2009 ENGINE

Mechanical (H6DO) - Tribeca

GENERAL DESCRIPTION

SPECIFICATION

ENGINE SPECIFICATION

Engine	Cylinder arrangement			Horizontally opposed, liquid cooled, 6-cylinder, 4-stroke gasoline engine
	Valve system mechanism			Chain driven, double overhead camshaft, 4-valve/cylinder
	Inside diameter x stroke mm (in)			92 x 91 (3.622 x 3.583)
	Displacement cm^3 (cu in)			3,630 (222)
	Compression ratio			10.5
	Compression pressure (350 rpm and fully open throttle): kPa (kgf/cm^2 psi)			1,275 - 1,471 (13.0 - 15.0,185 - 213)
	Number of piston rings			Pressure ring: 2, Oil ring: 1
	Intake valve timing	Min. advance	Open	BTDC 40°
			Close	ABDC 24°
		Max. retard	Open	ATDC 10°
			Close	ABDC 74°
	Exhaust valve timing	Min. advance	Open	BBDC 44°
			Close	ATDC 4°
		Max. retard	Open	BBDC 4°
			Close	ATDC 44°
	Valve clearance mm (in)	Intake		$0.20^{+0.04}_{-0.06}$ ($0.0079^{+00016}_{-0.0024}$)
		Exhaust		0.35±0.05 (0.0138±0.0020)
	Idle rpm ["P" or "N" range] rpm		No load	700±100
			A/C ON	805±100
	Ignition order			1 --> 6 --> 3 --> 2 --> 5 --> 4
	Ignition timing BTDC/rpm			15° ±8°/700
Camshaft	Bending limit mm (in)			0.020 (0.00079)
	Thrust clearance mm (in)	Intake	Standard	0.075 - 0.135 (0.0030 - 0.0053)
		Exhaust	Standard	0.075 - 0.135 (0.0030 - 0.0053)
	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 mm	Intake	Standard	36.00(1.4173)

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	diameter (in)	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)
Cylinder Head	Surface warping limit (mating with cylinder block) mm (in)				Standard	0.02 (0.0008)
	Inner diameter of valve lifter hole mm (in)					32.994 - 33.016 (1.2990 - 1.2998)
	Standard height mm (in)					124±0.05 (4.88±0.0020)
Valve seat	Seating angle					90°
	Contacting width mm (in)	Intake			Standard	1.0(0.039)
		Exhaust			Standard	1.5 (0.059)
Valve guide	Inside diameter mm (in)				Standard	5.500 - 5.512 (0.2165 - 0.2170)
	Protrusion above head	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)
	Stem outer diameter mm (in)	Intake				5.455 - 5.470 (0.2148 - 0.2154)
		Exhaust				5.445 - 5.460 (0.2144 - 0.2150)
	Stem oil clearance mm (in)	Intake			Standard	0.030 - 0.057 (0.0012 - 0.0022)
		Exhaust			Standard	0.040 - 0.067 (0.0016 - 0.0026)
	Overall length mm (in)	Intake				103.5(4.075)
		Exhaust				103.2(4.063)
	Outer diameter of valve lifter mm (in)				Standard	32.959 - 32.975 (1.2976 - 1.2982)
Valve spring	Free length mm (in)	Intake				41.51 (1.6342)
		Exhaust				41.51 (1.6342)
	Squareness	Intake				2.5°, 1.8 mm (0.071 in)
		Exhaust				2.5°, 1.8 mm (0.071 in)
Cylinder block	Standard height mm (in)					202 (7.95)
	Surface warping limit (Mating surface with cylinder head) mm (in)				Standard	0.02 (0.0008)
	Cylinder inner diameter mm (in)	Standard		A		92.005 - 92.015 (3.6222 - 3.6226)
				B		91.995 - 92.005 (3.6218 - 3.6222)
	Cylindricity mm (in)				Standard	0.030(0.0012)
	Out-of-roundness mm (in)				Standard	0.010(0.0004)
	Piston clearance mm (in)				Standard	-0.010 - 0.010 (-0.0004 - 0.0004)
Piston	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)
	Outer diameter mm (in)				Standard	21.994 - 22.000 (0.8659 - 0.8661)

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Piston pin	Standard clearance between piston and piston pin		mm (in)	Standard	0.004 - 0.008 (0.0002 - 0.0003)
Piston ring	Ring closed gap mm (in)	Top ring		Standard	0.20 - 0.25 (0.0079 - 0.0098)
		Second ring		Standard	0.40 - 0.50 (0.0157 - 0.0197)
		Oil ring		Standard	0.20 - 0.50 (0.0079 - 0.0197)
	Ring groove gap 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	Thrust clearance		mm (in)	Standard	0.070 - 0.330 (0.0028 - 0.0130)
Bearing of large end	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)
Crankshaft	Crank pin and crank journal	Out-of-roundness		mm (in)	0.005 (0.0002)
		Cylindricity		mm (in)	0.006 (0.0002)
	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)
	Crank journal outer diameter mm (in)	#1,#3, #5, #7		Standard	63.992 - 64.016 (2.5194 - 2.5203)
				0.03 (0.0012) US	63.962 - 63.978 (2.5182 - 2.5188)
				0.05 (0.0020) US	63.942 - 63.958 (2.5174 - 2.5180)
				0.25 (0.0098) US	63.742 - 63.758 (2.5095 - 2.5102)
		#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)
	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)
Main bearing	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)
		#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)
				Standard	1.992 - 2.009 (0.0784 - 0.0791)

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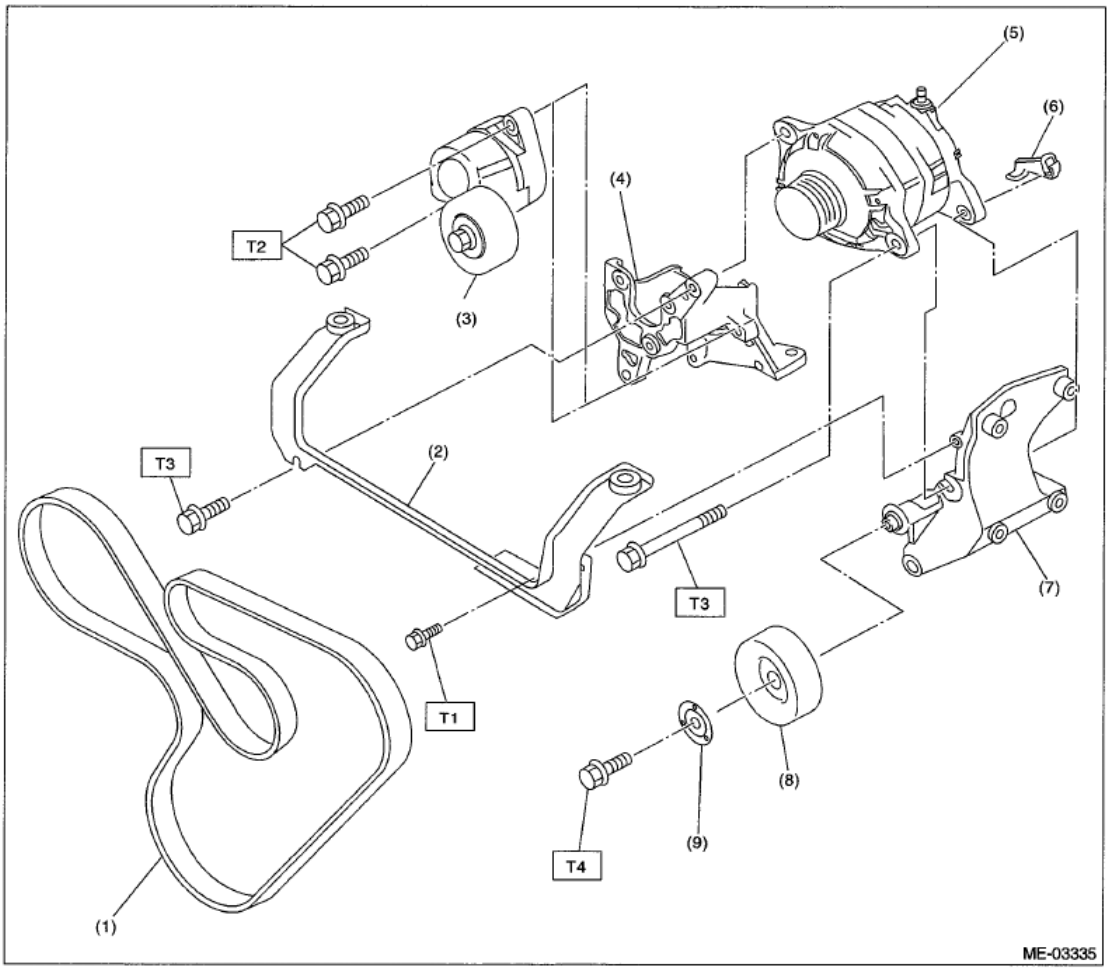
		#7	0.03 (0.0012) US	2.011 - 2.014 (0.0792 - 0.0793)
			0.05 (0.0020) US	2.021 - 2.024 (0.0796 - 0.0797)
			0.25 (0.0098) US	2.121 - 2.124 (0.0835 - 0.0836)

NOTE:
OS: Oversize
US: Undersize

COMPONENT

V-BELT



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

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

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

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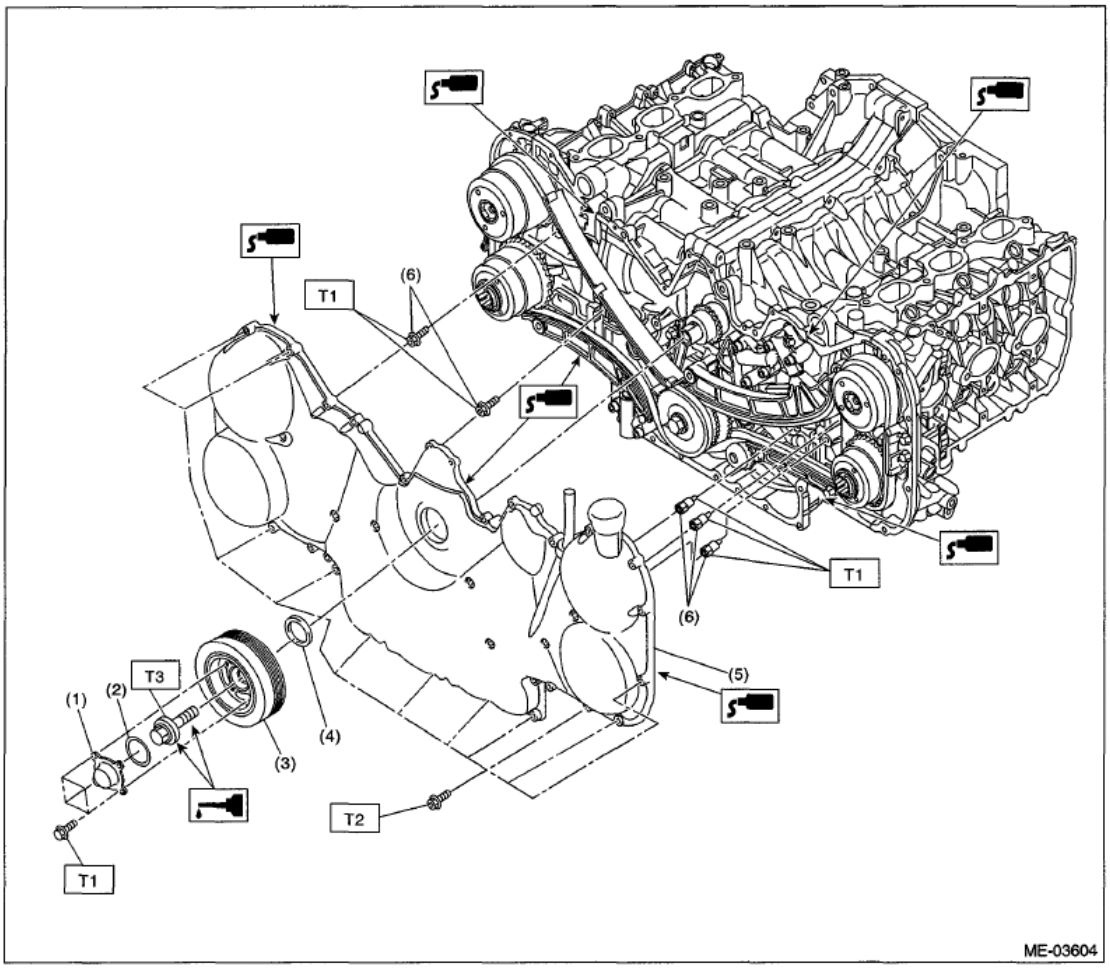
T1: 6.4(0.7,4.7)

T2: 20(2.0,14.8)

T3: 25 (2.5, 18.4)

T4: 33(3.4,24.3)

TIMING CHAIN COVER



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

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

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

T1: 6.4 (0.7, 4.7)

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T2: 10(1.0,7.4)

T3: 195(19.9, 143.8)

TIMING CHAIN

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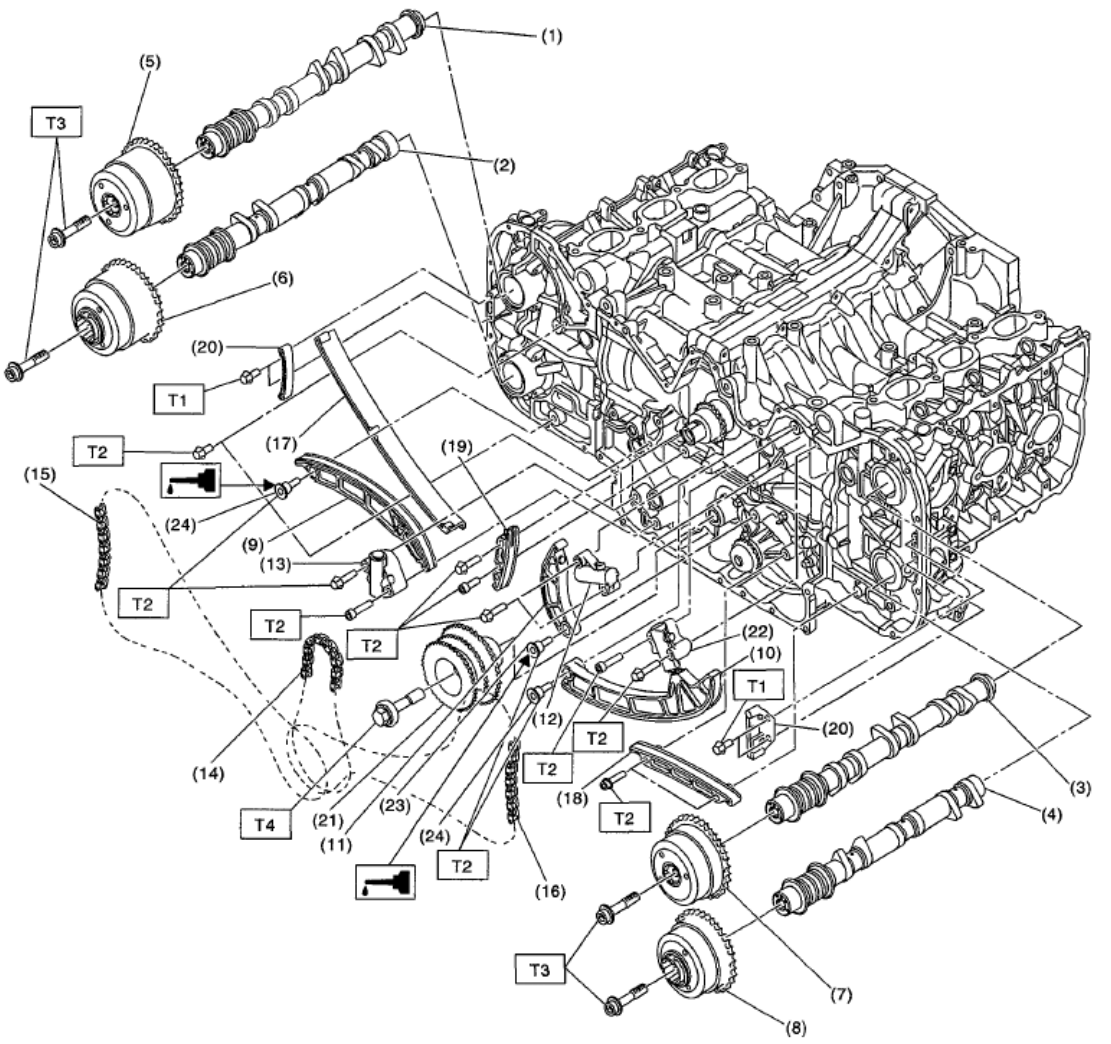

(1) Intake camshaft (RH)
(2) Exhaust camshaft (RH)
(3) Intake camshaft (LH)
(4) Exhaust camshaft (LH)
(5) Intake camshaft sprocket (RH)
(6) Exhaust camshaft sprocket (RH)
(7) Intake camshaft sprocket (LH)
(8) Exhaust camshaft sprocket (LH)
(9) Chain tensioner lever (RH)
(10) Chain tensioner lever (LH)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

Fig. 3: Identifying Timing Chain Components
Courtesy of SUBARU OF AMERICA, INC.

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

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T1: 6.4(0.7,4.7)

T2: 16(1.6,11.8)

T3: Ref. to **CAM SPROCKET**.

T4: 120(12.2,88.5)

CYLINDER HEAD AND CAMSHAFT

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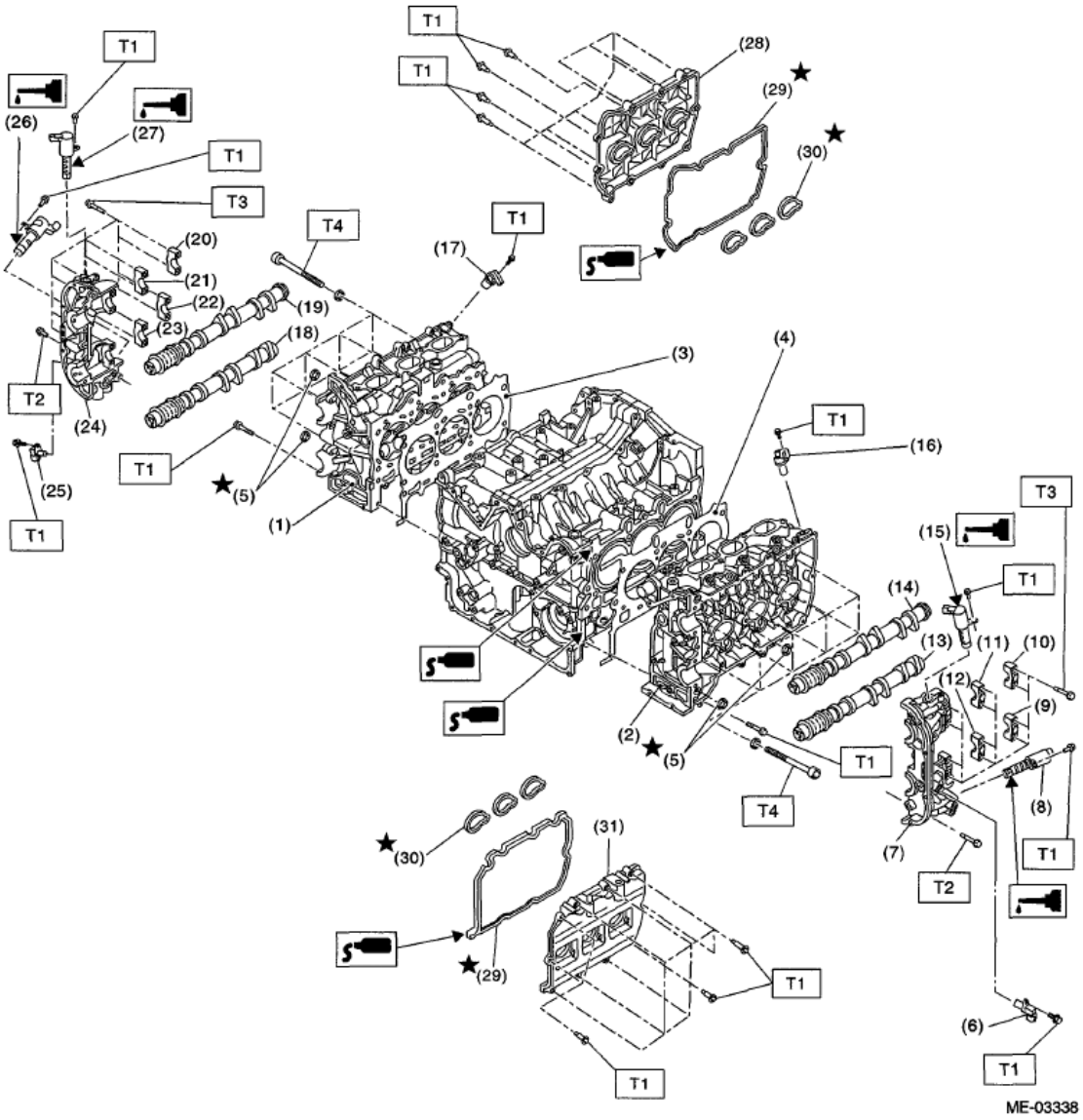

(1) Cylinder head (RH)
(2) Cylinder head (LH)
(3) Cylinder head gasket (RH)
(4) Cylinder head gasket (LH)
(5) O-ring
(6) Exhaust camshaft position sensor (LH)
(7) Front camshaft cap (LH)
(8) Exhaust oil flow control solenoid valve (LH)
(9) Exhaust camshaft cap (Rear LH)
(10) Intake camshaft cap (Rear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

Fig. 4: Identifying Cylinder Head And Camshaft Components

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Courtesy of SUBARU OF AMERICA, INC.

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

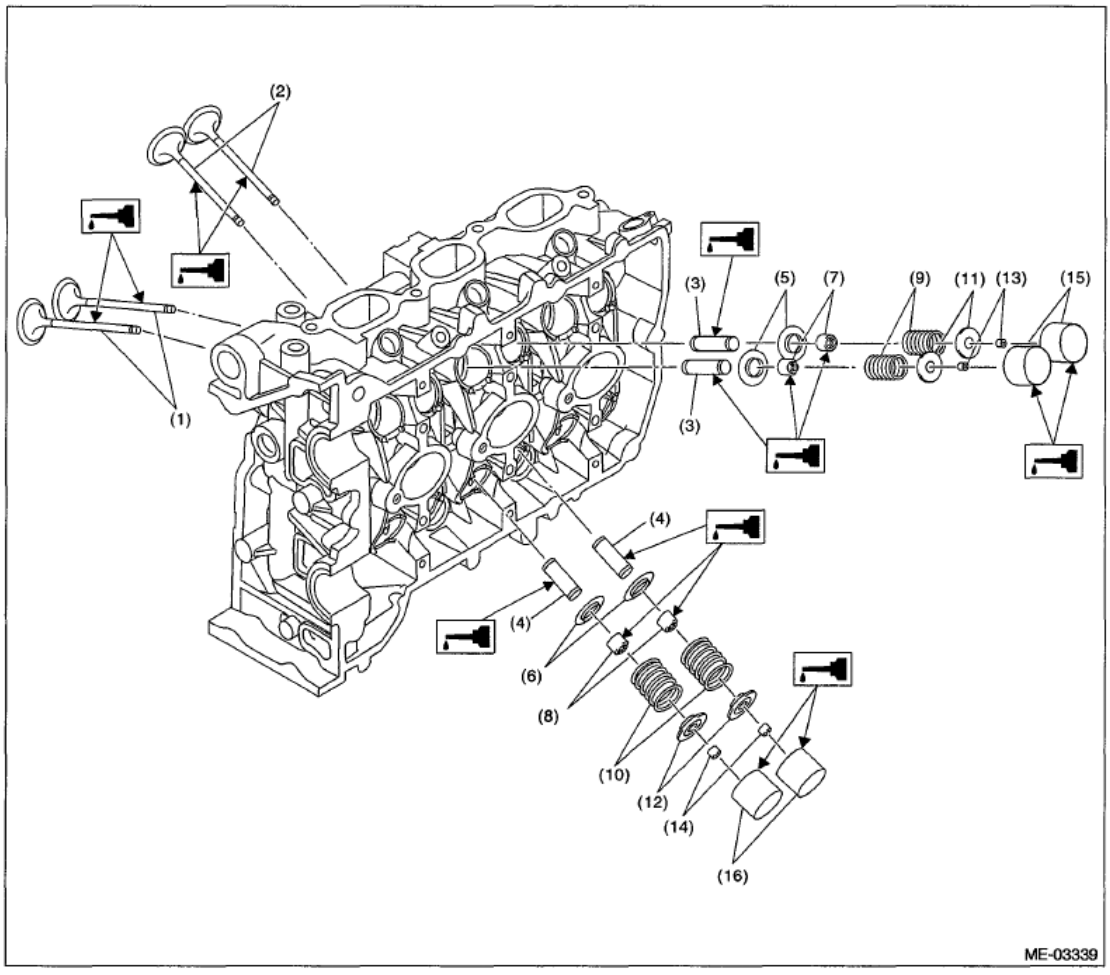
T1: 6.4(0.7,4.7)

T2: 9.75(1.0,7.2)

T3: 16(1.6,11.8)

T4: Ref. to **CYLINDER HEAD**.

CYLINDER HEAD AND VALVE ASSEMBLY



(1) Exhaust valve
(2) Intake valve
(3) Valve guide (Intake)
(4) Valve guide (Exhaust)
(5) Valve spring seat (Intake)
(6) Valve spring seat (Exhaust)
(7) Stem seal (Intake)
(8) Stem seal (Exhaust)
(9) Valve spring (Intake)
(10) Valve spring (Exhaust)
(11) Valve spring retainer (Intake)
(12) Valve spring retainer (Exhaust)
(13) Valve collet (Intake)
(14) Valve collet (Exhaust)
(15) Valve lifter (Intake)
(16) Valve lifter (Exhaust)

Fig. 5: Identifying Cylinder Head And Valve Assembly

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Courtesy of SUBARU OF AMERICA, INC.

CYLINDER BLOCK

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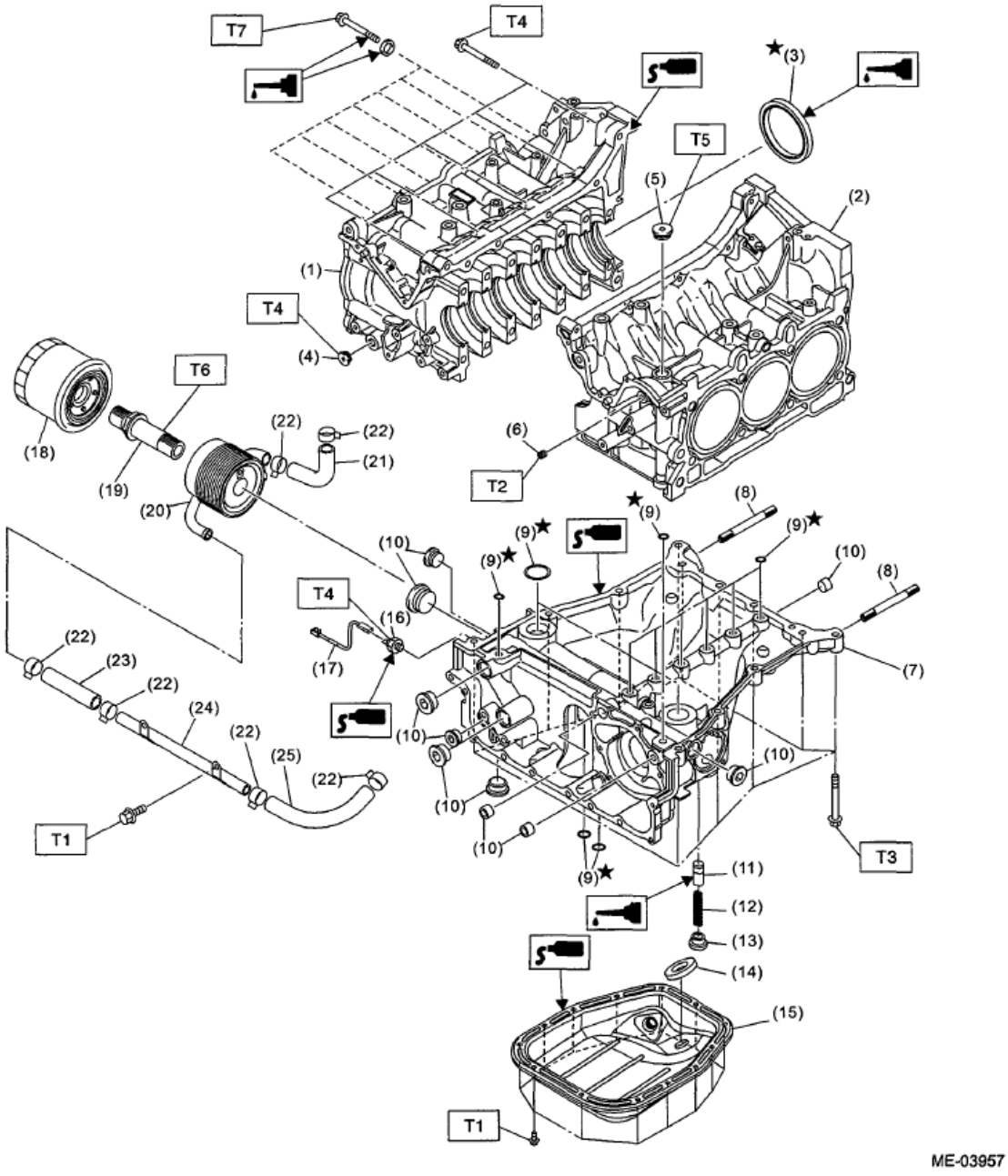

(1) Cylinder block (RH)
(2) Cylinder block (LH)
(3) Oil seal
(4) Plug
(5) Plug
(6) Orifice
(7) Oil pan upper
(8) Stud bolt
(9) O-ring
(10) Plug
(11) Relief valve
(12) Relief valve spring
(13) Relief plug
(14) Magnet
(15) Oil pan lower
(16) Oil pressure switch
(17) Oil pressure switch harness
(18) Oil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

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Fig. 6: Identifying Cylinder Block Components
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: , Ref. to **CYLINDER BLOCK**.

CRANKSHAFT AND PISTON

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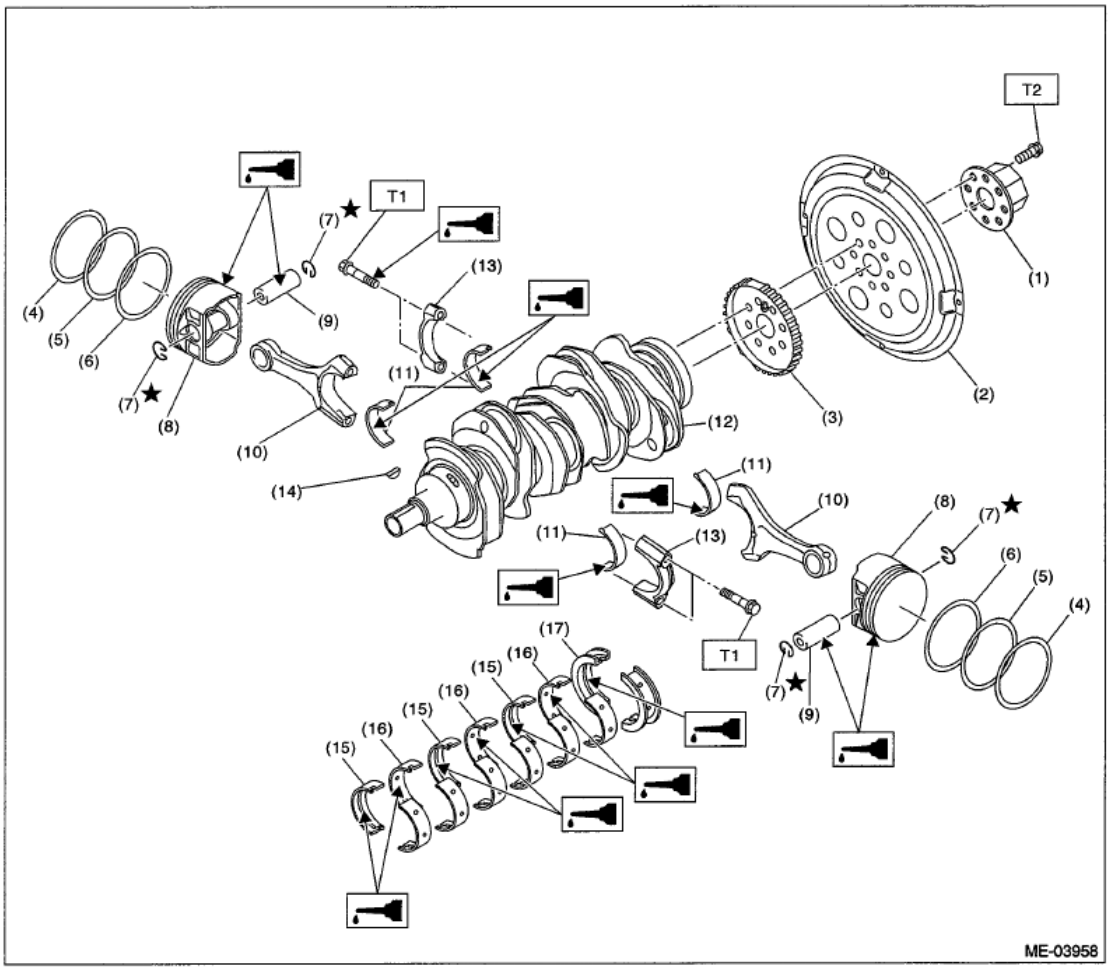

(1)	Reinforcement	(8)	Piston	(15)	Crankshaft bearing #1, #3, #5
(2)	Drive plate	(9)	Piston pin	(16)	Crankshaft bearing #2, #4, #6
(3)	Crankshaft sensor plate	(10)	Connecting rod	(17)	Crankshaft bearing #7
(4)	Top ring	(11)	Connecting rod bearing		
(5)	Second ring	(12)	Crankshaft		
(6)	Oil ring	(13)	Connecting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

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

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

T1: 60(6.1,44.3)

T2: 90(9.2,66.4)

ENGINE HARNESS

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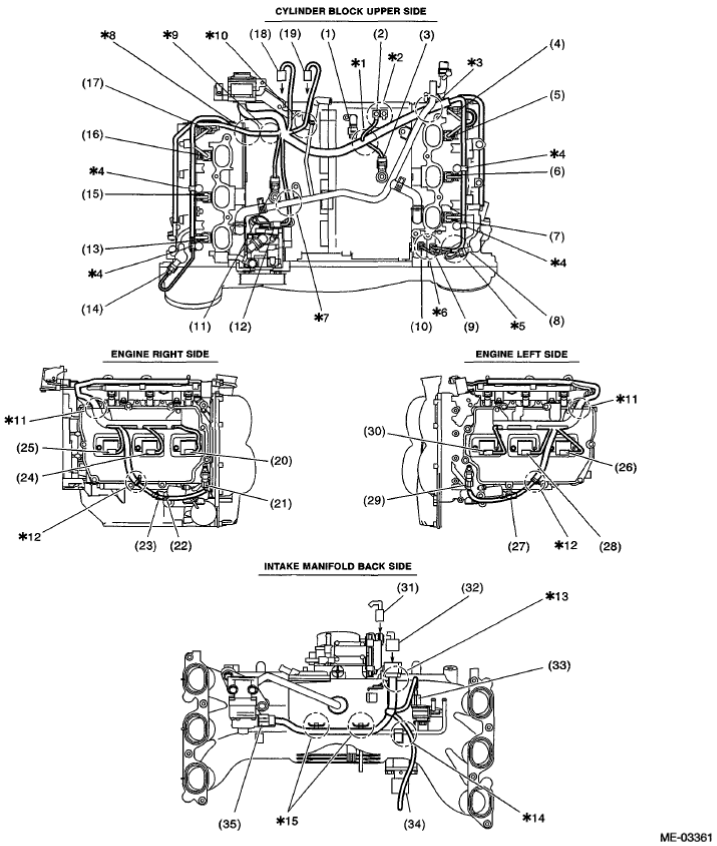

(1)	Crankshaft position sensor connector	(14)	Intake oil flow control solenoid valve RH connector	(25)	#5 ignition coil connector
(2)	Engine ground	(15)	#3 injector connector	(26)	#6 ignition coil connector
(3)	Knock sensor LH connector	(16)	#5 injector connector	(27)	Exhaust oil flow control solenoid valve LH connector
(4)	Intake camshaft position sensor LH connector	(17)	Intake camshaft position sensor RH connector	(28)	#4 ignition coil connector
(5)	#6 injector connector	(18)	Upper and lower joint connector (to intake manifold)	(29)	Exhaust camshaft position sensor LH connector
(6)	#4 injector connector	(19)	Electronic throttle control connector (to intake manifold)	(30)	#2 ignition coil connector
(7)	#2 injector connector	(20)	#1 ignition coil connector	(31)	Electronic throttle control connector (from cylinder block upper part)
(8)	Intake oil flow control solenoid valve LH connector	(21)	Exhaust camshaft position sensor RH	(32)	Upper and lower joint connector (from cylinder block upper part)
(9)	Oil temperature sensor connector	(22)	Oil pressure switch connector	(33)	Purge control solenoid valve connector
(10)	Engine coolant temperature sensor connector	(23)	Exhaust oil flow control solenoid valve RH connector	(34)	Manifold absolute pressure sensor connector
(11)	Knock sensor RH connector	(24)	#3 ignition coil connector	(35)	EGR valve connector
(12)	Power steering switch connector				
(13)	#1 injector connector				

*1: Route the harness between the crankshaft position sensor and the knock sensor LH.
*2: Install the engine ground terminal so that it faces the rear of the vehicle.
*3: Route the harness under the heater hose pipe.
*4: Install the engine harness fixing clip to the fuel pipe stay.
*5: Route the harness from the cutout portion of the fuel pipe protector LH.
*6: Do not confuse the oil temperature sensor connector and the engine coolant temperature sensor connector.
*7: Route the harness under the heater hose pipe.
*8: Route the harness under the fuel pipe.
*9: Install the engine harness fixing clip to the fixing boss of the cylinder block.
*10: Route the harness over the heater hose pipe stay.
*11: Align the edges of the engine harness stay and the engine harness identification tape.
*12: Install the engine harness fixing clip to the fixing boss of the rocker cover.
*13: Install the engine harness fixing stay securely.
*14: Route the harness outside the fuel pipe.
*15: Install the engine harness fixing clip to the fixing stay of the intake manifold.

Fig. 8: Identifying Engine Harness
Courtesy of SUBARU OF AMERICA, INC.

ENGINE MOUNTING

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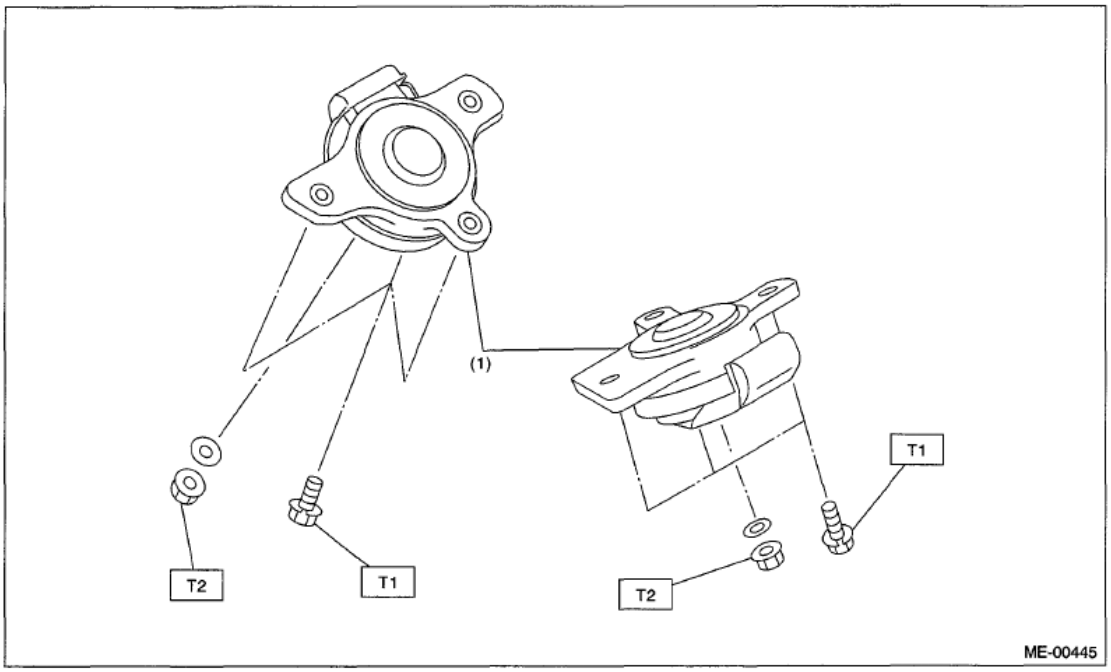

(1) Front cushion rubber

Fig. 9: Identifying Front Cushion Rubber
Courtesy of SUBARU OF AMERICA, INC.

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

T1: 35(3.6,25.8)

T2: 75(7.6,55.3)

CAUTION

- Wear appropriate work clothing, including a cap, protective goggles and protective shoes when performing any work.
- Remove contamination including dirt and corrosion before removal, installation or disassembly.
- Keep the disassembled parts in order and protect them from dust and dirt.
- Before removal, installation or disassembly, be sure to clarify the failure. Avoid unnecessary removal, installation, disassembly and replacement.
- Vehicle components are extremely hot after driving. Be wary of receiving burns from heated parts.
- Be sure to tighten fasteners including bolts and nuts to the specified torque.
- Place shop jacks or rigid racks at the specified points.
- Before disconnecting connectors of sensors or units, be sure to disconnect the ground cable from the battery.
- All parts should be thoroughly cleaned, paying special attention to engine oil passages, pistons and bearings.
- Before applying liquid gasket, completely remove the old liquid gasket and degrease it.

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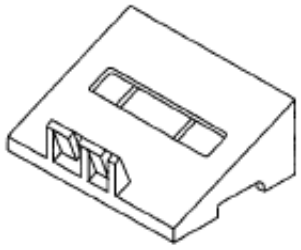
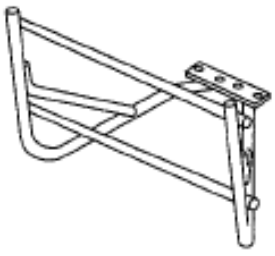
- Rotating parts and sliding parts such as piston, bearing and gear should be coated with oil prior to assembly.
- All removed parts, if to be reused, should be reinstalled in the original positions and directions.
- Bolts, nuts and washers should be replaced with new parts as required.
- Even if necessary inspections have been made in advance, proceed with assembly work while making re-checks.
- Remove or install the engine in an area where chain hoists, lifting devices, etc. are available for ready use.
- Be sure not to damage coated surfaces of body panels with tools, or not to stain seats and windows with coolant or oil. Place a cover over fender, as required, for protection.
- Prior to starting work, prepare the following:
- Service tools, clean cloth, containers to catch coolant and oil, wire ropes, chain hoist, transmission jacks, etc.
- Lift up or lower the vehicle when necessary. Make sure to support the correct positions.

PREPARATION TOOL

SPECIAL TOOL

SPECIAL TOOL REFERENCE

ILLUSTRATION	TOOL NUMBER	DESCRIPTION	REMARKS
 ST18250AA010	18250AA010	CYLINDER HEAD TABLE	• Used for replacing valve guides. • Used for removing and installing valve spring.
 ST18232AA000	18232AA000	ENGINE STAND	Used for disassembling and assembling engine.
	498497100	CRANKSHAFT	Used for stopping rotation of drive plate when loosening/tightening

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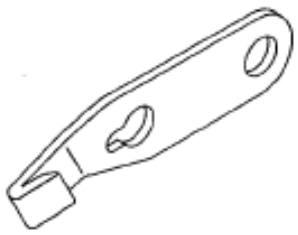
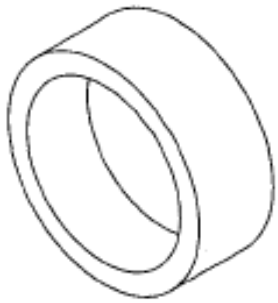
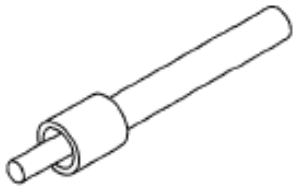
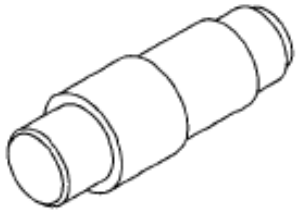
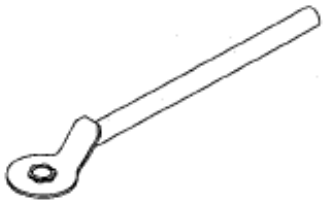
 ST-498497100		STOPPER	crank pulley bolt.
 ST-398744300	398744300	PISTON GUIDE	Used for installing piston in cylinder.
 ST-499585500	499585500	VALVE OIL SEAL GUIDE	Used for press-fitting of intake and exhaust valve guide oil seals.
 ST18350AA000	18350AA000	CONNECTING ROD BUSHING REMOVER AND INSTALLER	Used for removing and installing connecting rod bushing.
 ST-499977500	499977500	CAM SPROCKET WRENCH	Used for removing and installing camshaft sprocket.

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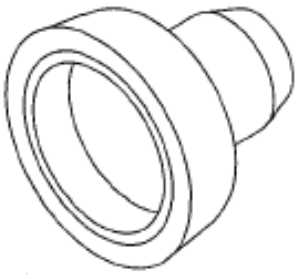
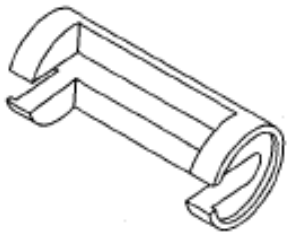
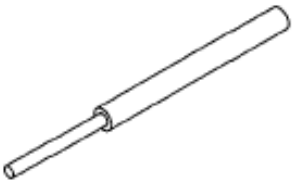
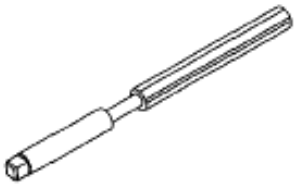
 ST-499587200	499587200	CRANKSHAFT OIL SEAL INSTALLER	• Used for installing crankshaft oil seal. • Used together with CRANKSHAFT OIL SEAL GUIDE (499597100).
 ST-499597100	499597100	CRANKSHAFT OIL SEAL GUIDE	• Used for installing crankshaft oil seal. • Used together with CRANKSHAFT OIL SEAL INSTALLER (499587200).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

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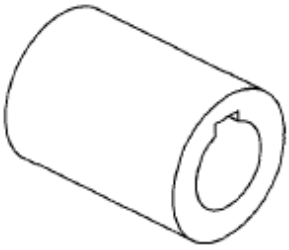
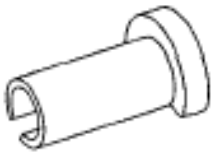
 ST18252AA000	18252AA000	CRANKSHAFT SOCKET	Used for rotating crankshaft.
 ST1B022XU0	1B022XU0	SUBARU SELECT MONITOR III KIT	Used for troubleshooting for electrical system.
 ST-498277200	498277200	STOPPER SET	Used for installing automatic transmission assembly to engine.
 ST42099AE000	42099AE000	QUICK CONNECTOR RELEASE	Used for disconnecting quick connector of the engine compartment.
	18471AA000	FUEL PIPE ADAPTER	Used for measuring fuel pressure.

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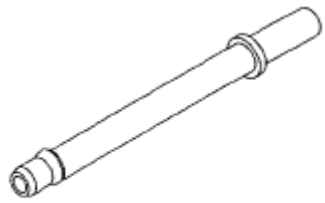
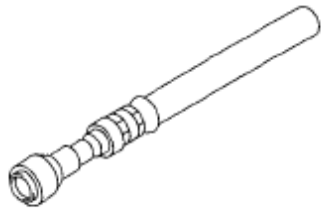
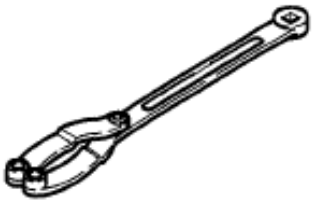
 ST18471AA000			
 ST42075AG690	42075AG690	FUEL HOSE	• Used for measuring fuel pressure. • This is a genuine Subaru part.
 ST18251AA050	18251AA050	VALVE GUIDE ADJUSTER	Used for installing intake valve guides.
 ST18251AA060	18251AA060	VALVE GUIDE ADJUSTER	Used for installing exhaust valve guides.
 ST18355AA000	18355AA000	PULLEY WRENCH	• Used for stopping rotation of crank pulley when removing and installing crank pulley bolt. • Used for stopping rotation of idler sprocket when removing and installing idler sprocket bolt.

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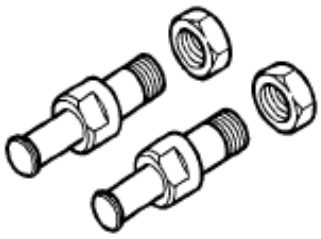 ST18334AA000	18355AA000	PULLEY WRENCH PIN SET	• Used for stopping rotation of crank pulley when removing and installing crank pulley bolt. • Used for stopping rotation of idler sprocket when removing and installing idler sprocket bolt.
 ST18332AA020	18332AA020	OIL FILTER WRENCH	Used for removing and installing oil filter.
 ST-499585700	499585700	OIL SEAL GUIDE	Used for installing the chain cover oil seal.

GENERAL TOOL

GENERAL TOOL REFERENCE

TOOL NAME	REMARKS
Compression gauge	Used for measuring compression.
Vacuum gauge	Used for measuring intake manifold vacuum.
Oil pressure gauge	Used for measuring engine oil pressure.
Fuel pressure gauge	Used for measuring fuel pressure.
TORX® socket (E12)	Used for removing and installing connecting rod cap.

PROCEDURE

It is possible to conduct the following service procedures with engine on vehicle, however, the procedures described in this information are based on the condition that the engine is removed from vehicle.

- V-belt

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- Timing chain

COMPRESSION

INSPECTION

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

1. Remove the collector cover.
2. After warming-up the engine, turn the ignition switch to OFF.
3. Make sure that the battery is fully charged.
4. Release the fuel pressure. Ref. to **RELEASING OF FUEL PRESSURE** , PROCEDURE, Fuel.
5. Remove all the spark plugs. Ref. to **REMOVAL** , Spark Plug.
6. Fully open the throttle valve.
7. Check the starter motor for satisfactory performance and operation.
8. Hold the compression gauge tightly against the spark plug hole.

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

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

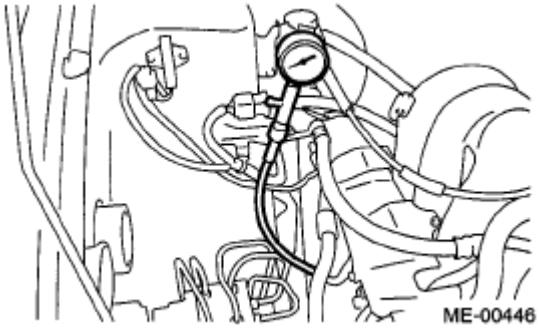

Fig. 10: Identifying Compression Gauge
Courtesy of SUBARU OF AMERICA, INC.

10. Perform at least two measurements per cylinder, and make sure that the values are correct.

Compression (350 rpm and fully open throttle): Standard: 1,275 - 1,471 kPa (13.0 - 15.0 kgf/cm^2 , 185 - 213 psi)

Service limit: 1,128 kPa (11.5 kgf/cm^2 , 164 psi)

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11. 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. Idle the engine.
3. Read the engine idle speed using Subaru Select Monitor. Ref. to **READ CURRENT DATA FOR ENGINE (NORMAL MODE)** , OPERATION, Subaru Select Monitor.
4. 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]: 700±100 rpm

5. Check the idle speed when loaded. (Turn the air conditioning switch "ON" and operate the compressor for at least one minute before measurement.)

    Idle speed [A/C "ON" and gears in "P" or "N" range]: 805±100 rpm

NOTE: Idle speed cannot be adjusted manually, because the idle speed is automatically adjusted. If the prescribed idle speed cannot be maintained, refer to General Diagnosis Table under "Engine Control System". Ref. to BASIC DIAGNOSTIC PROCEDURE .

IGNITION TIMING

INSPECTION

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

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

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Ignition timing [BTDC/rpm]: 15° ±8°/700

If the timing is not correct, check the ignition control system. Refer to "Engine Control System". Ref. to **BASIC DIAGNOSTIC PROCEDURE** .

INTAKE MANIFOLD VACUUM

INSPECTION

1. Idle the engine.
2. Disconnect the brake booster vacuum hose from the intake manifold, and install the vacuum gauge.
3. Keep the engine at idle speed and read the vacuum gauge indication. By observing the vacuum gauge needle movement, internal condition of the engine can be diagnosed as described below.

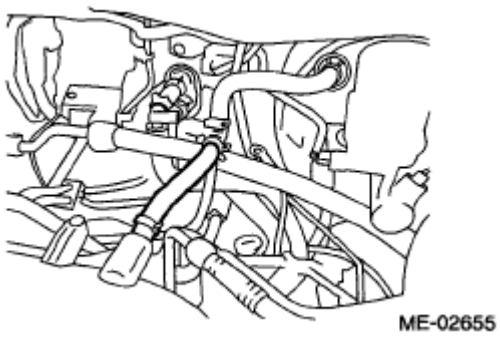

Fig. 11: Identifying Intake Manifold Vacuum
Courtesy of SUBARU OF AMERICA, INC.

Vacuum pressure (at idling, A/C OFF): -60.0 kPa (-450 mmHg, -17.72 inHg) or less

POSSIBLE ENGINE CONDITION CHART

Diagnosis of engine condition by measurement of intake manifold vacuum	
Vacuum gauge indication	**Possible engine condition**
1. Needle is steady but lower than normal position. This tendency becomes more evident as engine temperature rises.	Air leakage around intake manifold gasket, disconnection or damage of vacuum hose
2. Needle intermittently drops to position lower than normal position.	Leakage around cylinder
3. Needle drops suddenly and intermittently from normal position.	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 normal position in narrow range.	Defective ignition system

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ENGINE OIL PRESSURE

INSPECTION

1. Remove the oil pressure switch from the oil pan, upper. Ref. to **REMOVAL** , Oil Pressure Switch.
2. Connect the oil pressure gauge hose to the oil pan upper.
3. Connect the ground cable to battery.
4. Start the engine, and measure the oil pressure.

   Oil pressure (at oil temperature of 80°C (176°F)): Standard: 100 kPa (1.0 kgf/cm^2 , 15 psi) or more (at 700 rpm) 500 kPa (5.1 kgf/cm^2 , 73 psi) or more (at 5,000 rpm)

   - If the oil pressure is out of specification, check the oil pump, oil filter and lubrication line. Ref. to **INSPECTION** , General Diagnostic Table.
   - If the oil pressure warning light is ON and oil pressure is within specification, check the oil pressure switch. Ref. to **INSPECTION** , General Diagnostic Table.
5. After measuring the oil pressure, install the oil pressure switch. Ref. to **INSTALLATION** , Oil Pressure Switch.

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.**

NOTE: If the fuel pressure is out of specification, check or replace the fuel pump and fuel delivery line.

1. Remove the collector cover.
2. Release the fuel pressure. Ref. to **RELEASING OF FUEL PRESSURE** , PROCEDURE, Fuel.
3. Open the fuel filler lid, and remove the fuel filler cap.
4. Disconnect the fuel delivery hose and connect fuel pressure gauge.
   1. Disconnect the fuel delivery hose using the ST1.

      ST1 42099AE000 QUICK CONNECTOR RELEASE

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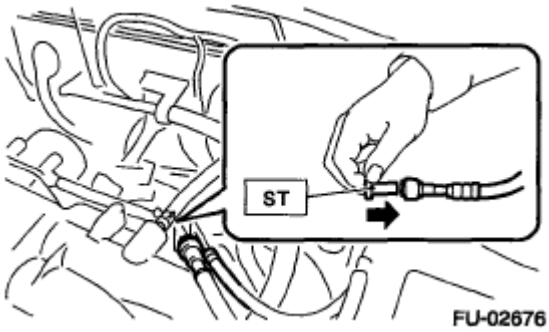


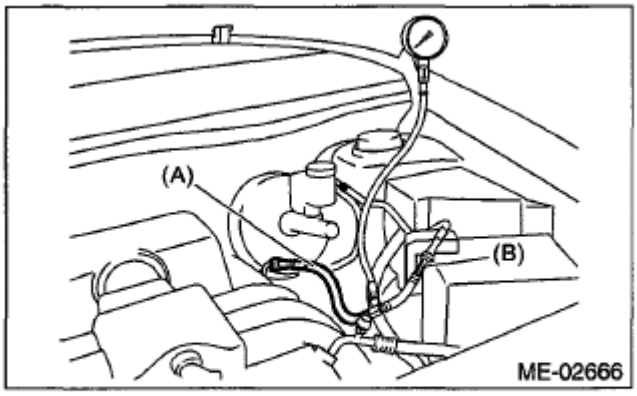
Fig. 12: Identifying Quick Connector Release
Courtesy of SUBARU OF AMERICA, INC.

2. Connect the fuel pressure meter using the ST2 and ST3.

NOTE: ST2 is a genuine Subaru part.

ST2 42075AG690 FUEL HOSE

ST3 18471AA000 FUEL PIPE ADAPTER



(A) ST2
(B) ST3

Fig. 13: Identifying Fuel Hose And Fuel Pipe Adapter
Courtesy of SUBARU OF AMERICA, INC.

5. Install the fuse of fuel pump to the main fuse box.

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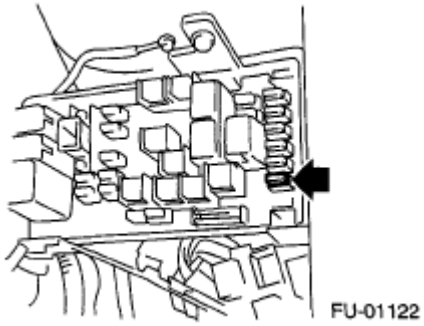

Fig. 14: Identifying Fuse Of Fuel Pump To Main Fuse Box
Courtesy of SUBARU OF AMERICA, INC.

6. Start the engine.
7. Measure the fuel pressure after warming up the engine.

Fuel pressure: Standard: 338 - 348 kPa (3.4 - 3.5 kgf/cm^2 , 49 - 50.5 psi)

NOTE: **The fuel pressure gauge registers 10 to 20 kPa (0.1 to 0.2 kgf/cm^2 , 1 to 3 psi) higher than standard values during high-altitude operations.**

VALVE CLEARANCE

INSPECTION

Inspection and adjustment of valve clearance should be performed while engine is cold.

1. Set the vehicle on a lift.
2. Remove the collector cover.
3. Disconnect the ground cable from battery.
4. Lift up the vehicle.
5. Remove the under cover.
6. Lower the vehicle.
7. When inspecting RH side cylinders:
    1. Remove the air intake duct and air cleaner case. Ref. to **REMOVAL** , Air Intake Duct. Ref. to **REMOVAL** , Air Cleaner Case.
    2. Remove the fuel pipe protector (RH).

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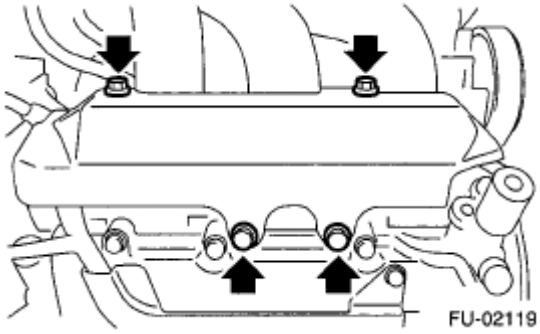

Fig. 15: Locating Fuel Pipe Protector (RH)
Courtesy of SUBARU OF AMERICA, INC.

3. Disconnect the connector of oil pressure switch.
4. Remove the ignition coil. Ref. to **REMOVAL** , Ignition Coil.
5. Remove the rocker cover (RH). Ref. to **REMOVAL**, Camshaft.

8. When inspecting LH side cylinders:
   1. Disconnect the battery cable, and then remove the battery and battery carrier.
   2. Disconnect the PCV hose and blow-by hose from the rocker cover (LH).

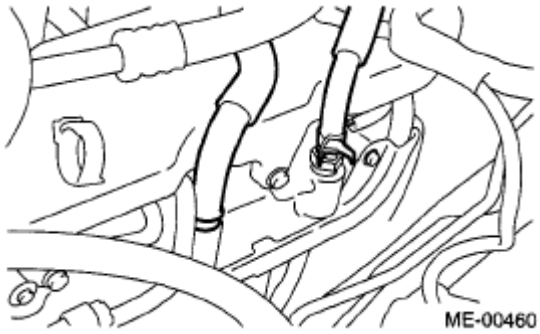

Fig. 16: Identifying PCV Hose And Blow-By Hose
Courtesy of SUBARU OF AMERICA, INC.

3. Remove the fuel pipe protector (LH).

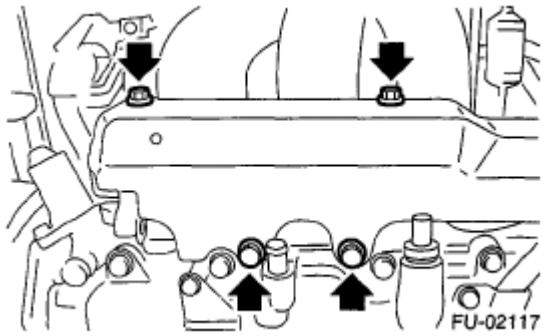

Fig. 17: Locating Fuel Pipe Protector (LH)

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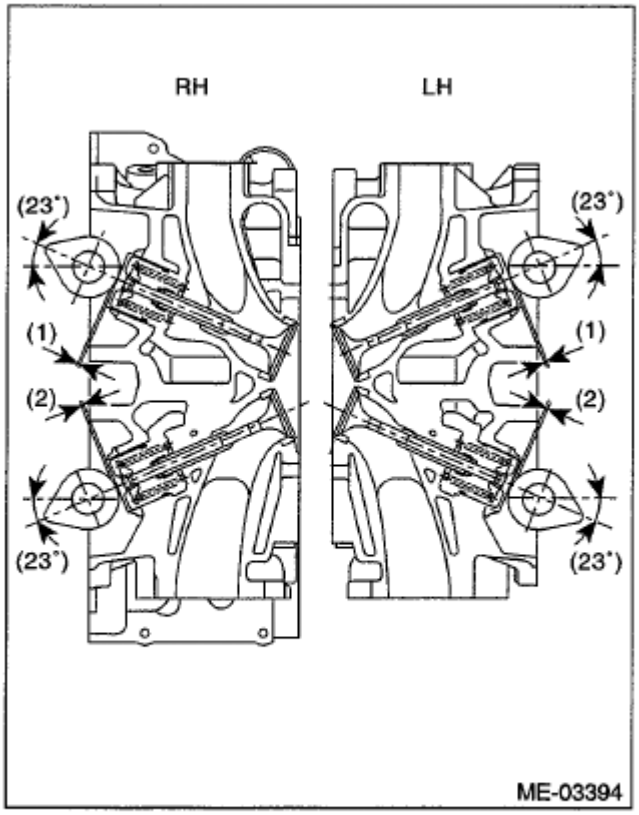
Courtesy of SUBARU OF AMERICA, INC.

4. Remove the ignition coil. Ref. to **REMOVAL** , Ignition Coil.
5. Remove the rocker cover (LH). Ref. to **REMOVAL**, Camshaft.

9. Turn the crankshaft clockwise until the cam is set to position shown in the figure.



(1) Valve clearance (Intake side)
(2) Valve clearance (Exhaust side)

Fig. 18: Identifying Valve Clearance (Intake/Exhaust Side)
Courtesy of SUBARU OF AMERICA, INC.

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

NOTE:

- **Measure it within the range of ±30° 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: Intake: $0.20^{+0.04}_{-0.06}$ mm ($0.0079^{+0.0016}_{-0.0024}$ in)

Exhaust: 0.35±0.05 mm (0.0138 ±0.0020 in)

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

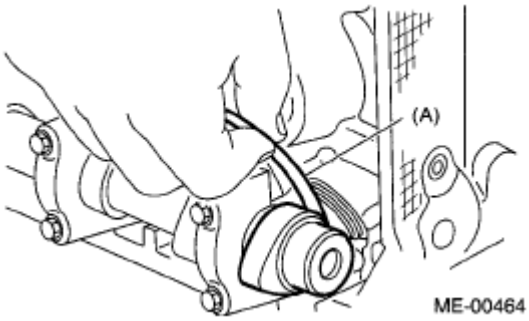

Fig. 19: Measuring Clearance Of Intake Valve And Exhaust Valve Using Thickness Gauge
Courtesy of SUBARU OF AMERICA, INC.

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

ADJUSTMENT

INTAKE SIDE

NOTE:
- **Adjustment of valve clearance should be performed while engine is cold.**
- **Do not wear gloves during removal and installation of valve lifter.**
- **Do not use valve lifters that were dropped or otherwise exposed to strong impacts.**

1. Measure all valve clearances. Ref. to **INSPECTION**, Valve Clearance.

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

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

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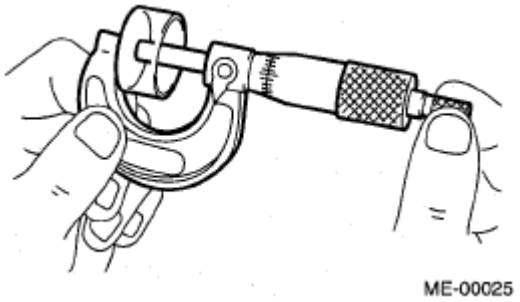

Fig. 20: Measuring Thickness Of Valve Lifter Using Micrometer
Courtesy of SUBARU OF AMERICA, INC.

7. Select and install a valve lifter of suitable thickness from the following table using the measured valve clearance and valve lifter thickness.

VALVE CLEARANCE REFERENCE

Unit: mm (in)
S = (V + T)-0.20 (0.0079)
S: Valve lifter thickness required V: Measured valve clearance T: Valve lifter thickness to be used

PART THICKNESS CHART

Part number	Thickness mm (in)
13228AD181	4.32 (0.1701)
13228AD191	4.34 (0.1709)
13228AD201	4.36 (0.1717)
13228AD211	4.38 (0.1724)
13228AD221	4.40 (0.1732)
13228AD231	4.42 (0.1740)
13228AD241	4.44 (0.1748)
13228AD251	4.46 (0.1756)
13228AD261	4.48 (0.1764)
13228AD271	4.50 (0.1772)
13228AD281	4.52 (0.1780)
13228AD291	4.54 (0.1787)
13228AD301	4.56 (0.1795)
13228AD311	4.58 (0.1803)
13228AD321	4.60 (0.1811)
13228AC581	4.62 (0.1819)
13228AC591	4.63 (0.1823)
13228AC601	4.64 (0.1827)
13228AC611	4.65 (0.1831)

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13228AC621	4.66 (0.1835)
13228AC631	4.67 (0.1839)
13228AC641	4.68 (0.1843)
13228AC651	4.69 (0.1846)
13228AC661	4.70 (0.1850)
13228AC671	4.71 (0.1854)
13228AC681	4.72 (0.1858)
13228AC691	4.73 (0.1862)
13228AC701	4.74 (0.1866)
13228AC711	4.75 (0.1870)
13228AC721	4.76 (0.1874)
13228AC731	4.77 (0.1878)
13228AC741	4.78 (0.1882)
13228AC751	4.79 (0.1886)
13228AC761	4.80 (0.1890)
13228AC771	4.81 (0.1894)
13228AC781	4.82 (0.1898)
13228AC791	4.83 (0.1902)
13228AC801	4.84 (0.1906)
13228AC811	4.85 (0.1909)
13228AC821	4.86 (0.1913)
13228AC831	4.87 (0.1917)
13228AC841	4.88 (0.1921)
13228AC851	4.89 (0.1925)
13228AC861	4.90 (0.1929)
13228AC871	4.91 (0.1933)
13228AC881	4.92 (0.1937)
13228AC891	4.93 (0.1941)
13228AC901	4.94 (0.1945)
13228AC911	4.95 (0.1949)
13228AC921	4.96 (0.1953)
13228AC931	4.97 (0.1957)
13228AC941	4.98 (0.1961)
13228AC951	4.99 (0.1965)
13228AC961	5.00 (0.1969)
13228AC971	5.01 (0.1972)
13228AC981	5.02 (0.1976)
13228AC991	5.03 (0.1980)
13228AD001	5.04 (0.1984)
13228AD011	5.05 (0.1988)
13228AD021	5.06 (0.1992)

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	5.07 (0.1996)
13228AD041	5.08 (0.2000)
13228AD051	5.09 (0.2004)
13228AD061	5.10 (0.2008)
13228AD071	5.11 (0.2012)
13228AD081	5.12 (0.2016)
13228AD091	5.13 (0.2020)
13228AD101	5.14 (0.2024)
13228AD111	5.15 (0.2028)
13228AD121	5.16 (0.2032)
13228AD131	5.17 (0.2035)
13228AD141	5.18 (0.2039)
13228AD151	5.19 (0.2043)
13228AD161	5.20 (0.2047)
13228AD171	5.21 (0.2051)
13228AD331	5.23 (0.2059)
13228AD341	5.25 (0.2067)
13228AD351	5.27 (0.2075)
13228AD361	5.29 (0.2083)
13228AD371	5.31 (0.2091)
13228AD381	5.33 (0.2098)
13228AD391	5.35 (0.2106)
13228AD401	5.37 (0.2114)
13228AD411	5.39 (0.2122)
13228AD421	5.41 (0.2130)
13228AD431	5.43 (0.2138)
13228AD441	5.45 (0.2146)
13228AD451	5.47 (0.2154)
13228AD461	5.49 (0.2161)
13228AD471	5.51 (0.2169)
13228AD481	5.53 (0.2177)
13228AD491	5.55 (0.2185)
13228AD501	5.57 (0.2193)
13228AD511	5.59 (0.2201)

8. Install the camshaft. Ref. to **INSTALLATION**, Camshaft.
9. Install the cam sprocket. Ref. to **INSTALLATION**, Cam Sprocket.
10. Install the timing chain assembly. Ref. to **INSTALLATION**, Timing Chain Assembly.
11. Re-measure all valve clearance at this time. If the valve clearance is not appropriate, repeat from the first step.
12. After measurement, install the related parts in the reverse order of removal.

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NOTE: Use a new rocker cover gasket.

EXHAUST SIDE

NOTE:

- **Adjustment of valve clearance should be performed while engine is cold.**
- **Do not wear gloves during removal and installation of valve lifter.**
- **Do not use valve lifters that were dropped or otherwise exposed to strong impacts.**

1. Measure all valve clearances. Ref. to **INSPECTION**, Valve Clearance.

NOTE: Record each valve clearance after measurement.

2. Remove the camshaft. Ref. to **REMOVAL**, Camshaft.
3. Remove the valve lifter.
4. Measure the thickness of valve lifter using micrometer.

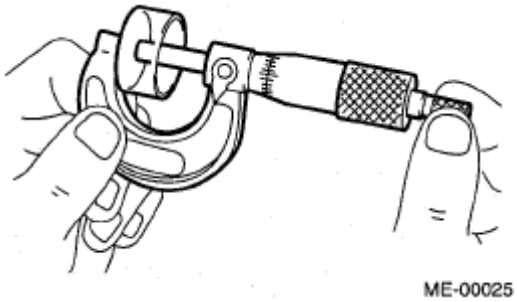

Fig. 21: Measuring Thickness Of Valve Lifter Using Micrometer
Courtesy of SUBARU OF AMERICA, INC.

5. Select and install a valve lifter of suitable thickness from the following table using the measured valve clearance and valve lifter thickness.

VALVE LIFTER THICKNESS CHART

Unit: mm (in)
S = (V + T)-0.35 (0.0138)
S: Valve lifter thickness required V: Measured valve clearance T: Valve lifter thickness to be used

PART THICKNESS CHART

Part number	Thickness mm (in)
13228AD181	4.32(0.1701)
13228AD191	4.34(0.1709)

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13228AD201	4.36 (0.1717)
13228AD211	4.38 (0.1724)
13228AD221	4.40(0.1732)
13228AD231	4.42 (0.1740)
13228AD241	4.44(0.1748)
13228AD251	4.46(0.1756)
13228AD261	4.48 (0.1764)
13228AD271	4.50(0.1772)
13228AD281	4.52 (0.1780)
13228AD291	4.54(0.1787)
13228AD301	4.56(0.1795)
13228AD311	4.58 (0.1803)
13228AD321	4.60(0.1811)
13228AC581	4.62(0.1819)
13228AC591	4.63(0.1823)
13228AC601	4.64(0.1827)
13228AC611	4.65(0.1831)
13228AC621	4.66(0.1835)
13228AC631	4.67(0.1839)
13228AC641	4.68(0.1843)
13228AC651	4.69(0.1846)
13228AC661	4.70(0.1850)
13228AC671	4.71 (0.1854)
13228AC681	4.72(0.1858)
13228AC691	4.73(0.1862)
13228AC701	4.74(0.1866)
13228AC711	4.75(0.1870)
13228AC721	4.76(0.1874)
13228AC731	4.77(0.1878)
13228AC741	4.78(0.1882)
13228AC751	4.79(0.1886)
13228AC761	4.80(0.1890)
13228AC771	4.81 (0.1894)
13228AC781	4.82(0.1898)
13228AC791	4.83(0.1902)
13228AC801	4.84(0.1906)
13228AC811	4.85(0.1909)
13228AC821	4.86(0.1913)
13228AC831	4.87(0.1917)
13228AC841	4.88(0.1921)
13228AC851	4.89(0.1925)

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	4.90(0.1929)
13228AC871	4.91 (0.1933)
13228AC881	4.92(0.1937)
13228AC891	4.93(0.1941)
13228AC901	4.94(0.1945)
13228AC911	4.95(0.1949)
13228AC921	4.96(0.1953)
13228AC931	4.97(0.1957)
13228AC941	4.98(0.1961)
13228AC951	4.99(0.1965)
13228AC961	5.00(0.1969)
13228AC971	5.01 (0.1972)
13228AC981	5.02(0.1976)
13228AC991	5.03(0.1980)
13228AD001	5.04(0.1984)
13228AD011	5.05(0.1988)
13228AD021	5.06(0.1992)
13228AD031	5.07(0.1996)
13228AD041	5.08 (0.2000)
13228AD051	5.09 (0.2004)
13228AD061	5.10(0.2008)
13228AD071	5.11 (0.2012)
13228AD081	5.12(0.2016)
13228AD091	5.13(0.2020)
13228AD101	5.14(0.2024)
13228AD111	5.15(0.2028)
13228AD121	5.16(0.2032)
13228AD131	5.17(0.2035)
13228AD141	5.18(0.2039)
13228AD151	5.19(0.2043)
13228AD161	5.20 (0.2047)
13228AD171	5.21 (0.2051)
13228AD331	5.23 (0.2059)
13228AD341	5.25 (0.2067)
13228AD351	5.27 (0.2075)
13228AD361	5.29 (0.2083)
13228AD371	5.31 (0.2091)
13228AD381	5.33 (0.2098)
13228AD391	5.35(0.2106)
13228AD401	5.37(0.2114)
13228AD411	5.39(0.2122)

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	5.41 (0.2130)
13228AD431	5.43(0.2138)
13228AD441	5.45(0.2146)
13228AD451	5.47(0.2154)
13228AD461	5.49(0.2161)
13228AD471	5.51 (0.2169)
13228AD481	5.53(0.2177)
13228AD491	5.55(0.2185)
13228AD501	5.57(0.2193)
13228AD511	5.59(0.2201)

6. Install the camshaft. Ref. to **INSTALLATION**, Camshaft.
7. Install the cam sprocket. Ref. to **INSTALLATION**, Cam Sprocket.
8. Install the timing chain assembly. Ref. to **INSTALLATION**, Timing Chain Assembly.
9. Re-measure all valve clearance at this time.

   If the valve clearance is not appropriate, repeat from the first step.

10. After measurement, install the related parts in the reverse order of removal.

NOTE: Use a new rocker cover gasket.

ENGINE ASSEMBLY

REMOVAL

1. Set the vehicle on a lift.
2. Change the bolt mounting position from (A) to (B), then completely open the front hood.

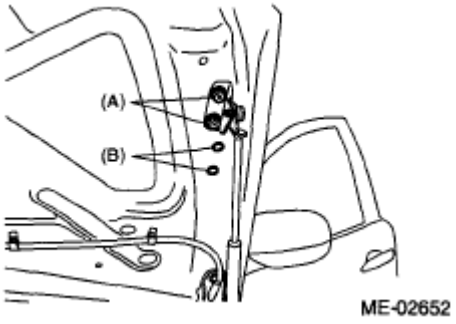

Fig. 22: Identifying Bolt Mounting Position
Courtesy of SUBARU OF AMERICA, INC.

3. Remove the collector cover.
4. Collect the refrigerant from A/C system. Ref. to **PROCEDURE** , Refrigerant Recovery Procedure.

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5. Release the fuel pressure. Ref. to **RELEASING OF FUEL PRESSURE** , PROCEDURE, Fuel.
6. Remove the battery from vehicle. Ref. to **REMOVAL** , Battery.
7. Remove the air intake duct, air cleaner case and air intake chamber. Ref. to **REMOVAL** , Air Intake Duct. Ref. to **REMOVAL** , Air Cleaner Case. Ref. to **REMOVAL** , Air Intake Chamber.
8. Remove the front upper cover.

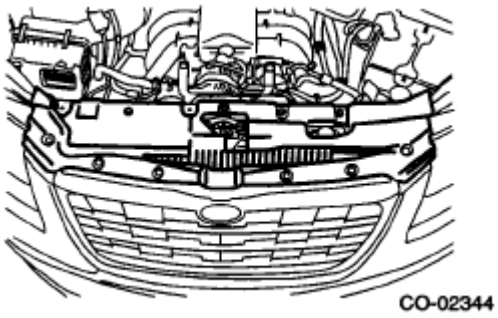

Fig. 23: Identifying Front Upper Cover
Courtesy of SUBARU OF AMERICA, INC.

9. Remove the front bumper. Ref. to **FRONT BUMPER FACE** , REMOVAL, Front Bumper.
10. Remove the radiator from vehicle. Ref. to **REMOVAL** , Radiator.

NOTE: Protect the condenser so that it will not be damaged.

11. Remove the fuel hose bracket.

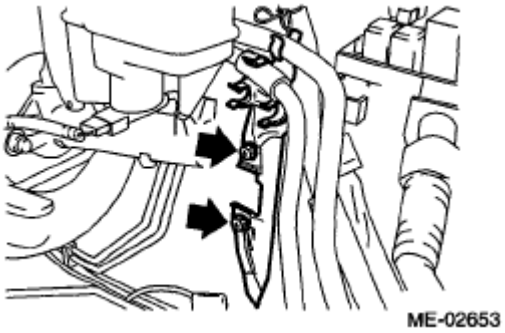

Fig. 24: Locating Fuel Hose Bracket
Courtesy of SUBARU OF AMERICA, INC.

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

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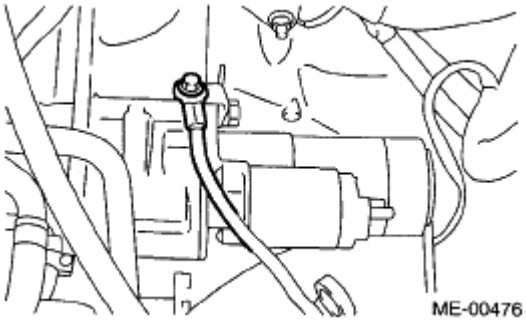

Fig. 25: Identifying Engine Ground Terminal
Courtesy of SUBARU OF AMERICA, INC.

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

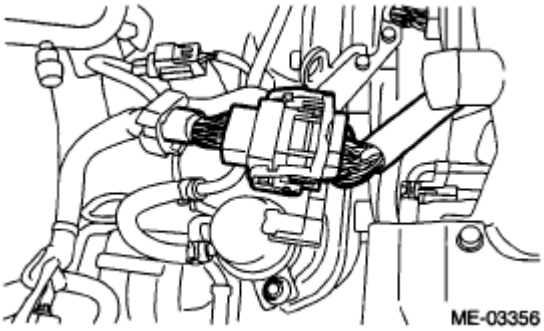

Fig. 26: Identifying Engine Harness Connectors
Courtesy of SUBARU OF AMERICA, INC.

    2. Generator connector, terminal and A/C compressor connector
    3. Power steering switch connector
16. Disconnect the following hoses.
    1. Brake booster vacuum hose

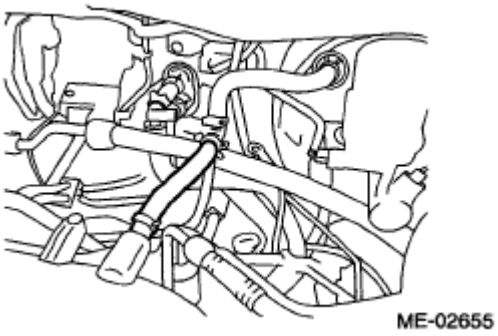

Fig. 27: Identifying Brake Booster Vacuum Hose
Courtesy of SUBARU OF AMERICA, INC.

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2. Heater inlet and outlet hoses

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

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

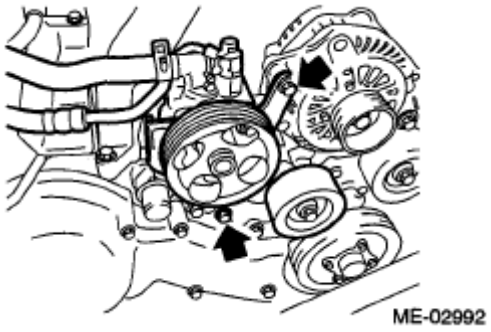

Fig. 28: Identifying Power Steering Pump With Bracket
Courtesy of SUBARU OF AMERICA, INC.

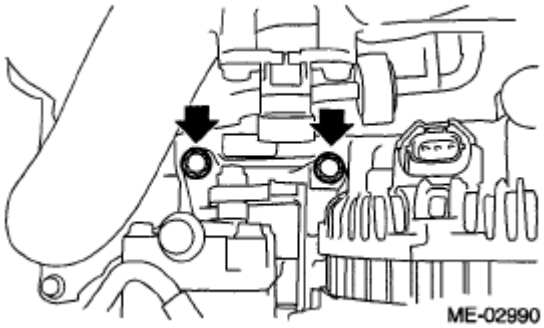

Fig. 29: Identifying Power Steering Pump Bolts
Courtesy of SUBARU OF AMERICA, INC.

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

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

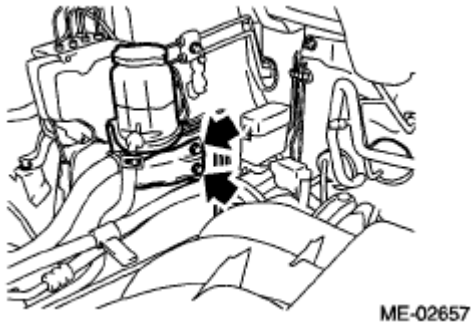

Fig. 30: Locating Power Reserve Tank Body

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Courtesy of SUBARU OF AMERICA, INC.

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

Fig. 31: Identifying Power Steering Pump
Courtesy of SUBARU OF AMERICA, INC.

20. Remove the bolts which hold the vacuum pump bracket to the engine. Ref. to **BRAKE VACUUM PUMP** , COMPONENT, General Description.
21. Lift up the vehicle.
22. Remove the front exhaust pipe. Ref. to **REMOVAL** , Front Exhaust Pipe.

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

23. Remove the ground cable from the chain cover lower (left and right).

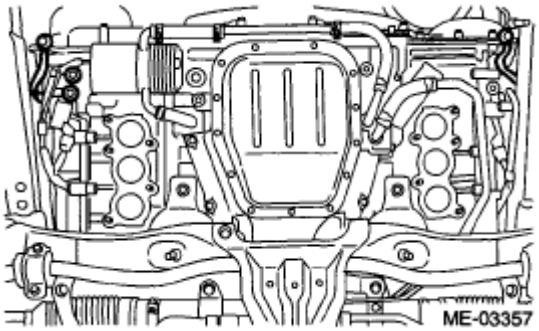

Fig. 32: Identifying Ground Cable To Chain Cover Lower (Left And Right)
Courtesy of SUBARU OF AMERICA, INC.

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

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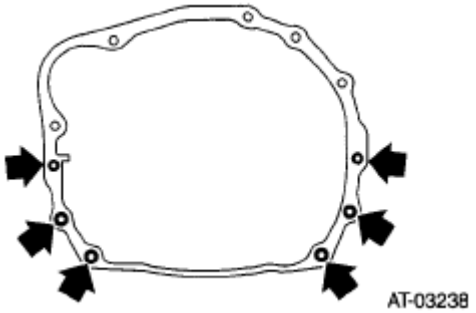

Fig. 33: Locating Transmission Bolts
Courtesy of SUBARU OF AMERICA, INC.

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

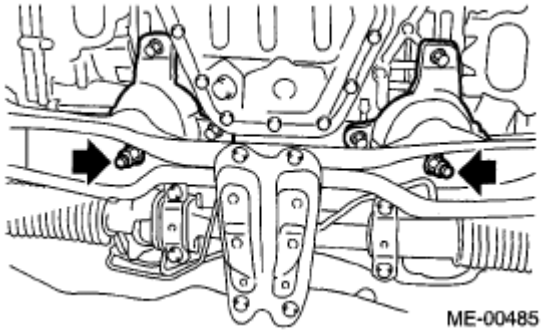

Fig. 34: Identifying Front Cushion Rubber
Courtesy of SUBARU OF AMERICA, INC.

27. Remove the two clutch housing securing bolts.

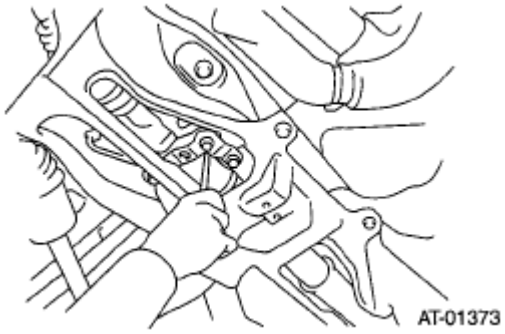

Fig. 35: Removing Clutch Housing Securing Bolts
Courtesy of SUBARU OF AMERICA, INC.

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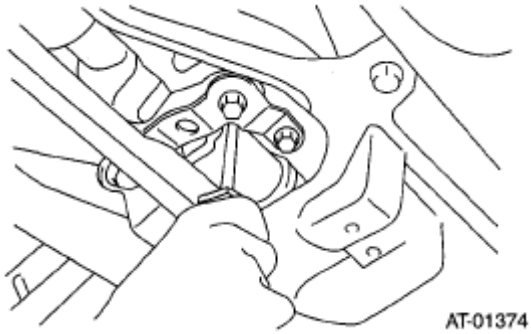
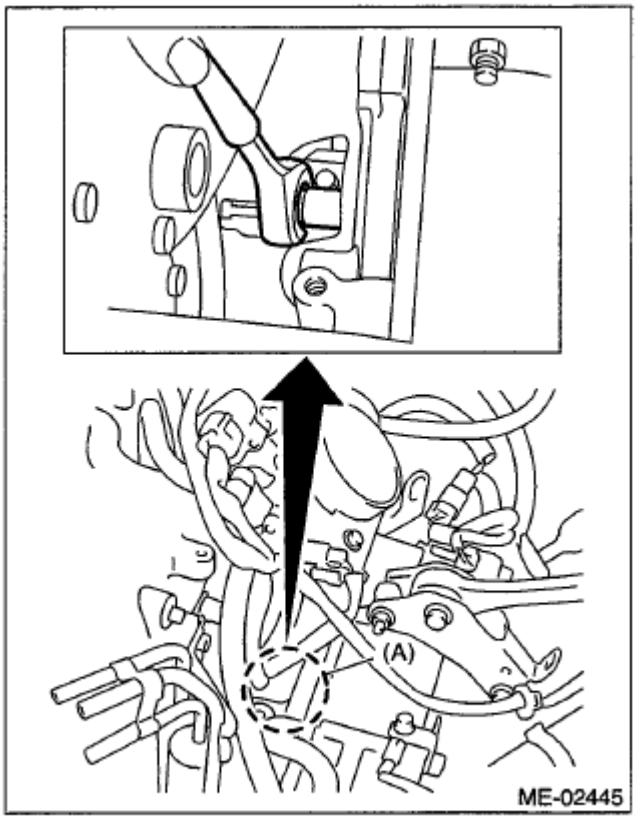


Fig. 36: Removing Clutch Housing Securing Bolts
Courtesy of SUBARU OF AMERICA, INC.

28. Lower the vehicle.
29. Separate the torque converter clutch from drive plate.
    1. Remove the throttle body securing bolts to and slide the throttle body over.
    2. Remove the service hole plug.
    3. Remove the bolts which hold torque converter clutch to drive plate.
    4. Remove other bolts while rotating the crankshaft using socket wrench.



(A) Service hole plug

Fig. 37: Identifying Service Hole Plug

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Courtesy of SUBARU OF AMERICA, INC.

30. Remove the pitching stopper.

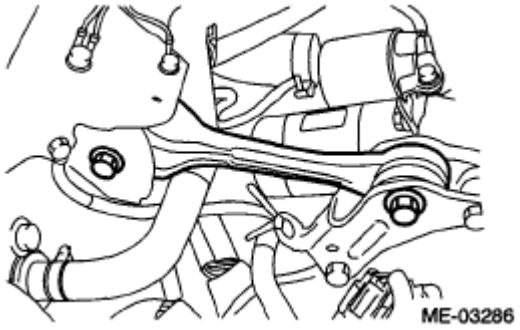

Fig. 38: Identifying Pitching Stopper
Courtesy of SUBARU OF AMERICA, INC.

31. Disconnect the fuel delivery hose and evaporation hose.
    1. Disconnect the connector of fuel pipe by pushing the ST in the direction of arrow.

       ST 42099AE000 QUICK CONNECTOR RELEASE

    2. Remove the clamp, and disconnect the evaporation hose from the pipe.

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

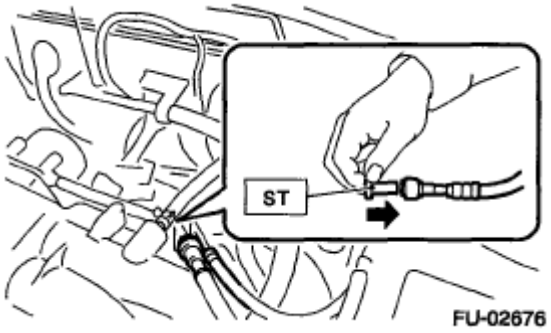

Fig. 39: Identifying Quick Connector Release
Courtesy of SUBARU OF AMERICA, INC.

32. Remove the radiator center bracket.

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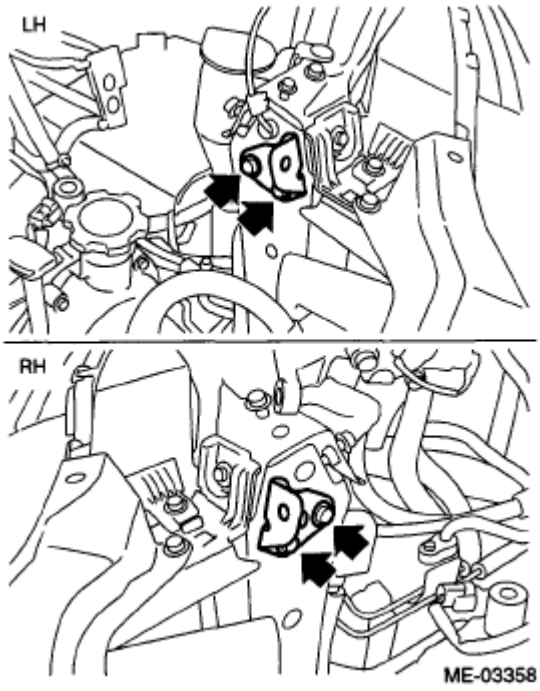
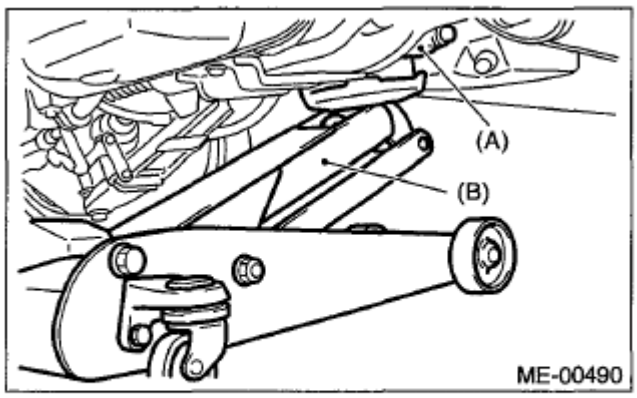


Fig. 40: Locating Radiator Center Bracket
Courtesy of SUBARU OF AMERICA, INC.

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

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



(A) Transmission
(B) Garage jack

Fig. 41: Identifying Transmission And Garage Jack
Courtesy of SUBARU OF AMERICA, INC.

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35. Separate the engine and transmission.

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

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

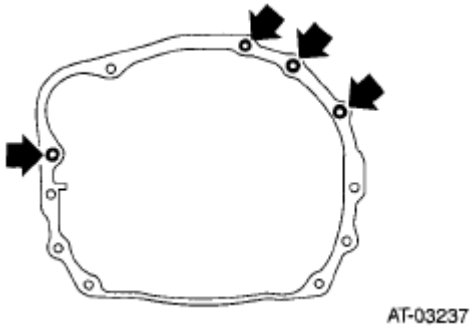

Fig. 42: Locating Transmission Bolt
Courtesy of SUBARU OF AMERICA, INC.

36. Attach the ST to converter case.

ST 498277200 STOPPER SET

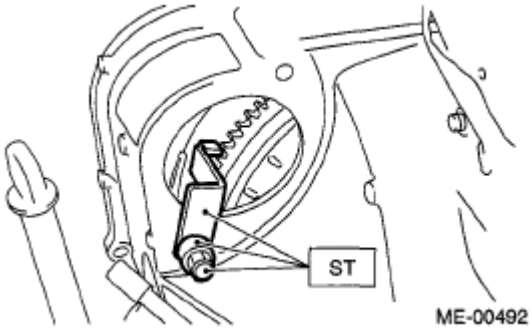

Fig. 43: Identifying Stopper Set
Courtesy of SUBARU OF AMERICA, INC.

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

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

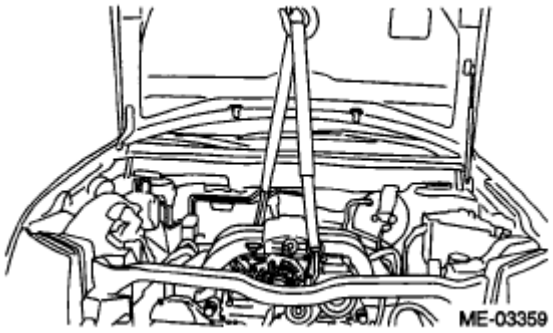
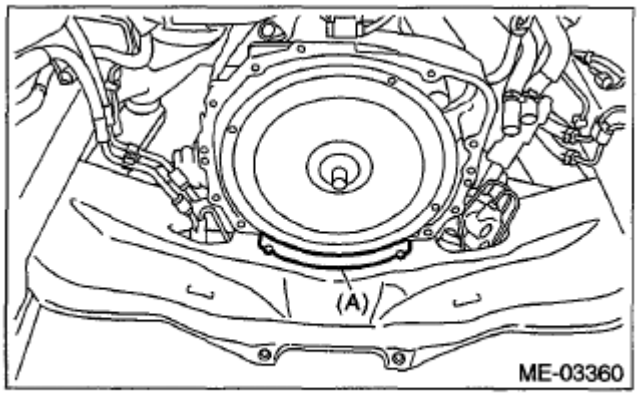


Fig. 44: Removing/Installing Engine From Vehicle
Courtesy of SUBARU OF AMERICA, INC.

38. Remove the engine mount.
39. Remove the clutch housing cover from vehicle.



(A) Clutch housing cover

Fig. 45: Identifying Clutch Housing Cover
Courtesy of SUBARU OF AMERICA, INC.

INSTALLATION

1. Set the clutch housing cover to the vehicle.

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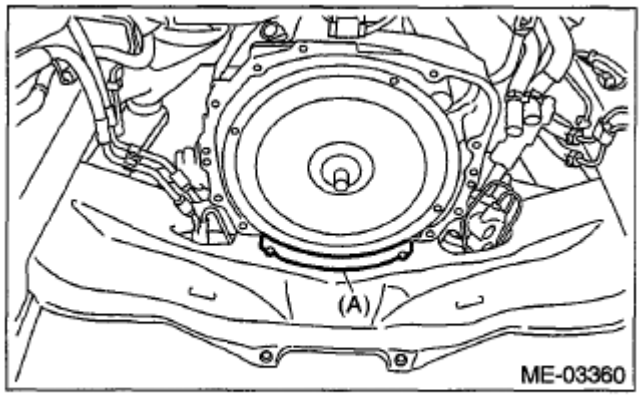

(A) Clutch housing cover

Fig. 46: Identifying Clutch Housing Cover
Courtesy of SUBARU OF AMERICA, INC.

2. Install the engine mount.

   Tightening torque: 35 N.m (3.6 kgf-m, 25.8 ft-lb)

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

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

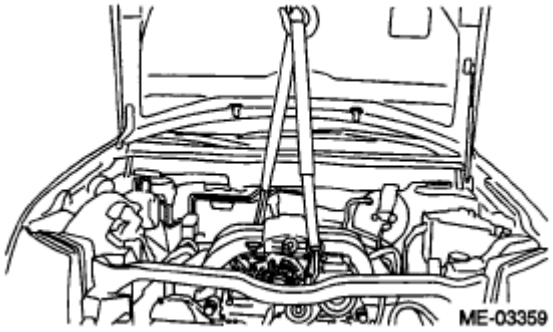

Fig. 47: Removing/Installing Engine From Vehicle
Courtesy of SUBARU OF AMERICA, INC.

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

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

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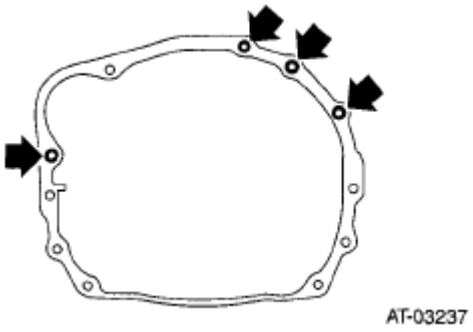

Fig. 48: Locating Transmission Bolt
Courtesy of SUBARU OF AMERICA, INC.

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

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

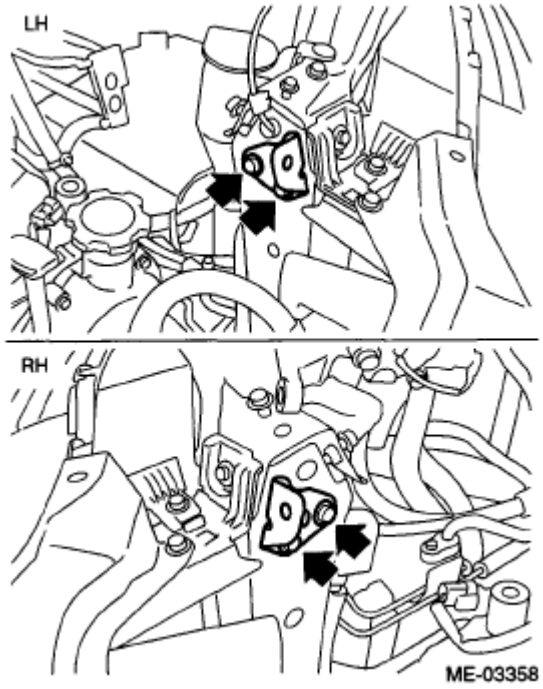

Fig. 49: Locating Radiator Center Bracket
Courtesy of SUBARU OF AMERICA, INC.

8. Install the pitching stopper.

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

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

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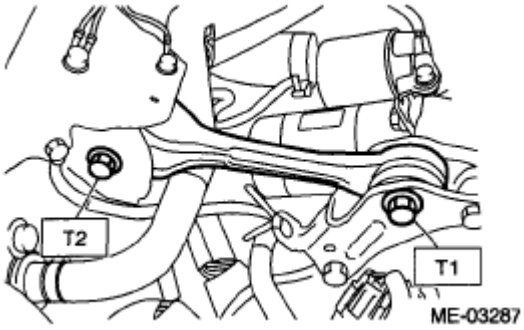

Fig. 50: Identifying Pitching Stopper
Courtesy of SUBARU OF AMERICA, INC.

9. Remove the ST from converter case.

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

ST 498277200 STOPPER SET

10. Install the starter. Ref. to **INSTALLATION** , Starter.
11. Install the torque converter clutch to drive plate.
    1. Tighten the bolts which hold torque converter clutch to drive plate.
    2. Tighten other bolts while rotating the crankshaft using socket wrench.

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

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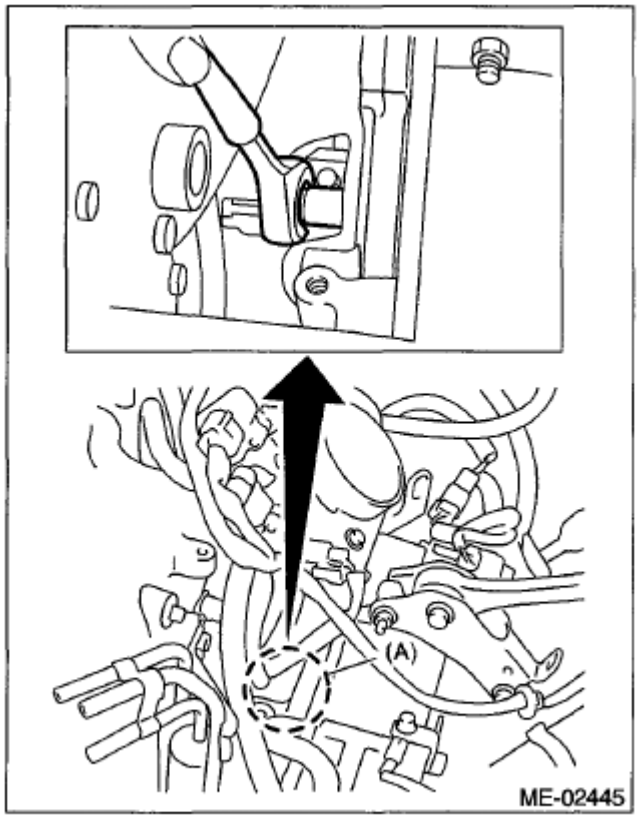

(A) Service hole plug

Fig. 51: Identifying Service Hole Plug
Courtesy of SUBARU OF AMERICA, INC.

3. Install the service hole plug to prevent foreign matter from being mixed.
4. Install the throttle body to intake manifold.

Tightening torque: 8 N.m (0.8 kgf-m, 5.9 ft-lb)

12. Lift up the vehicle.
13. Tighten the bolts and nuts which hold lower side of the transmission to engine.

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

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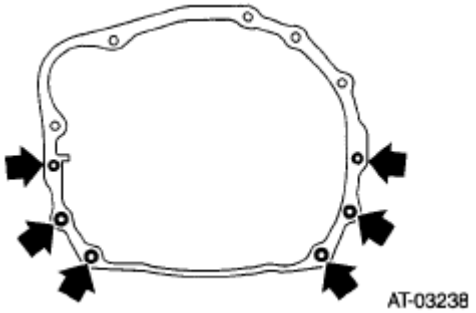

Fig. 52: Locating Transmission Bolts
Courtesy of SUBARU OF AMERICA, INC.

14. Tighten the bolts which holds the vacuum pump bracket to the transmission. Ref. to **BRAKE VACUUM PUMP** , COMPONENT, General Description.

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

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

    Tightening torque: 75 N.m (7.6 kgf-m, 55.3 ft-lb)

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

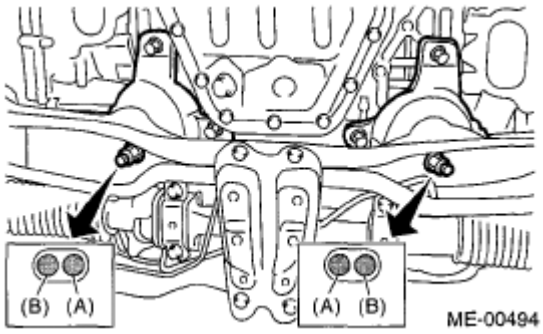

Fig. 53: Identifying Front Cushion Rubber Mounting Bolts And Locator
Courtesy of SUBARU OF AMERICA, INC.

16. Install the front exhaust pipe. Ref. to **INSTALLATION** , Front Exhaust Pipe.

    NOTE:
    - **Be care not to let the front exhaust pipe interfere with water pipes and crossmember on engine side.**
    - **Be care not to scratch the flange surface of front exhaust pipe with stud bolt on engine.**

17. Connect the ground cable to the chain cover lower (left and right).

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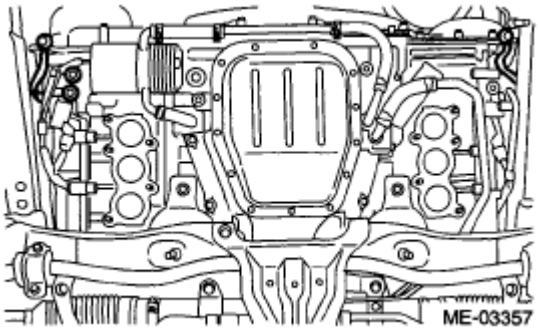

Fig. 54: Identifying Ground Cable To Chain Cover Lower (Left And Right)
Courtesy of SUBARU OF AMERICA, INC.

18. Lower the vehicle.
19. Install the fuel hose bracket.

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

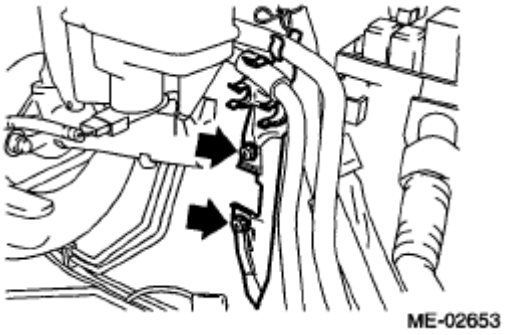

Fig. 55: Locating Fuel Hose Bracket
Courtesy of SUBARU OF AMERICA, INC.

20. Tighten the bolts which holds the vacuum pump bracket to the engine. Ref. to **BRAKE VACUUM PUMP** , COMPONENT, General Description.

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

21. Install the power steering pump.

    Tightening torque:

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

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

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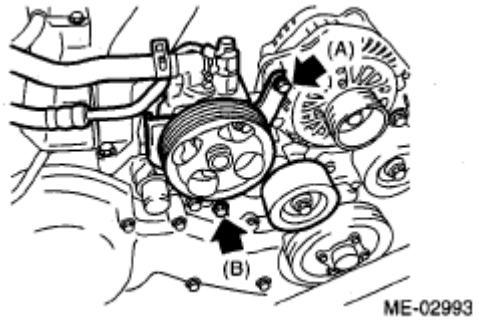

Fig. 56: Locating Power Steering Pump
Courtesy of SUBARU OF AMERICA, INC.

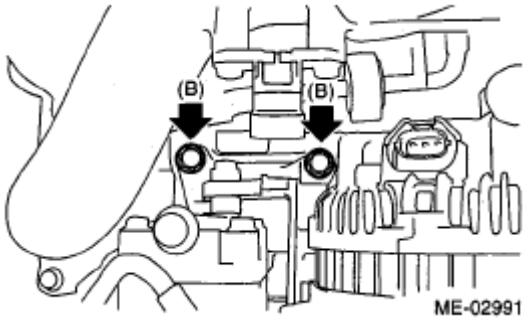

Fig. 57: Locating Power Steering Pump Bolt
Courtesy of SUBARU OF AMERICA, INC.

22. Install the reservoir tank.

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

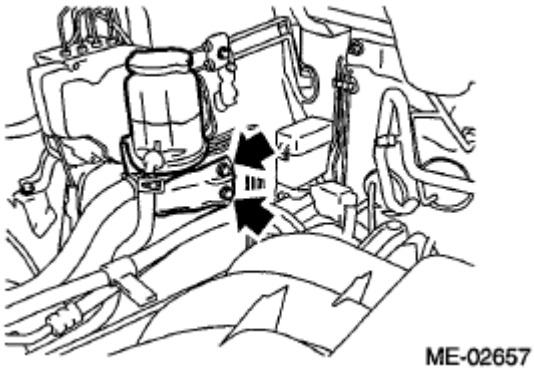

Fig. 58: Reservoir Tank
Courtesy of SUBARU OF AMERICA, INC.

23. Connect the following hoses.
    1. Fuel delivery hose and evaporation hose
    2. Heater inlet and outlet hoses

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3. Brake booster vacuum hose

24. Connect the following connectors.
    1. Engine harness connectors

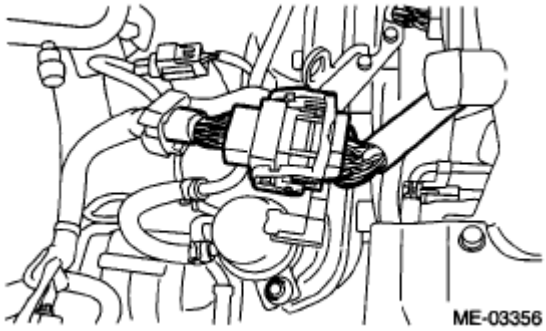

Fig. 59: Identifying Engine Harness Connectors
Courtesy of SUBARU OF AMERICA, INC.

    2. Generator connector and terminal
    3. A/C compressor connector
    4. Power steering switch connector

25. Connect the engine ground terminal.

Tightening torque: 14 N.m (1.4 kgf-m, 10.3 ft-lb)

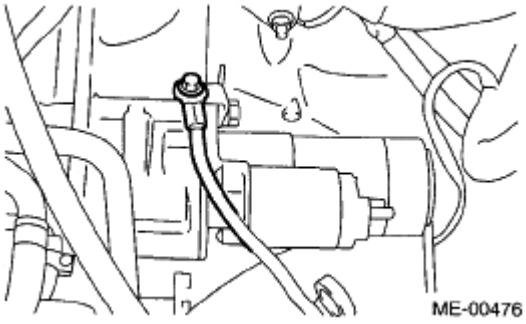

Fig. 60: Identifying Engine Ground Terminal
Courtesy of SUBARU OF AMERICA, INC.

26. Install the A/C pressure hoses. Ref. to **INSTALLATION** , Hose and Pipe.
27. Install the V-belts. Ref. to **INSTALLATION**, V-belt.
28. Install the radiator to vehicle. Ref. to **INSTALLATION** , Radiator.
29. Install the front bumper. Ref. to **FRONT BUMPER FACE** , INSTALLATION, Front Bumper.
30. Install the fuse of fuel pump to the main fuse box.
31. Install the battery to the vehicle. Ref. to **INSTALLATION** , Battery.
32. Fill engine coolant. Ref. to **FILLING OF ENGINE COOLANT** , REPLACEMENT, Engine Coolant.

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33. Check the ATF level and replenish it if necessary. Ref. to **INSPECTION** , Automatic Transmission Fluid.
34. Charge the A/C system with refrigerant. Ref. to **PROCEDURE** , Refrigerant Charging Procedure.
35. Install the front upper cover.

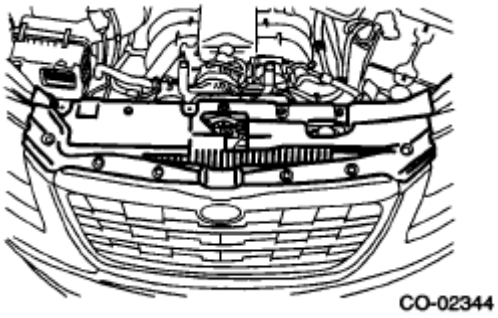

Fig. 61: Identifying Front Upper Cover
Courtesy of SUBARU OF AMERICA, INC.

36. Install the air intake duct, air cleaner case and air intake chamber. Ref. to **INSTALLATION** , Air Intake Duct. Ref. to **INSTALLATION** , Air Cleaner Case. Ref. to **INSTALLATION** , Air Intake Chamber.
37. Install the collector cover.
38. Change the bolt mounting position from (B) to (A), then close the front hood.

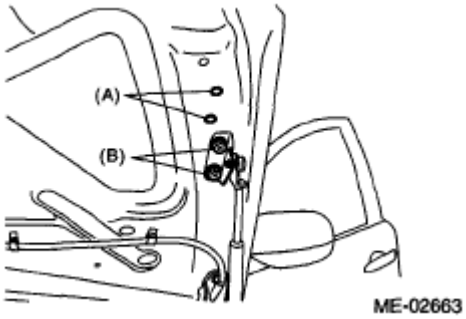

Fig. 62: Identifying Collector Cover Mounting Bolt
Courtesy of SUBARU OF AMERICA, INC.

39. Lower the vehicle from lift.

INSPECTION

1. Check the pipes and hoses are installed firmly.
2. Check the engine coolant and ATF are at specified levels.
3. Start the engine and check for leaks of fuel, exhaust gas, engine coolant, etc. Also check for noise and vibrations.

ENGINE MOUNTING

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REMOVAL

1. Remove the engine unit. Ref. to **REMOVAL**, Engine Assembly.
2. Remove the engine mounting from engine assembly.

INSTALLATION

Install in the reverse order of removal.

Tightening torque: 35 N.m (3.6 kgf-m, 25.8 ft-lb)

INSPECTION

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

PREPARATION FOR OVERHAUL

REMOVAL

1. Remove the engine from the body. Ref. to **REMOVAL**, Engine Assembly.
2. Set the engine on ST.

   ST 18232AA000 ENGINE STAND

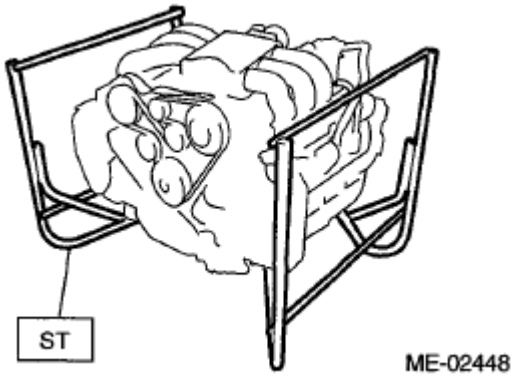

Fig. 63: Identifying Engine Stand
Courtesy of SUBARU OF AMERICA, INC.

3. Before servicing overhaul, remove the sensor, pipe and hose that installed to engine.
   1. Remove the intake manifold. Ref. to **REMOVAL** , Intake Manifold.
   2. Remove the generator. Ref. to **REMOVAL** , Generator.
   3. Remove the A/C compressor. Ref. to **REMOVAL** , Compressor.
   4. Disconnect the water pipe and hose.
   5. Disconnect the engine harness.

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6. Remove the spark plug. Ref. to **REMOVAL** , Spark Plug.
7. Remove the camshaft position sensor. Ref. to **REMOVAL** , Camshaft Position Sensor.
8. Remove the crankshaft position sensor. Ref. to **REMOVAL** , Crankshaft Position Sensor.
9. Remove the knock sensor. Ref. to **REMOVAL** , Knock Sensor.
10. Remove the engine coolant temperature sensor. Ref. to **REMOVAL** , Engine Coolant Temperature Sensor.
11. Remove the oil temperature sensor. Ref. to **REMOVAL** , Oil Temperature Sensor.
12. Remove the oil flow control solenoid valve. Ref. to **REMOVAL** , Oil Flow Control Solenoid Valve.
13. Remove the oil pressure switch. Ref. to **REMOVAL** , Oil Pressure Switch.
14. Remove the oil filter. Ref. to **REMOVAL** , Engine Oil Filter.
15. Remove the oil cooler. Ref. to **REMOVAL** , Oil Cooler.

V-BELT

REMOVAL

NOTE: Perform the work with the engine installed to body when replacing a single part.

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

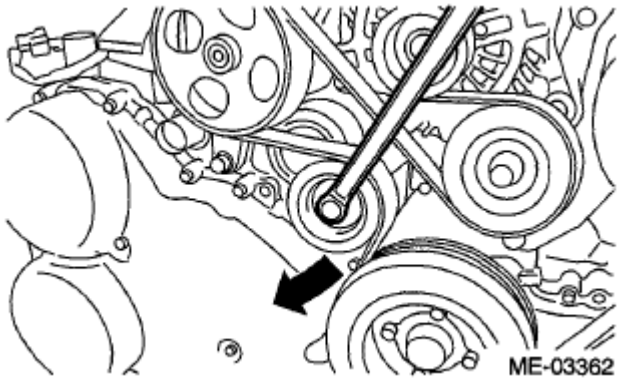

Fig. 64: Loosening V-belt
Courtesy of SUBARU OF AMERICA, INC.

INSTALLATION

Install in the reverse order of removal.

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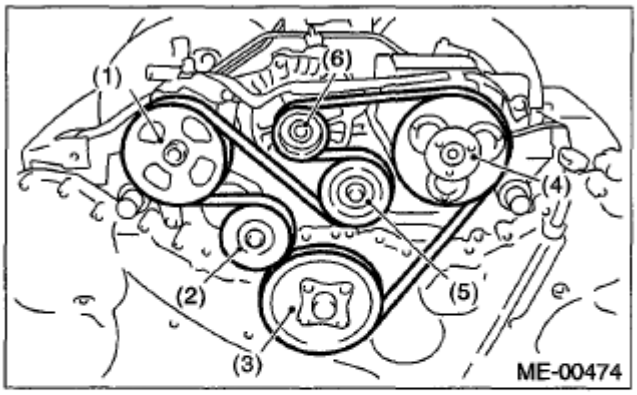

(1) Power steering oil pump pulley
(2) Belt tension adjuster ASSY
(3) Crank pulley
(4) A/C compressor pulley
(5) Belt idler
(6) Generator

Fig. 65: Identifying V-belt Components
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).

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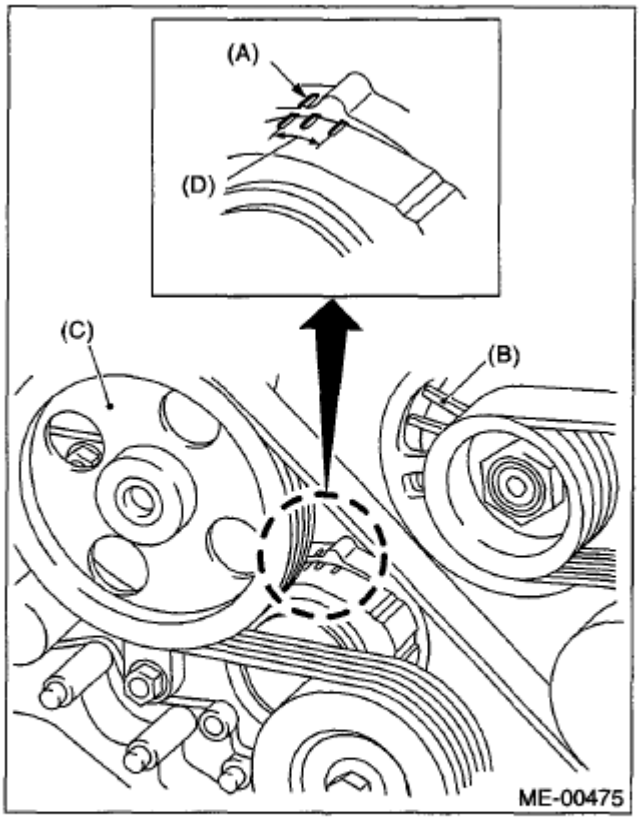

(A) Indicator
(B) Generator
(C) Power steering oil pump pulley
(D) Service limit

Fig. 66: Identifying V-belt Automatic Belt Tension Indicator
Courtesy of SUBARU OF AMERICA, INC.

CRANK PULLEY

REMOVAL

NOTE: Perform the work with the engine installed to body when replacing a single part.

1. Remove the V-belt. Ref. to **REMOVAL**, V-belt.
2. Remove the crank pulley cover.

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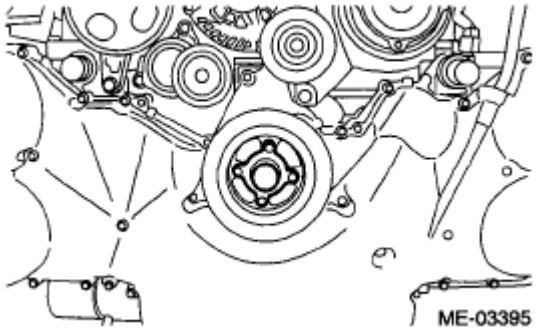

Fig. 67: Identifying Crank Pulley Cover
Courtesy of SUBARU OF AMERICA, INC.

3. Remove the crank pulley bolt. To lock the crankshaft, use ST.

   ST1 18355AA000 PULLEY WRENCH

   ST2 18334AA000 PULLEY WRENCH PIN SET

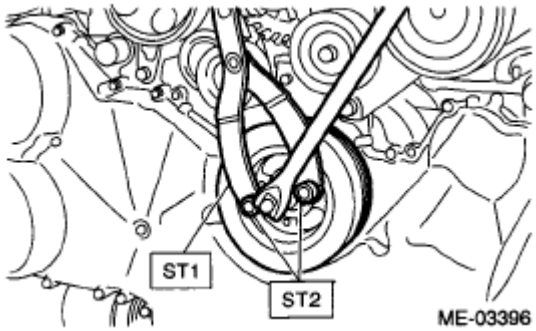

Fig. 68: Identifying Pulley Wrench And Pulley Wrench Pin Set
Courtesy of SUBARU OF AMERICA, INC.

4. Remove the crank pulley.

INSTALLATION

1. Install the crank pulley.
2. Install the crank pulley bolt. To lock the crankshaft, use ST.

   ST1 18355AA000 PULLEY WRENCH

   ST2 18334AA000 PULLEY WRENCH PIN SET

   1. Clean the crankshaft thread using compressed air.
   2. Apply engine oil to the crank pulley bolt seat and thread.
   3. Tighten the crank pulley bolts.

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Tightening torque: 195 N.m (19.9 kgf-m, 143.8 ft-lb)

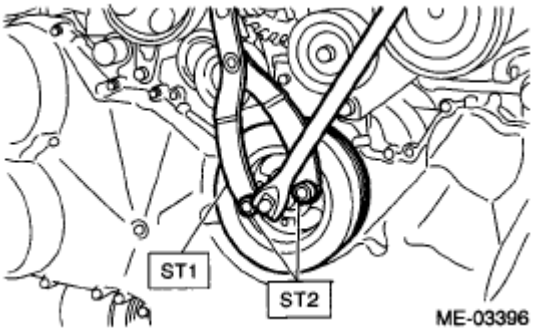

Fig. 69: Identifying Pulley Wrench And Pulley Wrench Pin Set
Courtesy of SUBARU OF AMERICA, INC.

3. Install the crank pulley cover.

NOTE: Assemble the O-ring to crank pulley cover.

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

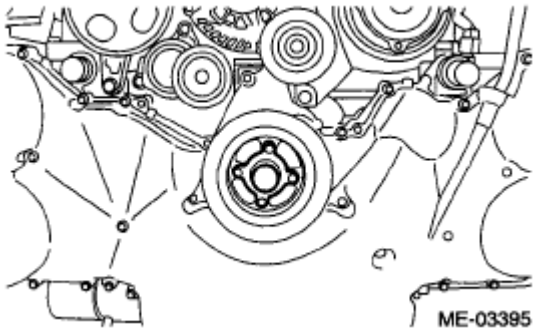

Fig. 70: Identifying Crank Pulley Cover
Courtesy of SUBARU OF AMERICA, INC.

4. Install the V-belt. Ref. to **INSTALLATION**, V-belt.

INSPECTION

1. Check the crank pulley cover for oil and air leakage.
2. Check the crank pulley for looseness.

CHAIN COVER

REMOVAL

NOTE: When replacing the single part, perform the work with the engine installed to

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body.

1. Drain the engine oil. Ref. to **REPLACEMENT** , Engine Oil.
2. Remove the V-belts. Ref. to **REMOVAL**, V-belt.
3. Remove the crank pulley. Ref. to **REMOVAL**, Crank Pulley.
4. Remove the bolts which hold oil cooler pipe to chain cover.

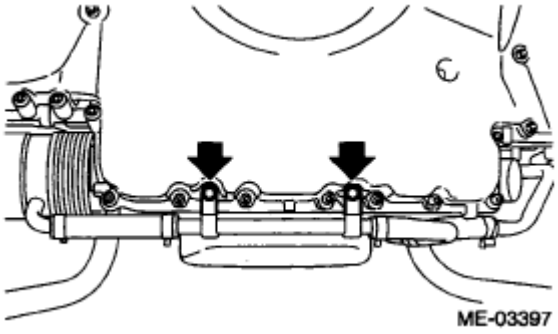

Fig. 71: Locating Oil Cooler Pipe Bolts
Courtesy of SUBARU OF AMERICA, INC.

5. 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.

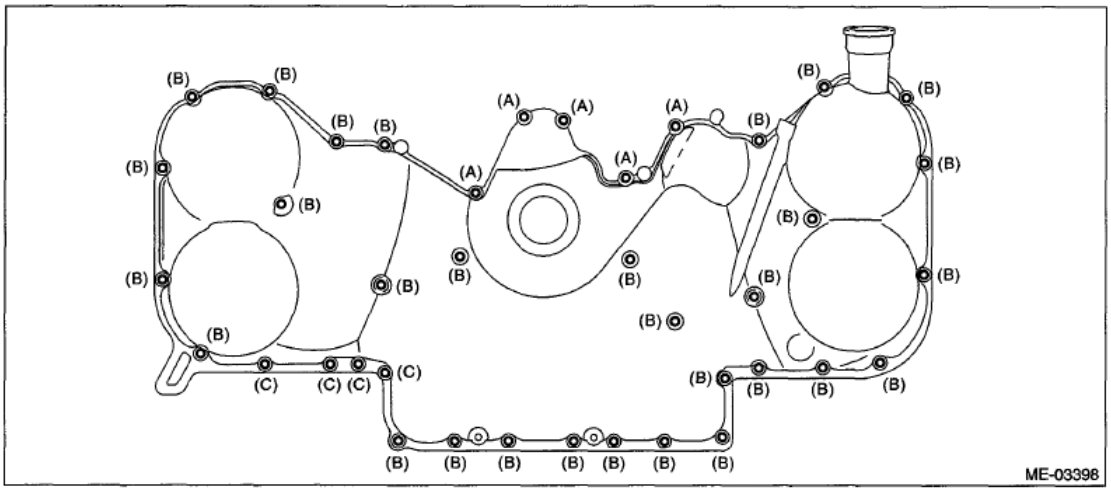

Fig. 72: Identifying Chain Cover Bolts
Courtesy of SUBARU OF AMERICA, INC.

INSTALLATION

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

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

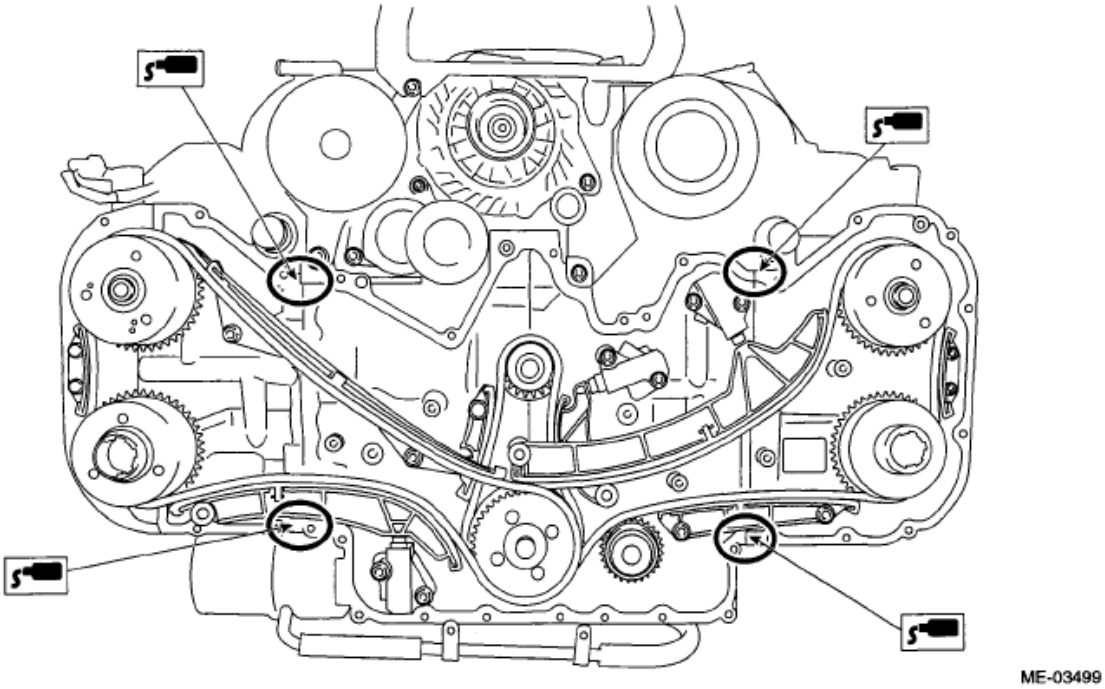

Fig. 73: Identifying Cylinder Head And Oil Pan Upper
Courtesy of SUBARU OF AMERICA, INC.

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

   NOTE: Install the oil pan lower within 5 minutes after applying liquid gasket.

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

   Applying liquid gasket diameter: 3.5±0.5 mm (0.138 ±0.020 in)

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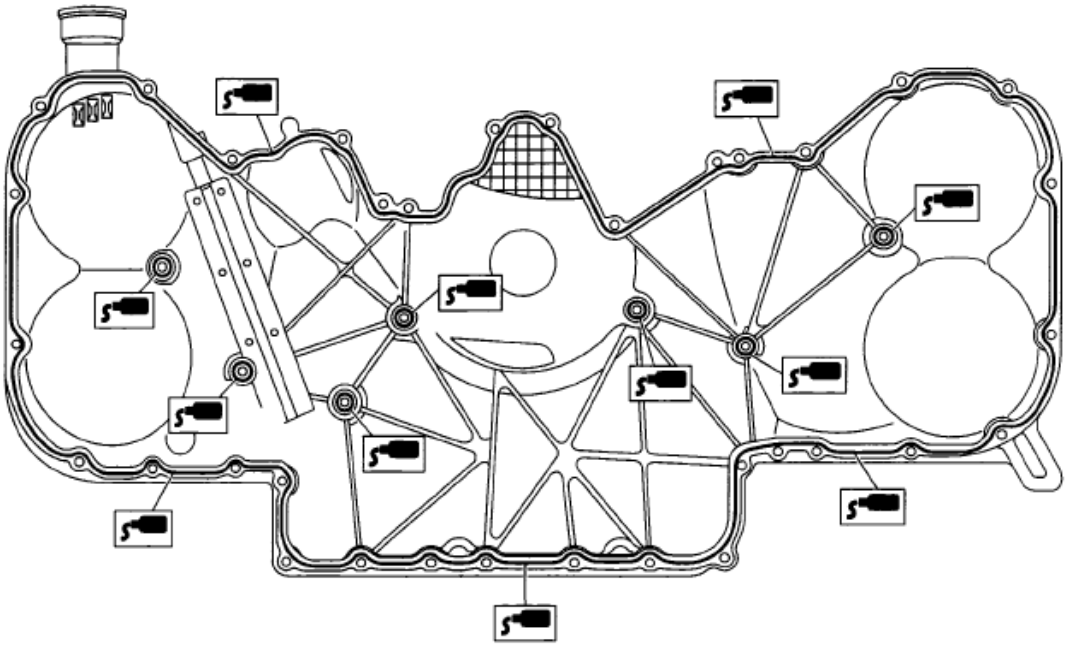
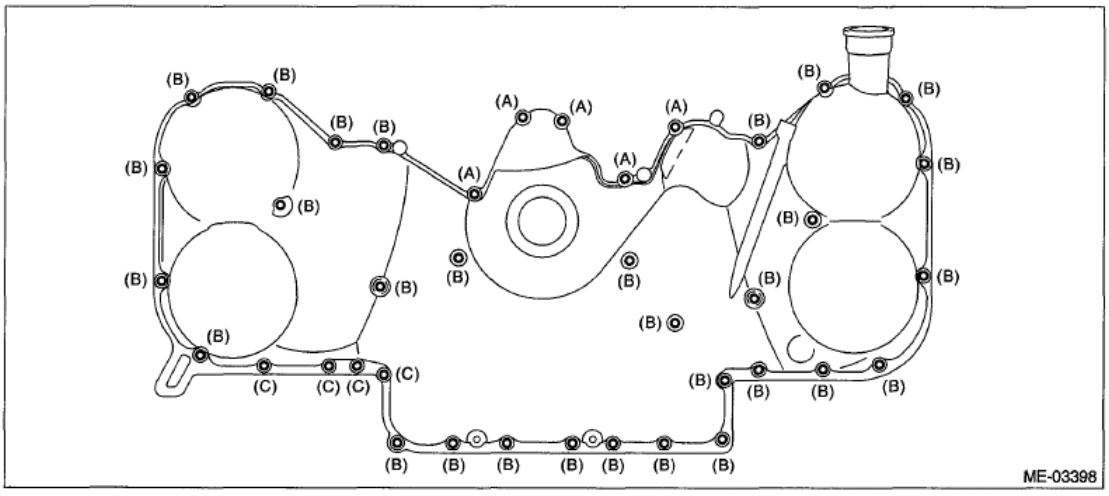


ME-03545

Fig. 74: Applying Liquid Gasket To Mating Surface Of Chain Cover
Courtesy of SUBARU OF AMERICA, INC.

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

CAUTION: Do not install the bolts in wrong place.



(A) M6 × 21 (B) M6 × 30 (C) M6 × 53

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Fig. 75: Identifying Chain Cover Bolts
Courtesy of SUBARU OF AMERICA, INC.

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

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

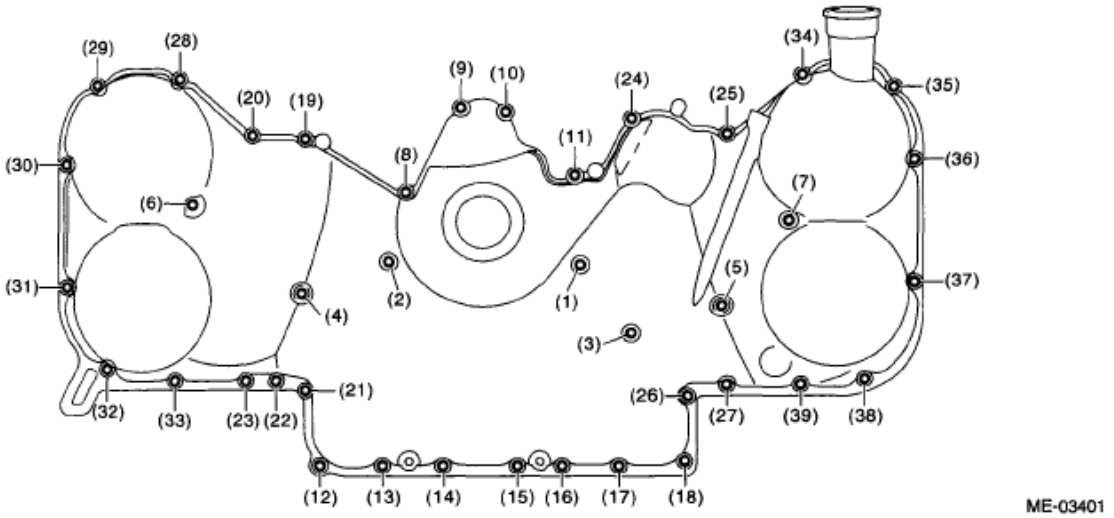

Fig. 76: Identifying Tightening Sequence Of Bolts
Courtesy of SUBARU OF AMERICA, INC.

5. Tighten the bolts which install oil cooler pipe on chain cover.

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

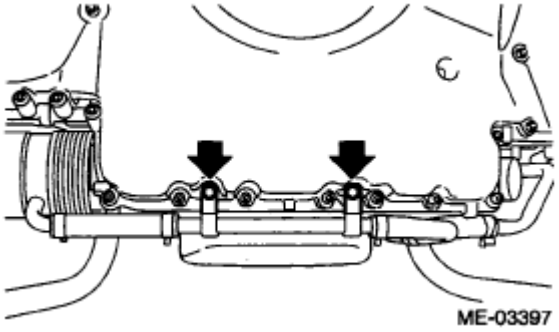

Fig. 77: Locating Oil Cooler Pipe Bolts
Courtesy of SUBARU OF AMERICA, INC.

6. Install the crank pulley. Ref. to **INSTALLATION**, Crank Pulley.
7. Install the V-belts. Ref. to **INSTALLATION**, V-belt.
8. Fill with engine oil. Ref. to **REPLACEMENT** , Engine Oil.
9. Confirm that there are no oil leakage at the chain cover mating surface.

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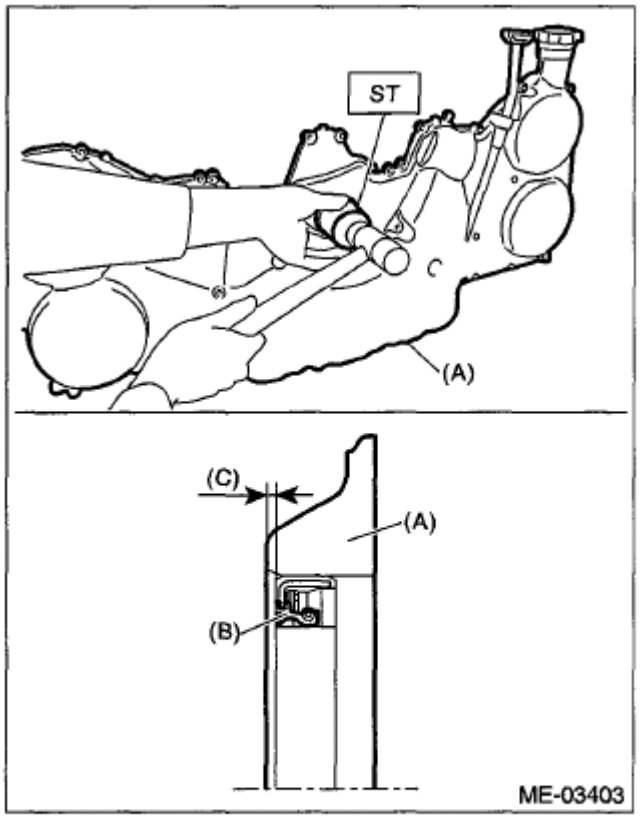
INSPECTION

1. Check the cover surface for scratch or dent.
2. Check for oil leakage on cover mating surface and installation part of crank pulley.

   If the oil leakage is found at the oil seal, replace the oil seal with a new part.

   ST 499585700 OIL SEAL GUIDE

   Oil seal press-fit position: Chain cover edge - -1 mm (-0.039 in) position from chain cover edge



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

Fig. 78: Identifying Oil Seal Guide
Courtesy of SUBARU OF AMERICA, INC.

TIMING CHAIN ASSEMBLY

LOCATION

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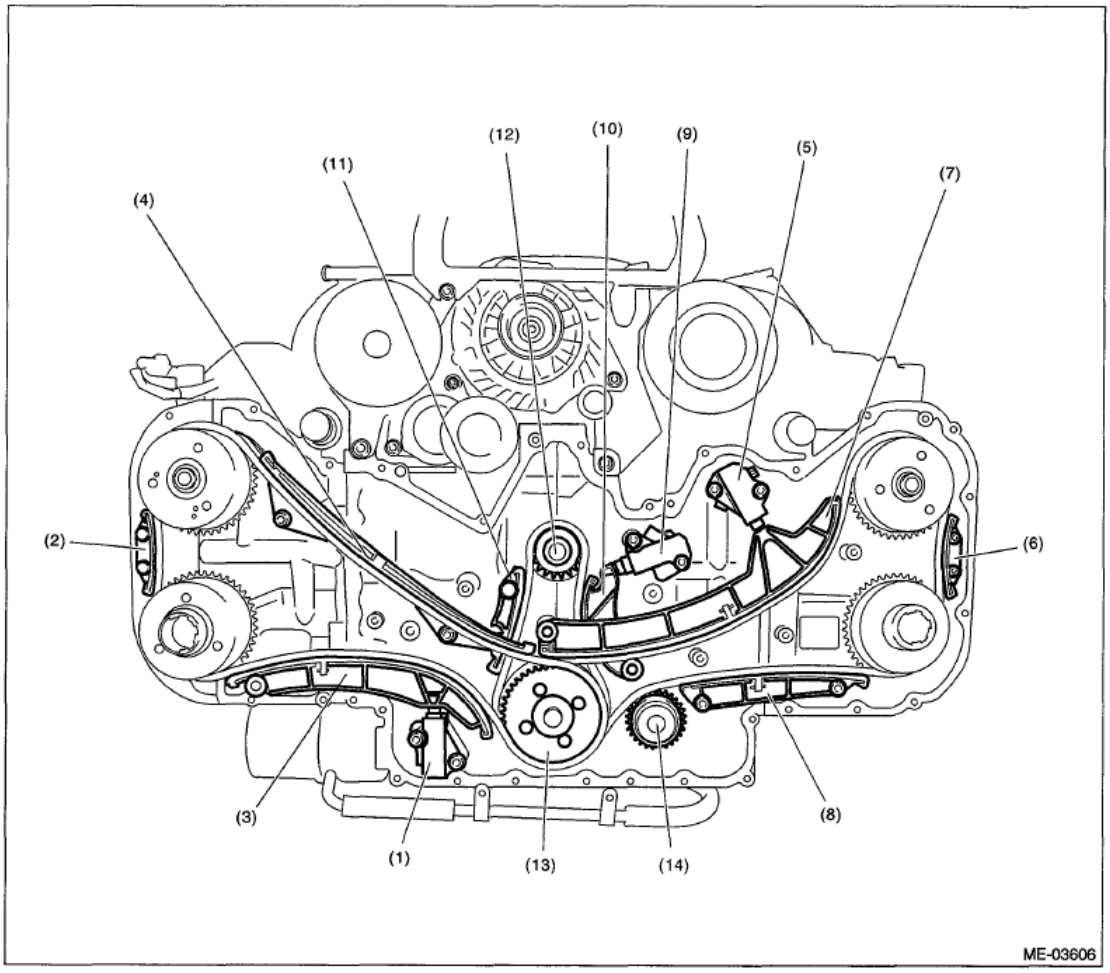

(1)	Chain tensioner (RH)	(6)	Chain guide (LH: between cams)	(11)	Chain guide (Main)
(2)	Chain guide (RH: between cams)	(7)	Chain tensioner lever (LH)	(12)	Crank sprocket
(3)	Chain tensioner lever (RH)	(8)	Chain guide (LH)	(13)	Idler sprocket
(4)	Chain guide (RH)	(9)	Chain tensioner (Main)	(14)	Water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

Fig. 79: Identifying Timing Chain Assembly
Courtesy of SUBARU OF AMERICA, INC.

REMOVAL

NOTE:

- **When replacing the single part, perform the work with the engine installed to body.**
- **After removal, arrange the timing chain components in proper order, to prevent confusion.**

1. Drain the engine oil. Ref. to **REPLACEMENT** , Engine Oil.
2. Remove the radiator. Ref. to **REMOVAL** , Radiator.
3. Remove the V-belts. Ref. to **REMOVAL**, V-belt.
4. Remove the crank pulley. Ref. to **REMOVAL**, Crank Pulley.

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5. Remove the chain cover. Ref. to **REMOVAL**, Chain Cover.
6. Remove the chain tensioner (RH).

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

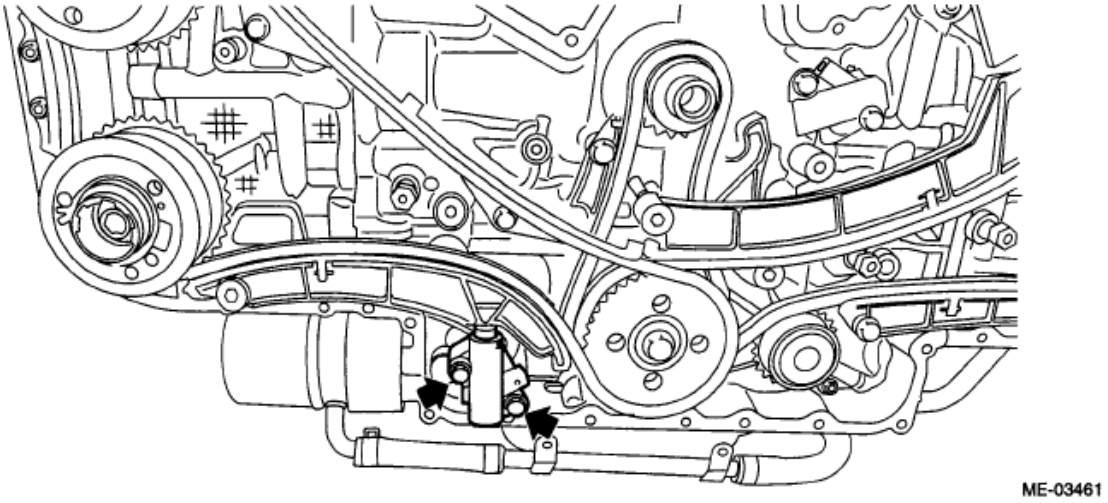

Fig. 80: Locating Chain Tensioner Lever (RH)
Courtesy of SUBARU OF AMERICA, INC.

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

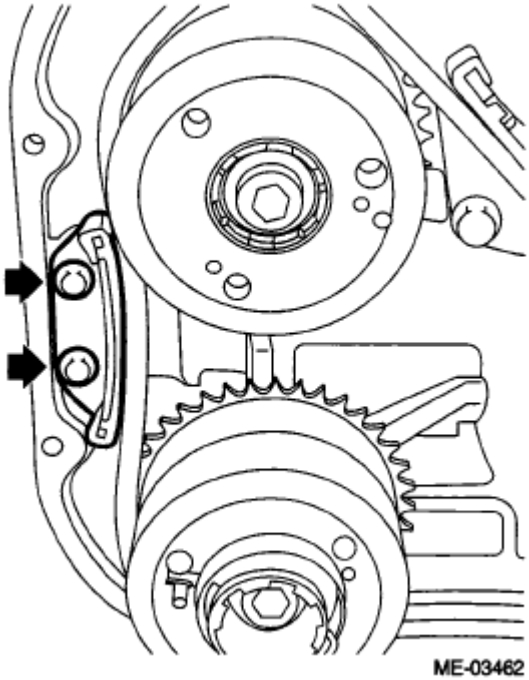

Fig. 81: Locating Chain Guide

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Courtesy of SUBARU OF AMERICA, INC.

8. Remove the chain tensioner lever (RH).

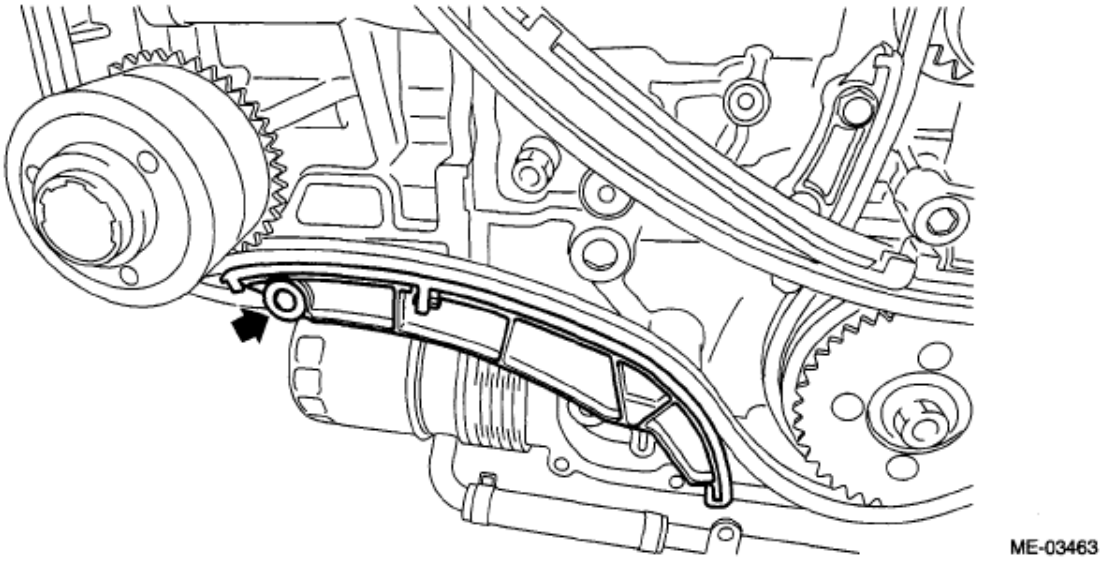

Fig. 82: Locating Chain Tensioner Lever (RH)
Courtesy of SUBARU OF AMERICA, INC.

9. Remove the chain guide (RH).

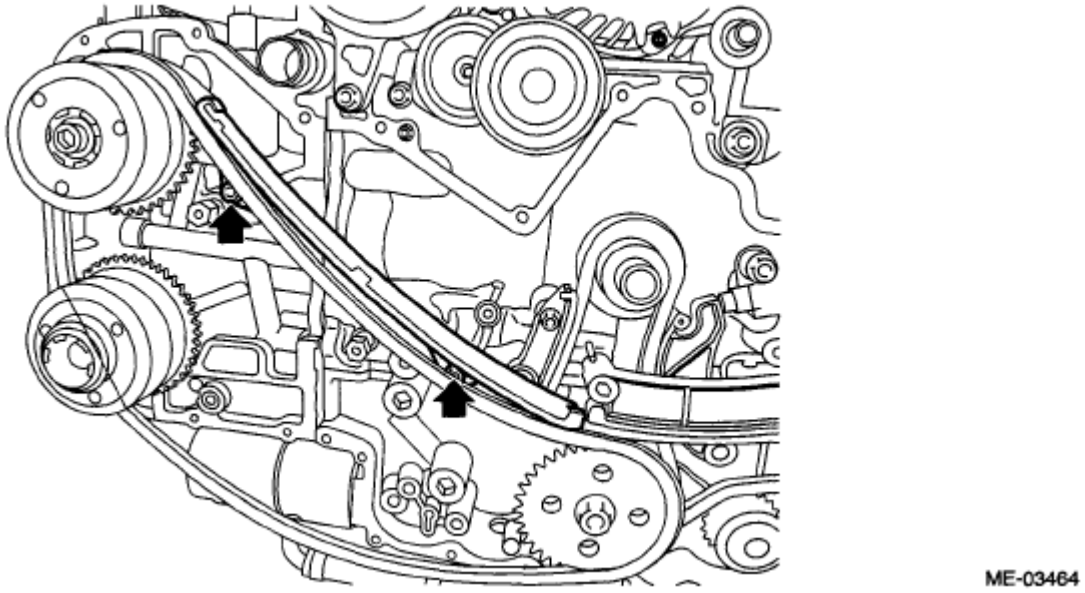

Fig. 83: Locating Chain Guide (RH)
Courtesy of SUBARU OF AMERICA, INC.

10. Remove the timing chain (RH).

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11. Remove the chain tensioner (LH).

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

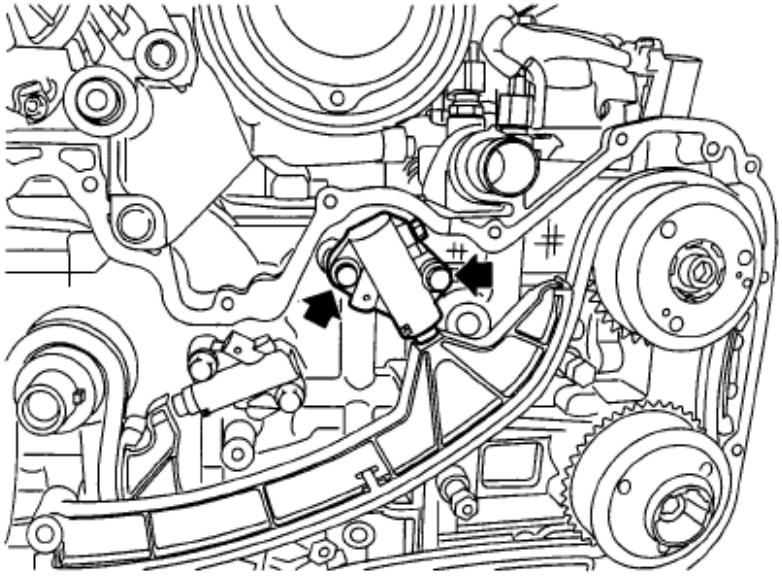

Fig. 84: Locating Timing Chain (RH)
Courtesy of SUBARU OF AMERICA, INC.

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

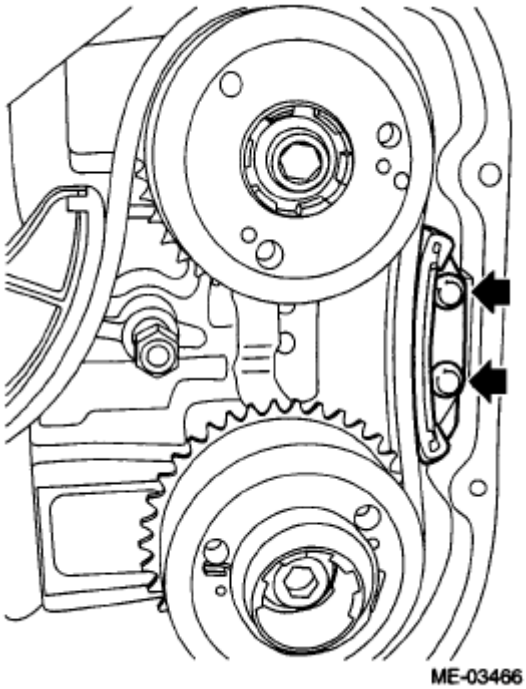

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Fig. 85: Locating Chain Guide (LH)
Courtesy of SUBARU OF AMERICA, INC.

13. Remove the chain tensioner lever (LH).

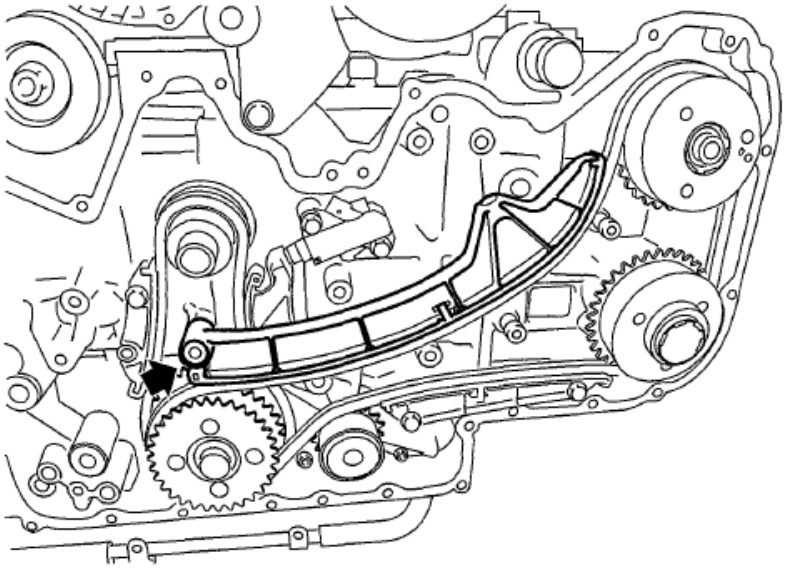

Fig. 86: Locating Chain Tensioner Lever (LH)
Courtesy of SUBARU OF AMERICA, INC.

14. Remove the chain guide (LH).

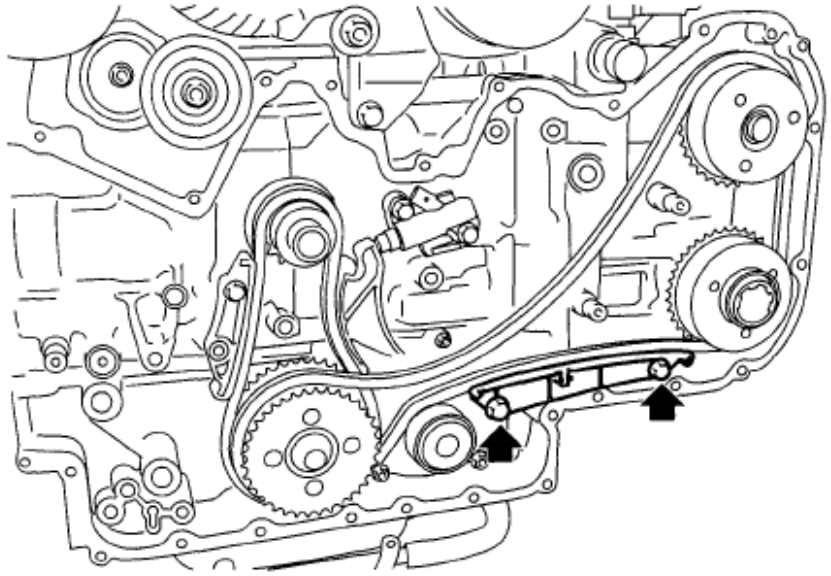

Fig. 87: Locating Chain Guide (LH)
Courtesy of SUBARU OF AMERICA, INC.

15. Remove the timing chain (LH).

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16. Remove the chain tensioner (Main).

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

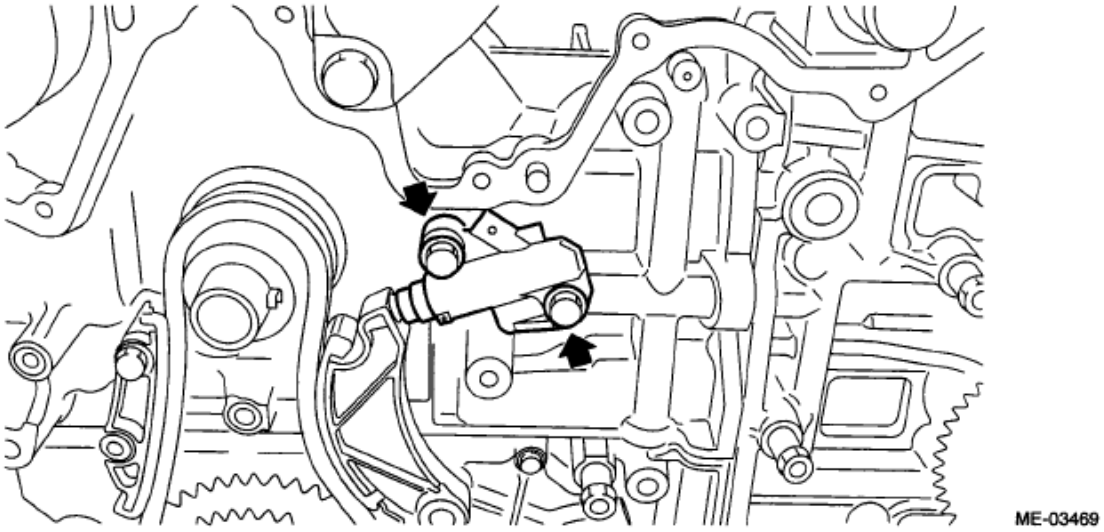

Fig. 88: Locating Timing Chain (LH)
Courtesy of SUBARU OF AMERICA, INC.

17. Remove the chain guide (Main).

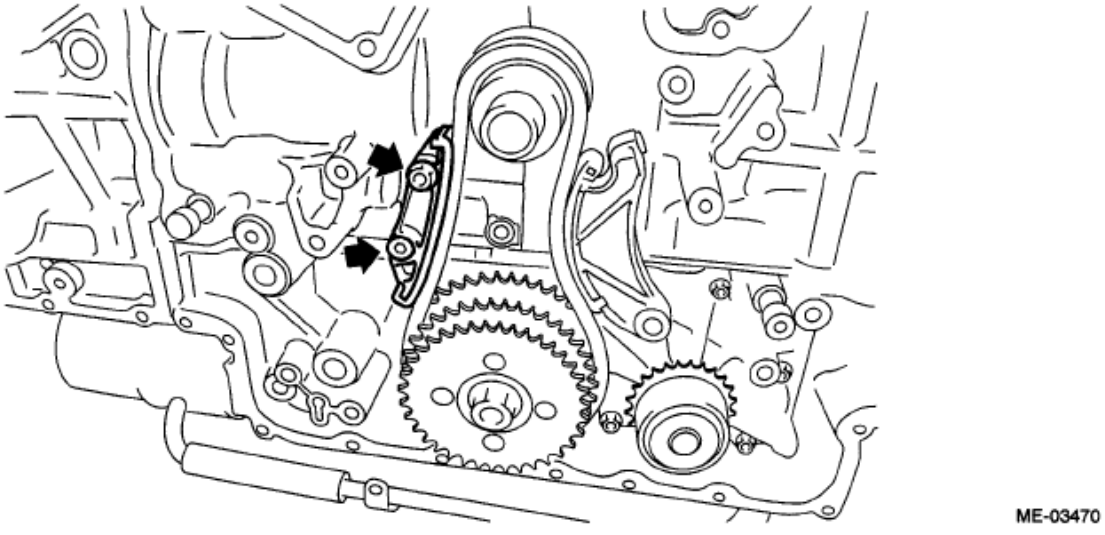

Fig. 89: Locating Chain Guide (Main)
Courtesy of SUBARU OF AMERICA, INC.

18. Remove the chain tensioner lever (Main).

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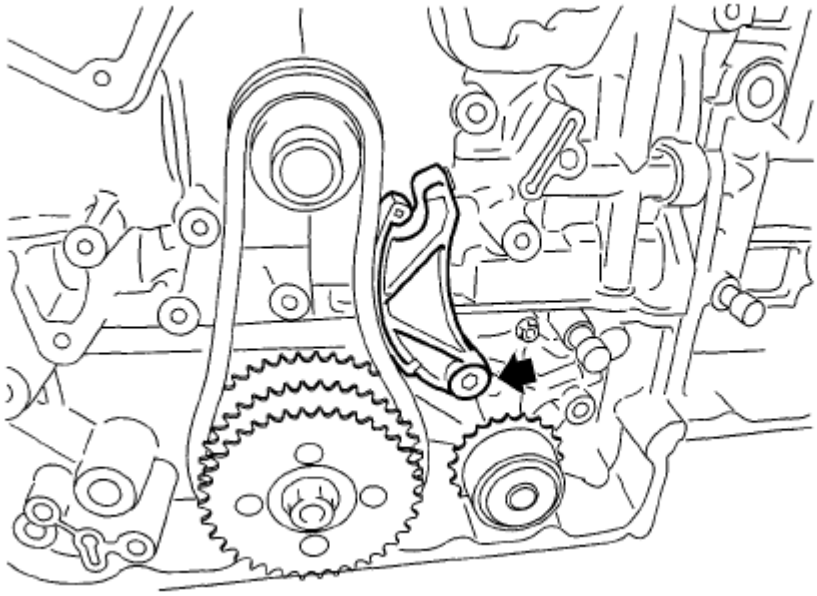

Fig. 90: Locating Chain Tensioner Lever (Main)
Courtesy of SUBARU OF AMERICA, INC.

19. Remove the idler sprocket, and then remove the idler sprocket and timing chain (Main).

    ST1 18355AAA000 PULLEY WRENCH

    ST2 18334AAA000 PULLEY WRENCH PIN SET

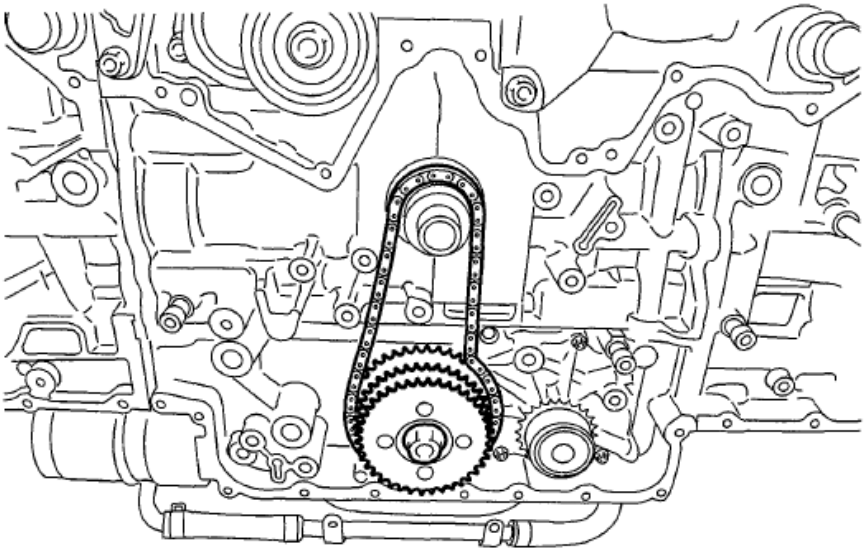

Fig. 91: Identifying Idler Sprocket And Timing Chain (Main)
Courtesy of SUBARU OF AMERICA, INC.

INSTALLATION

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NOTE:

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

1. Prepare for chain tensioner installation.
    1. Insert the screw, spring pin and plunger into the tensioner body.
    2. Rotate the rubber mat counterclockwise while pressing the chain tensioner from upper side by hand as shown in the figure.

NOTE: **Degrease the contact surface of the plunger head and rubber mat so that they do not slip.**

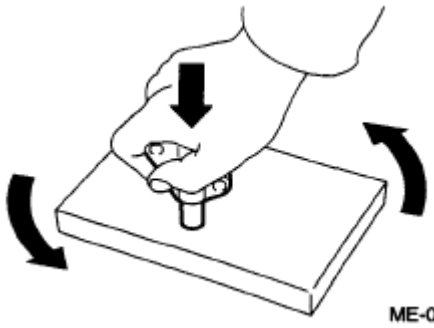

Fig. 92: Rotating Rubber Mat And Pressing Chain Tensioner
Courtesy of SUBARU OF AMERICA, INC.

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

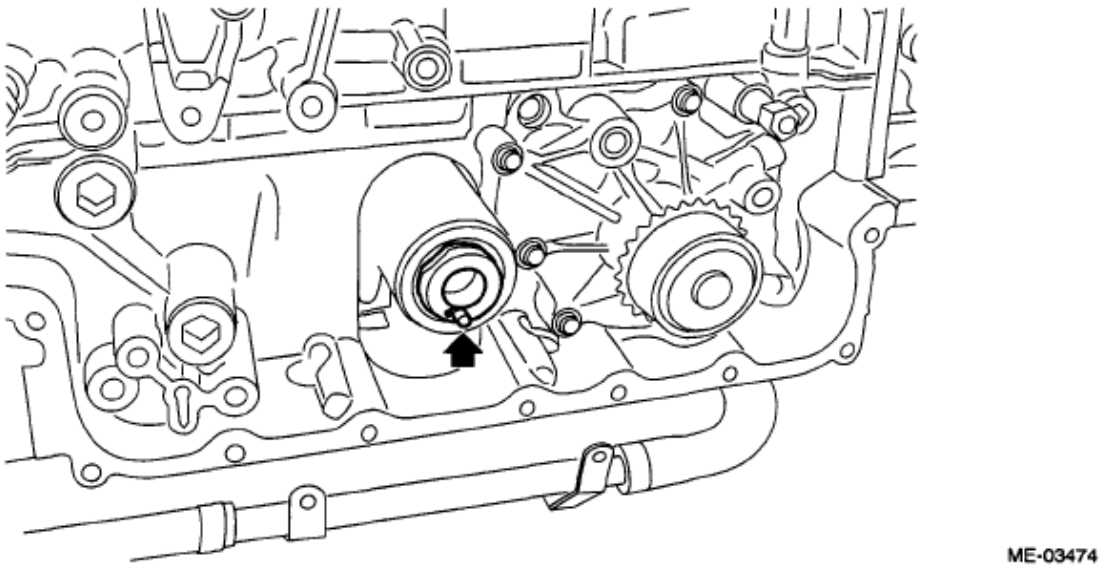

Fig. 93: Locating Oil Pump Shaft Knock Pin

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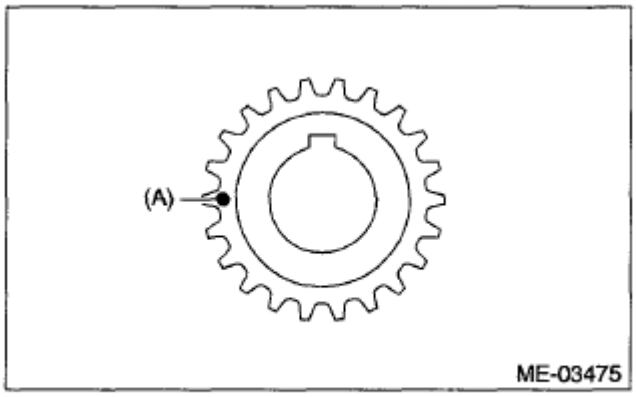
Courtesy of SUBARU OF AMERICA, INC.

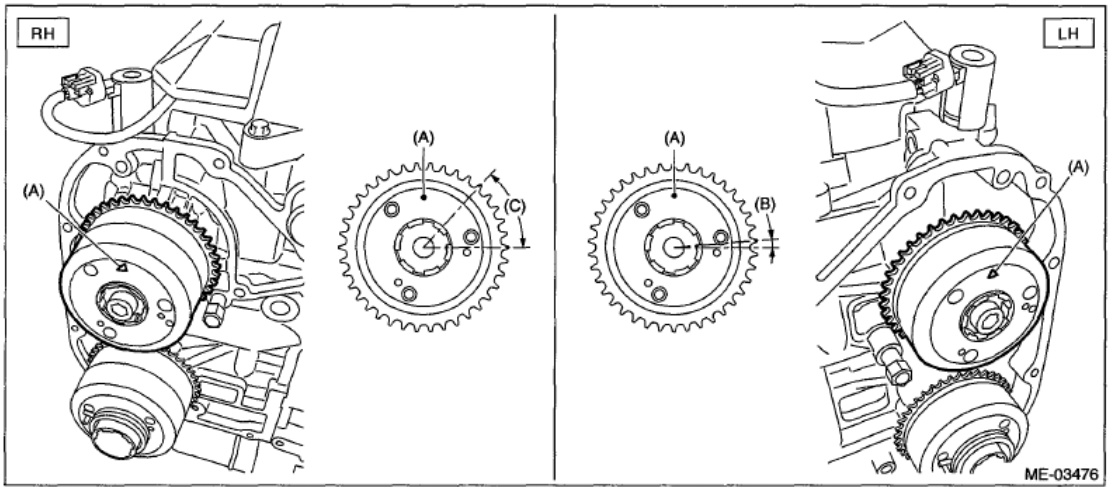
3. Using the ST, align the "Top mark" on crank sprocket to nine o'clock position as shown in the figure



(A) Top mark

Fig. 94: Identifying Top Mark" On Crank Sprocket
Courtesy of SUBARU OF AMERICA, INC.

4. Align the intake cam sprocket to 12 o'clock position as shown in the figure.



(A) Align the marking (Top mark) position to 12 o'clock position. (B) 6° (C) 47°

Fig. 95: Aligning Intake Cam Sprocket
Courtesy of SUBARU OF AMERICA, INC.

5. Align the exhaust cam sprocket to 12 o'clock position as shown in the figure.

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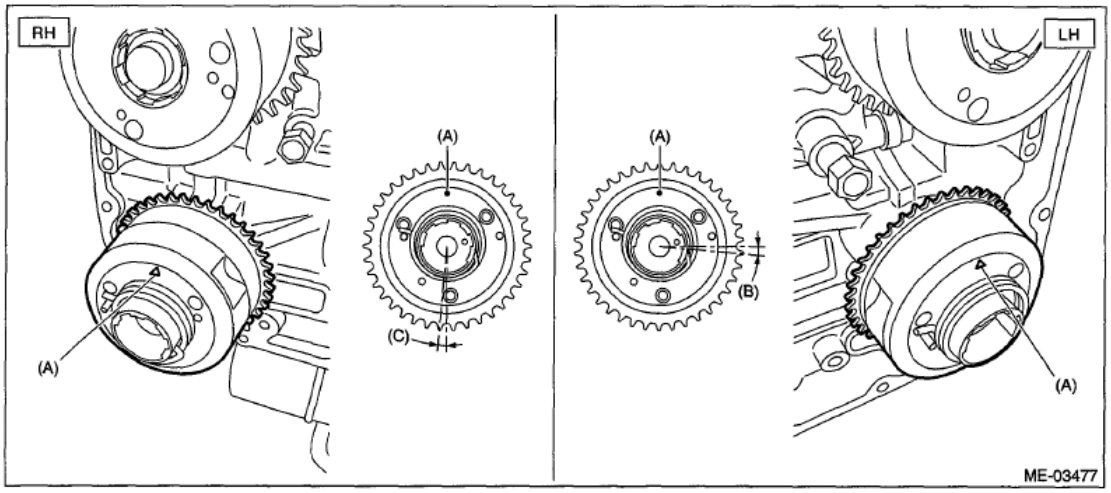


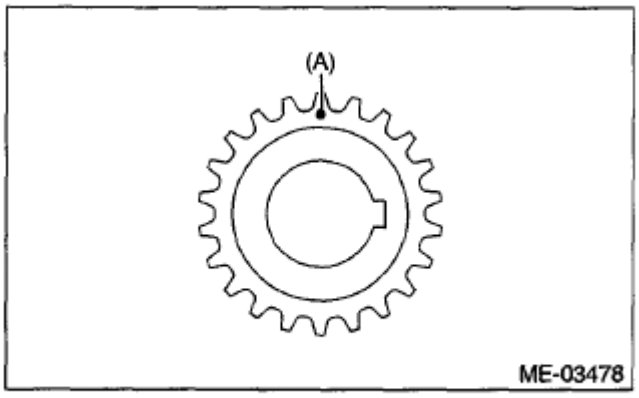
(A) Align the marking (Top mark) position to 12 o'clock position. (B) 5.5° (C) 3.5°

Fig. 96: Aligning Exhaust Cam Sprocket
Courtesy of SUBARU OF AMERICA, INC.

6. Using the ST, align the "Top mark" on crank sprocket to 12 o'clock position as shown in the figure

NOTE:

- **Piston #1 is in top dead center (TDC) position.**
- **Do not rotate the crankshaft and cam sprocket before completing timing chain installation.**
- **Crank sprocket key is located at three o'clock position.**



(A) Top mark

Fig. 97: Identifying Top Mark
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)

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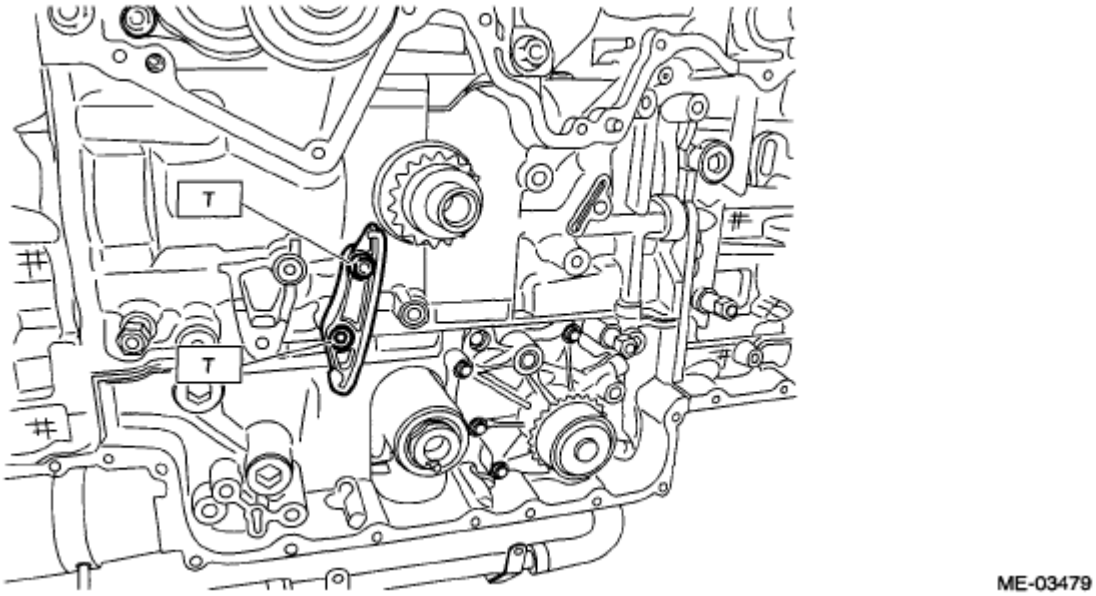

Fig. 98: Identifying Chain Guide (Main)
Courtesy of SUBARU OF AMERICA, INC.

8. Install the idler sprocket and timing chain (Main).
    1. Align the timing chain mark (gold) to the idler sprocket timing mark position.
    2. Align the idler sprocket timing mark to the six o'clock position, and then install the idler sprocket and timing chain.
    3. Confirm the timing chain mark (gold) is set to the crank sprocket 12 o'clock position.
    4. Install the idler sprocket bolt.

        ST1 18355AAA000 PULLEY WRENCH

        ST2 18334AAA000 PULLEY WRENCH PIN SET

        Tightening torque: 120 N.m (12.2 kgf-m, 88.5 ft-lb)

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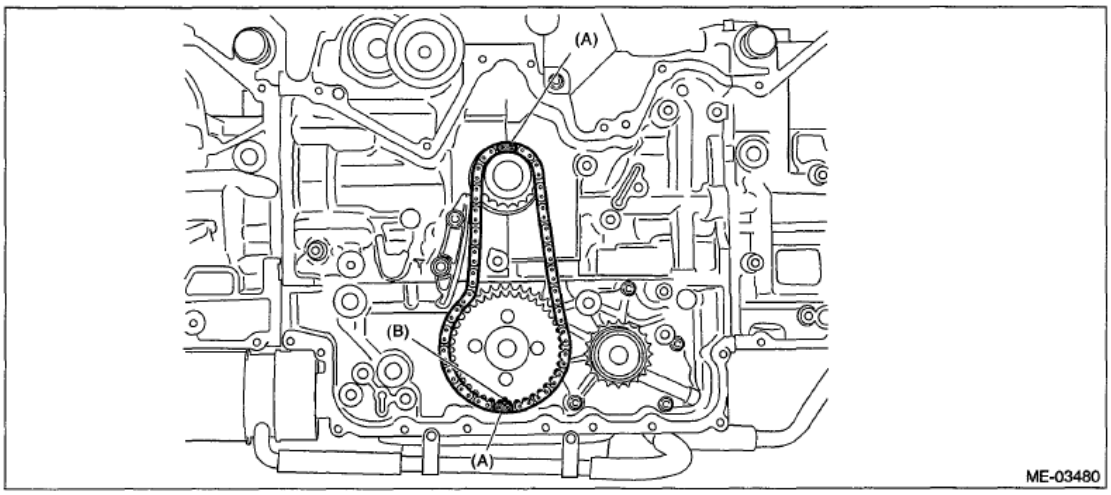

(A) Gold (B) Timing mark

Fig. 99: Identifying Timing Mark On Chain Sprocket
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)

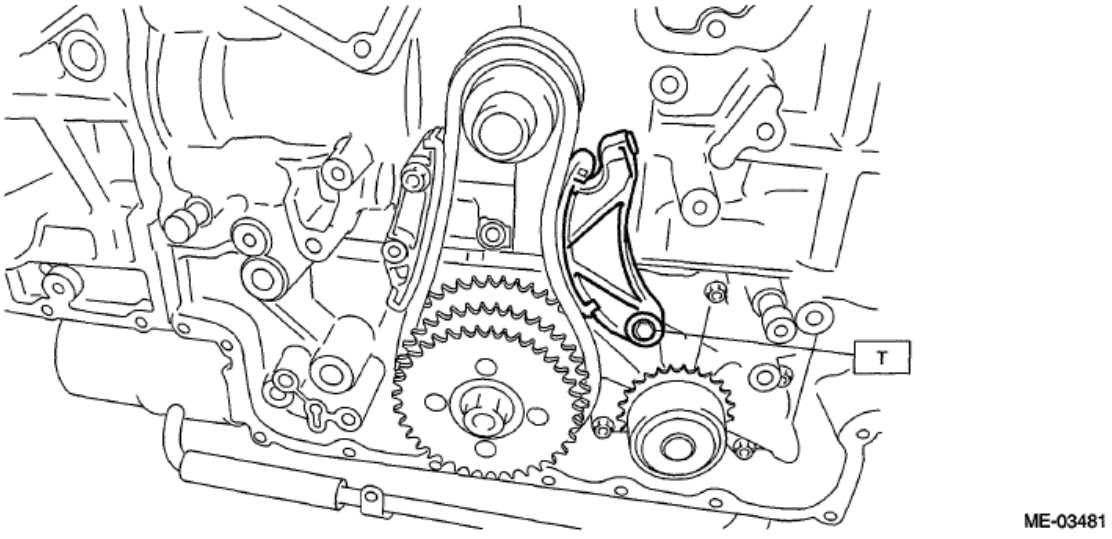

Fig. 100: Chain Tensioner Lever (Main)
Courtesy of SUBARU OF AMERICA, INC.

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

NOTE: Timing chain (main) components assembly is completed.

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

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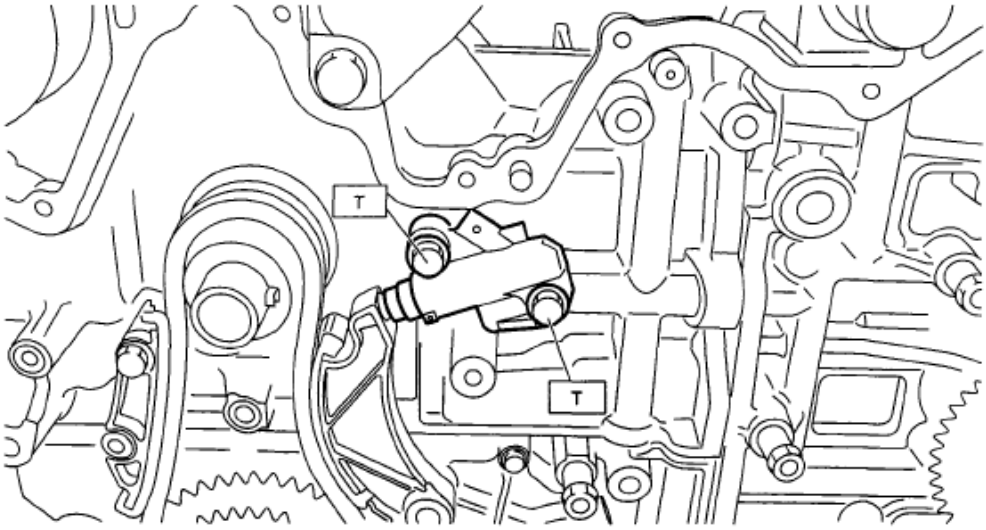

Fig. 101: Identifying Chain Tensioner And Stopper Pin
Courtesy of SUBARU OF AMERICA, INC.

11. Install the chain guide (LH).

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

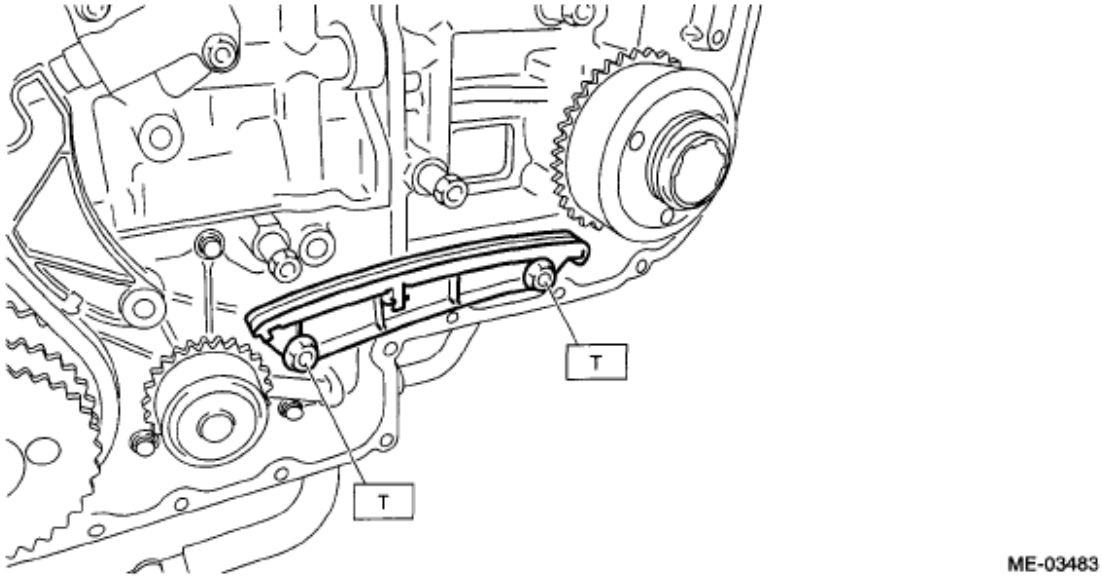

Fig. 102: Identifying Chain Guide (LH)
Courtesy of SUBARU OF AMERICA, INC.

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

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

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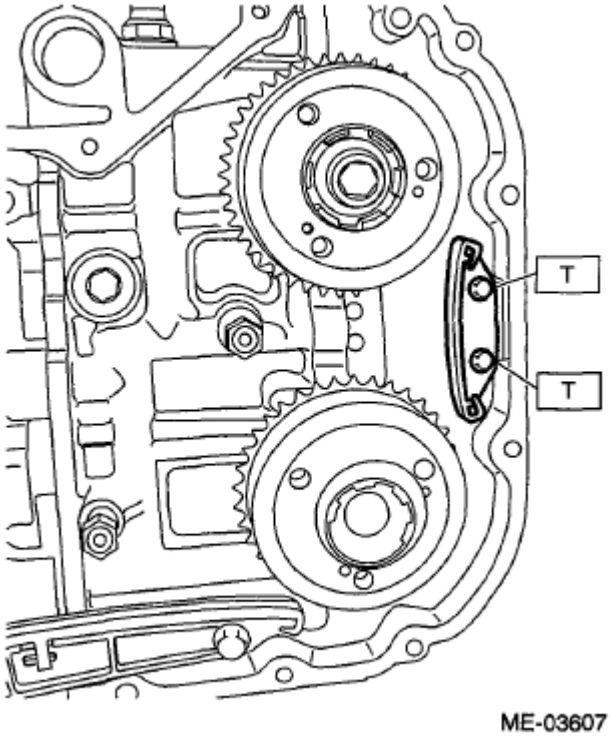

Fig. 103: Identifying Chain Guide (LH Between Cams)
Courtesy of SUBARU OF AMERICA, INC.

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

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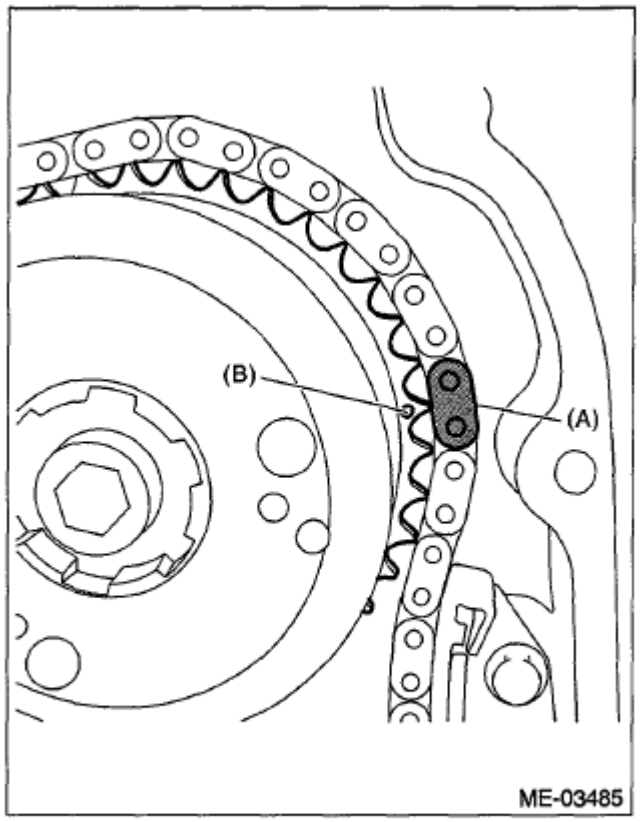

(A) Blue
(B) Timing mark

Fig. 104: Identifying Timing Mark Of Intake Cam Sprocket (LH)
Courtesy of SUBARU OF AMERICA, INC.

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

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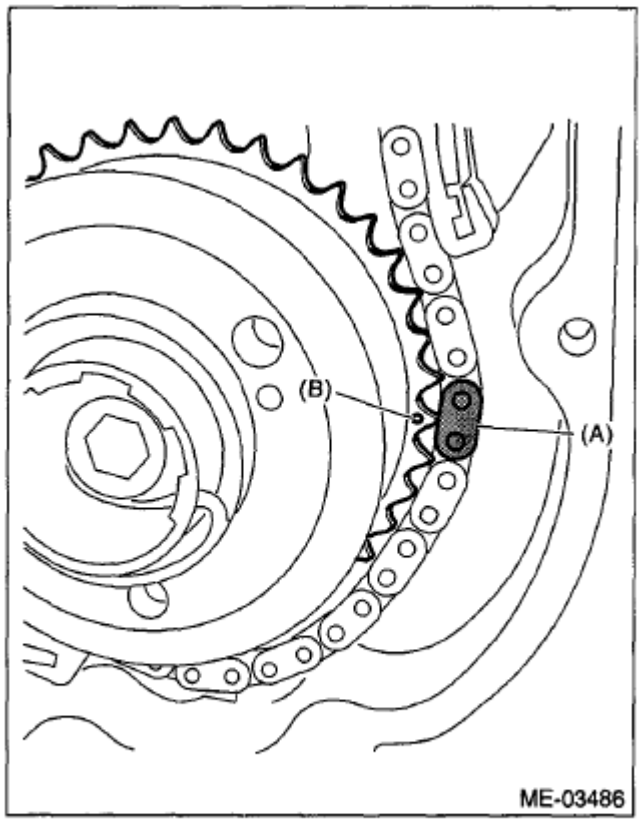
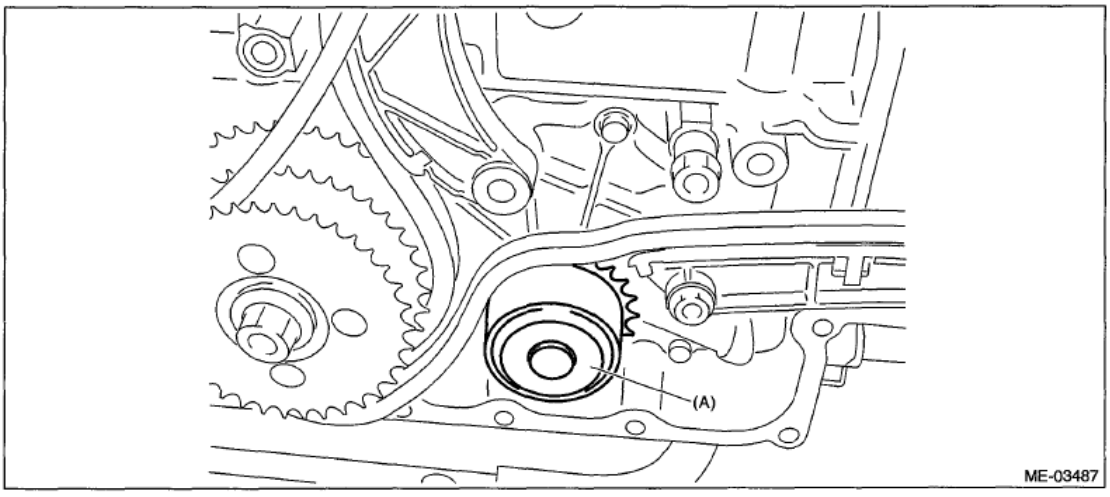


(A) Blue
(B) Timing mark

Fig. 105: Identifying Timing Mark Of Exhaust Cam Sprocket (LH)
Courtesy of SUBARU OF AMERICA, INC.

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



(A) Water pump sprocket

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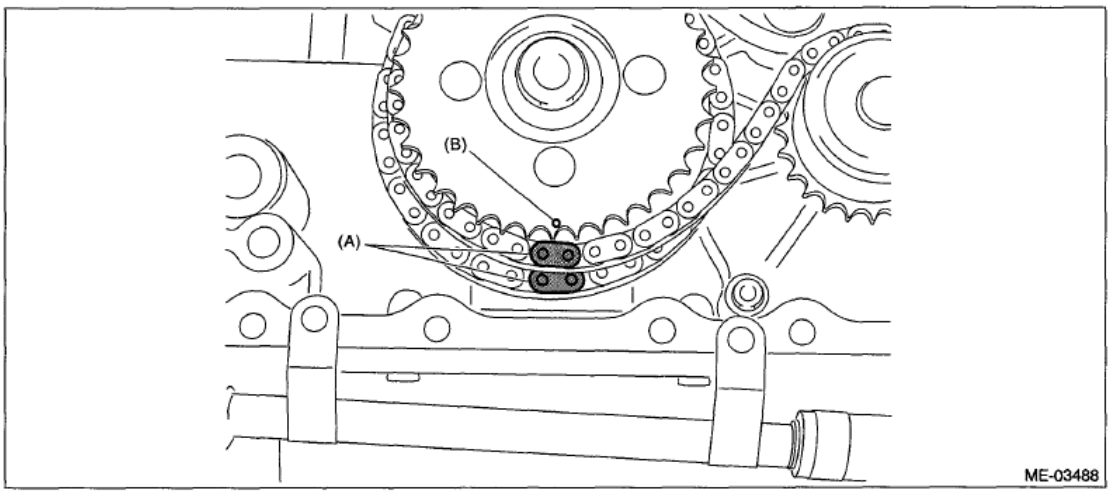
Fig. 106: Identifying Water Pump Sprocket
Courtesy of SUBARU OF AMERICA, INC.

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



(A) Gold (B) Timing mark

Fig. 107: Aligning Idler Sprocket Timing Mark To Timing Chain Mark (Gold)
Courtesy of SUBARU OF AMERICA, INC.

14. Install the chain tensioner lever (LH).

Tightening torque: 16 Win (1.6 kgf-m, 11.8 ft-lb)

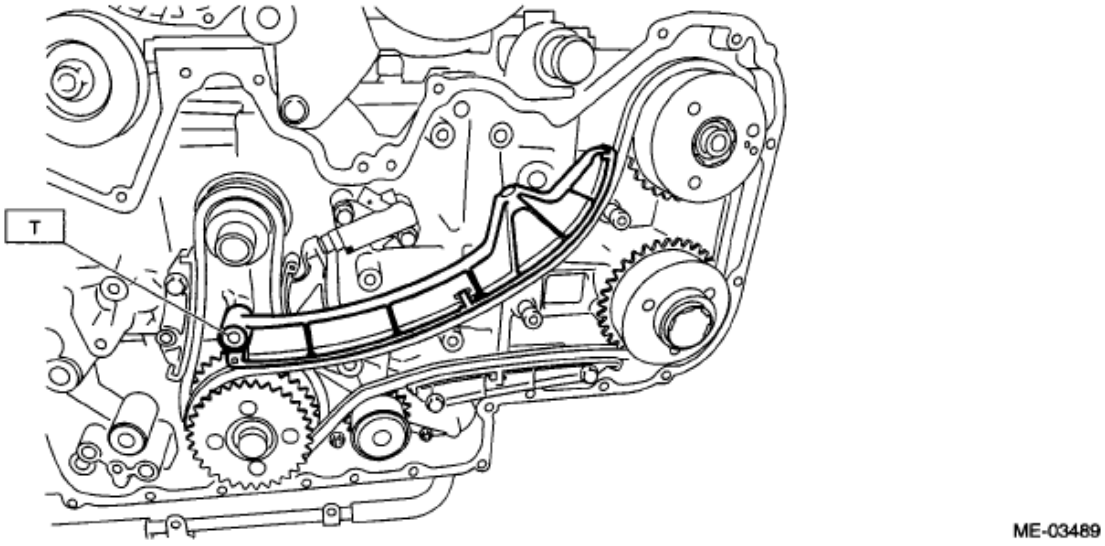


Fig. 108: Identifying Chain Tensioner Lever (LH)
Courtesy of SUBARU OF AMERICA, INC.

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

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NOTE:

- **Confirm the bolt is attached on the side of chain tensioner housing.**
- **Timing chain (LH) components assembly is completed.**

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

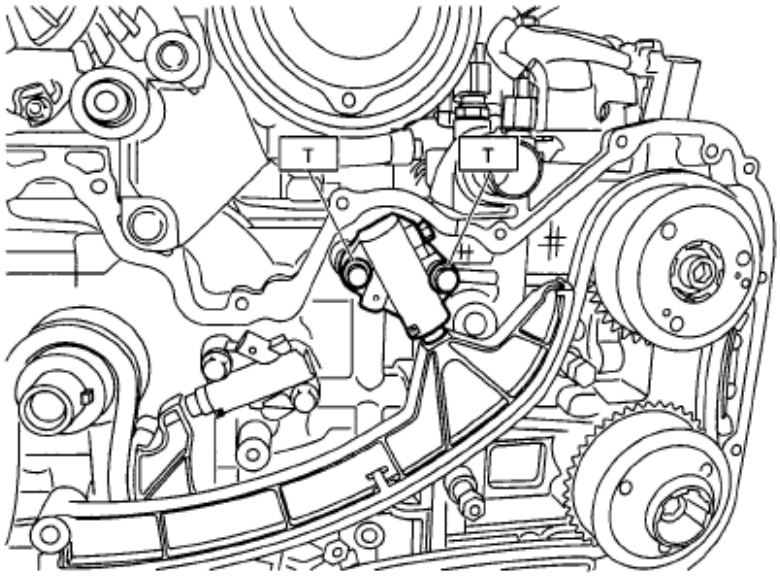

Fig. 109: Identifying Timing Chain (LH) Components Assembly
Courtesy of SUBARU OF AMERICA, INC.

16. Install the chain guide (RH).

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

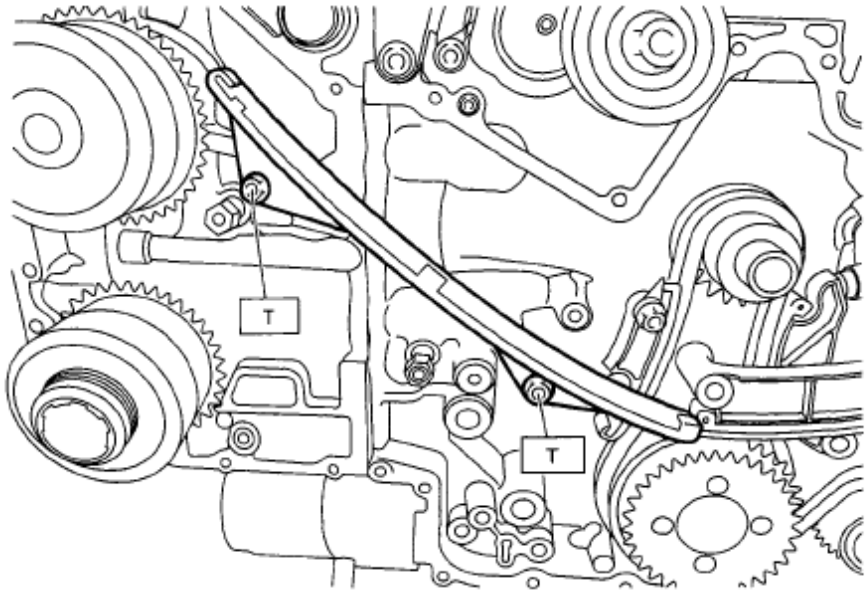

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Fig. 110: Identifying Chain Guide (RH)
Courtesy of SUBARU OF AMERICA, INC.

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

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

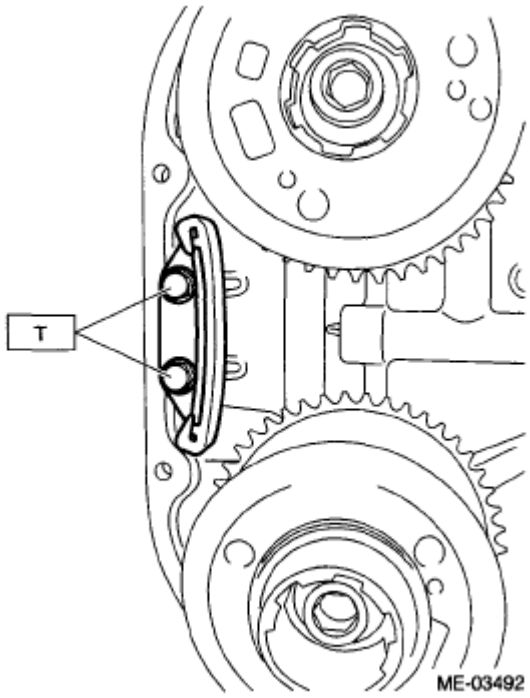

Fig. 111: Identifying Chain Guide (RH Between Cams)
Courtesy of SUBARU OF AMERICA, INC.

18. Install the timing chain (RH).
    1. Match the timing mark of the intake cam sprocket (RH) with the mark (blue) of the timing chain.

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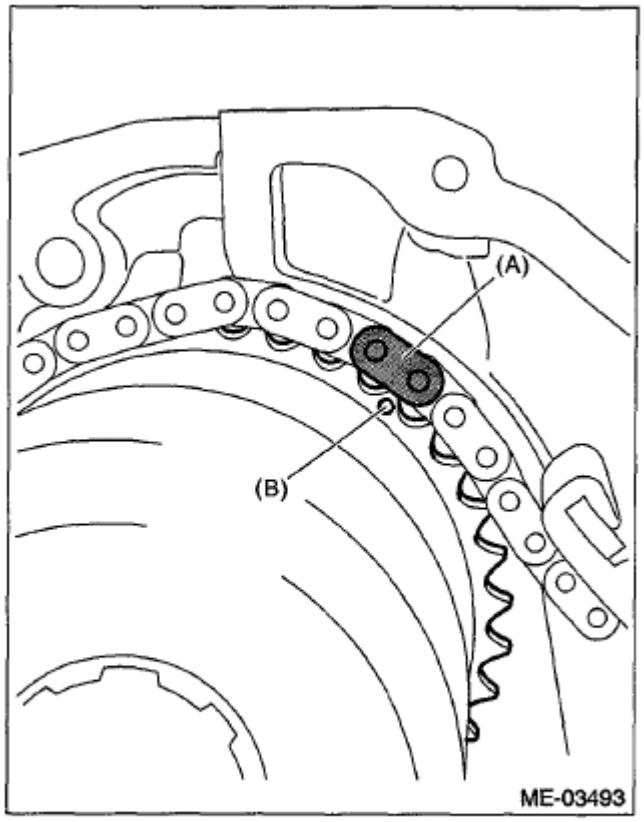

(A) Blue
(B) Timing mark

Fig. 112: Matching Timing Mark Of Intake Cam Sprocket (RH)
Courtesy of SUBARU OF AMERICA, INC.

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

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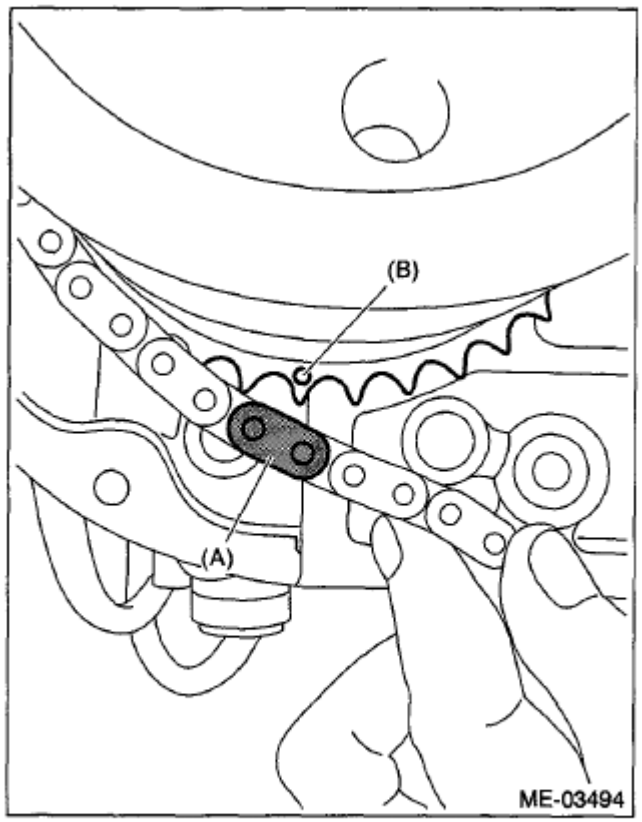
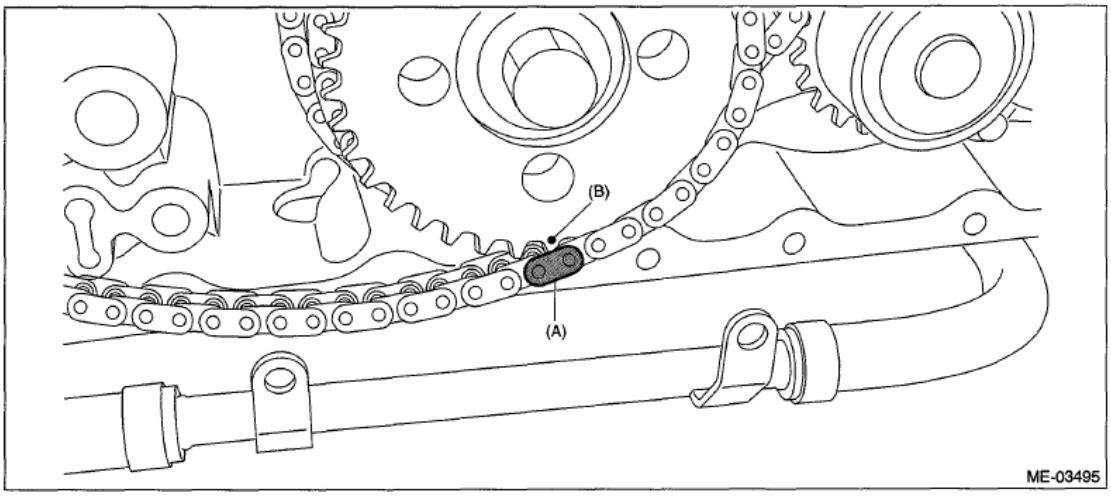


(A) Blue
(B) Timing mark

Fig. 113: Matching Timing Mark Of Exhaust Cam Sprocket (RH)
Courtesy of SUBARU OF AMERICA, INC.

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



(A) Gold (B) Timing mark

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Fig. 114: Aligning Idler Sprocket Timing Mark To Timing Chain Mark (Gold)
Courtesy of SUBARU OF AMERICA, INC.

19. Install the chain tensioner lever (RH).

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

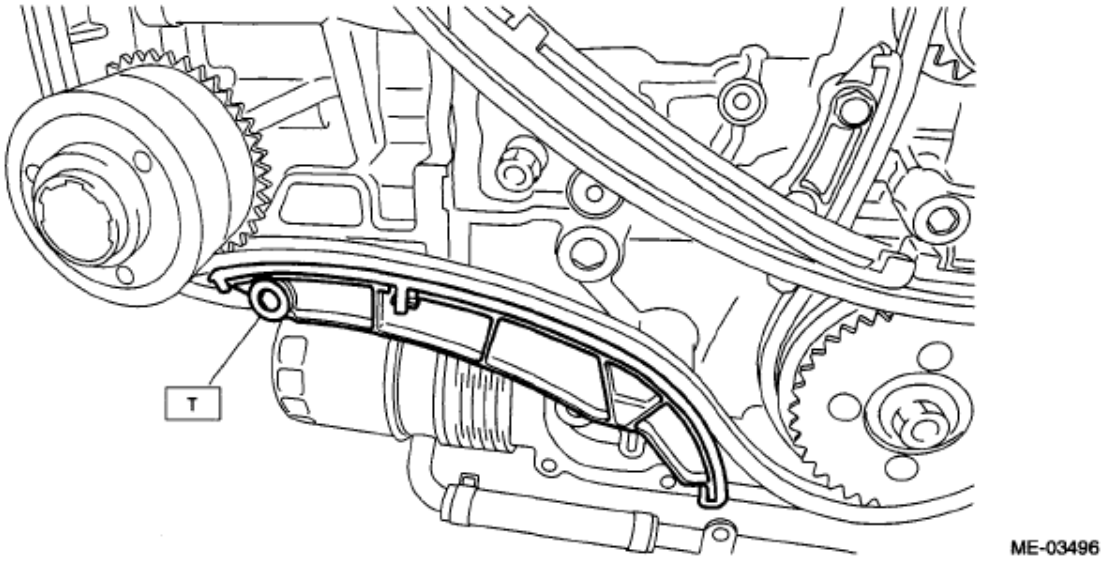

Fig. 115: Locating Chain Tensioner Lever (RH)
Courtesy of SUBARU OF AMERICA, INC.

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

NOTE: Timing chain (RH) components assembly is completed.

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

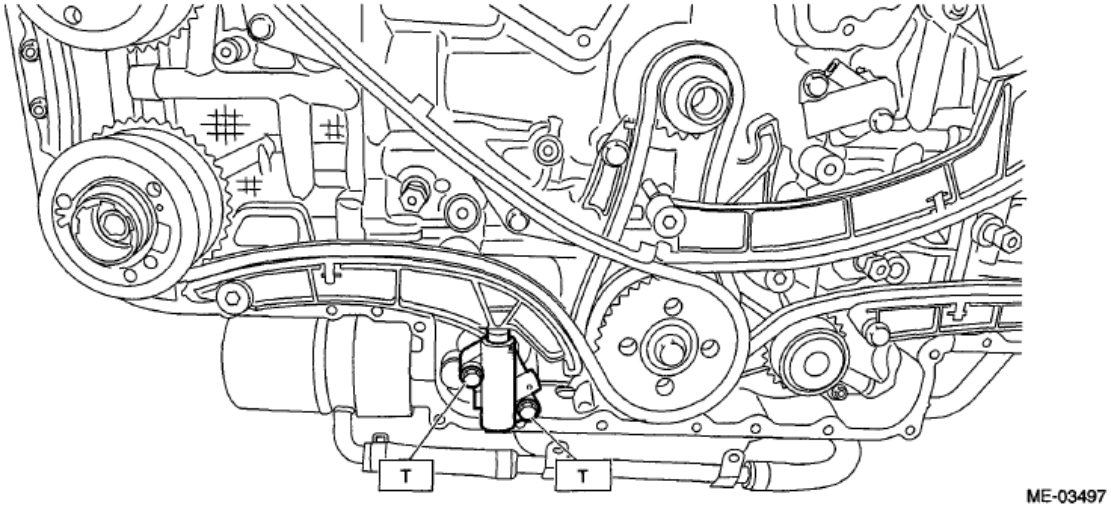

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Fig. 116: Identifying Chain Tensioner (RH) And Stopper Pin
Courtesy of SUBARU OF AMERICA, INC.

21. Confirm the following after installation.

CAUTION: Be sure to perform this confirmation.

1. Confirm that the idler sprocket timing mark and three timing chain marks (gold) are aligned.
2. Confirm that the crank sprocket 12 o'clock position and timing chain (main) mark (gold) are aligned.
3. Confirm that the LH cam sprocket timing mark and timing chain mark (blue) are aligned.
4. Confirm that the RH cam sprocket timing mark and timing chain mark (blue) are aligned.
5. Confirm that the bolts are tightened to the specified tightening torque.

22. Confirm that there are no abnormalities, while turning the crankshaft in the engine rotating direction using ST.

CAUTION: Be sure to perform this confirmation.

23. Install the chain cover. Ref. to **INSTALLATION**, Chain Cover.
24. Install the crank pulley. Ref. to **INSTALLATION**, Crank Pulley.
25. Install the V-belts. Ref. to **INSTALLATION**, V-belt.
26. Fill with engine oil. Ref. to **REPLACEMENT** , Engine Oil.
27. Confirm that there are no oil leakage at the chain cover mating surface.
28. Install the radiator. Ref. to **INSTALLATION** , Radiator.

CAM SPROCKET

REMOVAL

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

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

ST 499977500 CAM SPROCKET WRENCH

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- Intake side

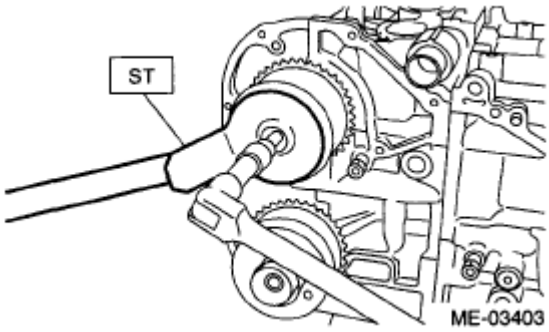

Fig. 117: Identifying Cam Sprocket Wrench (Intake Side)
Courtesy of SUBARU OF AMERICA, INC.

- Exhaust side

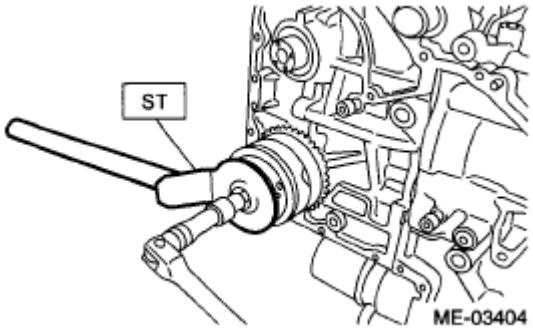

Fig. 118: Identifying Cam Sprocket Wrench (Exhaust Side)
Courtesy of SUBARU OF AMERICA, INC.

INSTALLATION

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

   Tightening torque: 29.5 N.m (3.0 kgf-m, 21.8 ft-lb)

2. Further tighten the bolt.

   Tightening angle: 45° ±5°

   ST 499977500 CAM SPROCKET WRENCH

   - Intake side

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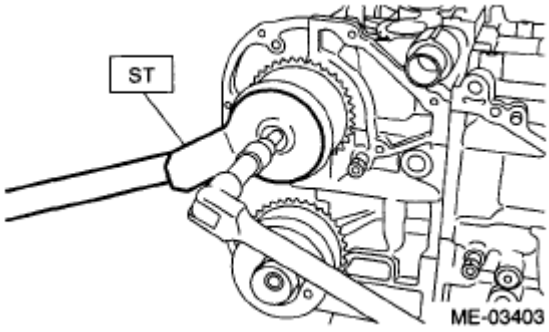

Fig. 119: Identifying Cam Sprocket Wrench (Intake Side)
Courtesy of SUBARU OF AMERICA, INC.

- Exhaust side

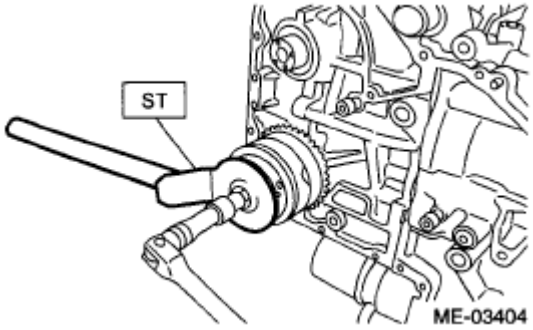

Fig. 120: Identifying Cam Sprocket Wrench (Exhaust Side)
Courtesy of SUBARU OF AMERICA, INC.

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

INSPECTION

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

CRANK SPROCKET

REMOVAL

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

1. Remove the V-belts. Ref. to **REMOVAL**, V-belt.

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2. Remove the crank pulley. Ref. to **REMOVAL**, Crank Pulley.
3. Remove the chain cover. Ref. to **REMOVAL**, Chain Cover.
4. Remove the timing chain assembly. Ref. to **REMOVAL**, Timing Chain Assembly.
5. Remove the crank sprocket (A).

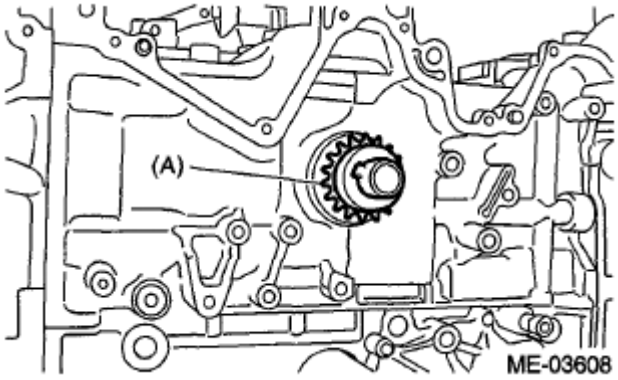

Fig. 121: Identifying Crank Sprocket
Courtesy of SUBARU OF AMERICA, INC.

INSTALLATION

1. Install the crank sprocket (A).

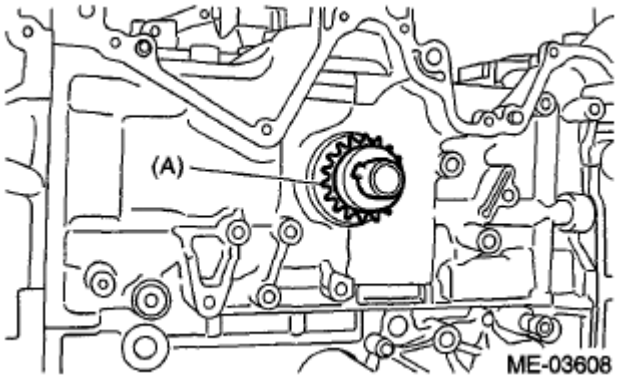

Fig. 122: Identifying Crank Sprocket
Courtesy of SUBARU OF AMERICA, INC.

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

INSPECTION

1. Check the crank sprocket teeth for abnormal wear and scratches.

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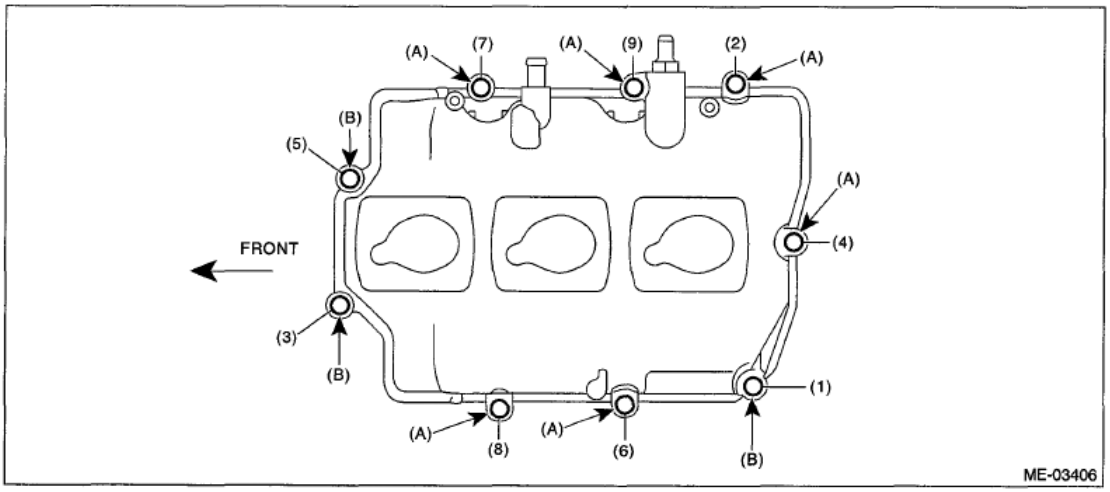
2. Make sure there is no free play between crank sprocket and key.

CAMSHAFT

REMOVAL

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



(A) M6 × 37 (B) M6 × 23

Fig. 123: Identifying Rocker Cover Bolt In Sequence (LH Side)
Courtesy of SUBARU OF AMERICA, INC.

   - RH side

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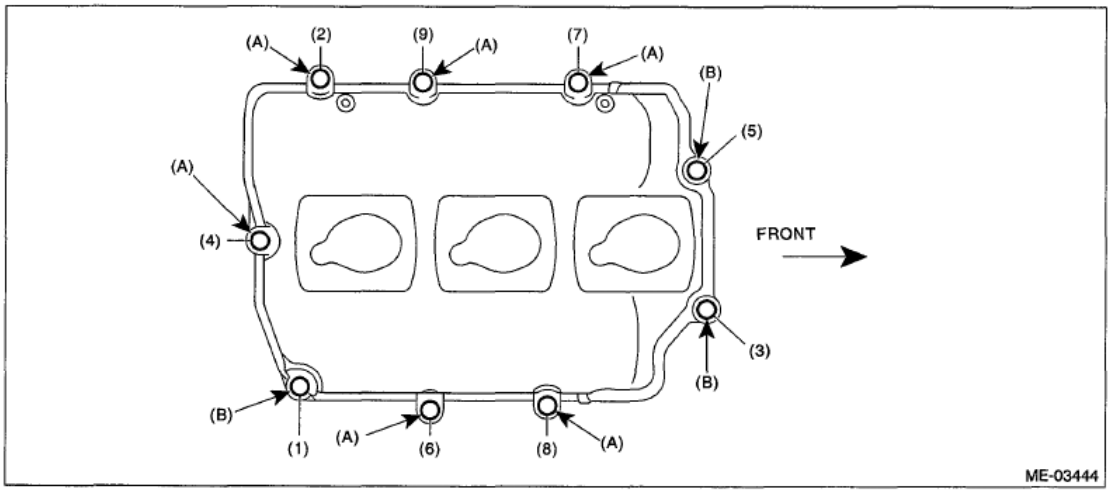

(A) M6 × 37 (B) M6 × 23

Fig. 124: Identifying Rocker Cover Bolt In Sequence (RH Side)
Courtesy of SUBARU OF AMERICA, INC.

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

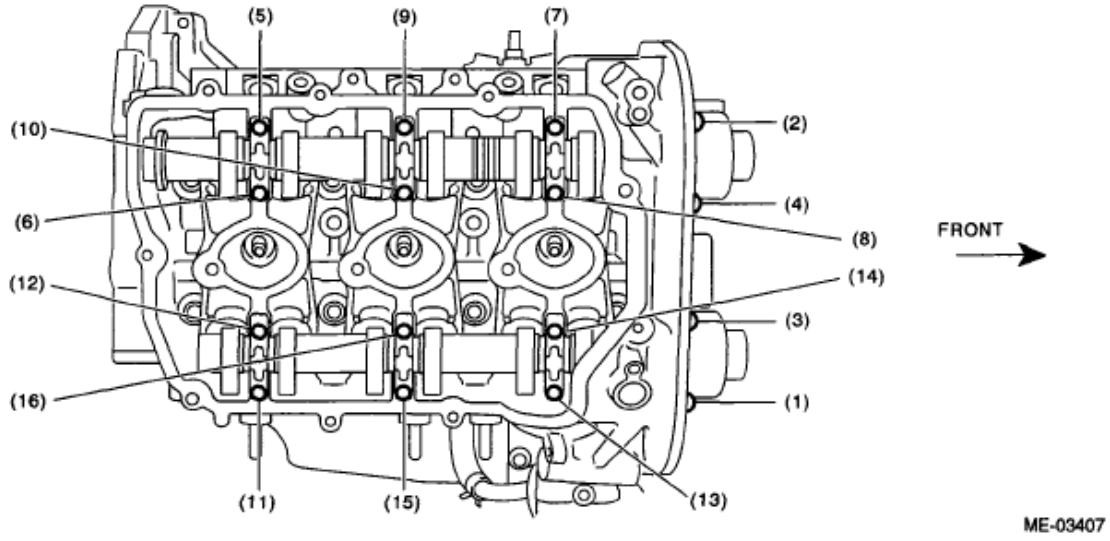

Fig. 125: Identifying Camshaft Cap Bolts Loosen Sequence
Courtesy of SUBARU OF AMERICA, INC.

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

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

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

INSTALLATION

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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 front camshaft cap as shown in the figure.

CAUTION: Do not apply liquid gasket excessively. Applying excessively may cause excess gasket to flow toward cam journal, resulting in engine seizure.

NOTE: Install the oil pan lower within 5 minutes after applying liquid gasket.

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

Applying liquid gasket diameter: 2.0±0.5 mm (0.079 ±0.020 in)

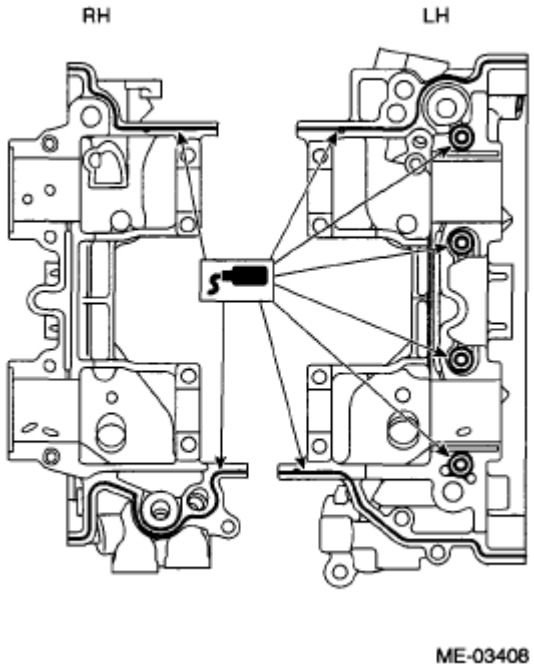

Fig. 126: Applying Liquid Gasket To Back Side Of Front Camshaft Cap
Courtesy of SUBARU OF AMERICA, INC.

    2. Apply engine oil to cap bearing surface, and install the cap to camshaft.
    3. Tighten the camshaft cap bolts in the numerical order as shown in the figure.

Tightening torque: (1) - (12): 16 N.m (1.6 kgf-m, 11.8 ft-lb) (13) - (16): 9.75 N.m (1.0 kgf-m, 7.2 ft-lb)

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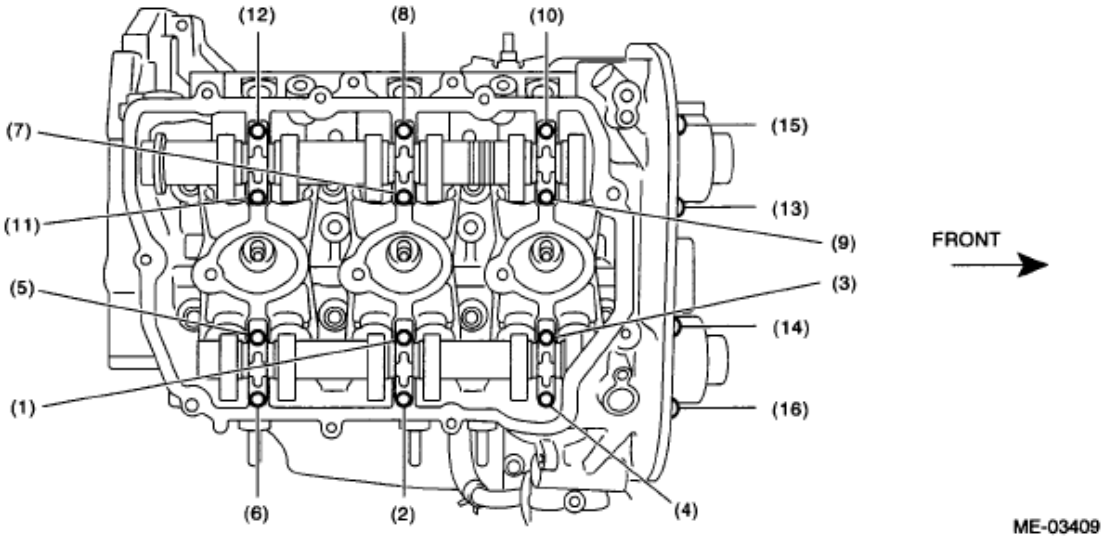

Fig. 127: Identifying Camshaft Cap Bolts Tighten Sequence
Courtesy of SUBARU OF AMERICA, INC.

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.

        CAUTION: Do not apply liquid gasket excessively. Applying excessively may cause excess gasket to flow toward cam journal, resulting in engine seizure.

        NOTE: Install the oil pan lower within 5 minutes after applying liquid gasket.

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

        Applying liquid gasket diameter: 3.5±0.5 mm (0.138 ±0.020 in)

        - LH side

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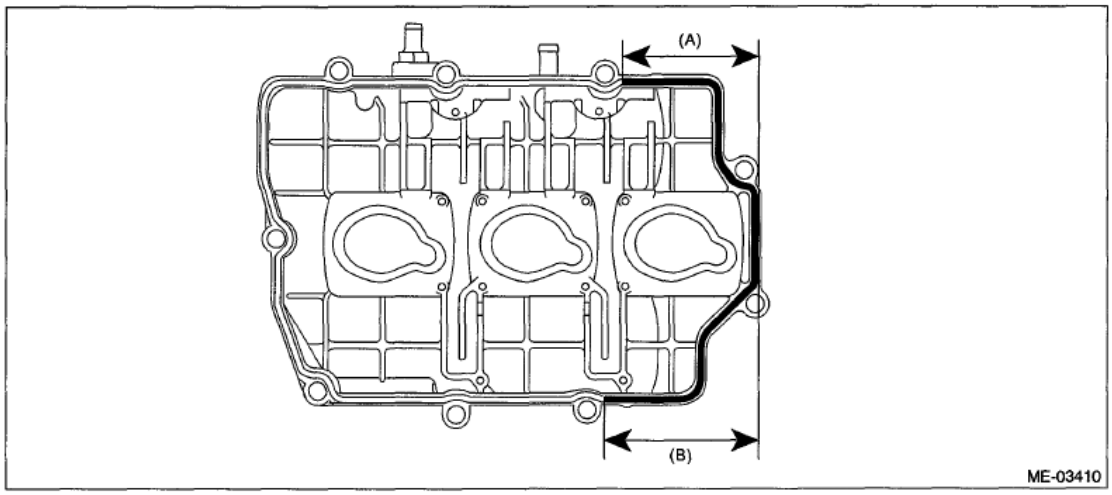
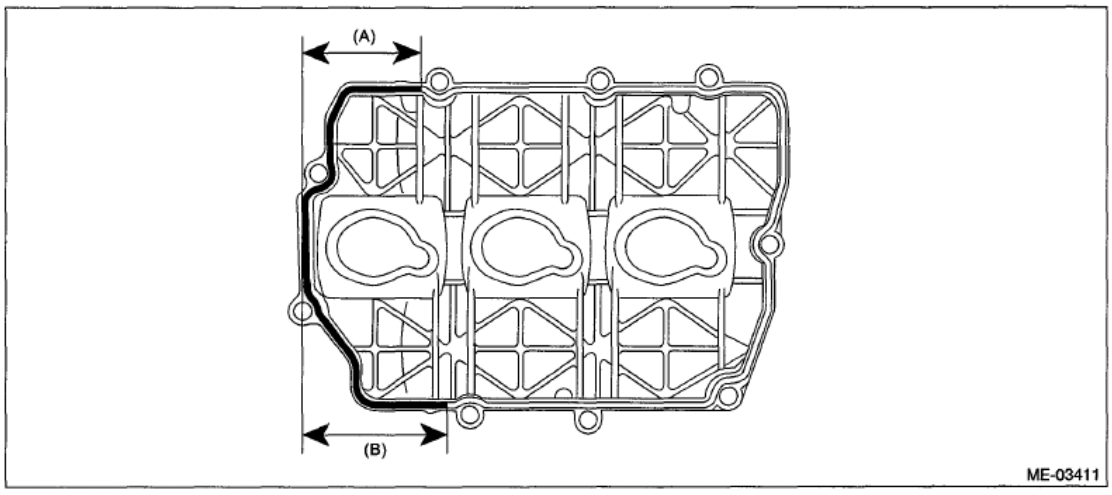


(A) 90 mm (3.543 in) or more (B) 105 mm (4.134 in) or more

Fig. 128: Applying Liquid Gasket To Oil Pan Lower (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. 129: Applying Liquid Gasket To Oil Pan Lower (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

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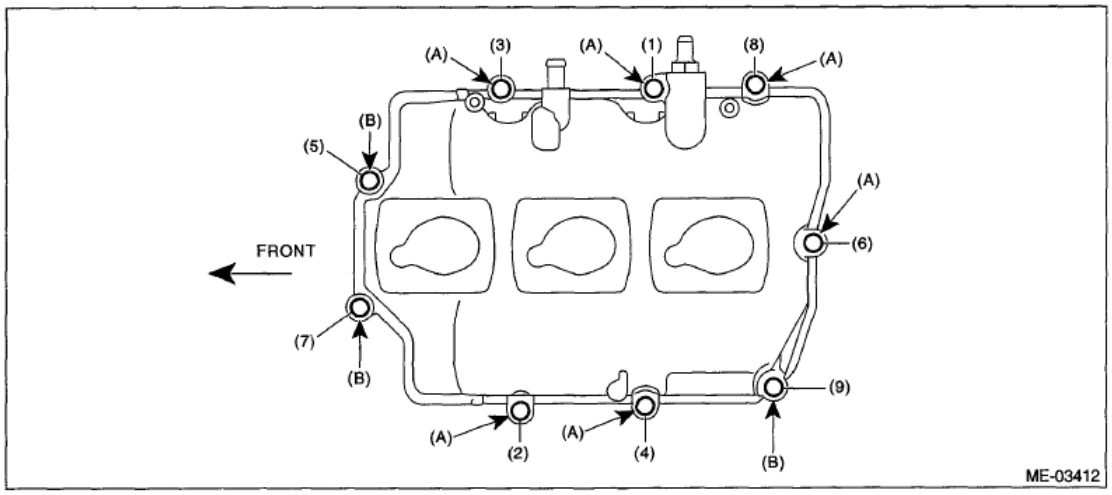
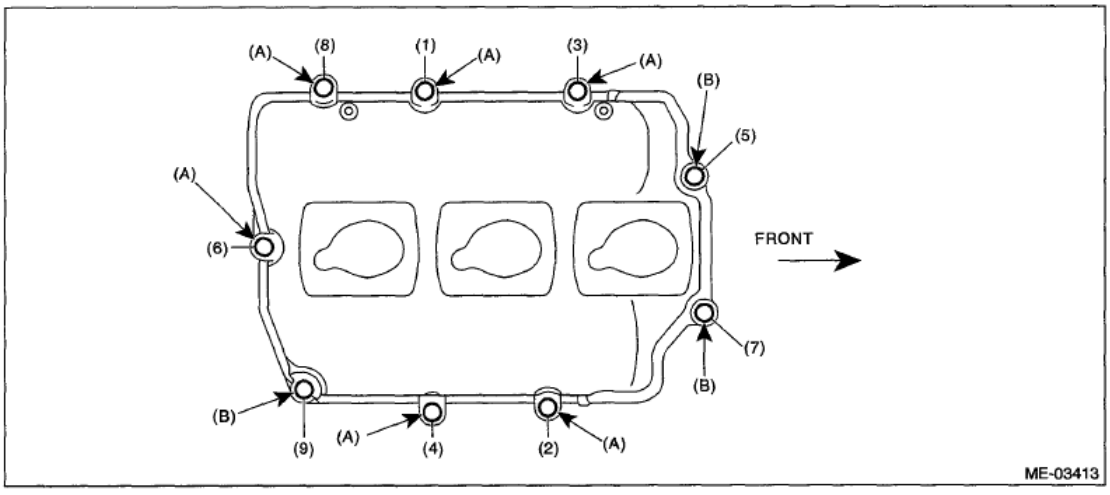


(A) M6 × 37 (B) M6 × 23

Fig. 130: Identifying Rocker Cover Bolts Tighten Sequence (LH Side)
Courtesy of SUBARU OF AMERICA, INC.

- RH side



(A) M6 × 37 (B) M6 × 23

Fig. 131: Identifying Rocker Cover Bolts Tighten Sequence (RH Side)
Courtesy of SUBARU OF AMERICA, INC.

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

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INSPECTION

1. Measure the bend of camshaft. Repair or replace if bended.

   Service limit: 0.020 mm (0.00079 in)

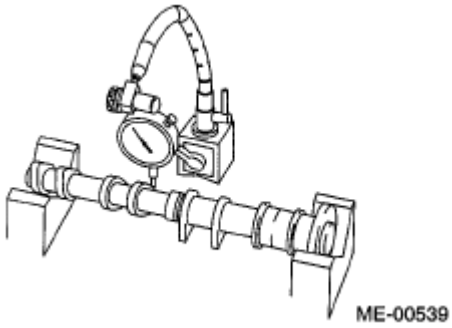

Fig. 132: Measuring Bend Of Camshaft
Courtesy of SUBARU OF AMERICA, INC.

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

CAMSHAFT JOURNAL CHART

	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)

5. Measurement of the camshaft journal oil clearance:
   1. Clean the camshaft cap and cylinder head camshaft journal.
   2. Place the camshafts on the cylinder head. (Without installing the valve rocker.)
   3. Place a plastigage across each camshaft journals.
   4. Install the camshaft cap.

      NOTE: Do not turn the camshaft.

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

      Standard: 0.037 - 0.072 mm (0.0015 - 0.0028 in)

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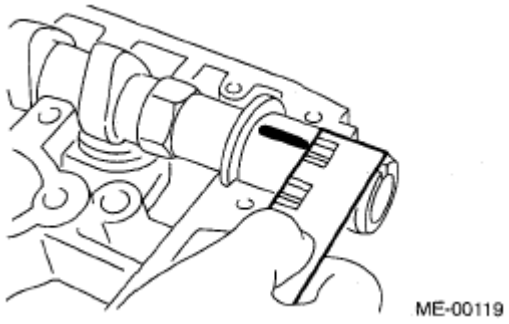

Fig. 133: Measuring Widest Point Of Plastigage
Courtesy of SUBARU OF AMERICA, INC.

7. Completely remove the plastigage.

6. Check the cam face condition; remove the minor faults by grinding with oil stone. Measure the cam height H. If it exceeds the standard or offset wear occurs, replace it.

   Cam 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: Intake: 36.00 mm (1.4173 in)

   Exhaust: 36.00 mm (1.4173 in)

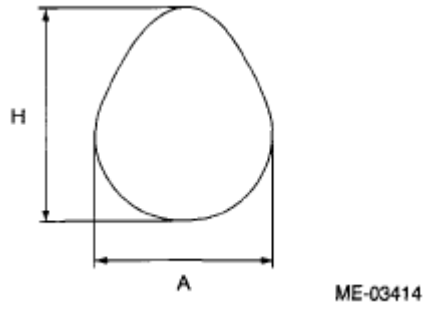

Fig. 134: Identifying Cam Base Circle Diameter And Height
Courtesy of SUBARU OF AMERICA, INC.

7. Measure the thrust clearance of camshaft with dial gauge. If the clearance exceeds the standard or offset wear occurs, replace the camshaft caps and cylinder head as a set. If necessary replace the camshaft.

   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

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

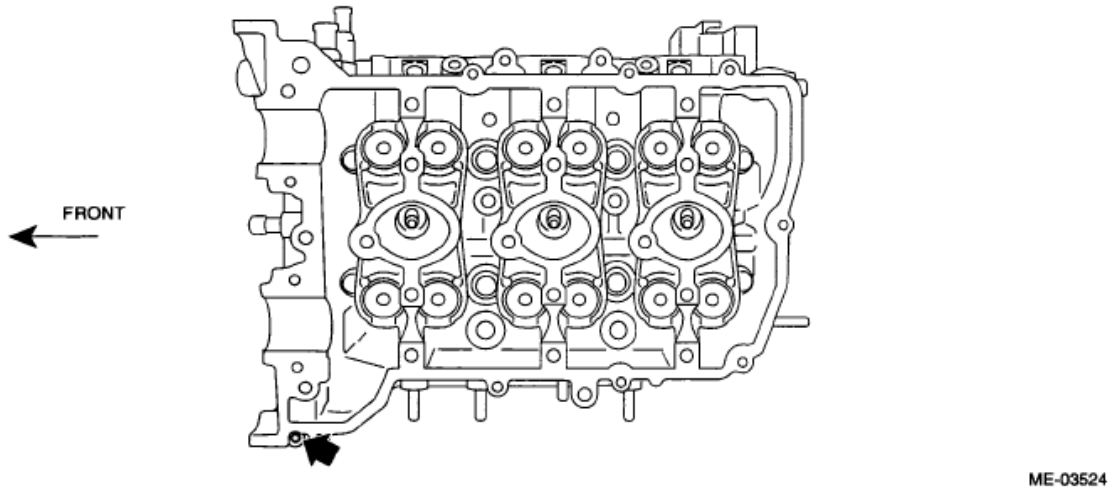

Fig. 135: Locating Seal Bolts
Courtesy of SUBARU OF AMERICA, INC.

9. Remove the cylinder head bolts in the numerical order as shown in the figure. Leave bolts (2) and (4) engaged by three or four threads to prevent the cylinder head from falling.

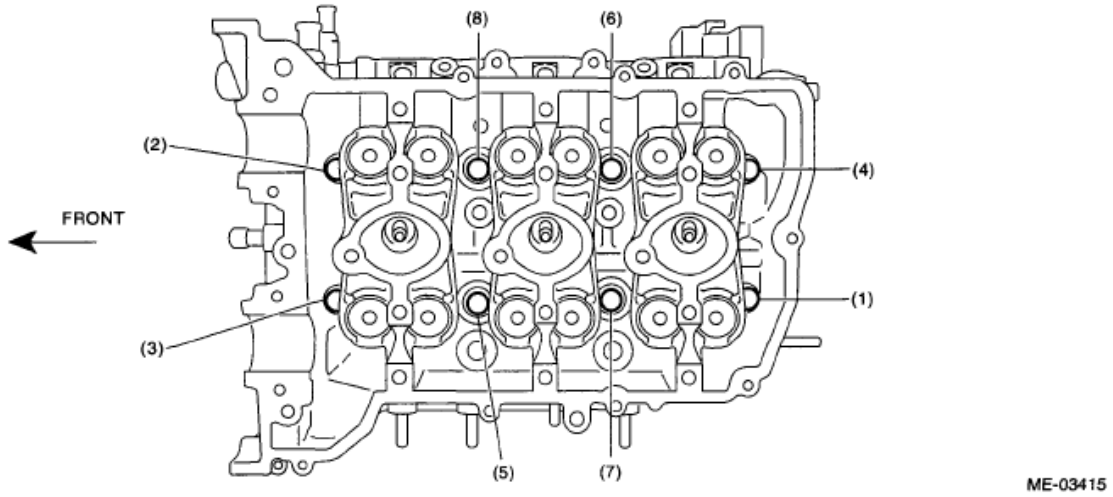

Fig. 136: Identifying Cylinder Head Bolts In Sequence

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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 surfaces of the cylinder head and cylinder block.

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

INSTALLATION

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

CAUTION: Do not apply liquid gasket excessively. If applying excessively, remove the excess liquid gasket that flowed out.

NOTE: Install the oil pan lower within 5 minutes after applying liquid gasket.

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

Applying liquid gasket diameter: 3.5±1.0 mm (0.138 ±0.039 in)

- LH side

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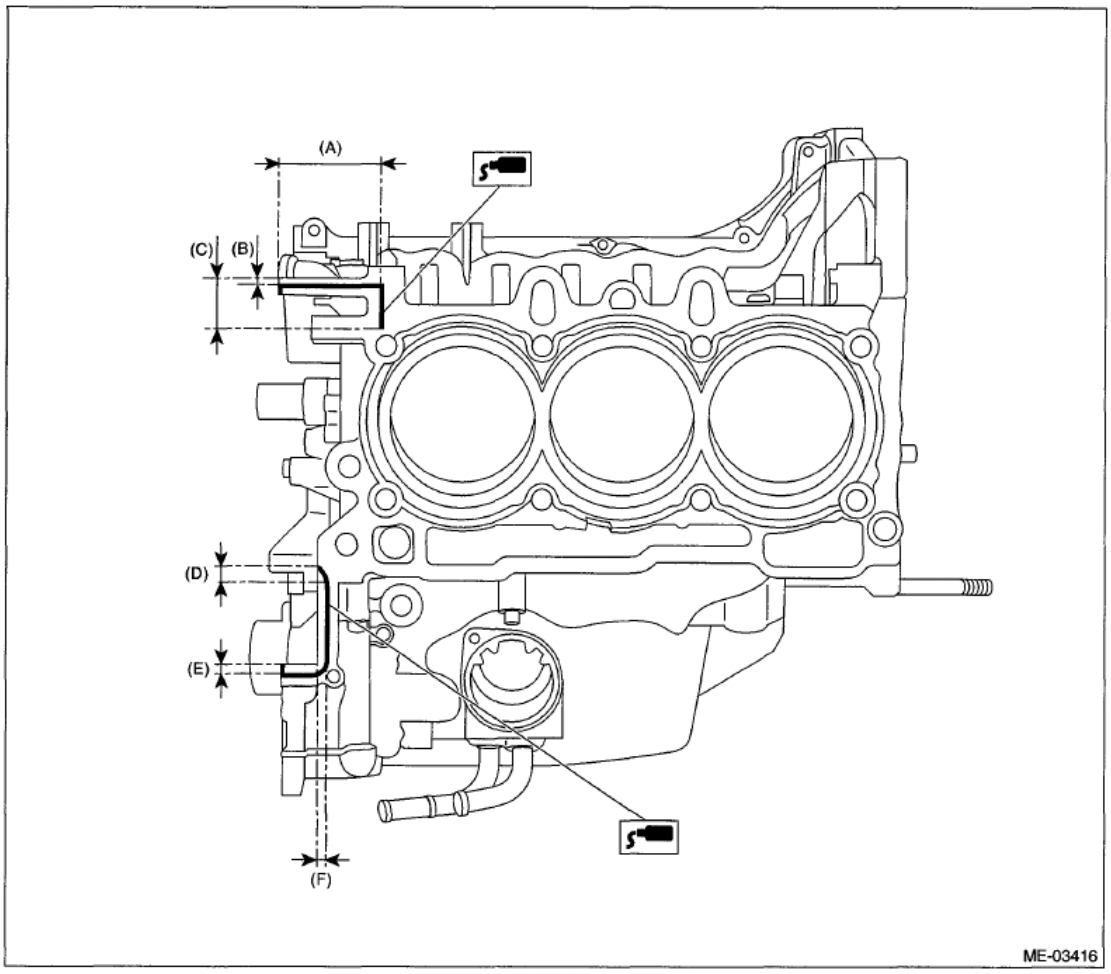

(A) 59 mm (2.323 in)
(B) 2 mm (0.079 in)
(C) 20 mm (0.787 in)
(D) 7 mm (0.276 in)
(E) 4 mm (0.157 in)
(F) 4 mm (0.157 in)

Fig. 137: Applying Liquid Gasket To Oil Pan Lower Gasket Area (LH Side)
Courtesy of SUBARU OF AMERICA, INC.

- RH side

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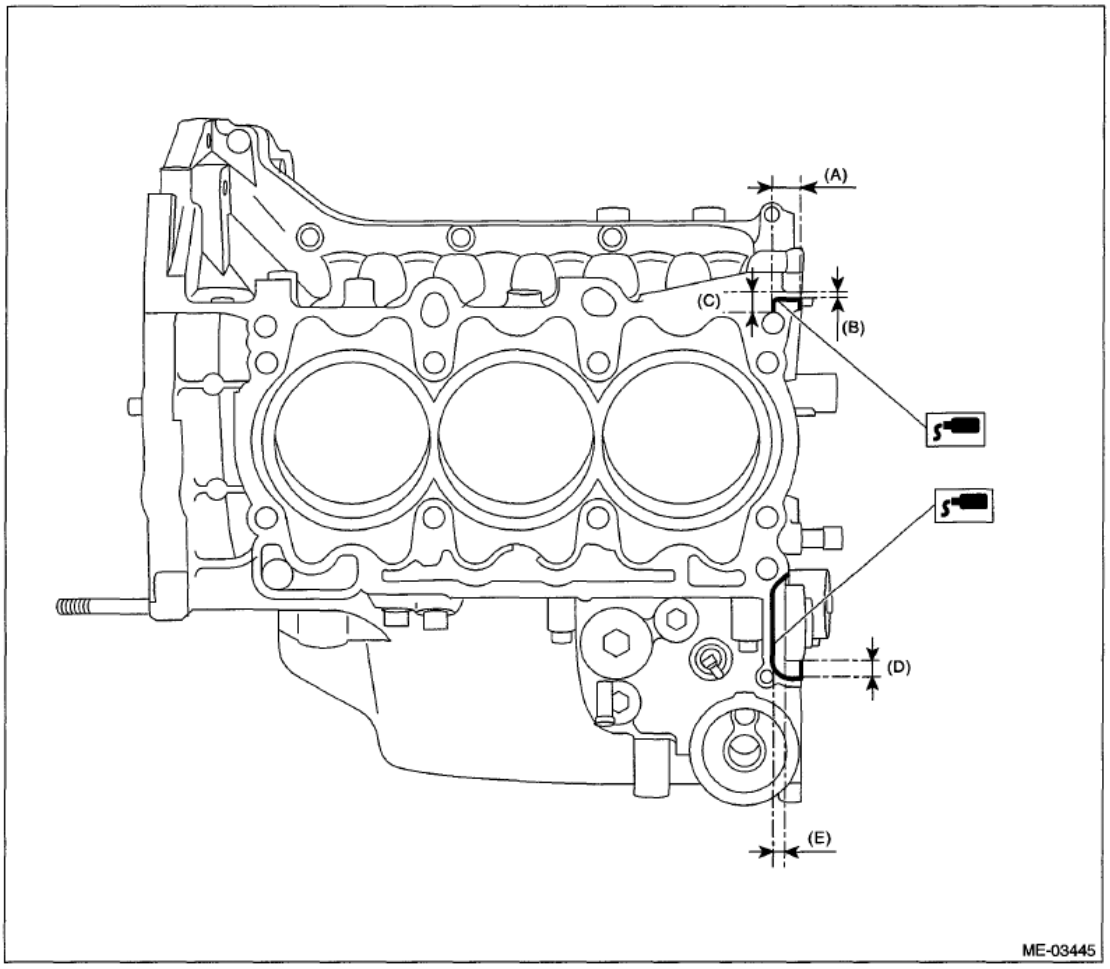

(A) 17 mm (0.669 in)
(B) 2 mm (0.079 in)
(C) 9 mm (0.354 in)
(D) 4 mm (0.157 in)
(E) 4 mm (0.157 in)

Fig. 138: Applying Liquid Gasket To Oil Pan Lower Gasket Area (RH Side)
Courtesy of SUBARU OF AMERICA, INC.

2. Install the cylinder head gaskets (LH and RH) on cylinder blocks.

NOTE: Use a new cylinder head gasket.

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

CAUTION: Do not apply liquid gasket excessively. If applying excessively, remove the excess liquid gasket that flowed out.

NOTE: Install the oil pan lower within 5 minutes after applying liquid gasket.

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

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Applying liquid gasket diameter: 3.5±1.0 mm (0.138 ±0.039 in)

- LH side

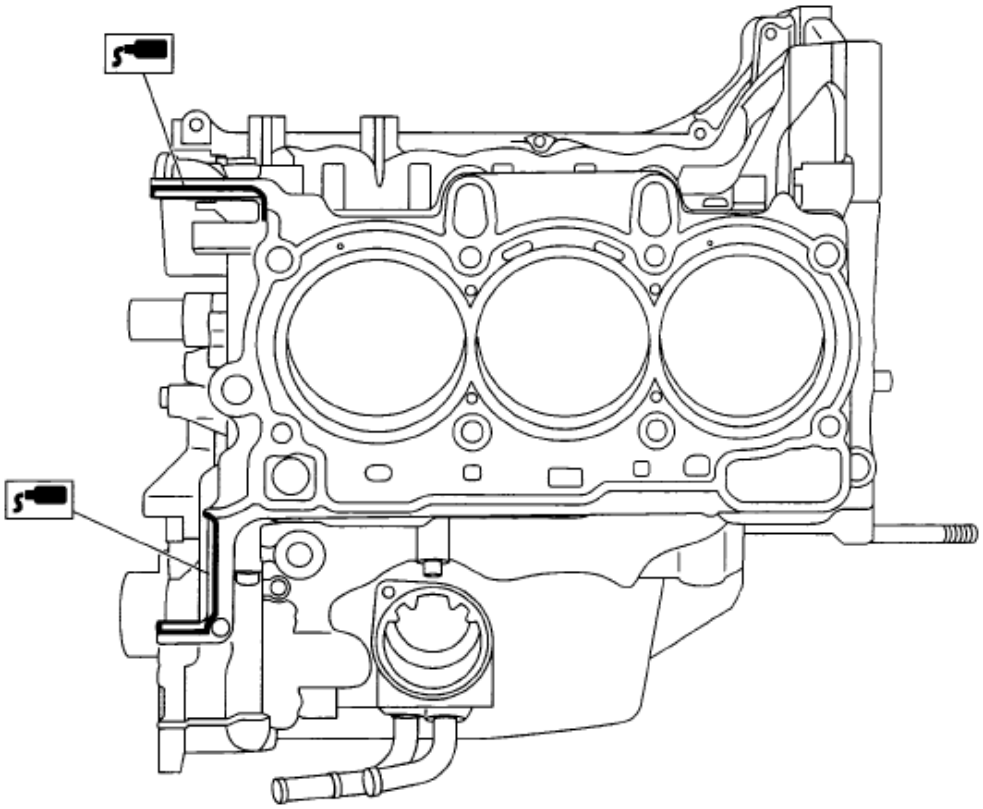

Fig. 139: Applying Liquid Gasket To Oil Pan Lower Area (LH Side)
Courtesy of SUBARU OF AMERICA, INC.

- RH side

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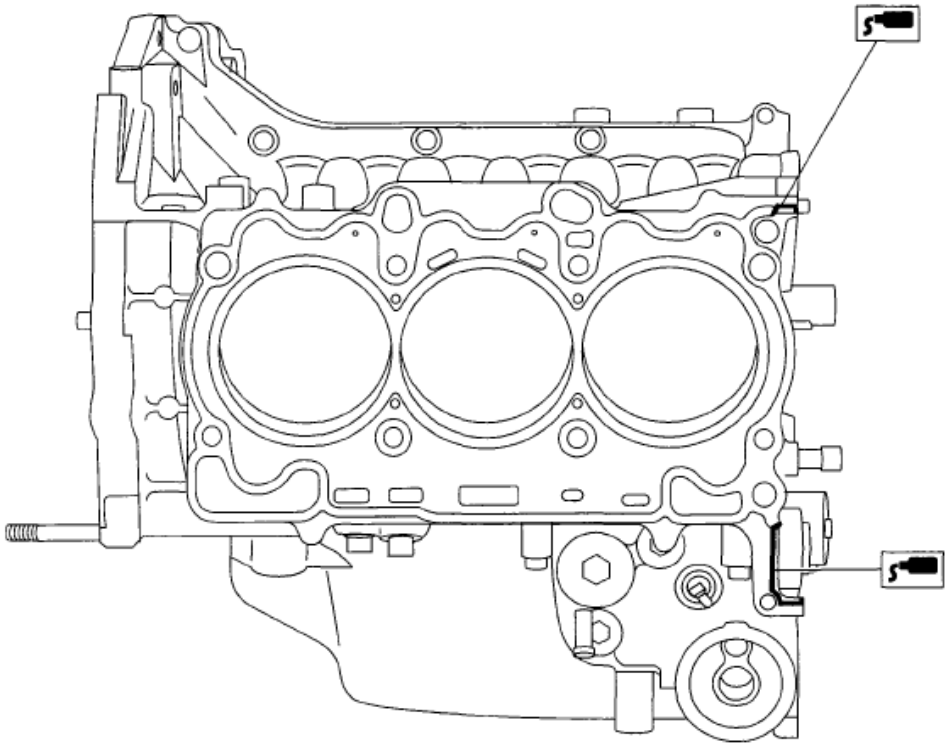

Fig. 140: Applying Liquid Gasket To Oil Pan Lower Area (RH Side)
Courtesy of SUBARU OF AMERICA, INC.

4. Install the cylinder head to cylinder block.

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

5. Tighten the cylinder head bolts.
    1. Apply a coat of engine oil to washers and cylinder head bolt threads.
    2. Install the cylinder head to cylinder block, and then 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.
    3. Tighten the bolts with torque of 50 N.m (5.1 kgf-m, 36.9 ft-lb) in numerical sequence as shown 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) with torque of 48 N.m (4.9 kgf-m, 35.4 ft-lb) in numerical sequence.
    7. Tighten the bolts (5) - (8) with torque of 44 N.m (4.5 kgf-m, 32.5 ft-lb) in numerical sequence.

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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.

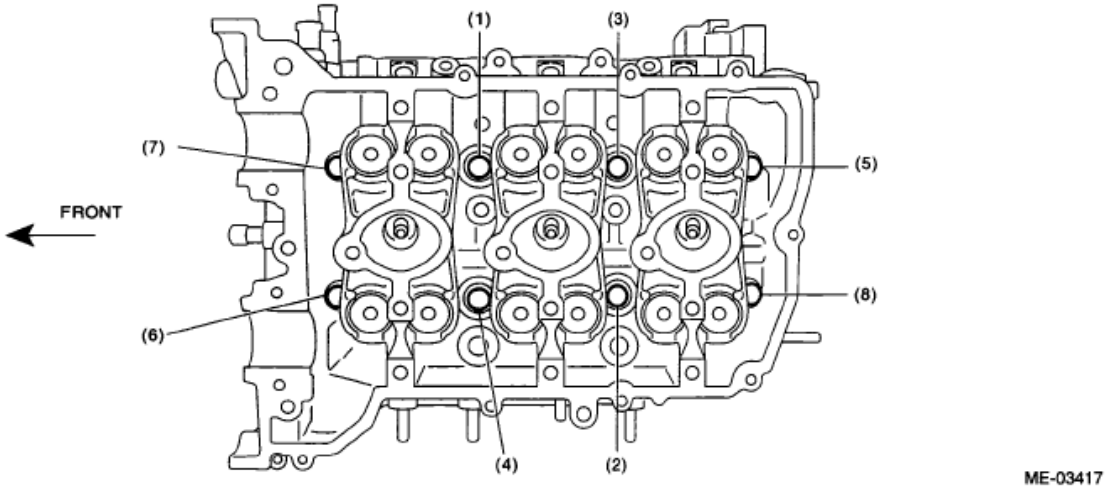

Fig. 141: Identifying Oil Pan Bolts Tighten Sequence
Courtesy of SUBARU OF AMERICA, INC.

6. Install the seal bolts as shown in the figure.

NOTE: Apply seal material on the bolt threads before installing the seal bolts.

Seal material: THREE BOND 1324 (Part No. 004403042) or equivalent

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

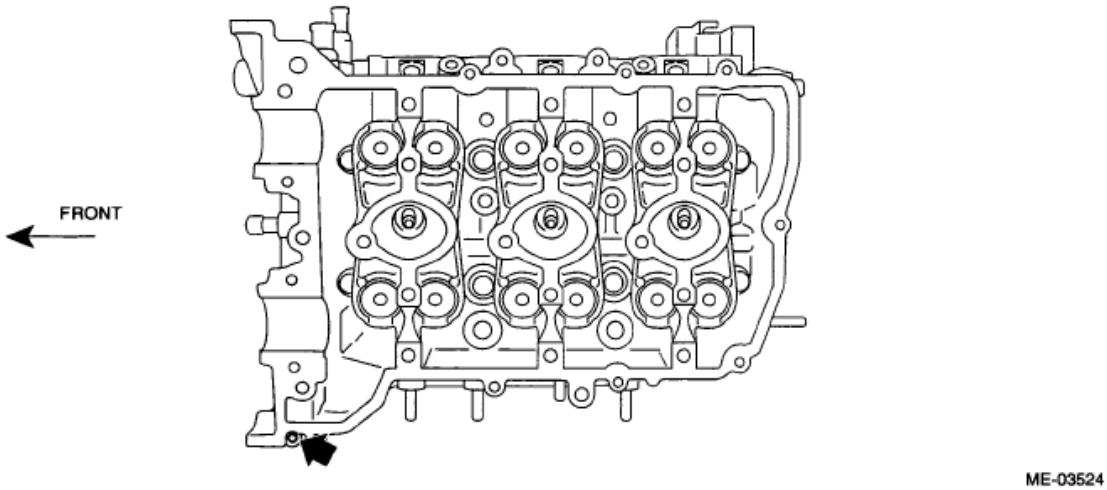

Fig. 142: Locating Seal Bolts
Courtesy of SUBARU OF AMERICA, INC.

7. Install the camshaft. Ref. to **INSTALLATION**, Camshaft.

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

DISASSEMBLY

1. Set the cylinder head on ST.

   ST 18250AA010 CYLINDER HEAD TABLE

2. Remove the valve lifter.
3. Set the ST on valve spring retainer. Compress the valve spring and remove the valve spring retainer key. Remove 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.**
- **Refer to INSPECTION for removal and installation procedures of valve guide, intake valve oil seal and exhaust valve oil seal. Ref. to VALVE GUIDE, INSPECTION, Cylinder Head. Ref. to INTAKE AND EXHAUST VALVE OIL SEAL, INSPECTION, Cylinder Head.**

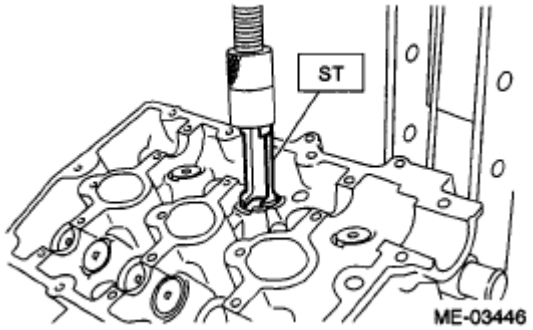

Fig. 143: Installing Valve Guide
Courtesy of SUBARU OF AMERICA, INC.

ASSEMBLY

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1. Installation of valve spring and valve:
    1. Set the cylinder head on ST.

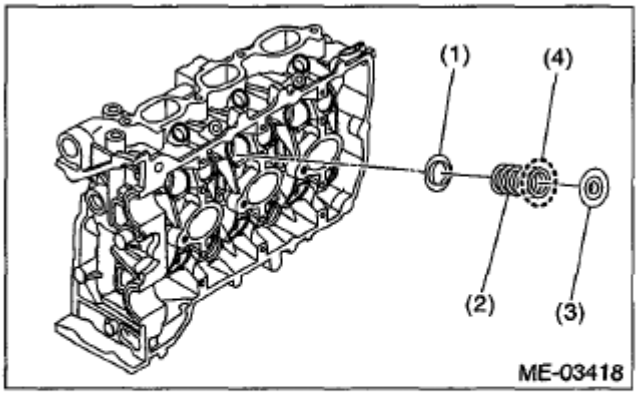
       ST 18250AA010 CYLINDER HEAD TABLE

    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. 144: 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

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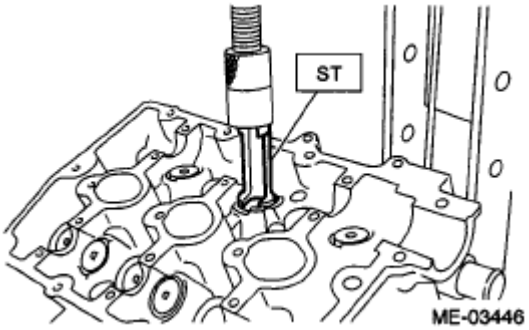

Fig. 145: Identifying Valve Spring Remover
Courtesy of SUBARU OF AMERICA, INC.

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.

INSPECTION

CYLINDER HEAD

1. Make sure that no crack or other damages do not exist. In addition to visual inspection, inspect important areas using liquid penetrant tester. 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.

   Surface warpage limit: 0.02 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 warping. When reinstalling, pay special attention to the torque so as to tighten evenly.

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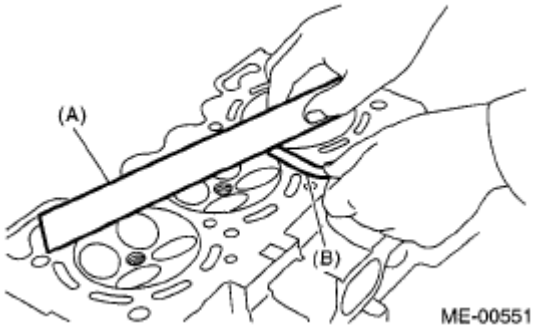

Fig. 146: Checking Warpage For Mating Surface Between Cylinder Block And Cylinder Head
Courtesy of SUBARU OF AMERICA, INC.

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.

Valve seat width W: Intake: Standard: 1.0 mm (0.039 in)

Exhaust: Standard: 1.5 mm (0.059 in)

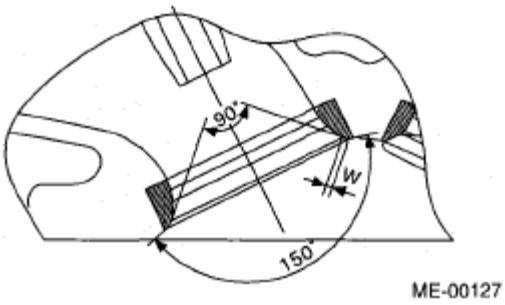

Fig. 147: Checking Valve Seat Width
Courtesy of SUBARU OF AMERICA, INC.

VALVE GUIDE

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

   Clearance between the valve guide and valve stem:

   Standard: Intake: 0.030 - 0.057 mm (0.0012 - 0.0022 in)

   Exhaust: 0.040 - 0.067 mm (0.0016 - 0.0026 in)

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

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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

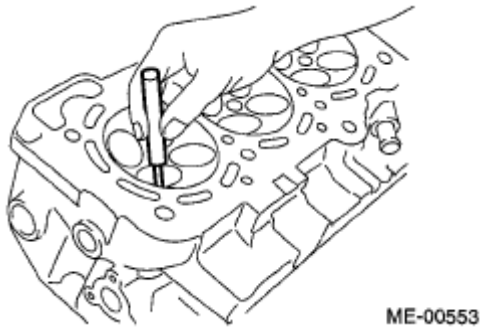

Fig. 148: Placing Cylinder Head On ST1
Courtesy of SUBARU OF AMERICA, INC.

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)

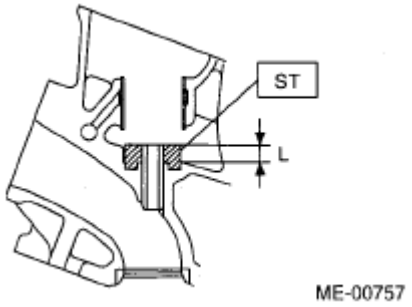

Fig. 149: Identifying Valve Guide Adjuster ST 18251AA020
Courtesy of SUBARU OF AMERICA, INC.

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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 cylinder, 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)

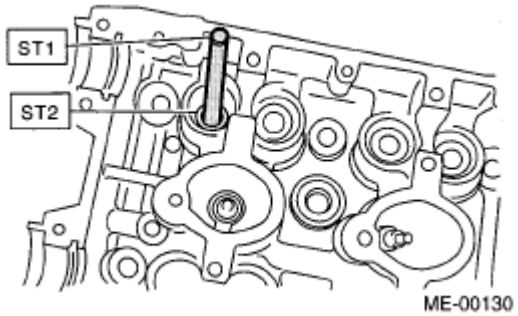

Fig. 150: Identifying Valve Guide Remover ST1 (499767200) And Valve Guide Adjuster ST2 (18251AA020)
Courtesy of SUBARU OF AMERICA, INC.

6. Check the valve guide protrusion.

   Valve guide protrusion 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 reamer in valve guide, and rotate the reamer slowly clockwise while pushing it lightly. Bring the reamer back while rotating it clockwise.

   ST 499765900 VALVE GUIDE REAMER

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

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

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1. Inspect the flange and stem of valve, and replace if damaged, worn or deformed, or if dimension of "H" in the figure exceeds the standard, or if offset wear occurs.

   Head edge thickness H: Intake (A): Standard 1.0 mm (0.039 in)

   Exhaust (B): Standard 1.2 mm (0.047 in)

   Valve overall length: Intake (A): 103.5 mm (4.075 in)

   Exhaust (B): 103.2 mm (4.063 in)

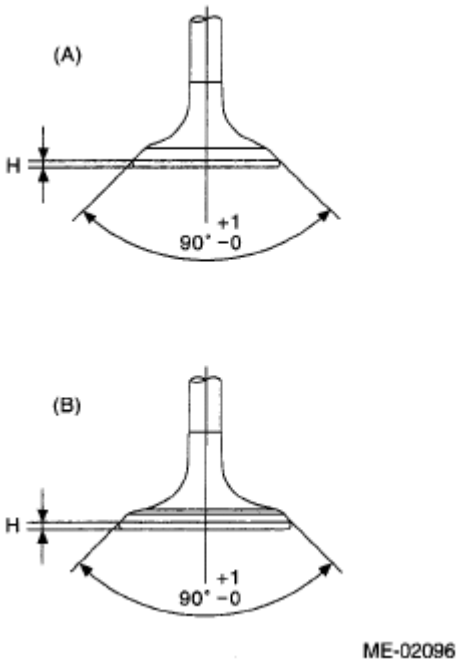

Fig. 151: Identifying Intake And Exhaust Valve
Courtesy of SUBARU OF AMERICA, INC.

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

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.

VALVE SPRING LENGTH CHART

Free length mm (in)	Intake	41.51 (1.6342)
	Exhaust	41.51 (1.6342)
Squareness	Intake	2.5°, 1.8 mm (0.071 in)
	Exhaust	2.5°, 1.8 mm (0.071 in)

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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 valve spring using a try square.

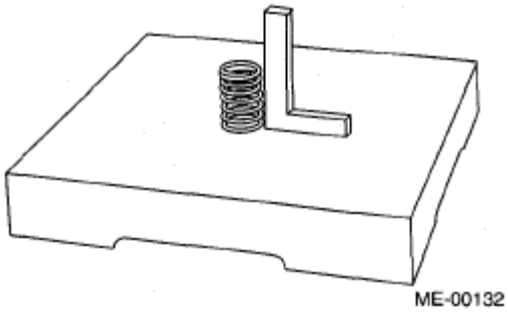

Fig. 152: Measuring Squareness Of Valve Spring
Courtesy of SUBARU OF AMERICA, INC.

INTAKE AND EXHAUST VALVE OIL SEAL

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 intake valve and valve seat.
- When replacing the intake valve guide.

1. Set the cylinder head on ST1.
2. Using the ST2, press in the oil seal.

ST1 18250AA010 CYLINDER HEAD TABLE

ST2 499585500 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.**

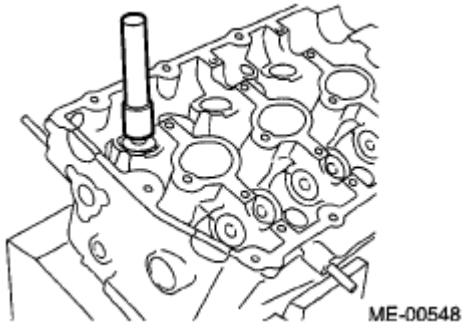

Fig. 153: Applying Engine Oil To Oil Seal

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Courtesy of SUBARU OF AMERICA, INC.

VALVE LIFTER

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

   Outer diameter: 32.959 - 32.975 mm (1.2976 - 1.2982 in)

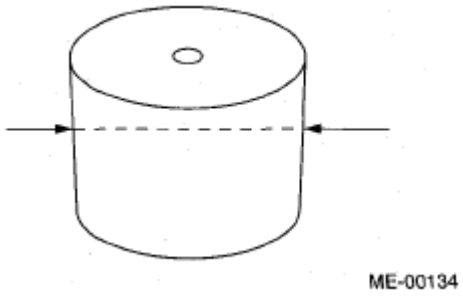

Fig. 154: Checking Outer Diameter Of Valve Lifter
Courtesy of SUBARU OF AMERICA, INC.

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

   Inner diameter: 32.994 - 33.016 mm (1.2990 - 1.2998 in)

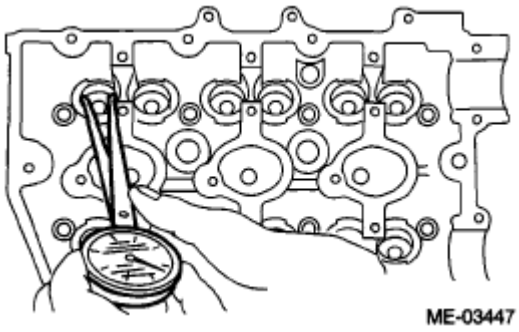

Fig. 155: Measuring Inner Diameter Of Valve Lifter Hole Of Cylinder Head
Courtesy of SUBARU OF AMERICA, INC.

NOTE: If difference between outer diameter of valve lifter and inner diameter of valve lifter hole is out of the standard or offset wearing exists, replace the cylinder head.

Standard: 0.019 - 0.057 mm (0.0007 - 0.0022 in)

CYLINDER BLOCK

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REMOVAL

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

1. Remove the engine from vehicle. Ref. to **REMOVAL**, Engine Assembly.
2. Remove the crank pulley. Ref. to **REMOVAL**, Crank Pulley.
3. Remove the chain cover. Ref. to **REMOVAL**, Chain Cover.
4. Remove the timing chain assembly. Ref. to **REMOVAL**, Timing Chain Assembly.
5. Remove the cam sprocket. Ref. to **REMOVAL**, Cam Sprocket.
6. Remove the crank sprocket. Ref. to **REMOVAL**, Crank Sprocket.
7. Remove the camshaft. Ref. to **REMOVAL**, Camshaft.
8. Remove the cylinder head. Ref. to **REMOVAL**, Cylinder Head.
9. Using the ST, lock the crankshaft and remove drive plate.

   ST 498497100 CRANKSHAFT STOPPER

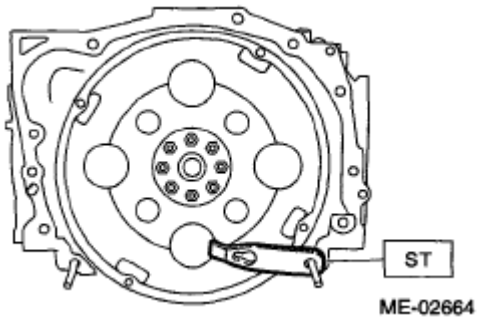

Fig. 156: Identifying Crankshaft Stopper
Courtesy of SUBARU OF AMERICA, INC.

10. Remove the crankshaft position sensor.

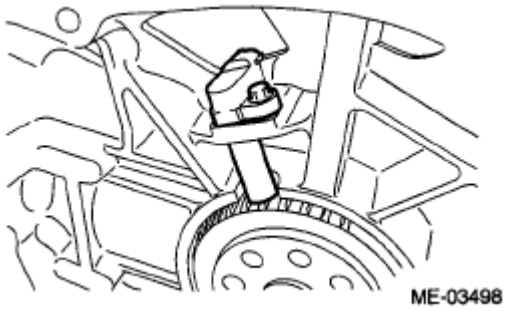

Fig. 157: Identifying Crankshaft Position Sensor
Courtesy of SUBARU OF AMERICA, INC.

11. Remove the crankshaft position sensor plate.

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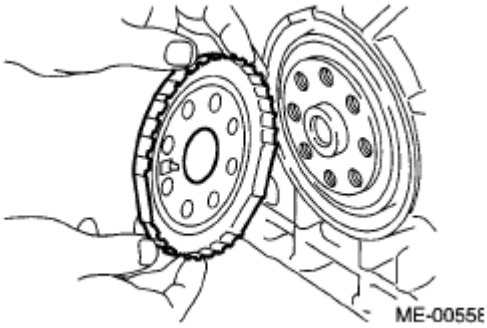

Fig. 158: Removing/Installing Crankshaft Position Sensor Plate
Courtesy of SUBARU OF AMERICA, INC.

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

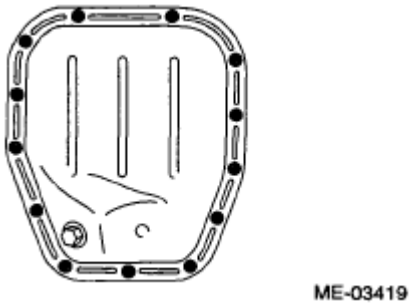

Fig. 159: Identifying Oil Pan Upper
Courtesy of SUBARU OF AMERICA, INC.

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

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

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

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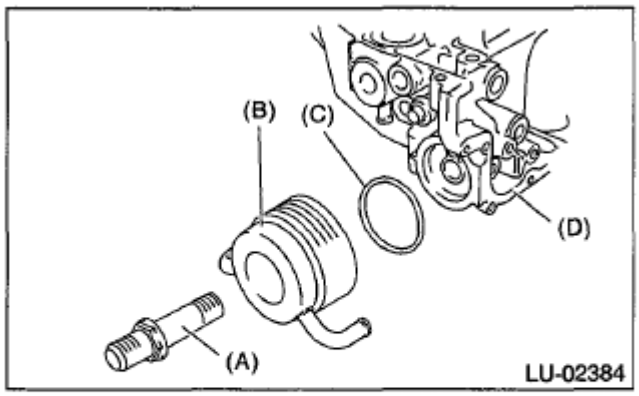

(A) Oil cooler connector
(B) Oil cooler
(C) O-ring
(D) Oil pan upper

Fig. 160: Identifying Oil Cooler Connector And Oil Cooler
Courtesy of SUBARU OF AMERICA, INC.

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

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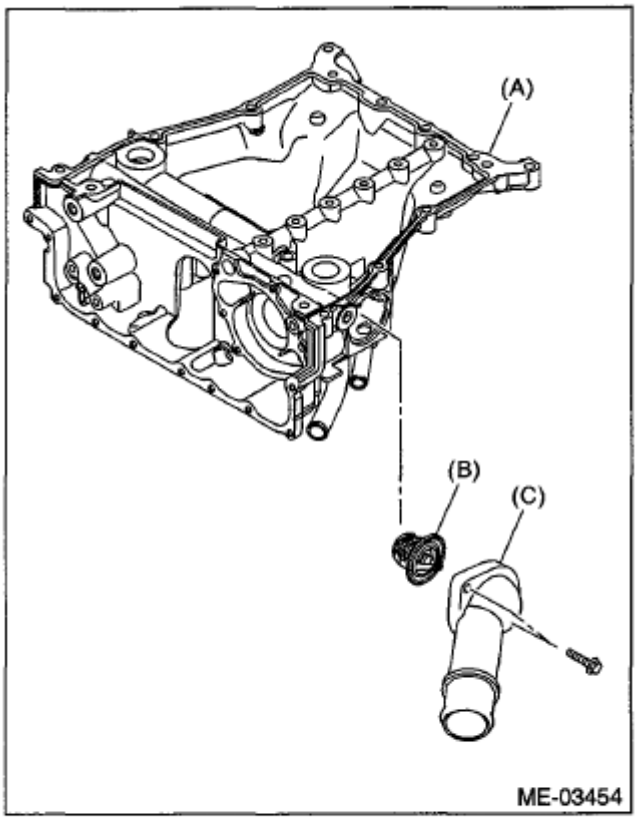

(A) Oil pan upper
(B) Thermostat
(C) Thermostat cover

Fig. 161: Identifying Thermostat Cover And Thermostat
Courtesy of SUBARU OF AMERICA, INC.

18. Remove the oil pan upper.

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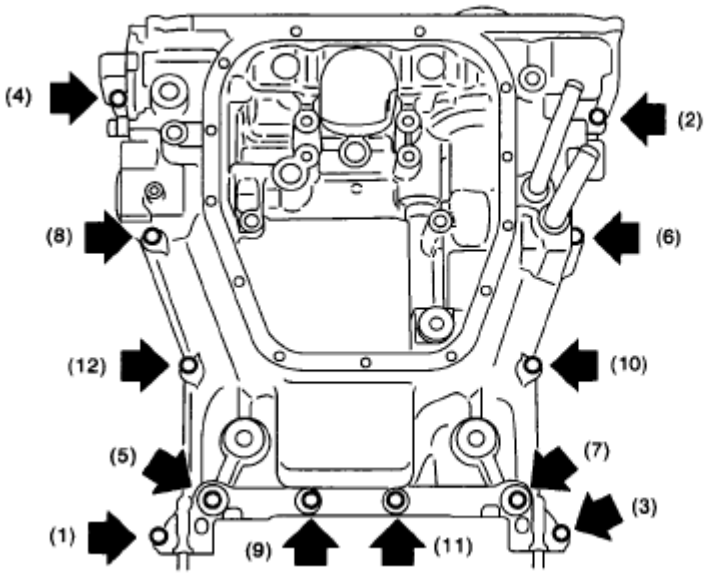

Fig. 162: Locating Oil Pan Upper
Courtesy of SUBARU OF AMERICA, INC.

19. Set the engine with front side facing upward.

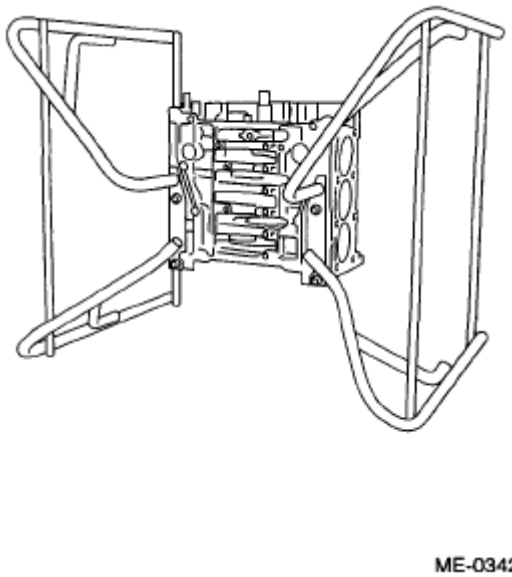

Fig. 163: Setting Engine With Front Side Facing Upward
Courtesy of SUBARU OF AMERICA, INC.

20. Remove the O-rings (10 pcs) under the cylinder block.

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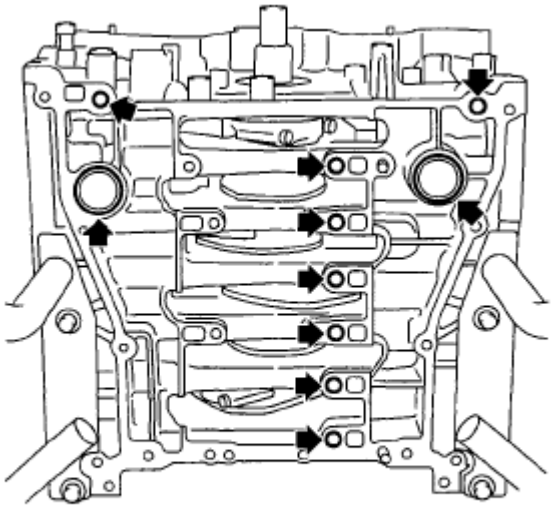

Fig. 164: Removing O-rings
Courtesy of SUBARU OF AMERICA, INC.

21. Mark the all connecting rod caps with the front direction and the number of cylinder from which they were removed.
22. Remove the # 1, # 4 connecting rod caps and pistons from cylinder block.

NOTE:

- **Use the 3/8 inch (9.5 sq.) for extension and TORX® socket (E12).**
- **Remove the connecting rod cap by turning the crankshaft (ST) in counterclockwise direction after removing two connecting rod joint bolts.**
- **Mark the all connecting rod caps and pistons with the number of the cylinder from which they were removed.**
- **Removal of the connecting rod caps and pistons should be performed in three stages. First, remove the # 1, # 4 connecting rod caps and pistons at the same time, then remove the # 2, # 5 connecting rod caps and pistons at the same time, then # 3, # 6 connecting rod caps and pistons at the same time.**

1. Turn the crankshaft using ST, to set the # 1 piston at the middle position between top dead center and bottom dead center.

   ST 18252AA000 CRANKSHAFT SOCKET

2. Remove the two # 1 connecting rod cap joint bolts, then remove the connecting rod cap.

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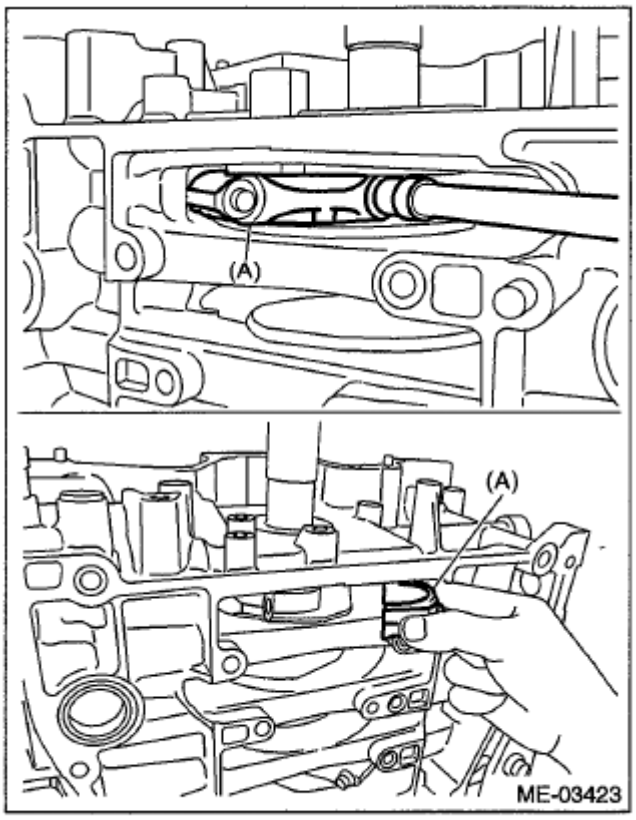

(A) # 1 connecting rod cap

Fig. 165: Identifying #1 Connecting Rod Cap
Courtesy of SUBARU OF AMERICA, INC.

3. Remove the two # 4 connecting rod cap joint bolts, then remove the connecting rod cap.

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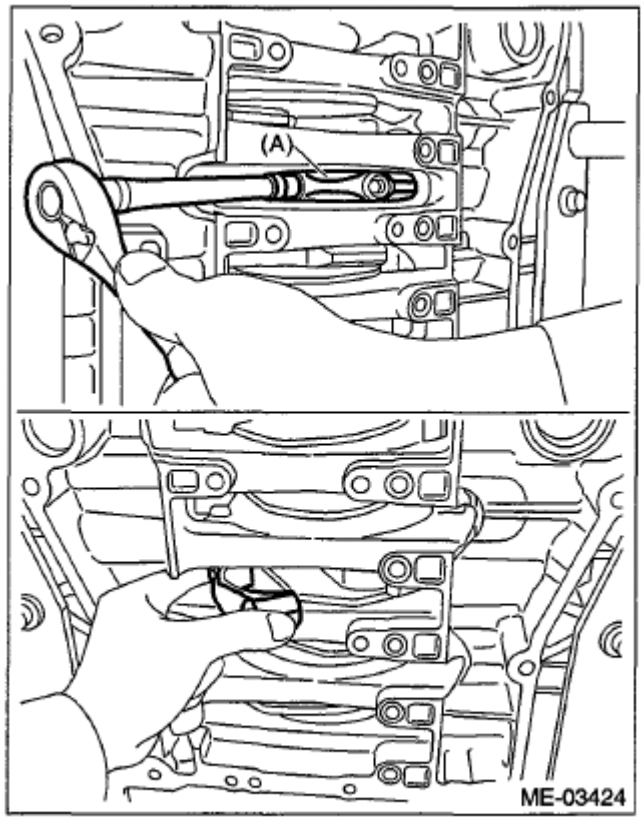

(A) # 4 connecting rod cap

Fig. 166: Identifying #4 Connecting Rod Cap
Courtesy of SUBARU OF AMERICA, INC.

4. Turn the crankshaft using ST, to set apart the crank pin and the # 1 connecting rod large end position.

   ST 18252AA000 CRANKSHAFT SOCKET

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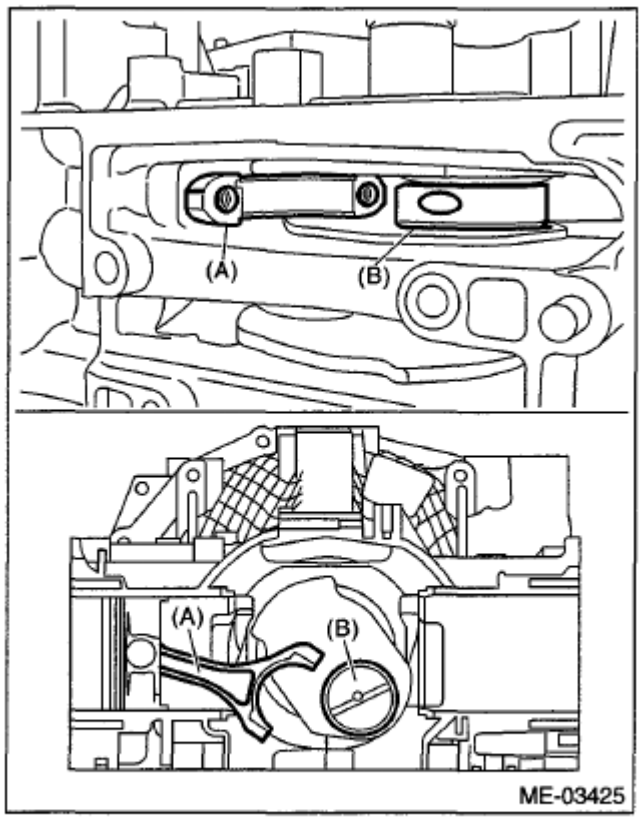
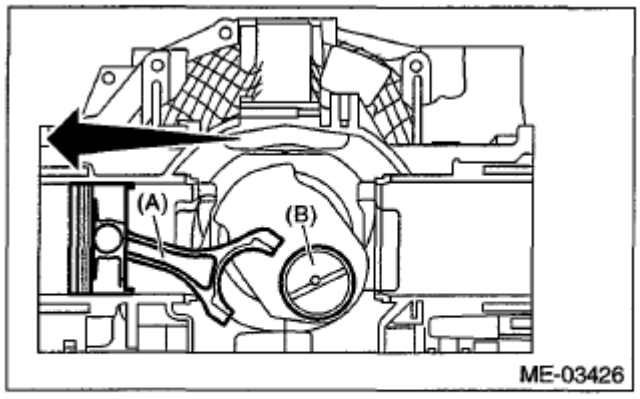


(A) # 1 connecting rod
(B) Crank pin

Fig. 167: Identifying Crank Pin And #1 Connecting Rod
Courtesy of SUBARU OF AMERICA, INC.

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



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

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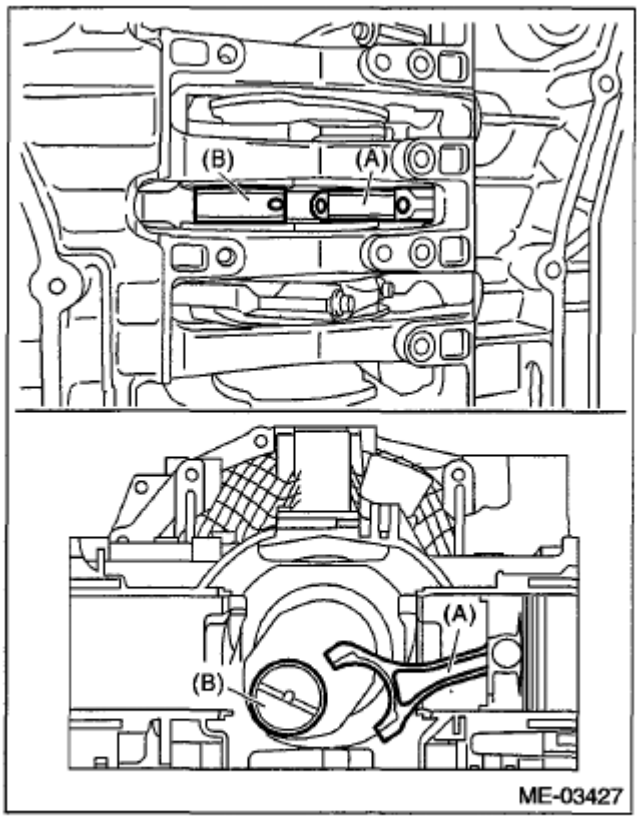
Fig. 168: Identifying Crank Pin And #1 Connecting Rod
Courtesy of SUBARU OF AMERICA, INC.

6. Turn the crankshaft using ST, to set apart the crank pin and the # 4 connecting rod large end position.

   ST 18252AA000 CRANKSHAFT SOCKET



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

Fig. 169: Identifying Crank Pin And #4 Connecting Rod
Courtesy of SUBARU OF AMERICA, INC.

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

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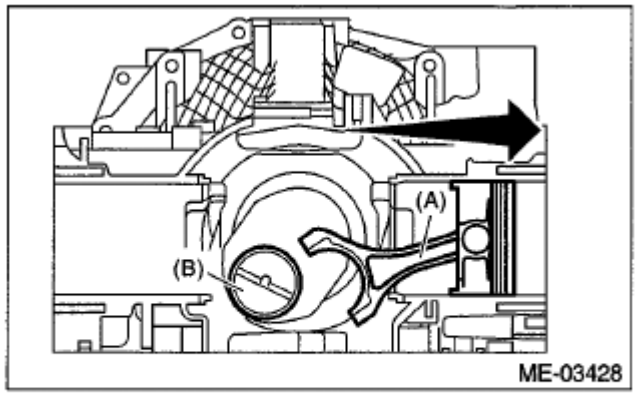

(A) # 4 connecting rod
(B) Crank pin

Fig. 170: Identifying Crank Pin And #4 Connecting Rod
Courtesy of SUBARU OF AMERICA, INC.

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

    ST 18252AA000 CRANKSHAFT SOCKET

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

    ST 18252AA000 CRANKSHAFT SOCKET

25. Set the engine with the cylinder block (RH) facing upward.

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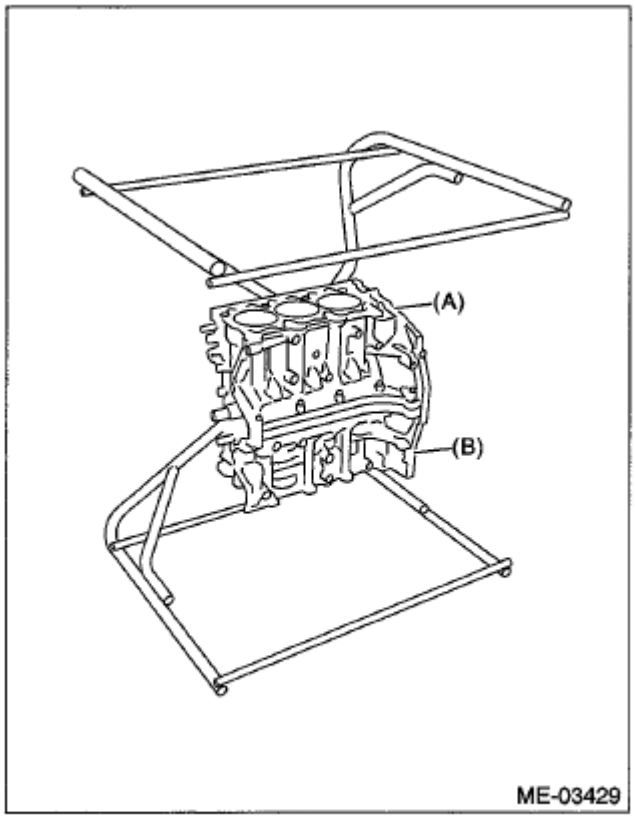

(A) Cylinder block (RH)
(B) Cylinder block (LH)

Fig. 171: Identifying Cylinder Block
Courtesy of SUBARU OF AMERICA, INC.

26. Remove the upper bolt.

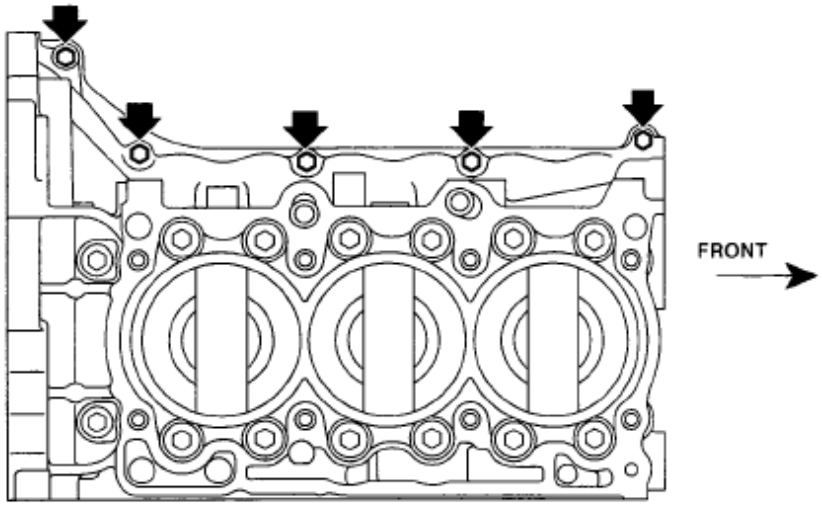

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Fig. 172: Locating Cylinder Block Upper Bolt
Courtesy of SUBARU OF AMERICA, INC.

27. Loosen the cylinder block bolts in the numerical order as shown in the figure, then separate the cylinder block (RH) and (LH).

NOTE: Make sure that the crankshaft remains in the cylinder block (LH).

Separating the cylinder block (RH) carelessly by lifting it will cause the crankshaft inside the cylinder block (RH) to fall down.

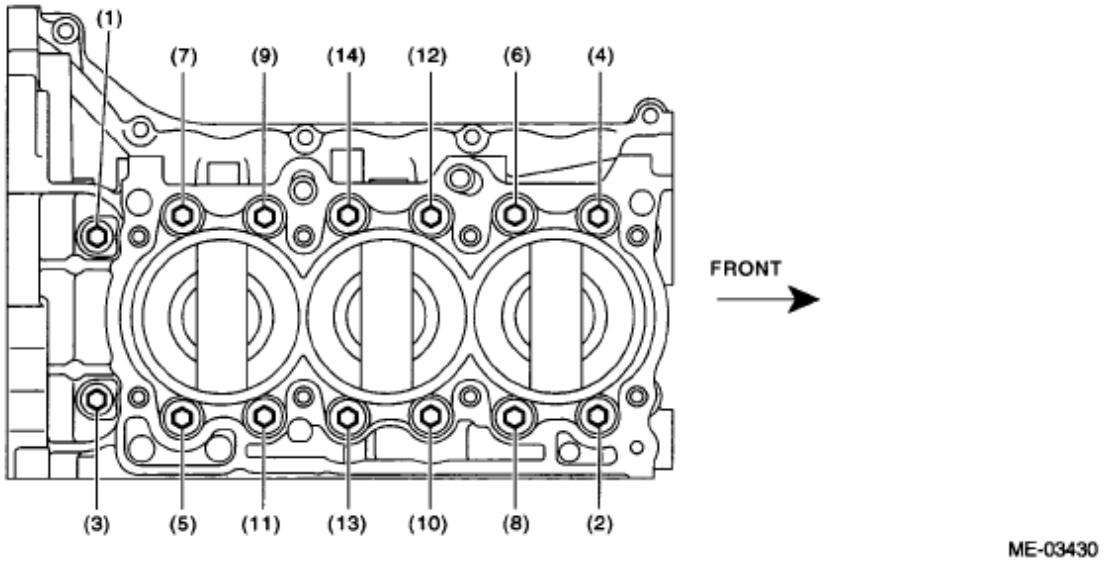

Fig. 173: Identifying Cylinder Block Upper Bolts Loosen Sequence
Courtesy of SUBARU OF AMERICA, INC.

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

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

INSTALLATION

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

ST 18232AA000 ENGINE STAND

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

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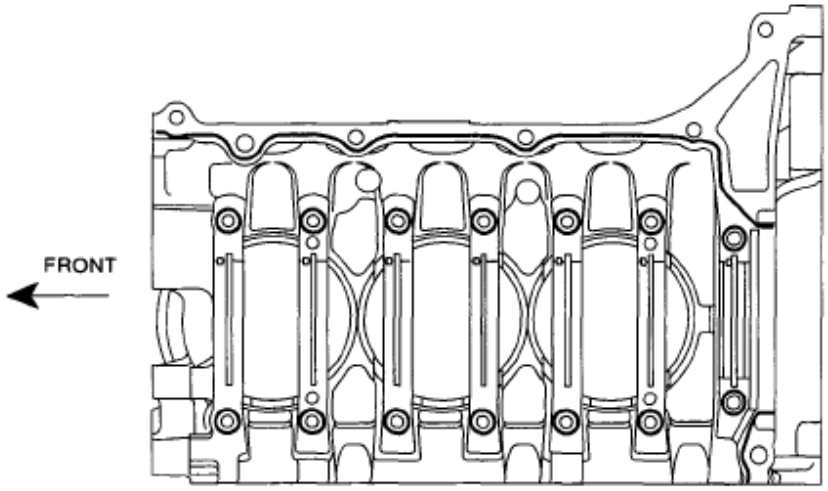
2. Install the crankshaft to cylinder block (LH).
3. Apply liquid gasket to the matching surface of cylinder block (RH).

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

NOTE: Install the oil pan lower within 5 minutes after applying liquid gasket.

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

Applying liquid gasket diameter: 1.0±0.2 mm (0.039±0.008 in)



ME-03431

Fig. 174: Identifying Cylinder Block
Courtesy of SUBARU OF AMERICA, INC.

4. Install the 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)

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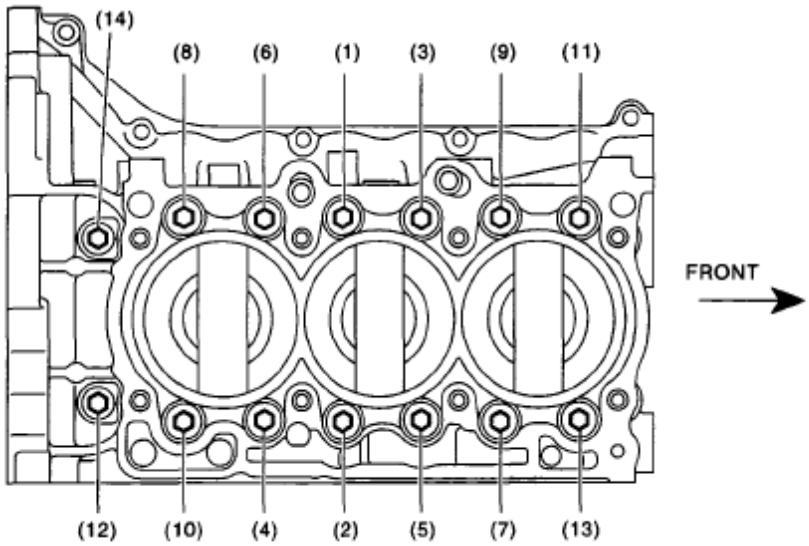

Fig. 175: Identifying Cylinder Block Bolts Tighten Sequence
Courtesy of SUBARU OF AMERICA, INC.

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)

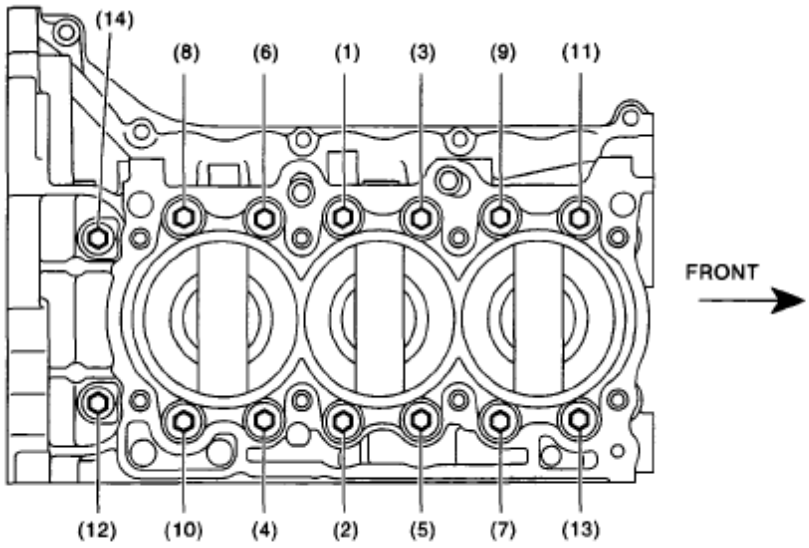

Fig. 176: Identifying Cylinder Block Bolts Tighten Sequence
Courtesy of SUBARU OF AMERICA, INC.

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

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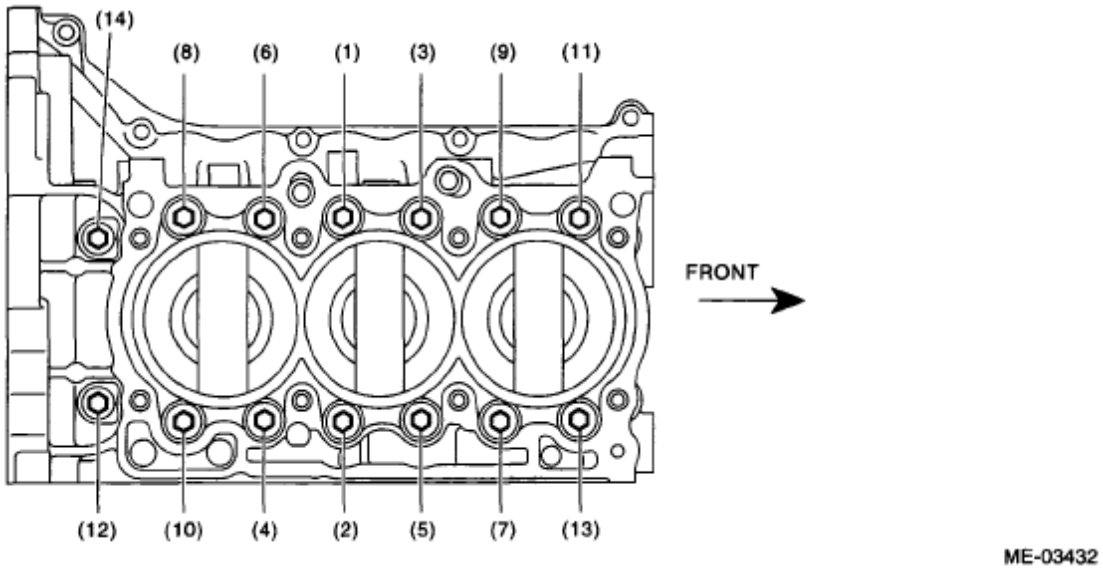

Fig. 177: Identifying Cylinder Block Bolts Tighten Sequence
Courtesy of SUBARU OF AMERICA, INC.

9. Install the upper bolt to cylinder block.

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

   NOTE: After tightening the cylinder block connecting bolts, remove the liquid gasket which is running over to the sealing surface for chain cover and oil pan upper.

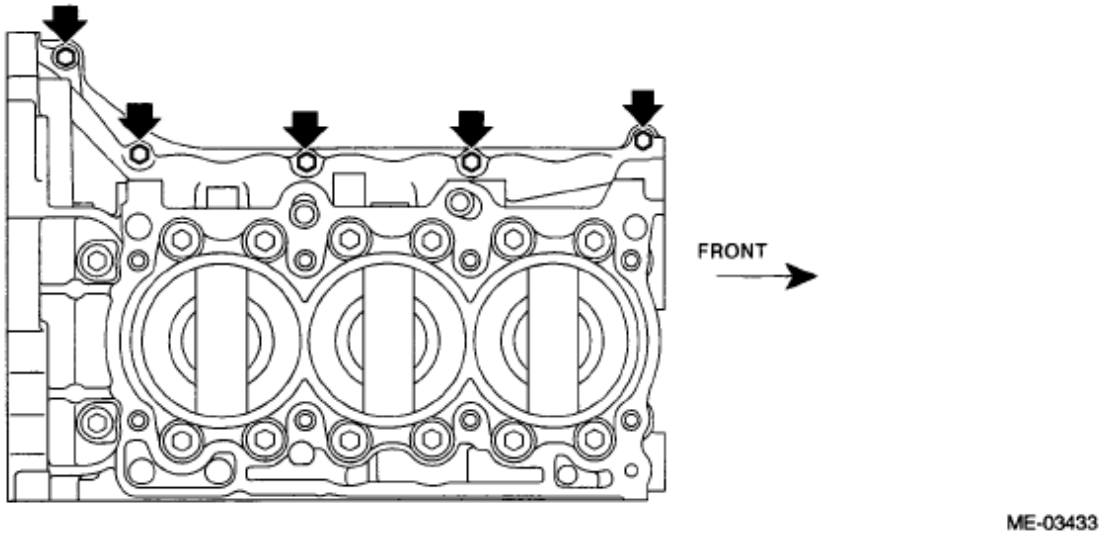

Fig. 178: Locating Cylinder Block Upper Bolt
Courtesy of SUBARU OF AMERICA, INC.

10. Apply a coat of engine oil to the oil seal periphery, then install the rear oil seal using ST1 and ST2.

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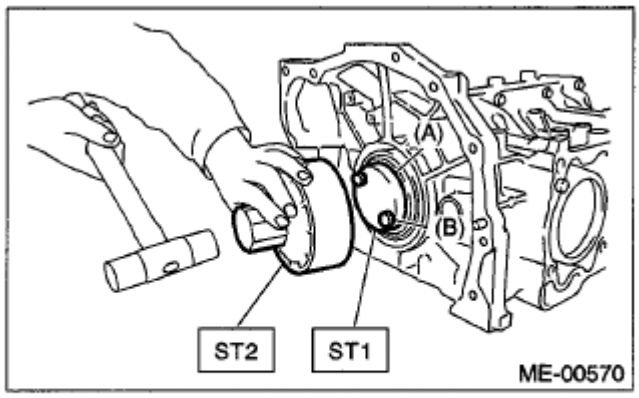
NOTE: Use a new rear oil seal.

ST1 499597100 CRANKSHAFT OIL SEAL GUIDE

ST2 499587200 CRANKSHAFT OIL SEAL INSTALLER



(A) Rear oil seal
(B) Drive plate installation bolt

Fig. 179: Installing Rear Oil Seal Using ST1 And ST2
Courtesy of SUBARU OF AMERICA, INC.

11. Set the engine with front side facing upward.

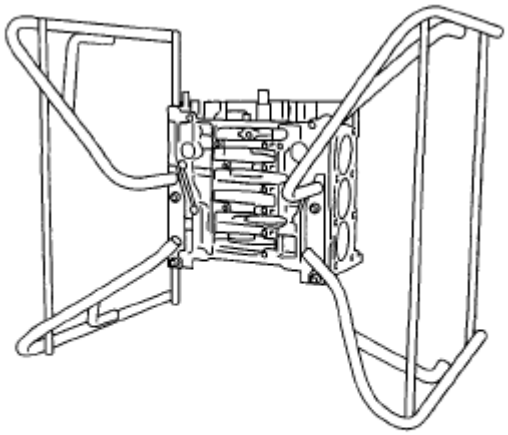


Fig. 180: Setting Engine With Front Side Facing Upward
Courtesy of SUBARU OF AMERICA, INC.

12. Install the piston ring and oil ring to the piston.

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

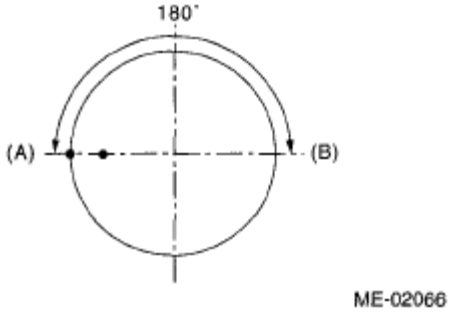

Fig. 181: Positioning Ring Gap
Courtesy of SUBARU OF AMERICA, INC.

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.

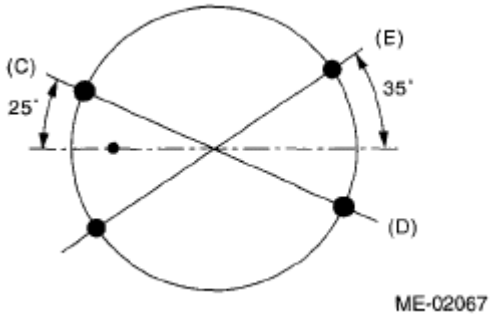

Fig. 182: Positioning Lower Rail Gap
Courtesy of SUBARU OF AMERICA, INC.

CAUTION:
- **Make sure ring gaps do not face the same direction.**
- **Make sure ring gaps are not within the piston skirt area.**
- **Assemble it so that R mark faces to top side of piston.**

13. Install the # 1 piston and connecting rod on the cylinder block.
    1. Apply engine oil to the periphery of piston and cylinder block inner surface.
    2. Set the piston in the ST with the front mark (A) facing the front of engine.

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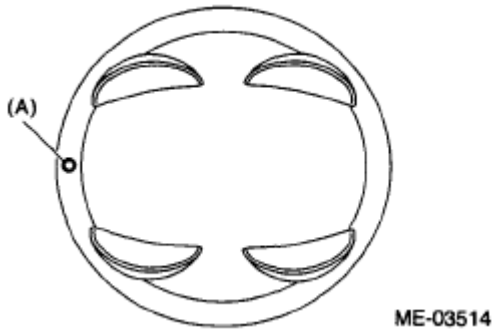

Fig. 183: Setting Piston In ST With Front Mark
Courtesy of SUBARU OF AMERICA, INC.

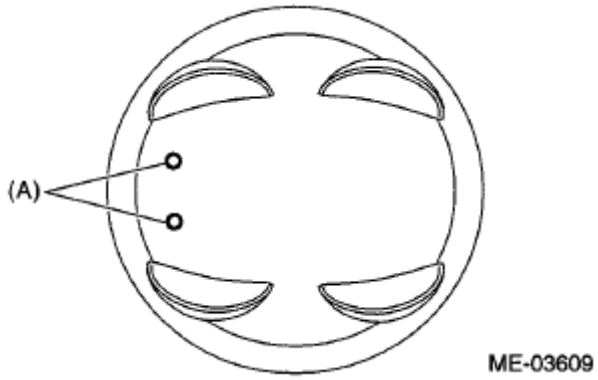

Fig. 184: Setting Piston In ST With Front Mark
Courtesy of SUBARU OF AMERICA, INC.

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

NOTE: Follow the notes below while inserting the piton into the cylinder block.

- **Insert the piston while tapping the top of piston using a plastic hammer handle.**
- **Continually check during insertion that the large end of the connecting rod will not scratch the cylinder liner.**
- **Insert the piston so that the connecting rod large end does not touche the crankshaft.**

ST 398744300 PISTON GUIDE

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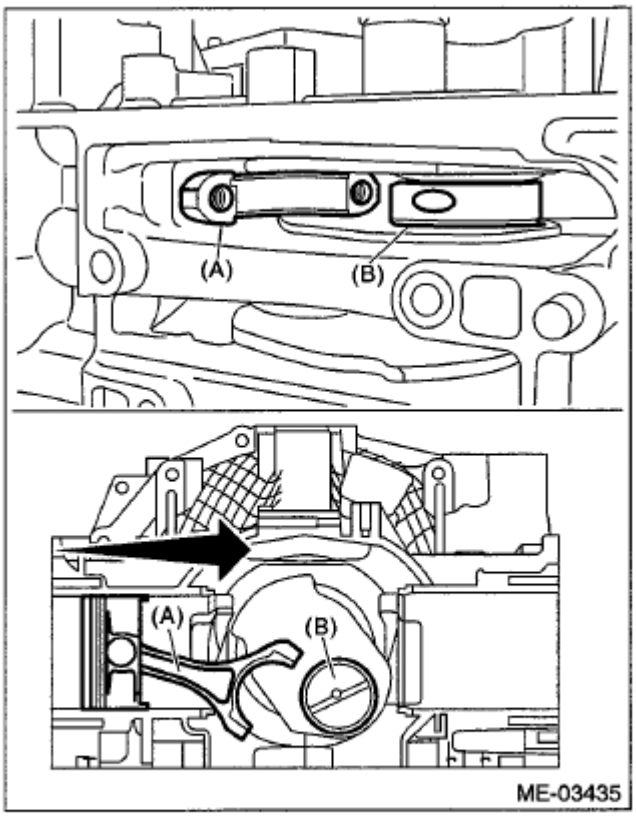

(A) # 1 connecting rod
(B) Crank pin

Fig. 185: Identifying Crank Pin And #1 Connecting Rod
Courtesy of SUBARU OF AMERICA, INC.

4. Turn the crankshaft using ST, to align the crank pin and the connecting rod large end position.

   ST 18252AA000 CRANKSHAFT SOCKET

5. Install the connecting rod cap.

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

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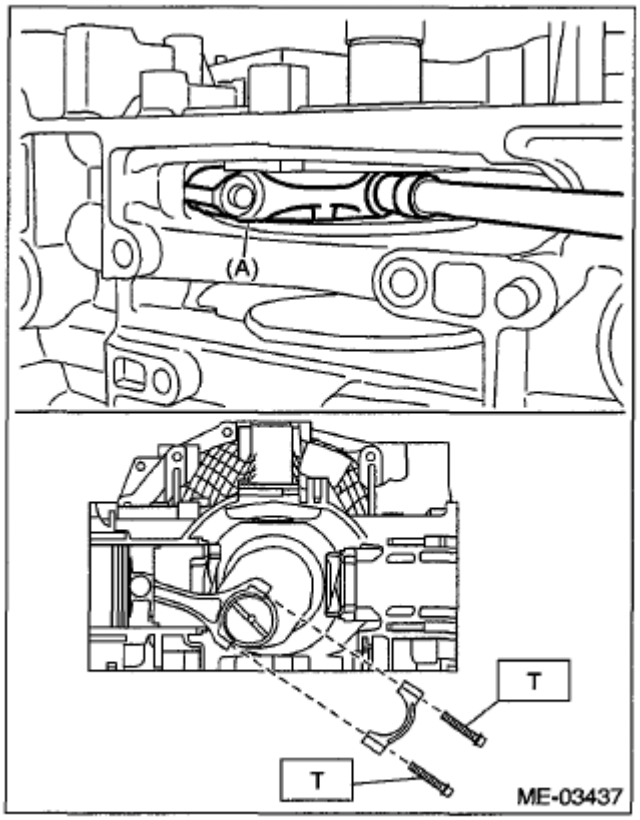

(A) # 1 connecting rod

Fig. 186: Identifying Connecting Rod Cap
Courtesy of SUBARU OF AMERICA, INC.

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

NOTE: Use new O-rings.

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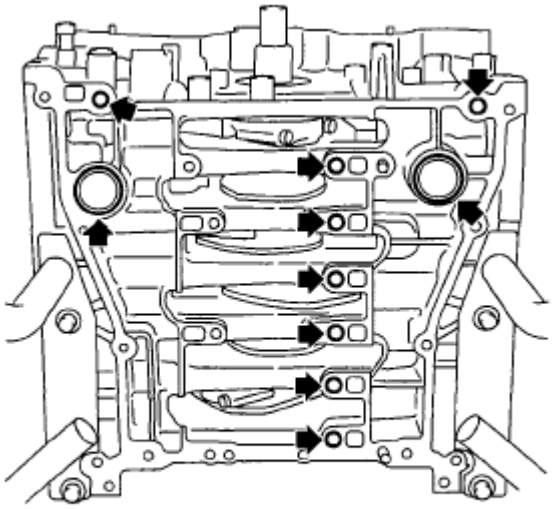

Fig. 187: Locating O-ring And Cylinder Block
Courtesy of SUBARU OF AMERICA, INC.

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

NOTE: Install the oil pan lower within 5 minutes after applying liquid gasket.

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

Applying liquid gasket diameter: 5.0±1.0 mm (0.20±0.04 in)

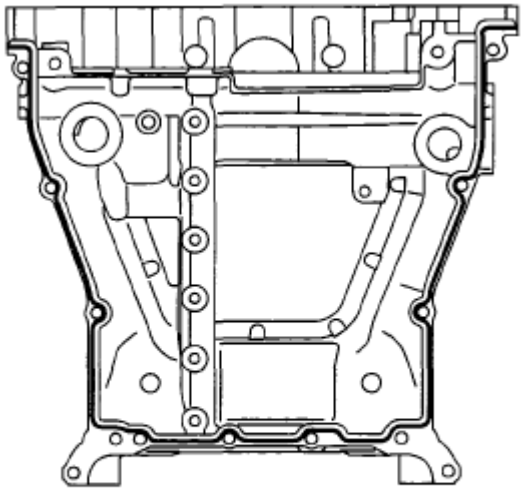

Fig. 188: Identifying Mating Surface Of Oil Pan Upper

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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)

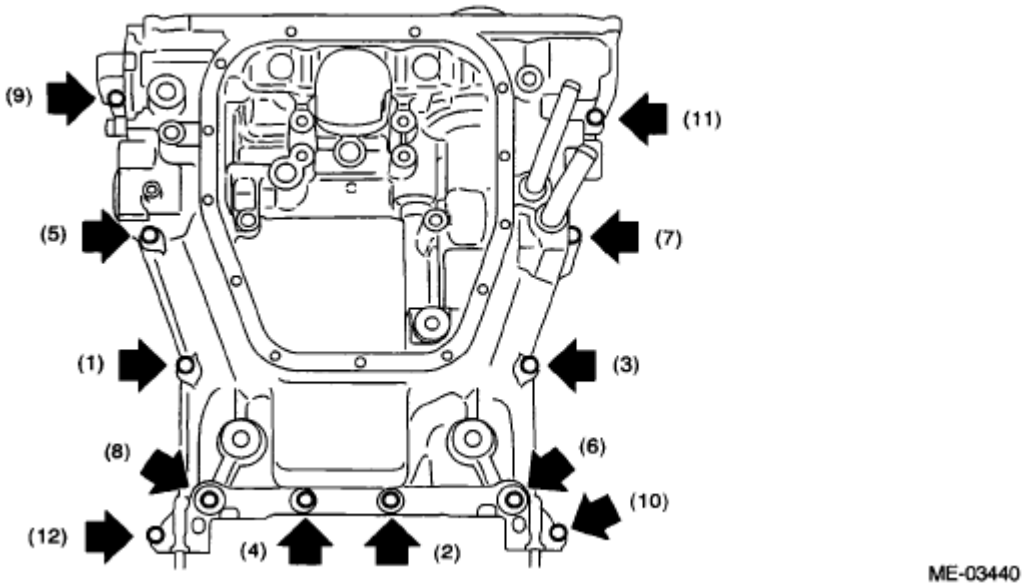

Fig. 189: Locating Oil Pan Upper Bolts
Courtesy of SUBARU OF AMERICA, INC.

19. Install the oil pump. Ref. to **INSTALLATION** , Oil Pump.
20. Install the thermostat and thermostat cover.

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

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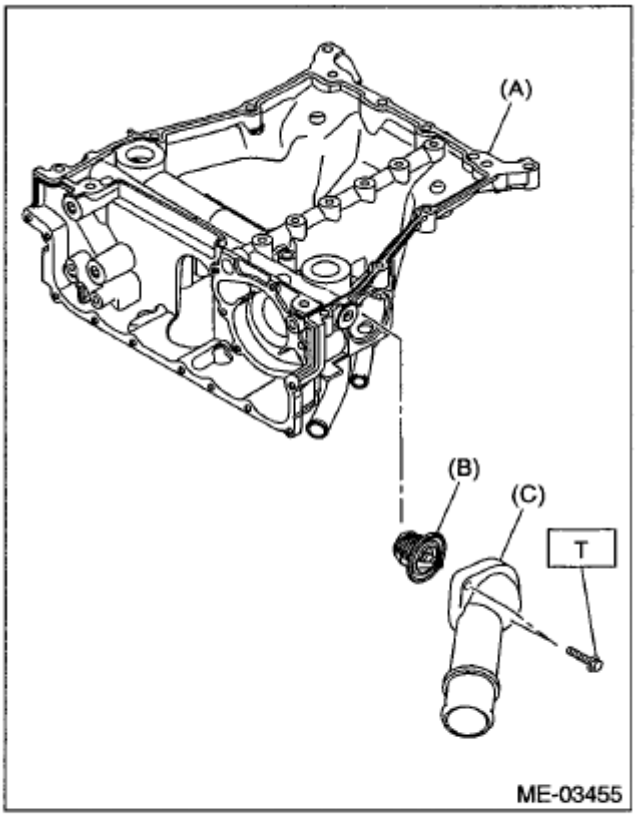

(A) Oil pan upper
(B) Thermostat
(C) Thermostat cover

Fig. 190: Identifying Thermostat And Thermostat Cover
Courtesy of SUBARU OF AMERICA, INC.

21. Tighten the oil cooler connector and install the oil cooler to oil pan upper.

Tightening torque: 54 N.m (5.5 kgf-m, 39.8 ft-lb)

NOTE: Use new O-rings.

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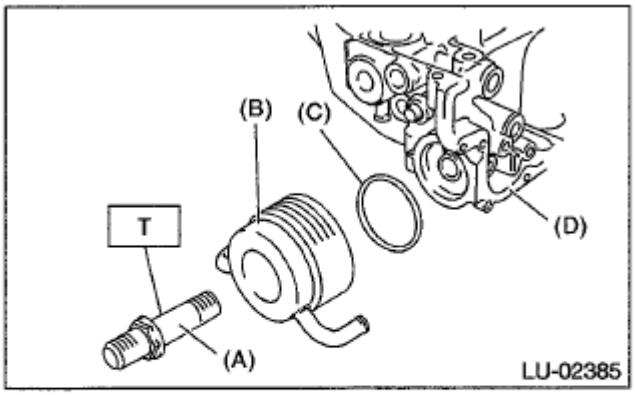

(A) Oil cooler connector
(B) Oil cooler
(C) O-ring
(D) Oil pan upper

Fig. 191: Identifying Oil Cooler Connector, Oil Cooler And O-Ring
Courtesy of SUBARU OF AMERICA, INC.

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

NOTE: Install the oil pan lower within 5 minutes after applying liquid gasket.

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

Applying liquid gasket diameter: 5.0±1.0 mm (0.20±0.04 in)

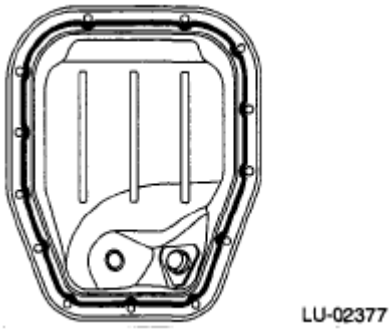

Fig. 192: Identifying Oil Pan Lower
Courtesy of SUBARU OF AMERICA, INC.

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

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

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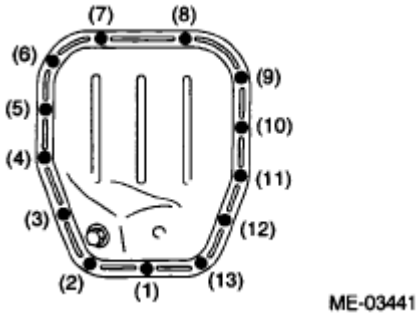

Fig. 193: Identifying Oil Pan Lower Bolts
Courtesy of SUBARU OF AMERICA, INC.

24. Install the crankshaft position sensor plate.

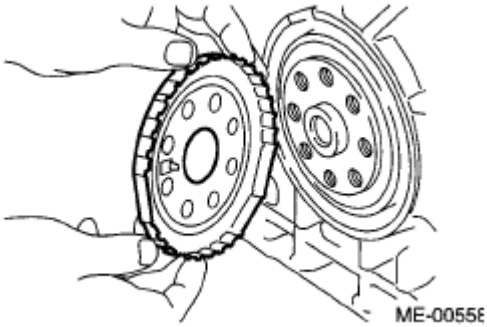

Fig. 194: Removing/Installing Crankshaft Position Sensor Plate
Courtesy of SUBARU OF AMERICA, INC.

25. Install the crankshaft position sensor.

Tightening torque: 6.4 N.m (0.7 kgf-m, 4.7 Mb)

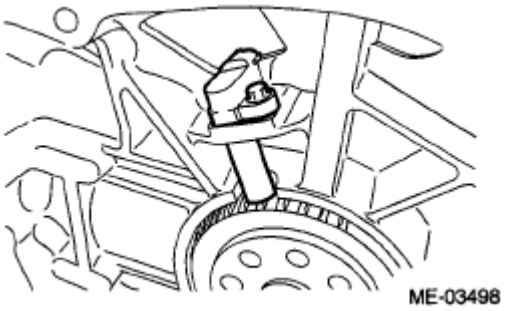

Fig. 195: Identifying Crankshaft Position Sensor
Courtesy of SUBARU OF AMERICA, INC.

26. Using the ST, lock the crankshaft and install drive plate.

ST 498497100 CRANKSHAFT STOPPER

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Tightening torque: 90 N.m (9.2 kgf-m, 66.4 ft-lb)

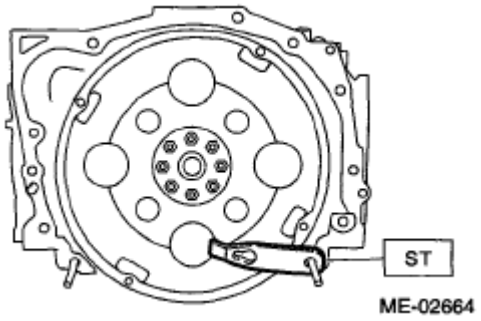

Fig. 196: Identifying Crankshaft And Drive Plate
Courtesy of SUBARU OF AMERICA, INC.

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

DISASSEMBLY

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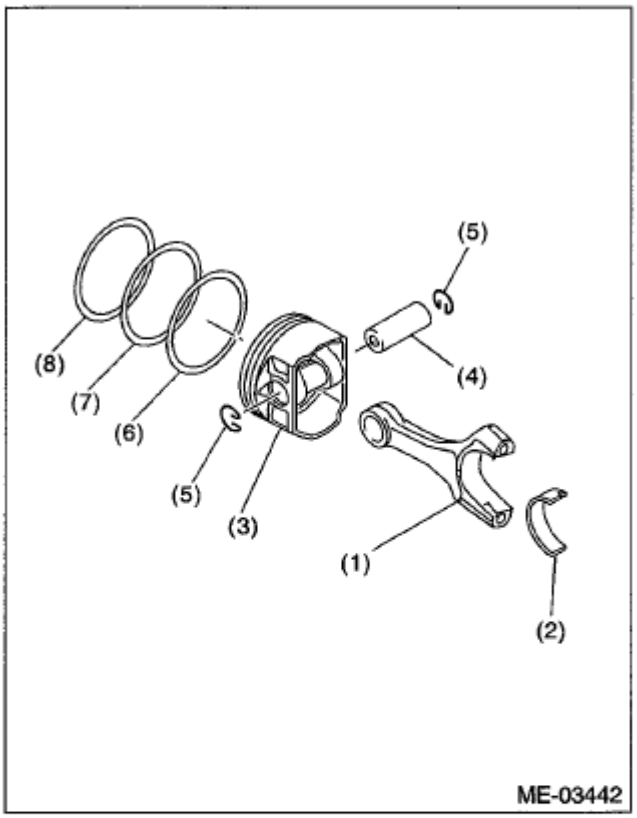

(1) Connecting rod
(2) Connecting rod bearing
(3) Piston
(4) Piston pin
(5) Snap ring
(6) Oil ring
(7) Second ring
(8) Top ring

Fig. 197: Identifying Connecting Rod, Connecting Rod Bearing, Piston And Snap Ring
Courtesy of SUBARU OF AMERICA, INC.

NOTE: Mark each part to prevent parts mixing.

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 snap ring.
5. Using a snap ring pliers, remove the snap ring.

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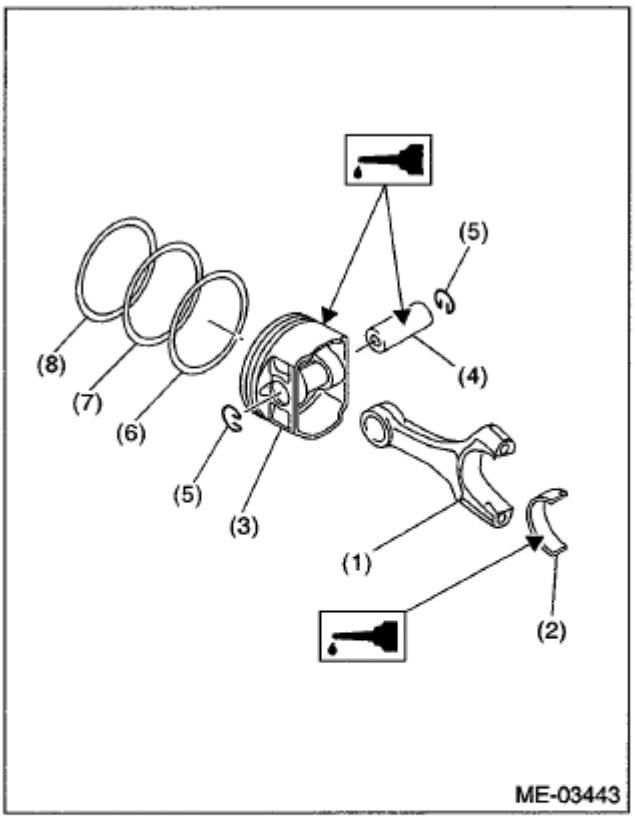
6. Remove the piston pin from piston.
7. Separate the piston and connecting rod.
8. Remove the plug and orifice from cylinder block. Ref. to **CYLINDER BLOCK**, COMPONENT, General Description.

ASSEMBLY



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

Fig. 198: Identifying Connecting Rod, Connecting Rod Bearing, Piston And Snap Ring
Courtesy of SUBARU OF AMERICA, INC.

1. Apply oil to the surfaces of the connecting rod bearings. Install the connecting rod bearings on connecting rods.
2. Joint the piston and connecting rod.

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NOTE: Position each connecting rod with the marking side facing forward.

3. Apply engine oil to the piston pin, then install the piston pin.
4. Using a snap ring pliers, install the snap ring.
5. Install the oil ring spacer, upper rail and lower rail by hand. Install the second ring and top ring using piston ring expander.

INSPECTION

CYLINDER BLOCK

1. Visually check for cracks and damage. Especially, inspect the important parts using liquid penetrant tester.
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.

Surface warpage limit: 0.02 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)

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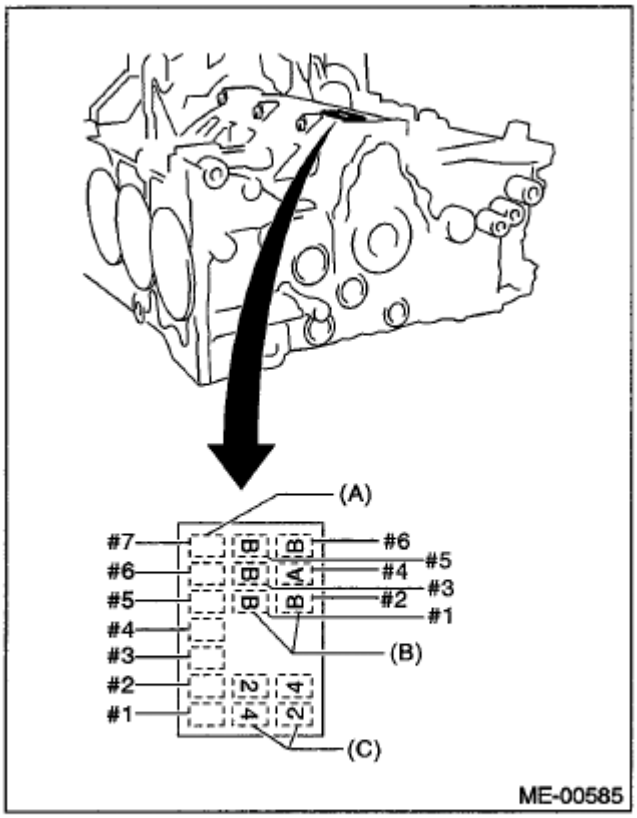

(A) Main journal size mark
(B) Cylinder bore size mark
(C) Cylinder block (RH) – (LH) combination mark

Fig. 199: Identifying Cylinder Bore Size Stamped On Front Upper Face Of Cylinder Block
Courtesy of SUBARU OF AMERICA, INC.

2. How to measure the inner diameter of each cylinder:

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

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

   Cylindricality: Standard: 0.030 mm (0.0012 in)

   Out-of-roundness: Standard: 0.010 mm (0.0004 in)

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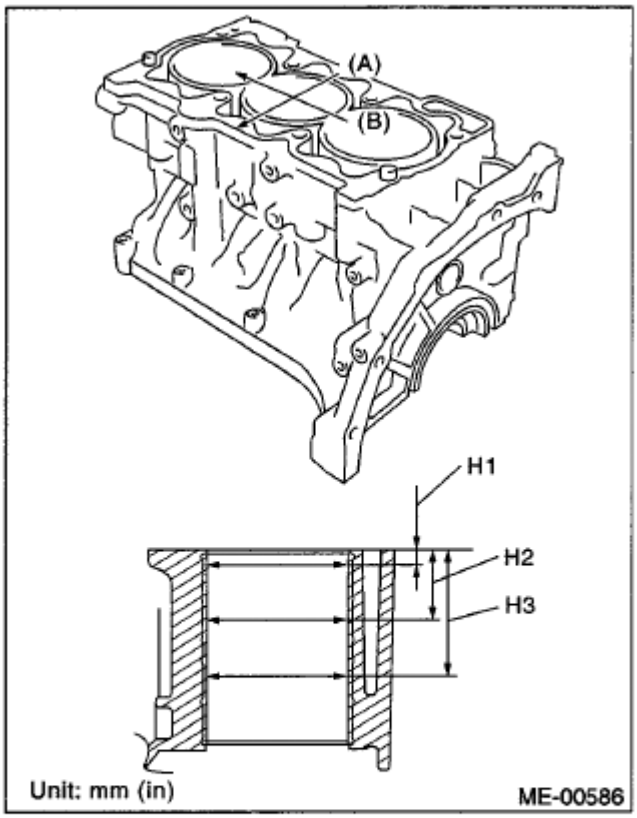

(A) Thrust direction
(B) Piston pin direction
H1: 10 mm (0.39 in)
H2: 45 mm (1.77 in)
H3: 80 mm (3.15 in)

Fig. 200: Identifying Piston Pin Direction
Courtesy of SUBARU OF AMERICA, INC.

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

   Measure the outer diameter of each piston at the height 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)

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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)

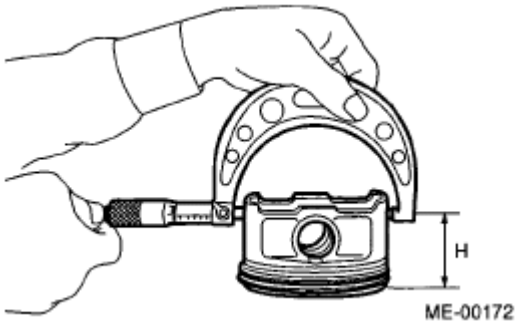

Fig. 201: Measuring Outer Diameter Of Piston
Courtesy of SUBARU OF AMERICA, INC.

5. Calculate the clearance between cylinder and piston.

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

Cylinder to piston clearance at 20°C (68°F): Standard: -0.010 - 0.010 mm (-0.0004 - 0.0004 in)

6. Boring and honing:
   1. If the value of cylindricality, out-of-round-ness, or cylinder-to-piston clearance measured is out of standard or if there is any damage on the cylinder wall, rebore it to use an oversize piston.

CAUTION:
- **When any of the cylinders needs reboring, all other cylinders must be bored at the same time, and use oversize pistons.**
- **Do not perform boring on one cylinder only. Nor use an oversize piston for one cylinder only.**

   2. If the cylinder inner diameter exceeds 92.515 mm (3.6317 in) 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, pay attention to this when measuring the cylinder diameter.

PISTON AND PISTON PIN

1. Check the pistons and piston pins for damage, cracks and wear, and the piston ring grooves for wear and damage. Replace if faulty.
2. Measure the clearance between each cylinder piston and cylinders. Ref. to **CYLINDER AND PISTON**,

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INSPECTION, Cylinder Block. If any of the clearances is not within standard, replace the piston, or bore the cylinder to use an oversize piston.

3. Check that the piston pin can be inserted into the piston pin hole just by using your thumb at 20°C (68°F). Replace if faulty.

Standard clearance between piston pin and hole in piston: Standard: 0.004 - 0.008 mm (0.0002 - 0.0003 in)

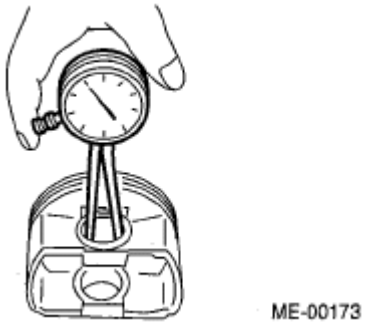

Fig. 202: Checking Clearance Between Piston Pin And Hole In Piston
Courtesy of SUBARU OF AMERICA, INC.

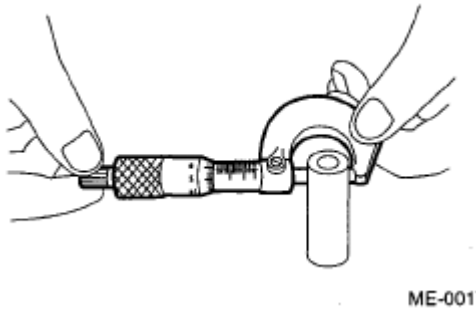

Fig. 203: Measuring Piston Pin Diameter
Courtesy of SUBARU OF AMERICA, INC.

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

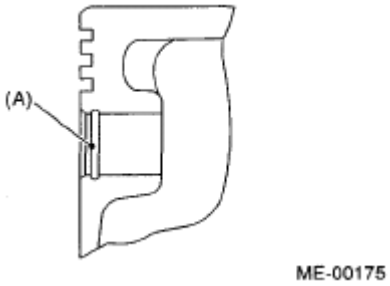

Fig. 204: Identifying Circlip Installation Groove On Piston
Courtesy of SUBARU OF AMERICA, INC.

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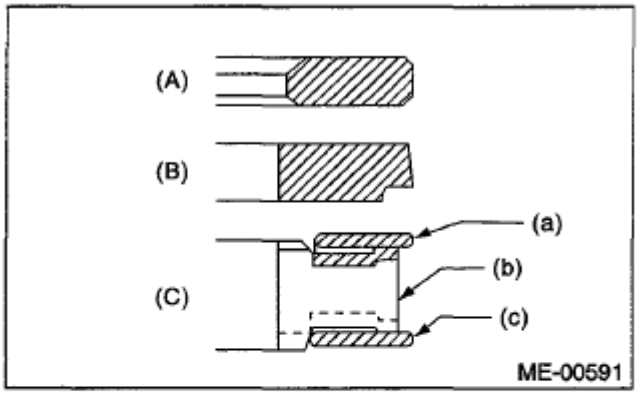
5. Check the piston pin snap ring for distortion, cracks and wear.

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.

CAUTION:
- **Marks are displayed on the end of top and second rings. When installing the ring to piston, face this mark upward.**
- **Oil ring consists of the upper rail, expander and lower rail. When installing on 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. 205: Identifying Piston Ring
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 SPECIFICATION

		Standard mm (in)
Piston ring gap	Top ring	0.20 - 0.25 (0.0079 - 0.0098)
	Second ring	0.40 - 0.50 (0.0157 - 0.0197)
	Oil ring	0.20 - 0.50 (0.0079 - 0.0197)

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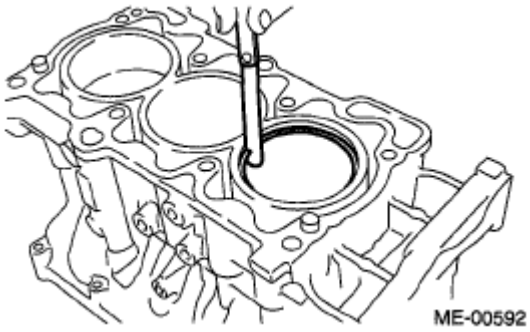

Fig. 206: Measuring Piston Ring Gap With Thickness Gauge
Courtesy of SUBARU OF AMERICA, INC.

3. 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 SPECIFICATION

		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)

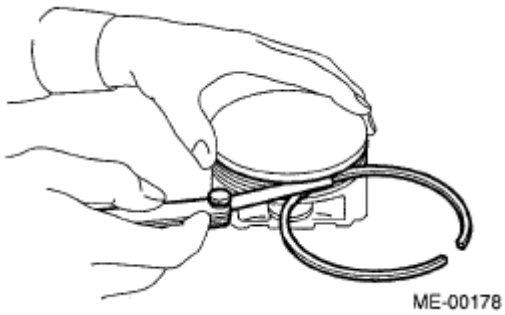

Fig. 207: Measuring Clearance Between Piston Ring And Piston Ring Groove
Courtesy of SUBARU OF AMERICA, INC.

CONNECTING ROD

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

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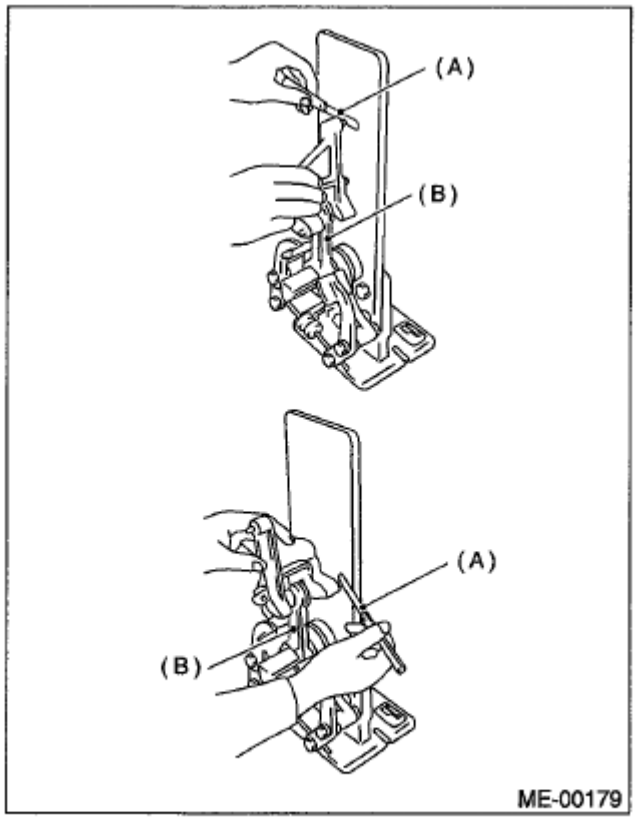

(A) Thickness gauge
(B) Connecting rod

Fig. 208: Checking For Bend And Twist Using Connecting Rod Aligner
Courtesy of SUBARU OF AMERICA, INC.

3. Install the connecting rod fitted with bearing to crankshaft and measure the thrust clearance. If the clearance exceeds the standard or offset wear occurs, replace the connecting rod.

Connecting rod thrust clearance: Standard: 0.070 - 0.330 mm (0.0028 - 0.0130 in)

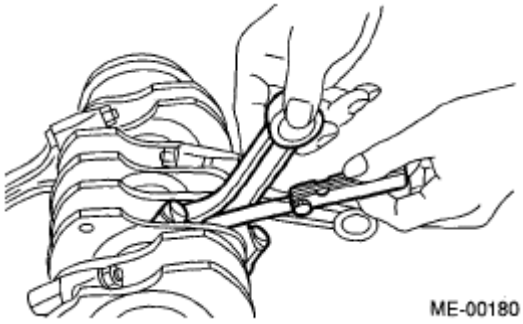

Fig. 209: Checking Connecting Rod Side Clearance
Courtesy of SUBARU OF AMERICA, INC.

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

   Connecting rod oil clearance: Standard: 0.016 - 0.043 mm (0.0006 - 0.0017 in)

   BEARING SIZE THICKNESS CHART

		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 if worn or damaged. Also measure the piston pin clearance on the smaller end of the connecting rod.

   Clearance between piston pin and bushing: Standard: 0 - 0.022 mm (0 - 0.0009 in)

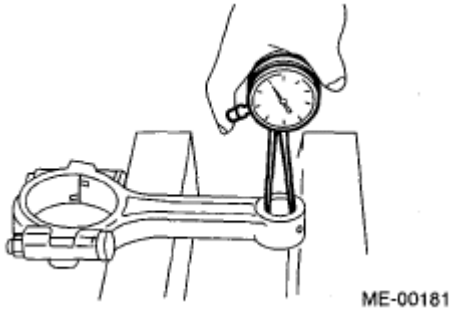

Fig. 210: Checking Clearance Between Piston Pin And Bushing
Courtesy of SUBARU OF AMERICA, INC.

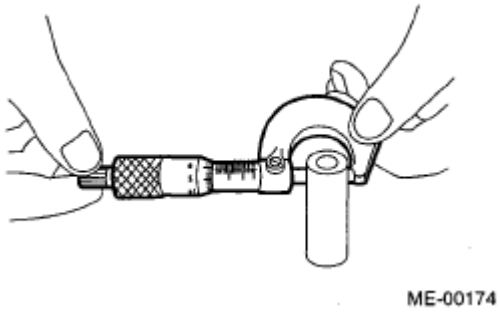

Fig. 211: Measuring Piston Pin Diameter
Courtesy of SUBARU OF AMERICA, INC.

7. Replacement procedure is as follows.

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1. Remove the bushing from connecting rod with ST and press.
2. Press the bushing with ST after applying oil on the periphery of the new bushing.

   ST 18350AA000 CONNECTING ROD BUSHING REMOVER AND INSTALLER

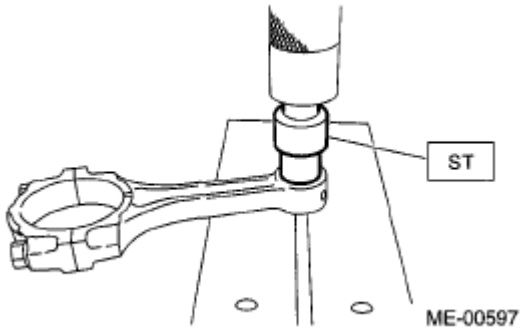

Fig. 212: Identifying ST 18350Aa000 Connecting Rod Bushing Remover And Installer
Courtesy of SUBARU OF AMERICA, INC.

3. Make two 3 mm (0.12 in) holes in the pressed bushing by aligning with the pre-manufactured holes on the connecting rod. Ream the inside of 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. Replace if defective.
2. Check the crankshaft for bend, and repair or replace if needed. Repair or replace if bended.

NOTE: If a suitable V-block is not available, install #1 and #7 crankshaft bearing on cylinder block, position the crankshaft on these bearings, and then check the crankshaft bend using a dial gauge.

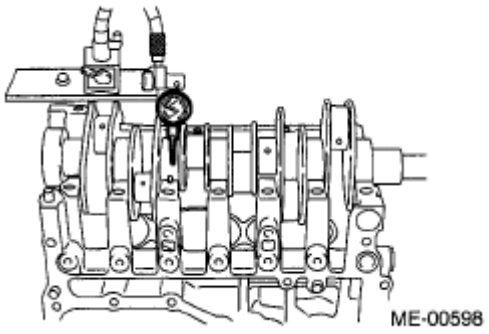

Fig. 213: Checking Crankshaft For Bend
Courtesy of SUBARU OF AMERICA, INC.

3. Inspect the crank journal and crank pin for wear. If they are not within the specification, replace the

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bearing with a suitable (undersize) one, and replace or readjust 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 and crank journal: Out-of-roundness: 0.005 mm (0.0002 in)

Cylindricality: 0.006 mm (0.0002 in)

Fig. 214: Inspecting Crank Journal And Crank Pin
Courtesy of SUBARU OF AMERICA, INC.

CRANK JOURNAL DIAMETER CHART

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 - 1.501 (0.0586 - 0.0591)
0.03(0.0012) Undersize	Journal O.D.	63.962 - 63.978 (2.5182 - 2.5188)			51.954 - 51.970 (2.0454 - 2.0461)
	Bearing size (Thickness at center)	2.011 - 2.014 (0.0792 - 0.0793)		2.015 - 2.018 (0.0793 - 0.0794)	1.507 - 1.515 (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)		2.025 - 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)		2.125 - 2.128 (0.0837 - 0.0838)	1.617 - 1.625 (0.0637 - 0.0640)

4. Use a thickness gauge to measure the thrust clearance of crankshaft at center bearing. If clearance exceeds

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the standard, replace the bearing.

Crankshaft thrust clearance: Standard: 0.030 - 0.115 mm (0.0012 - 0.0045 in)

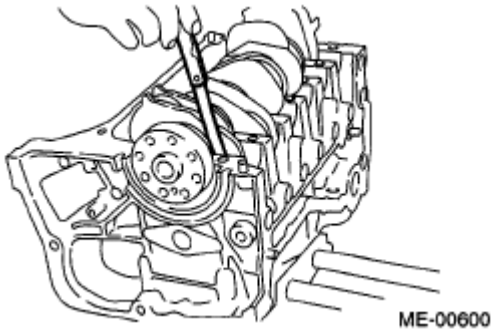

Fig. 215: Measuring Thrust Clearance Of Crankshaft Center Bearing
Courtesy of SUBARU OF AMERICA, INC.

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

Crankshaft oil clearance: Standard: 0.010 - 0.030 mm (0.0004 - 0.0012 in)

OIL FLOW CONTROL SOLENOID VALVE

REMOVAL

For oil flow control solenoid valve, refer to **REMOVAL** , Oil Flow Control Solenoid Valve.

INSTALLATION

For oil flow control solenoid valve, refer to **INSTALLATION** , Oil Flow Control Solenoid Valve.

INTAKE AND EXHAUST VALVE

SPECIFICATION

Refer to "Cylinder Head" for removal and installation procedures of intake and exhaust valves. Ref. to **REMOVAL**, Cylinder Head. Ref. to **INSTALLATION**, Cylinder Head.

PISTON

SPECIFICATION

Refer to "Cylinder Block" for removal and installation procedures of pistons. Ref. to **REMOVAL**, Cylinder

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Block. Ref. to **INSTALLATION**, Cylinder Block.

CONNECTING ROD

SPECIFICATION

Refer to "Cylinder Block" for removal and installation procedures of connecting rod. Ref. to **REMOVAL**, Cylinder Block. Ref. to **INSTALLATION**, Cylinder Block.

CRANKSHAFT

SPECIFICATION

Refer to "Cylinder Block" for removal and installation procedures of crankshaft. Ref. to **REMOVAL**, Cylinder Block. Ref. to **INSTALLATION**, Cylinder Block.

ENGINE TROUBLE IN GENERAL

INSPECTION

NOTE: The "RANK" shown in the chart shows the possibilities of the cause of trouble in order from "most likely" to "rarely".

A - Most likely

B - Sometimes

C - Rarely

SYMPTOM CHART

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

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2) Initial combustion does not occur.	Starter	Defective starter	C
	Engine control system, Ref. to **BASIC DIAGNOSTIC PROCEDURE** .		A
	Fuel line	Defective fuel pump and relay	A
		Clogged fuel line	C
		Lack of 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
3) Initial combustion occurs.	Engine control system, Ref. to **BASIC DIAGNOSTIC PROCEDURE** .		A
	Intake system	Defective intake manifold gasket	B
		Defective throttle body gasket	B
	Fuel line	Defective fuel pump and relay	C
		Clogged fuel line	C
		Lack of or insufficient fuel	B
	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, Ref. to **BASIC DIAGNOSTIC PROCEDURE** .		A
		Loosened or cracked intake duct	B

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4) Engine stalls after initial combustion.	Intake system	Loosened or cracked PCV hose	C
		Loosened or cracked vacuum hose	C
		Defective intake manifold gasket	B
		Defective throttle body gasket	B
		Dirty air cleaner element	C
	Fuel line	Clogged fuel line	C
		Lack of or insufficient fuel	B
	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
2. Rough idle and engine stall	Engine control system, Ref. to **BASIC DIAGNOSTIC PROCEDURE** .		A
	Intake system	Loosened or cracked intake duct	A
		Loosened or cracked PCV hose	A
		Loosened or cracked vacuum hose	A
		Defective intake manifold gasket	B
		Defective throttle body gasket	B
		Defective PCV valve	C
		Loosened oil filler cap	B
		Dirty air cleaner element	C
	Fuel line	Defective fuel pump and relay	C
		Clogged fuel line	C
		Lack of or insufficient fuel	B
	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	

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		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, Ref. to **BASIC DIAGNOSTIC PROCEDURE** .		A
	Intake system	Loosened or cracked intake duct	A
		Loosened or cracked PCV hose	A
		Loosened or cracked vacuum hose	B
		Defective intake manifold gasket	B
		Defective throttle body gasket	B
		Defective PCV valve	B
		Loosened oil filler cap	B
		Dirty air cleaner element	A
	Fuel line	Defective fuel pump and relay	B
		Clogged fuel line	B
		Lack of or insufficient fuel	C
	Timing chain	Defective timing	B
	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	C
		Incorrect valve timing	A
		Improper engine oil (low viscosity)	B
	Lubrication system	Incorrect oil pressure	B
	Cooling system	Over-heating	C
		Over-cooling	C
	Others	Evaporative emission control system malfunction	A
	Engine control system, Ref. to **BASIC DIAGNOSTIC PROCEDURE** .		A

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4. Surging	Intake system	Loosened or cracked intake duct	A
		Loosened or cracked PCV hose	A
		Loosened or cracked vacuum hose	A
		Defective intake manifold gasket	B
		Defective throttle body gasket	B
		Defective PCV valve	B
		Loosened oil filler cap	B
		Dirty air cleaner element	B
	Fuel line	Defective fuel pump and relay	B
		Clogged fuel line	B
		Lack of or insufficient fuel	C
	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
5. Engine does not return to idle.	Engine control system, Ref. to **BASIC DIAGNOSTIC PROCEDURE** .		A
	Intake system	Loosened or cracked vacuum hose	A
	Others	Stuck or damaged throttle valve	A
6. Dieseling (Run-on)	Engine control system, Ref. to **BASIC DIAGNOSTIC PROCEDURE** .		A
	Cooling system	Over-heating	B
	Others	Evaporative emission control system malfunction	B
	Engine control system, Ref. to **BASIC DIAGNOSTIC PROCEDURE** .		A
	Intake system	Loosened or cracked intake duct	C
		Loosened or cracked PCV hose	C
		Loosened or cracked vacuum hose	B
		Defective PCV valve	B
		Loosened oil filler cap	C

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7. After burning in exhaust system	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, Ref. to **BASIC DIAGNOSTIC PROCEDURE** .		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
9. Excessive engine oil consumption	Intake system	Loosened or cracked PCV hose	A
		Defective PCV valve	B
		Loosened oil filler cap	C
	Compression	Defective valve stem	A
		Worn or stuck piston rings, cylinder and piston	A
	Lubrication system	Loosened oil pump attaching bolts and defective gasket	B
		Defective oil filter 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
	Engine control system, Ref. to **BASIC DIAGNOSTIC PROCEDURE** .		A
	Intake system	Dirty air cleaner element	A
	Timing chain	Defective timing	B
		Incorrect valve clearance	B

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10. Excessive fuel consumption	Compression	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

POSSIBLE CAUSE SYMPTOM

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
Heavy and dull clank	Oil pressure is low.	• Worn camshaft main bearing • Worn connecting rod bearing (large end)
	Oil pressure is normal.	Damaged engine mounting
High-pitched clank	Sound is noticeable when accelerating with an overload condition.	• Ignition timing advanced • Accumulation of carbon inside combustion chamber • Wrong thermal value spark plug • Gasoline of improper octane number
Clank when engine speed is between 1,000 and 2,000 rpm.	Sound is reduced when fuel injector connector of noisy cylinder is disconnected. (1)	• Worn crankshaft main bearing • Worn connecting rod bearing (large end)
	Sound is reduced when fuel	• Worn cylinder liner and piston ring

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Knocking sound when engine is operating under idling speed and engine is warm	injector connector of noisy cylinder is disconnected. (1)	• 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	-	• Loose drive 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 • Contact of timing chain 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, Ref. to **OPERATION** , Clear Memory Mode. and Inspection Mode, Ref. to **PROCEDURE** , Inspection Mode. after connecting the fuel injector connector.		

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