

2013 Subaru Legacy

2013 ENGINE Engine Mechanical (H6DO) - Legacy/Outback

2013 ENGINE

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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 ³ (cu in)	3, 630 (221.5)
	Compression ratio		10.5
	Compression (350 rpm and fully open throttle)	kPa (kgf/cm ² , 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	Intake	
		mm (in)	
	Valve clearance	Exhaust	
		mm (in)	
	Idle speed		No load Standard 700±100

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	["P" or "N" range]		rpm	A/C ON	Standard	700 - 910±100
	Ignition order					1 --> 6 --> 3 --> 2 --> 5 --> 4
	Ignition timing			BTDC/rpm	Standard	15°±8°/700
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)
				Intake		103.5 (4.075)

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	Overall length	mm (in)	Exhaust	103.2 (4.063)	
Valve spring	Free length	mm (in)	Intake	49.06 (1.9315)	
			Exhaust	49.06 (1.9315)	
	Tension/spring height	N (kgf, lb)/mm (in)	Set	182 - 210 (18.6 - 21.4, 40.9 - 47.2)/31.0 (1.220)	
			Lift	316 - 350 (32.2 - 35.7, 71.0 - 78.7)/21.0 (0.827)	
	Squareness			2.5°, 2.1 mm (0.083 in)	
Valve lifter	Outer diameter	mm (in)	Standard	32.959 - 32.975 (1.2976 - 1.2982)	
	Valve lifter mating surface inner diameter	mm (in)	Standard	32.994 - 33.016 (1.2990 - 1.2998)	
	Valve lifter and valve lifter mating surface clearance	mm (in)	Standard	0.019 - 0.057 (0.0007 - 0.0022)	
Cylinder block	Warping limit (Mating surface with cylinder head)	mm (in)		0.020 (0.0008)	
	Standard height	mm (in)		202 (7.95)	
	Cylindricity	mm (in)	Limit	0.030 (0.0012)	
	Out-of-roundness	mm (in)	Limit	0.010 (0.0004)	
	Clearance between cylinder and piston at 20°C (68°F)	mm (in)	Standard	-0.010 - 0.010 (-0.0004 - 0.0004)	
	Cylinder inner diameter boring limit (diameter)	mm (in)		92.515 (3.6717)	
Piston	Piston grade point	mm (in)		37.3 (1.4685)	
	Outer diameter	mm (in)	Standard	A	92.005 - 92.015 (3.6222 - 3.6226)
				B	91.995 - 92.005 (3.6218 - 3.6222)
		0.25 (0.0098) OS			92.245 - 92.265 (3.6317 - 3.6325)
		0.50 (0.0197) OS			92.495 - 92.515 (3.6415 - 3.6423)
	Inner diameter of piston pin hole	mm (in)	Standard	22.000 - 22.006 (0.8661 - 0.8664)	
Piston pin	Degree of fit			Piston pin must be fitted into position with thumb at 20°C (68°F).	
	Outer diameter	mm (in)	Standard	21.994 - 22.000 (0.8659 - 0.8661)	
	Clearance between piston and piston pin	mm (in)	Standard	0.004 - 0.008 (0.0002 - 0.0003)	
	Piston ring gap	mm (in)	Top ring	Standard	0.20 - 0.35 (0.0079 - 0.0138)
			Second ring	Standard	0.40 - 0.50 (0.0157 - 0.0197)

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Piston ring			Oil ring	Standard	0.20 - 0.50 (0.0079 - 0.0197)	
	Clearance between piston ring and piston ring groove	mm (in)	Top ring	Standard	0.040 - 0.080 (0.0016 - 0.0031)	
			Second ring	Standard	0.030 - 0.070 (0.0012 - 0.0028)	
			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)	mm (in)	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		mm (in)	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)
				Standard		63.992 - 64.016 (2.5194 - 2.5203)
						63.962 - 63.978 (2.5182 -

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Crankshaft and crankshaft bearing	Crank journal outer diameter	mm (in)	#1, #3, #5, #7	0.03 (0.0012) US	2.5188)
				0.05 (0.0020) US	63.942 - 63.958 (2.5174 - 2.5180)
				0.25 (0.0098) US	63.742 - 63.758 (2.5095 - 2.5102)
		mm (in)	#2, #4, #6	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)
				0.25 (0.0098) US	63.742 - 63.758 (2.5095 - 2.5102)
	Bearing size (Thickness at center)	mm (in)	#1, #3, #5	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)
				0.25 (0.0098) US	2.121 - 2.124 (0.0835 - 0.0836)
		mm (in)	#2, #4, #6	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)
		mm (in)	#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)

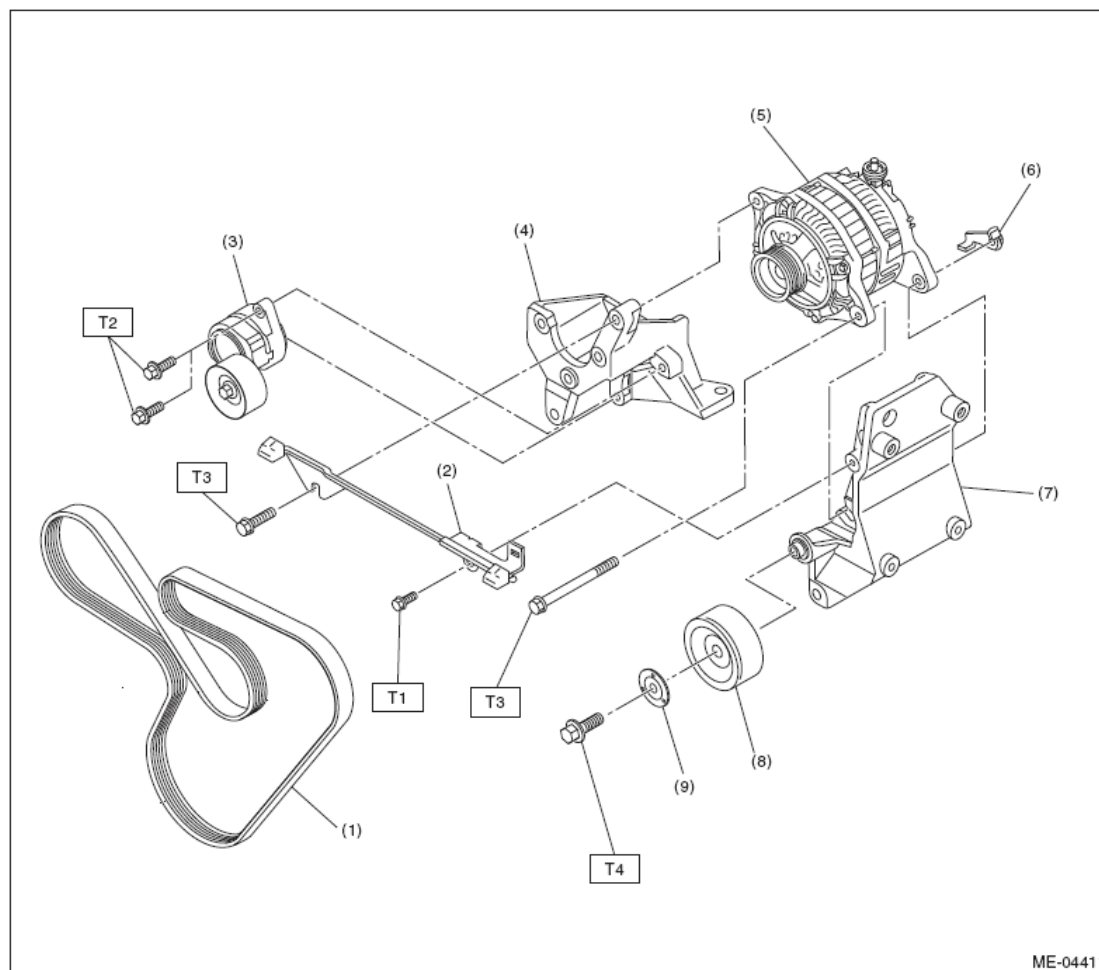
NOTE:

OS: Oversize

US: Undersize

COMPONENT

V-BELT



- | | |
|---------------------------------|-------------------------|
| (1) V-belt | (6) Generator plate |
| (2) Collector cover bracket | (7) A/C compressor stay |
| (3) Belt tensioner ASSY | (8) Idler pulley |
| (4) Power steering pump bracket | (9) Idler pulley cover |
| (5) Generator | |

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

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

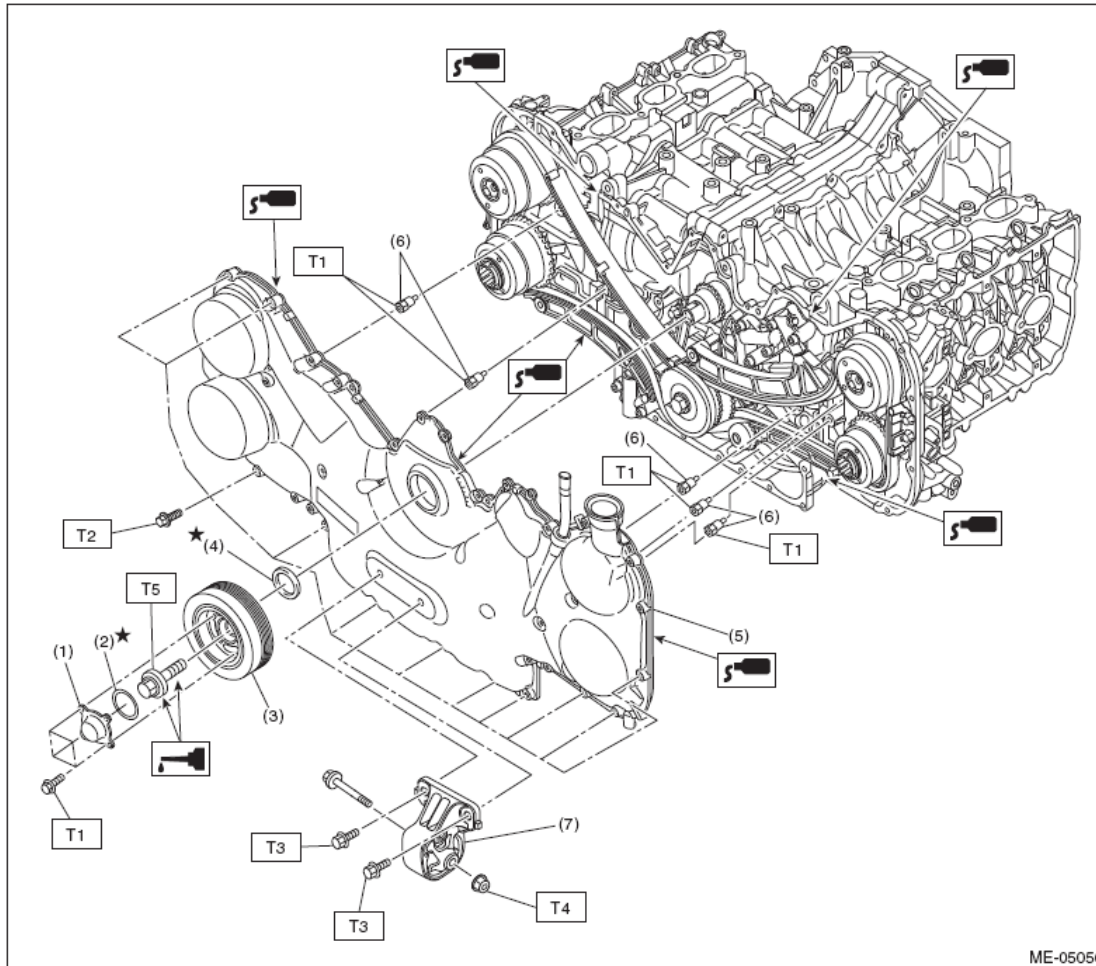
T1: 6.4 (0.7, 4.7)

T2: 20 (2.0, 14.8)

T3: 25 (2.5, 18.4)

T4: 33 (3.4, 24.3)

CHAIN COVER



ME-05056

- (1) Crank pulley cover
- (2) O-ring
- (3) Crank pulley
- (4) Oil seal
- (5) Chain cover
- (6) Bolt
- (7) Front mount

Fig. 2: Identifying 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)

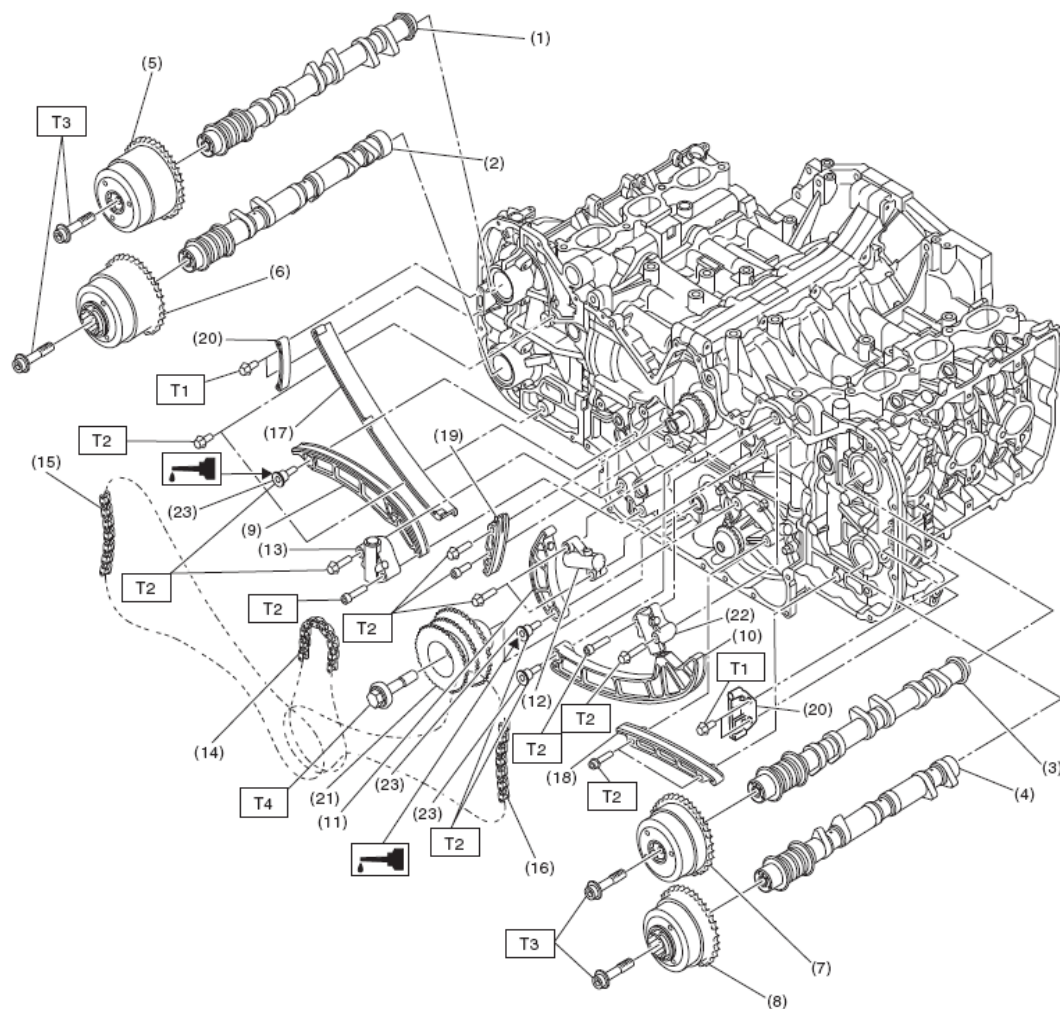
T2: 10 (1.0, 7.4)

T3: 25 (2.5, 18.4)

T4: 45 (4.6, 33.2)

T5: 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)

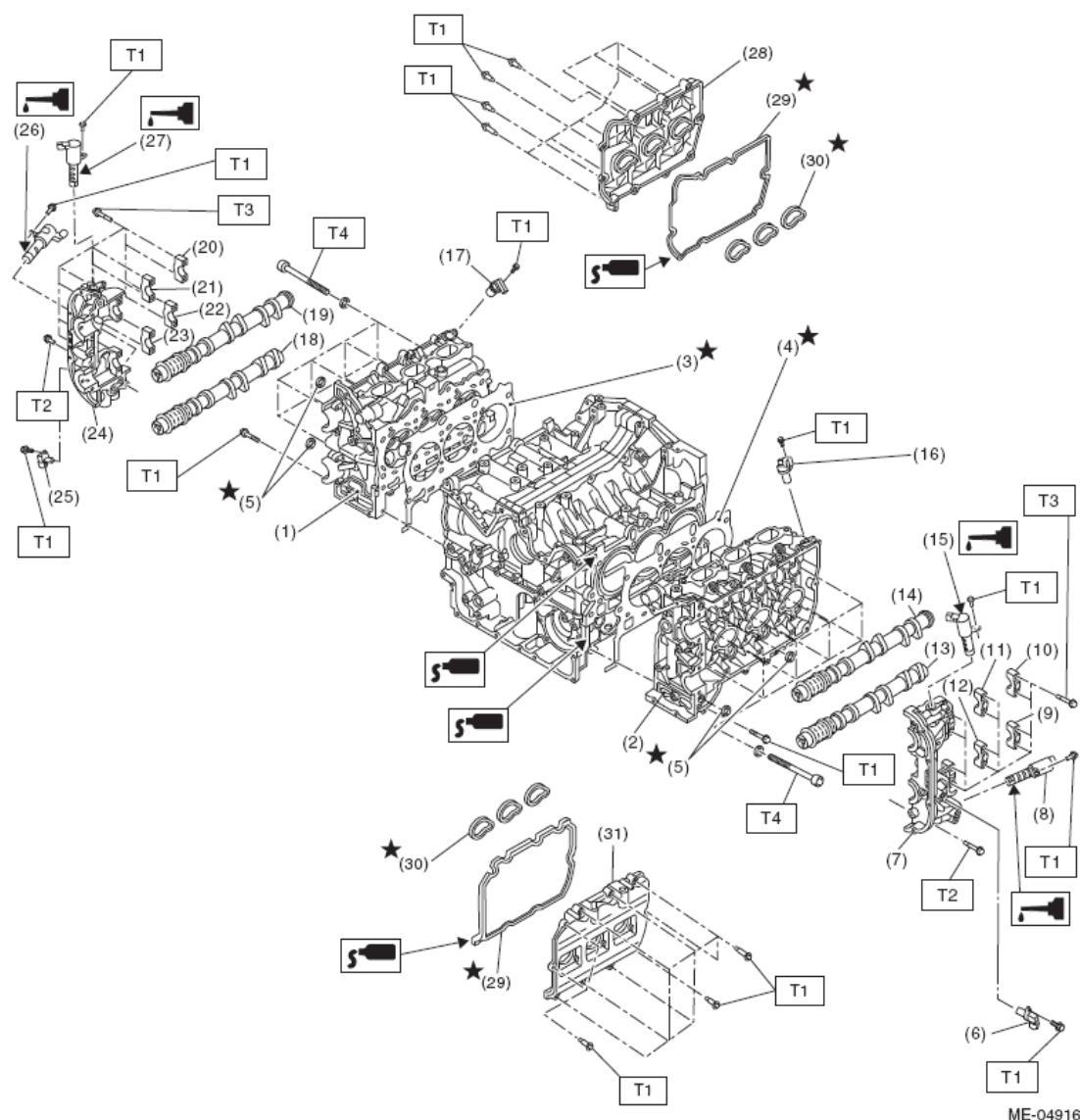
T1: 6.4 (0.7, 4.7)

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 (RH) | |

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)

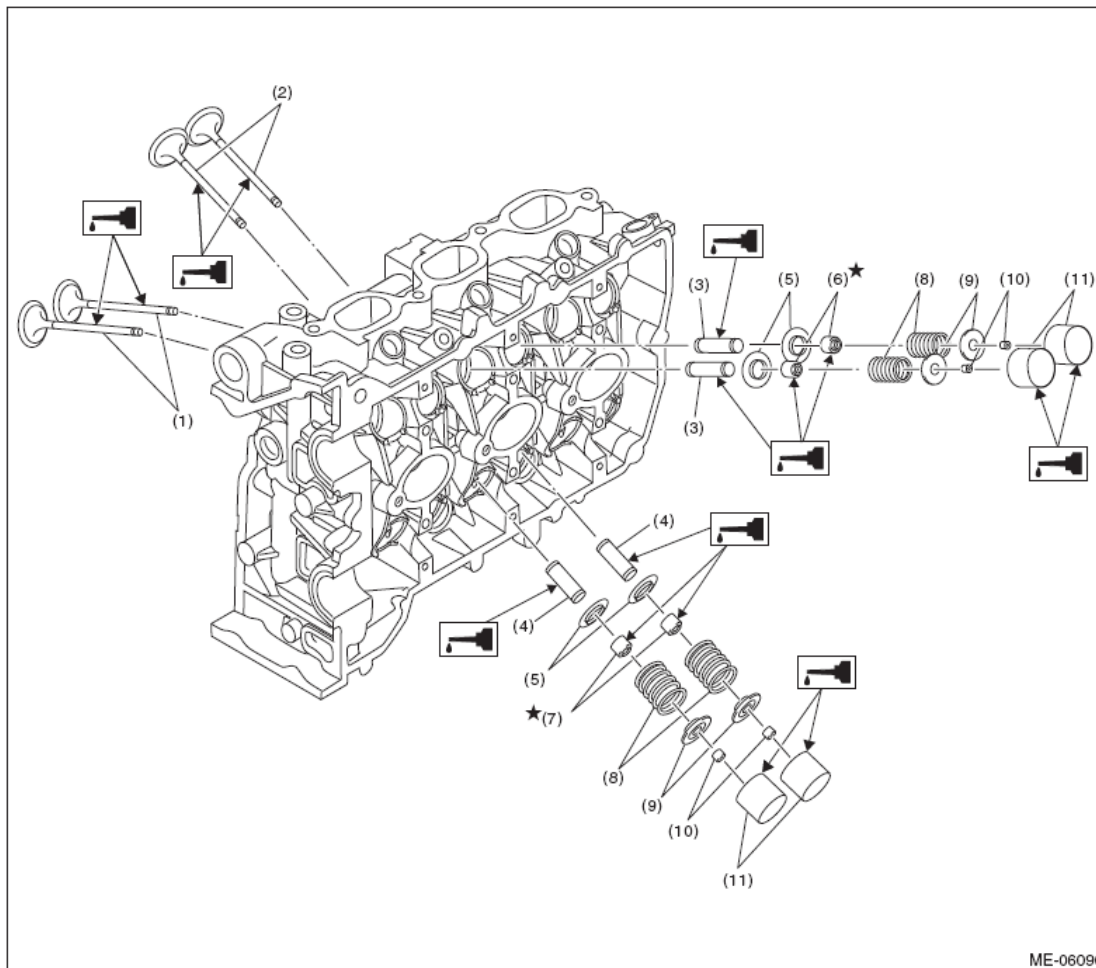
T1: 6.4 (0.7, 4.7)

T2: 9.75 (1.0, 7.2)

T3: 16 (1.6, 11.8)

T4: Refer to CYLINDER HEAD.

CYLINDER HEAD AND VALVE ASSEMBLY

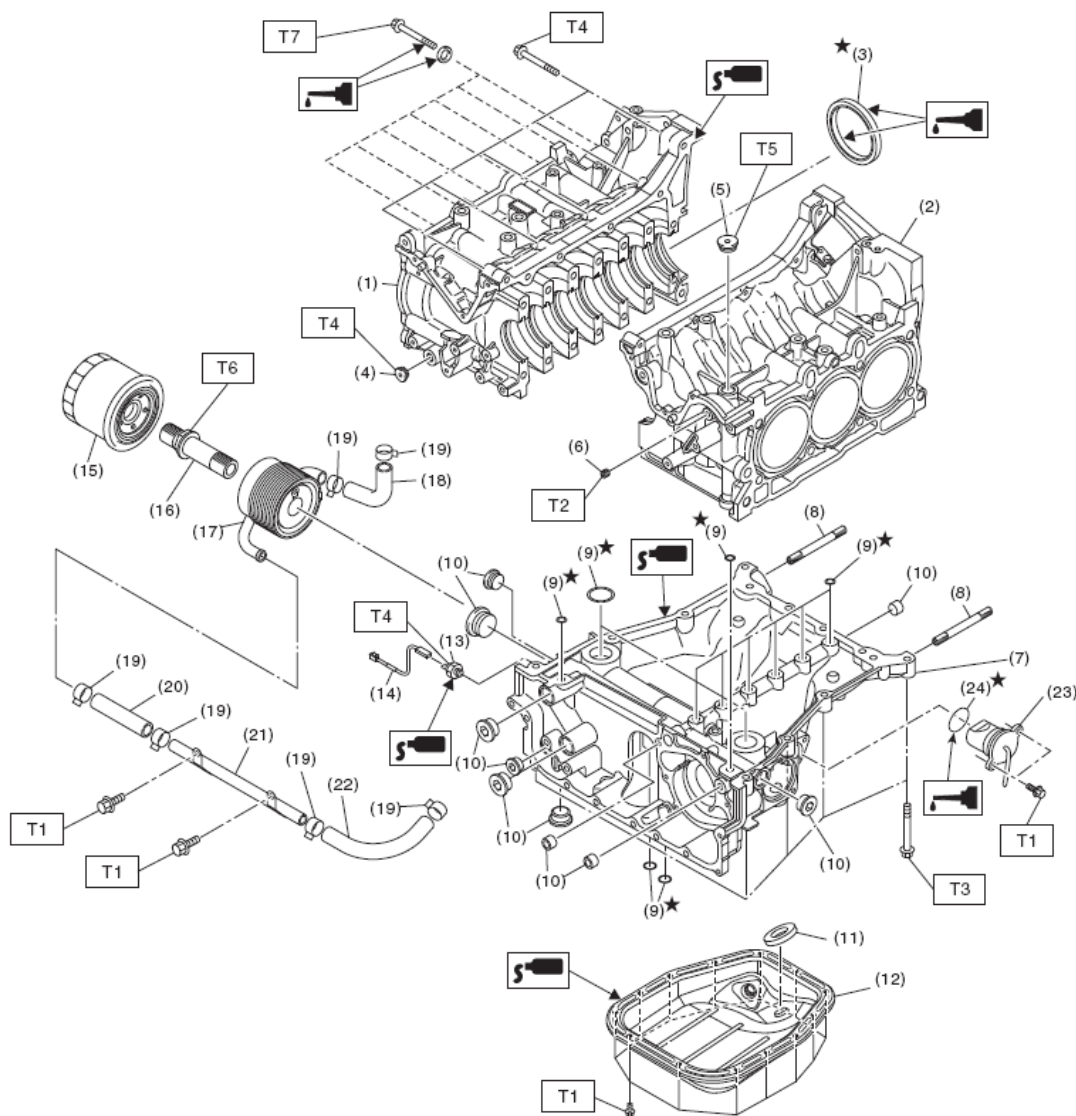


- | | | |
|---------------------------|-------------------------|---------------------------|
| (1) Intake valve | (5) Valve spring seat | (9) Valve spring retainer |
| (2) Exhaust valve | (6) Stem seal (intake) | (10) Valve collet |
| (3) Valve guide (intake) | (7) Stem seal (exhaust) | (11) Valve lifter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

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

Courtesy of SUBARU OF AMERICA, INC.

CYLINDER BLOCK



ME-05816

- | | | |
|-------------------------|----------------------------------|-----------------------|
| (1) Cylinder block (RH) | (12) Oil pan lower | (23) Oil level switch |
| (2) Cylinder block (LH) | (13) Oil pressure switch | (24) O-ring |
| (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)

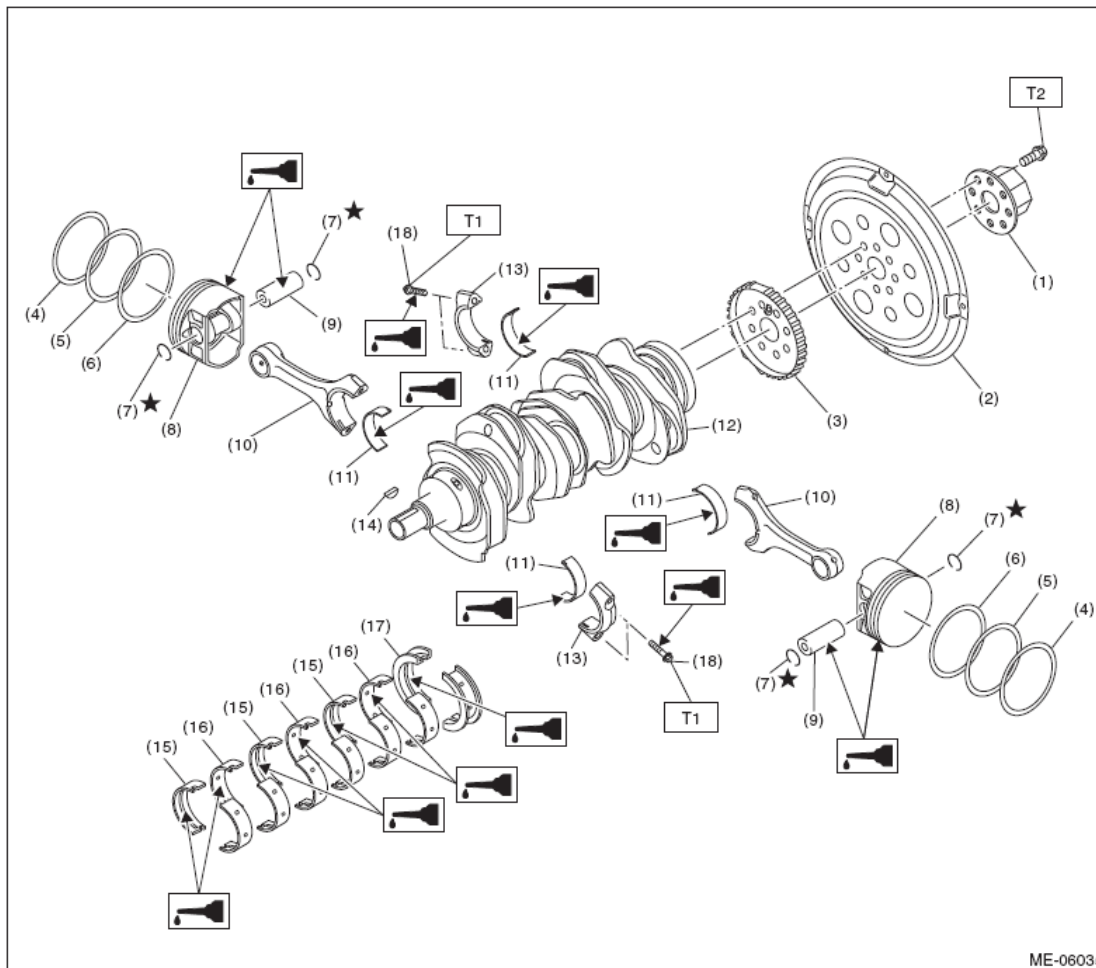
T4: 25 (2.5, 18.4)

T5: 37 (3.8, 27.3)

T6: 54 (5.5, 39.8)

T7: Refer to CYLINDER BLOCK.

CRANKSHAFT AND PISTON



ME-06035

- | | | |
|-----------------------------|------------------------------------|------------------------------|
| (1) Reinforcement | (9) Piston pin | (17) Crankshaft bearing #7 |
| (2) Drive plate | (10) Connecting rod | (18) Connecting rod cap bolt |
| (3) Crankshaft sensor plate | (11) Connecting rod bearing | |
| (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 | (16) Crankshaft bearing #2, #4, #6 | |

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

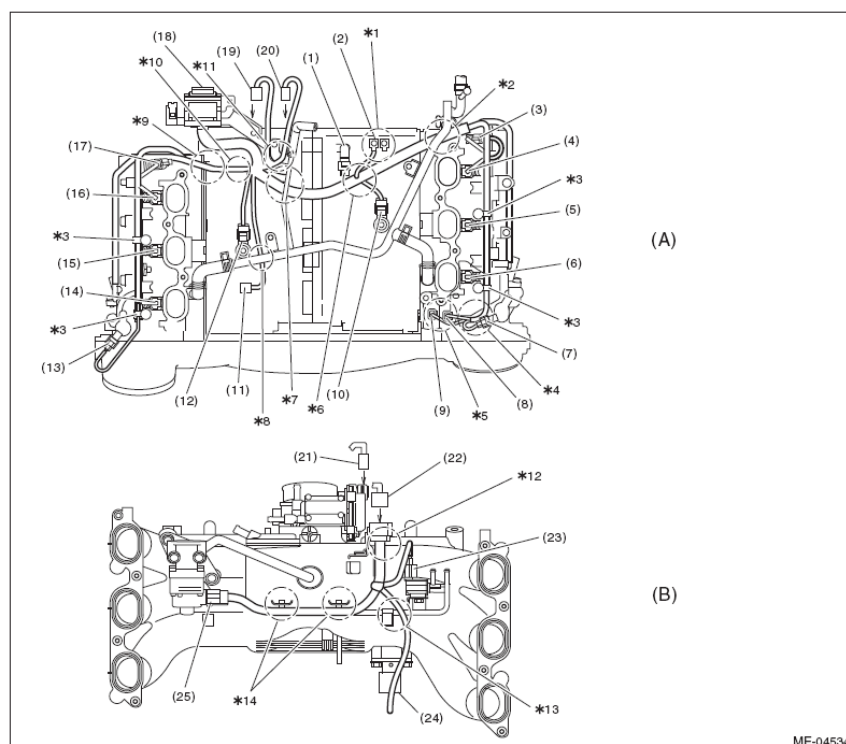
Tightening torque: N.m (kgf-m, ft-lb)

T1: 60 (6.1, 44.3)

T2: Refer to INSTALLATION.

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.

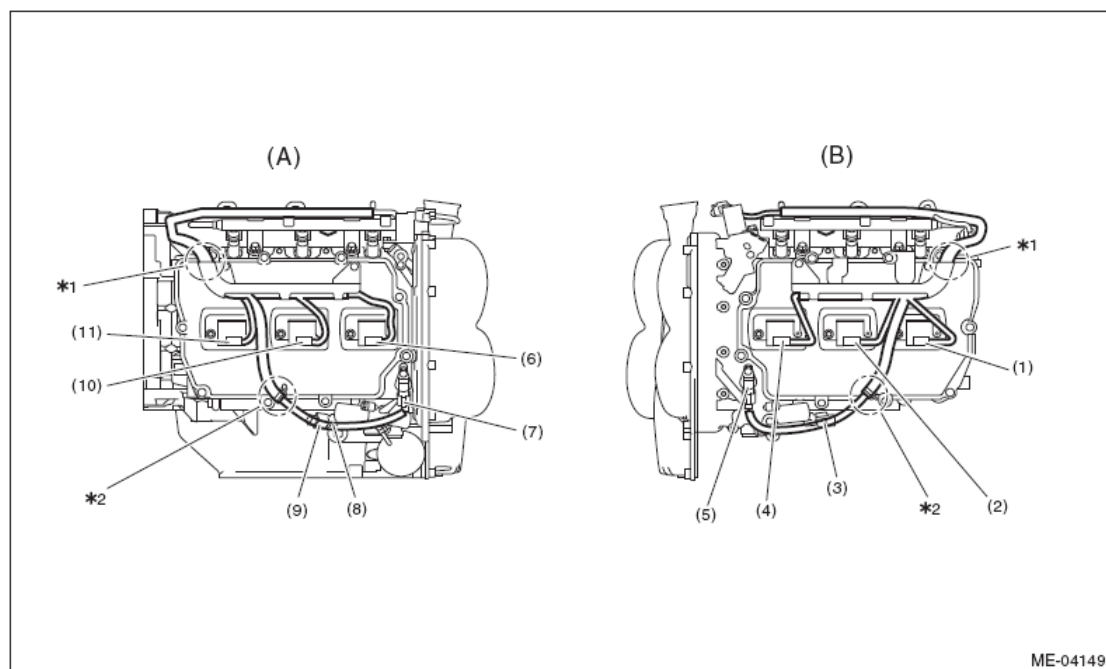
*13: Route outside the fuel pipe.

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

Fig. 8: 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 solenoid RH connector

(2) #4 ignition coil connector

(6) #1 injector connector

(10) #3 ignition coil connector

(3) Exhaust oil flow control valve solenoid LH connector

(7) Exhaust camshaft position sensor RH connector

(11) #5 ignition coil connector

(4) #2 ignition coil connector

(8) Oil pressure switch connector

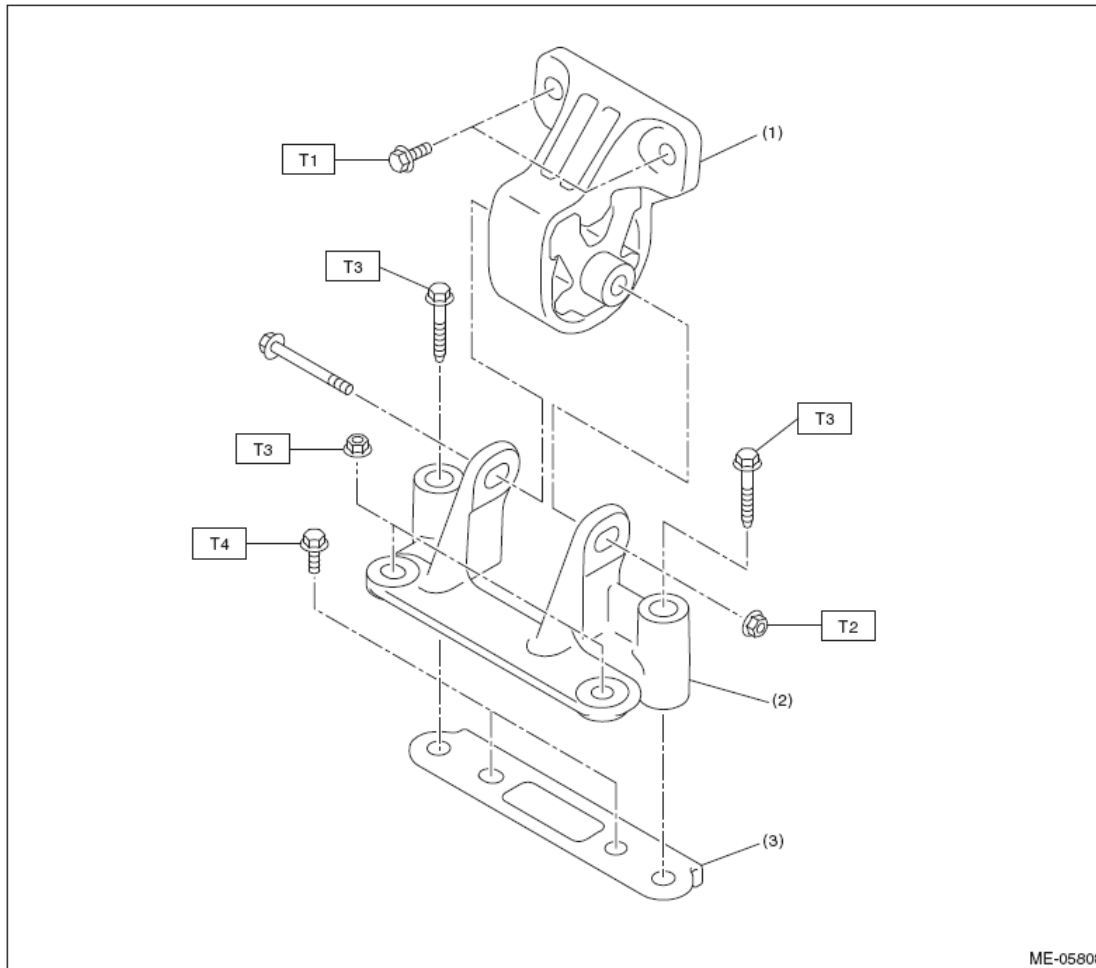
*1: Align the engine harness stay end with the end of engine harness identification tape.

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

Fig. 9: Engine Harness Assembly Diagram 2

Courtesy of SUBARU OF AMERICA, INC.

ENGINE MOUNTING



- (1) Front mount
(2) Front mounting bracket
(3) Bracket

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

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

T1: 25 (2.5, 18.4)

T2: 45 (4.6, 33.2)

T3: 60 (6.1, 44.3)

T4: 65 (6.6, 47.9)

CAUTION

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

goggles, etc. if necessary.

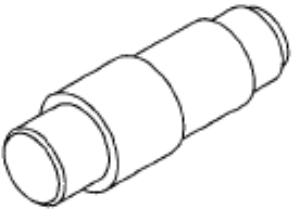
2. Protect the vehicle using a seat cover, fender cover, etc.

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

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

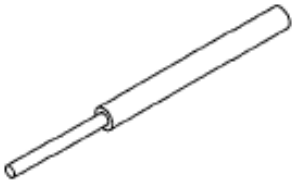
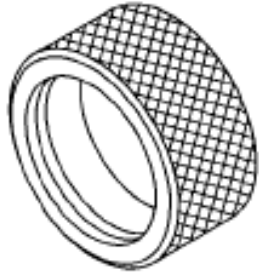
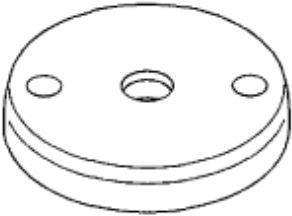
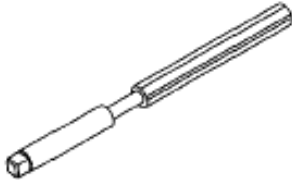
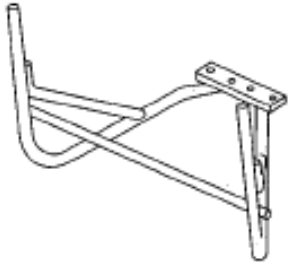
PREPARATION TOOL

SPECIAL TOOL

ILLUSTRATION	TOOL NUMBER	DESCRIPTION	REMARKS
 ST18350AA000	18250AA010	CYLINDER HEAD TABLE	• Used for replacing valve guides. • Used for removing and installing valve spring.
	18232AA000	ENGINE STAND	Used for disassembling and assembling engine.

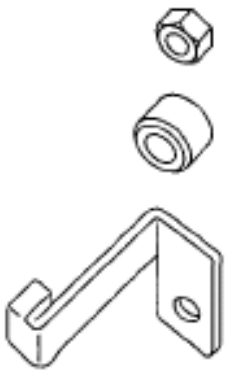
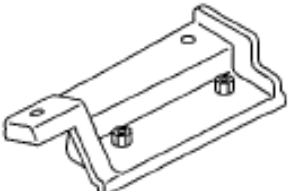
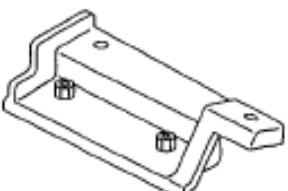
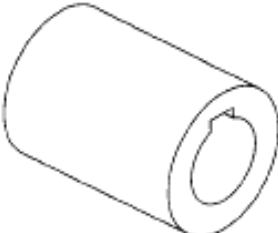
2013 Subaru Legacy

2013 ENGINE Engine Mechanical (H6DO) - Legacy/Outback

 ST-499765700			
 ST-398437700	398744300	PISTON GUIDE	Used for installing piston in cylinder.
 ST18671AA020	18261AA010	VALVE OIL SEAL GUIDE	Used for press-fitting of intake valve guide oil seals and exhaust valve guide oil seals.
 ST-499765900	18350AA000	CONNECTING ROD BUSHING REMOVER AND INSTALLER	Used for removing and installing connecting rod bushing.
 ST-499817100	499977500	CAM SPROCKET WRENCH	Used for removing and installing cam sprocket.

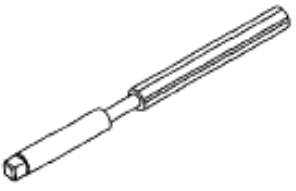
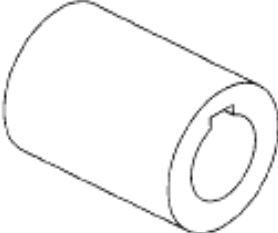
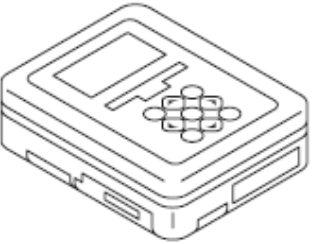
2013 Subaru Legacy

2013 ENGINE Engine Mechanical (H6DO) - Legacy/Outback

 ST-498277200	499587200	CRANKSHAFT OIL SEAL INSTALLER	• Used for installing crankshaft oil seal. • Used together with CRANKSHAFT OIL SEAL GUIDE (499597100).
 ST-498457000	499597100	CRANKSHAFT OIL SEAL GUIDE	• Used for installing crankshaft oil seal. • Used together with CRANKSHAFT OIL SEAL INSTALLER (499587200).
 ST-498457100	499718000	VALVE SPRING REMOVER	Used for removing and installing valve spring.
 ST18252AA000	499765700	VALVE GUIDE REMOVER	Used for removing valve guides.
	499765900	VALVE GUIDE REAMER	Used for reaming valve guides.

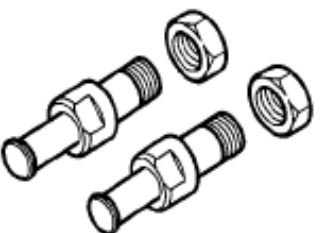
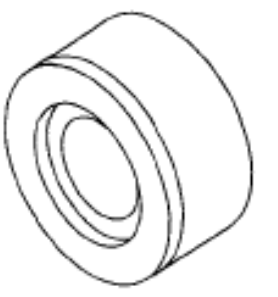
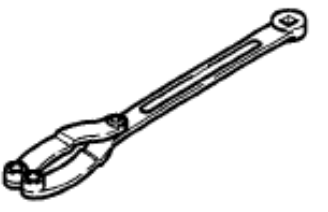
2013 Subaru Legacy

2013 ENGINE Engine Mechanical (H6DO) - Legacy/Outback

 ST-499765900			
 ST18252AA000	18252AA000	CRANKSHAFT SOCKET	Used for rotating crankshaft.
 ST1B022XU0	1B022XU0	SUBARU SELECT MONITOR III KIT	Used for various inspections.
 ST-498277200	498277200	STOPPER SET	Used for installing automatic transmission assembly to engine.
	499585700	OIL SEAL GUIDE	Used for installing the chain cover oil seal.

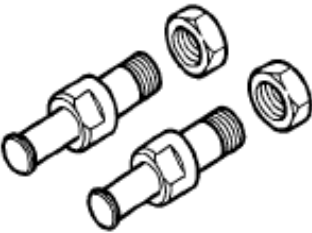
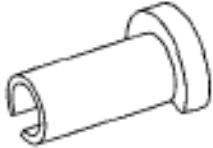
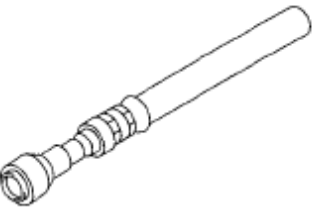
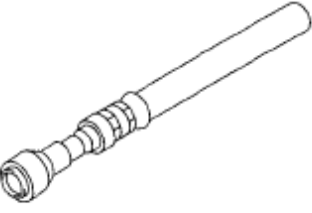
2013 Subaru Legacy

2013 ENGINE Engine Mechanical (H6DO) - Legacy/Outback

 ST-499585700			
 ST18334AA000	18251AA050	VALVE GUIDE ADJUSTER	Used for installing intake valve guides.
 ST18251AA060	18251AA060	VALVE GUIDE ADJUSTER	Used for installing exhaust valve guides.
 ST18355AA000	18355AA000	PULLEY WRENCH	• Used for removing and installing the crank pulley. • Used for removing and installing the idler sprocket. • Used together with PULLEY WRENCH PIN SET (18334AA000).
	18334AA000	PULLEY WRENCH PIN SET	• Used for removing and installing the crank pulley. • Used for removing and installing the idler sprocket. • Used together with PULLEY WRENCH

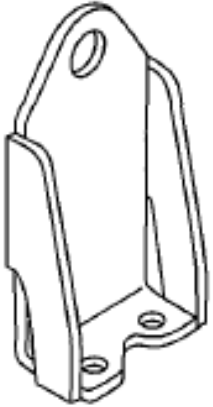
2013 Subaru Legacy

2013 ENGINE Engine Mechanical (H6DO) - Legacy/Outback

 ST18334AA000			(18355AA000).
 ST18332AA020	18332AA020	OIL FILTER WRENCH	Used for removing and installing oil filter.
 ST42099AE000	42099AE000	QUICK CONNECTOR RELEASE	Used for disconnecting quick connector of the engine compartment.
 ST42075AG690	18471AA000	FUEL PIPE ADAPTER	Used for inspecting the fuel pressure.
 ST42075AG690	42075AG690	FUEL HOSE	Used for inspecting the fuel pressure. NOTE: This is the SUBARU genuine part.

2013 Subaru Legacy

2013 ENGINE Engine Mechanical (H6DO) - Legacy/Outback

 ST18360AA020	18360AA020	HANGER	Used for hanging the engine.
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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.

NOTE: Follow the steps below when removing the collector cover.

1. Pull up the two points at the rear (A).
2. Pull up the two points at the front (B) while moving them forward.

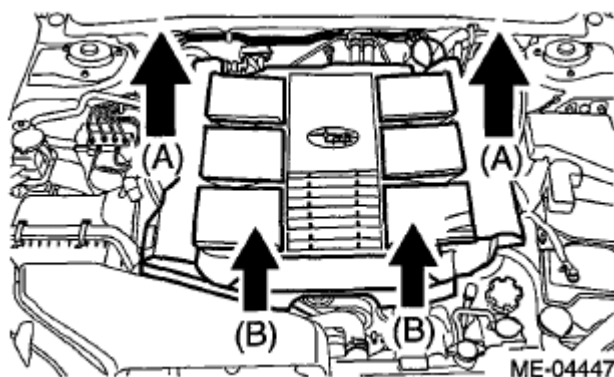
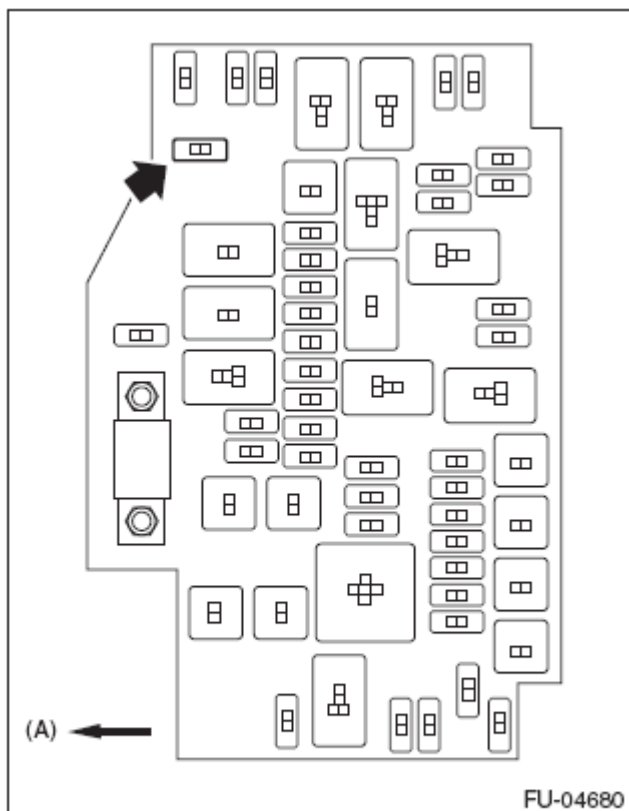


Fig. 11: Removing Collector Cover
Courtesy of SUBARU OF AMERICA, INC.

2. After warming-up the engine, turn the ignition switch to OFF.
3. Make sure that the battery is fully charged.
4. Remove the fuse of fuel pump from main fuse box.



(A) Front side

Fig. 12: Locating Fuel Pump Fuse On Main Fuse Box
Courtesy of SUBARU OF AMERICA, INC.

5. Start the engine and run it until it stalls.
6. After the engine stalls, crank it for five more seconds.
7. Turn the ignition switch to OFF.
8. Remove all spark plugs. Refer to **REMOVAL**.
9. Fully open the throttle valve.
10. Check the starter motor for satisfactory performance and operation.
11. 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.

12. 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/cm², 185 - 213 psi)

Limit

1, 128 kPa (11.5 kgf/cm², 164 psi)

Difference between cylinders

49 kPa (0.5 kgf/cm², 7 psi) or less

13. 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)**.

NOTE:

- Idle speed cannot be adjusted manually, because the idle speed is automatically adjusted.
- If idle speed is out of standard, refer to the **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

700 - 910±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)**.

NOTE: If ignition timing is out of standard, check the ignition 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.

NOTE: Follow these procedures for removal of the collector cover.

1. Lift up the rear side holding two positions (A).
2. Lift up the front side holding two positions (B) while moving it in the forward direction of the vehicle.

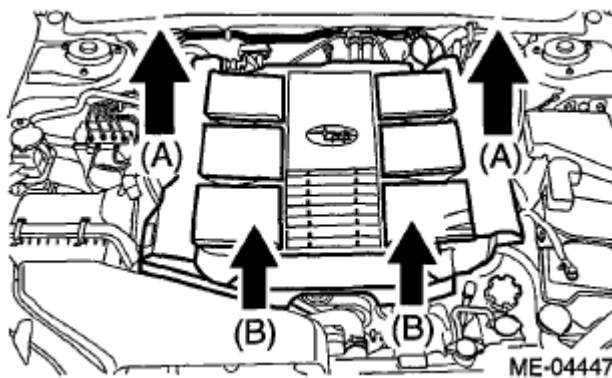


Fig. 13: Removing Collector Cover
Courtesy of SUBARU OF AMERICA, INC.

5. Disconnect the ground cable from battery.
6. Remove the air intake duct. Refer to **REMOVAL** .
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 ground cable to battery.
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 BASIC DIAGNOSTIC PROCEDURE .

Ignition timing [BTDC/rpm]:

Standard

15°±8°/700

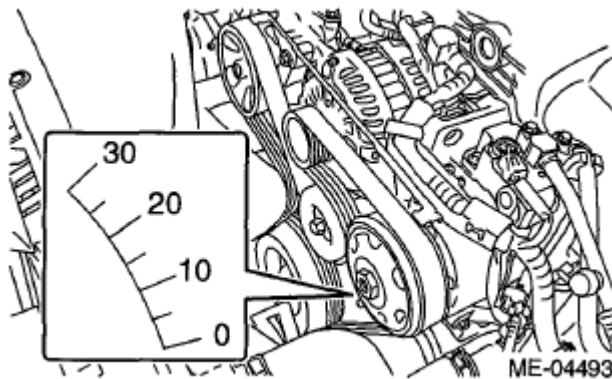


Fig. 14: Identifying Ignition Timing
Courtesy of SUBARU OF AMERICA, INC.

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.

NOTE: Follow the steps below when removing the collector cover.

1. Pull up the two points at the rear (A).
2. Pull up the two points at the front (B) while moving them forward.

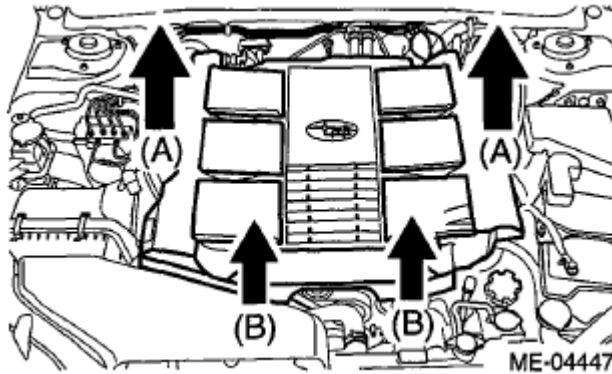


Fig. 15: Removing Collector Cover
Courtesy of SUBARU OF AMERICA, INC.

3. Disconnect the brake booster vacuum hose from the intake manifold, and attach the vacuum gauge.

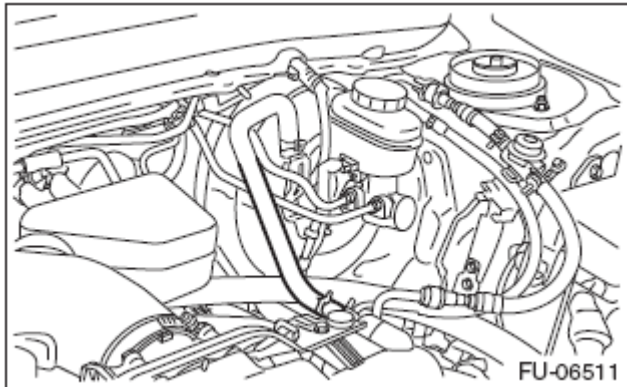


Fig. 16: Identifying Brake Booster Vacuum Hose
Courtesy of SUBARU OF AMERICA, INC.

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)

5. 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

1. Disconnect the ground cable from battery.
2. Remove the oil pressure switch from the oil pan upper. Refer to **REMOVAL** .
3. Attach the oil pressure gauge to the oil pan upper.
4. Connect the battery ground terminal.
5. 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 **ENGINE LUBRICATION SYSTEM TROUBLE IN GENERAL** .
- If the oil pressure warning light is ON and oil pressure is within specification, check the oil pressure switch. Refer to **OIL PRESSURE SYSTEM** and **OIL PRESSURE SWITCH** .

Engine oil pressure (at oil temperature of 120°C (248°F)):

Standard

100 kPa (1.0 kgf/cm² , 15 psi) or more (at 700 rpm)

500 kPa (5.1 kgf/cm² , 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.

NOTE: Follow the steps below when removing the collector cover.

1. Pull up the two points at the rear (A).
2. Pull up the two points at the front (B) while moving them forward.

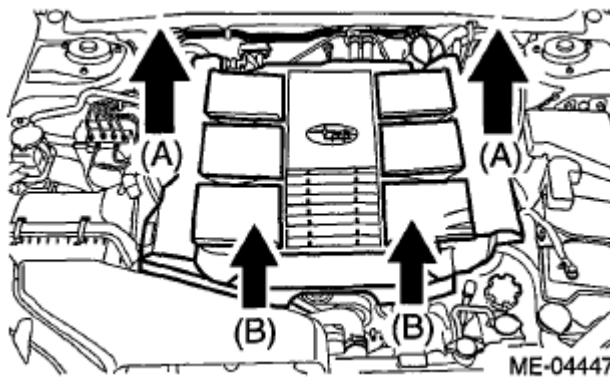


Fig. 17: Removing Collector Cover
Courtesy of SUBARU OF AMERICA, INC.

2. Release the fuel pressure. Refer to RELEASING OF FUEL PRESSURE .
3. Open the fuel filler lid and remove the fuel filler cap.
4. Disconnect the fuel delivery hose from fuel damper, and connect fuel pressure gauge.

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

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

ST 42099AE000 QUICK CONNECTOR RELEASE

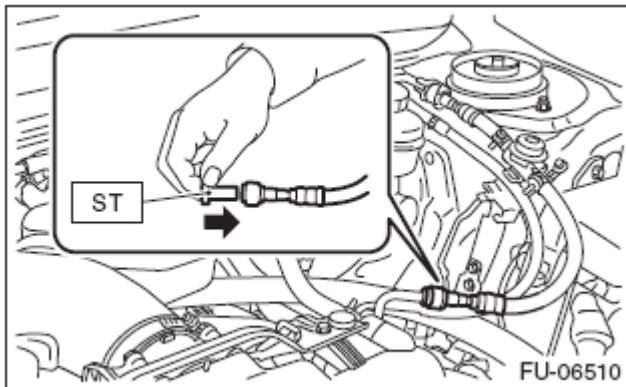


Fig. 18: Attaching Special Tool To Fuel Delivery Pipe
Courtesy of SUBARU OF AMERICA, INC.

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

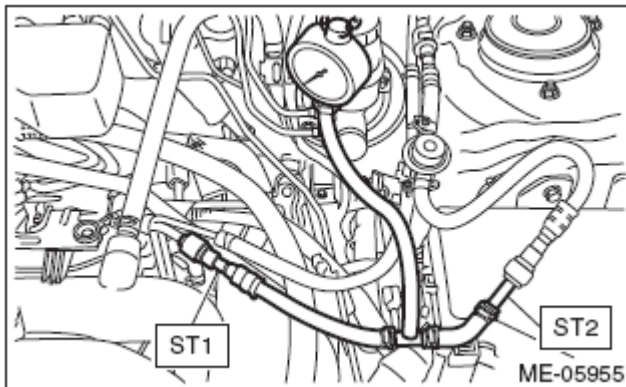


Fig. 19: Identifying Fuel Pressure Gauge Attached With Special Tools
Courtesy of SUBARU OF AMERICA, INC.

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/cm² , 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/cm² , 49.3 - 58 psi)

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

VALVE CLEARANCE**INSPECTION**

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

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

1. Remove the collector cover.

NOTE: Follow the steps below when removing the collector cover.

1. Pull up the two points at the rear (A).
2. Pull up the two points at the front (B) while moving them forward.

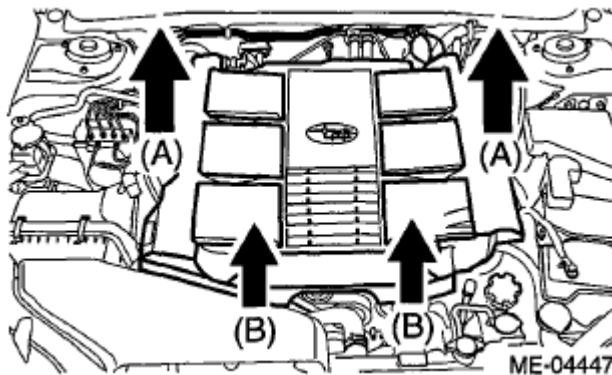


Fig. 20: Removing Collector Cover
Courtesy of SUBARU OF AMERICA, INC.

2. Disconnect the ground cable from battery.
3. Lift up the vehicle.
4. Remove the under cover. Refer to **REMOVAL** .
5. Lower the vehicle.
6. When inspecting valve clearances for #1, #3 and #5
7. Loosen the clamp (A) which connects the air intake boot assembly.
8. Loosen the bolt (B) which secures the air intake boot assembly to the collector cover bracket.

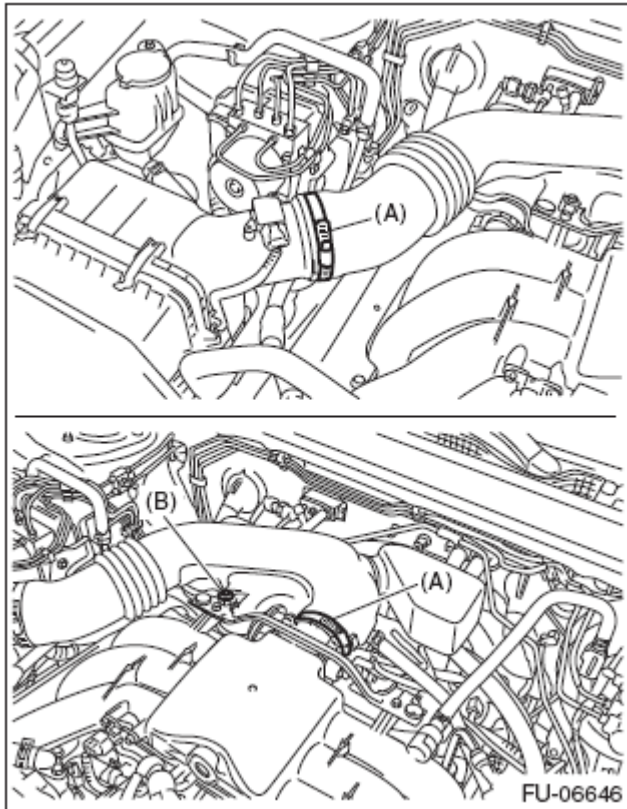


Fig. 21: Identifying Air Intake Boot Assembly Connecting Clamp
Courtesy of SUBARU OF AMERICA, INC.

1. Remove the air intake boot assembly, and move it to the left side wheel apron.

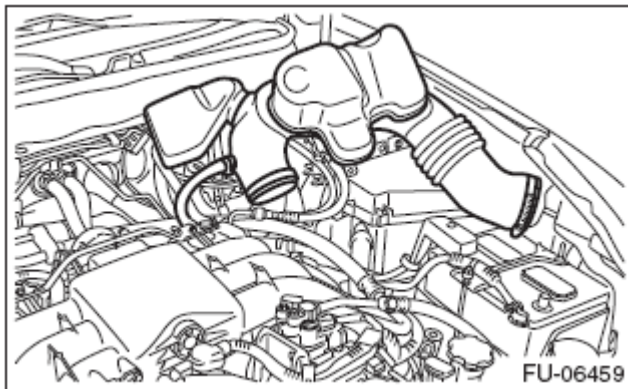


Fig. 22: Identifying Air Intake Boot Assembly
Courtesy of SUBARU OF AMERICA, INC.

2. Remove the air intake duct and air cleaner case. Refer to **REMOVAL** and **REMOVAL**.
3. Remove the fuel pipe protector (RH).

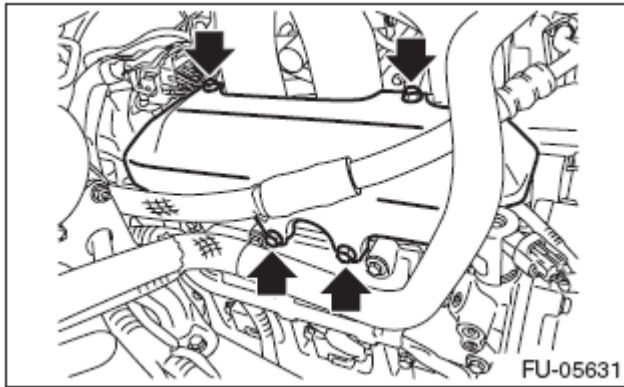


Fig. 23: Locating Air Intake Duct And Air Cleaner Case Mounting Nuts
Courtesy of SUBARU OF AMERICA, INC.

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

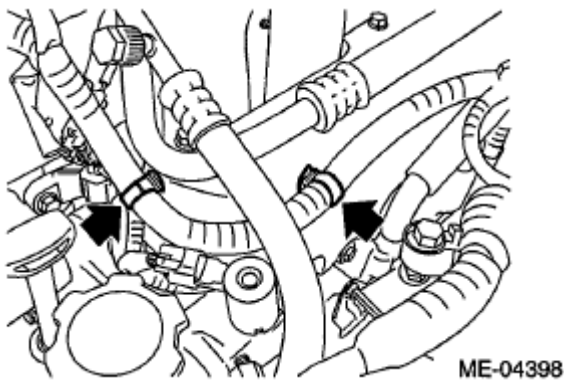
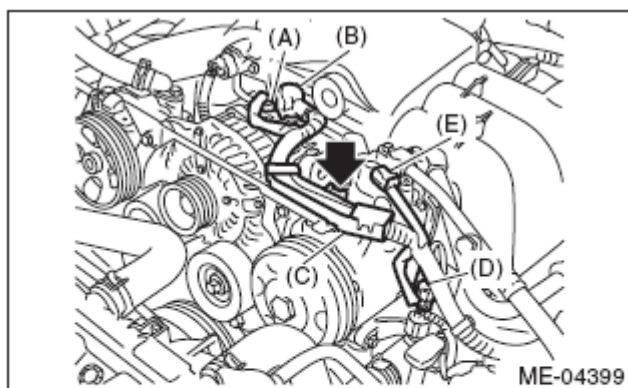


Fig. 24: Locating Fixing Clips On Fuel Pipe Protector (LH)
Courtesy of SUBARU OF AMERICA, INC.

3. Generator connector
4. Generator terminal B
5. Remove the harness cover from collector cover bracket.
6. A/C compressor solenoid connector
7. Flow sensor connector



- (A) Generator connector
- (B) Terminal B
- (C) Harness cover
- (D) A/C compressor solenoid connector
- (E) Flow sensor connector

Fig. 25: Identifying Generator Connector, Terminal B, Harness Cover, A/C Compressor Solenoid And Flow Sensor Connector
Courtesy of SUBARU OF AMERICA, INC.

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

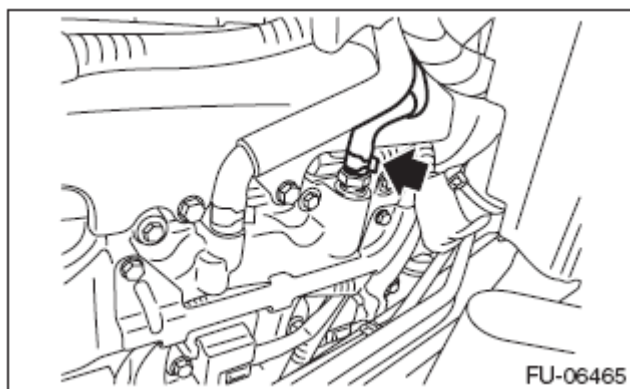


Fig. 26: Locating Rocker Cover (LH) PCV Hose
Courtesy of SUBARU OF AMERICA, INC.

10. Remove the fuel pipe protector (LH).

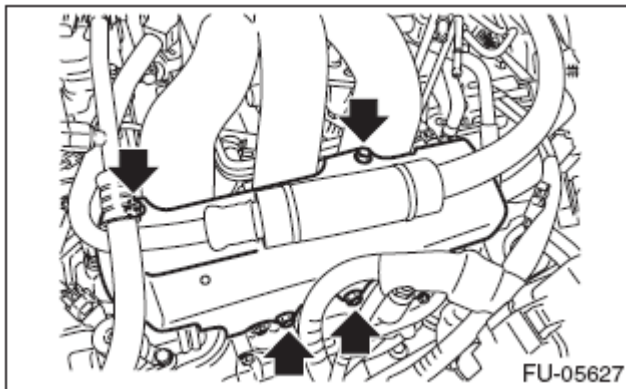
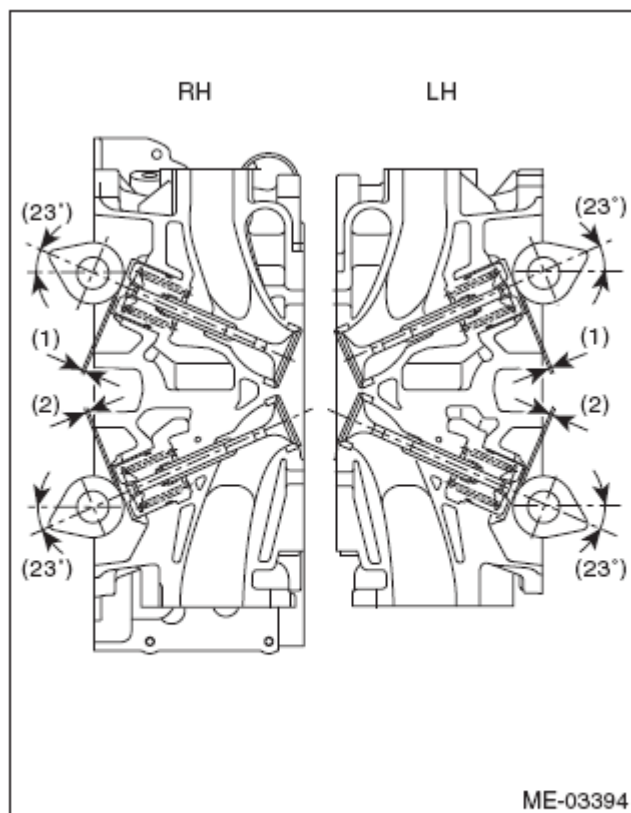


Fig. 27: Locating Fuel Pipe Protector (LH) Mounting Nuts
Courtesy of SUBARU OF AMERICA, INC.

11. Remove the ignition coil. Refer to **REMOVAL**.
12. Remove the rocker cover (LH). Refer to **REMOVAL**.
10. 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. 28: Turning Crankshaft Clockwise
Courtesy of SUBARU OF AMERICA, INC.

11. 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.

Valve clearance (inspection value):

Intake

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

Exhaust

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

- If the measured value is not within specification, take notes of the value in order to adjust the valve clearance later on.

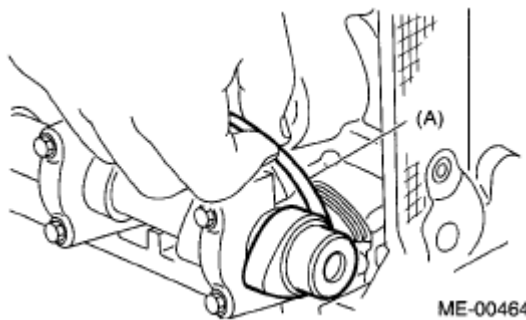


Fig. 29: Measuring Clearance Of Intake Valve And Exhaust Valve Using Thickness Gauge
Courtesy of SUBARU OF AMERICA, INC.

12. If necessary, adjust the valve clearance. Refer to ADJUSTMENT.
13. Further turn the crank pulley clockwise and then measure the valve clearances again.
14. After inspection, install the related parts in the reverse order of removal. Refer to INSTALLATION.

ADJUSTMENT**INTAKE SIDE**

1. Remove the engine from vehicle. Refer to REMOVAL.
2. Measure all the valve clearances. Refer to INSPECTION.

NOTE:

Record each valve clearance after measurement.

3. Remove the timing chain assembly. Refer to **REMOVAL**.
4. Remove the cam sprocket. Refer to **REMOVAL**.
5. Remove the camshaft. Refer to **REMOVAL**.
6. Remove the valve lifter.
7. Measure the thickness of valve lifter using micrometer.

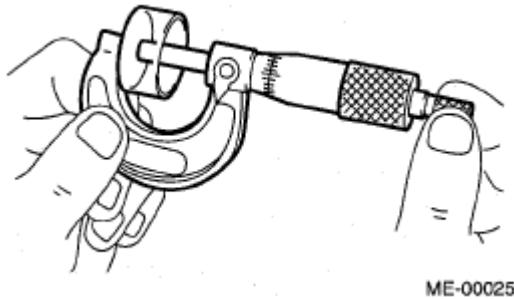


Fig. 30: Measuring Thickness Of Valve Lifter Using Micrometer
Courtesy of SUBARU OF AMERICA, INC.

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**.
10. Install the cam sprocket. Refer to **INSTALLATION**.
11. Install the timing chain assembly. Refer to **INSTALLATION**.
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 **INSTALLATION** when installing the rocker cover. .

EXHAUST SIDE

1. Remove the engine from vehicle. Refer to **REMOVAL**.
2. Measure all the valve clearances. Refer to **INSPECTION**.

NOTE: Record each valve clearance after measurement.

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

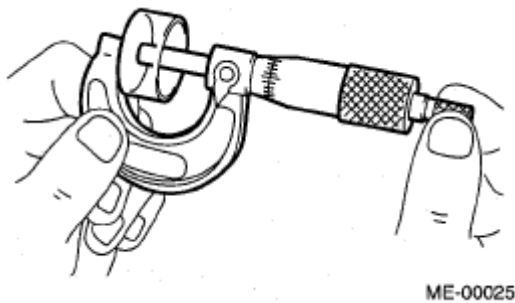


Fig. 31: Measuring Thickness Of Valve Lifter Using Micrometer
Courtesy of SUBARU OF AMERICA, INC.

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**.
8. Install the cam sprocket. Refer to **INSTALLATION**.
9. Install the timing chain assembly. Refer to **INSTALLATION**.
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 INSTALLATION when installing the rocker cover. .

ENGINE ASSEMBLY

REMOVAL

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

Tightening torque:

20 N.m (2.0 kgf-m, 14.8 ft-lb)

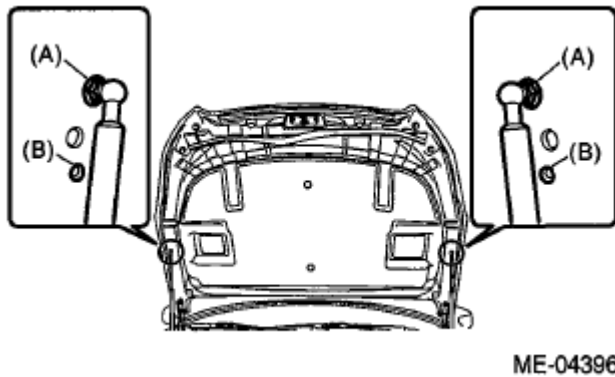


Fig. 32: Identifying Front Hood Damper Bolt Mounting Position
Courtesy of SUBARU OF AMERICA, INC.

2. Remove the collector cover.

NOTE: Follow the steps below when removing the collector cover.

1. Pull up the two points at the rear (A).
2. Pull up the two points at the front (B) while moving them forward.

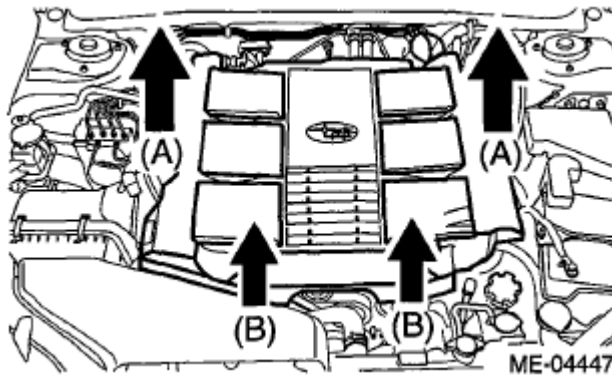


Fig. 33: Removing Collector Cover
Courtesy of SUBARU OF AMERICA, INC.

3. Collect the refrigerant from A/C system. Refer to **PROCEDURE** .
4. Release the fuel pressure. Refer to **PROCEDURE** .
5. Disconnect the ground cable from battery.
6. Open the fuel filler lid and remove the fuel filler cap.
7. Remove the air intake duct, air cleaner case and air intake boot assembly. Refer to **REMOVAL** , Air Intake Duct, **REMOVAL** , Air Cleaner Case, and **REMOVAL** , Air Intake Boot.
8. Remove the V-belts. Refer to **REMOVAL**.
9. Disconnect the following connector.
 1. Remove two fixing clips on the fuel pipe protector (LH).

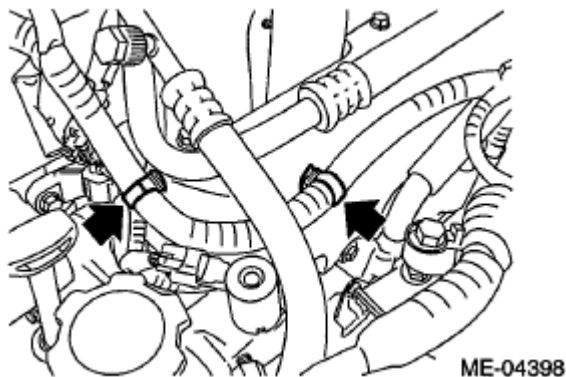
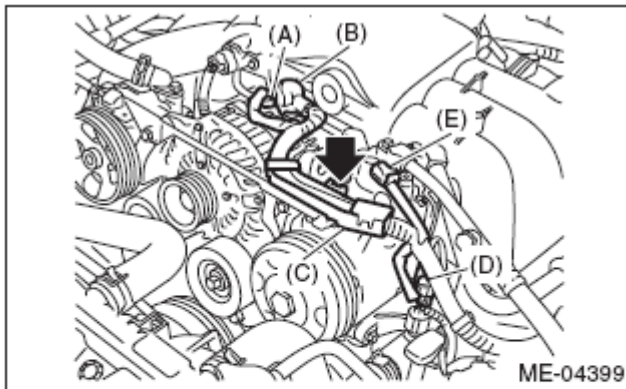


Fig. 34: Locating Fixing Clips On Fuel Pipe Protector (LH)
Courtesy of SUBARU OF AMERICA, INC.

2. Generator connector
3. Generator terminal B
4. Remove the harness cover from collector cover bracket.
5. A/C compressor solenoid connector
6. Flow sensor connector



- (A) Generator connector
- (B) Terminal B
- (C) Harness cover
- (D) A/C compressor solenoid connector
- (E) Flow sensor connector

Fig. 35: Identifying Generator Connector, Terminal B, Harness Cover, A/C Compressor Solenoid And Flow Sensor Connector
 Courtesy of SUBARU OF AMERICA, INC.

7. Slide the harness and connector to the battery side.
10. Remove the power steering pump together with the bracket.

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

1. Disconnect the manifold absolute pressure sensor connector (A) and power steering pump connector (B).

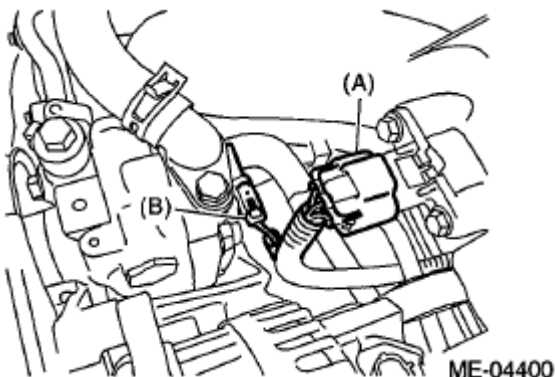


Fig. 36: Identifying Manifold Absolute Pressure Sensor And Power Steering Pump Connector
 Courtesy of SUBARU OF AMERICA, INC.

2. Remove the securing bolts of collector cover bracket and power steering pump bracket.

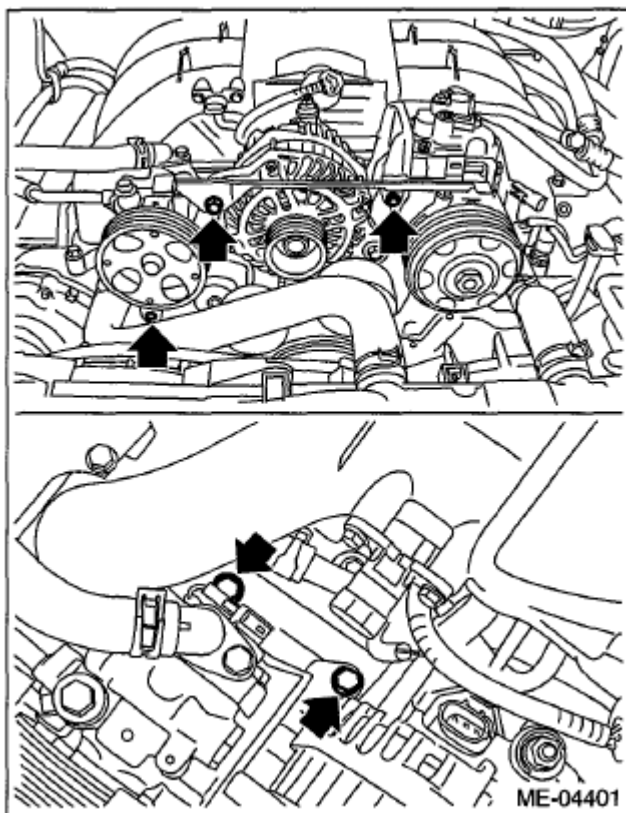


Fig. 37: Locating Securing Bolts Of Collector Cover Bracket And Power Steering Pump Bracket

Courtesy of SUBARU OF AMERICA, INC.

3. Use a cloth to protect the power steering pump and place it on the RH front strut using a wire.

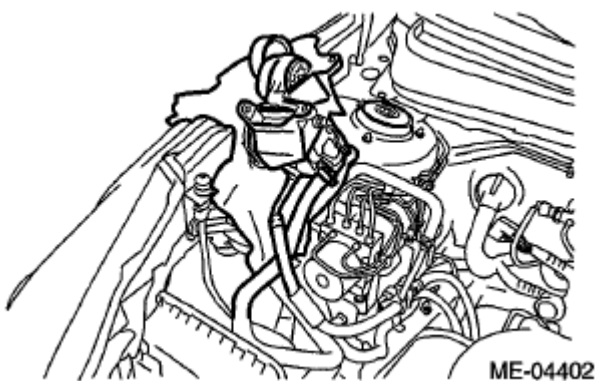


Fig. 38: Identifying Power Steering Pump

Courtesy of SUBARU OF AMERICA, INC.

11. Remove the brake booster vacuum hose.

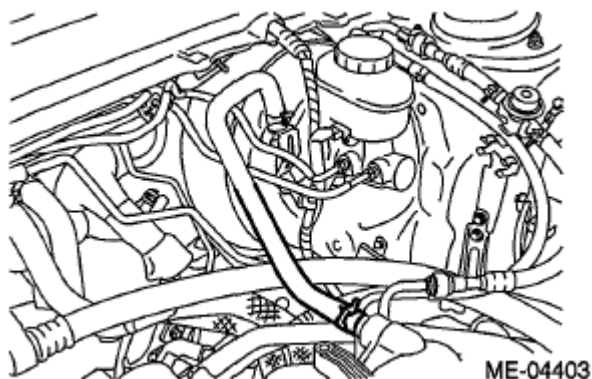


Fig. 39: Identifying Brake Booster Vacuum Hose
Courtesy of SUBARU OF AMERICA, INC.

12. Remove the engine ground.

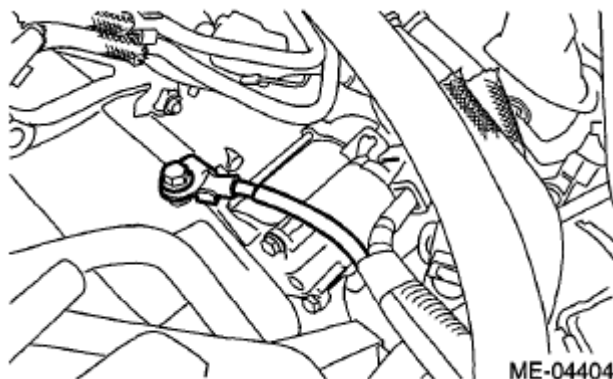


Fig. 40: Identifying Engine Ground
Courtesy of SUBARU OF AMERICA, INC.

13. Remove the starter harness and engine ground from bracket.

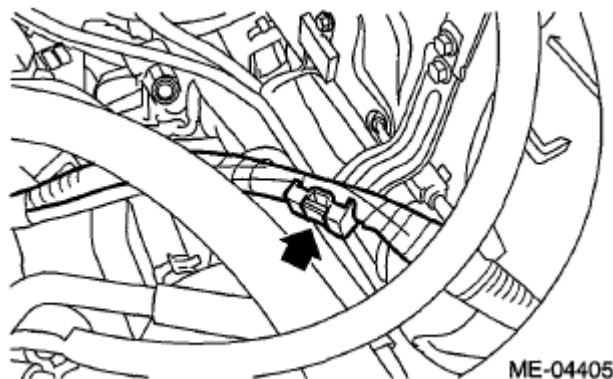


Fig. 41: Locating Bracket Starter Harness And Engine Ground
Courtesy of SUBARU OF AMERICA, INC.

14. Remove the starter. Refer to **REMOVAL** .
15. Remove the grille bracket.

NOTE: Remove ten clips when removing the grille bracket.

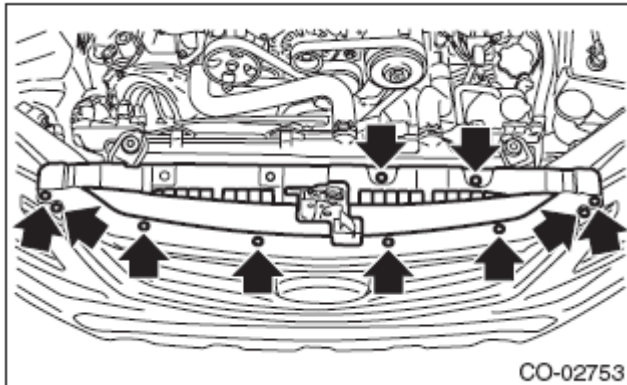


Fig. 42: Locating Grille Bracket Fixing Clips
Courtesy of SUBARU OF AMERICA, INC.

16. Lift up the vehicle.
17. Remove the under cover. Refer to **REMOVAL** .
18. Drain engine coolant completely. Refer to **DRAINING OF ENGINE COOLANT** .
19. Remove the front exhaust pipe. Refer to **REMOVAL** .
20. Remove the ground cable from the underside of chain cover.

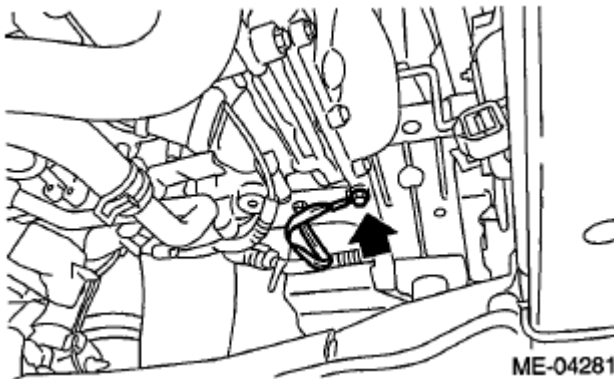


Fig. 43: Locating Ground Cable On Underside Of Chain Cover
Courtesy of SUBARU OF AMERICA, INC.

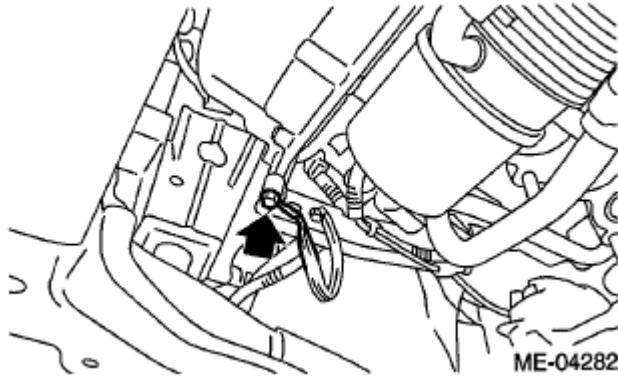


Fig. 44: Locating Ground Cable Fixing Bolt
Courtesy of SUBARU OF AMERICA, INC.

21. Remove the connecting bolts and nuts (lower side) between the engine and transmission.

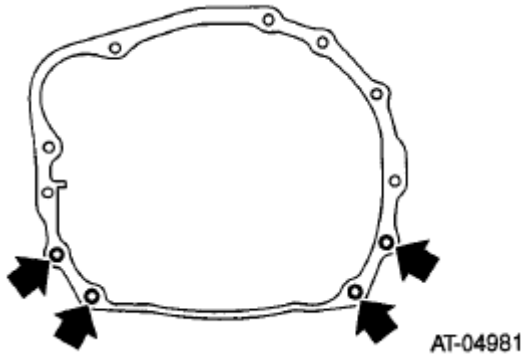


Fig. 45: Locating Engine And Transmission Connecting Bolts And Nuts
Courtesy of SUBARU OF AMERICA, INC.

22. Lower the vehicle.
23. Remove the radiator main fan & fan motor and radiator sub fan & fan motor. Refer to **REMOVAL** and **REMOVAL** .
24. Remove the radiator. Refer to **REMOVAL** .
25. Remove the heater inlet hose and heater outlet hose.

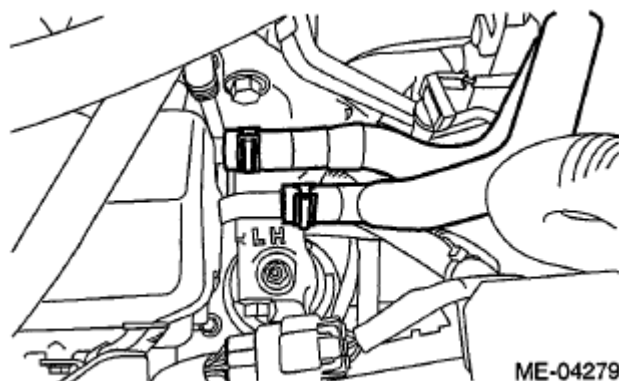


Fig. 46: Identifying Heater Inlet And Outlet Hose
Courtesy of SUBARU OF AMERICA, INC.

26. Disconnect the engine harness connector.

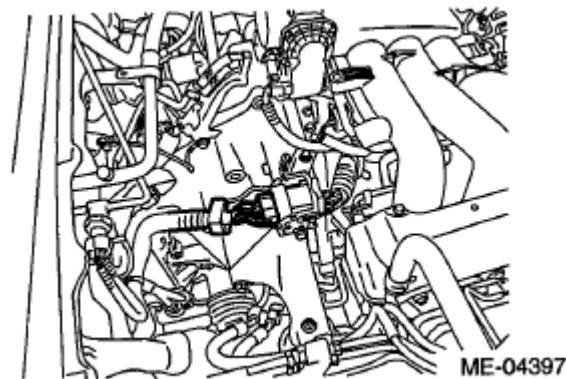


Fig. 47: Identifying Engine Harness Connector
Courtesy of SUBARU OF AMERICA, INC.

27. Disconnect the connector from the throttle body.



Fig. 48: Identifying Throttle Body Connector
Courtesy of SUBARU OF AMERICA, INC.

28. Remove the engine harness connector from the engine hanger bracket.

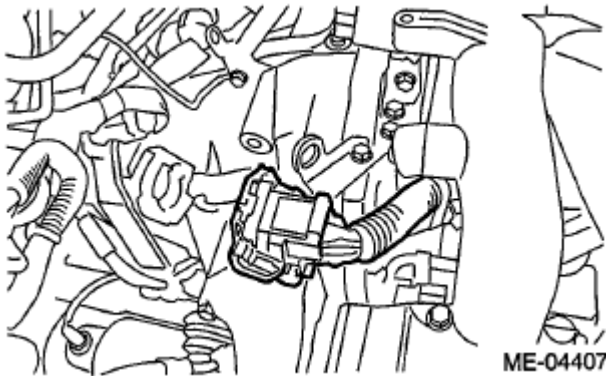


Fig. 49: Identifying Engine Hanger Bracket Harness Connector
Courtesy of SUBARU OF AMERICA, INC.

29. Remove the engine hanger bracket.

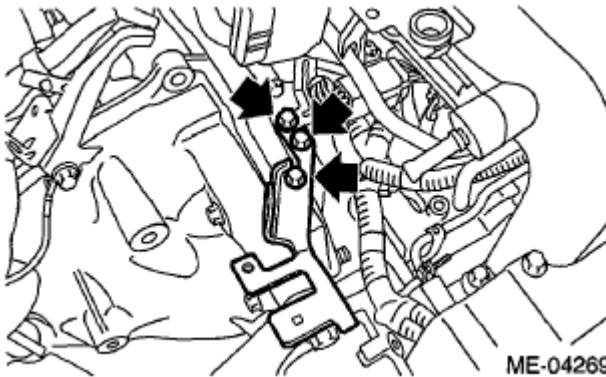


Fig. 50: Locating Engine Hanger Bracket Mounting Bolts
Courtesy of SUBARU OF AMERICA, INC.

30. Remove the throttle body from the intake manifold.

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

31. Attach the ST.

ST 18360AA020 HANGER

Tightening torque:

19 N.m (1.9 kgf-m, 14.0 ft-lb)

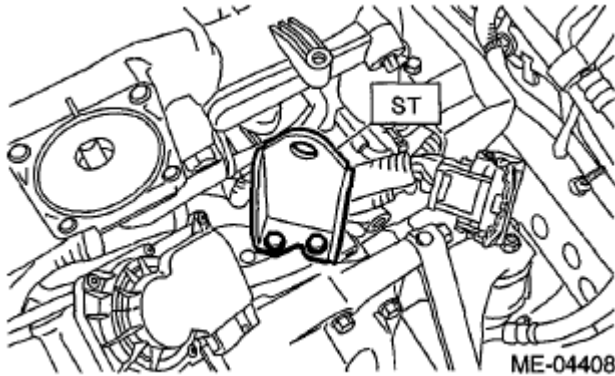


Fig. 51: Attaching Special Tool To Inlet And Outlet Hoses Of Engine Coolant
Courtesy of SUBARU OF AMERICA, INC.

32. Separate the torque converter clutch from drive plate.
 1. Remove the service hole plug.

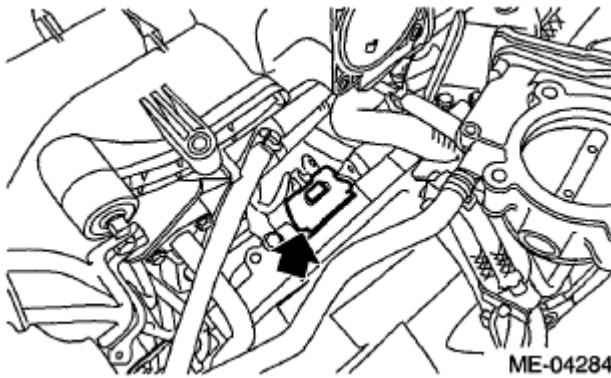


Fig. 52: Locating Service Hole Plug
Courtesy of SUBARU OF AMERICA, INC.

2. Rotate the crank pulley to align the drive plate to the service hole, and remove four bolts.
33. Disconnect the fuel delivery hose and evaporation hose.

CAUTION:

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

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

ST 42099AE000 QUICK CONNECTOR RELEASE

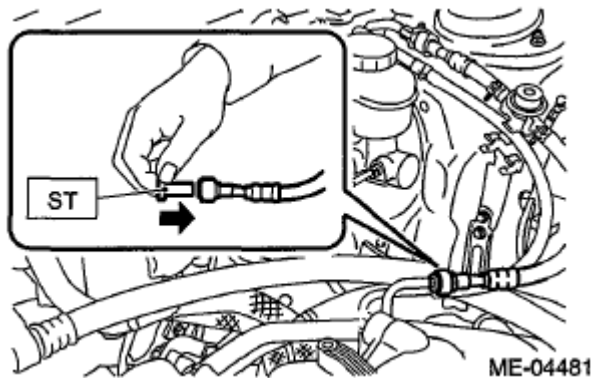


Fig. 53: Attaching Special Tool To Fuel Delivery Pipe
Courtesy of SUBARU OF AMERICA, INC.

2. Remove the clip and disconnect the evaporation hose.
34. Disconnect the A/C pressure hoses from A/C compressor. Refer to **REMOVAL**.
35. Remove the connecting bolts (upper side) between engine and transmission.

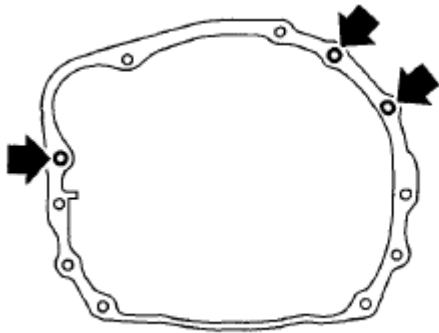


Fig. 54: Locating Engine And Transmission Connecting Bolts (Upper Side)
Courtesy of SUBARU OF AMERICA, INC.

36. Set the ST to torque converter clutch case.

ST 498277200 STOPPER SET

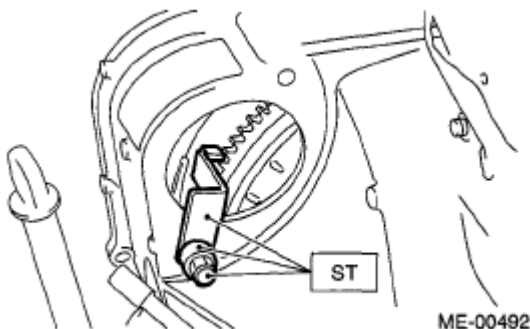


Fig. 55: Setting Special Tool To Torque Converter Clutch Case

Courtesy of SUBARU OF AMERICA, INC.

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

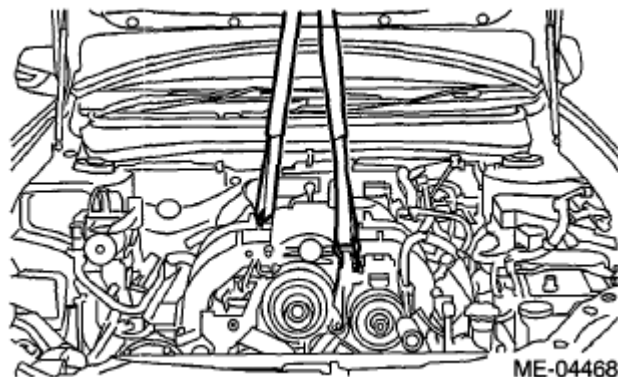


Fig. 56: Supporting Engine Using Lifting Device And Wire Ropes
Courtesy of SUBARU OF AMERICA, INC.

38. Remove the front mount.

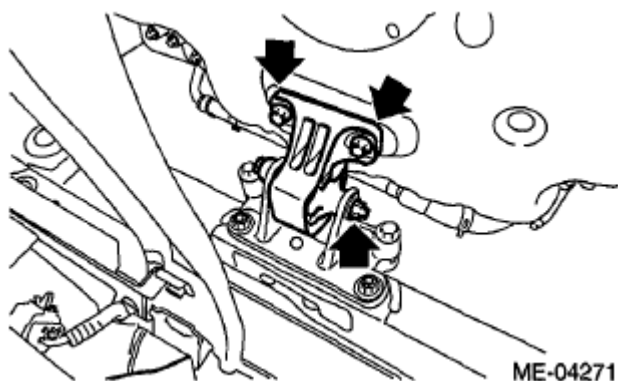


Fig. 57: Locating Engine Assembly Front Mounting Bolts
Courtesy of SUBARU OF AMERICA, INC.

39. Remove the front mounting bracket from the cradle.

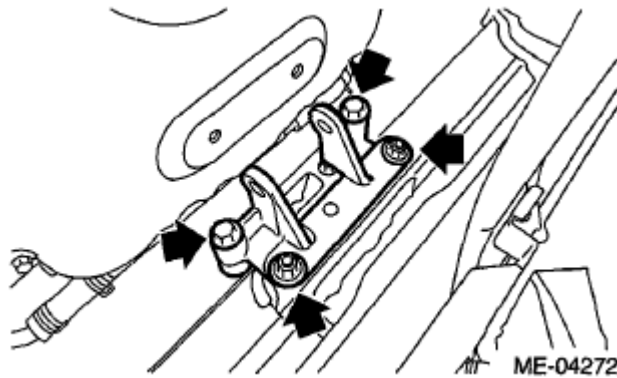


Fig. 58: Locating Cradle Front Mounting Bracket Bolts
Courtesy of SUBARU OF AMERICA, INC.

40. Remove the engine from the engine compartment.
 1. Operate the lifter to set the engine horizontally.
 2. Move the engine towards the front of the vehicle to disconnect it from the torque converter clutch case.
 3. Operate the lifter to take out the engine from the engine compartment.

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

INSTALLATION

1. Install the engine to the vehicle.
 1. Operate the lifter to place the engine in the engine compartment.
 2. Operate the lifter to set the engine horizontally.
 3. Move the engine towards the rear of the vehicle to connect it to the torque converter clutch case.

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

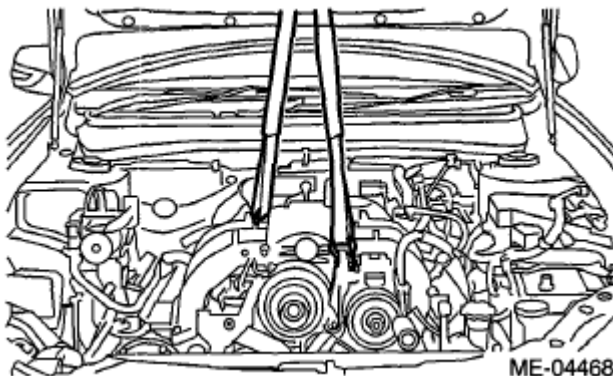


Fig. 59: Supporting Engine Using Lifting Device And Wire Ropes
Courtesy of SUBARU OF AMERICA, INC.

2. Install front mounting bracket to the cradle.

Tightening torque:

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

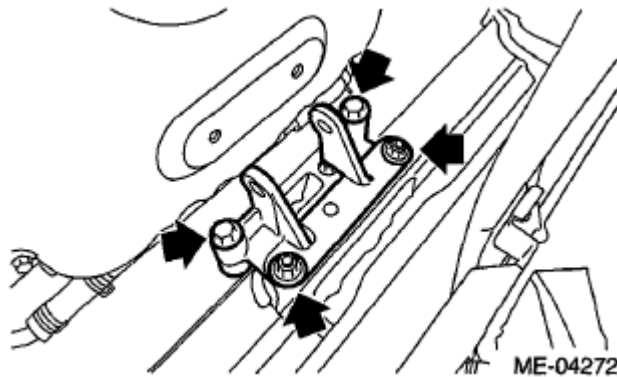


Fig. 60: Locating Cradle Front Mounting Bracket Bolts
Courtesy of SUBARU OF AMERICA, INC.

3. Install the front mount.

Tightening torque:

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

T2: 45 N.m (4.6 kgf-m, 33.2 ft-lb)

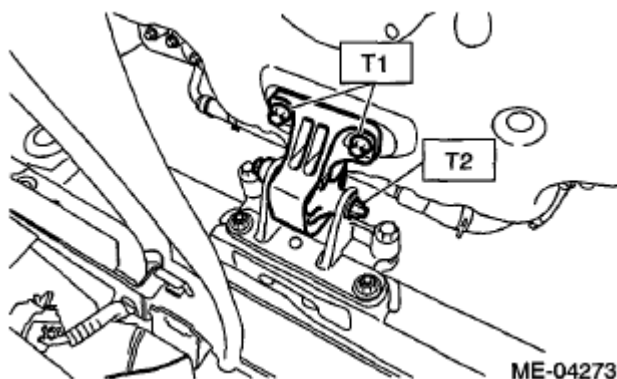


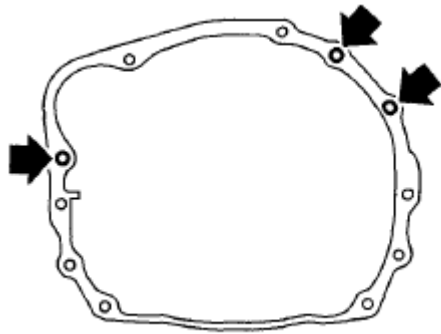
Fig. 61: Identifying Front Mounting Bolts Tightening Torques
Courtesy of SUBARU OF AMERICA, INC.

4. Install the connecting bolts (upper side) between engine and transmission.

Tightening torque:

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

NOTE: Make sure there are no gaps in the mating surfaces between engine and transmission. If there are gaps, loosen the connecting bolts, and adjust the position while retightening the bolts.



AT-04980

Fig. 62: Locating Engine And Transmission Connecting Bolts (Upper Side)
Courtesy of SUBARU OF AMERICA, INC.

5. Remove the lifting device and wire ropes.
6. Remove the ST from torque converter clutch case.

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

7. Install the radiator. Refer to **INSTALLATION**.
8. Install the radiator main fan & fan motor and radiator sub fan & fan motor. Refer to **INSTALLATION** and **INSTALLATION**.
9. Lift up the vehicle.
10. Attach the connecting bolts and nuts (lower side) between the engine and transmission.

Tightening torque:

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

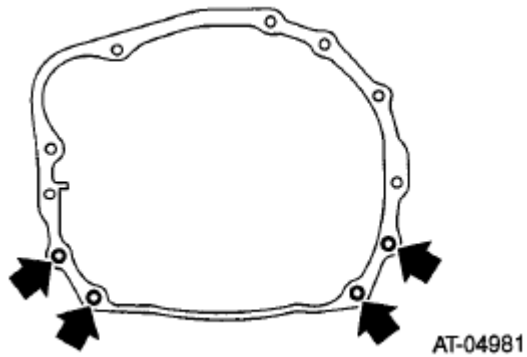


Fig. 63: Locating Engine And Transmission Connecting Bolts And Nuts
Courtesy of SUBARU OF AMERICA, INC.

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

Tightening torque:

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

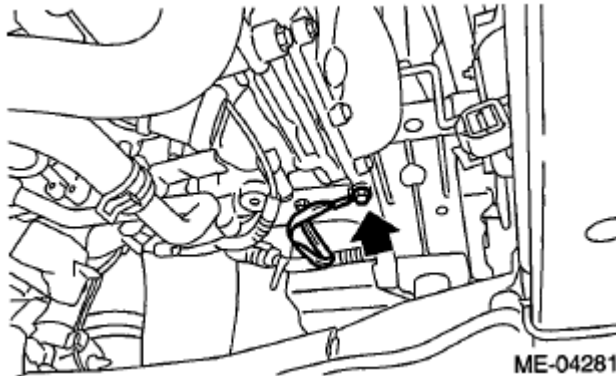


Fig. 64: Locating Ground Cable On Underside Of Chain Cover
Courtesy of SUBARU OF AMERICA, INC.

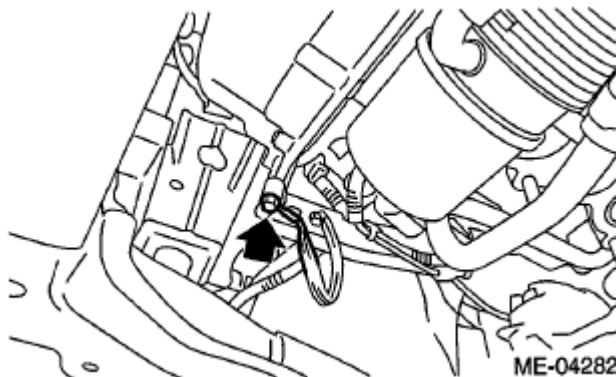


Fig. 65: Locating Ground Cable Fixing Bolt
Courtesy of SUBARU OF AMERICA, INC.

12. Install the front exhaust pipe. Refer to **INSTALLATION** .
13. Install the under cover. Refer to **INSTALLATION** .
14. Lower the vehicle.
15. Install the A/C pressure hoses to A/C compressor. Refer to **INSTALLATION** .
16. Connect the fuel delivery hose (A) and evaporation hose (B).

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

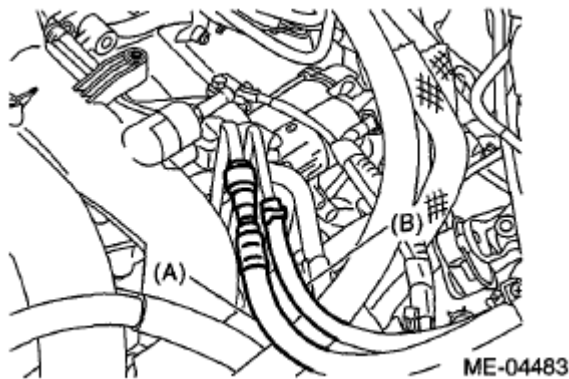


Fig. 66: Identifying Fuel Delivery And Evaporation Hose
 Courtesy of SUBARU OF AMERICA, INC.

17. Connect the torque converter clutch to the drive plate.
 1. Rotate the clank 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.

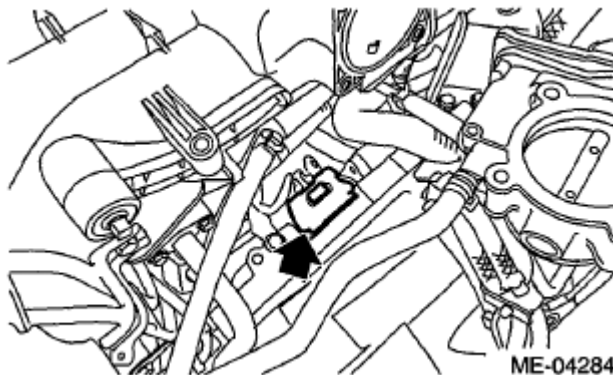


Fig. 67: Locating Service Hole Plug
 Courtesy of SUBARU OF AMERICA, INC.

18. Remove the ST.

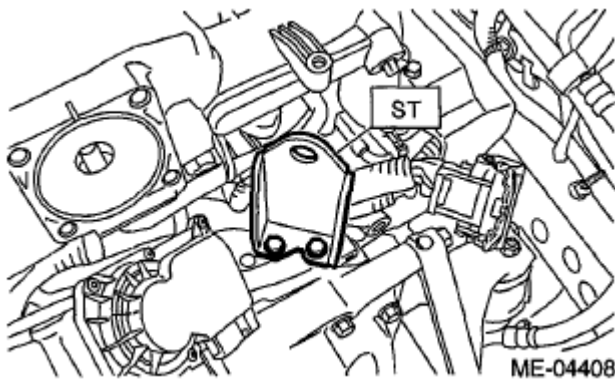


Fig. 68: Identifying Special Tool Attached To Engine Assembly
Courtesy of SUBARU OF AMERICA, INC.

19. 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)

20. Install the engine hanger bracket.

Tightening torque:

19 N.m (1.9 kgf-m, 14.0 ft-lb)

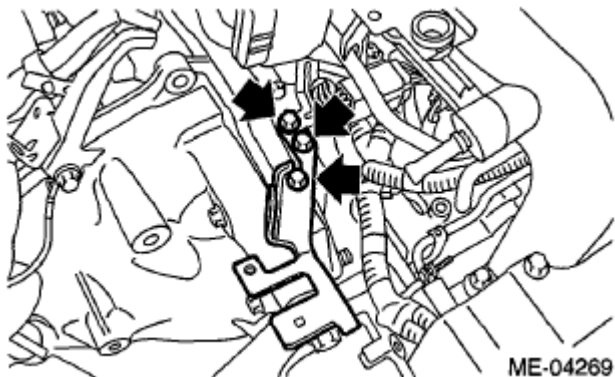


Fig. 69: Locating Engine Hanger Bracket Mounting Bolts
Courtesy of SUBARU OF AMERICA, INC.

21. Install the engine harness connector to the engine hanger bracket.

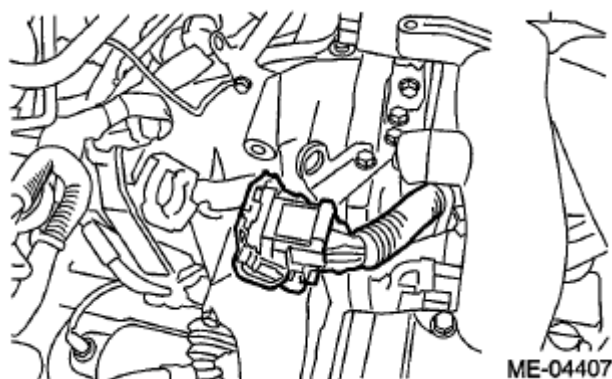


Fig. 70: Identifying Engine Hanger Bracket Harness Connector
Courtesy of SUBARU OF AMERICA, INC.

22. Connect the connector to the throttle body.

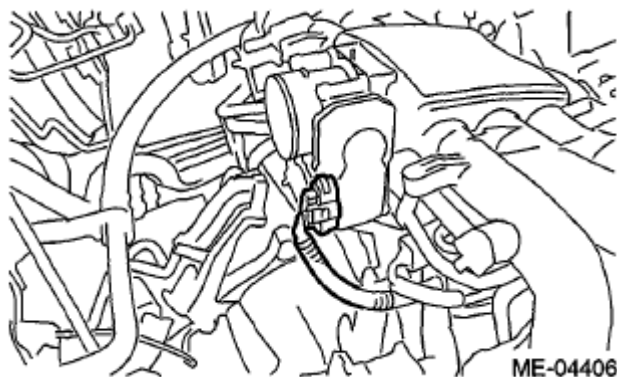


Fig. 71: Identifying Throttle Body Connector
Courtesy of SUBARU OF AMERICA, INC.

23. Connect the engine harness.

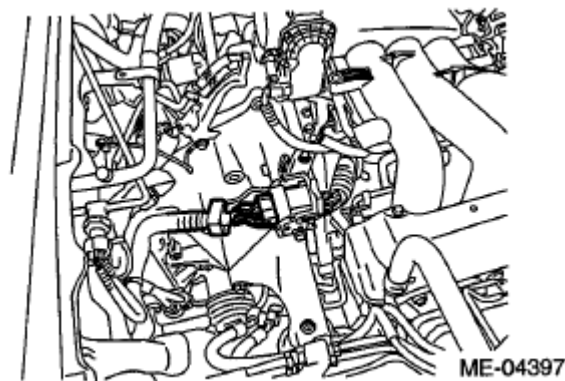


Fig. 72: Identifying Engine Harness
Courtesy of SUBARU OF AMERICA, INC.

24. Install the heater inlet hose and heater outlet hose.

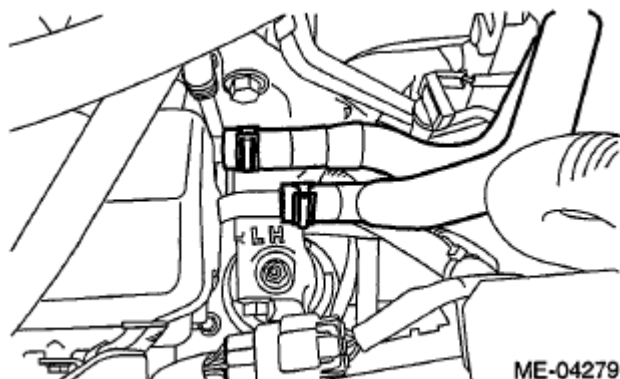


Fig. 73: Identifying Heater Inlet And Outlet Hose
Courtesy of SUBARU OF AMERICA, INC.

25. Attach the grille bracket.

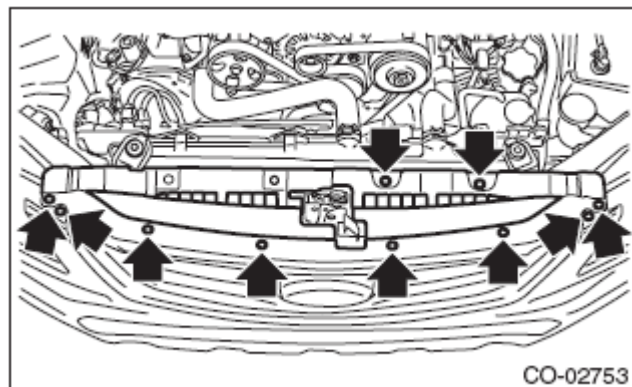


Fig. 74: Locating Grille Bracket Fixing Clips
Courtesy of SUBARU OF AMERICA, INC.

26. Install the starter. Refer to **INSTALLATION** .
27. Install the starter harness and engine ground to the bracket.

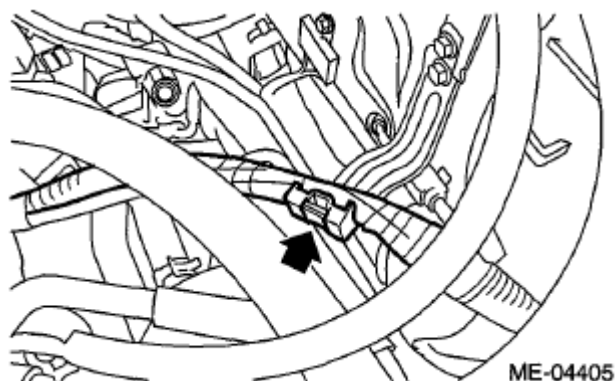


Fig. 75: Locating Starter Harness
Courtesy of SUBARU OF AMERICA, INC.

28. Install the engine ground.

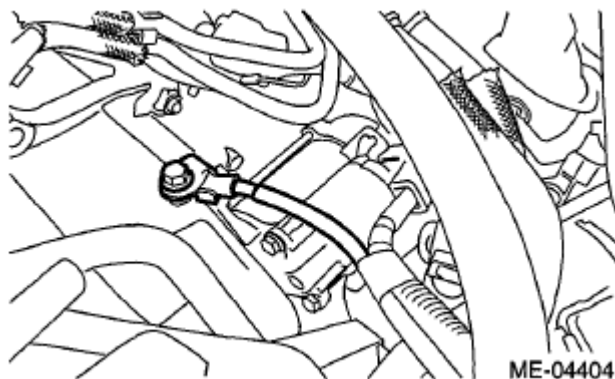


Fig. 76: Identifying Engine Ground
Courtesy of SUBARU OF AMERICA, INC.

29. Install the brake booster vacuum hose.

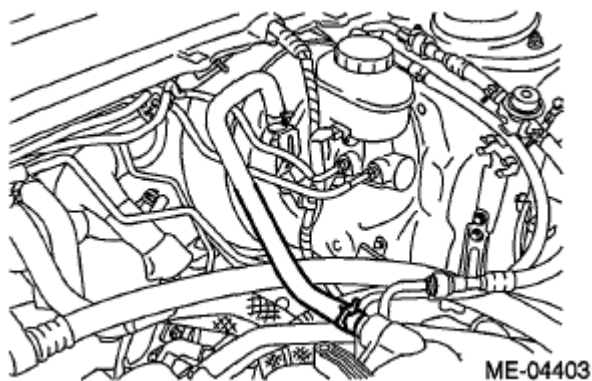


Fig. 77: Identifying Brake Booster Vacuum Hose
Courtesy of SUBARU OF AMERICA, INC.

30. Install the power steering pump together with the bracket.
 1. Install the power steering pump and power steering pump bracket to the cylinder block.
 2. Install the collector cover bracket and power steering pump bracket.

Tightening torque:

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

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

T3: 33 N.m (3.4 kgf-m, 24.3 ft-lb)

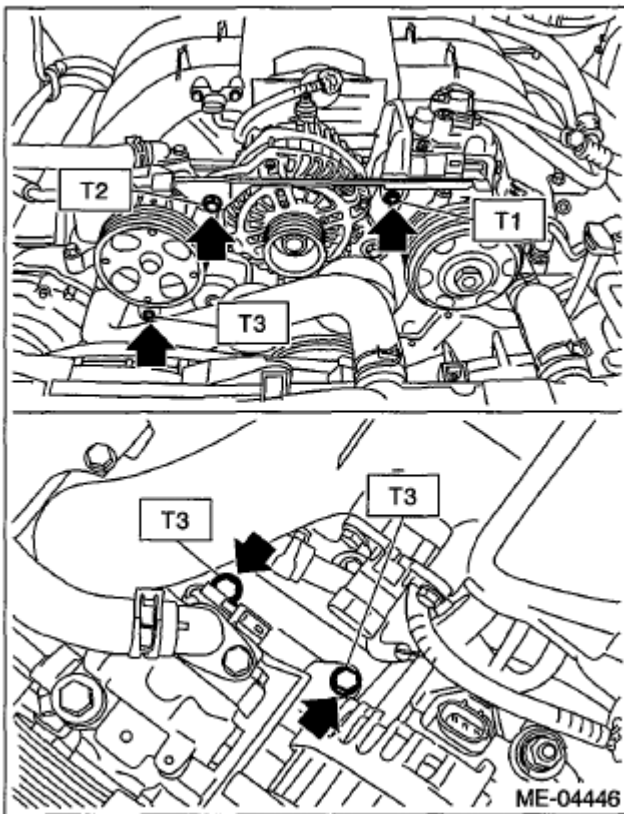


Fig. 78: Identifying Power Steering Pump Bracket Mounting Bolts With Torque Specifications

Courtesy of SUBARU OF AMERICA, INC.

3. Connect the manifold absolute pressure sensor connector (A) and power steering pump connector (B).

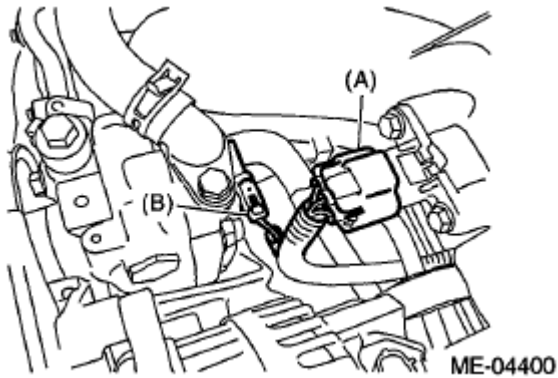


Fig. 79: Identifying Manifold Absolute Pressure Sensor And Power Steering Pump Connector
Courtesy of SUBARU OF AMERICA, INC.

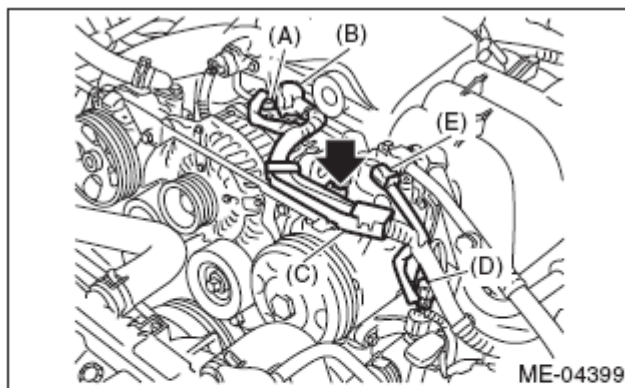
31. Connect the following connectors.

1. Generator connector
2. Generator terminal B

Tightening torque:

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

3. Install the harness cover to the collector cover bracket.
4. A/C compressor solenoid connector
5. Flow sensor connector



- (A) Generator connector
- (B) Generator terminal B
- (C) Install the harness cover to the collector cover bracket.
- (D) A/C compressor solenoid connector
- (E) Flow sensor connector

Fig. 80: Locating Flow Sensor Connector

Courtesy of SUBARU OF AMERICA, INC.

6. Install with the securing clips to the two locations on the fuel pipe protector (LH).

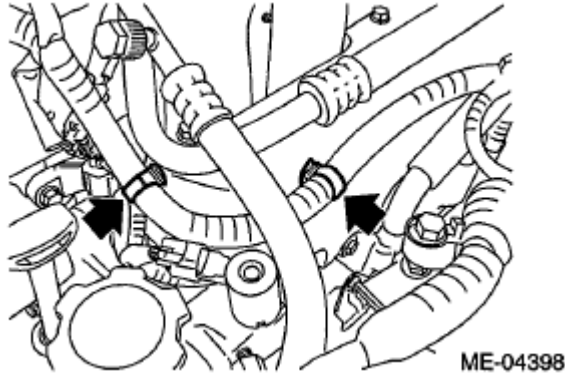
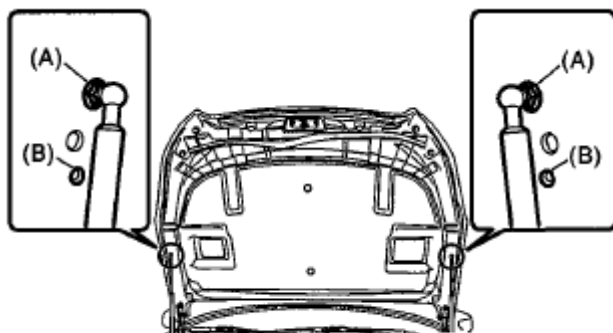


Fig. 81: Locating Fuel Pipe Protector (LH) Securing Clips
Courtesy of SUBARU OF AMERICA, INC.

32. Install the V-belts. Refer to **INSTALLATION**.
33. Install the air intake duct, air cleaner case and air intake boot assembly. Refer to **INSTALLATION** , Air Intake Duct, Refer to **INSTALLATION** , Air Cleaner Case, and Refer to **INSTALLATION** , Air Intake Boot.
34. Connect the ground cable to battery.
35. Fill engine coolant. Refer to **FILLING OF ENGINE COOLANT** .
36. Charge the A/C system with refrigerant. Refer to **PROCEDURE** .
37. Check the ATF level and replenish it if necessary. Refer to **INSPECTION** .
38. Install the collector cover.
39. Change the front hood damper bolt mounting position from (B) to (A), and completely close the front hood.

Tightening torque:

20 N.m (2.0 kgf-m, 14.8 ft-lb)



ME-04396

Fig. 82: Identifying Front Hood Damper Bolt Mounting Position
Courtesy of SUBARU OF AMERICA, INC.

INSPECTION

1. Check that the pipes, hoses, connectors and clips are securely connected.
2. Check that the engine coolant is up to specified level.
3. Check that the ATF is up to specified level.
4. Start the engine and check for exhaust gas, engine coolant, leaks of fuel, etc. Also check for noise and vibrations.

ENGINE MOUNTING

REMOVAL

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

Tightening torque:

20 N.m (2.0 kgf-m, 14.8 ft-lb)

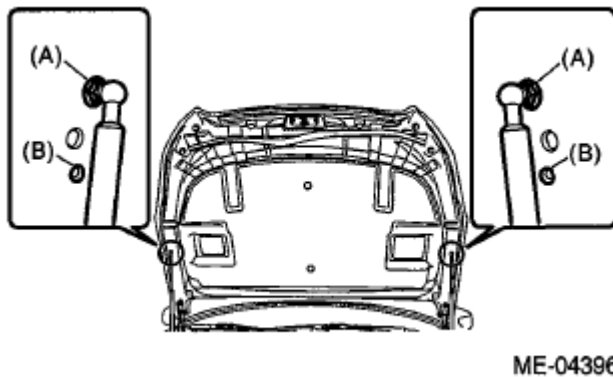


Fig. 83: Identifying Front Hood Damper Bolt Mounting Position
Courtesy of SUBARU OF AMERICA, INC.

2. Remove the collector cover.

NOTE: Follow the steps below when removing the collector cover.

1. Pull up the two points at the rear (A).
2. Pull up the two points at the front (B) while moving them forward.

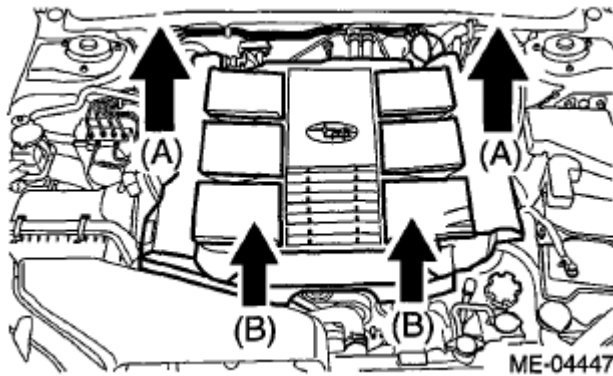


Fig. 84: Removing Collector Cover
Courtesy of SUBARU OF AMERICA, INC.

3. Loosen the clamp (A) which connects the air intake boot assembly.
4. Loosen the bolt (B) which secures the air intake boot assembly to the collector cover bracket.

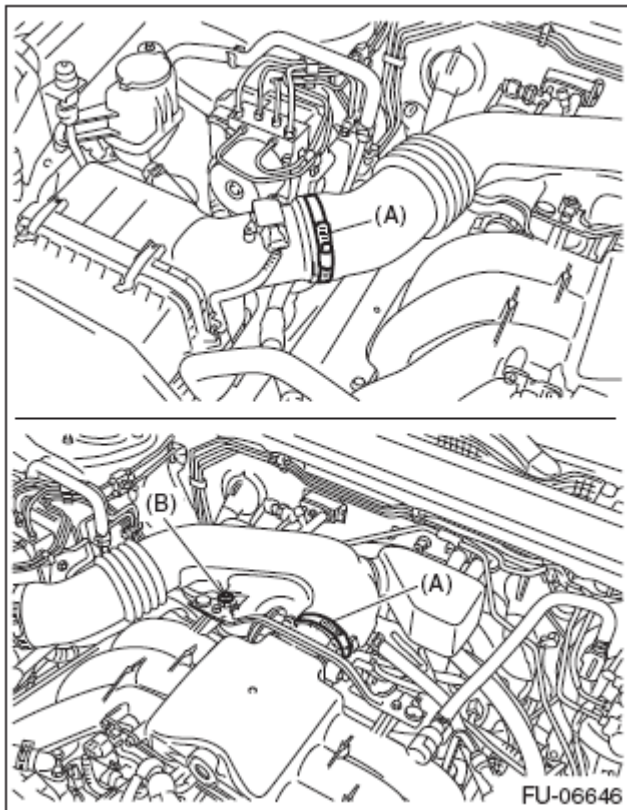


Fig. 85: Identifying Clamp Securing Air Intake Boot Assembly To Collector Cover Bracket
Courtesy of SUBARU OF AMERICA, INC.

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

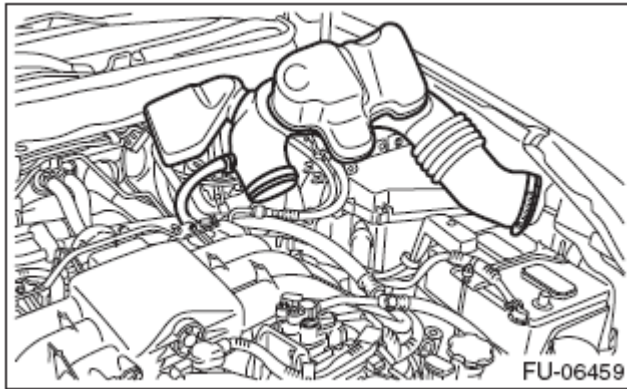


Fig. 86: Identifying Air Intake Boot Assembly
 Courtesy of SUBARU OF AMERICA, INC.

6. Remove the air intake duct and air cleaner case. Refer to **REMOVAL** and **REMOVAL** .
7. Remove the grille bracket.

NOTE: Remove ten clips when removing the grille bracket.

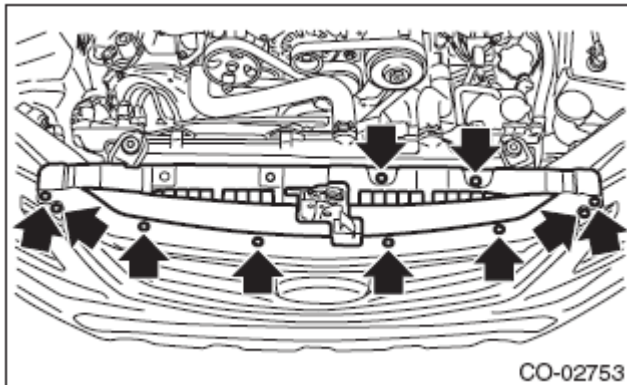


Fig. 87: Locating Grille Bracket Fixing Clips
 Courtesy of SUBARU OF AMERICA, INC.

8. Lift up the vehicle.
9. Remove the under cover. Refer to **REMOVAL** .
10. Drain engine coolant completely. Refer to **DRAINING OF ENGINE COOLANT** .
11. Lower the vehicle.
12. Remove the radiator main fan & fan motor and radiator sub fan & fan motor. Refer to **REMOVAL** and **REMOVAL** .
13. Disconnect the engine harness.

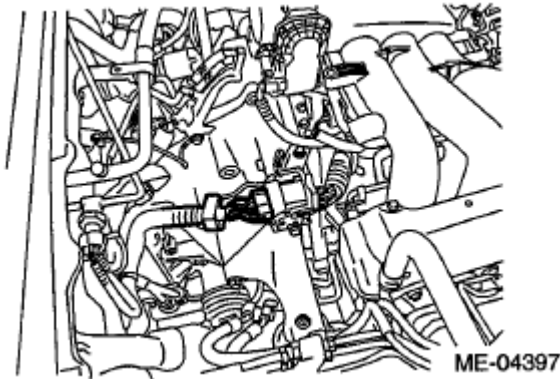


Fig. 88: Identifying Engine Harness
Courtesy of SUBARU OF AMERICA, INC.

14. Disconnect the connector from the throttle body.

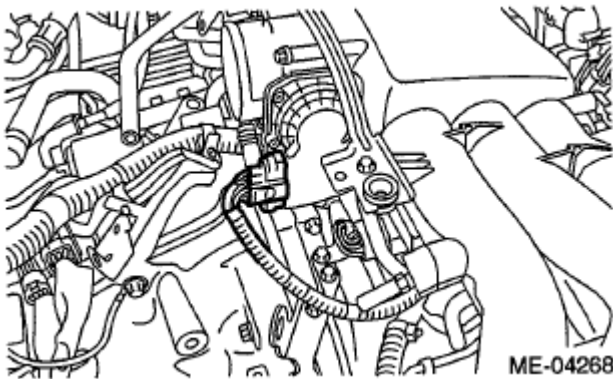


Fig. 89: Identifying Throttle Body Connector
Courtesy of SUBARU OF AMERICA, INC.

15. Remove the engine harness connector from the engine hanger bracket.

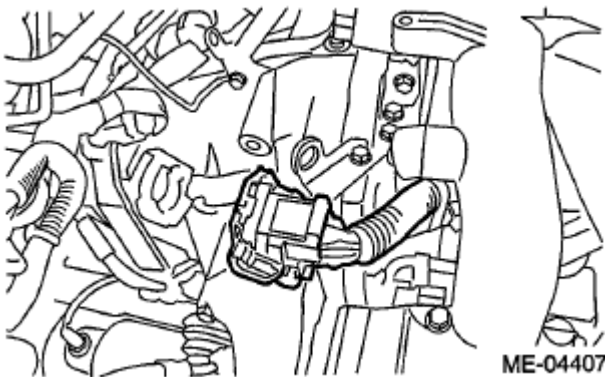


Fig. 90: Identifying Engine Hanger Bracket Harness Connector
Courtesy of SUBARU OF AMERICA, INC.

16. Remove the engine hanger bracket.

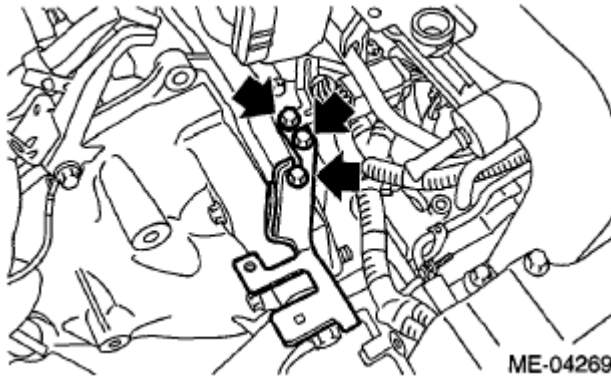


Fig. 91: Locating Engine Hanger Bracket Mounting Bolts
Courtesy of SUBARU OF AMERICA, INC.

17. Remove the throttle body from the intake manifold.

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

18. Attach the ST.

ST 18360AA020 HANGER

Tightening torque:

19 N.m (1.9 kgf-m, 14.0 ft-lb)

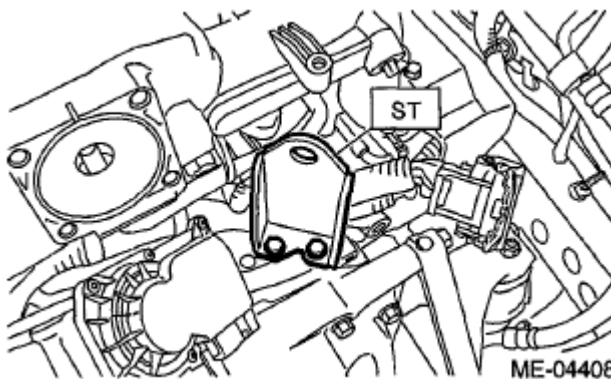


Fig. 92: Identifying Special Tool Connected To Inlet And Outlet Hoses Of Engine Coolant
Courtesy of SUBARU OF AMERICA, INC.

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

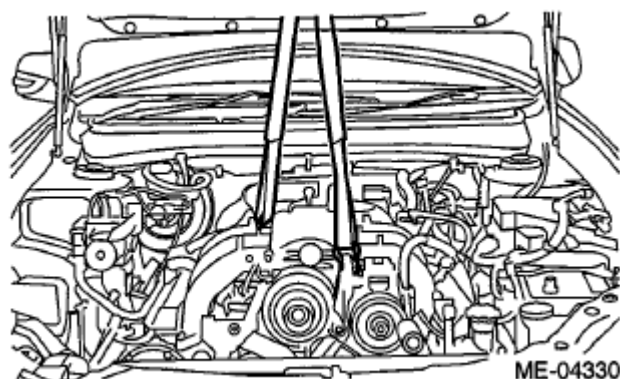


Fig. 93: Supporting Engine Using Lifting Device And Wire Ropes
Courtesy of SUBARU OF AMERICA, INC.

20. Remove the front mount.

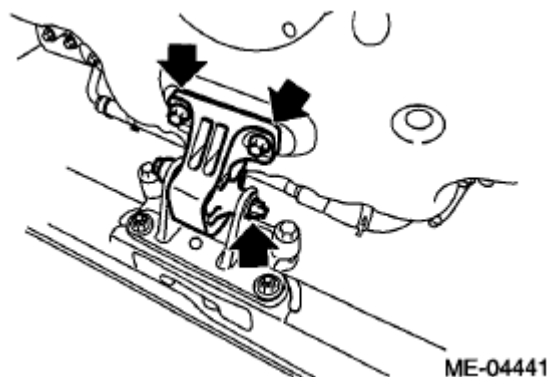


Fig. 94: Locating Engine Front Mounting Bolts
Courtesy of SUBARU OF AMERICA, INC.

21. Remove the front mounting bracket from the cradle.

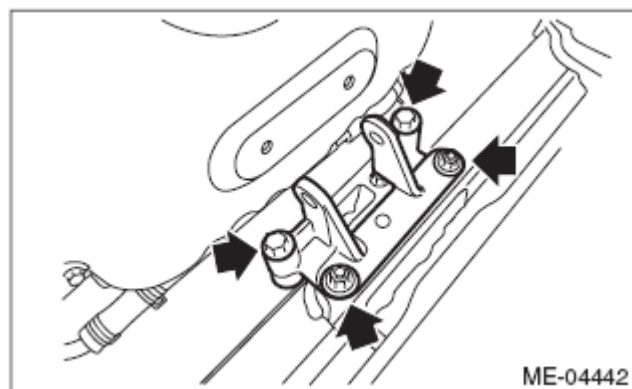


Fig. 95: Locating Cradle Front Mounting Bracket Bolts
Courtesy of SUBARU OF AMERICA, INC.

22. Remove the bracket from the cradle.

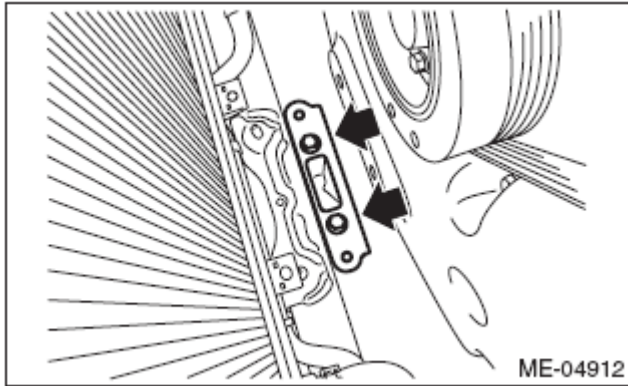


Fig. 96: Locating Cradle Bracket Mounting Bolts
Courtesy of SUBARU OF AMERICA, INC.

INSTALLATION

1. Install the bracket to the cradle.

Tightening torque:

65 N.m (6.6 kgf-m, 47.9 ft-lb)

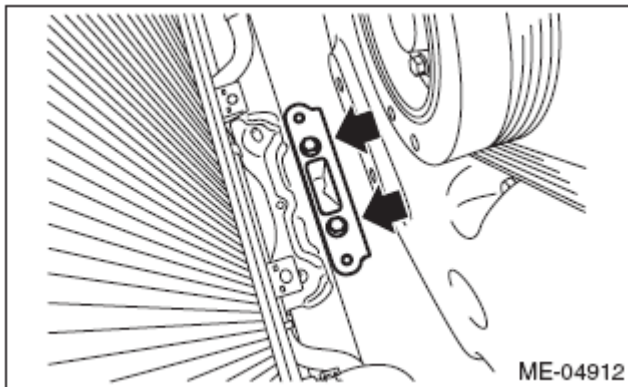


Fig. 97: Locating Cradle Bracket Mounting Bolts
Courtesy of SUBARU OF AMERICA, INC.

2. Install front mounting bracket to the cradle.

Tightening torque:

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

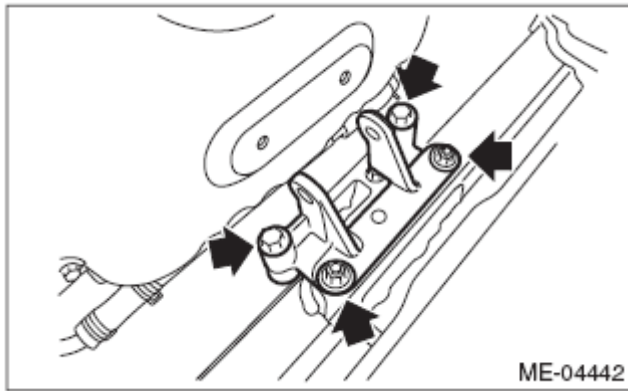


Fig. 98: Locating Cradle Front Mounting Bracket Bolts
Courtesy of SUBARU OF AMERICA, INC.

3. Install the front mount.

Tightening torque:

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

T2: 45 N.m (4.6 kgf-m, 33.2 ft-lb)

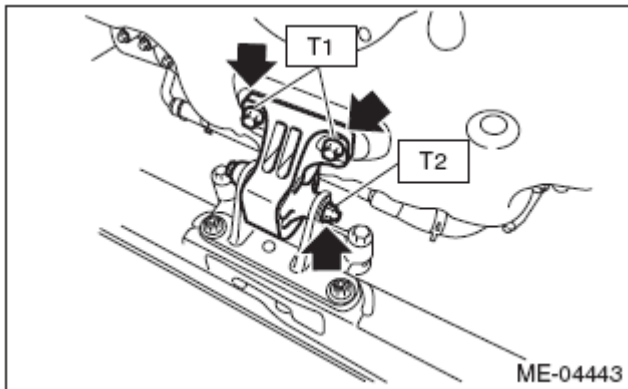


Fig. 99: Locating Engine Front Mounting Bolts With Tightening Torques
Courtesy of SUBARU OF AMERICA, INC.

4. Remove the lifting device and wire ropes.

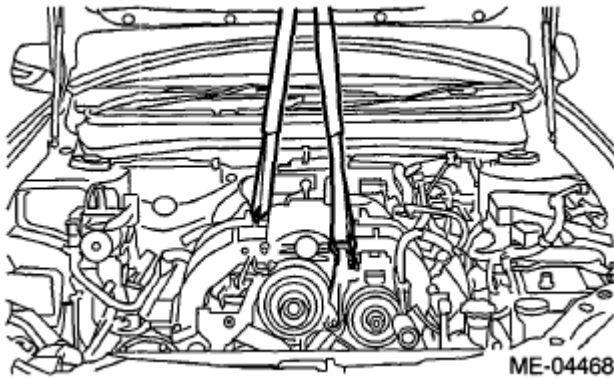


Fig. 100: Supporting Engine Using Lifting Device And Wire Ropes
Courtesy of SUBARU OF AMERICA, INC.

5. Install the radiator main fan & fan motor and radiator sub fan & fan motor. Refer to **INSTALLATION** and **INSTALLATION** .
6. Lift up the vehicle.
7. Install the under cover. Refer to **INSTALLATION** .
8. Lower the vehicle.
9. Remove the ST.

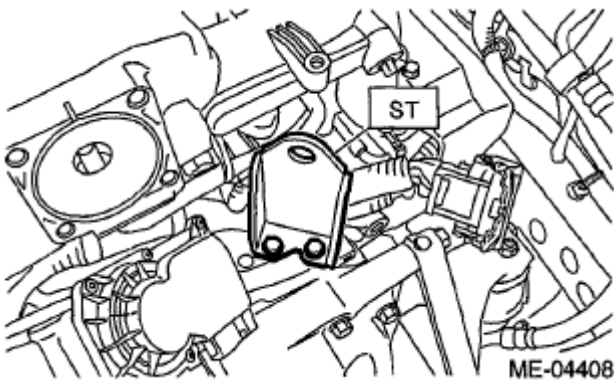


Fig. 101: Identifying Special Tool Connected To Inlet And Outlet Hoses Of Engine Coolant
Courtesy of SUBARU OF AMERICA, INC.

10. 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)

11. Install the engine hanger bracket.

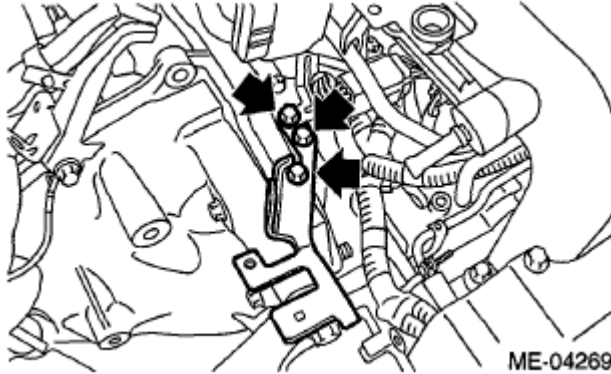
Tightening torque:***19 N.m (1.9 kgf-m, 14.0 ft-lb)***

Fig. 102: Locating Engine Hanger Bracket Mounting Bolts
Courtesy of SUBARU OF AMERICA, INC.

12. Install the engine harness connector to the engine hanger bracket.

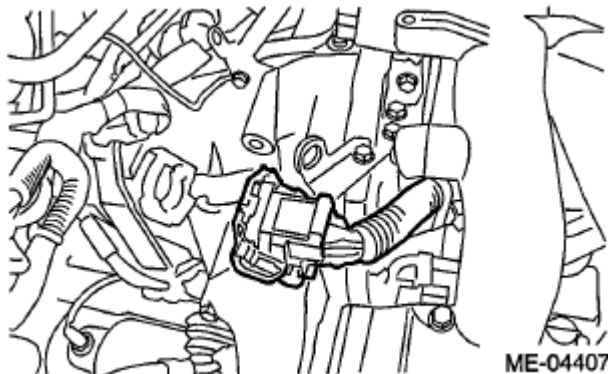


Fig. 103: Identifying Engine Hanger Bracket Harness Connector
Courtesy of SUBARU OF AMERICA, INC.

13. Connect the connector to the throttle body.

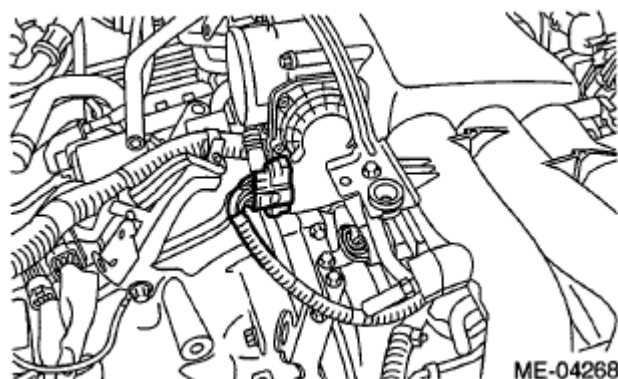


Fig. 104: Identifying Throttle Body Connector
Courtesy of SUBARU OF AMERICA, INC.

14. Connect the engine harness.

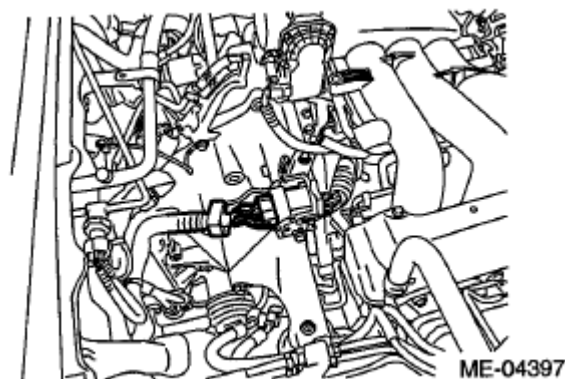


Fig. 105: Identifying Engine Harness
Courtesy of SUBARU OF AMERICA, INC.

15. Attach the grille bracket.

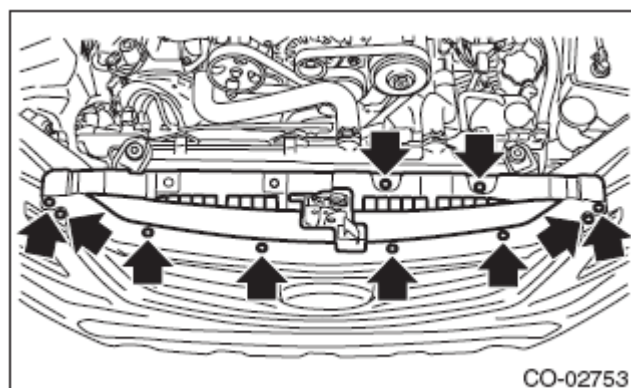


Fig. 106: Locating Grille Bracket Fixing Clips
Courtesy of SUBARU OF AMERICA, INC.

16. Install the air intake duct and air cleaner case. Refer to **INSTALLATION** and **INSTALLATION** .
17. Install the air intake boot assembly.

Tightening torque:

Clamp (A)

3 N.m (0.3 kgf-m, 2.2 ft-lb)

Bolt (B)

6.5 N.m (0.7 kgf-m, 4.8 ft-lb)

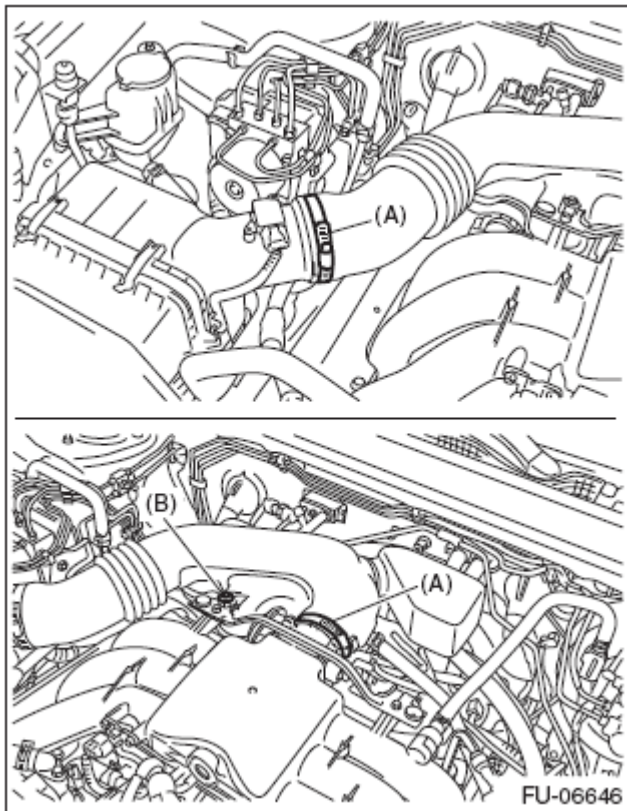


Fig. 107: Identifying Clamp Securing Air Intake Boot Assembly To Collector Cover Bracket
Courtesy of SUBARU OF AMERICA, INC.

18. Connect the ground cable to battery.
19. Fill engine coolant. Refer to **FILLING OF ENGINE COOLANT** .
20. Install the collector cover.
21. Change the front hood damper bolt mounting position from (B) to (A), and completely close the front hood.

Tightening torque:

20 N.m (2.0 kgf-m, 14.8 ft-lb)

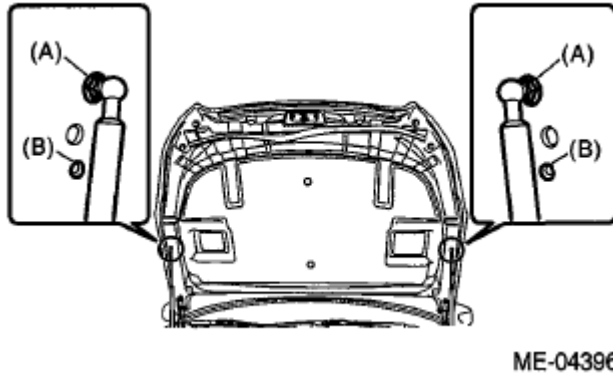


Fig. 108: Identifying Front Hood Damper Bolt Mounting Position
Courtesy of SUBARU OF AMERICA, INC.

INSPECTION

Check that the front mount and front mount bracket have no deformation, cracks and other damages.

PREPARATION FOR OVERHAUL**REMOVAL**

1. Remove the engine from vehicle. Refer to **REMOVAL**.
2. Set the engine on ST.

ST 18232AA000 ENGINE STAND

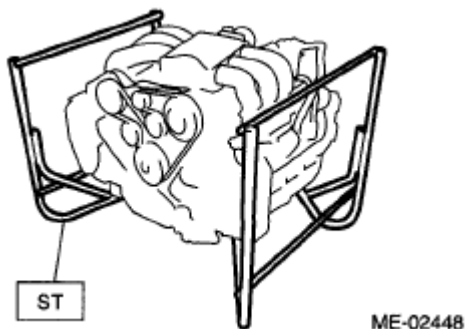


Fig. 109: Identifying Engine Supported On Stand
Courtesy of SUBARU OF AMERICA, INC.

3. Before servicing overhaul, remove the sensor, pipe and hose that installed to engine.
 1. Remove the intake manifold. Refer to **REMOVAL**.

2. Remove the generator. Refer to REMOVAL .
3. Remove the A/C compressor. Refer to REMOVAL .
4. Disconnect the water pipe and hose.
5. Disconnect the engine harness.
6. Remove the spark plug. Refer to REMOVAL .
7. Remove the camshaft position sensor. Refer to REMOVAL .
8. Remove the crankshaft position sensor. Refer to REMOVAL .
9. Remove the knock sensor. Refer to REMOVAL .
10. Remove the engine coolant temperature sensor. Refer to REMOVAL .
11. Remove the oil temperature sensor. Refer to REMOVAL .
12. Remove the oil flow control solenoid valve. Refer to REMOVAL .
13. Remove the oil pressure switch. Refer to REMOVAL .
14. Remove the oil filter. Refer to REMOVAL .
15. Remove the oil cooler. Refer to REMOVAL .

V-BELT

REMOVAL

1. Remove the collector cover.

NOTE: Follow the steps below when removing the collector cover.

1. Pull up the two points at the rear (A).
2. Pull up the two points at the front (B) while moving them forward.

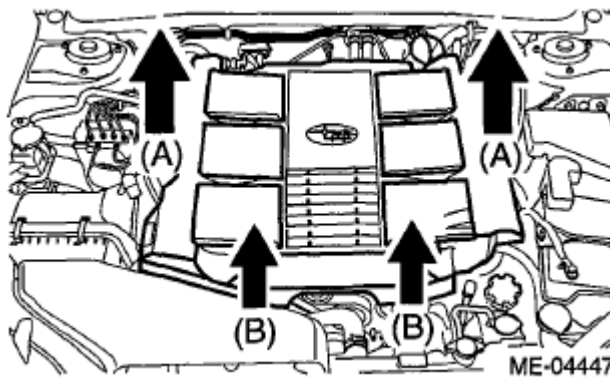


Fig. 110: Removing Collector Cover
Courtesy of SUBARU OF AMERICA, INC.

2. Remove the air intake duct. Refer to REMOVAL .
3. Install the tool to the pulley bolt of the belt tension adjuster assembly.

4. Rotate the tool clockwise and loosen the V-belt to remove.

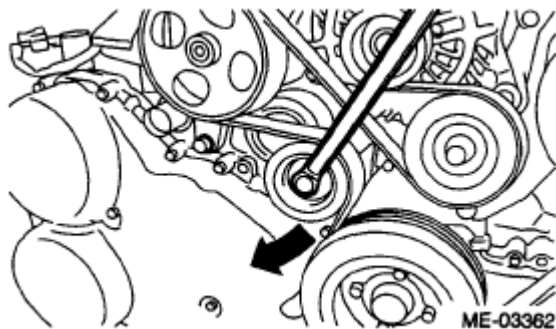
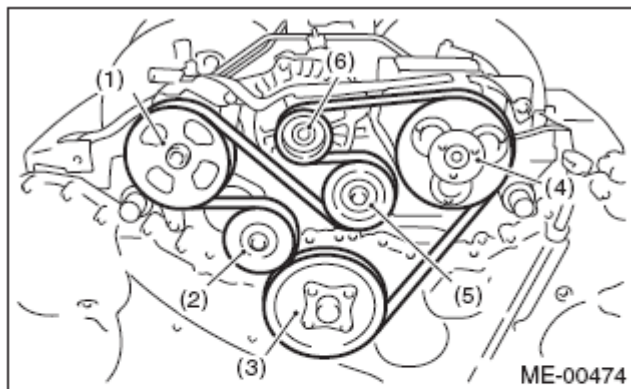


Fig. 111: Loosening V-Belt

Courtesy of SUBARU OF AMERICA, INC.

INSTALLATION

Install in the reverse order of removal.



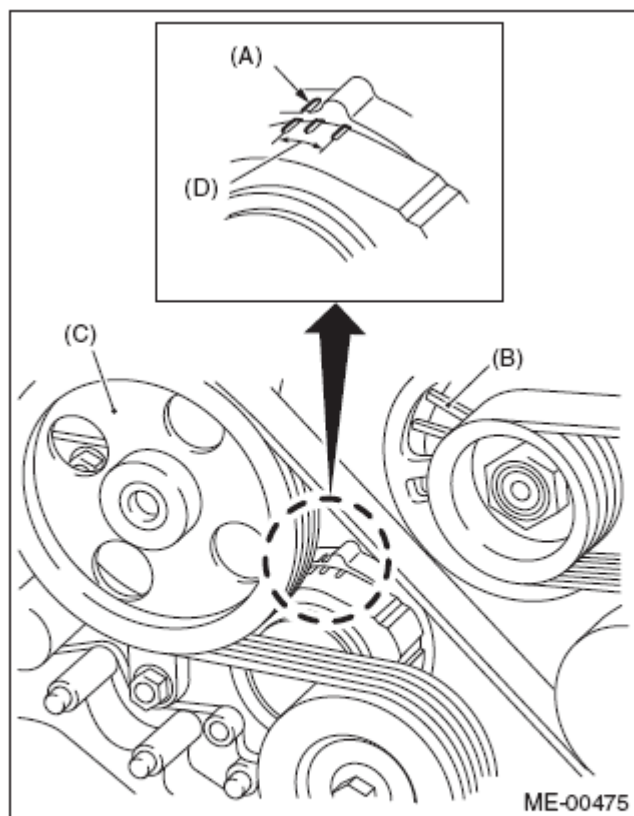
- (1) Power steering oil pump pulley
- (2) Belt tension adjuster ASSY
- (3) Crank pulley
- (4) A/C compressor pulley
- (5) Belt idler
- (6) Generator

Fig. 112: Identifying V-Belt Mounting Positions

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. 113: Identifying Power Steering Oil Pump Pulley, Indicator And Generator
Courtesy of SUBARU OF AMERICA, INC.

CRANK PULLEY

REMOVAL

1. Remove the V-belts. Refer to **REMOVAL**.
2. Remove the crank pulley cover.

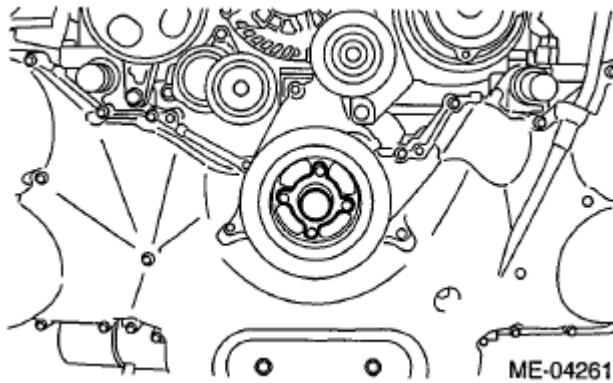


Fig. 114: Identifying Crank Pulley Cover
Courtesy of SUBARU OF AMERICA, INC.

3. Use the ST to lock the crank pulley, and remove the crank pulley bolt.

ST1 18355AA000 PULLEY WRENCH

ST2 18334AA000 PULLEY WRENCH PIN SET

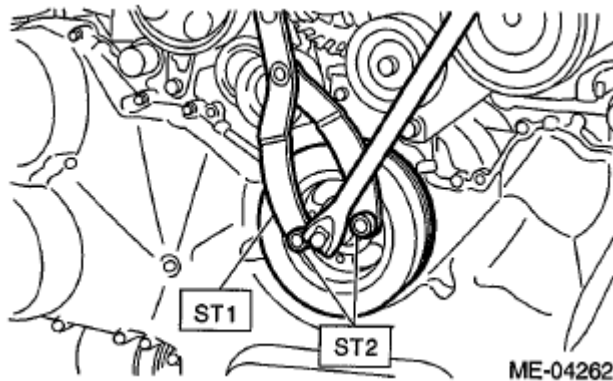


Fig. 115: Removing Crank Pulley Bolt Using Special Tool
Courtesy of SUBARU OF AMERICA, INC.

4. 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)

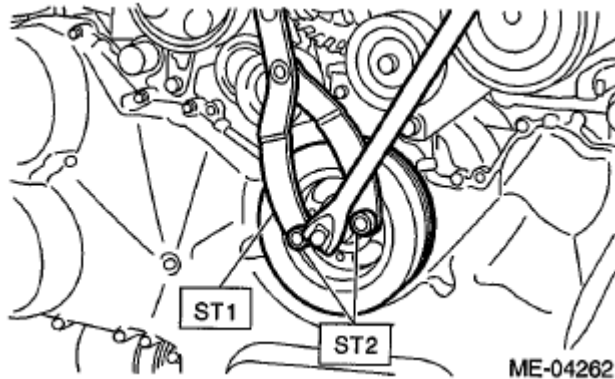


Fig. 116: Removing Crank Pulley Bolt Using Special Tool
Courtesy of SUBARU OF AMERICA, INC.

5. Install the O-ring, and install the crank pulley cover.

NOTE: Use new O-rings.

Tightening torque:

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

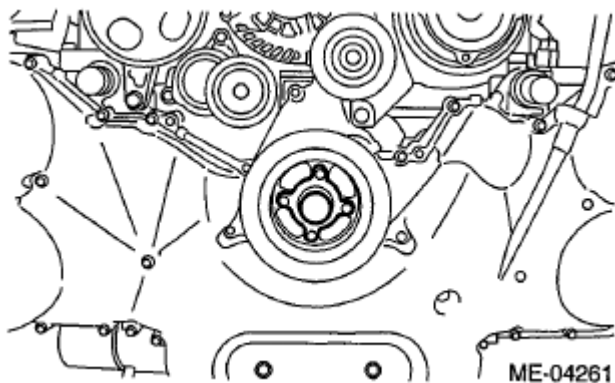


Fig. 117: Identifying Crank Pulley Cover
Courtesy of SUBARU OF AMERICA, INC.

6. Install the V-belts. Refer to **INSTALLATION**.

INSPECTION

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

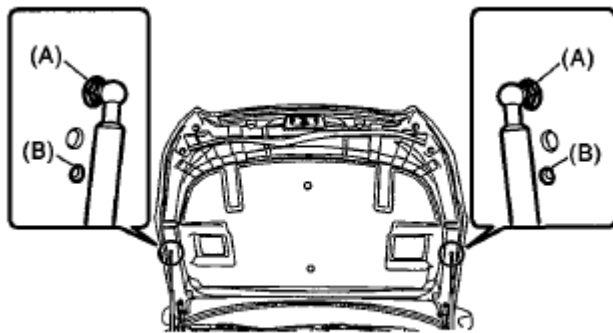
CHAIN COVER

REMOVAL

1. Drain the engine oil. Refer to **REPLACEMENT** .
2. Lift up the vehicle.
3. Remove the under cover. Refer to **REMOVAL** .
4. Drain engine coolant. Refer to **DRAINING OF ENGINE COOLANT** .
5. Remove the front exhaust pipe. Refer to **REMOVAL** .
6. Lower the vehicle.
7. Change the bolt mounting position from (A) to (B), and completely open the front hood.

Tightening torque:

20 N.m (2.0 kgf-m, 14.8 ft-lb)



ME-04396

Fig. 118: Identifying Front Hood Damper Bolt Mounting Position
Courtesy of SUBARU OF AMERICA, INC.

8. Loosen the clamp (A) which connects the air intake boot assembly.
9. Loosen the bolt (B) which secures the air intake boot assembly to the collector cover bracket.

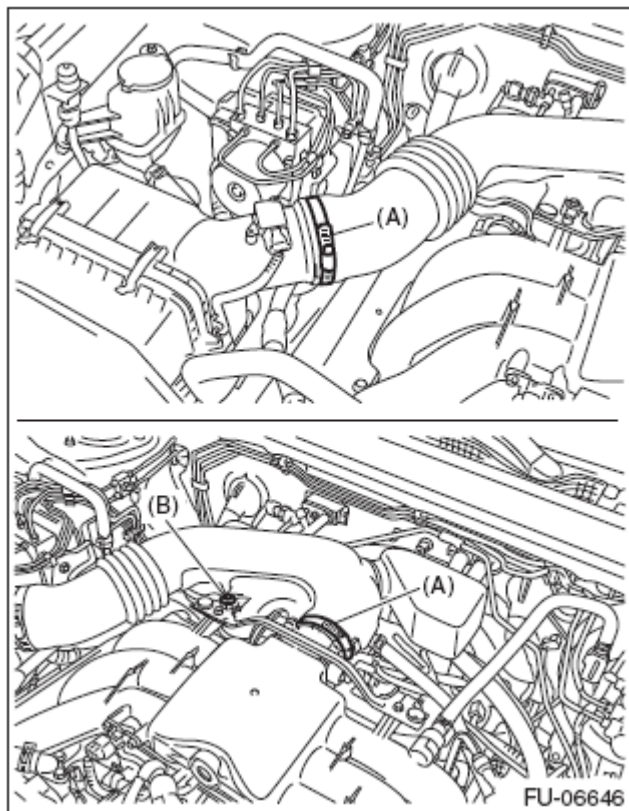


Fig. 119: Identifying Clamp Securing Air Intake Boot Assembly To Collector Cover Bracket
Courtesy of SUBARU OF AMERICA, INC.

10. Remove the air intake boot assembly, and move it to the left side wheel apron.

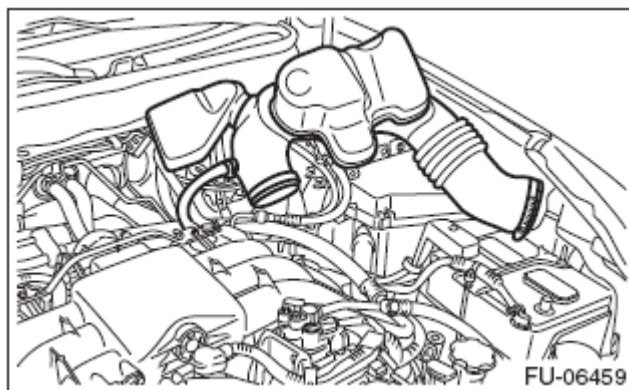


Fig. 120: Identifying Air Intake Boot Assembly
Courtesy of SUBARU OF AMERICA, INC.

11. Remove the air intake duct. Refer to **REMOVAL** .
12. Disconnect the engine harness connector.

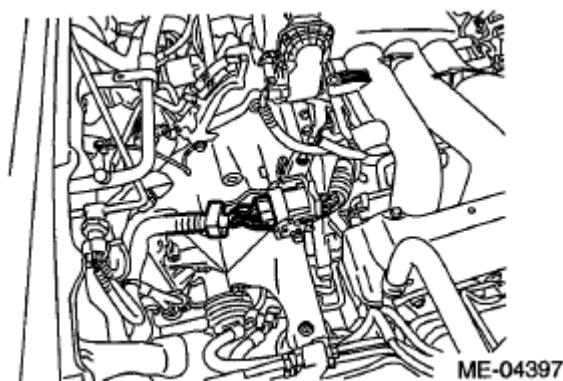


Fig. 121: Identifying Engine Harness Connector
Courtesy of SUBARU OF AMERICA, INC.

13. Disconnect the connector from the throttle body.

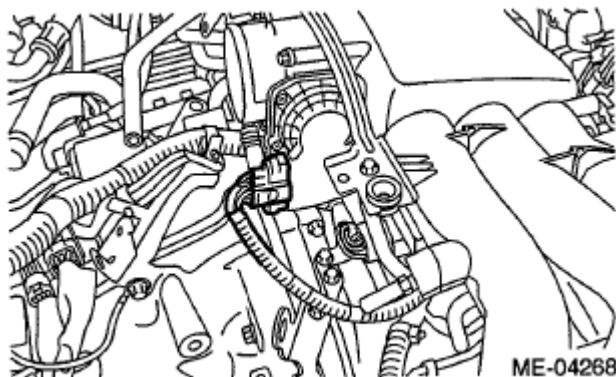


Fig. 122: Identifying Throttle Body Connector
Courtesy of SUBARU OF AMERICA, INC.

14. Remove the engine harness connector from the engine hanger bracket.

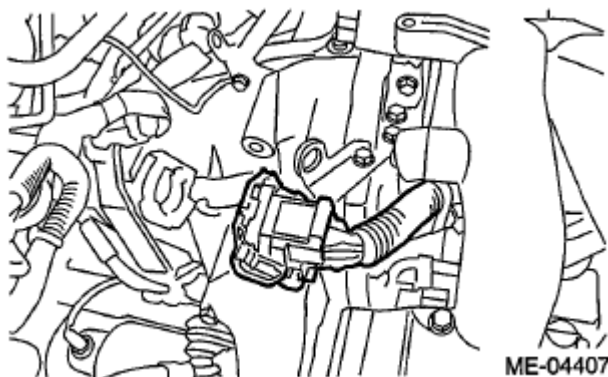


Fig. 123: Identifying Engine Hanger Bracket Harness Connector
Courtesy of SUBARU OF AMERICA, INC.

15. Remove the engine hanger bracket.

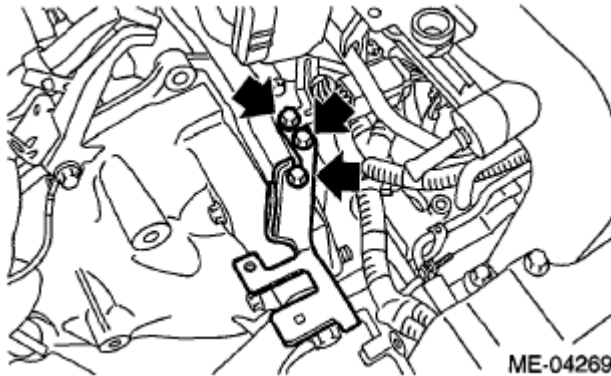


Fig. 124: Locating Engine Hanger Bracket Mounting Bolts
 Courtesy of SUBARU OF AMERICA, INC.

16. Remove the throttle body from the intake manifold.

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

17. Attach the ST.

ST 18360AA020 HANGER

Tightening torque:

19 N.m (1.9 kgf-m, 14.0 ft-lb)

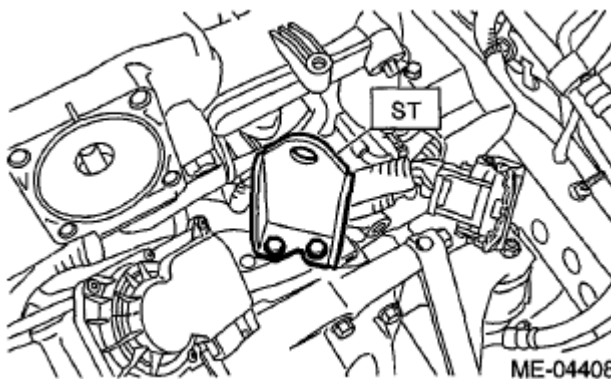


Fig. 125: Identifying Special Tool Connected To Inlet And Outlet Hoses Of Engine Coolant
 Courtesy of SUBARU OF AMERICA, INC.

18. Remove the grille bracket.

NOTE: Remove ten clips when removing the grille bracket.

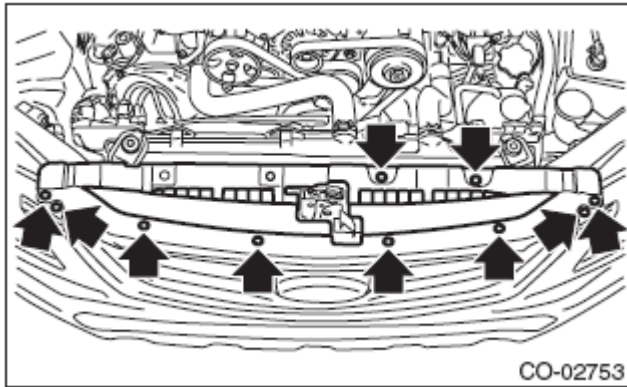


Fig. 126: Locating Grille Bracket Fixing Clips
Courtesy of SUBARU OF AMERICA, INC.

19. Remove the V-belts. Refer to **REMOVAL**.
20. Remove the reservoir tank. Refer to **REMOVAL**.
21. Remove the radiator main fan & fan motor and radiator sub fan & fan motor. Refer to **REMOVAL**.
22. Remove the radiator. Refer to **REMOVAL**.
23. Remove the crank pulley. Refer to **REMOVAL**.
24. Support the engine with a lifting device and wire ropes.
25. Remove the front mount from the chain cover.

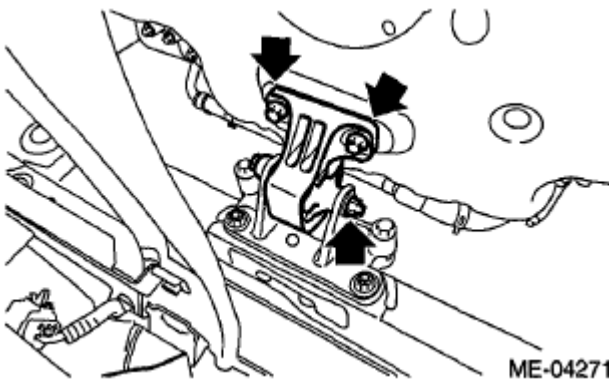


Fig. 127: Locating Engine Assembly Front Mounting Bolts
Courtesy of SUBARU OF AMERICA, INC.

26. Remove the front mounting bracket from the cradle.

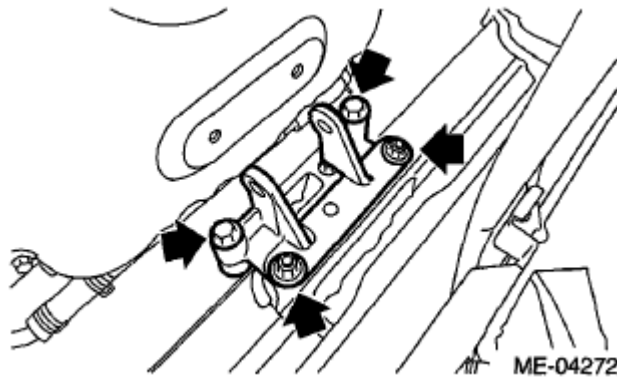


Fig. 128: Locating Cradle Front Mounting Bracket Bolts
Courtesy of SUBARU OF AMERICA, INC.

27. Remove the oil cooler pipe from the chain cover.

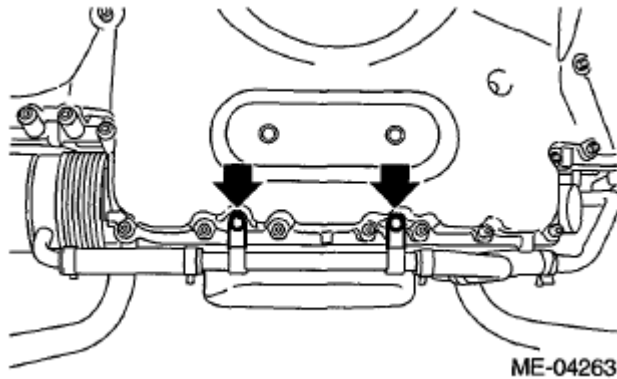


Fig. 129: Locating Oil Cooler Pipe Mounting Bolts
Courtesy of SUBARU OF AMERICA, INC.

28. 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.

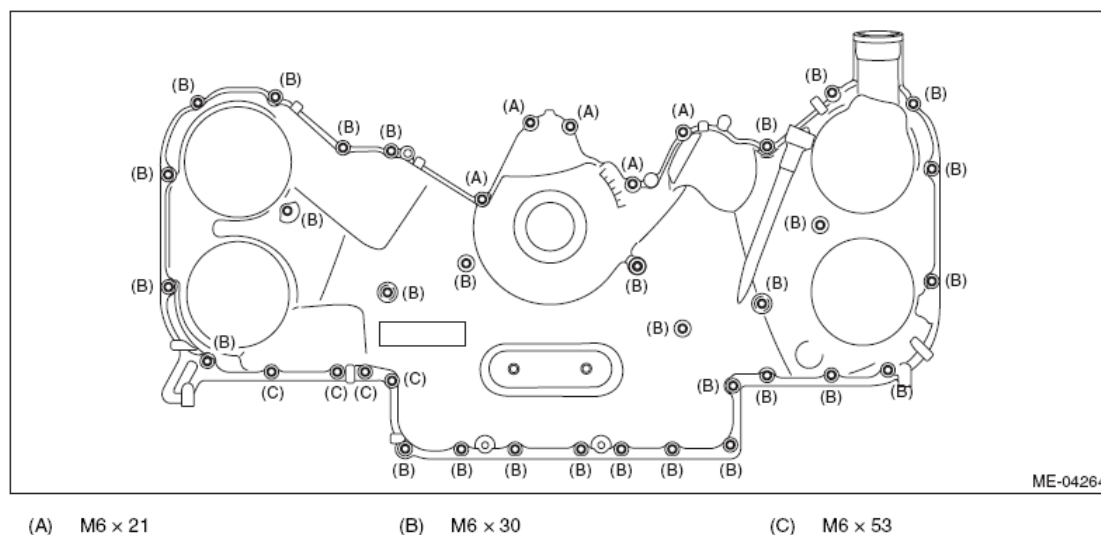


Fig. 130: Identifying Chain Cover Mounting Bolts
Courtesy of SUBARU OF AMERICA, INC.

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

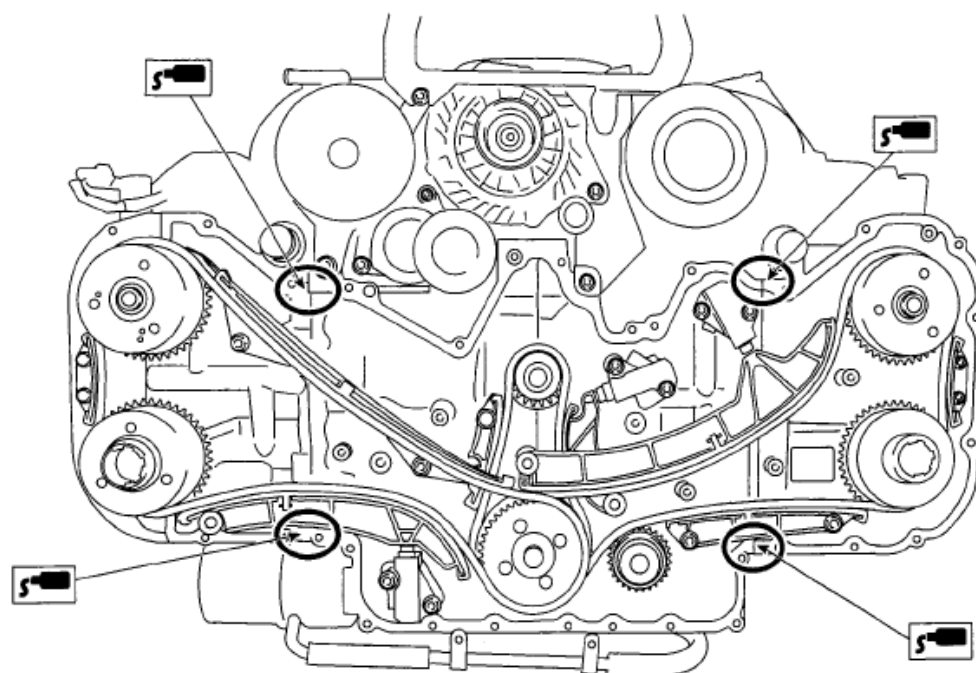


Fig. 131: Applying Liquid Gasket To Mating Surfaces Of Cylinder Block, Cylinder Head And Oil Pan Upper
Courtesy of SUBARU OF AMERICA, INC.

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

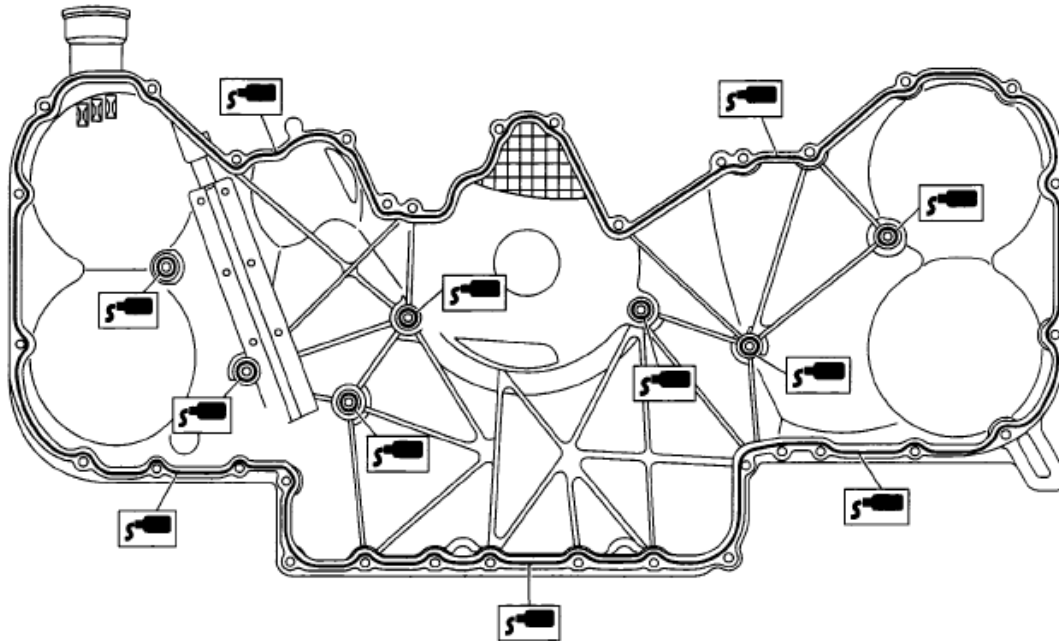
NOTE: Install within 5 min. after applying liquid gasket.

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

3. Attach the chain cover and temporarily tighten the chain cover installation bolts.

CAUTION: Do not install the chain cover installation bolts in wrong place.

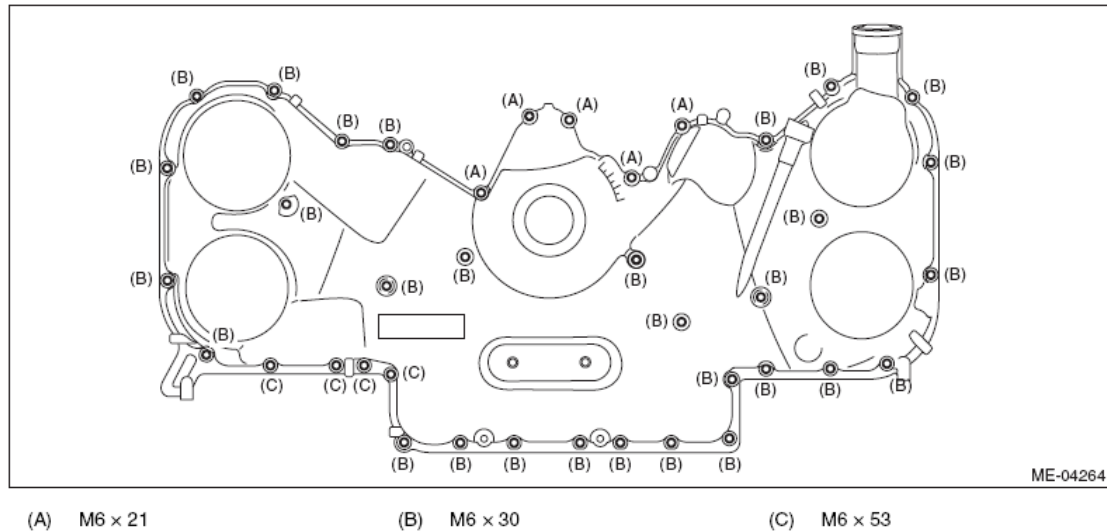


Fig. 133: Identifying Chain Cover Mounting Bolts
Courtesy of SUBARU OF AMERICA, INC.

4. Tighten the chain cover installing bolts in the numerical order as shown in the figure.

Tightening torque:

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

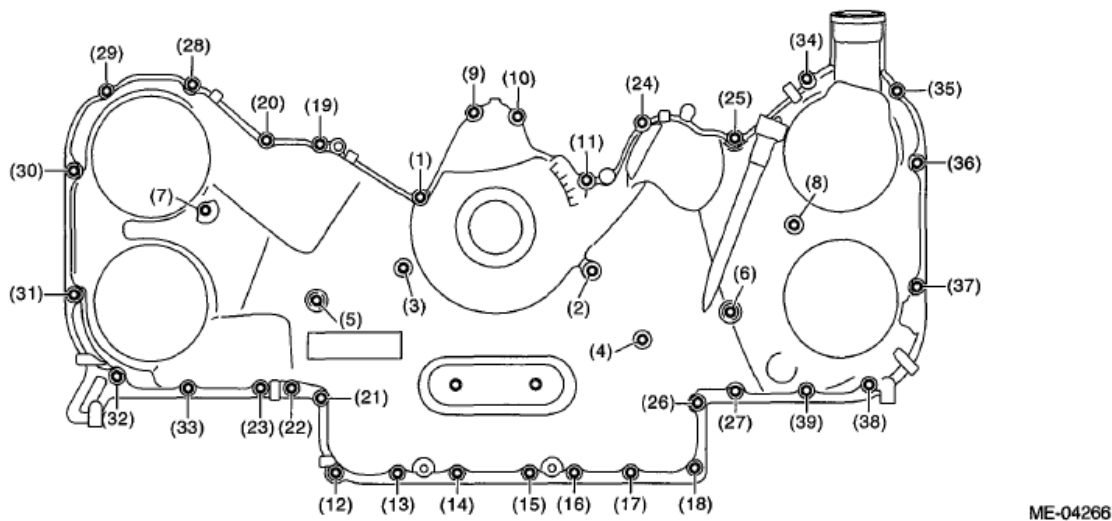


Fig. 134: Identifying Chain Cover Mounting Bolts Tightening Sequence
Courtesy of SUBARU OF AMERICA, INC.

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

Tightening torque:

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

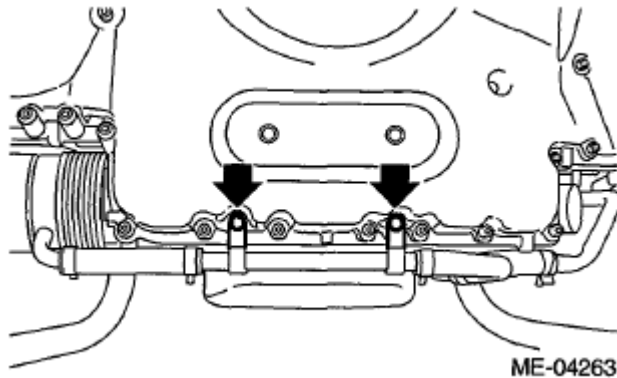


Fig. 135: Locating Oil Cooler Pipe Mounting Bolts
Courtesy of SUBARU OF AMERICA, INC.

6. Install front mounting bracket to the cradle.

Tightening torque:

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

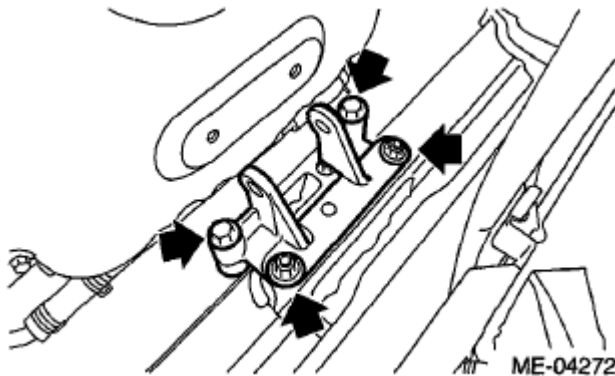


Fig. 136: Locating Cradle Front Mounting Bracket Bolts
Courtesy of SUBARU OF AMERICA, INC.

7. Install the front mount.

Tightening torque:

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

T2: 45 N.m (4.6 kgf-m, 33.2 ft-lb)

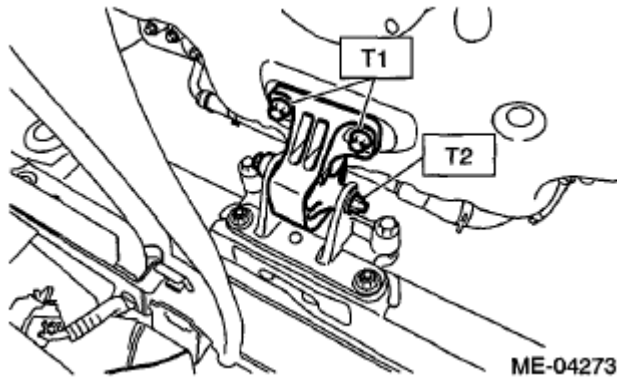


Fig. 137: Identifying Front Mounting Bolts Tightening Torques
 Courtesy of SUBARU OF AMERICA, INC.

8. Remove the lifting device and wire ropes.
9. Install the crank pulley. Refer to **INSTALLATION**.
10. Install the radiator. Refer to **INSTALLATION**.
11. Install the radiator main & fan motor and radiator sub fan & fan motor. Refer to **INSTALLATION**.
12. Install the reservoir tank. Refer to **REMOVAL**.
13. Install the V-belts. Refer to **INSTALLATION**.
14. Attach the grille bracket.

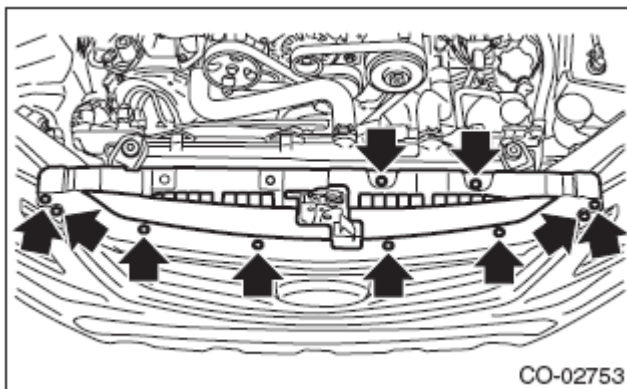


Fig. 138: Locating Grille Bracket Fixing Clips
 Courtesy of SUBARU OF AMERICA, INC.

15. 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)

16. Remove the ST (HANGER) and install the engine hanger bracket.

Tightening torque:

19 N.m (1.9 kgf-m, 14.0 ft-lb)

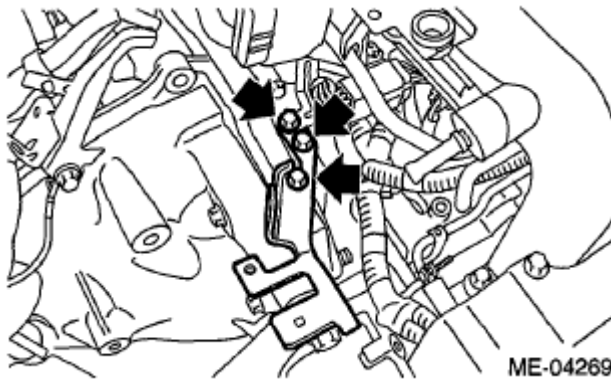


Fig. 139: Locating Engine Hanger Bracket Mounting Bolts
Courtesy of SUBARU OF AMERICA, INC.

17. Install the engine harness connector to the engine hanger bracket.

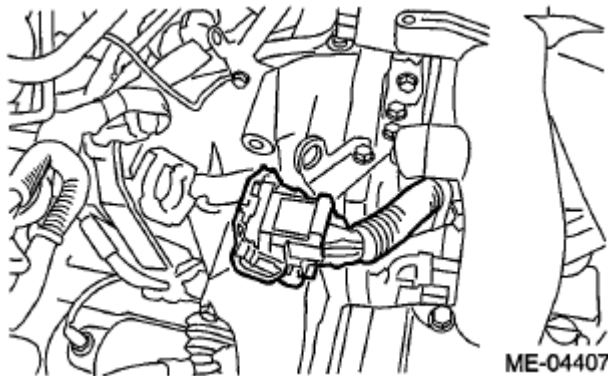


Fig. 140: Identifying Engine Hanger Bracket Harness Connector
Courtesy of SUBARU OF AMERICA, INC.

18. Connect the connector to the throttle body.

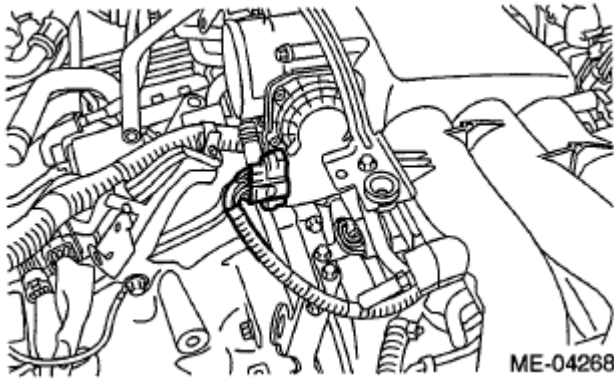


Fig. 141: Identifying Throttle Body Connector
Courtesy of SUBARU OF AMERICA, INC.

19. Connect the engine harness connector.

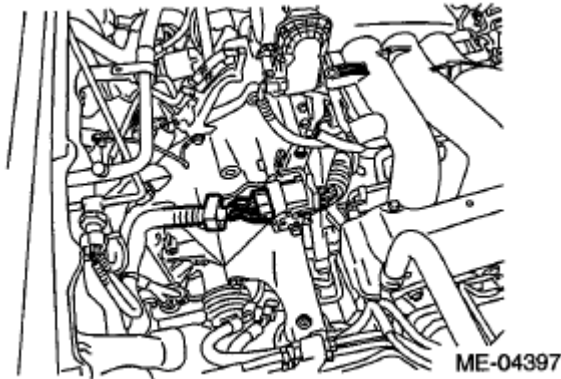


Fig. 142: Identifying Engine Harness Connector
Courtesy of SUBARU OF AMERICA, INC.

20. Install the V-belts. Refer to **INSTALLATION**.
21. Install the air intake boot assembly.

Tightening torque:

Clamp (A)

3 N.m (0.3 kgf-m, 2.2 ft-lb)

Bolt (B)

6.5 N.m (0.7 kgf-m, 4.8 ft-lb)

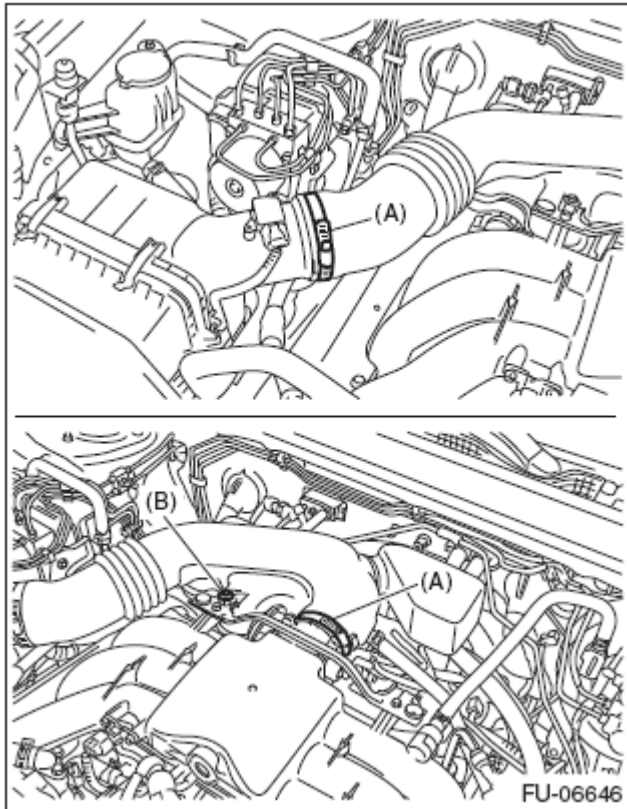
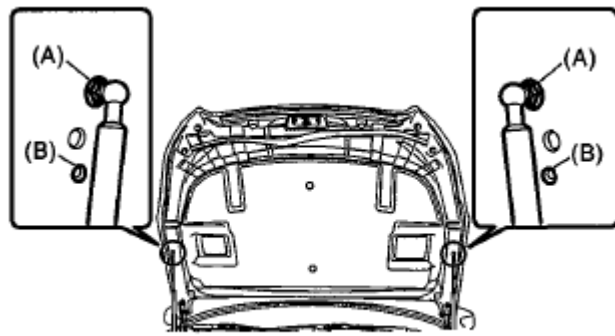


Fig. 143: Identifying Clamp Securing Air Intake Boot Assembly To Collector Cover Bracket
Courtesy of SUBARU OF AMERICA, INC.

22. Install the air intake duct. Refer to **INSTALLATION** .
23. Install the front exhaust pipe. Refer to **INSTALLATION** .
24. Fill engine coolant. Refer to **FILLING OF ENGINE COOLANT** .
25. Fill engine oil. Refer to **REPLACEMENT** .
26. Make sure there is no oil leaks in the chain cover mating surface.
27. Install the under cover. Refer to **INSTALLATION** .
28. Install the collector cover.
29. Change the bolt mounting position from (B) to (A), and completely close the front hood.

Tightening torque:

20 N.m (2.0 kgf-m, 14.8 ft-lb)



ME-04396

Fig. 144: Identifying Front Hood Damper Bolt Mounting Position
Courtesy of SUBARU OF AMERICA, INC.

INSPECTION

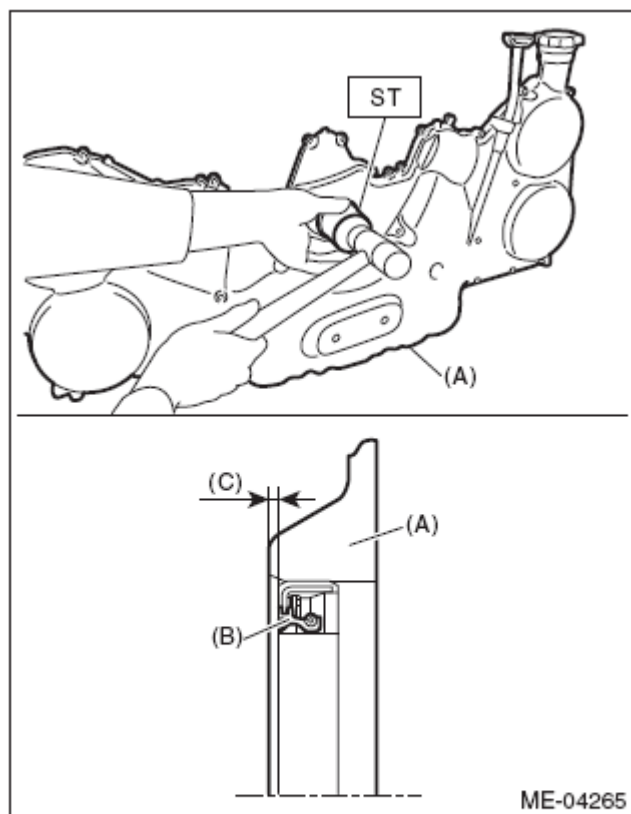
1. Check the chain cover surface for scratches or dents.
2. Check for oil leakage on the chain cover mating surface and installation part of crank pulley. If there is an oil leak from the oil seal, perform replacement with a new oil seal.

ST 499585700 OIL SEAL GUIDE

Oil seal press-fit position:

Chain cover end face - Position -1 mm

(-0.039 in) from the chain cover end face.

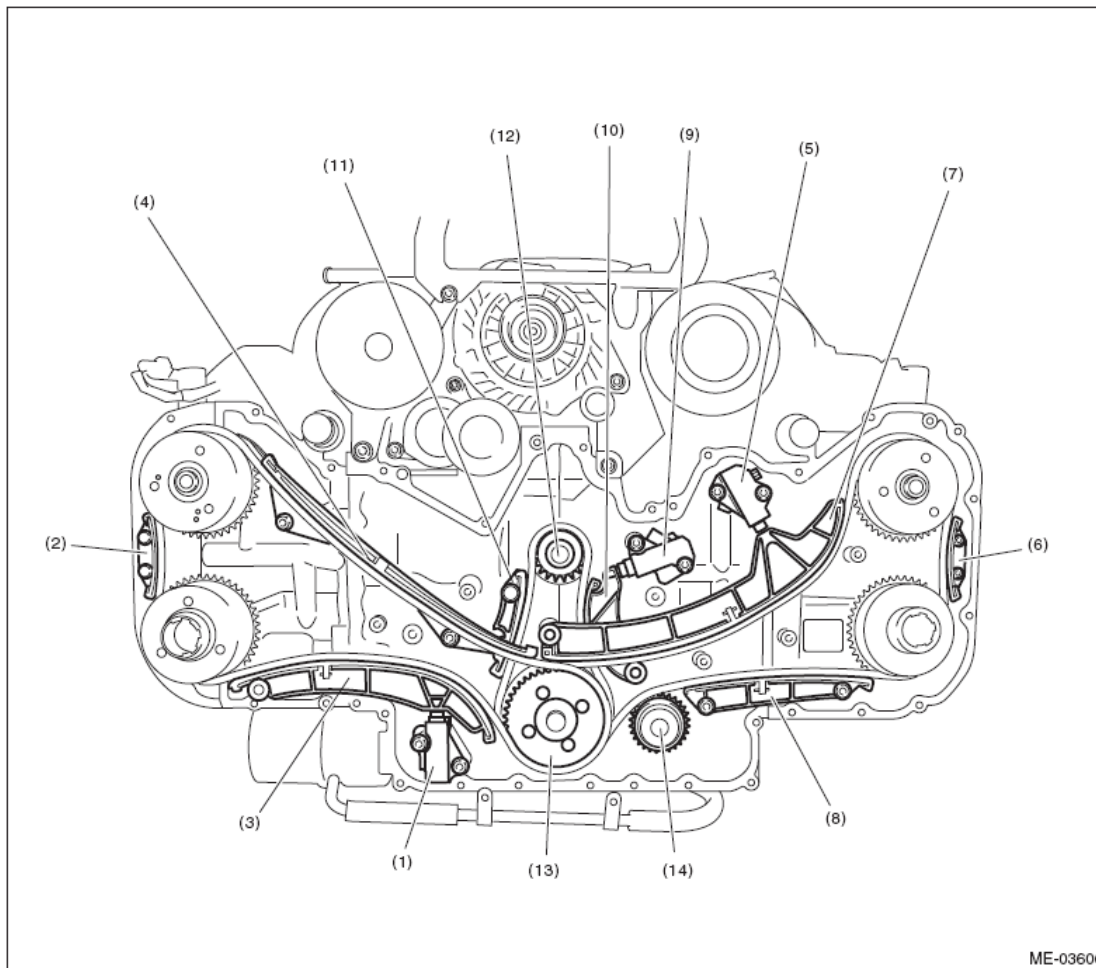


- (A) Chain cover
- (B) Oil seal
- (C) Oil seal press-fit position (chain cover edge
-1 mm (-0.039 in) position)

Fig. 145: 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 (between cams, LH) | (11) Chain guide (main) |
| (2) Chain guide (between cams, RH) | (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. 146: Timing Chain Assembly Components Location
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** .
2. Remove the radiator. Refer to **REMOVAL** .
3. Remove the V-belts. Refer to **REMOVAL**.
4. Remove the crank pulley. Refer to **REMOVAL**.
5. Remove the chain cover. Refer to **REMOVAL**.
6. Remove the chain tensioner (RH).

NOTE: When removing chain tensioner (RH), hold the plunger by hand so that it does not come flying out.

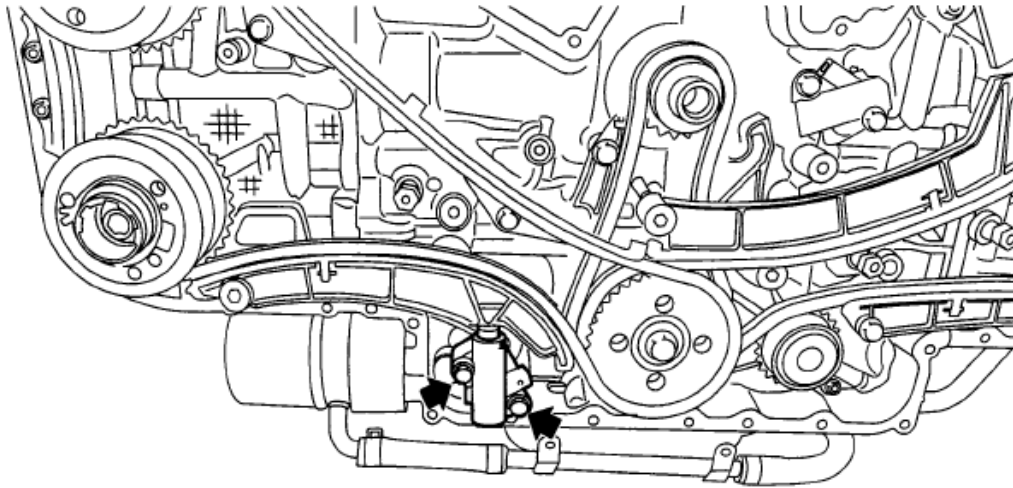


Fig. 147: Locating Chain Tensioner (RH) Mounting Bolts
Courtesy of SUBARU OF AMERICA, INC.

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

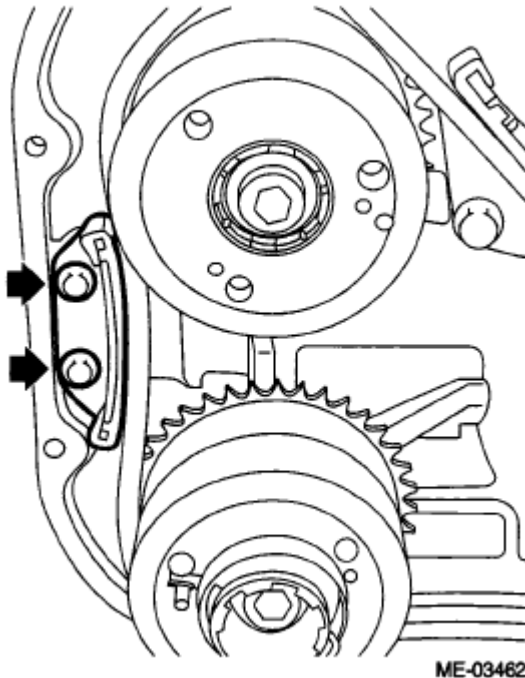
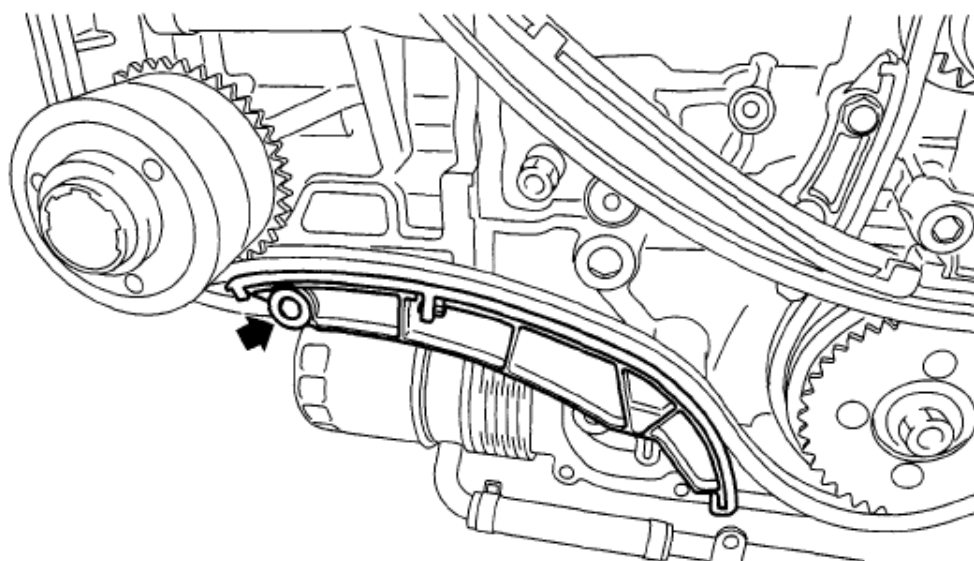


Fig. 148: Locating Chain Guide (RH: Between Cams) Mounting Bolts
Courtesy of SUBARU OF AMERICA, INC.

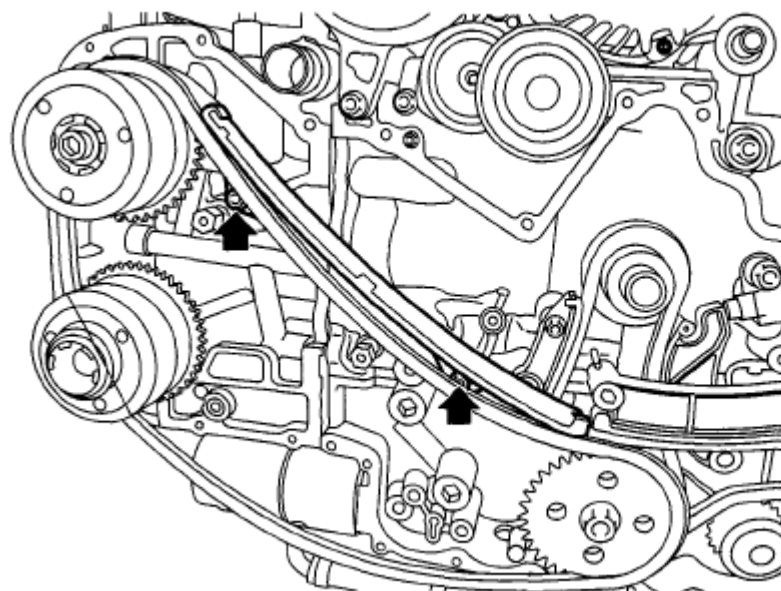
8. Remove the chain tensioner lever (RH).



ME-03463

Fig. 149: Locating Chain Tensioner Lever (RH) Mounting Bolt Position
Courtesy of SUBARU OF AMERICA, INC.

9. Remove the chain guide (RH).

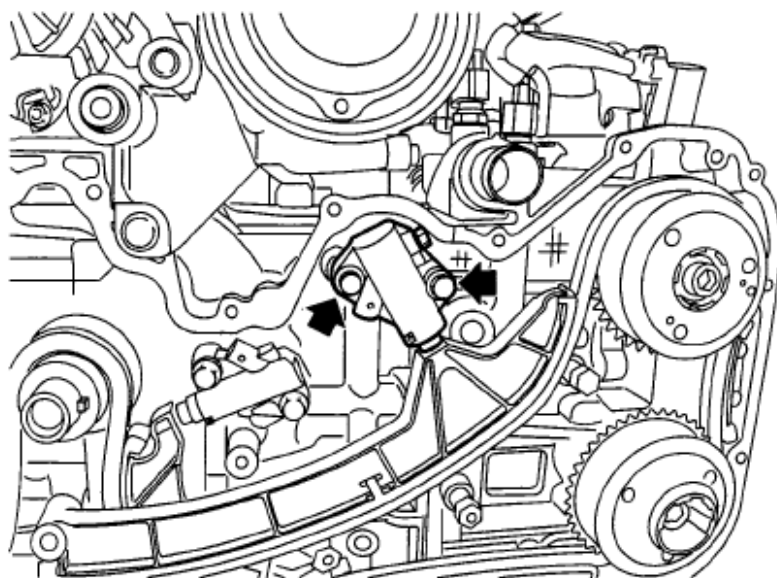


ME-03464

Fig. 150: Locating Chain Guide (RH)
Courtesy of SUBARU OF AMERICA, INC.

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

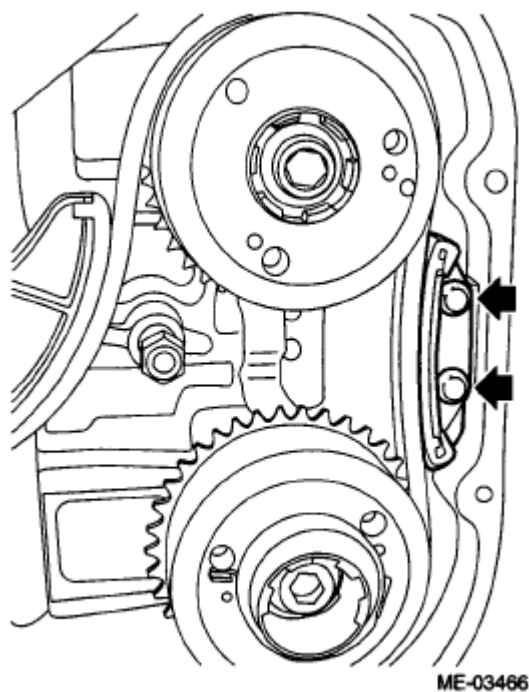
NOTE: When removing chain tensioner (LH), hold the plunger by hand so that it does not come flying out.



ME-03465

Fig. 151: Locating Chain Tensioner (LH)
Courtesy of SUBARU OF AMERICA, INC.

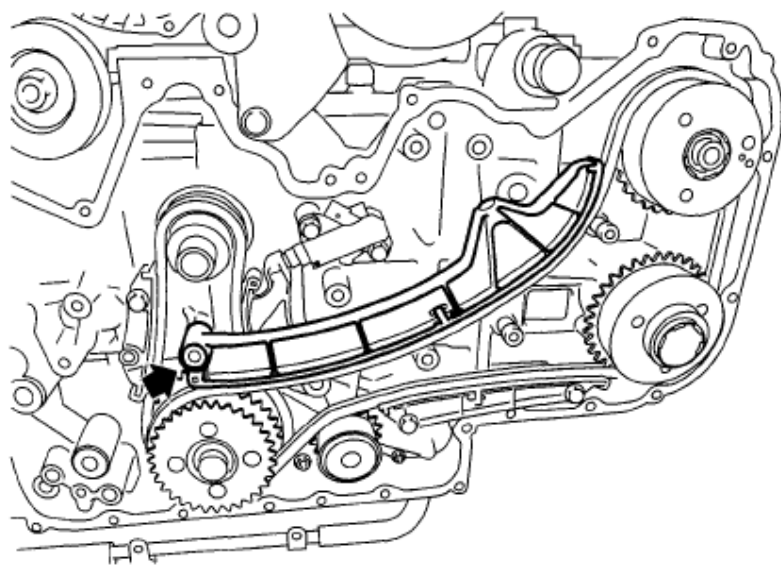
12. Remove the chain guide (LH: between cams).



ME-03466

Fig. 152: Locating Chain Guide (LH: Between Cams)
Courtesy of SUBARU OF AMERICA, INC.

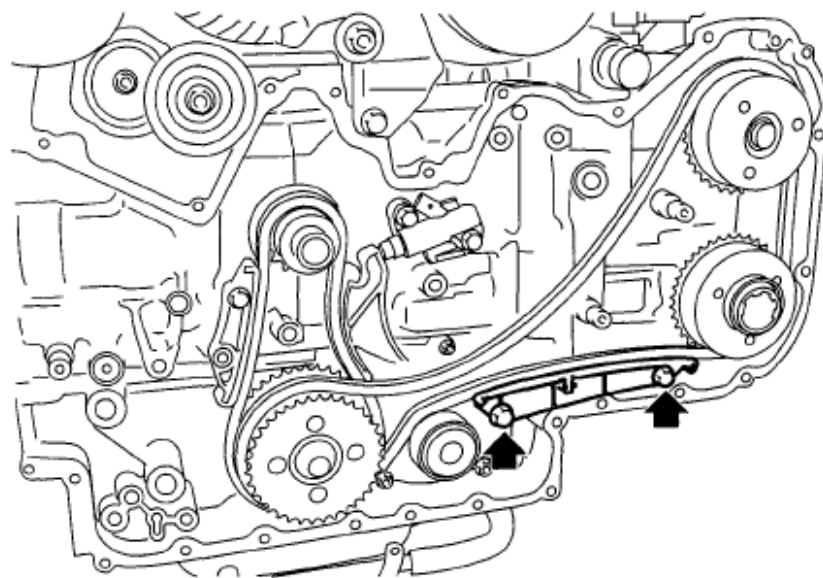
13. Remove the chain tensioner lever (LH).



ME-03467

Fig. 153: Locating Chain Tensioner Lever (LH)
Courtesy of SUBARU OF AMERICA, INC.

14. Remove the chain guide (LH).

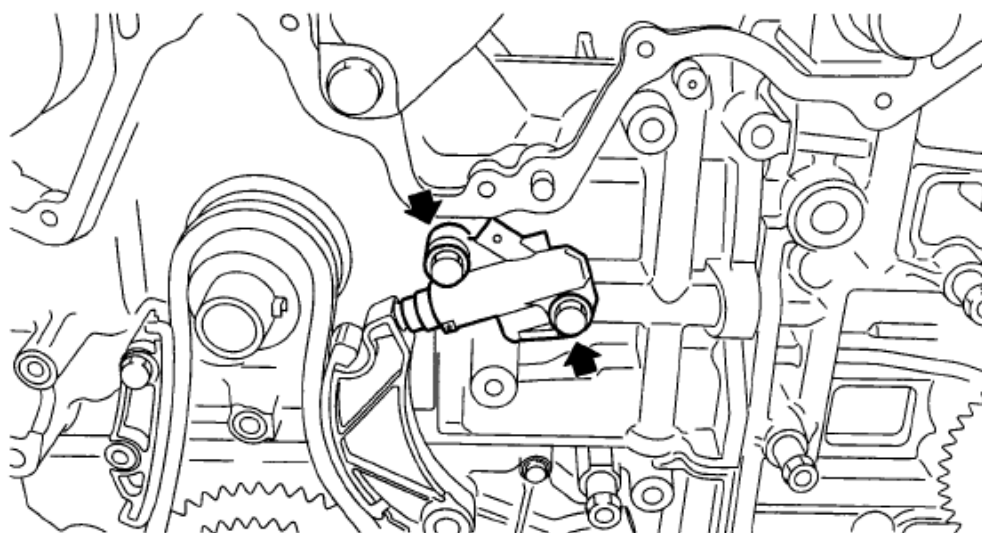


ME-03468

Fig. 154: Locating Chain Guide (LH)
Courtesy of SUBARU OF AMERICA, INC.

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

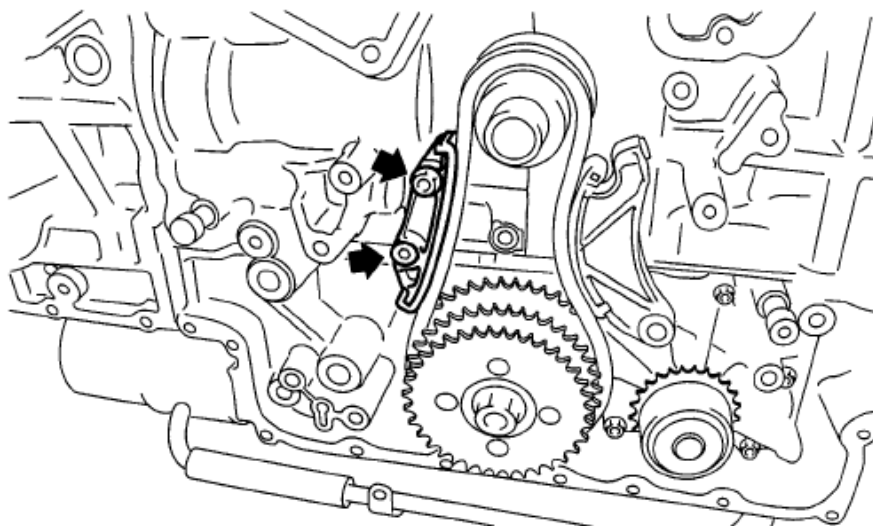
NOTE: When removing chain tensioner (main), hold the plunger by hand so that it does not come flying out.



ME-03469

Fig. 155: Locating Chain Tensioner (Main)
Courtesy of SUBARU OF AMERICA, INC.

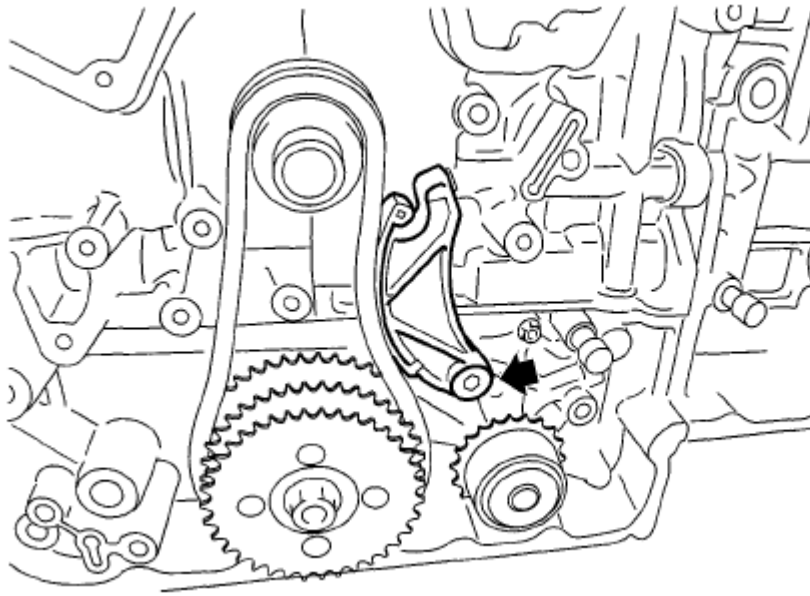
17. Remove the chain guide (main).



ME-03470

Fig. 156: Locating Chain Guide (Main)
Courtesy of SUBARU OF AMERICA, INC.

18. Remove the chain tensioner lever (main).



ME-03471

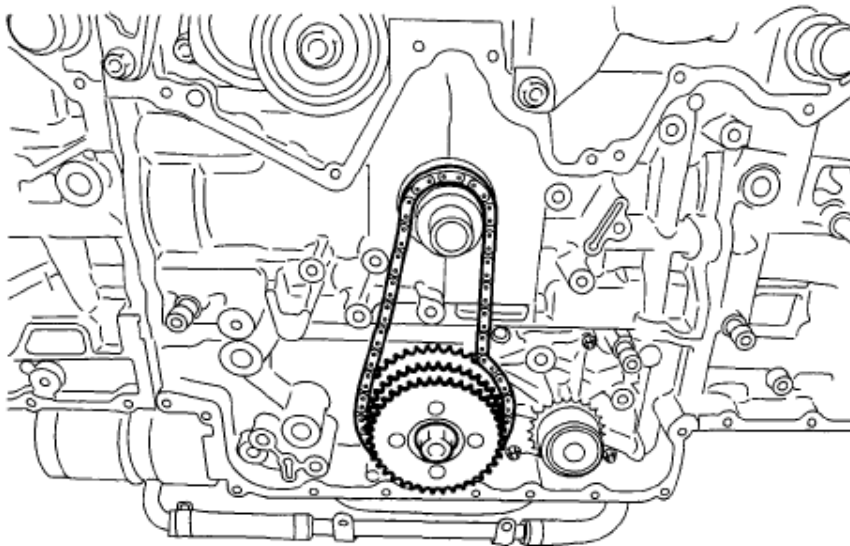
Fig. 157: Locating Chain Tensioner Lever (Main)
Courtesy of SUBARU OF AMERICA, INC.

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 bolts, and remove the idler sprocket and timing chain (main).



ME-03472

Fig. 158: 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 the 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.

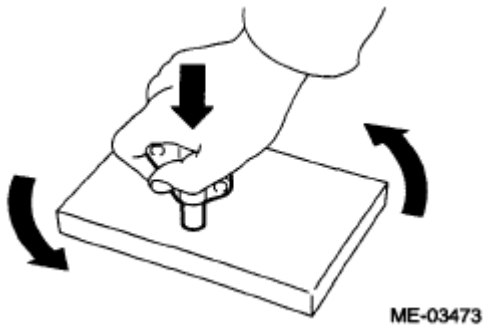
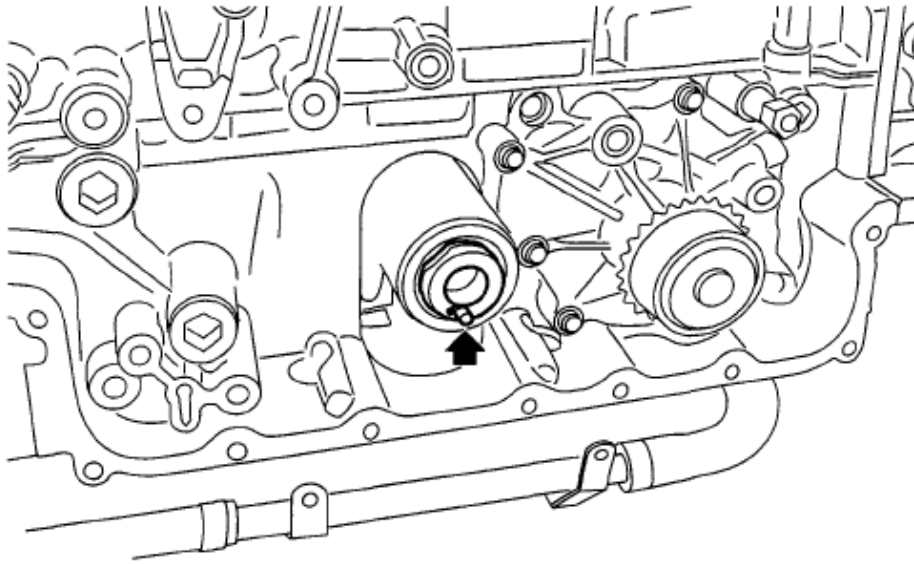


Fig. 159: Degreasing Contact Surface Between Plunger Head And Rubber Mat
Courtesy of SUBARU OF AMERICA, INC.

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.

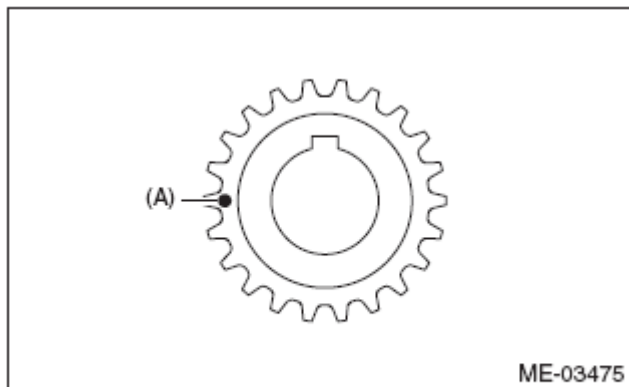


ME-03474

Fig. 160: Locating Position Of Oil Pump Shaft Knock Pin At Six O'Clock Position
Courtesy of SUBARU OF AMERICA, INC.

- 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. 161: Identifying Top Mark On Crank Sprocket
Courtesy of SUBARU OF AMERICA, INC.

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

ST 499977500 CAM SPROCKET WRENCH

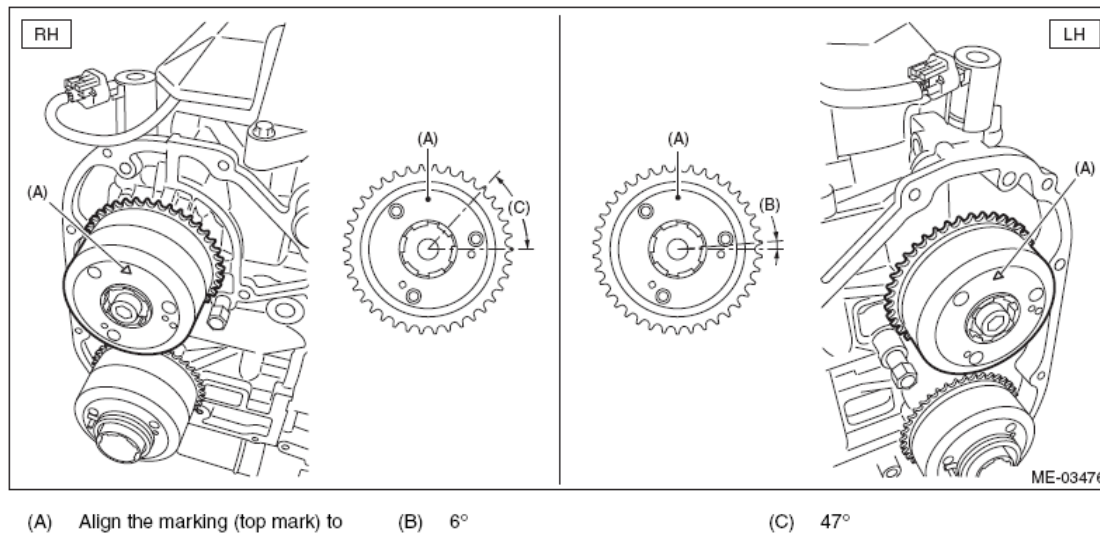


Fig. 162: Aligning Intake Cam Sprocket To Twelve O'Clock Position
Courtesy of SUBARU OF AMERICA, INC.

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

ST 499977500 CAM SPROCKET WRENCH

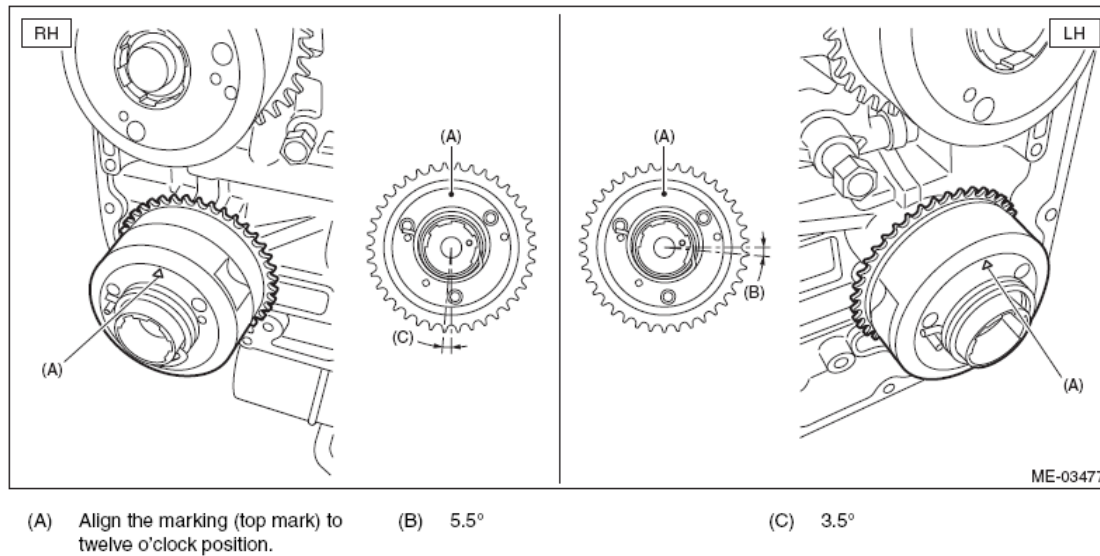


Fig. 163: Aligning Exhaust Cam Sprocket To Twelve O'Clock Position
Courtesy of SUBARU OF AMERICA, INC.

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

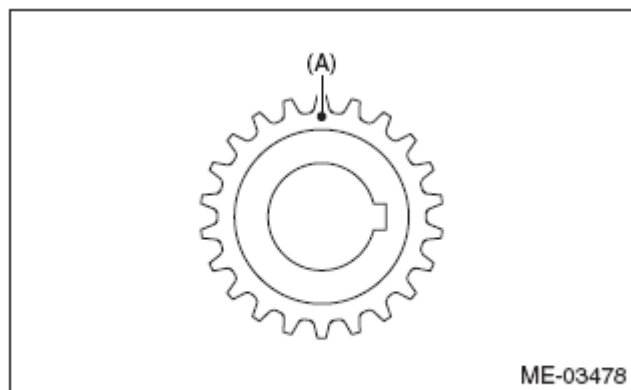
NOTE:

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

timing chain installation.

- At this time, crank sprocket key is at three o'clock position.

ST 18252AA000 CRANKSHAFT SOCKET



(A) Top mark

Fig. 164: Identifying Top Mark On Crank Sprocket
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)

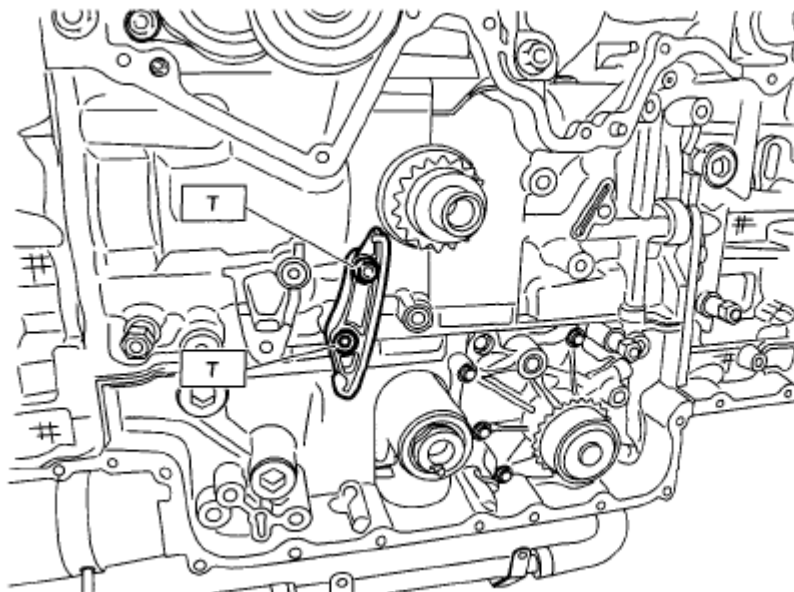


Fig. 165: Identifying Main Chain Guide Mounting Bolts With Tightening Torques
Courtesy of SUBARU OF AMERICA, INC.

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 ST 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)

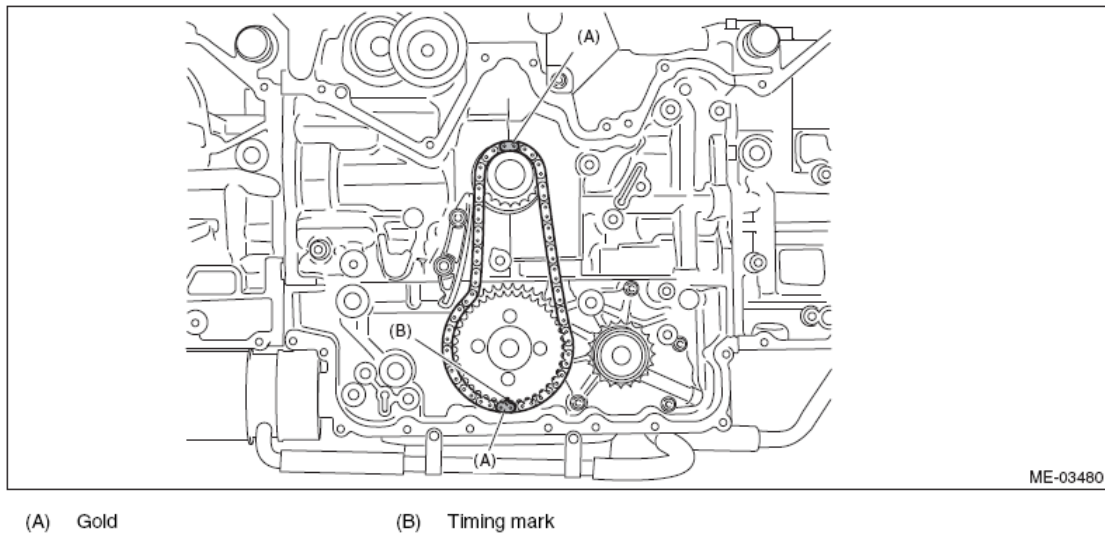
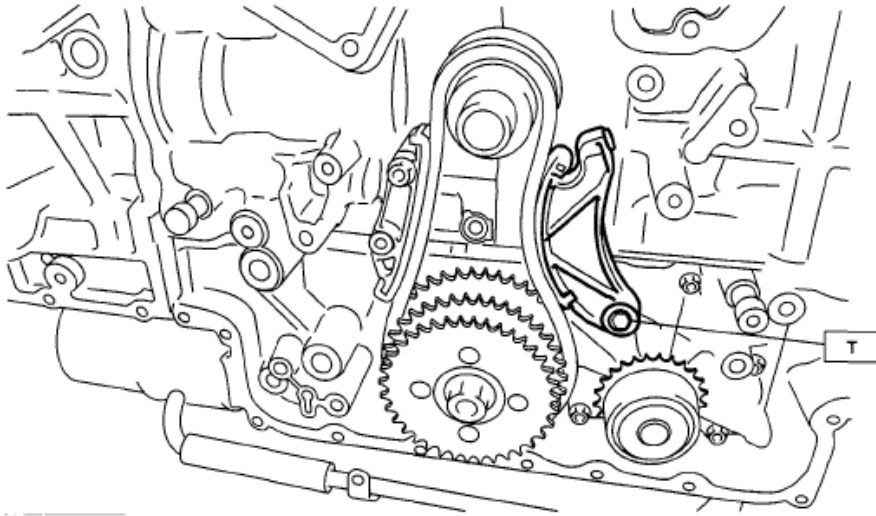


Fig. 166: Identifying Gold And Timing Mark On Idler Sprocket And Timing Chain (Main)
Courtesy of SUBARU OF AMERICA, INC.

9. Install the chain tensioner lever (main).

Tightening torque:

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



ME-03481

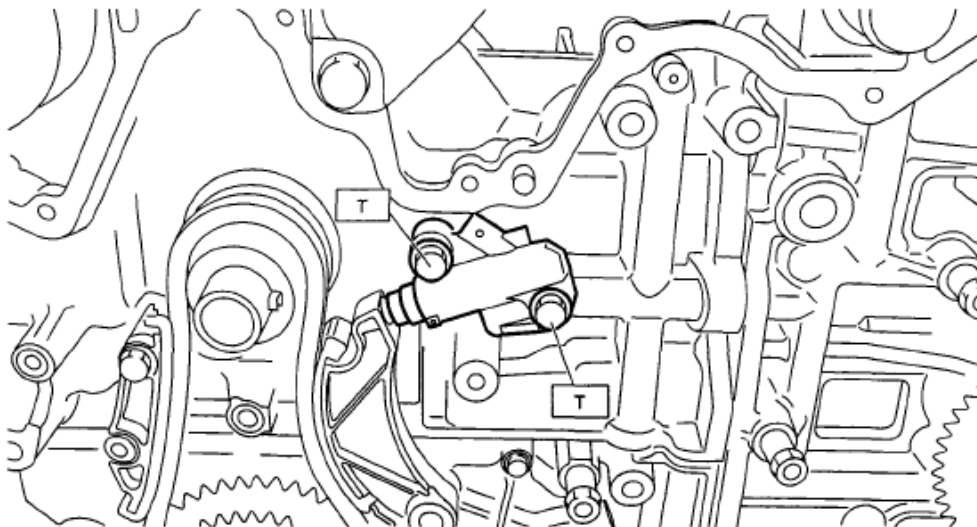
Fig. 167: Identifying Chain Tensioner Lever (Main) Tightening Torque
Courtesy of SUBARU OF AMERICA, INC.

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

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

Tightening torque:

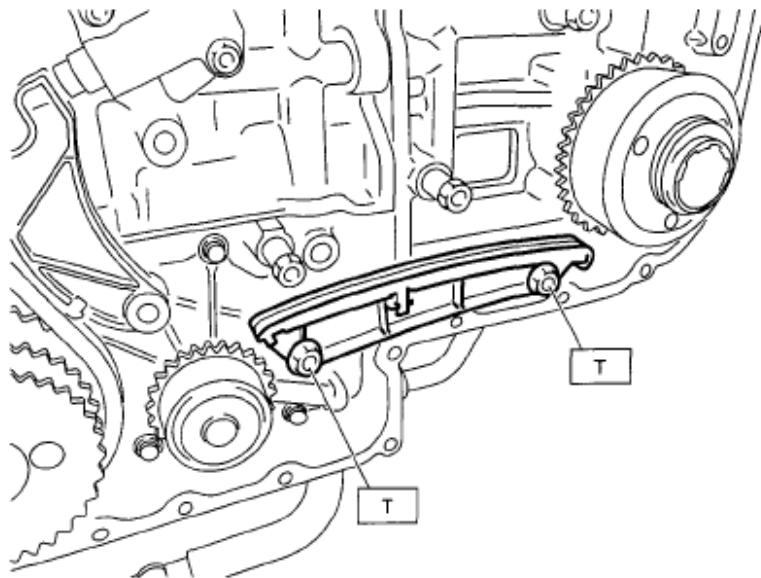
16 N.m (1.6 kgf-m, 11.8 ft-lb)



ME-03482

Fig. 168: Identifying Chain Tensioner (Main) Mounting Bolts With Tightening Torque
Courtesy of SUBARU OF AMERICA, INC.

11. Install the chain guide (LH).

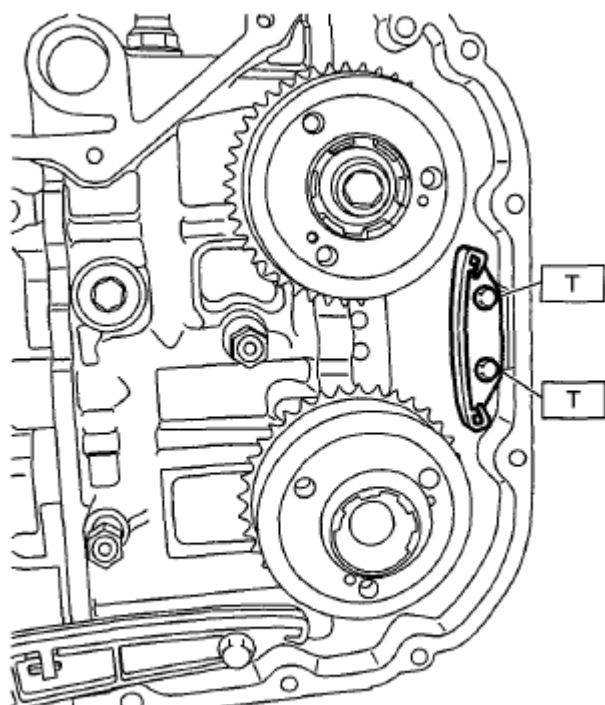
Tightening torque:***16 N.m (1.6 kgf-m, 11.8 ft-lb)***

ME-03483

Fig. 169: Identifying Chain Guide (LH) Mounting Bolts With Tightening Torque
Courtesy of SUBARU OF AMERICA, INC.

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

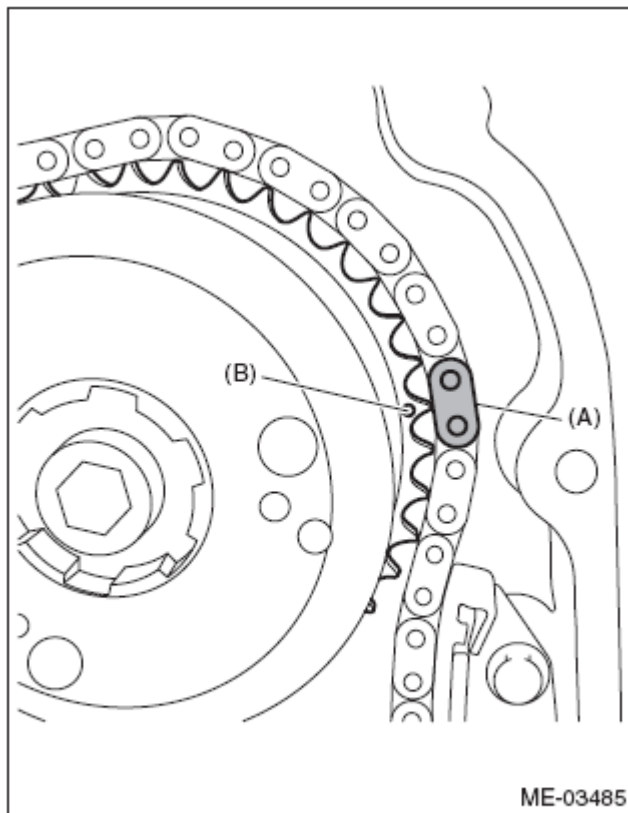
Tightening torque:***6.4 N.m (0.7 kgf-m, 4.7 ft-lb)***



ME-03607

Fig. 170: Identifying Chain Guide (LH: Between Cams) Mounting Bolts Tightening Torque
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).

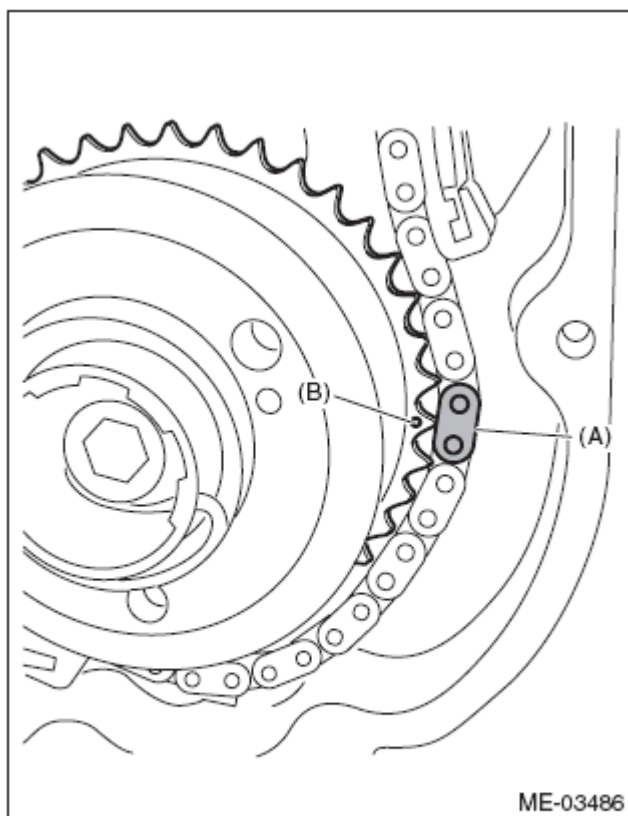


(A) Blue

(B) Timing mark

Fig. 171: Identifying Blue And Timing Mark On Intake Cam Sprocket (LH)
Courtesy of SUBARU OF AMERICA, INC.

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

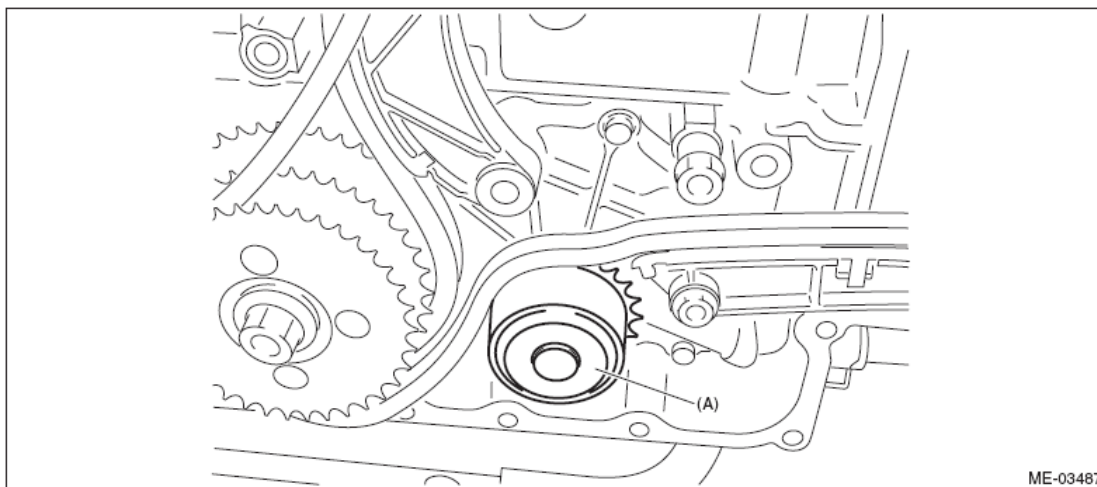


(A) Blue

(B) Timing mark

Fig. 172: Identifying Blue And Timing Mark On Exhaust Cam Sprocket (LH)
 Courtesy of SUBARU OF AMERICA, INC.

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



(A) Water pump sprocket

Fig. 173: Identifying Water Pump Sprocket
Courtesy of SUBARU OF AMERICA, INC.

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

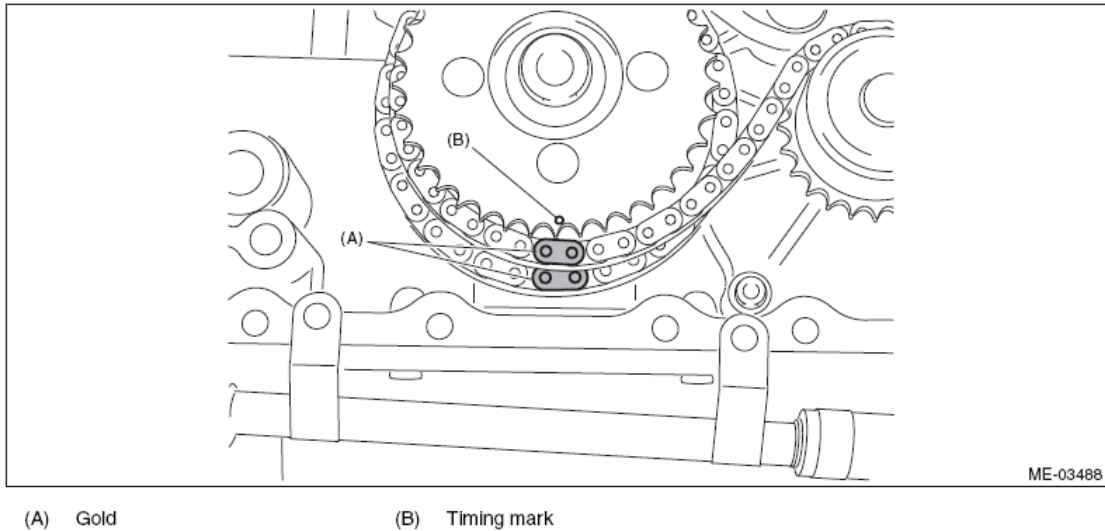


Fig. 174: Matching Timing Mark Of Idler Sprocket To Timing Chain Mark (Gold)
Courtesy of SUBARU OF AMERICA, INC.

14. Install the chain tensioner lever (LH).

Tightening torque:

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

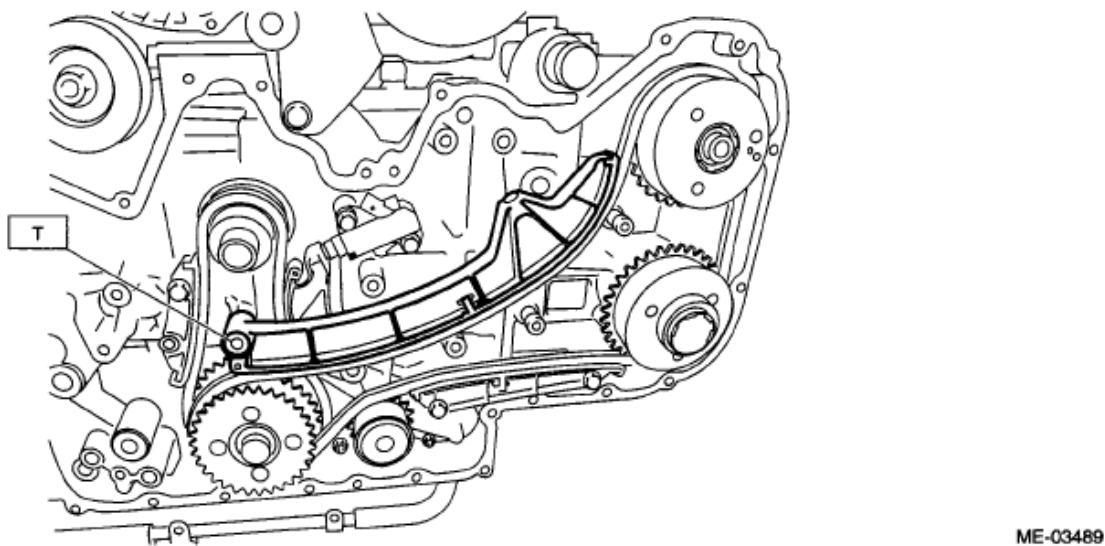


Fig. 175: Identifying Chain Tensioner Lever (LH) With Tightening Torque
Courtesy of SUBARU OF AMERICA, INC.

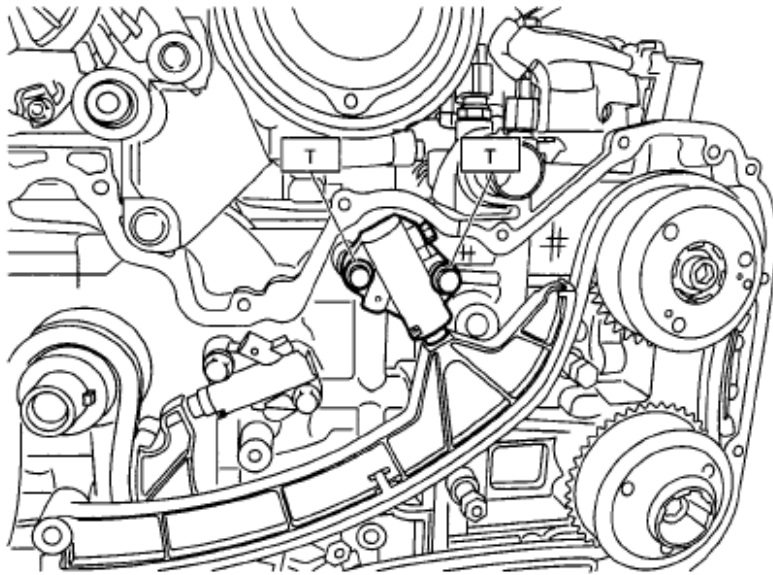
15. Install the chain tensioner (LH) and pull out the stopper pin.

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)



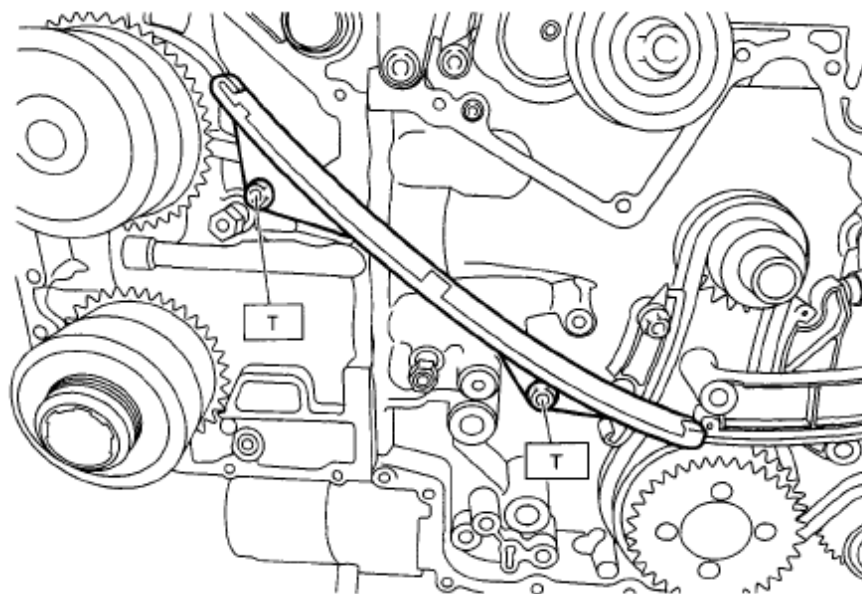
ME-03490

Fig. 176: Identifying Chain Tensioner (LH) With Tightening Torque
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)



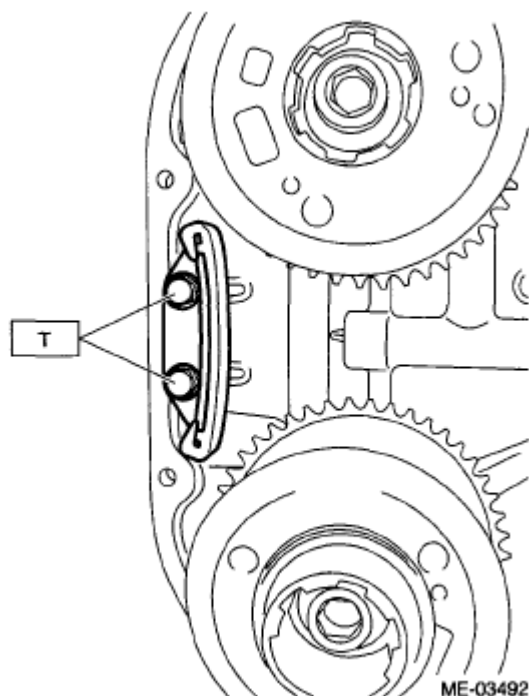
ME-03491

Fig. 177: Identifying Chain Guide (RH) 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)



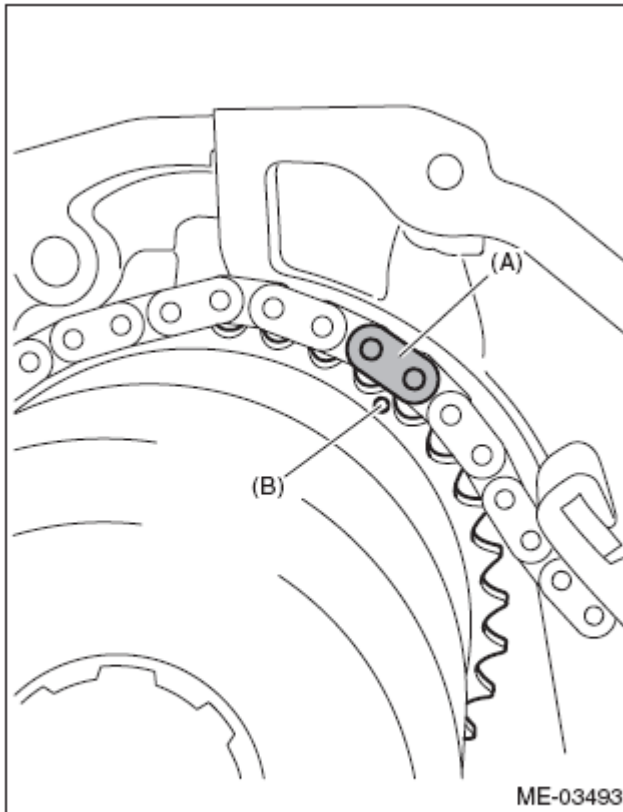
ME-03492

Fig. 178: Identifying Chain Guide (RH: Between Cams) With 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).



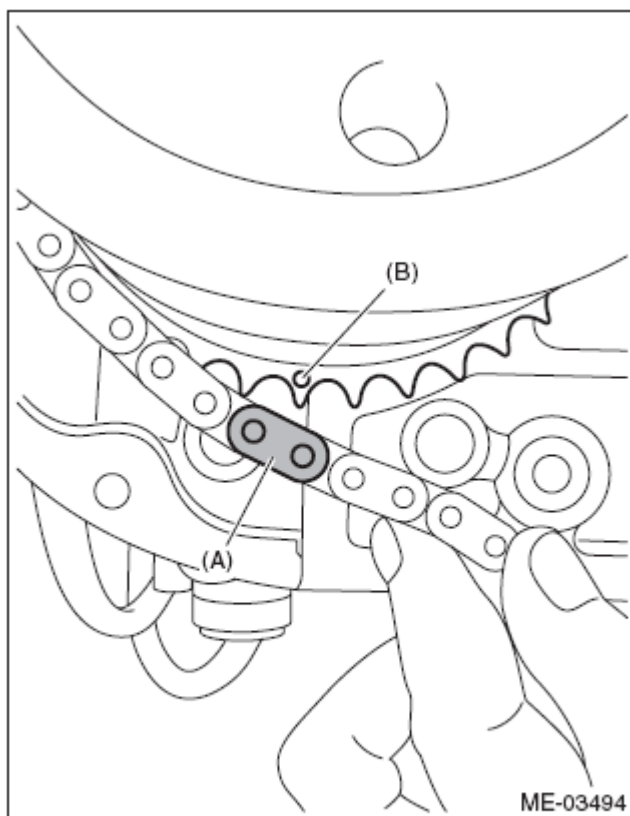
(A) Blue

(B) Timing mark

Fig. 179: Matching 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).



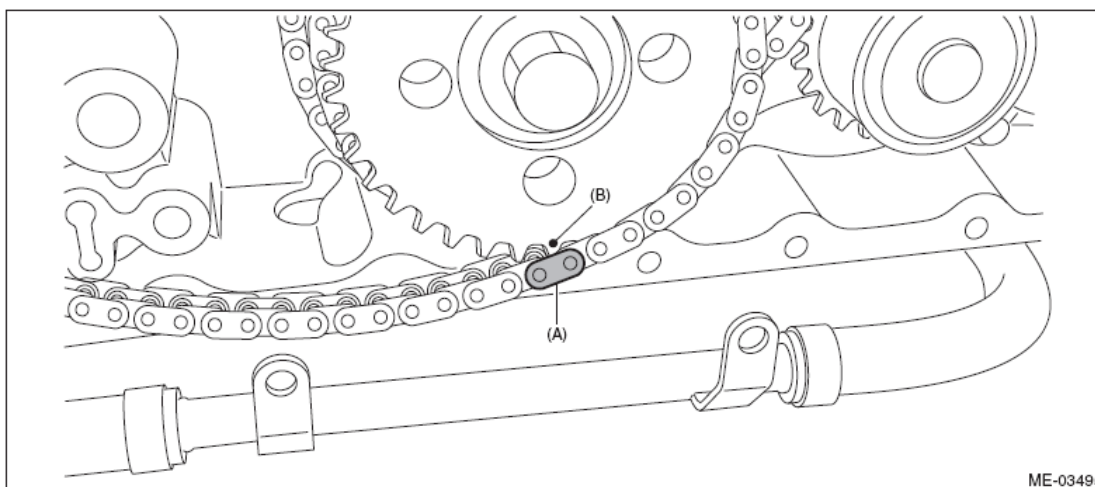
(A) Blue

(B) Timing mark

Fig. 180: Matching 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

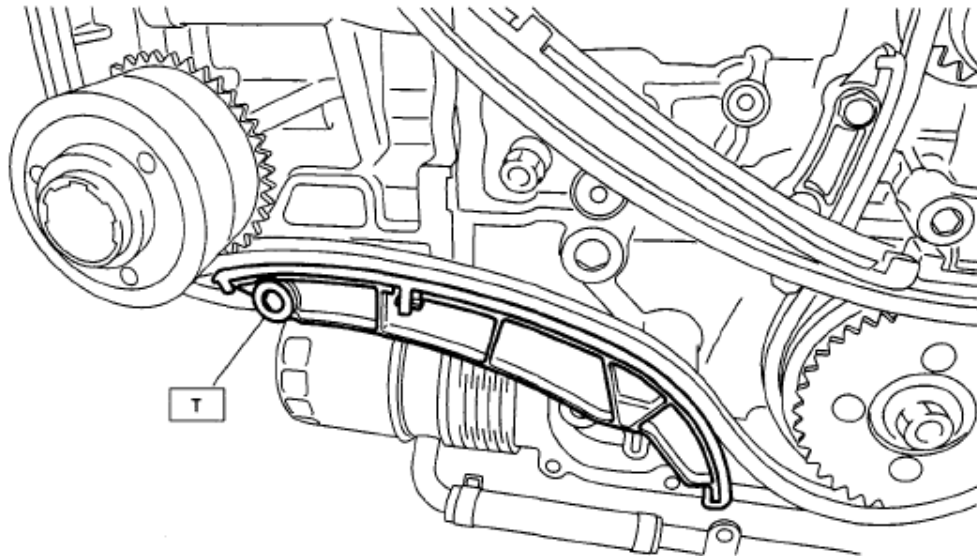
(B) Timing mark

Fig. 181: Matching 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. 182: Identifying Chain Tensioner Lever (RH) With 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)

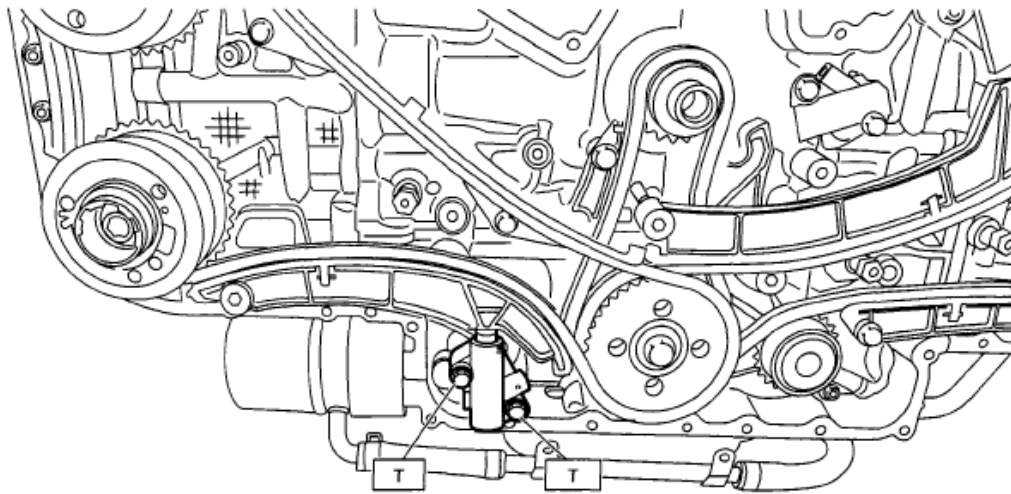


Fig. 183: Identifying Chain Tensioner (RH) Mounting Bolts With Torque Specification
Courtesy of SUBARU OF AMERICA, INC.

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**.
24. Install the crank pulley. Refer to **INSTALLATION**.
25. Install the V-belts. Refer to **INSTALLATION**.
26. Fill engine oil. Refer to **REPLACEMENT**.
27. Make sure there is no oil leaks in the chain cover mating surface.
28. Install the radiator. Refer to **INSTALLATION**.

CAM SPROCKET

REMOVAL

1. Remove the V-belts. Refer to **REMOVAL**.
2. Remove the crank pulley. Refer to **REMOVAL**.
3. Remove the chain cover. Refer to **REMOVAL**.
4. Remove the timing chain assembly. Refer to **REMOVAL**.
5. Use the ST to lock the cam sprocket, and remove the cam sprocket bolt.

ST 499977500 CAM SPROCKET WRENCH

- IN side

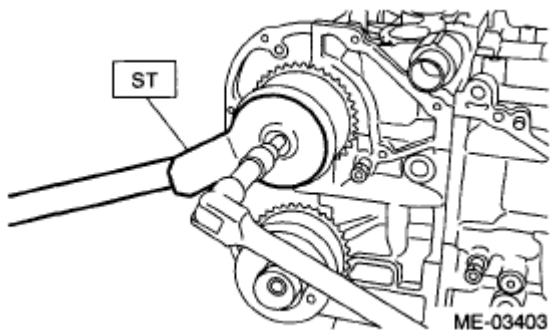


Fig. 184: Removing Cam Sprocket Bolt Using Wrench (IN Side)
Courtesy of SUBARU OF AMERICA, INC.

- EX side

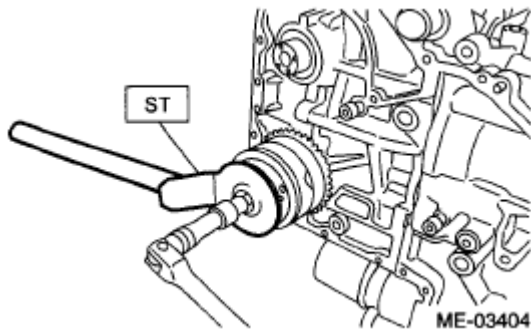


Fig. 185: Removing Cam Sprocket Bolt Using Wrench (EX Side)
Courtesy of SUBARU OF AMERICA, INC.

6. Remove the cam sprocket.

INSTALLATION

1. Remove the cam sprocket.
2. Use the ST to lock the cam sprocket, and install the cam sprocket bolt.

Tightening torque:

Tighten to 29.5 N.m (3.0 kgf-m, 21.8 ft-lb) of torque, and then tighten further by 45°.

ST 499977500 CAM SPROCKET WRENCH

- IN side

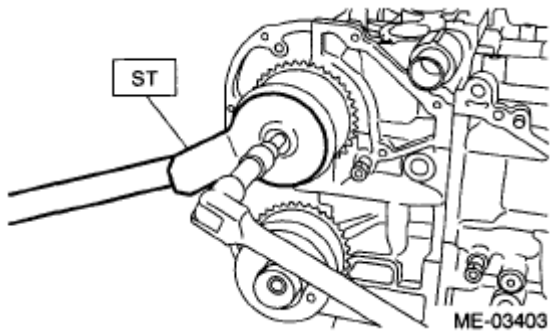


Fig. 186: Removing Cam Sprocket Bolt Using Wrench (IN Side)
Courtesy of SUBARU OF AMERICA, INC.

- EX side

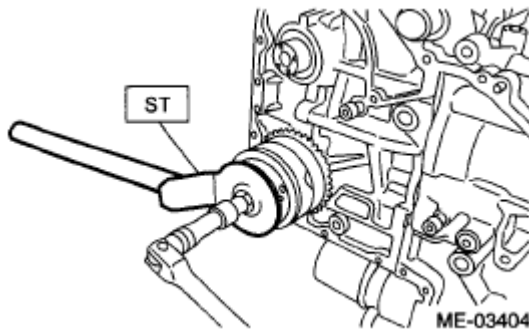


Fig. 187: Removing Cam Sprocket Bolt Using Wrench (EX Side)
Courtesy of SUBARU OF AMERICA, INC.

3. Install the timing chain assembly. Refer to **INSTALLATION**.
4. Install the chain cover. Refer to **INSTALLATION**.
5. Install the crank pulley. Refer to **INSTALLATION**.
6. Install the V-belts. Refer to **INSTALLATION**.

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**.
2. Remove the crank pulley. Refer to **REMOVAL**.
3. Remove the chain cover. Refer to **REMOVAL**.
4. Remove the timing chain assembly. Refer to **REMOVAL**.
5. Remove the crank sprocket (A).

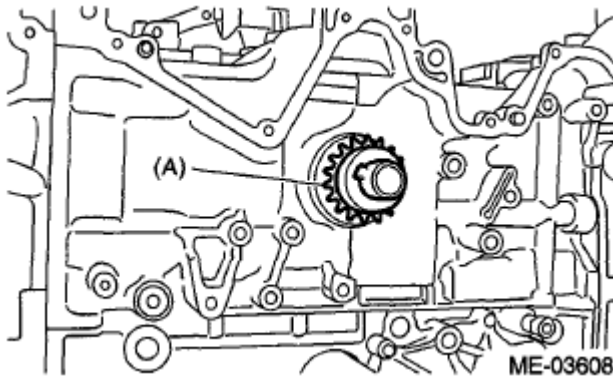


Fig. 188: Identifying Crank Sprocket
Courtesy of SUBARU OF AMERICA, INC.

INSTALLATION

1. Install the crank sprocket (A).

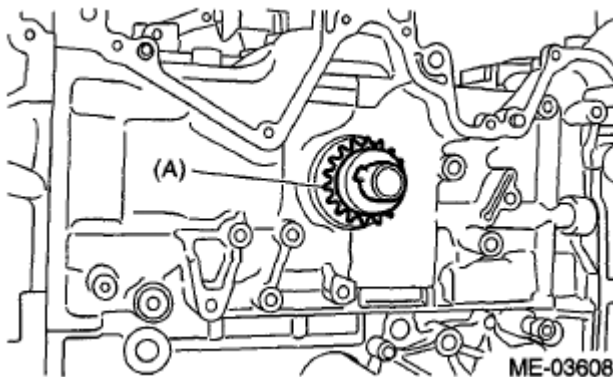


Fig. 189: Identifying Crank Sprocket
Courtesy of SUBARU OF AMERICA, INC.

2. Install the timing chain assembly. Refer to **INSTALLATION**.
3. Install the chain cover. Refer to **INSTALLATION**.
4. Install the crank pulley. Refer to **INSTALLATION**.

5. Install the V-belts. Refer to **INSTALLATION**.

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**.
2. Remove the crank pulley. Refer to **REMOVAL**.
3. Remove the chain cover. Refer to **REMOVAL**.
4. Remove the timing chain assembly. Refer to **REMOVAL**.
5. Remove the cam sprocket. Refer to **REMOVAL**.
6. Remove the crank sprocket. Refer to **REMOVAL**.
7. Remove the exhaust oil flow control solenoid valve. Refer to **REMOVAL**.
8. Remove the camshaft position sensor. Refer to **REMOVAL**.
9. Loosen the rocker cover bolts in the order indicated in the figure, and remove the rocker cover.
 - LH side

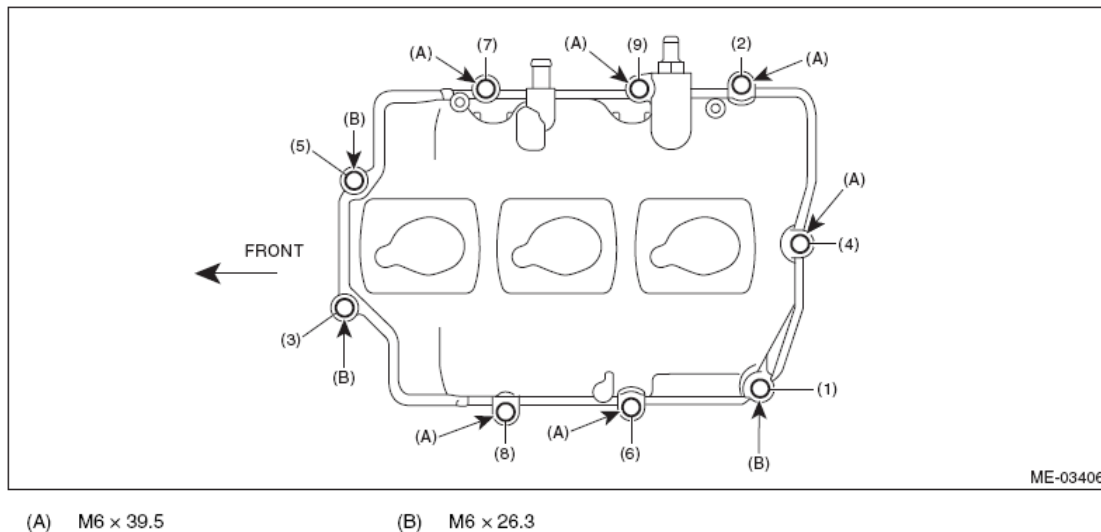


Fig. 190: Identifying Rocker Cover Bolts Loosening Sequence (LH Side)
 Courtesy of SUBARU OF AMERICA, INC.

- RH side

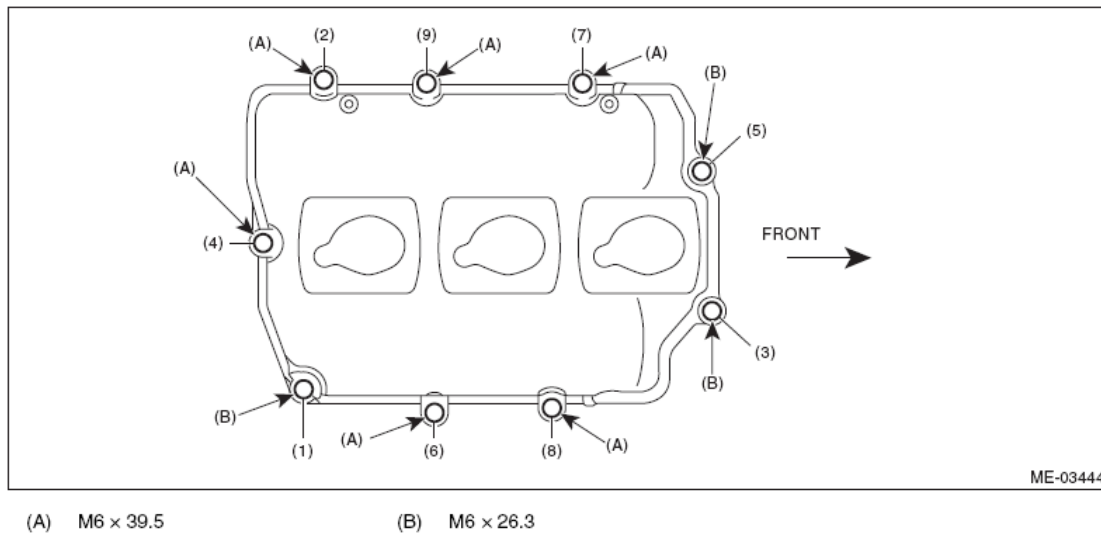


Fig. 191: Identifying Rocker Cover Bolts Loosening Sequence (RH Side)
Courtesy of SUBARU OF AMERICA, INC.

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

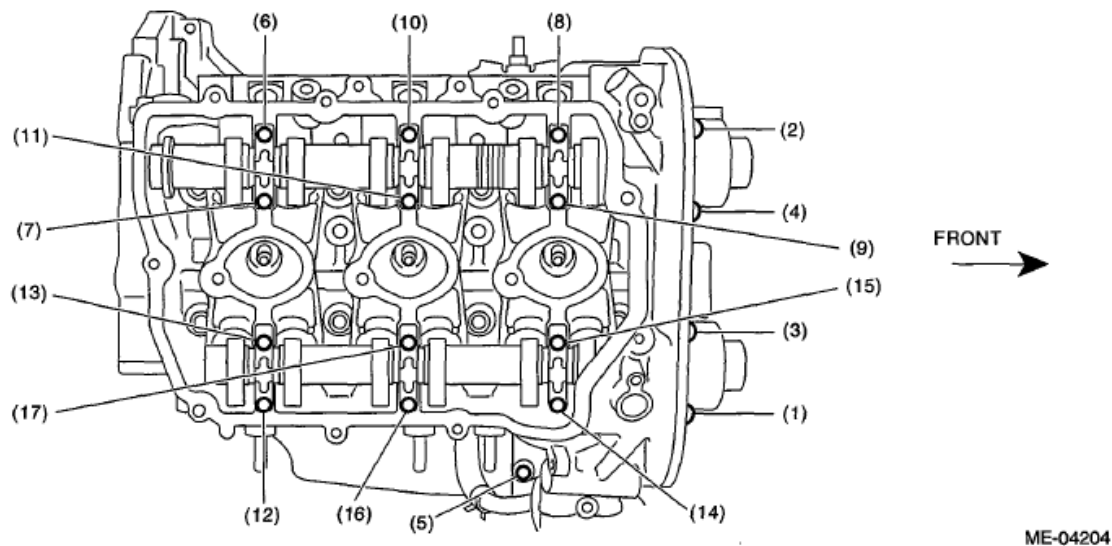


Fig. 192: Identifying Camshaft Cap Bolts Loosening Sequence
Courtesy of SUBARU OF AMERICA, INC.

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 camshaft (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)

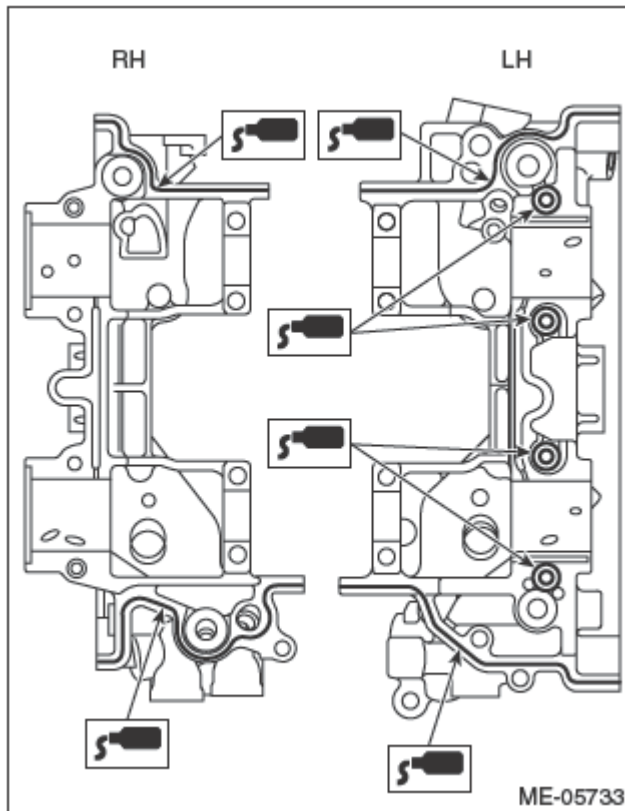


Fig. 193: Applying Liquid Gasket Sparingly To Back Side Of Front Camshaft Cap
 Courtesy of SUBARU OF AMERICA, INC.

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

NOTE: Use new O-rings.

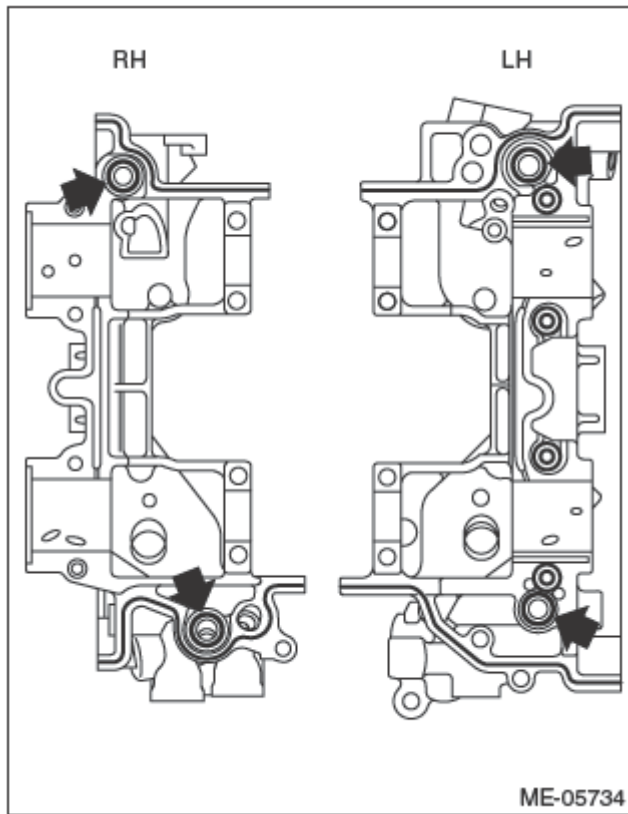


Fig. 194: Locating O-Ring On Front Camshaft Cap
 Courtesy of SUBARU OF AMERICA, INC.

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)

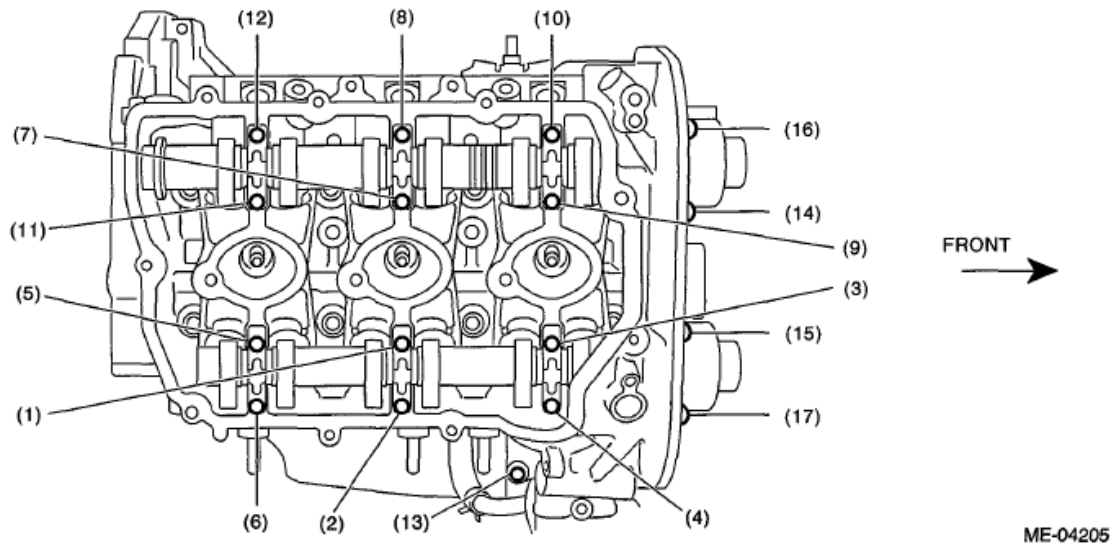


Fig. 195: Identifying Camshaft Cap Bolts Tightening Sequence
Courtesy of SUBARU OF AMERICA, INC.

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.

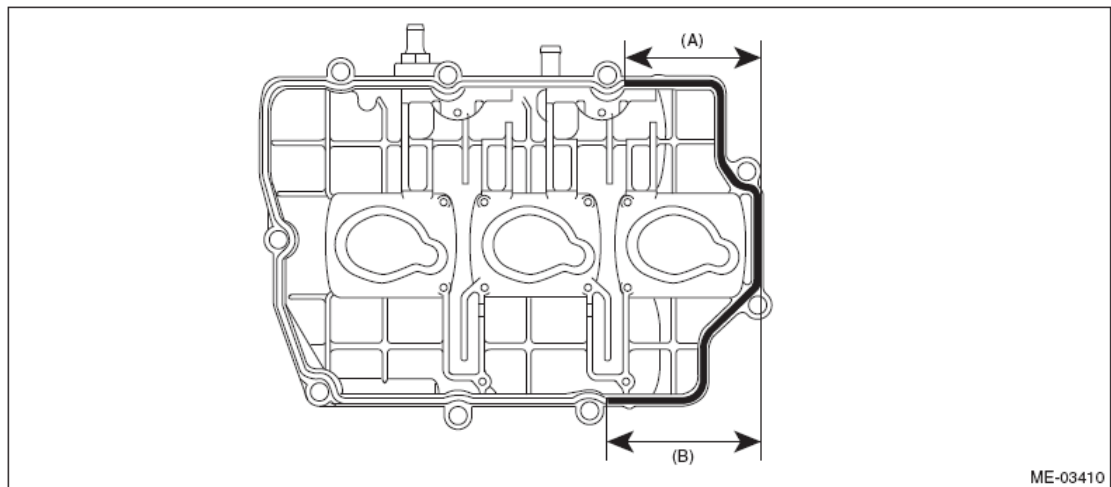
Liquid gasket:

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

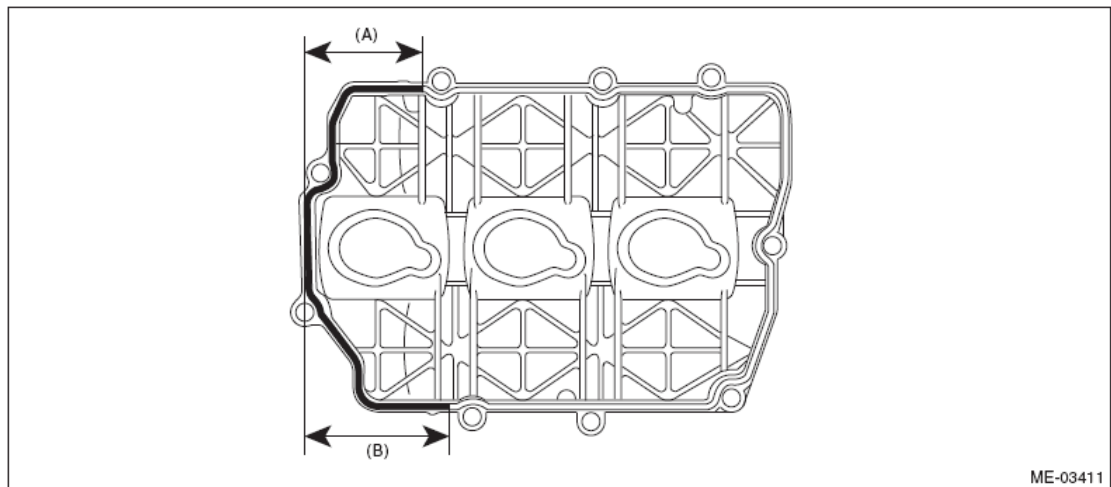


(A) 90 mm (3.543 in) or more

(B) 105 mm (4.134 in) or more

Fig. 196: Identifying Liquid Gasket Applying Diameter (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. 197: Identifying Liquid Gasket Applying Diameter (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

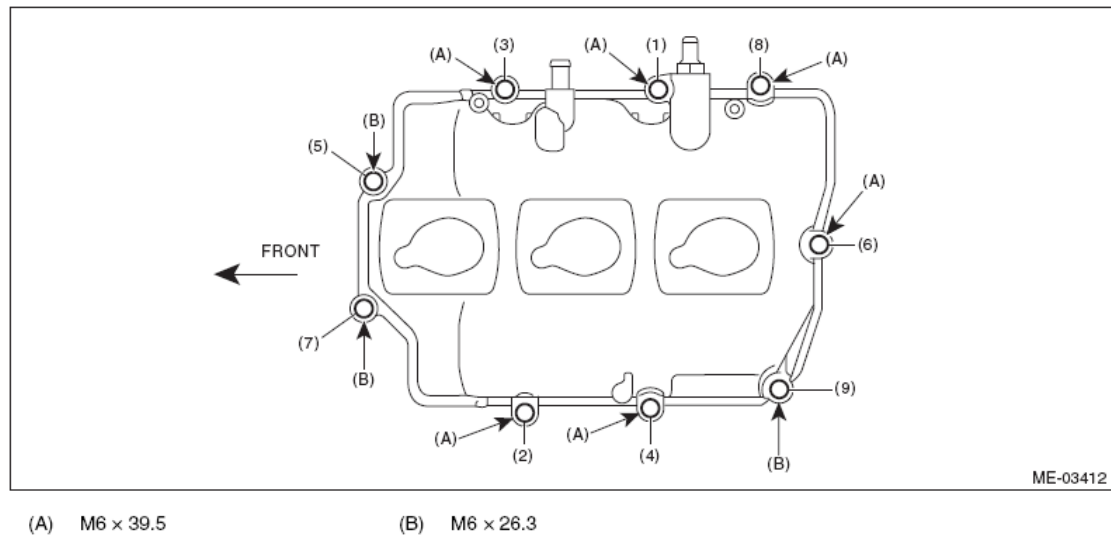


Fig. 198: Identifying Rocker Cover Bolts Tightening Sequence (LH Side)
 Courtesy of SUBARU OF AMERICA, INC.

- RH side

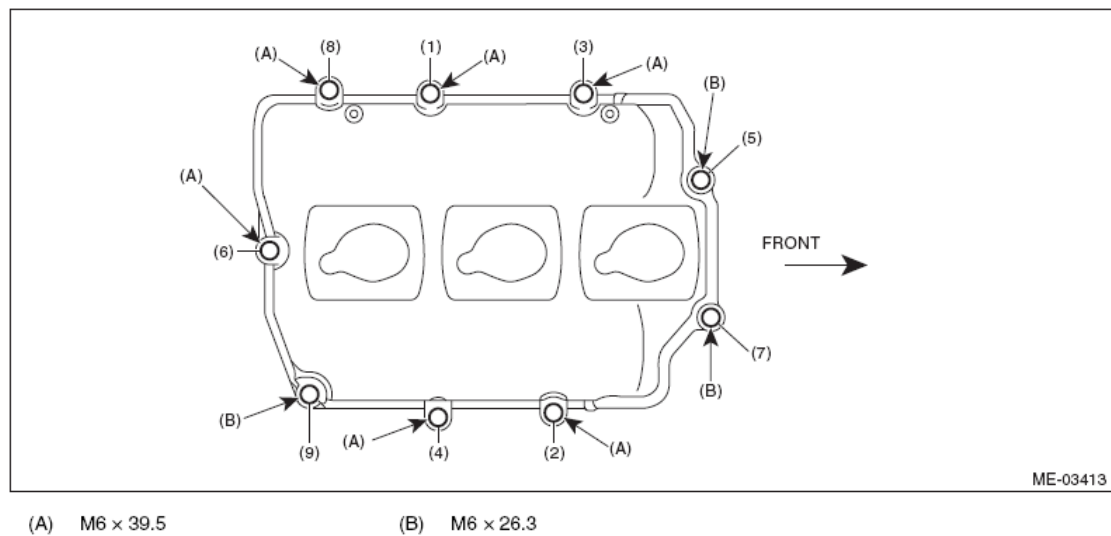


Fig. 199: Identifying Rocker Cover Bolts Tightening Sequence (RH Side)
 Courtesy of SUBARU OF AMERICA, INC.

4. Install the crank sprocket. Refer to **INSTALLATION**.
5. Install the cam sprocket. Refer to **INSTALLATION**.
6. Install the timing chain assembly. Refer to **INSTALLATION**.
7. Install the chain cover. Refer to **INSTALLATION**.
8. Install the crank pulley. Refer to **INSTALLATION**.
9. Install the engine to the vehicle. Refer to **INSTALLATION**.

INSPECTION

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

Camshaft bend limit:

0.020 mm (0.00079 in)

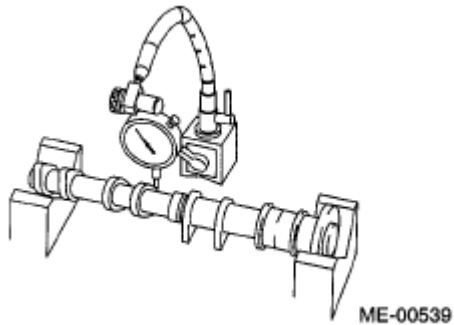


Fig. 200: Measuring Camshaft Bend Limit
Courtesy of SUBARU OF AMERICA, INC.

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)

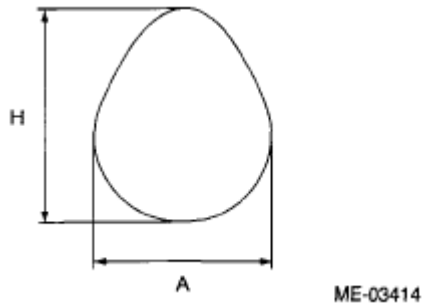


Fig. 201: Identifying Cam Base Circle Diameter And Cam Lobe Height
Courtesy of SUBARU OF AMERICA, INC.

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 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)

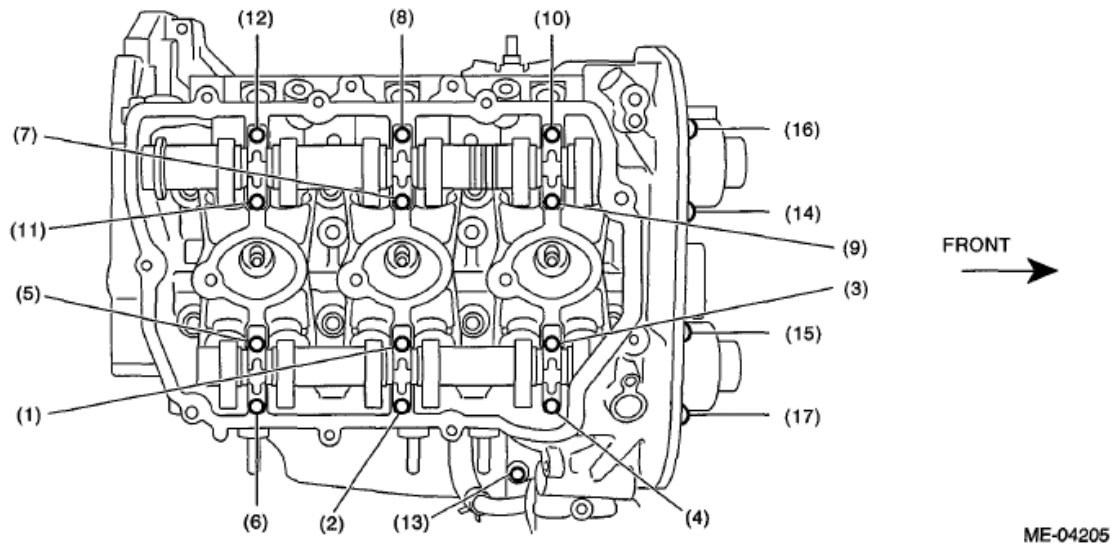


Fig. 202: Identifying Camshaft Cap Bolts Tightening Sequence
Courtesy of SUBARU OF AMERICA, INC.

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)

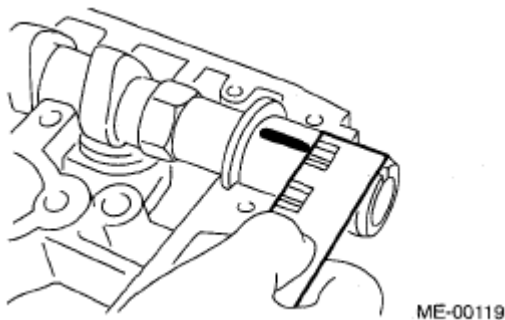


Fig. 203: Measuring Camshaft Oil Clearance
Courtesy of SUBARU OF AMERICA, INC.

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)

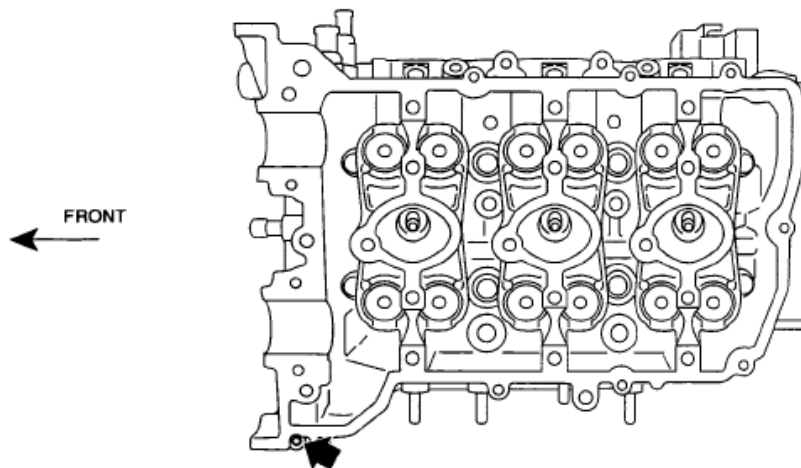
Exhaust

0.075 - 0.135 mm (0.0030 - 0.0053 in)

CYLINDER HEAD

REMOVAL

1. Remove the engine from vehicle. Refer to **REMOVAL**.
2. Remove the crank pulley. Refer to **REMOVAL**.
3. Remove the chain cover. Refer to **REMOVAL**.
4. Remove the timing chain assembly. Refer to **REMOVAL**.
5. Remove the cam sprocket. Refer to **REMOVAL**.
6. Remove the crank sprocket. Refer to **REMOVAL**.
7. Remove the camshaft. Refer to **REMOVAL**.
8. Remove the seal bolt shown in the figure.



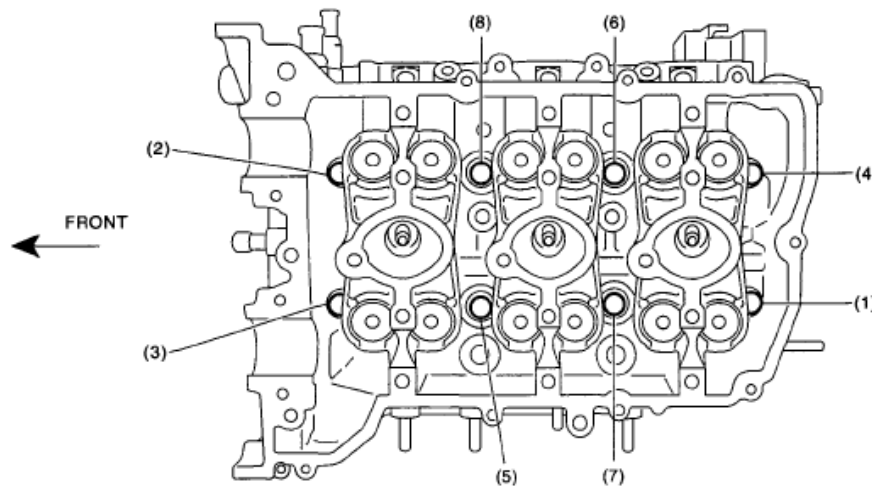
ME-03524

Fig. 204: Locating 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.



ME-03415

Fig. 205: 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.

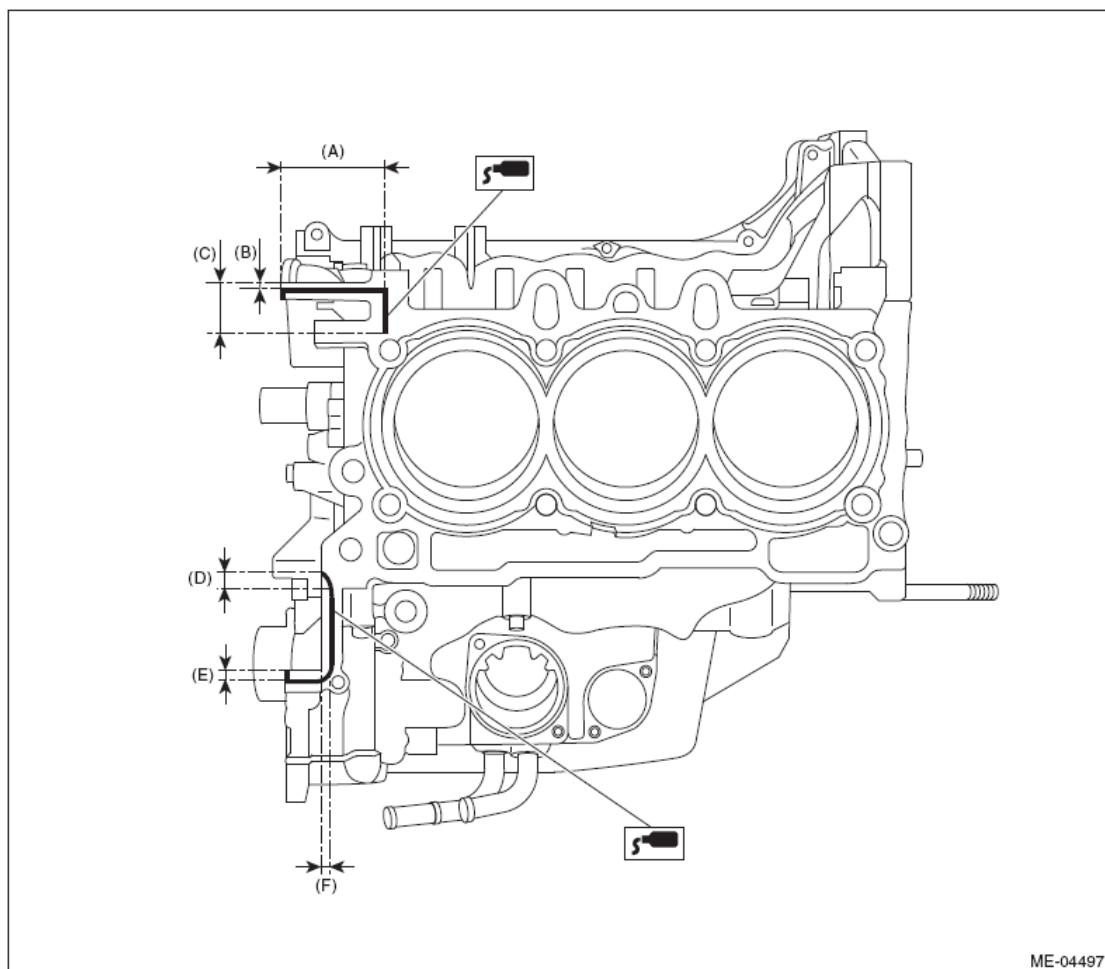
Liquid gasket:

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

Liquid gasket applying diameter:

3.5±1.0 mm (0.138±0.039 in)

- LH side



(A) 59 mm (2.323 in)

(B) 2 mm (0.079 in)

(C) 20 mm (0.787 in)

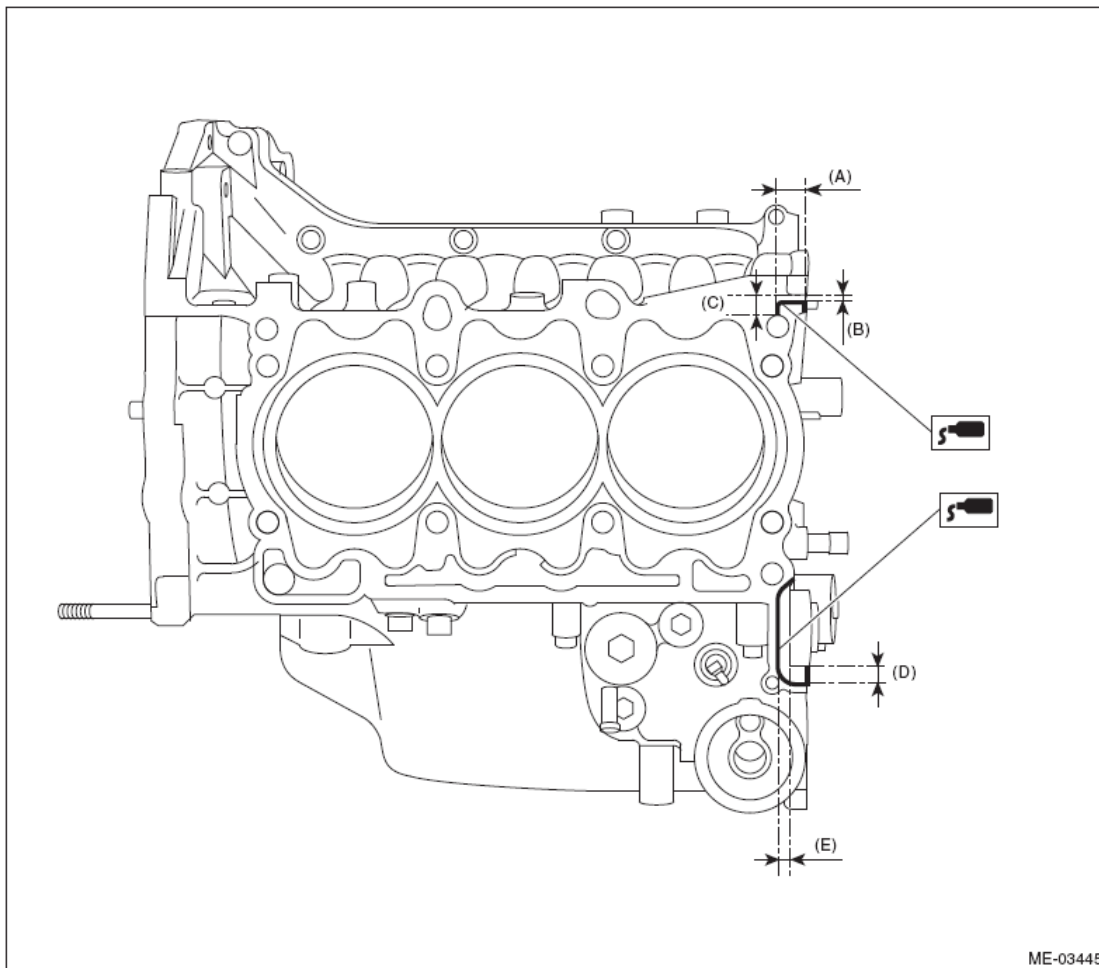
(D) 7 mm (0.276 in)

(E) 4 mm (0.157 in)

(F) 4 mm (0.157 in)

Fig. 206: 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. 207: 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.

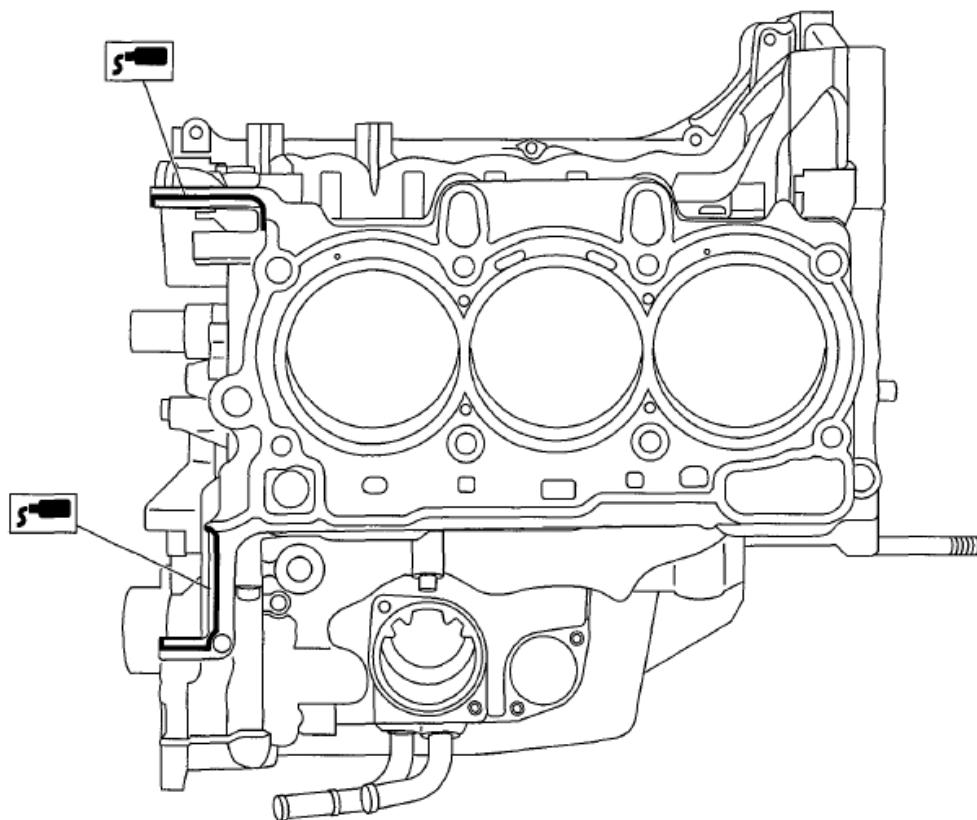
Liquid gasket:

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

Liquid gasket applying diameter:

3.5±1.0 mm (0.138±0.039 in)

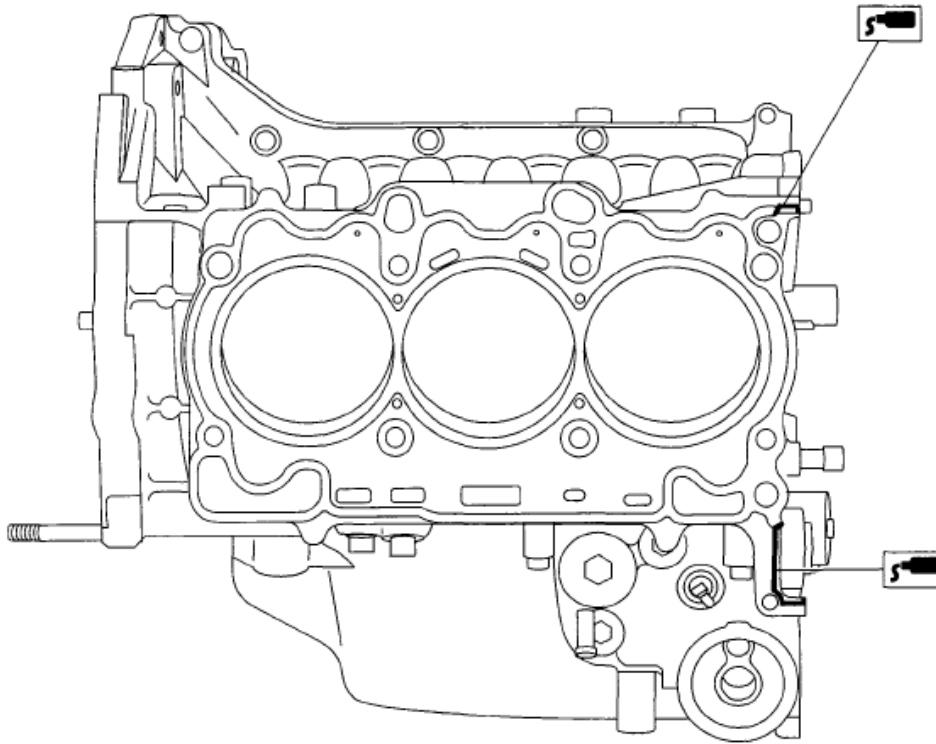
- LH side



ME-04498

Fig. 208: Applying Liquid Gasket To Mating Surface Of Cylinder Head Gasket (LH Side)
Courtesy of SUBARU OF AMERICA, INC.

- RH side



ME-03544

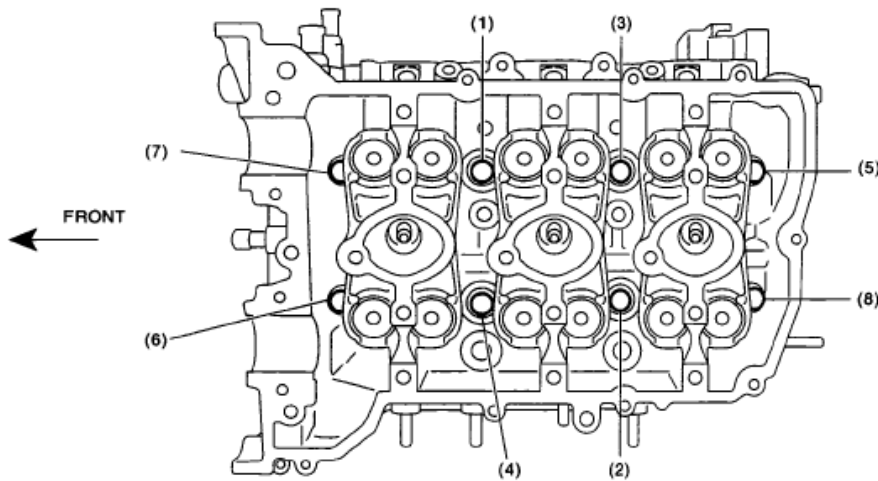
Fig. 209: Applying Liquid Gasket To Mating Surface Of Cylinder Head Gasket (RH Side)
Courtesy of SUBARU OF AMERICA, INC.

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. 210: Identifying Cylinder Head Bolts Tightening Sequence
Courtesy of SUBARU OF AMERICA, INC.

6. Install the seal bolt shown in the figure.

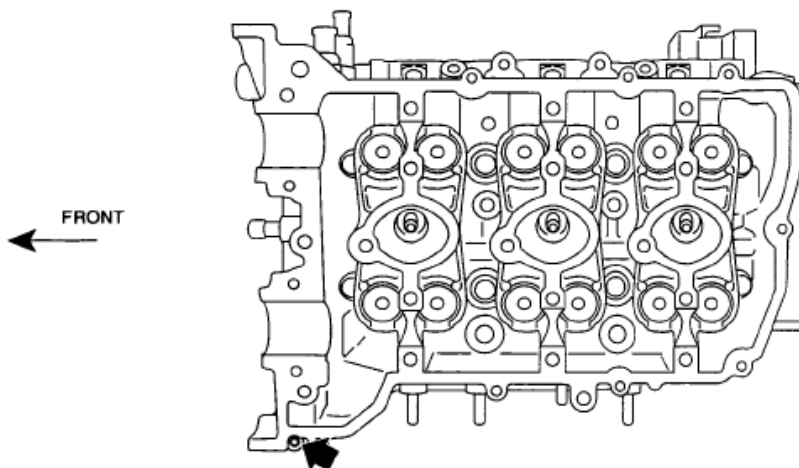
NOTE: Before installing seal bolts, apply a sealing material to bolt threads.

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. 211: Locating Cylinder Head Sealing Bolt

Courtesy of SUBARU OF AMERICA, INC.

7. Install the camshaft. Refer to INSTALLATION.
8. Install the crank sprocket. Refer to INSTALLATION.
9. Install the cam sprocket. Refer to INSTALLATION.
10. Install the timing chain assembly. Refer to INSTALLATION.
11. Install the chain cover. Refer to INSTALLATION.
12. Install the crank pulley. Refer to INSTALLATION.
13. Install the engine to the vehicle. Refer to INSTALLATION.

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 VALVE GUIDE and INTAKE AND EXHAUST VALVE OIL SEAL.

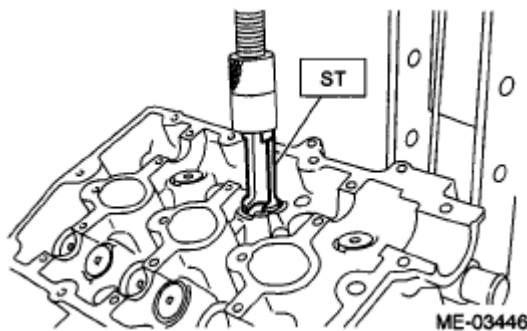
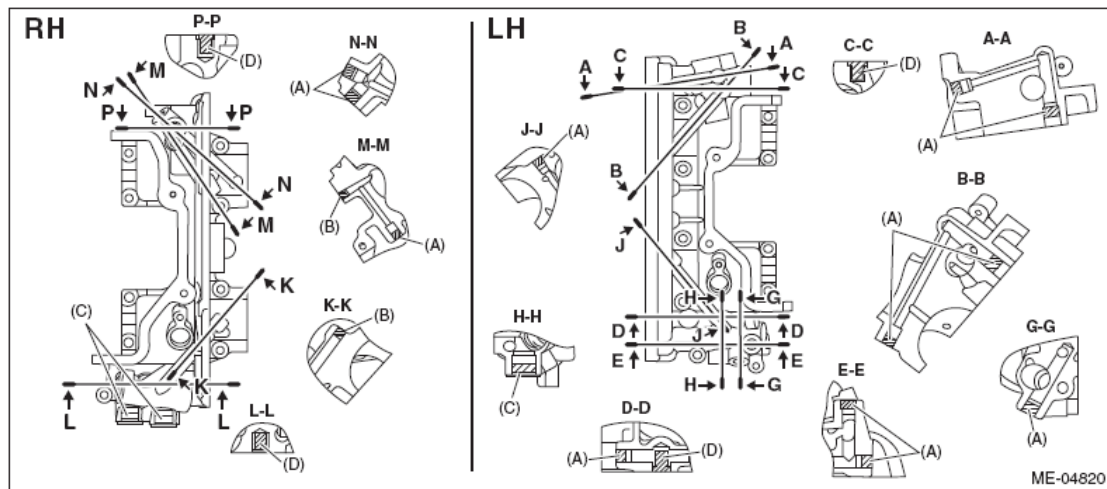


Fig. 212: Compressing Valve Spring Using Special Tool
Courtesy of SUBARU OF AMERICA, INC.

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



(A) Plug (PT 1/8)
(B) Plug (PT 1/16)

(C) Plug (M16 x 1.5)

(D) Filter

Fig. 213: Overview For Removal Of Plug And Filter From Front Camshaft Cap
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

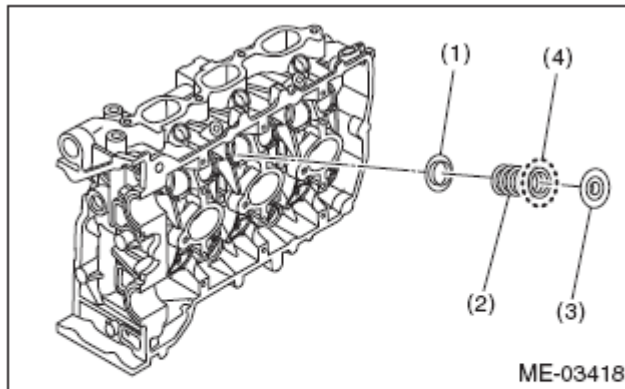
2. Coat the stem of each valve with engine oil and insert the valve into valve guide.

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. 214: Identifying Seat, Valve Spring, Retainer And Painted Face
 Courtesy of SUBARU OF AMERICA, INC.

4. Set the ST on valve spring.

ST 499718000 VALVE SPRING REMOVER

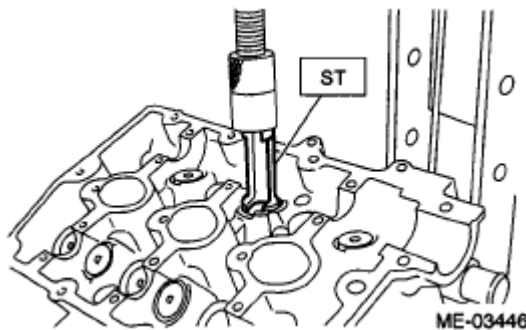


Fig. 215: Setting Special Tool On Valve Spring
 Courtesy of SUBARU OF AMERICA, INC.

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)

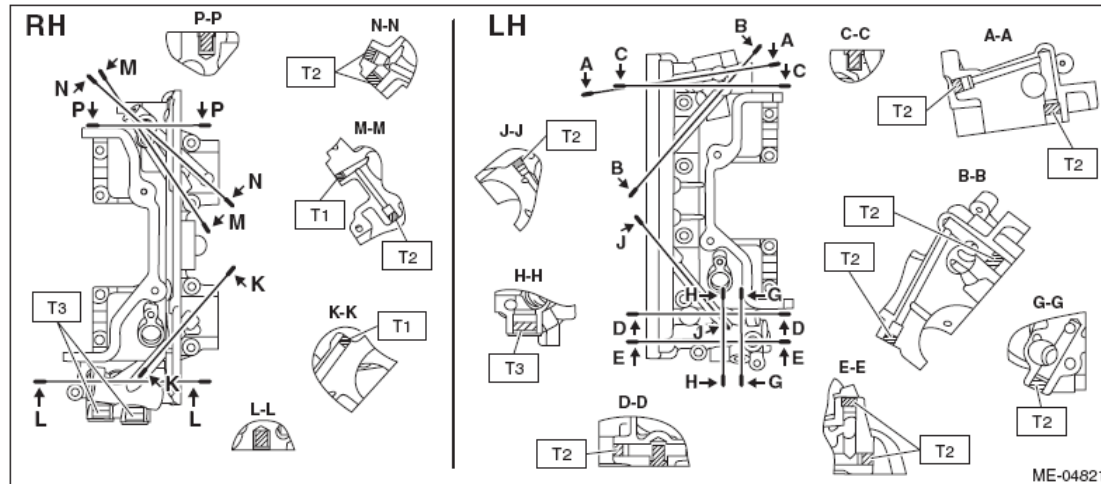


Fig. 216: Overview For Installing Plug And Filter To Front Camshaft Cap
Courtesy of SUBARU OF AMERICA, INC.

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.

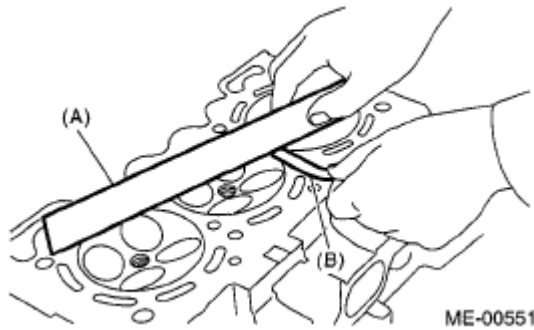


Fig. 217: Checking For Warpage At Mating Surface Between Cylinder Block And Cylinder Head Using Straight Edge
Courtesy of SUBARU OF AMERICA, INC.

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)

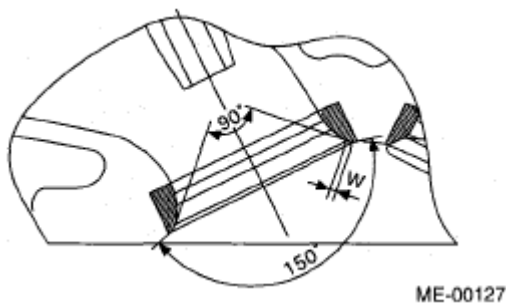


Fig. 218: Identifying Contacting Width Of Valve Seat
Courtesy of SUBARU OF AMERICA, INC.

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

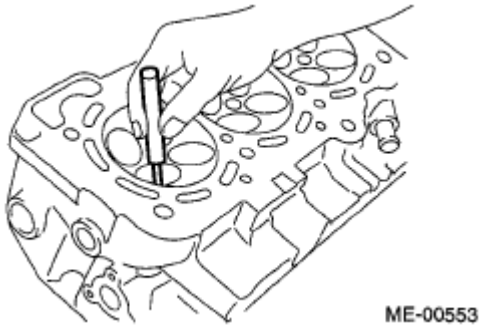


Fig. 219: Inserting Special Tool Into Valve Guide
Courtesy of SUBARU OF AMERICA, INC.

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)

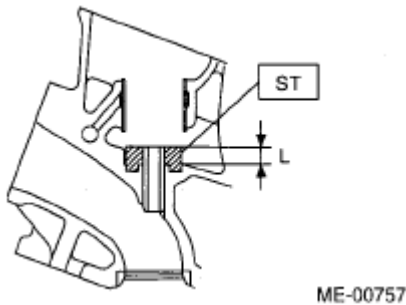


Fig. 220: Turning Cylinder Head Upside Down
Courtesy of SUBARU OF AMERICA, INC.

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)

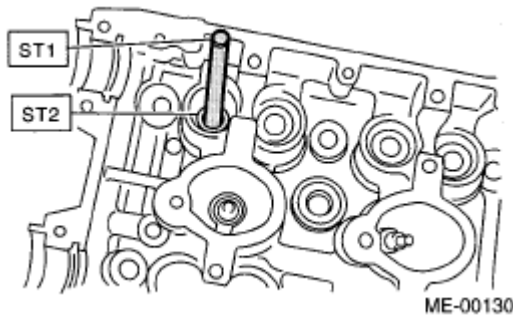


Fig. 221: Inserting Special Tool Into Valve Guide
Courtesy of SUBARU OF AMERICA, INC.

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:

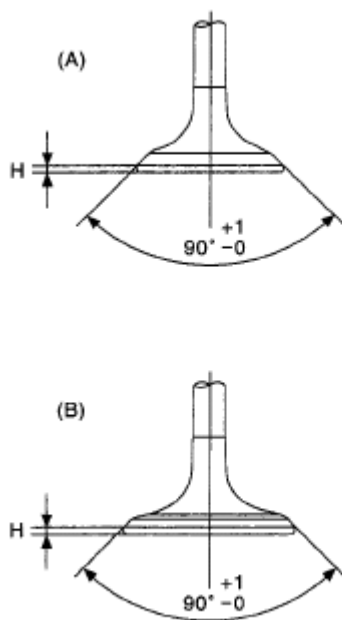
Standard

Intake (A)

1.0 mm (0.039 in)

Exhaust (B)

1.2 mm (0.047 in)



ME-02096

Fig. 222: Identifying Head Edge Thickness (Standard And Exhaust)

Courtesy of SUBARU OF AMERICA, INC.

2. 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 (18.6 - 21.4, 40.9 - 47.2)/31.0 (1.220 in)
	Lift	316 - 350 (32.2 - 35.7, 71.0 - 78.7)/21.0 (0.827 in)
Squareness		2.5°, 2.1 mm (0.083 in) or less

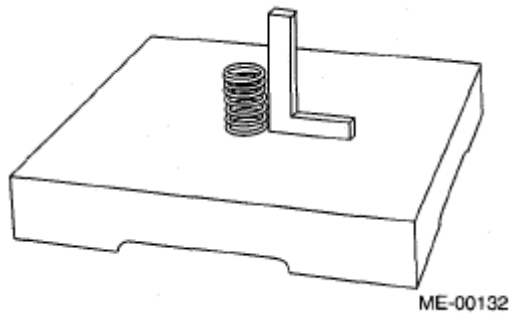


Fig. 223: Measuring Squareness Of Valve Spring
Courtesy of SUBARU OF AMERICA, INC.

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.

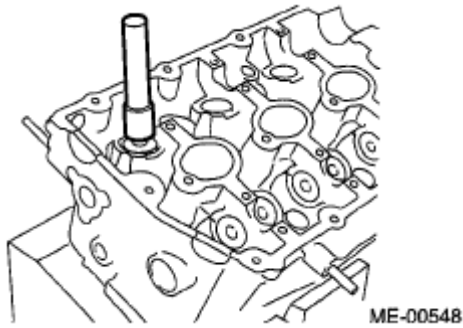


Fig. 224: Press-Fitting Oil Seal
Courtesy of SUBARU OF AMERICA, INC.

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)

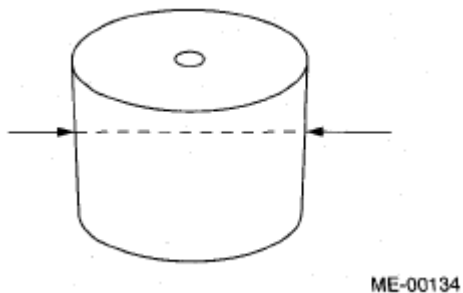


Fig. 225: Identifying Outer Diameter Of Valve Lifter
Courtesy of SUBARU OF AMERICA, INC.

3. Measure the inner diameter of valve lifter mating surface on cylinder head.

Inner diameter of valve lifter mating surface:

32.994 - 33.016 mm (1.2990 - 1.2998 in)

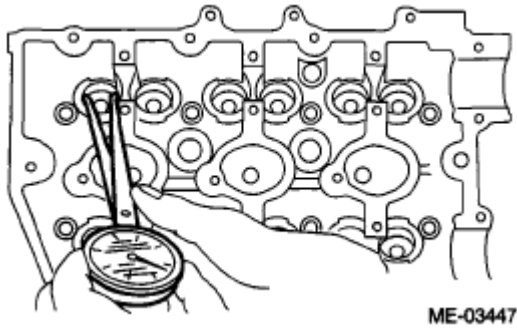


Fig. 226: Measuring Inner Diameter Of Valve Lifter Mating Surface On Cylinder Head
Courtesy of SUBARU OF AMERICA, INC.

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

Valve lifter and valve lifter mating surface clearance:

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**.
2. Remove the crank pulley. Refer to **REMOVAL**.
3. Remove the chain cover. Refer to **REMOVAL**.
4. Remove the timing chain assembly. Refer to **REMOVAL**.
5. Remove the cam sprocket. Refer to **REMOVAL**.
6. Remove the crank sprocket. Refer to **REMOVAL**.
7. Remove the camshaft. Refer to **REMOVAL**.
8. Remove the cylinder head. Refer to **REMOVAL**.
9. Remove the drive plate. Refer to **REMOVAL**.
10. Remove the crankshaft position sensor.

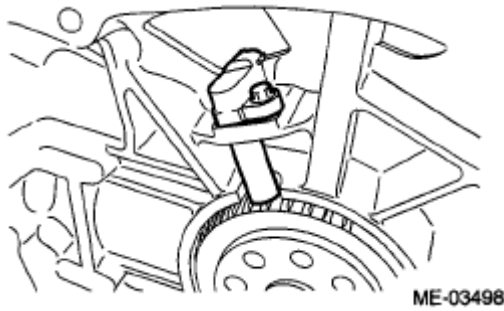


Fig. 227: Identifying Crankshaft Position Sensor
Courtesy of SUBARU OF AMERICA, INC.

11. Remove the crankshaft position sensor plate.

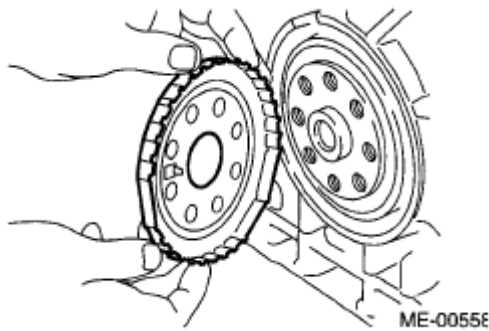


Fig. 228: Removing/Installing Crankshaft Position Sensor Plate
Courtesy of SUBARU OF AMERICA, INC.

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

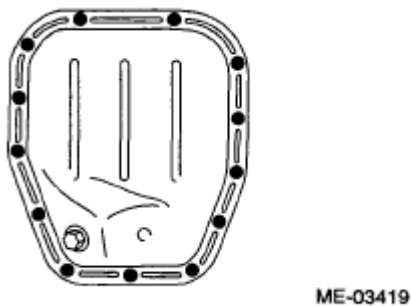
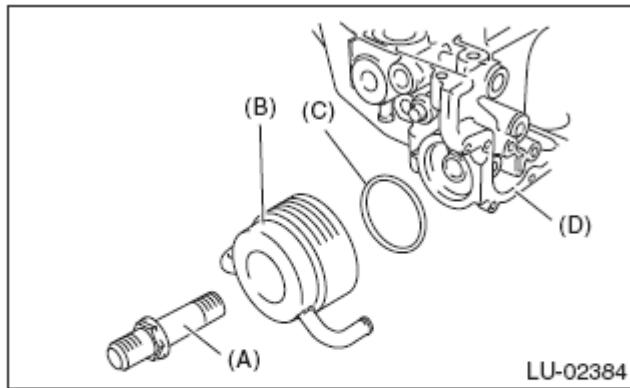


Fig. 229: Identifying Oil Pan Lower To Upper Securing Bolts
Courtesy of SUBARU OF AMERICA, INC.

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.

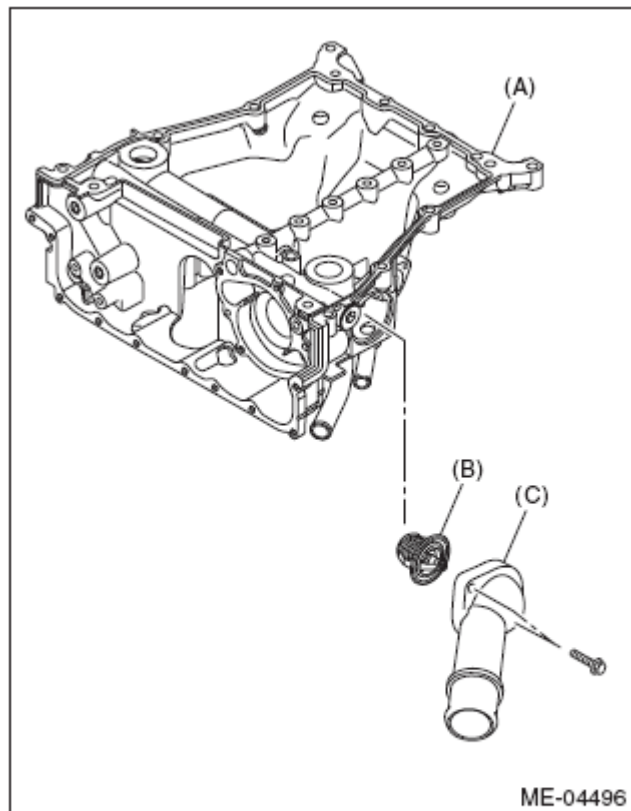
15. Remove the oil cooler connector and remove the oil cooler.



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

Fig. 230: Identifying Oil Cooler And Connector, O-Ring And Oil Pan Upper
Courtesy of SUBARU OF AMERICA, INC.

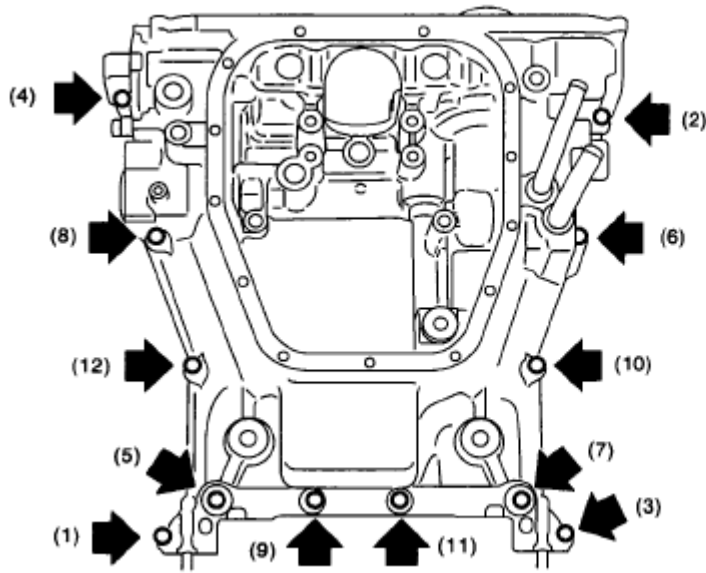
16. Remove the oil pump. Refer to **REMOVAL** .
17. Remove the oil level switch. Refer to **REMOVAL** .
18. Remove the thermostat cover, and then remove the thermostat.



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

Fig. 231: Identifying Oil Pan Upper, Thermostat And Cover
Courtesy of SUBARU OF AMERICA, INC.

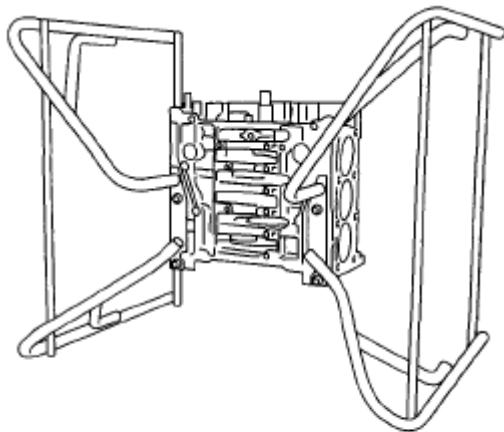
19. Remove the oil pan upper.



ME-03420

Fig. 232: Locating Oil Pan Upper Mounting Bolts
Courtesy of SUBARU OF AMERICA, INC.

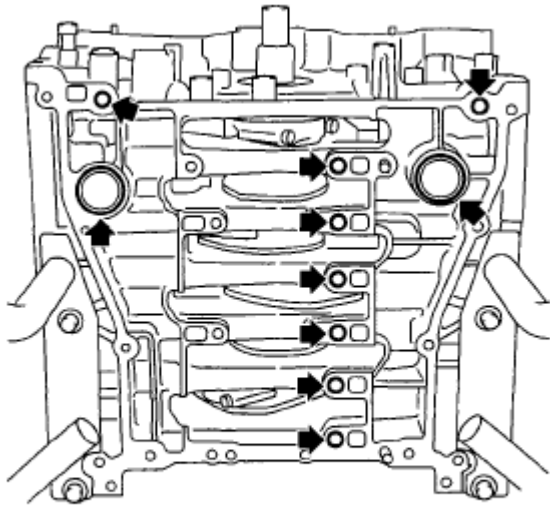
20. Face the front of the engine up, standing the engine on one end.



ME-03421

Fig. 233: Identifying Engine Supported On Stand
Courtesy of SUBARU OF AMERICA, INC.

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



ME-03422

Fig. 234: Locating O-Rings On Underside Of Cylinder Block
Courtesy of SUBARU OF AMERICA, INC.

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

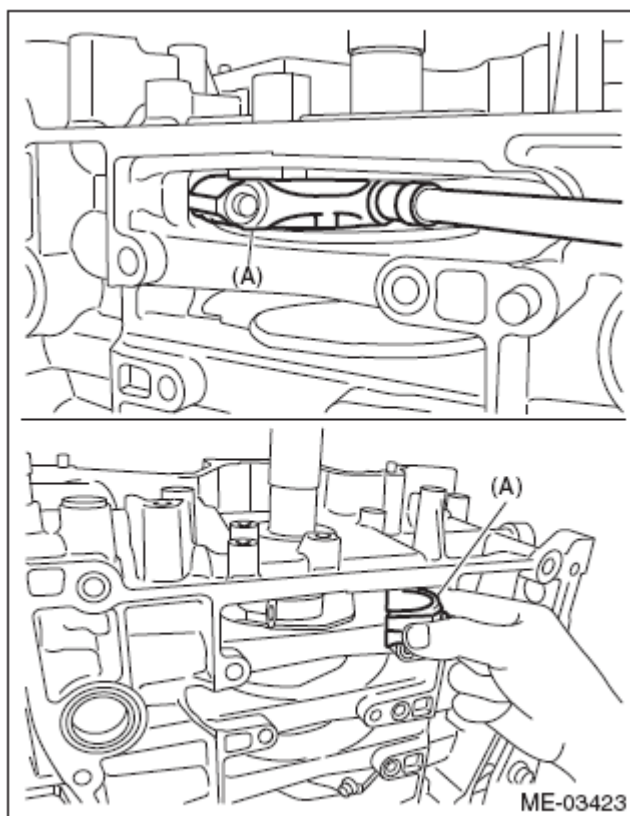
NOTE:

- 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

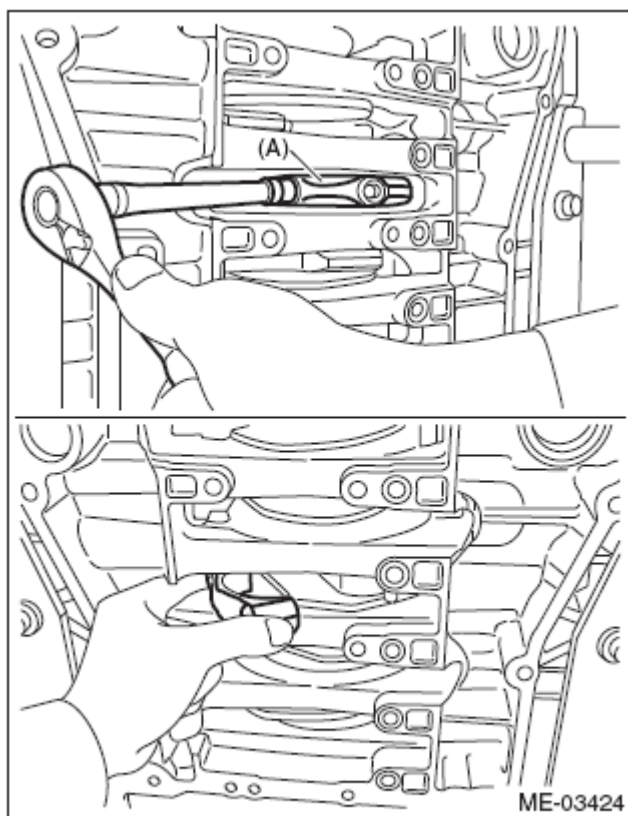
2. Remove the two #1 connecting rod cap connection bolts, and remove the connecting rod cap.



(A) #1 connecting rod cap

Fig. 235: Removing Two No. 1 Connecting Rod Cap Connection Bolts
Courtesy of SUBARU OF AMERICA, INC.

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

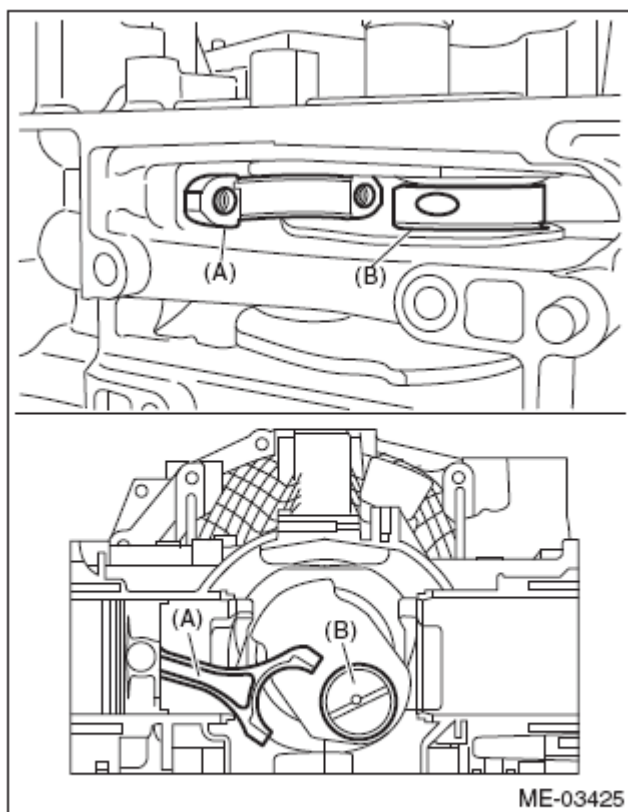


(A) #4 connecting rod cap

Fig. 236: Removing Two No. 4 Connecting Rod Cap Connection Bolts
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.

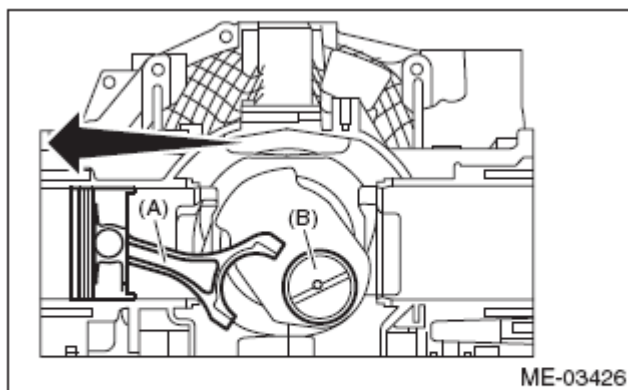
ST 18252AA000 CRANKSHAFT SOCKET



- (A) #1 connecting rod
(B) Crank pin

Fig. 237: Turning Crankshaft
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.

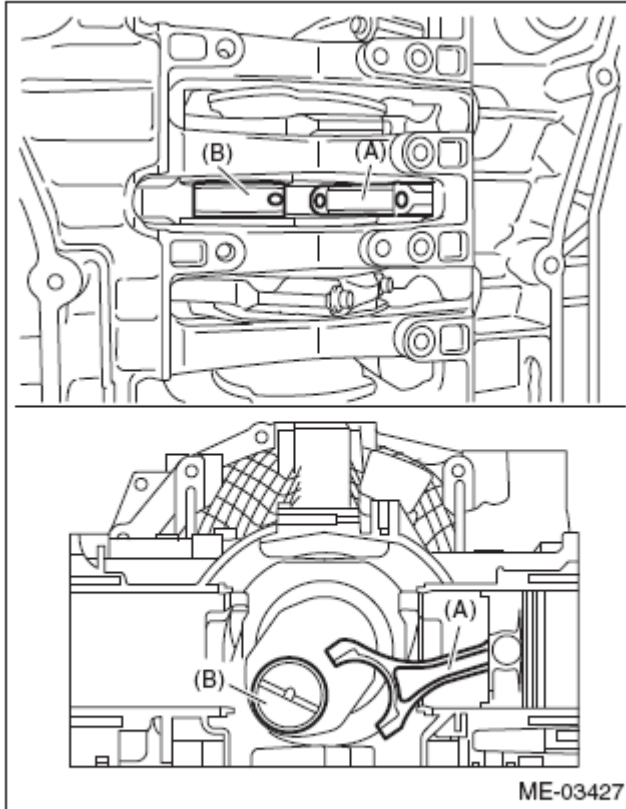


- (A) #1 connecting rod
(B) Crank pin

Fig. 238: Pushing No. 1 Connecting Rod
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.

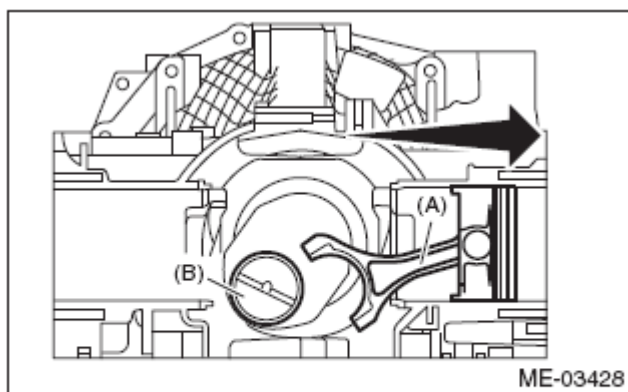
ST 18252AA000 CRANKSHAFT SOCKET



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

Fig. 239: Identifying No. 4 Connecting Rod And Crank Pin
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. 240: Pushing No. 4 Connecting Rod
Courtesy of SUBARU OF AMERICA, INC.

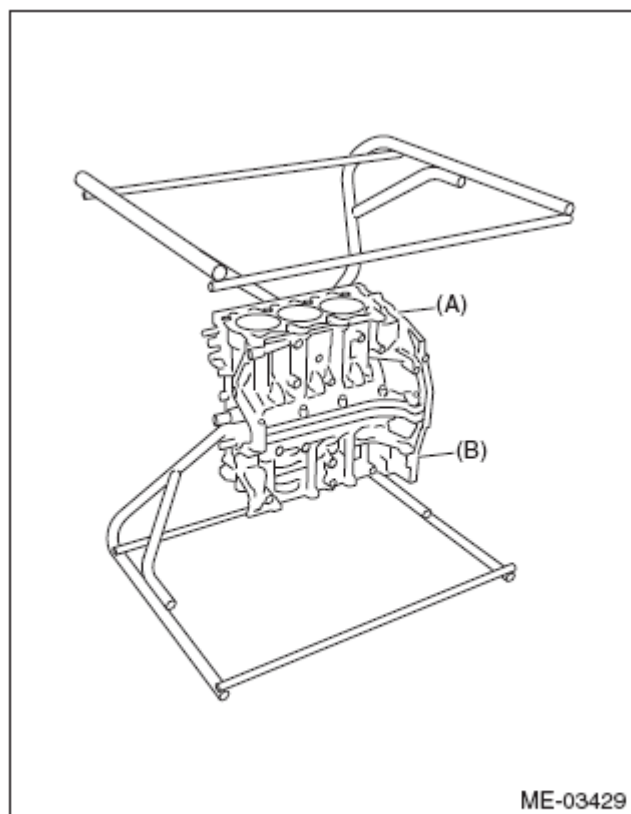
24. Remove the #2 and #5 connecting rods and pistons from the cylinder block in the same manner.

ST 18252AA000 CRANKSHAFT SOCKET

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

ST 18252AA000 CRANKSHAFT SOCKET

26. Face the cylinder block (RH) up.

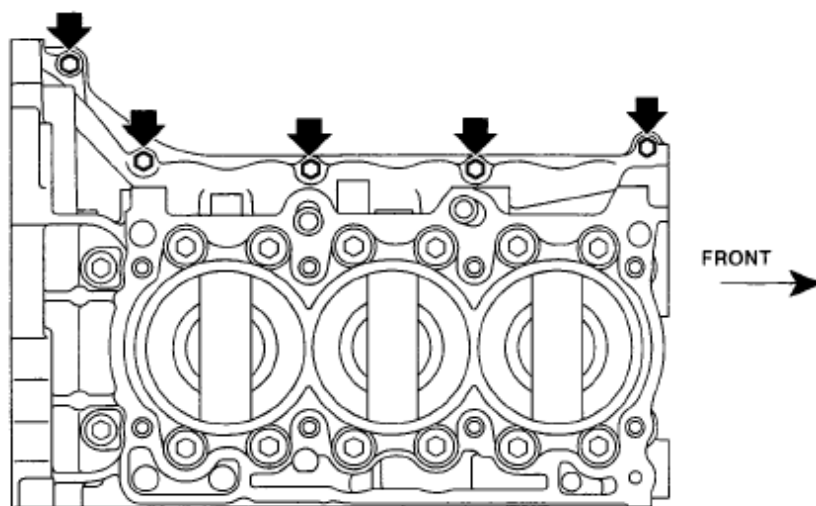


(A) Cylinder block (RH)

(B) Cylinder block (LH)

Fig. 241: Facing Cylinder Block (RH) Up
Courtesy of SUBARU OF AMERICA, INC.

27. Remove the upper bolt.

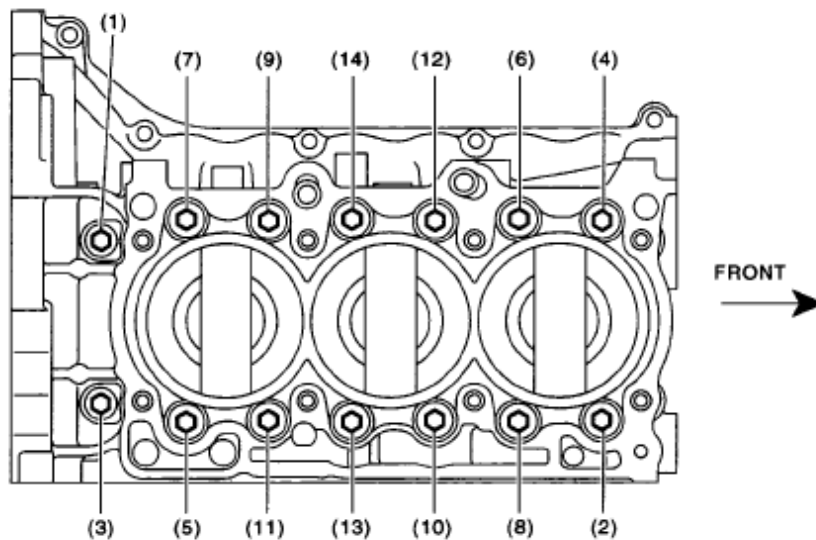


ME-03433

Fig. 242: Locating Cylinder Block Upper Mounting Bolts
 Courtesy of SUBARU OF AMERICA, INC.

28. 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. 243: Identifying Cylinder Block Bolts Loosening Sequence
 Courtesy of SUBARU OF AMERICA, INC.

29. Remove the rear oil seal.
 30. Remove the crankshaft from cylinder block (LH).
 31. 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.

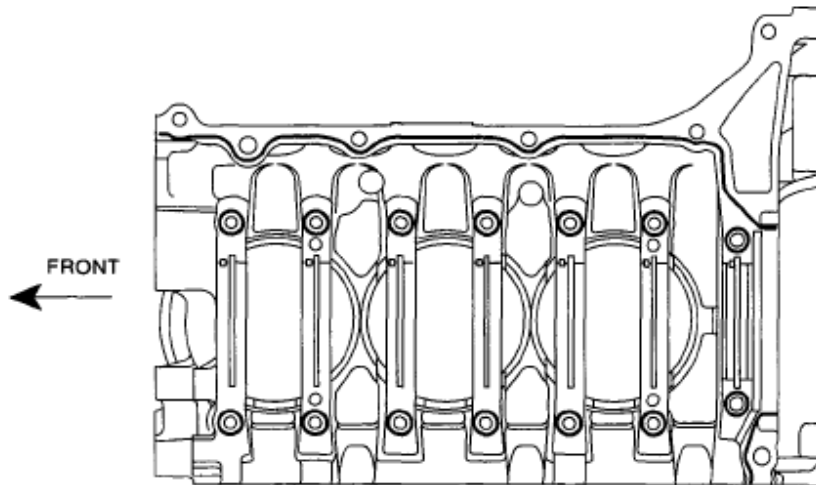
NOTE: Install within 5 min. after applying liquid gasket.

Liquid gasket:

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

Liquid gasket applying diameter:

$1.0 \pm 0.2 \text{ mm}$ ($0.039 \pm 0.008 \text{ in}$)



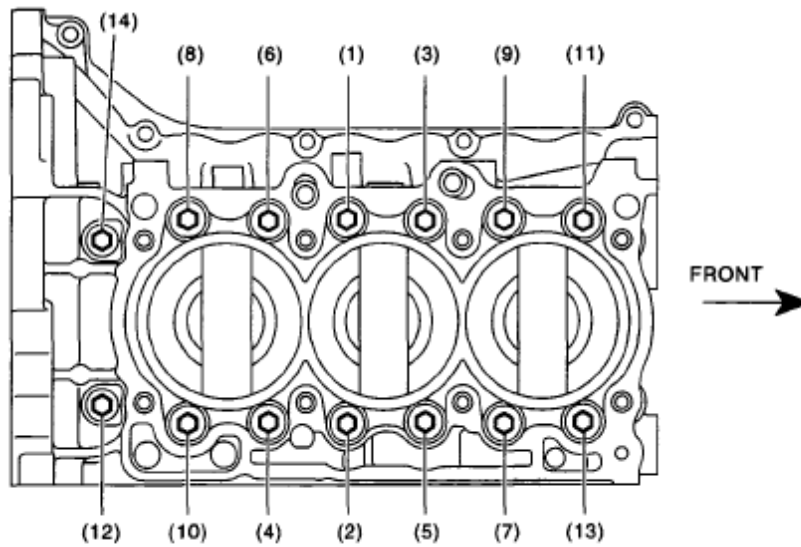
ME-03431

Fig. 244: Identifying Liquid Gasket Applying Diameter
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)



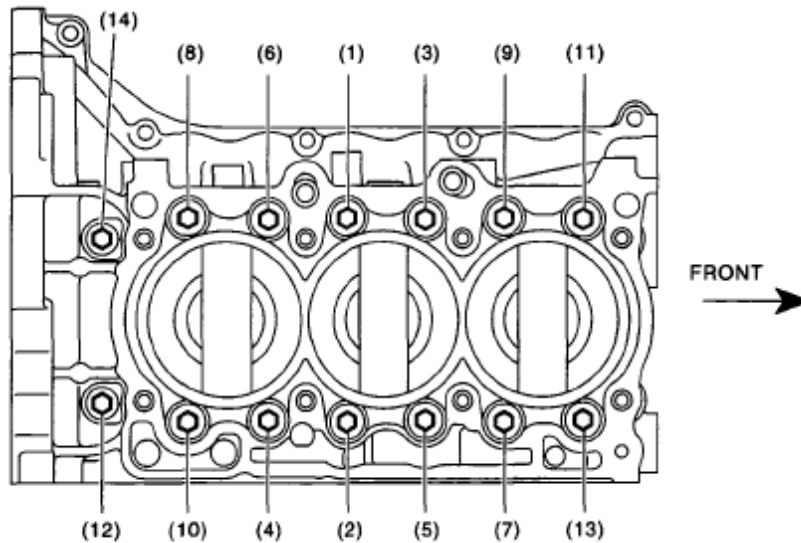
ME-03432

Fig. 245: Identifying Cylinder Block Tightening Sequence
Courtesy of SUBARU OF AMERICA, INC.

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

Tightening torque:

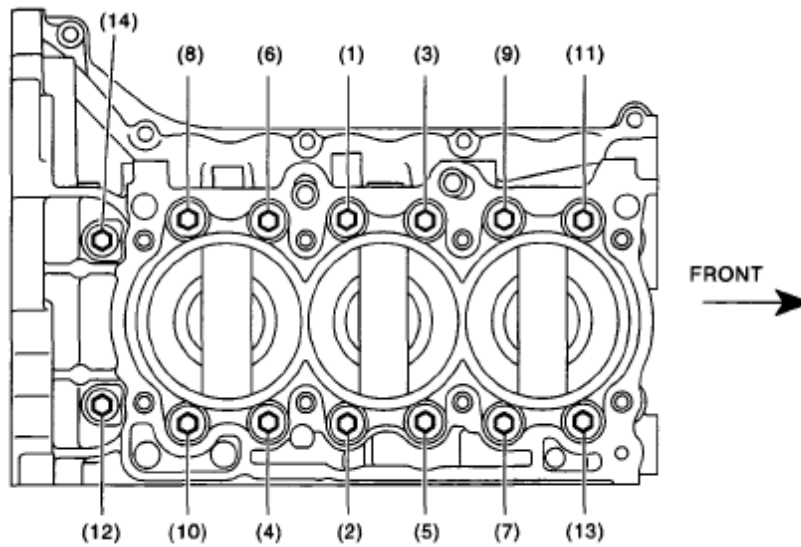
18 N.m (1.8 kgf-m, 13.3 ft-lb)



ME-03432

Fig. 246: Identifying Cylinder Block Tightening Sequence
Courtesy of SUBARU OF AMERICA, INC.

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



ME-03432

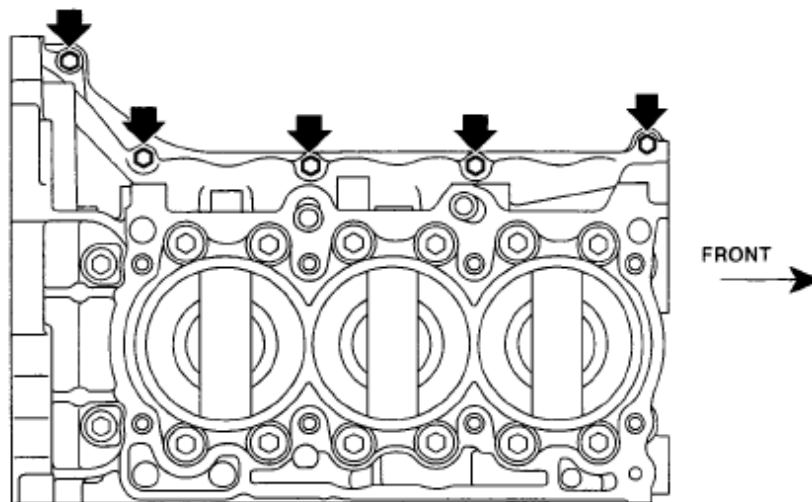
Fig. 247: Identifying Cylinder Block Tightening Sequence
Courtesy of SUBARU OF AMERICA, INC.

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.



ME-03433

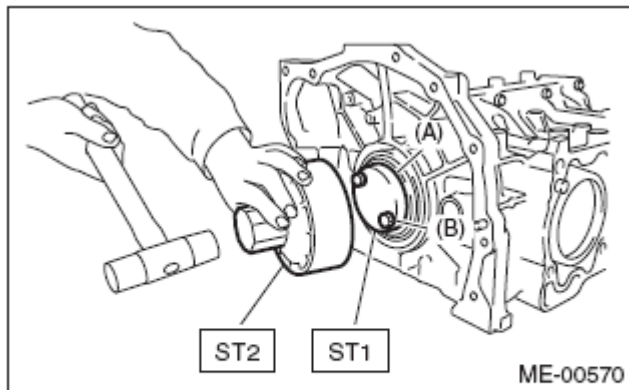
Fig. 248: Locating Cylinder Block Upper Mounting Bolts
Courtesy of SUBARU OF AMERICA, INC.

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

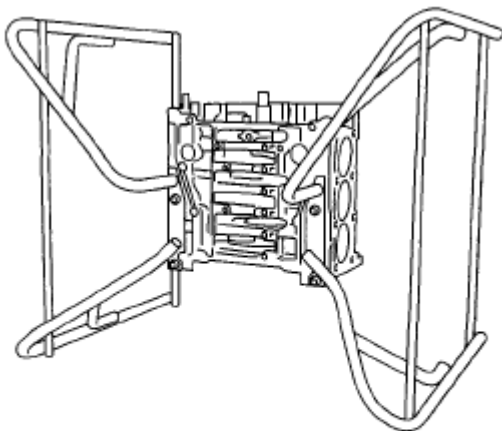


(A) Rear oil seal

(B) Drive plate installation bolt

Fig. 249: 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.

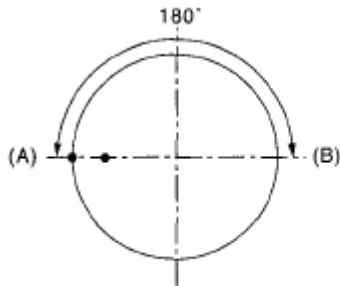


ME-03421

Fig. 250: Identifying Engine Placed On Stand

Courtesy of SUBARU OF AMERICA, INC.

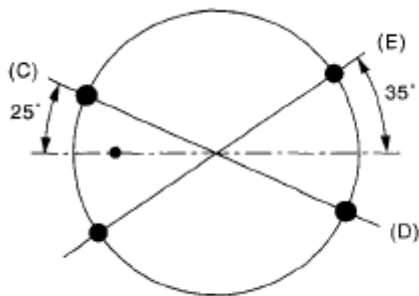
12. Attach the piston ring and oil ring to the piston.
 1. Position the top ring gap at (A) in the figure.
 2. Position the second ring gap at (B).



ME-02066

Fig. 251: Identifying 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. 252: Identifying Expander, Lower And Upper 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.

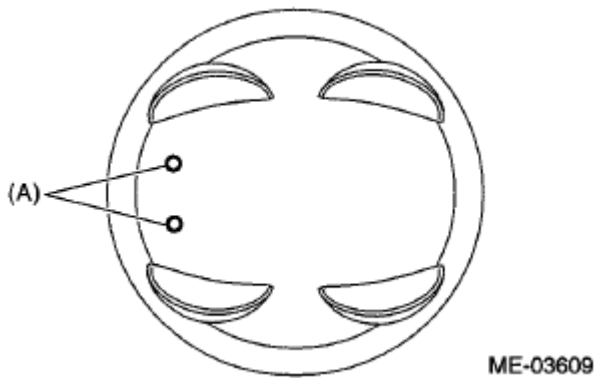


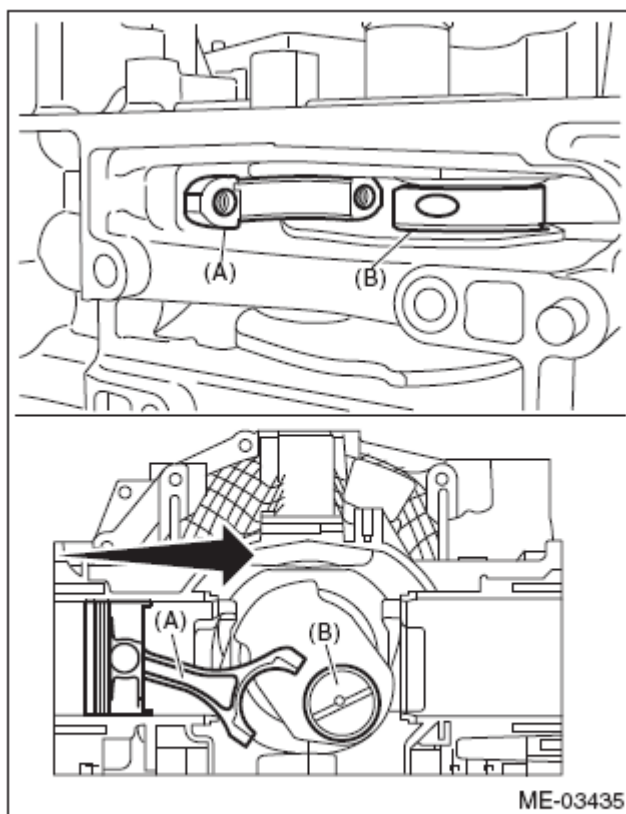
Fig. 253: Identifying Front Mark Of Piston
Courtesy of SUBARU OF AMERICA, INC.

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. 254: Identifying No. 1 Connecting Rod And Crank Pin
Courtesy of SUBARU OF AMERICA, INC.

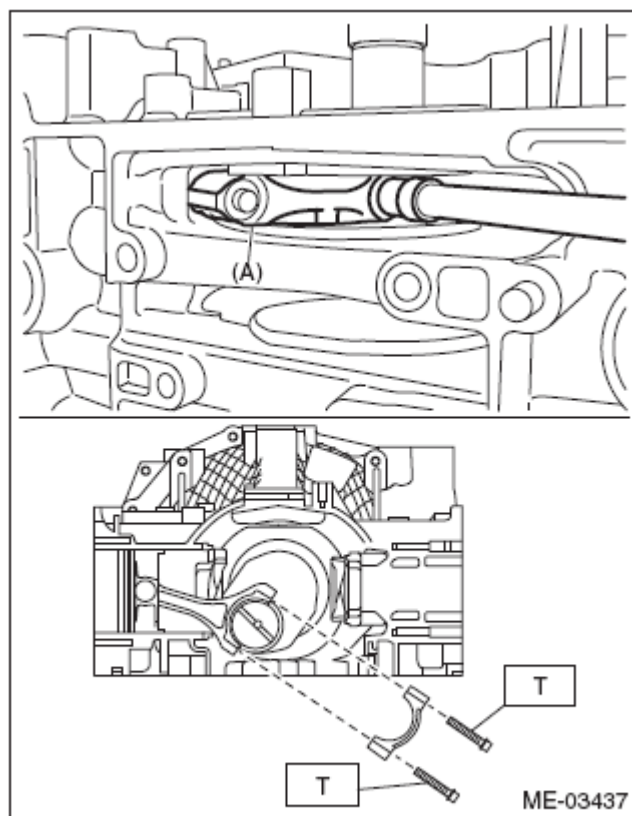
4. Using the ST, turn the crankshaft and match the positions of the crank pin and the large end of the connecting rod.

ST 18252AA000 CRANKSHAFT SOCKET

5. Install the connecting rod cap.

Tightening torque:

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

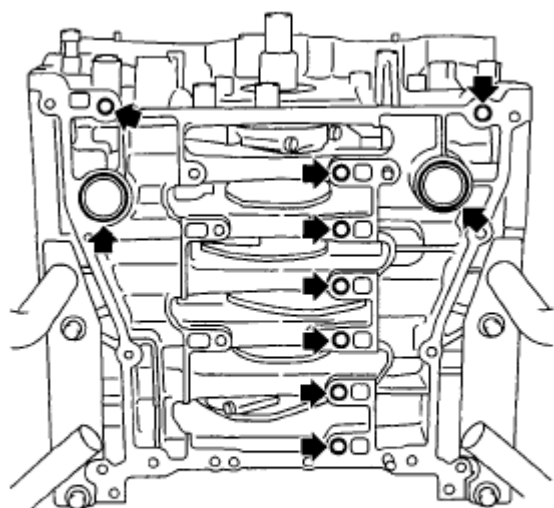


(A) #1 connecting rod

Fig. 255: Identifying Connecting Rod Cap Mounting Bolts With Tightening Torques
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. 256: Locating 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.

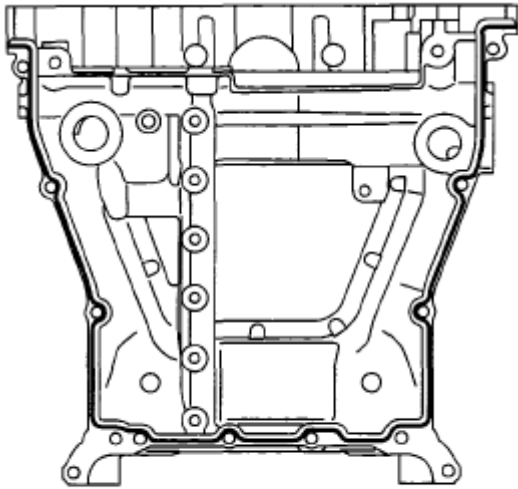
NOTE: Install within 5 min. after applying liquid gasket.

Liquid gasket:

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

Liquid gasket applying diameter:

5.0±1.0 mm (0.20±0.04 in)



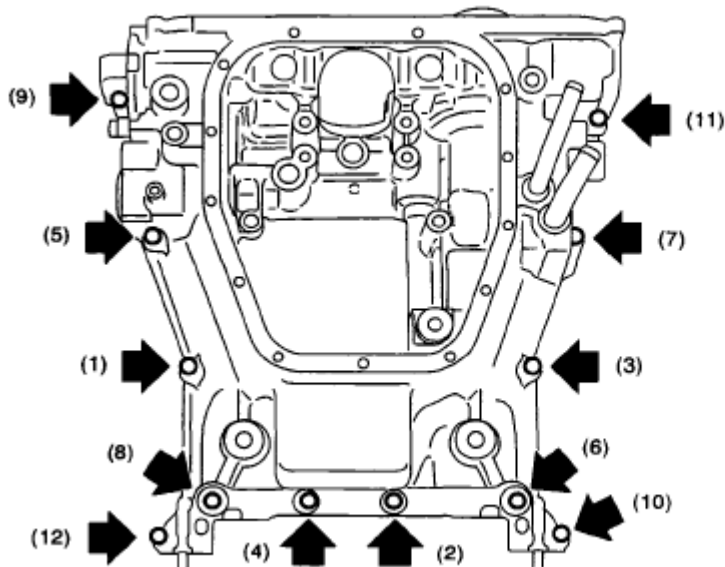
ME-03438

Fig. 257: 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)



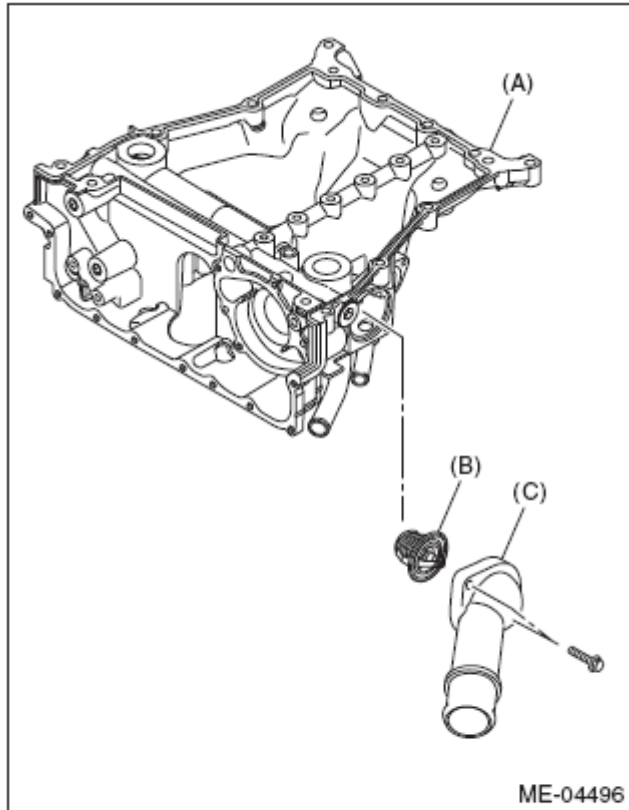
ME-03440

Fig. 258: Identifying Oil Pan Upper Mounting 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

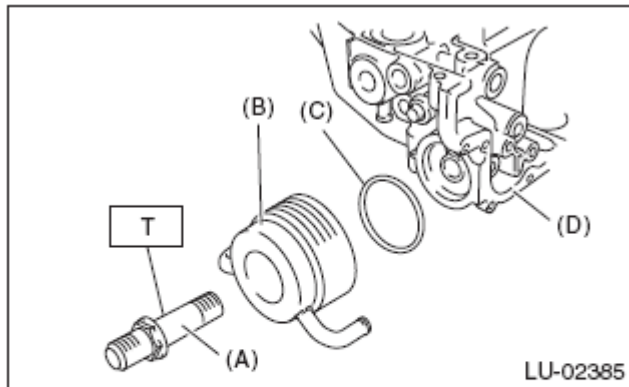
Fig. 259: Identifying Oil Pan Upper, Thermostat And Cover
Courtesy of SUBARU OF AMERICA, INC.

20. Install the oil level switch. Refer to **INSTALLATION** .
21. Install the oil pump. Refer to **INSTALLATION** .
22. 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. 260: Identifying Oil Cooler And Connector, O-Ring And Oil Pan Upper
Courtesy of SUBARU OF AMERICA, INC.

23. 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)

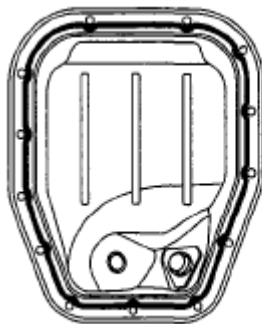


Fig. 261: Identifying Liquid Gasket Applying Areas On Matching Surface Of Oil Pan Lower
Courtesy of SUBARU OF AMERICA, INC.

24. 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)

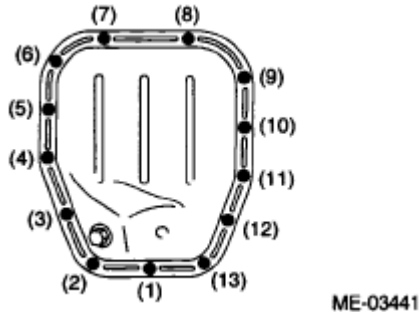


Fig. 262: Identifying Oil Pan Lower Installing Bolts Tightening Sequence
 Courtesy of SUBARU OF AMERICA, INC.

25. Install the crankshaft position sensor plate.

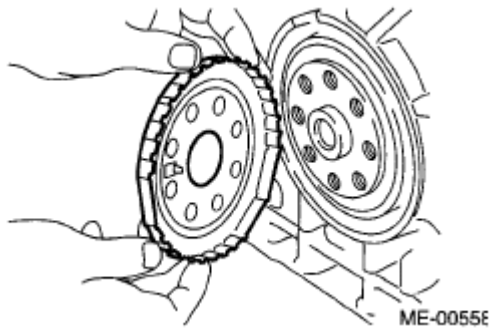


Fig. 263: Removing/Installing Crankshaft Position Sensor Plate
 Courtesy of SUBARU OF AMERICA, INC.

26. Install the crankshaft position sensor.

Tightening torque:

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

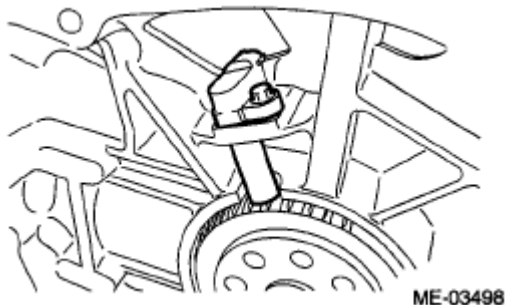
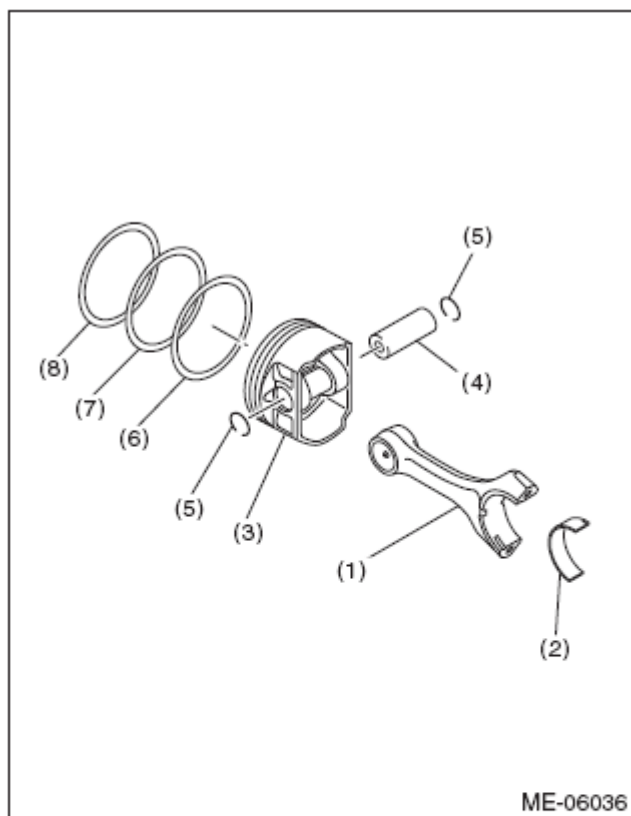


Fig. 264: Identifying Crankshaft Position Sensor
Courtesy of SUBARU OF AMERICA, INC.

27. Install the drive plate. Refer to INSTALLATION .
28. Install the cylinder head. Refer to INSTALLATION.
29. Install the camshaft. Refer to INSTALLATION.
30. Install the crank sprocket. Refer to INSTALLATION.
31. Install the cam sprocket. Refer to INSTALLATION.
32. Install the timing chain assembly. Refer to INSTALLATION.
33. Install the chain cover. Refer to INSTALLATION.
34. Install the crank pulley. Refer to INSTALLATION.
35. Install the engine to the vehicle. Refer to INSTALLATION.

DISASSEMBLY



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

Fig. 265: Identifying Connecting Rod 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.

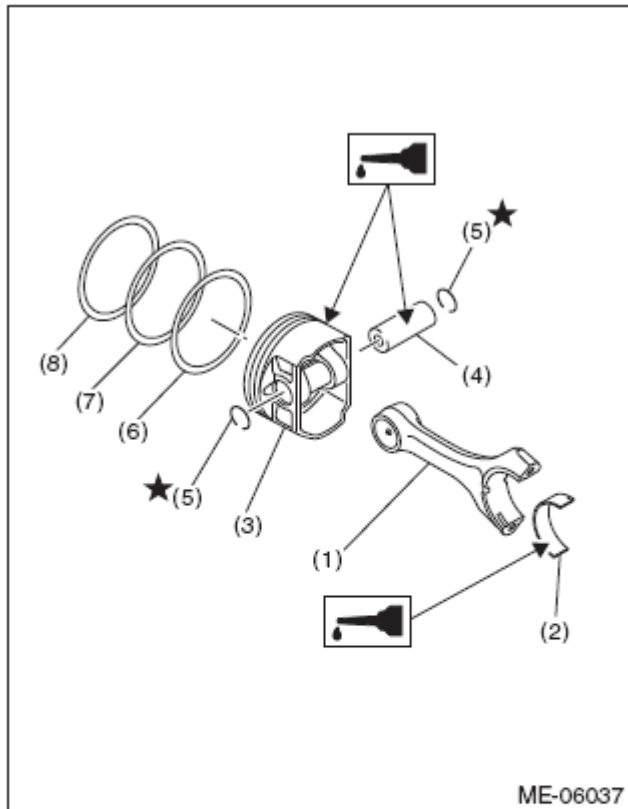
NOTE: Mark the direction of front side to each connecting rod.

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**.

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. 266: Identifying Connecting Rod 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.

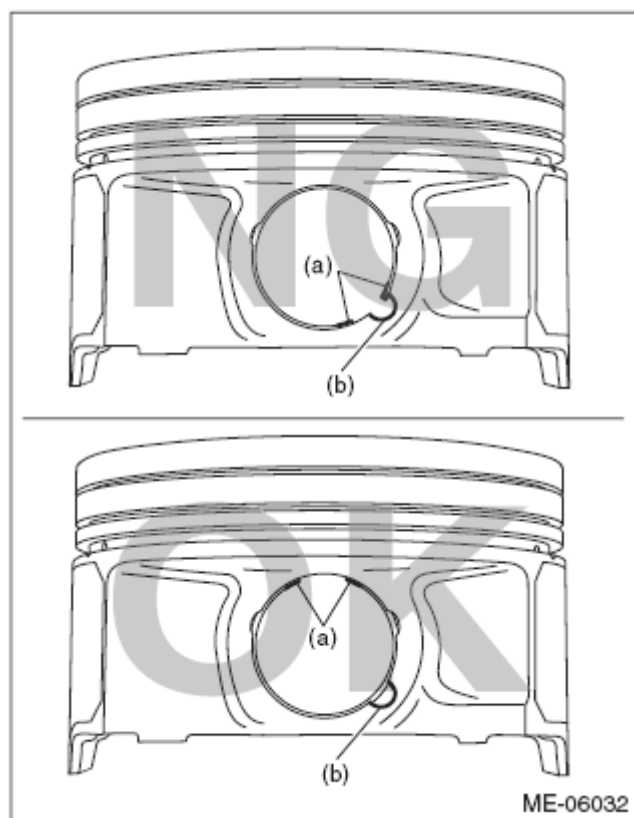
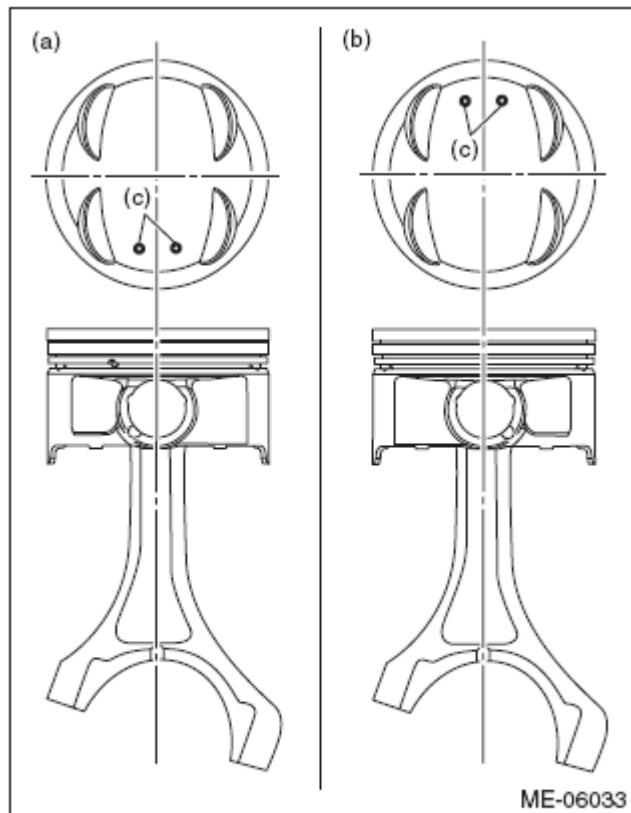


Fig. 267: Rotating Circlip So That Its End Part And Cutout Portion Of Circlip Groove Do Not Match

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. 268: Identifying Aligning Mark On Piston And Connecting Rod (RH And LH Side)
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.

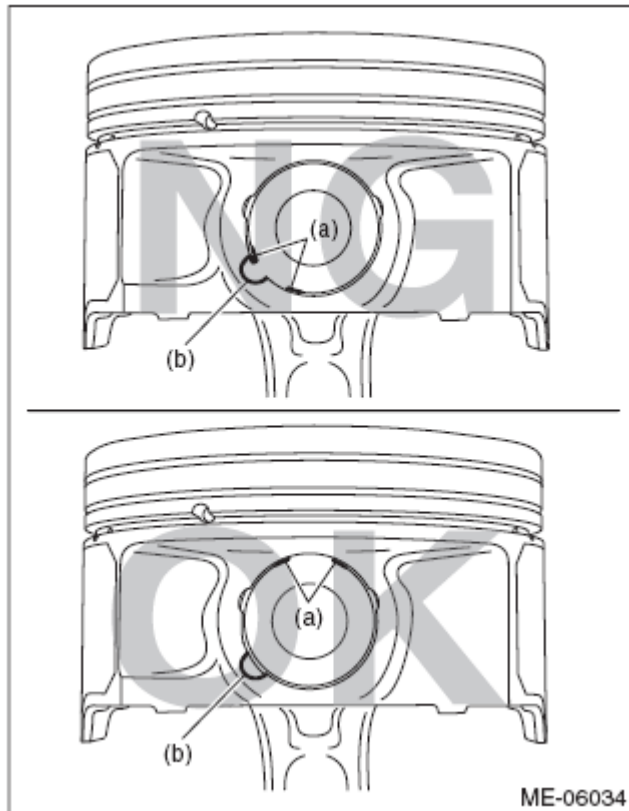


Fig. 269: Rotating Circlip So That Its End Part And Cutout Portion Of Circlip Groove Do Not Match

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**.

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.

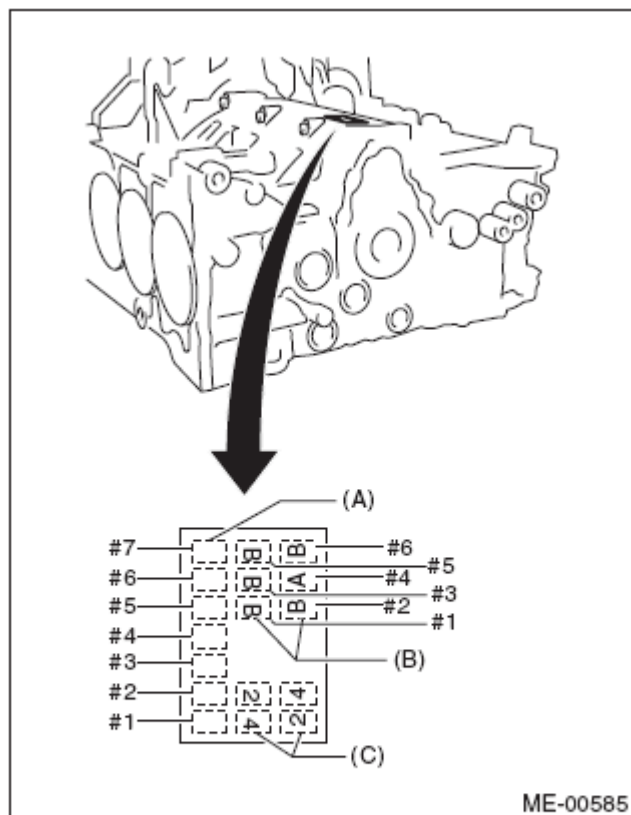
NOTE:

- 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. 270: Identifying Main Journal And Cylinder Bore Size Mark And Cylinder Block (RH) - (LH) 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:

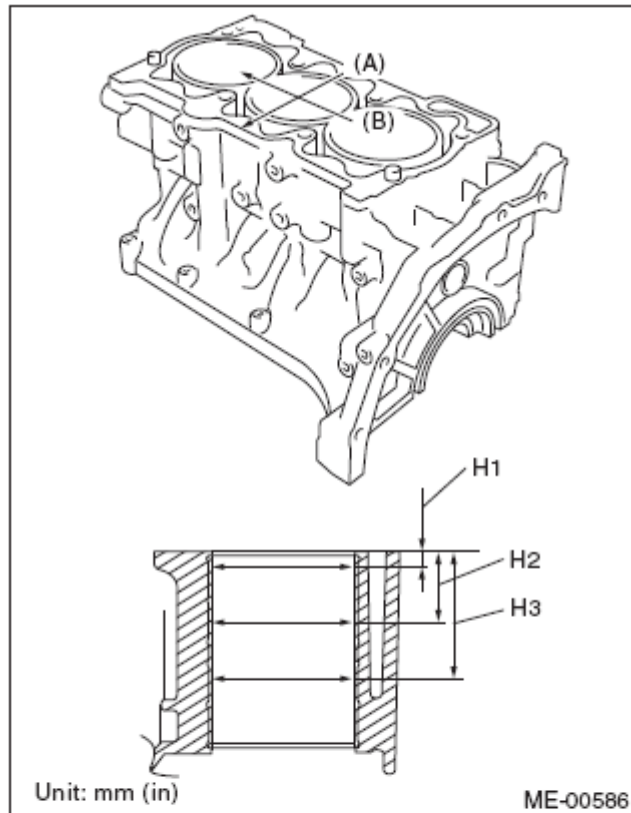
Limit

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. 271: Measuring Inner Diameter Of Each Cylinder In Both Thrust And Piston Pin Directions At Heights

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)

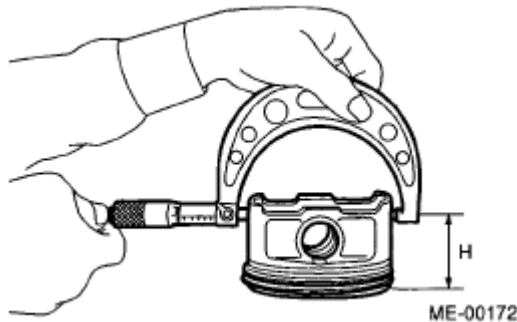


Fig. 272: Measuring Outer Diameter Of Each Piston At Height
Courtesy of SUBARU OF AMERICA, INC.

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:

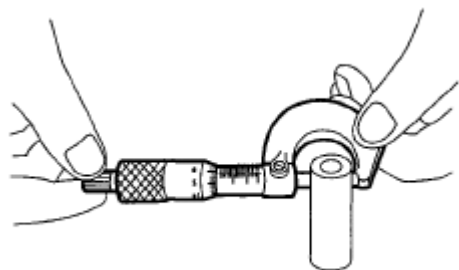
Standard

0.004 - 0.008 mm (0.0002 - 0.0003 in)



ME-00173

Fig. 273: Measuring Cylinder Inner Diameter Boring Limit
 Courtesy of SUBARU OF AMERICA, INC.

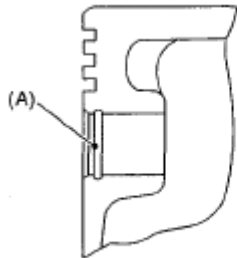


ME-00174

Fig. 274: Measuring Clearance Between Piston Pin Hole And Piston Pin

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

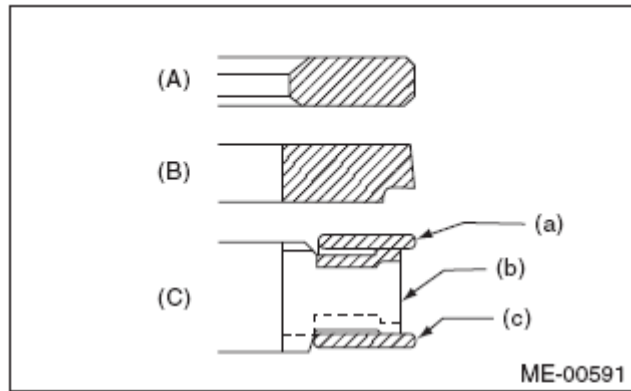
5. Check the piston pin snap ring for distortion, cracks and wear.

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. 276: Identifying Top, Second And Oil Ring, Upper And Lower Rail, Expander
 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 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)

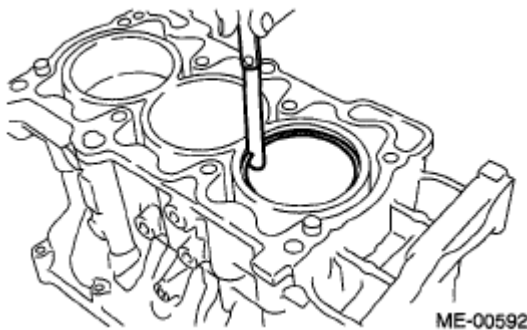


Fig. 277: Measuring Piston Ring Gap Using Thickness Gauge
 Courtesy of SUBARU OF AMERICA, INC.

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 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)

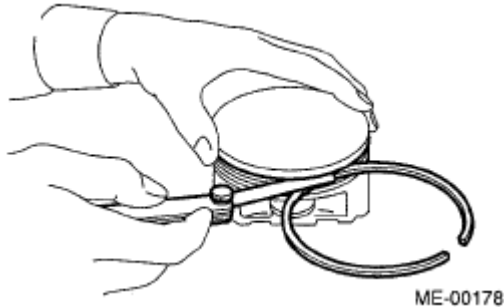


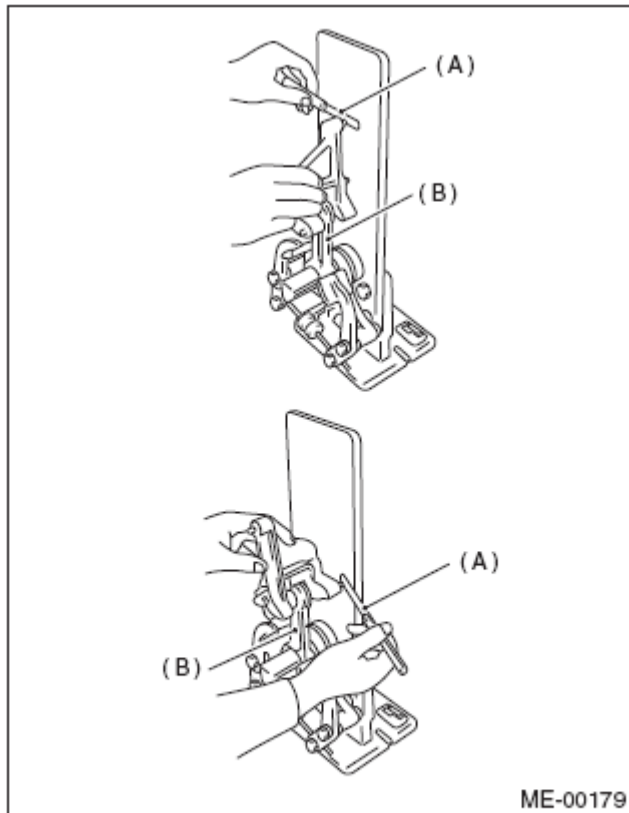
Fig. 278: Measuring Clearance Between Piston Ring And Groove Using Thickness Gauge
Courtesy of SUBARU OF AMERICA, INC.

CONNECTING ROD

1. Replace the connecting rod, if the large or small 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. 279: Checking Bend Or Twist Using Connecting Rod 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)

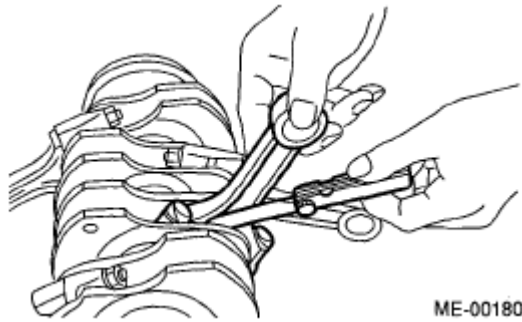


Fig. 280: Measuring Connecting Rod Thrust Clearance Using Thickness Gauge
Courtesy of SUBARU OF AMERICA, INC.

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)

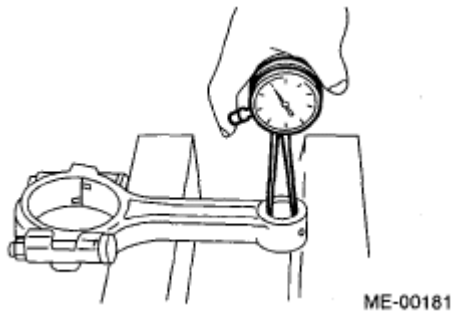


Fig. 281: Measuring Connecting Rod Inner Diameter
Courtesy of SUBARU OF AMERICA, INC.

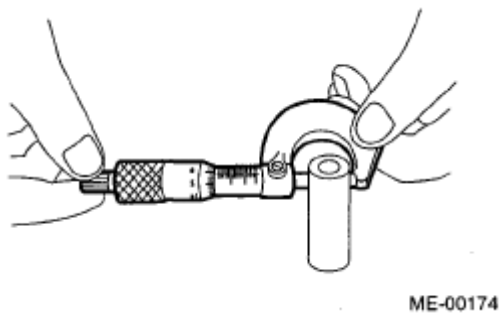


Fig. 282: Measuring Clearance Between Piston Pin And Bushing
Courtesy of SUBARU OF AMERICA, INC.

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

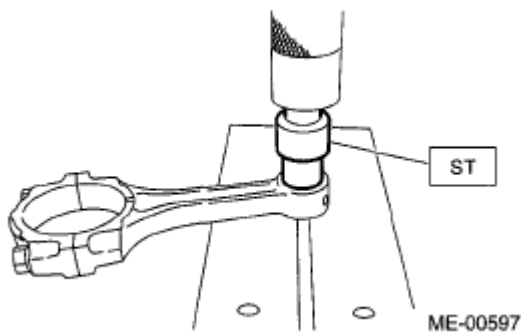


Fig. 283: Pressing Connecting Rod Bushing Using Special Tool
Courtesy of SUBARU OF AMERICA, INC.

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)

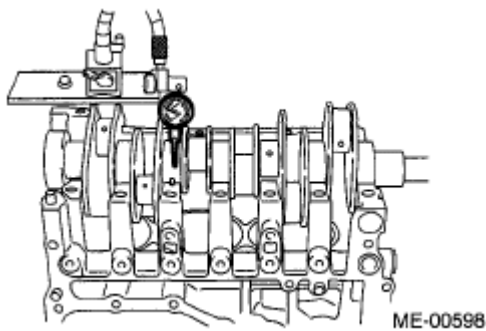


Fig. 284: Measuring Crankshaft Bend Limit Using Dial Gauge
Courtesy of SUBARU OF AMERICA, INC.

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)

Cylindricality

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. 285: Measuring Crank Journal Cylindricity
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 (2.0463 - 2.0472)
	Bearing size (Thickness at center)	1.996 - 2.013 (0.0786 - 0.0793)	1.992 - 2.009 (0.0784 - 0.0791)	1.996 - 2.013 (0.0786 - 0.0793)	1.489 - 1.505 (0.0586 - 0.0593)
0.03 (0.0012) Undersize	Journal O.D.	63.962 - 63.978 (2.5182 - 2.5188)			51.954 - 51.970 (2.0454 - 2.0461)
	Bearing size (Thickness at	2.011 - 2.014 (0.0792 -	2.011 - 2.014 (0.0792 -	2.015 - 2.018 (0.0793 -	1.507 - 1.515

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

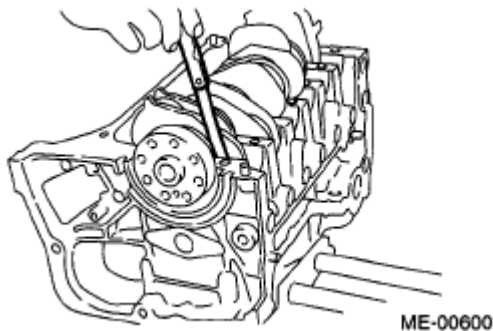


Fig. 286: Measuring Thrust Clearance Of Crankshaft At Center Bearing Using Thickness Gauge
Courtesy of SUBARU OF AMERICA, INC.

- 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

Specifications for the oil flow control solenoid valve are included in the Fuel Injection System article. Refer to **REMOVAL** .

INSTALLATION

Specifications for the oil flow control solenoid valve are included in the Fuel Injection System article. Refer to **INSTALLATION** .

INTAKE AND EXHAUST VALVE

SPECIFICATION

Refer to **REMOVAL** and **INSTALLATION** for removal and installation procedures of the intake and exhaust valves.

PISTON

SPECIFICATION

Refer to **REMOVAL** and **INSTALLATION** for removal and installation procedures of pistons.

CONNECTING ROD

SPECIFICATION

Refer to **REMOVAL** and **INSTALLATION** for removal and installation procedures of connecting rods.

CRANKSHAFT

SPECIFICATION

Refer to **REMOVAL** and **INSTALLATION** for removal and installation procedures of the crankshaft.

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

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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 <u>BASIC DIAGNOSTIC PROCEDURE</u> .		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 <u>BASIC DIAGNOSTIC PROCEDURE</u> .		A
	Intake system	Defective intake manifold gasket	B
		Defective throttle body gasket	B
	Fuel line	Defective fuel pump and relay	C
		Clogged fuel line	C
		Lack of fuel or insufficient fuel	B

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3) Initial combustion occurs.	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 <u>BASIC DIAGNOSTIC PROCEDURE</u> .		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 <u>BASIC DIAGNOSTIC PROCEDURE</u> .		A
		Loosened or cracked intake duct	A
		Loosened or cracked PCV hose	A
		Loosened or cracked vacuum hose	A
		Defective intake manifold gasket	B

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2. Rough idle and engine stall	Intake system	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
3. Low output, hesitation and poor acceleration	Engine control system Refer to <u>BASIC DIAGNOSTIC PROCEDURE</u> .		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
		Loosened spark plug or defective gasket	B
		Loosened cylinder head bolt or defective	

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	Compression	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 <u>BASIC DIAGNOSTIC PROCEDURE</u> .		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
	Others	Evaporative emission control system malfunction	C

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5. Engine does not return to idle.	Engine control system Refer to <u>BASIC DIAGNOSTIC PROCEDURE</u> .		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 <u>BASIC DIAGNOSTIC PROCEDURE</u> .		A
	Cooling system	Over-heating	B
	Others	Evaporative emission control system malfunction	B
7. After burning in exhaust system	Engine control system Refer to <u>BASIC DIAGNOSTIC PROCEDURE</u> .		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 <u>BASIC DIAGNOSTIC PROCEDURE</u> .		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
		Loosened oil filler cap	C

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9. Excessive engine oil consumption	Compression	Defective valve stem	A
		Worn or stuck piston rings, cylinder and piston	A
	Lubrication system	Loosened oil pump attaching bolts and defective gasket	B
		Defective oil filter 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 <u>BASIC DIAGNOSTIC PROCEDURE</u> .		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.	- Valve mechanism is defective. - Incorrect valve clearance - Worn camshaft - Broken valve spring - Trouble of valve lifter
		Worn camshaft main bearing

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Heavy and dull clank	Oil pressure is low.	Worn connecting rod bearing (large end)
	Oil pressure is normal.	Damaged front mount
High-pitched clank	Sound is noticeable when accelerating with an overload condition.	- Ignition timing advanced - Accumulation of carbon inside combustion chamber - Wrong heat range of spark plug - Improper octane value gasoline
Clank when engine speed is between 1, 000 and 2, 000 rpm.	Noise is reduced when fuel injector connector of noisy cylinder is disconnected. ⁽¹⁾	- Worn crankshaft main bearing - Worn connecting rod bearing (large end)
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. ⁽¹⁾	- Worn cylinder liner and piston ring - Broken or stuck piston ring - Worn piston pin and hole at piston end of connecting rod
	Sound is not reduced if each fuel injector connector is disconnected in turn. ⁽¹⁾	- Unusually worn valve lifter - Worn cam gear - Worn camshaft journal bore in cylinder head
Squeaky sound	-	Insufficient generator lubrication
Rubbing sound	-	Poor contact of generator brush and rotor
Gear scream when starting engine	-	- Defective ignition starter switch - Worn gear and starter pinion
Sound like polishing glass with a dry cloth	-	- V-belt - Defective water pump shaft
Hissing sound	-	- Insufficient compression - Air leakage in air intake system, hose, connection or manifold
Timing chain noise	-	- Loose timing chain - Timing chain contacting with adjacent part
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** and **PROCEDURE** .