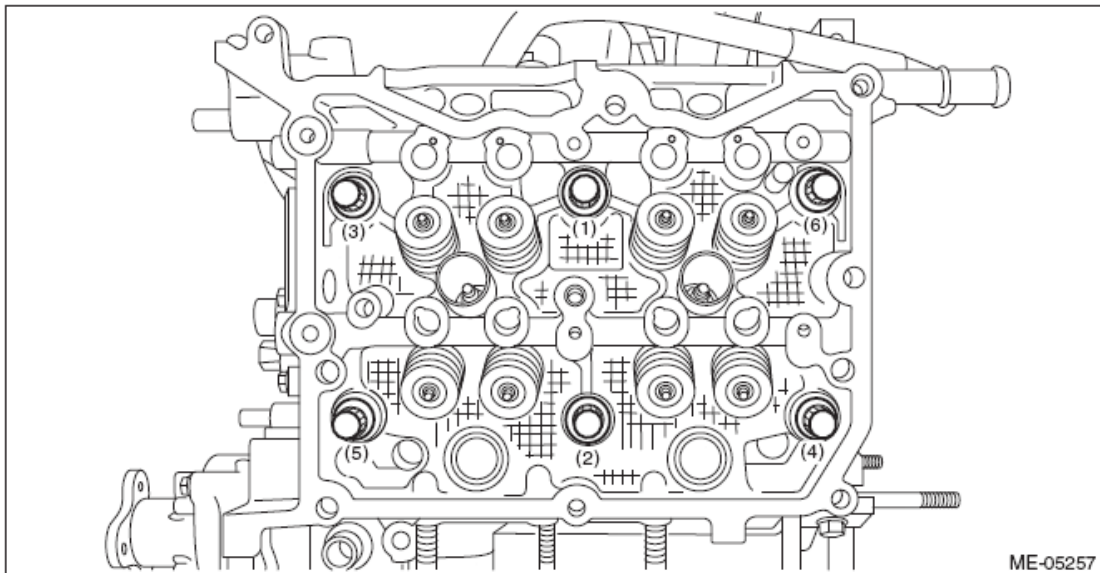
Courtesy of SUBARU OF AMERICA, INC.

4. Loosen all cylinder head bolts 180° in numerical order as shown in the figure, and then loosen all cylinder head bolts 180° further in numerical order as shown in the figure.



**Fig. 300: Identifying Loosening Sequence Of Cylinder Head Mounting Bolts**  
Courtesy of SUBARU OF AMERICA, INC.

5. Tighten all cylinder head bolts with a torque of 42 N.m (4.3 kgf-m, 31.0 ft-lb) in numerical order as shown in the figure.



**Fig. 301: Identifying Tightening Sequence Of Cylinder Head Mounting Bolts**  
Courtesy of SUBARU OF AMERICA, INC.

6. Using ST2, tighten all cylinder head bolts with specified angle in numerical order as shown in the figure.

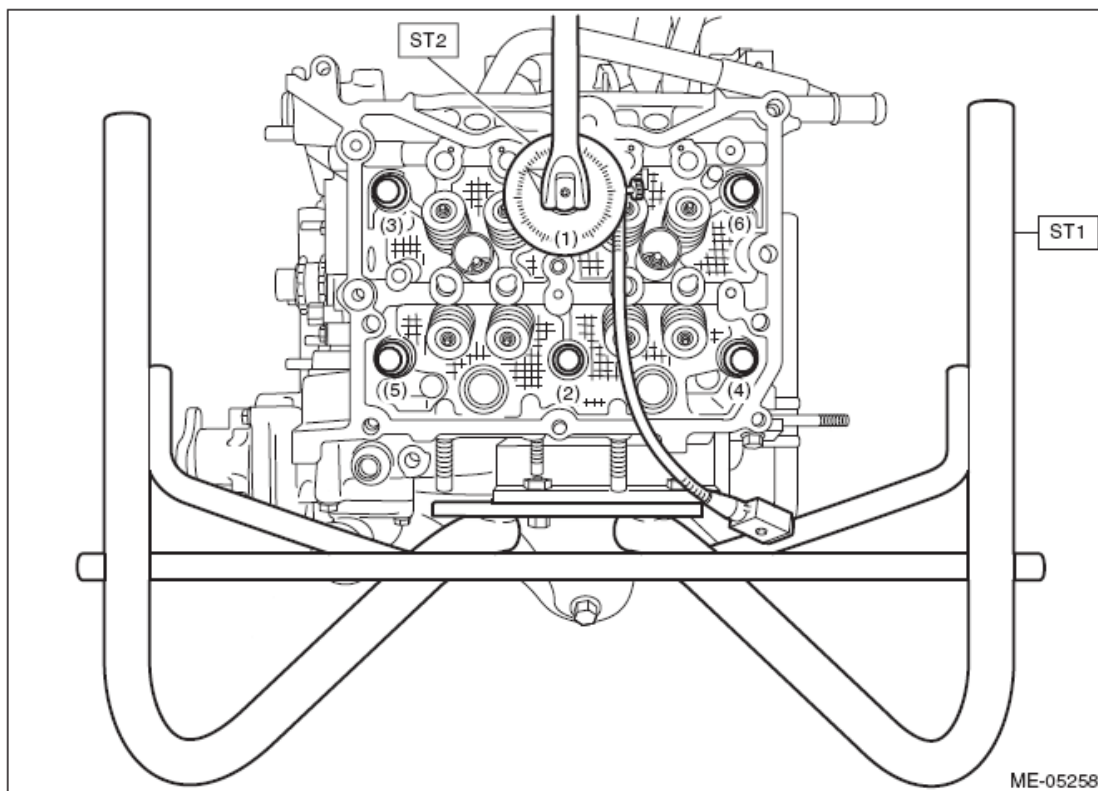
**NOTE:** Attach the magnet used for securing the ST2 (ANGLE GAUGE) to ST1.

ST1 499817100 ENGINE STAND

ST2 18854AA000 ANGLE GAUGE

*Tightening angle:*

$80^{\circ} \pm 2^{\circ}$



**Fig. 302: Tightening Cylinder Head Bolts Using Angle Gauge**  
Courtesy of SUBARU OF AMERICA, INC.

7. Using ST2, tighten the cylinder head bolts (2 places) with specified angle in numerical order as shown in the figure.

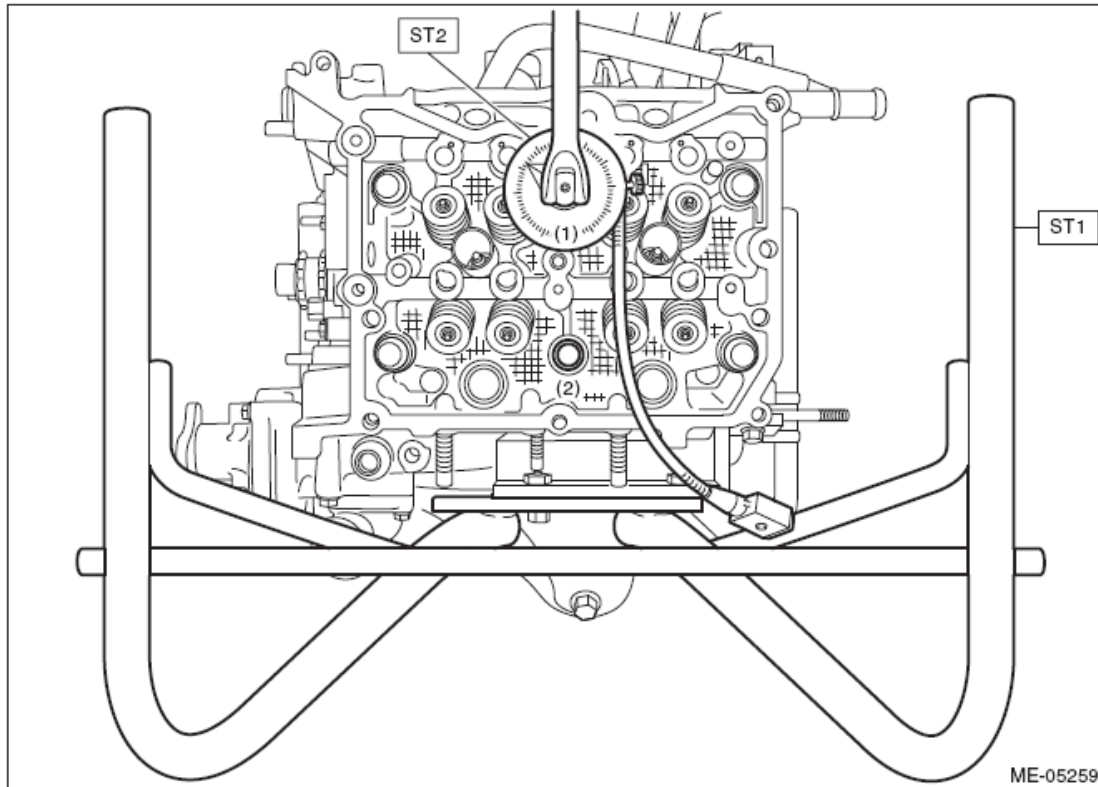
**NOTE:** Attach the magnet used for securing the ST2 (ANGLE GAUGE) to ST1.

ST1 499817100 ENGINE STAND

ST2 18854AA000 ANGLE GAUGE

***Tightening angle:***

$75^{\circ} \pm 2^{\circ}$



**Fig. 303: Tightening Cylinder Head Bolts Using Angle Gauge**  
 Courtesy of SUBARU OF AMERICA, INC.

8. Using ST2, tighten the cylinder head bolts (4 places) with specified angle in numerical order as shown in the figure.

**NOTE:**

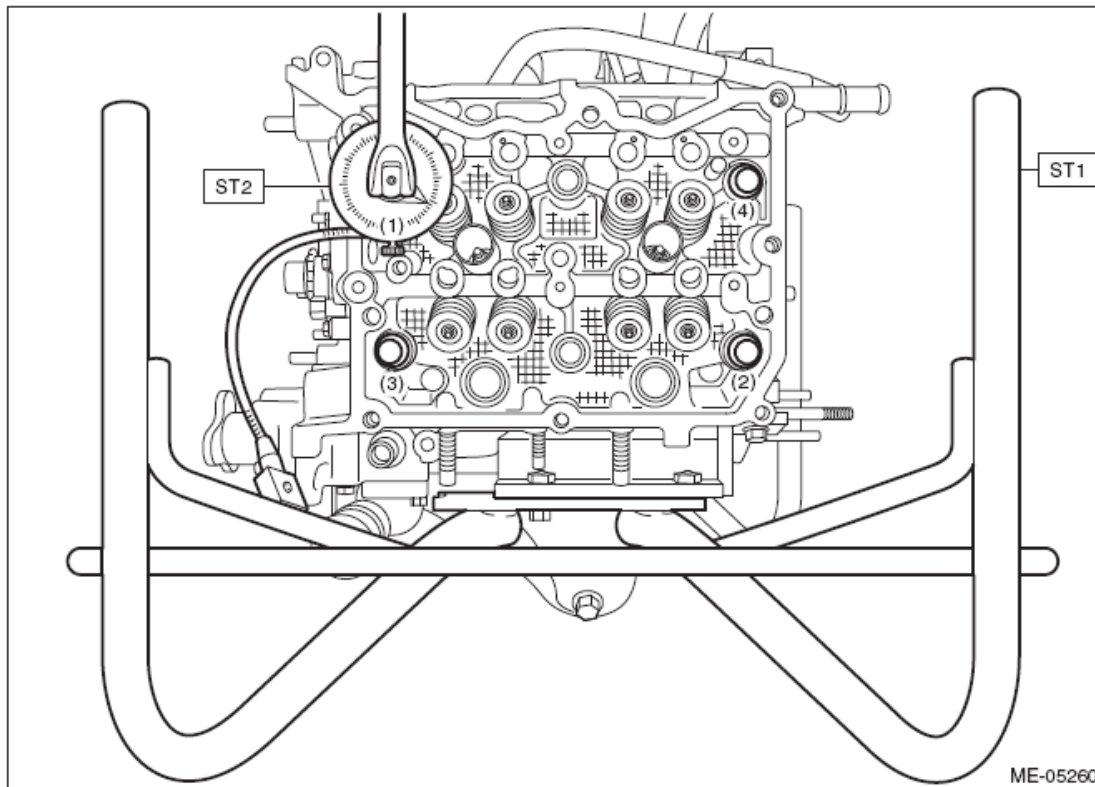
- After tightening, if the liquid gasket is squeezed out onto the seal surface of the chain cover, completely remove any squeezed-out liquid gasket.
- Attach the magnet used for securing the ST2 (ANGLE GAUGE) to ST1.

ST1 499817100 ENGINE STAND

ST2 18854AA000 ANGLE GAUGE

***Tightening angle:***

$30^{\circ} \pm 2^{\circ}$

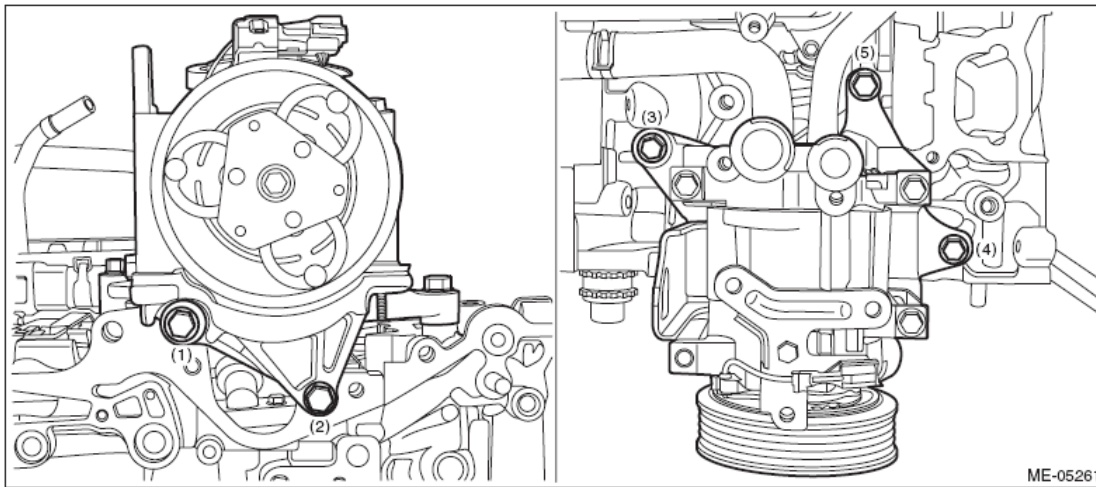


**Fig. 304: Tightening Cylinder Head Bolts Using Angle Gauge**  
 Courtesy of SUBARU OF AMERICA, INC.

5. Set the A/C compressor bracket to the cylinder head LH, and tighten the bolts in numerical order as shown in the figure.

***Tightening torque:***

***36 N.m (3.7 kgf-m, 26.6 ft-lb)***



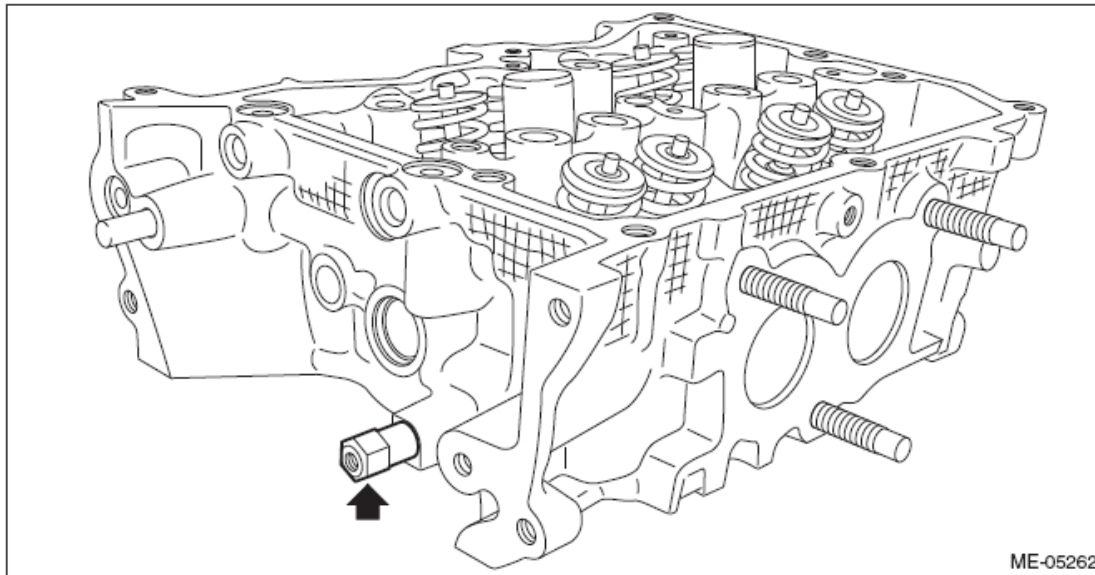
**Fig. 305: Identifying Tightening Sequence Of A/C Compressor Bracket To Cylinder Head LH Mounting Bolts**

Courtesy of SUBARU OF AMERICA, INC.

6. Install the cam carrier LH. < Refer to **CAM CARRIER LH**, INSTALLATION, Cam Carrier. >
7. Install the rocker cover LH. < Refer to **ROCKER COVER LH**, INSTALLATION, Rocker Cover. >
8. Install the chain cover. < Refer to **INSTALLATION**, Chain Cover. >
9. Install the tumble generator valve assembly LH. < Refer to **INSTALLATION** , Tumble Generator Valve Assembly. >
10. Install the intake manifold. < Refer to **INSTALLATION** , Intake Manifold. >
11. Install the engine to the vehicle. < Refer to **INSTALLATION**, Engine Assembly. >

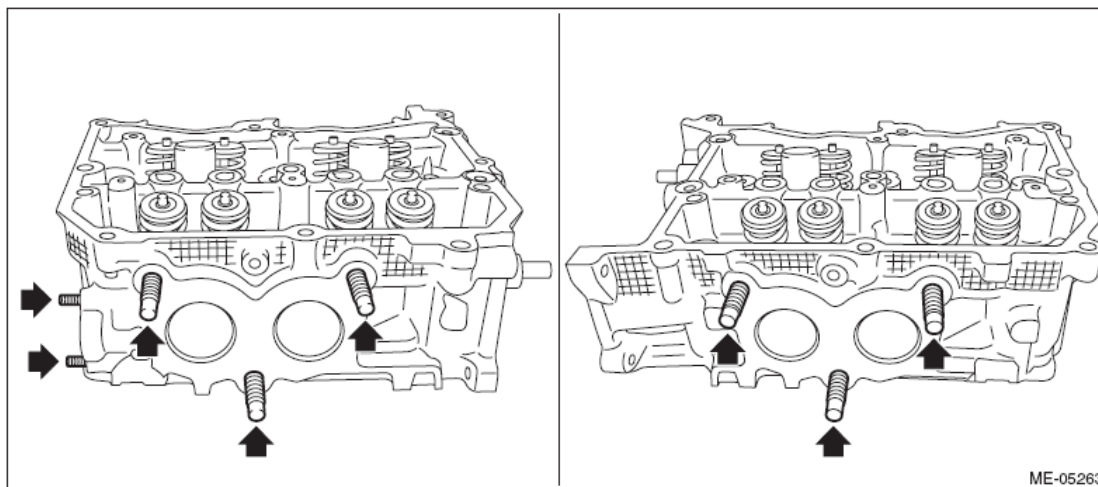
## DISASSEMBLY

1. Remove the chain cover securing bolt from the cylinder head LH.



**Fig. 306: Locating Cylinder Head LH Chain Cover Securing Bolt**  
 Courtesy of SUBARU OF AMERICA, INC.

2. Remove the stud bolts from the cylinder head.



**Fig. 307: Locating Cylinder Head Stud Bolts**  
 Courtesy of SUBARU OF AMERICA, INC.

3. Remove the valve collet, valve, valve spring retainer, valve spring and valve spring seat from the cylinder head RH.

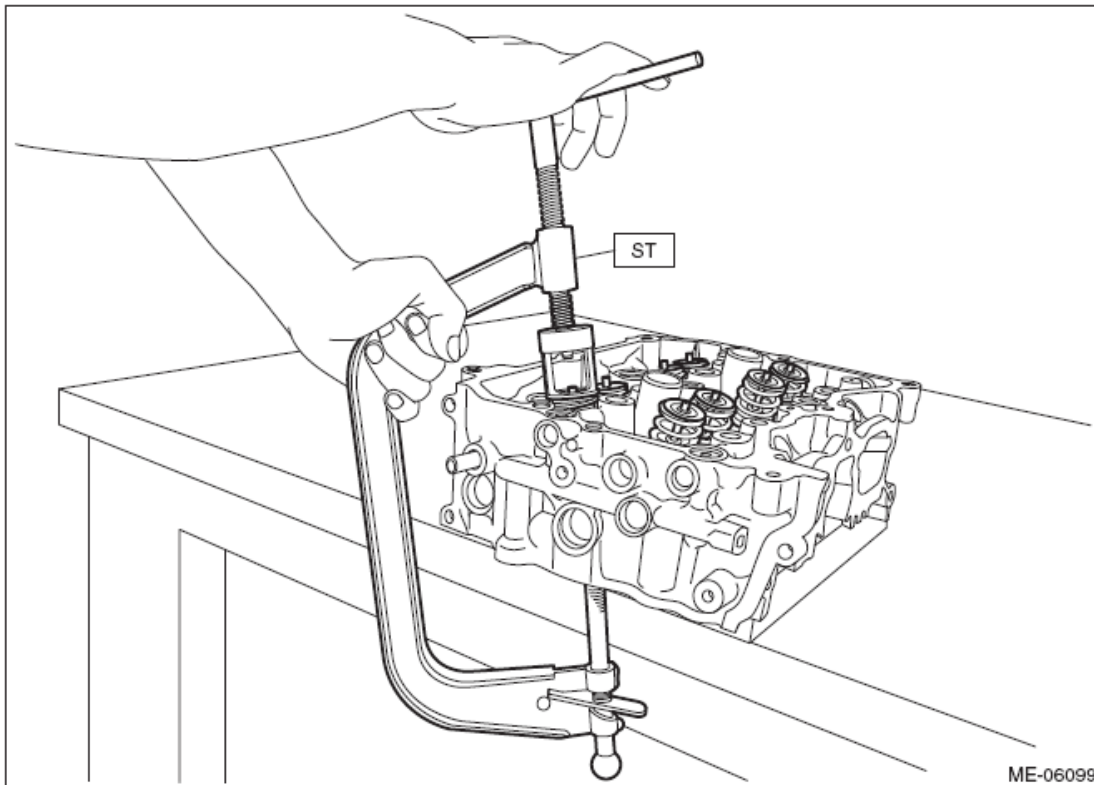
**CAUTION:** During work, place a waste cloth, etc. to avoid scratching the mating surface of the cylinder head RH.

**NOTE:** • Mark each part to prevent confusion.

- **Keep all the removed parts in order for re-installing in their original positions.**

1. Compress the valve spring and remove the valve collet using ST.

ST 0920287002000 REMOVER AND REPLACER



**Fig. 308: Compress Valve Spring Using Remover And Replacer**  
Courtesy of SUBARU OF AMERICA, INC.

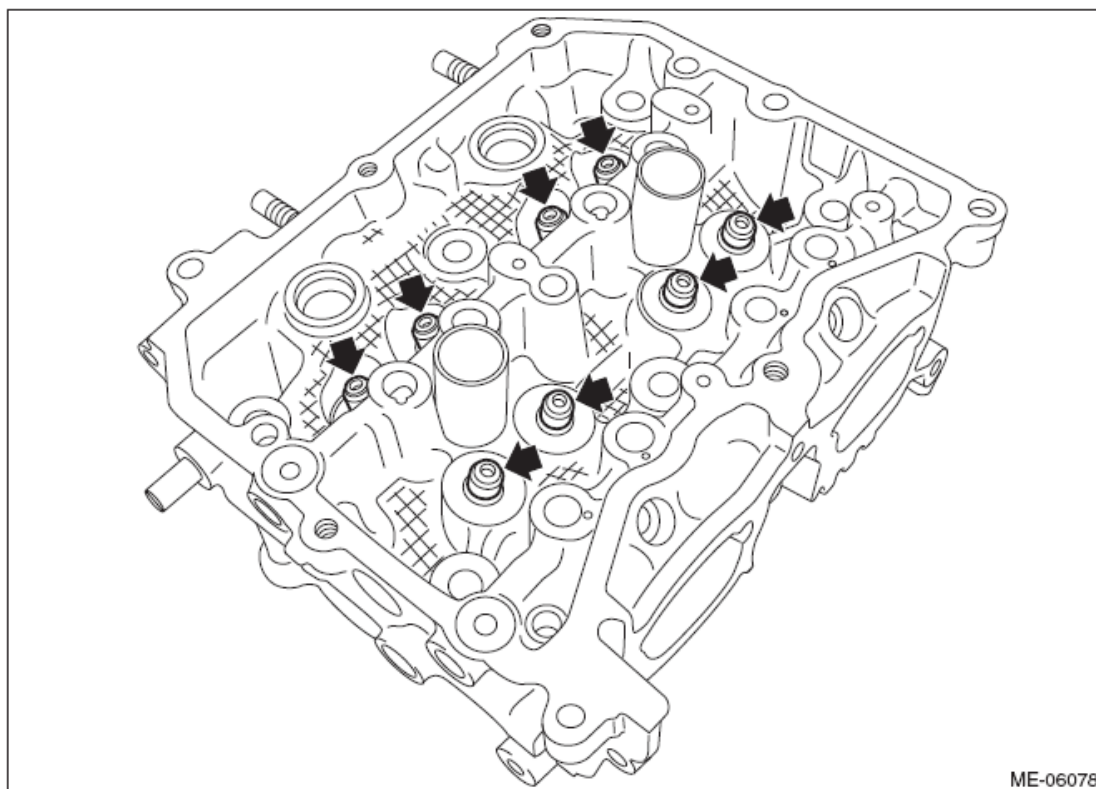
2. Remove valve, valve spring retainer, valve spring and valve spring seat.
4. Remove the valve collet, valve, valve spring retainer, valve spring and valve spring seat from the cylinder head LH.
5. Remove the valve oil seal from the valve guide.

**CAUTION:**

- During work, place a waste cloth, etc. to avoid scratching the mating surface of the cylinder head RH.
- Use special care not to damage the cylinder head RH and guide during work.

**NOTE:**

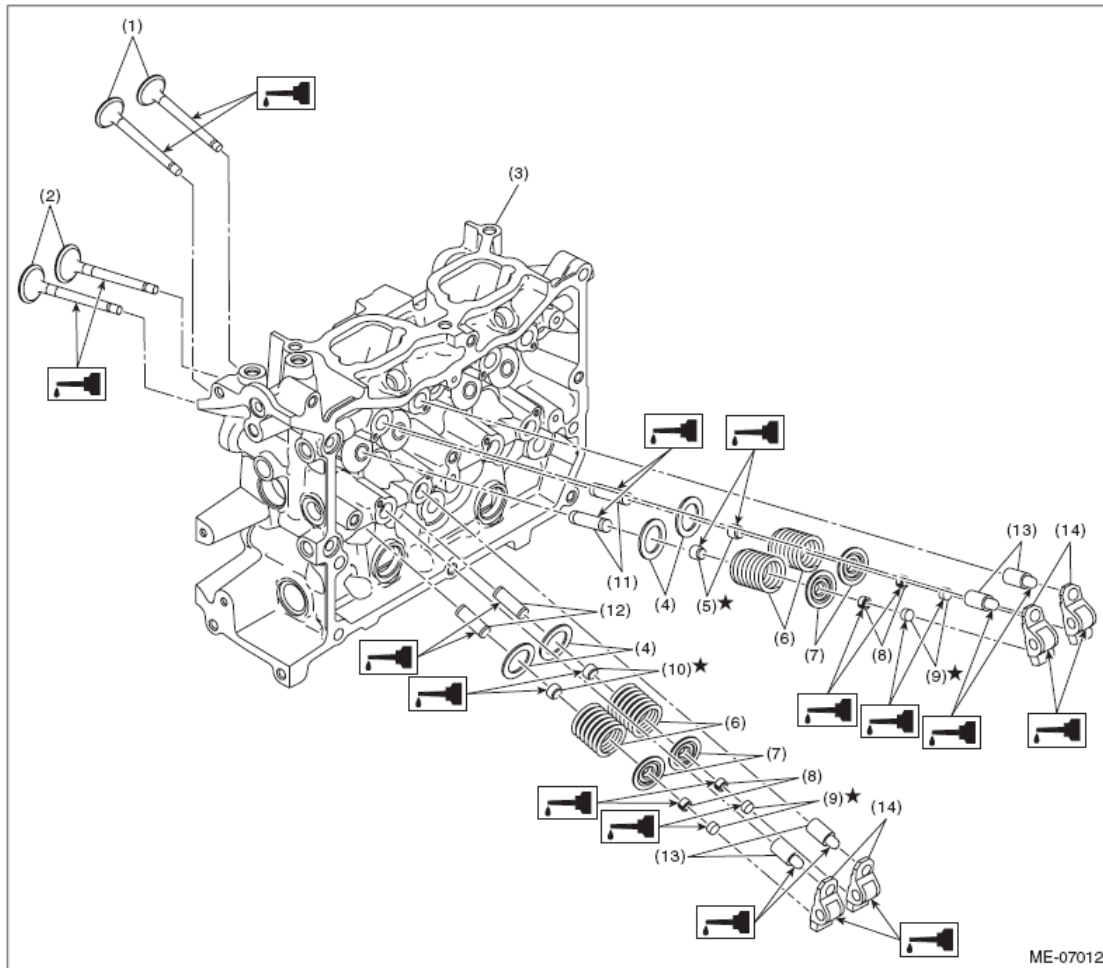
For removal of valve guide, refer to INSPECTION. < Refer to VALVE GUIDE, INSPECTION, Cylinder Head. >



**Fig. 309: Locating Valve Guide Oil Seal**  
**Courtesy of SUBARU OF AMERICA, INC.**

6. For cylinder head LH, remove the valve oil seal in the same manner.

## ASSEMBLY



- |                           |                             |                              |
|---------------------------|-----------------------------|------------------------------|
| (1) Exhaust valve         | (6) Valve spring            | (11) Intake valve guide      |
| (2) Intake valve          | (7) Valve spring retainer   | (12) Exhaust valve guide     |
| (3) Cylinder head         | (8) Valve collet            | (13) Roller rocker arm pivot |
| (4) Valve spring seat     | (9) Valve shim              | (14) Roller rocker arm       |
| (5) Intake valve oil seal | (10) Exhaust valve oil seal |                              |

**Fig. 310: Exploded View Of Cylinder Head Assembly**  
Courtesy of SUBARU OF AMERICA, INC.

1. Using the ST, install the valve oil seal to the valve guide.

**CAUTION:**

- During work, place a waste cloth, etc. to avoid scratching the mating surface of the cylinder head RH.
- Use special care not to damage the cylinder head RH and guide during work.
- When installing the valve oil seal, press the ST with hands to install it and never drive the ST with a plastic hammer, otherwise the valve oil seal can be damaged.

**NOTE:**

- Use a new valve oil seal.
- Apply engine oil to valve oil seal before installing.
- The intake valve oil seals and exhaust valve oil seals are distinguished by their colors.

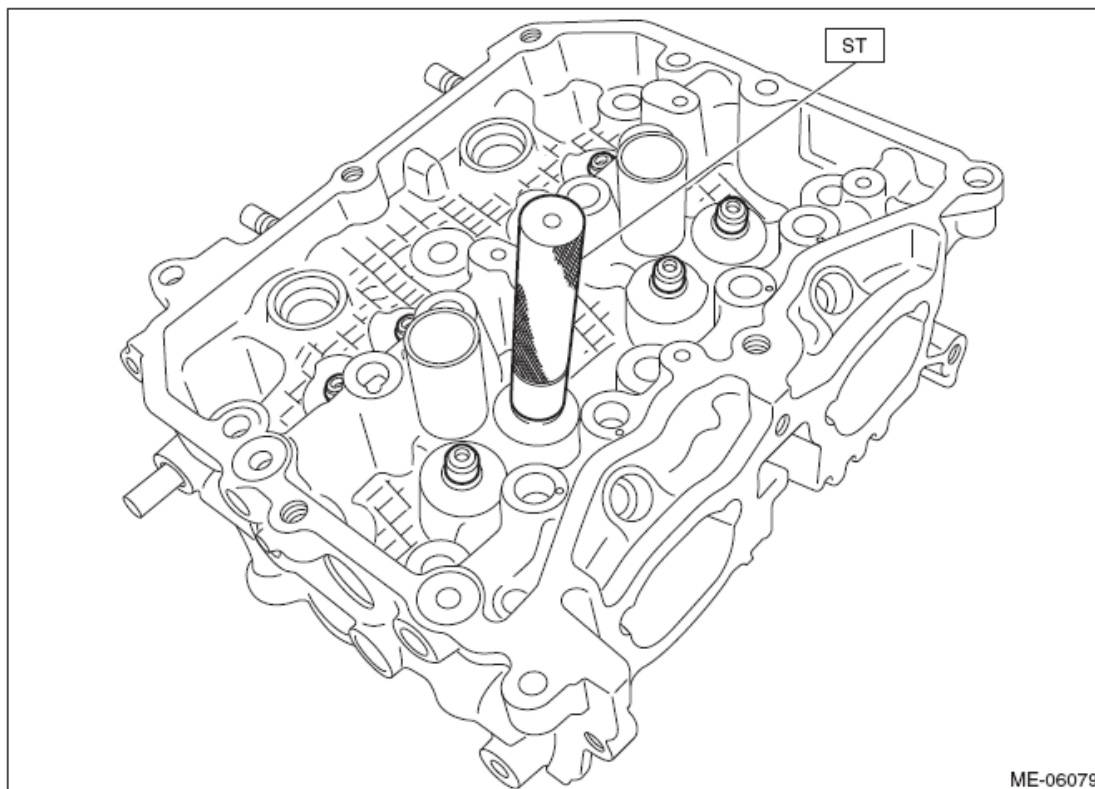
*Identification colors:*

*Intake [Gray]*

*Exhaust [Green]*

- For installation of valve guide, refer to INSPECTION. < Refer to **VALVE GUIDE**, INSPECTION, Cylinder Head. >

ST 18261AA010 VALVE OIL SEAL GUIDE



**Fig. 311: Installing Valve Guide Using Valve Oil Seal Guide**  
Courtesy of SUBARU OF AMERICA, INC.

2. For cylinder head LH, install the valve oil seal in the same manner.
3. Install the valve spring seat, valve spring, valve spring retainer, valve and valve collet to the cylinder head RH.

**CAUTION:** During work, place a waste cloth, etc. to avoid scratching the mating surface of the cylinder head RH.

1. Set the valve spring seat, valve spring and valve spring retainer onto the cylinder head RH.

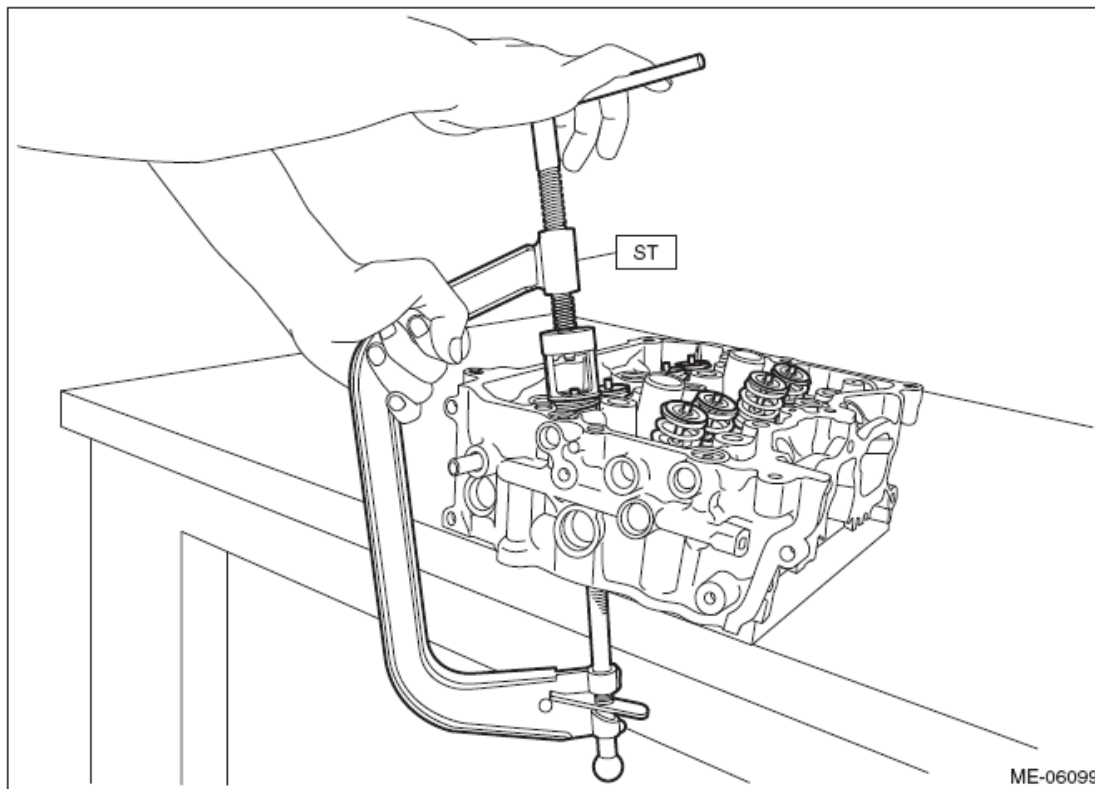
**NOTE:** Be sure to install the valve spring with its close-coiled end facing the cylinder head side.

2. Coat the valve stem of each valve with engine oil and insert the valve into valve guide.

**NOTE:** When inserting the valve into valve guide, use special care not to damage the oil seal lip.

3. Compress the valve spring and install the valve collet using ST.

ST 0920287002000 REMOVER AND REPLACER



**Fig. 312: Compressing Valve Spring Using Remover And Replacer**  
Courtesy of SUBARU OF AMERICA, INC.

4. Install the valve spring seat, valve spring, valve spring retainer, valve and valve collet to the cylinder head LH.
5. Lightly tap the valve spring retainer with a plastic hammer, and make sure that the valve collet is securely

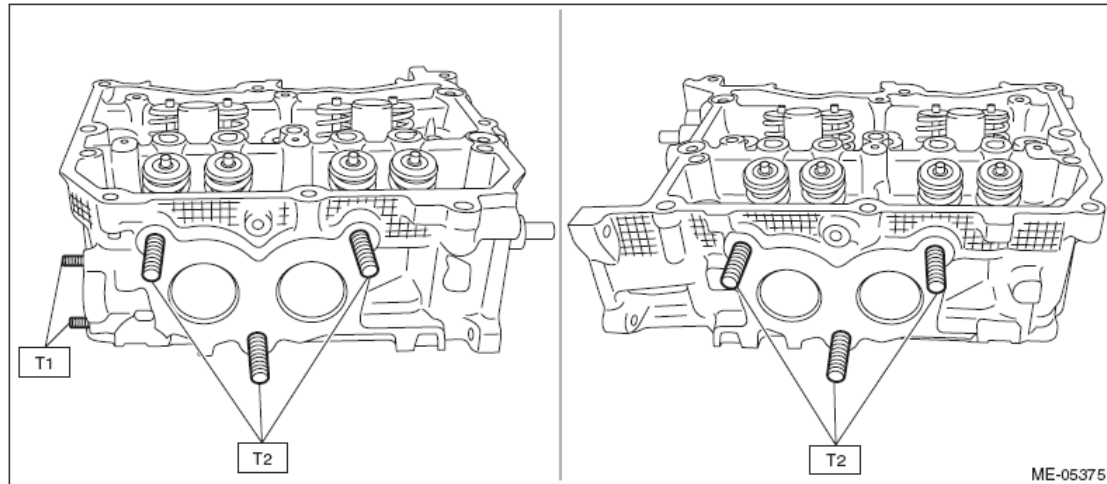
attached.

6. Install the stud bolts onto cylinder heads.

***Tightening torque:***

***T1: 6.4 N.m (0.7 kgf-m, 4.7 ft-lb)***

***T2: 18 N.m (1.8 kgf-m, 13.3 ft-lb)***

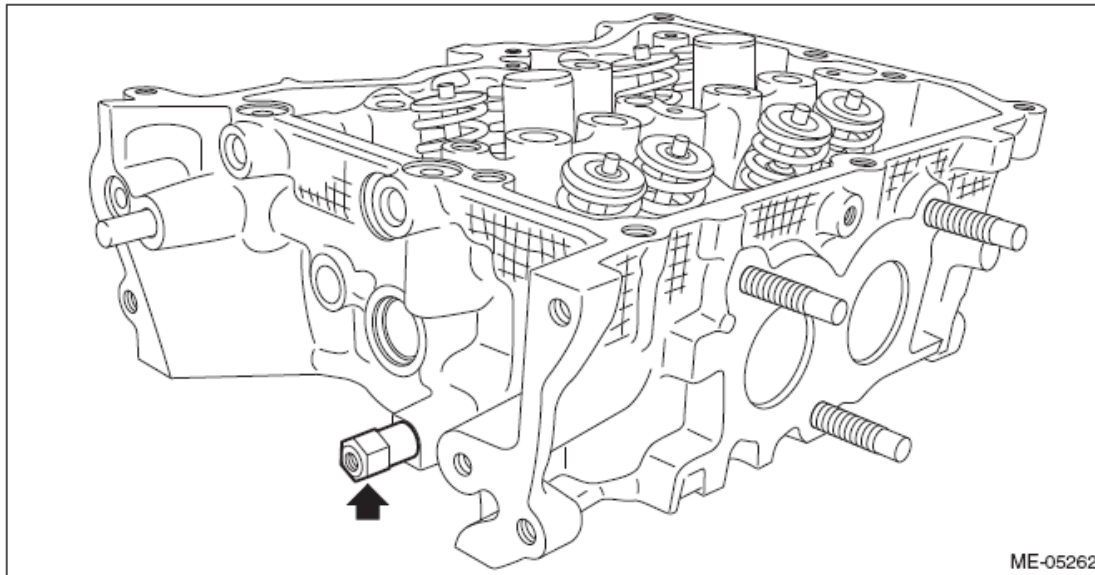


**Fig. 313: Identifying Cylinder Heads Stud Bolts With Torque Specifications**  
Courtesy of SUBARU OF AMERICA, INC.

7. Install the chain cover securing bolt to the cylinder head LH.

***Tightening torque:***

***6.4 N.m (0.7 kgf-m, 4.7 ft-lb)***



**Fig. 314: Locating Cylinder Head LH Chain Cover Securing Bolt**  
Courtesy of SUBARU OF AMERICA, INC.

## INSPECTION

### CYLINDER HEAD

1. Visually inspect to make sure that there are no cracks, scratches or other damage.
2. Use liquid penetrant tester on the important sections to check for fissures.
3. Check that there are no marks of gas leaking or water leaking on gasket attachment surface.
4. Check the warping of the cylinder head mating surface that mates with cylinder block using a straight edge (A) and thickness gauge (B) at the locations shown in the figure. If it exceeds the limit, correct the surface by grinding it with a surface grinder or replace the cylinder head.

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

*Warping limit:*

**0.035 mm (0.0014 in)**

*Grinding limit:*

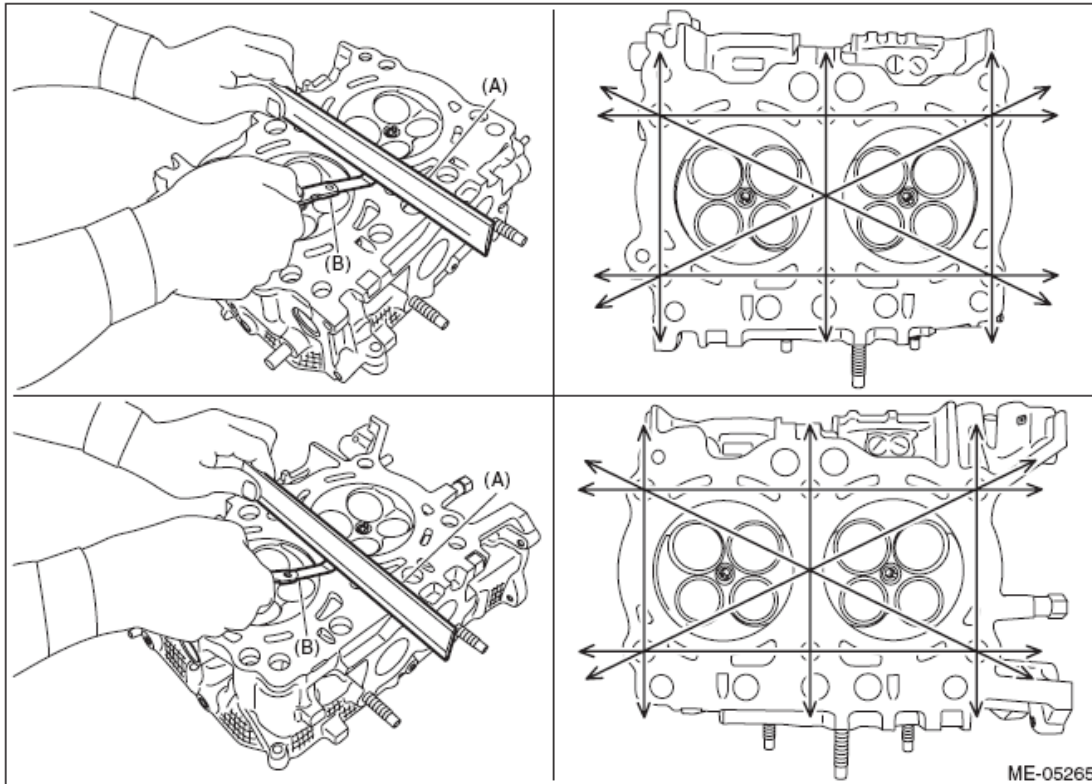
**0.1 mm (0.004 in)**

*Standard height of cylinder head:*

**98.5 mm (3.878 in)**

**NOTE:** If the cylinder head bolt tightening torques and angle tightening is uneven,

warpage of the cylinder head may occur. During installation work, make sure that tightening torque and angle tightening work is performed precisely so that it is tightened evenly.



**Fig. 315: Checking Warping Of Cylinder Head Mating Surface With Cylinder Block Using Straight Edge And Thickness Gauge**

Courtesy of SUBARU OF AMERICA, INC.

#### VALVE SEAT

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

*Contacting width  $W$  between valve and valve seat:*

#### *Intake*

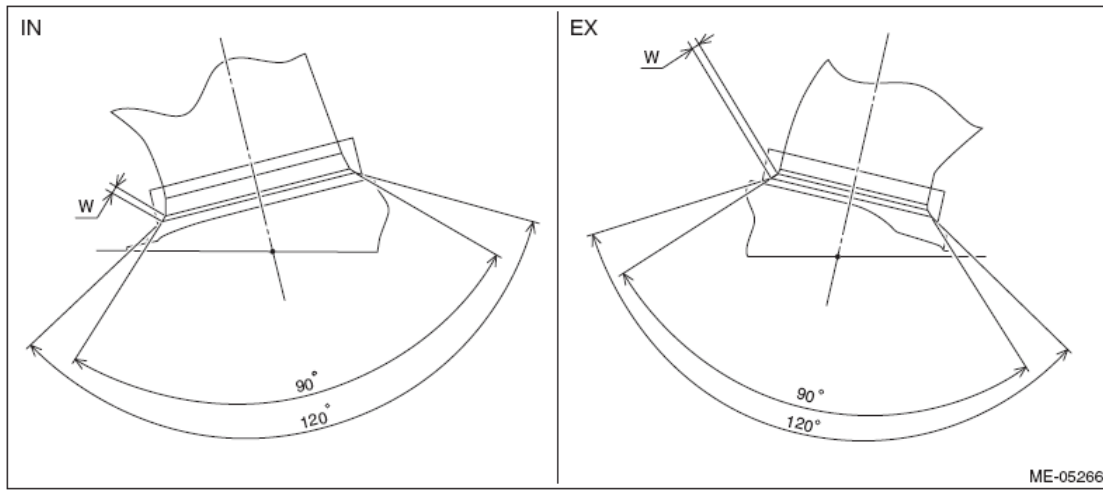
##### *Standard*

*0.8 - 1.6 mm (0.031 - 0.063 in)*

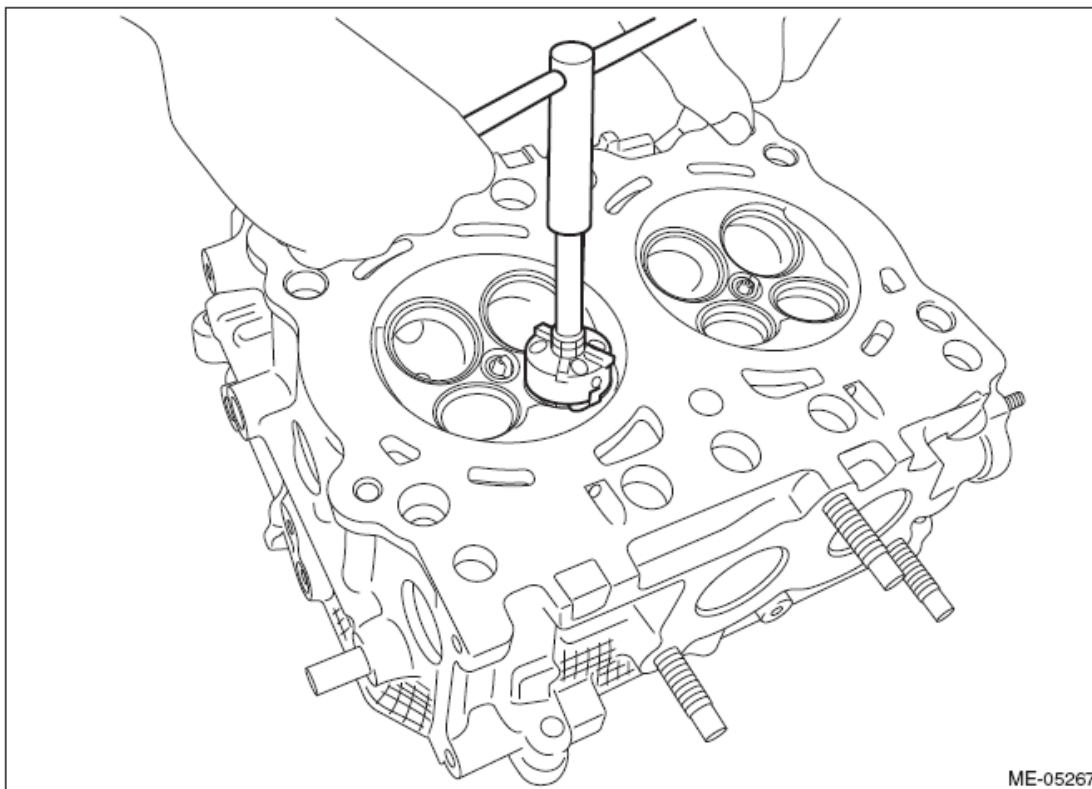
#### *Exhaust*

##### *Standard*

**1.1 - 1.7 mm (0.043 - 0.067 in)**



**Fig. 316: Identifying Contacting Width Between Valve And Valve Seat**  
Courtesy of SUBARU OF AMERICA, INC.



**Fig. 317: Creating Gap Between Valve Seat Correcting Surface**  
Courtesy of SUBARU OF AMERICA, INC.

#### VALVE GUIDE

1. Check the clearance between valve guide and valve stem. Check the clearance between valve guide and valve stem by measuring the outer diameter of valve stem and the inner diameter of valve guide respectively.
  1. Measure the outer diameter of valve stem with a micrometer. If it is not within the standard, replace the valve.

**NOTE:**

- Measurement should be performed at a temperature of 20°C (68° F).
- Measure the outer diameter of the valve stem at the three locations as shown in the figure, and read the value of most worn location.
- If the valve is replaced, put a small amount of grinding compound on the valve seat surface of cylinder head, and lap the valve and valve seat surfaces.

*Valve stem outer diameters:*

*Intake*

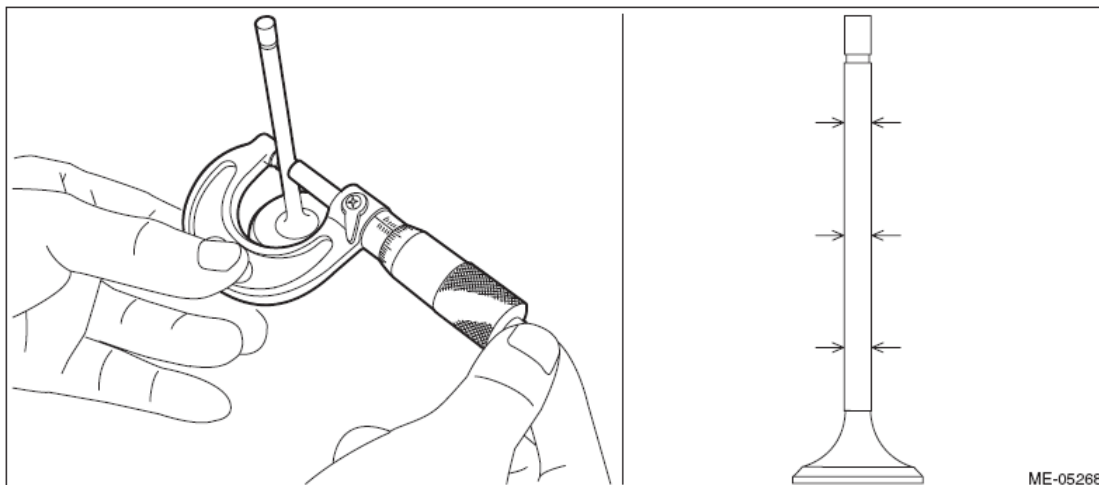
*Standard*

5.455 - 5.470 mm (0.2148 - 0.2154 in)

*Exhaust*

*Standard*

5.445 - 5.460 mm (0.2144 - 0.2150 in)



**Fig. 318: Measuring Valve Stem Outer Diameter Using Micrometer**  
Courtesy of SUBARU OF AMERICA, INC.

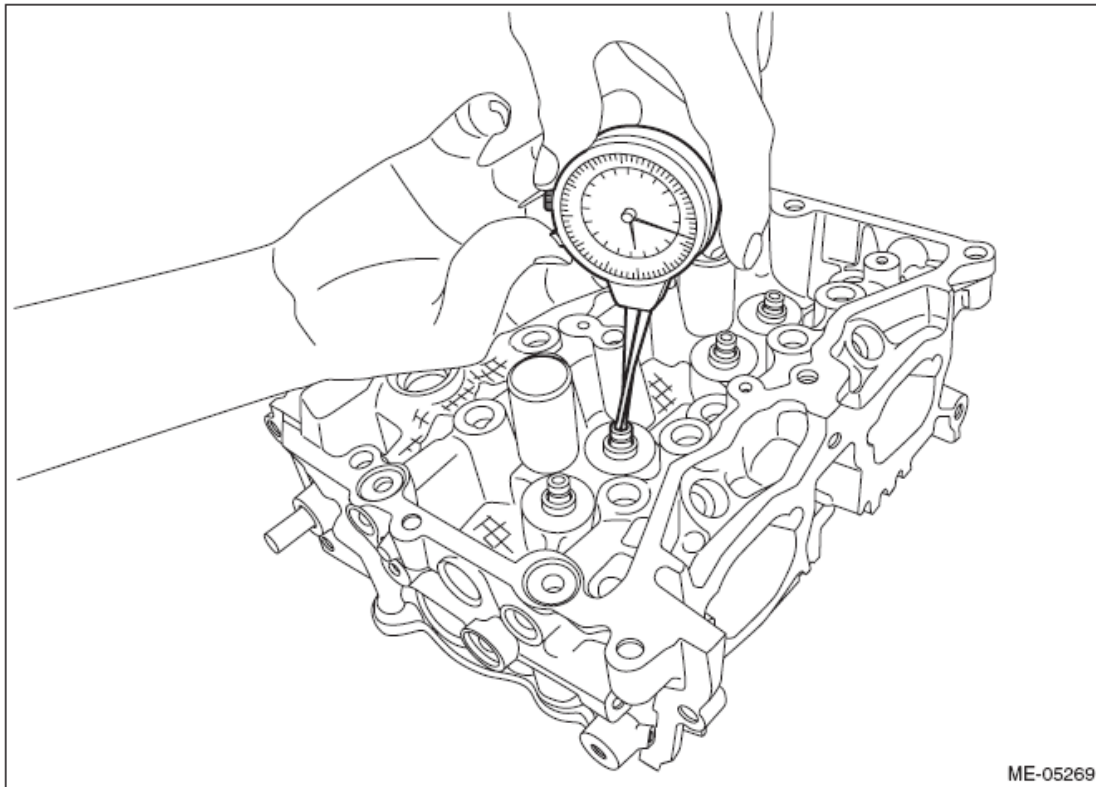
2. Using a caliper gauge, measure the inner diameter of valve guide. If it is not within the standard, replace the valve guide. For replacement procedure, refer to step 2).

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

*Valve guide inner diameter:*

*Standard*

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



**Fig. 319: Measuring Valve Guide Inner Diameter**  
Courtesy of SUBARU OF AMERICA, INC.

3. Calculate the clearance between valve guide and valve stem.

*Clearance between the valve guide and valve stem:*

*Intake*

*Standard*

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

**Exhaust****Standard**

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

2. If the clearance between valve guide and valve stem exceeds the standard, replace the valve guide or valve, whichever shows the greater amount of wear or damage. For replacement procedure of valve guide, refer to the following.

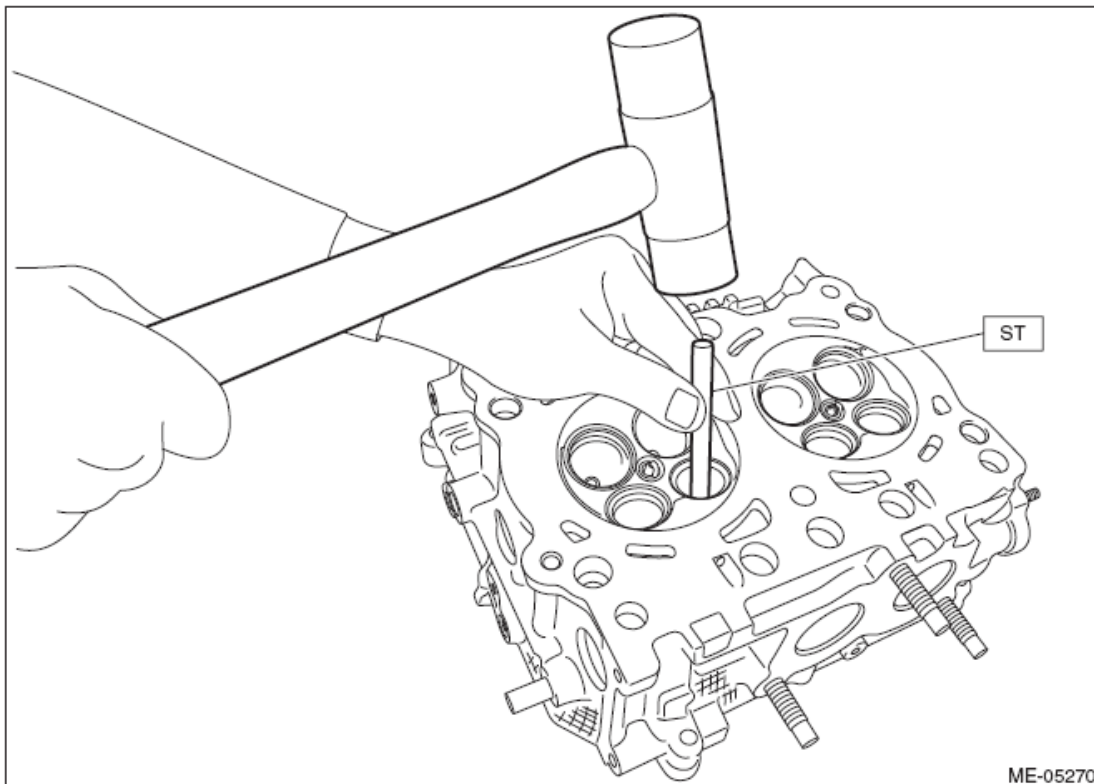
**NOTE:** If the valve is replaced, put a small amount of grinding compound on the valve seat surface of cylinder head, and lap the valve and valve seat surfaces.

1. Insert ST into the valve guide with the combustion chamber upward and remove the valve guide using plastic hammer.

**CAUTION:**

- Place a wood board wrapped with a waste cloth to stabilize the cylinder head before work.
- Use special care not to damage the cylinder head during work.

ST 499765700 VALVE GUIDE REMOVER AND INSTALLER



**Fig. 320: Removing Valve Guide Using Plastic Hammer**  
Courtesy of SUBARU OF AMERICA, INC.

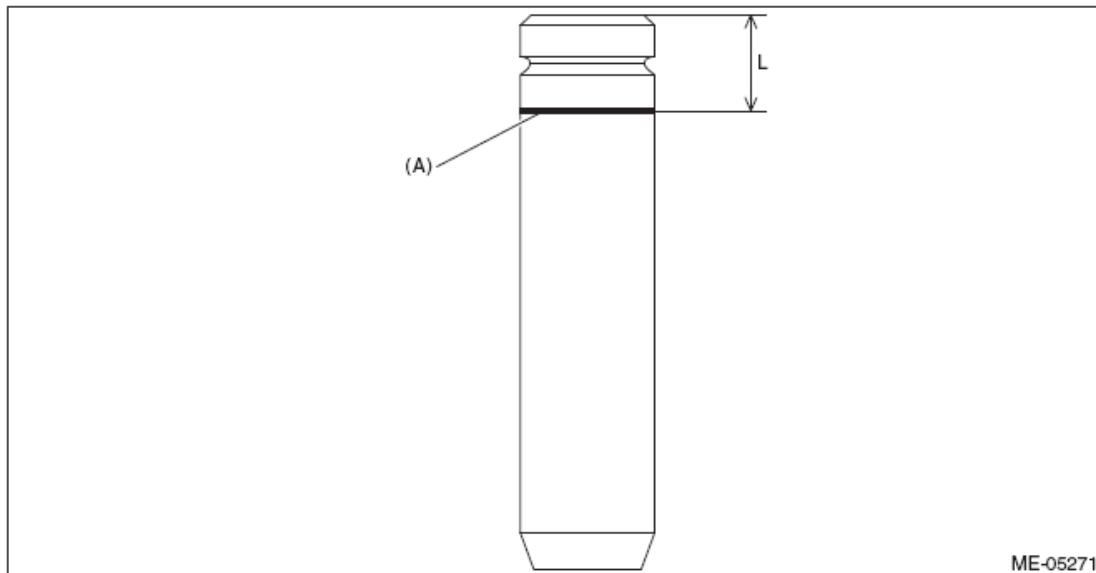
2. Before installing the valve guide, make sure that neither scratches nor damages exist on the inner surface of valve guide holes in cylinder head.
3. Draw a reference line (A) for insert on the valve guide using a marker as shown in the figure.

**NOTE:**

- Use a new valve guide.
- A reference line for insert is used as a guide when tapping-in the valve guide.

*Valve guide inserting reference line position L:*

*15 mm (0.5906 in)*



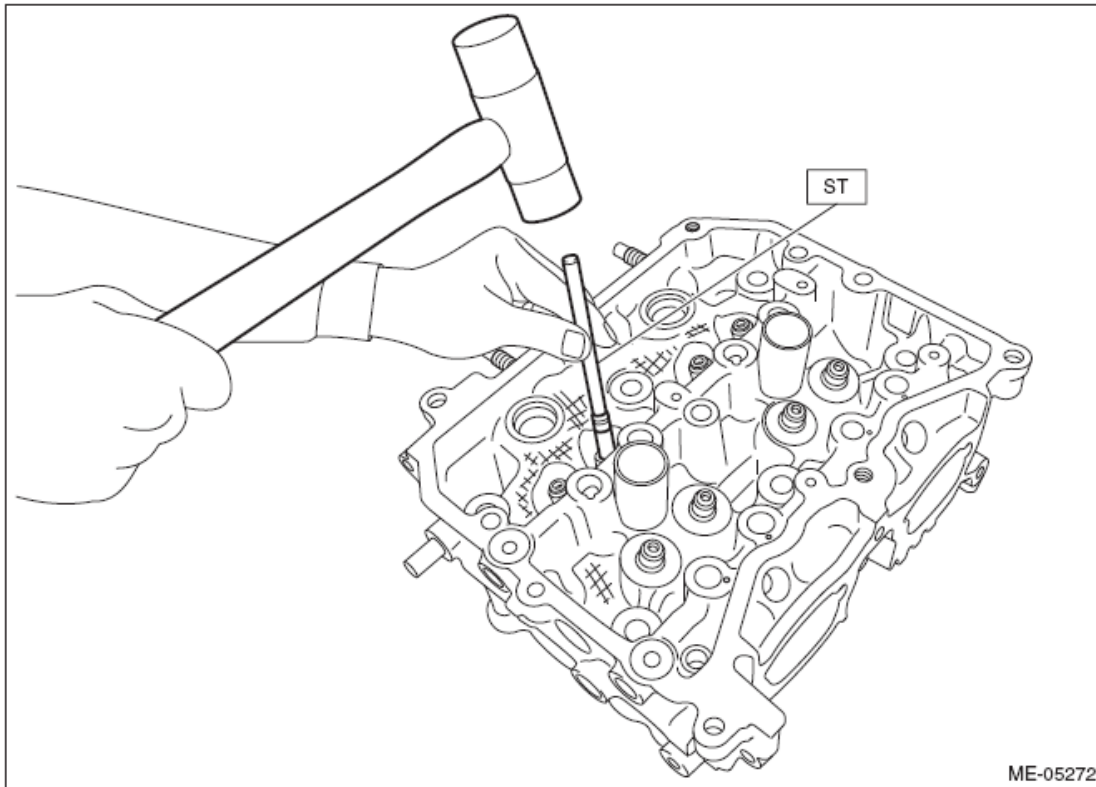
**Fig. 321: Identifying Length Of Valve Guide From Reference Line**  
Courtesy of SUBARU OF AMERICA, INC.

4. Apply a enough coat of engine oil to the valve guide, and set the valve guide on the cylinder head with the combustion chamber downward.
5. Insert the ST into the valve guide, and tap-in the valve guide to the reference line (A) for insert using plastic hammer.

**CAUTION:**

- During work, place a waste cloth, etc. to avoid scratching the mating surface of the cylinder head.
- Use special care not to damage the cylinder head during work.

## ST 499765700 VALVE GUIDE REMOVER AND INSTALLER



**Fig. 322: Tapping Valve Guide To Reference Line Using Plastic Hammer**  
Courtesy of SUBARU OF AMERICA, INC.

6. Measure the valve guide protrusion amount "L" as shown in the figure using a caliper gauge. Insert the ST into the valve guide again, and tap-in the valve guide so that it is positioned within standard by referring to the measured value using plastic hammer.

**CAUTION:**

- During work, place a waste cloth, etc. to avoid scratching the mating surface of the cylinder head.
- Use special care not to damage the cylinder head during work.

**NOTE:**

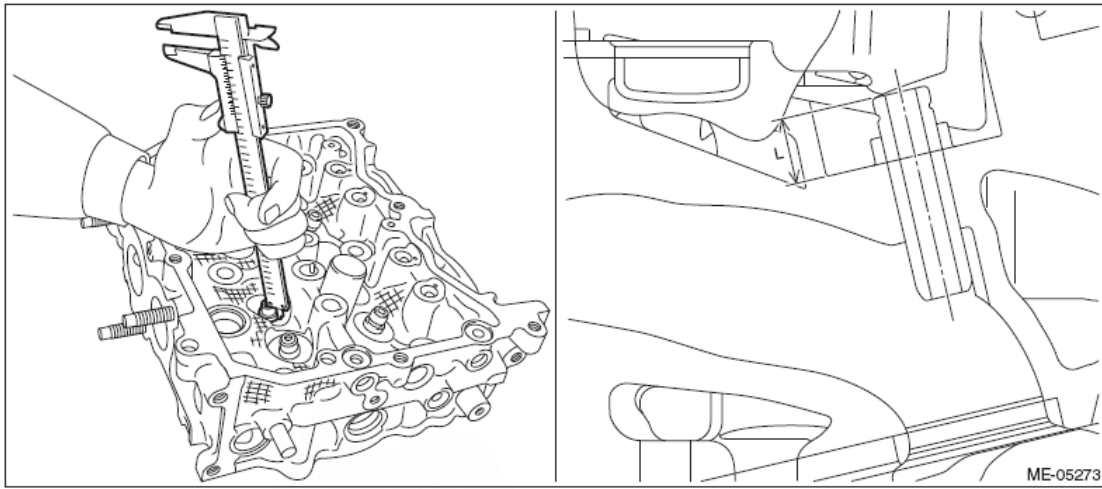
Be careful not to tap-in excessively by repeating the steps of Tapping-in --> Measurement --> Tapping-in --> Measurement... when installing the valve guide.

## ST 499765700 VALVE GUIDE REMOVER AND INSTALLER

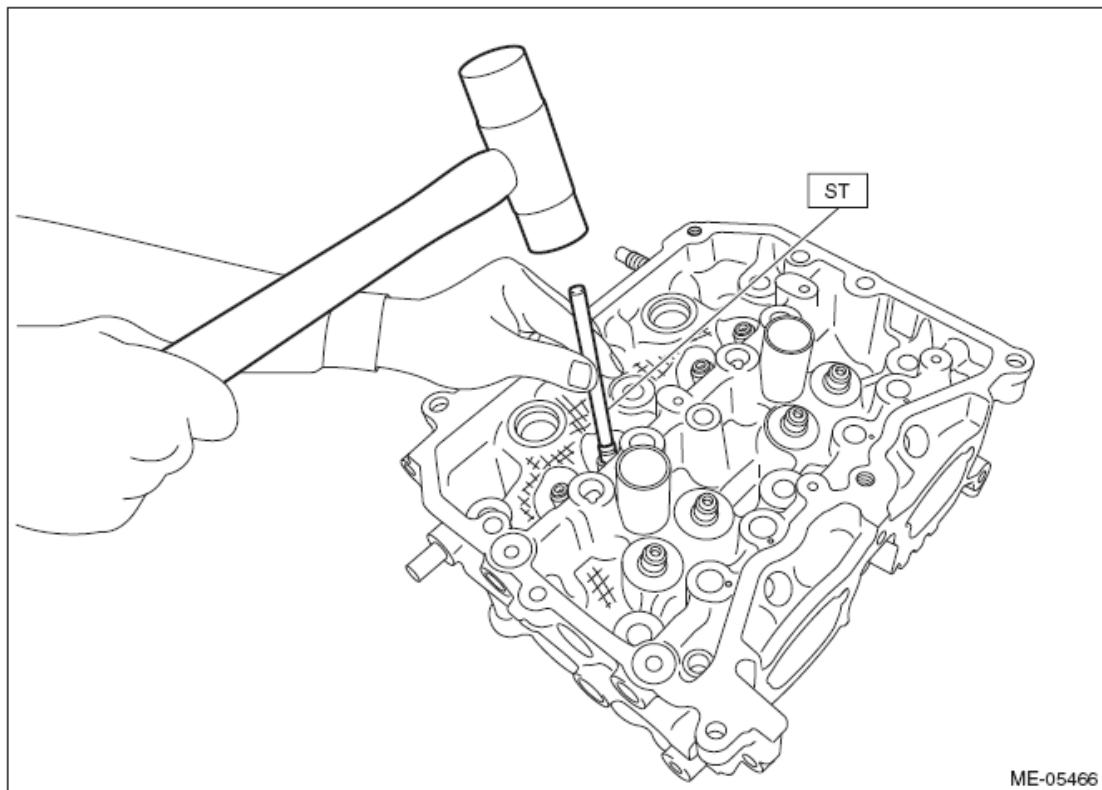
*Valve guide protrusion amount L:*

*Standard*

*11.4 - 11.8 mm (0.449 - 0.465 in)*



**Fig. 323: Measuring Valve Guide Protrusion Length**  
Courtesy of SUBARU OF AMERICA, INC.



**Fig. 324: Pressing To Fitting Valve Guide To Position**  
Courtesy of SUBARU OF AMERICA, INC.

7. Ream the inside of valve guide with the combustion chamber upward using ST. Put the ST in valve guide, and rotate the ST slowly clockwise while pushing it lightly. Bring the ST back while rotating

it clockwise.

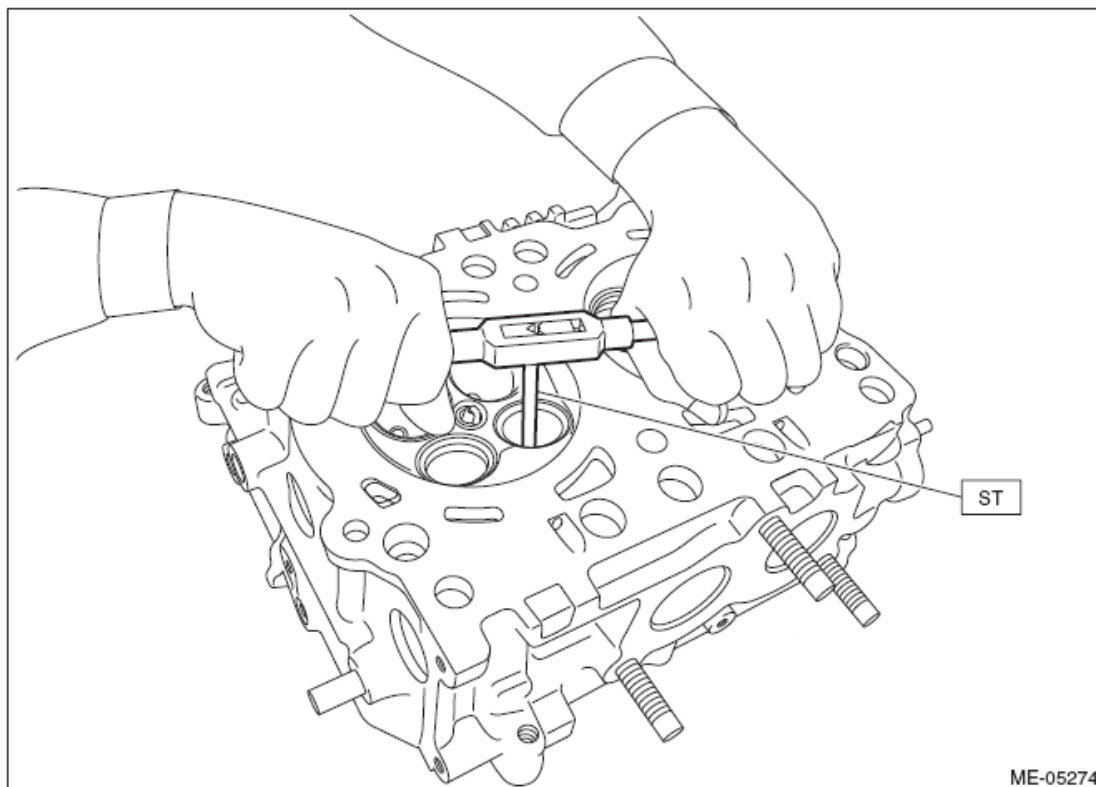
**CAUTION:**

- Place a wood board wrapped with a waste cloth to stabilize the cylinder head before work.
- Use special care not to damage the cylinder head during work.

**NOTE:**

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

ST 499765900 VALVE GUIDE REAMER



**Fig. 325: Reaming Inside Of Valve Guide With Combustion Chamber Using Valve Guide Reamer**

**Courtesy of SUBARU OF AMERICA, INC.**

8. After reaming, clean the valve guide to remove chips.
9. Recheck the contact condition between valve and valve seat after replacing the valve guide.

**INTAKE VALVE AND EXHAUST VALVE**

1. Check the valve flange and valve stem for damage, wear or deformation.
2. Check the height "H" in the figure using a caliper gauge. If it is not within the standard, replace the valve.

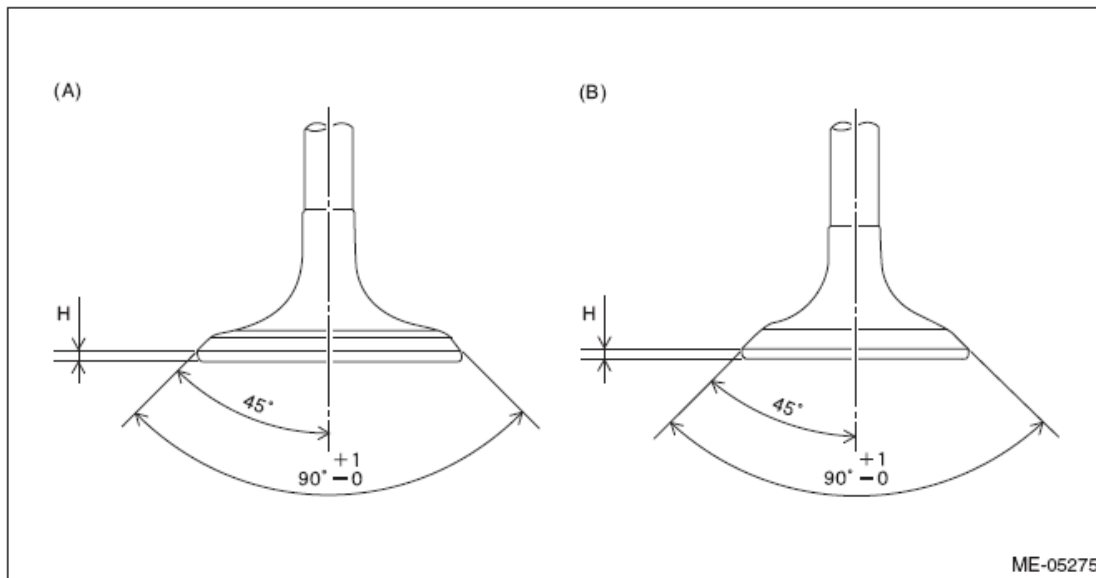
**NOTE:**

- It is possible to differentiate between the intake valve and the exhaust valve by their overall length.

***Valve overall length:******Intake******103.3 mm (4.067 in)******Exhaust******94.1 mm (3.705 in)***

- If the valve is replaced, put a small amount of grinding compound on the valve seat surface of cylinder head, and lap the valve and valve seat surfaces.

***Head edge thickness H:******Intake (A)******Standard******0.8 - 1.2 mm (0.031 - 0.047 in)******Exhaust (B)******Standard******1.0 - 1.4 mm (0.039 - 0.055 in)***

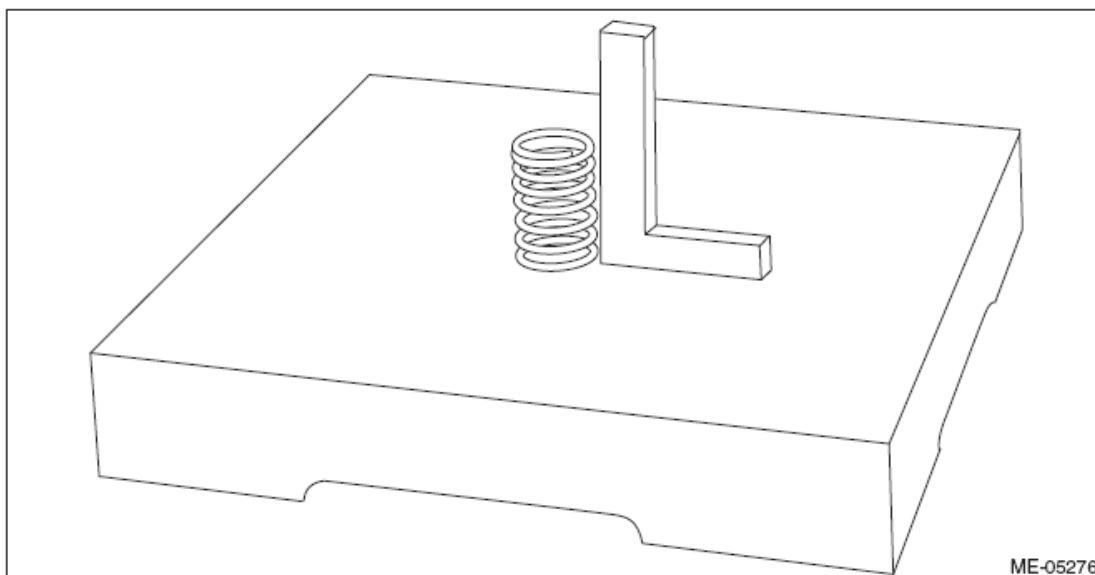


**Fig. 326: Identifying Intake Valve And Exhaust Valve Dimension**  
Courtesy of SUBARU OF AMERICA, INC.

#### VALVE SPRING

1. Check the valve spring for damage and deformation.
2. Check the valve spring free length, tension and squareness. If it is not within the standard, replace the valve spring.

**NOTE:** To check the squareness of the valve spring, stand the valve spring on a surface plate and check its deflection at the top of the valve spring using a try square.



**Fig. 327: Checking Valve Spring Free Length, Tension And Squareness**  
Courtesy of SUBARU OF AMERICA, INC.

***Free length:***

***Standard***

***41.06 mm (1.617 in)***

***Tension/spring height:***

***Set***

***Standard***

***182 - 210 N (18.56 - 21.41 kgf, 40.92 - 47.22 lbf)/33.0 mm (1.299 in)***

***Lift***

***Standard***

***552 - 610 N (56.29 - 62.20 kgf, 124.11 - 137.15 lbf)/22.0 mm (0.866 in)***

***Squareness:***

***Standard***

***2.5°, 1.8 mm (0.071 in) or less***

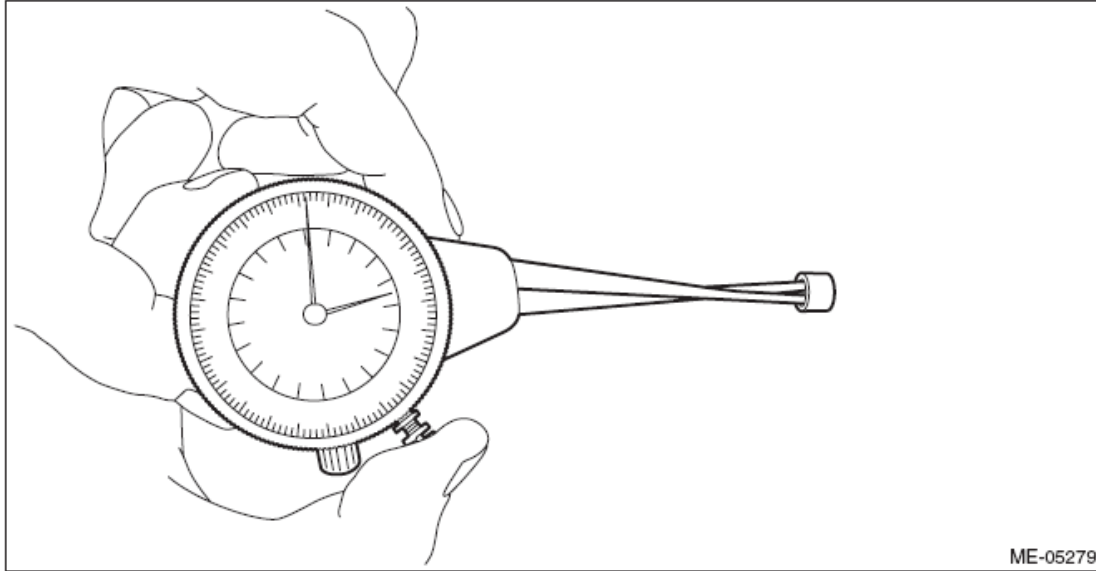
**VALVE SHIM**

1. Visually check the valve shim for damage.
2. Check the clearance between valve shim and valve stem end. Check the clearance between valve shim and valve stem end by measuring the inner diameter of valve shim and the outer diameter of valve stem end respectively.
  1. Using a caliper gauge, measure the inner diameter of valve shim. If it is not within the standard, replace the valve shim.

**NOTE:**

- **Measurement should be performed at a temperature of 20°C (68° F).**
- **If the valve shim has to be replaced, check the cam clearance and replace with the suitable valve shim. < Refer to WHEN TIMING CHAIN ASSEMBLY IS REMOVED, INSPECTION, Cam Clearance. >**

***Valve shim inner diameter:***

**Standard****5.500 - 5.560 mm (0.2165 - 0.2189 in)**

ME-05279

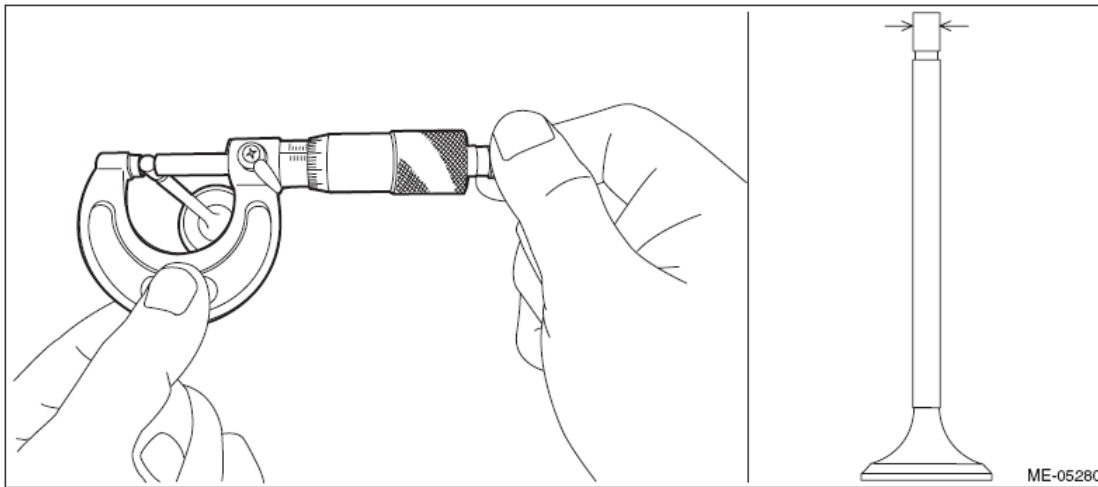
**Fig. 328: Measuring Inner Diameter Of Valve Shim Using Caliper Gauge**  
Courtesy of SUBARU OF AMERICA, INC.

2. Measure the outer diameter of valve stem end with a micrometer. If it is not within the standard, replace the valve.

**NOTE:**

- Measurement should be performed at a temperature of 20°C (68° F).
- If the valve is replaced, put a small amount of grinding compound on the valve seat surface of cylinder head, and lap the valve and valve seat surfaces.

**Valve stem end outer diameter:****Intake****Standard****5.455 - 5.470 mm (0.2148 - 0.2154 in)****Exhaust****Standard****5.445 - 5.460 mm (0.2144 - 0.2150 in)**



**Fig. 329: Measuring Outer Diameter Of Valve Stem End With Micrometer**  
Courtesy of SUBARU OF AMERICA, INC.

3. Calculate the clearance between valve shim and valve stem end. If the clearance exceeds the standard, replace the valve shim or valve, whichever shows the greater amount of wear or damage.

**NOTE:**

- If the valve is replaced, put a small amount of grinding compound on the valve seat surface of cylinder head, and lap the valve and valve seat surfaces.
- If the valve shim has to be replaced, check the cam clearance and replace with the suitable valve shim. < Refer to WHEN TIMING CHAIN ASSEMBLY IS REMOVED, INSPECTION, Cam Clearance. >

*Clearance between the valve and valve stem end:*

*Intake*

*Standard*

*0.030 - 0.105 mm (0.0012 - 0.0041 in)*

*Exhaust*

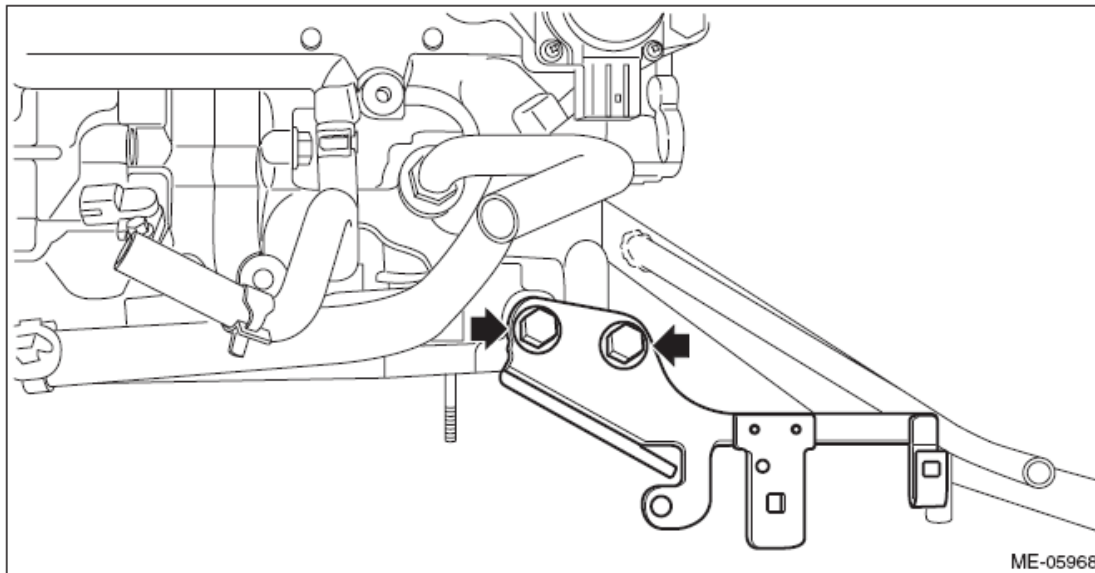
*Standard*

*0.040 - 0.115 mm (0.0016 - 0.0045 in)*

## CYLINDER BLOCK

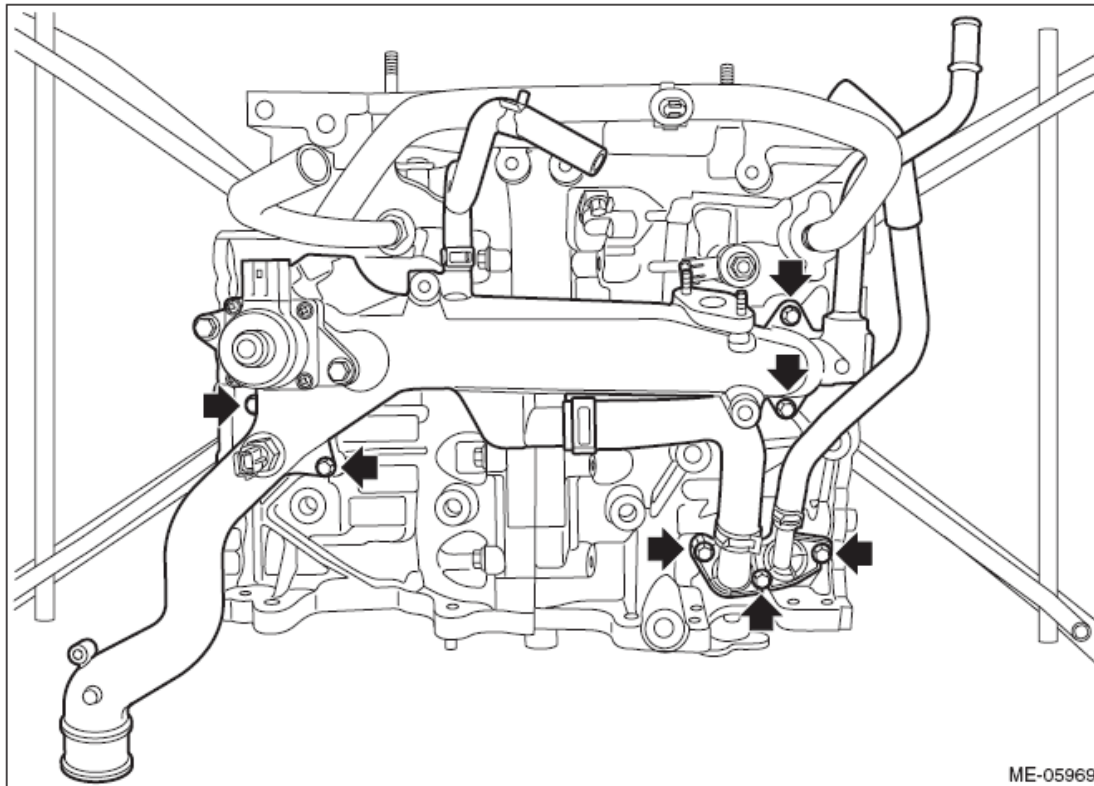
### REMOVAL

1. Remove the engine from the vehicle. < Refer to **REMOVAL**, Engine Assembly. >
2. Remove the intake manifold. < Refer to **REMOVAL** , Intake Manifold. >
3. Remove the tumble generator valve assembly. < Refer to **REMOVAL** , Tumble Generator Valve Assembly. >
4. Remove the chain cover. < Refer to **REMOVAL**, Chain Cover. >
5. Remove the rocker cover. < Refer to **REMOVAL**, Rocker Cover. >
6. Remove the cam carrier. < Refer to **REMOVAL**, Cam Carrier. >
7. Remove the cylinder head. < Refer to **REMOVAL**, Cylinder Head. >
8. Remove the crank sprocket. < Refer to **REMOVAL**, Crank Sprocket. >
9. Remove the engine rear hanger from cylinder block RH.



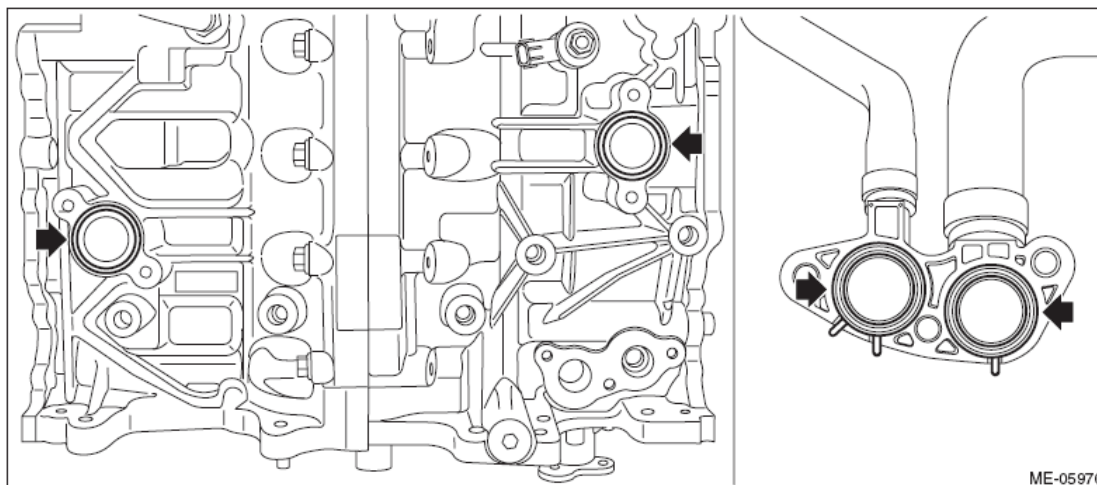
**Fig. 330: Locating Cylinder Block RH Engine Rear Hanger Mounting Bolts**  
Courtesy of SUBARU OF AMERICA, INC.

10. Remove the bolts securing the water pipe assembly and PCV connector to the cylinder block, and remove the water pipe assembly and PCV connector as a set from cylinder block.



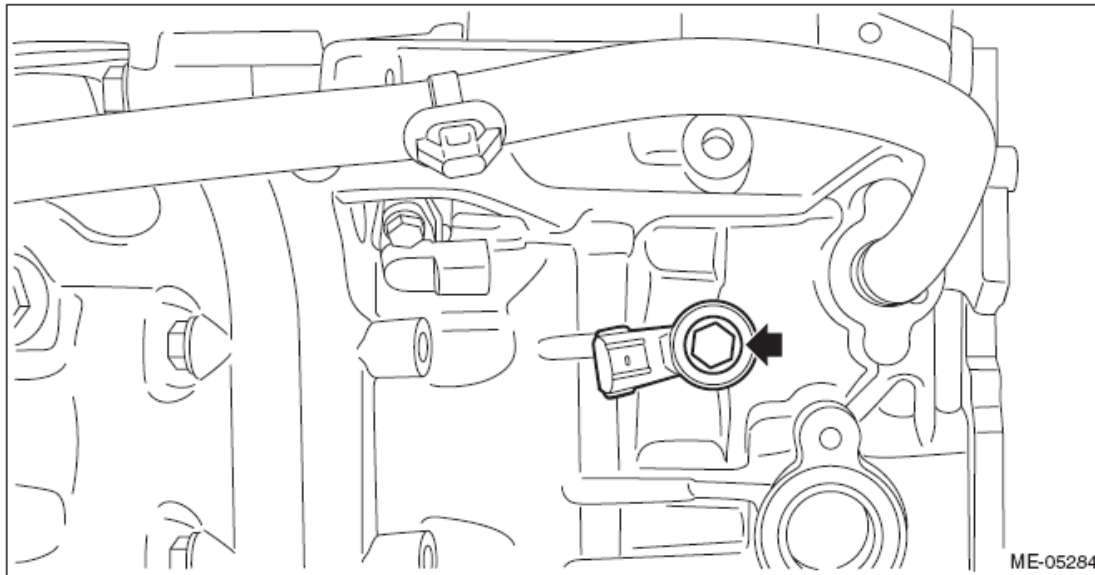
**Fig. 331: Locating Water Pipe Assembly And PCV Connector Mounting Bolts**  
 Courtesy of SUBARU OF AMERICA, INC.

11. Remove the O-ring from the cylinder block and PCV connector.



**Fig. 332: Locating Cylinder Block And PCV Connector O-Rings**  
 Courtesy of SUBARU OF AMERICA, INC.

12. Remove the knock sensor from cylinder block LH.

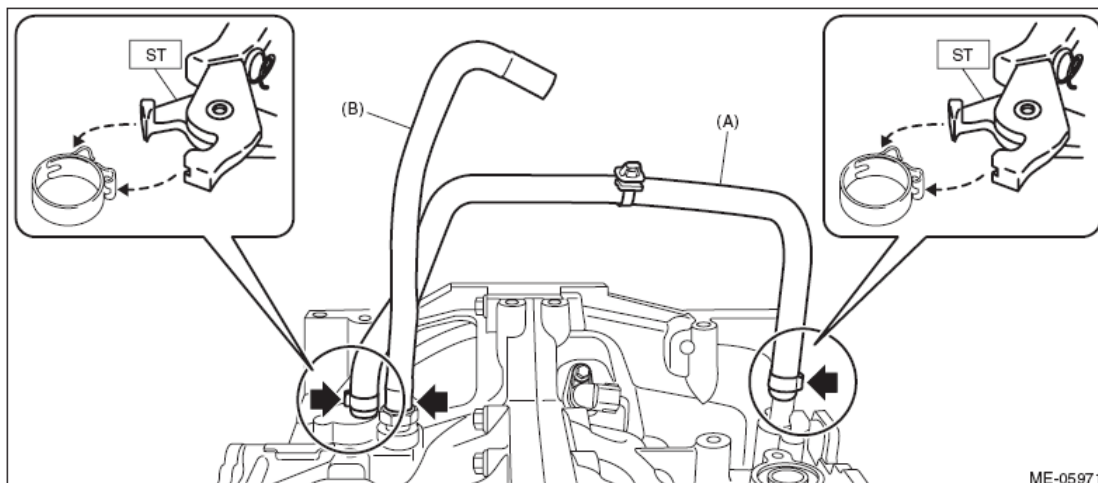


**Fig. 333: Locating Knock Sensor Of Cylinder Block LH**  
Courtesy of SUBARU OF AMERICA, INC.

13. Remove the PCV hose assembly (A) and the vacuum hose (B) from cylinder block and PCV valve.

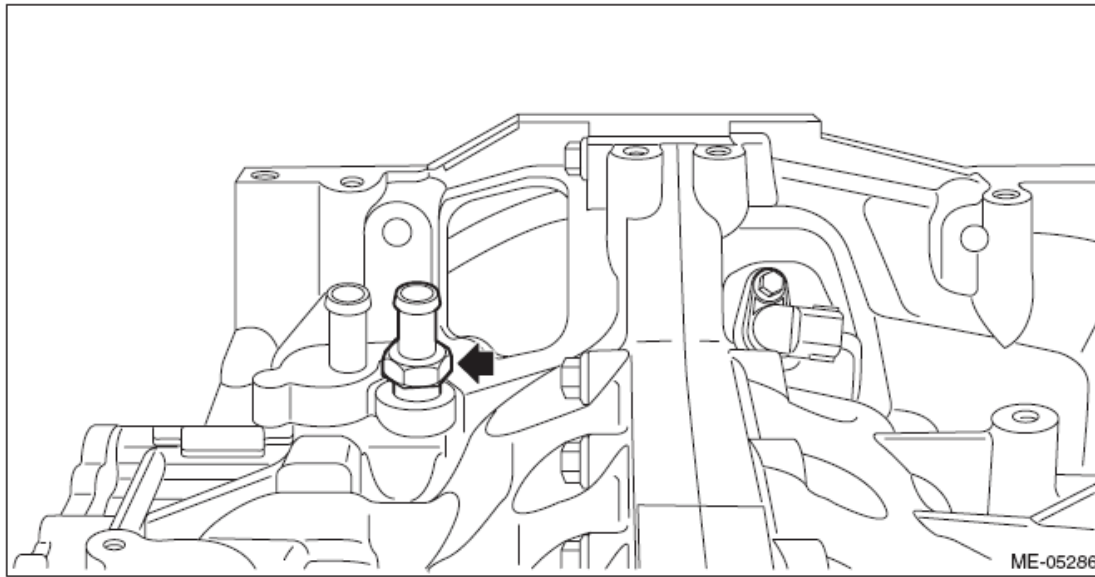
**NOTE:** Pinch the clamp of the PCV hose assembly (A) by fitting the cut out in the ST with the protrusion on the clamp as shown in the figure, and unlock the clamp.

ST 18353AA000 CLAMP PLIERS



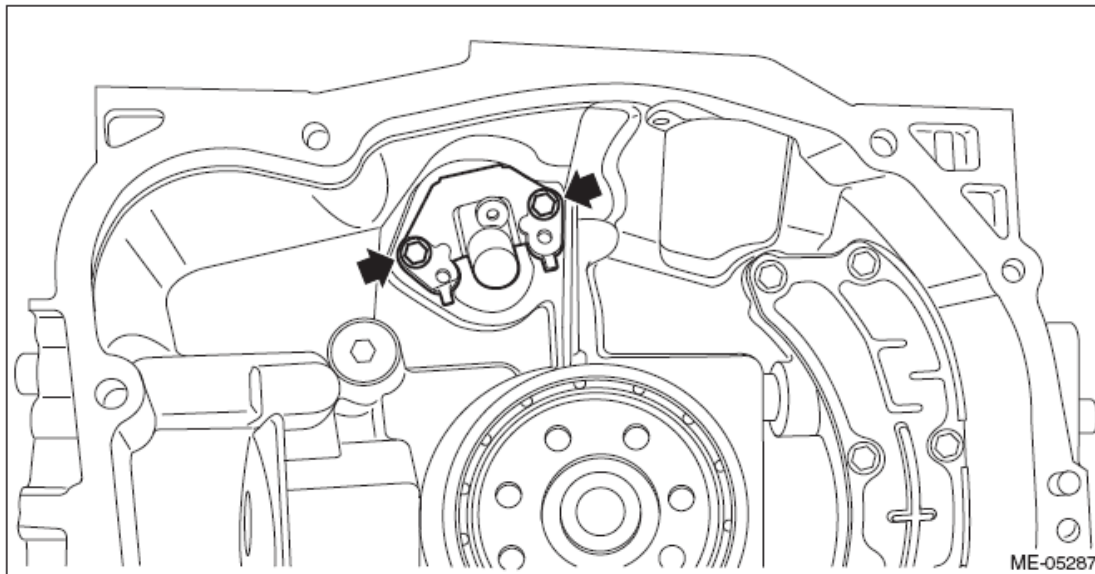
**Fig. 334: Removing/Installing PCV Hose Assembly And Vacuum Hose Clamps**  
Courtesy of SUBARU OF AMERICA, INC.

14. Remove the PCV valve from the cylinder block RH.



**Fig. 335: Locating Cylinder Block RH PCV Valve**  
Courtesy of SUBARU OF AMERICA, INC.

15. Remove the crankshaft position sensor plate with drive plate. (AT model) < Refer to **REMOVAL** , Drive Plate. >
16. Remove the clutch disc and cover. (MT model) < Refer to **REMOVAL** , Clutch Disc and Cover. >
17. Remove the crankshaft position sensor plate with flywheel. (MT model) < Refer to **REMOVAL** , Flywheel. >
18. Remove the bolts securing the crankshaft position sensor holder from the cylinder block LH, and remove the crankshaft position sensor with crankshaft position sensor holder.



**Fig. 336: Locating Crankshaft Position Sensor Holder Mounting Bolts**  
Courtesy of SUBARU OF AMERICA, INC.

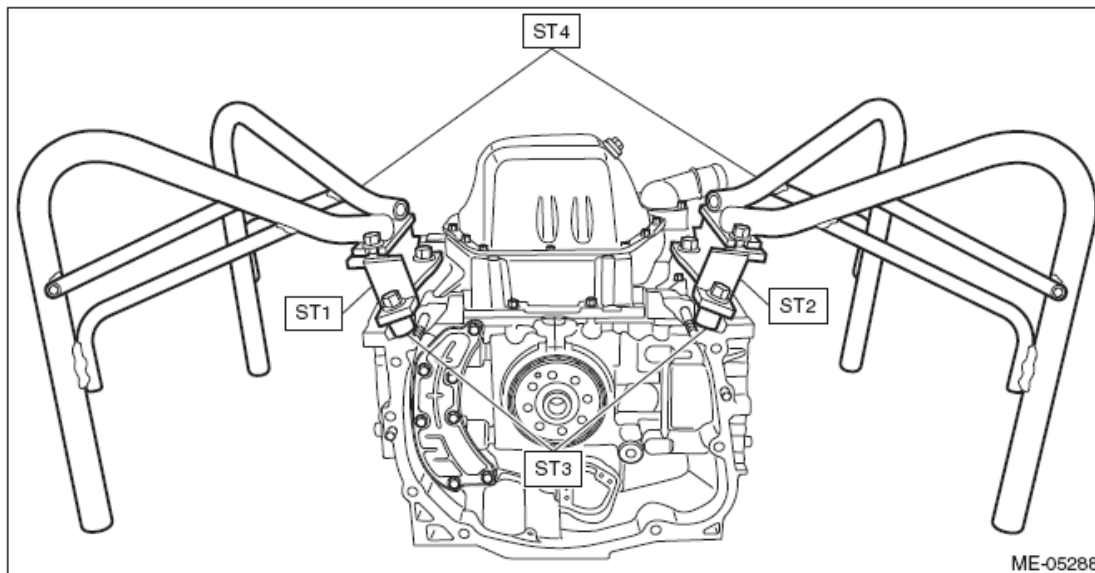
19. Set the cylinder block so that the oil pan is on the upper side, remove the ST1, ST2, ST3 and ST4 from cylinder block and oil pan upper.

ST1 498457000 ENGINE STAND ADAPTER RH

ST2 498457100 ENGINE STAND ADAPTER LH

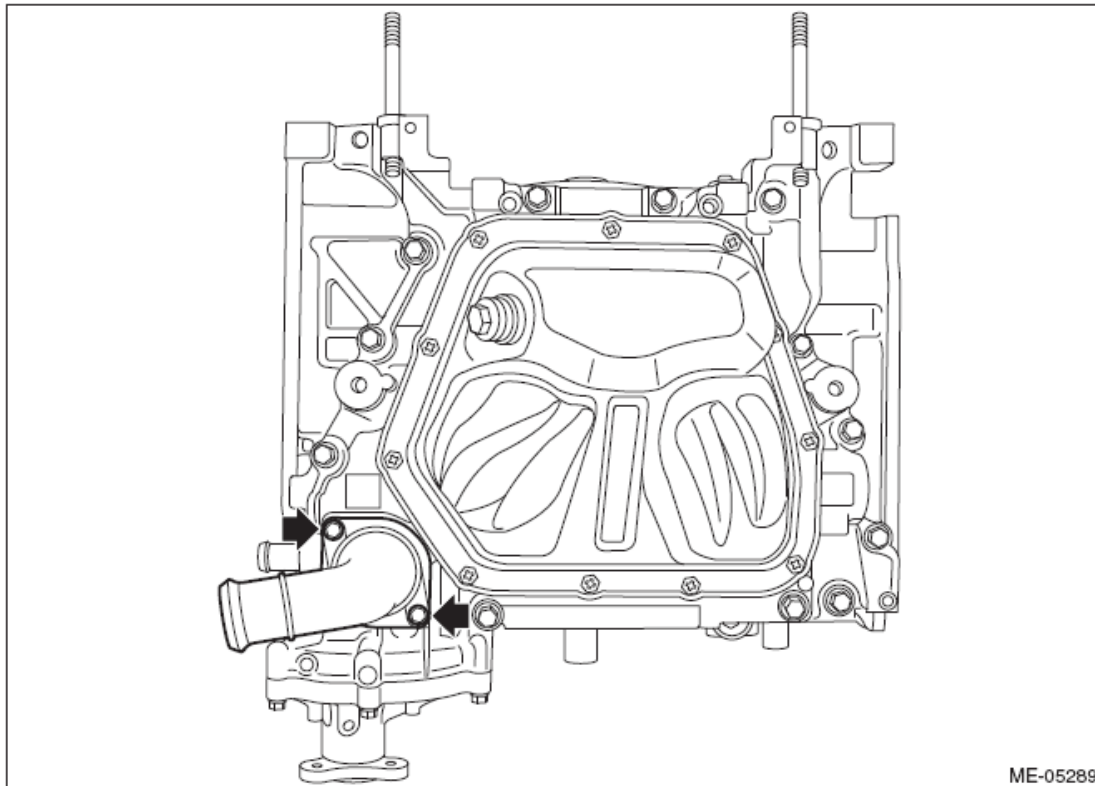
ST3 18362AA020 ADAPTER

ST4 499817100 ENGINE STAND



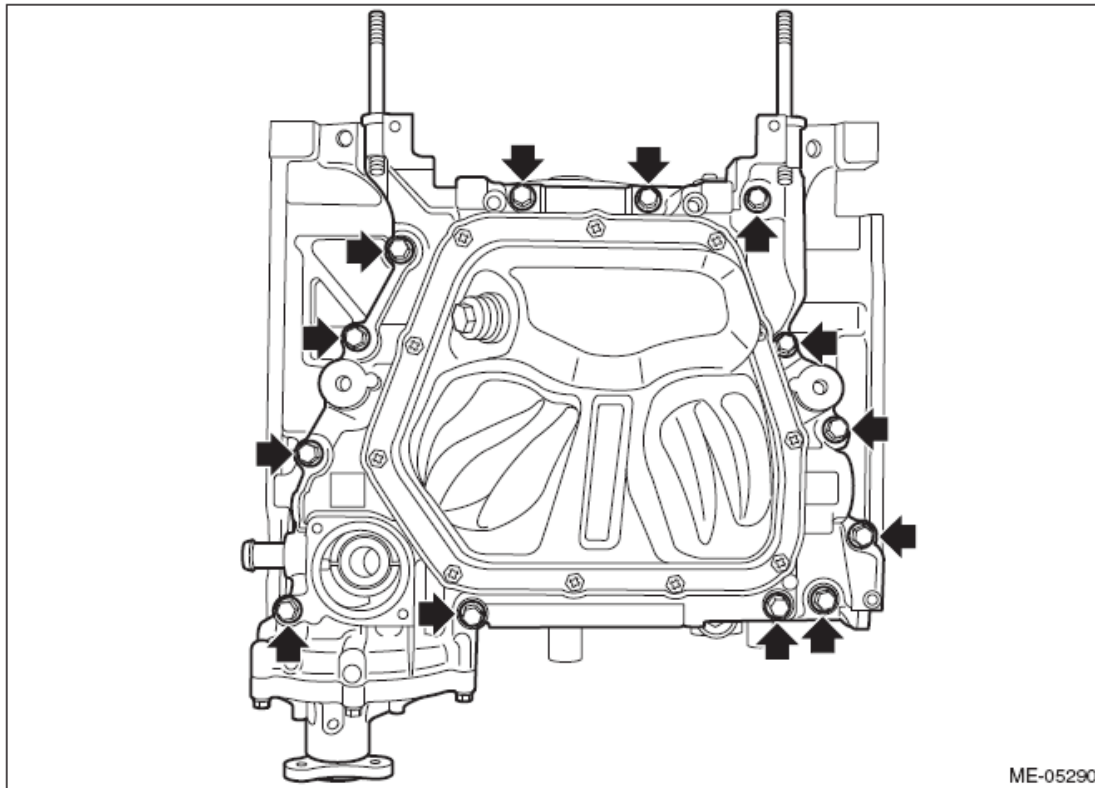
**Fig. 337: Removing ST1, ST2, ST3 And ST4 From Cylinder Block And Oil Pan Upper**  
Courtesy of SUBARU OF AMERICA, INC.

20. Remove the thermostat cover from oil pan upper, and then remove the thermostat.



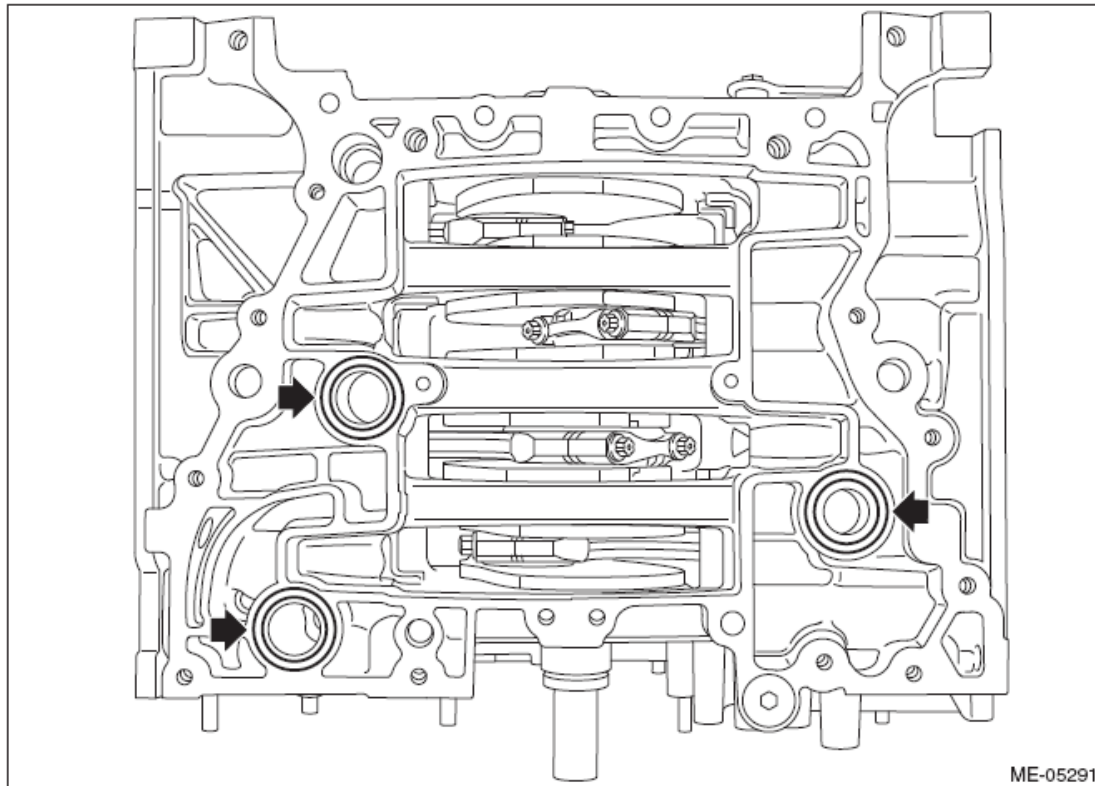
**Fig. 338: Locating Thermostat Cover Mounting Bolts**  
Courtesy of SUBARU OF AMERICA, INC.

21. Remove the oil pan upper with oil pan from cylinder block.



**Fig. 339: Locating Cylinder Block Oil Pan Upper Mounting Bolts**  
Courtesy of SUBARU OF AMERICA, INC.

22. Remove the O-ring from the cylinder block.

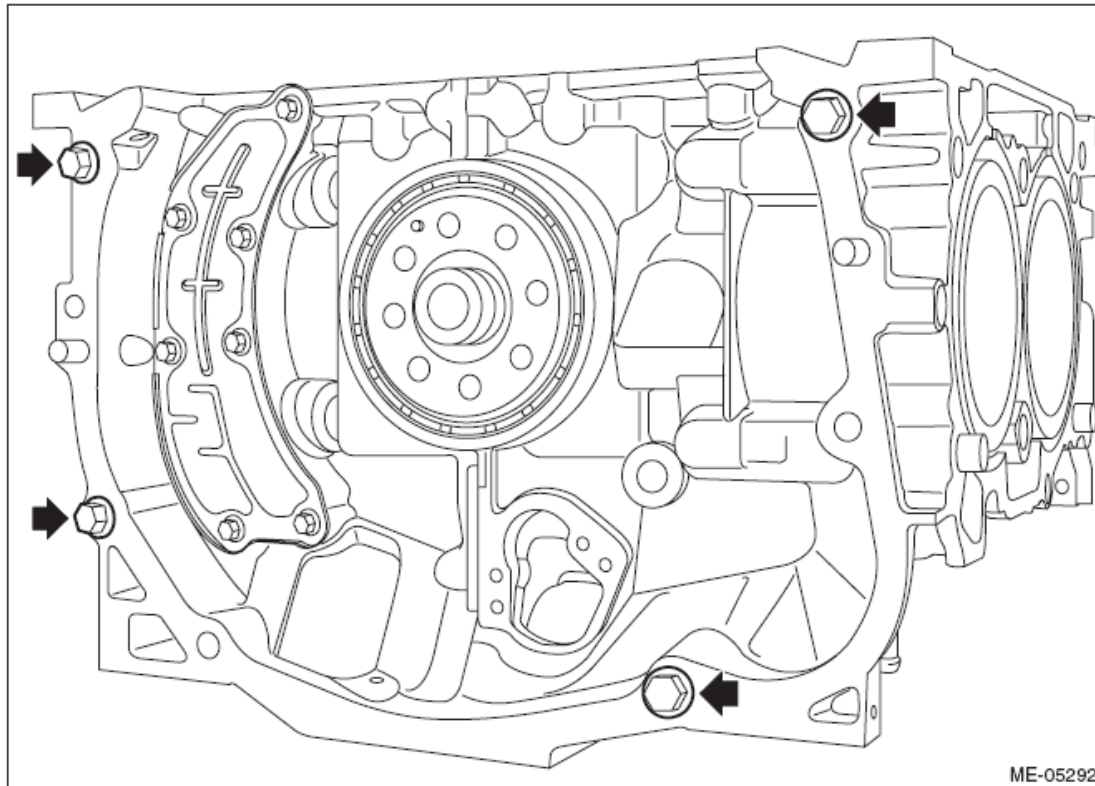


**Fig. 340: Locating Cylinder Block O-Rings**  
Courtesy of SUBARU OF AMERICA, INC.

23. Install the A/C compressor bracket bolts and the power steering pump bracket bolts at the locations shown in the figure.

**NOTE:**

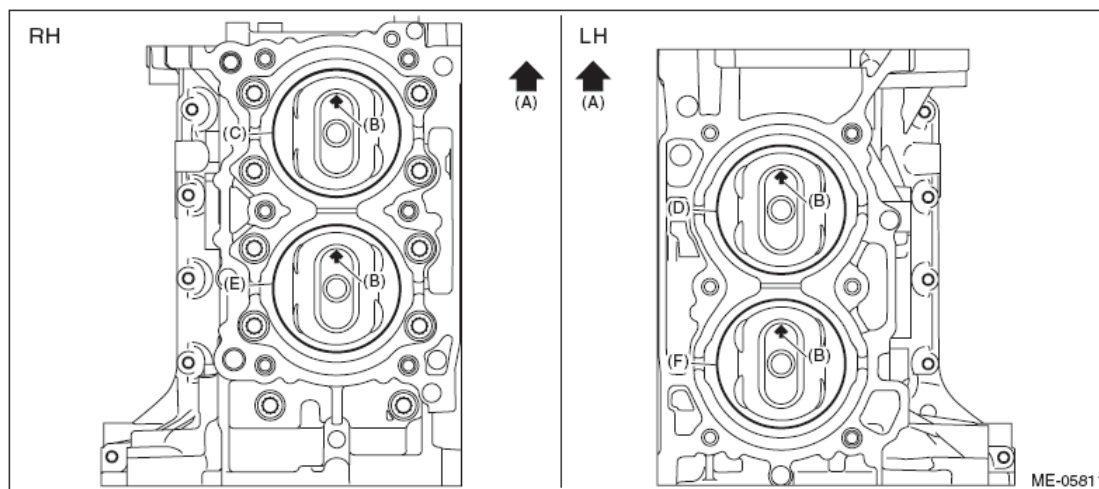
- This procedure is required to prevent the knock pin damage when the cylinder block is raised in the next step.
- Use the same length bolt for the four bolts.



ME-05292

**Fig. 341: Locating A/C Compressor Bracket Bolts And Power Steering Pump Bracket Bolts**  
Courtesy of SUBARU OF AMERICA, INC.

24. Raise the cylinder block so that the rear oil seal is on the lower side.
25. Add a front mark on the piston using a marker as shown in the figure.



ME-05811

(A) Front of engine  
(B) Front mark

(C) # 1 piston  
(D) # 2 piston

(E) # 3 piston  
(F) # 4 piston

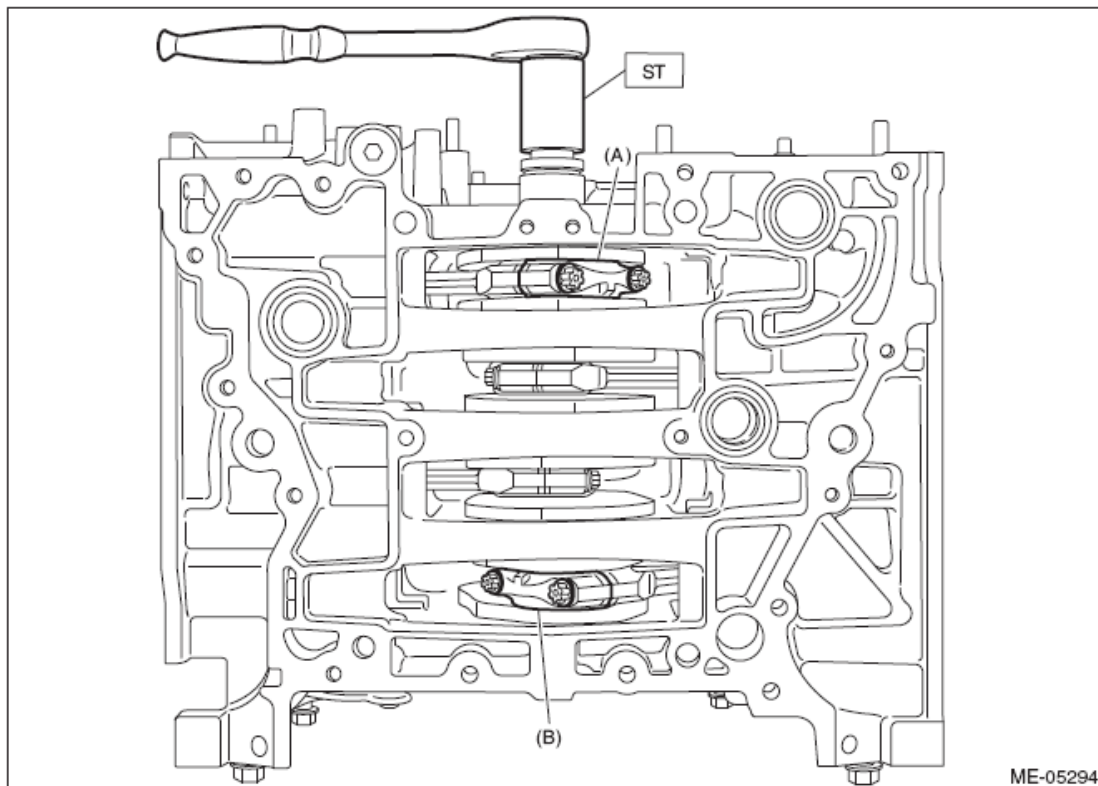
**Fig. 342: Identifying Piston Front Mark**  
Courtesy of SUBARU OF AMERICA, INC.

26. Remove the #1 and #4 connecting rod caps and pistons from the cylinder block.

**NOTE:** Mark each connecting rod cap and piston with a cylinder number.

1. Turn the crankshaft so that the #1 connecting rod cap (A) and #4 connecting rod cap (B) is located at the position shown in the figure using ST.

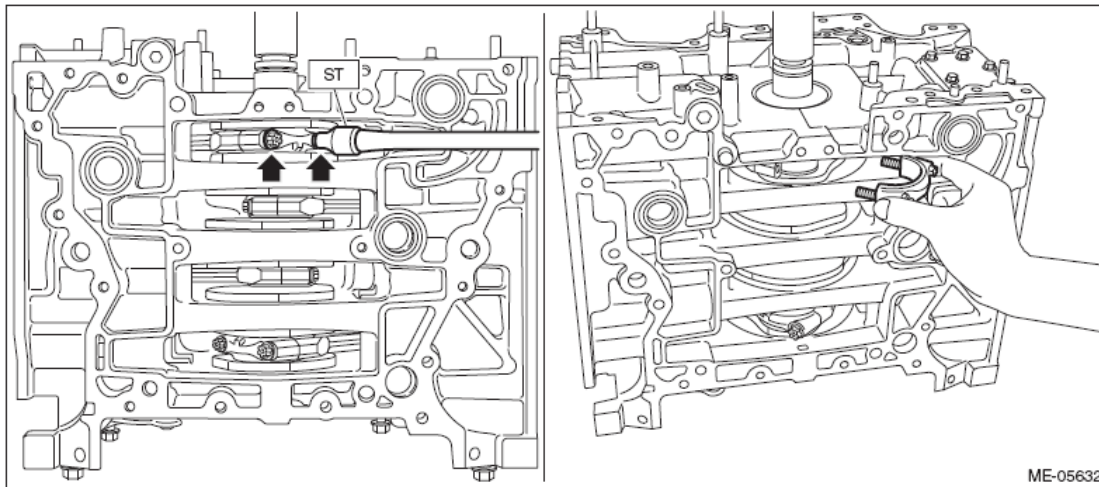
ST 18252AA000 CRANKSHAFT SOCKET



**Fig. 343: Turning Crankshaft Using Crankshaft Socket**  
Courtesy of SUBARU OF AMERICA, INC.

2. Using ST, loosen the #1 connecting rod cap bolt, and remove the #1 connecting rod cap bolt and #1 connecting rod cap.

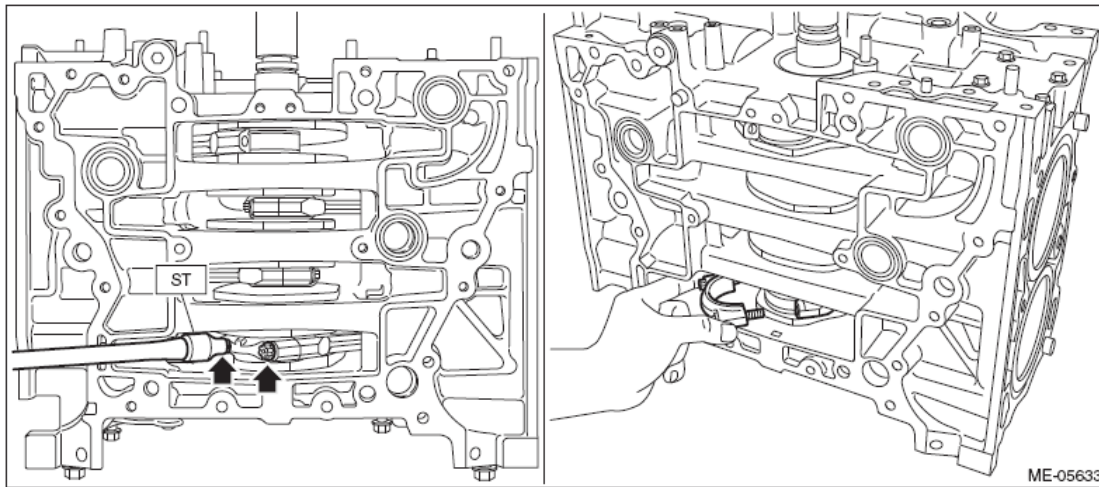
ST 18270AA020 SOCKET



**Fig. 344: Removing No. 1 Connecting Rod Cap And Bolt**  
Courtesy of SUBARU OF AMERICA, INC.

3. Using ST, loosen the #4 connecting rod cap bolt, and remove the #4 connecting rod cap bolt and #4 connecting rod cap.

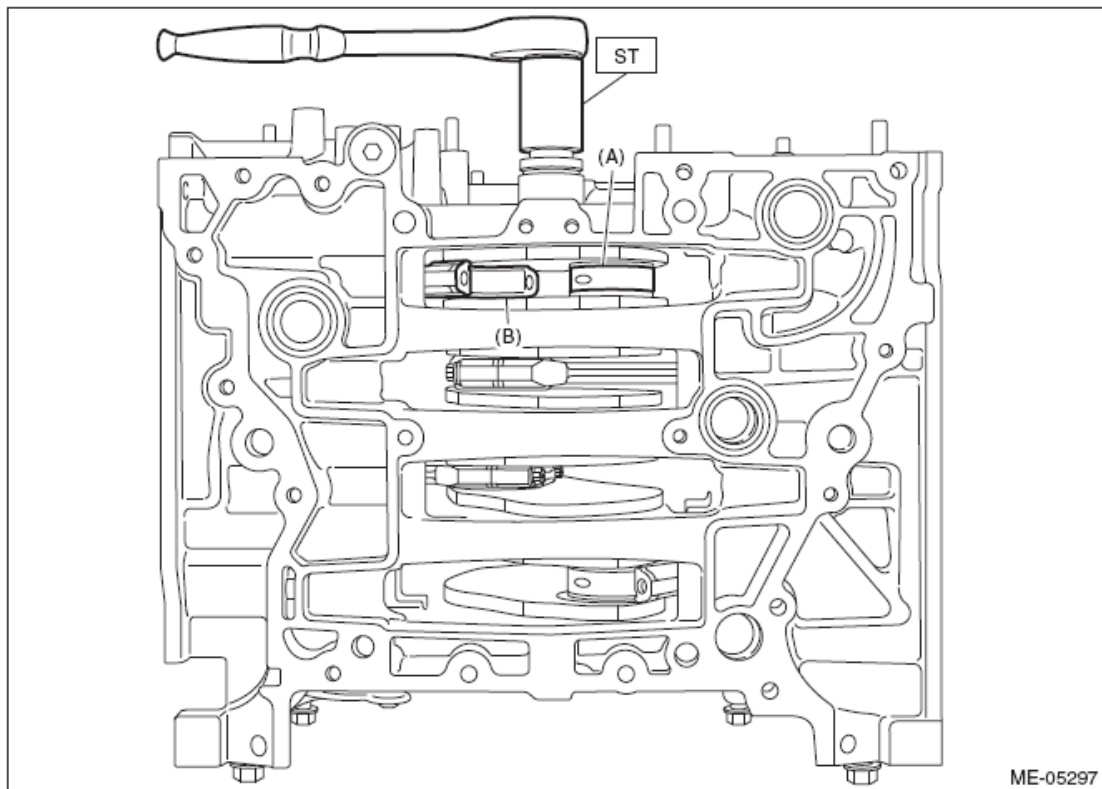
ST 18270AA020 SOCKET



**Fig. 345: Removing No. 4 Connecting Rod Cap**  
Courtesy of SUBARU OF AMERICA, INC.

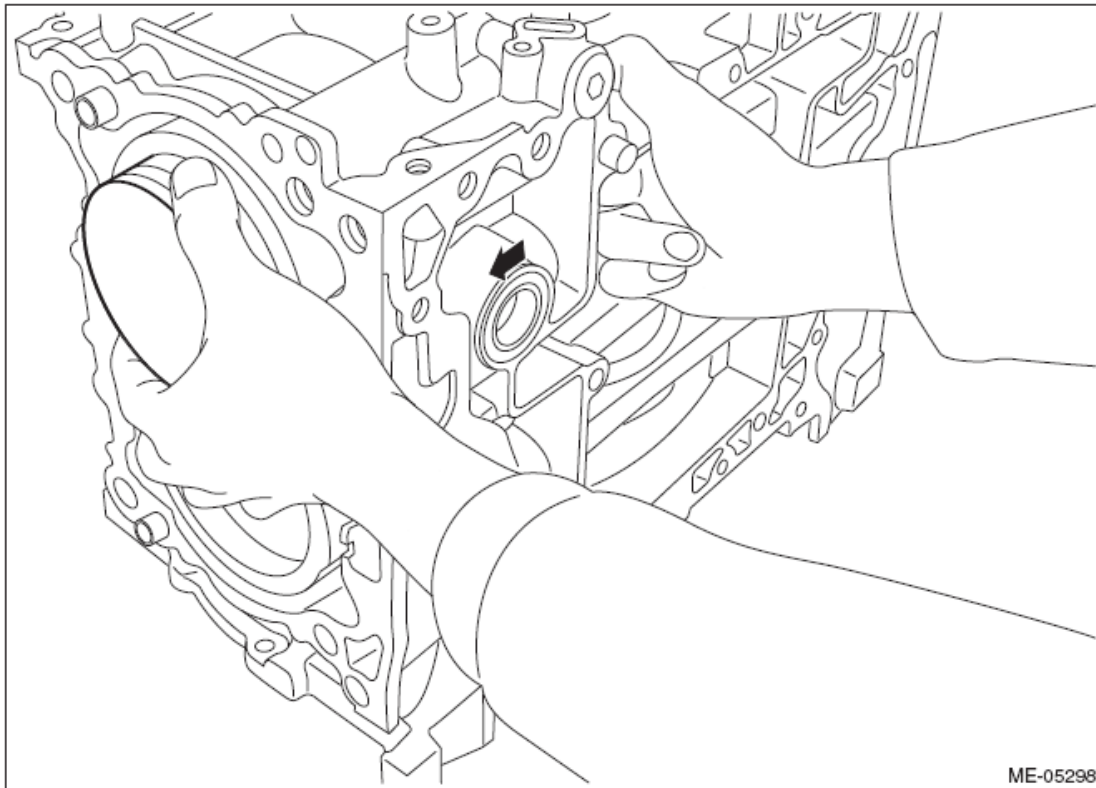
4. Using the ST, turn the crankshaft clockwise and separate the positions of the #1 crank pin (A) and the large end of the #1 connecting rod (B).

ST 18252AA000 CRANKSHAFT SOCKET



**Fig. 346: Turning Crankshaft Using Crankshaft Socket**  
Courtesy of SUBARU OF AMERICA, INC.

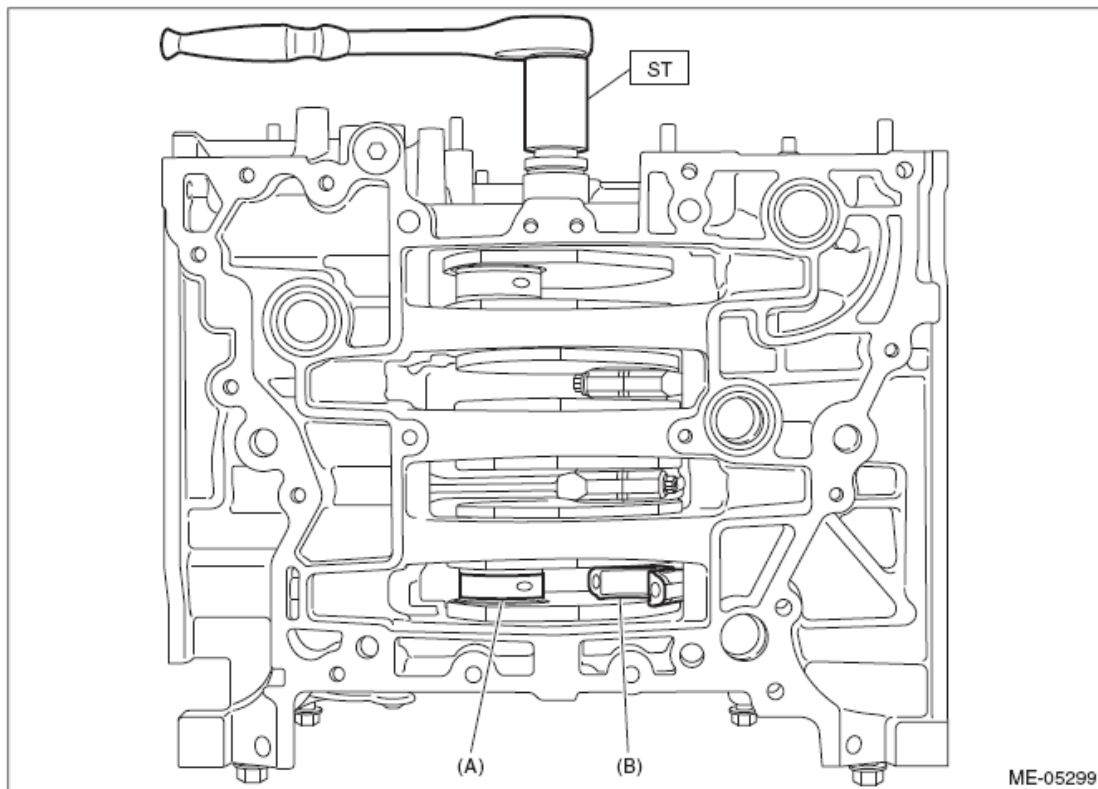
5. Push the #1 connecting rod in the direction of the arrow, and remove the #1 piston with #1 connecting rod from the cylinder block.



**Fig. 347: Removing No. 1 Piston And No. 1 Connecting Rod From Cylinder Block**  
Courtesy of SUBARU OF AMERICA, INC.

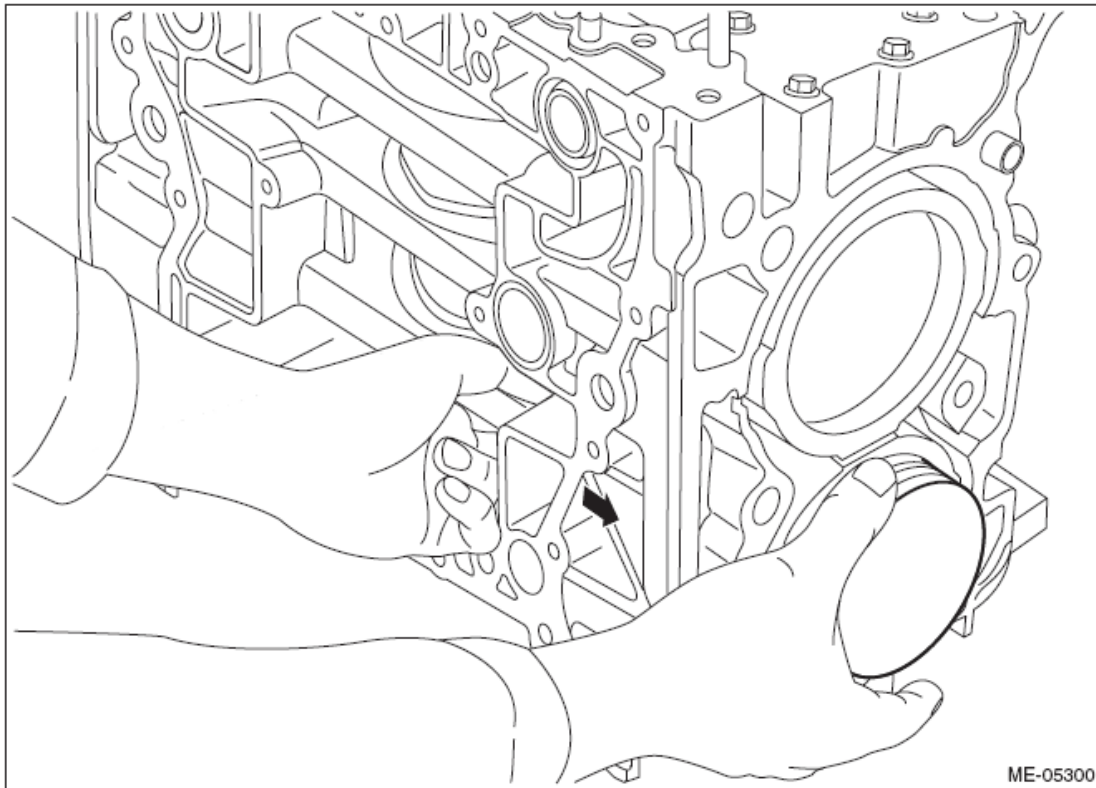
6. Using the ST, turn the crankshaft counterclockwise and separate the positions of the #4 crank pin (A) and the large end of the #4 connecting rod (B).

ST 18252AA000 CRANKSHAFT SOCKET



**Fig. 348: Aligning No. 4 Crank Pin And Large End Of No. 4 Connecting Rod Using Crankshaft Socket**  
Courtesy of SUBARU OF AMERICA, INC.

7. Push the #4 connecting rod in the direction of the arrow, and remove the #4 piston with #4 connecting rod from the cylinder block.



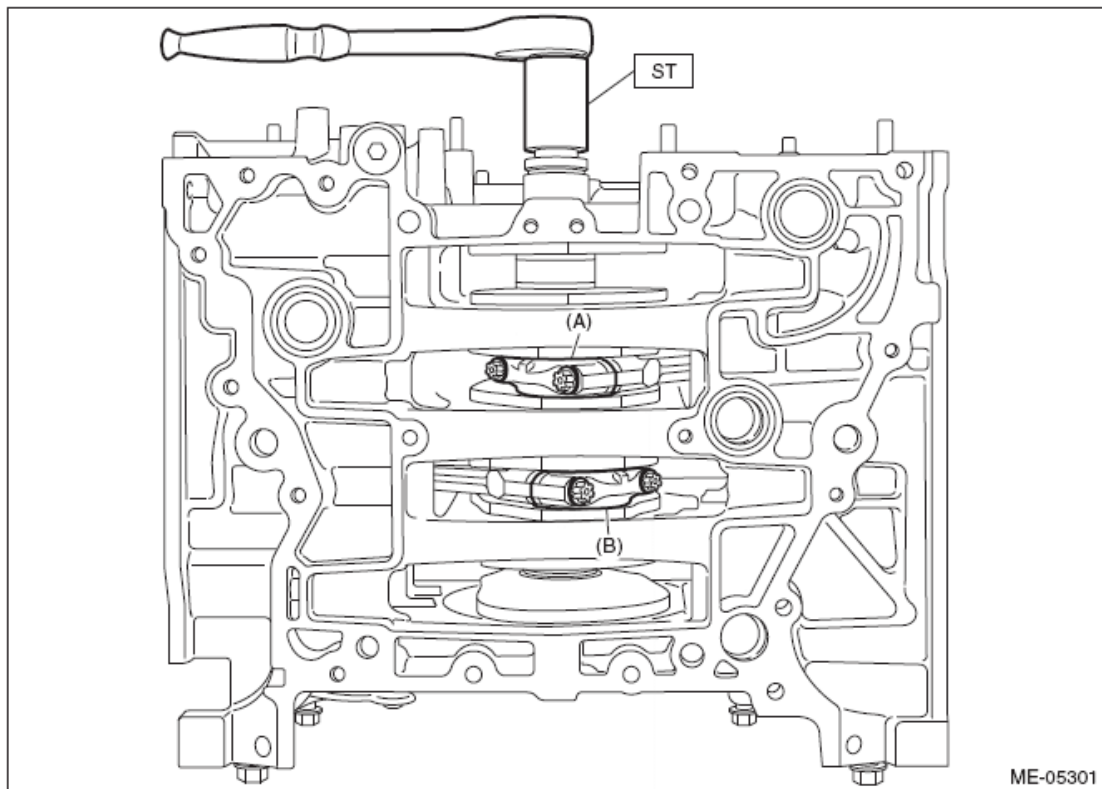
**Fig. 349: Removing No. 4 Piston And No. 4 Connecting Rod From Cylinder Block**  
Courtesy of SUBARU OF AMERICA, INC.

27. Remove the #2 and #3 connecting rod caps and pistons from the cylinder block.

**NOTE:** Mark each connecting rod cap and piston with a cylinder number.

1. Turn the crankshaft so that the #2 connecting rod cap (A) and #3 connecting rod cap (B) is located at the position shown in the figure using ST.

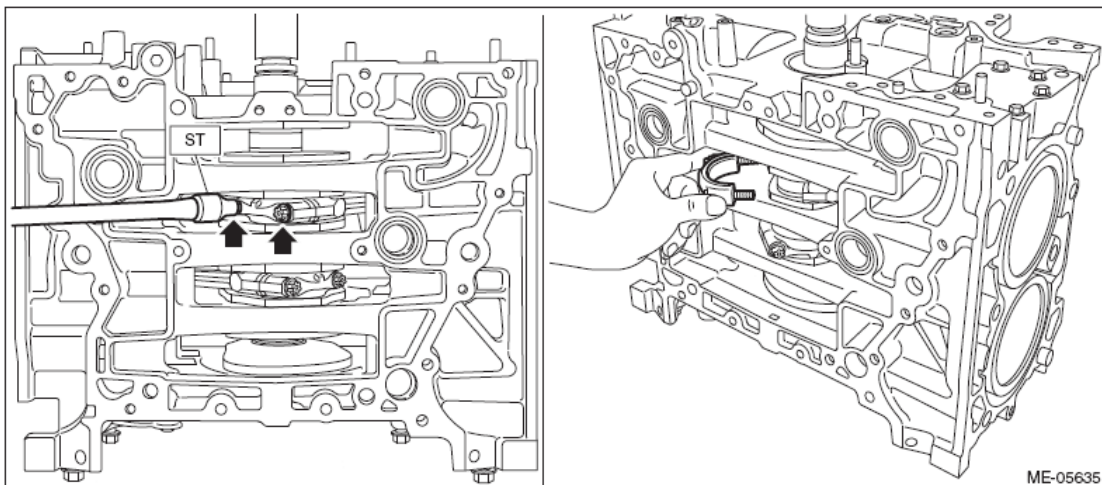
ST 18252AA000 CRANKSHAFT SOCKET



**Fig. 350: Turning Crankshaft Using Crankshaft Socket**  
Courtesy of SUBARU OF AMERICA, INC.

2. Using ST, loosen the #2 connecting rod cap bolt, and remove the #2 connecting rod cap bolt and #2 connecting rod cap.

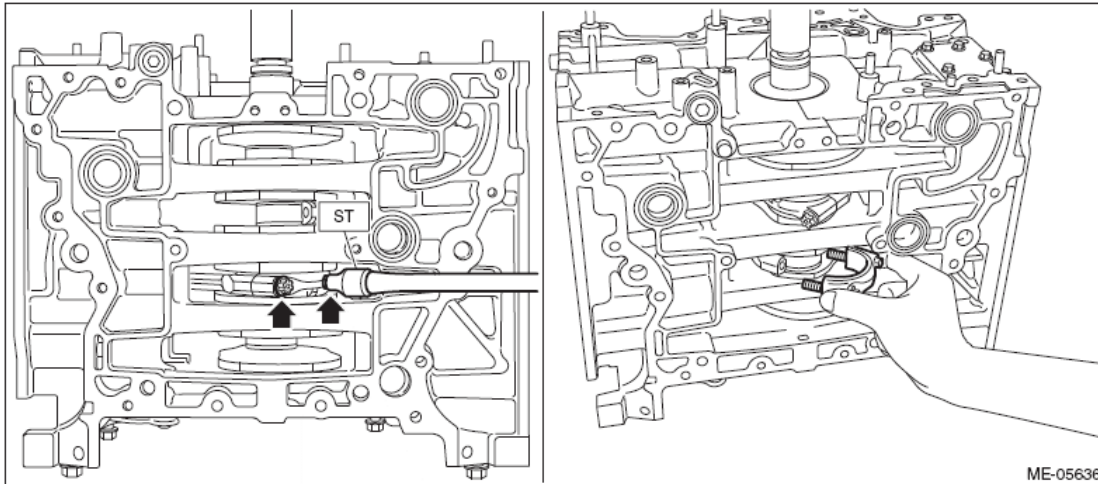
ST 18270AA020 SOCKET



**Fig. 351: Removing No. 2 Connecting Rod Cap**  
Courtesy of SUBARU OF AMERICA, INC.

3. Using ST, loosen the #3 connecting rod cap bolt, and remove the #3 connecting rod cap bolt and #3 connecting rod cap.

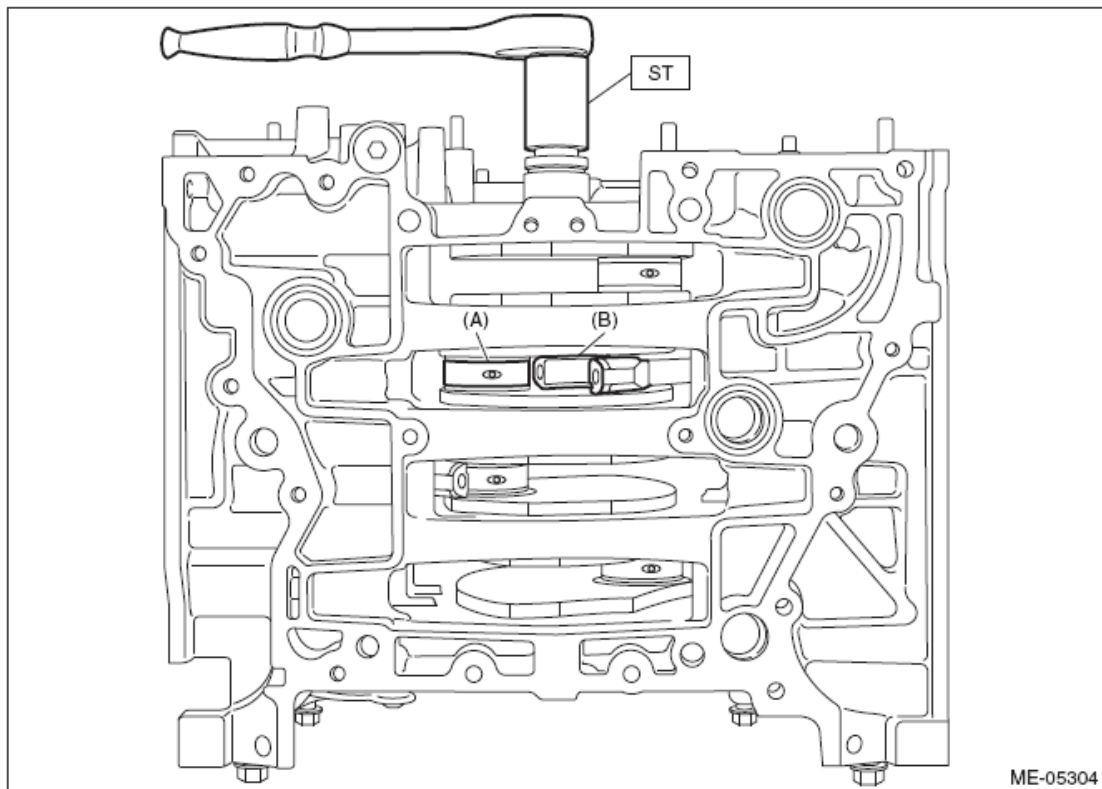
ST 18270AA020 SOCKET



**Fig. 352: Removing No. 3 Connecting Rod Cap**  
Courtesy of SUBARU OF AMERICA, INC.

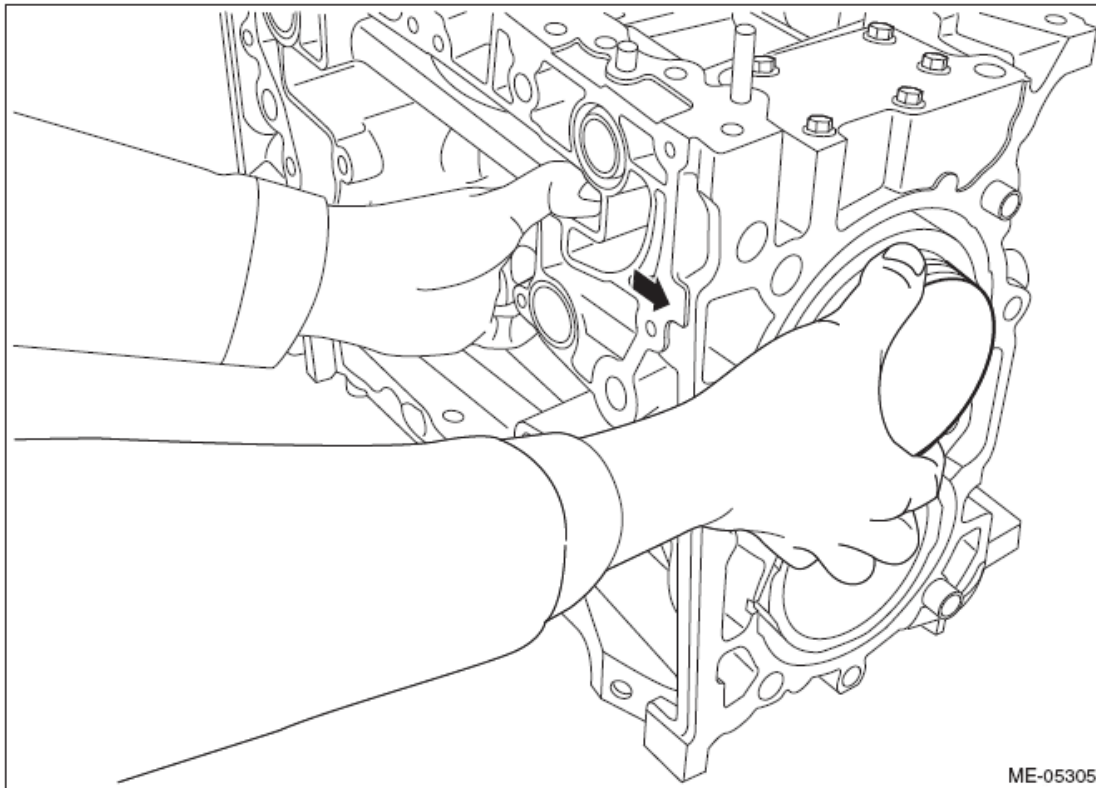
4. Using the ST, turn the crankshaft counterclockwise and separate the positions of the #2 crank pin (A) and the large end of the #2 connecting rod (B).

ST 18252AA000 CRANKSHAFT SOCKET



**Fig. 353: Turning Crankshaft Counterclockwise Using ST**  
**Courtesy of SUBARU OF AMERICA, INC.**

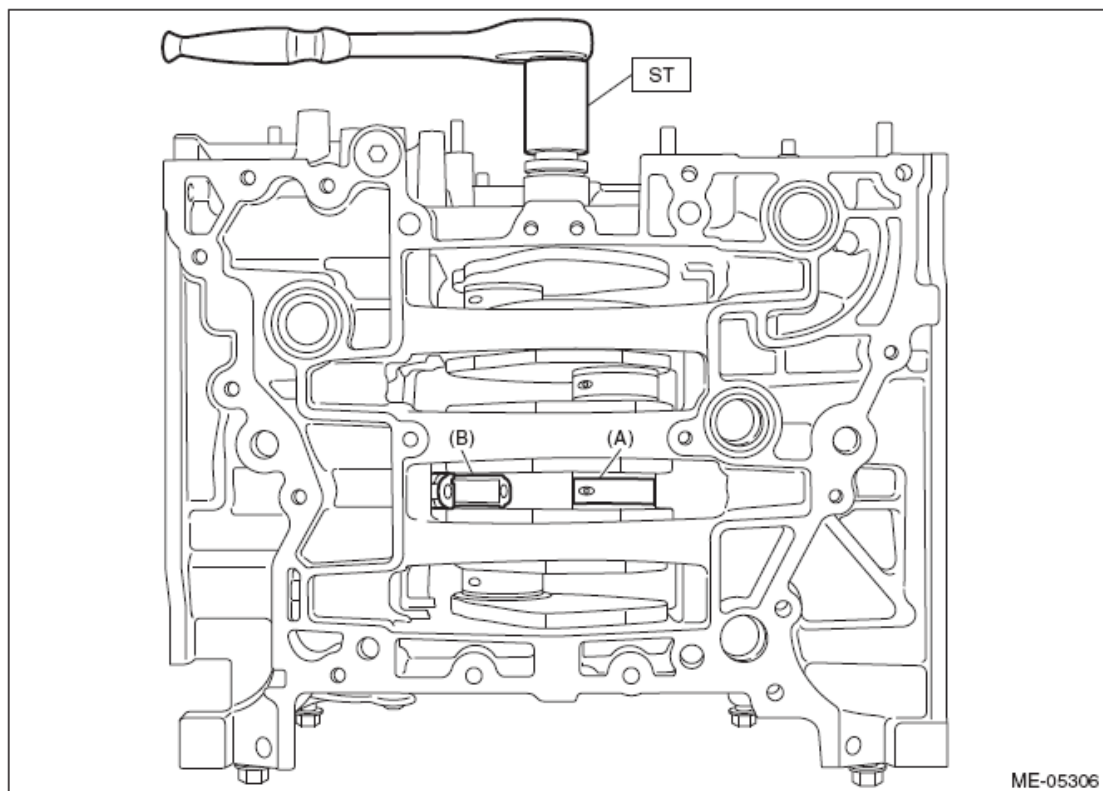
5. Push the #2 connecting rod in the direction of the arrow, and remove the #2 piston with #2 connecting rod from the cylinder block.



**Fig. 354: Removing No. 2 Piston And No. 2 Connecting Rod From Cylinder Block**  
Courtesy of SUBARU OF AMERICA, INC.

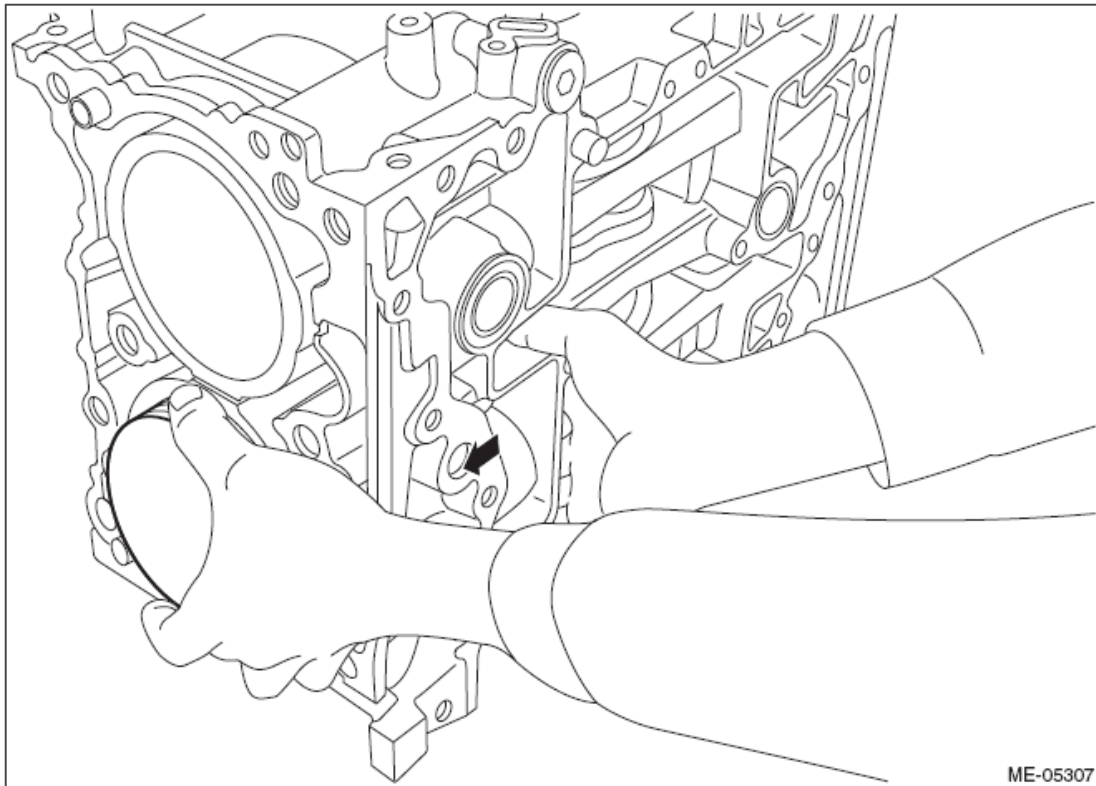
6. Using the ST, turn the crankshaft clockwise and separate the positions of the #3 crank pin (A) and the large end of the #3 connecting rod (B).

ST 18252AA000 CRANKSHAFT SOCKET



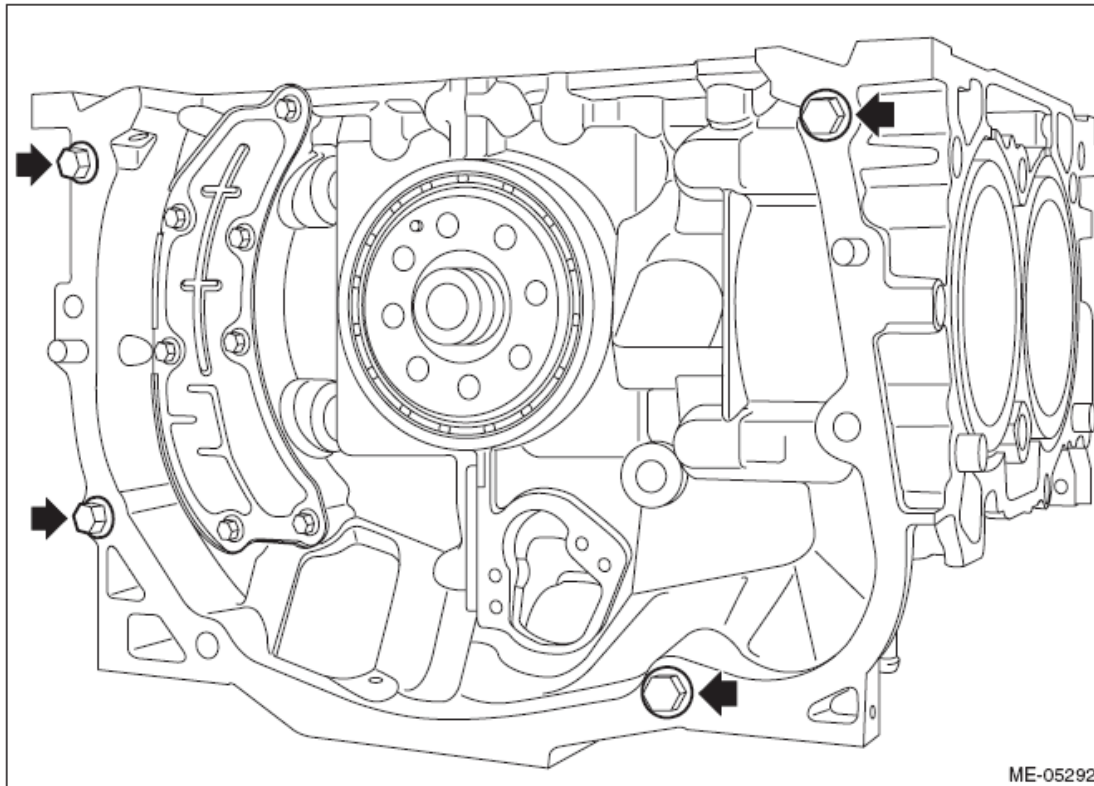
**Fig. 355: Turning Crankshaft Clockwise Using ST**  
Courtesy of SUBARU OF AMERICA, INC.

7. Push the #3 connecting rod in the direction of the arrow, and remove the #3 piston with #3 connecting rod from the cylinder block.



**Fig. 356: Removing No. 3 Piston And No. 3 Connecting Rod From Cylinder Block**  
Courtesy of SUBARU OF AMERICA, INC.

28. Set the cylinder block so that the oil pan side is on the upper side, and remove the A/C compressor bracket bolts and the power steering pump bracket bolts attached at the locations shown in the figure.



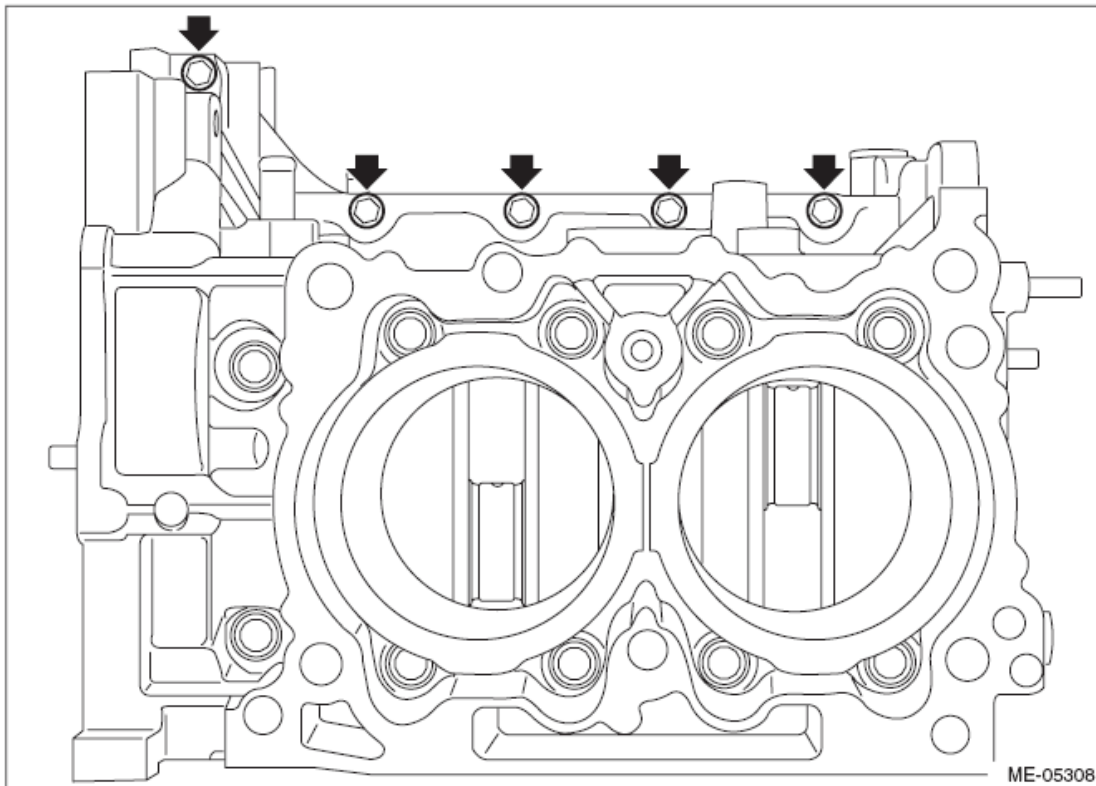
**Fig. 357: Locating A/C Compressor Bracket Bolts And Power Steering Pump Bracket Bolts**  
 Courtesy of SUBARU OF AMERICA, INC.

29. Set the part so that the cylinder block RH is on the upper side, and separate the cylinder block.

**CAUTION:**

- Place a wood board wrapped with a waste cloth to prevent the knock pin damage and to stabilize the cylinder block before work.
- Be careful not to scratch the mating surface of cylinder block during work.

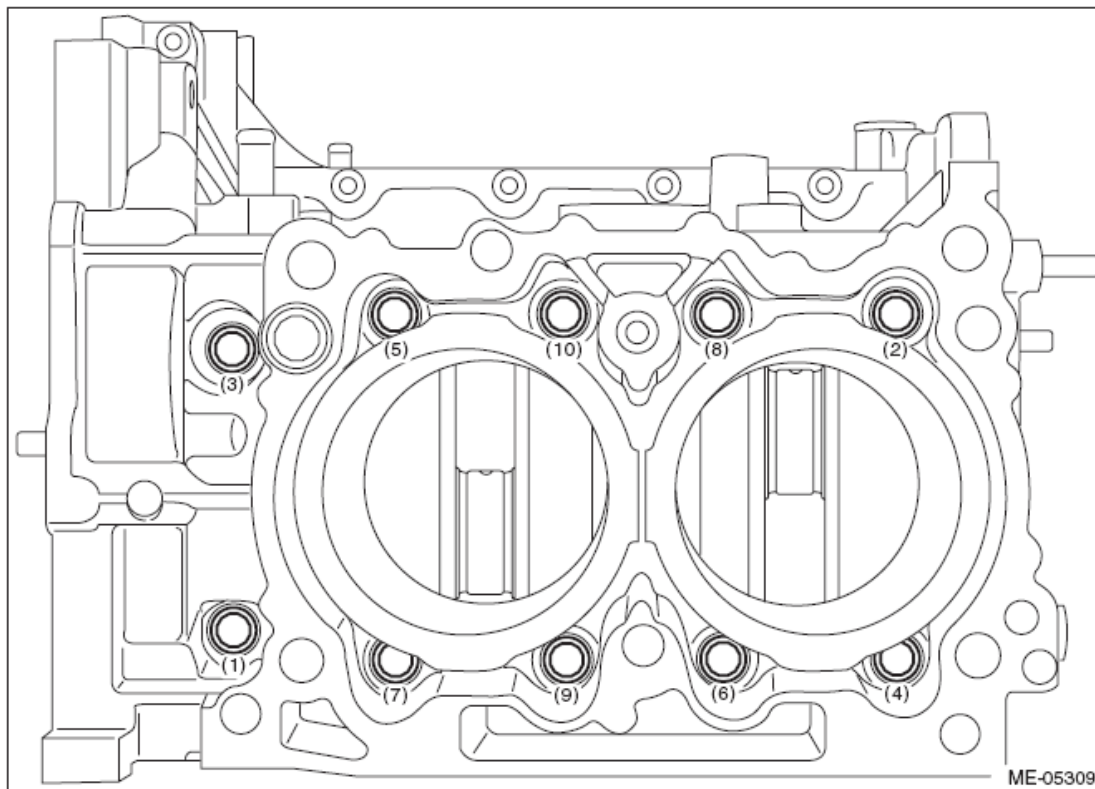
1. Remove the bolt shown in the figure.



**Fig. 358: Locating Cylinder Block RH Upper Side Mounting Bolts**  
Courtesy of SUBARU OF AMERICA, INC.

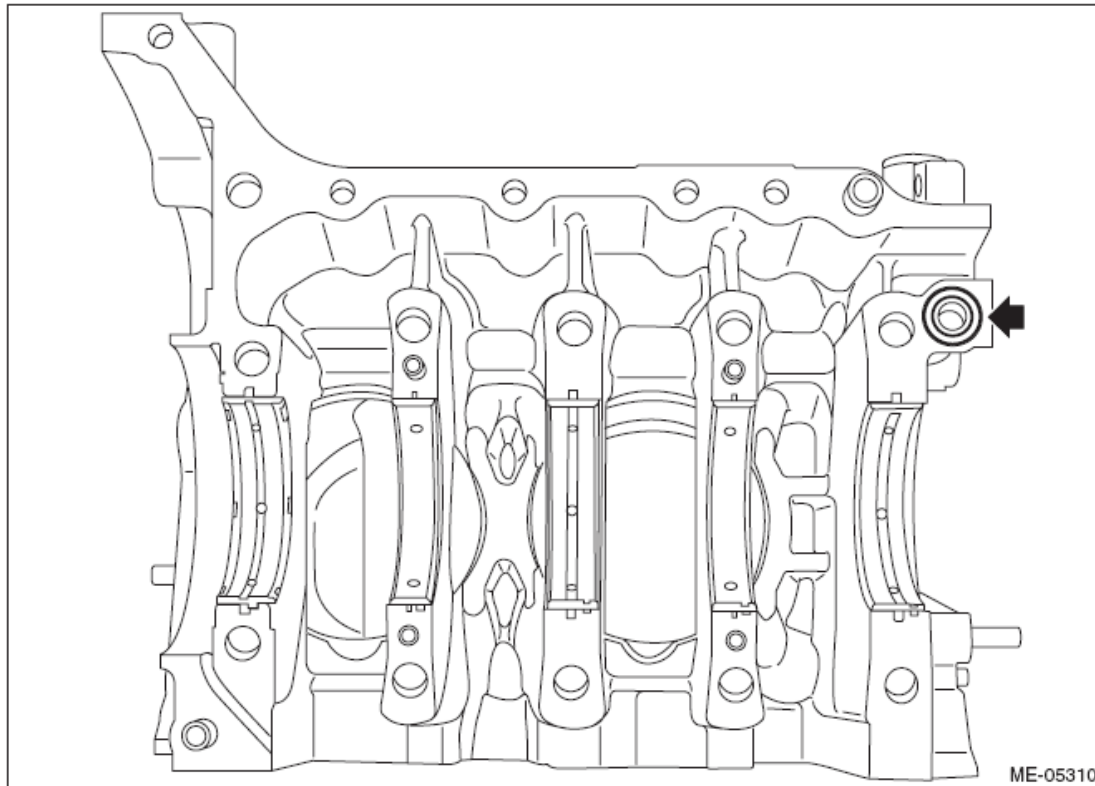
2. Loosen the cylinder block mounting bolts in numerical order as shown in the figure, and separate the cylinder block RH and LH.

**NOTE:** Lift the cylinder block RH slightly, and confirm that the crankshaft is remaining in the cylinder block LH. If the cylinder block RH is lifted carelessly when separating, the crankshaft may stick to cylinder block RH, then fall off.



**Fig. 359: Identifying Cylinder Block Mounting Bolts Loosening Sequence**  
 Courtesy of SUBARU OF AMERICA, INC.

30. Remove the crankshaft from cylinder block LH, and remove the rear oil seal.
31. Remove the O-ring from the cylinder block LH.

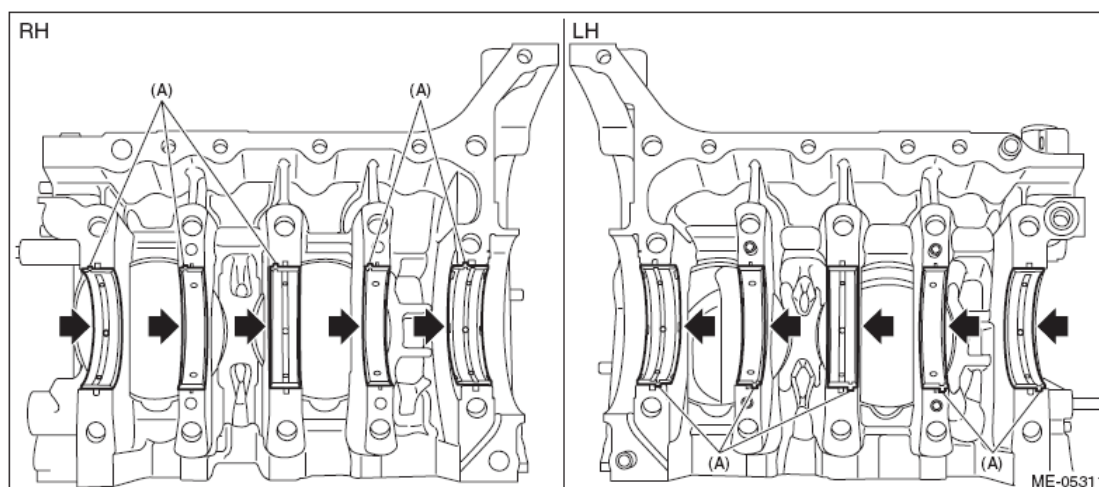


**Fig. 360: Locating Cylinder Block LH O-Ring**  
 Courtesy of SUBARU OF AMERICA, INC.

32. Remove the crankshaft bearings from the cylinder block.

**NOTE:**

- Be careful not to confuse the crankshaft bearing combination.
- Press the bearing at the end opposite to locking lip (A).



**Fig. 361: Pressing Bearing At Opposite End Of Locking Lip**

Courtesy of SUBARU OF AMERICA, INC.

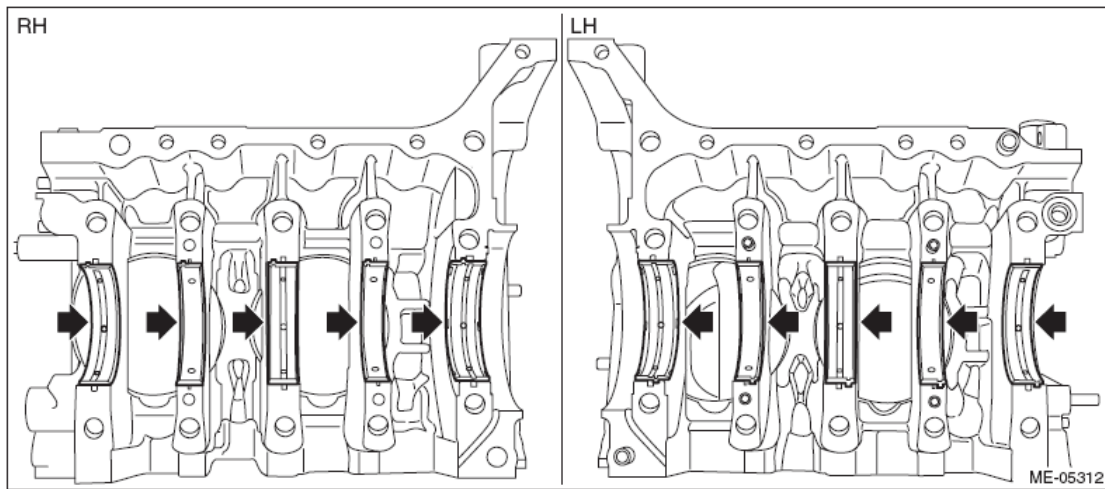
33. Remove the liquid gasket from cylinder block.

## INSTALLATION

1. Apply engine oil to the crankshaft bearing, and install the crankshaft bearing to the cylinder block.

### CAUTION:

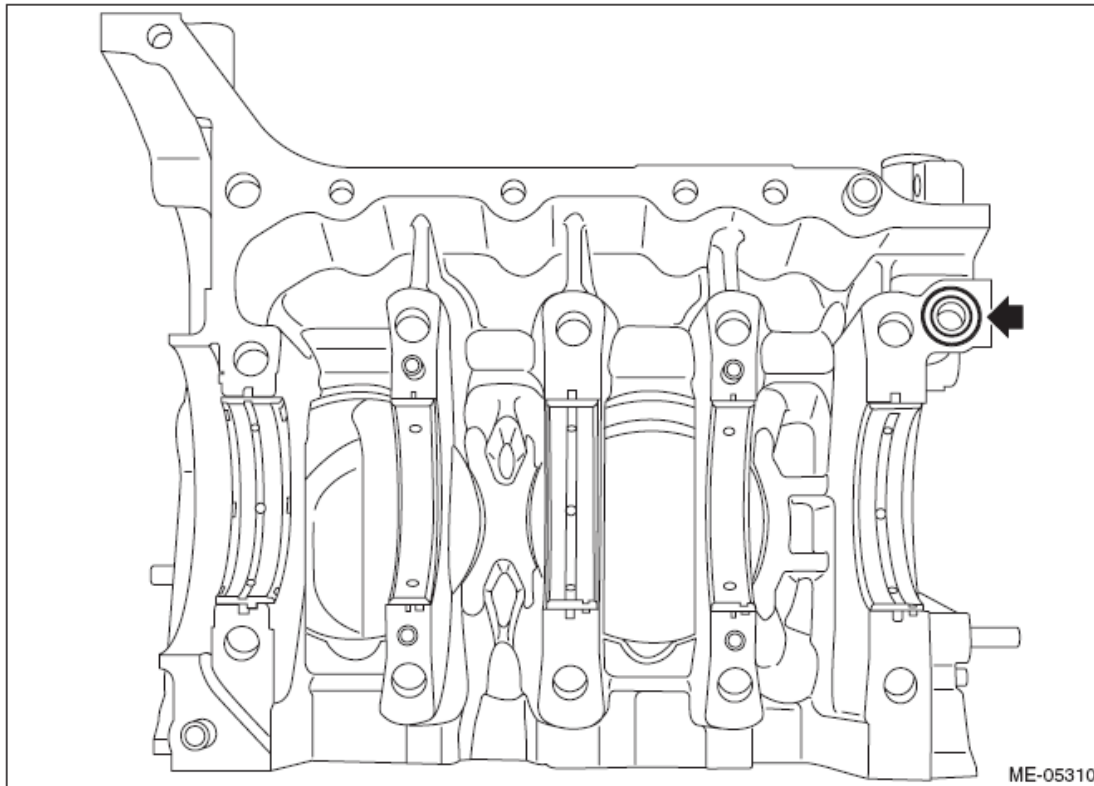
- Place a wood board wrapped with a waste cloth to prevent the knock pin damage and to stabilize the cylinder block before work.
- Be careful not to scratch the mating surface of cylinder block during work.



**Fig. 362: Locating Crankshaft Bearing To Cylinder Block**  
Courtesy of SUBARU OF AMERICA, INC.

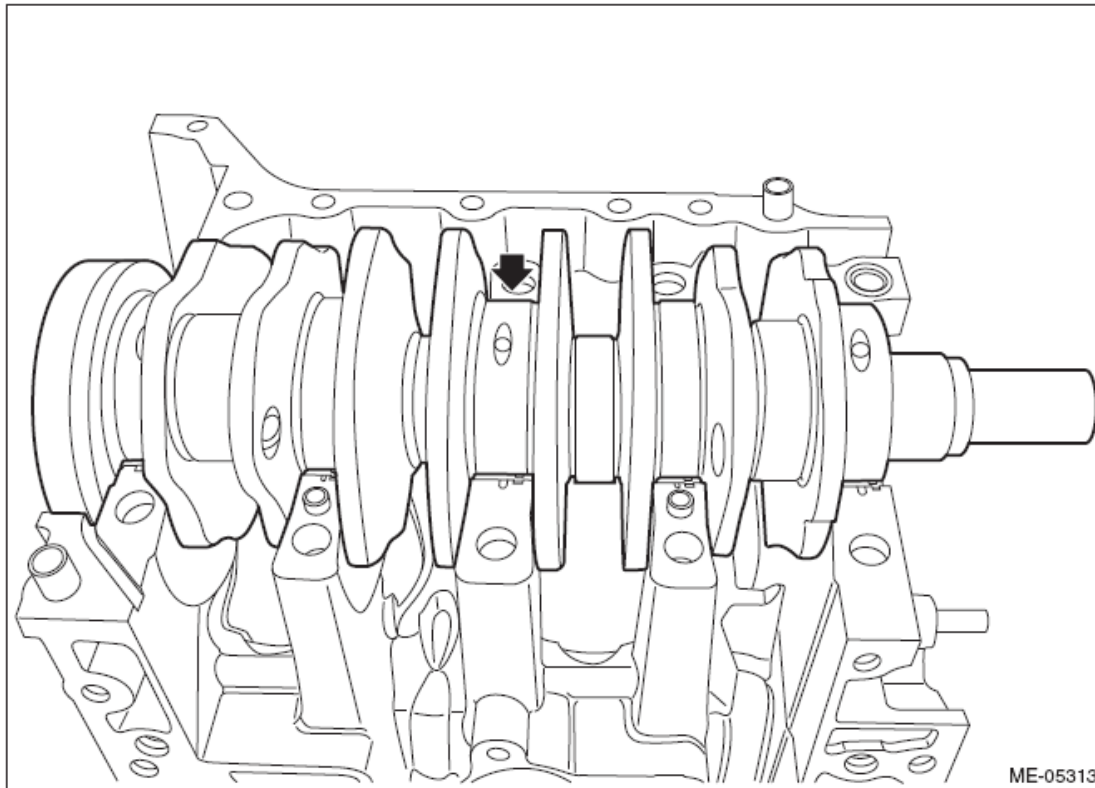
2. Install O-rings to the cylinder block LH.

**NOTE:** Use new O-rings.



**Fig. 363: Locating Cylinder Block LH O-Ring**  
Courtesy of SUBARU OF AMERICA, INC.

3. Apply engine oil to the crankshaft journal, and set the crankshaft to the cylinder block LH.



**Fig. 364: Applying Engine Oil On Crankshaft Journal**  
Courtesy of SUBARU OF AMERICA, INC.

4. Apply liquid gasket to the mating surface of cylinder block RH as shown in the figure.

**CAUTION:** Do not let the liquid gasket overflow to the oil passage, journal groove, because the engine seizure may result.

**NOTE:**

- Before applying liquid gasket, degrease the old liquid gasket seal surface of the cylinder block RH and cylinder block LH.
- Install within 5 min. after applying liquid gasket.

**Liquid gasket:**

**THREE BOND 1217G (Part No. K0877Y0100) or equivalent**

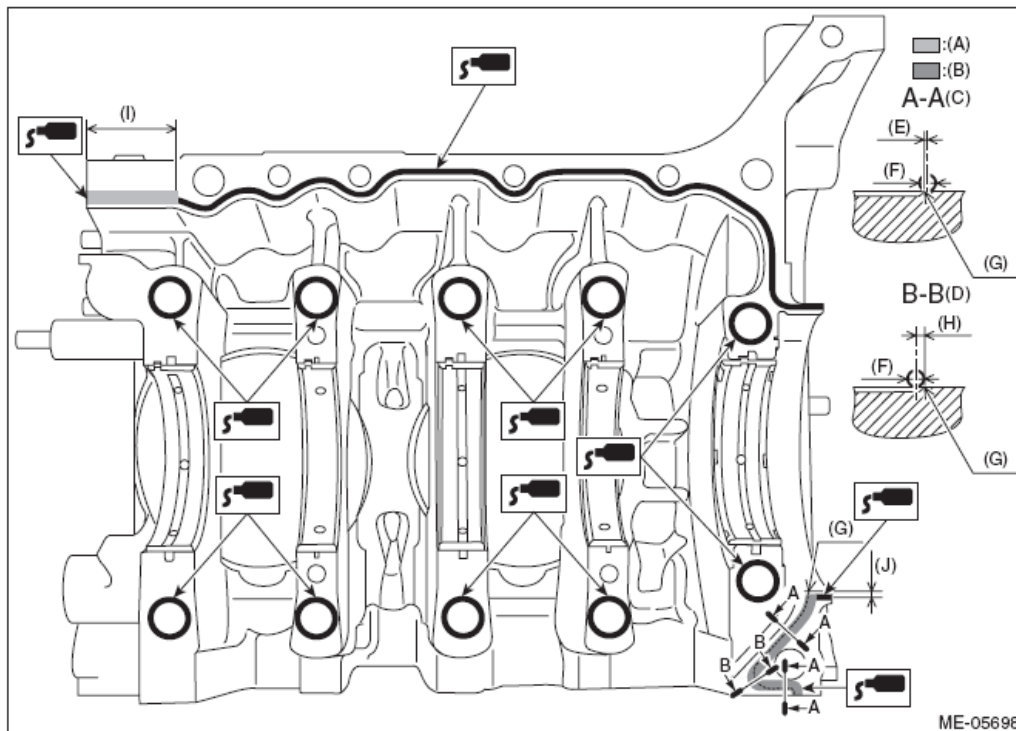
**Liquid gasket applying diameter:**

**Mating surfaces other than ranges A and B**

**1±0.5 mm (0.0394±0.0197 in)**

**Mating surfaces of ranges A and B**

$4\pm0.5 \text{ mm } (0.1575\pm0.0197 \text{ in})$



- |                                                                                         |                                                        |                        |
|-----------------------------------------------------------------------------------------|--------------------------------------------------------|------------------------|
| (A) Range A                                                                             | (E) 1 mm (0.0394 in) or less                           | (I) 36 mm (1.4173 in)  |
| (B) Range B                                                                             | (F) $4\pm0.5 \text{ mm } (0.1575\pm0.0197 \text{ in})$ | (J) 2.5 mm (0.0984 in) |
| (C) Liquid gasket applying position of mating surfaces (other than the edge) of range B | (G) Chamfer edge                                       |                        |
| (D) Liquid gasket applying position of mating surfaces (the edge) of range B            | (H) 2 mm (0.0787 in)                                   |                        |

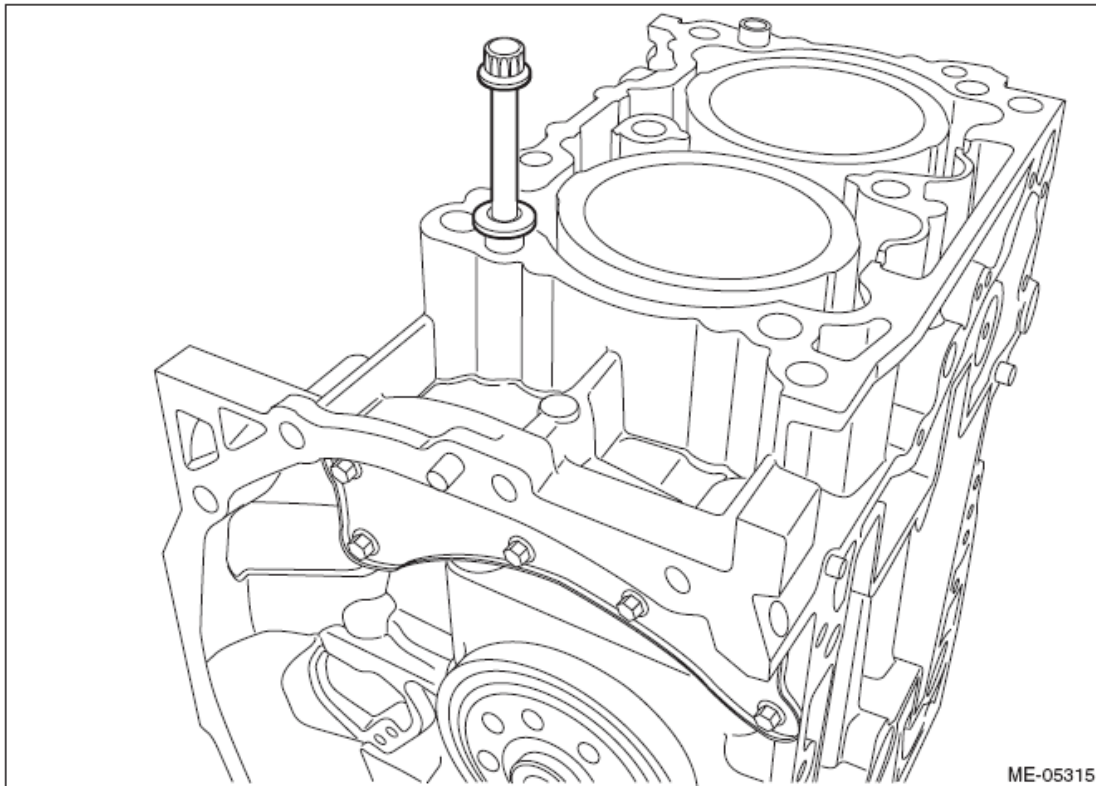
**Fig. 365: Identifying Liquid Gasket Applying Area On Mating Surface Of Cylinder Block RH**  
Courtesy of SUBARU OF AMERICA, INC.

5. Install the cylinder block RH to the cylinder block LH.
6. Join the cylinder blocks.
  1. Apply a coat of engine oil to the washers and cylinder block mounting bolt threads.

**NOTE:** To prevent mixture of engine oil into the water jacket, do not apply a large amount.

2. Install the cylinder head bolt at the locations shown in the figure.

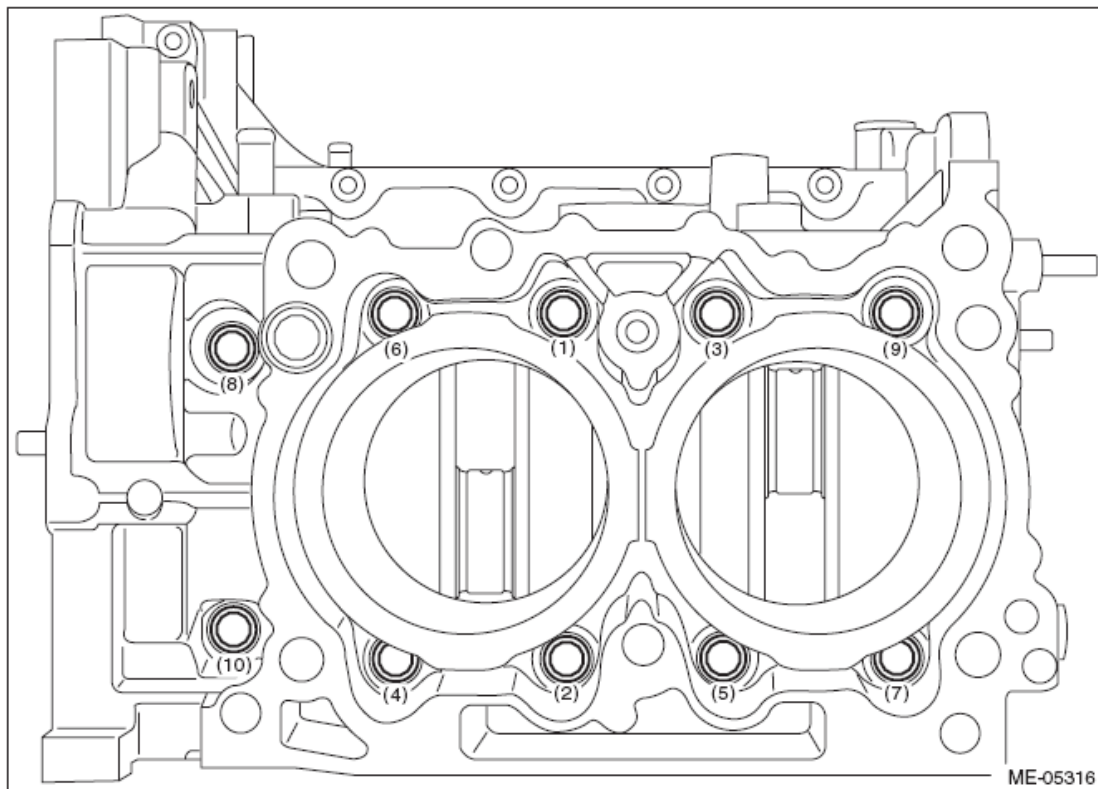
**NOTE:** This procedure is required to tighten the cylinder block mounting bolts with specified angle using ST.



**Fig. 366: Cylinder Head Bolt Locations**  
Courtesy of SUBARU OF AMERICA, INC.

3. Tighten all mounting bolts with a torque of 35 N.m (3.6 kgf-m, 25.8 ft-lb) in numerical order as shown in the figure.

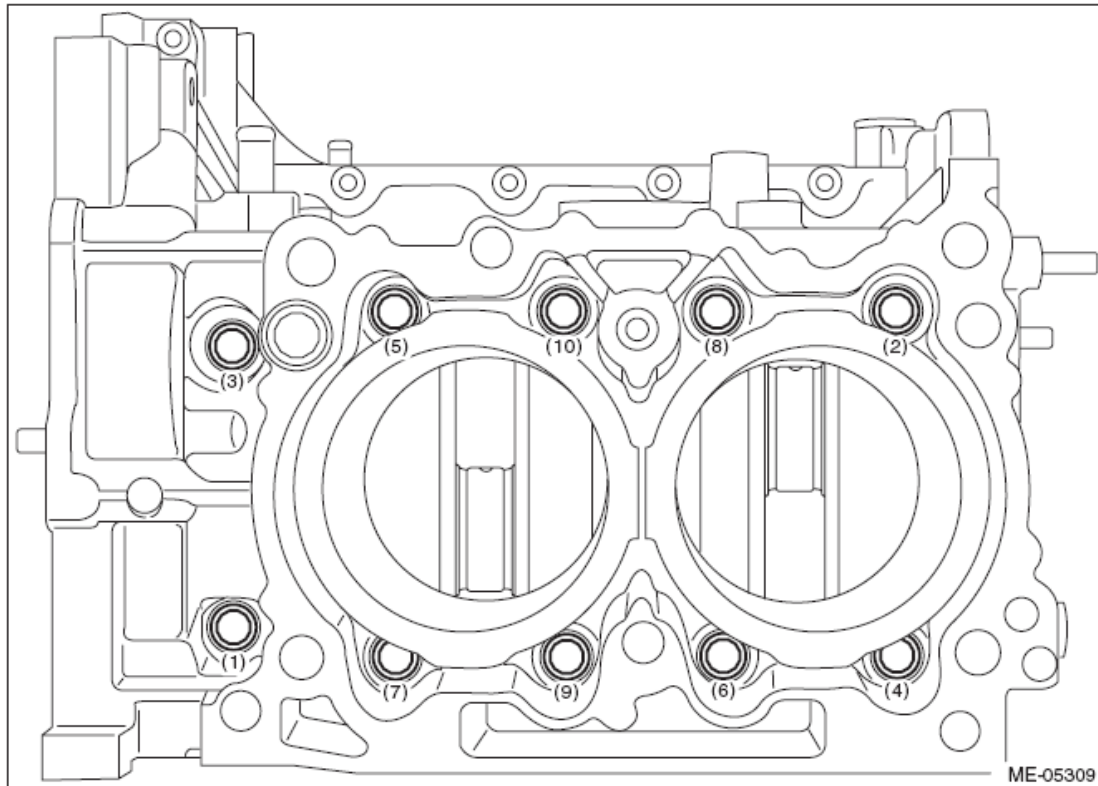
**CAUTION:** When tightening the mounting bolts with specified torque, hold the cylinder block LH while not holding the cylinder block RH to ensure the joint accuracy of the cylinder block.



**Fig. 367: Identifying Cylinder Block Mounting Bolts Tightening Sequence**  
Courtesy of SUBARU OF AMERICA, INC.

4. Loosen all mounting bolts by 180° in numerical order as shown in the figure.

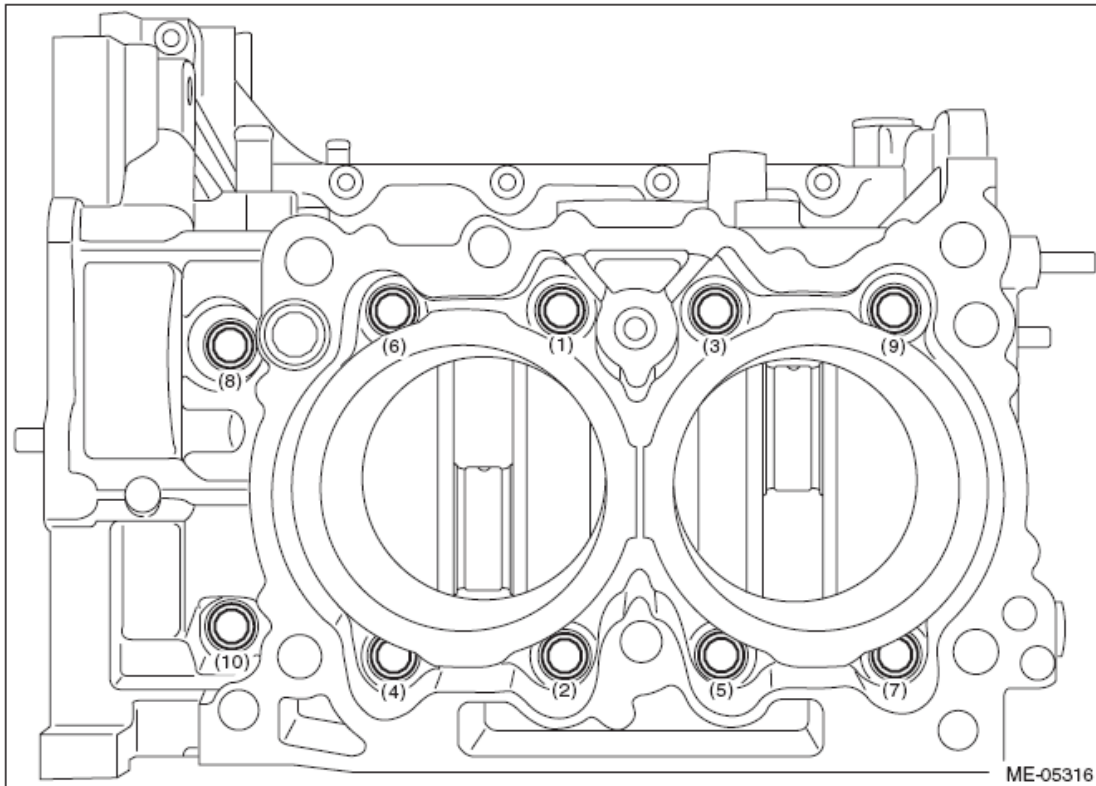
**CAUTION:** When loosening the mounting bolts, hold the cylinder block LH while not holding the cylinder block RH to ensure the joint accuracy of the cylinder block.



**Fig. 368: Identifying Cylinder Block Mounting Bolts Loosening Sequence**  
Courtesy of SUBARU OF AMERICA, INC.

5. Tighten all mounting bolts with a torque of 35 N.m (3.6 kgf-m, 25.8 ft-lb) in numerical order as shown in the figure.

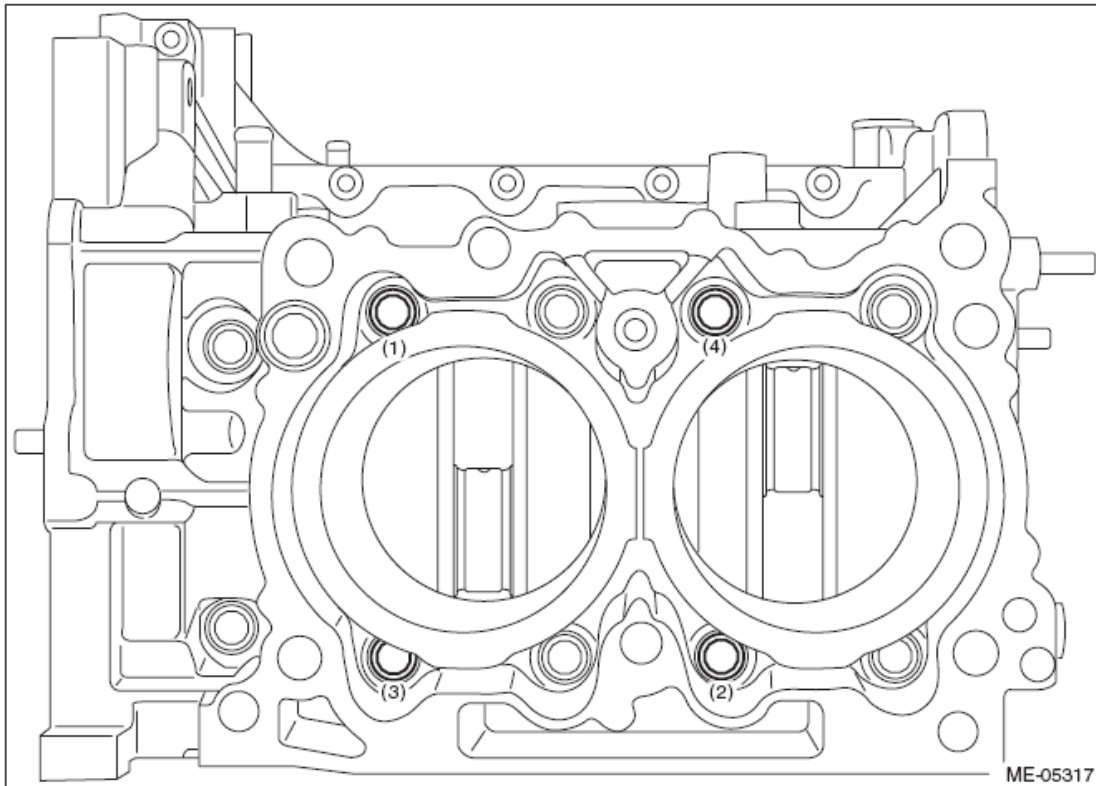
**CAUTION:** When tightening the mounting bolts with specified torque, hold the cylinder block LH while not holding the cylinder block RH to ensure the joint accuracy of the cylinder block.



**Fig. 369: Identifying Cylinder Block Mounting Bolts Tightening Sequence**  
Courtesy of SUBARU OF AMERICA, INC.

6. Loosen the mounting bolts (4 places) by 180° in numerical order as shown in the figure.

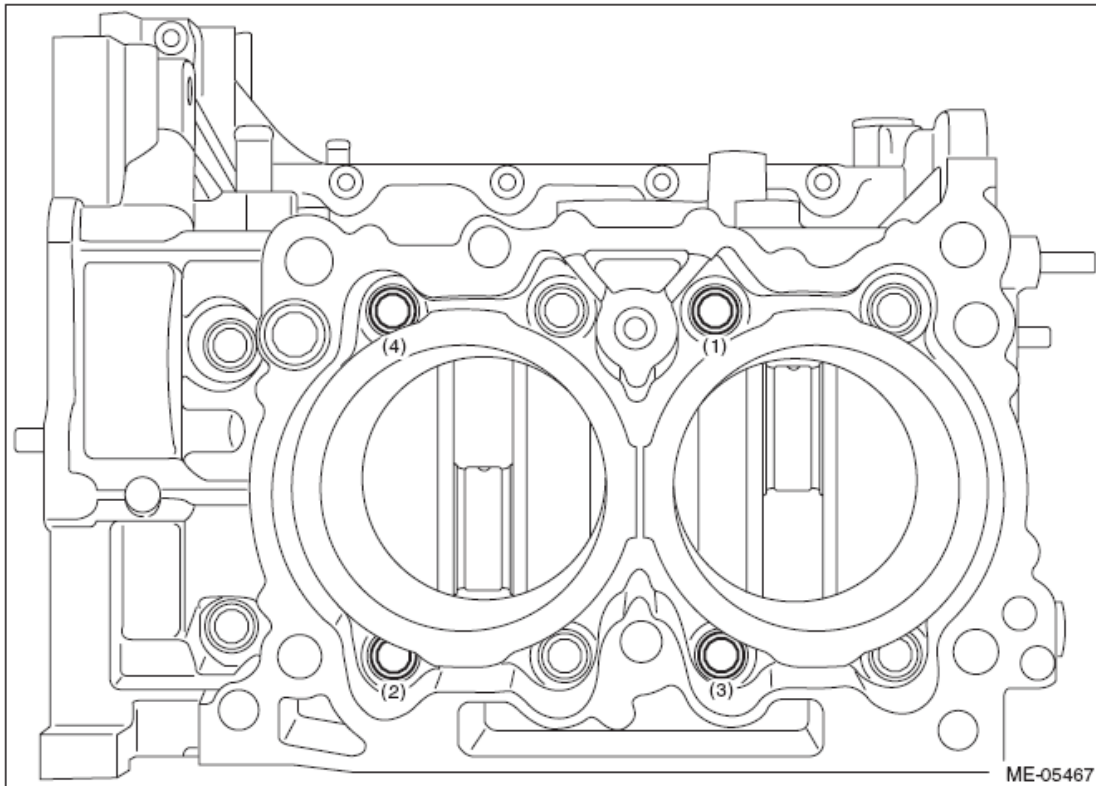
**CAUTION:** When loosening the mounting bolts, hold the cylinder block LH while not holding the cylinder block RH to ensure the joint accuracy of the cylinder block.



**Fig. 370: Identifying Cylinder Block Mounting Bolts Loosening Sequence**  
Courtesy of SUBARU OF AMERICA, INC.

7. Tighten the mounting bolts (4 places) with a torque of 17 N.m (1.7 kgf-m, 12.5 ft-lb) in numerical order as shown in the figure.

**CAUTION:** When tightening the mounting bolts with specified torque, hold the cylinder block LH while not holding the cylinder block RH to ensure the joint accuracy of the cylinder block.



**Fig. 371: Identifying Tightening Sequence Of Cylinder Block Mounting Bolts**  
Courtesy of SUBARU OF AMERICA, INC.

8. Using ST, tighten the mounting bolts (4 places) with specified angle in numerical order as shown in the figure.

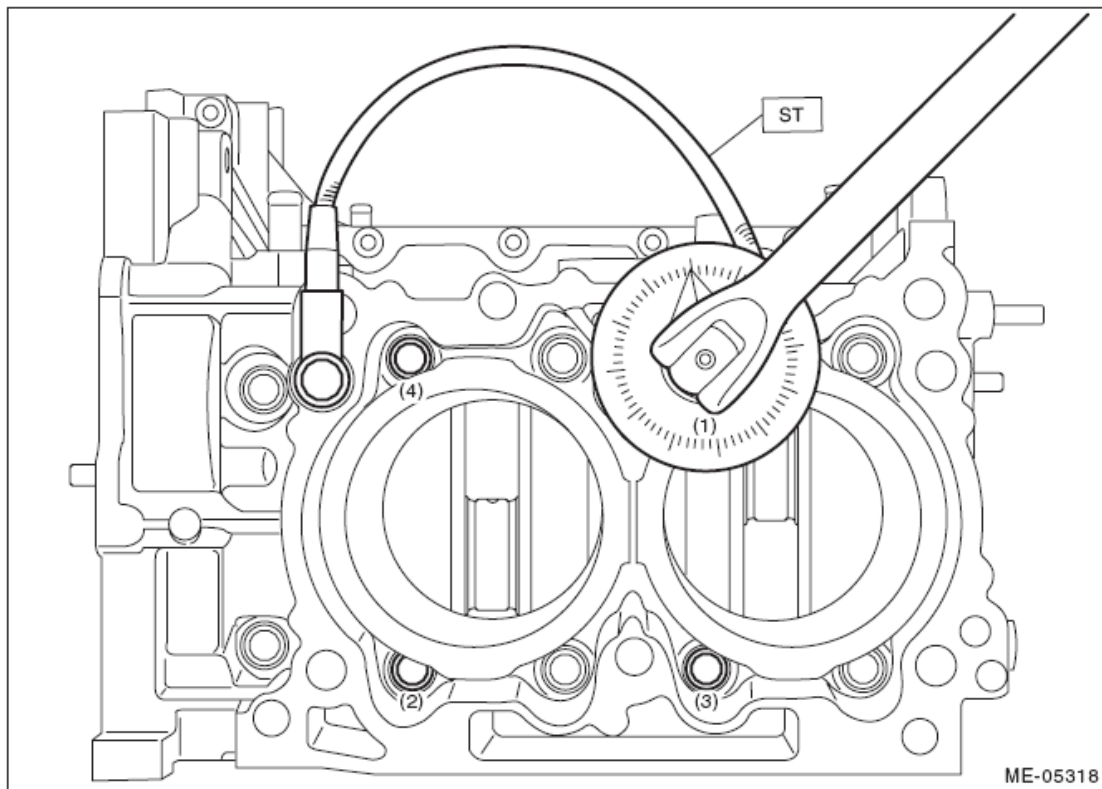
**CAUTION:** When tightening the mounting bolts with specified angle, hold the cylinder block LH while not holding the cylinder block RH to ensure the joint accuracy of the cylinder block.

**NOTE:** Attach the magnet used for securing the ST (ANGLE GAUGE) to the cylinder head bolt attached in step (2).

ST 18854AA000 ANGLE GAUGE

***Tightening angle:***

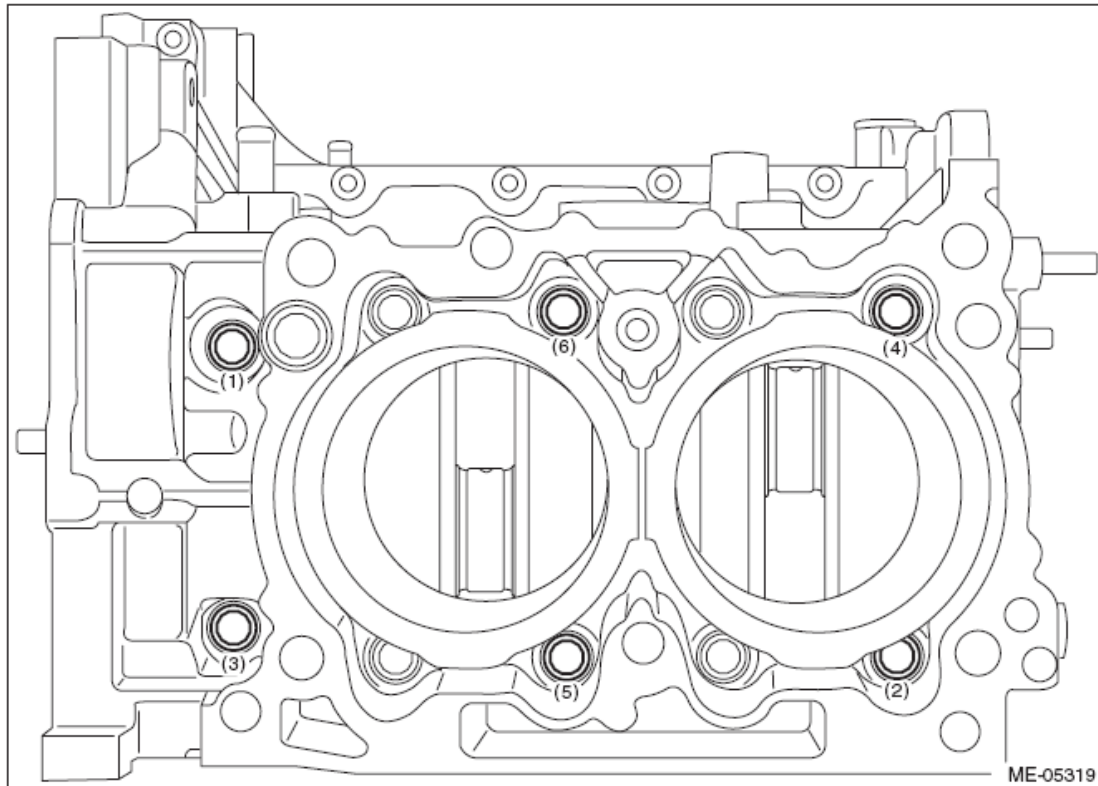
**$60^{\circ} \pm 2^{\circ}$**



**Fig. 372: Tightening Cylinder Block Mounting Bolts Using Angle Gauge**  
Courtesy of SUBARU OF AMERICA, INC.

9. Loosen the mounting bolts (6 places) by 180° in numerical order as shown in the figure.

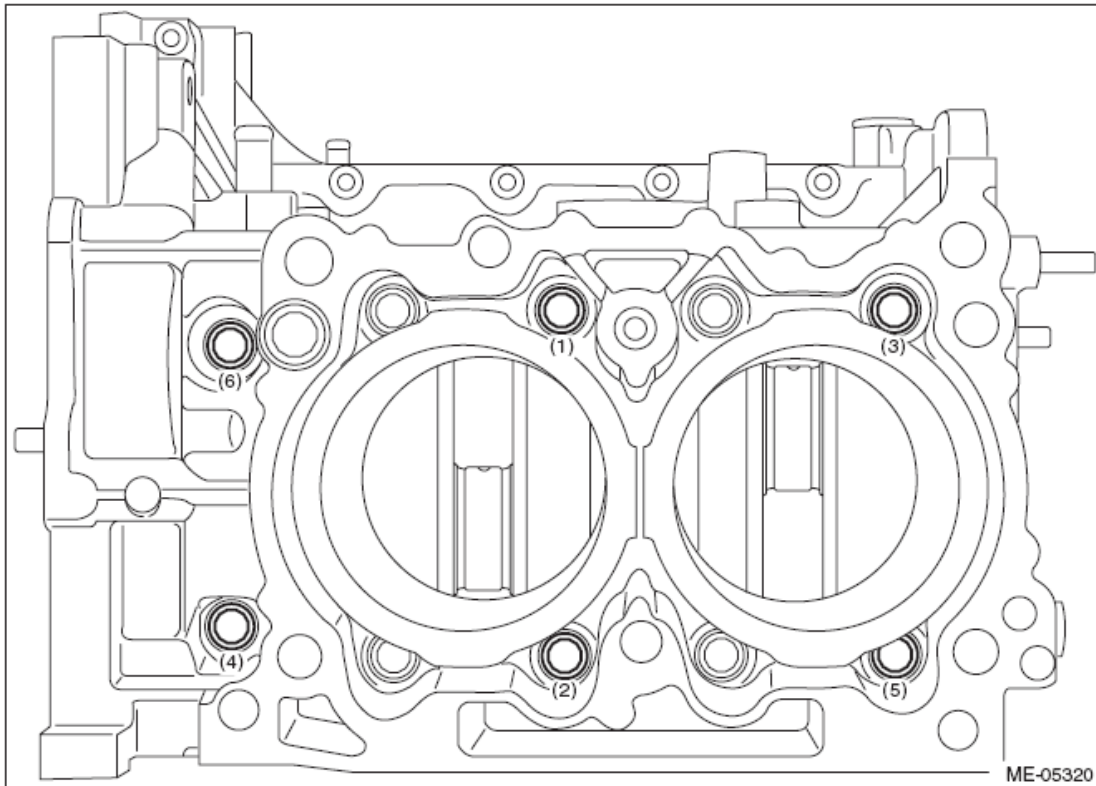
**CAUTION:** When loosening the mounting bolts, hold the cylinder block LH while not holding the cylinder block RH to ensure the joint accuracy of the cylinder block.



**Fig. 373: Identifying Loosening Sequence Of Cylinder Block Mounting Bolts**  
Courtesy of SUBARU OF AMERICA, INC.

10. Tighten the mounting bolts (6 places) with a torque of 17 N.m (1.7 kgf-m, 12.5 ft-lb) in numerical order as shown in the figure.

**CAUTION:** When tightening the mounting bolts with specified torque, hold the cylinder block LH while not holding the cylinder block RH to ensure the joint accuracy of the cylinder block.



**Fig. 374: Identifying Tightening Sequence Of Cylinder Block Mounting Bolts**  
Courtesy of SUBARU OF AMERICA, INC.

11. Using ST, tighten the mounting bolts (6 places) with specified angle in numerical order as shown in the figure.

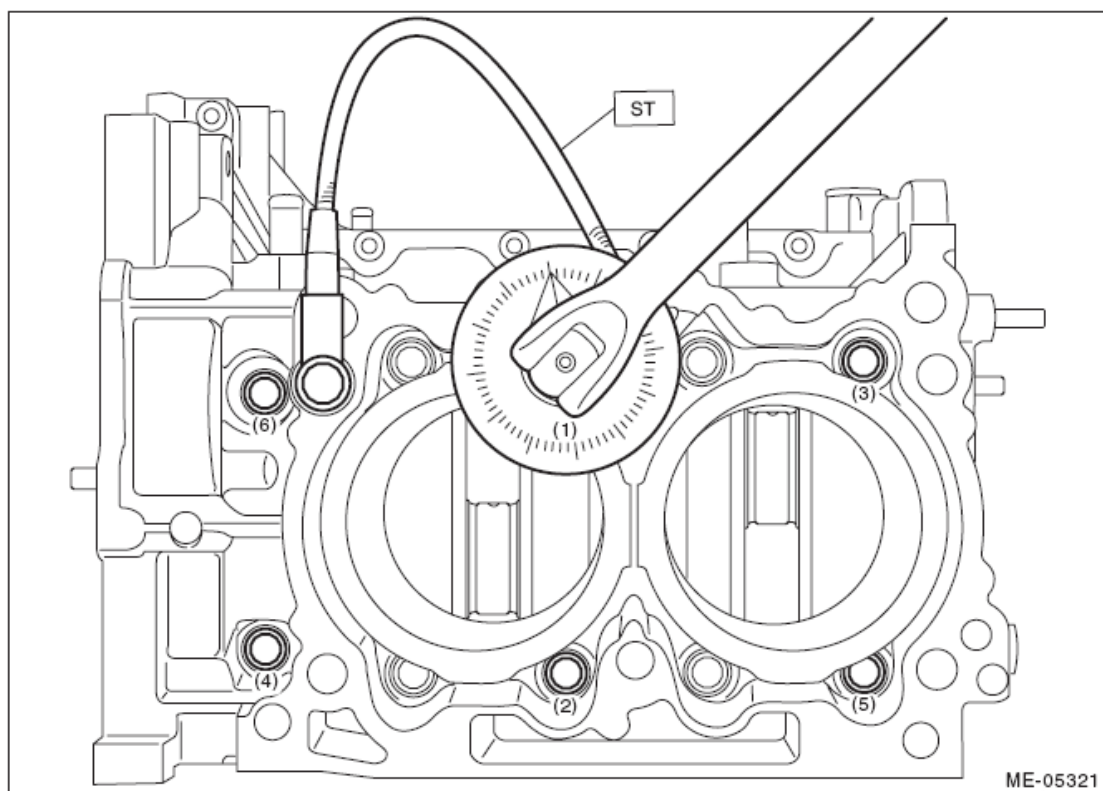
**CAUTION:** When tightening the mounting bolts with specified angle, hold the cylinder block LH while not holding the cylinder block RH to ensure the joint accuracy of the cylinder block.

**NOTE:** Attach the magnet used for securing the ST (ANGLE GAUGE) to the cylinder head bolt attached in step (2).

ST 18854AA000 ANGLE GAUGE

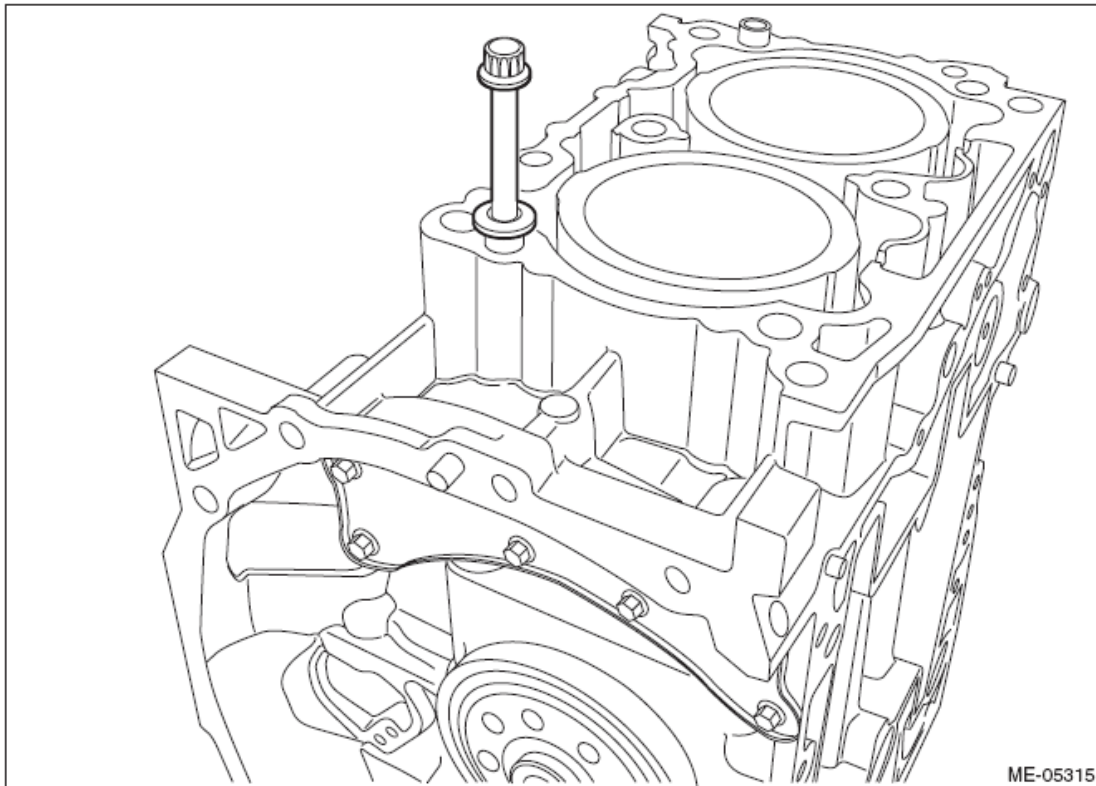
***Tightening angle:***

**$60^{\circ} \pm 2^{\circ}$**



**Fig. 375: Tightening Cylinder Block Mounting Bolts Using Angle Gauge**  
 Courtesy of SUBARU OF AMERICA, INC.

12. Remove the cylinder head bolt attached at the locations shown in the figure.



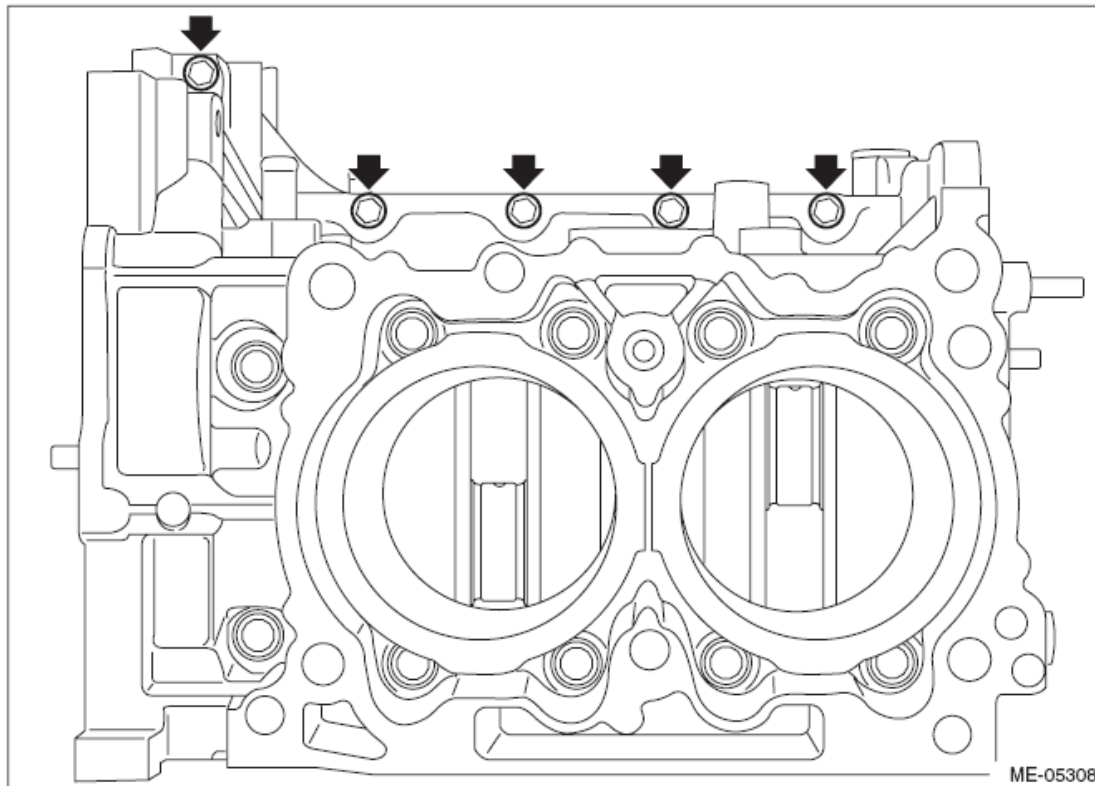
**Fig. 376: Identifying Cylinder Head Bolt**  
Courtesy of SUBARU OF AMERICA, INC.

13. Install the bolt shown in the figure.

**NOTE:** After tightening, if the liquid gasket is squeezed out in the seal surface area of the chain cover and oil pan upper, completely remove any liquid gasket that is squeezed out. Any liquid gasket on the chamfer area, however, should not be removed.

***Tightening torque:***

***25 N.m (2.5 kgf-m, 18.4 ft-lb)***



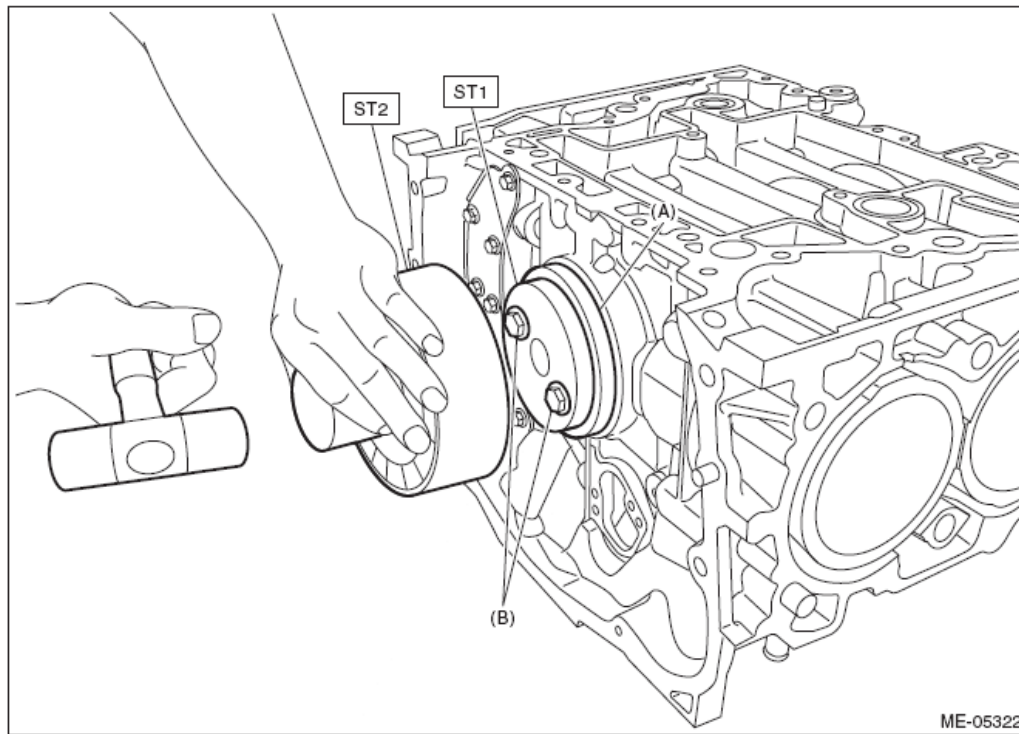
**Fig. 377: Locating Cylinder Block RH Bolts (Upper Side)**  
**Courtesy of SUBARU OF AMERICA, INC.**

7. Set the part so that the oil pan side of cylinder block is on the upper side.
8. Apply a coat of engine oil to the oil seal inner periphery and outer periphery, and install the rear oil seal using ST1 and ST2.

**NOTE: Use a new rear oil seal.**

ST1 18671AA020 OIL SEAL GUIDE

ST2 18657AA030 OIL SEAL INSTALLER



(A) Rear oil seal

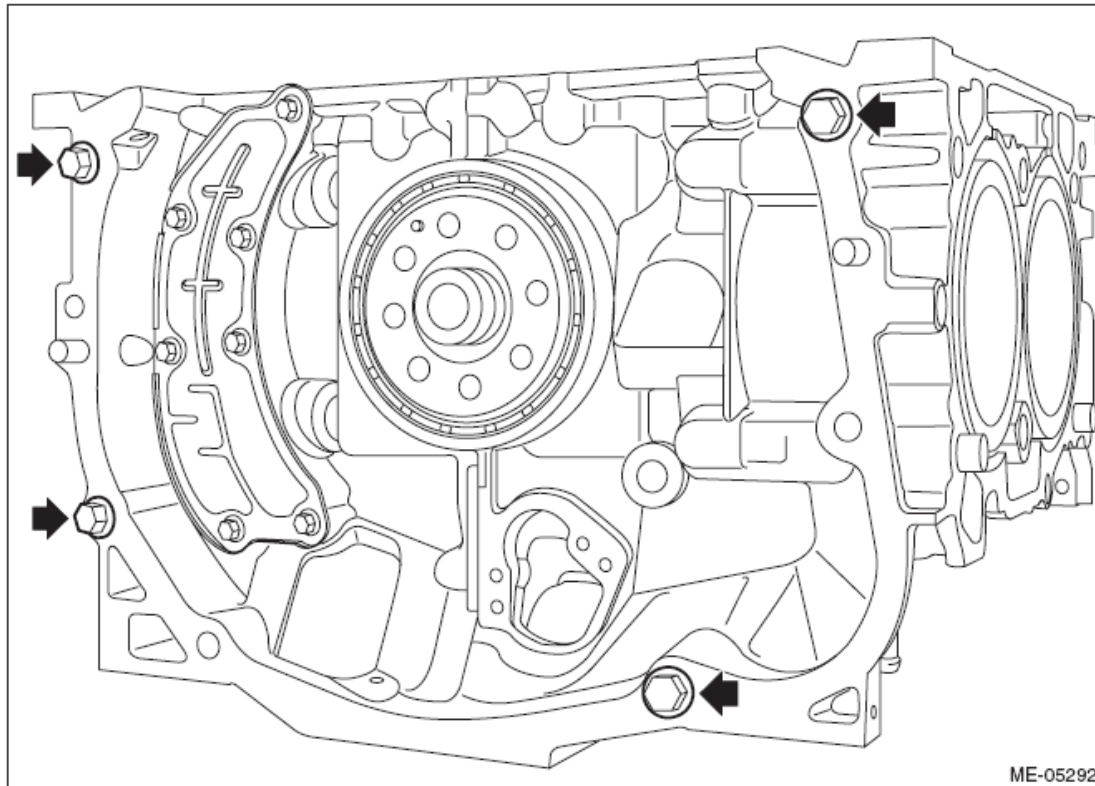
(B) Drive plate or flywheel mounting bolt

**Fig. 378: Installing Rear Oil Seal Using ST1 And ST2**  
**Courtesy of SUBARU OF AMERICA, INC.**

9. Install the A/C compressor bracket bolts and the power steering pump bracket bolts at the locations shown in the figure.

**NOTE:**

- This procedure is required to prevent the knock pin damage when the cylinder block is raised in the next step.
- Use the same length bolt for the four bolts.



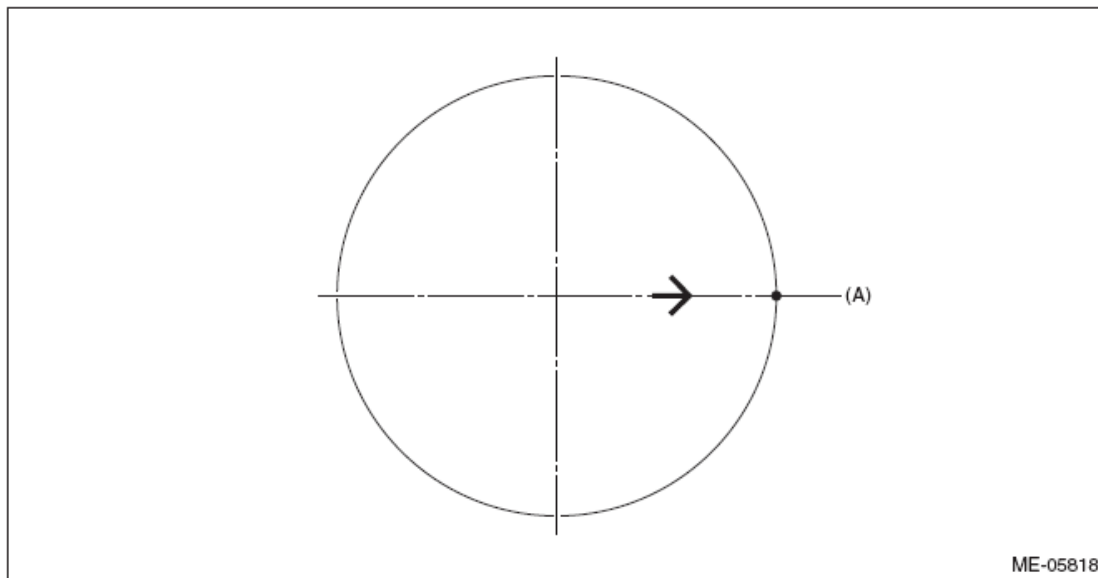
**Fig. 379: Locating A/C Compressor Bracket Bolts And Power Steering Pump Bracket Bolts**  
 Courtesy of SUBARU OF AMERICA, INC.

10. Raise the cylinder block so that the rear oil seal is on the lower side.
11. Align the ring closed gaps of piston ring and oil ring for each piston.

**NOTE:**

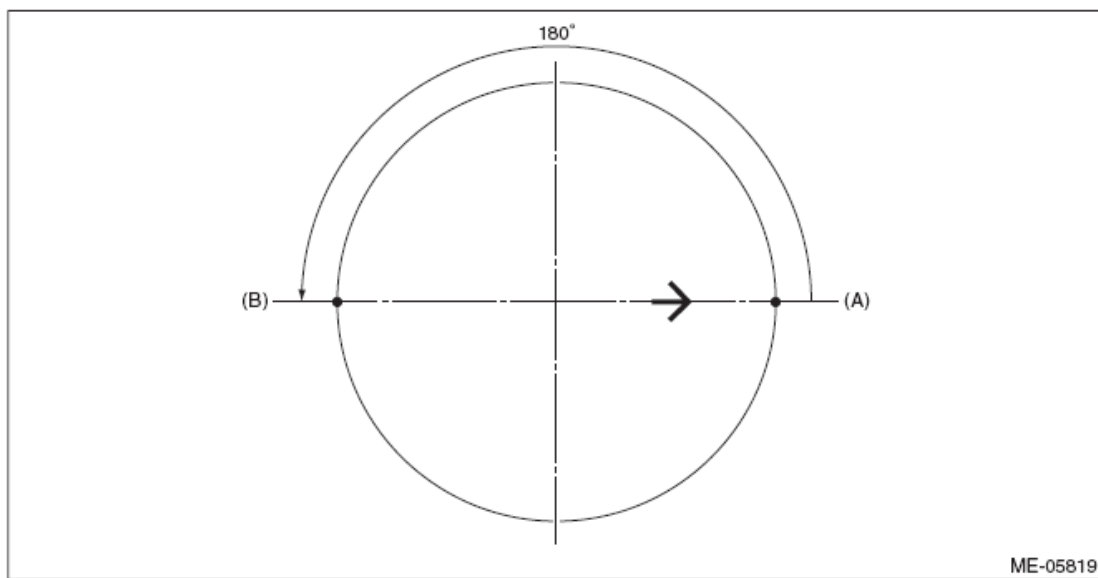
- **Make sure ring gaps do not face the same direction.**
- **Check that the piston ring mark of top ring and second ring faces the top side of the piston.**
- **Check that the ring gaps is not positioned within the range of piston skirt extended line.**

1. Set the ring gap of the top ring to the position (A) in the figure.



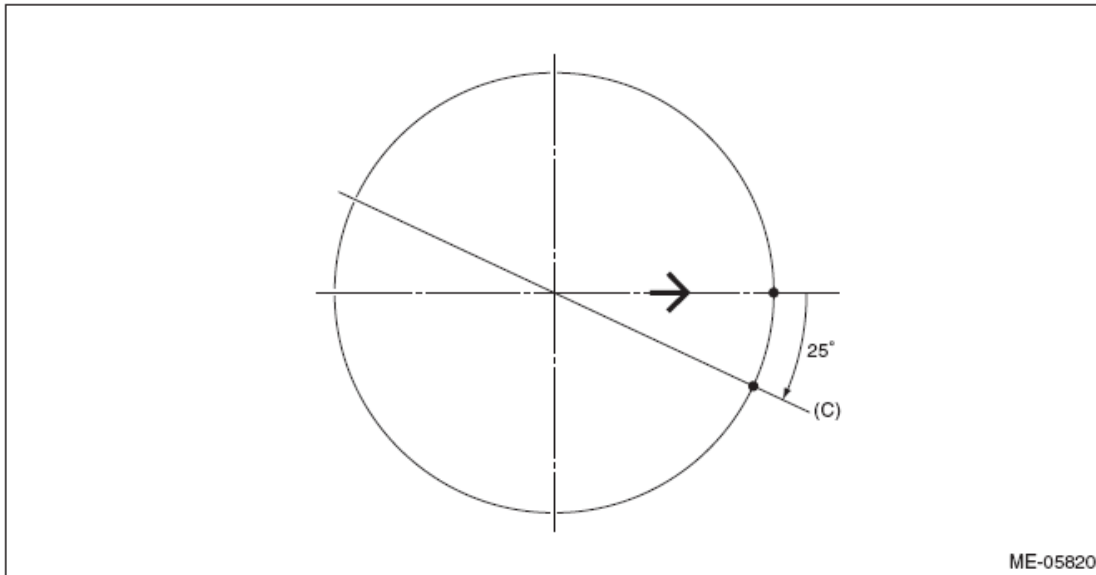
**Fig. 380: Setting Ring Gap Of Top Ring To Position A**  
Courtesy of SUBARU OF AMERICA, INC.

2. Position the ring gap of second ring at (B) in the figure on the 180° opposite direction of (A).



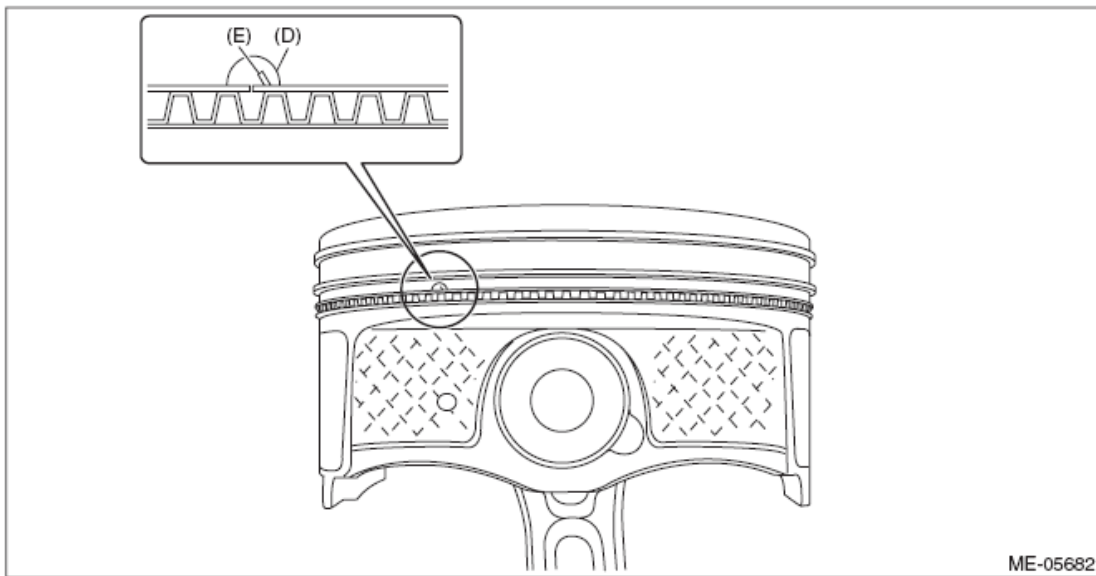
**Fig. 381: Positioning Ring Gap Of Second Ring At B**  
Courtesy of SUBARU OF AMERICA, INC.

3. Set the ring gap of the upper rail to the position (C) in the figure.



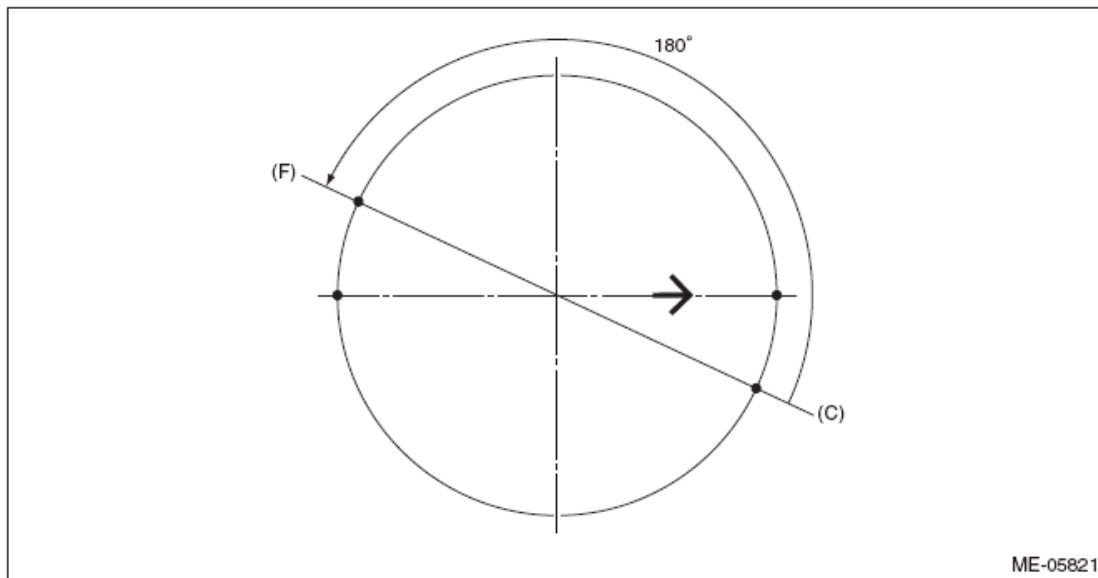
**Fig. 382: Setting Ring Gap Of Upper Rail To Position C**  
Courtesy of SUBARU OF AMERICA, INC.

4. Align the upper rail spin stopper (E) to the side hole (D) on the piston.



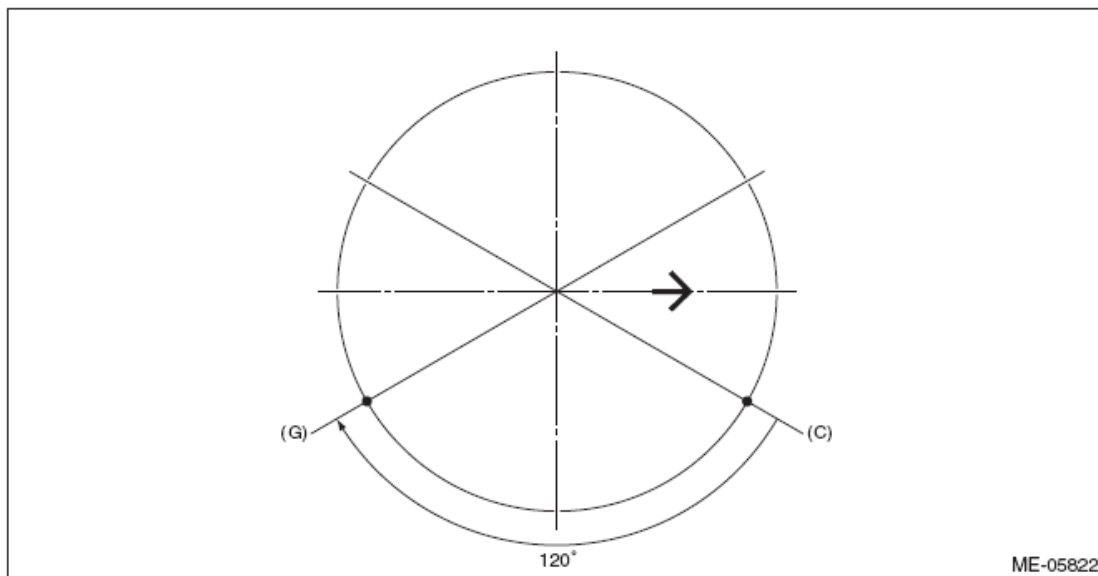
**Fig. 383: Aligning Upper Rail Spin Stopper (E) To Side Hole (D) On The Piston.**  
Courtesy of SUBARU OF AMERICA, INC.

5. Position the ring gap of expander at (F) in the figure on the 180° opposite direction of (C).



**Fig. 384: Positioning Ring Gap Of Expander At (F)**  
 Courtesy of SUBARU OF AMERICA, INC.

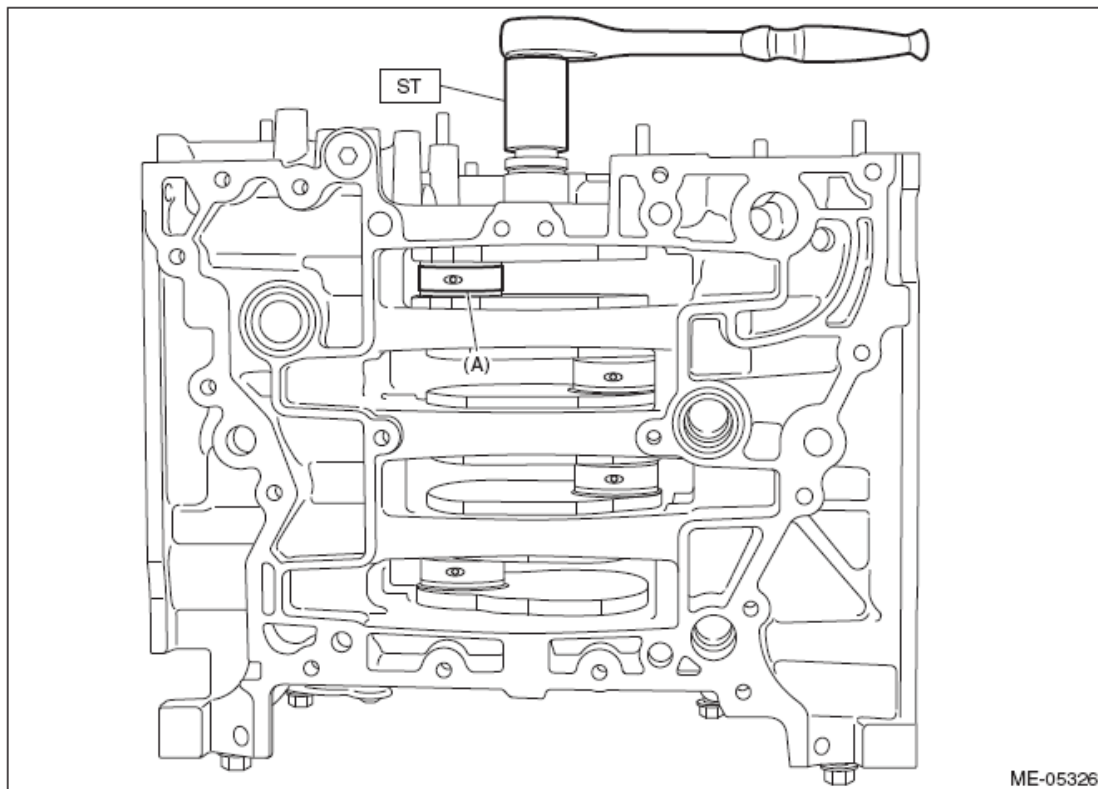
6. Set the ring gap of lower rail at position (G), located 120° clockwise from (C) in the figure.



**Fig. 385: Setting Ring Gap Of Lower Rail At Position G**  
 Courtesy of SUBARU OF AMERICA, INC.

12. Install the piston and connecting rod to the cylinder block.
  1. Apply engine oil to the outer circumference of each piston, crank pin, and in the cylinder block.
  2. Turn the crankshaft so that the #1 crank pin (A) is positioned at TDC using ST.

ST 18252AA000 CRANKSHAFT SOCKET



**Fig. 386: Turning Crankshaft Using Crankshaft Socket**  
Courtesy of SUBARU OF AMERICA, INC.

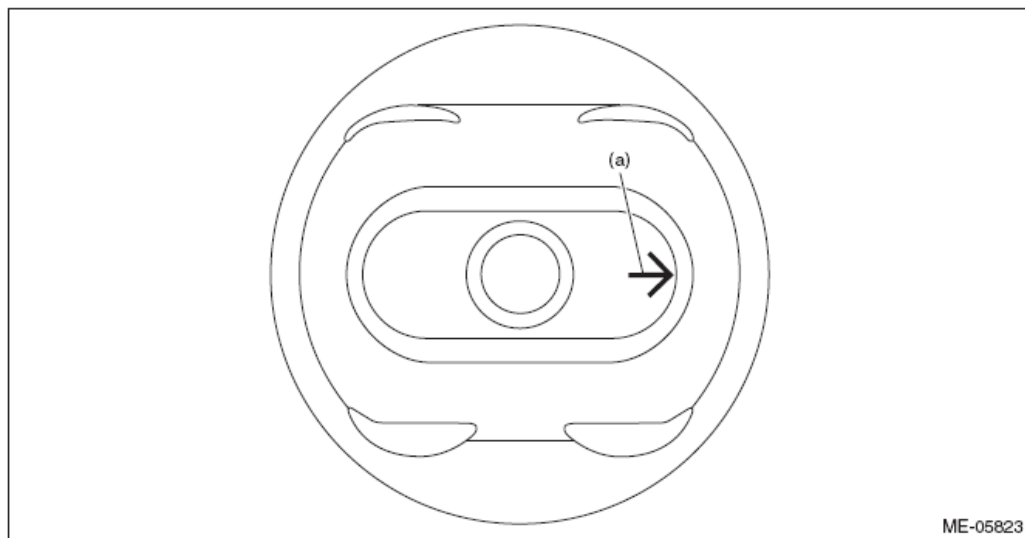
3. Compress the piston ring using piston ring compressor, and insert the #1 connecting rod with #1 piston into cylinder block.

**CAUTION:**

- Be careful not to damage the cylinder liner and #1 crank pin by the #1 connecting rod large end.
- Be careful not to apply strong impact when inserting to prevent connecting rod bearing from falling off.

**NOTE:**

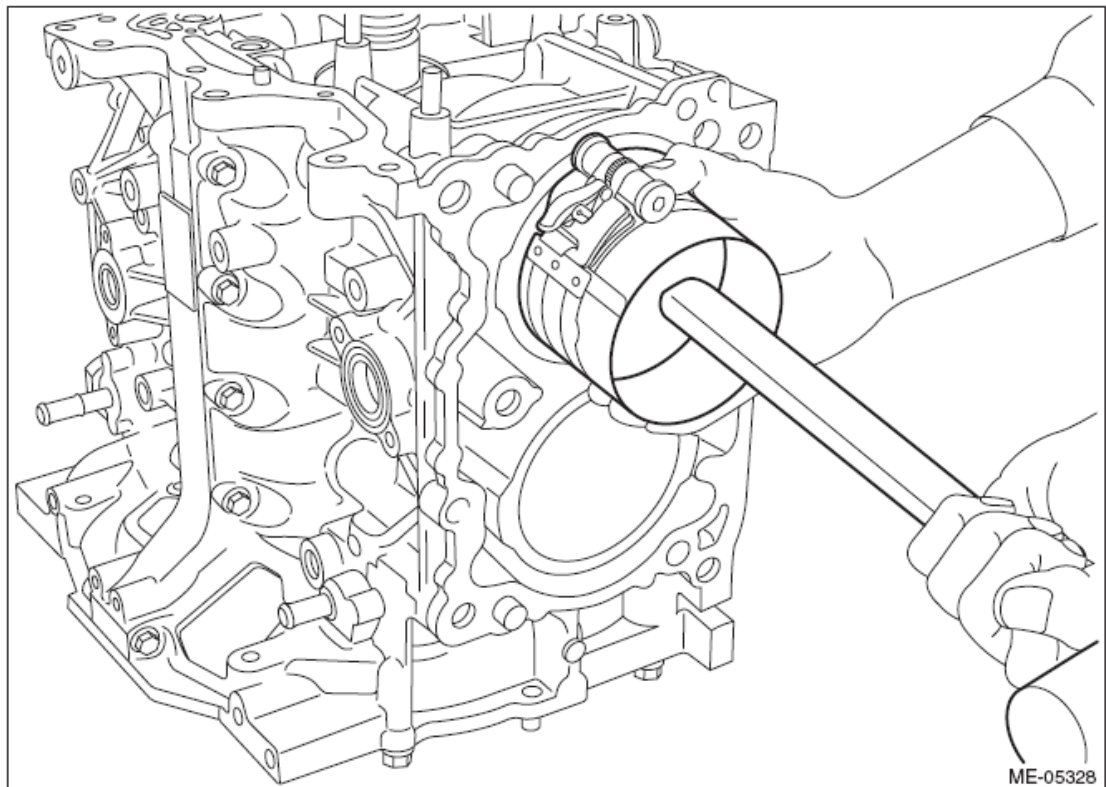
- Face the piston front mark (arrow) towards the front of the engine.



(a) Front mark

**Fig. 387: Face Piston Front Mark (Arrow) Towards Front Of Engine.**  
Courtesy of SUBARU OF AMERICA, INC.

- Insert while lightly tapping the crown of the piston with the handle of a plastic hammer.



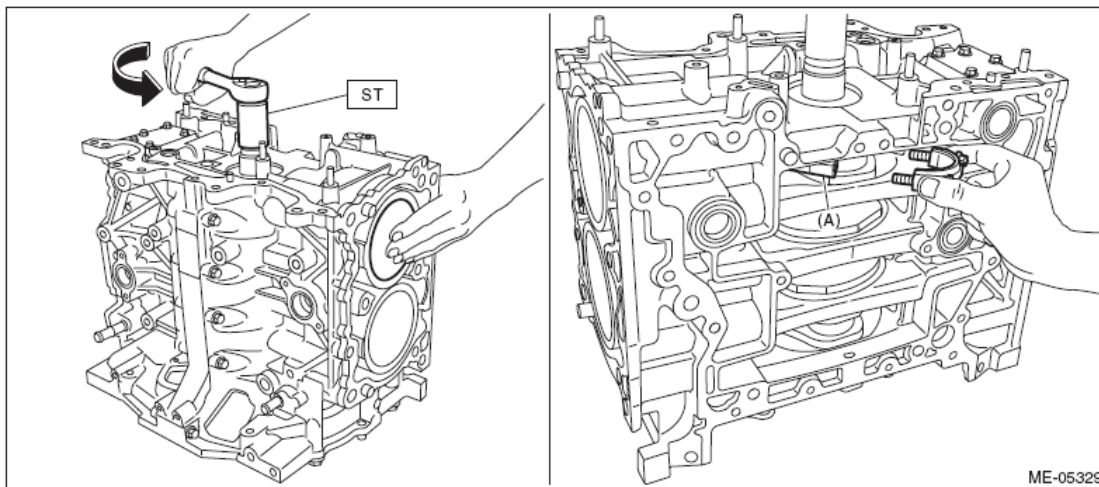
**Fig. 388: Tapping Crown Of Piston Using Handle Of Plastic Hammer**  
Courtesy of SUBARU OF AMERICA, INC.

4. Turn the crankshaft counterclockwise so that the #1 crank pin and the large end of #1 connecting rod (A) are positioned as shown in the figure using ST, while pressing the #1 piston crown, and then set the #1 connecting rod cap and #1 connecting rod cap bolt.

**NOTE:**

- Each connecting rod has its own mating cap. Make sure that they are assembled correctly by checking their matching symbol.
- Use a new connecting rod cap bolt.
- Apply a coat of engine oil to the #1 connecting rod cap seat and the connecting rod cap bolt threads.

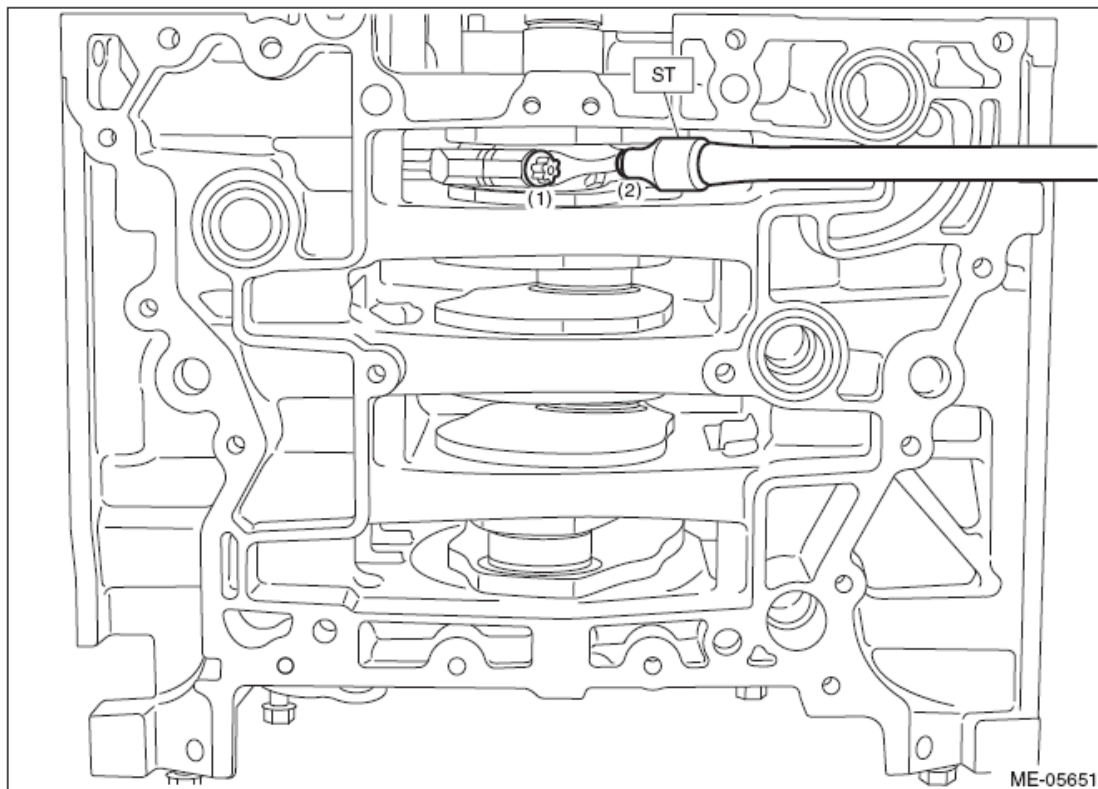
ST 18252AA000 CRANKSHAFT SOCKET



**Fig. 389: Aligning No. 1 Crank Pin And Large End Of No. 1 Connecting Rod Using Crankshaft Socket**  
 Courtesy of SUBARU OF AMERICA, INC.

5. Using ST, tighten the #1 connecting rod cap bolts to 10 N.m (1.0 kgf-m, 7.4 ft-lb) in numerical order as shown in the figure, then retighten the bolts to 22 N.m (2.2 kgf-m, 16.2 ft-lb) in numerical order as shown in the figure.

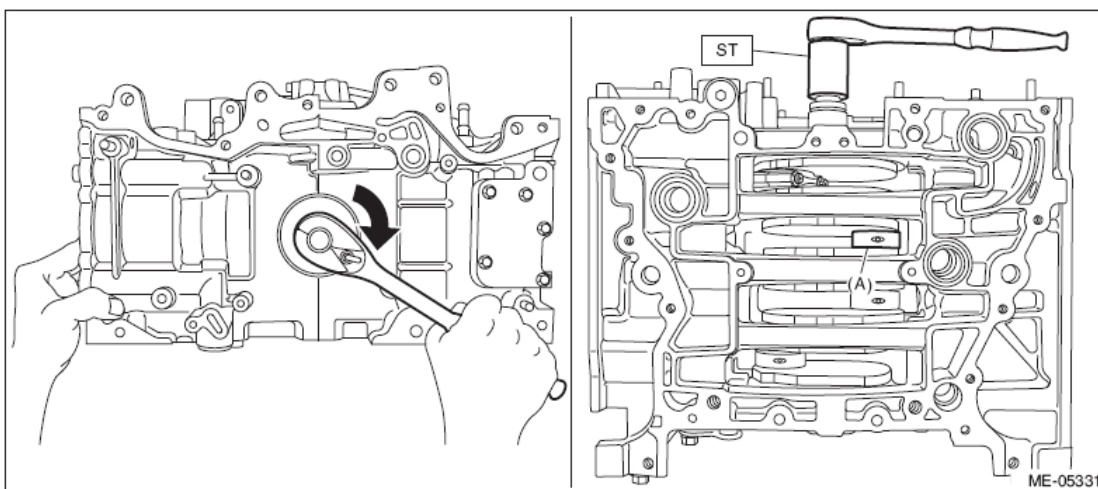
ST 18270AA020 SOCKET



**Fig. 390: Tightening No. 1 Connecting Rod Cap Bolts Using ST**  
Courtesy of SUBARU OF AMERICA, INC.

6. Turn the crankshaft clockwise so that the #2 crank pin (A) is positioned at TDC using ST.

ST 18252AA000 CRANKSHAFT SOCKET



**Fig. 391: Aligning Of Crankshaft No. 2 Pin A Positioned TDC Using ST**  
Courtesy of SUBARU OF AMERICA, INC.

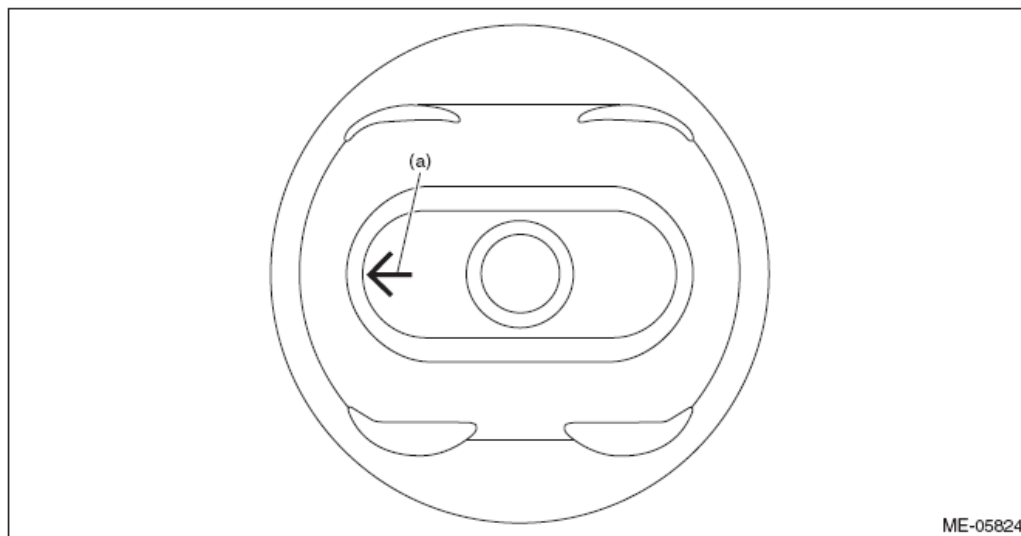
7. Compress the piston ring using piston ring compressor, and insert the #2 connecting rod with #2 piston into cylinder block.

**CAUTION:**

- Be careful not to damage the cylinder liner and #2 crank pin by the #2 connecting rod large end.
- Be careful not to apply strong impact when inserting to prevent connecting rod bearing from falling off.

**NOTE:**

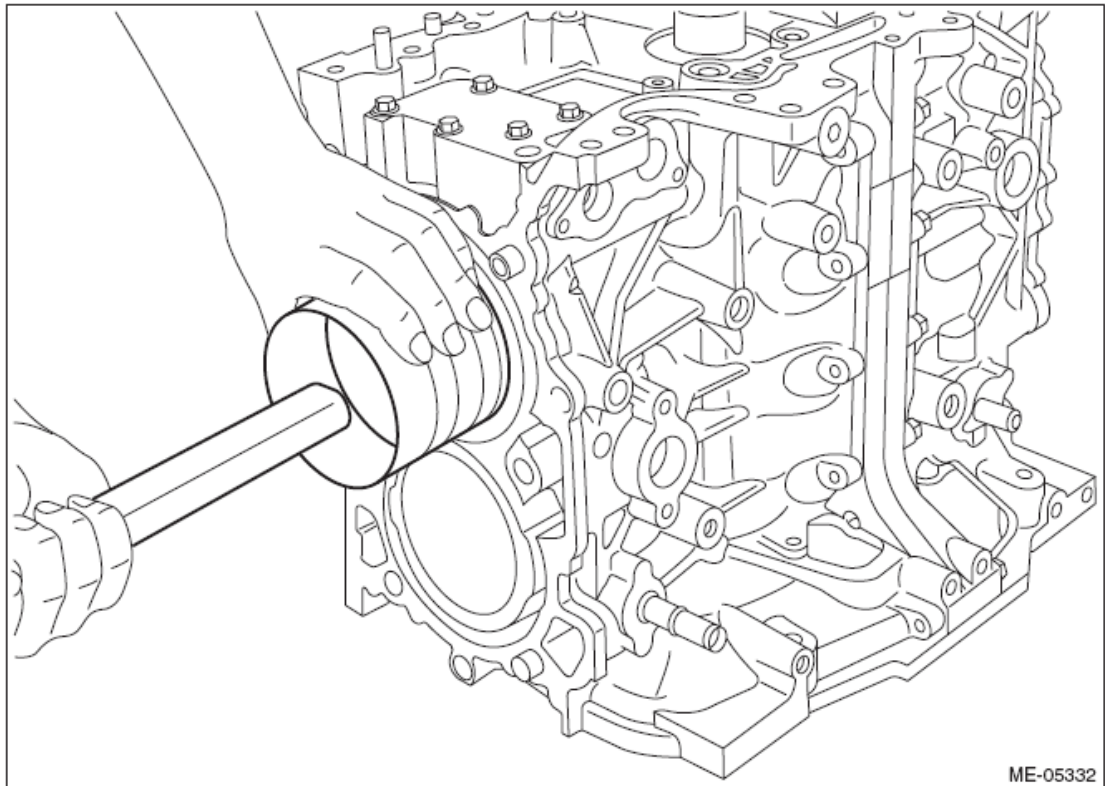
- Face the piston front mark (arrow) towards the front of the engine.



(a) Front mark

**Fig. 392: Identifying Piston Front Mark**  
Courtesy of SUBARU OF AMERICA, INC.

- Insert while lightly tapping the crown of the piston with the handle of a plastic hammer.



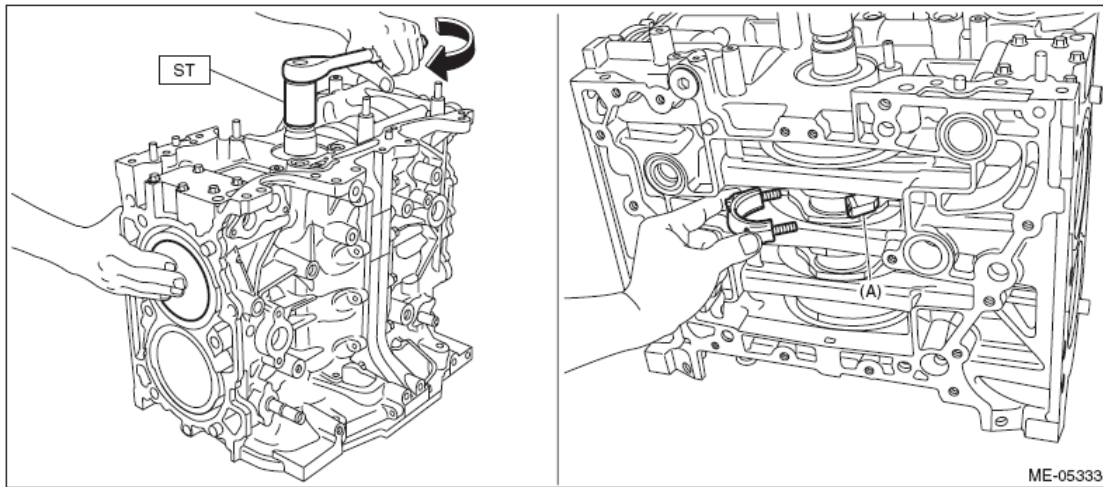
**Fig. 393: Tapping Crown Of Piston Using Handle Of Plastic Hammer**  
Courtesy of SUBARU OF AMERICA, INC.

8. Turn the crankshaft clockwise so that the #2 crank pin and the large end of #2 connecting rod (A) are positioned as shown in the figure using ST, while pressing the #2 piston crown, and then set the #2 connecting rod cap and #2 connecting rod cap bolt.

**NOTE:**

- Each connecting rod has its own mating cap. Make sure that they are assembled correctly by checking their matching symbol.
- Use a new connecting rod cap bolt.
- Apply a coat of engine oil to the #2 connecting rod cap seat and the connecting rod cap bolt threads.

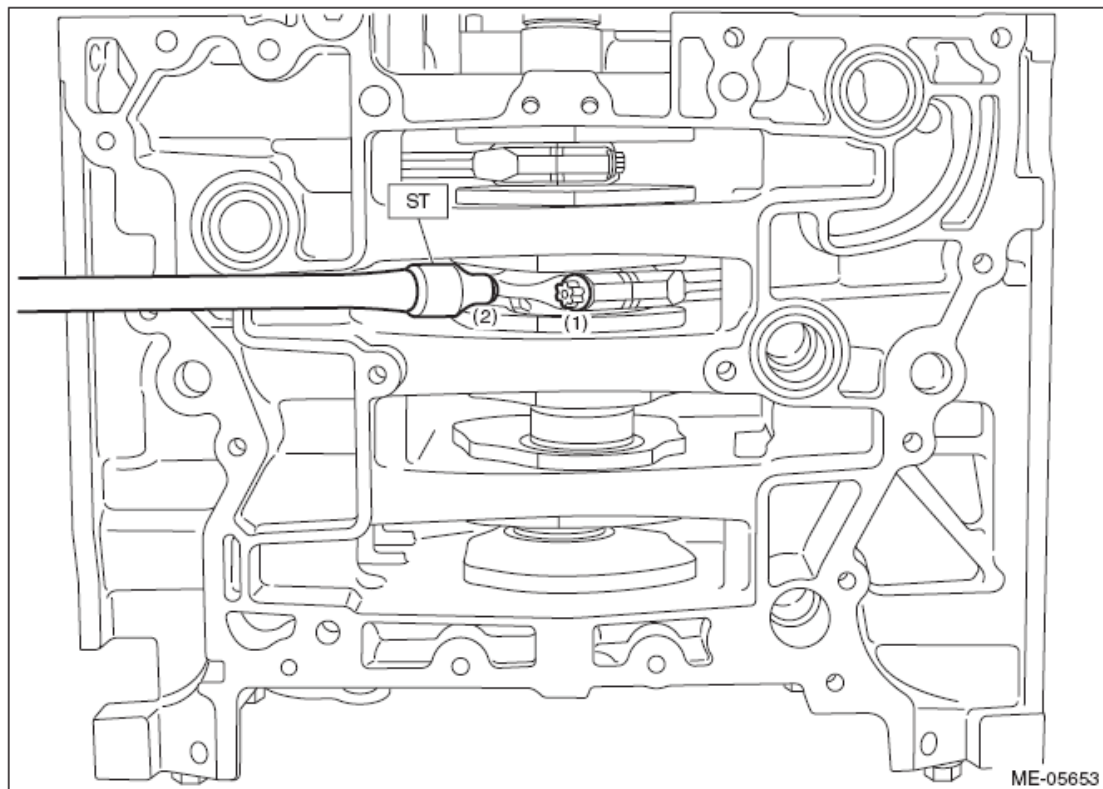
ST 18252AA000 CRANKSHAFT SOCKET



**Fig. 394: Turning Crankshaft Clockwise Using Crankshaft Socket**  
**Courtesy of SUBARU OF AMERICA, INC.**

9. Using ST, tighten the #2 connecting rod cap bolts to 10 N.m (1.0 kgf-m, 7.4 ft-lb) in numerical order as shown in the figure, then retighten the bolts to 22 N.m (2.2 kgf-m, 16.2 ft-lb) in numerical order as shown in the figure.

ST 18270AA020 SOCKET

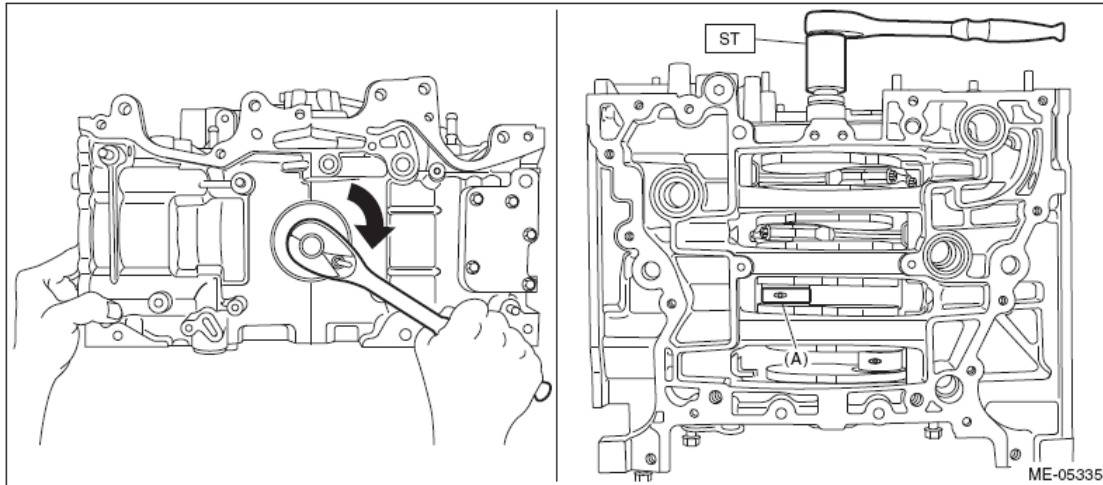


**Fig. 395: Tightening No. 2 Connecting Rod Cap Bolts Using ST**

Courtesy of SUBARU OF AMERICA, INC.

10. Turn the crankshaft clockwise so that the #3 crank pin (A) is positioned at TDC using ST.

ST 18252AA000 CRANKSHAFT SOCKET



**Fig. 396: Aligning No. 3 Crank Pin At TDC**  
Courtesy of SUBARU OF AMERICA, INC.

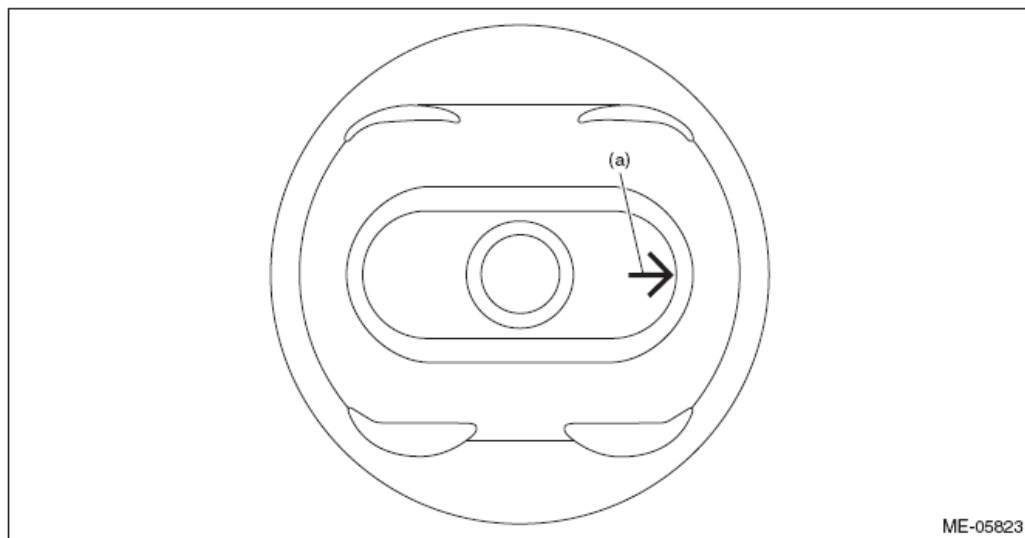
11. Compress the piston ring using piston ring compressor, and insert the #3 connecting rod with #3 piston into cylinder block.

**CAUTION:**

- Be careful not to damage the cylinder liner and #3 crank pin by the #3 connecting rod large end.
- Be careful not to apply strong impact when inserting to prevent connecting rod bearing from falling off.

**NOTE:**

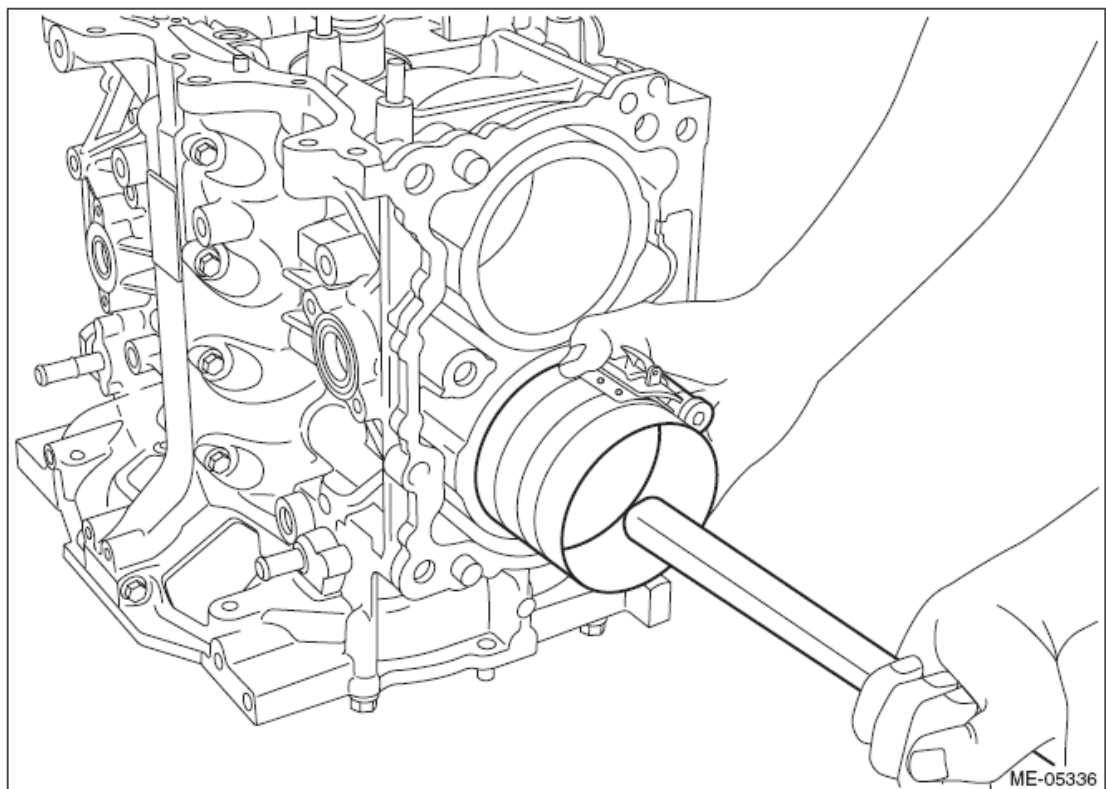
- Face the piston front mark (arrow) towards the front of the engine.



(a) Front mark

**Fig. 397: Identifying Piston Front Mark**  
Courtesy of SUBARU OF AMERICA, INC.

- Insert while lightly tapping the crown of the piston with the handle of a plastic hammer.



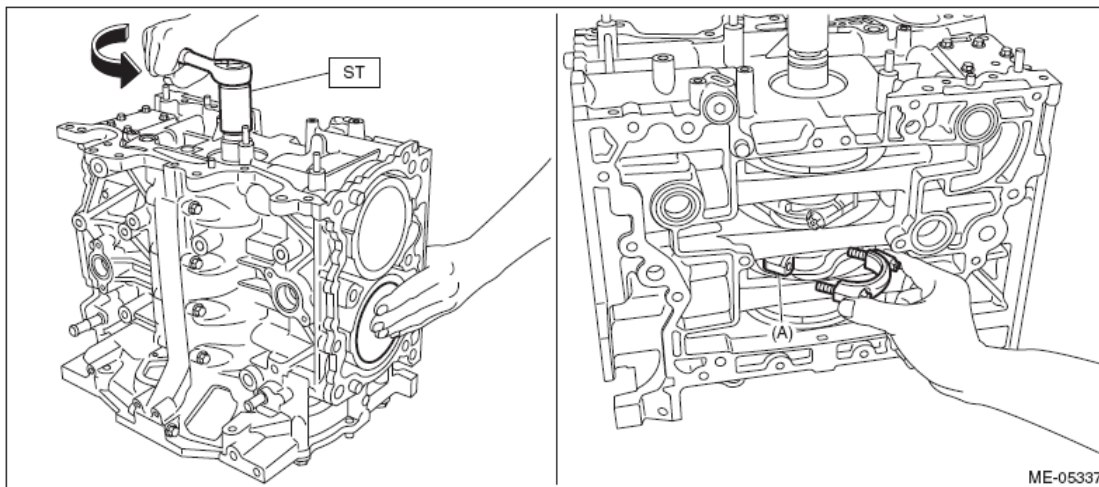
**Fig. 398: Tapping Crown Of Piston Using Handle Of Plastic Hammer**  
Courtesy of SUBARU OF AMERICA, INC.

12. Turn the crankshaft counterclockwise so that the #3 crank pin and the large end of #3 connecting rod (A) are positioned as shown in the figure using ST, while pressing the #3 piston crown, and then set the #3 connecting rod cap and #3 connecting rod cap bolt.

**NOTE:**

- Each connecting rod has its own mating cap. Make sure that they are assembled correctly by checking their matching symbol.
- Use a new connecting rod cap bolt.
- Apply a coat of engine oil to the #3 connecting rod cap seat and the connecting rod cap bolt threads.

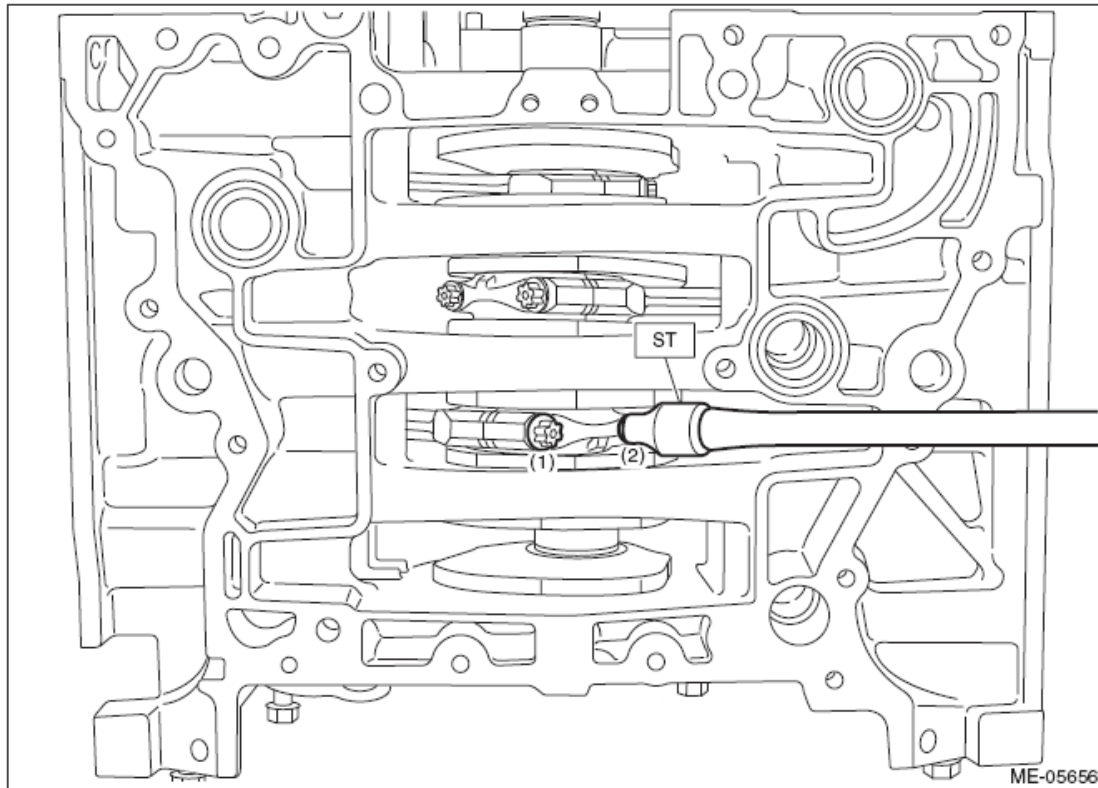
ST 18252AA000 CRANKSHAFT SOCKET



**Fig. 399: Aligning No. 3 Crank Pin And Large End Of No. 3 Connecting Rod Using Crankshaft Socket**  
 Courtesy of SUBARU OF AMERICA, INC.

13. Using ST, tighten the #3 connecting rod cap bolts to 10 N.m (1.0 kgf-m, 7.4 ft-lb) in numerical order as shown in the figure, then retighten the bolts to 22 N.m (2.2 kgf-m, 16.2 ft-lb) in numerical order as shown in the figure.

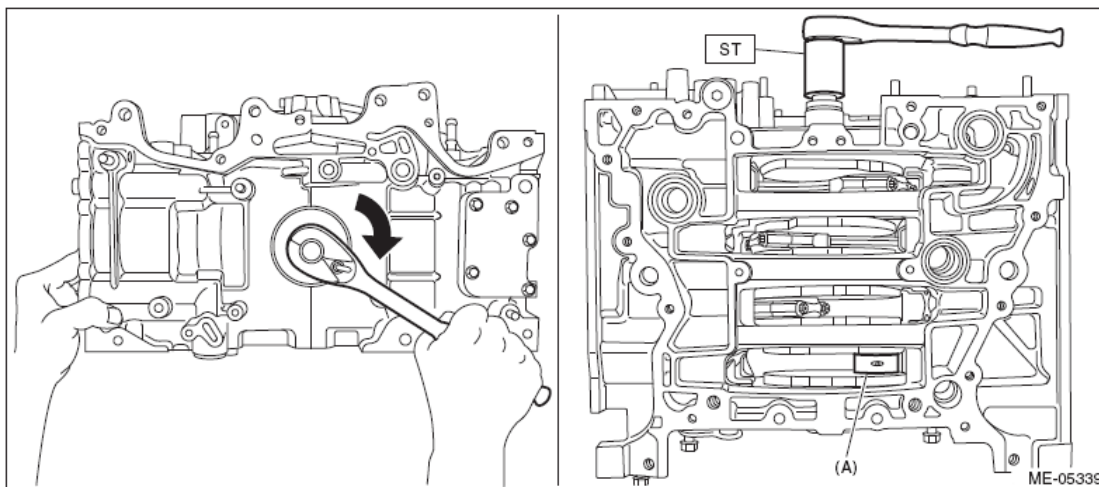
ST 18270AA020 SOCKET



**Fig. 400: Tightening No. 3 Connecting Rod Cap Bolts Using Tool**  
Courtesy of SUBARU OF AMERICA, INC.

14. Turn the crankshaft clockwise so that the #4 crank pin (A) is positioned at TDC using ST.

ST 18252AA000 CRANKSHAFT SOCKET



**Fig. 401: Turning Crankshaft Clockwise Using Crankshaft Socket**  
Courtesy of SUBARU OF AMERICA, INC.

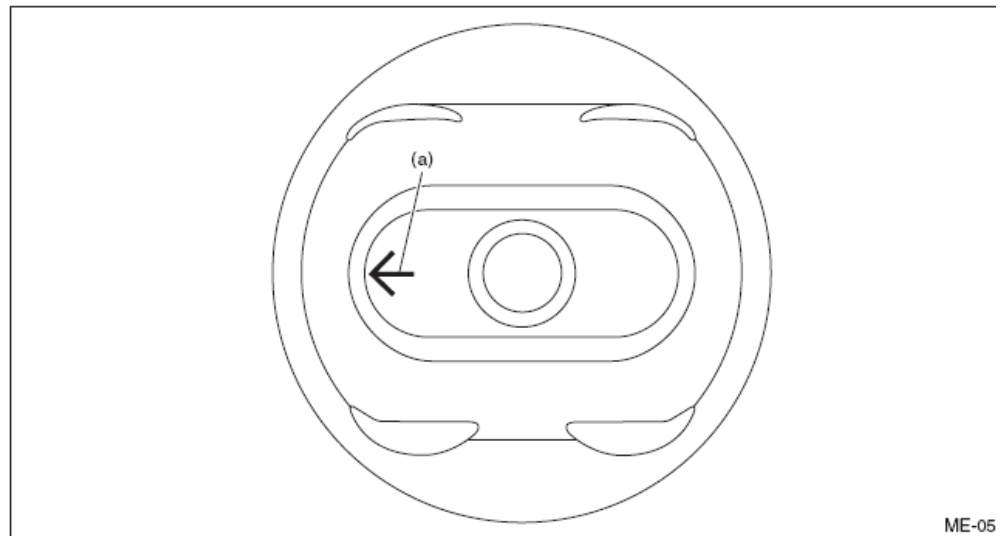
15. Compress the piston ring using piston ring compressor, and insert the #4 connecting rod with #4 piston into cylinder block.

**CAUTION:**

- Be careful not to damage the cylinder liner and #4 crank pin by the #4 connecting rod large end.
- Be careful not to apply strong impact when inserting to prevent connecting rod bearing from falling off.

**NOTE:**

- Face the piston front mark (arrow) towards the front of the engine.

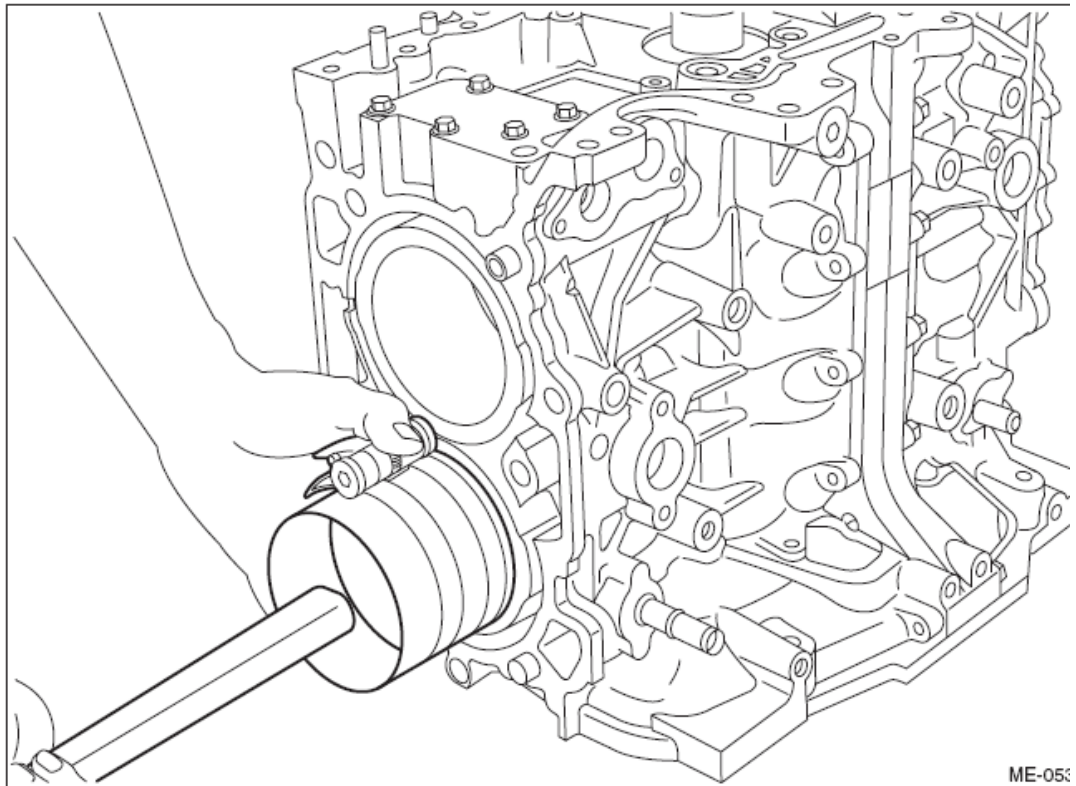


ME-05

(a) Front mark

**Fig. 402: Identifying Piston Front Mark**  
Courtesy of SUBARU OF AMERICA, INC.

- Insert while lightly tapping the crown of the piston with the handle of a plastic hammer.



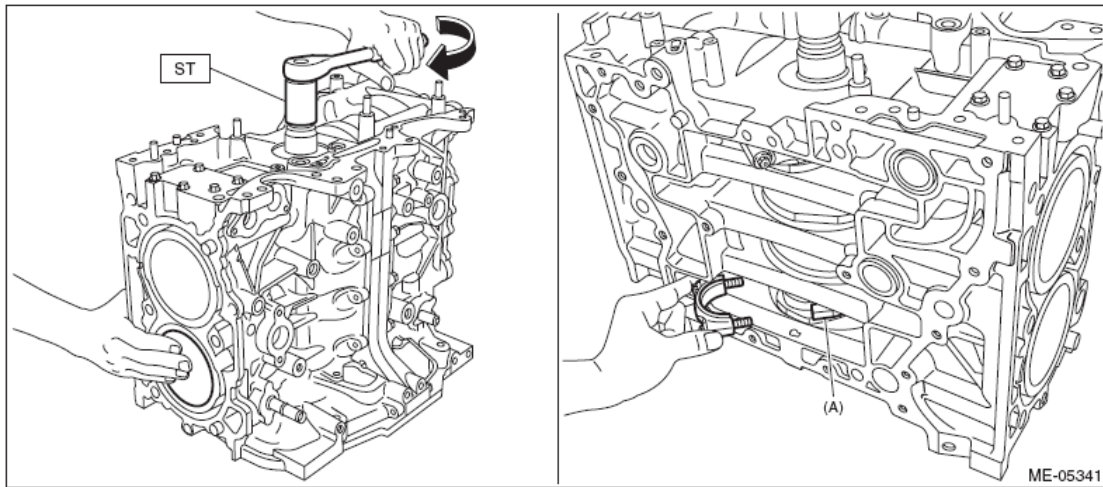
**Fig. 403: Tapping Crown Of Piston Using Handle Of Plastic Hammer**  
**Courtesy of SUBARU OF AMERICA, INC.**

16. Turn the crankshaft clockwise so that the #4 crank pin and the large end of #4 connecting rod (A) are positioned as shown in the figure using ST, while pressing the #4 piston crown, and then set the #4 connecting rod cap and #4 connecting rod cap bolt.

**NOTE:**

- Each connecting rod has its own mating cap. Make sure that they are assembled correctly by checking their matching symbol.
- Use a new connecting rod cap bolt.
- Apply a coat of engine oil to the #4 connecting rod cap seat and the connecting rod cap bolt threads.

ST 18252AA000 CRANKSHAFT SOCKET

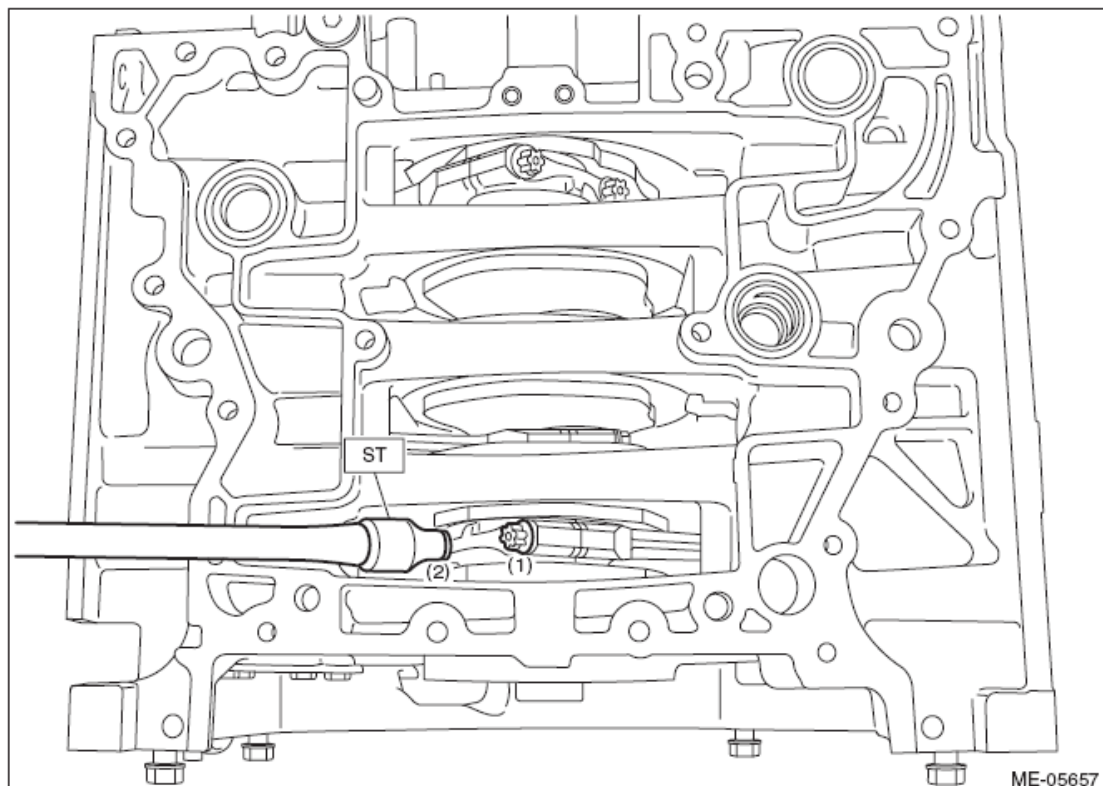


**Fig. 404: Aligning No. 4 Crank Pin And Large End Of No. 4 Connecting Rod Using Crankshaft Socket**

Courtesy of SUBARU OF AMERICA, INC.

17. Using ST, tighten the #4 connecting rod cap bolts to 10 N.m (1.0 kgf-m, 7.4 ft-lb) in numerical order as shown in the figure, then retighten the bolts to 22 N.m (2.2 kgf-m, 16.2 ft-lb) in numerical order as shown in the figure.

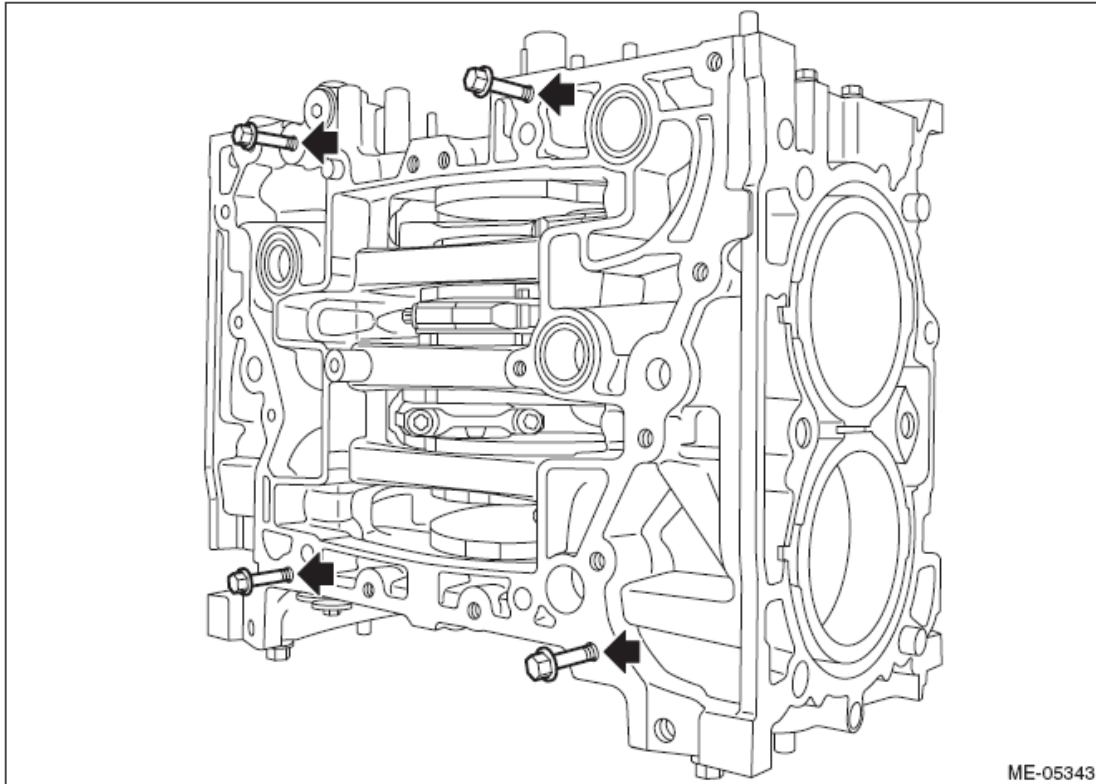
ST 18270AA020 SOCKET



**Fig. 405: Tightening No. 4 Connecting Rod Cap Bolts Using Socket**  
Courtesy of SUBARU OF AMERICA, INC.

18. Install the cam carrier mounting bolts at the locations shown in the figure.

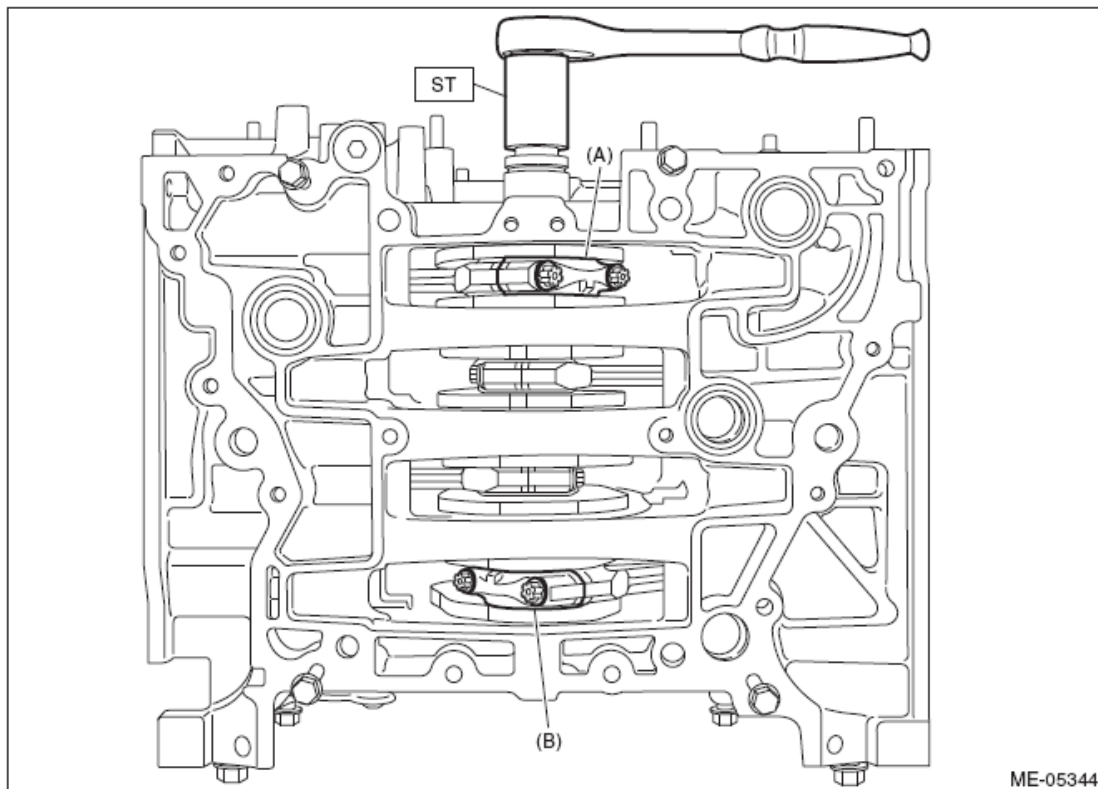
**NOTE:** This procedure is required to tighten the connecting rod cap bolts with specified angle using ST.



**Fig. 406: Locating Cam Carrier Mounting Bolts**  
Courtesy of SUBARU OF AMERICA, INC.

19. Turn the crankshaft so that the #1 connecting rod cap (A) and #4 connecting rod cap (B) is located at the position shown in the figure using ST.

ST 18252AA000 CRANKSHAFT SOCKET



**Fig. 407: Aligning No. 1 Connecting Rod Cap And No. 4 Connecting Rod Cap Using Crankshaft Socket**  
 Courtesy of SUBARU OF AMERICA, INC.

20. Using ST1 and ST2, tighten the #1 connecting rod cap bolts and #4 connecting rod cap bolts with specified angle in numerical order as shown in the figure.

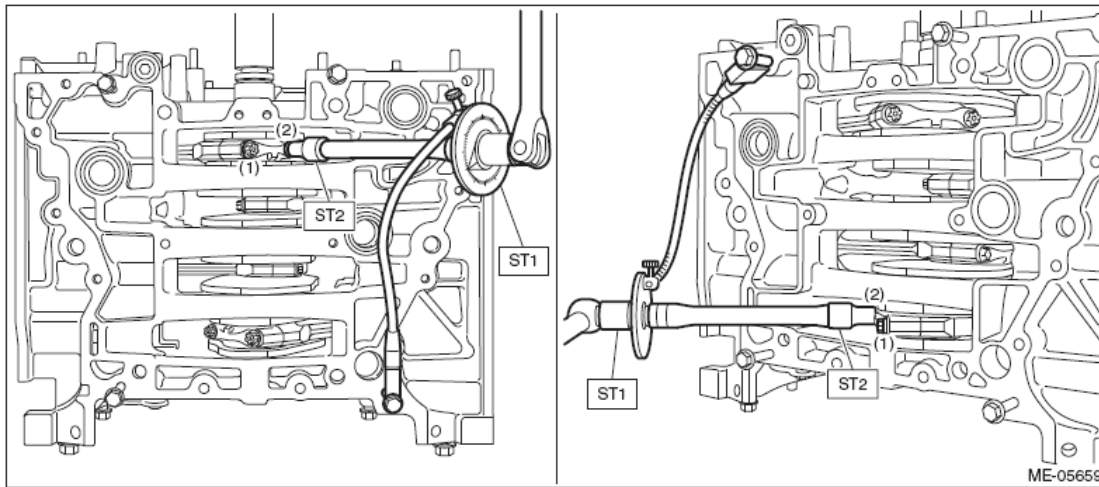
**NOTE:** Attach the magnet used for securing the ST1 (ANGLE GAUGE) to the cam carrier mounting bolt attached in step (18).

ST1 18854AA000 ANGLE GAUGE

ST2 18270AA020 SOCKET

***Tightening angle:***

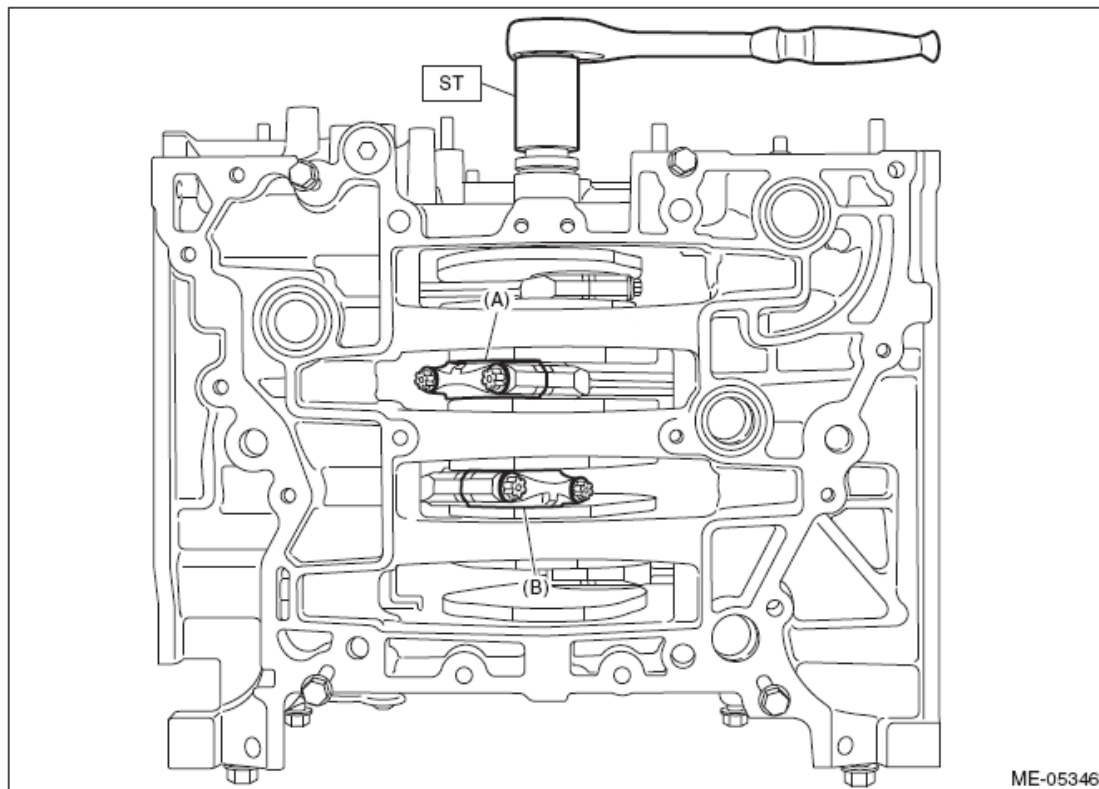
***137°±2°***



**Fig. 408: Tightening No. 1 Connecting Rod Cap Bolts And No. 4 Connecting Rod Cap Bolts**  
**Courtesy of SUBARU OF AMERICA, INC.**

21. Turn the crankshaft so that the #2 connecting rod cap (A) and #3 connecting rod cap (B) is located at the position shown in the figure using ST.

ST 18252AA000 CRANKSHAFT SOCKET



**Fig. 409: Aligning No. 2 Connecting Rod Cap And No. 3 Connecting Rod Cap Using Crankshaft Socket**

Courtesy of SUBARU OF AMERICA, INC.

22. Using ST1 and ST2, tighten the #2 connecting rod cap bolts and #3 connecting rod cap bolts with specified angle in numerical order as shown in the figure.

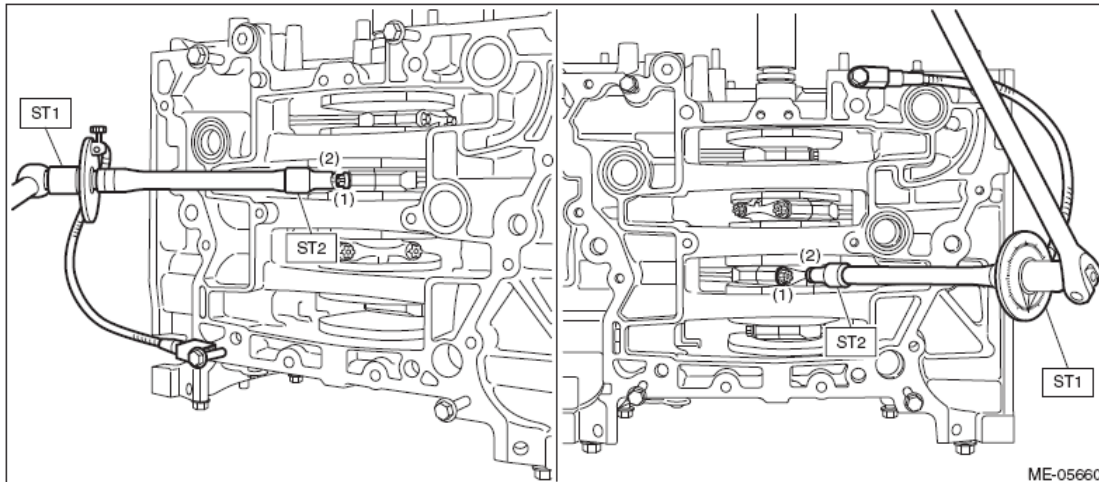
**NOTE:** Attach the magnet used for securing the ST1 (ANGLE GAUGE) to the cam carrier mounting bolt attached in step (18).

ST1 18854AA000 ANGLE GAUGE

ST2 18270AA020 SOCKET

*Tightening angle:*

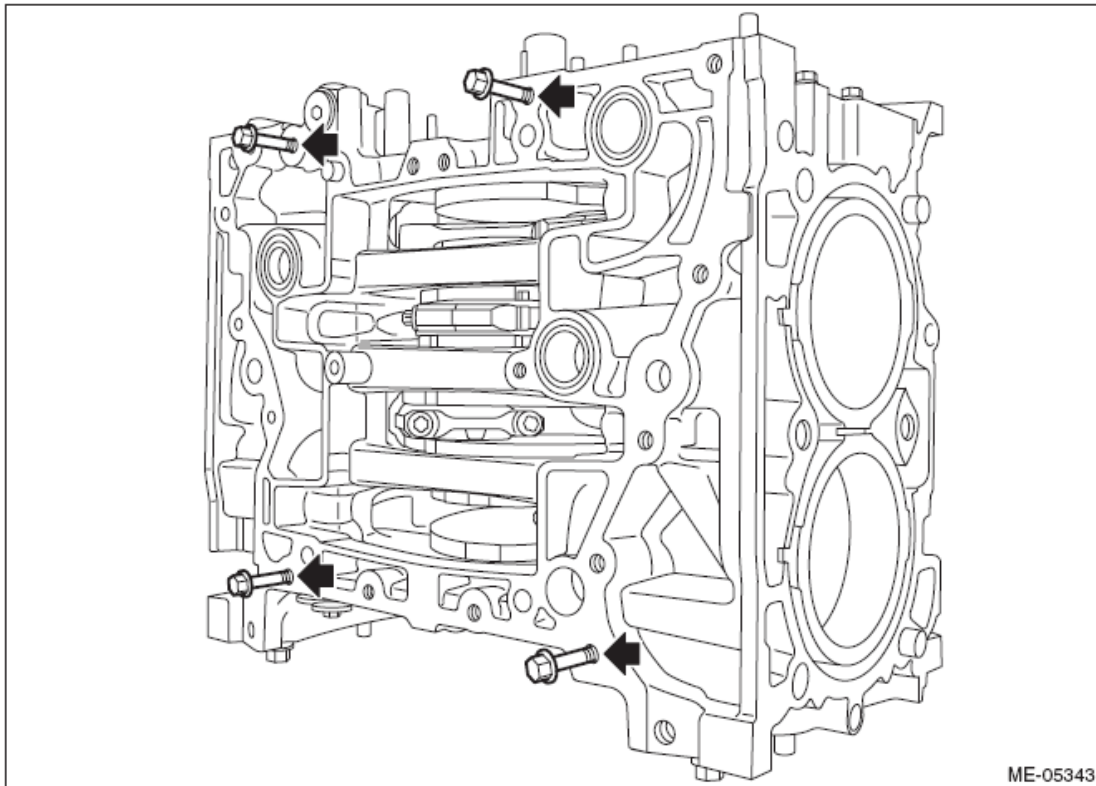
$137^{\circ} \pm 2^{\circ}$



**Fig. 410: Aligning No. 2 Connecting Rod Cap Bolts And No. 3 Connecting Rod Cap Bolts Using ST**

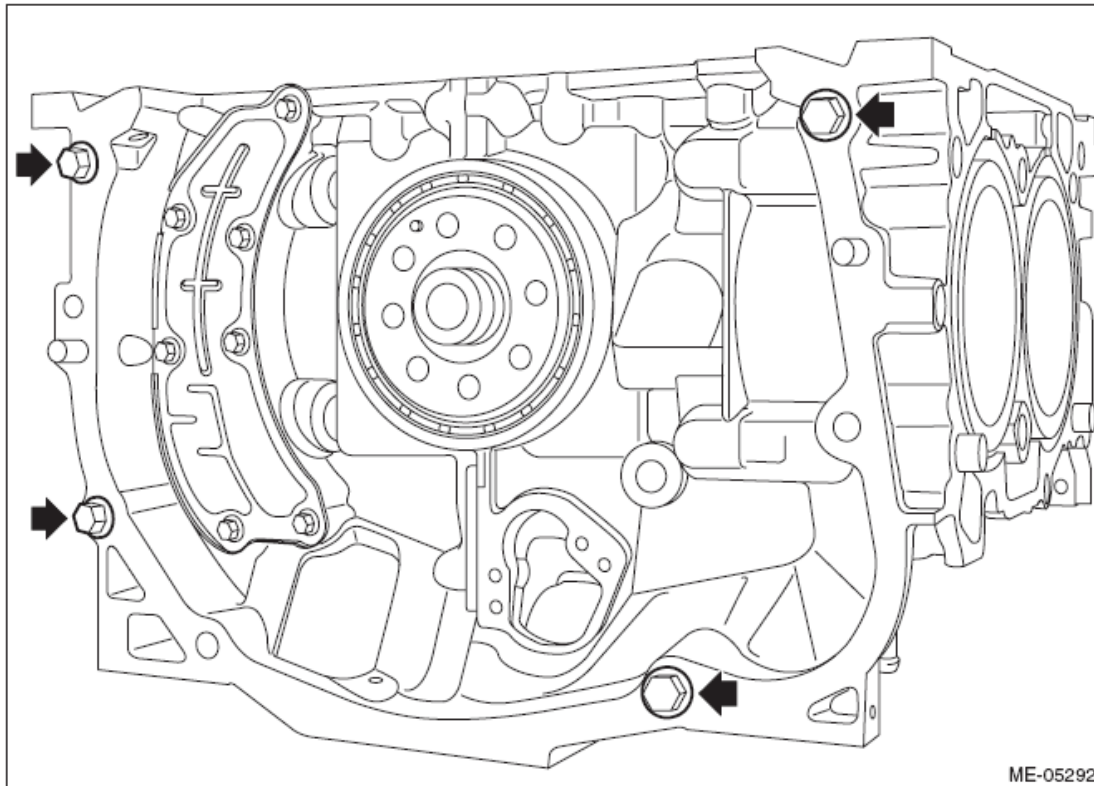
Courtesy of SUBARU OF AMERICA, INC.

23. Remove the cam carrier mounting bolts attached at the locations shown in the figure.



**Fig. 411: Locating Cam Carrier Mounting Bolts**  
**Courtesy of SUBARU OF AMERICA, INC.**

13. Set the cylinder block so that the oil pan side is on the upper side, and remove the A/C compressor bracket bolts and the power steering pump bracket bolts attached at the locations shown in the figure.



**Fig. 412: Locating A/C Compressor Bracket And Power Steering Pump Bracket Bolts**  
Courtesy of SUBARU OF AMERICA, INC.

14. Install the oil pan upper with oil pan to the cylinder block.
  1. Apply liquid gasket to the mating surface of oil pan upper as shown in the figure.

**NOTE:**

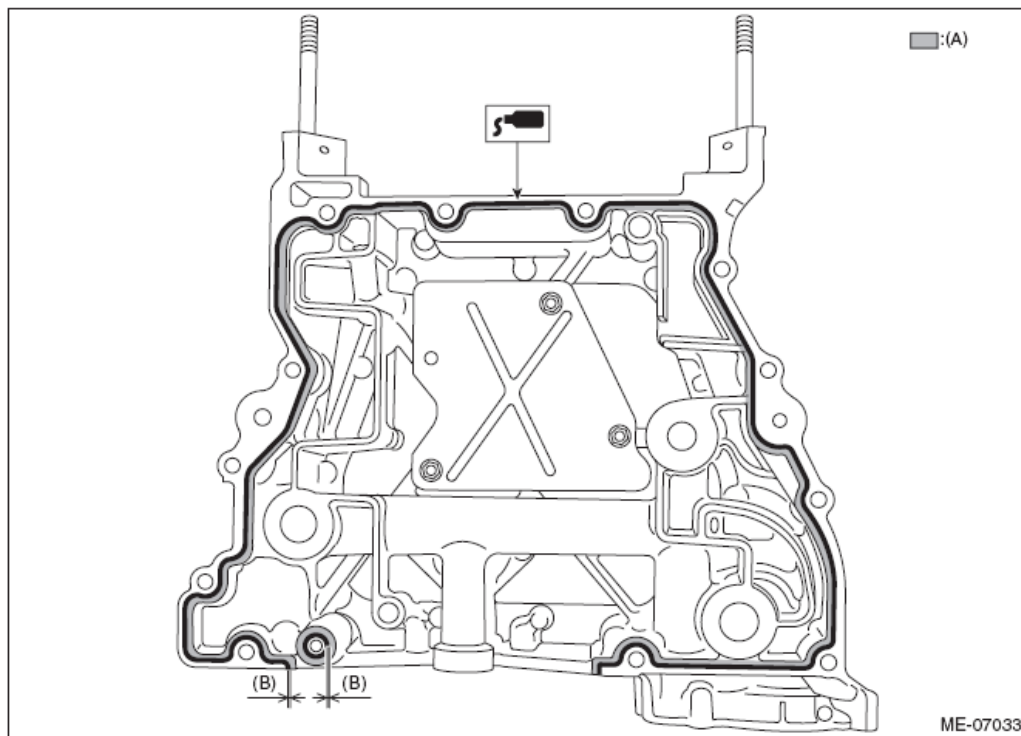
- Before applying liquid gasket, degrease the old liquid gasket seal surface of the cylinder block and the oil pan upper.
- Install within 5 min. after applying liquid gasket.
- Apply liquid gasket 1.5 mm (0.0591 in) outside from the chamfer surface. However, application of liquid gasket on the chamfer surface around the bolt hole is allowed.

***Liquid gasket:***

***THREE BOND 1217G (Part No. 0877Y0100) or equivalent***

***Liquid gasket applying diameter:***

***5±1 mm (0.1969±0.0394 in)***



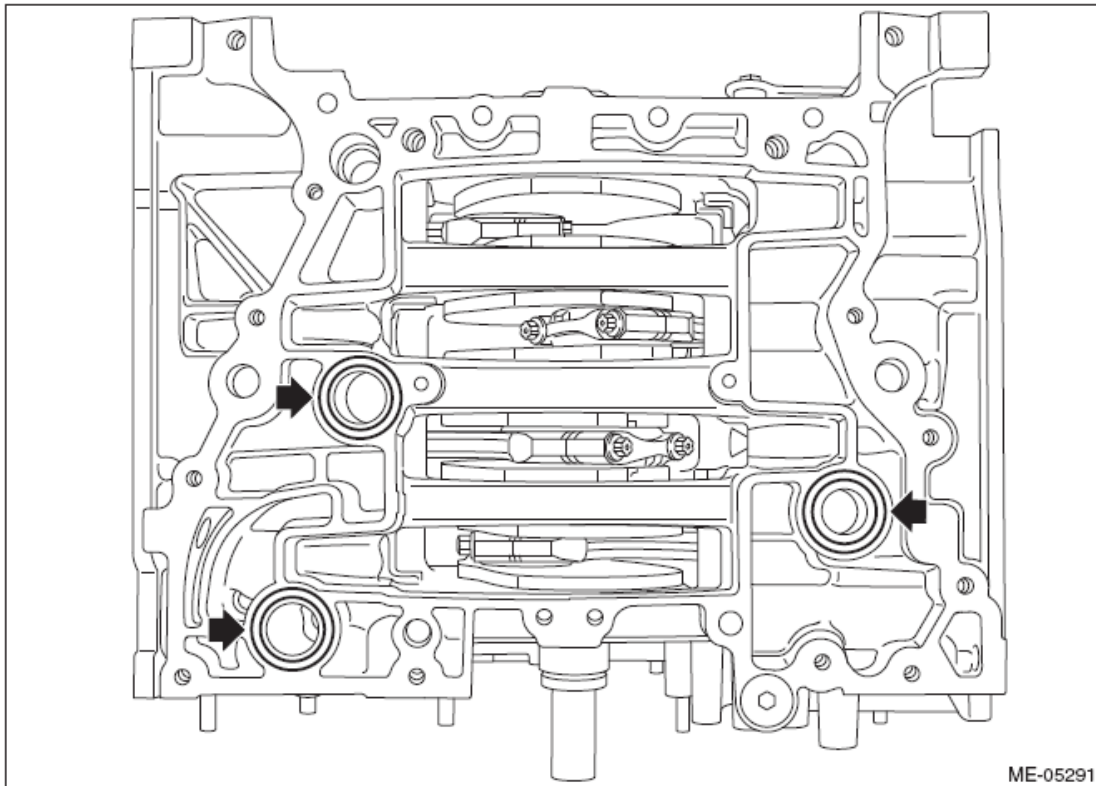
(A) Chamfer surface

(B) 1.5 mm (0.0591 in)

**Fig. 413: Identifying Liquid Gasket Applying Area On Mating Surface Of Oil Pan Upper**  
 Courtesy of SUBARU OF AMERICA, INC.

2. Install the O-ring to the cylinder block.

**NOTE:** Use new O-rings.



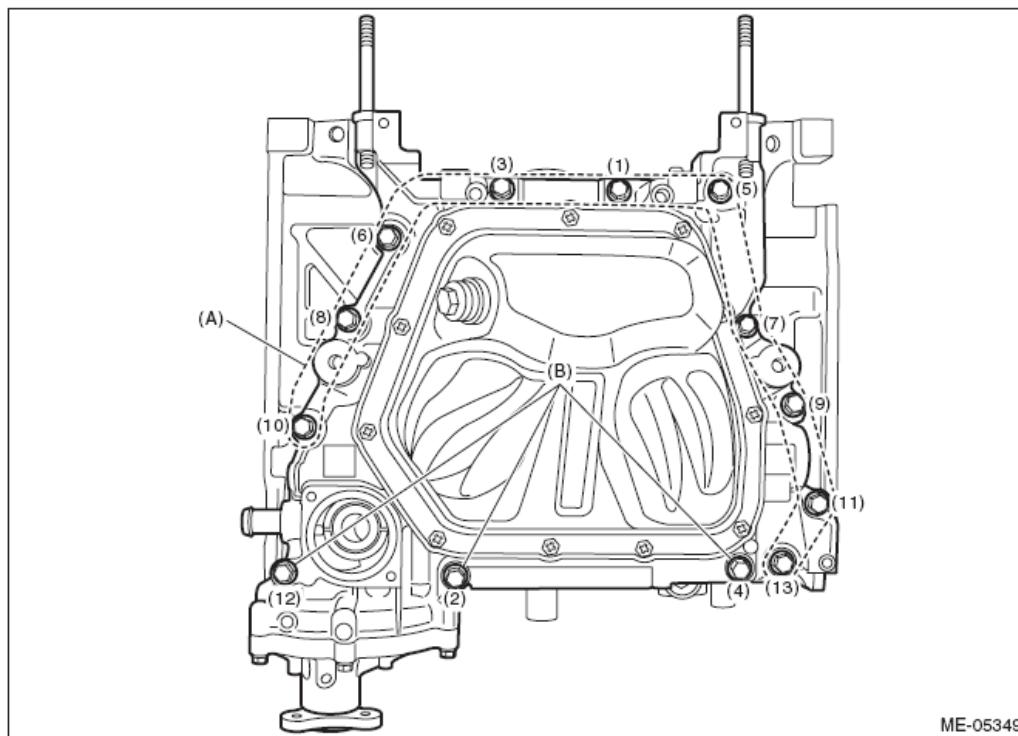
**Fig. 414: Locating Cylinder Block O-Rings**  
Courtesy of SUBARU OF AMERICA, INC.

3. Set the oil pan with oil pan upper to the cylinder block, and tighten the bolts in numerical order as shown in the figure.

**NOTE:** After tightening, if the liquid gasket is squeezed out onto the seal surface of the chain cover, completely remove any squeezed-out liquid gasket.

***Tightening torque:***

***18 N.m (1.8 kgf-m, 13.3 ft-lb)***



(A) M8 × 25

(B) M8 × 75

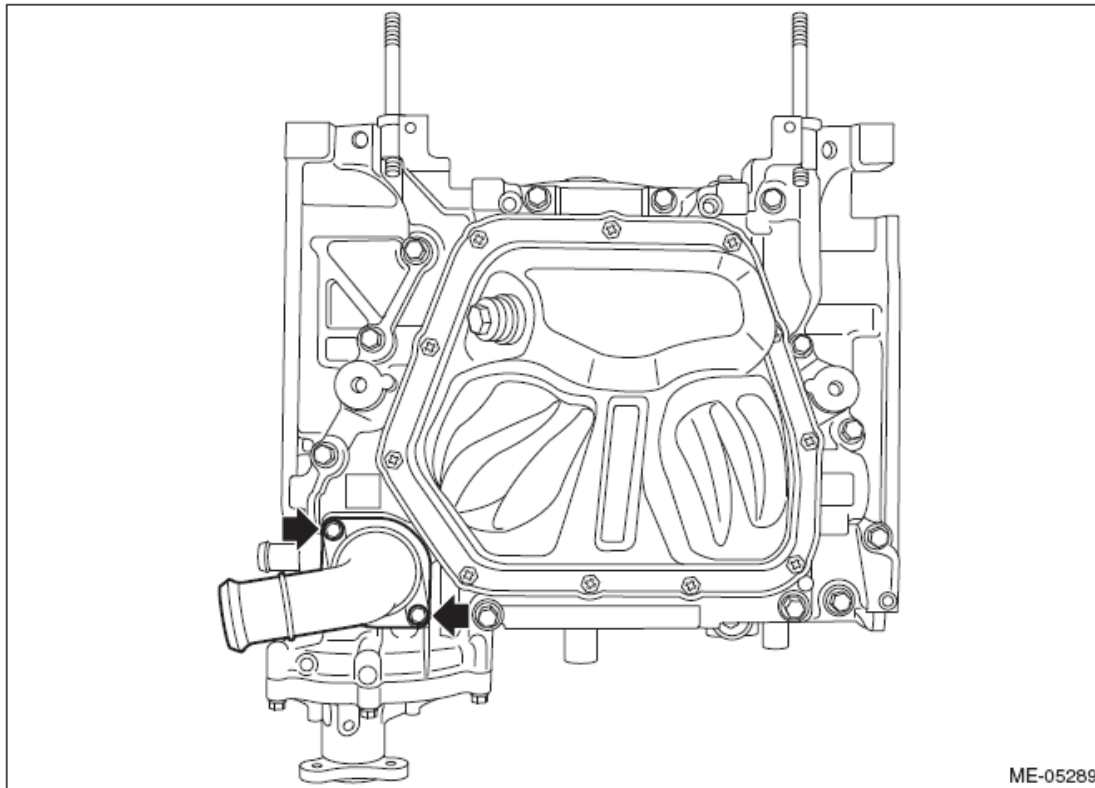
**Fig. 415: Identifying Tightening Sequence Of Oil Pan Upper To Cylinder Block Mounting Bolts**  
Courtesy of SUBARU OF AMERICA, INC.

15. Set the thermostat to the oil pan upper, and install the thermostat cover.

**NOTE:** Use a new gasket.

*Tightening torque:*

**6.4 N.m (0.7 kgf-m, 4.7 ft-lb)**



**Fig. 416: Locating Thermostat Cover Mounting Bolts**  
Courtesy of SUBARU OF AMERICA, INC.

16. Install the ST1, ST2, ST3 and ST4 to the cylinder block and oil pan upper.

ST1 498457000 ENGINE STAND ADAPTER RH

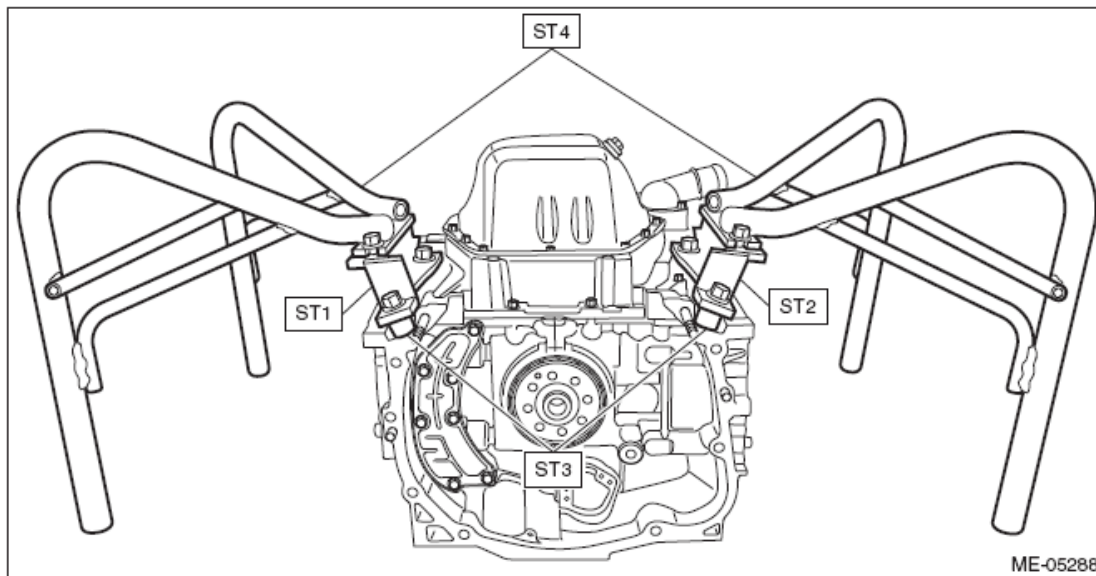
ST2 498457100 ENGINE STAND ADAPTER LH

ST3 18362AA020 ADAPTER

ST4 499817100 ENGINE STAND

***Tightening torque:***

***35 N.m (3.6 kgf-m, 25.8 ft-lb)***

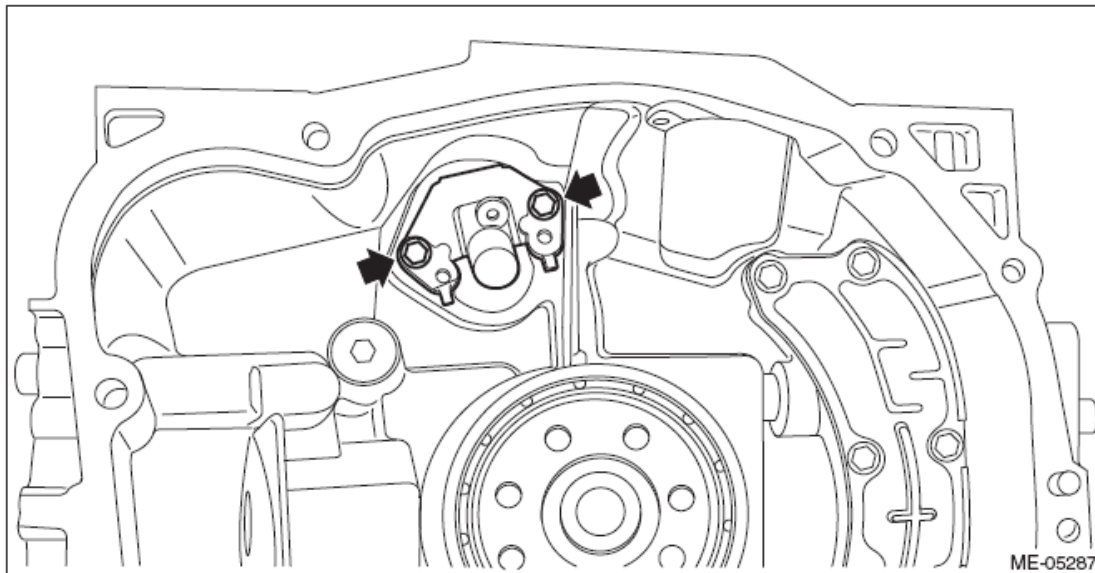


**Fig. 417: Installing ST1, ST2, ST3 And ST4 To Cylinder Block And Oil Pan Upper**  
Courtesy of SUBARU OF AMERICA, INC.

17. Install the crankshaft position sensor with crankshaft position sensor holder to the cylinder block LH.

***Tightening torque:***

***6.4 N.m (0.7 kgf-m, 4.7 ft-lb)***



**Fig. 418: Locating Crankshaft Position Sensor Holder Mounting Bolts**  
Courtesy of SUBARU OF AMERICA, INC.

18. Install the crankshaft position sensor plate with drive plate. (AT model) < Refer to **INSTALLATION** , Drive Plate. >

19. Install the crankshaft position sensor plate with flywheel. (MT model) < Refer to **INSTALLATION** , Flywheel. >
20. Install the clutch disc and cover. (MT model) < Refer to **INSTALLATION** , Clutch Disc and Cover. >
21. Install the PCV valve onto the cylinder block RH.

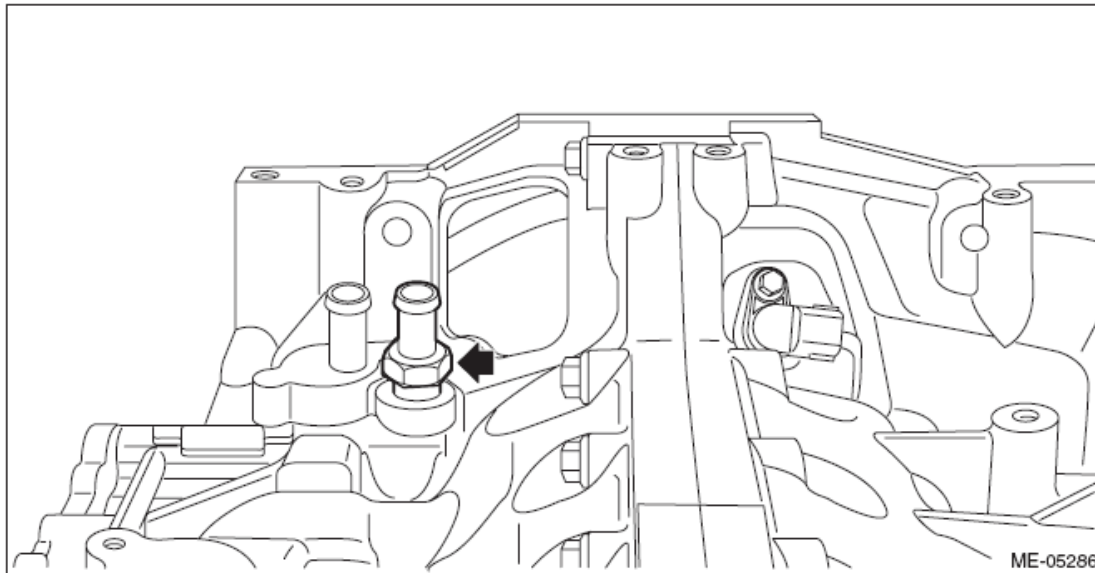
**NOTE:**        **Apply liquid gasket to the bolt threads of PCV valve.**

*Liquid gasket:*

**THREE BOND 1141G or equivalent**

*Tightening torque:*

**23 N.m (2.3 kgf-m, 17.0 ft-lb)**

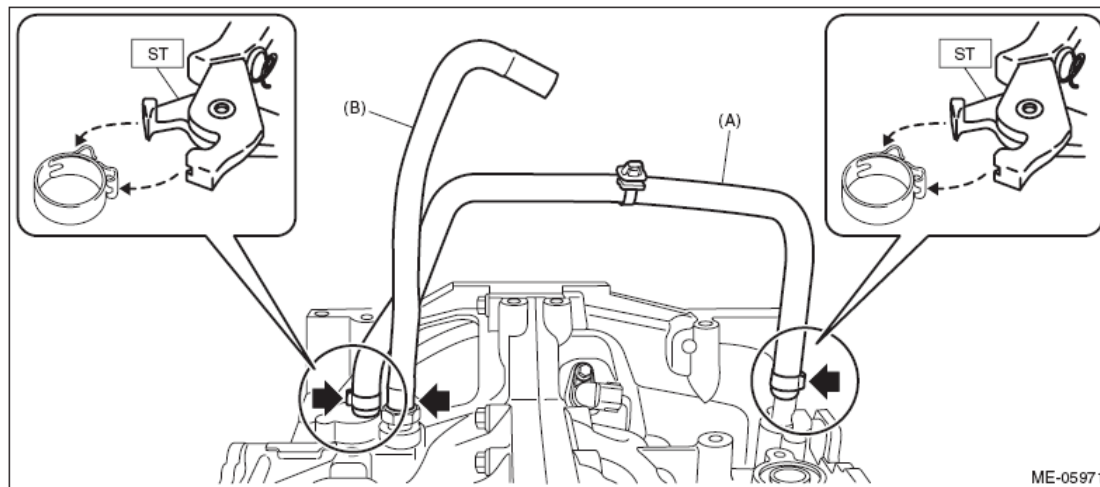


**Fig. 419: Locating Cylinder Block RH PCV Valve**  
Courtesy of SUBARU OF AMERICA, INC.

22. Install the PCV hose assembly (A) and the vacuum hose (B) to cylinder block and PCV valve.

**NOTE:**        **Use a new clamp for the PCV hose assembly (A), fit the cut out in the ST with the protrusion on the clamp as shown in the figure, and lock the clamp.**

ST 18353AA000 CLAMP PLIERS



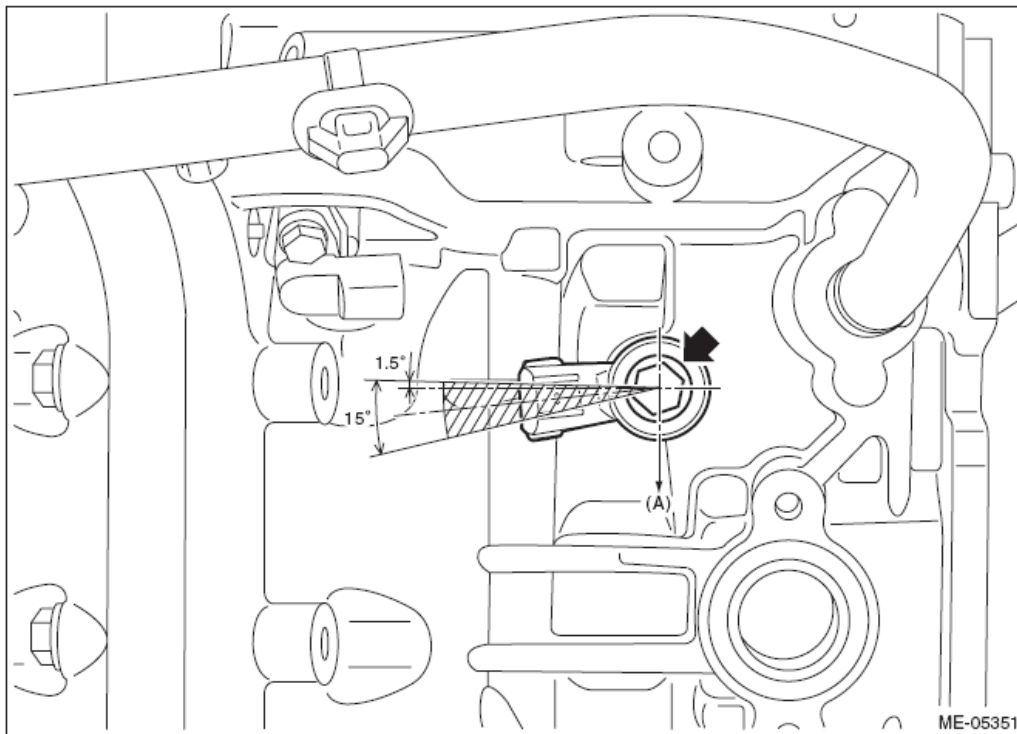
**Fig. 420: Removing/Installing PCV Hose Assembly And Vacuum Hose Clamps**  
 Courtesy of SUBARU OF AMERICA, INC.

23. Install the knock sensor to the cylinder block LH.

**NOTE:** Knock sensor must be positioned toward engine front so that the connector center position is within the range of 76.5 - 91.5° (shaded area).

**Tightening torque:**

**24 N.m (2.4 kgf-m, 17.7 ft-lb)**

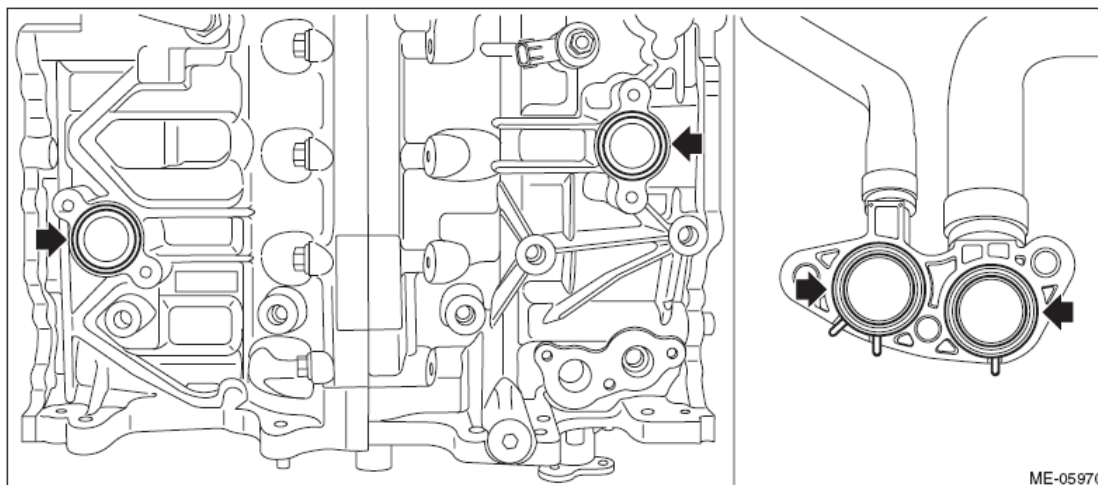


(A) Front of engine

**Fig. 421: Positioning Of Cylinder Block LH Knock Sensor**  
Courtesy of SUBARU OF AMERICA, INC.

24. Install the O-ring to the cylinder block and PCV connector.

**NOTE:** Use new O-rings.

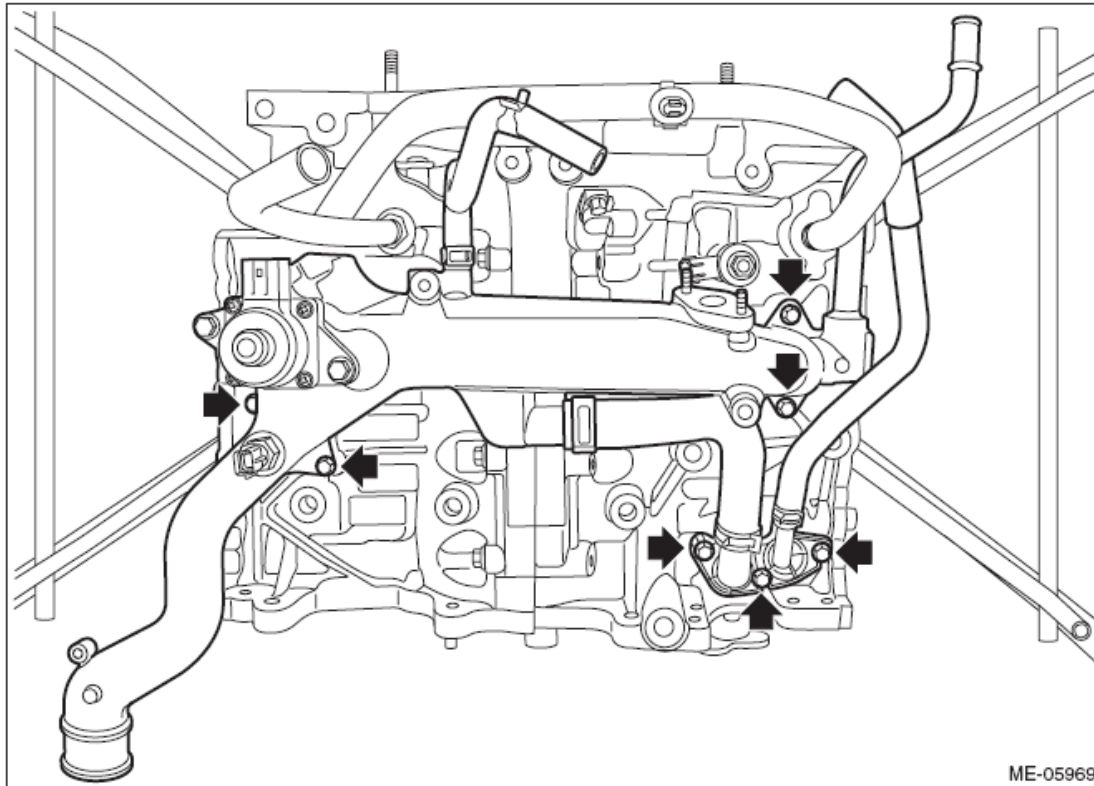


**Fig. 422: Locating Cylinder Block And PCV Connector O-Rings**  
Courtesy of SUBARU OF AMERICA, INC.

25. Install the water pipe assembly and PCV connector to the cylinder block.

***Tightening torque:***

***6.4 N.m (0.7 kgf-m, 4.7 ft-lb)***

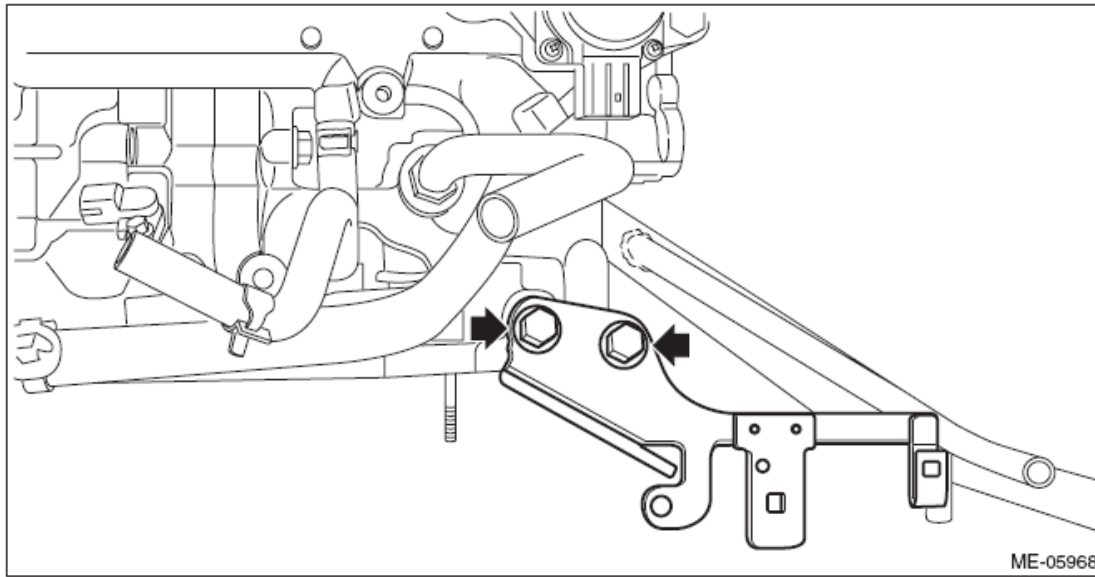


**Fig. 423: Locating Water Pipe Assembly And PCV Connector Mounting Bolts**  
Courtesy of SUBARU OF AMERICA, INC.

26. Install the engine rear hanger to the cylinder block RH.

***Tightening torque:***

***21 N.m (2.1 kgf-m, 15.5 ft-lb)***



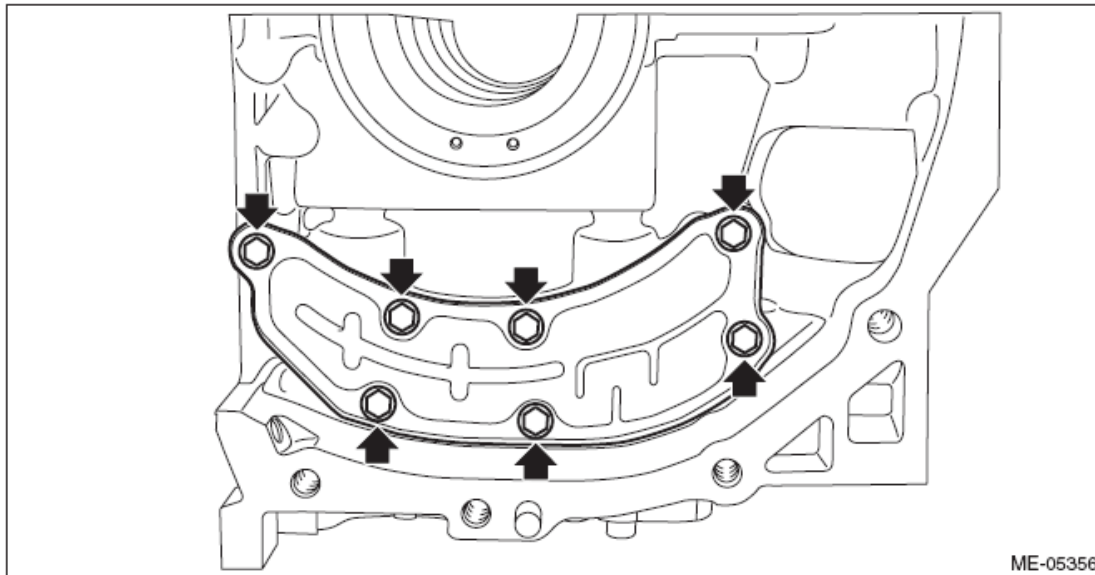
**Fig. 424: Locating Cylinder Block RH Engine Rear Hanger Mounting Bolts**  
 Courtesy of SUBARU OF AMERICA, INC.

27. Install the crank sprocket. < Refer to **INSTALLATION**, Crank Sprocket. >
28. Install the cylinder head. < Refer to **INSTALLATION**, Cylinder Head. >
29. Install the cam carrier. < Refer to **INSTALLATION**, Cam Carrier. >
30. Install the rocker cover. < Refer to **INSTALLATION**, Rocker Cover. >
31. Install the chain cover. < Refer to **INSTALLATION**, Chain Cover. >
32. Install the tumble generator valve assembly. < Refer to **INSTALLATION**, Tumble Generator Valve Assembly. >
33. Install the intake manifold. < Refer to **INSTALLATION**, Intake Manifold. >
34. Install the engine to the vehicle. < Refer to **INSTALLATION**, Engine Assembly. >

## DISASSEMBLY

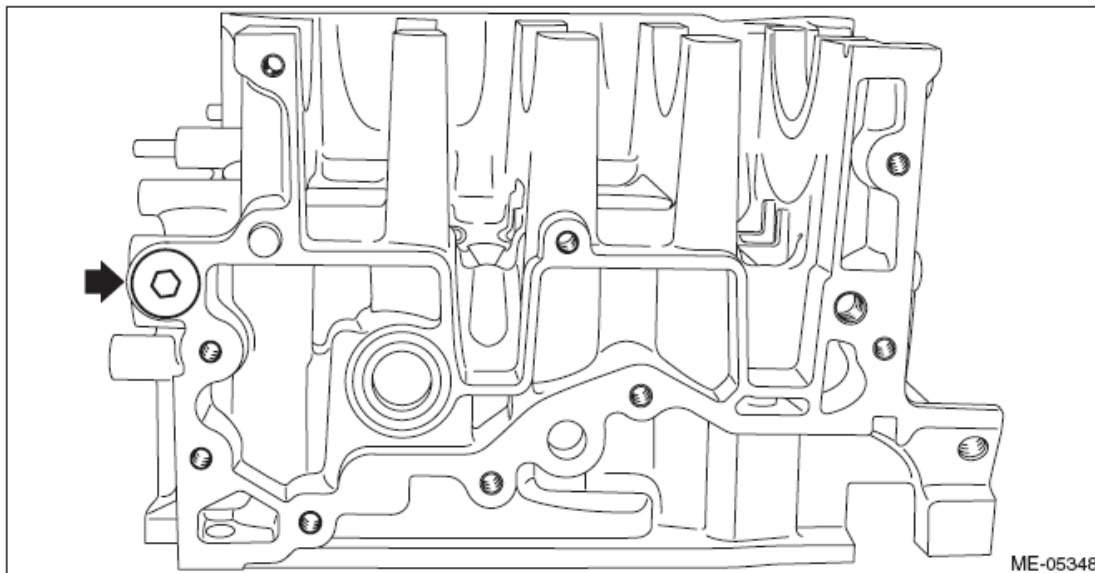
### CYLINDER BLOCK

1. Remove the oil separator cover from cylinder block RH.



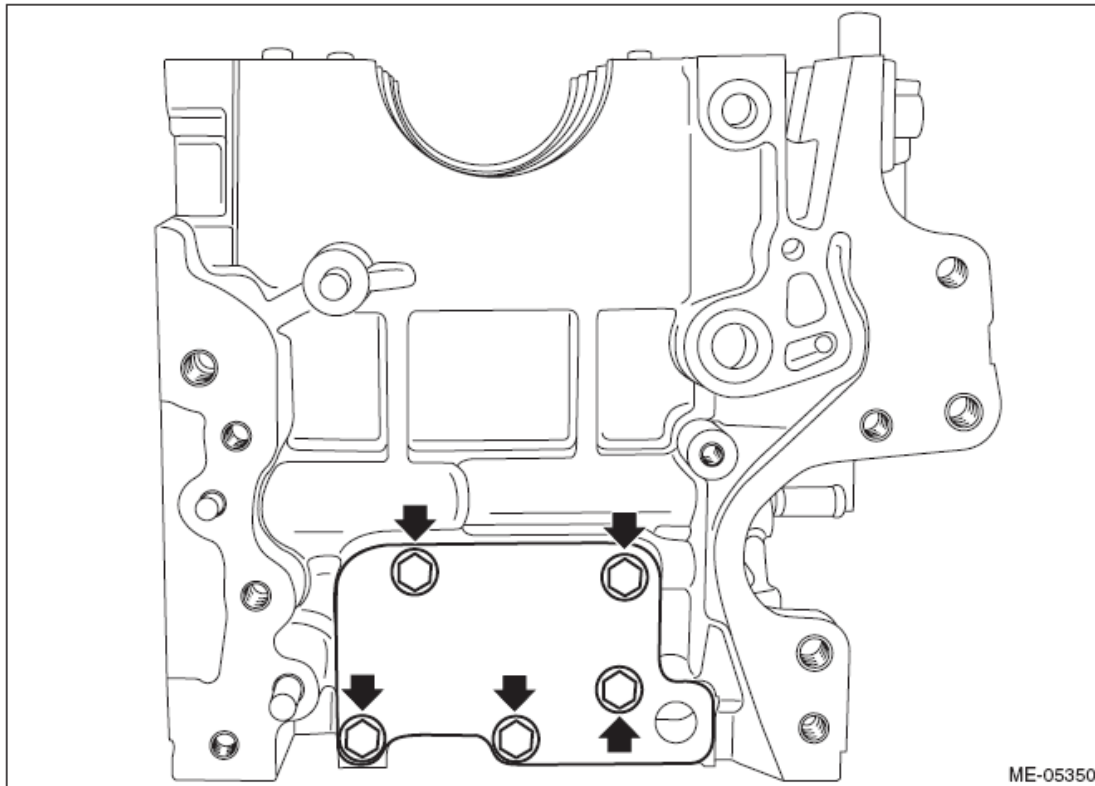
**Fig. 425: Locating Oil Separator Cover Bolts Of Cylinder Block RH**  
Courtesy of SUBARU OF AMERICA, INC.

2. Remove the liquid gasket from cylinder block RH.
3. Remove the main gallery plug from cylinder block RH.



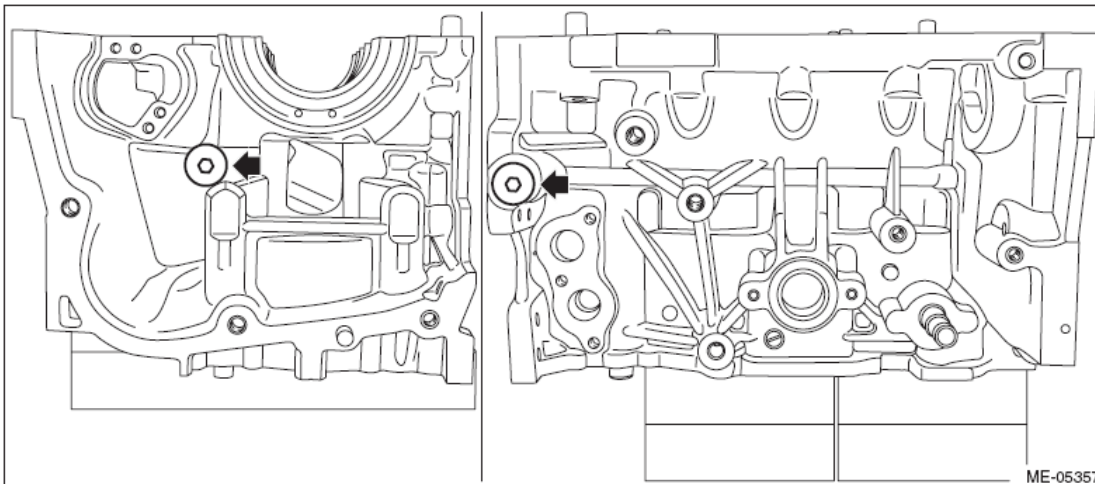
**Fig. 426: Locating Cylinder Block RH Main Gallery Plug**  
Courtesy of SUBARU OF AMERICA, INC.

4. Remove the liquid gasket from the bolt holes in the cylinder block RH and the threaded portion of the main gallery plug.
5. Remove the cylinder block plate from cylinder block LH.



**Fig. 427: Locating Cylinder Block LH Block Plate Mounting Bolts**  
 Courtesy of SUBARU OF AMERICA, INC.

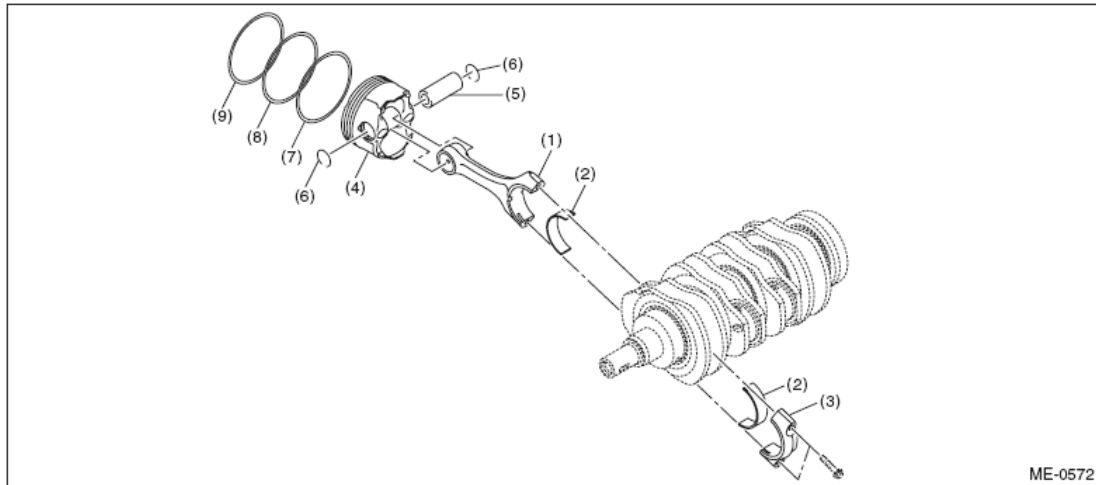
6. Remove the main gallery plug from cylinder block LH.



**Fig. 428: Locating Cylinder Block LH Main Gallery Plug**  
 Courtesy of SUBARU OF AMERICA, INC.

7. Remove the liquid gasket from the bolt holes in the cylinder block LH and the threaded portion of the main gallery plug.

## PISTON AND CONNECTING ROD



- |                            |                |                 |
|----------------------------|----------------|-----------------|
| (1) Connecting rod         | (4) Piston     | (7) Oil ring    |
| (2) Connecting rod bearing | (5) Piston pin | (8) Second ring |
| (3) Connecting rod cap     | (6) Circlip    | (9) Top ring    |

**Fig. 429: Identifying Piston And Connecting Rod And Related Components**  
Courtesy of SUBARU OF AMERICA, INC.

**NOTE:** To prevent confusion of various parts, mark each part.

1. Remove the connecting rod bearing from connecting rod and connecting rod cap.
2. Remove the piston rings using piston ring expander, and remove the oil ring by hand.

**NOTE:**

- Arrange the piston rings and oil rings in order so that they can be installed in their original positions.
- Be careful not to confuse the piston rings and oil rings.

3. Remove the circlip on one end from the piston using a flat tip screwdriver.

**NOTE:** Be careful not damage the piston and piston pin, by wrapping the tip of flat tip screwdriver with tape.

4. Remove the piston pin from piston, and remove the connecting rod from piston.
5. Remove the circlip on other end from the piston using a flat tip screwdriver.

**NOTE:** Be careful not damage the piston and piston pin, by wrapping the tip of flat tip screwdriver with tape.

## ASSEMBLY

### CYLINDER BLOCK

1. Install the oil separator cover to the cylinder block RH.
  1. Apply liquid gasket to the mating surfaces of oil separator cover.

**NOTE:**

- Use new oil separator cover.
- Before applying liquid gasket, degrease the old liquid gasket seal surface of cylinder block RH.
- Install within 5 min. after applying liquid gasket.

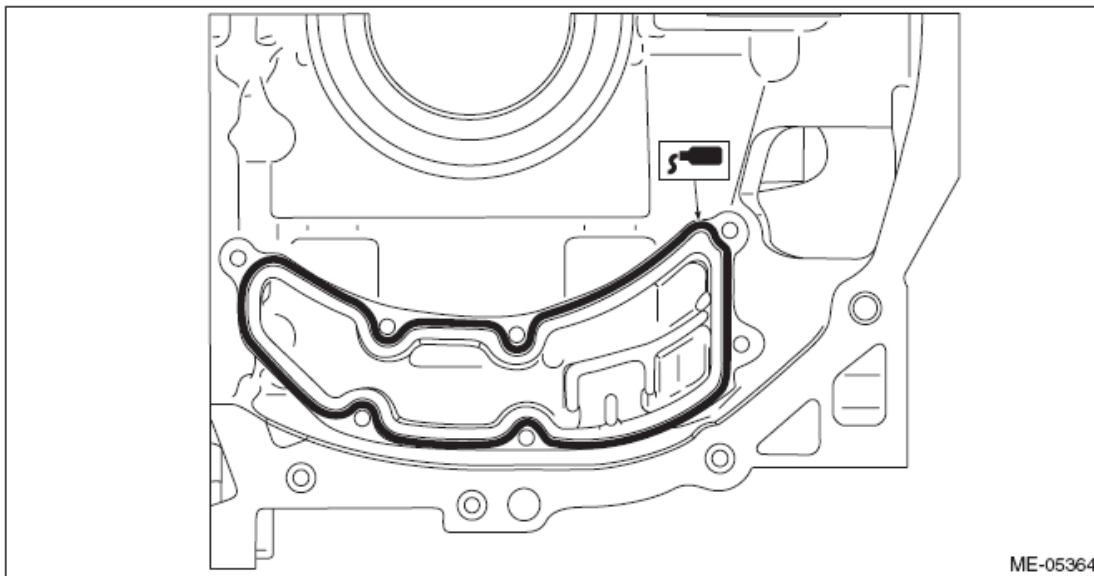
*Liquid gasket:*

*Mating surface*

**THREE BOND 1217G (Part No. K0877Y0100) or equivalent**

*Liquid gasket applying diameter:*

**4±1 mm (0.1772±0.0197 in)**



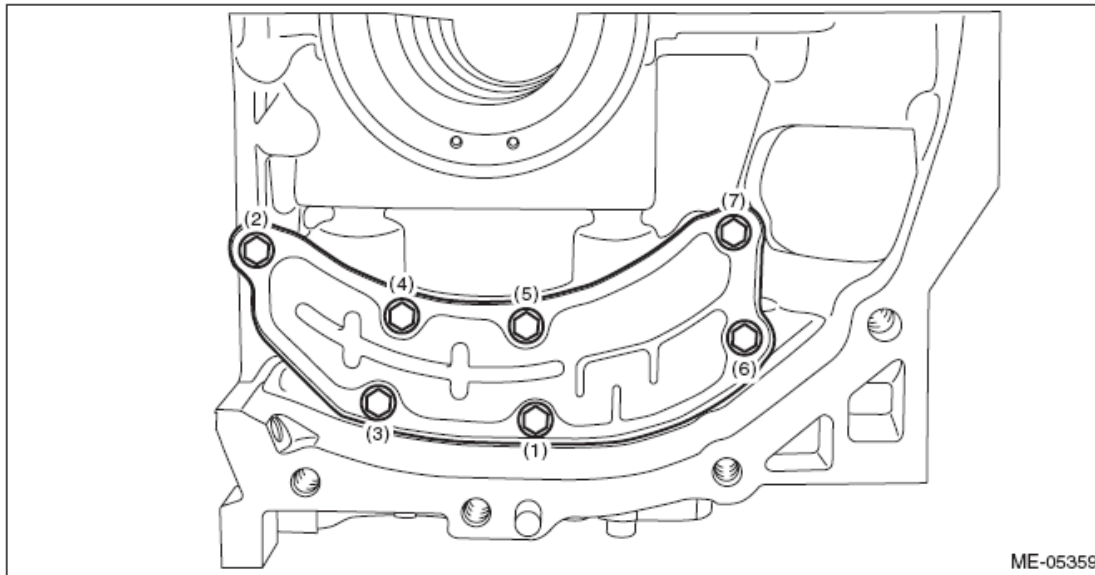
**Fig. 430: Identifying Liquid Gasket Applying Area On Mating Surfaces Of Oil Separator Cover**

**Courtesy of SUBARU OF AMERICA, INC.**

2. Install the oil separator cover to the cylinder block RH, and tighten the oil separator cover bolts in numerical order as shown in the figure.

*Tightening torque:*

**6.4 N.m (0.7 kgf-m, 4.7 ft-lb)**



**Fig. 431: Identifying Tightening Sequence Of Oil Separator Cover Mounting Bolts**  
Courtesy of SUBARU OF AMERICA, INC.

2. Apply liquid gasket to the threaded portion of the main gallery plug, and install the main gallery plug to the cylinder block RH.

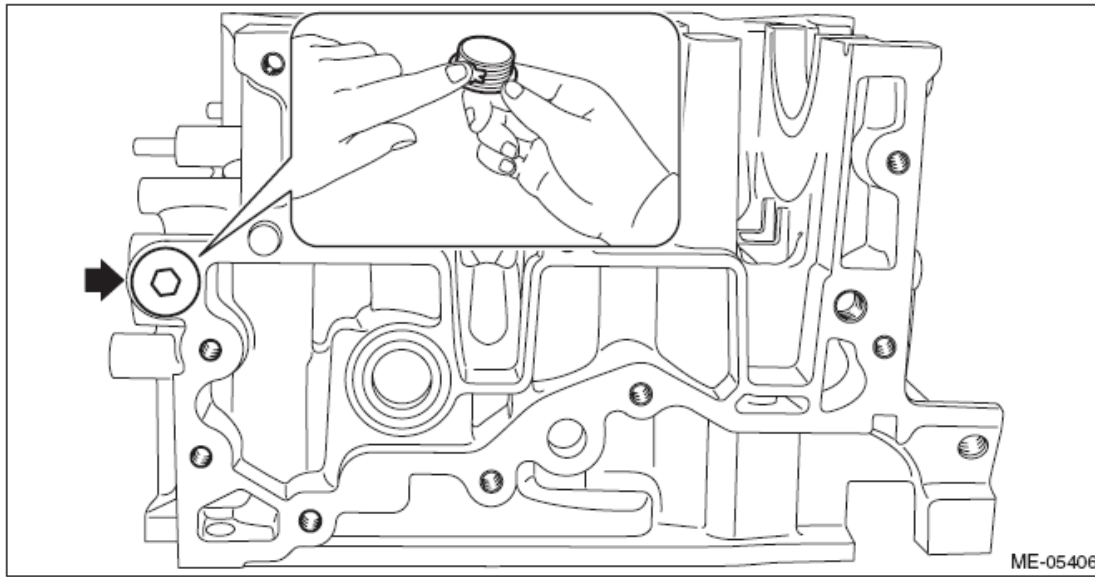
**NOTE:** Before applying liquid gasket, degrease the thread holes of the cylinder block RH and main gallery plug.

***Liquid gasket:***

***THREE BOND 1105 (Part No. 004403010) or equivalent***

***Tightening torque:***

***37 N.m (3.8 kgf-m, 27.3 ft-lb)***



**Fig. 432: Applying Liquid Gasket To Threaded Portion Of Main Gallery Plug**  
 Courtesy of SUBARU OF AMERICA, INC.

3. Apply liquid gasket to the threaded portion of the main gallery plug, and install the main gallery plug to the cylinder block LH.

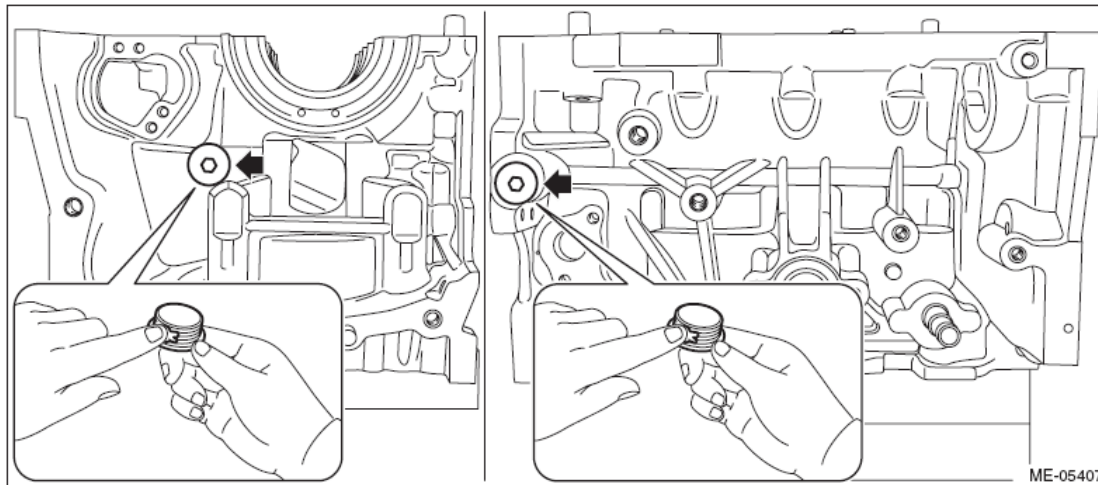
**NOTE:** Before applying liquid gasket, degrease the thread holes of the cylinder block LH and main gallery plug.

*Liquid gasket:*

**THREE BOND 1105 (Part No. 004403010) or equivalent**

*Tightening torque:*

**37 N.m (3.8 kgf-m, 27.3 ft-lb)**

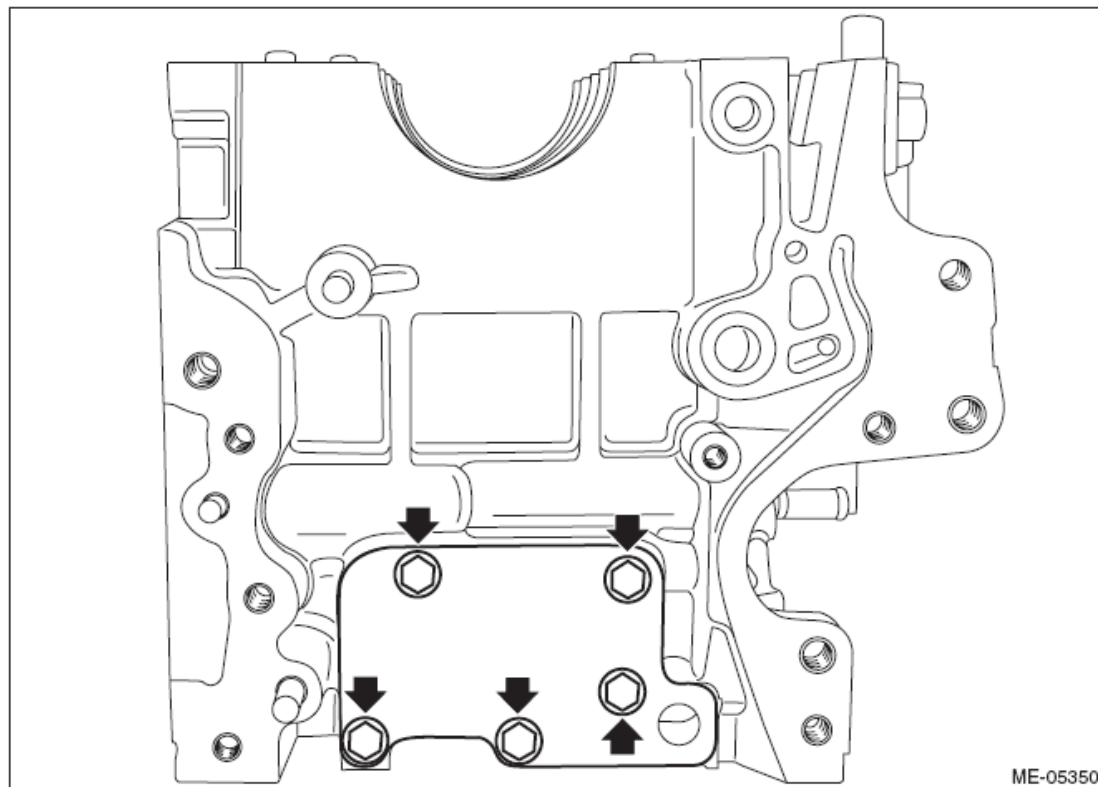


**Fig. 433: Applying Liquid Gasket To Threaded Portion Of Main Gallery Plug**  
Courtesy of SUBARU OF AMERICA, INC.

4. Install the cylinder block plate onto cylinder block LH.

***Tightening torque:***

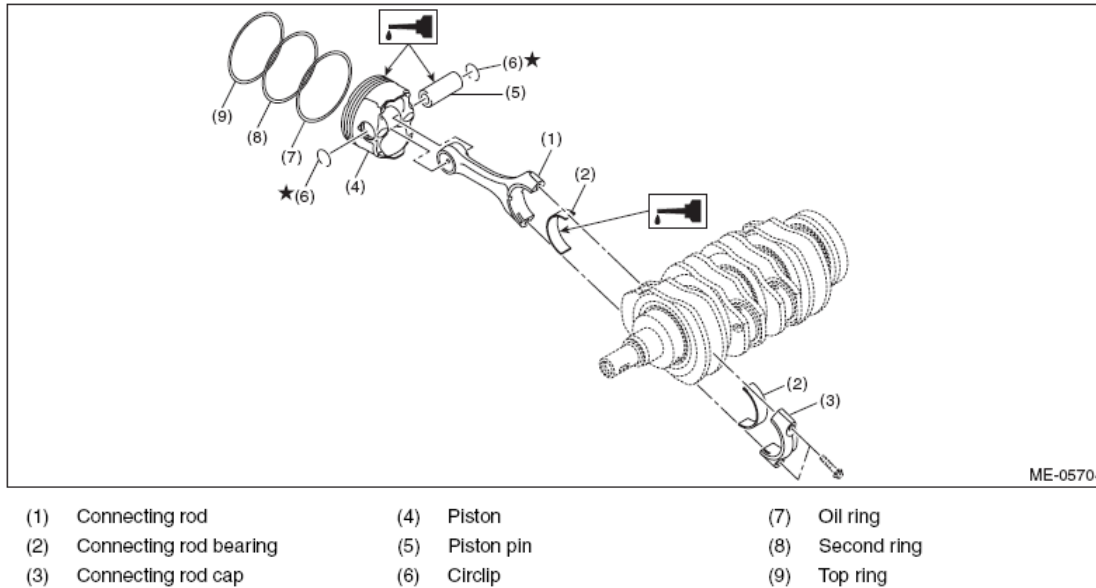
***6.4 N.m (0.7 kgf-m, 4.7 ft-lb)***



**Fig. 434: Locating Cylinder Block LH Block Plate Mounting Bolts**

Courtesy of SUBARU OF AMERICA, INC.

### PISTON AND CONNECTING ROD

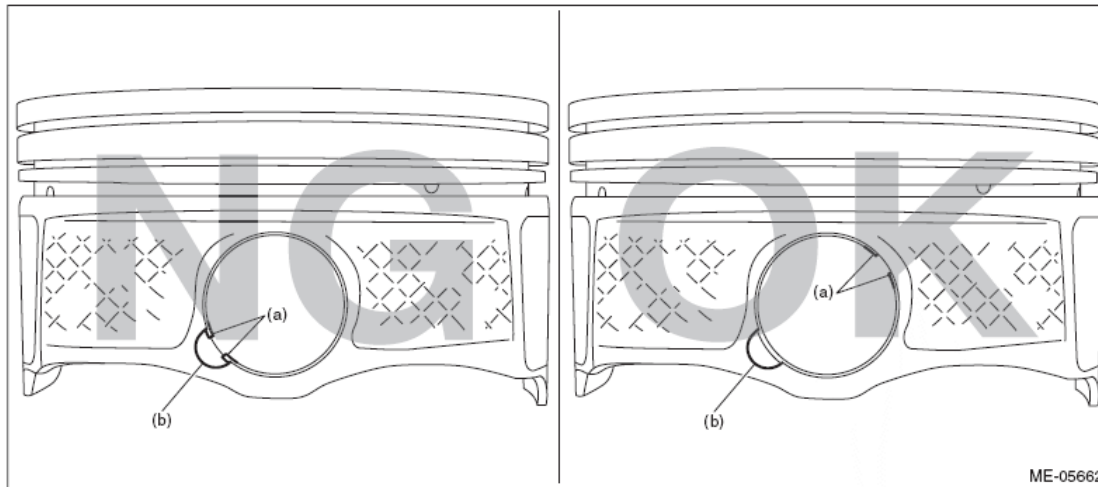


**Fig. 435: Identifying Piston And Connecting Rod And Related Components**  
 Courtesy of SUBARU OF AMERICA, INC.

1. Install the connecting rod bearing to the connecting rod and connecting rod cap.
2. Install the circlip on one end of the piston using a flat tip screwdriver.

#### NOTE:

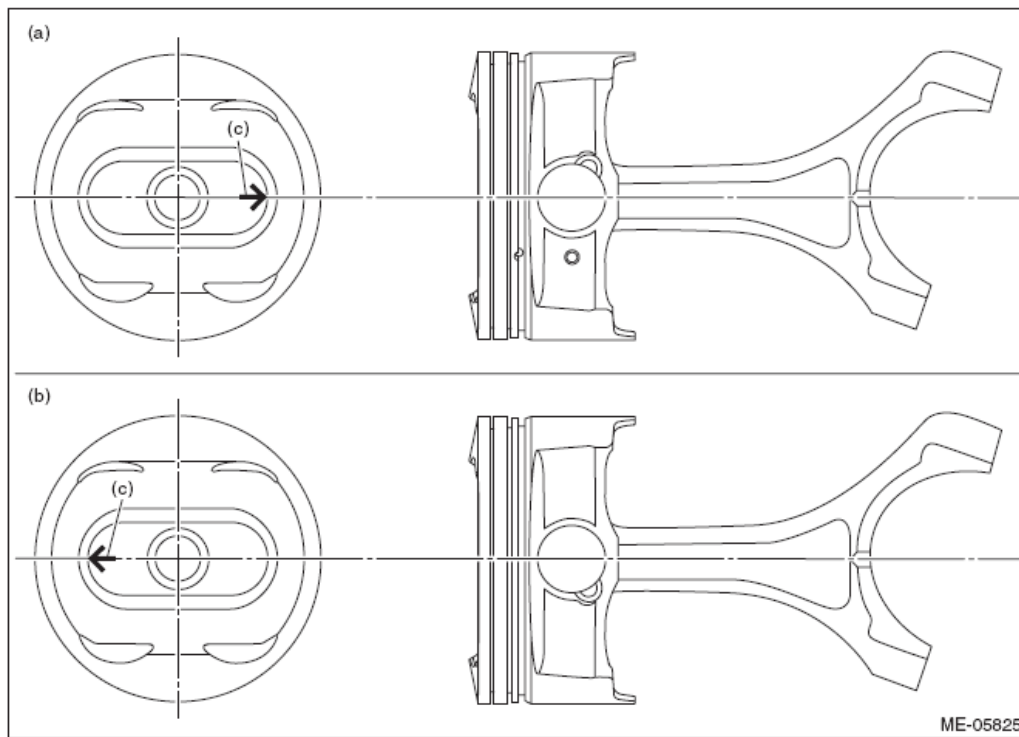
- Be careful not damage the piston, by wrapping the tip of flat tip screwdriver with tape.
- Make sure the circlip is firmly inserted into the circlip groove.
- After installing the circlip, rotate the circlip so that its end part (a) and the cutout portion of circlip groove (b) do not match.



**Fig. 436: Caution For Installing Circlip On Piston End**  
Courtesy of SUBARU OF AMERICA, INC.

3. Set the piston to the connecting rod.

**NOTE:** Align the front mark of piston and the connecting rod direction correctly as shown in the figure.



(a) RH side (#1 and #3)

(b) LH side (#2 and #4)

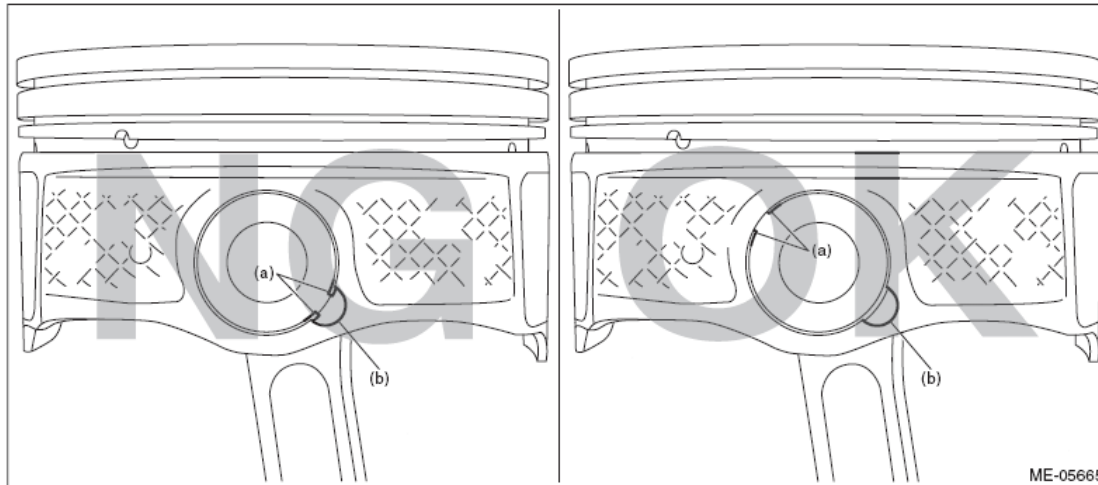
(c) Front mark

**Fig. 437: Identifying Piston Front Mark**  
Courtesy of SUBARU OF AMERICA, INC.

4. Apply engine oil to the piston pin, and attach the piston pin.
5. Install the circlip on the piston using a flat tip screwdriver.

**NOTE:**

- Be careful not damage the piston and piston pin, by wrapping the tip of flat tip screwdriver with tape.
- Make sure the circlip is firmly inserted into the circlip groove.
- After installing the circlip, rotate the circlip so that its end part (a) and the cutout portion of circlip groove (b) do not match.

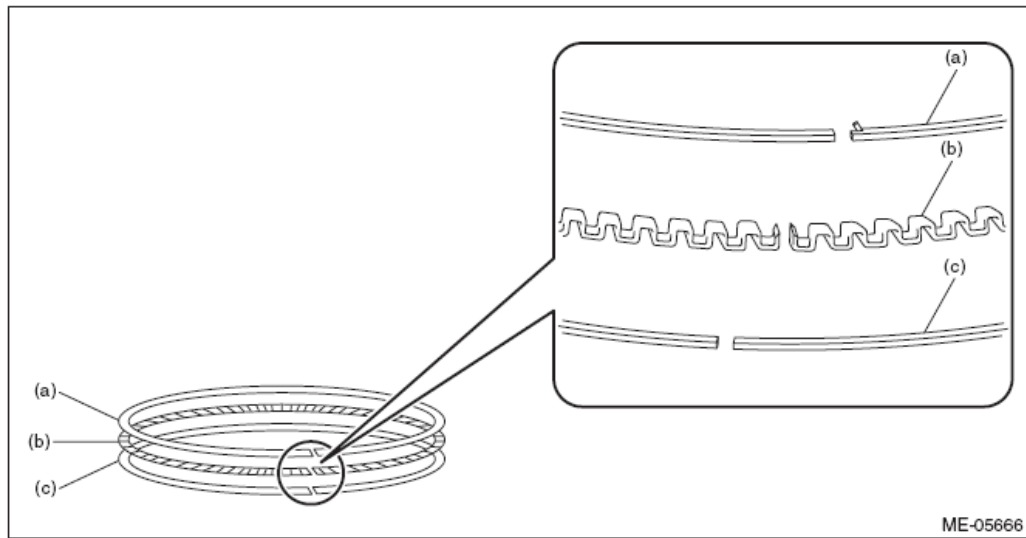


**Fig. 438: Caution For Installing Circlip On Piston End**  
Courtesy of SUBARU OF AMERICA, INC.

6. Install the oil ring upper rail, expander and lower rail by hand.

**NOTE:**

**Oil ring consists of the upper rail, expander and lower rail.**



(a) Upper rail

(b) Expander

(c) Lower rail

**Fig. 439: Identifying Oil Ring Upper Rail, Expander And Lower Rail**  
Courtesy of SUBARU OF AMERICA, INC.

7. Install the second ring and top ring using piston ring expander.

**NOTE:** Install so that the piston ring mark faces the top side of the piston.

## INSPECTION

### CYLINDER BLOCK

1. Visually inspect to make sure that there are no cracks, scratches or other damage.
2. Use liquid penetrant tester on the important sections to check for fissures.
3. Check that there are no traces of gas leaking or water leaking on the gasket attachment surface.
4. Check the oil passages for clogging.
5. Check for warpage of mating surfaces of the cylinder block that contacts cylinder head using a straight edge and thickness gauge. If it exceeds the limit, correct the surface by grinding it with a surface grinder or replace the cylinder block.

**Warping limit:**

**0.025 mm (0.00098 in)**

**Grinding limit:**

**0.1 mm (0.004 in)**

**Standard height of cylinder block:**

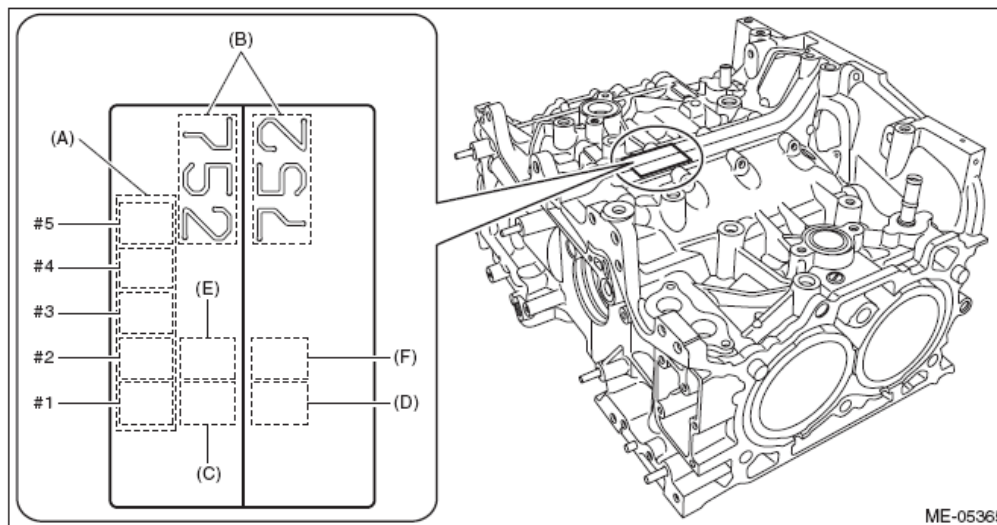
**205.0 mm (8.07 in)**

## CYLINDER AND PISTON

- Using a cylinder bore gauge, check the inner diameter of cylinder liner, cylindricity, out-of-roundness. If it is not within the standard, perform boring and honing, or replace the cylinder block and piston as a set. For boring and honing procedure, refer to step 3).

### NOTE:

- Measurement should be performed at a temperature of 20°C (68°F).
- Measure the inner diameter of each cylinder liner in both the thrust and piston pin directions at the heights as shown in the figure.
- The cylinder bore size mark is stamped on the upper face of the cylinder block.



- |                                                 |                                |                                |
|-------------------------------------------------|--------------------------------|--------------------------------|
| (A) Main journal size mark                      | (C) #1 cylinder bore size mark | (E) #3 cylinder bore size mark |
| (B) Cylinder block (RH) – (LH) combination mark | (D) #2 cylinder bore size mark | (F) #4 cylinder bore size mark |

**Fig. 440: Identifying Cylinder Bore Size Marks, Combination Marks And Main Journal Size Marks**

Courtesy of SUBARU OF AMERICA, INC.

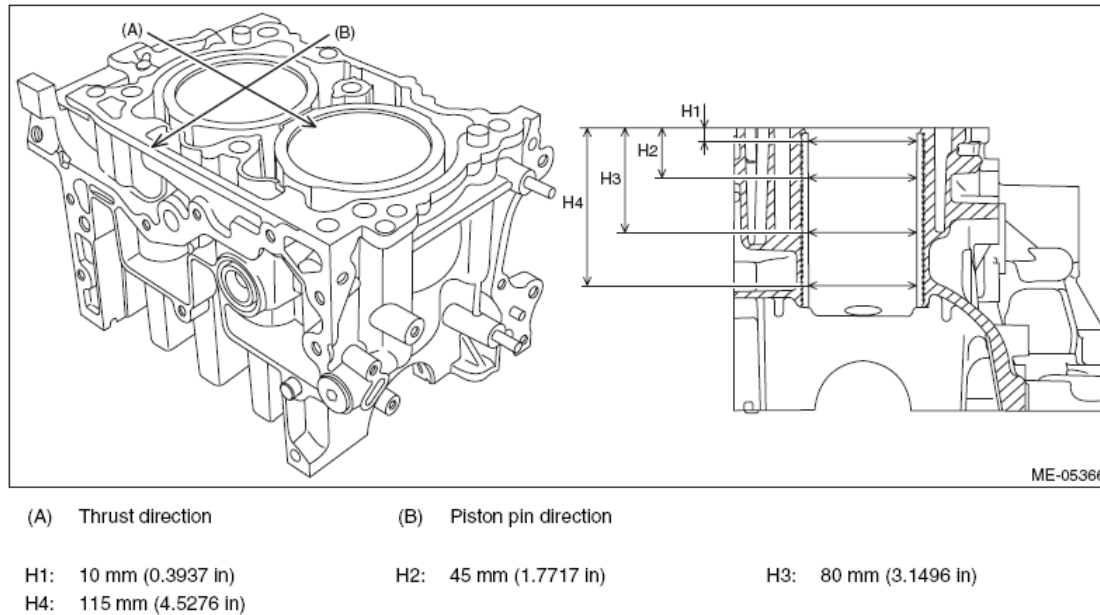
**Inner diameter of cylinder liner:**

**Standard**

**A: 94.005 - 94.015 mm (3.7010 - 3.7014 in)**

**B: 93.995 - 94.005 mm (3.7006 - 3.7010 in)**

**Cylindricity:**

**Limit****0.015 mm (0.0006 in)****Out-of-roundness:****Limit****0.010 mm (0.0004 in)**

**Fig. 441: Identifying Inner Diameter Of Cylinder Liner**  
 Courtesy of SUBARU OF AMERICA, INC.

2. Check the clearance between cylinder liner and piston. Check the clearance between cylinder liner and piston by measuring the inner diameter of cylinder liner and the outer diameter of piston respectively.

**NOTE:** For the measurement of the inner diameter of cylinder liner, refer to step 1).

1. Check the outer diameter of piston with a micrometer. If it is not within the standard, replace the piston.

**NOTE:**

- Measurement should be performed at a temperature of 20°C (68° F).
- Measure the outer diameter of each piston in thrust direction at the height as shown in the figure.
- Standard sized pistons are classified into two grades, "A" and "B". These grades should be used as guide lines in selecting a

**standard piston.**

- **If the piston is replaced, check the clearance between cylinder liner and piston in the step (2), and select a suitable sized piston.**

***Piston grade point H:***

***13.3 mm (0.52 in)***

***Piston outer diameter:***

***Standard size***

***Standard***

***A: 93.980 - 93.990 mm (3.7000 - 3.7004 in)***

***B: 93.970 - 93.980 mm (3.6996 - 3.7000 in)***

***0.25 mm (0.0098 in) oversize***

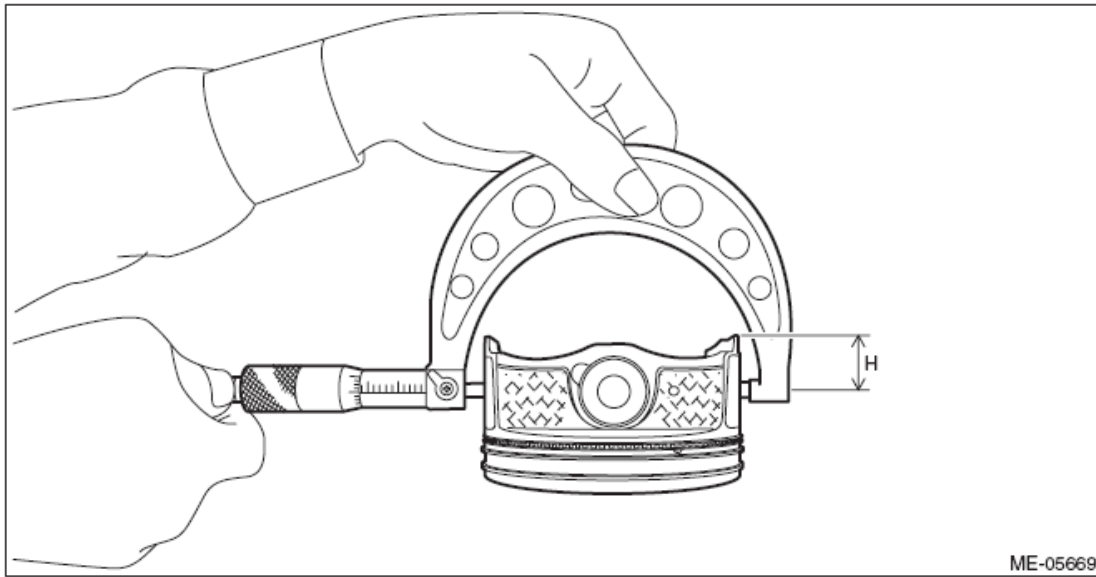
***Standard***

***94.220 - 94.240 mm (3.7094 - 3.7102 in)***

***0.50 mm (0.0197 in) oversize***

***Standard***

***94.470 - 94.490 mm (3.7193 - 3.7201 in)***



**Fig. 442: Measuring Piston Outer Diameter Using Micrometer**  
Courtesy of SUBARU OF AMERICA, INC.

2. Calculate the clearance between cylinder liner and piston. If it is not within the standard, perform boring and honing, or replace the cylinder block and piston as a set. For boring and honing procedure, refer to step 3).

***Clearance between cylinder liner and piston at 20°C (68°F):***

***Standard***

***0.015 - 0.035 mm (0.00059 - 0.00138 in)***

3. Boring and honing

1. If any of the inner diameter, cylindricity, out-of-roundness or cylinder-to-piston clearance is out of standard or if there is any damage on the cylinder liner, rebore it to replace with an oversize piston.

**CAUTION: When any of the cylinder liner needs reboring, all other cylinder liners must be bored at the same time, and replaced with oversize pistons.**

2. If the inner diameter of cylinder liner exceeds the limit after boring and honing, replace the cylinder block and piston as a set.

**NOTE:**

- Immediately after reboring, the inner diameter of cylinder liner may differ from its real diameter due to temperature rise. Thus, when measuring the inner diameter of cylinder liner, wait until it has cooled to normal temperature.

- For the measurement of the inner diameter of cylinder liner, refer to step 1).

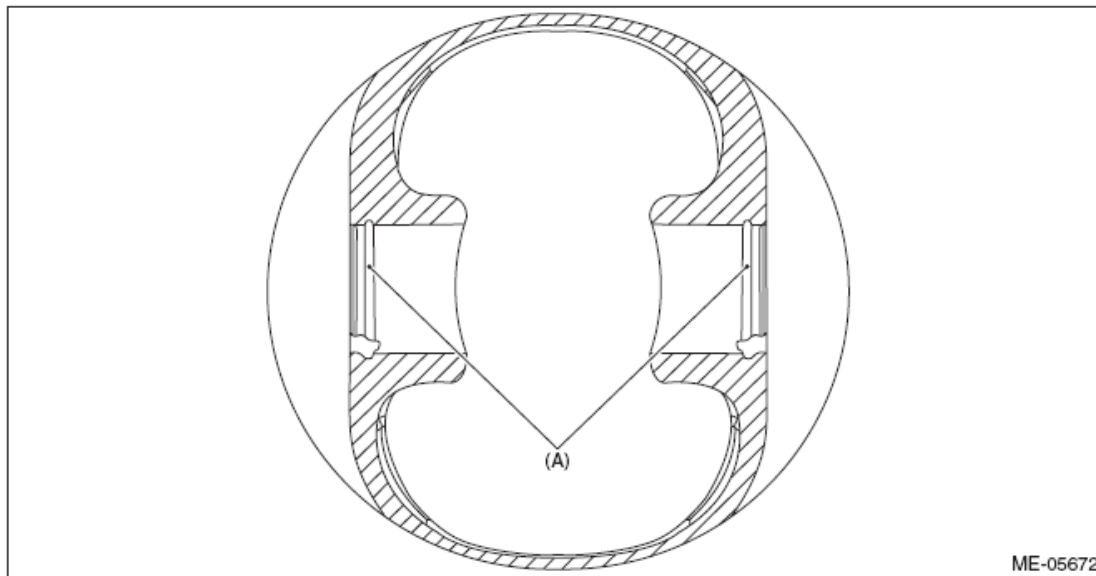
*Inner diameter of cylinder liner boring limit (diameter):*

*To 94.505 mm (3.7207 in)*

#### PISTON AND PISTON PIN

1. Check the piston and piston pin for wear or crack.
2. Check the snap ring for distortion or wear.
3. Check the piston ring groove for damage.
4. Check the circlip groove (A) for burr.

**NOTE:** If the burr is found, remove the burr from groove.



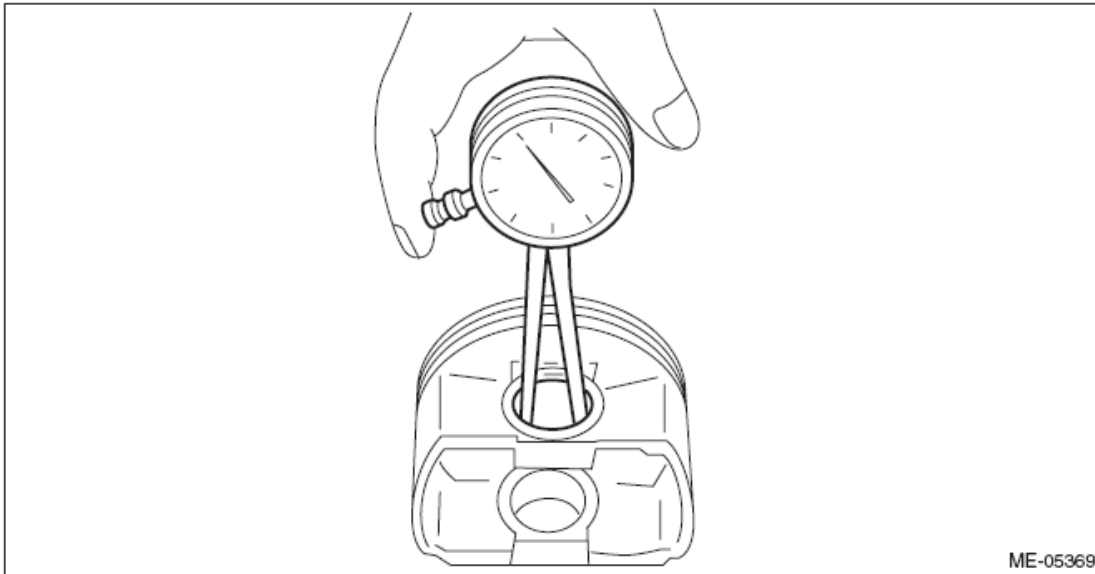
**Fig. 443: Identifying Piston And Piston Pin Circlip Groove**  
Courtesy of SUBARU OF AMERICA, INC.

5. Check that the piston pin can be inserted into the piston pin hole with a thumb at 20°C (68°F).
6. Check the clearance between piston pin hole and piston pin. Check the clearance between piston pin hole and piston pin by measuring the inner diameter of piston pin hole and the outer diameter of piston pin respectively.
  1. Using a caliper gauge, measure the inner diameter of piston pin hole.

**NOTE:**

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

- **Record the measured value.**

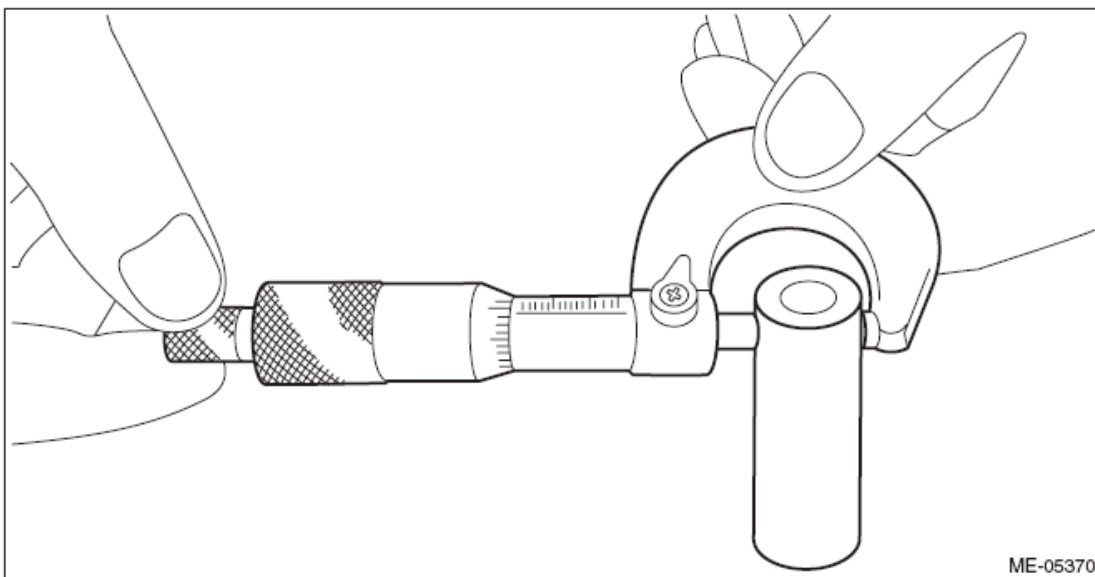


**Fig. 444: Measuring Inner Diameter Of Piston Pin Hole Using Caliper Gauge**  
Courtesy of SUBARU OF AMERICA, INC.

2. Measure the outer diameter of piston pin with a micrometer.

**NOTE:**

- **Measurement should be performed at a temperature of 20°C (68° F).**
- **Record the measured value.**



**Fig. 445: Measuring Outer Diameter Of Piston Pin Using Micrometer**

**Courtesy of SUBARU OF AMERICA, INC.**

3. Calculate the clearance between piston pin hole and piston pin. If it is not within the standard, replace the piston and piston pin as a set.

***Clearance between piston pin hole and piston pin:***

***Standard***

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

## **PISTON RING**

1. Make sure the piston ring is not broken or damaged.
2. Using a cylindrical guide, insert the piston ring and oil ring into the cylinder liner so that they are perpendicular to the cylinder wall, and check the piston ring gap using a thickness gauge. If it is not within the standard, replace the piston ring or oil ring.

**NOTE: Use piston ring with same size as piston when replacing piston ring.**

***Piston ring gap:***

***Top ring***

***Standard***

***0.20 - 0.30 mm (0.0079 - 0.0118 in)***

***Second ring***

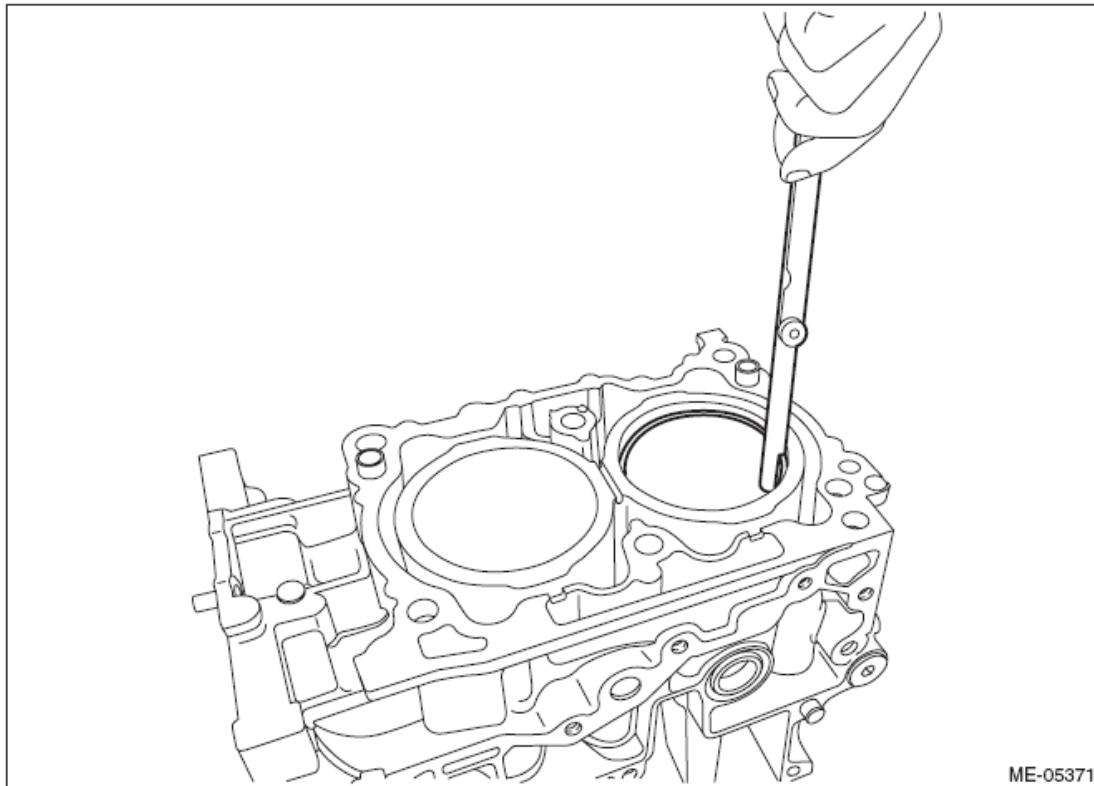
***Standard***

***0.30 - 0.45 mm (0.0118 - 0.0177 in)***

***Oil ring rail***

***Standard***

***0.20 - 0.50 mm (0.0079 - 0.0197 in)***



**Fig. 446: Measuring Piston Ring Gap Using Thickness Gauge**  
Courtesy of SUBARU OF AMERICA, INC.

3. Fit the piston ring straight into the piston ring groove, then check the clearance between piston ring and piston ring groove with a thickness gauge. If it is not within the standard, replace the piston ring or oil ring.

**NOTE:**

- Before measuring the clearance, clean the piston ring groove and piston ring.
- Use piston ring with same size as piston when replacing piston ring.

*Clearance between piston ring and piston ring groove:*

*Top ring*

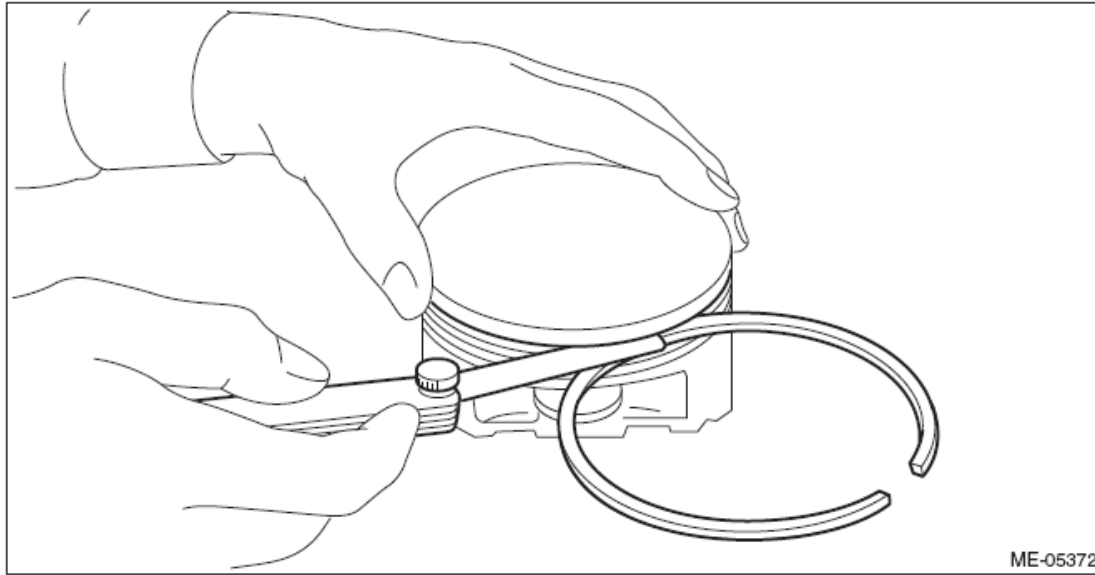
*Standard*

*0.040 - 0.080 mm (0.0016 - 0.0031 in)*

*Second ring*

*Standard*

*0.030 - 0.070 mm (0.0012 - 0.0028 in)*



**Fig. 447: Measuring Clearance Between Compression Ring And Piston Using Thickness Gauge**  
Courtesy of SUBARU OF AMERICA, INC.

#### CONNECTING ROD

1. Check that the large or small end thrust surface is not damaged.
2. Install the connecting rod to the crankshaft, and check the thrust clearance using a thickness gauge. If it is not within the standard, replace the connecting rod.

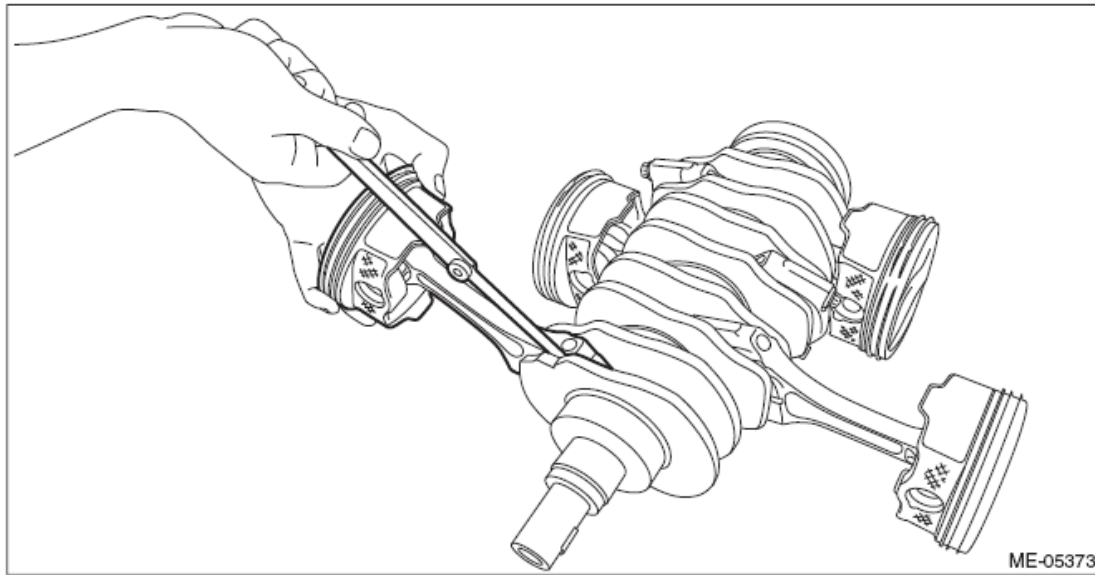
**NOTE:**

- Do not forget to install the connecting rod bearing and the connecting rod cap bearing, when installing the connecting rod to the crankshaft.
- Measurement should be performed at a temperature of 20°C (68°F).
- Measure the thrust clearance of each connecting rod at several points, and replace the connecting rod if there is uneven wear.

*Connecting rod thrust clearance:*

*Standard*

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

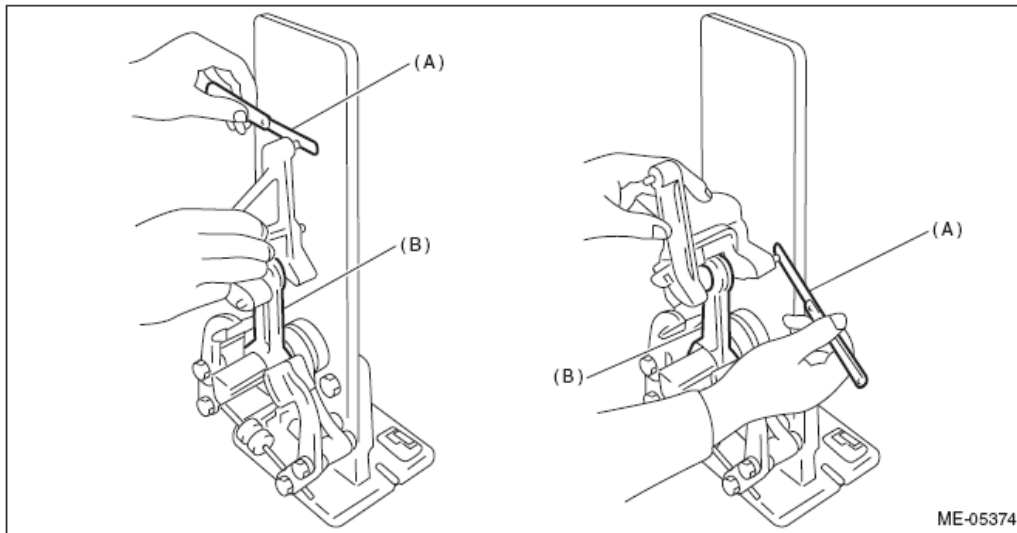


**Fig. 448: Measuring Connecting Rod Thrust Clearance Using Thickness Gauge**  
Courtesy of SUBARU OF AMERICA, INC.

3. Check for bend or twist using a connecting rod aligner. If it exceeds the limit, replace the connecting rod.

*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

**Fig. 449: Checking Bend Or Twist Using Connecting Rod Aligner**  
Courtesy of SUBARU OF AMERICA, INC.

4. Inspect the connecting rod bearing for scar, peeling, seizure, melting or wear, etc.

5. Check the oil clearance on each connecting rod bearing using plastigauge. If it is not within the standard, replace the connecting rod bearing.

**NOTE:**

- Measurement should be performed at a temperature of 20°C (68°F).
- Measure the outer diameter of crank pin using micrometer, and select the suitable size connecting rod bearing when replacing the connecting rod bearing.

| Unit: mm (in)           |                                    |                                   |
|-------------------------|------------------------------------|-----------------------------------|
| Bearing                 | Bearing size (Thickness at center) | Outer diameter of crank pin       |
| Standard                | 1.492 - 1.508 (0.0587 - 0.0594)    | 47.976 - 48.000 (1.8888 - 1.8898) |
| 0.03 (0.0012) Undersize | 1.511 - 1.515 (0.0595 - 0.0596)    | 47.946 - 47.970 (1.8876 - 1.8886) |
| 0.05 (0.0020) Undersize | 1.521 - 1.525 (0.0599 - 0.0600)    | 47.926 - 47.950 (1.8868 - 1.8878) |
| 0.25 (0.0098) Undersize | 1.621 - 1.625 (0.0638 - 0.0640)    | 47.726 - 47.750 (1.8790 - 1.8799) |

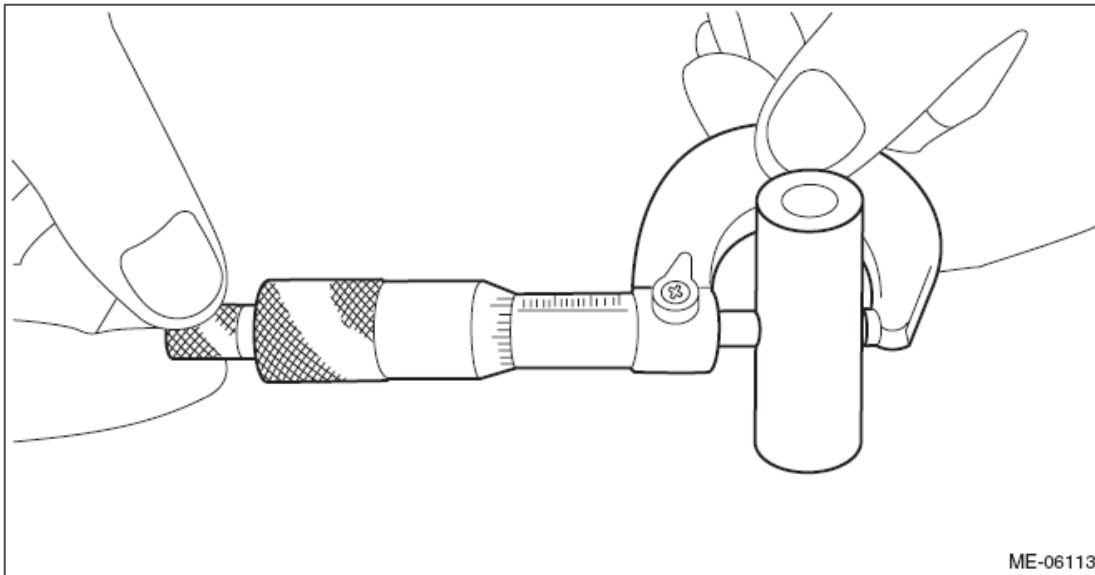
**Connecting rod oil clearance:****Standard**

**0.017 - 0.047 mm (0.0007 - 0.0019 in)**

6. Check that the connecting rod bushing is not damaged.
7. Check the clearance between piston pin and connecting rod bushing. Check the clearance between piston pin and connecting rod bushing by measuring the outer diameter of piston pin and the inner diameter of connecting rod bushing respectively.
1. Measure the outer diameter of piston pin with a micrometer.

**NOTE:**

- Measurement should be performed at a temperature of 20°C (68°F).
- Record the measured value.

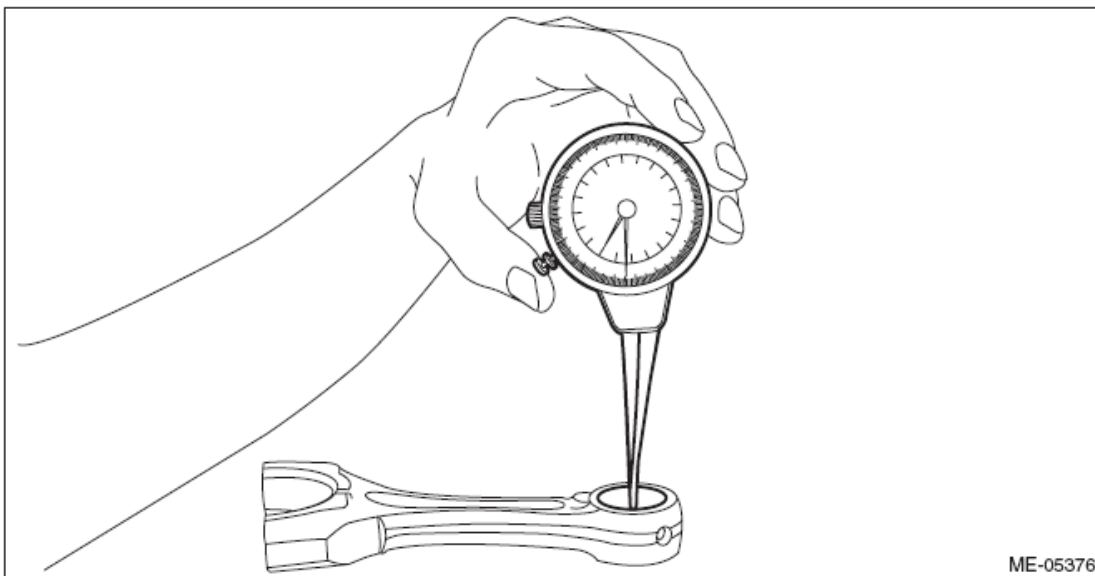


**Fig. 450: Measuring Outer Diameter Of Piston Pin Using Micrometer**  
Courtesy of SUBARU OF AMERICA, INC.

2. Using a caliper gauge, measure the inner diameter of connecting rod bushing.

**NOTE:**

- Measurement should be performed at a temperature of 20°C (68° F).
- Record the measured value.



**Fig. 451: Measuring Inner Diameter Of Connecting Rod Bushing Using Caliper Gauge**  
Courtesy of SUBARU OF AMERICA, INC.

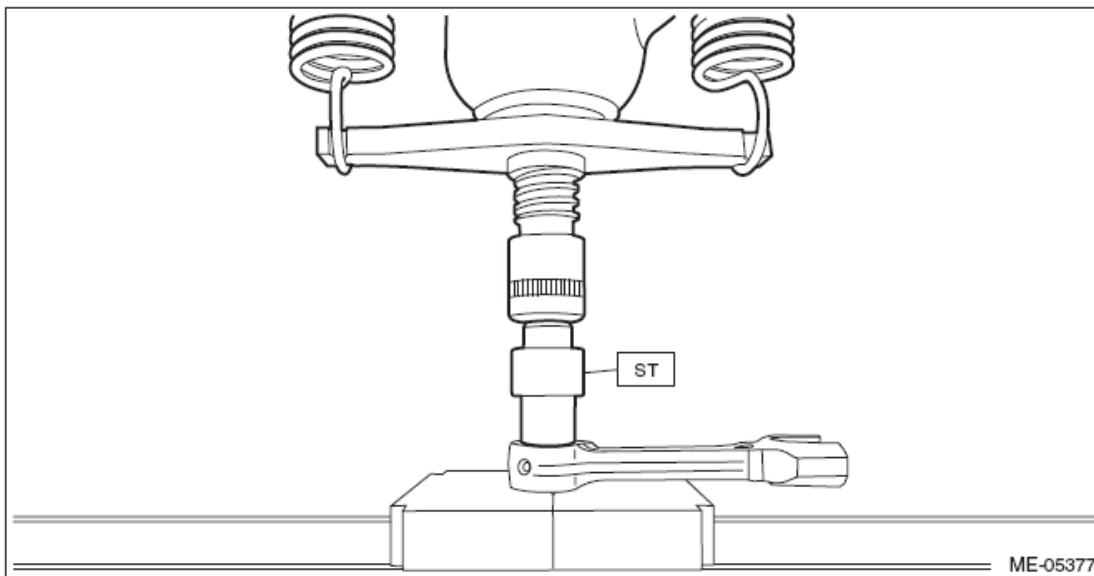
3. Calculate the clearance between piston pin and connecting rod bushing.

***Clearance between piston pin and connecting rod bushing:******Standard******0.004 - 0.026 mm (0.0002 - 0.0010 in)***

8. If the clearance between piston pin and connecting rod bushing is not within the standard, replace the connecting rod bushing and piston pin as a set. For replacement procedure of connecting rod bushing, refer to the following.
  1. Using the ST and a press, pull out the connecting rod bushing from the small end of the connecting rod.

**NOTE:**      **The direction of ST for pulling out and for press fitting is different. Therefore, attention must be paid to the direction of usage for ST.**

ST 18350AA000 CONNECTING ROD BUSHING REMOVER AND INSTALLER

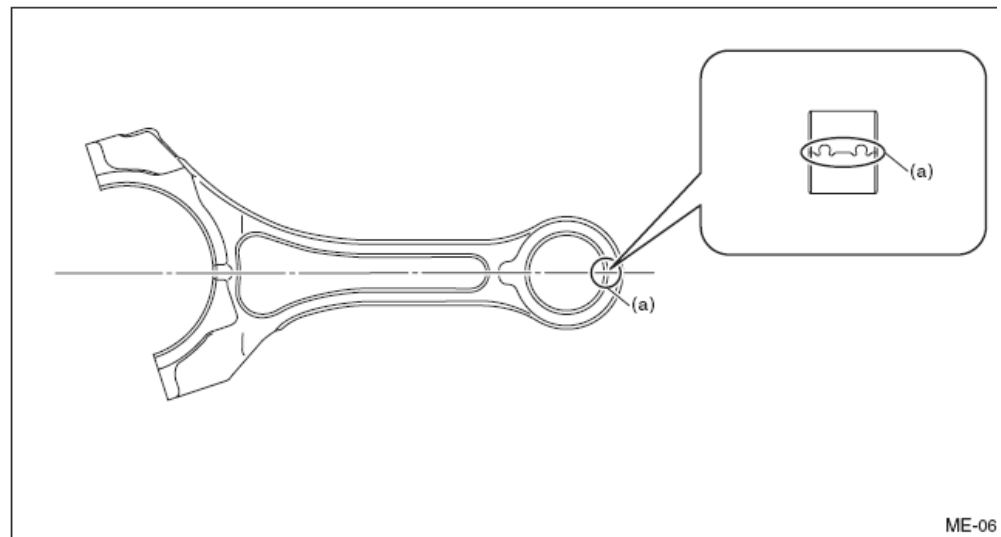


**Fig. 452: Removing Connecting Rod Bushing From Connecting Rod Small End Using ST And Press**

Courtesy of SUBARU OF AMERICA, INC.

2. Press the connecting rod bushing with ST and the press, after applying engine oil on the periphery of connecting rod bushing.

**NOTE:**      • **Clinch area of the connecting rod bushing is as shown in the figure.**



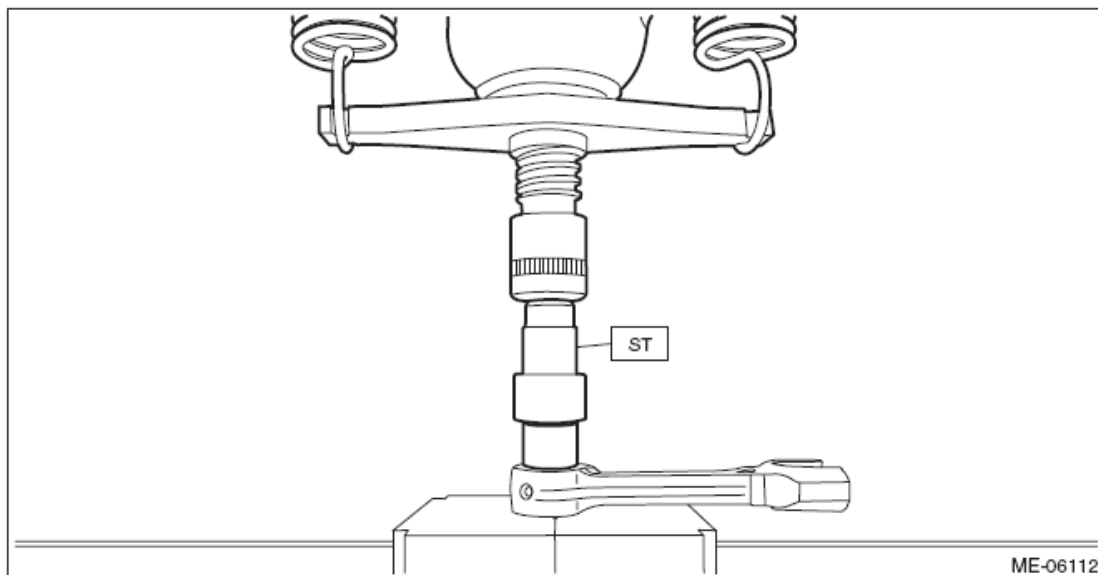
ME-06

(a) Clinch area of connecting rod bushing

**Fig. 453: Identifying Connecting Rod Bushing Clinch Area**  
Courtesy of SUBARU OF AMERICA, INC.

- The direction of ST for pulling out and for press fitting is different. Therefore, attention must be paid to the direction of usage for ST.

ST 18350AA000 CONNECTING ROD BUSHING REMOVER AND INSTALLER



ME-06112

**Fig. 454: Removing Connecting Rod Bushing From Connecting Rod Small End Using Tool**  
Courtesy of SUBARU OF AMERICA, INC.

3. Make two 3 mm (0.12 in) holes in the pressed connecting rod bushing by aligning with the pre-manufactured holes provided on the small end of the connecting rod.

4. Using a reamer, ream the inside surface of the connecting rod bushing. Insert the reamer in the connecting rod bushing, and turn slowly clockwise while pushing lightly. Bring the reamer back while rotating it clockwise.

**NOTE:**

- Use a reamer with a diameter of  $\varnothing 22$ .
- Apply engine oil to the reamer.
- If the inner surface of valve guide is damaged, the edge of reamer should be slightly ground with oil stone.
- If the inner surface of connecting rod bushing becomes lustrous and the reamer does not chip, use a new reamer or remedy the reamer.

5. After completion of reaming, clean the connecting rod bushing to remove chips.

**CRANKSHAFT AND CRANKSHAFT BEARING**

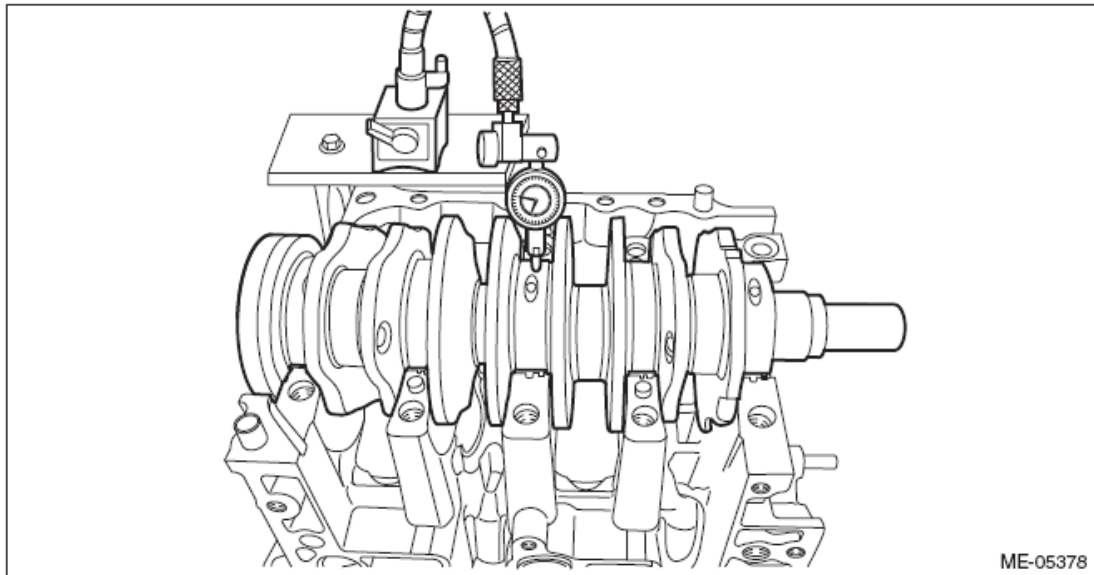
1. Clean the crankshaft completely, and check it for cracks using liquid penetrant tester.
2. Using a dial gauge, check the crankshaft bend. If it exceeds the limit, grind to correct or replace the crankshaft.

**NOTE:**

- If a suitable V-block is not available, using just the #1 and #5 crankshaft bearings on cylinder block, position the crankshaft on cylinder block. Then, measure the crankshaft bend using a dial gauge.
- Measurement should be performed at a temperature of 20°C (68°F).
- When grinding to correct the crankshaft, refer to step 3).

*Crankshaft bend limit:*

*0.035 mm (0.0014 in)*



**Fig. 455: Checking Crankshaft Bend Using Dial Gauge**  
Courtesy of SUBARU OF AMERICA, INC.

3. Using micrometer, check the outer diameter of crank journal and crank pin, cylindricity, out-of-roundness. If it is not within the standard, replace the connecting rod bearing or crankshaft bearing, and grind to correct or replace the crankshaft as required.
  - Measurement should be performed at a temperature of 20°C (68°F).
  - Select the suitable size connecting rod bearing or crankshaft bearing when replacing the connecting rod bearing or crankshaft bearing.
  - When grinding to correct the crank journal or crank pin, finish them to the suitable dimensions as shown in the table below according to the undersize bearing to be used.

| Unit: mm (in)              |                                       |                                      |                                      |                                      |
|----------------------------|---------------------------------------|--------------------------------------|--------------------------------------|--------------------------------------|
|                            |                                       | Crank journal diameter               |                                      | Crank pin outer diameter             |
|                            |                                       | #1, #2, #3, #4                       | #5                                   |                                      |
| Standard                   | Journal O.D.                          | 67.985 - 68.009<br>(2.6766 - 2.6775) | 67.985 - 68.009<br>(2.6766 - 2.6775) | 47.976 - 48.000<br>(1.8888 - 1.8898) |
|                            | Bearing size<br>(Thickness at center) | 2.495 - 2.513<br>(0.0982 - 0.0989)   | 2.493 - 2.511<br>(0.0981 - 0.0989)   | 1.492 - 1.508 (0.0587<br>- 0.0594)   |
| 0.03 (0.0012)<br>Undersize | Journal O.D.                          | 67.955 - 67.979<br>(2.6754 - 2.6763) | 67.955 - 67.979<br>(2.6754 - 2.6763) | 47.946 - 47.970<br>(1.8876 - 1.8886) |
|                            | Bearing size<br>(Thickness at center) | 2.519 - 2.522<br>(0.0992 - 0.0993)   | 2.517 - 2.520<br>(0.0991 - 0.0992)   | 1.511 - 1.515 (0.0595<br>- 0.0596)   |
| 0.05 (0.0020)<br>Undersize | Journal O.D.                          | 67.935 - 67.959<br>(2.6746 - 2.6755) | 67.935 - 67.959<br>(2.6746 - 2.6755) | 47.926 - 47.950<br>(1.8868 - 1.8878) |
|                            | Bearing size<br>(Thickness at center) | 2.529 - 2.532<br>(0.0996 - 0.0997)   | 2.527 - 2.530<br>(0.0995 - 0.0996)   | 1.521 - 1.525 (0.0599<br>- 0.0600)   |
|                            | Journal O.D.                          | 67.735 - 67.759                      | 67.735 - 67.759                      | 47.726 - 47.750                      |

|               |                                       |                                    |                                    |                                    |
|---------------|---------------------------------------|------------------------------------|------------------------------------|------------------------------------|
| 0.25 (0.0098) |                                       | (2.6667 - 2.6677)                  | (2.6667 - 2.6677)                  | (1.8790 - 1.8799)                  |
| Undersize     | Bearing size<br>(Thickness at center) | 2.629 - 2.632<br>(0.1035 - 0.1036) | 2.627 - 2.630<br>(0.1034 - 0.1035) | 1.621 - 1.625 (0.0638<br>- 0.0640) |

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

***Cylindricity***

***Limit***

***0.006 mm (0.0002 in)***

***Out-of-roundness***

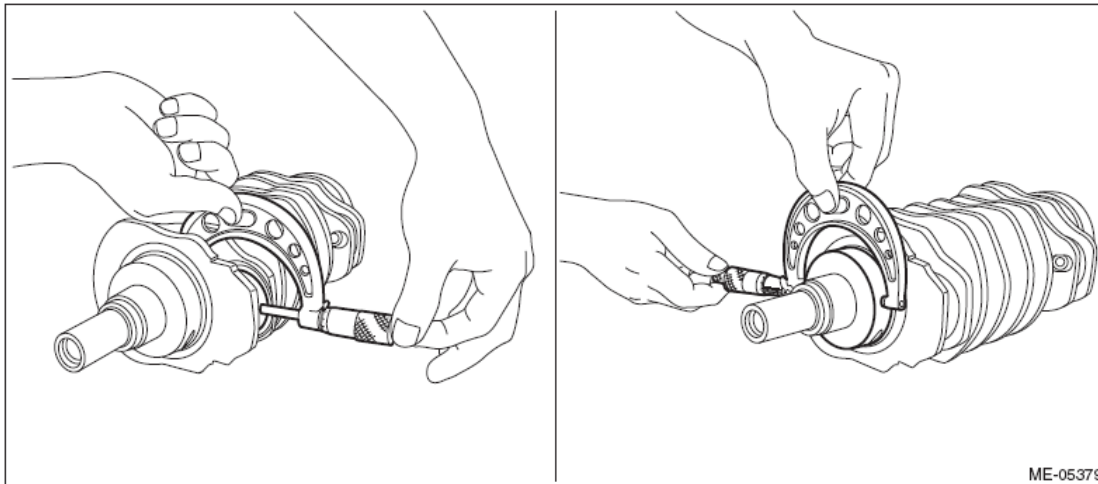
***Limit***

***0.005 mm (0.0002 in)***

***Grinding limit (dia.)***

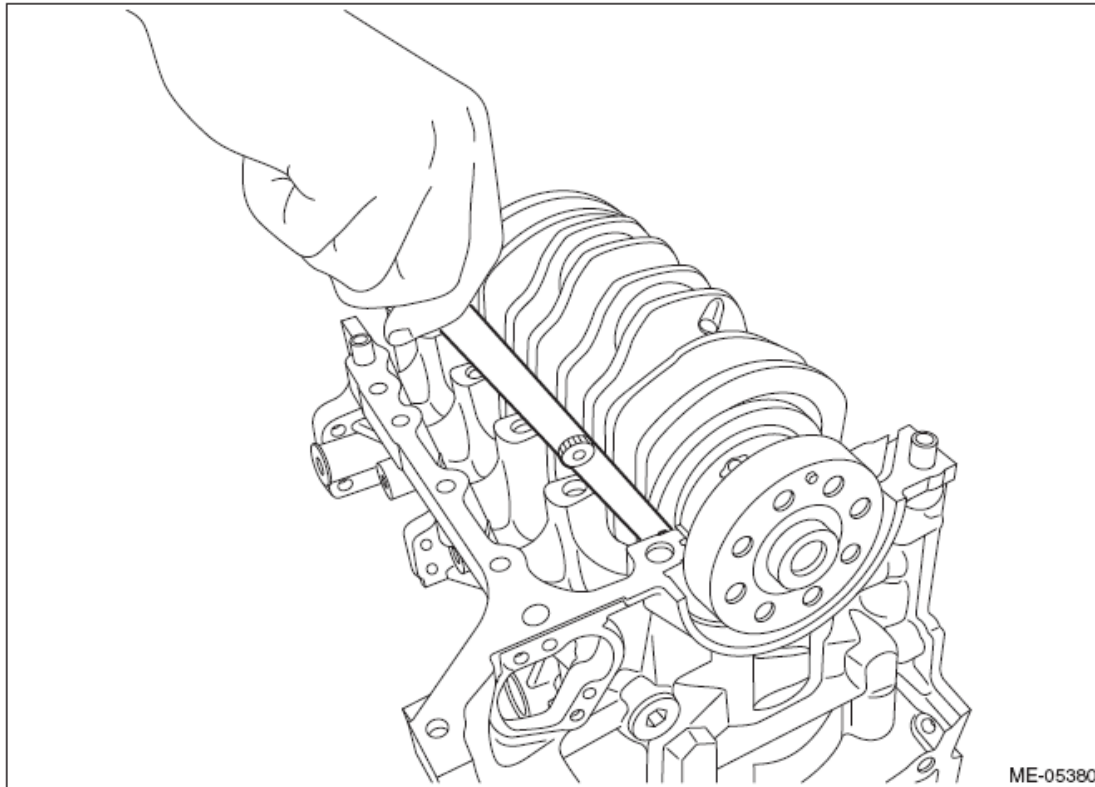
***Crank pin: To 47.726 mm (1.8790 in)***

***Crank journal: To 67.735 mm (2.6667 in)***



**Fig. 456: Measuring Crankshaft Pin And Crankshaft Journal Using Micrometer**  
**Courtesy of SUBARU OF AMERICA, INC.**

4. Inspect the crankshaft bearing for scar, peeling, seizure, melting or wear, etc.
5. Use a thickness gauge to check the thrust clearance of crankshaft at #5 crankshaft bearing. If it is not within the standard, replace the #5 crankshaft bearing.
  - Measurement should be performed at a temperature of 20°C (68°F).
  - Select the suitable size by referring to step 3) when replacing #5 crankshaft bearing.

***Crankshaft thrust clearance:******Standard******0.130 - 0.308 mm (0.00512 - 0.01213 in)***

**Fig. 457: Measuring Crankshaft Thrust Clearance Using Thickness Gauge**  
Courtesy of SUBARU OF AMERICA, INC.

6. Check the oil clearance on each crankshaft bearing using plastigauge. If it is not within the standard, replace the crankshaft bearing, and grind to correct or replace the crankshaft as required.
  - Measurement should be performed at a temperature of 20°C (68°F).
  - Select the suitable size by referring to step 3) when replacing crankshaft bearing.
  - When grinding to correct the crank journal, finish it to the suitable dimensions by referring to step 3) according to the undersize bearing to be used.

***Crankshaft oil clearance:******Standard******0.013 - 0.031 mm (0.00051 - 0.00122 in)*****INTAKE AND EXHAUST VALVE**

**SPECIFICATION**

Refer to "Cylinder Head" for removal and installation procedures of the intake and exhaust valves. < Refer to **REMOVAL**, Cylinder Head. > < Refer to **INSTALLATION**, Cylinder Head. >

**PISTON****SPECIFICATION**

Refer to "Cylinder Block" for removal and installation procedures of pistons. < Refer to **REMOVAL**, Cylinder Block. > < Refer to **INSTALLATION**, Cylinder Block. >

**CONNECTING ROD****SPECIFICATION**

Refer to "Cylinder Block" for removal and installation procedures of connecting rod. < Refer to **REMOVAL**, Cylinder Block. > < Refer to **INSTALLATION**, Cylinder Block. >

**CRANKSHAFT****SPECIFICATION**

Refer to "Cylinder Block" for removal and installation procedures of the crankshaft. < Refer to **REMOVAL**, Cylinder Block. > < Refer to **INSTALLATION**, Cylinder Block. >

**ENGINE TROUBLE IN GENERAL****INSPECTION**

**NOTE:** The "RANK" shown in the chart shows the possibilities of the cause of trouble in order from "Very often" to "Rarely".

**A - Very often**

**B - Sometimes**

**C - Rarely**

| Symptoms                  | Problem parts etc. | Possible cause                       | RANK |
|---------------------------|--------------------|--------------------------------------|------|
| 1. Engine does not start. | Starter            | Defective battery-to-starter harness | B    |
|                           |                    | Defective starter switch             | C    |
|                           |                    | Defective inhibitor switch           | C    |
|                           |                    | Defective starter                    | B    |
|                           | Battery            | Improper connection of terminal      | A    |
|                           |                    | Run-down battery                     | A    |

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|                                       |                                                                        |                                                               |   |
|---------------------------------------|------------------------------------------------------------------------|---------------------------------------------------------------|---|
| 1) Starter does not turn.             |                                                                        | Defective charging system                                     | B |
|                                       | Friction                                                               | Seizure of crankshaft and connecting rod bearing              | C |
|                                       |                                                                        | Seized camshaft                                               | C |
|                                       |                                                                        | Seized or stuck piston and cylinder                           | C |
|                                       | Immobilizer system < Refer to <b>BASIC DIAGNOSTIC PROCEDURE</b> . >    |                                                               | A |
| 2) Initial combustion does not occur. | Starter                                                                | Defective starter                                             | C |
|                                       | Engine control system < Refer to <b>BASIC DIAGNOSTIC PROCEDURE</b> . > |                                                               | A |
|                                       | Fuel line                                                              | Defective fuel pump and relay                                 | A |
|                                       |                                                                        | Clogged fuel line                                             | C |
|                                       |                                                                        | Lack of fuel or insufficient fuel                             | B |
|                                       | Timing chain                                                           | Trouble                                                       | B |
|                                       |                                                                        | Defective timing                                              | B |
|                                       | Compression                                                            | Incorrect cam clearance                                       | C |
|                                       |                                                                        | Loosened spark plug or defective gasket                       | C |
|                                       |                                                                        | Loosened cylinder head bolt or defective cylinder head gasket | C |
|                                       |                                                                        | Improper valve sealing                                        | C |
|                                       |                                                                        | Defective valve stem                                          | C |
|                                       |                                                                        | Worn or broken valve spring                                   | B |
|                                       |                                                                        | Worn or stuck piston rings, cylinder liner and piston         | C |
|                                       |                                                                        | Incorrect valve timing                                        | B |
|                                       |                                                                        | Improper engine oil (low viscosity)                           | B |
| 3) Initial combustion occurs.         | Engine control system < Refer to <b>BASIC DIAGNOSTIC PROCEDURE</b> . > |                                                               | 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 fuel or insufficient fuel                             | B |
|                                       | Timing chain                                                           | Trouble                                                       | B |
|                                       |                                                                        | Defective timing                                              | B |
|                                       | Compression                                                            | Incorrect cam clearance                                       | C |
|                                       |                                                                        | Loosened spark plug or defective gasket                       | C |
|                                       |                                                                        | Loosened cylinder head bolt or defective cylinder head gasket | C |
|                                       |                                                                        | Improper valve sealing                                        | C |
|                                       |                                                                        | Defective valve stem                                          | C |
|                                       |                                                                        | Worn or broken valve spring                                   | B |

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|                                            |                                                                               |                                                               |   |
|--------------------------------------------|-------------------------------------------------------------------------------|---------------------------------------------------------------|---|
|                                            |                                                                               | Worn or stuck piston rings, cylinder liner and piston         | C |
|                                            |                                                                               | Incorrect valve timing                                        | B |
|                                            |                                                                               | Improper engine oil (low viscosity)                           | B |
| 4) Engine stalls after initial combustion. | Engine control system < Refer to <b><u>BASIC DIAGNOSTIC PROCEDURE</u></b> . > |                                                               | 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 fuel or insufficient fuel                             | B |
|                                            | Timing chain                                                                  | Trouble                                                       | B |
|                                            |                                                                               | Defective timing                                              | B |
|                                            | Compression                                                                   | Incorrect cam clearance                                       | C |
|                                            |                                                                               | Loosened spark plug or defective gasket                       | C |
|                                            |                                                                               | Loosened cylinder head bolt or defective cylinder head gasket | C |
|                                            |                                                                               | Improper valve sealing                                        | 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 control system < Refer to <b><u>BASIC DIAGNOSTIC PROCEDURE</u></b> . > |                                                               | 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 filler cap                                       | B |
|                                            |                                                                               | Dirty air cleaner element                                     | C |
|                                            | Fuel line                                                                     | Defective fuel pump and relay                                 | C |
|                                            |                                                                               | Clogged fuel line                                             | C |
|                                            |                                                                               | Lack of fuel or insufficient fuel                             | B |
|                                            | Timing chain                                                                  | Defective timing                                              | C |
|                                            |                                                                               | Incorrect cam clearance                                       | B |

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|                                                 |                                                                        |                                                               |   |
|-------------------------------------------------|------------------------------------------------------------------------|---------------------------------------------------------------|---|
| 2. Rough idle and engine stall                  | Compression                                                            | Loosened spark plug or defective gasket                       | B |
|                                                 |                                                                        | Loosened cylinder head bolt or defective cylinder head gasket | B |
|                                                 |                                                                        | Improper valve sealing                                        | 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                                                         | Over-heating                                                  | C |
|                                                 | Others                                                                 | Evaporative emission control system malfunction               | A |
|                                                 |                                                                        | Stuck or damaged throttle valve                               | B |
| 3. Low output, hesitation and poor acceleration | Engine control system < Refer to <b>BASIC DIAGNOSTIC PROCEDURE</b> . > |                                                               | 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 fuel or insufficient fuel                             | C |
|                                                 | Timing chain                                                           | Defective timing                                              | B |
|                                                 | Compression                                                            | Incorrect cam clearance                                       | B |
|                                                 |                                                                        | Loosened spark plug or defective gasket                       | B |
|                                                 |                                                                        | Loosened cylinder head bolt or defective cylinder head gasket | B |
|                                                 |                                                                        | Improper valve sealing                                        | 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                                                            | Incorrect oil pressure                                        | B |

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|                                    |                                                                               |                                                               |   |
|------------------------------------|-------------------------------------------------------------------------------|---------------------------------------------------------------|---|
|                                    | system                                                                        |                                                               |   |
|                                    | Cooling system                                                                | Over-heating                                                  | C |
|                                    |                                                                               | Over-cooling                                                  | C |
|                                    | Others                                                                        | Evaporative emission control system malfunction               | A |
| 4. Surging                         | Engine control system < Refer to <b><u>BASIC DIAGNOSTIC PROCEDURE</u></b> . > |                                                               | 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 fuel or insufficient fuel                             | C |
|                                    | Timing chain                                                                  | Defective timing                                              | B |
|                                    | Compression                                                                   | Incorrect cam clearance                                       | B |
|                                    |                                                                               | Loosened spark plug or defective gasket                       | C |
|                                    |                                                                               | Loosened cylinder head bolt or defective cylinder head gasket | C |
|                                    |                                                                               | Improper valve sealing                                        | 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                                                                | Over-heating                                                  | B |
|                                    | Others                                                                        | Evaporative emission control system malfunction               | C |
| 5. Engine does not return to idle. | Engine control system < Refer to <b><u>BASIC DIAGNOSTIC PROCEDURE</u></b> . > |                                                               | A |
|                                    | Intake system                                                                 | Loosened or cracked vacuum hose                               | A |
|                                    | Others                                                                        | Stuck or damaged throttle valve                               | A |
| 6. Dieseling (Run-on)              | Engine control system < Refer to <b><u>BASIC DIAGNOSTIC PROCEDURE</u></b> . > |                                                               | A |
|                                    | Cooling system                                                                | Over-heating                                                  | B |
|                                    | Others                                                                        | Evaporative emission control system malfunction               | B |

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|                                     |                                                                        |                                                               |   |
|-------------------------------------|------------------------------------------------------------------------|---------------------------------------------------------------|---|
| 7. After burning in exhaust system  | Engine control system < Refer to <b>BASIC DIAGNOSTIC PROCEDURE</b> . > |                                                               | 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 |
|                                     | Timing chain                                                           | Defective timing                                              | B |
|                                     | Compression                                                            | Incorrect cam clearance                                       | B |
|                                     |                                                                        | Loosened spark plug or defective gasket                       | C |
|                                     |                                                                        | Loosened cylinder head bolt or defective cylinder head gasket | C |
|                                     |                                                                        | Improper valve sealing                                        | 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                                                                 | Evaporative emission control system malfunction               | C |
| 8. Knocking                         | Engine control system < Refer to <b>BASIC DIAGNOSTIC PROCEDURE</b> . > |                                                               | A |
|                                     | Intake system                                                          | Loosened oil filler cap                                       | B |
|                                     | Timing chain                                                           | Defective timing                                              | B |
|                                     | Compression                                                            | Incorrect cam clearance                                       | C |
|                                     |                                                                        | Incorrect valve timing                                        | B |
|                                     | Cooling system                                                         | Over-heating                                                  | 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 gasket                                   | B |
|                                     |                                                                        | Defective crankshaft oil seal                                 | B |
|                                     |                                                                        | Defective rocker cover gasket                                 | B |
|                                     |                                                                        | Loosened oil drain plug or defective gasket                   | B |

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|                                |                                                                        |                                                          |   |
|--------------------------------|------------------------------------------------------------------------|----------------------------------------------------------|---|
|                                |                                                                        | Loosened oil pan mounting bolt or defective oil pan      | B |
| 10. Excessive fuel consumption | Engine control system < Refer to <b>BASIC DIAGNOSTIC PROCEDURE</b> . > |                                                          | A |
|                                | Intake system                                                          | Dirty air cleaner element                                | A |
|                                | Timing chain                                                           | Defective timing                                         | B |
|                                | Compression                                                            | Incorrect cam clearance                                  | B |
|                                |                                                                        | Loosened spark plug or defective gasket                  | C |
|                                |                                                                        | Loosened cylinder head bolt or defective cylinder gasket | C |
|                                |                                                                        | Improper valve sealing                                   | 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 |

## ENGINE NOISE

### 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 cam clearance</li> <li>Worn camshaft</li> <li>Broken valve spring</li> <li>Defective valve shim</li> </ul>                   |
| Heavy and dull clank   | Oil pressure is low.                                              | <ul style="list-style-type: none"> <li>Worn crankshaft bearing</li> <li>Worn connecting rod bearing and connecting rod cap bearing at connecting rod large end</li> </ul>                                            |
|                        | Oil pressure is normal.                                           | <ul style="list-style-type: none"> <li>Loosened flywheel mounting bolt</li> <li>Damaged engine mounting</li> </ul>                                                                                                   |
| High-pitched clank     | Sound is noticeable when accelerating with an overload condition. | <ul style="list-style-type: none"> <li>Ignition timing advanced</li> <li>Accumulation of carbon inside combustion chamber</li> <li>Wrong heat range of spark plug</li> <li>Improper octane value gasoline</li> </ul> |

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|                                                                               |                                                                                                         |                                                                                                                                                                                                            |
|-------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Clank when engine speed is between 1, 000 and 2, 000 rpms.                    | Sound is reduced when the fuel injector connector of the noisy cylinder is disconnected. <sup>(1)</sup> | <ul style="list-style-type: none"> <li>Worn crankshaft bearing</li> <li>Worn connecting rod bearing and connecting rod cap bearing at connecting rod large end</li> </ul>                                  |
| Knocking sound when engine is operating under idling speed and engine is warm | Sound is reduced when the fuel injector connector of the noisy cylinder is disconnected. <sup>(1)</sup> | <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 piston pin hole of piston</li> </ul>                          |
|                                                                               | Sound is not reduced if each fuel injector connector is disconnected in turn. <sup>(1)</sup>            | <ul style="list-style-type: none"> <li>Unusually worn valve rocker</li> <li>Unusually worn valve shim</li> <li>Worn cam sprocket</li> <li>Worn camshaft journal of cam carrier and camshaft cap</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>Poor contact of generator brush and rotor</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>Defective automatic belt tensioner adjuster assembly (Loose V-belt)</li> <li>Defective water pump shaft</li> </ul>                                                  |
| Hissing sound                                                                 | -                                                                                                       | <ul style="list-style-type: none"> <li>Insufficient compression</li> <li>Air leakage in air intake system, hose, connection or manifold</li> </ul>                                                         |
| Timing chain noise                                                            | -                                                                                                       | <ul style="list-style-type: none"> <li>Loose timing chain</li> <li>Timing chain contacting with adjacent part</li> </ul>                                                                                   |
| Valve noise                                                                   | -                                                                                                       | <ul style="list-style-type: none"> <li>Incorrect cam clearance</li> </ul>                                                                                                                                  |

(1) When disconnecting the fuel injector connector, the malfunction indicator light illuminates and DTC is stored in ECM memory. Therefore, perform the Clear Memory Mode < Refer to **OPERATION** , Clear Memory Mode. > and Inspection Mode < Refer to **PROCEDURE** , Inspection Mode. > after connecting the fuel injector connector.