

## 2014 ENGINE

### Engine Mechanical - Tribeca

## GENERAL DESCRIPTION

### SPECIFICATION

|        |                                               |                                 |              |                                                                                        |
|--------|-----------------------------------------------|---------------------------------|--------------|----------------------------------------------------------------------------------------|
| Engine | Model                                         |                                 |              | 3.6 L                                                                                  |
|        | Cylinder arrangement                          |                                 |              | Horizontally opposed, liquid cooled, 6-cylinder, 4-stroke gasoline engine              |
|        | Valve system mechanism                        |                                 |              | Chain driven, double overhead camshaft, 4-valve/cylinder                               |
|        | Bore x Stroke                                 | mm (in)                         |              | 92 x 91 (3.622 x 3.583)                                                                |
|        | Displacement                                  | cm <sup>3</sup> (cu in)         |              | 3, 630 (221.5)                                                                         |
|        | Compression ratio                             |                                 |              | 10.5                                                                                   |
|        | Compression (350 rpm and fully open throttle) | kPa (kgf/cm <sup>2</sup> , psi) | Standard     | 1, 275 - 1, 471 (13.0 - 15.0, 185 - 213)                                               |
|        | Number of piston rings                        |                                 |              | Pressure ring: 2, Oil ring: 1                                                          |
|        | Intake valve timing                           | Open                            | Max. retard  | ATDC 10°                                                                               |
|        |                                               |                                 | Min. advance | BTDC 40°                                                                               |
|        |                                               | Close                           | Max. retard  | ABDC 74°                                                                               |
|        |                                               |                                 | Min. advance | ABDC 24°                                                                               |
|        | Exhaust valve timing                          | Open                            | Max. retard  | BBDC 4°                                                                                |
|        |                                               |                                 | Min. advance | BBDC 44°                                                                               |
|        |                                               | Close                           | Max. retard  | ATDC 44°                                                                               |
|        |                                               |                                 | Min. advance | ATDC 4°                                                                                |
|        | Valve clearance                               | mm (in)                         | Intake       | 0.20 <sup>+0.04</sup> <sub>-0.06</sub> (0.0079 <sup>+0.0016</sup> <sub>-0.0024</sub> ) |
|        |                                               |                                 | Exhaust      | 0.35±0.05 (0.0138±0.0020)                                                              |
|        | Idle speed ["P" or "N" range]                 | No load                         | Standard     | 700±100                                                                                |
|        |                                               | A/C ON                          | Standard     | 805±100                                                                                |
|        | Ignition order                                |                                 |              | 1 --> 6 --> 3 --> 2 --> 5 --> 4                                                        |
|        | Ignition timing                               | BTDC/rpm                        | Standard     | 15°±8°/700                                                                             |

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|                  |                                                    |         |                               |                                 |                                   |
|------------------|----------------------------------------------------|---------|-------------------------------|---------------------------------|-----------------------------------|
| Camshaft         | Bending limit                                      |         | mm (in)                       |                                 | 0.020 (0.00079)                   |
|                  | Cam lobe height                                    | mm (in) | Intake                        | Standard                        | 45.90 - 46.00 (1.8071 - 1.8110)   |
|                  |                                                    |         | Exhaust                       | Standard                        | 44.65 - 44.75 (1.7579 - 1.7618)   |
|                  | Cam base circle diameter                           | mm (in) | Intake                        | Standard                        | 36.00 (1.4173)                    |
|                  |                                                    |         | Exhaust                       | Standard                        | 36.00 (1.4173)                    |
|                  | Journal O.D.                                       | mm (in) | Front                         | Standard                        | 37.946 - 37.963 (1.4939 - 1.4946) |
|                  |                                                    |         | Except for front              | 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)                                            | Intake  | Standard                      | 0.075 - 0.135 (0.0030 - 0.0053) |                                   |
|                  |                                                    | Exhaust | Standard                      | 0.075 - 0.135 (0.0030 - 0.0053) |                                   |
| Cylinder head    | Warping limit (Mating surface with cylinder block) |         |                               | mm (in)                         | 0.020 (0.0008)                    |
|                  | Standard height                                    |         |                               | mm (in)                         | 124±0.05 (4.88±0.0020)            |
| Valve seat       | Seating angle between valve and valve seat         |         |                               |                                 | 90°                               |
|                  | Contacting width between valve and valve seat      | mm (in) | Intake                        | Standard                        | 1.0 (0.039)                       |
|                  |                                                    |         | Exhaust                       | Standard                        | 1.5 (0.059)                       |
| 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)                         | 5.500 - 5.512 (0.2165 - 0.2170)   |
|                  | Valve stem outer diameters                         | mm (in) | Intake                        | 5.455 - 5.470 (0.2148 - 0.2154) |                                   |
|                  |                                                    |         | Exhaust                       | 5.445 - 5.460 (0.2144 - 0.2150) |                                   |
|                  | Valve guide protrusion amount                      | Intake  |                               | mm (in)                         | 8.6 - 9.0 (0.3386 - 0.3543)       |
| Exhaust          |                                                    | mm (in) | 10.7 - 11.1 (0.4213 - 0.4370) |                                 |                                   |
| Valve            | Head edge thickness                                | mm (in) | Intake                        | Standard                        | 1.0 (0.039)                       |
|                  |                                                    |         | Exhaust                       | Standard                        | 1.2 (0.047)                       |
|                  | Overall length                                     |         | mm (in)                       | Intake                          | 103.5 (4.075)                     |
|                  |                                                    |         | Exhaust                       | 103.2 (4.063)                   |                                   |
|                  | Free length                                        | mm (in) | Intake                        |                                 | 49.06 (1.9315)                    |
|                  |                                                    |         | Exhaust                       |                                 | 49.06 (1.9315)                    |
|                  |                                                    |         |                               | Set                             | 182 - 210 (18.6 - 21.4, 40.9 -    |

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|                |                                                          |            |                        |          |                                                                    |
|----------------|----------------------------------------------------------|------------|------------------------|----------|--------------------------------------------------------------------|
| Valve spring   | Tension/spring height                                    |            | N (kgf, lb)/mm<br>(in) | Lift     | 47.2)/31.0 (1.220)                                                 |
|                | Squareness                                               |            |                        |          | 316 - 350 (32.2 - 35.7, 71.0 - 78.7)/21.0 (0.827)                  |
| Valve lifter   | Outer diameter                                           | mm<br>(in) | Standard               |          | 2.5°, 2.1 mm (0.083 in)                                            |
|                | Inner diameter of valve lifter hole                      | mm<br>(in) | Standard               |          | 32.959 - 32.975 (1.2976 - 1.2982)                                  |
|                | Clearance between the valve lifter and valve lifter hole | mm<br>(in) | Standard               |          | 32.994 - 33.016 (1.2990 - 1.2998)                                  |
| Cylinder block | Warping limit<br>(Mating surface with cylinder head)     | mm (in)    |                        |          | 0.019 - 0.057 (0.0007 - 0.0022)                                    |
|                | Standard height                                          | mm (in)    |                        |          | 0.020 (0.0008)                                                     |
|                | Cylindricity                                             | mm<br>(in) | Limit                  |          | 202 (7.95)                                                         |
|                | Out-of-roundness                                         | mm<br>(in) | Limit                  |          | 0.030 (0.0012)                                                     |
|                | Clearance between cylinder and piston at 20°C (68°F)     | mm<br>(in) | Standard               |          | 0.010 (0.0004)                                                     |
|                | Cylinder inner diameter boring limit (diameter)          | mm (in)    |                        |          | -0.010 - 0.010 (-0.0004 - 0.0004)                                  |
| Piston         | Piston grade point                                       | mm (in)    |                        |          | 92.515 (3.6717)                                                    |
|                | Outer diameter                                           | mm<br>(in) | Standard               | A        | 37.3 (1.4685)                                                      |
|                |                                                          |            |                        | B        | 92.005 - 92.015 (3.6222 - 3.6226)                                  |
|                |                                                          |            | 0.25 (0.0098) OS       |          | 91.995 - 92.005 (3.6218 - 3.6222)                                  |
|                |                                                          |            | 0.50 (0.0197) OS       |          | 92.245 - 92.265 (3.6317 - 3.6325)                                  |
|                | Inner diameter of piston pin hole                        | mm<br>(in) | Standard               |          | 92.495 - 92.515 (3.6415 - 3.6423)                                  |
| Piston pin     | Degree of fit                                            |            |                        |          | 22.000 - 22.006 (0.8661 - 0.8664)                                  |
|                | Outer diameter                                           | mm<br>(in) | Standard               |          | Piston pin must be fitted into position with thumb at 20°C (68°F). |
|                | Clearance between piston and piston pin                  | mm<br>(in) | Standard               |          | 21.994 - 22.000 (0.8659 - 0.8661)                                  |
| Piston ring    | Piston ring gap                                          | mm<br>(in) | Top ring               | Standard | 0.004 - 0.008 (0.0002 - 0.0003)                                    |
|                |                                                          |            | Second ring            | Standard | 0.20 - 0.35 (0.0079 - 0.0138)                                      |
|                |                                                          |            | Oil ring               | Standard | 0.40 - 0.50 (0.0157 - 0.0197)                                      |
|                |                                                          |            | Top ring               | Standard | 0.20 - 0.50 (0.0079 - 0.0197)                                      |

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|                                           |                                                      |                  |                |                  |          |                                   |
|-------------------------------------------|------------------------------------------------------|------------------|----------------|------------------|----------|-----------------------------------|
|                                           | Clearance between piston ring and piston ring groove |                  | mm (in)        | Second ring      | Standard | 0.030 - 0.070 (0.0012 - 0.0028)   |
|                                           |                                                      |                  |                | Oil ring         | Standard | 0.065 - 0.165 (0.0026 - 0.0065)   |
| Connecting rod and connecting rod bearing | Bend or twist per 100 mm (3.94 in) in length         |                  |                | mm (in)          | Limit    | 0.10 (0.0039 in)                  |
|                                           | Thrust clearance                                     |                  |                | mm (in)          | Standard | 0.070 - 0.330 (0.0028 - 0.0130)   |
|                                           | Oil clearance                                        |                  |                | mm (in)          | Standard | 0.016 - 0.043 (0.0006 - 0.0017)   |
|                                           | Bearing size (Thickness at center)                   |                  |                | Standard         |          | 1.489 - 1.505 (0.0586 - 0.0593)   |
|                                           |                                                      |                  |                | 0.03 (0.0012) US |          | 1.507 - 1.515 (0.0593 - 0.0596)   |
|                                           |                                                      |                  |                | 0.05 (0.0020) US |          | 1.517 - 1.525 (0.0597 - 0.0600)   |
|                                           |                                                      |                  |                | 0.25 (0.0098) US |          | 1.617 - 1.625 (0.0637 - 0.0640)   |
| Bushing of small end                      | Clearance between piston pin and bushing             |                  |                | mm (in)          | Standard | 0 - 0.022 (0 - 0.0009)            |
|                                           | Bending limit                                        |                  |                |                  | mm (in)  | 0.035 (0.0014)                    |
|                                           | Crank pin                                            | Out-of-roundness | mm (in)        | Limit            |          | 0.005 (0.0002)                    |
|                                           |                                                      | Cylindricality   | mm (in)        | Limit            |          | 0.006 (0.0002)                    |
|                                           |                                                      | Grinding limit   | mm (in)        |                  |          | 51.734 (2.0368)                   |
|                                           | Crank journal                                        | Out-of-roundness | mm (in)        | Limit            |          | 0.005 (0.0002)                    |
|                                           |                                                      | Cylindricality   | mm (in)        | Limit            |          | 0.006 (0.0002)                    |
|                                           |                                                      | Grinding limit   | mm (in)        |                  |          | 63.742 (2.5095)                   |
|                                           | Crank pin outer diameter                             |                  |                | Standard         |          | 51.976 - 52.000 (2.0463 - 2.0472) |
|                                           |                                                      |                  |                | 0.03 (0.0012) US |          | 51.954 - 51.970 (2.0454 - 2.0461) |
|                                           |                                                      |                  |                | 0.05 (0.0020) US |          | 51.934 - 51.950 (2.0446 - 2.0453) |
|                                           |                                                      |                  |                | 0.25 (0.0098) US |          | 51.734 - 51.750 (2.0368 - 2.0374) |
|                                           |                                                      |                  | #1, #3, #5, #7 | Standard         |          | 63.992 - 64.016 (2.5194 - 2.5203) |
|                                           |                                                      |                  |                | 0.03 (0.0012) US |          | 63.962 - 63.978 (2.5182 - 2.5188) |
|                                           |                                                      |                  |                | 0.05 (0.0020)    |          | 63.942 - 63.958 (2.5174 -         |

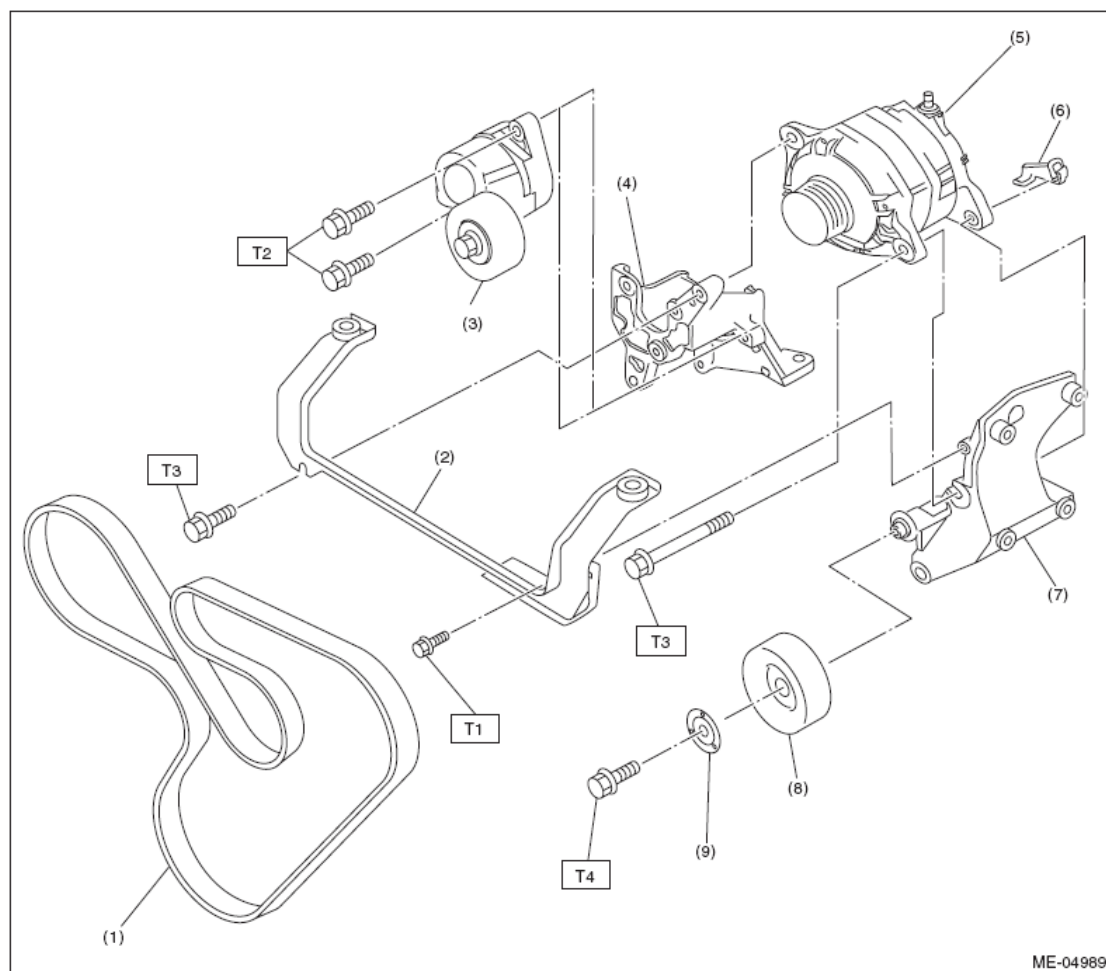
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|                                                             |                                    |                       |                  |                                   |
|-------------------------------------------------------------|------------------------------------|-----------------------|------------------|-----------------------------------|
| Crankshaft and crankshaft bearing                           | Crank journal outer diameter       | mm (in)<br>#2, #4, #6 | US               | 2.5180)                           |
|                                                             |                                    |                       | 0.25 (0.0098) US | 63.742 - 63.758 (2.5095 - 2.5102) |
|                                                             |                                    |                       | Standard         | 63.992 - 64.016 (2.5194 - 2.5203) |
|                                                             |                                    |                       | 0.03 (0.0012) US | 63.962 - 63.978 (2.5182 - 2.5188) |
|                                                             |                                    |                       | 0.05 (0.0020) US | 63.942 - 63.958 (2.5174 - 2.5180) |
|                                                             | Bearing size (Thickness at center) | #1, #3, #5            | 0.25 (0.0098) US | 63.742 - 63.758 (2.5095 - 2.5102) |
|                                                             |                                    |                       | Standard         | 1.996 - 2.013 (0.0786 - 0.0793)   |
|                                                             |                                    |                       | 0.03 (0.0012) US | 2.011 - 2.014 (0.0792 - 0.0793)   |
|                                                             |                                    |                       | 0.05 (0.0020) US | 2.021 - 2.024 (0.0796 - 0.0797)   |
|                                                             |                                    | #2, #4, #6            | 0.25 (0.0098) US | 2.121 - 2.124 (0.0835 - 0.0836)   |
|                                                             |                                    |                       | Standard         | 1.996 - 2.013 (0.0786 - 0.0793)   |
|                                                             |                                    |                       | 0.03 (0.0012) US | 2.015 - 2.018 (0.0793 - 0.0794)   |
|                                                             |                                    |                       | 0.05 (0.0020) US | 2.025 - 2.028 (0.0797 - 0.0798)   |
|                                                             |                                    |                       | 0.25 (0.0098) US | 2.125 - 2.128 (0.0837 - 0.0838)   |
|                                                             |                                    | #7                    | Standard         | 1.992 - 2.009 (0.0784 - 0.0791)   |
|                                                             |                                    |                       | 0.03 (0.0012) US | 2.011 - 2.014 (0.0792 - 0.0793)   |
|                                                             |                                    |                       | 0.05 (0.0020) US | 2.021 - 2.024 (0.0796 - 0.0797)   |
|                                                             |                                    |                       | 0.25 (0.0098) US | 2.121 - 2.124 (0.0835 - 0.0836)   |
|                                                             | Thrust clearance                   | mm (in)               | Standard         | 0.030 - 0.115 (0.0012 - 0.0045)   |
|                                                             | Oil clearance                      | mm (in)               | Standard         | 0.010 - 0.030 (0.0004 - 0.0012)   |
| <b>NOTE:</b><br><b>OS: Oversize</b><br><b>US: Undersize</b> |                                    |                       |                  |                                   |

## COMPONENT

## V-BELT



ME-04989

**Fig. 1: Identifying V-Belt And Related Components With Torque Specifications**  
 Courtesy of SUBARU OF AMERICA, INC.

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

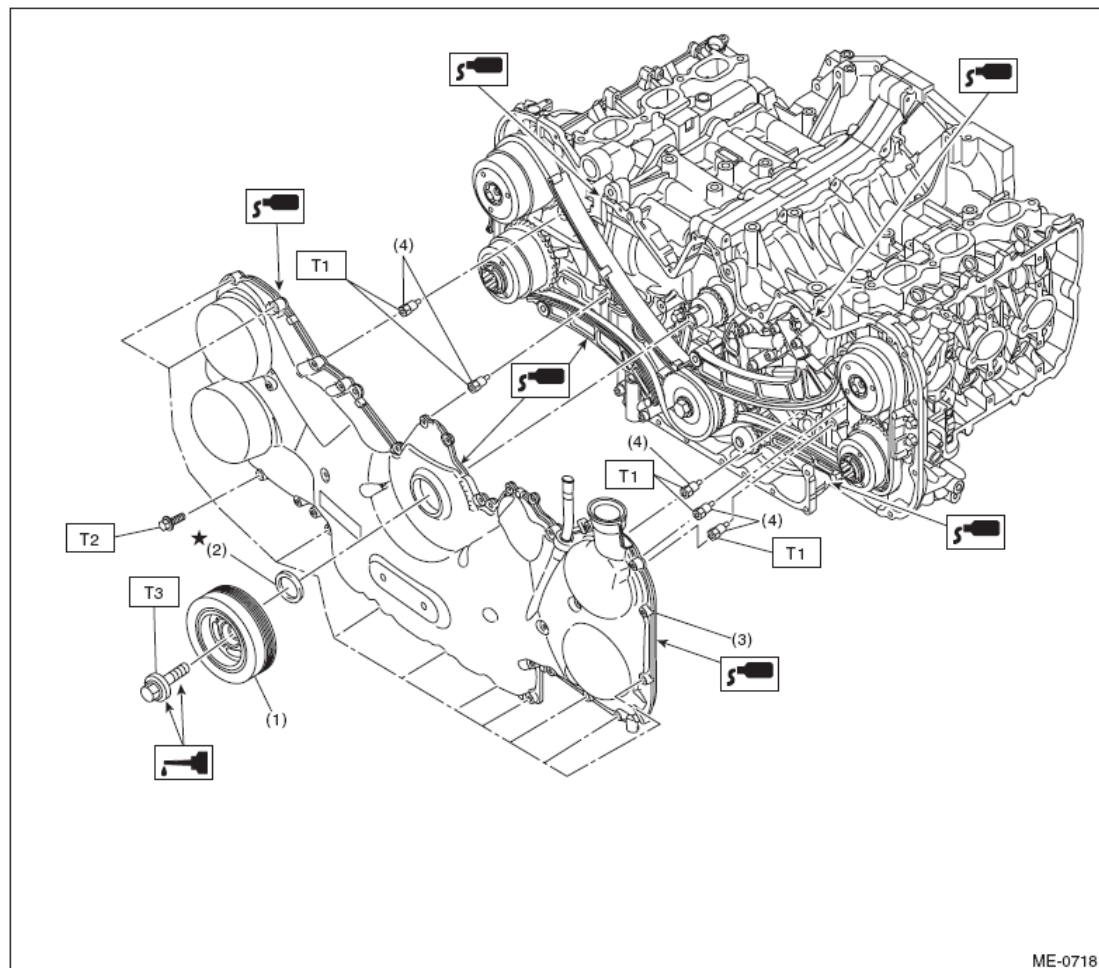
**T1: 6.4 (0.7, 4.7)**

**T2: 20 (2.0, 14.8)**

**T3: 25 (2.5, 18.4)**

**T4: 33 (3.4, 24.3)**

## TIMING CHAIN COVER



- (1) Crank pulley
- (2) Oil seal
- (3) Chain cover
- (4) Bolt

**Fig. 2: Identifying Timing Chain Cover Components With Torque Specifications**  
Courtesy of SUBARU OF AMERICA, INC.

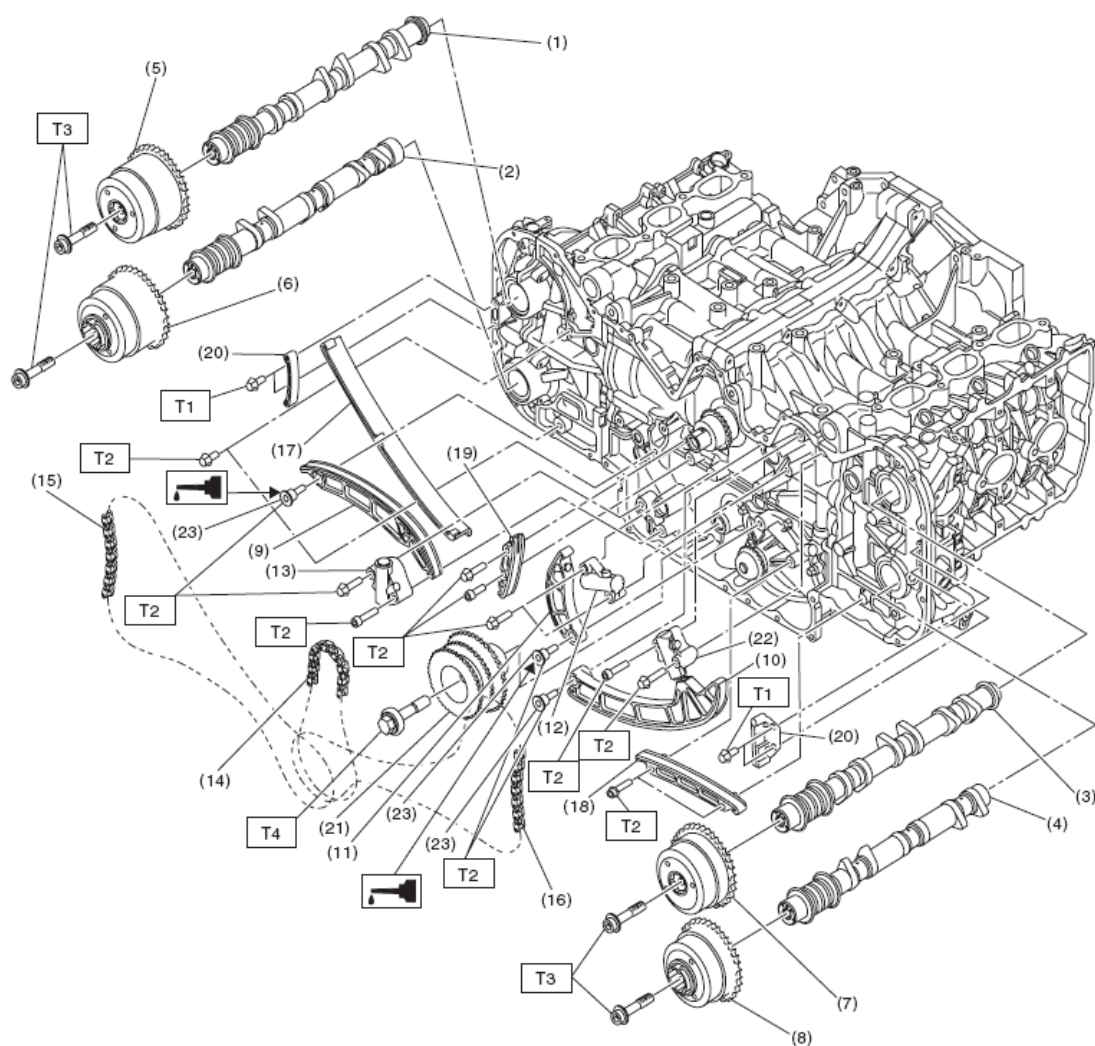
**Tightening torque: N.m (kgf-m, ft-lb)**

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

**T2: 10 (1.0, 7.4)**

**T3: 195 (19.9, 143.8)**

## TIMING CHAIN



ME-04428

- |                                 |                                   |                                  |
|---------------------------------|-----------------------------------|----------------------------------|
| (1) Intake camshaft (RH)        | (11) Chain tensioner lever (main) | (21) Idler sprocket              |
| (2) Exhaust camshaft (RH)       | (12) Chain tensioner (main)       | (22) Chain tensioner (LH)        |
| (3) Intake camshaft (LH)        | (13) Chain tensioner (RH)         | (23) Chain tensioner lever shaft |
| (4) Exhaust camshaft (LH)       | (14) Timing chain (main)          |                                  |
| (5) Intake cam sprocket (RH)    | (15) Timing chain (RH)            |                                  |
| (6) Exhaust cam sprocket (RH)   | (16) Timing chain (LH)            |                                  |
| (7) Intake cam sprocket (LH)    | (17) Chain guide (RH)             |                                  |
| (8) Exhaust cam sprocket (LH)   | (18) Chain guide (LH)             |                                  |
| (9) Chain tensioner lever (RH)  | (19) Chain guide (main)           |                                  |
| (10) Chain tensioner lever (LH) | (20) Chain guide (between cams)   |                                  |

**Fig. 3: Identifying Timing Chain Components With Torque Specifications**  
**Courtesy of SUBARU OF AMERICA, INC.**

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

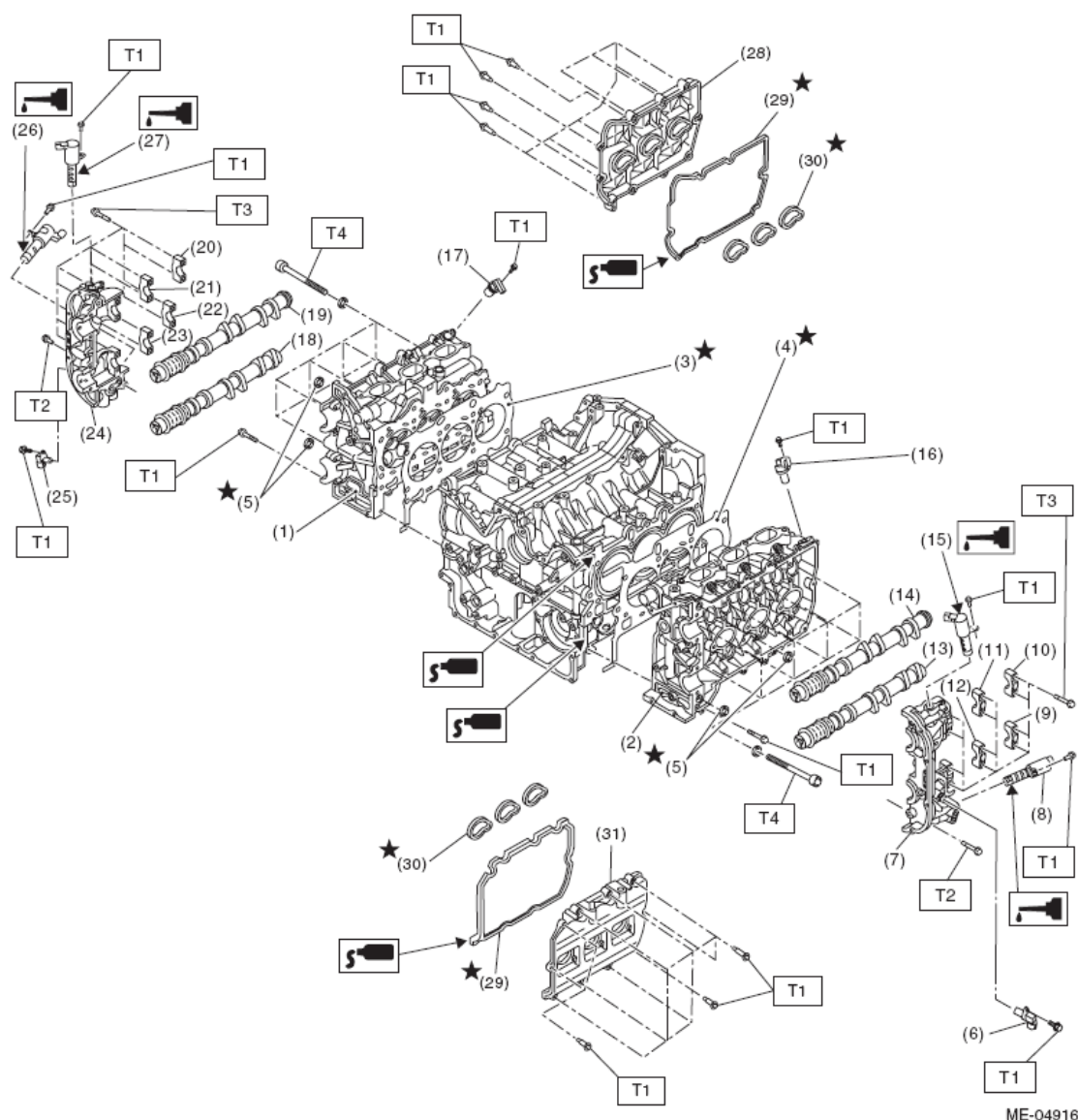
***T1: 6.4 (0.7, 4.7)***

***T2: 16 (1.6, 11.8)***

***T3: < Refer to CAM SPROCKET. >***

***T4: 120 (12.2, 88.5)***

**CYLINDER HEAD AND CAMSHAFT**



ME-04916

- |                                                  |                                                  |                                                  |
|--------------------------------------------------|--------------------------------------------------|--------------------------------------------------|
| (1) Cylinder head (RH)                           | (14) Intake camshaft (LH)                        | (27) Intake oil flow control solenoid valve (RH) |
| (2) Cylinder head (LH)                           | (15) Intake oil flow control solenoid valve (LH) | (28) Rocker cover (RH)                           |
| (3) Cylinder head gasket (RH)                    | (16) Intake camshaft position sensor (LH)        | (29) Gasket                                      |
| (4) Cylinder head gasket (LH)                    | (17) Intake camshaft position sensor (RH)        | (30) Gasket                                      |
| (5) O-ring                                       | (18) Exhaust camshaft (RH)                       | (31) Rocker cover (LH)                           |
| (6) Exhaust camshaft position sensor (LH)        | (19) Intake camshaft (RH)                        |                                                  |
| (7) Front camshaft cap (LH)                      | (20) Intake camshaft cap (rear RH)               |                                                  |
| (8) Exhaust oil flow control solenoid valve (LH) | (21) Intake camshaft cap (center RH)             |                                                  |
| (9) Exhaust camshaft cap (rear LH)               | (22) Exhaust camshaft cap (rear RH)              |                                                  |
| (10) Intake camshaft cap (rear LH)               | (23) Exhaust camshaft cap (center RH)            |                                                  |
| (11) Intake camshaft cap (center LH)             | (24) Front camshaft cap (RH)                     |                                                  |
| (12) Exhaust camshaft cap (center LH)            | (25) Exhaust camshaft position sensor            |                                                  |

**Fig. 4: Identifying Cylinder Head And Camshaft Components With Torque Specifications**  
 Courtesy of SUBARU OF AMERICA, INC.

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

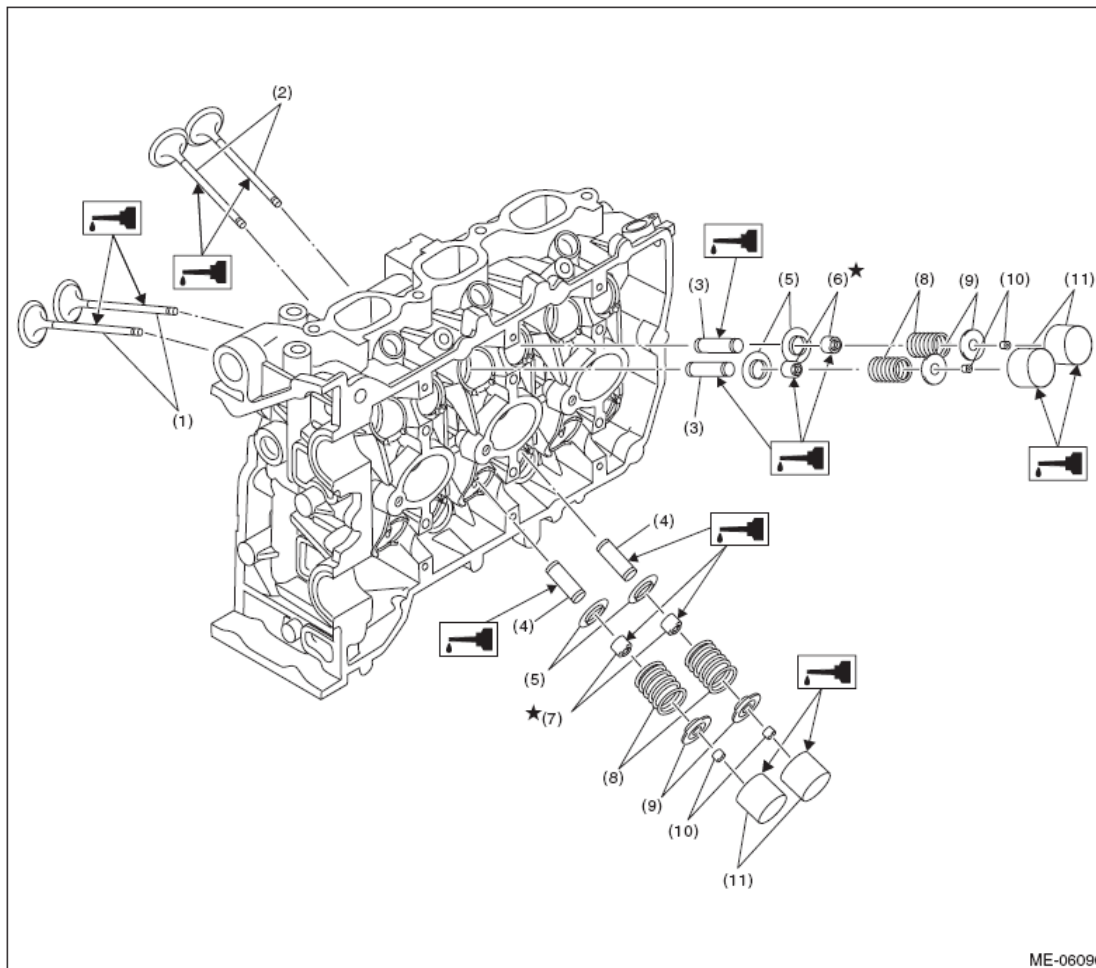
**T1: 6.4 (0.7, 4.7)**

**T2: 9.75 (1.0, 7.2)**

**T3: 16 (1.6, 11.8)**

**T4: < Refer to CYLINDER HEAD. >**

**CYLINDER HEAD AND VALVE ASSEMBLY**

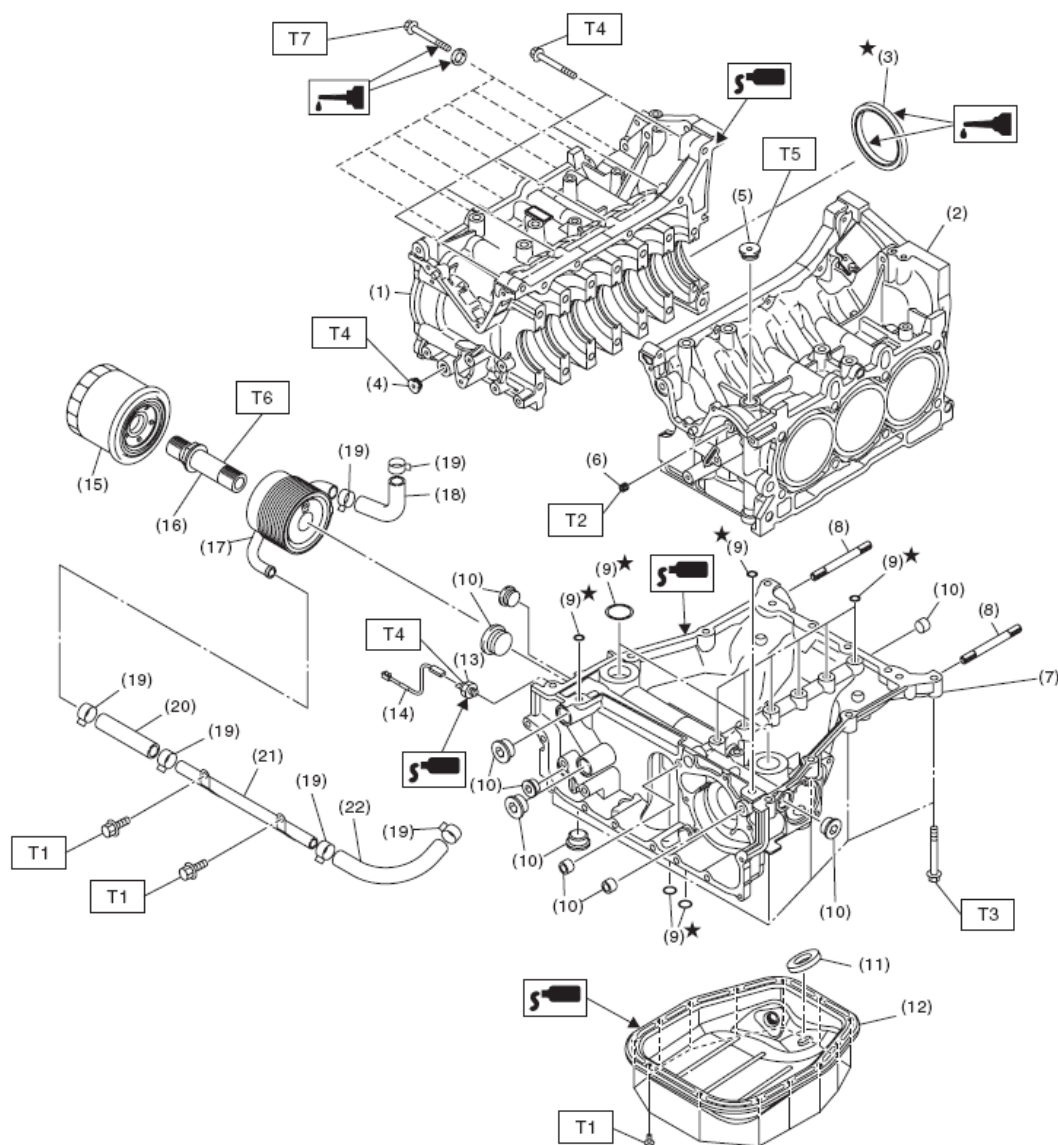


- |                           |                         |                           |
|---------------------------|-------------------------|---------------------------|
| (1) Intake valve          | (5) Valve spring seat   | (9) Valve spring retainer |
| (2) Exhaust valve         | (6) Stem seal (intake)  | (10) Valve collet         |
| (3) Valve guide (intake)  | (7) Stem seal (exhaust) | (11) Valve lifter         |
| (4) Valve guide (exhaust) | (8) Valve spring        |                           |

**Fig. 5: Identifying Cylinder Head And Valve Assembly With Torque Specifications**

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

**CYLINDER BLOCK**



ME-04988

- |                         |                                  |
|-------------------------|----------------------------------|
| (1) Cylinder block (RH) | (12) Oil pan lower               |
| (2) Cylinder block (LH) | (13) Oil pressure switch         |
| (3) Oil seal            | (14) Oil pressure switch harness |
| (4) Plug                | (15) Oil filter                  |
| (5) Plug                | (16) Oil cooler connector        |
| (6) Orifice             | (17) Oil cooler                  |
| (7) Oil pan upper       | (18) Hose                        |
| (8) Stud bolt           | (19) Clamp                       |
| (9) O-ring              | (20) Hose                        |
| (10) Plug               | (21) Oil cooler pipe             |
| (11) Magnet             | (22) Hose                        |

**Fig. 6: Identifying Cylinder Block Components 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: 17 (1.7, 12.5)*

*T3: 18 (1.8, 13.3)*

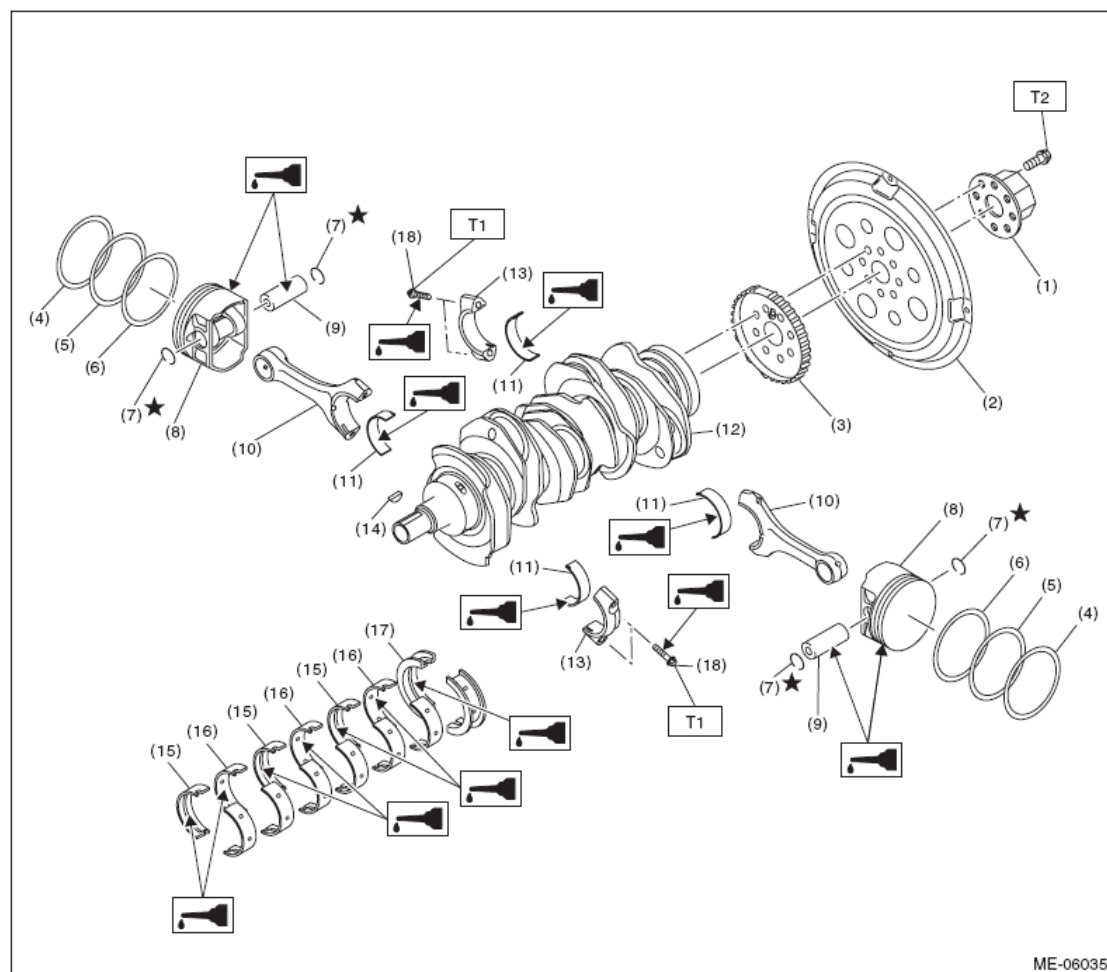
*T4: 25 (2.5, 18.4)*

*T5: 37 (3.8, 27.3)*

*T6: 54 (5.5, 39.8)*

*T7: < Refer to CYLINDER BLOCK. >*

CRANKSHAFT AND PISTON



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

**Fig. 7: Identifying Crankshaft And Piston Components With Torque Specifications**  
 Courtesy of SUBARU OF AMERICA, INC.

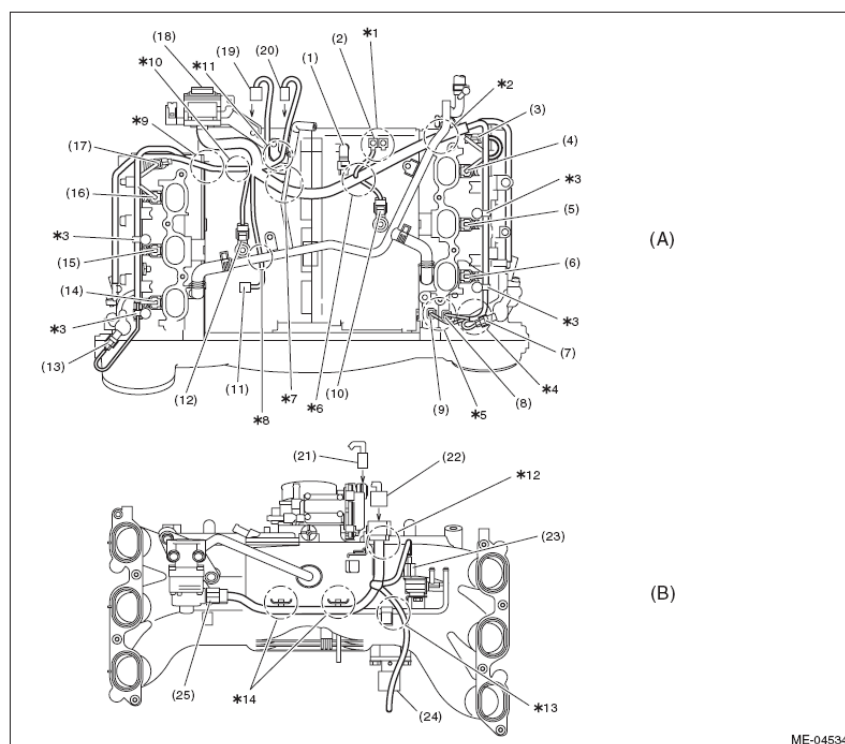
**Tightening torque: N.m (kgf-m, ft-lb)**

**T1: 60 (6.1, 44.3)**

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

## ENGINE HARNESS

Engine harness assembly diagram 1



ME-04534

(A) Cylinder block upper face

(B) Intake manifold back surface

- |                                                         |                                                          |                                                                                    |
|---------------------------------------------------------|----------------------------------------------------------|------------------------------------------------------------------------------------|
| (1) Crankshaft position sensor connector                | (10) Knock sensor LH connector                           | (19) Upper/lower connection connector (to intake manifold)                         |
| (2) Engine ground                                       | (11) Power steering switch connector                     | (20) Electronic throttle control connector (to intake manifold)                    |
| (3) Intake camshaft position sensor LH connector        | (12) Knock sensor RH connector                           | (21) Electronic throttle control connector (from upper part of the cylinder block) |
| (4) #6 injector connector                               | (13) Intake oil flow control solenoid valve RH connector | (22) Upper/lower connection connector (from upper part of the cylinder block)      |
| (5) #4 injector connector                               | (14) #1 injector connector                               | (23) Purge control solenoid valve connector                                        |
| (6) #2 injector connector                               | (15) #3 injector connector                               | (24) Manifold absolute pressure sensor connector                                   |
| (7) Intake oil flow control solenoid valve LH connector | (16) #5 injector connector                               | (25) EGR valve connector                                                           |
| (8) Oil temperature sensor connector                    | (17) Intake camshaft position sensor RH connector        |                                                                                    |
| (9) Engine coolant temperature sensor connector         | (18) Engine harness docking connector                    |                                                                                    |

\*1: Install so that engine ground terminals face the rear side of vehicle.

\*2: Route under the heater pipe.

\*3: Attach the engine harness fixing clip to the fuel pipe stay.

\*4: Route from the cutout portion on the fuel pipe protector LH.

\*5: Be careful not to mix up the connectors of oil temperature sensor and engine coolant temperature sensor.

\*6: Route between crankshaft position sensor and knock sensor LH.

\*7: Route under the heater pipe.

\*8: Route under the heater pipe.

\*9: Route under the fuel pipe.

\*10: Attach the engine harness fixing clip to the fixing boss on the cylinder block.

\*11: Route over the heater pipe stay.

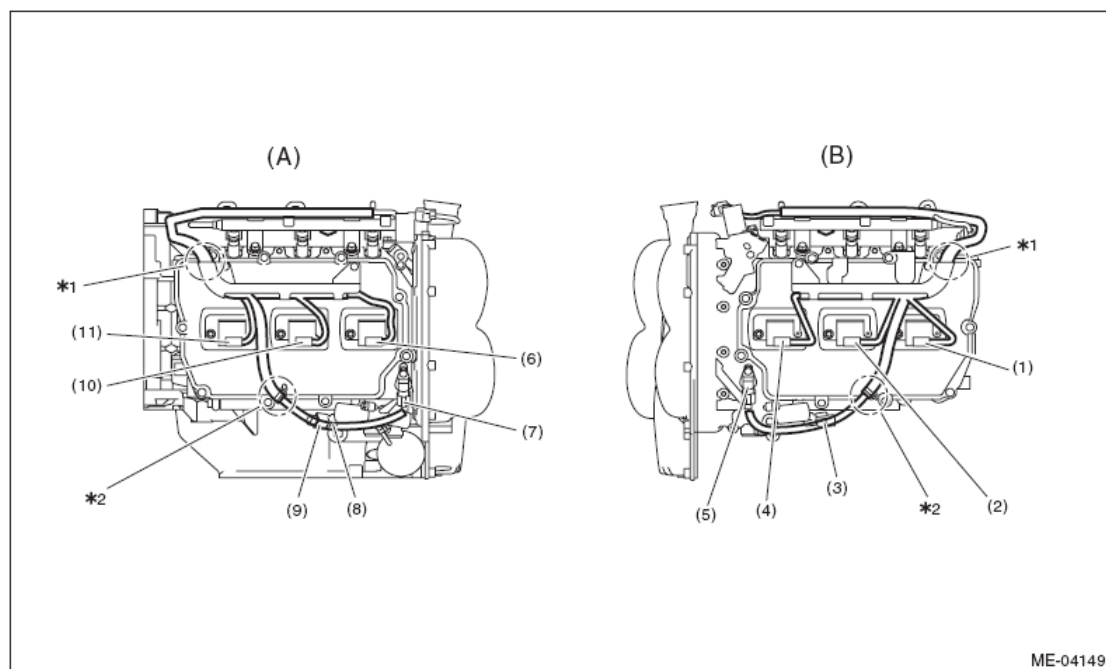
\*12: Securely install the engine harness fixing stay.

\*13: Route outside the fuel pipe.

\*14: Attach the engine harness fixing clip to the fixing stay on the intake manifold.

**Fig. 8: Identifying Engine Harness Assembly Diagram 1**  
**Courtesy of SUBARU OF AMERICA, INC.**

#### Engine harness assembly diagram 2



ME-04149

(A) Right side of the engine

(B) Left side of the engine

(1) #6 ignition coil connector

(5) Exhaust camshaft position sensor  
LH connector

(9) Exhaust oil flow control valve sole-  
noid RH connector

(2) #4 ignition coil connector

(6) #1 injector connector

(10) #3 ignition coil connector

(3) Exhaust oil flow control valve sole-  
noid LH connector

(7) Exhaust camshaft position sensor  
RH connector

(11) #5 ignition coil connector

(4) #2 ignition coil connector

(8) Oil pressure switch connector

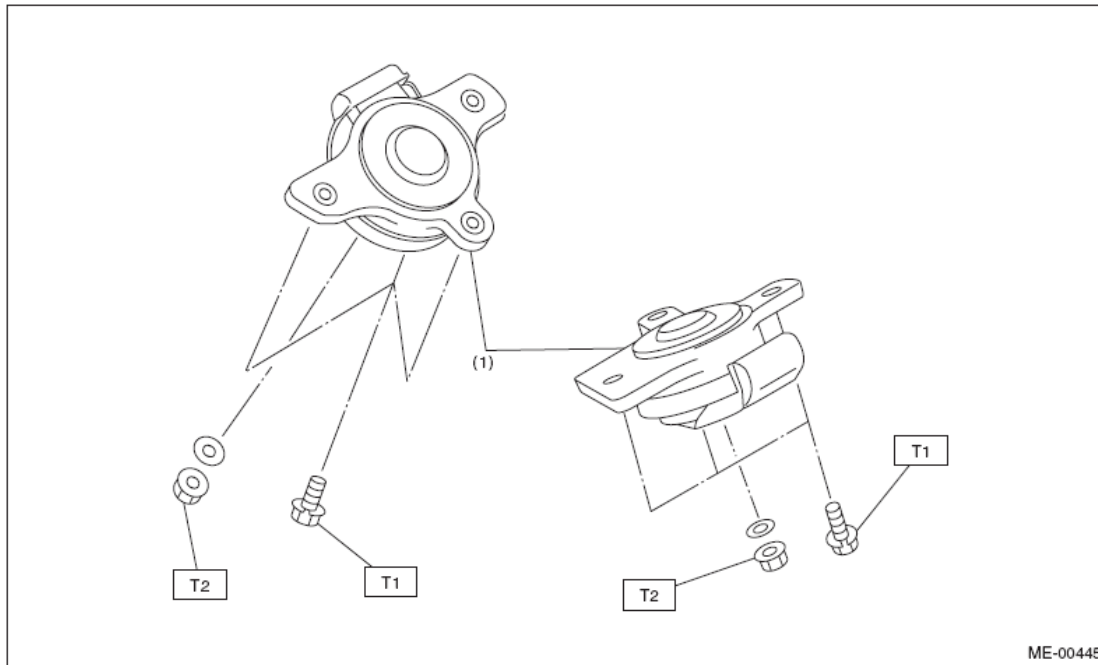
\*1: Align the engine harness stay end with the end of engine harness identification tape.

\*2: Attach the engine harness fixing clip to the fixing boss on the rocker cover.

### **Fig. 9: Identifying Engine Harness Assembly Diagram 2**

Courtesy of SUBARU OF AMERICA, INC.

### **ENGINE MOUNTING**



(1) Front cushion rubber

**Fig. 10: Identifying Engine Mounting With Torque Specifications**  
Courtesy of SUBARU OF AMERICA, INC.

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

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

**T2: 75 (7.6, 55.3)**

### CAUTION

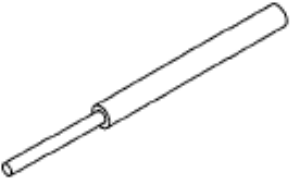
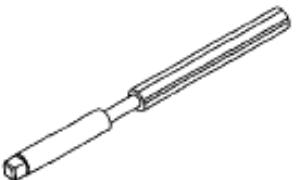
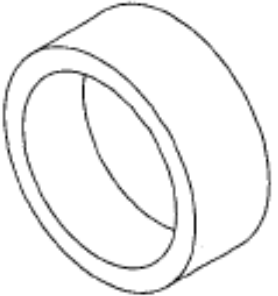
- Prior to starting work, pay special attention to the following:
  1. Always wear work clothes, a safety cap, protective shoes. Additionally, wear a helmet, protective goggles, etc. if necessary.
  2. Protect the vehicle using a seat cover, fender cover, etc.
  3. Prepare the service tools, clean cloth, 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.
- Remove contamination including dirt and corrosion before removal, installation, disassembly or

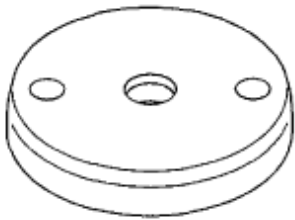
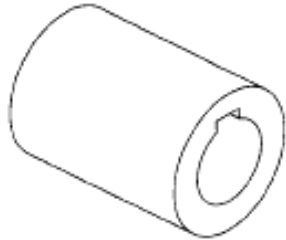
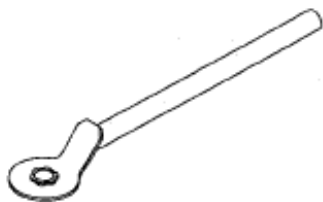
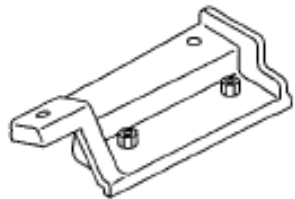
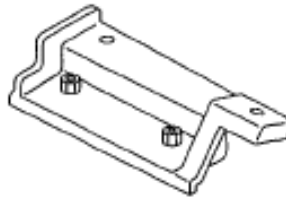
assembly.

- 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

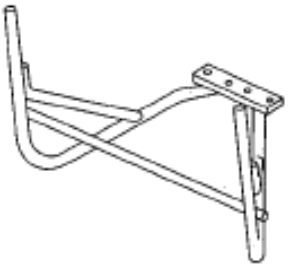
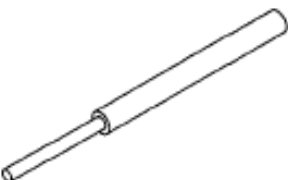
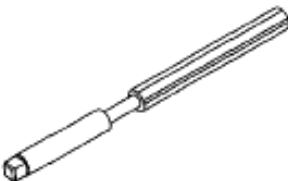
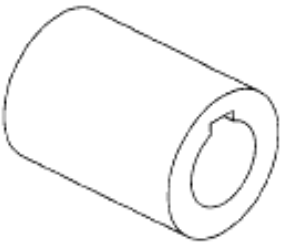
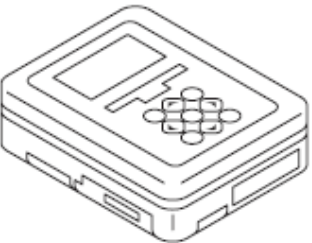
### SPECIAL TOOL

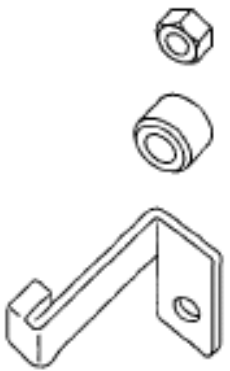
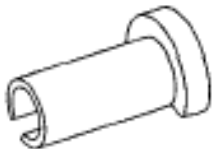
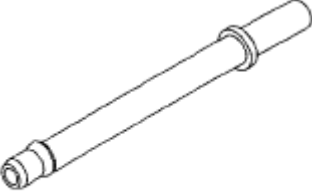
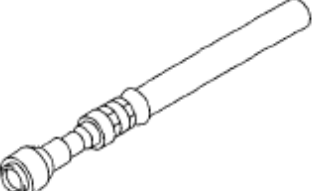
| ILLUSTRATION                                                                                        | TOOL NUMBER | DESCRIPTION         | REMARKS                                                                                                                                        |
|-----------------------------------------------------------------------------------------------------|-------------|---------------------|------------------------------------------------------------------------------------------------------------------------------------------------|
| <br>ST-499765700  | 18250AA010  | CYLINDER HEAD TABLE | <ul style="list-style-type: none"> <li>• Used for replacing valve guides.</li> <li>• Used for removing and installing valve spring.</li> </ul> |
| <br>ST-499765900 | 18232AA000  | ENGINE STAND        | Used for disassembling and assembling engine.                                                                                                  |
| <br>ST-398744300 | 398744300   | PISTON GUIDE        | Used for installing piston in cylinder.                                                                                                        |
|                                                                                                     |             |                     |                                                                                                                                                |

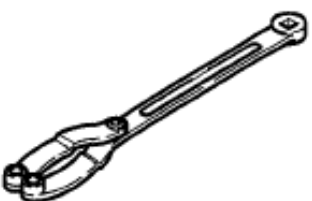
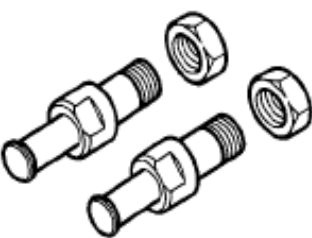
|                                                                                                         |            |                                              |                                                                                                                                                                       |
|---------------------------------------------------------------------------------------------------------|------------|----------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  <p>ST18671AA020</p>   | 18261AA010 | VALVE OIL SEAL GUIDE                         | Used for press-fitting of intake valve guide oil seals and exhaust valve guide oil seals.                                                                             |
|  <p>ST18252AA000</p>   | 18350AA000 | CONNECTING ROD BUSHING REMOVER AND INSTALLER | Used for removing and installing connecting rod bushing.                                                                                                              |
|  <p>ST-499977500</p>  | 499977500  | CAM SPROCKET WRENCH                          | Used for removing and installing cam sprocket.                                                                                                                        |
|  <p>ST-498457000</p> | 499587200  | CRANKSHAFT OIL SEAL INSTALLER                | <ul style="list-style-type: none"> <li>• Used for installing crankshaft oil seal.</li> <li>• Used together with CRANKSHAFT OIL SEAL GUIDE (499597100).</li> </ul>     |
|  <p>ST-498457100</p> | 499597100  | CRANKSHAFT OIL SEAL GUIDE                    | <ul style="list-style-type: none"> <li>• Used for installing crankshaft oil seal.</li> <li>• Used together with CRANKSHAFT OIL SEAL INSTALLER (499587200).</li> </ul> |
|                                                                                                         |            |                                              |                                                                                                                                                                       |

# 2014 Subaru Tribeca Limited

2014 ENGINE Engine Mechanical - Tribeca

|                                                                                                         |            |                                  |                                                |
|---------------------------------------------------------------------------------------------------------|------------|----------------------------------|------------------------------------------------|
|  <p>ST-499817100</p>   | 499718000  | VALVE SPRING<br>REMOVER          | Used for removing and installing valve spring. |
|  <p>ST-499765700</p>   | 499765700  | VALVE GUIDE<br>REMOVER           | Used for removing valve guides.                |
|  <p>ST-499765900</p>  | 499765900  | VALVE GUIDE<br>REAMER            | Used for reaming valve guides.                 |
|  <p>ST18252AA000</p> | 18252AA000 | CRANKSHAFT<br>SOCKET             | Used for rotating crankshaft.                  |
|  <p>ST1B022XU0</p>   | 1B022XU0   | SUBARU SELECT<br>MONITOR III KIT | Used for various inspections.                  |
|                                                                                                         |            |                                  |                                                |

|                                                                                                         |            |                            |                                                                                                                                   |
|---------------------------------------------------------------------------------------------------------|------------|----------------------------|-----------------------------------------------------------------------------------------------------------------------------------|
|  <p>ST-498277200</p>   | 498277200  | STOPPER SET                | Used for installing automatic transmission assembly to engine.                                                                    |
|  <p>ST42099AE000</p>   | 42099AE000 | QUICK CONNECTOR<br>RELEASE | Used for disconnecting quick connector of the engine compartment.                                                                 |
|  <p>ST18471AA000</p> | 18471AA000 | FUEL PIPE ADAPTER          | Used for measuring fuel pressure.                                                                                                 |
|  <p>ST42075AG690</p> | 42075AG690 | FUEL HOSE                  | <ul style="list-style-type: none"> <li>• Used for measuring fuel pressure.</li> <li>• This is the SUBARU genuine part.</li> </ul> |
|                                                                                                         | 18251AA050 | VALVE GUIDE<br>ADJUSTER    | Used for installing intake valve guides.                                                                                          |

|                                                                                                         |            |                          |                                                                                                                                                                                                                                          |
|---------------------------------------------------------------------------------------------------------|------------|--------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  <p>ST18251AA050</p>   |            |                          |                                                                                                                                                                                                                                          |
|  <p>ST18251AA060</p>   | 18251AA060 | VALVE GUIDE<br>ADJUSTER  | Used for installing exhaust valve guides.                                                                                                                                                                                                |
|  <p>ST18355AA000</p>  | 18355AA000 | PULLEY WRENCH            | <ul style="list-style-type: none"> <li>• Used for removing and installing the crank pulley.</li> <li>• Used for removing and installing the idler sprocket.</li> <li>• Used together with PULLEY WRENCH PIN SET (18334AA000).</li> </ul> |
|  <p>ST18334AA000</p> | 18334AA000 | PULLEY WRENCH PIN<br>SET | <ul style="list-style-type: none"> <li>• Used for removing and installing the crank pulley.</li> <li>• Used for removing and installing the idler sprocket.</li> <li>• Used together with PULLEY WRENCH (18355AA000).</li> </ul>         |
|                                                                                                         | 18332AA020 | OIL FILTER WRENCH        | Used for removing and installing oil filter.                                                                                                                                                                                             |

|                                                                                                       |                  |                       |                                                      |
|-------------------------------------------------------------------------------------------------------|------------------|-----------------------|------------------------------------------------------|
|  <p>ST18332AA020</p> |                  |                       |                                                      |
|  <p>ST-499585700</p> | <p>499585700</p> | <p>OIL SEAL GUIDE</p> | <p>Used for installing the chain cover oil seal.</p> |

#### GENERAL TOOL

| TOOL NAME           | REMARKS                                              |
|---------------------|------------------------------------------------------|
| Compression gauge   | Used for inspecting compression pressure.            |
| Timing light        | Used for inspecting the ignition timing.             |
| Vacuum gauge        | Used for inspecting intake manifold vacuum.          |
| Oil pressure gauge  | Used for inspecting engine oil pressure.             |
| Fuel pressure gauge | Used for inspecting fuel pressure.                   |
| TORX® socket (E12)  | Used for removing and installing connecting rod cap. |

## COMPRESSION

### INSPECTION

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

1. Remove the collector cover.
2. After warming-up the engine, turn the ignition switch to OFF.
3. Make sure that the battery is fully charged.
4. Release the fuel pressure. < Refer to **RELEASING OF FUEL PRESSURE** , PROCEDURE, Fuel. >
5. Remove all spark plugs. < Refer to **REMOVAL** , Spark Plug. >
6. Fully open the throttle valve.

7. Check the starter motor for satisfactory performance and operation.
8. Secure the compression gauge tightly against the spark plug hole.

**NOTE:** When using a screw-in type compression gauge, the screw should be less than 18 mm (0.71 in) long.

9. Crank the engine by the starter motor, and read the maximum value on the gauge when the needle of gauge is steady.

**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 (350 rpm and fully open throttle):*

*Standard*

*1, 275 - 1, 471 kPa (13.0 - 15.0 kgf/cm<sup>2</sup> , 185 - 213 psi)*

*Limit*

*1, 128 kPa (11.5 kgf/cm<sup>2</sup> , 164 psi)*

*Difference between cylinders*

*49 kPa (0.5 kgf/cm<sup>2</sup> , 7 psi) or less*

10. 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)

*Idle speed (No load and gears in "P" or "N" range):*

*Standard*

*700±100 rpm*

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.)

*Idle speed (A/C ON and gear in "P" or "N" range):*

*Standard*

*805±100 rpm*

## IGNITION TIMING

### INSPECTION

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

### METHOD WITH SUBARU SELECT MONITOR

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. >

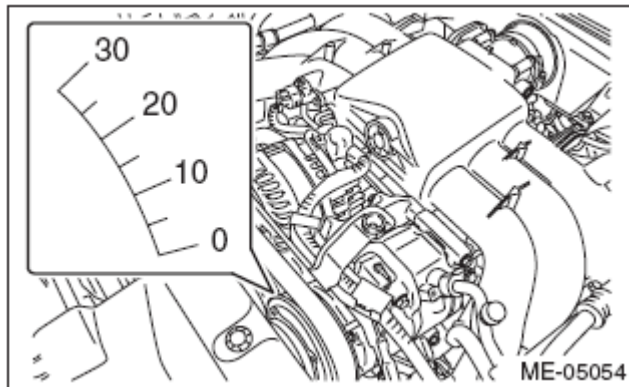
**NOTE:** If ignition timing is out of standard, check the ignition control system. Refer to "Engine Control System". < Refer to **BASIC DIAGNOSTIC PROCEDURE** . >

***Ignition timing [BTDC/rpm]:******Standard******15°±8°/700*****METHOD WITH TIMING LIGHT**

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. Stop the engine, and turn the ignition switch to OFF.
4. Remove the collector cover.
5. Disconnect the ground cable from battery.
6. Remove the air intake duct. < Refer to **REMOVAL** , Air Intake Duct. >
7. Disconnect the connector from mass air flow and intake air temperature sensor.
8. Remove the air cleaner case and element.
9. Connect the timing light to the power wire of #1 ignition coil.
10. Install the connectors of air cleaner case, element, and the mass air flow and intake air temperature sensor.
11. Connect the battery ground terminal.
12. Start the engine, turn the timing light to the crank pulley, and check the ignition timing through the chain cover gauge.

**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******15°±8°/700***



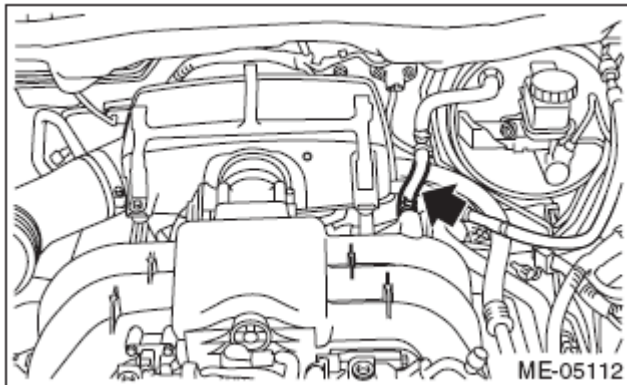
**Fig. 11: Identifying Ignition Timing Marks**  
Courtesy of SUBARU OF AMERICA, INC.

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

## INTAKE MANIFOLD VACUUM

### INSPECTION

1. Warm up the engine.
2. Remove the collector cover.
3. Disconnect the brake booster vacuum hose from the intake manifold, and install the vacuum gauge.



**Fig. 12: Identifying Brake Booster Vacuum Hose**  
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**

**Less than -60.0 kPa (-450 mmHg, -17.72 inHg)**

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

| Diagnosis of engine condition by measurement of intake manifold vacuum                                                                                  |                                                                               |
|---------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------|
| Vacuum gauge indication                                                                                                                                 | 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                                                     |

## ENGINE OIL PRESSURE

### INSPECTION

- Disconnect the ground cable from battery.
- Remove the oil pressure switch from the oil pan upper. < Refer to **REMOVAL** , Oil Pressure Switch. >
- Connect the oil pressure gauge hose to the oil pan upper.
- Connect the battery ground terminal.
- Start the engine, and check the oil pressure.

**NOTE:**

- If the oil pressure is out of specification, check oil pump, oil filter and lubrication line. < Refer to **GENERAL DIAGNOSTIC TABLE** . >
- If the oil pressure warning light is ON and oil pressure is within specification, check the oil pressure switch. < Refer to **OIL PRESSURE SYSTEM** . >

**Engine oil pressure (at oil temperature of 80°C (176°F)):**

**Standard**

**100 kPa (1.0 kgf/cm<sup>2</sup> , 15 psi) or more (at 700 rpm)**

**500 kPa (5.1 kgf/cm<sup>2</sup> , 73 psi) or more (at 5, 000 rpm)**

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

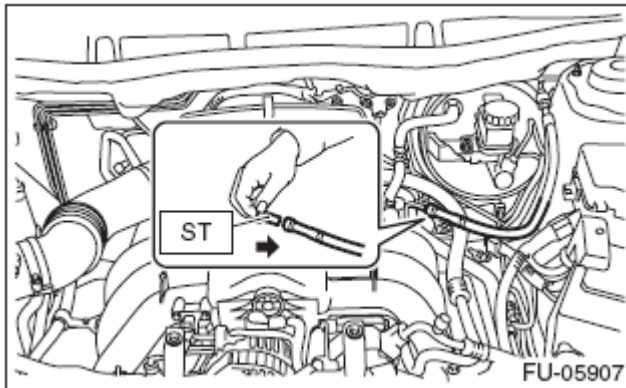
## FUEL PRESSURE

### 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. Remove the collector cover.
2. Release the fuel pressure. < Refer to **RELEASING OF FUEL PRESSURE** , PROCEDURE, Fuel. >
3. Open the fuel filler lid and remove the fuel filler cap.
4. Disconnect the fuel delivery hose and connect the fuel pressure gauge.
  1. Disconnect the fuel delivery hose using the ST.

ST 42099AE000 QUICK CONNECTOR RELEASE

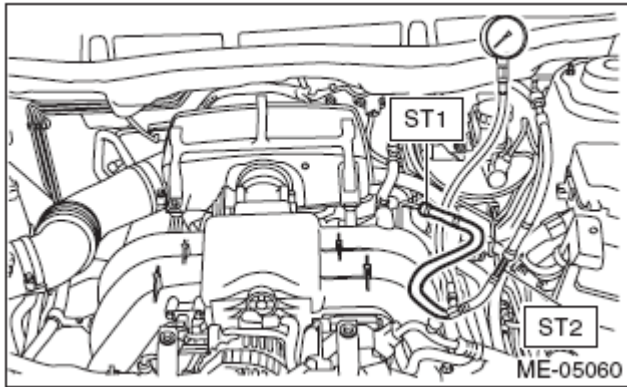


**Fig. 13: Disconnecting Fuel Delivery Hose Using Special Tool**  
Courtesy of SUBARU OF AMERICA, INC.

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. 14: Connecting Fuel Pressure Gauge With Special Tools**  
Courtesy of SUBARU OF AMERICA, INC.

5. Start the engine.
6. 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> , 49.3 - 58 psi)***

## VALVE CLEARANCE

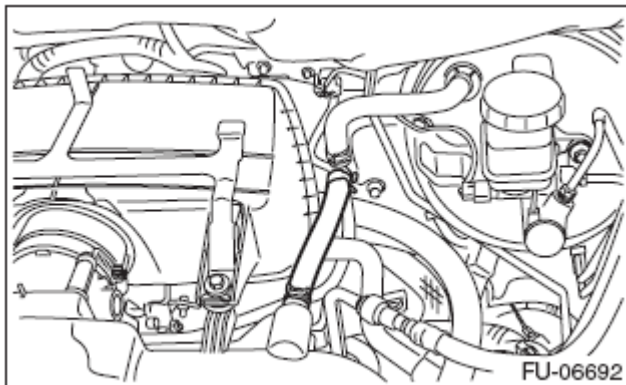
### INSPECTION

**CAUTION:** If engine oil is spilled onto the exhaust pipe, wipe it off with cloth to avoid emission of smoke or causing a fire.

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

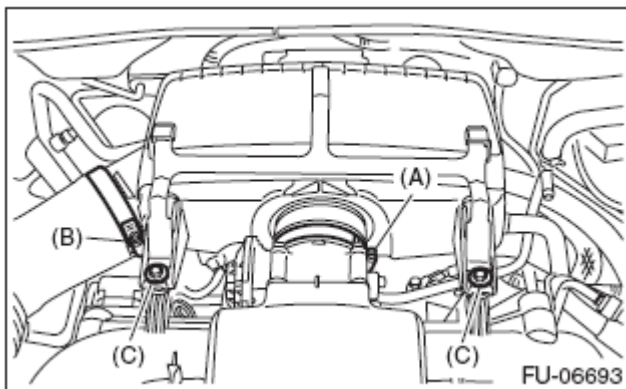
1. Remove the collector cover.
2. Disconnect the ground cable from battery.
3. Lift up the vehicle.
4. Remove the under cover. < Refer to **REMOVAL** , Front Under Cover. >
5. Lower the vehicle.

6. When inspecting the valve clearances for #1, #3 and #5
  1. Disconnect the brake booster vacuum hose from the intake manifold.



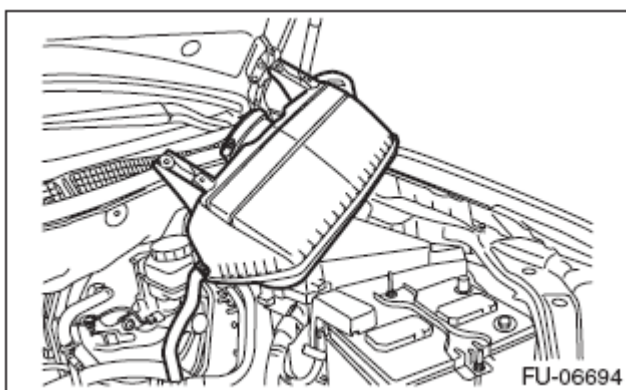
**Fig. 15: Identifying Brake Booster Vacuum Hose**  
Courtesy of SUBARU OF AMERICA, INC.

2. Loosen the clamp (A) which connects air intake chamber to throttle body.
3. Loosen the clamp (B) which connects intake boot to air intake chamber.
4. Loosen the bolt (C) which secures air intake chamber and collector cover bracket to the stay.



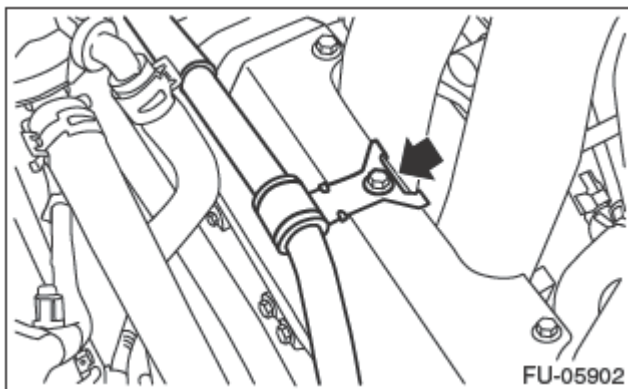
**Fig. 16: Identifying Clamp Connecting Air Intake Chamber To Throttle Body, Intake Boot To Air Intake Chamber And Mounting Bolt**  
Courtesy of SUBARU OF AMERICA, INC.

5. Remove the air intake chamber, and move it to the left side wheel apron.



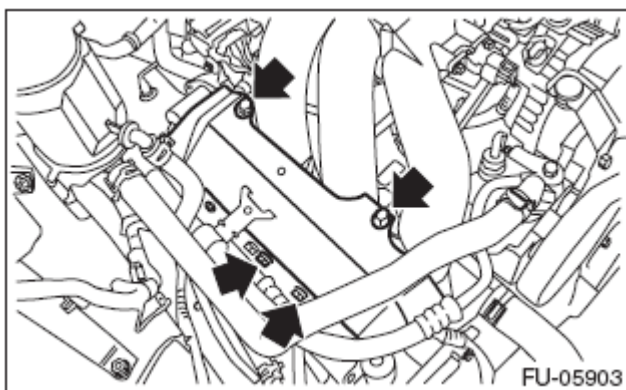
**Fig. 17: Removing Air Intake Chamber**  
Courtesy of SUBARU OF AMERICA, INC.

6. Remove the air cleaner case and intake boot. < Refer to **REMOVAL** , Air Cleaner Case. >
7. Remove the feed hose from the fuel pipe protector (RH).



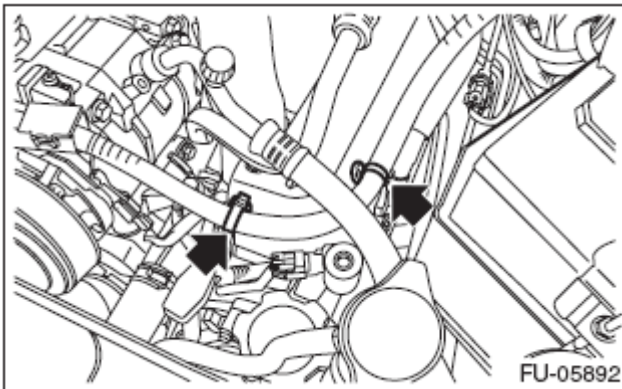
**Fig. 18: Identifying Feed Hose Mounting Bolt**  
Courtesy of SUBARU OF AMERICA, INC.

8. Remove the fuel pipe protector (RH).



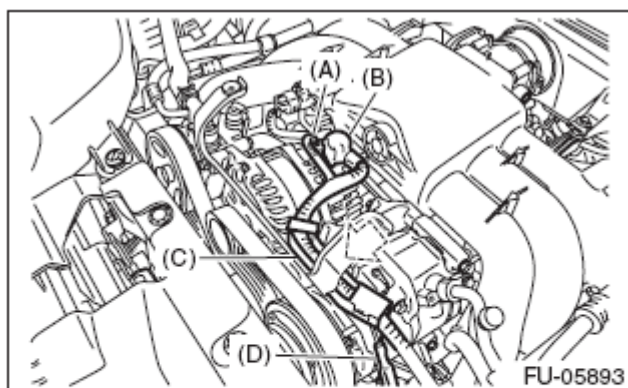
**Fig. 19: Identifying Fuel Pipe Protector (RH) Mounting Bolts**  
Courtesy of SUBARU OF AMERICA, INC.

9. Disconnect the connector of oil pressure switch.
10. Remove the ignition coil. < Refer to **REMOVAL** , Ignition Coil. >
11. Remove the rocker cover (RH). < Refer to **REMOVAL**, Camshaft. >
7. When inspecting the valve clearances for #2, #4 and #6
  1. Remove the battery and battery carrier. < Refer to **REMOVAL** , Battery. >
  2. Remove two fixing clips on the fuel pipe protector (LH).



**Fig. 20: Identifying Fixing Clips On Fuel Pipe Protector (LH)**  
Courtesy of SUBARU OF AMERICA, INC.

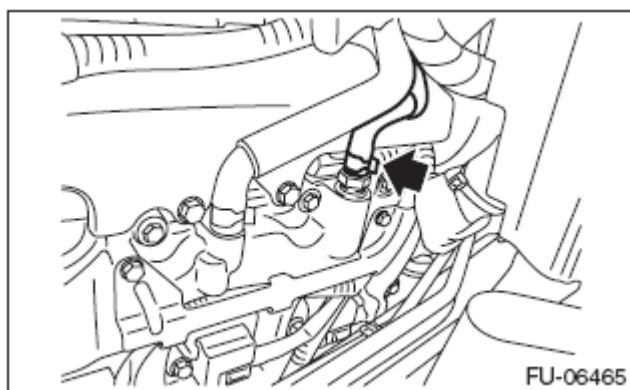
3. Generator connector
4. Generator terminal B
5. Remove the harness cover from collector cover bracket.
6. Magnet clutch connector



- (A) Generator connector
- (B) Terminal B
- (C) Remove the harness cover from collector cover bracket.
- (D) Magnet clutch connector

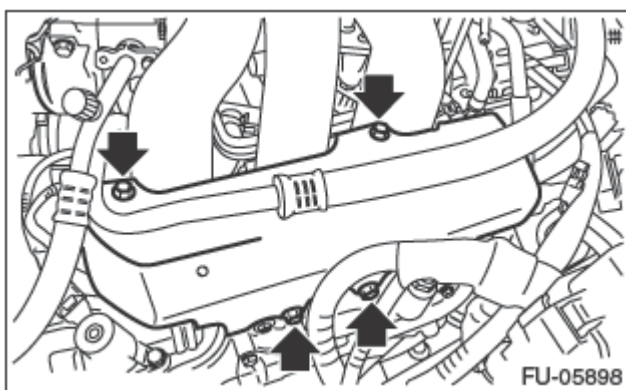
**Fig. 21: Identifying Generator Connector, Collector Cover Bracket Harness Cover And Magnet Clutch Connector**  
Courtesy of SUBARU OF AMERICA, INC.

- 7. Slide the harness and connector to the battery side.
- 8. Disconnect the PCV hose from rocker cover (LH).



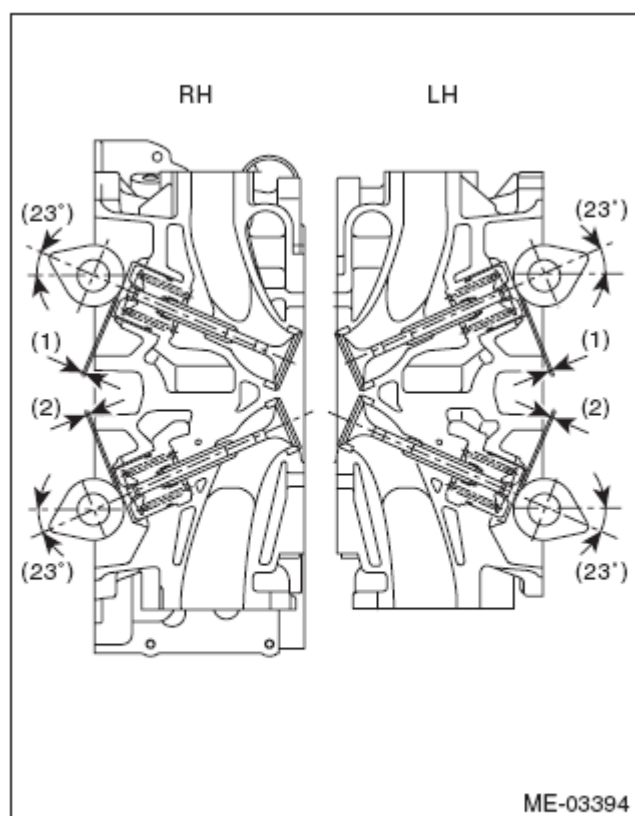
**Fig. 22: Identifying PCV Hose Mounting Clamp**  
Courtesy of SUBARU OF AMERICA, INC.

- 9. Remove the fuel pipe protector (LH).



**Fig. 23: Identifying Fuel Pipe Protector (LH) Mounting Bolts**  
Courtesy of SUBARU OF AMERICA, INC.

10. Remove the ignition coil. < Refer to **REMOVAL** , Ignition Coil. >
11. Remove the rocker cover (LH). < Refer to **REMOVAL**, Camshaft. >
8. Turn the crankshaft clockwise until the camshaft is set to position shown in the figure.



- (1) Valve clearance (intake side)
- (2) Valve clearance (exhaust side)

**Fig. 24: Turning Crankshaft Clockwise Until Camshaft Is Set**  
Courtesy of SUBARU OF AMERICA, INC.

9. Measure the clearance of intake valve and exhaust valve using thickness gauge (A).

**NOTE:**

- Measure it within the range of  $\pm 30^\circ$  from specified position shown in the figure.
- Insert a thickness gauge in a direction as horizontal as possible with respect to the valve lifter.
- If the measured value is not within specification, take notes of the value in order to adjust the valve clearance later on.

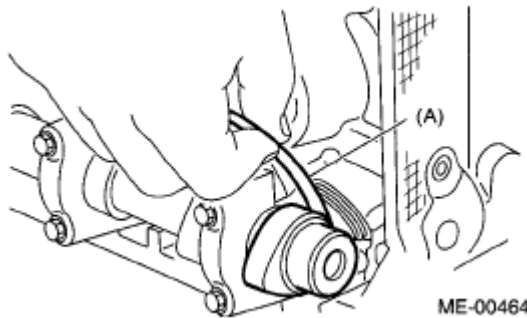
*Valve clearance (inspection value):*

**Intake**

$0.20^{+0.04}_{-0.06} \text{ mm } (0.0079^{+0.0016}_{-0.0024} \text{ in})$

**Exhaust**

$0.35 \pm 0.05 \text{ mm } (0.0138 \pm 0.0020 \text{ in})$



**Fig. 25: Measuring Clearance Of Intake And Exhaust Valve Using Thickness Gauge**  
Courtesy of SUBARU OF AMERICA, INC.

10. If necessary, adjust the valve clearance. < Refer to **ADJUSTMENT**, Valve Clearance. >
11. Further turn the crank pulley clockwise and then measure the valve clearances again.
12. After inspection, install the related parts in the reverse order of removal. < Refer to **INSTALLATION**, Camshaft. >

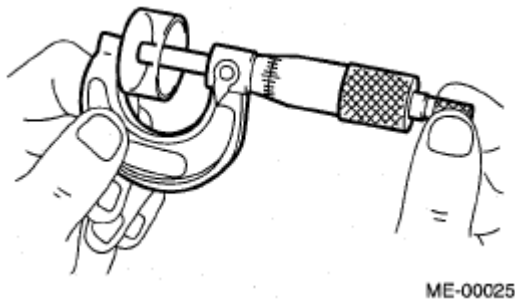
**ADJUSTMENT****INTAKE SIDE**

1. Remove the engine from vehicle. < Refer to **REMOVAL**, Engine Assembly. >
2. Measure all the valve clearances. < Refer to **INSPECTION**, Valve Clearance. >

**NOTE:**

**Record each valve clearance after measurement.**

3. Remove the timing chain assembly. < Refer to **REMOVAL**, Timing Chain Assembly. >
4. Remove the cam sprocket. < Refer to **REMOVAL**, Cam Sprocket. >
5. Remove the camshaft. < Refer to **REMOVAL**, Camshaft. >
6. Remove the valve lifter.
7. Measure the thickness of valve lifter using micrometer.



**Fig. 26: Measuring Valve Lifter Thickness Using Micrometer**  
 Courtesy of SUBARU OF AMERICA, INC.

8. Select a valve lifter of suitable thickness using the measured valve clearance and valve lifter thickness, and install it.

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

| Unit: mm (in)                      |
|------------------------------------|
| $S = (V + T) - 0.20 (0.0079)$      |
| S: Valve lifter thickness required |
| V: Measured valve clearance        |
| T: Current valve lifter thickness  |

9. Install the camshaft. < Refer to **INSTALLATION**, Camshaft. >
10. Install the cam sprocket. < Refer to **INSTALLATION**, Cam Sprocket. >
11. Install the timing chain assembly. < Refer to **INSTALLATION**, Timing Chain Assembly. >
12. Measure all valve clearance again at this time. If the valve clearance is not within the adjustment value, repeat the procedure from step 3).

**Valve clearance (adjustment value):**

$$0.20^{+0.04}_{-0.06} \text{ mm } (0.0079^{+0.0016}_{-0.0024} \text{ in})$$

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

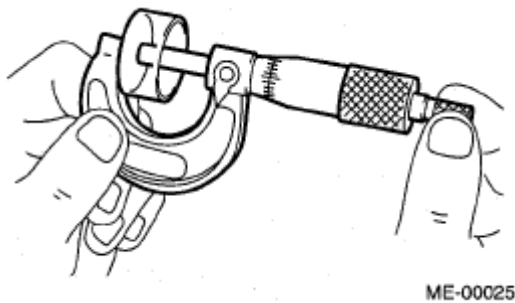
**NOTE:** Refer to "Camshaft" when installing the rocker cover. < Refer to **INSTALLATION**, Camshaft. >

**EXHAUST SIDE**

1. Remove the engine from vehicle. < Refer to **REMOVAL**, Engine Assembly. >
2. Measure all the valve clearances. < Refer to **INSPECTION**, Valve Clearance. >

**NOTE:** Record each valve clearance after measurement.

3. Remove the camshaft. < Refer to **REMOVAL**, Camshaft. >
4. Remove the valve lifter.
5. Measure the thickness of valve lifter using micrometer.



**Fig. 27: Measuring Valve Lifter Thickness Using Micrometer**  
Courtesy of SUBARU OF AMERICA, INC.

6. Select a valve lifter of suitable thickness using the measured valve clearance and valve lifter thickness, and install it.

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

| Unit: mm (in)                      |
|------------------------------------|
| $S = (V + T) - 0.35 (0.0138)$      |
| S: Valve lifter thickness required |
| V: Measured valve clearance        |
| T: Current valve lifter thickness  |

7. Install the camshaft. < Refer to **INSTALLATION**, Camshaft. >
8. Install the cam sprocket. < Refer to **INSTALLATION**, Cam Sprocket. >
9. Install the timing chain assembly. < Refer to **INSTALLATION**, Timing Chain Assembly. >
10. Measure all valve clearance again at this time. If the valve clearance is not within the adjustment value, repeat the procedure from step 3).

**Valve clearance (adjustment value):**

**$0.35 \pm 0.05 \text{ mm } (0.0138 \pm 0.0020 \text{ in})$**

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

**NOTE:** Refer to "Camshaft" when installing the rocker cover. < Refer to INSTALLATION, Camshaft. >

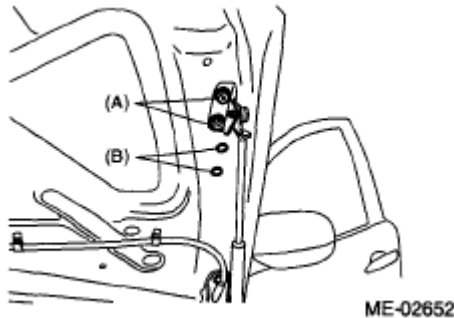
## ENGINE ASSEMBLY

### REMOVAL

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

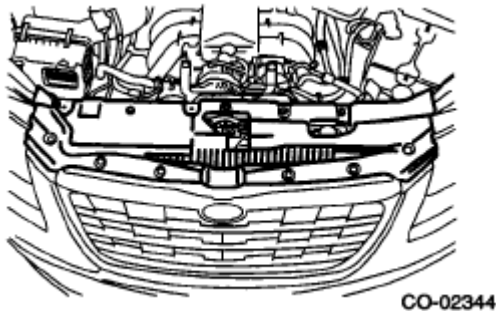
***Tightening torque:***

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



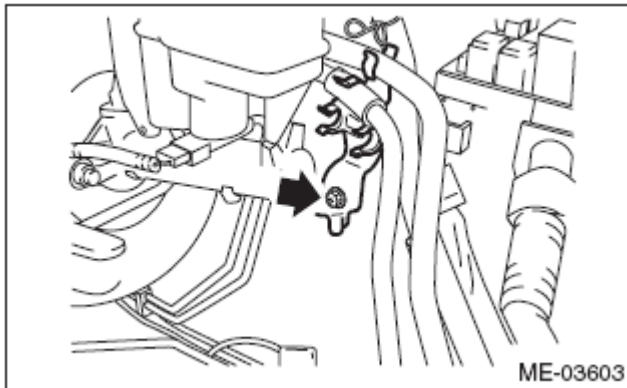
**Fig. 28: Identifying Front Hood Bolt Mounting Position**  
Courtesy of SUBARU OF AMERICA, INC.

2. Remove the collector cover.
3. Collect the refrigerant from A/C system. < Refer to PROCEDURE , Refrigerant Recovery Procedure. >
4. Release the fuel pressure. < Refer to RELEASING OF FUEL PRESSURE , PROCEDURE, Fuel. >
5. Remove the battery from vehicle. < Refer to REMOVAL , Battery. >
6. Remove the air intake duct, air cleaner case and air intake chamber. < Refer to REMOVAL , Air Intake Duct. > < Refer to REMOVAL , Air Cleaner Case. > < Refer to REMOVAL , Air Intake Chamber. >
7. Remove the front upper cover.



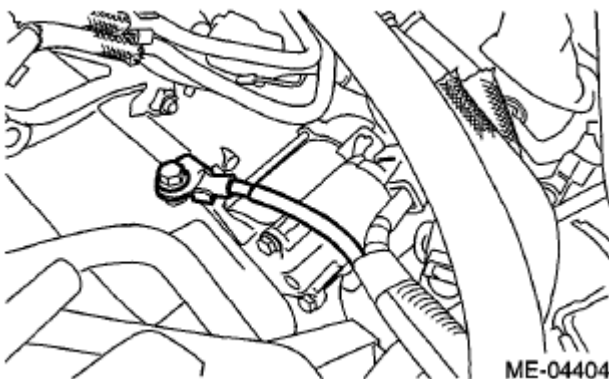
**Fig. 29: Identifying Front Upper Cover**  
Courtesy of SUBARU OF AMERICA, INC.

8. Remove the front bumper. < Refer to **FRONT BUMPER FACE** , REMOVAL, Front Bumper. >
9. Remove the radiator main fan & fan motor and radiator sub fan & fan motor. < Refer to **REMOVAL** , Radiator Main Fan and Fan Motor. > < Refer to **REMOVAL** , Radiator Sub Fan and Fan Motor. >
10. Remove the radiator. < Refer to **REMOVAL** , Radiator. >
11. Remove the fuel hose bracket.



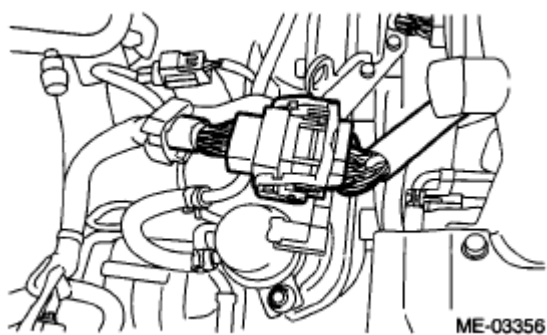
**Fig. 30: Identifying Fuel Hose Bracket Mounting Nut**  
Courtesy of SUBARU OF AMERICA, INC.

12. Remove the V-belts. < Refer to **REMOVAL** , V-belt. >
13. Disconnect the A/C pressure hoses from A/C compressor. < Refer to **REMOVAL** , Hose and Pipe. >
14. Remove the engine ground.



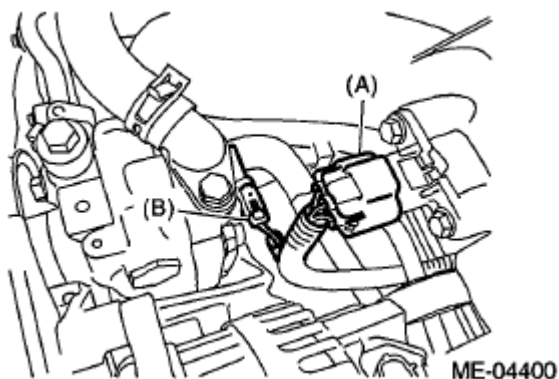
**Fig. 31: Removing/Installing Engine Ground Cable**  
Courtesy of SUBARU OF AMERICA, INC.

15. Disconnect the following connector.
  1. Engine harness connectors



**Fig. 32: Identifying Engine Harness Connectors**  
Courtesy of SUBARU OF AMERICA, INC.

2. Generator connector, terminal B and magnet clutch connector
3. Manifold absolute pressure sensor connector (A) and power steering pump connector (B)



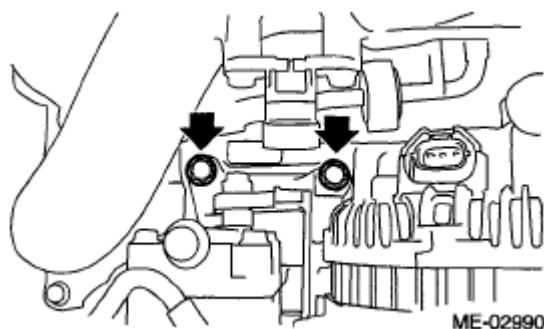
**Fig. 33: Identifying Absolute Pressure Sensor And Power Steering Pump Connector**  
Courtesy of SUBARU OF AMERICA, INC.

16. Remove the power steering pump together with the bracket.

**NOTE:** Do not disconnect the hose and pipe from the power steering pump body.



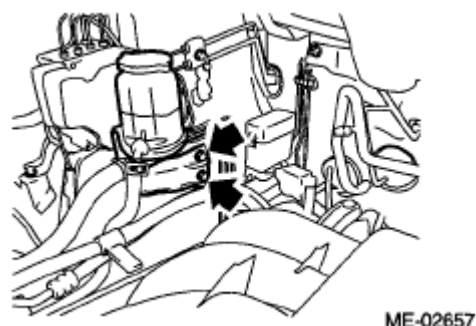
**Fig. 34: Identifying Power Steering Pump Bracket Mounting Bolts**  
Courtesy of SUBARU OF AMERICA, INC.



**Fig. 35: Identifying Power Steering Pump Body Mounting Bolts**  
 Courtesy of SUBARU OF AMERICA, INC.

17. Remove the power reserve tank together with the bracket.

**NOTE:** Do not disconnect the hose from the reservoir tank body.



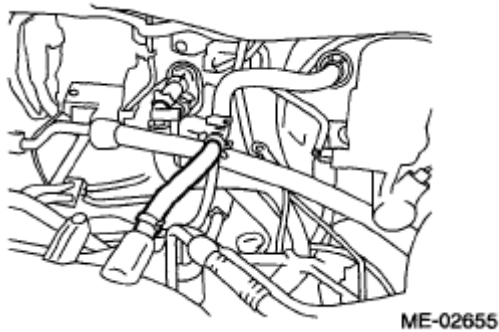
**Fig. 36: Identifying Reservoir Tank Body Hose Mounting Bolts**  
 Courtesy of SUBARU OF AMERICA, INC.

18. Suspend the power steering pump using wire, etc.



**Fig. 37: Suspending Power Steering Pump Using Wire**  
 Courtesy of SUBARU OF AMERICA, INC.

19. Disconnect the following hoses.
  1. Brake booster vacuum hose

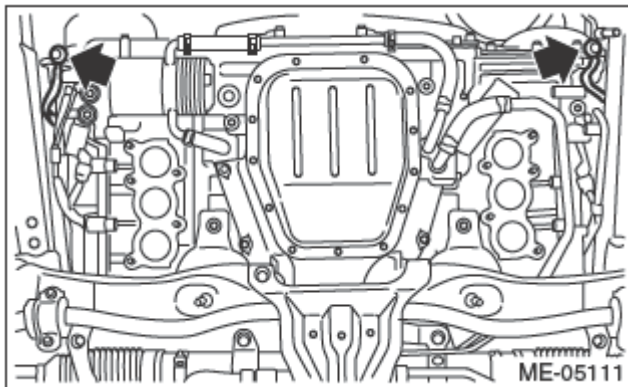


**Fig. 38: Identifying Brake Booster Vacuum Hose**  
Courtesy of SUBARU OF AMERICA, INC.

2. Heater inlet and outlet hoses
20. Remove the bolts which hold the vacuum pump bracket to the engine. < Refer to **BRAKE VACUUM PUMP** , COMPONENT, General Description. >
21. Lift up the vehicle.
22. Remove the front exhaust pipe. < Refer to **REMOVAL** , Front Exhaust Pipe. >

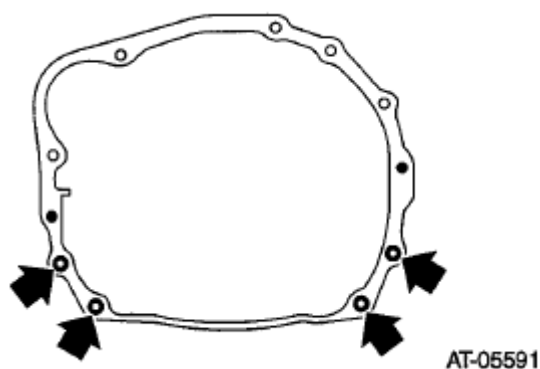
**NOTE:** Be careful not to let the front exhaust pipe interfere with water pipes on engine side.

23. Remove the ground cable from the underside of chain cover.



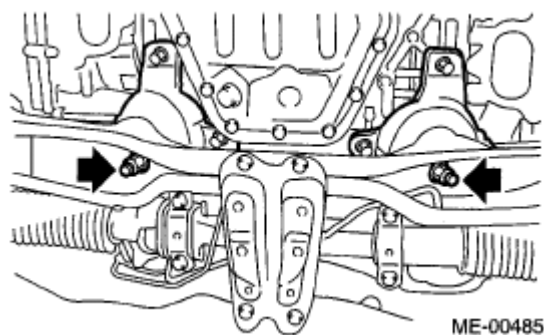
**Fig. 39: Identifying Ground Cable Mounting Bolts**  
Courtesy of SUBARU OF AMERICA, INC.

24. Remove the bolts which hold the vacuum pump bracket to the transmission, then remove the vacuum pump together with the bracket. < Refer to **BRAKE VACUUM PUMP** , COMPONENT, General Description. >
25. Remove the bolts and nuts which hold lower side of transmission to engine.



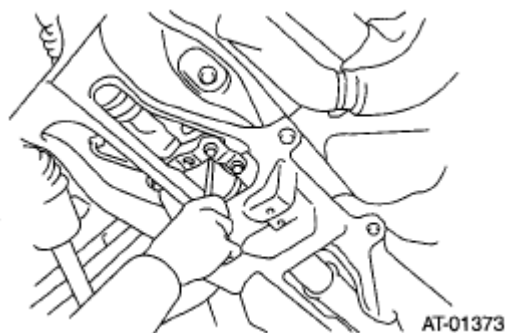
**Fig. 40: Identifying Lower Side Of Transmission To Engine Holding Bolts And Nuts**  
Courtesy of SUBARU OF AMERICA, INC.

26. Remove the nuts which install front cushion rubber onto front crossmember.

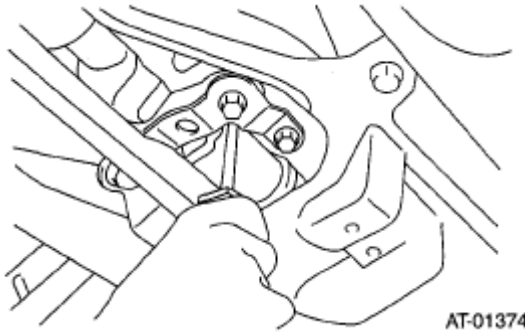


**Fig. 41: Identifying Front Cushion Rubber Onto Front Crossmember Installing Nuts**  
Courtesy of SUBARU OF AMERICA, INC.

27. Remove the two clutch housing cover securing bolts.



**Fig. 42: Removing/Installing Clutch Housing Cover Securing Bolts**  
Courtesy of SUBARU OF AMERICA, INC.

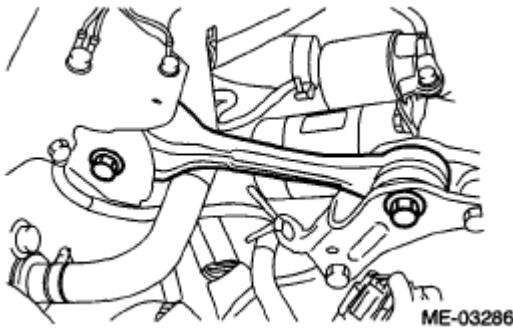


**Fig. 43: Removing/Installing Clutch Housing Cover Securing Bolts**  
Courtesy of SUBARU OF AMERICA, INC.

28. Lower the vehicle.
29. Remove the throttle body from the intake manifold.

**NOTE:** Do not disconnect the inlet and outlet hoses of engine coolant.

30. Separate the torque converter clutch from drive plate.
  1. Remove the service hole plug.
  2. Rotate the clank pulley to align the drive plate to the service hole, and remove four bolts.
31. Remove the pitching stopper.



**Fig. 44: Identifying Pitching Stopper**  
Courtesy of SUBARU OF AMERICA, INC.

32. Disconnect the fuel delivery hose and evaporation hose.

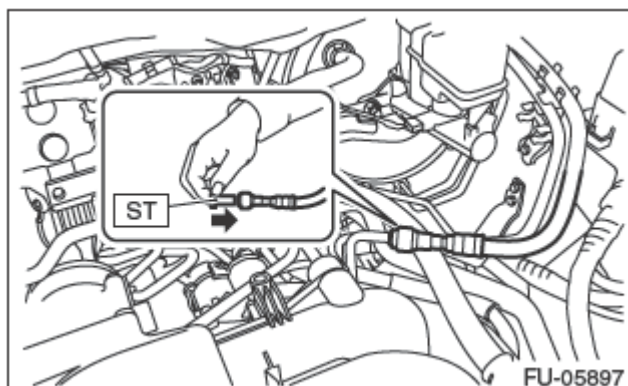
**CAUTION:**

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

1. Disconnect the connector of fuel pipe by pushing the ST in the direction of arrow.

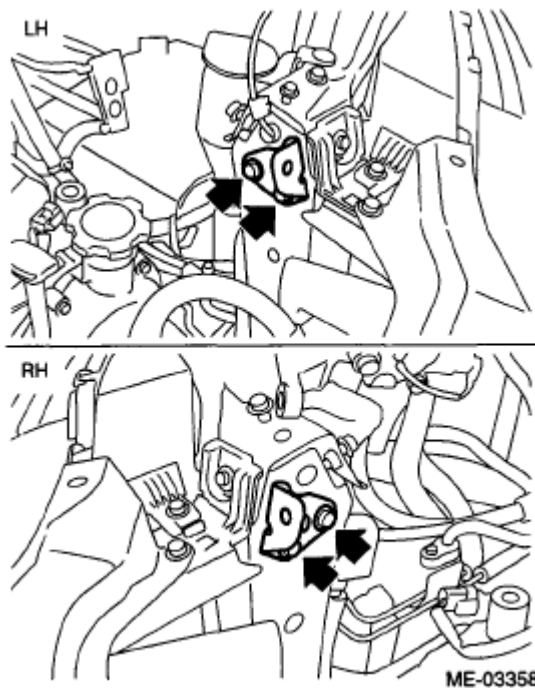
ST 42099AE000 QUICK CONNECTOR RELEASE

2. Remove the clamp and disconnect the evaporation hose.



**Fig. 45: Disconnecting Fuel Pipe Connector By Pushing Special Tool**  
Courtesy of SUBARU OF AMERICA, INC.

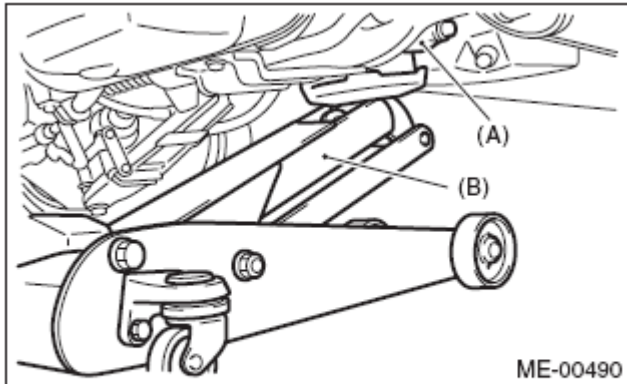
33. Remove the radiator center bracket.



**Fig. 46: Identifying Radiator Center Bracket Mounting Bolts**  
Courtesy of SUBARU OF AMERICA, INC.

34. Support the engine with a lifting device and wire ropes.
35. Support the transmission with a garage jack.

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



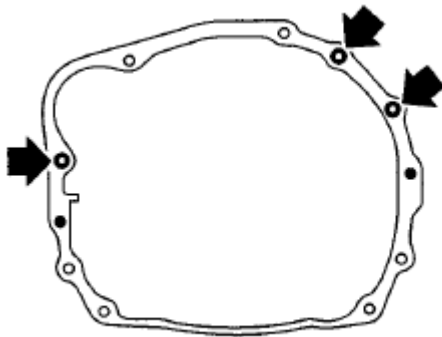
- (A) Transmission
- (B) Garage jack

**Fig. 47: Supporting Transmission With Garage Jack**  
 Courtesy of SUBARU OF AMERICA, INC.

36. Separate the engine and transmission.

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

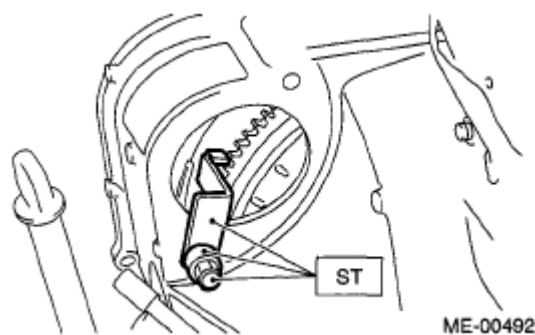
1. Remove the starter. < Refer to **REMOVAL** , Starter. >
2. Remove the bolts which hold upper side of transmission to engine.



**Fig. 48: Identifying Upper Side Of Transmission To Engine Holding Bolts**  
 Courtesy of SUBARU OF AMERICA, INC.

37. Attach the ST to converter case.

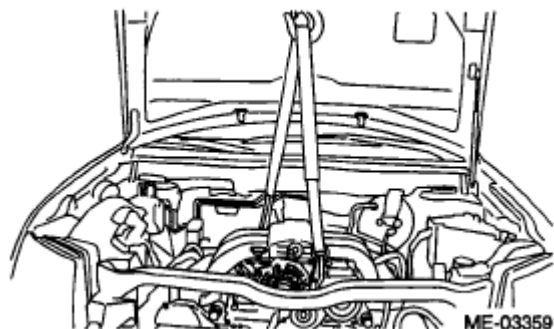
ST 498277200 STOPPER SET



**Fig. 49: Attaching Special Tool To Converter Case**  
Courtesy of SUBARU OF AMERICA, INC.

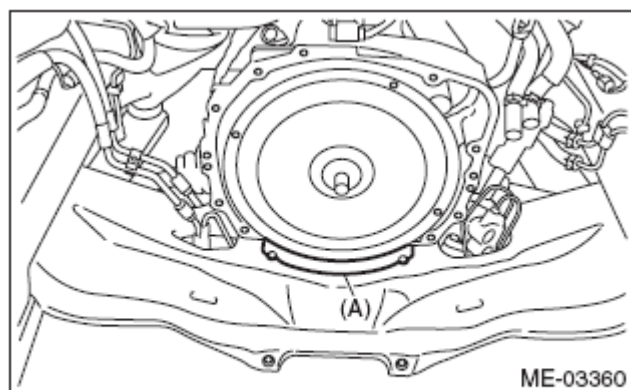
38. Remove the engine from vehicle.
  1. Slightly raise the engine.
  2. Raise the transmission with garage jack.
  3. Move the engine horizontally until main shaft is withdrawn from clutch cover.
  4. Slowly move the engine away from engine compartment.

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



**Fig. 50: Positioning Engine In Engine Compartment And Aligning With Transmission**  
Courtesy of SUBARU OF AMERICA, INC.

39. Remove the engine mounting.
40. Remove the clutch housing cover from vehicle.

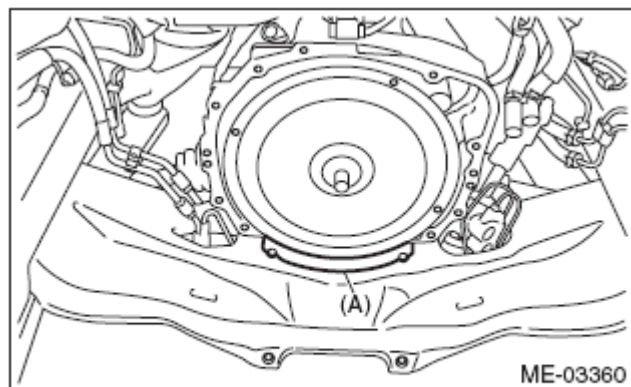


(A) Clutch housing cover

**Fig. 51: Identifying Clutch Housing Cover**  
Courtesy of SUBARU OF AMERICA, INC.

## INSTALLATION

1. Set the clutch housing cover to the vehicle.



(A) Clutch housing cover

**Fig. 52: Identifying Clutch Housing Cover**  
Courtesy of SUBARU OF AMERICA, INC.

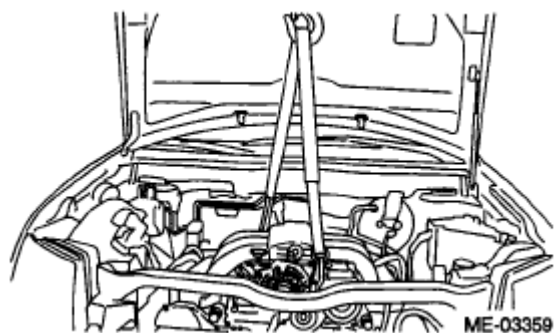
2. Install the engine mount.

### ***Tightening torque:***

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

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.

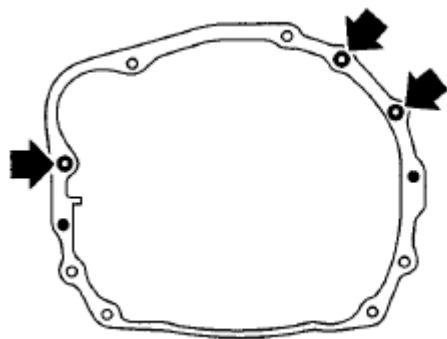


**Fig. 53: Positioning Engine In Engine Compartment And Aligning With Transmission**  
Courtesy of SUBARU OF AMERICA, INC.

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)***

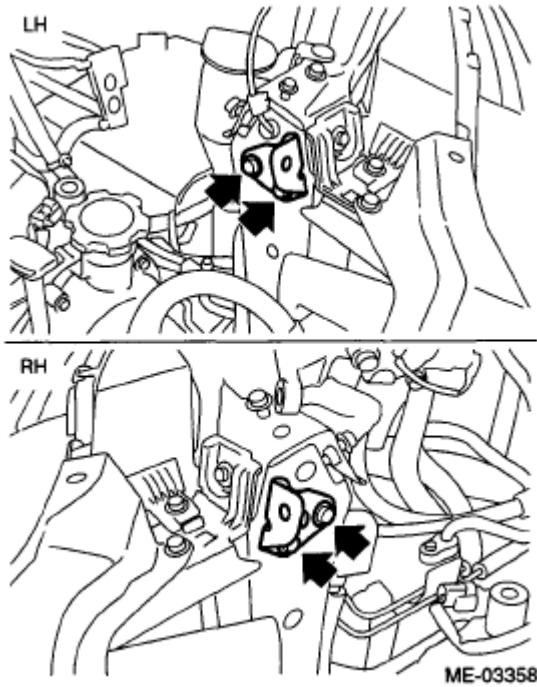


**Fig. 54: Identifying Upper Side Of Transmission To Engine Holding Bolts**  
Courtesy of SUBARU OF AMERICA, INC.

5. Remove the lifting device and wire ropes.
6. Remove the garage jack.
7. Install the radiator center bracket.

***Tightening torque:***

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



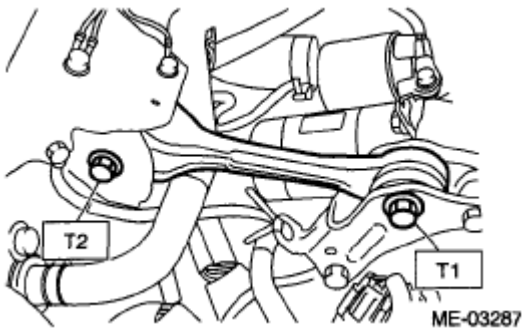
**Fig. 55: Identifying Radiator Center Bracket Mounting Bolts**  
Courtesy of SUBARU OF AMERICA, INC.

8. 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. 56: Identifying Pitching Stopper**  
Courtesy of SUBARU OF AMERICA, INC.

9. Remove the ST from converter case.

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

**ST.**

10. Install the starter. < Refer to **INSTALLATION** , Starter. >
11. Connect the torque converter clutch to the drive plate.
  1. Rotate the crank pulley to align the drive plate to the service hole, and tighten four bolts.

***Tightening torque:***

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

2. Install the service hole plug.
12. Install the throttle body to intake manifold.

**NOTE:        Use a new gasket.**

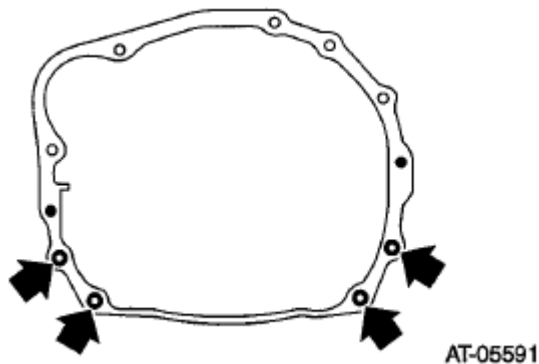
***Tightening torque:***

**8 N.m (0.8 kgf-m, 5.9 ft-lb)**

13. Lift up the vehicle.
14. Tighten 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)**



**Fig. 57: Identifying Lower Side Of Transmission To Engine Holding Bolts And Nuts**  
Courtesy of SUBARU OF AMERICA, INC.

15. Tighten the bolts which holds the vacuum pump bracket to the transmission. < Refer to **BRAKE VACUUM PUMP** , COMPONENT, General Description. >

***Tightening torque:***

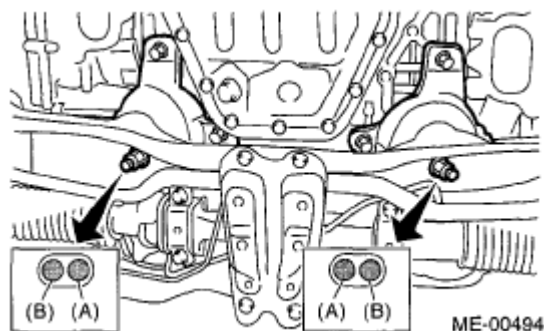
*25 N.m (2.5 kgf-m, 18.4 ft-lb)*

16. Tighten the nuts which install the front cushion rubber onto crossmember.

**NOTE:** Make sure the front cushion rubber mounting bolts (A) and locator (B) are securely installed.

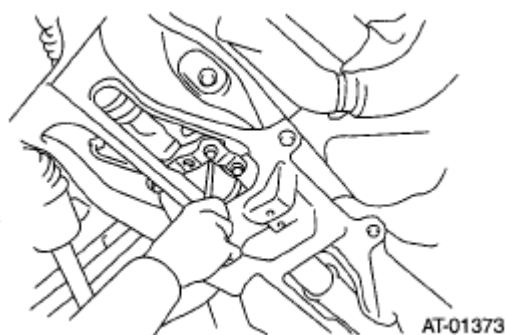
*Tightening torque:*

*75 N.m (7.6 kgf-m, 55.3 ft-lb)*

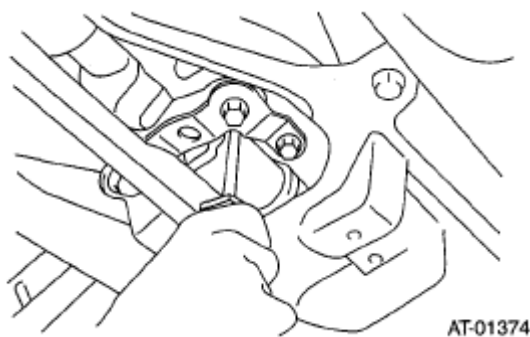


**Fig. 58: Identifying Front Cushion Rubber Mounting Bolts And Locator**  
Courtesy of SUBARU OF AMERICA, INC.

17. Install the clutch housing cover securing bolts.



**Fig. 59: Removing/Installing Clutch Housing Cover Securing Bolts**  
Courtesy of SUBARU OF AMERICA, INC.

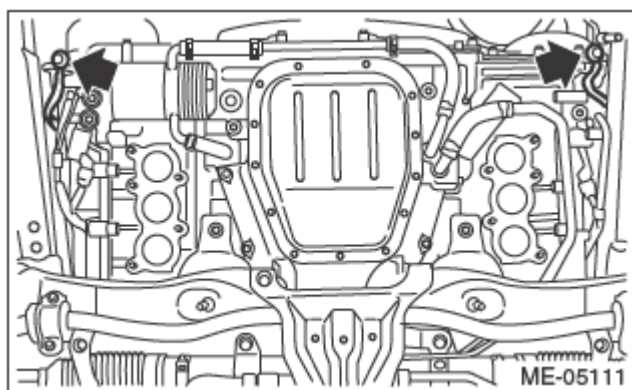


**Fig. 60: Removing/Installing Clutch Housing Cover Securing Bolts**  
Courtesy of SUBARU OF AMERICA, INC.

18. Install the ground cable to the underside of chain cover.

***Tightening torque:***

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

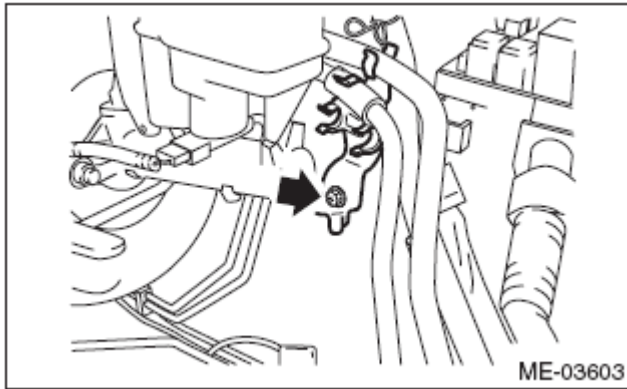


**Fig. 61: Identifying Ground Cable Mounting Bolts**  
Courtesy of SUBARU OF AMERICA, INC.

19. Install the front exhaust pipe. < Refer to **INSTALLATION** , Front Exhaust Pipe. >
20. Lower the vehicle.
21. Install the fuel hose bracket.

***Tightening torque:***

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



**Fig. 62: Identifying Fuel Hose Bracket Mounting Nut**  
 Courtesy of SUBARU OF AMERICA, INC.

22. Tighten the bolts which holds the vacuum pump bracket to the engine. < Refer to **BRAKE VACUUM PUMP** , COMPONENT, General Description. >

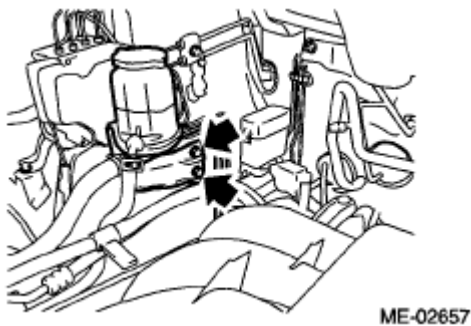
***Tightening torque:***

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

23. Install the reservoir tank.

***Tightening torque:***

***33 N.m (3.4 kgf-m, 24.3 ft-lb)***



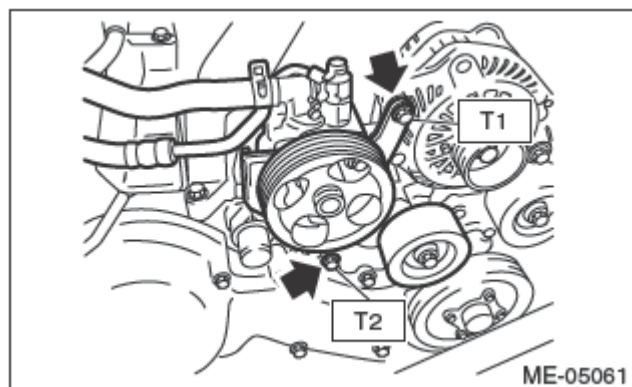
**Fig. 63: Identifying Reservoir Tank Body Hose Mounting Bolts**  
 Courtesy of SUBARU OF AMERICA, INC.

24. Install the power steering pump.

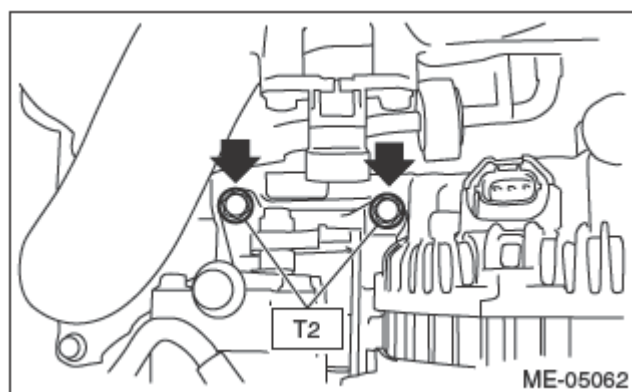
***Tightening torque:***

***T1: 25 N.m (2.5 kgf-m, 18.4 ft-lb)***

**T2: 33 N.m (3.4 kgf-m, 24.3 ft-lb)**



**Fig. 64: Identifying Power Steering Pump Mounting Bolts**  
Courtesy of SUBARU OF AMERICA, INC.

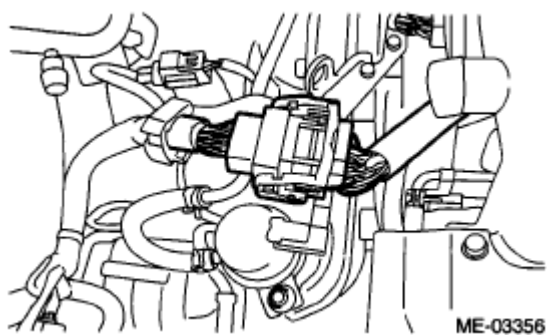


**Fig. 65: Identifying Power Steering Pump Mounting Bolts**  
Courtesy of SUBARU OF AMERICA, INC.

25. Connect the following hoses.
1. Fuel delivery hose and evaporation hose

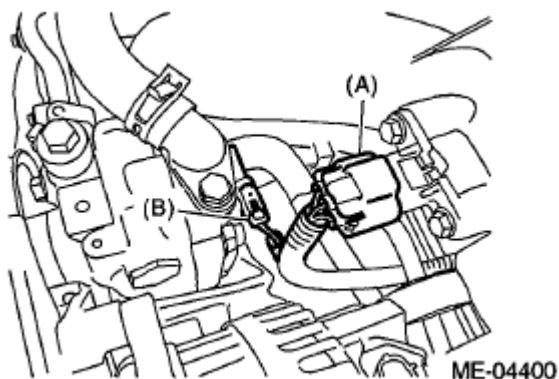
**NOTE:** If fuel hoses or clamps are damaged, replace them with new parts.

2. Heater inlet and outlet hoses
  3. Brake booster vacuum hose
26. Connect the following connectors.
1. Engine harness connectors



**Fig. 66: Identifying Engine Harness Connectors**  
Courtesy of SUBARU OF AMERICA, INC.

2. Generator connector, terminal B and magnet clutch connector
3. Manifold absolute pressure sensor connector (A) and power steering pump connector (B)

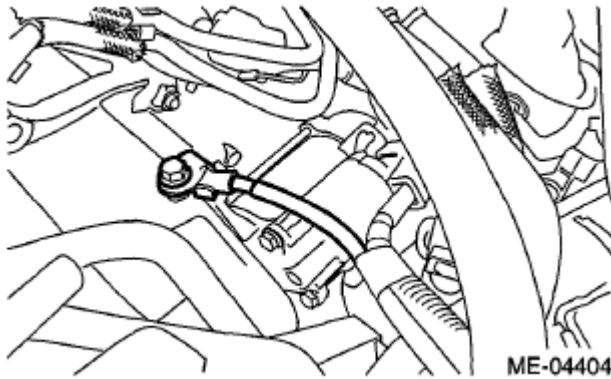


**Fig. 67: Identifying Absolute Pressure Sensor And Power Steering Pump Connector**  
Courtesy of SUBARU OF AMERICA, INC.

27. Install the engine ground.

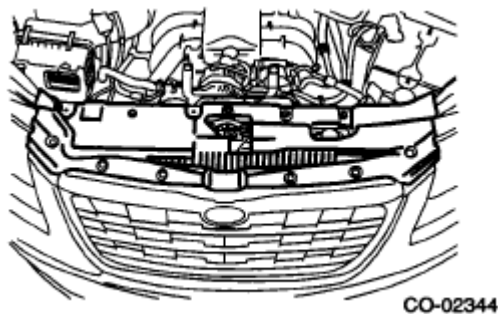
***Tightening torque:***

***14 N.m (1.4 kgf-m, 10.3 ft-lb)***



**Fig. 68: Removing/Installing Engine Ground Cable**  
Courtesy of SUBARU OF AMERICA, INC.

28. Install the A/C pressure hoses. < Refer to **INSTALLATION** , Hose and Pipe. >
29. Install the V-belts. < Refer to **INSTALLATION**, V-belt. >
30. Install the radiator to vehicle. < Refer to **INSTALLATION** , Radiator. >
31. Install the radiator main fan & fan motor and radiator sub fan & fan motor. < Refer to **INSTALLATION** , Radiator Main Fan and Fan Motor. > < Refer to **INSTALLATION** , Radiator Sub Fan and Fan Motor. >
32. Install the front bumper. < Refer to **FRONT BUMPER FACE** , INSTALLATION, Front Bumper. >
33. Install the battery to the vehicle. < Refer to **INSTALLATION** , Battery. >
34. Fill engine coolant. < Refer to **FILLING OF ENGINE COOLANT** , REPLACEMENT, Engine Coolant. >
35. Check the ATF level and replenish it if necessary. < Refer to **INSPECTION** , Automatic Transmission Fluid. >
36. Charge the A/C system with refrigerant. < Refer to **PROCEDURE** , Refrigerant Charging Procedure. >
37. Install the front upper cover.



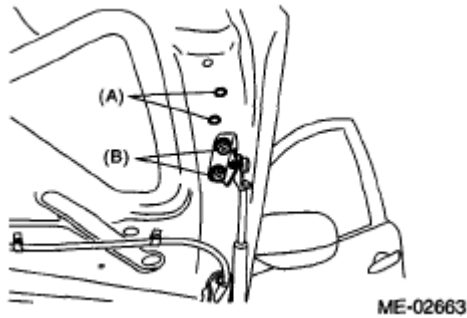
**Fig. 69: Identifying Front Upper Cover**  
Courtesy of SUBARU OF AMERICA, INC.

38. Install the air intake duct, air cleaner case and air intake chamber. < Refer to **INSTALLATION** , Air Intake Duct. > < Refer to **INSTALLATION** , Air Cleaner Case. > < Refer to **INSTALLATION** , Air Intake Chamber. >

39. Install the collector cover.
40. Change the bolt mounting 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. 70: Identifying Front Hood Bolts Mounting Position**  
Courtesy of SUBARU OF AMERICA, INC.

41. Lower the vehicle from lift.

## INSPECTION

1. Check that the pipes, hoses, connectors and clips are securely connected.
2. Check the engine coolant is at specified level.
3. Check that the ATF is at specified level.
4. Start the engine, and then check exhaust gas and engine coolant. And check for fuel leakage, noise, vibrations, etc.

## ENGINE MOUNTING

### REMOVAL

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

### INSTALLATION

Install in the reverse order of removal.

***Tightening torque:***

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

### INSPECTION

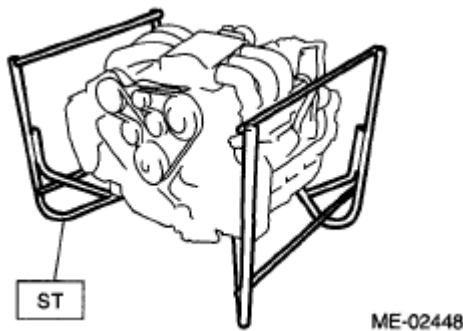
Make sure that no crack or other damages do not exist.

## PREPARATION FOR OVERHAUL

### REMOVAL

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

ST 18232AA000 ENGINE STAND



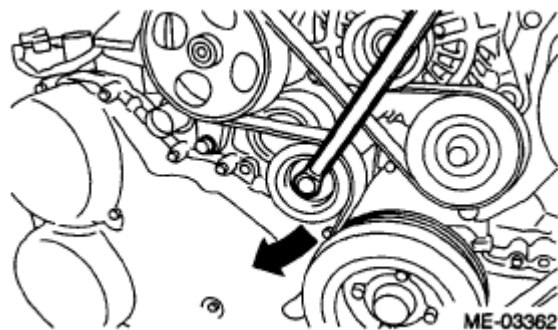
**Fig. 71: Setting Engine On Special Tool**  
Courtesy of SUBARU OF AMERICA, INC.

3. Before servicing overhaul, remove the sensor, pipe and hose that installed to engine.
  1. Remove the intake manifold. < Refer to **REMOVAL**, Intake Manifold. >
  2. Remove the generator. < Refer to **REMOVAL**, Generator. >
  3. Remove the A/C compressor. < Refer to **REMOVAL**, Compressor. >
  4. Disconnect the water pipe and hose.
  5. Disconnect the engine harness.
  6. Remove the spark plug. < Refer to **REMOVAL**, Spark Plug. >
  7. Remove the camshaft position sensor. < Refer to **REMOVAL**, Camshaft Position Sensor. >
  8. Remove the crankshaft position sensor. < Refer to **REMOVAL**, Crankshaft Position Sensor. >
  9. Remove the knock sensor. < Refer to **REMOVAL**, Knock Sensor. >
  10. Remove the engine coolant temperature sensor. < Refer to **REMOVAL**, Engine Coolant Temperature Sensor. >
  11. Remove the oil temperature sensor. < Refer to **REMOVAL**, Oil Temperature Sensor. >
  12. Remove the oil flow control solenoid valve. < Refer to **REMOVAL**, Oil Flow Control Solenoid Valve. >
  13. Remove the oil pressure switch. < Refer to **REMOVAL**, Oil Pressure Switch. >
  14. Remove the oil filter. < Refer to **REMOVAL**, Engine Oil Filter. >
  15. Remove the oil cooler. < Refer to **REMOVAL**, Oil Cooler. >

## V-BELT

### REMOVAL

1. Remove the collector cover.
2. Remove the air intake duct.
3. Install the tool to belt tension adjuster assembly installation bolt.
4. Rotate the tool clockwise and loosen the V-belt to remove.

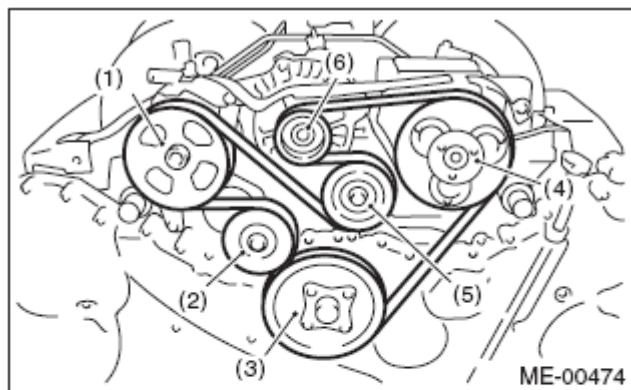


**Fig. 72: Loosening V-Belt**

Courtesy of SUBARU OF AMERICA, INC.

### INSTALLATION

Install in the reverse order of removal.



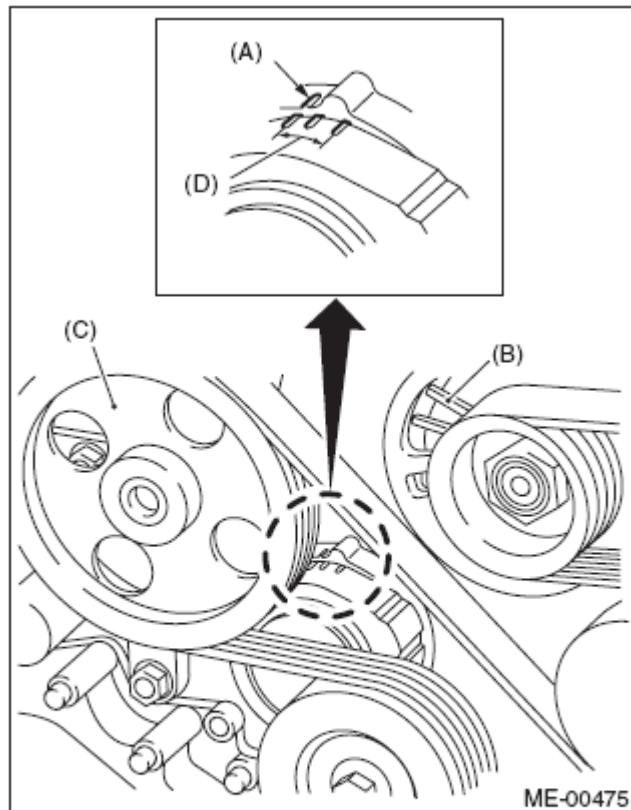
- (1) Power steering oil pump pulley
- (2) Belt tension adjuster ASSY
- (3) Crank pulley
- (4) A/C compressor pulley
- (5) Belt idler
- (6) Generator

**Fig. 73: Identifying Belt Routing**

Courtesy of SUBARU OF AMERICA, INC.

## INSPECTION

1. Replace the V-belt, if cracks, fraying or wear is found.
2. Make sure that the V-belt automatic belt tension indicator (A) is within the range (D).



- (A) Indicator
- (B) Generator
- (C) Power steering oil pump pulley
- (D) Service limit

**Fig. 74: Identifying V-Belt Automatic Belt Tension Indicator**  
Courtesy of SUBARU OF AMERICA, INC.

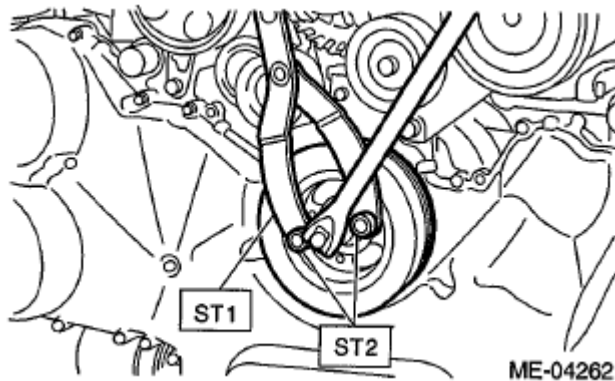
## CRANK PULLEY

### REMOVAL

1. Remove the V-belts. < Refer to **REMOVAL**, V-belt. >
2. Use the ST to lock the crank pulley, and remove the crank pulley bolt.

ST1 18355AA000 PULLEY WRENCH

ST2 18334AA000 PULLEY WRENCH PIN SET



**Fig. 75: Removing/Installing Crank Pulley Bolt Using Special Tool**  
 Courtesy of SUBARU OF AMERICA, INC.

3. Remove the crank pulley.

**INSTALLATION**

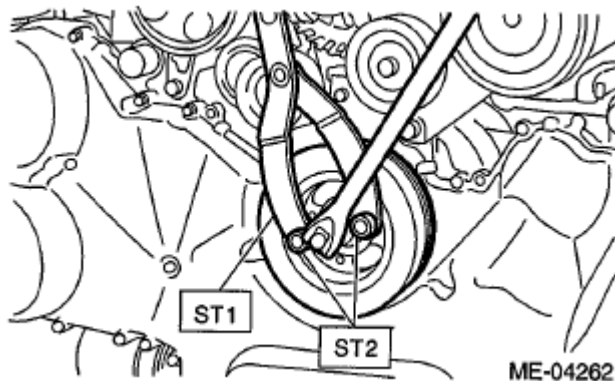
1. Clean the crankshaft thread using compressed air.
2. Install the crank pulley.
3. Apply engine oil to the crank pulley bolt seat and thread.
4. Use the ST to lock the crank pulley, and tighten the crank pulley bolt.

ST1 18355AA000 PULLEY WRENCH

ST2 18334AA000 PULLEY WRENCH PIN SET

***Tightening torque:***

***195 N.m (19.9 kgf-m, 143.8 ft-lb)***



**Fig. 76: Removing/Installing Crank Pulley Bolt Using Special Tool**

Courtesy of SUBARU OF AMERICA, INC.

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

## INSPECTION

1. Check for oil leaks in the crank pulley bolt.
2. Check the crank pulley for looseness.

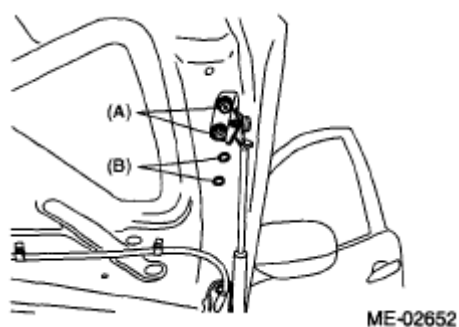
## CHAIN COVER

### REMOVAL

1. Lift up the vehicle.
2. Remove the under cover. < Refer to **REMOVAL**, Front Under Cover. >
3. Drain the engine oil. < Refer to **REPLACEMENT**, Engine Oil. >
4. Drain engine coolant. < Refer to **DRAINING OF ENGINE COOLANT**, REPLACEMENT, Engine Coolant. >
5. Lower the vehicle.
6. Change the bolt mounting position from (A) to (B), then completely open the front hood.

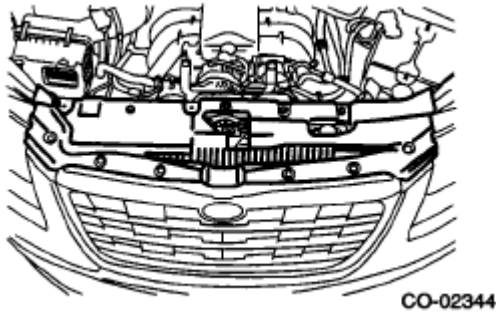
**Tightening torque:**

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



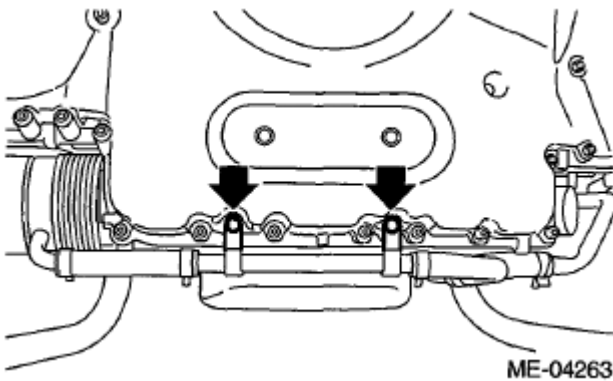
**Fig. 77: Identifying Front Hood Bolt Mounting Position**  
Courtesy of SUBARU OF AMERICA, INC.

7. Remove the air intake duct. < Refer to **REMOVAL**, Air Intake Duct. >
8. Remove the V-belts. < Refer to **REMOVAL**, V-belt. >
9. Remove the crank pulley. < Refer to **REMOVAL**, Crank Pulley. >
10. Remove the front upper cover.



**Fig. 78: Identifying Front Upper Cover**  
 Courtesy of SUBARU OF AMERICA, INC.

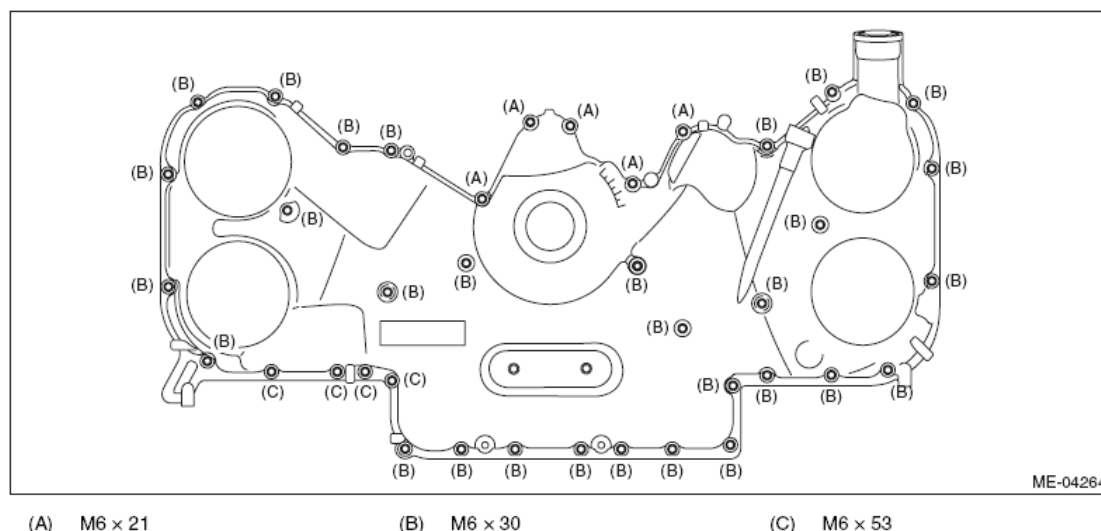
11. Remove the reservoir tank. < Refer to **REMOVAL** , Reservoir Tank. >
12. Remove the radiator main fan & fan motor and radiator sub fan & fan motor. < Refer to **REMOVAL** , Radiator Main Fan and Fan Motor. >
13. Remove the radiator. < Refer to **REMOVAL** , Radiator. >
14. Remove the oil cooler pipe from the chain cover.



**Fig. 79: Identifying Oil Cooler Pipe Mounting Bolts**  
 Courtesy of SUBARU OF AMERICA, INC.

15. Remove the chain cover.

**NOTE:** Chain cover installation bolt has three different sizes. To prevent the confusion in installation, keep these bolts on container individually.



**Fig. 80: Identifying Chain Cover Installation Bolts**

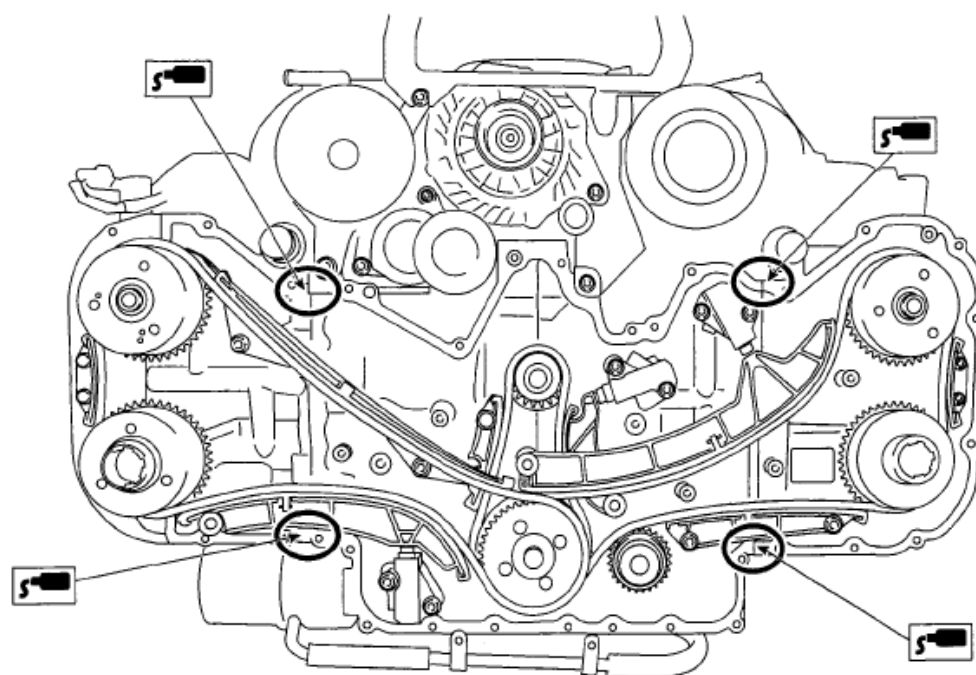
Courtesy of SUBARU OF AMERICA, INC.

## INSTALLATION

1. Apply liquid gasket to the mating surfaces of the cylinder block, cylinder head and oil pan upper as shown in the figure.

**Liquid gasket:**

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



**Fig. 81: Applying Liquid Gasket To Mating Surfaces Of Cylinder Block, Cylinder Head And Oil Pan Upper**  
Courtesy of SUBARU OF AMERICA, INC.

2. Apply liquid gasket to the mating surface of the chain cover.

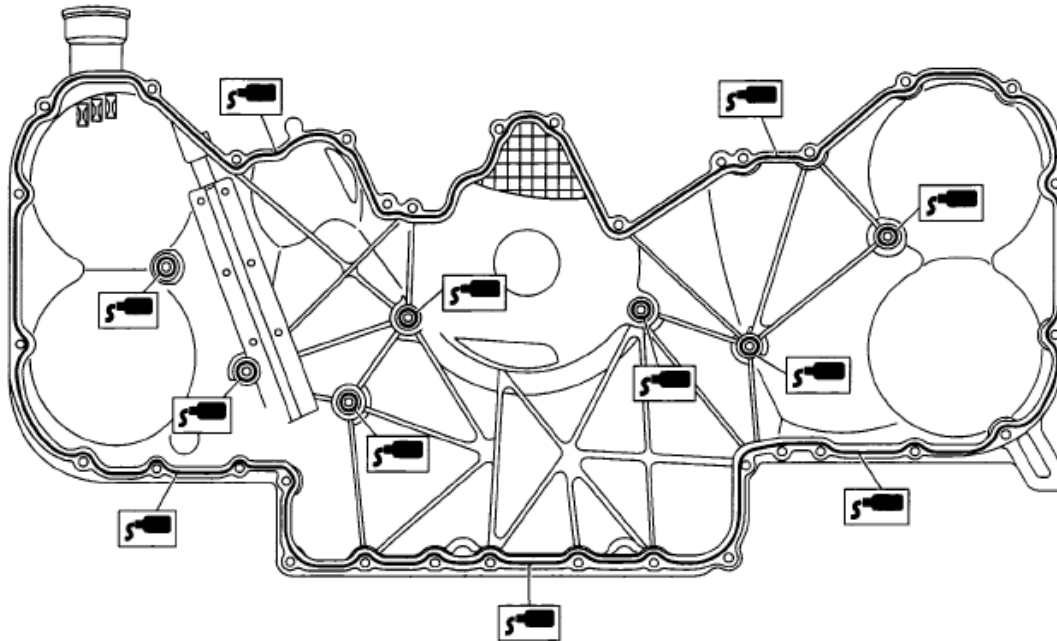
**NOTE:** Install within 5 min. after applying liquid gasket.

*Liquid gasket:*

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

*Liquid gasket applying diameter:*

**$3.5 \pm 0.5 \text{ mm}$  ( $0.138 \pm 0.020 \text{ in}$ )**

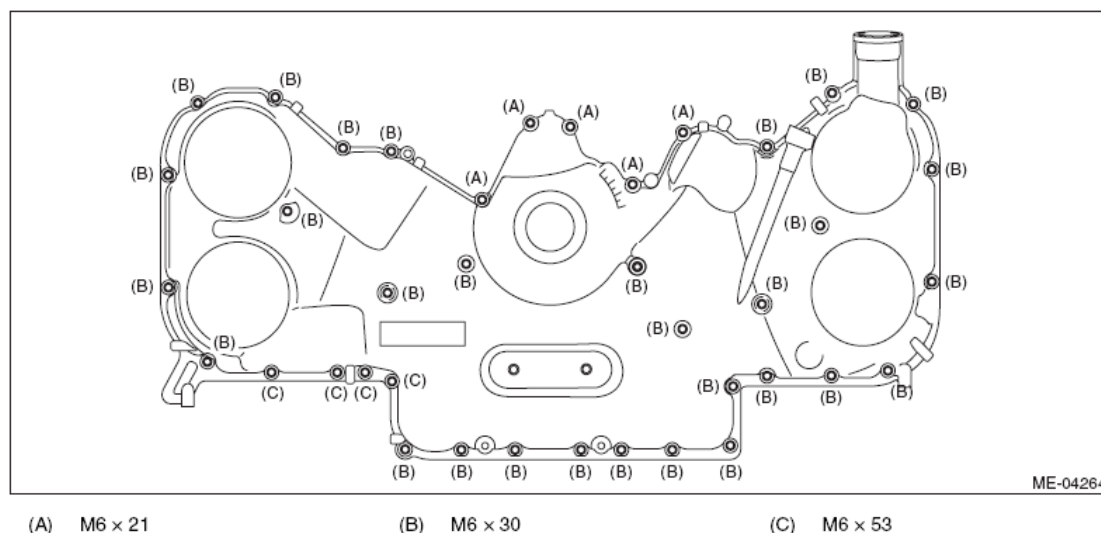


ME-03545

**Fig. 82: Applying Liquid Gasket To Mating Surface Of Chain Cover**  
Courtesy of SUBARU OF AMERICA, INC.

3. Install the chain cover and temporarily tighten the bolts.

**CAUTION:** Do not install the bolts in wrong place.

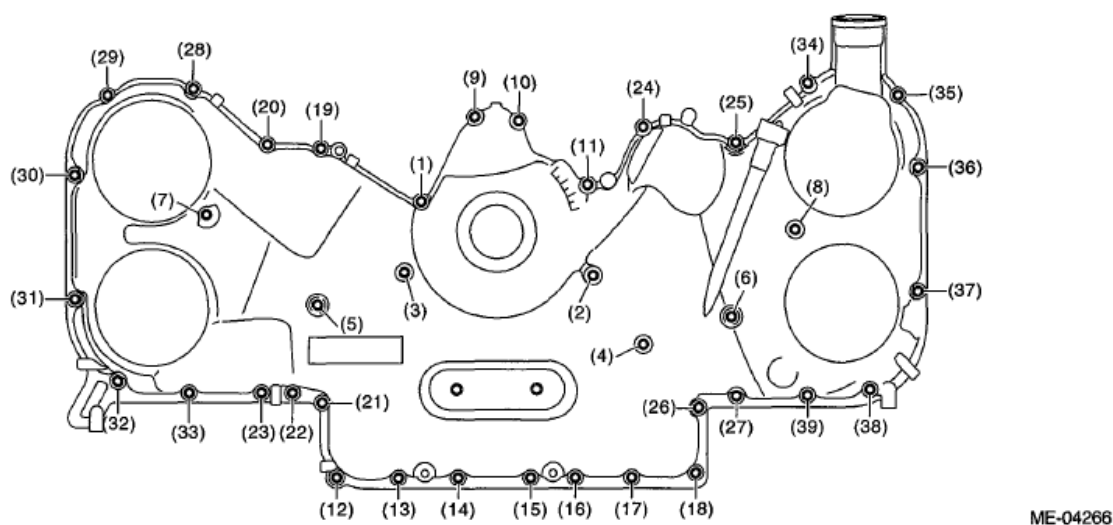


**Fig. 83: Identifying Chain Cover Mounting Bolts**  
Courtesy of SUBARU OF AMERICA, INC.

4. Tighten the bolts in the numerical order as shown in the figure.

**Tightening torque:**

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

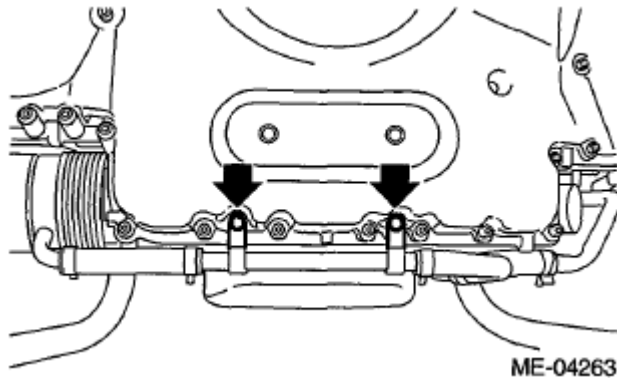


**Fig. 84: Chain Cover Mounting Bolts Tightening Sequence**  
Courtesy of SUBARU OF AMERICA, INC.

5. Install the oil cooler pipe to the chain cover.

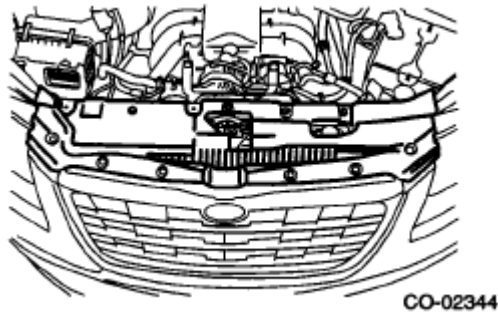
**Tightening torque:**

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



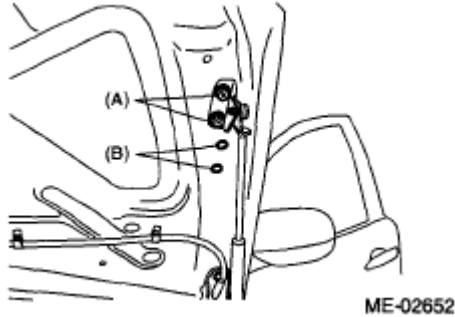
**Fig. 85: Identifying Oil Cooler Pipe To Chain Cover Mounting Bolts**  
Courtesy of SUBARU OF AMERICA, INC.

6. Install the radiator. < Refer to **INSTALLATION** , Radiator. >
7. Install the radiator main & fan motor and radiator sub fan & fan motor. < Refer to **INSTALLATION** , Radiator Main Fan and Fan Motor. >
8. Install the reservoir tank. < Refer to **INSTALLATION** , Reservoir Tank. >
9. Install the front upper cover.



**Fig. 86: Identifying Front Upper Cover**  
Courtesy of SUBARU OF AMERICA, INC.

10. Install the crank pulley. < Refer to **INSTALLATION** , Crank Pulley. >
11. Install the V-belts. < Refer to **INSTALLATION** , V-belt. >
12. Install the air intake duct. < Refer to **INSTALLATION** , Air Intake Duct. >
13. Fill engine coolant. < Refer to **FILLING OF ENGINE COOLANT** , REPLACEMENT, Engine Coolant. >
14. Fill engine oil. < Refer to **REPLACEMENT** , Engine Oil. >
15. Make sure there is no oil leaks in the chain cover mating surface.
16. Install the under cover. < Refer to **INSTALLATION** , Front Under Cover. >
17. Install the collector cover.
18. Change the bolt mounting position from (B) to (A), and completely close the front hood.

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

**Fig. 87: Identifying Front Hood Bolt Mounting Position**  
**Courtesy of SUBARU OF AMERICA, INC.**

**INSPECTION**

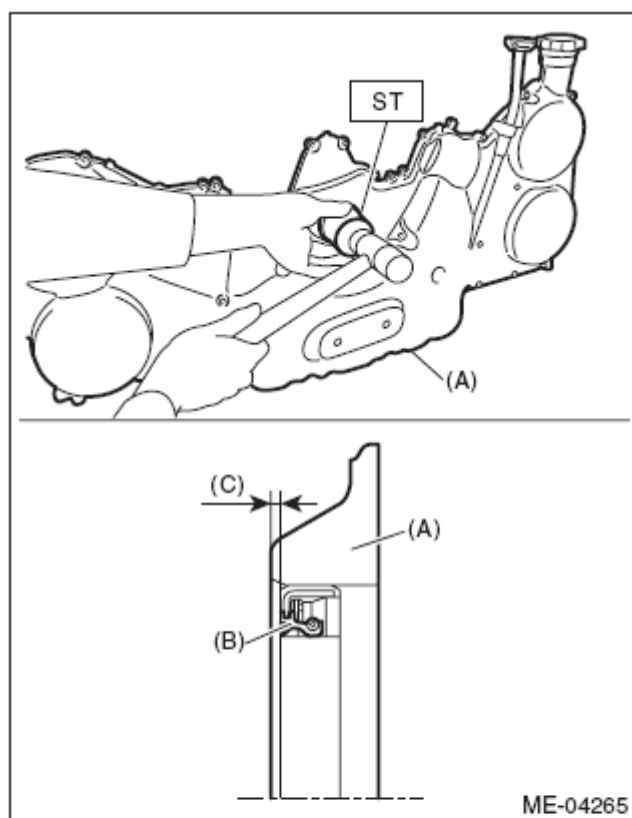
1. Check the chain cover surface for scratches or dents.
2. Check for oil leakage on the chain cover mating surface and installation part of crank pulley.

If there is an oil leak from the oil seal, perform replacement with a new oil seal.

ST 499585700 OIL SEAL GUIDE

***Oil seal press-fit position:***

***Chain cover end face - Position of -1 mm (-0.039 in) from the chain cover end face***

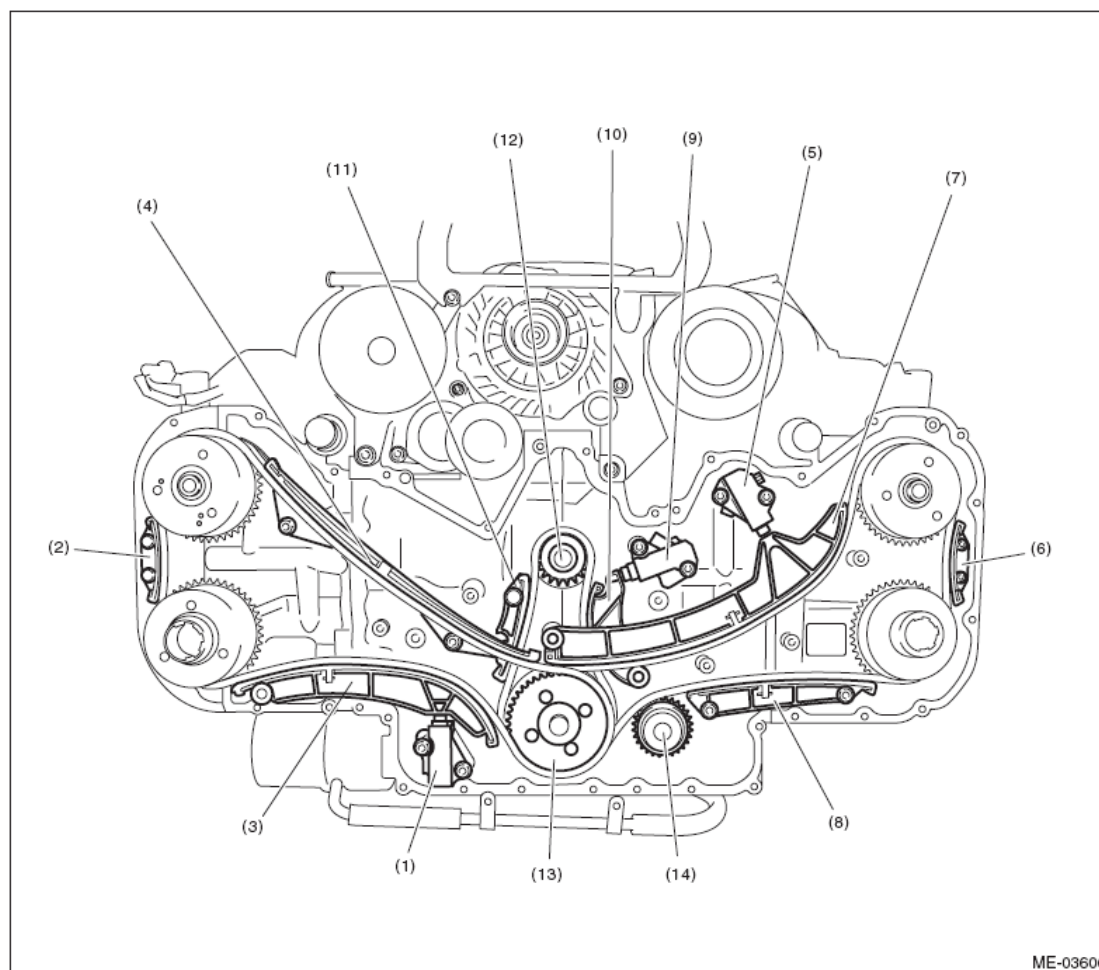


- (A) Chain cover
- (B) Oil seal
- (C) Oil seal press-fit position (Chain cover end face  
— Position of 1 mm (0.039 in) from the chain  
cover end face)

**Fig. 88: Replacing Oil Seal Using Special Tool**  
Courtesy of SUBARU OF AMERICA, INC.

## TIMING CHAIN ASSEMBLY

### LOCATION



ME-03606

- |                                    |                                    |                          |
|------------------------------------|------------------------------------|--------------------------|
| (1) Chain tensioner (RH)           | (6) Chain guide (LH: between cams) | (11) Chain guide (main)  |
| (2) Chain guide (RH: between cams) | (7) Chain tensioner lever (LH)     | (12) Crank sprocket      |
| (3) Chain tensioner lever (RH)     | (8) Chain guide (LH)               | (13) Idler sprocket      |
| (4) Chain guide (RH)               | (9) Chain tensioner (main)         | (14) Water pump sprocket |
| (5) Chain tensioner (LH)           | (10) Chain tensioner lever (main)  |                          |

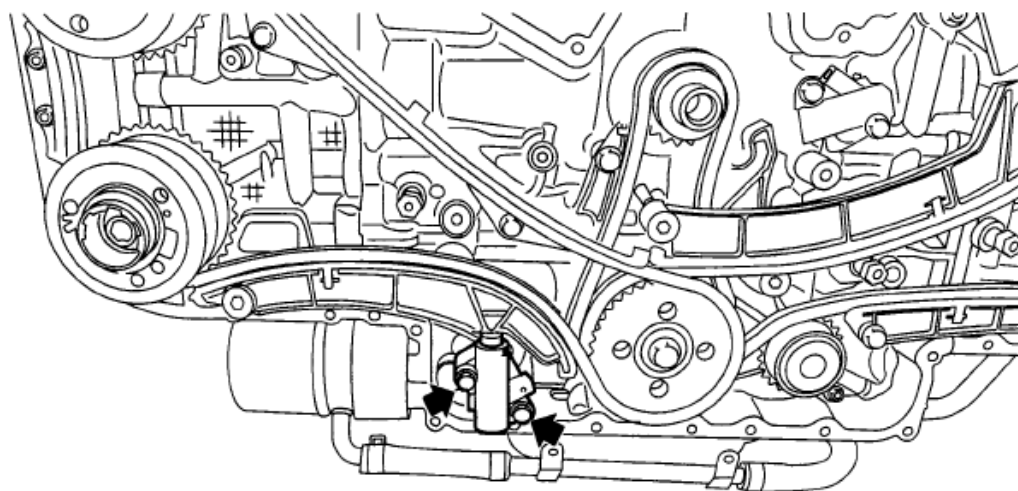
**Fig. 89: Identifying Timing Chain Assembly Components**  
 Courtesy of SUBARU OF AMERICA, INC.

## REMOVAL

**NOTE:** To avoid mixing the timing chain component parts, separate each part after their removal.

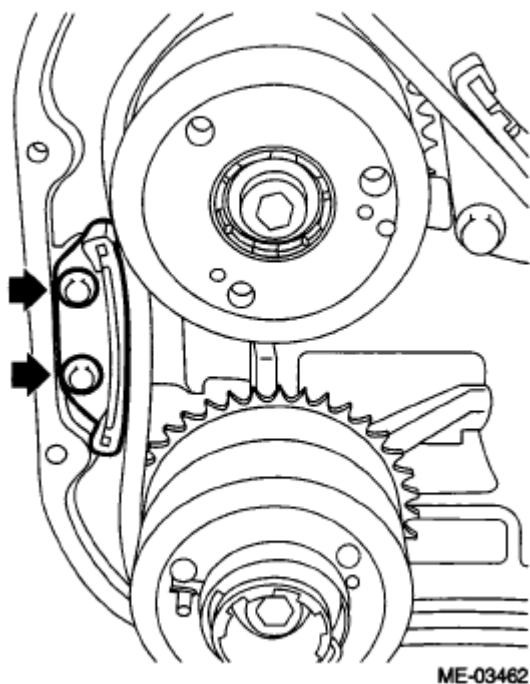
1. Drain the engine oil. < Refer to **REPLACEMENT** , Engine Oil. >
2. Remove the radiator. < Refer to **REMOVAL** , Radiator. >
3. Remove the V-belts. < Refer to **REMOVAL** , V-belt. >
4. Remove the crank pulley. < Refer to **REMOVAL** , Crank Pulley. >
5. Remove the chain cover. < Refer to **REMOVAL** , Chain Cover. >
6. Remove the chain tensioner (RH).

**NOTE:** During removal of chain tensioner (RH) from chain tensioner lever (RH), press the plunger by hand to prevent it from popping out.



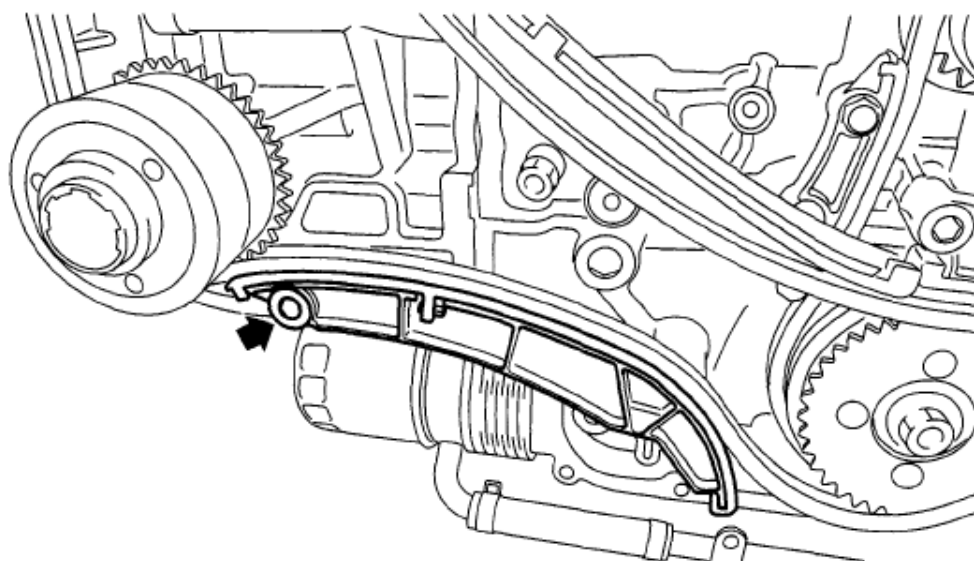
**Fig. 90: Identifying Chain Tensioner Lever**  
Courtesy of SUBARU OF AMERICA, INC.

7. Remove the chain guide (RH: between cams).



**Fig. 91: Identifying Chain Guide Mounting Bolts**  
Courtesy of SUBARU OF AMERICA, INC.

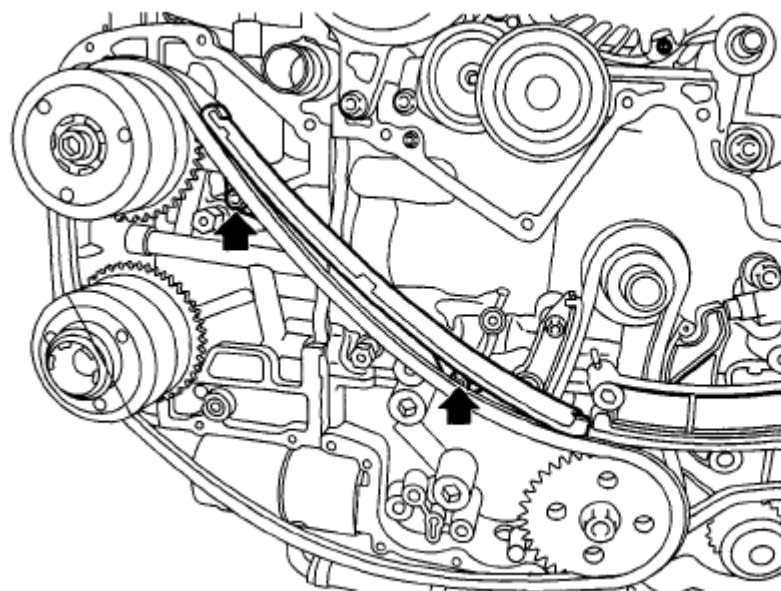
8. Remove the chain tensioner lever (RH).



ME-03463

**Fig. 92: Identifying Chain Tensioner Lever Mounting Bolt**  
Courtesy of SUBARU OF AMERICA, INC.

9. Remove the chain guide (RH).

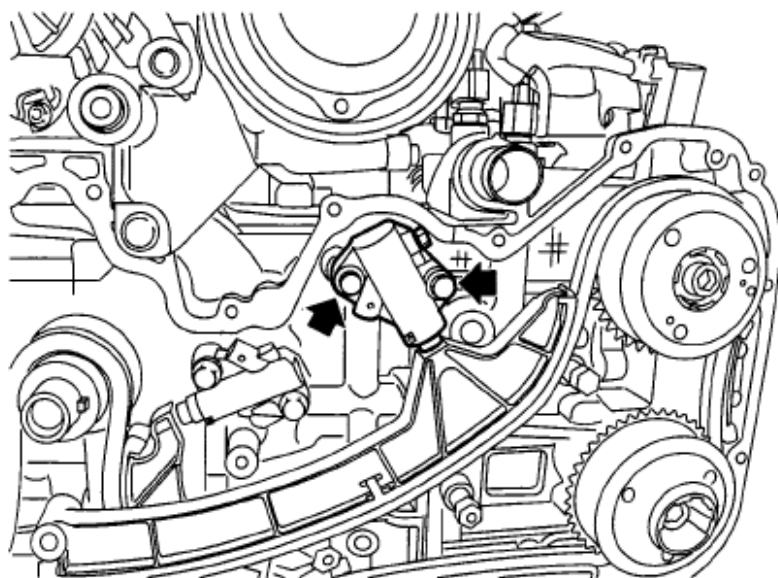


ME-03464

**Fig. 93: Identifying Chain Guide (RH)**  
Courtesy of SUBARU OF AMERICA, INC.

10. Remove the timing chain (RH).
11. Remove the chain tensioner (LH).

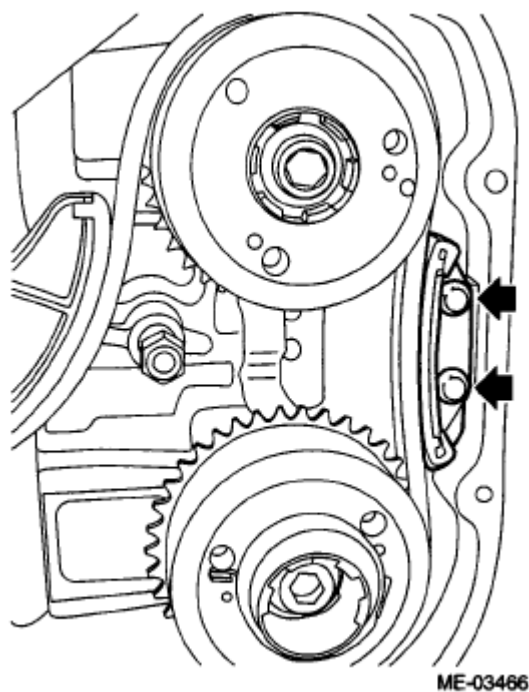
**NOTE:** During removal of chain tensioner (LH) from chain tensioner lever (LH), press the plunger by hand to prevent it from popping out.



ME-03465

**Fig. 94: Identifying Chain Tensioner Lever (LH) Mounting Bolts**  
Courtesy of SUBARU OF AMERICA, INC.

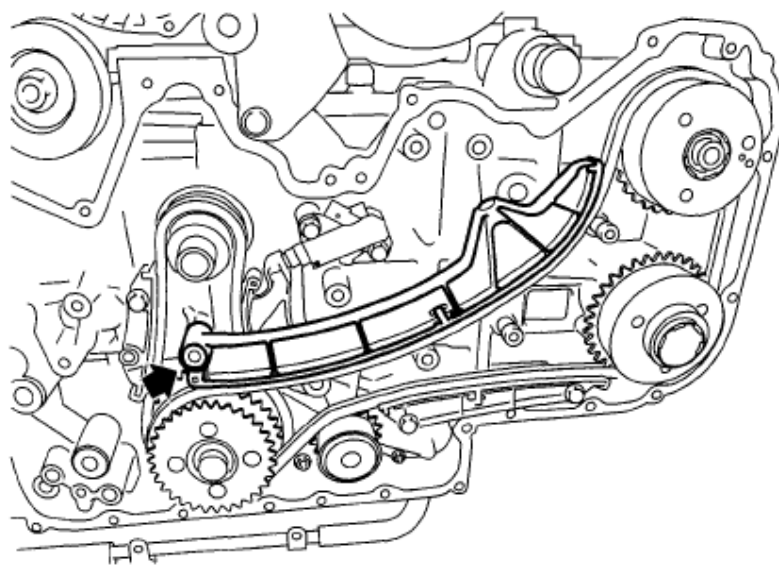
12. Remove the chain guide (LH: between cams).



ME-03466

**Fig. 95: Identifying Chain Guide (LH: Between Cams) Mounting Bolts**  
Courtesy of SUBARU OF AMERICA, INC.

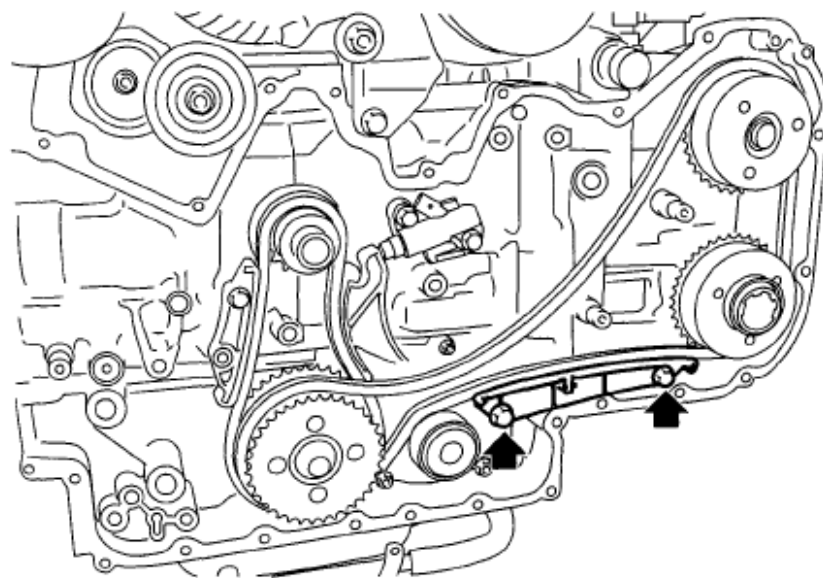
13. Remove the chain tensioner lever (LH).



ME-03467

**Fig. 96: Identifying Chain Tensioner Lever (LH)**  
Courtesy of SUBARU OF AMERICA, INC.

14. Remove the chain guide (LH).

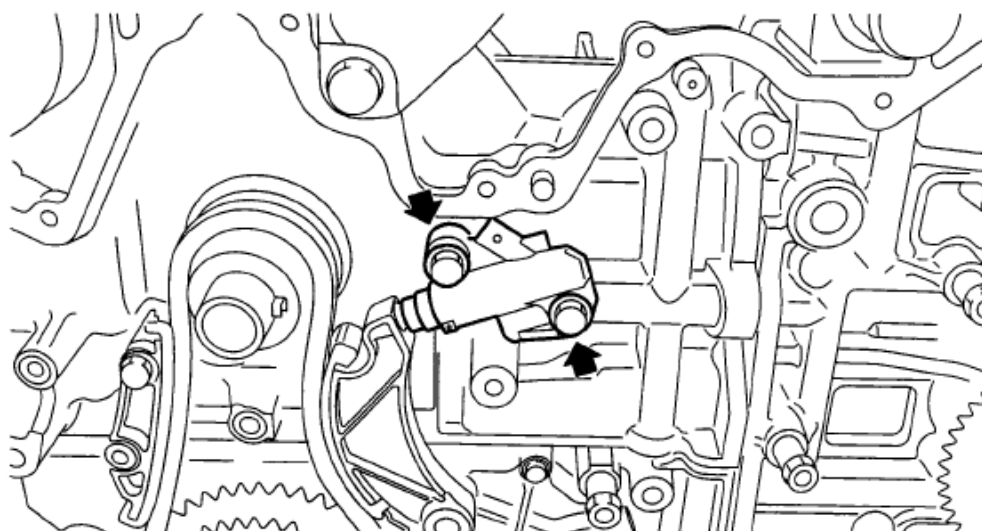


ME-03468

**Fig. 97: Identifying Chain Guide (LH)**  
Courtesy of SUBARU OF AMERICA, INC.

15. Remove the timing chain (LH).
16. Remove the chain tensioner (main).

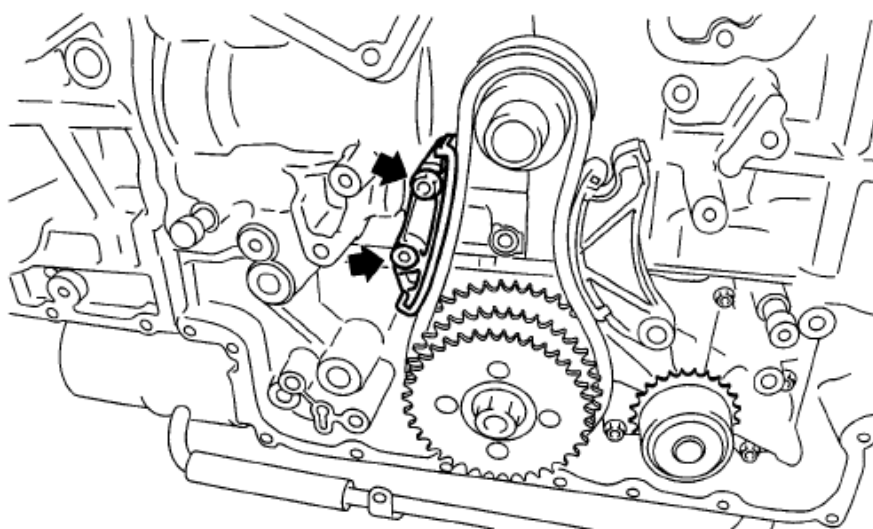
**NOTE:** During removal of chain tensioner (main) from chain tensioner lever (main), press the plunger by hand to prevent it from popping out.



ME-03469

**Fig. 98: Identifying Chain Tensioner (Main) Mounting Bolts**  
Courtesy of SUBARU OF AMERICA, INC.

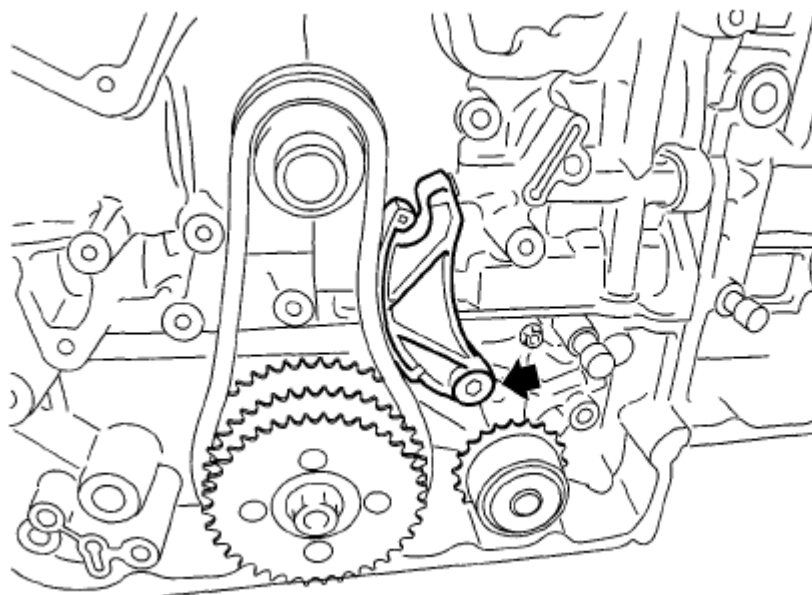
17. Remove the chain guide (main).



ME-03470

**Fig. 99: Identifying Chain Guide (Main) Mounting Bolts**  
Courtesy of SUBARU OF AMERICA, INC.

18. Remove the chain tensioner lever (main).



ME-03471

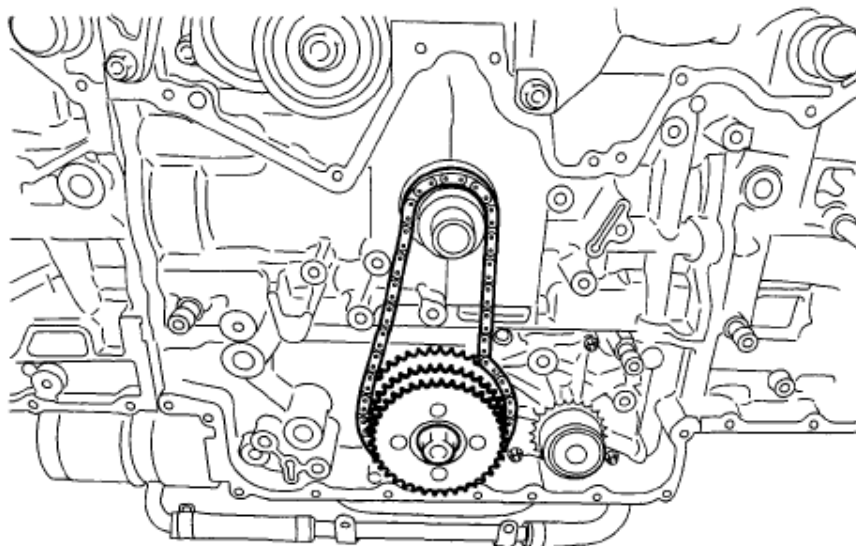
**Fig. 100: Identifying Chain Tensioner Lever (Main)**  
 Courtesy of SUBARU OF AMERICA, INC.

19. Use the ST to lock the idler sprocket, and loosen the idler sprocket bolt.

ST1 18355AA000 PULLEY WRENCH

ST2 18334AA000 PULLEY WRENCH PIN SET

20. Remove the idler sprocket, and then remove the idler sprocket and timing chain (main).



ME-03472

**Fig. 101: Identifying Idler Sprocket And Timing Chain (Main)**  
 Courtesy of SUBARU OF AMERICA, INC.

## INSTALLATION

**NOTE:**

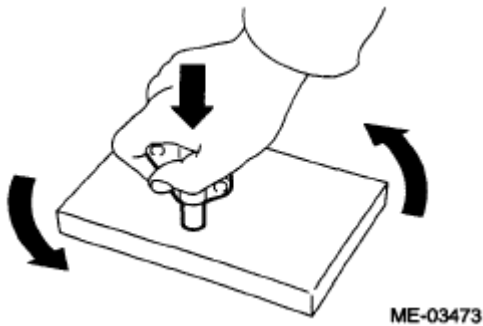
- Be careful that the foreign matter is not into or onto assembled component during installation.
- Apply engine oil to all component parts of the timing chain.

1. Prepare to attach the chain tensioner.

1. Insert the screw, spring pin and plunger into the tensioner body.
2. As shown in the figure, turn the rubber mat counterclockwise while holding the chain tensioner from above by hand.

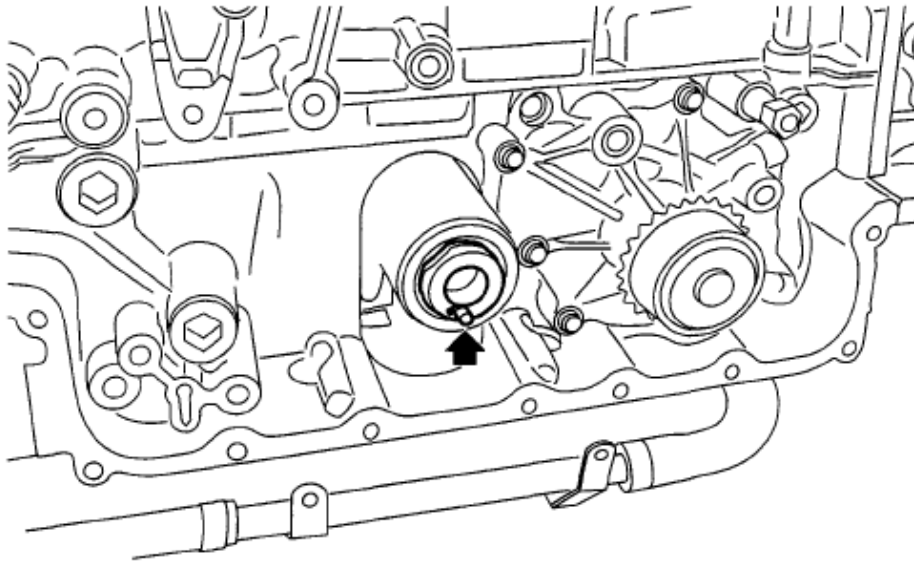
**NOTE:**

**Degrease the contact surface between the plunger head and rubber mat, so that they do not slip.**



**Fig. 102: Degreasing Contact Surface Between Plunger Head And Rubber Mat**  
Courtesy of SUBARU OF AMERICA, INC.

3. Insert the stopper pin into the hole on the chain tensioner body.
2. Align the position of oil pump shaft knock pin to six o'clock position as shown in the figure.

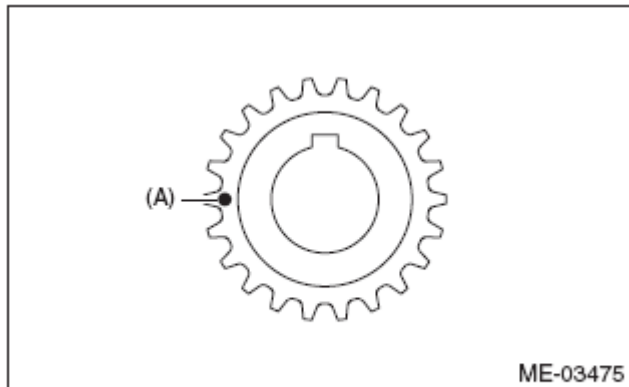


ME-03474

**Fig. 103: Aligning Position Of Oil Pump Shaft Knock Pin To Six O'Clock Position**  
Courtesy of SUBARU OF AMERICA, INC.

3. Using ST, align the "Top mark" on crank sprocket to nine o'clock position as shown in the figure.

ST 18252AA000 CRANKSHAFT SOCKET



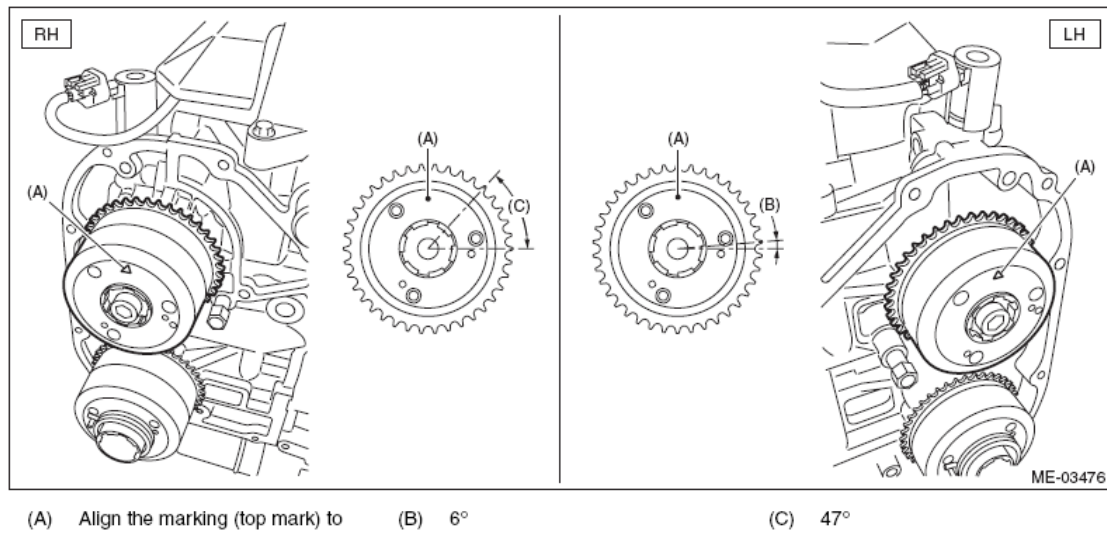
ME-03475

(A) Top mark

**Fig. 104: Identifying Top Mark On Crankshaft Socket**  
Courtesy of SUBARU OF AMERICA, INC.

4. Align the intake cam sprocket to twelve o'clock position as shown in the figure.

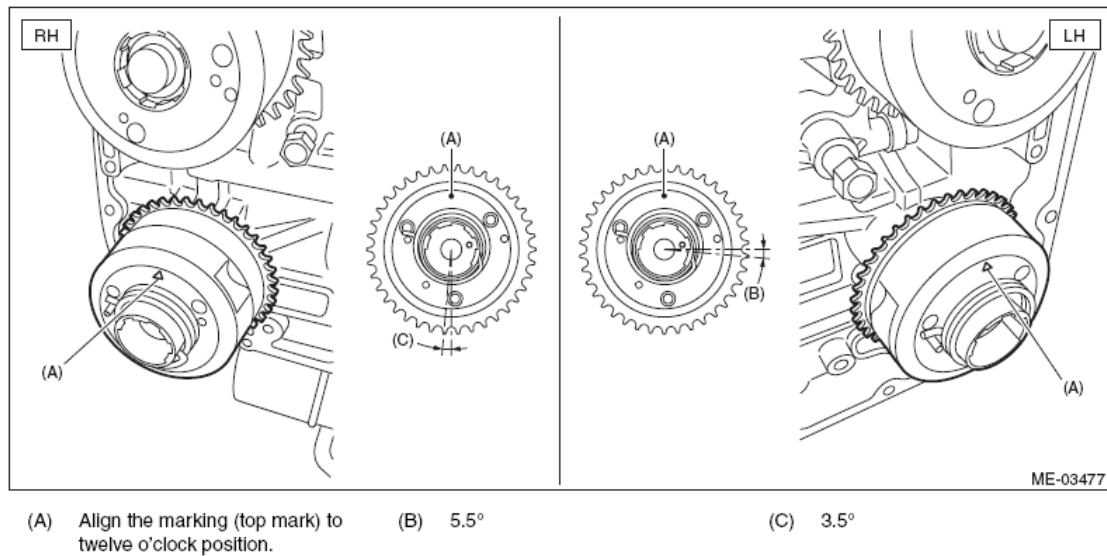
ST 499977500 CAM SPROCKET WRENCH



**Fig. 105: Aligning Intake Cam Sprocket To Twelve O'Clock Position**  
 Courtesy of SUBARU OF AMERICA, INC.

5. Align the exhaust cam sprocket to twelve o'clock position as shown in the figure.

ST 499977500 CAM SPROCKET WRENCH



**Fig. 106: Aligning Exhaust Cam Sprocket To Twelve O'Clock Position**  
 Courtesy of SUBARU OF AMERICA, INC.

6. Using ST, align the "Top mark" on crank sprocket to twelve o'clock position as shown in the figure.

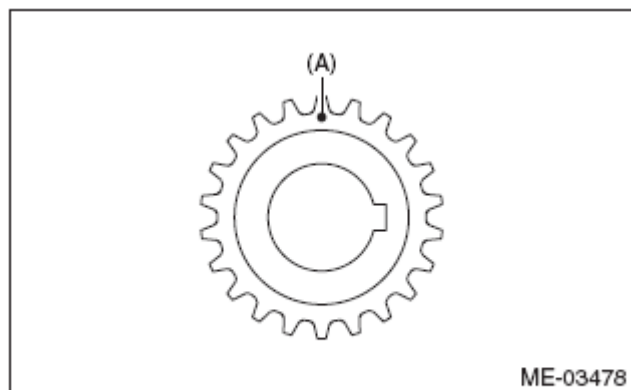
**NOTE:**

- The #1 piston is positioned at TDC.
- Do not rotate the crankshaft and cam sprocket before completing

timing chain installation.

- Crank sprocket key is located at three o'clock position.

ST 18252AA000 CRANKSHAFT SOCKET



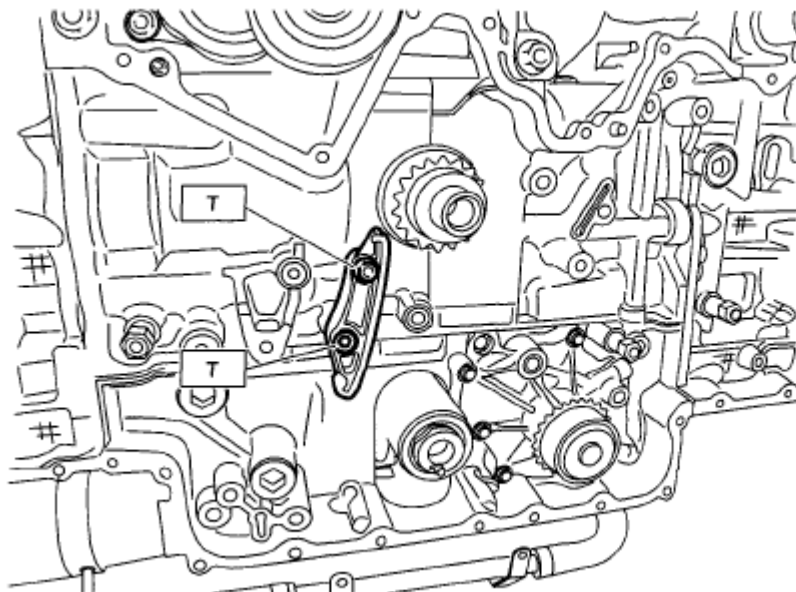
(A) Top mark

**Fig. 107: Identifying Top Mark On Crankshaft Socket**  
Courtesy of SUBARU OF AMERICA, INC.

7. Install the chain guide (main).

***Tightening torque:***

***16 N.m (1.6 kgf-m, 11.8 ft-lb)***



**Fig. 108: Identifying Chain Guide (Main) Mounting Bolts Tightening Torque**  
Courtesy of SUBARU OF AMERICA, INC.

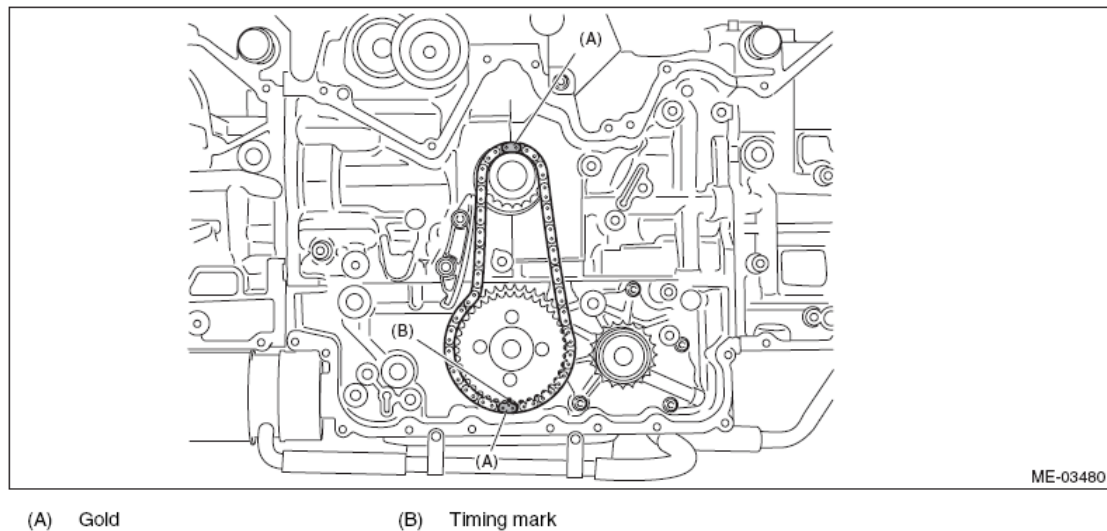
8. Install the idler sprocket and timing chain (main).
  1. Match the timing chain mark (gold) to the timing mark position of the idler sprocket.
  2. Align the idler sprocket timing mark at six o'clock position, and install the idler sprocket and timing chain.
  3. Make sure that the timing chain mark (gold) is located at twelve o'clock position on the crank sprocket.
  4. Use the ST1 and ST2 to lock the idler sprocket, and install the idler sprocket bolt.

ST1 18355AA000 PULLEY WRENCH

ST2 18334AA000 PULLEY WRENCH PIN SET

***Tightening torque:***

***120 N.m (12.2 kgf-m, 88.5 ft-lb)***

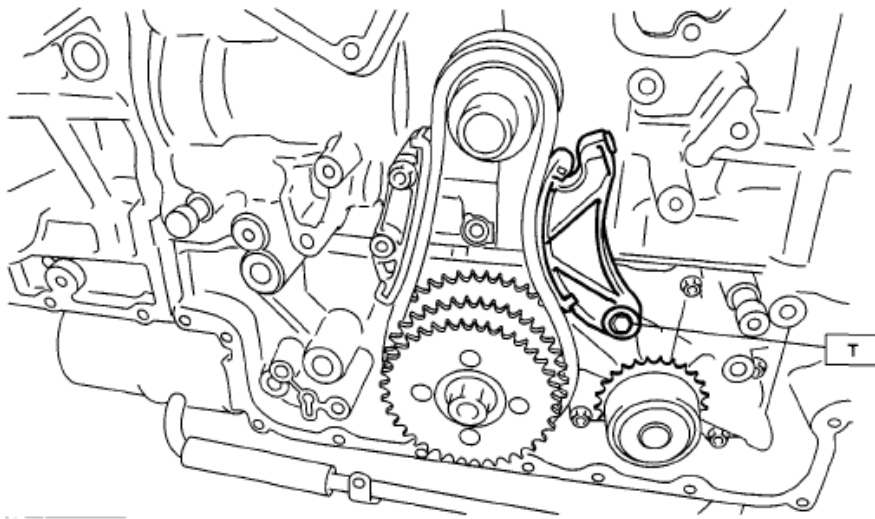


**Fig. 109: Installing Idler Sprocket Bolt Using Special Tools**  
**Courtesy of SUBARU OF AMERICA, INC.**

9. Install the chain tensioner lever (main).

***Tightening torque:***

***16 N.m (1.6 kgf-m, 11.8 ft-lb)***



ME-03481

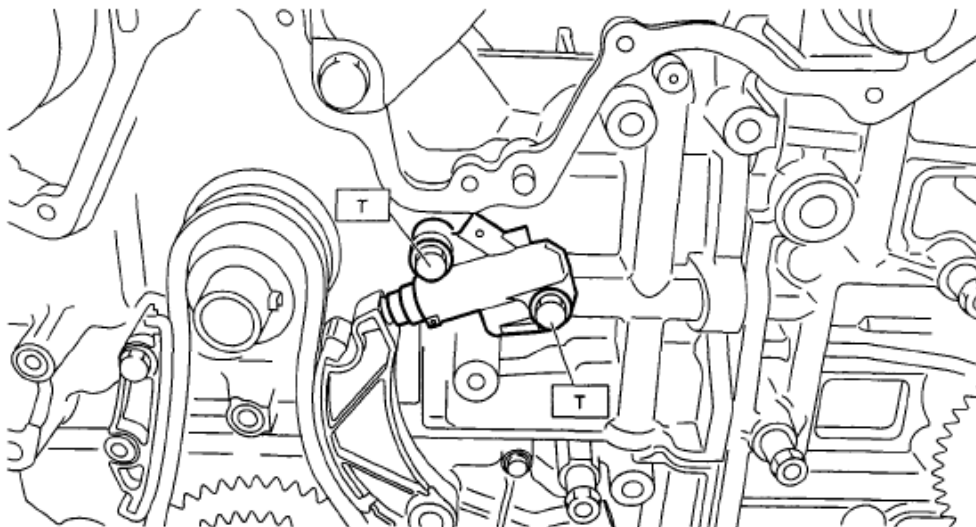
**Fig. 110: Identifying Chain Tensioner Lever (Main) Mounting Bolt Tightening Torque**  
Courtesy of SUBARU OF AMERICA, INC.

10. Install the chain tensioner (main) and pull out the stopper pin.

**NOTE:** The timing chain (main) line will be complete.

*Tightening torque:*

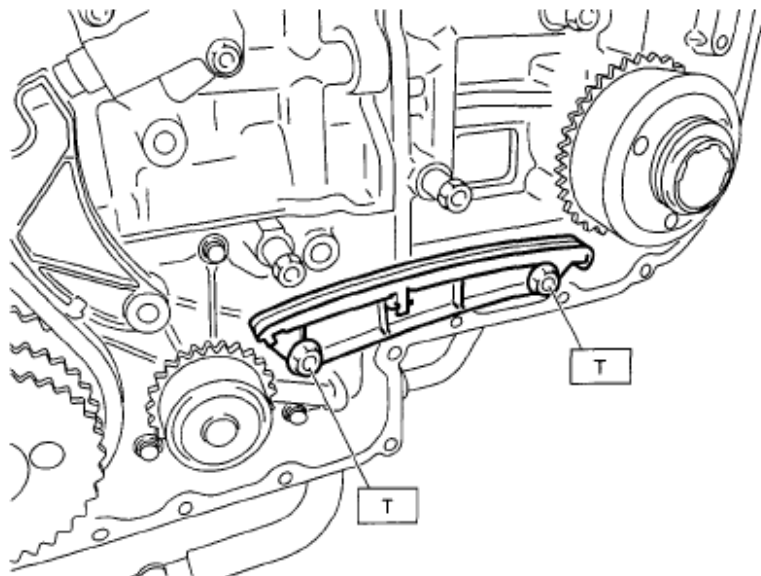
**16 N.m (1.6 kgf-m, 11.8 ft-lb)**



ME-03482

**Fig. 111: Identifying Chain Tensioner (Main) Mounting Bolts Tightening Torque**  
Courtesy of SUBARU OF AMERICA, INC.

11. Install the chain guide (LH).

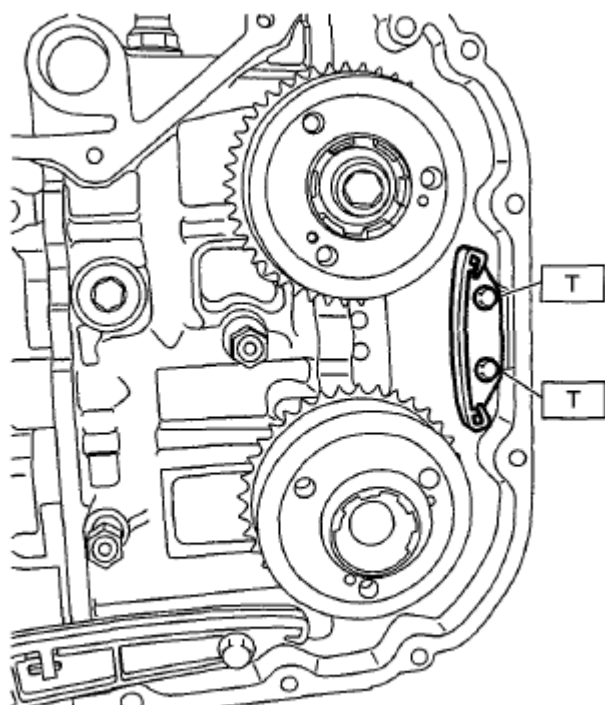
***Tightening torque:******16 N.m (1.6 kgf-m, 11.8 ft-lb)***

ME-03483

**Fig. 112: Identifying Chain Guide (LH) Mounting Bolts Tightening Torque**  
**Courtesy of SUBARU OF AMERICA, INC.**

12. Install the chain guide (LH: between cams).

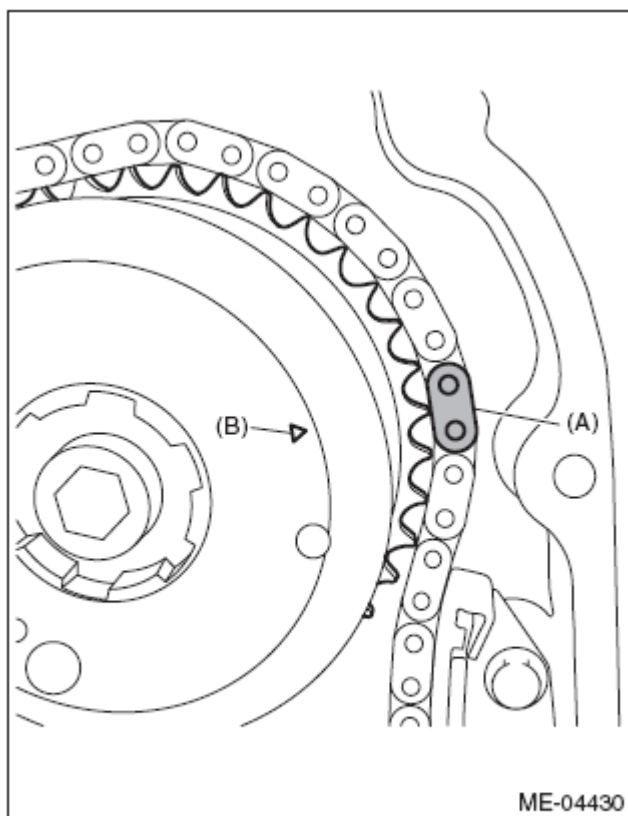
***Tightening torque:******6.4 N.m (0.7 kgf-m, 4.7 ft-lb)***



ME-03607

**Fig. 113: Identifying Chain Guide (LH: Between Cams) Mounting Bolts Tightening Torques**  
**Courtesy of SUBARU OF AMERICA, INC.**

13. Install timing chain (LH).
  1. Match the timing mark of intake cam sprocket (LH) to the timing chain mark (blue).



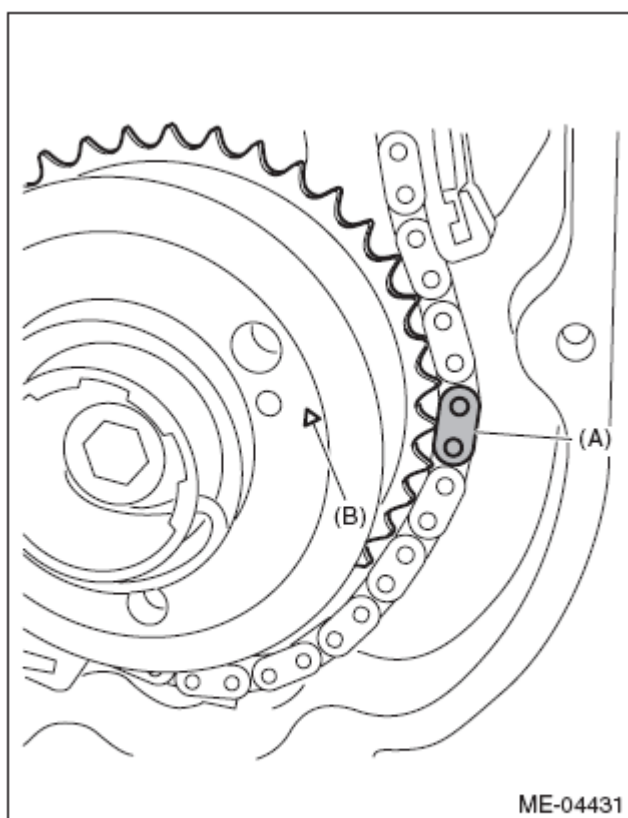
(A) Blue

(B) Timing mark

**Fig. 114: Aligning Timing Mark Of Intake Cam Sprocket (LH) To Timing Chain Mark (Blue)**

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

2. Match the timing mark of exhaust cam sprocket (LH) to the timing chain mark (blue).



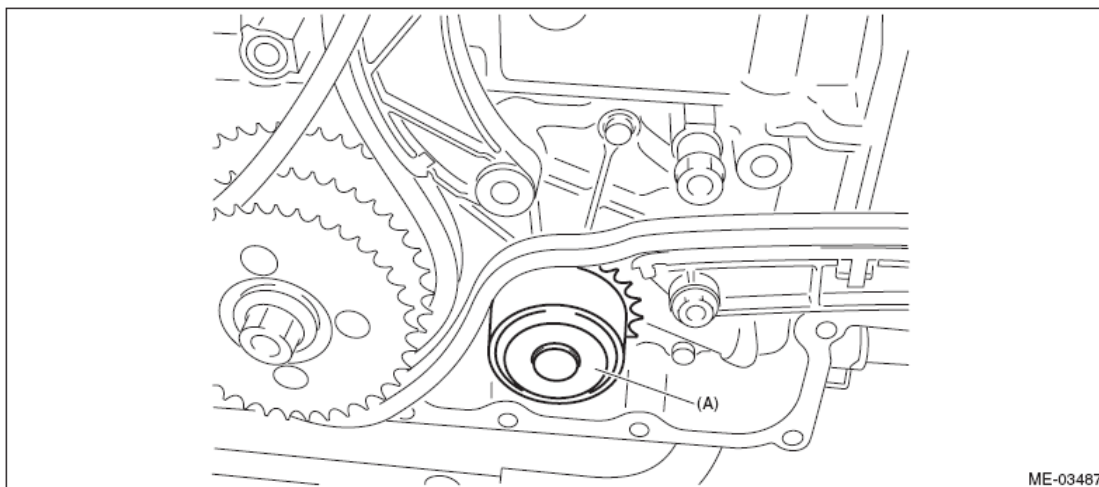
(A) Blue

(B) Timing mark

**Fig. 115: Aligning Timing Mark Of Exhaust Cam Sprocket (LH) To Timing Chain Mark (Blue)**

Courtesy of SUBARU OF AMERICA, INC.

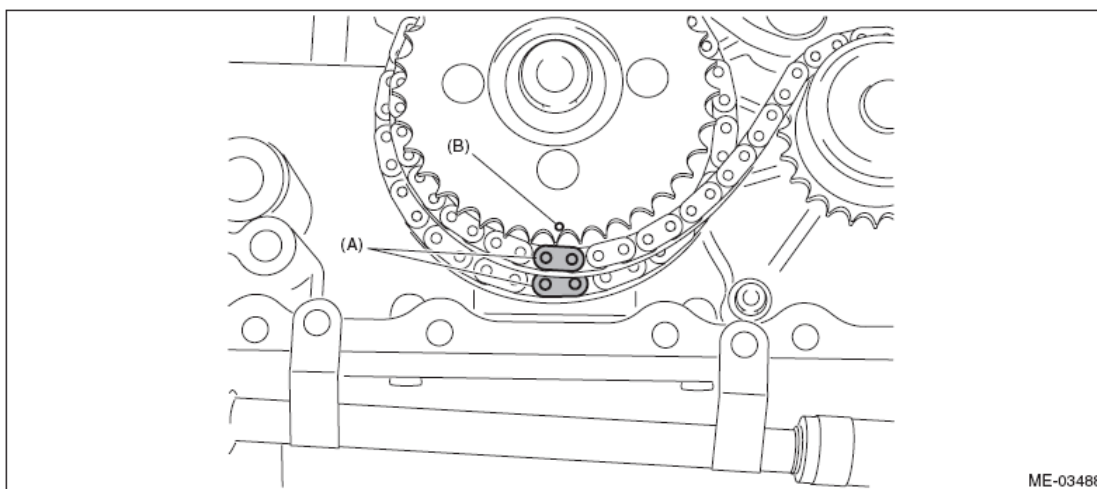
3. Install the timing chain to the water pump sprocket.



(A) Water pump sprocket

**Fig. 116: Identifying Water Pump Sprocket**  
Courtesy of SUBARU OF AMERICA, INC.

4. Match the timing mark of idler sprocket to the timing chain mark (gold).



(A) Gold

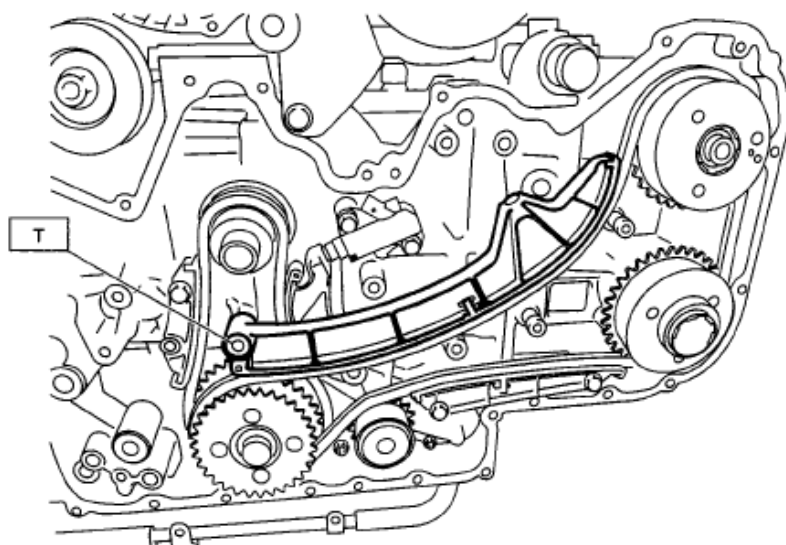
(B) Timing mark

**Fig. 117: Aligning Timing Mark Of Idler Sprocket To Timing Chain Mark (Gold)**  
Courtesy of SUBARU OF AMERICA, INC.

14. Install the chain tensioner lever (LH).

**Tightening torque:**

**16 N.m (1.6 kgf-m, 11.8 ft-lb)**



**Fig. 118: Identifying Chain Tensioner Lever (LH) Mounting Bolts Tightening Torque**  
Courtesy of SUBARU OF AMERICA, INC.

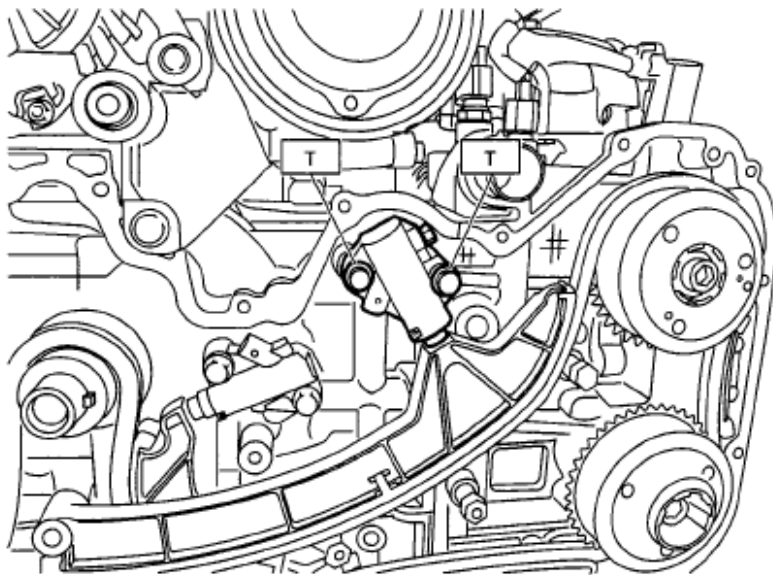
15. Install the chain tensioner (LH) and pull out the stopper pin.

**NOTE:**

- Make sure that there is a bolt attached on the side face of the chain tensioner housing.
- The timing chain (LH) line will be complete.

***Tightening torque:***

***16 N.m (1.6 kgf-m, 11.8 ft-lb)***



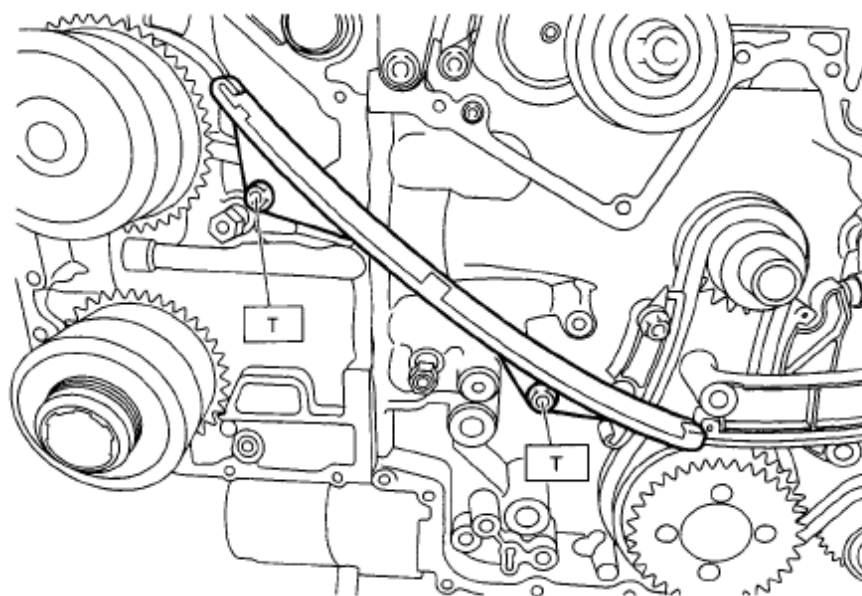
ME-03490

**Fig. 119: Identifying Chain Tensioner Housing Mounting Bolts Tightening Torques**  
Courtesy of SUBARU OF AMERICA, INC.

16. Install the chain guide (RH).

***Tightening torque:***

***16 N.m (1.6 kgf-m, 11.8 ft-lb)***



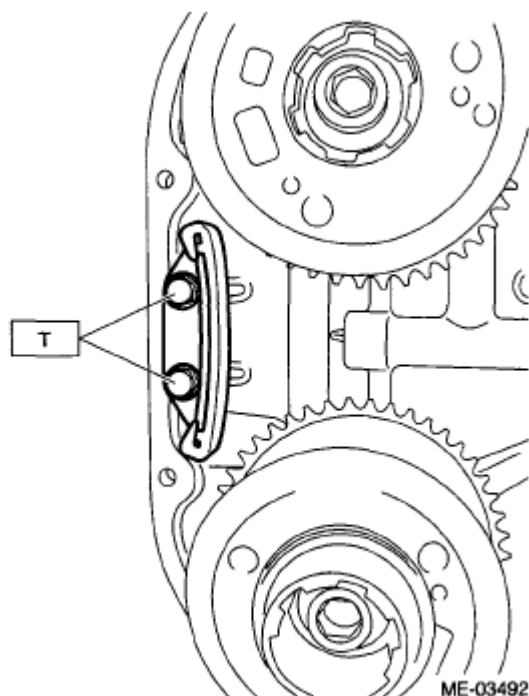
ME-03491

**Fig. 120: Identifying Chain Guide (RH) Mounting Bolts Tightening Torque**  
Courtesy of SUBARU OF AMERICA, INC.

17. Install the chain guide (RH: between cams).

***Tightening torque:***

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



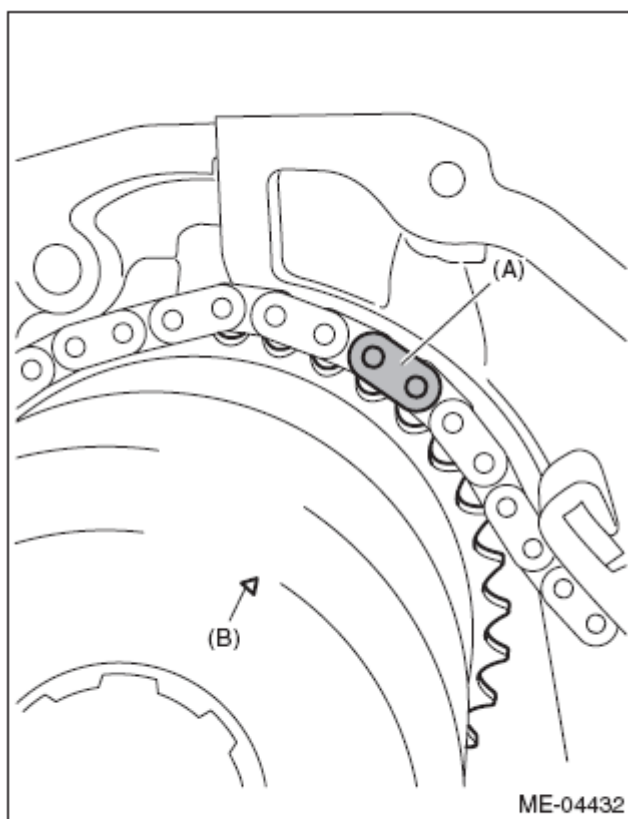
ME-03492

**Fig. 121: Identifying Chain Guide (RH: Between Cams) Mounting Bolts Tightening Torque**

Courtesy of SUBARU OF AMERICA, INC.

18. Install timing chain (RH).

1. Match the timing mark of intake cam sprocket (RH) to the timing chain mark (blue).



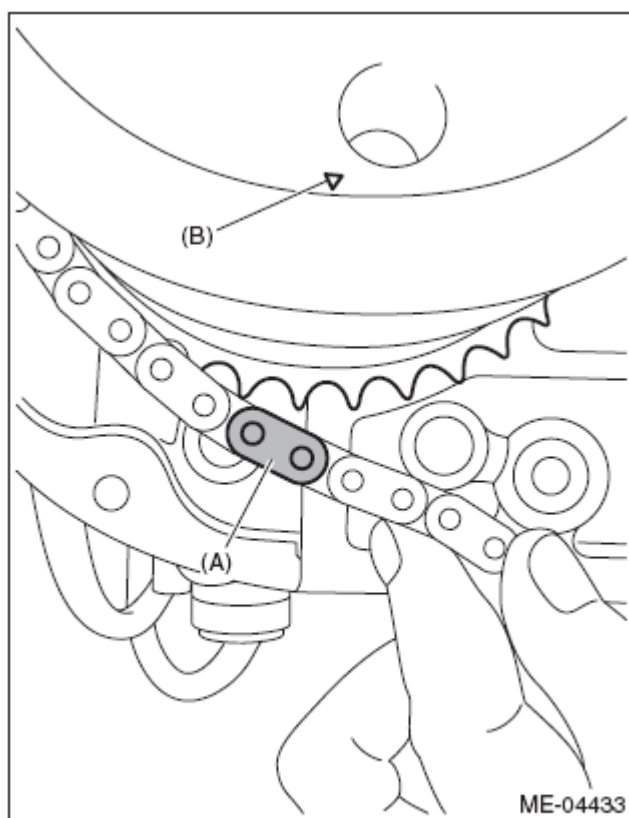
(A) Blue

(B) Timing mark

**Fig. 122: Aligning Timing Mark Of Intake Cam Sprocket (RH) To Timing Chain Mark (Blue)**

Courtesy of SUBARU OF AMERICA, INC.

2. Match the timing mark of exhaust cam sprocket (RH) to the timing chain mark (blue).



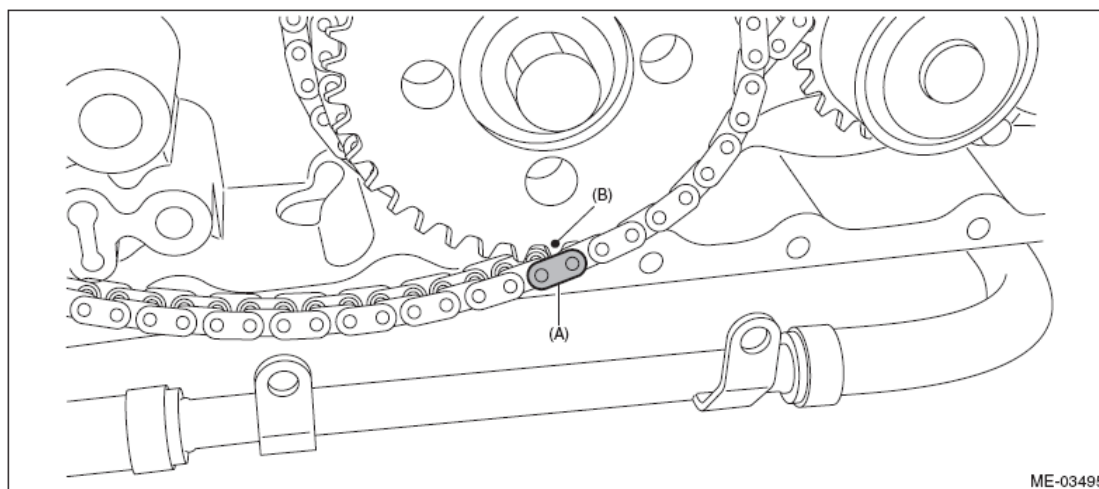
(A) Blue

(B) Timing mark

**Fig. 123: Aligning Timing Mark Of Exhaust Cam Sprocket (RH) To Timing Chain Mark (Blue)**

Courtesy of SUBARU OF AMERICA, INC.

3. Match the timing mark of idler sprocket to the timing chain mark (gold).



(A) Gold

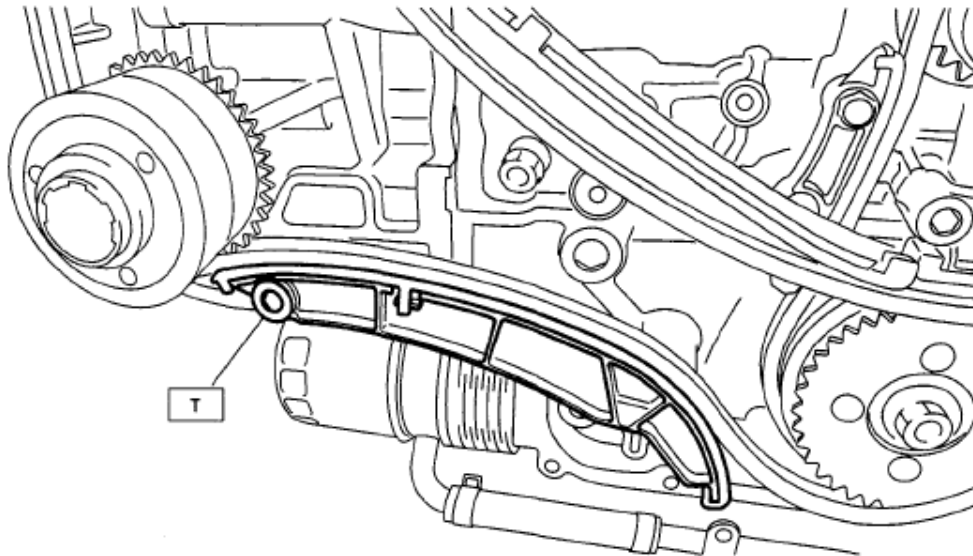
(B) Timing mark

**Fig. 124: Aligning Timing Mark Of Idler Sprocket To Timing Chain Mark (Gold)**  
Courtesy of SUBARU OF AMERICA, INC.

19. Install the chain tensioner lever (RH).

***Tightening torque:***

***16 N.m (1.6 kgf-m, 11.8 ft-lb)***



ME-03496

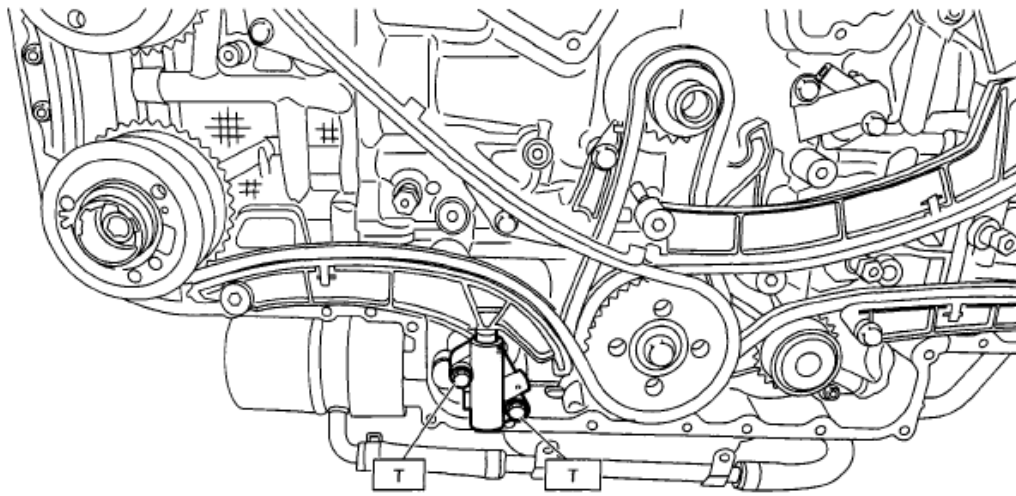
**Fig. 125: Identifying Chain Tensioner Lever (RH) Mounting Bolts Tightening Torque**  
Courtesy of SUBARU OF AMERICA, INC.

20. Install the chain tensioner (RH) and pull out the stopper pin.

**NOTE:** The timing chain (RH) line will be complete.

***Tightening torque:***

***16 N.m (1.6 kgf-m, 11.8 ft-lb)***



**Fig. 126: Identifying Timing Chain (RH) Mounting Bolts Tightening Torque**  
Courtesy of SUBARU OF AMERICA, INC.

21. After installation, perform the following confirmations.

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

1. Make sure that the timing mark of idler sprocket is aligned to three timing chain marks (gold).
  2. Make sure that the twelve o'clock position on the crank sprocket is aligned to the timing chain (main) mark (gold).
  3. Make sure that the LH side cam sprocket timing mark is aligned to the timing chain mark (blue).
  4. Make sure that the RH side cam sprocket timing mark is aligned to the timing chain mark (blue).
  5. Make sure that all bolts are tightened at the specified torque.
22. Using the ST, turn the crankshaft in the direction of engine rotation, and make sure that there are no abnormal conditions.

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

23. Install the chain cover. < Refer to **INSTALLATION**, Chain Cover. >
24. Install the crank pulley. < Refer to **INSTALLATION**, Crank Pulley. >
25. Install the V-belts. < Refer to **INSTALLATION**, V-belt. >
26. Fill engine oil. < Refer to **REPLACEMENT**, Engine Oil. >
27. Make sure there is no oil leaks in the chain cover mating surface.
28. Install the radiator. < Refer to **INSTALLATION**, Radiator. >

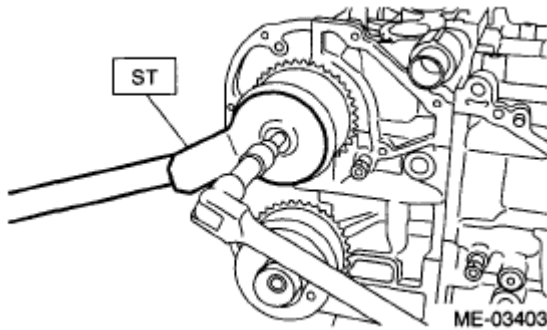
## CAM SPROCKET

## REMOVAL

1. Remove the V-belts. < Refer to **REMOVAL**, V-belt. >
2. Remove the crank pulley. < Refer to **REMOVAL**, Crank Pulley. >
3. Remove the chain cover. < Refer to **REMOVAL**, Chain Cover. >
4. Remove the timing chain assembly. < Refer to **REMOVAL**, Timing Chain Assembly. >
5. Remove the cam sprocket. To lock the camshaft, use the ST.

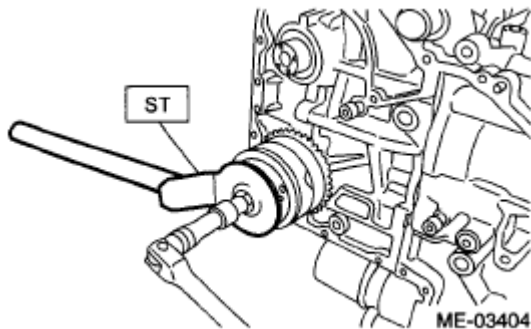
ST 499977500 CAM SPROCKET WRENCH

- IN side



**Fig. 127: Removing/Installing Cam Sprocket Using Special Tool (IN Side)**  
Courtesy of SUBARU OF AMERICA, INC.

- EX side



**Fig. 128: Removing/Installing Cam Sprocket Using Special Tool (EX Side)**  
Courtesy of SUBARU OF AMERICA, INC.

## INSTALLATION

1. Install the cam sprocket. To lock the camshaft, use the ST.

***Tightening torque:***

**29.5 N.m (3.0 kgf-m, 21.8 ft-lb)**

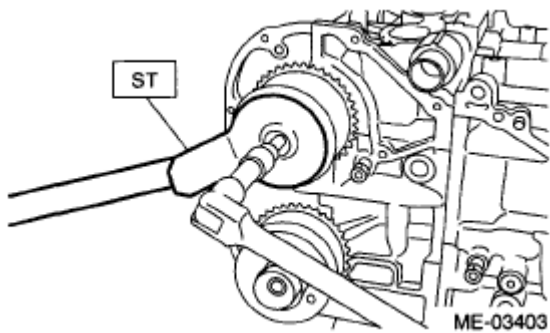
2. Further tighten the bolt.

***Tightening angle:***

**45°±5°**

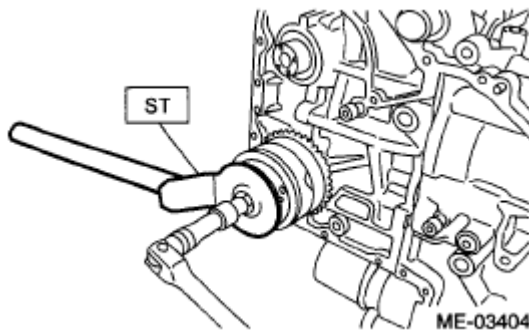
ST 499977500 CAM SPROCKET WRENCH

- IN side



**Fig. 129: Removing/Installing Cam Sprocket Using Special Tool (IN Side)**  
Courtesy of SUBARU OF AMERICA, INC.

- EX side



**Fig. 130: Removing/Installing Cam Sprocket Using Special Tool (EX Side)**  
Courtesy of SUBARU OF AMERICA, INC.

3. Install the timing chain assembly. < Refer to **INSTALLATION**, Timing Chain Assembly. >
4. Install the chain cover. < Refer to **INSTALLATION**, Chain Cover. >
5. Install the crank pulley. < Refer to **INSTALLATION**, Crank Pulley. >
6. Install the V-belts. < Refer to **INSTALLATION**, V-belt. >

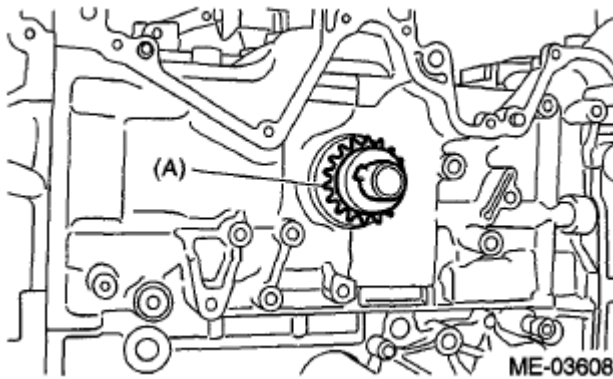
## INSPECTION

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

## CRANK SPROCKET

### REMOVAL

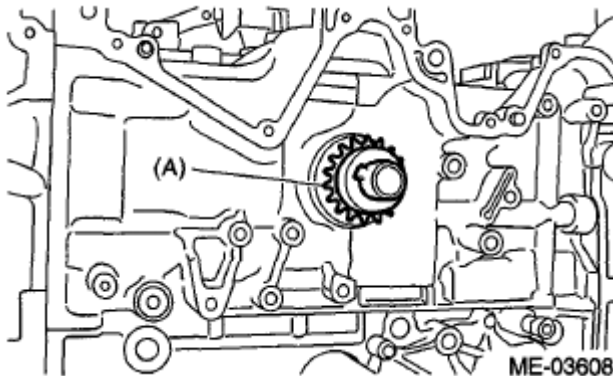
1. Remove the V-belts. < Refer to **REMOVAL**, V-belt. >
2. Remove the crank pulley. < Refer to **REMOVAL**, Crank Pulley. >
3. Remove the chain cover. < Refer to **REMOVAL**, Chain Cover. >
4. Remove the timing chain assembly. < Refer to **REMOVAL**, Timing Chain Assembly. >
5. Remove the crank sprocket (A).



**Fig. 131: Identifying Crank Sprocket**  
Courtesy of SUBARU OF AMERICA, INC.

### INSTALLATION

1. Install the crank sprocket (A).



**Fig. 132: Identifying Crank Sprocket**  
Courtesy of SUBARU OF AMERICA, INC.

2. Install the timing chain assembly. < Refer to **INSTALLATION**, Timing Chain Assembly. >
3. Install the chain cover. < Refer to **INSTALLATION**, Chain Cover. >
4. Install the crank pulley. < Refer to **INSTALLATION**, Crank Pulley. >
5. Install the V-belts. < Refer to **INSTALLATION**, V-belt. >

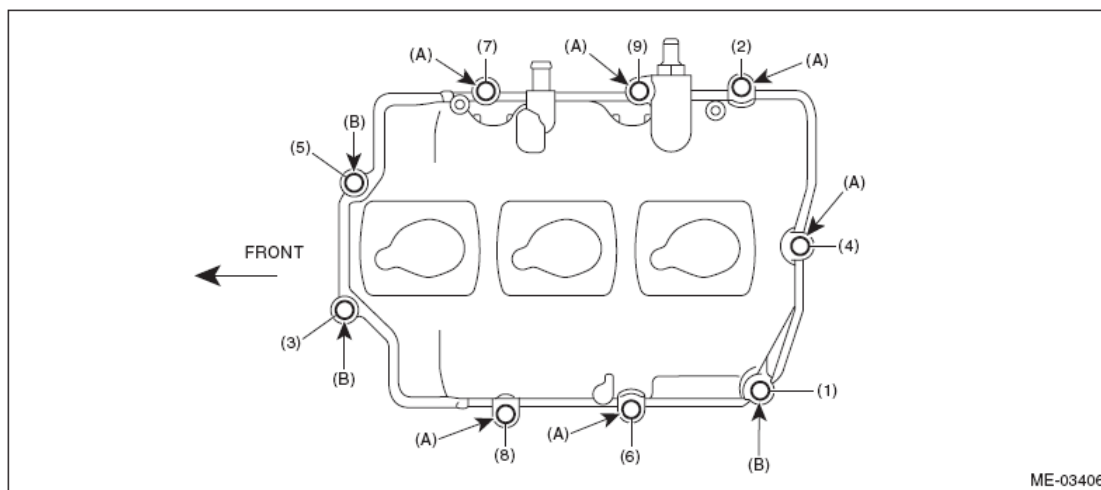
## INSPECTION

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

## CAMSHAFT

### REMOVAL

1. Remove the engine from vehicle. < Refer to **REMOVAL**, Engine Assembly. >
2. Remove the crank pulley. < Refer to **REMOVAL**, Crank Pulley. >
3. Remove the chain cover. < Refer to **REMOVAL**, Chain Cover. >
4. Remove the timing chain assembly. < Refer to **REMOVAL**, Timing Chain Assembly. >
5. Remove the cam sprocket. < Refer to **REMOVAL**, Cam Sprocket. >
6. Remove the crank sprocket. < Refer to **REMOVAL**, Crank Sprocket. >
7. Remove the exhaust oil flow control solenoid valve. < Refer to **REMOVAL**, Oil Flow Control Solenoid Valve. >
8. Remove the camshaft position sensor. < Refer to **REMOVAL**, Camshaft Position Sensor. >
9. Loosen the rocker cover bolts in the order indicated in the figure, and remove the rocker cover.
  - LH side

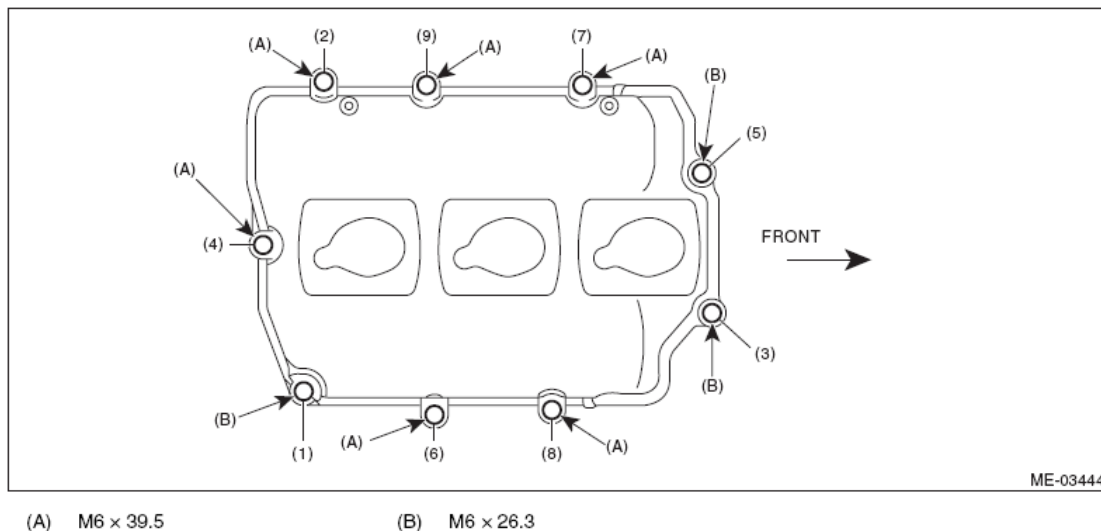


(A) M6 × 39.5

(B) M6 × 26.3

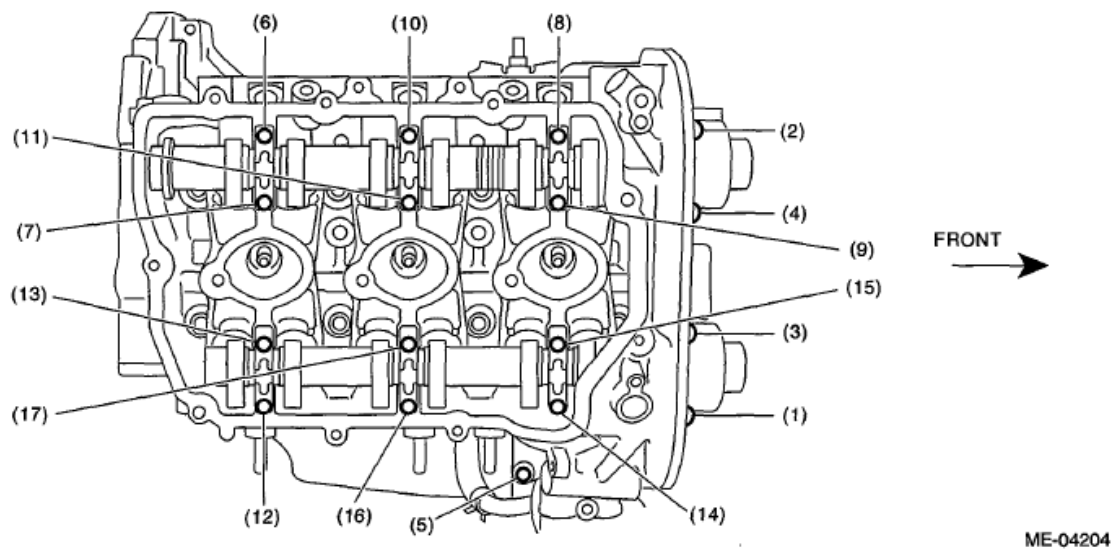
**Fig. 133: Identifying Rocker Cover Bolts Loosening Sequence (LH Side)**  
 Courtesy of SUBARU OF AMERICA, INC.

- RH side



**Fig. 134: Identifying Rocker Cover Bolts Loosening Sequence (RH Side)**  
Courtesy of SUBARU OF AMERICA, INC.

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



**Fig. 135: Identifying Camshaft Cap Bolts Loosening Sequence**  
Courtesy of SUBARU OF AMERICA, INC.

11. Remove the camshaft caps and camshaft (RH).

**NOTE:**                      **Arrange camshaft caps in order so that they can be installed in their original positions.**

12. Similarly, remove the camshafts (LH) and related parts.

## INSTALLATION

1. Apply engine oil to camshaft journals, and install the camshaft.
2. Install the camshaft cap.
  1. Apply liquid gasket sparingly to back side of the front camshaft cap as shown in the figure.

### NOTE:

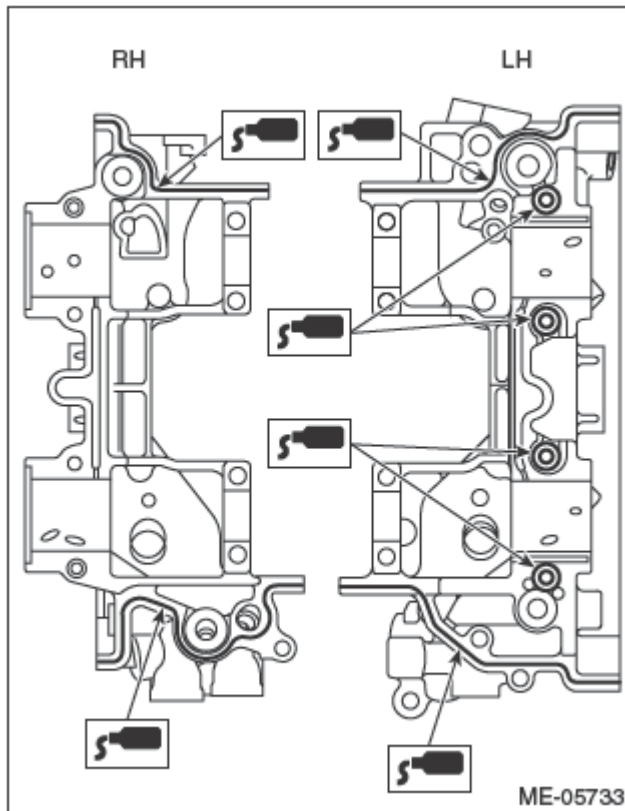
- Install within 5 min. after applying liquid gasket.
- Do not apply liquid gasket excessively. Applying excessively may cause excess gasket to come out and flow toward cam journal, resulting in engine seizure.

*Liquid gasket:*

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

*Liquid gasket applying diameter:*

*2.0±0.5 mm (0.079±0.020 in)*

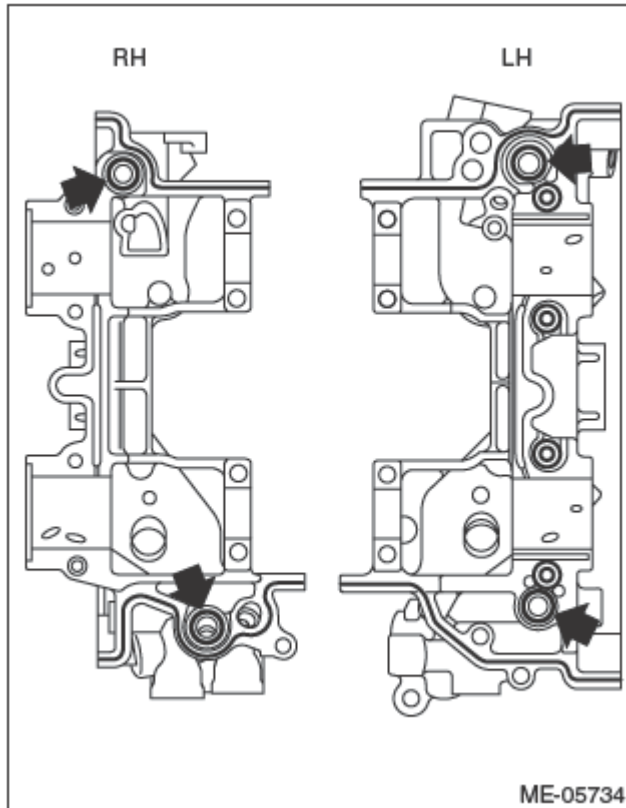


**Fig. 136: Applying Liquid Gasket Sparingly To Back Side Of Front Camshaft Cap**

Courtesy of SUBARU OF AMERICA, INC.

2. Install the O-ring to the front camshaft cap.

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



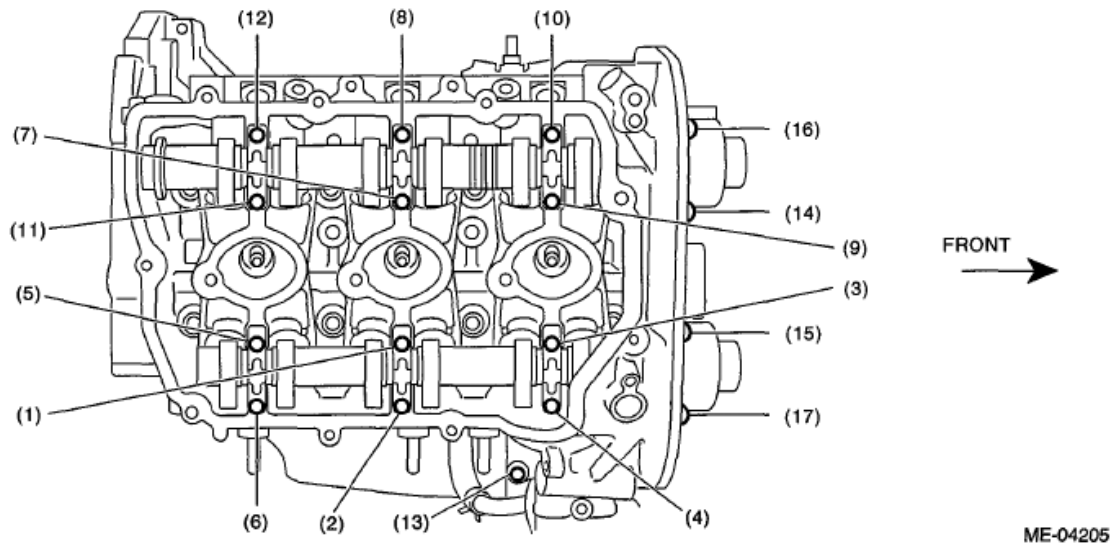
**Fig. 137: Identifying Front Camshaft Cap O-Rings (RH And LH)**  
Courtesy of SUBARU OF AMERICA, INC.

3. Apply a thin coat of engine oil to the cap journal surface, and install the camshaft cap to the camshaft.
4. Gradually tighten the camshaft cap in at least two stages in the numerical order shown in the figure, then tighten to specified torque.

***Tightening torque:***

***(1) - (12): 16 N.m (1.6 kgf-m, 11.8 ft-lb)***

***(13) - (17): 9.75 N.m (1.0 kgf-m, 7.2 ft-lb)***



**Fig. 138: Identifying Camshaft Cap Mounting Bolts Tightening Sequence**  
Courtesy of SUBARU OF AMERICA, INC.

5. After tightening the camshaft cap, ensure the camshaft rotates only slightly while holding it at base circle.
3. Install the rocker cover.
  1. Install the rocker cover gasket to the rocker cover.

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

2. Apply liquid gasket sparingly to the mating surface of cylinder head and rocker cover as shown in the figure.

**NOTE:**

- Install within 5 min. after applying liquid gasket.
- Do not apply liquid gasket excessively. Applying excessively may cause excess gasket to come out and flow toward cam journal, resulting in engine seizure.

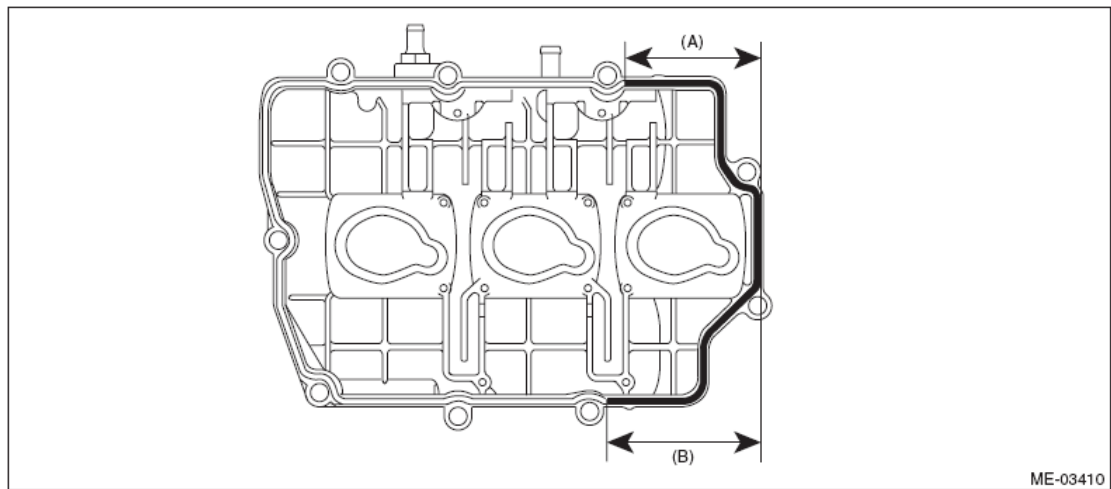
**Liquid gasket:**

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

**Liquid gasket applying diameter:**

**$3.5 \pm 0.5 \text{ mm}$  ( $0.138 \pm 0.020 \text{ in}$ )**

- LH side

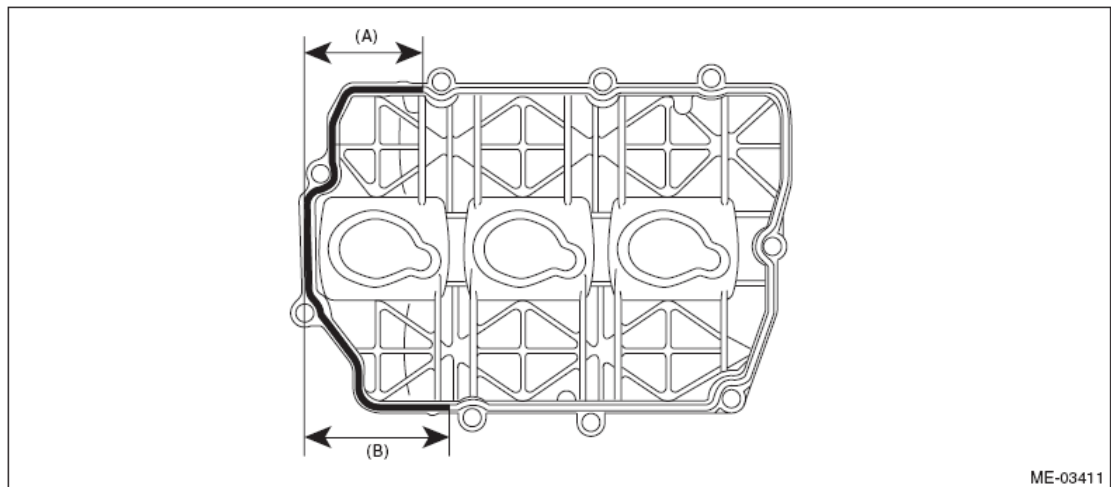


(A) 90 mm (3.543 in) or more (B) 105 mm (4.134 in) or more

**Fig. 139: Applying Liquid Gasket Sparingly To Mating Surface Of Cylinder Head And Rocker Cover (LH Side)**

Courtesy of SUBARU OF AMERICA, INC.

- RH side



(A) 80 mm (3.150 in) or more (B) 100 mm (3.937 in) or more

**Fig. 140: Applying Liquid Gasket Sparingly To Mating Surface Of Cylinder Head And Rocker Cover (RH Side)**

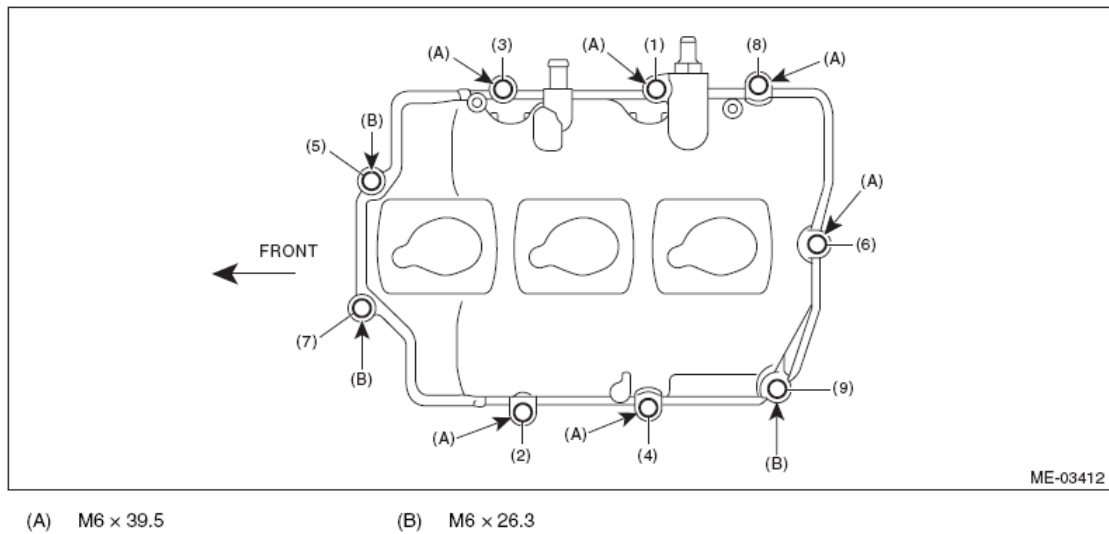
Courtesy of SUBARU OF AMERICA, INC.

3. Tighten the rocker cover bolts in the numerical order as shown in the figure.

***Tightening torque:***

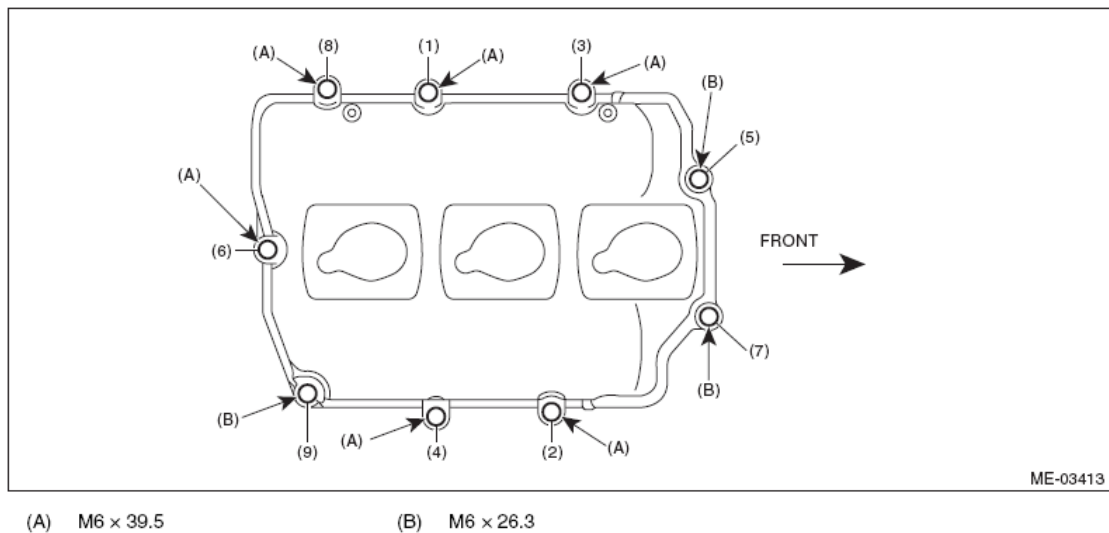
***6.4 N.m (0.7 kgf-m, 4.7 ft-lb)***

- LH side



**Fig. 141: Identifying Rocker Cover Bolts Tightening Sequence (LH Side)**  
Courtesy of SUBARU OF AMERICA, INC.

- RH side



**Fig. 142: Identifying Rocker Cover Bolts Tightening Sequence (RH Side)**  
Courtesy of SUBARU OF AMERICA, INC.

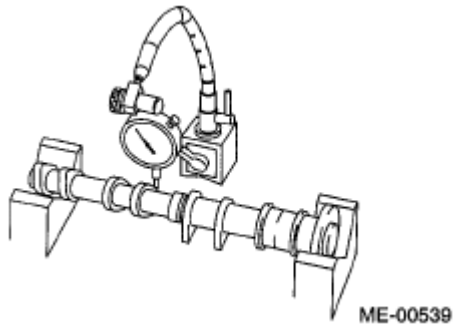
4. Install the crank sprocket. < Refer to **INSTALLATION**, Crank Sprocket. >
5. Install the cam sprocket. < Refer to **INSTALLATION**, Cam Sprocket. >
6. Install the timing chain assembly. < Refer to **INSTALLATION**, Timing Chain Assembly. >
7. Install the chain cover. < Refer to **INSTALLATION**, Chain Cover. >
8. Install the crank pulley. < Refer to **INSTALLATION**, Crank Pulley. >
9. Install the engine to the vehicle. < Refer to **INSTALLATION**, Engine Assembly. >

**INSPECTION**

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

***Camshaft bend limit:***

***0.020 mm (0.00079 in)***



**Fig. 143: Measuring Camshaft Bend Limit**  
Courtesy of SUBARU OF AMERICA, INC.

2. Check the journal for damage and wear. Replace if faulty.
3. Check the cutout portion used for camshaft sensor for damage. Replace if faulty.
4. Check the cam face condition; remove the minor faults by grinding with oil stone. Replace if there is uneven wear or others.
5. Measure the cam lobe height "H" and cam base circle diameter "A". If it exceeds the standard or offset wear occurs, replace it.

***Cam lobe height H:***

***Standard***

***Intake***

***45.90 - 46.00 mm (1.8071 - 1.8110 in)***

***Exhaust***

***44.65 - 44.75 mm (1.7579 - 1.7618 in)***

***Cam base circle diameter A:***

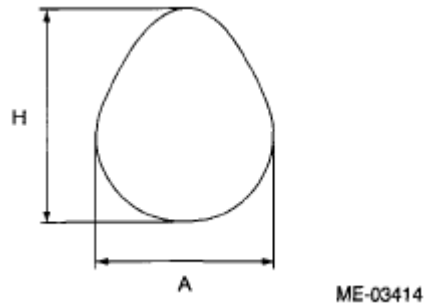
***Standard***

***Intake***

**36.00 mm (1.4173 in)**

**Exhaust**

**36.00 mm (1.4137 in)**



**Fig. 144: Identifying Cam Lobe Height And Base Circle Diameter**  
**Courtesy of SUBARU OF AMERICA, INC.**

6. Measure the outside diameter of camshaft journal. If the journal diameter is not within specification, check the oil clearance.

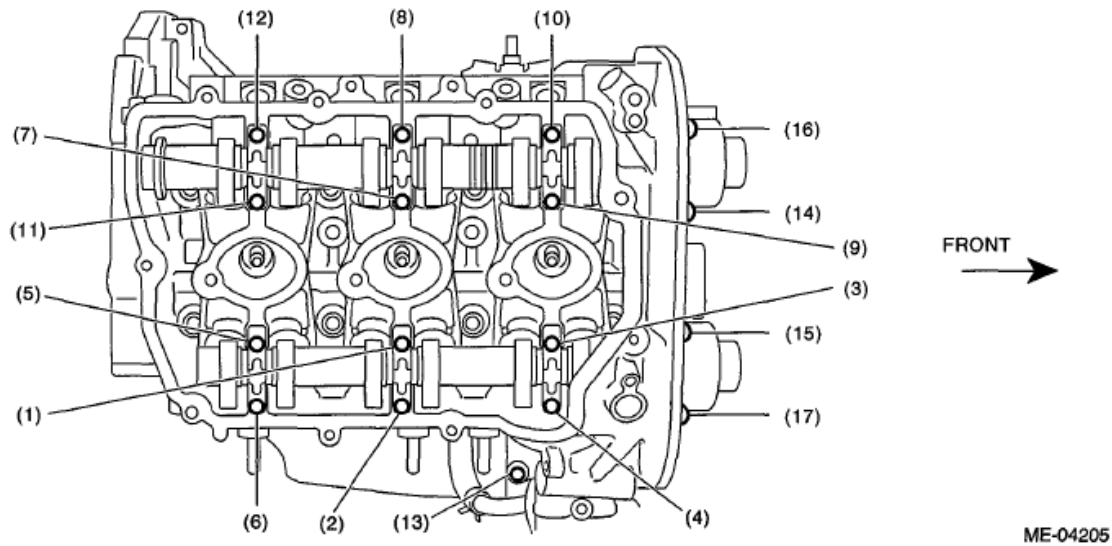
|                     | Camshaft journal                  |                                   |
|---------------------|-----------------------------------|-----------------------------------|
|                     | Front                             | Except for front                  |
| Standard<br>mm (in) | 37.946 - 37.963 (1.4939 - 1.4946) | 25.946 - 25.963 (1.0215 - 1.0222) |

7. Measure the oil clearance of camshaft journal.
  1. Clean the camshaft cap and cylinder head camshaft journal.
  2. Place the camshaft on cylinder head. (Without installing the valve lifter)
  3. Place a plastigauge across each camshaft journals.
  4. Gradually tighten the camshaft cap in at least two stages in the numerical order shown in the figure, then tighten to specified torque. Do not turn the camshaft.

***Tightening torque:***

***(1) - (12): 16 N.m (1.6 kgf-m, 11.8 ft-lb)***

***(13) - (17): 9.75 N.m (1.0 kgf-m, 7.2 ft-lb)***



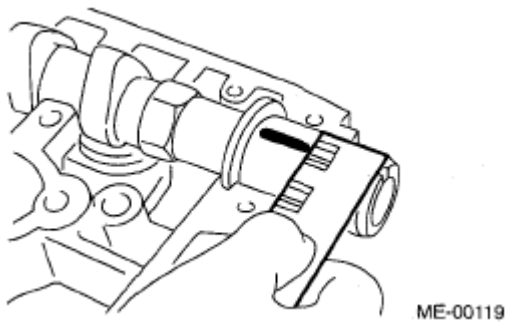
**Fig. 145: Identifying Camshaft Cap Bolts Tightening Sequence**  
Courtesy of SUBARU OF AMERICA, INC.

5. Remove the camshaft cap.
6. Measure the widest point of the plastigauge on each journal. If oil clearance exceeds the standard, replace the camshaft. If necessary, replace the camshaft caps and cylinder head as a set.

**Camshaft oil clearance:**

**Standard**

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



**Fig. 146: Measuring Camshaft Oil Clearance**  
Courtesy of SUBARU OF AMERICA, INC.

7. Completely remove the plastigauge.
8. Measure the thrust clearance with setting the dial gauge at end surface of camshaft. If the thrust clearance is not within the standard or there is offset wear, replace the camshaft caps and cylinder head as a set. If necessary replace the camshaft.

**Camshaft thrust clearance:****Standard****Intake**

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

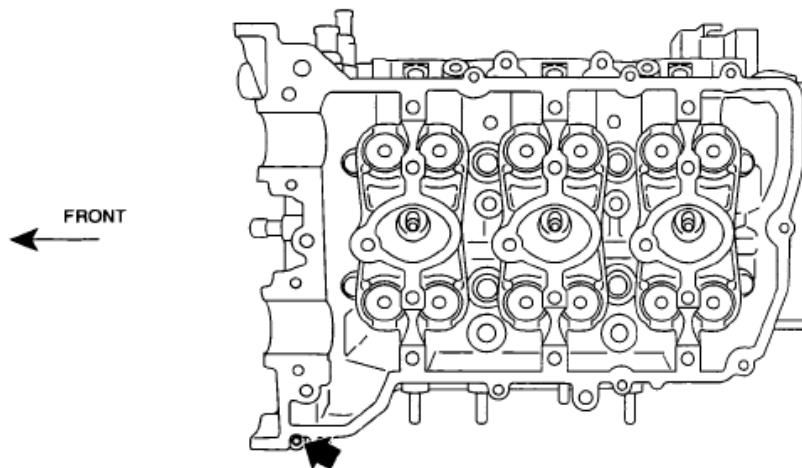
**Exhaust**

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

## CYLINDER HEAD

### REMOVAL

1. Remove the engine from vehicle. < Refer to **REMOVAL**, Engine Assembly. >
2. Remove the crank pulley. < Refer to **REMOVAL**, Crank Pulley. >
3. Remove the chain cover. < Refer to **REMOVAL**, Chain Cover. >
4. Remove the timing chain assembly. < Refer to **REMOVAL**, Timing Chain Assembly. >
5. Remove the cam sprocket. < Refer to **REMOVAL**, Cam Sprocket. >
6. Remove the crank sprocket. < Refer to **REMOVAL**, Crank Sprocket. >
7. Remove the camshaft. < Refer to **REMOVAL**, Camshaft. >
8. Remove the seal bolt shown in the figure.



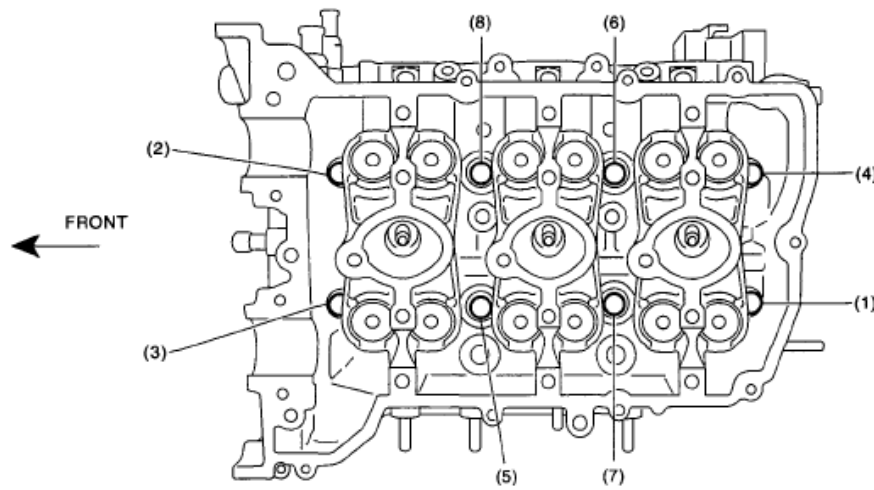
ME-03524

**Fig. 147: Identifying Cylinder Head Sealing Bolt**  
Courtesy of SUBARU OF AMERICA, INC.

9. Remove the cylinder head bolts in the numerical order as shown in the figure.

**NOTE:** Leave bolts (2) and (4) engaged by three or four threads to prevent the

cylinder head from falling.



**Fig. 148: Identifying Cylinder Head Bolts Removal Sequence**  
Courtesy of SUBARU OF AMERICA, INC.

10. While tapping the cylinder head with a plastic hammer, separate it from cylinder block.
11. Remove the bolts (2) and (4) to remove cylinder head.
12. Remove the cylinder head gasket.

**CAUTION:** Be careful not to scratch the mating surface of cylinder head and cylinder block.

13. Similarly, remove the cylinder head (RH).

## INSTALLATION

1. Apply liquid gasket to the mating surface of cylinder block shown in the figure.

### NOTE:

- Install within 5 min. after applying liquid gasket.
- Do not apply liquid gasket excessively. If too much is applied, remove any liquid gasket that is squeezed out.

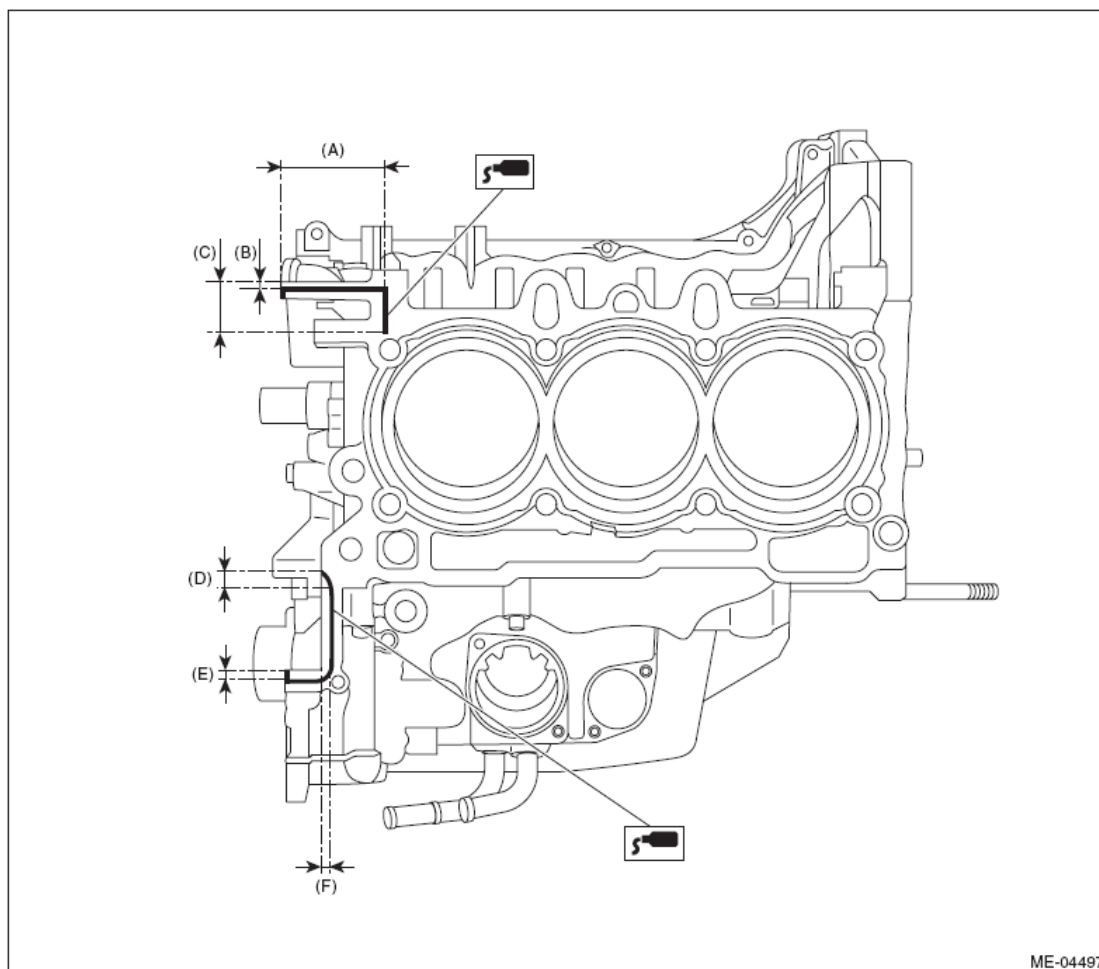
*Liquid gasket:*

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

*Liquid gasket applying diameter:*

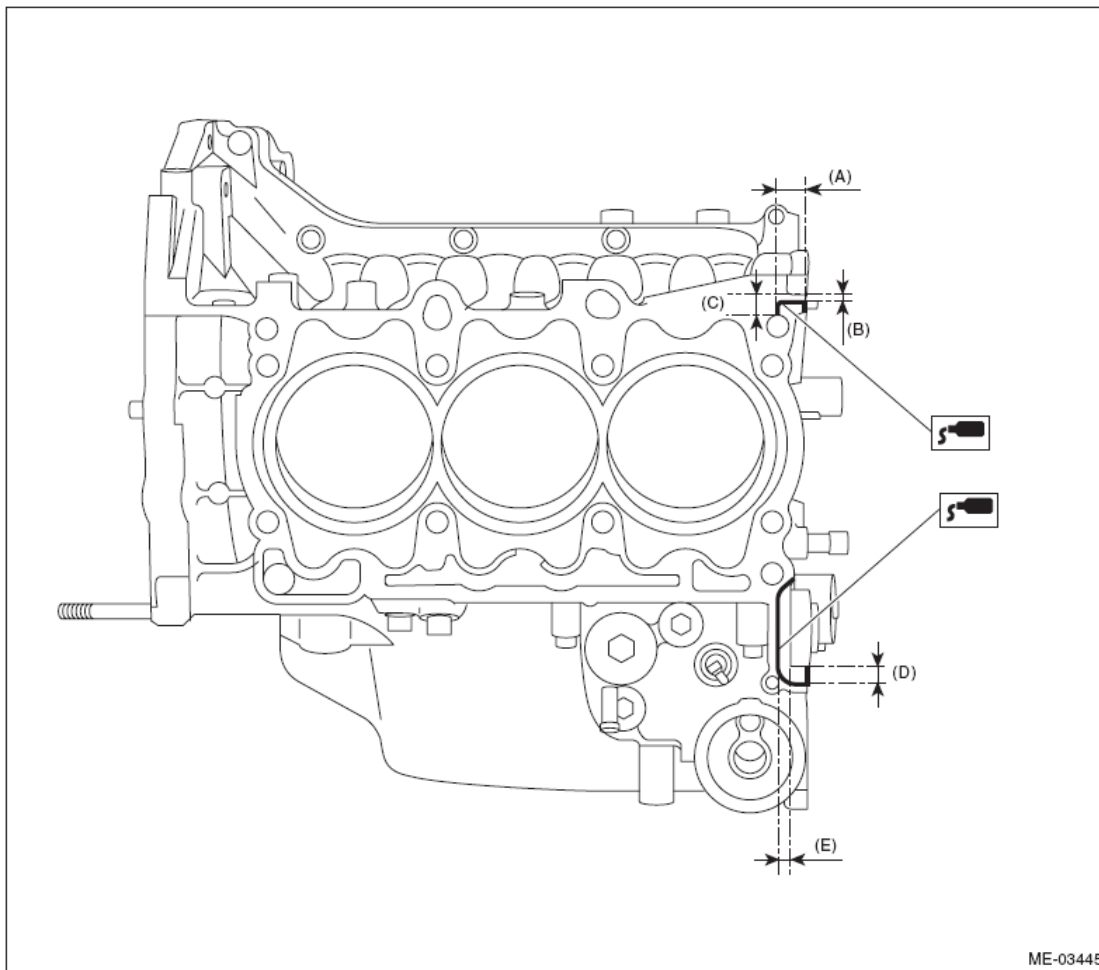
**3.5±1.0 mm (0.138±0.039 in)**

- LH side



**Fig. 149: Applying Liquid Gasket To Mating Surface Of Cylinder Block (LH Side)**  
Courtesy of SUBARU OF AMERICA, INC.

- RH side



(A) 17 mm (0.669 in)

(B) 2 mm (0.079 in)

(C) 9 mm (0.354 in)

(D) 4 mm (0.157 in)

(E) 4 mm (0.157 in)

**Fig. 150: Applying Liquid Gasket To Mating Surface Of Cylinder Block (RH Side)**  
Courtesy of SUBARU OF AMERICA, INC.

2. Install the cylinder head gaskets LH and RH onto the cylinder block.

**NOTE:** Use a new cylinder head gasket.

3. Apply liquid gasket to the mating surface of cylinder head gasket shown in the figure.

**NOTE:**

- Install within 5 min. after applying liquid gasket.
- Do not apply liquid gasket excessively. If too much is applied, remove any liquid gasket that is squeezed out.

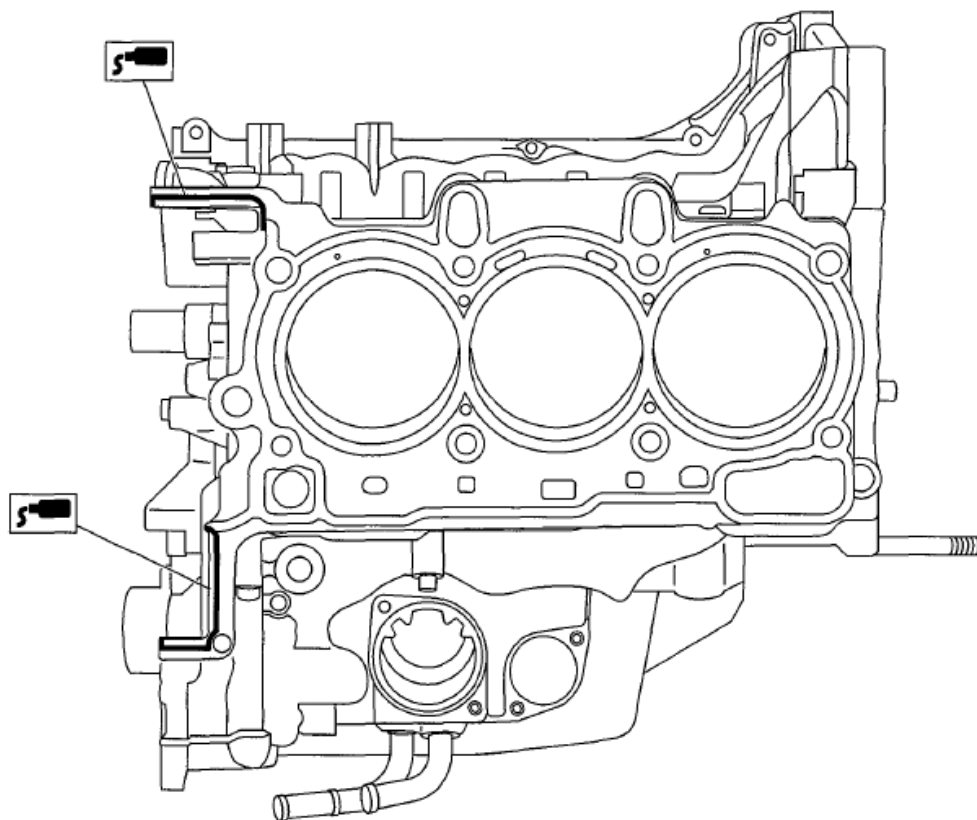
*Liquid gasket:*

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

***Liquid gasket applying diameter:***

***3.5±1.0 mm (0.138±0.039 in)***

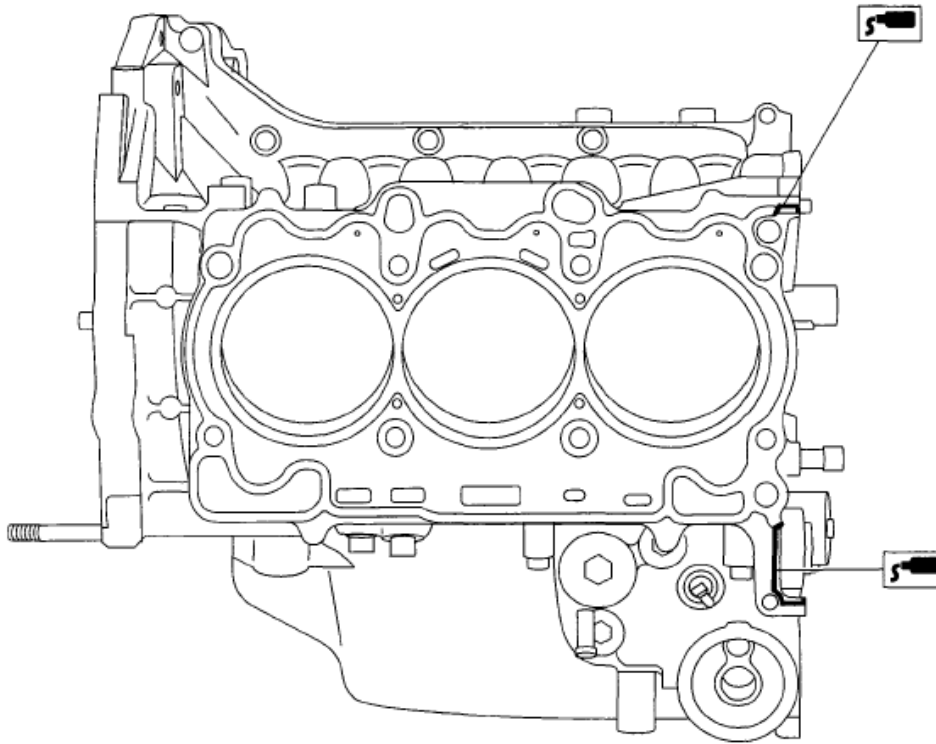
- LH side



ME-04498

**Fig. 151: Applying Liquid Gasket To Mating Surface Of Cylinder Block (LH Side)**  
Courtesy of SUBARU OF AMERICA, INC.

- RH side



ME-03544

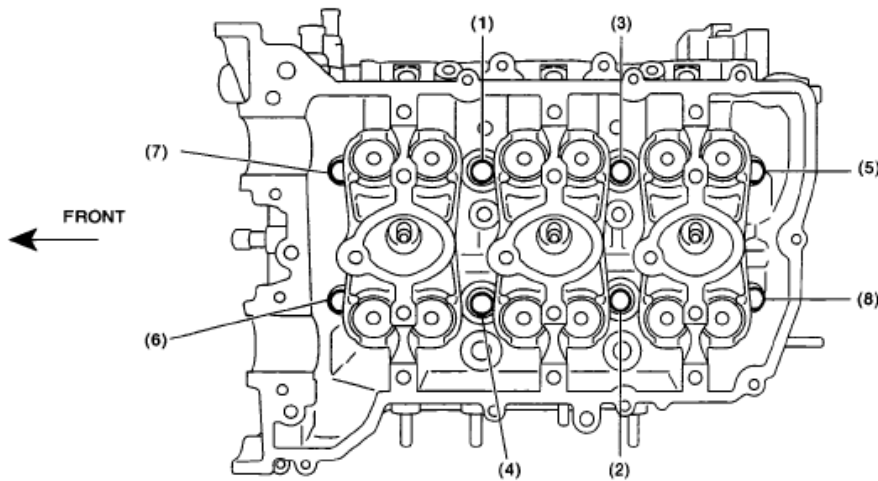
**Fig. 152: Applying Liquid Gasket To Mating Surface Of Cylinder Block (RH Side)**  
Courtesy of SUBARU OF AMERICA, INC.

4. Attach the cylinder head to the cylinder block.

**CAUTION: Be careful not to scratch the mating surface of cylinder head and cylinder block.**

5. Tighten the cylinder head bolts.
  1. Apply a thin coat of engine oil to washers and cylinder head bolt threads.
  2. Mount the cylinder head onto the cylinder block, then tighten the bolts with a torque of 20 N.m (2.0 kgf-m, 14.8 ft-lb) in the order indicated in the figure.
  3. Tighten the bolts with a torque of 50 N.m (5.1 kgf-m, 36.9 ft-lb) in the order indicated in the figure.
  4. Loosen all the bolts by 180° in the reverse order of installing, and loosen them further by 180°.
  5. Tighten the bolts with torque of 20 N.m (2.0 kgf-m, 14.8 ft-lb) in numerical sequence as shown in the figure.
  6. Tighten the bolts (1) - (4) in the order indicated with a torque of 48 N.m (4.9 kgf-m, 35.4 ft-lb).
  7. Tighten the bolts (5) - (8) in the order indicated with a torque of 44 N.m (4.5 kgf-m, 32.5 ft-lb).
  8. Tighten all bolts 90° in the numerical order as shown in the figure.

9. Tighten the bolt (1) - (4) by 45° in the numerical order.



ME-03417

**Fig. 153: Identifying Cylinder Head Bolts Tightening Sequence**  
Courtesy of SUBARU OF AMERICA, INC.

6. Install the seal bolt shown in the figure.

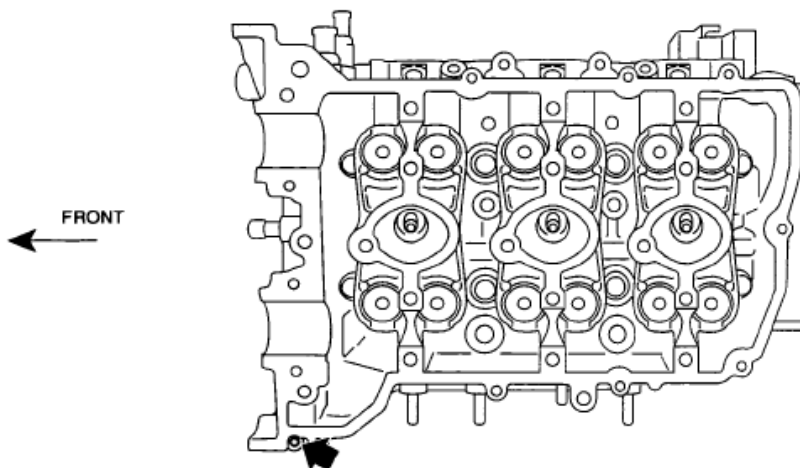
**NOTE:** Before installing seal bolts, apply a sealing material to bolt threads.

*Seal material:*

**THREE BOND 1324 (Part No. 004403042) or equivalent**

*Tightening torque:*

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



ME-03524

**Fig. 154: Identifying Cylinder Head Sealing Bolt**

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

7. Install the camshaft. < Refer to **INSTALLATION**, Camshaft. >
8. Install the crank sprocket. < Refer to **INSTALLATION**, Crank Sprocket. >
9. Install the cam sprocket. < Refer to **INSTALLATION**, Cam Sprocket. >
10. Install the timing chain assembly. < Refer to **INSTALLATION**, Timing Chain Assembly. >
11. Install the chain cover. < Refer to **INSTALLATION**, Chain Cover. >
12. Install the crank pulley. < Refer to **INSTALLATION**, Crank Pulley. >
13. Install the engine to the vehicle. < Refer to **INSTALLATION**, Engine Assembly. >

**DISASSEMBLY**

1. Set the cylinder head on ST.

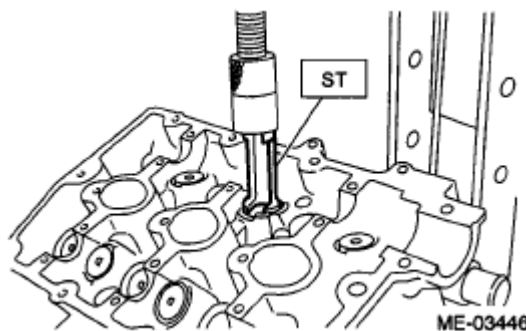
ST 18250AA010 CYLINDER HEAD TABLE

2. Remove the valve lifter.
3. Compress the valve spring using ST, and remove the valve spring retainer key, each valve and valve spring.

ST 499718000 VALVE SPRING REMOVER

**NOTE:**

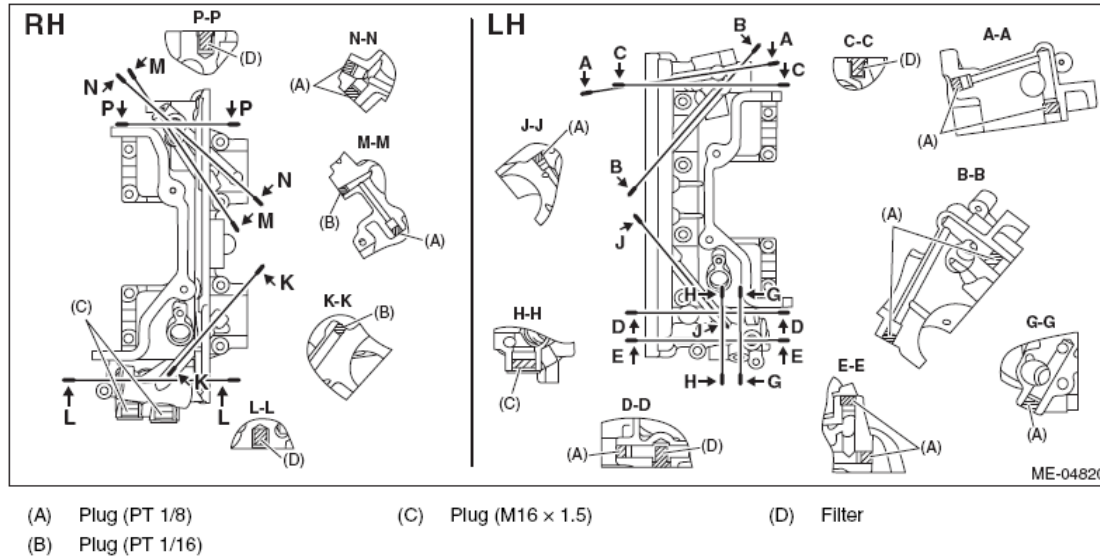
- **Mark each valve to prevent confusion.**
- **Pay careful attention not to damage the lips of intake valve oil seals and exhaust valve oil seals.**
- **Keep all the removed parts in order for re-installing in their original positions.**
- **For removal and installation procedures of the valve guide, intake valve oil seal and exhaust valve oil seal, refer to "INSPECTION". < Refer to **VALVE GUIDE**, **INSPECTION**, Cylinder Head. > < Refer to **INTAKE AND EXHAUST VALVE OIL SEAL**, **INSPECTION**, Cylinder Head. >**



**Fig. 155: Compressing Cylinder Head Valve Spring Using Special**

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

4. Remove the plug and filter from the front camshaft cap as necessary.



**Fig. 156: Removing Plug And Filter From Front Camshaft Cap (RH And LH)**  
**Courtesy of SUBARU OF AMERICA, INC.**

**ASSEMBLY**

1. Install the valve spring and valve.
  1. Set the cylinder head on ST.

ST 18250AA010 CYLINDER HEAD TABLE

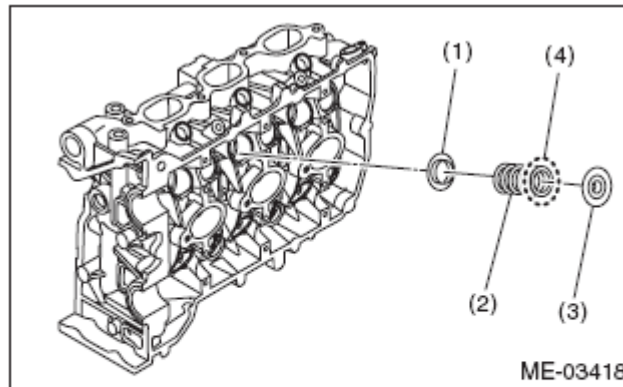
2. Coat the stem of each valve with engine oil and insert the valve into valve guide.

**NOTE:**                      **When inserting the valve into valve guide, use special care not to damage the oil seal lip.**

3. Install the valve spring and retainer.

**NOTE:**

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

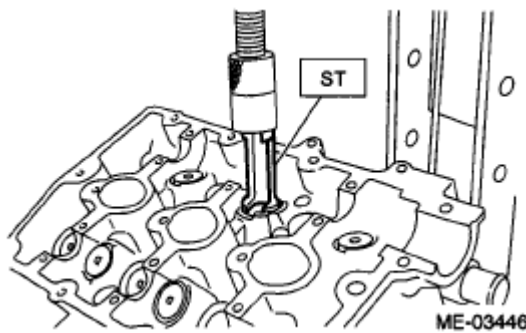


- (1) Seat
- (2) Valve spring
- (3) Retainer
- (4) Painted face

**Fig. 157: Identifying Seat, Valve Spring And Retainer**  
Courtesy of SUBARU OF AMERICA, INC.

4. Set the ST on valve spring.

ST 499718000 VALVE SPRING REMOVER



**Fig. 158: Compressing Cylinder Head Valve Spring Using Special Tool**  
Courtesy of SUBARU OF AMERICA, INC.

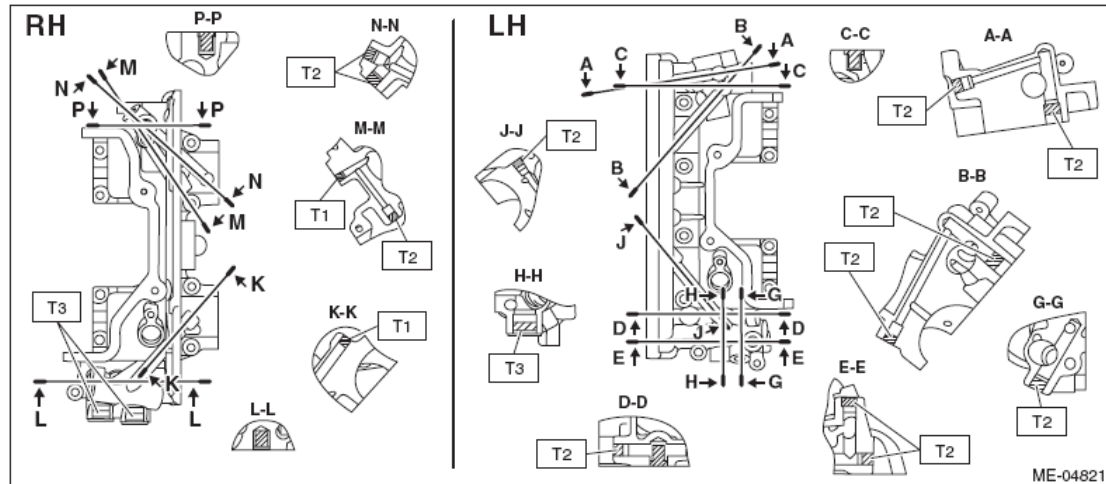
5. Compress the valve spring and fit the valve spring retainer key.
6. After installing, tap the valve spring retainers lightly with a wooden hammer for better seating.
2. Apply oil to the surface of valve lifter.
3. Install the valve lifter.
4. Install the plug and filter to the front camshaft cap as necessary.

***Tightening torque:***

***T1: 9 N.m (0.9 kgf-m, 6.6 ft-lb)***

**T2: 17 N.m (1.7 kgf-m, 12.5 ft-lb)**

**T3: 23 N.m (2.3 kgf-m, 17.0 ft-lb)**



**Fig. 159: Installing Plug And Filter To Front Camshaft Cap**  
 Courtesy of SUBARU OF AMERICA, INC.

## INSPECTION

### CYLINDER HEAD

1. Make sure that there are no cracks or other damages. Perform visual check, and use liquid penetrant tester on the important sections. Check that there are no marks of gas leaking or water leaking on gasket installing surface.
2. Set the cylinder head on ST.

#### ST 18250AA010 CYLINDER HEAD TABLE

3. Check for warpage at mating surface between the cylinder block and cylinder head using a straight edge (A) and thickness gauge (B). If the warpage exceeds limit, replace the cylinder head.

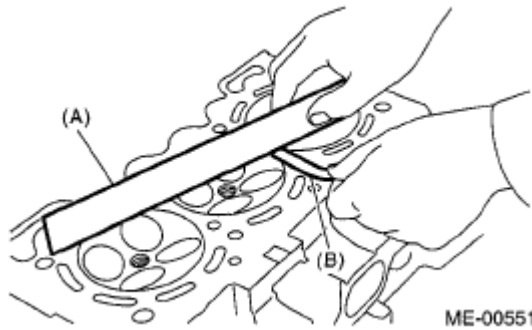
#### *Warping limit:*

**0.020 mm (0.0008 in)**

#### *Standard height of cylinder head:*

**124±0.05 mm (4.88±0.0020 in)**

**NOTE:** Uneven torque for the cylinder head bolts can cause warpage. When reinstalling, pay special attention to the torque so as to tighten evenly.



**Fig. 160: Checking For Warpage At Mating Surface Between Cylinder Block And Cylinder Head Using Straight Edge And Thickness Gauge**  
 Courtesy of SUBARU OF AMERICA, INC.

### VALVE SEAT

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

*Contacting width of valve seat  $W$ :*

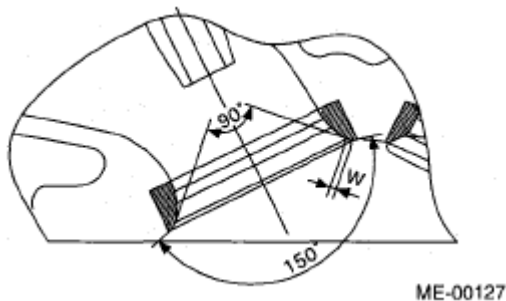
*Standard*

*Intake*

*1.0 mm (0.039 in)*

*Exhaust*

*1.5 mm (0.059 in)*



**Fig. 161: Identifying Contacting Width Of Valve Seat**  
 Courtesy of SUBARU OF AMERICA, INC.

### VALVE GUIDE

1. Check the clearance between valve guide and valve stem. The clearance can be checked by measuring respectively the outer diameter of valve stem with a micrometer and the inner diameter of valve guide

with a caliper gauge.

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

***Standard***

***Intake***

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

***Exhaust***

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

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

***Valve guide inner diameter:***

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

***Valve stem outer diameters:***

***Intake***

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

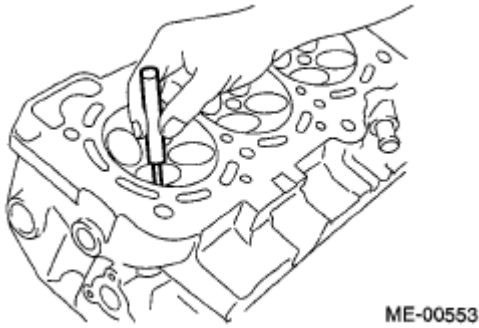
***Exhaust***

***5.445 - 5.460 mm (0.2144 - 0.2150 in)***

1. Place the cylinder head on ST1 with the combustion chamber upward so that valve guides fit the holes in ST1.
2. Insert the ST2 into valve guide and press it down to remove the valve guide.

ST1 18250AA010 CYLINDER HEAD TABLE

ST2 499765700 VALVE GUIDE REMOVER

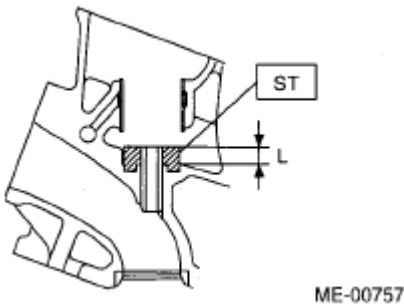


**Fig. 162: Removing Valve Guide Using Special Tool**  
Courtesy of SUBARU OF AMERICA, INC.

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

ST 18251AA050 VALVE GUIDE ADJUSTER (INTAKE SIDE)

ST 18251AA060 VALVE GUIDE ADJUSTER (EXHAUST SIDE)



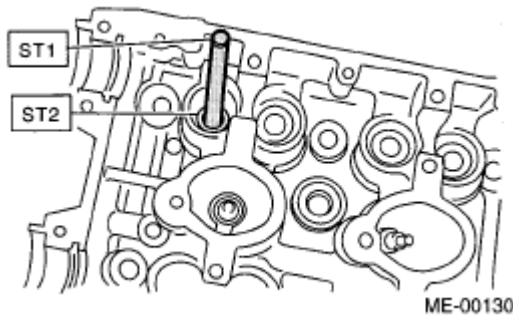
**Fig. 163: Turning Cylinder Head Upside Down**  
Courtesy of SUBARU OF AMERICA, INC.

4. Before installing a new valve guide, make sure that neither scratches nor damages exist on the inner surface of valve guide holes in cylinder head.
5. Put a new valve guide, coated with sufficient oil, in the cylinder head, and insert the ST1 into valve guide. Press in until the valve guide upper end is flush with the upper surface of ST2.

ST1 499765700 VALVE GUIDE REMOVER

ST2 18251AA050 VALVE GUIDE ADJUSTER (INTAKE SIDE)

ST2 18251AA060 VALVE GUIDE ADJUSTER (EXHAUST SIDE)



**Fig. 164: Inserting Special Tool Into Valve Guide**  
Courtesy of SUBARU OF AMERICA, INC.

6. Check the valve guide protrusion amount "L".

***Valve guide protrusion amount L:***

***Intake***

***8.6 - 9.0 mm (0.3386 - 0.3543 in)***

***Exhaust***

***10.7 - 11.1 mm (0.4213 - 0.4370 in)***

7. Ream the inside of valve guide 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.

ST 499765900 VALVE GUIDE REAMER

**NOTE:**

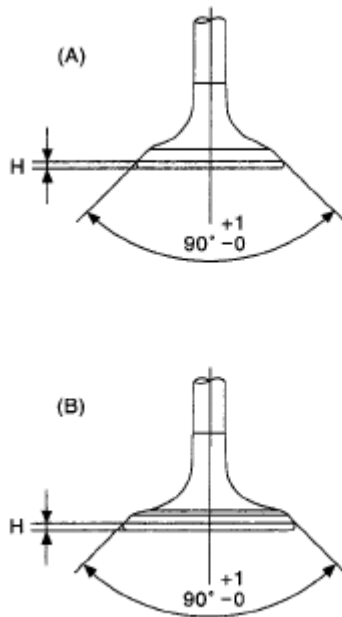
- Apply engine oil to the ST when reaming.
- If the inner surface of valve guide is damaged, the edge of ST should be slightly ground with oil stone.
- If the inner surface of valve guide becomes lustrous and the ST does not chip, use a new ST or remedy the ST.

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 AND EXHAUST VALVE**

1. Check the flange and stem of the valve, and replace the valve with new one if damaged, worn, or deformed, "H" exceeds the standard, or if there is uneven wear.

***Head edge thickness H:***

**Standard****Intake (A)****1.0 mm (0.039 in)****Exhaust (B)****1.2 mm (0.047 in)**

ME-02096

**Fig. 165: Identifying Intake And Exhaust Head Edge Thickness**  
 Courtesy of SUBARU OF AMERICA, INC.

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

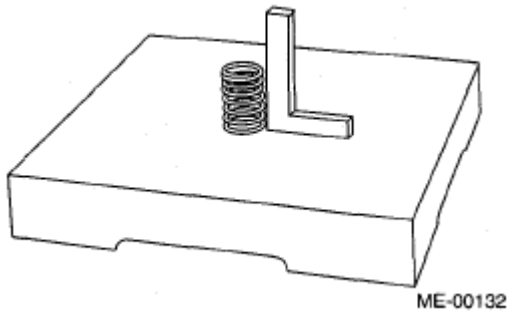
**NOTE:** It is possible to differentiate between the intake valve and the exhaust valve by their overall length.

**Valve overall length:****Intake****103.5 mm (4.075 in)****Exhaust****103.2 mm (4.063 in)**

**VALVE SPRING**

1. Check the valve springs for damage, free length, and tension. Replace the valve spring if it is not within the standard value presented in the table.
2. To measure the squareness of the valve spring, stand the valve spring on a surface plate and measure its deflection at the top of the spring using a try square.

|                                           |         |                                                         |
|-------------------------------------------|---------|---------------------------------------------------------|
| Free length                               | mm (in) | 49.06 (1.9315)                                          |
| Tension/spring height N (kgf, lb)/mm (in) | Set     | 182 - 210<br>(18.6 - 21.4, 40.9 - 47.2)/31.0 (1.220 in) |
|                                           | Lift    | 316 - 350<br>(32.2 - 35.7, 71.0 - 78.7)/21.0 (0.827 in) |
| Squareness                                |         | 2.5°, 2.1 mm (0.083 in) or less                         |



**Fig. 166: Checking Valve Spring Squareness**  
**Courtesy of SUBARU OF AMERICA, INC.**

**INTAKE AND EXHAUST VALVE OIL SEAL**

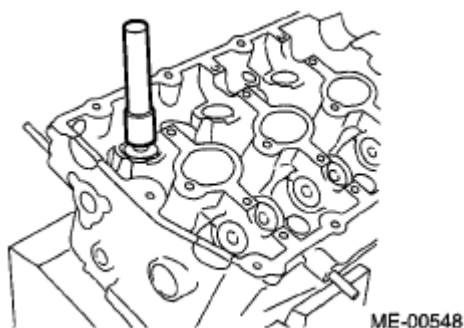
1. For the following, replace the oil seal with a new part.
  - When the lip is damaged.
  - When the spring is out of the specified position.
  - When readjusting the surfaces of valve and valve seat.
  - When replacing the valve guide.
2. Set the cylinder head on ST1.
3. Using the ST2, press in the oil seal.

ST1 18250AA010 CYLINDER HEAD TABLE

ST2 18261AA010 VALVE OIL SEAL GUIDE

**NOTE:**

- **Apply engine oil to oil seal before press-fitting.**
- **When press-fitting the oil seal, do not use a hammer to strike in.**



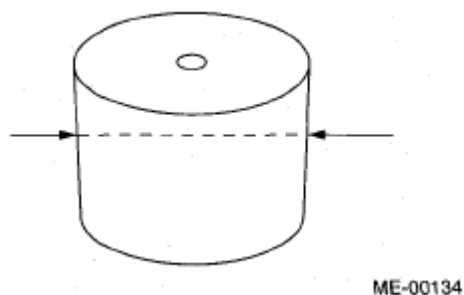
**Fig. 167: Press-Fitting Oil Seal**  
Courtesy of SUBARU OF AMERICA, INC.

#### VALVE LIFTER

1. Check the valve lifter visually.
2. Measure the outer diameter of valve lifter.

*Outer diameter of valve lifter:*

**32.959 - 32.975 mm (1.2976 - 1.2982 in)**

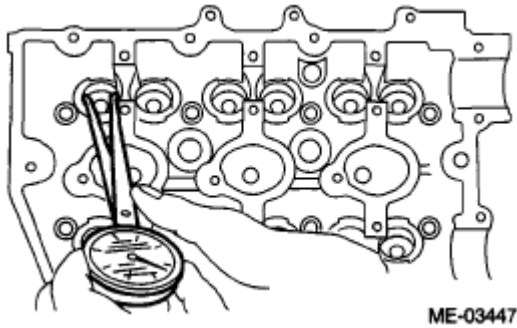


**Fig. 168: Identifying Valve Lifter Outer Diameter**  
Courtesy of SUBARU OF AMERICA, INC.

3. Measure the inner diameter of valve lifter hole of cylinder head.

*Inner diameter of valve lifter hole:*

**32.994 - 33.016 mm (1.2990 - 1.2998 in)**



**Fig. 169: Measuring Inner Diameter Of Valve Lifter Hole Of Cylinder Head**  
Courtesy of SUBARU OF AMERICA, INC.

4. Check the clearance between valve lifter and valve lifter hole. The clearance can be checked by measuring the outer diameter of valve lifter and the inner diameter of valve lifter hole. If it exceeds the standard or offset wear occurs, replace the cylinder head.

**Clearance between the valve lifter and valve lifter hole:**

*Standard*

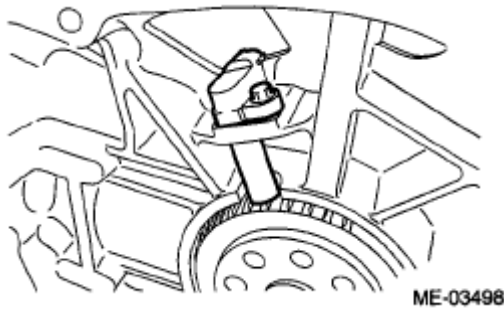
*0.019 - 0.057 mm (0.0007 - 0.0022 in)*

## CYLINDER BLOCK

### REMOVAL

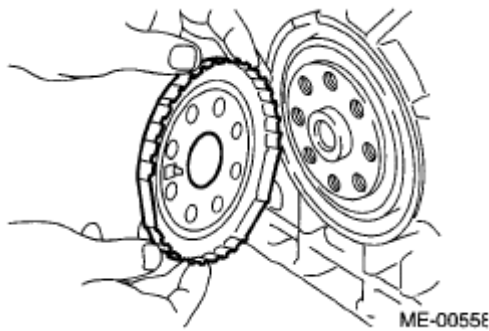
**NOTE:** Before conducting this procedure, drain the engine oil completely.

1. Remove the engine from vehicle. < Refer to **REMOVAL**, Engine Assembly. >
2. Remove the crank pulley. < Refer to **REMOVAL**, Crank Pulley. >
3. Remove the chain cover. < Refer to **REMOVAL**, Chain Cover. >
4. Remove the timing chain assembly. < Refer to **REMOVAL**, Timing Chain Assembly. >
5. Remove the cam sprocket. < Refer to **REMOVAL**, Cam Sprocket. >
6. Remove the crank sprocket. < Refer to **REMOVAL**, Crank Sprocket. >
7. Remove the camshaft. < Refer to **REMOVAL**, Camshaft. >
8. Remove the cylinder head. < Refer to **REMOVAL**, Cylinder Head. >
9. Remove the drive plate. < Refer to **REMOVAL**, Drive Plate. >
10. Remove the crankshaft position sensor.



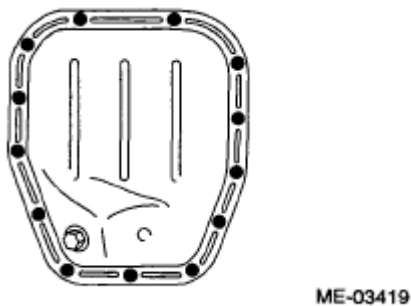
**Fig. 170: Identifying Crankshaft Position Sensor**  
Courtesy of SUBARU OF AMERICA, INC.

11. Remove the crankshaft position sensor plate.



**Fig. 171: Identifying Crankshaft Position Sensor Plate**  
Courtesy of SUBARU OF AMERICA, INC.

12. Rotate the engine to set oil pan upper.
13. Remove the bolts which secure oil pan lower to oil pan upper.

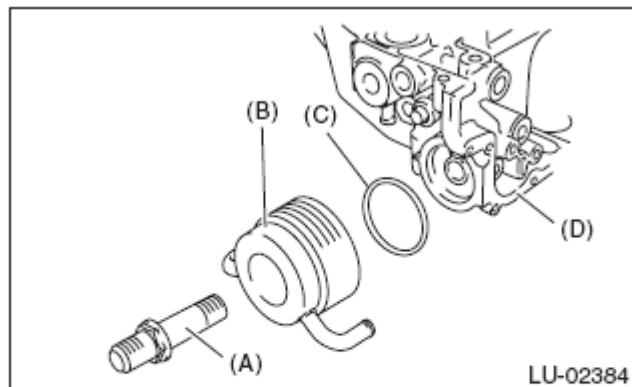


**Fig. 172: Identifying Bolts Secure Oil Pan Lower To Oil Pan Upper**  
Courtesy of SUBARU OF AMERICA, INC.

14. Insert an oil pan cutter blade into the gap between oil pan upper and oil pan lower, and remove the oil pan lower.

**CAUTION: Do not use a screwdriver or similar tools in place of oil pan cutter.**

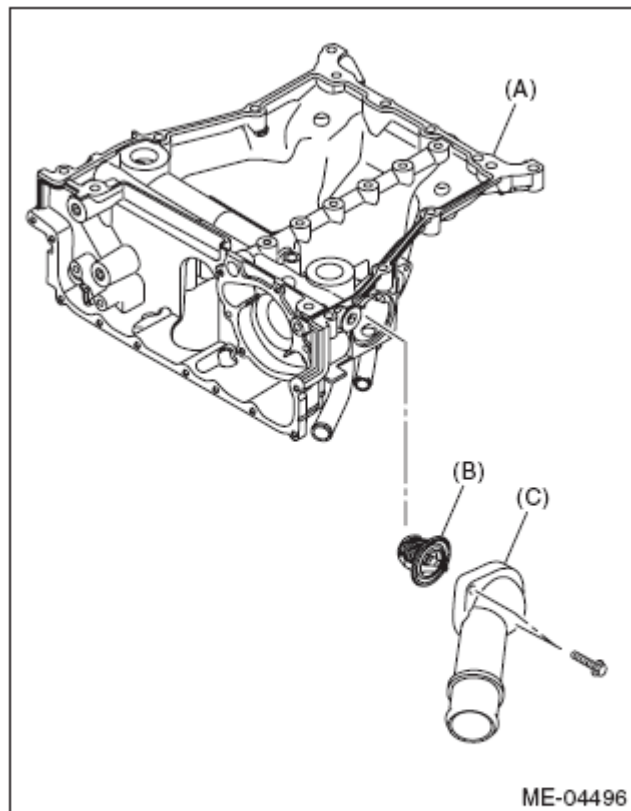
15. Remove the oil cooler connector and remove the oil cooler.



- (A) Oil cooler connector  
(B) Oil cooler  
(C) O-ring  
(D) Oil pan upper

**Fig. 173: Identifying Oil Cooler And Connector, O-Ring**  
Courtesy of SUBARU OF AMERICA, INC.

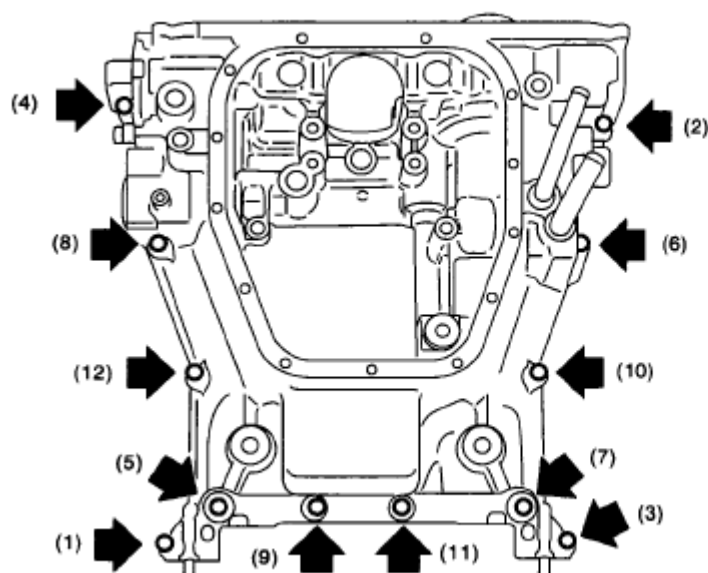
16. Remove the oil pump. < Refer to **REMOVAL** , Oil Pump. >  
17. Remove the thermostat cover, and then remove the thermostat.



- (A) Oil pan upper
- (B) Thermostat
- (C) Thermostat cover

**Fig. 174: Identifying Oil Pan Upper, Thermostat And Cover**  
Courtesy of SUBARU OF AMERICA, INC.

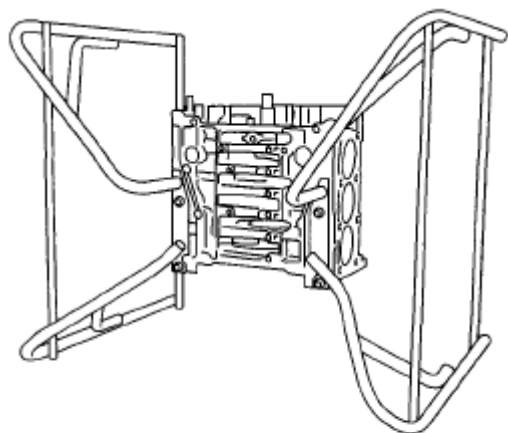
18. Remove the oil pan upper.



ME-03420

**Fig. 175: Identifying Oil Pan Upper Mounting Bolts**  
Courtesy of SUBARU OF AMERICA, INC.

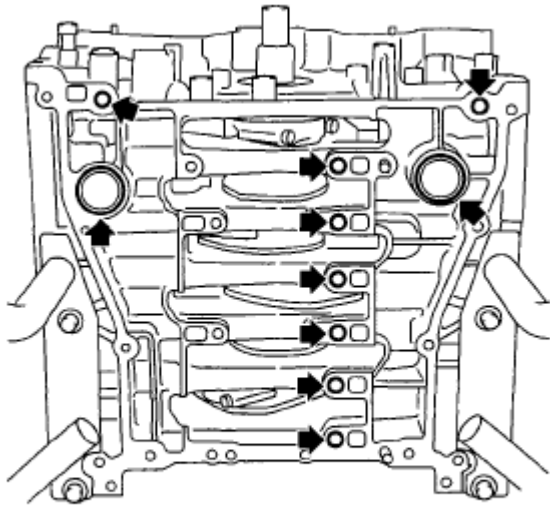
19. Face the front of the engine up, standing the engine on one end.



ME-03421

**Fig. 176: Supporting Engine On One End**  
Courtesy of SUBARU OF AMERICA, INC.

20. Remove ten O-rings from the underside of the cylinder block.



ME-03422

**Fig. 177: Identifying O-Rings From Underside Of Cylinder Block**  
Courtesy of SUBARU OF AMERICA, INC.

21. Mark the direction of front and the number of connecting rod caps.
22. Remove the #1 and #4 connecting rod caps and pistons from the cylinder block.

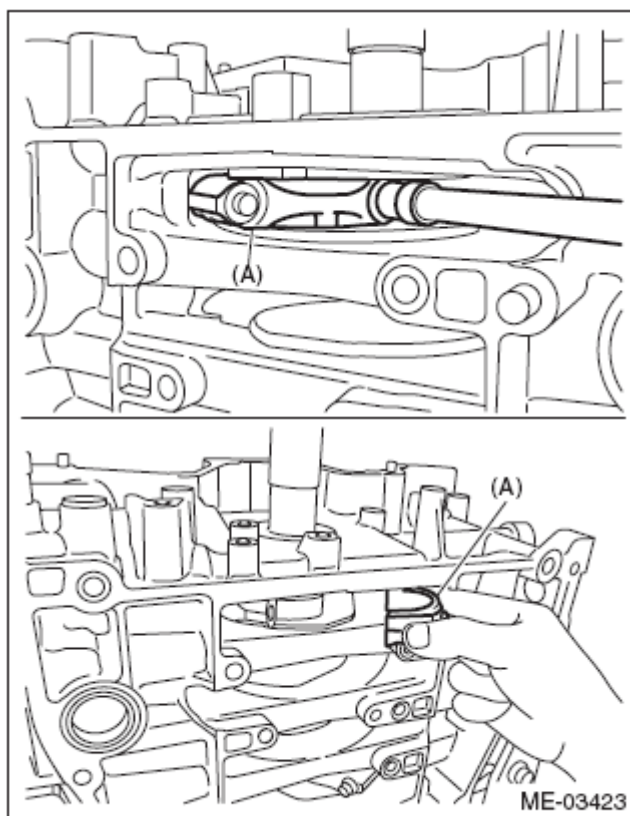
**NOTE:**

- Use 3/8 inch (9.5 sq.) for the extension and TORX® socket (E12).
- After removing the two connecting rod connection bolts, turning the crankshaft (ST) counterclockwise will remove the connecting rod cap.
- Mark each connecting rod cap and piston with connecting rod cap number and piston number.
- The removal of all connecting rod caps and pistons are performed in three separate steps. First, remove the #1 and #4 connecting rod caps and pistons simultaneously, then the #2 and #5 connecting rod caps and pistons simultaneously, and then the #3 and #6 connecting rod caps and pistons simultaneously.

1. Using the ST, turn the crankshaft and set the #1 piston at the mid point between TDC and BDC.

ST 18252AA000 CRANKSHAFT SOCKET

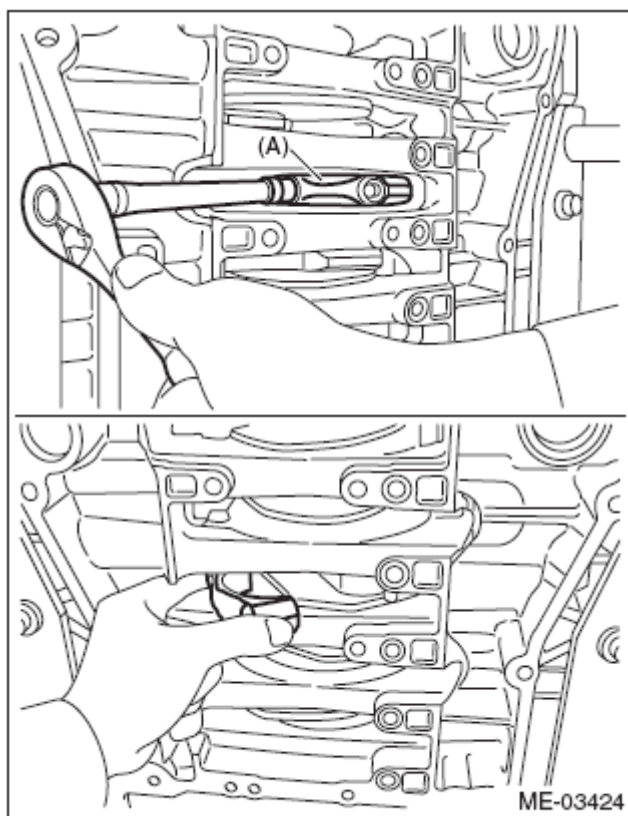
2. Remove the two #1 connecting rod cap connection bolts, and remove the connecting rod cap.



(A) #1 connecting rod cap

**Fig. 178: Turning Crankshaft Using Special Tool**  
Courtesy of SUBARU OF AMERICA, INC.

3. Remove the two #4 connecting rod cap connection bolts, and remove the connecting rod cap.

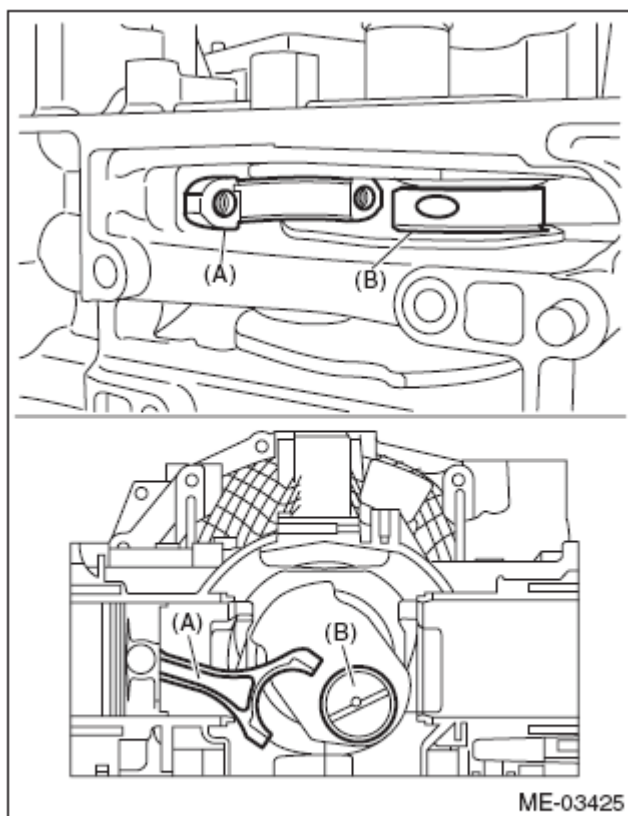


(A) #4 connecting rod cap

**Fig. 179: Removing Connecting Rod Cap Using Tool**  
Courtesy of SUBARU OF AMERICA, INC.

4. Using the ST, turn the crankshaft and separate the positions of the crank pin and the large end of the #1 connecting rod.

ST 18252AA000 CRANKSHAFT SOCKET



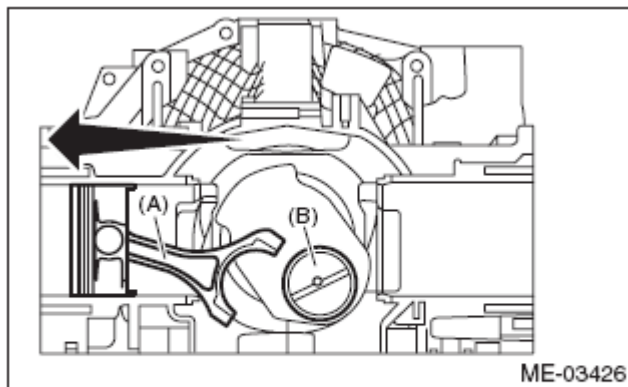
(A) #1 connecting rod

(B) Crank pin

**Fig. 180: Separating The Portions Of The Crank Pin And The Large End Of The Connecting Rod**

Courtesy of SUBARU OF AMERICA, INC.

5. Push the #1 connecting rod in the direction of the arrow, and remove the #1 piston and connecting rod from the cylinder block.



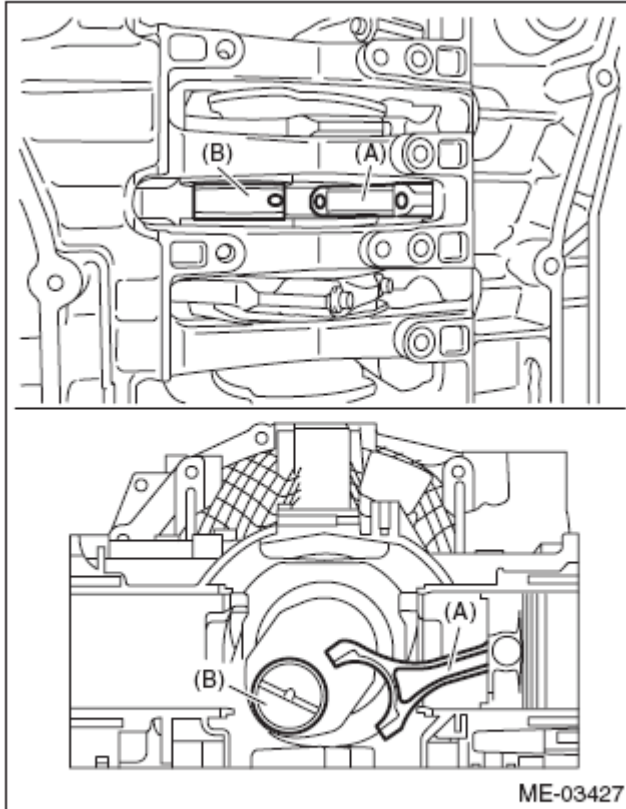
(A) #1 connecting rod

(B) Crank pin

**Fig. 181: Removing Piston And Connecting Rod From Cylinder Block**  
Courtesy of SUBARU OF AMERICA, INC.

6. Using the ST, turn the crankshaft and separate the positions of the crank pin and the large end of the #4 connecting rod.

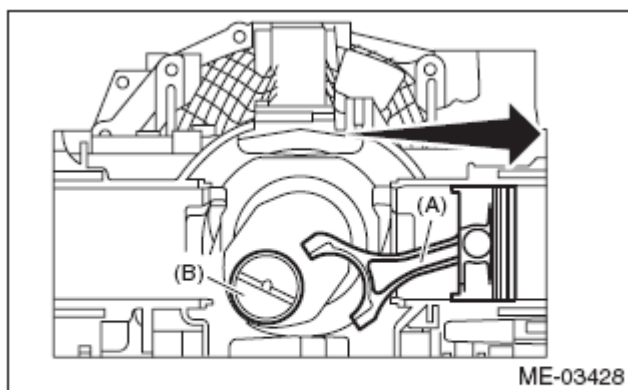
ST 18252AA000 CRANKSHAFT SOCKET



- (A) #4 connecting rod  
(B) Crank pin

**Fig. 182: Separating The Portions Of The Crank Pin And The Large End Of The Connecting Rod**  
Courtesy of SUBARU OF AMERICA, INC.

7. Push the #4 connecting rod in the direction of the arrow, and remove the #4 piston and connecting rod from the cylinder block.



(A) #4 connecting rod

(B) Crank pin

**Fig. 183: Removing No. 4 Piston And Connecting Rod From Cylinder Block**  
Courtesy of SUBARU OF AMERICA, INC.

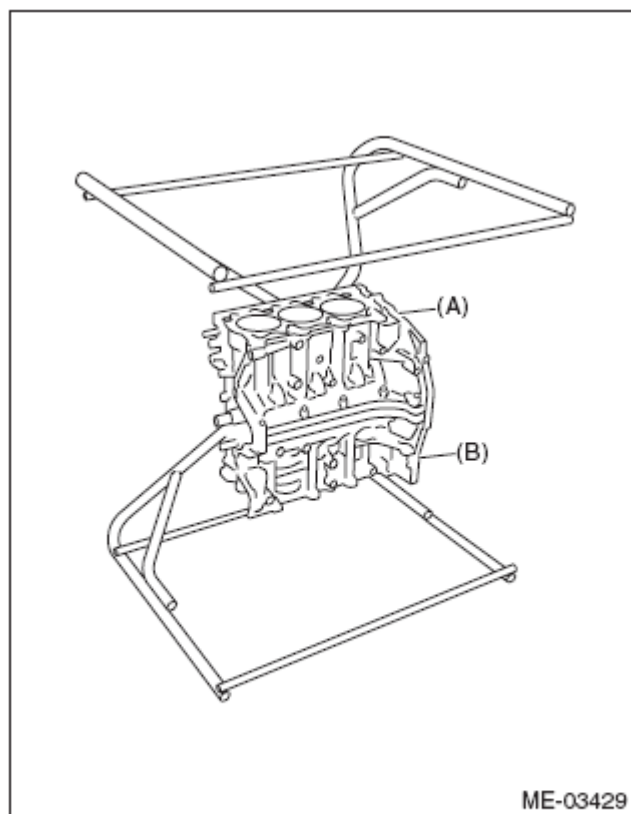
23. Remove the #2 and #5 connecting rods and pistons from the cylinder block in the same manner.

ST 18252AA000 CRANKSHAFT SOCKET

24. Remove the #3 and #6 connecting rods and pistons from the cylinder block in the same manner.

ST 18252AA000 CRANKSHAFT SOCKET

25. Face the cylinder block (RH) up.

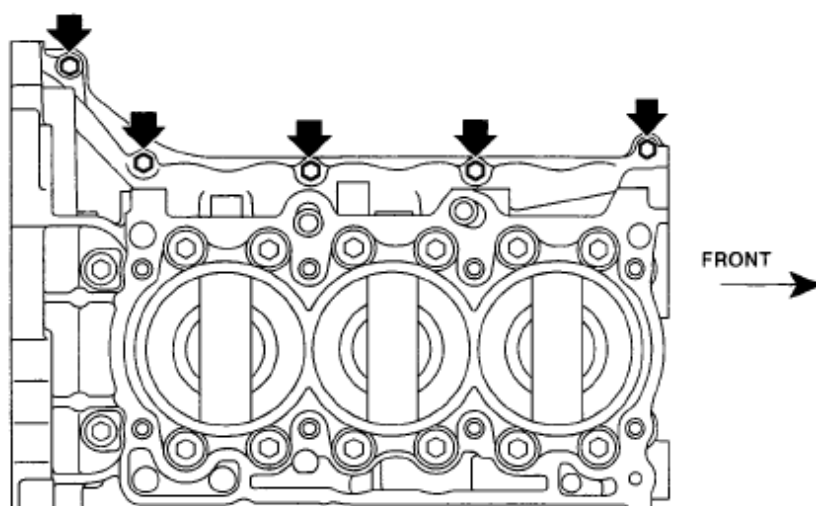


(A) Cylinder block (RH)

(B) Cylinder block (LH)

**Fig. 184: Facing Cylinder Block (RH) Up**  
 Courtesy of SUBARU OF AMERICA, INC.

26. Remove the upper bolt.



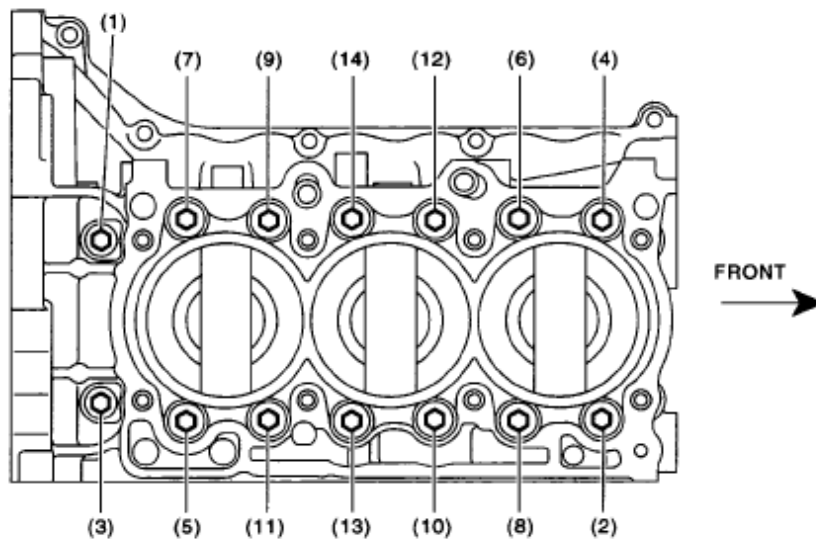
ME-03433

**Fig. 185: Identifying Cylinder Block Upper Bolt**  
 Courtesy of SUBARU OF AMERICA, INC.

27. Loosen the cylinder block bolts in the order indicated in the figure, and separate cylinder block (RH) and (LH).

**NOTE:** 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.



ME-03430

**Fig. 186: Identifying Cylinder Block Bolts Loosening Sequence**  
 Courtesy of SUBARU OF AMERICA, INC.

28. Remove the rear oil seal.  
 29. Remove the crankshaft from cylinder block (LH).  
 30. Remove the crankshaft bearings from cylinder block using a hammer handle.

**NOTE:**

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

## INSTALLATION

1. After setting the cylinder block to ST, install the crankshaft bearing.

ST 18232AA000 ENGINE STAND

**NOTE:** Apply a coat of engine oil to the bearing and crankshaft journal.

2. Mount the crankshaft in cylinder block (LH).
3. Apply liquid gasket to the mating surfaces of cylinder block (RH).

**CAUTION:** Do not allow liquid gasket to run over into oil passages, bearing grooves, etc.

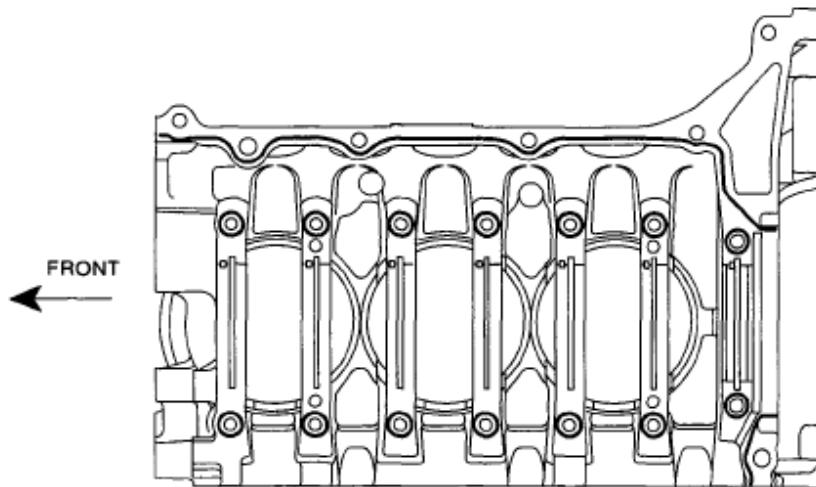
**NOTE:** Install within 5 min. after applying liquid gasket.

*Liquid gasket:*

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

*Liquid gasket applying diameter:*

**$1.0 \pm 0.2$  mm ( $0.039 \pm 0.008$  in)**



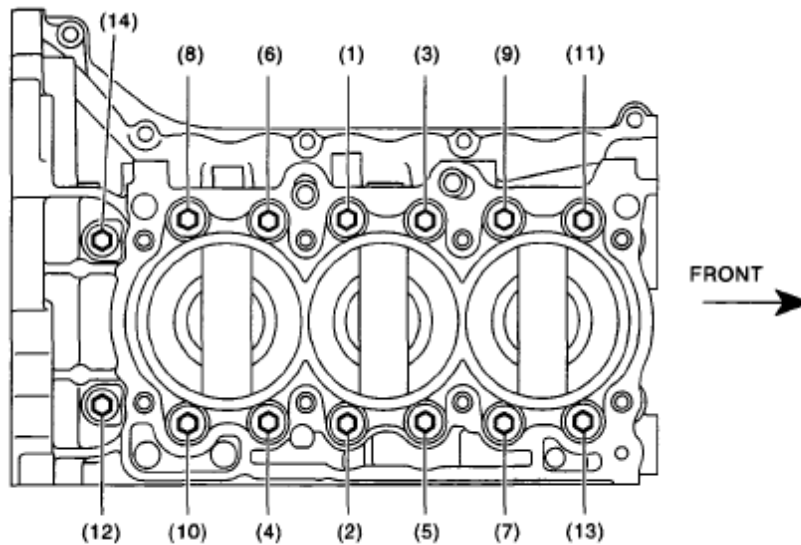
ME-03431

**Fig. 187: Identifying Liquid Gasket Applying Area To Mating Surfaces Of Cylinder Block (RH)**  
Courtesy of SUBARU OF AMERICA, INC.

4. Attach cylinder block (RH) to cylinder block (LH).
5. Apply a coat of engine oil to the washer and bolt thread.
6. Tighten all bolts in the numerical order as shown in the figure.

*Tightening torque:*

**$12$  N.m ( $1.2$  kgf-m,  $8.9$  ft-lb)**



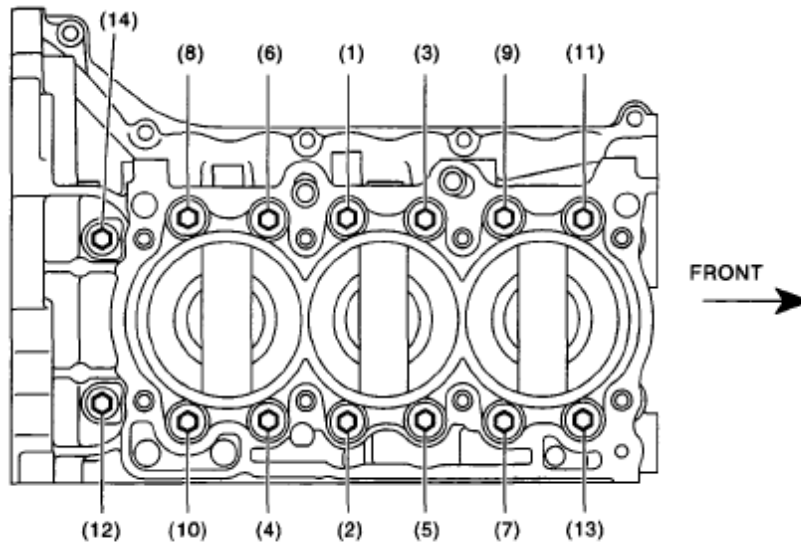
ME-03432

**Fig. 188: Identifying Cylinder Block Bolts Tightening Sequence**  
 Courtesy of SUBARU OF AMERICA, INC.

7. Retighten all bolts in the numerical order as shown in the figure.

**Tightening torque:**

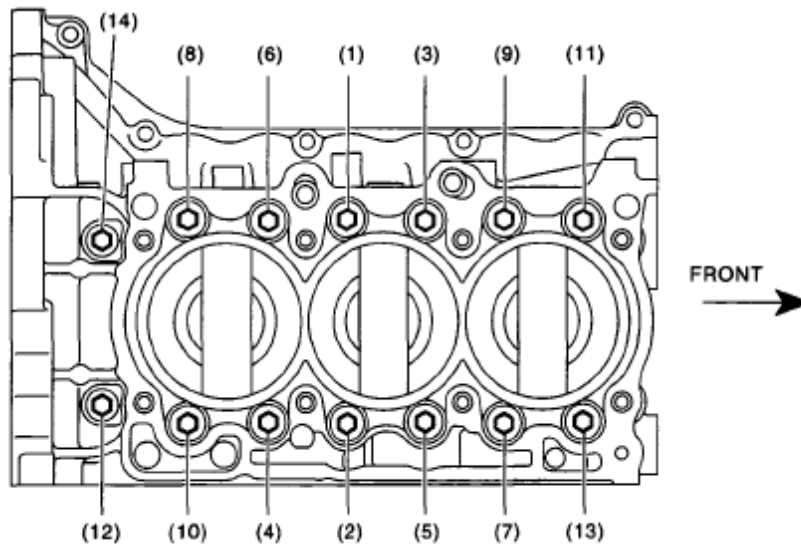
**18 N.m (1.8 kgf-m, 13.3 ft-lb)**



ME-03432

**Fig. 189: Identifying Cylinder Block Bolts Tightening Sequence**  
 Courtesy of SUBARU OF AMERICA, INC.

8. Tighten all bolts by 90° in numerical order as shown in the figure.



ME-03432

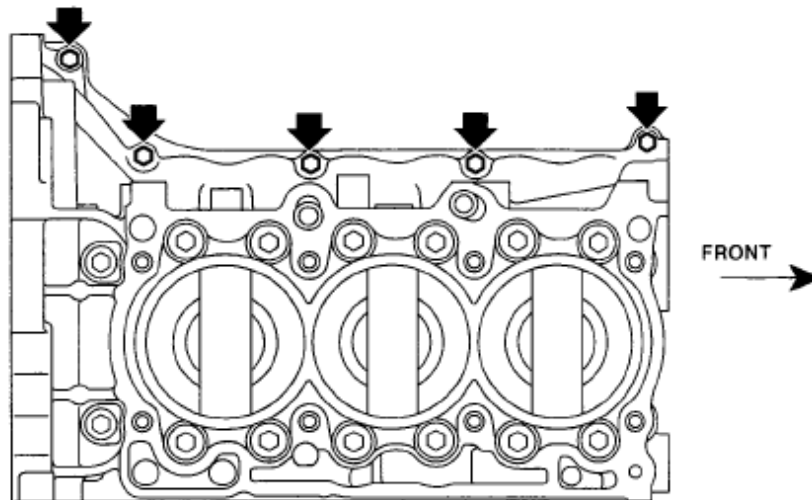
**Fig. 190: Identifying Cylinder Block Bolts Tightening Sequence**  
Courtesy of SUBARU OF AMERICA, INC.

9. Install the upper bolt to cylinder block.

**Tightening torque:**

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

**NOTE:** Remove any liquid gasket squeezed out onto the seal surface between the chain cover and oil pan upper, after tightening the cylinder block connecting bolts.



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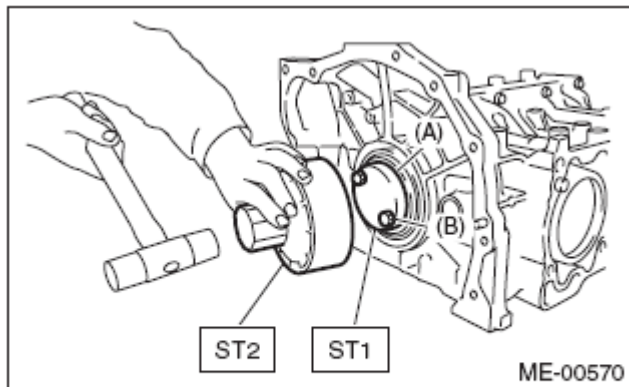
**Fig. 191: Identifying Cylinder Block Upper Bolts**  
Courtesy of SUBARU OF AMERICA, INC.

10. 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 499597100 CRANKSHAFT OIL SEAL GUIDE

ST2 499587200 CRANKSHAFT OIL SEAL INSTALLER

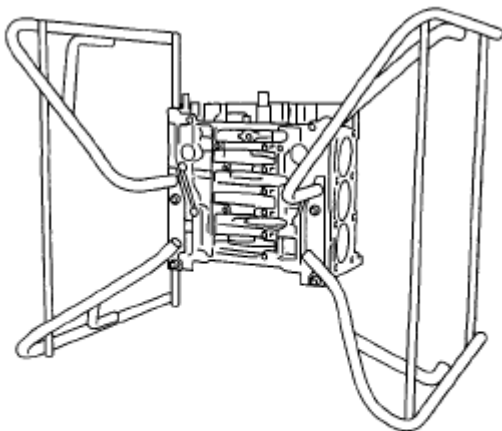


(A) Rear oil seal

(B) Drive plate installation bolt

**Fig. 192: Installing Rear Oil Seal Using Special Tools**  
Courtesy of SUBARU OF AMERICA, INC.

11. Face the front of the engine up, standing the engine on one end.

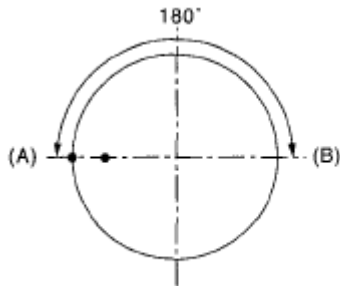


ME-03421

**Fig. 193: Supporting Engine On Stand**

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

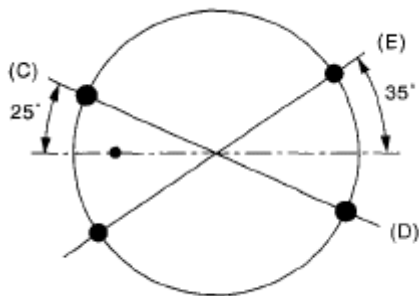
12. Attach the piston ring and oil ring to the piston.
  1. Position the top ring gap at (A) in the figure.
  2. Position the second ring gap at (B).



ME-02066

**Fig. 194: Positioning Top And Second Ring Gap**  
**Courtesy of SUBARU OF AMERICA, INC.**

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



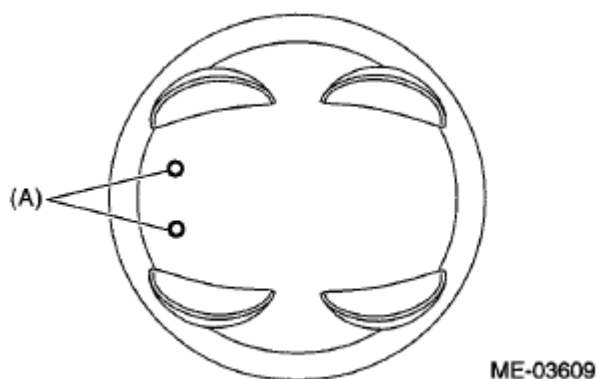
ME-02067

**Fig. 195: Positioning Upper Rail, Expander And Lower Rail Gap**  
**Courtesy of SUBARU OF AMERICA, INC.**

**CAUTION:**

- Make sure ring gaps do not face the same direction.
- Make sure ring gaps are not within the piston skirt area.
- Assemble so that the stamp mark N faces towards the top of the piston.

13. Install the #1 piston and connecting rod to the cylinder block.
  1. Apply engine oil to the outer circumference of the piston and in the cylinder block.
  2. Face the front mark of piston (A) towards the front of the engine, and set the piston to the ST.



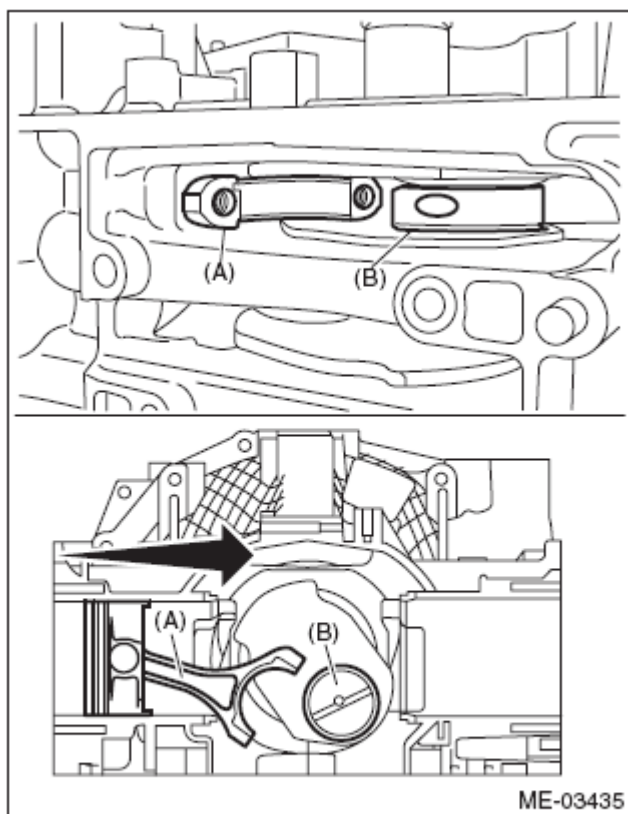
**Fig. 196: Identifying Piston Front Mark**  
Courtesy of SUBARU OF AMERICA, INC.

3. Using ST, press-fit the piston into cylinder block.

**NOTE:** When inserting the piston into the cylinder block, perform according to the items listed below.

- Insert while lightly tapping the top of the piston with the handle of a plastic hammer.
- Insert while making sure that the large end of the connecting rod does not scratch the cylinder liner.
- Insert while continually making sure that the large end of the connecting rod does not touch the crankshaft.

ST 398744300 PISTON GUIDE



(A) #1 connecting rod

(B) Crank pin

**Fig. 197: Identifying Connecting Rod And Crank Pin**  
**Courtesy of SUBARU OF AMERICA, INC.**

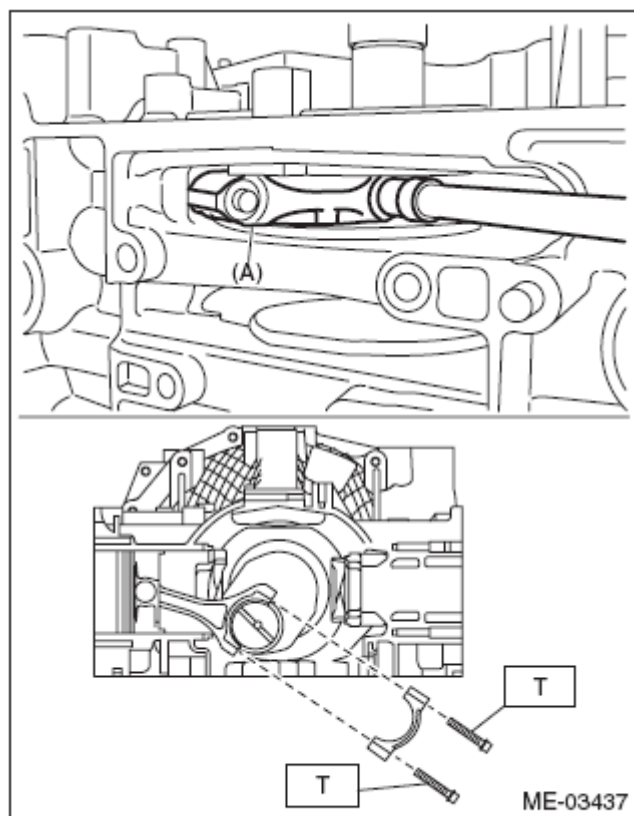
4. Using the ST, turn the crankshaft and match the positions of the crank pin and the large end of the connecting rod.

ST 18252AA000 CRANKSHAFT SOCKET

5. Install the connecting rod cap.

***Tightening torque:***

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



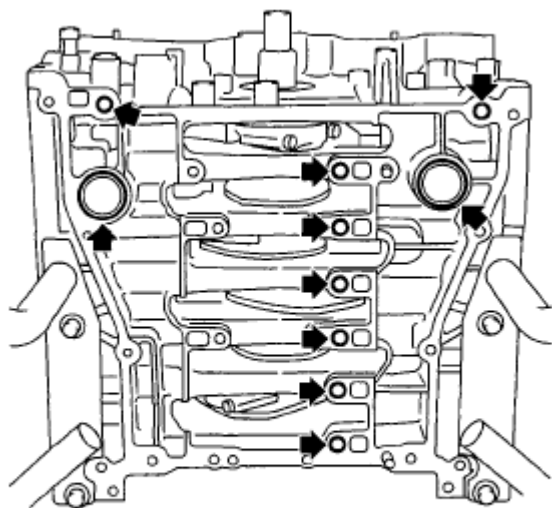
(A) #1 connecting rod

**Fig. 198: Identifying Connecting Rod With Mounting Bolts**

Courtesy of SUBARU OF AMERICA, INC.

14. In the same procedures as for the #1 piston, install the piston and connecting rods to the cylinder block, in the order of #2, #3, #4, #5 and #6.
15. Install the O-ring to the underside of the cylinder block.

**NOTE:**        **Use new O-rings.**



ME-03422

**Fig. 199: Identifying O-Rings On Underside Of Cylinder Block**  
 Courtesy of SUBARU OF AMERICA, INC.

16. Apply liquid gasket to the mating surface of oil pan upper.

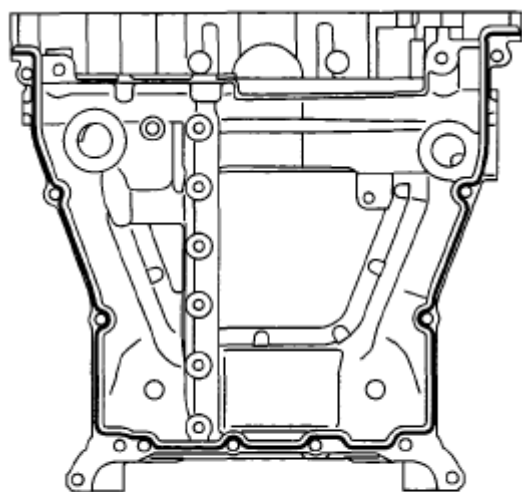
**NOTE:** Install within 5 min. after applying liquid gasket.

*Liquid gasket:*

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

*Liquid gasket applying diameter:*

**5.0±1.0 mm (0.20±0.04 in)**



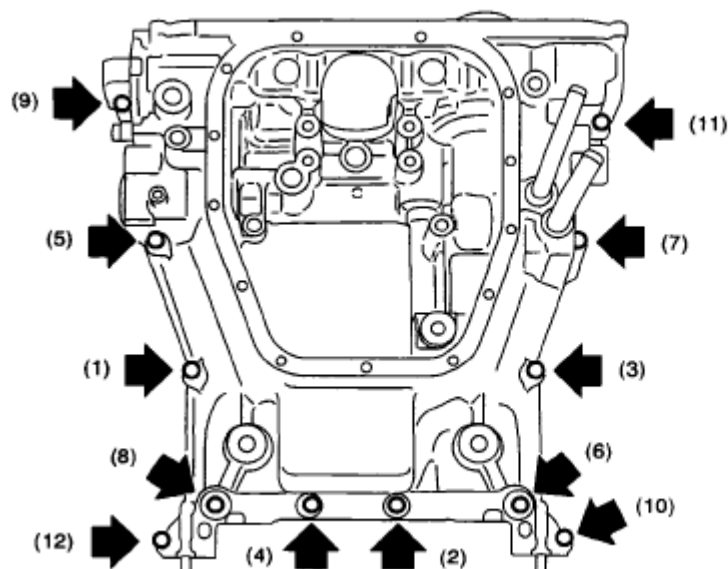
ME-03438

**Fig. 200: Identifying Liquid Gasket Applying Area On Mating Surface Of Oil Pan Upper**  
 Courtesy of SUBARU OF AMERICA, INC.

17. Temporarily tighten the oil pan upper.
18. Tighten the oil pan upper installing bolts in the numerical order as shown in the figure.

***Tightening torque:***

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



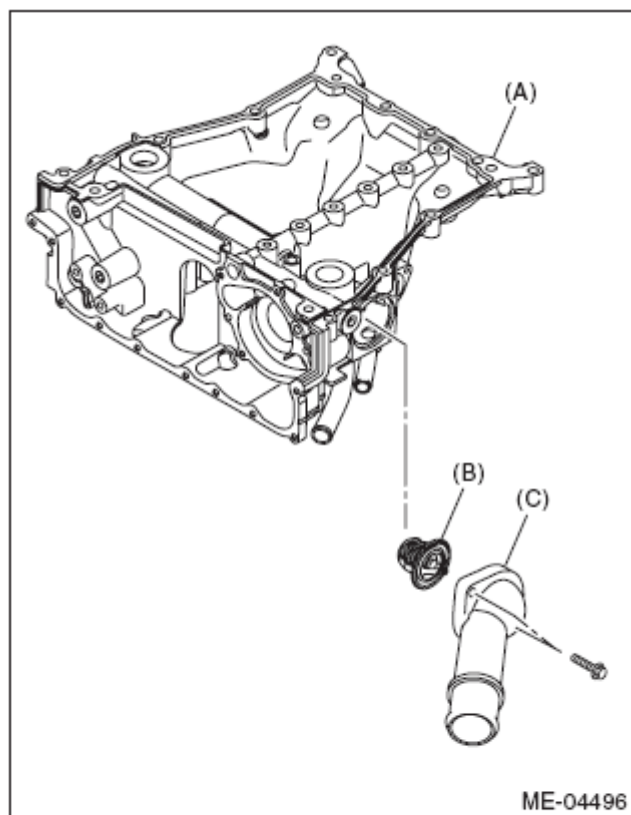
ME-03440

**Fig. 201: Identifying Oil Pan Upper Installing Bolts Tightening Sequence**  
 Courtesy of SUBARU OF AMERICA, INC.

19. Install the thermostat and thermostat cover.

***Tightening torque:***

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



- (A) Oil pan upper  
(B) Thermostat  
(C) Thermostat cover

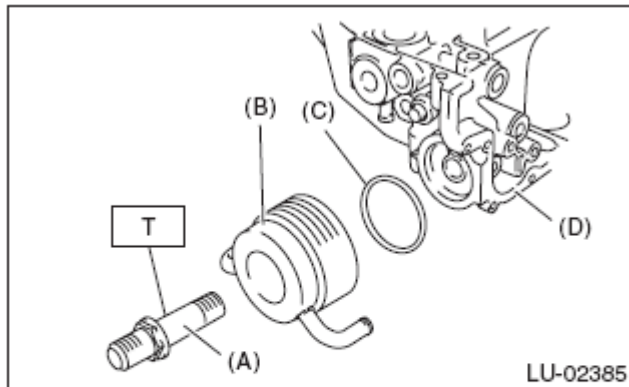
**Fig. 202: Identifying Oil Pan Upper, Thermostat And Cover**  
Courtesy of SUBARU OF AMERICA, INC.

20. Install the oil pump. < Refer to **INSTALLATION** , Oil Pump. >  
21. Tighten the oil cooler connector to install the oil cooler to the oil pan upper.

***Tightening torque:***

***54 N.m (5.5 kgf-m, 39.8 ft-lb)***

**NOTE:        Use new O-rings.**



- (A) Oil cooler connector
- (B) Oil cooler
- (C) O-ring
- (D) Oil pan upper

**Fig. 203: Tightening Oil Cooler Connector**  
Courtesy of SUBARU OF AMERICA, INC.

22. Apply liquid gasket to the matching surface of oil pan lower.

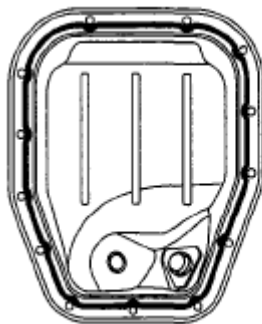
**NOTE:** Install within 5 min. after applying liquid gasket.

*Liquid gasket:*

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

*Liquid gasket applying diameter:*

**5.0±1.0 mm (0.20±0.04 in)**

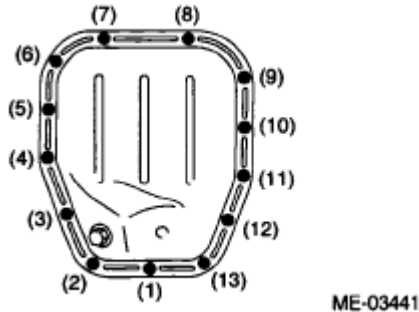


**Fig. 204: Identifying Liquid Gasket Applying Area On Matching Surface Of Oil Pan Lower**  
Courtesy of SUBARU OF AMERICA, INC.

23. Tighten the oil pan lower installing bolts in the numerical order as shown in the figure.

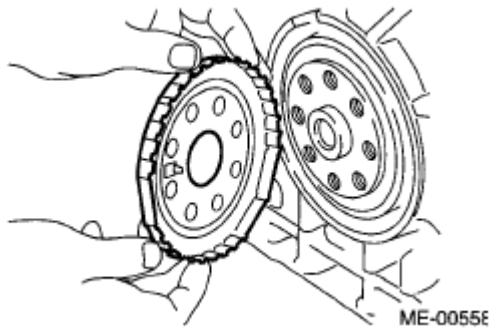
***Tightening torque:***

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



**Fig. 205: Identifying Oil Pan Lower Installing Bolts Tightening Sequence**  
 Courtesy of SUBARU OF AMERICA, INC.

24. Install the crankshaft position sensor plate.

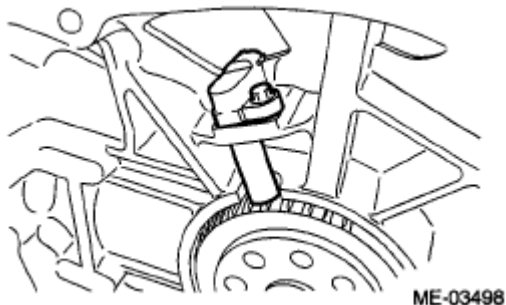


**Fig. 206: Identifying Crankshaft Position Sensor Plate**  
 Courtesy of SUBARU OF AMERICA, INC.

25. Install the crankshaft position sensor.

***Tightening torque:***

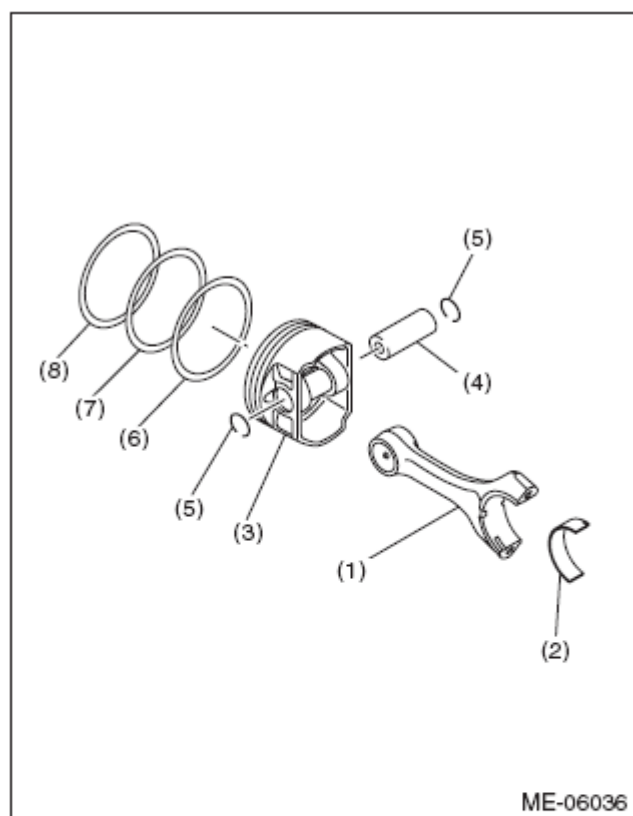
**6.4 N.m (0.7 kgf-m, 4.7 ft-lb)**



**Fig. 207: Identifying Crankshaft Position Sensor**  
**Courtesy of SUBARU OF AMERICA, INC.**

26. Install the drive plate. < Refer to **INSTALLATION** , Drive Plate. >
27. Install the cylinder head. < Refer to **INSTALLATION**, Cylinder Head. >
28. Install the camshaft. < Refer to **INSTALLATION**, Camshaft. >
29. Install the crank sprocket. < Refer to **INSTALLATION**, Crank Sprocket. >
30. Install the cam sprocket. < Refer to **INSTALLATION**, Cam Sprocket. >
31. Install the timing chain assembly. < Refer to **INSTALLATION**, Timing Chain Assembly. >
32. Install the chain cover. < Refer to **INSTALLATION**, Chain Cover. >
33. Install the crank pulley. < Refer to **INSTALLATION**, Crank Pulley. >
34. Install the engine to the vehicle. < Refer to **INSTALLATION**, Engine Assembly. >

**DISASSEMBLY**



ME-06036

- (1) Connecting rod
- (2) Connecting rod bearing
- (3) Piston
- (4) Piston pin
- (5) Circlip
- (6) Oil ring
- (7) Second ring
- (8) Top ring

**Fig. 208: Identifying 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.
2. Remove the piston rings using piston ring expander.
3. Remove the oil ring by hand.

**NOTE:** Arrange the removed piston rings in proper order, to prevent confusion.

4. Remove the circlip on one end from the piston using a flat tip screwdriver.

**NOTE:**        **Be careful not damage the piston, by wrapping the tip of flat tip screwdriver with tape.**

5. Remove the piston pin from the piston.
6. Separate the piston and connecting rod.

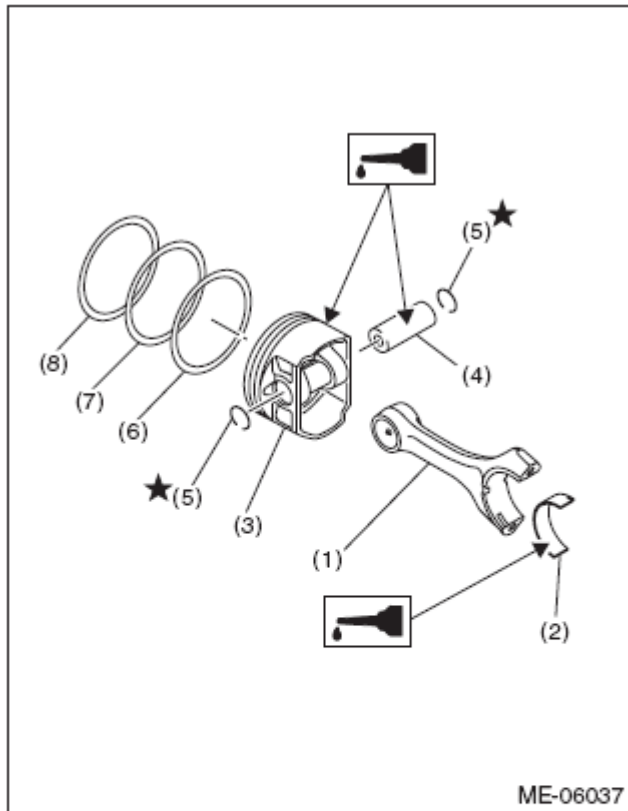
**NOTE:**        **Mark the direction of front side to each connecting rod.**

7. Remove the circlip on other end from the piston using a flat tip screwdriver.

**NOTE:**        **Be careful not damage the piston, by wrapping the tip of flat tip screwdriver with tape.**

8. Remove the plug and orifice from the cylinder block as necessary. < Refer to **CYLINDER BLOCK**, COMPONENT, General Description. >

## **ASSEMBLY**



- (1) Connecting rod
- (2) Connecting rod bearing
- (3) Piston
- (4) Piston pin
- (5) Circlip
- (6) Oil ring
- (7) Second ring
- (8) Top ring

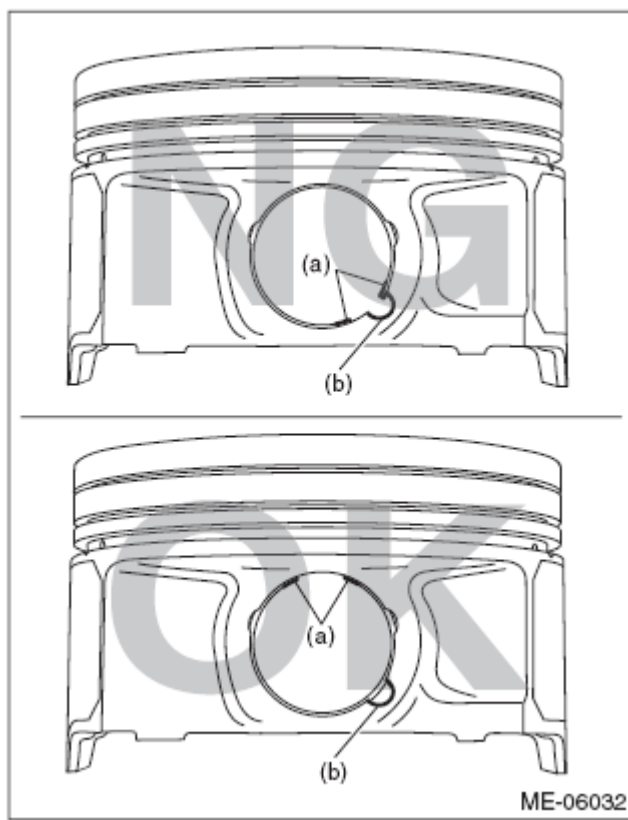
**Fig. 209: Identifying Connecting Rod And Related Components**

Courtesy of SUBARU OF AMERICA, INC.

1. Apply engine oil to the surface of the connecting rod bearing. Attach the connecting rod bearing to the connecting rod.
2. Install the circlip on one end of the piston using a flat tip screwdriver.

**NOTE:**

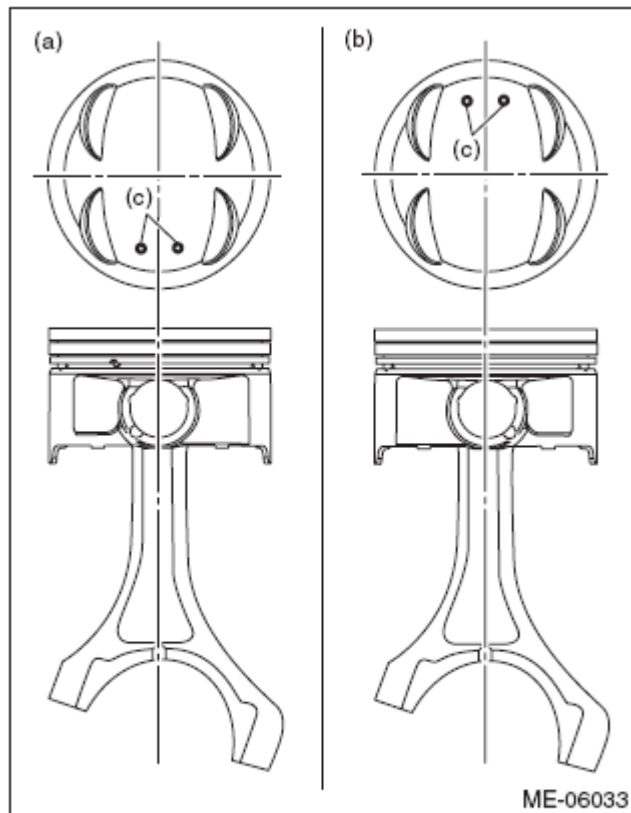
- Be careful not damage the piston, by wrapping the tip of flat tip screwdriver with tape.
- Make sure the circlip is firmly inserted into the circlip groove.
- After installing the circlip, rotate the circlip so that its end part (a) and the cutout portion of circlip groove (b) do not match.



**Fig. 210: Caution For Setting Piston To Connecting Rod**  
**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.**



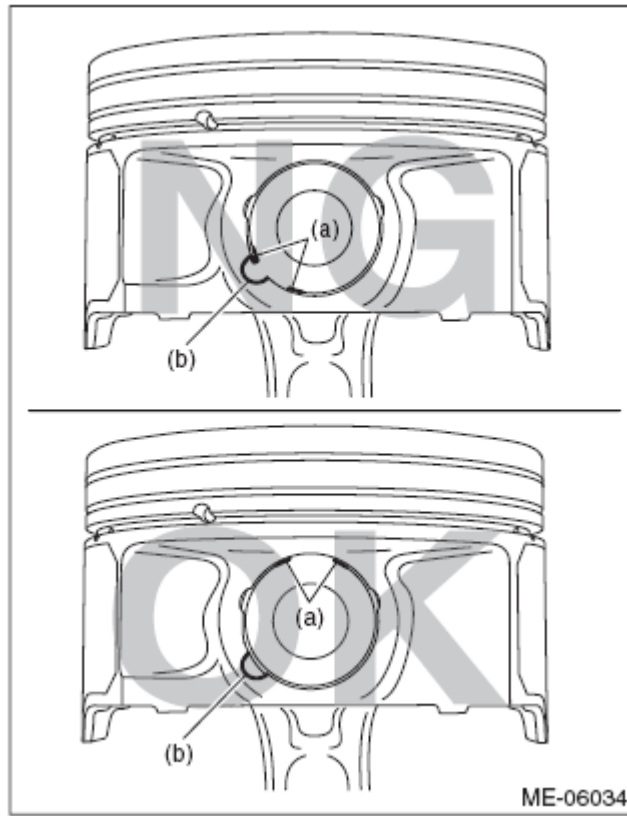
- (a) RH side (#1, #3 and #5)  
(b) LH side (#2, #4 and #6)  
(c) Front mark

**Fig. 211: Aligning Front Mark Of Piston And Connecting Rod Direction Correctly**  
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. 212: Caution For Installing Circlip**  
**Courtesy of SUBARU OF AMERICA, INC.**

6. Install the oil ring upper rail, expander and lower rail by hand.
7. Install the second ring and top ring using piston ring expander.
8. Install the plug and orifice to the cylinder block as necessary. < Refer to **CYLINDER BLOCK**, COMPONENT, General Description. >

## INSPECTION

### CYLINDER BLOCK

1. Visually check for cracks or damage. Use liquid penetrant tester on the important sections for checking. Check that there are no marks of gas leaking or water leaking on gasket installing surface.
2. Check the oil passages for clogging.
3. Inspect the cylinder block surface that mates with cylinder head for warping by using a straight edge. If the warpage exceeds limit, replace the cylinder block.

***Warping limit:***

***0.020 mm (0.0008 in)***

**Standard height of cylinder block:**

**202 mm (7.95 in)**

## CYLINDER AND PISTON

1. The cylinder bore size is stamped on the front upper face of the cylinder block.

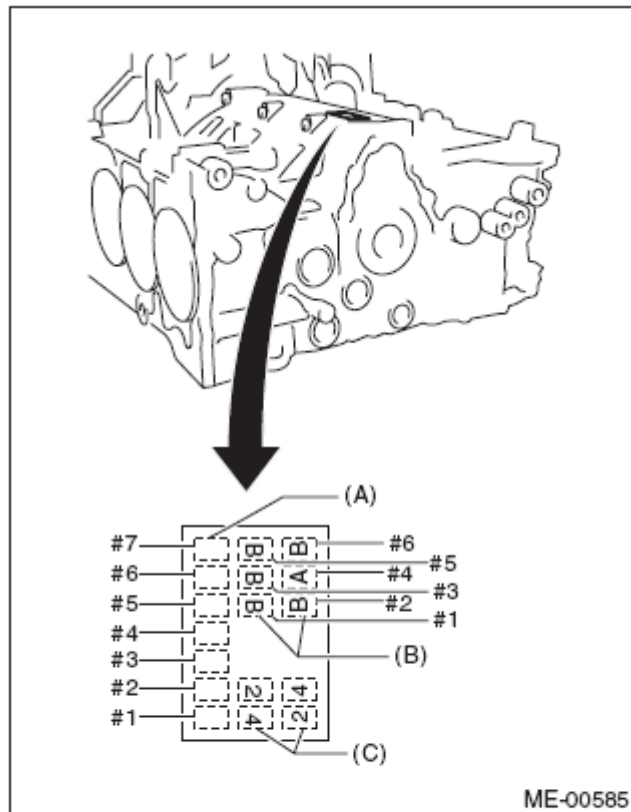
### NOTE:

- Measurement should be performed at a temperature of 20°C (68°F).
- Standard sized pistons are classified into two grades, "A" and "B". These grades should be used as guide lines in selecting a standard piston.

**Standard diameter:**

**A: 92.005 - 92.015 mm (3.6222 - 3.6226 in)**

**B: 91.995 - 92.005 mm (3.6218 - 3.6222 in)**



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

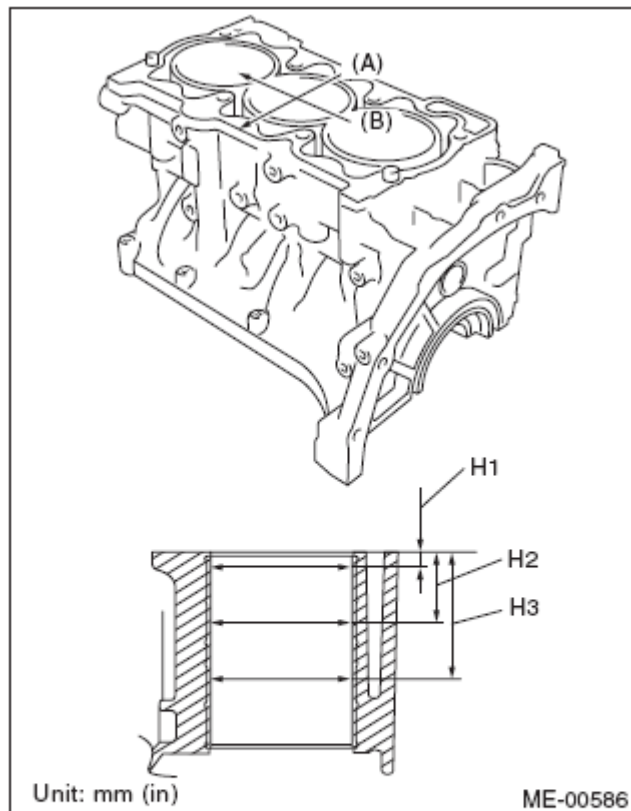
**Fig. 213: Identifying Main Journal And Cylinder Bore Size Mark, Cylinder Block Combination Mark****Courtesy of SUBARU OF AMERICA, INC.**

2. Measure inner diameter of each cylinder.

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

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

***Cylindricity:******Limit******0.030 mm (0.0012 in)******Out-of-roundness:******Limit******0.010 mm (0.0004 in)***



(A) Thrust direction

(B) Piston pin direction

H1: 10 mm (0.39 in)

H2: 45 mm (1.77 in)

H3: 80 mm (3.15 in)

**Fig. 214: Measuring Inner Diameter Of Each Cylinder In Both Thrust And Piston Pin Directions**  
**Courtesy of SUBARU OF AMERICA, INC.**

3. When the piston is to be replaced due to general or cylinder wear, select a suitable sized piston by measuring the piston clearance.
4. Measure outer diameter of each piston.

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

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

**Piston grade point H:**

**37.3 mm (1.4685 in)**

**Piston outer diameter:**

**Standard**

**A: 92.005 - 92.015 mm (3.6222 - 3.6226 in)**

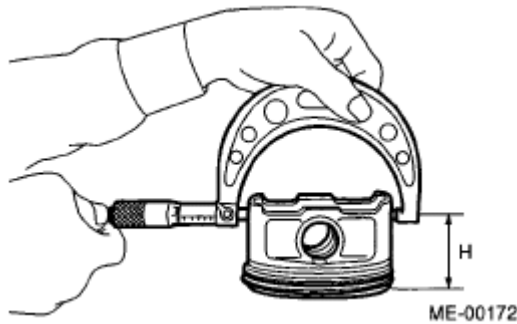
**B: 91.995 - 92.005 mm (3.6218 - 3.6222 in)**

**0.25 mm (0.0098 in) oversize**

**92.245 - 92.265 mm (3.6317 - 3.6325 in)**

**0.50 mm (0.0197 in) oversize**

**92.495 - 92.515 mm (3.6415 - 3.6423 in)**



**Fig. 215: Measuring Outer Diameter Of Each Piston At Height**  
Courtesy of SUBARU OF AMERICA, INC.

5. Calculate the clearance between cylinder and piston.

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

**Clearance between cylinder and piston at 20°C (68°F):**

**Standard**

**-0.010 - 0.010 mm (-0.0004 - 0.0004 in)**

6. Boring and honing

1. If any of the measured value of cylindricality, out-of-roundness or cylinder-to-piston clearance is out of standard or if there is any damage on the cylinder wall, rebores it to replace with an oversize piston.

**CAUTION:** When any of the cylinders needs reboring, all other cylinders must be bored at the same time, and replaced with oversize pistons.

2. If the cylinder inner diameter exceeds the limit after boring and honing, replace the cylinder block.

**NOTE:** Immediately after reboring, the cylinder diameter may differ from its real diameter due to temperature rise. Thus, when measuring the cylinder diameter, wait until it has cooled to room temperature.

*Cylinder inner diameter boring limit (diameter):*

*To 92.515 mm (3.6717 in)*

#### PISTON AND PISTON PIN

1. Check the piston and piston pin for damage, cracks or wear. Replace if faulty.
2. Check the piston ring groove for wear or damage. Replace if faulty.
3. Make sure that the piston pin can be inserted into the piston pin hole with a thumb at 20°C (68°F). Replace if faulty.

*Clearance between piston pin hole and piston pin:*

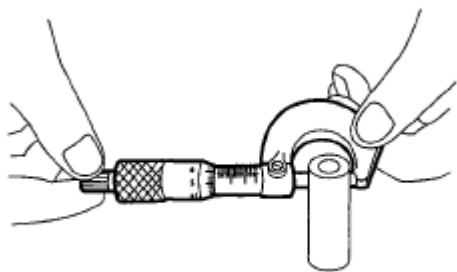
*Standard*

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



ME-00173

**Fig. 216: Measuring Clearance Between Piston Pin Hole And Piston Pin**  
Courtesy of SUBARU OF AMERICA, INC.

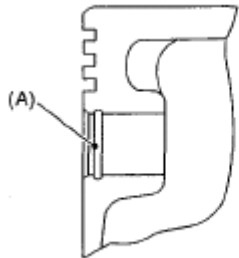


ME-00174

**Fig. 217: Measuring Piston Pin Outer Diameter**

Courtesy of SUBARU OF AMERICA, INC.

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



ME-00175

**Fig. 218: Identifying Snap Ring Installation Groove On Piston**  
Courtesy of SUBARU OF AMERICA, INC.

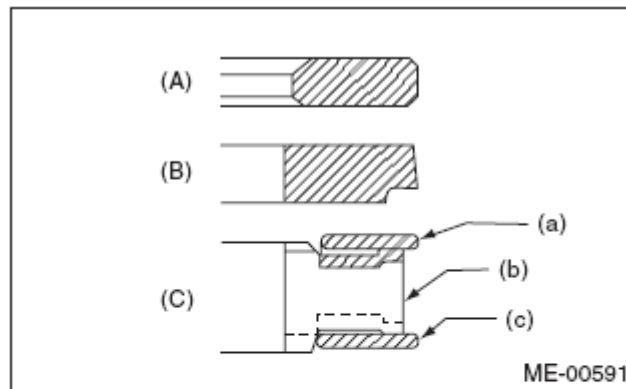
5. Check the piston pin snap ring for distortion, cracks and wear.

#### PISTON RING

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

#### NOTE:

- The top ring and second ring have the mark to determine the direction for installing. When installing the ring to piston, face marks to the top side.
- Oil ring consists of the upper rail, expander and lower rail. When installing to the piston, be careful of the direction of each rail.

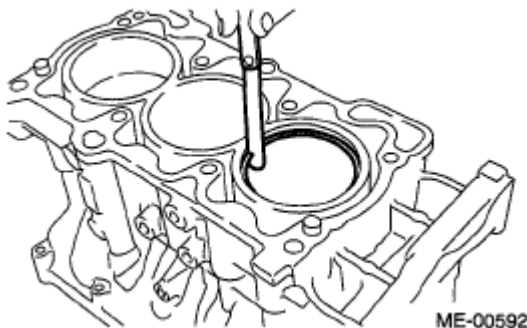


- (A) Top ring
- (B) Second ring
- (C) Oil ring
- (a) Upper rail
- (b) Expander
- (c) Lower rail

**Fig. 219: Identifying Rings And Related Components**  
**Courtesy of SUBARU OF AMERICA, INC.**

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

|                 |             | Standard<br>mm (in)           |
|-----------------|-------------|-------------------------------|
| Piston ring gap | Top ring    | 0.20 - 0.35 (0.0079 - 0.0138) |
|                 | Second ring | 0.40 - 0.50 (0.0157 - 0.0197) |
|                 | Oil ring    | 0.20 - 0.50 (0.0079 - 0.0197) |

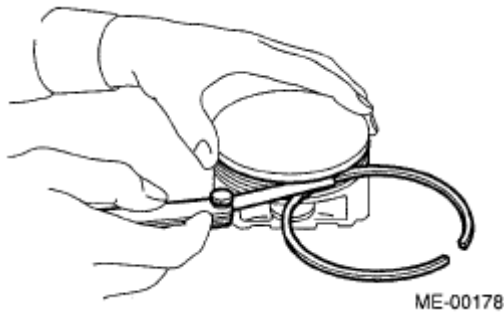


**Fig. 220: Measuring Piston Ring Gap Using Thickness Gauge**  
**Courtesy of SUBARU OF AMERICA, INC.**

3. Fit the piston ring straight into the piston ring groove, then measure the clearance between piston ring and piston ring groove with a thickness gauge.

**NOTE:** Before measuring the clearance, clean the piston ring groove and piston ring.

|                                                      |             | Standard<br>mm (in)             |
|------------------------------------------------------|-------------|---------------------------------|
| Clearance between piston ring and piston ring groove | Top ring    | 0.040 - 0.080 (0.0016 - 0.0031) |
|                                                      | Second ring | 0.030 - 0.070 (0.0012 - 0.0028) |
| Clearance between oil ring and oil ring groove       |             | 0.065 - 0.165 (0.0026 - 0.0065) |



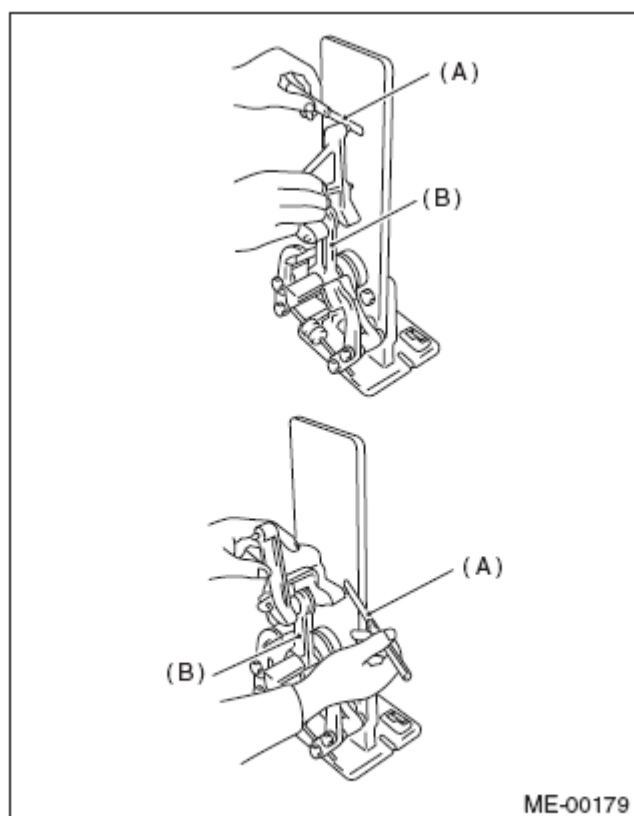
**Fig. 221: Measuring Clearance Between Piston Ring And Piston Ring Groove**  
Courtesy of SUBARU OF AMERICA, INC.

#### CONNECTING ROD

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

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

***0.10 mm (0.0039 in)***



(A) Thickness gauge

(B) Connecting rod

**Fig. 222: Checking Connecting Rod Bend Or Twist Using Aligner**

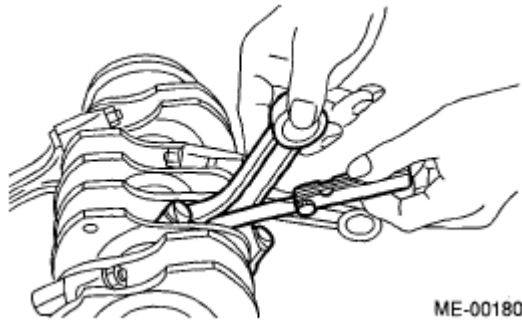
Courtesy of SUBARU OF AMERICA, INC.

3. Install the connecting rod with bearings attached to the crankshaft, and using a thickness gauge, measure the thrust clearance. If the thrust clearance exceeds the standard or uneven wear is found, replace the connecting rod.

***Connecting rod thrust clearance:***

***Standard***

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



**Fig. 223: Measuring Connecting Rod Thrust Clearance Using Thickness Gauge**  
**Courtesy of SUBARU OF AMERICA, INC.**

4. Inspect the connecting rod bearing for scar, peeling, seizure, melting, wear, etc.
5. Measure the oil clearance on each connecting rod bearing using plastigauge. If any oil clearance is not within the standard, replace the defective bearing with a new part of standard size or undersize as necessary.

***Connecting rod oil clearance:***

***Standard***

***0.016 - 0.043 mm (0.0006 - 0.0017 in)***

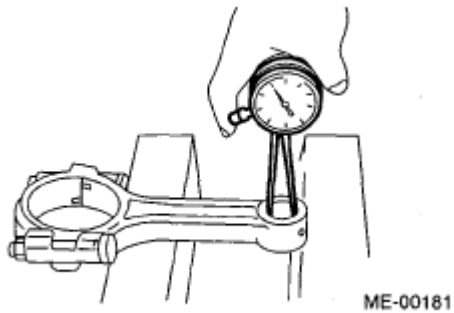
| Unit: mm (in)           |                                    |                                   |
|-------------------------|------------------------------------|-----------------------------------|
| Bearing                 | Bearing size (Thickness at center) | Outer diameter of crank pin       |
| Standard                | 1.489 - 1.505 (0.0586 - 0.0593)    | 51.976 - 52.000 (2.0463 - 2.0472) |
| 0.03 (0.0012) Undersize | 1.507 - 1.515 (0.0593 - 0.0596)    | 51.954 - 51.970 (2.0454 - 2.0461) |
| 0.05 (0.0020) Undersize | 1.517 - 1.525 (0.0597 - 0.0600)    | 51.934 - 51.950 (2.0446 - 2.0453) |
| 0.25 (0.0098) Undersize | 1.617 - 1.625 (0.0637 - 0.0640)    | 51.734 - 51.750 (2.0368 - 2.0374) |

6. Inspect the bushing at connecting rod small end, and replace with a new part if worn or damaged.
7. Measure the piston pin clearance at connecting rod small end. If the measured value is not within the standard, replace it with a new part.

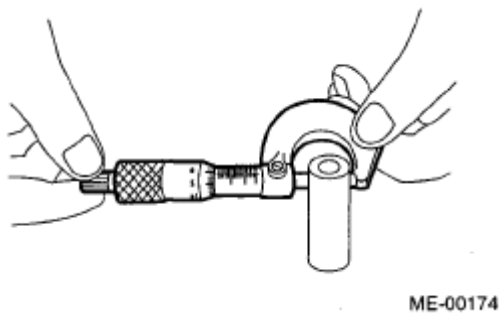
***Clearance between piston pin and bushing:***

***Standard***

***0 - 0.022 mm (0 - 0.0009 in)***



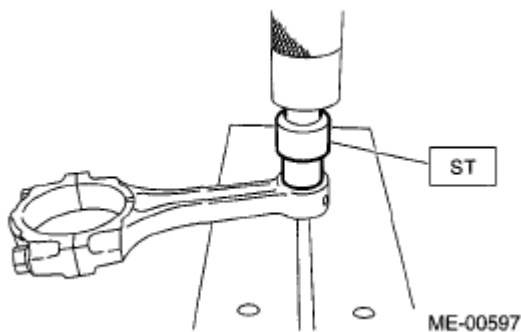
**Fig. 224: Measuring Clearance Between Piston Pin And Bushing**  
Courtesy of SUBARU OF AMERICA, INC.



**Fig. 225: Measuring Piston Pin Outer Diameter**  
Courtesy of SUBARU OF AMERICA, INC.

8. The replacement procedure for the connecting rod small end bushing is as follows.
  1. Remove the bushing from connecting rod with ST and press.
  2. Press the bushing with the ST after applying oil on the periphery of new bushing.

ST 18350AA000 CONNECTING ROD BUSHING REMOVER AND INSTALLER



**Fig. 226: Pressing Connecting Rod Bushing Using Special Tool**  
Courtesy of SUBARU OF AMERICA, INC.

3. Make two 3 mm (0.12 in) holes in the pressed bushing to match the pre-manufactured holes on the connecting rod, then ream the inside of the bushing.

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

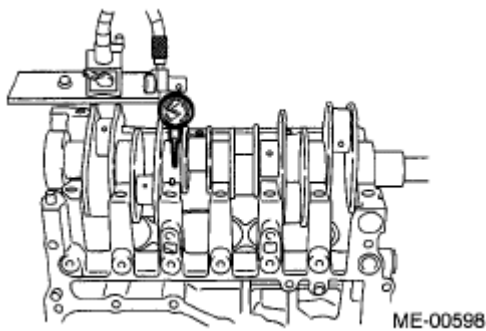
## CRANKSHAFT AND CRANKSHAFT BEARING

1. Clean the crankshaft completely, and check it for cracks using liquid penetrant tester. If defective, replace the crankshaft.
2. Check the crankshaft for bend, and repair or replace if needed. If it exceeds the limit, correct or replace it.

**NOTE:** If a suitable V-block is not available, using the #1 and #7 crankshaft bearings on cylinder block, position the crankshaft on cylinder block. Then, measure the crankshaft bend using a dial gauge.

*Crankshaft bend limit:*

*0.035 mm (0.0014 in)*



**Fig. 227: Measuring Crankshaft Bend Limit Using Dial Gauge**  
Courtesy of SUBARU OF AMERICA, INC.

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

*Crank pin:*

*Out-of-roundness*

*Limit*

*0.005 mm (0.0002 in)*

*Cylindricity*

*Limit*

*0.006 mm (0.0002 in)*

**Grinding limit (dia.)**

**To 51.734 mm (2.0368 in)**

**Crank journal:**

**Out-of-roundness**

**Limit**

**0.005 mm (0.0002 in)**

**Cylindricity**

**Limit**

**0.006 mm (0.0002 in)**

**Grinding limit (dia.)**

**To 63.742 mm (2.5095 in)**



**Fig. 228: Checking Crank Journal**  
Courtesy of SUBARU OF AMERICA, INC.

| Unit: mm (in)              |                                       |                                    |                                    |                                    |                                      |
|----------------------------|---------------------------------------|------------------------------------|------------------------------------|------------------------------------|--------------------------------------|
|                            |                                       | Crank journal diameter             |                                    |                                    | Crank pin outer diameter             |
|                            |                                       | #1, #3, #5                         | #7                                 | #2, #4, #6                         |                                      |
| Standard                   | Journal O.D.                          | 63.992 - 64.016 (2.5194 - 2.5203)  |                                    |                                    | 51.976 - 52.000<br>(2.0463 - 2.0472) |
|                            | Bearing size<br>(Thickness at center) | 1.996 - 2.013<br>(0.0786 - 0.0793) | 1.992 - 2.009<br>(0.0784 - 0.0791) | 1.996 - 2.013<br>(0.0786 - 0.0793) | 1.489 - 1.505<br>(0.0586 - 0.0593)   |
| 0.03 (0.0012)<br>Undersize | Journal O.D.                          | 63.962 - 63.978 (2.5182 - 2.5188)  |                                    |                                    | 51.954 - 51.970<br>(2.0454 - 2.0461) |
|                            | Bearing size<br>(Thickness at         | 2.011 - 2.014<br>(0.0792 -         | 2.011 - 2.014<br>(0.0792 -         | 2.015 - 2.018<br>(0.0793 -         | 1.507 - 1.515                        |

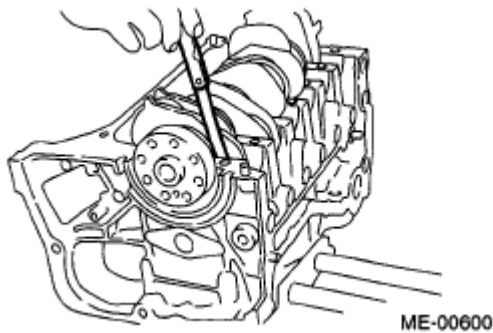
|                            |                                          |                                       |                                       |                                       |                                      |
|----------------------------|------------------------------------------|---------------------------------------|---------------------------------------|---------------------------------------|--------------------------------------|
|                            | center)                                  | 0.0793)                               | 0.0793)                               | 0.0794)                               | (0.0593 - 0.0596)                    |
| 0.05 (0.0020)<br>Undersize | Journal O.D.                             | 63.942 - 63.958 (2.5174 - 2.5180)     |                                       |                                       | 51.934 - 51.950<br>(2.0446 - 2.0453) |
|                            | Bearing size<br>(Thickness at<br>center) | 2.021 - 2.024<br>(0.0796 -<br>0.0797) | 2.021 - 2.024<br>(0.0796 -<br>0.0797) | 2.025 - 2.028<br>(0.0797 -<br>0.0798) | 1.517 - 1.525<br>(0.0597 - 0.0600)   |
| 0.25 (0.0098)<br>Undersize | Journal O.D.                             | 63.742 - 63.758 (2.5095 - 2.5102)     |                                       |                                       | 51.734 - 51.750<br>(2.0368 - 2.0374) |
|                            | Bearing size<br>(Thickness at<br>center) | 2.121 - 2.124<br>(0.0835 -<br>0.0836) | 2.121 - 2.124<br>(0.0835 -<br>0.0836) | 2.125 - 2.128<br>(0.0837 -<br>0.0838) | 1.617 - 1.625<br>(0.0637 - 0.0640)   |

- Use a thickness gauge to measure the thrust clearance of crankshaft at center bearing. If clearance exceeds the standard, replace the bearing.

***Crankshaft thrust clearance:***

***Standard***

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



**Fig. 229: Measuring Thrust Clearance Of Crankshaft At Center Bearing Using Thickness Gauge**  
**Courtesy of SUBARU OF AMERICA, INC.**

- Inspect individual crankshaft bearings for signs of flaking, seizure, melting and wear.
- Measure the oil clearance on each crankshaft bearing using plastigauge. If the measured value is out of standard, replace the defective bearing with an undersize one, and replace or grind to correct the crankshaft as necessary.

***Crankshaft oil clearance:***

***Standard***

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

## OIL FLOW CONTROL SOLENOID VALVE

## REMOVAL

The oil flow control solenoid valve is listed in the Fuel System service information. < Refer to **REMOVAL** , Oil Flow Control Solenoid Valve. >

## INSTALLATION

The oil flow control solenoid valve is listed in the Fuel System service information. < Refer to **INSTALLATION** , Oil Flow Control Solenoid Valve. >

## INTAKE AND EXHAUST VALVE

### SPECIFICATION

Refer to "Cylinder Head" for removal and installation procedures of 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 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.             |                                                                        |                                                  |      |
| 1) Starter does not turn.             | 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    |
|                                       |                                                                        | Defective charging system                        | B    |
|                                       | Friction                                                               | Seizure of crankshaft and connecting rod bearing | C    |
|                                       |                                                                        | Seized camshaft                                  | C    |
|                                       |                                                                        | Seized or stuck piston and cylinder              | C    |
| 2) Initial combustion does not occur. | Starter                                                                | Defective starter                                | C    |
|                                       | Engine control system < 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 valve clearance                        | C    |
|                                       |                                                                        | Loosened spark plug or defective gasket          | C    |
|                                       |                                                                        | Loosened cylinder head bolt or defective 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>BASIC DIAGNOSTIC PROCEDURE</b> . > |                                                  | A    |
|                                       | Intake system                                                          | Defective intake manifold gasket                 | B    |
|                                       |                                                                        | Defective throttle body gasket                   | B    |
|                                       |                                                                        | Defective fuel pump and relay                    | C    |

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|                                            |                                                                               |                                                 |   |
|--------------------------------------------|-------------------------------------------------------------------------------|-------------------------------------------------|---|
| 3) Initial combustion occurs.              | Fuel line                                                                     | Clogged fuel line                               | C |
|                                            |                                                                               | Lack of fuel or insufficient fuel               | B |
|                                            | Timing chain                                                                  | Trouble                                         | B |
|                                            |                                                                               | Defective timing                                | B |
|                                            | Compression                                                                   | Incorrect valve clearance                       | C |
|                                            |                                                                               | Loosened spark plug or defective gasket         | C |
|                                            |                                                                               | Loosened cylinder head bolt or defective 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 |
| 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 valve clearance                       | C |
|                                            |                                                                               | Loosened spark plug or defective gasket         | C |
|                                            |                                                                               | Loosened cylinder head bolt or defective 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 |
|                                            |                                                                               | Loosened or cracked intake duct                 | A |
|                                            |                                                                               | Loosened or cracked PCV hose                    | A |

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|                                |                                                                               |                                                 |   |
|--------------------------------|-------------------------------------------------------------------------------|-------------------------------------------------|---|
| 2. Rough idle and engine stall | Intake system                                                                 | 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 |
|                                | Compression                                                                   | Incorrect valve clearance                       | B |
|                                |                                                                               | Loosened spark plug or defective gasket         | B |
|                                |                                                                               | Loosened cylinder head bolt or defective 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 |
|                                | 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                 | 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 |
|                                |                                                                               | Incorrect valve clearance                       | B |

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|                                                 |                                                                        |                                                 |   |
|-------------------------------------------------|------------------------------------------------------------------------|-------------------------------------------------|---|
| 3. Low output, hesitation and poor acceleration | Compression                                                            | Loosened spark plug or defective gasket         | B |
|                                                 |                                                                        | Loosened cylinder head bolt or defective 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 system                                                     | Incorrect oil pressure                          | B |
|                                                 |                                                                        | Defective rocker cover gasket                   | C |
|                                                 | Cooling system                                                         | Over-heating                                    | C |
|                                                 |                                                                        | Over-cooling                                    | C |
|                                                 | Others                                                                 | Evaporative emission control system malfunction | A |
| 4. Surging                                      | 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                 | 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 valve clearance                       | B |
|                                                 |                                                                        | Loosened spark plug or defective gasket         | C |
|                                                 |                                                                        | Loosened cylinder head bolt or defective 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 |

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|                                    |                                                                               |                                                 |   |
|------------------------------------|-------------------------------------------------------------------------------|-------------------------------------------------|---|
|                                    | 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 |
| 7. After burning in exhaust system | Engine control system < Refer to <b><u>BASIC DIAGNOSTIC PROCEDURE</u></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 valve clearance                       | B |
|                                    |                                                                               | Loosened spark plug or defective gasket         | C |
|                                    |                                                                               | Loosened cylinder head bolt or defective 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><u>BASIC DIAGNOSTIC PROCEDURE</u></b> . > |                                                 | A |
|                                    | Intake system                                                                 | Loosened oil filler cap                         | B |
|                                    | Timing chain                                                                  | Defective timing                                | B |
|                                    | Compression                                                                   | Incorrect valve clearance                       | C |
|                                    |                                                                               | Incorrect valve timing                          | B |
|                                    | Cooling system                                                                | Over-heating                                    | A |
|                                    | Intake system                                                                 | Loosened or cracked PCV hose                    | A |
|                                    |                                                                               | Defective PCV valve                             | B |

|                                     |                                                                        |                                                        |   |
|-------------------------------------|------------------------------------------------------------------------|--------------------------------------------------------|---|
| 9. Excessive engine oil consumption | Compression                                                            | Loosened oil filler cap                                | C |
|                                     |                                                                        | 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 O-ring                            | B |
|                                     |                                                                        | Defective crankshaft oil seal                          | B |
|                                     |                                                                        | Defective rocker cover gasket                          | B |
|                                     |                                                                        | Loosened oil drain plug or defective gasket            | B |
|                                     |                                                                        | Loosened oil pan fitting bolts or defective oil pan    | B |
| 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 valve clearance                              | B |
|                                     |                                                                        | Loosened spark plug or defective gasket                | C |
|                                     |                                                                        | Loosened cylinder head bolt or defective 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 valve clearance</li> <li>Worn camshaft</li> <li>Broken valve spring</li> <li>Trouble of valve lifter</li> </ul> |
|                        |                                            | <ul style="list-style-type: none"> <li>Worn camshaft main bearing</li> </ul>                                                                                                                           |

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|                                                                               |                                                                                                 |                                                                                                                                                                                                                          |
|-------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Heavy and dull clank                                                          | Oil pressure is low.                                                                            | <ul style="list-style-type: none"> <li>Worn connecting rod bearing (large end)</li> </ul>                                                                                                                                |
|                                                                               | Oil pressure is normal.                                                                         | Damaged engine mounting                                                                                                                                                                                                  |
| 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>Gasoline of improper octane number</li> </ul> |
| Clank when engine speed is between 1, 000 and 2, 000 rpm.                     | Noise is reduced when fuel injector connector of noisy cylinder is disconnected. <sup>(1)</sup> | <ul style="list-style-type: none"> <li>Worn crankshaft main bearing</li> <li>Worn connecting rod bearing (large end)</li> </ul>                                                                                          |
| Knocking sound when engine is operating under idling speed and engine is warm | Noise is reduced when fuel injector connector of 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 hole at piston end of connecting rod</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 lifter</li> <li>Worn cam sprocket tooth surface</li> <li>Worn camshaft journal bore in cylinder head</li> </ul>                                              |
| Squeaky sound                                                                 | -                                                                                               | Insufficient generator lubrication                                                                                                                                                                                       |
| Rubbing sound                                                                 | -                                                                                               | Poor contact of generator brush and rotor                                                                                                                                                                                |
| 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>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 lifter noise                                                            | -                                                                                               | Incorrect valve clearance                                                                                                                                                                                                |

- (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.