2009 ENGINE

Mechanical (H6DO) - Legacy and Outback

GENERAL DESCRIPTION

SPECIFICATION

SPECIFICATION CHART

Engine	Cylinder arrangement				Horizontally opposed, liquid cooled, 6-cylinder, 4-stroke gasoline engine
	Valve system mechanism				Chain driven, double overhead camshaft, 4-valve/cylinder
	Bore x Stroke			mm (in)	89.2x80 (3.512 x 3.150)
	Displacement			cm^3 (cu in)	3,000 (183)
	Compression ratio				10.7
	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 47°
				Close	ABDC 23°
		Max. retard		Open	ATDC 3°
				Close	ABDC 73°
	Exhaust valve timing			Open	BBDC 46°
				Close	ATDC 6°
	Valve clearance mm (in)	Intake			$0.20^{+0.04}_{-0.06}$ ($0.0079^{+0.0016}_{-0.00024}$)
		Exhaust			0.35±0.05 (0.0138±0.0020)
	Idle RPM ["P" or "N" range] RPM			No load	650±50
				A/C ON	770±50
	Ignition order				1 --> 6 --> 3 --> 2 --> 5 --> 4
	Ignition timing			BTDC/RPM	15°±8°/650
	Bending limit			mm (in)	0.020 (0.00079)
	Side clearance mm (in)	Intake		Standard	0.075 - 0.135 (0.0030 - 0.0053)
		Exhaust		Standard	0.030 - 0.090 (0.0012 - 0.0035)
	Cam lobe height mm (in)	Intake	HIGH	Standard	42.09 - 42.19 (1.6571 - 1.6610)
			LOW1	Standard	38.14 - 38.24(1.5016 - 1.5055)
			LOW2	Standard	38.14 - 38.24 (1.5016 - 1.5055)
		Exhaust		Standard	40.45 - 40.55 (1.5925 - 1.5965)
			HIGH	Standard	32.00 (1.2598)

Camshaft	Cam base circle diameter mm (in)	Intake	LOW1	Standard	31.84 (1.2535)
			LOW2	Standard	31.84 (1.2535)
		Exhaust		Standard	32.00 (1.2598)
	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	Warping limit (Mating surface 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)				5.500 - 5.512 (0.2165 - 0.2170)
	Protrusion above head mm (in)				11.4 - 11.8 (0.449 - 0.465)
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			99.7 (3.925)
		Exhaust			105.2 (4.142)
	Outer diameter of valve lifter mm (in)				32.959 - 32.975 (1.2976 - 1.2982)
Valve spring	Free length mm (in)	Intake		Inner	39.55 (1.5571)
				Outer	41.18 (1.6213)
		Exhaust			46.32 (1.8236)
	Squareness	Intake		Inner	2.5°, 1.7 mm (0.067 in) or less
				Outer	2.5°, 1.8 mm (0.071 in) or less
		Exhaust			2.5°, 2.0 mm (0.079 in) or less
Cylinder block	Standard height mm (in)				202 (7.95)
	Warping limit (Mating surface with cylinder head) mm (in)			Standard	0.02 (0.0008)
	Cylinder inner diameter mm (in)	Standard		A	89.205 - 89.215 (3.5120 - 3.5124)
				B	89.195 - 89.205 (3.5116 - 3.5120)
	Cylindrically mm (in)			Standard	0.030 (0.0012)

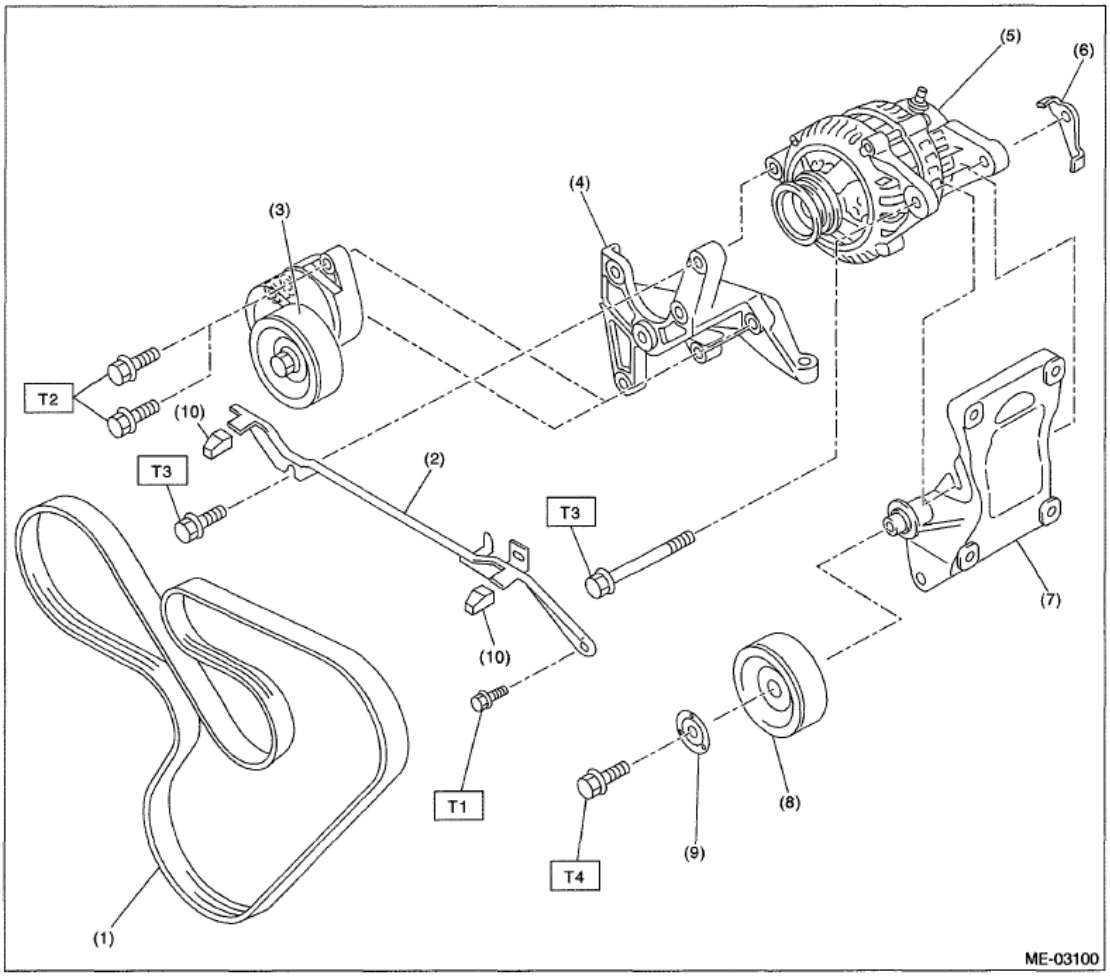
	Out-of-roundness			mm (in)	Standard	0.010 (0.0004)
	Piston clearance			mm (in)	Standard	-0.010 - 0.010 (-0.0004 - 0.0004)
	Cylinder inner diameter boring limit (diameter)			mm (in)		To 89.715 (3.5321)
Piston	Outer diameter	mm (in)	Standard		A	89.205 - 89.215 (3.5120 - 3.5124)
					B	89.195 - 89.205 (3.5116 - 3.5120)
			0.25 (0.0098) OS			89.445 - 89.465 (3.5215 - 3.5222)
			0.50 (0.0197) OS			89.695 - 89.715 (3.5313 - 3.5321)
	Inner diameter of piston pin hole			mm (in)	Standard	22.000 - 22.006 (0.8661 - 0.8664)
Piston pin	Outer diameter			mm (in)	Standard	21.994 - 22.000 (0.8659 - 0.8661)
	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 - 0.35 (0.0079 - 0.0138)
			Second ring		Standard	0.35 - 0.50 (0.0138 - 0.0197)
			Oil ring		Standard	0.20 - 0.60 (0.0079 - 0.0236)
	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	0.045 - 0.125 (0.0018 - 0.0049)
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			1.490 - 1.506 (0.0587 - 0.0593)
			0.03 (0.0012) US			1.509 - 1.513 (0.0594 - 0.0596)
			0.05 (0.0020) US			1.519 - 1.523 (0.0598 - 0.0600)
			0.25 (0.0098) US			1.619 - 1.623 (0.0637 - 0.0639)
Bushing of small end	Clearance between piston pin and bushing			mm (in)	Standard	0 - 0.022 (0 - 0.0009)
	Crank pin and crank journal	Out-of-roundness		mm (in)		0.005 (0.0002)
		Cylindrically		mm (in)		0.006 (0.0002)
	Crank pin outer diameter	mm (in)	Standard			51.984 - 52.000 (2.0466 - 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)

Crankshaft	Crank journal outer diameter	mm (in)	#1,#3, #5, #7	Standard	63.992 - 64.008 (2.5194 - 2.5200)
				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 - 64.008 (2.5194 - 2.5200)
				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, #7	Standard	1.992 - 2.005 (0.0784 - 0.0789)
				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 - 2.009 (0.0786 - 0.0791)
				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)

NOTE:
OS: Oversize
US: Undersize

COMPONENT

V-BELT



(1)	V-belt	(6)	Generator plate
(2)	Collector cover bracket	(7)	A/C compressor stay
(3)	Belt tension adjuster ASSY	(8)	Idler pulley
(4)	Power steering pump bracket	(9)	Idler pulley cover
(5)	Generator	(10)	Cushion

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

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

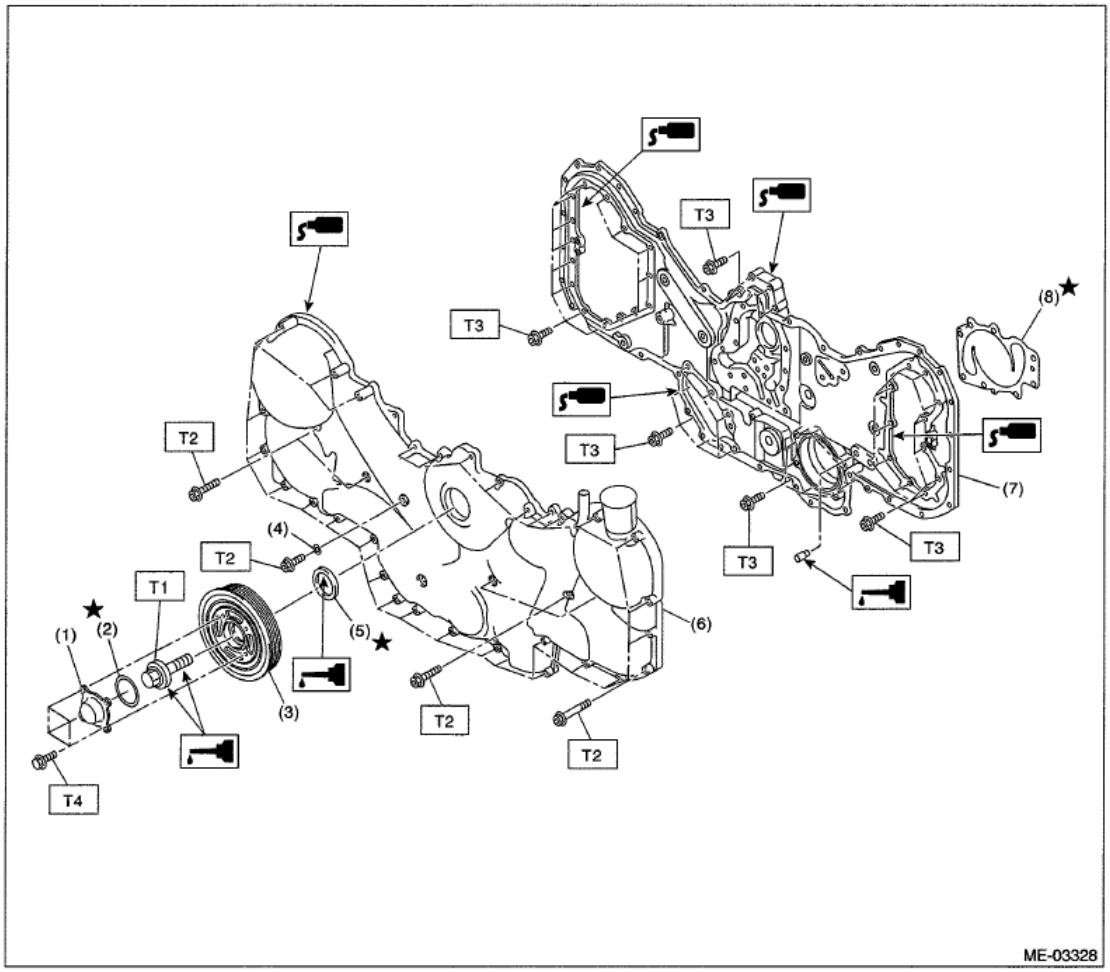
T1: 6.4 (0.7, 4.7)

T2: 20 (2.0, 14.8)

T3: 25 (2.5, 18.4)

T4: 33 (3.4, 24.3)

TIMING CHAIN COVER



(1) Crank pulley cover
(2) O-ring
(3) Crank pulley
(4) Sealing washer
(5) Oil seal
(6) Front chain cover
(7) Rear chain cover
(8) Water pump gasket

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

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

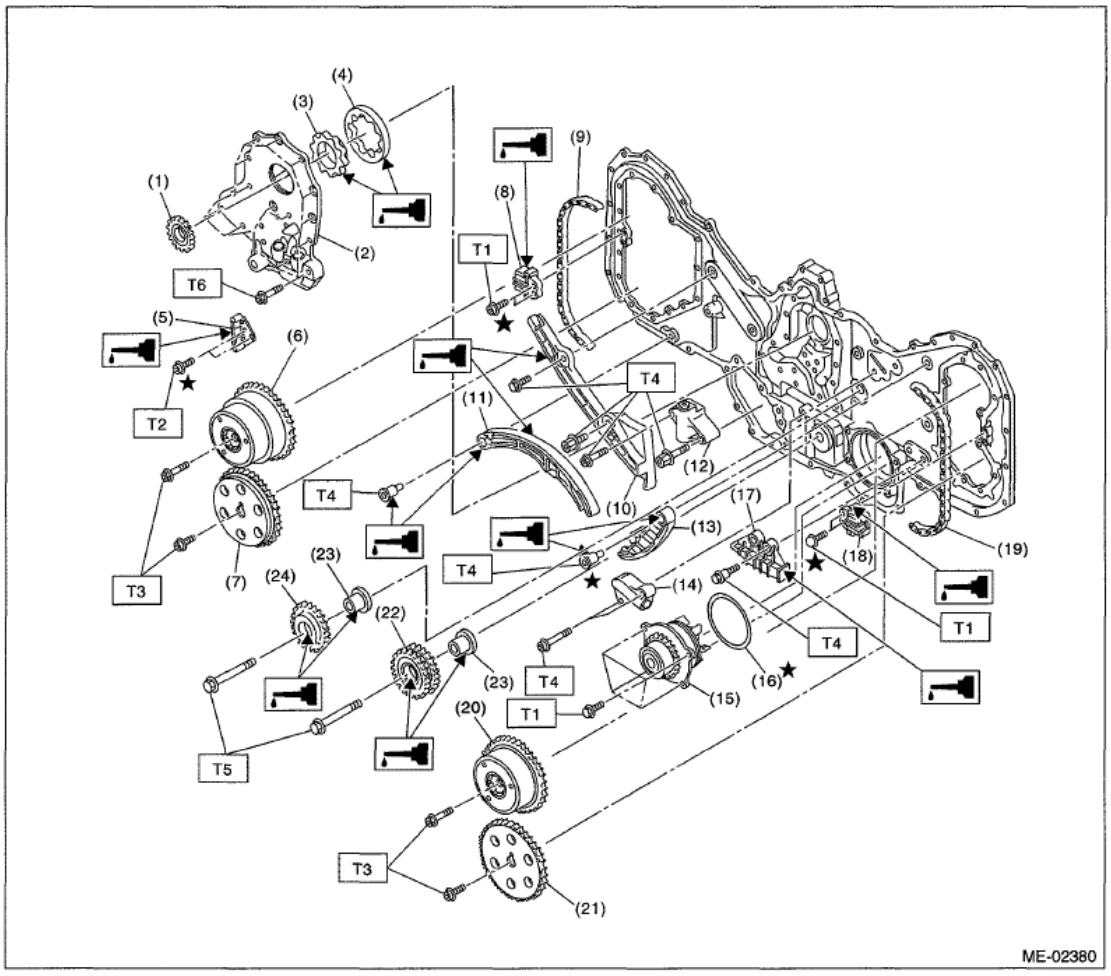
T1: Refer to CRANK PULLEY.

T2: Refer to FRONT CHAIN COVER.

T3: Refer to REAR CHAIN COVER.

T4: 6.4 (0.7, 4.7)

TIMING CHAIN



(1)	Crank sprocket	(12)	Chain tensioner (RH)	(23)	Idler sprocket collar
(2)	Oil relief case	(13)	Chain tensioner lever (LH)	(24)	Idler sprocket (upper)
(3)	Inner rotor	(14)	Chain tensioner (LH)		
(4)	Outer rotor	(15)	Water pump		
(5)	Chain guide (center)	(16)	O-ring		
(6)	Intake cam sprocket (RH)	(17)	Chain guide (LH)		
(7)	Exhaust cam sprocket (RH)	(18)	Chain guide (LH: between cams)		
(8)	Chain guide (RH: between cams)	(19)	Timing chain (LH)		
(9)	Timing chain (RH)	(20)	Intake cam sprocket (LH)		
(10)	Chain guide (RH)	(21)	Exhaust cam sprocket (LH)		
(11)	Chain tensioner lever (RH)	(22)	Idler sprocket (lower)		

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

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

T1: 6.4 (0.7, 4.7)

T2: 7.8 (0.8, 5.8)

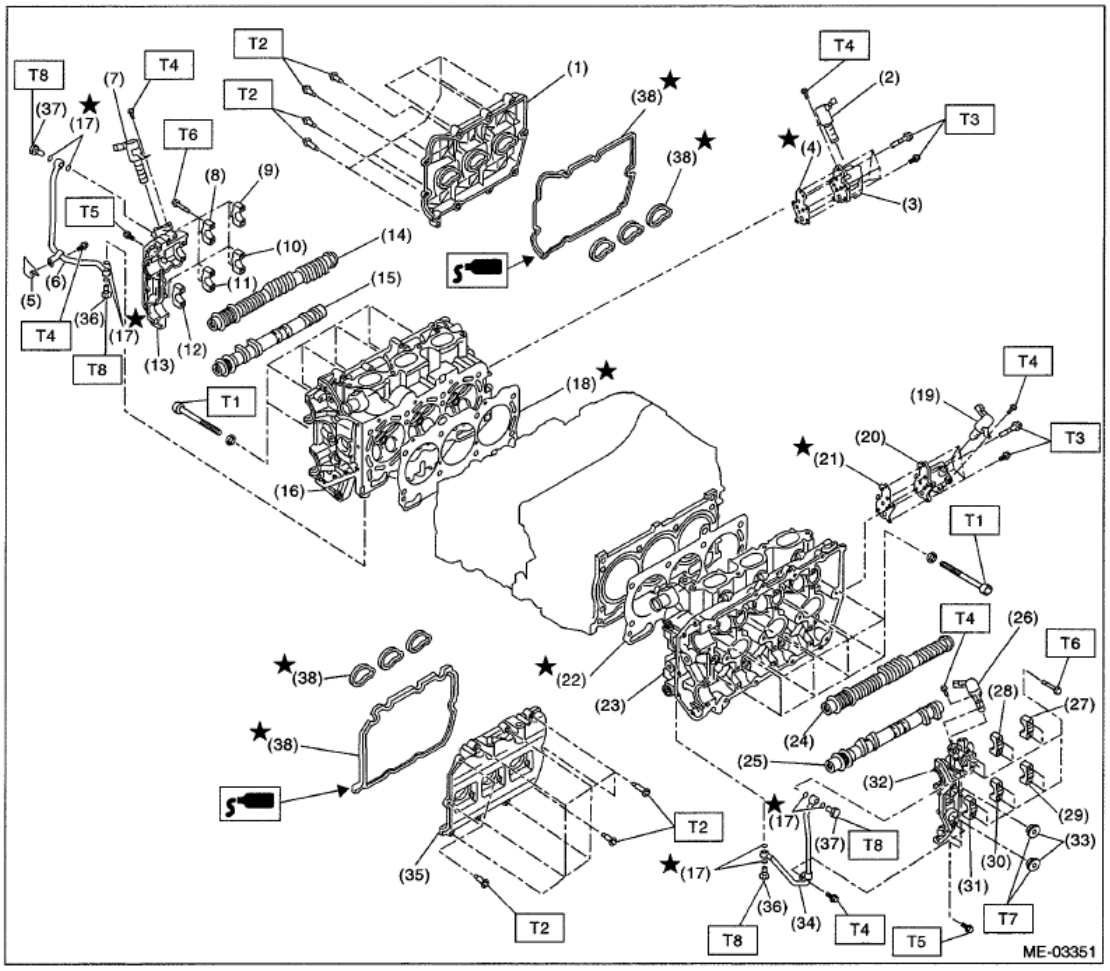
T3: Refer to CAM SPROCKET.

T4: 16 (1.6, 11.8)

T5: 69 (7.0, 50.9)

T6: Refer to **OIL PUMP** .

CYLINDER HEAD AND CAMSHAFT



(1)	Rocker cover (RH)	(18)	Cylinder head gasket (RH)	(35)	Rocker cover (LH)
(2)	Oil switching solenoid valve (RH)	(19)	Oil switching solenoid valve (LH)	(36)	Union screw with filter (with protrusion)
(3)	Oil switching solenoid valve holder (RH)	(20)	Oil switching solenoid valve holder (LH)	(37)	Union screw without filter (without protrusion)
(4)	Oil switching solenoid valve gasket (RH)	(21)	Oil switching solenoid valve gasket (LH)	(38)	Rocker cover gasket
(5)	Front chain cover	(22)	Cylinder head gasket (LH)		
(6)	Oil pipe (RH)	(23)	Cylinder head (LH)		
(7)	Oil flow control solenoid valve (RH)	(24)	Intake camshaft (LH)		
(8)	Intake camshaft cap (Center RH)	(25)	Exhaust camshaft (LH)		
(9)	Intake camshaft cap (Rear RH)	(26)	Oil flow control solenoid valve (LH)		
(10)	Exhaust camshaft cap (Rear RH)	(27)	Intake camshaft cap (Rear LH)		
(11)	Exhaust camshaft cap (Center RH)	(28)	Intake camshaft cap (Center LH)		
(12)	Exhaust camshaft cap (Front RH)	(29)	Exhaust camshaft cap (Rear LH)		
(13)	Front camshaft cap (RH)	(30)	Exhaust camshaft cap (Center LH)		
(14)	Intake camshaft (RH)	(31)	Exhaust camshaft cap (Front LH)		
(15)	Exhaust camshaft (RH)	(32)	Front camshaft cap (LH)		
(16)	Cylinder head (RH)	(33)	Plug		
(17)	Gasket	(34)	Oil pipe (LH)		

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

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

T1: Refer to CYLINDER HEAD.

T2: Refer to CAMSHAFT.

T3: Refer to OIL SWITCHING SOLENOID VALVE.

T4: 6.4 (0.7, 4.7)

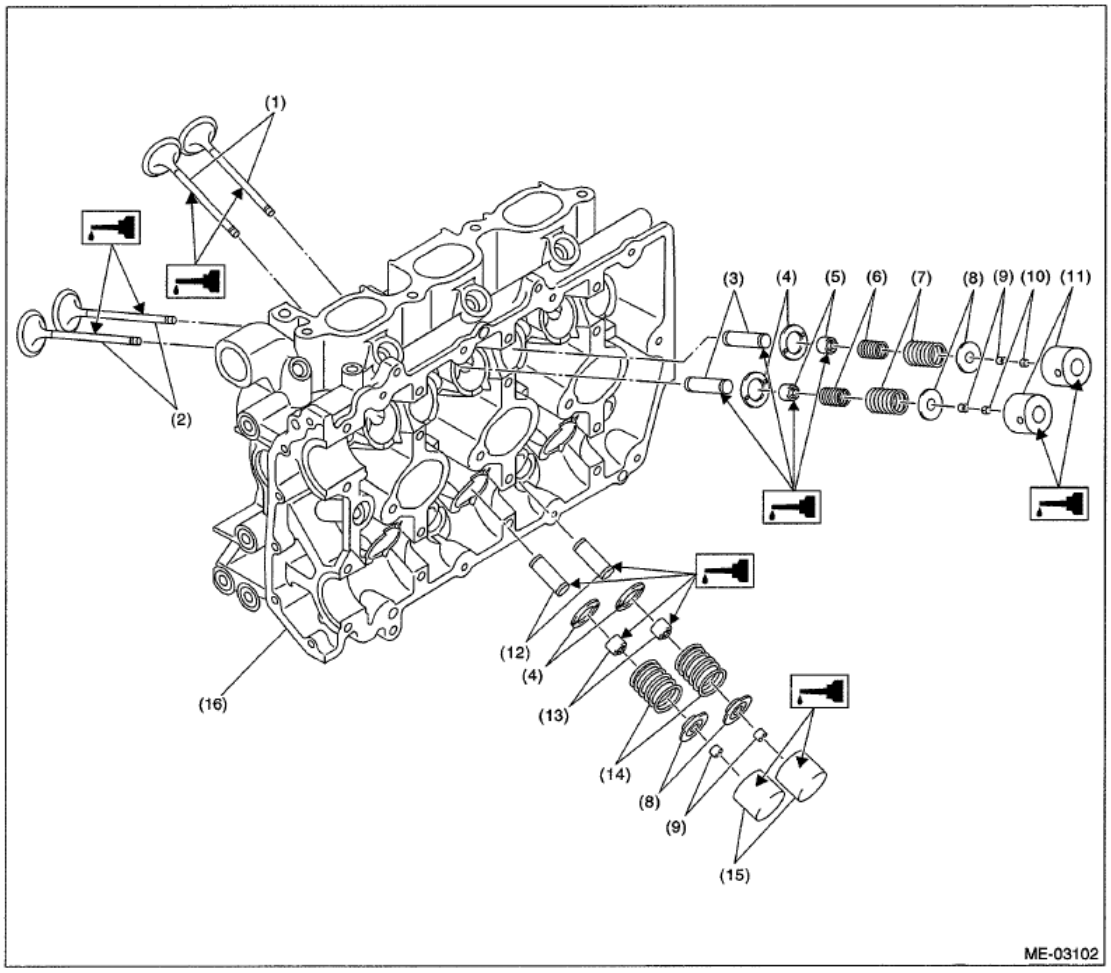
T5: 9.75 (1.0, 7.2)

T6: 16 (1.6, 11.8)

T7: 60 (6.1, 44.3)

T8: 29 (3.0, 21.4)

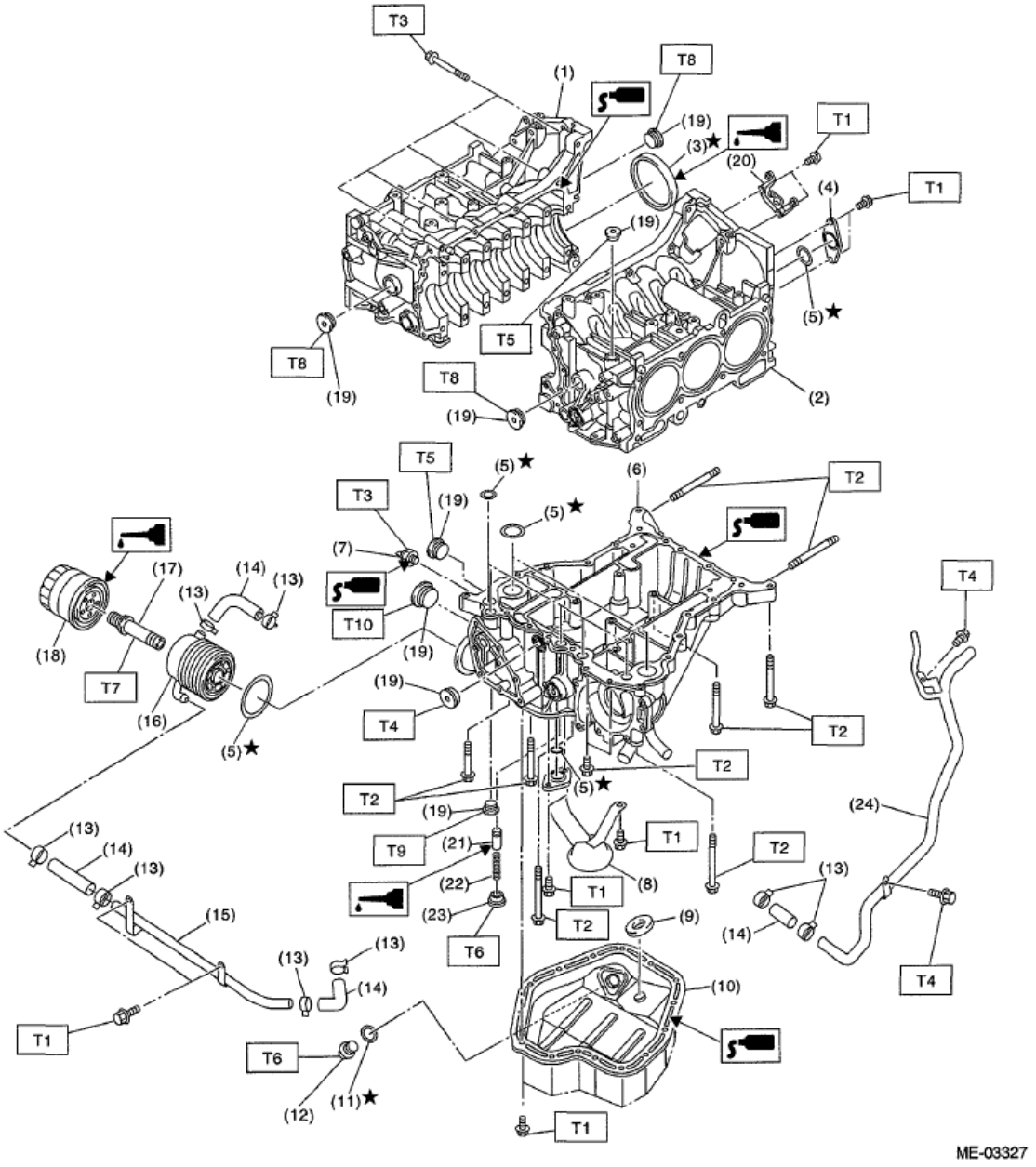
CYLINDER HEAD AND VALVE ASSEMBLY



(1) Exhaust valve
(2) Intake valve
(3) Intake valve guide
(4) Valve spring seat
(5) Intake valve stem seal
(6) Valve spring (Inner)
(7) Valve spring (Outer)
(8) Retainer
(9) Retainer key
(10) Shim
(11) Valve lifter (Intake)
(12) Exhaust valve guide
(13) Exhaust valve stem seal
(14) Valve spring
(15) Valve lifter (Exhaust)
(16) Cylinder head

Fig. 5: Identifying Cylinder Head And Valve Assembly Components
Courtesy of SUBARU OF AMERICA, INC.

CYLINDER BLOCK



(1)	Cylinder block (RH)	(13)	Clamp
(2)	Cylinder block (LH)	(14)	Hose
(3)	Rear oil seal	(15)	Oil cooler pipe
(4)	Service hole cover	(16)	Oil cooler
(5)	O-ring	(17)	Oil cooler connector
(6)	Oil pan upper	(18)	Oil filter
(7)	Oil pressure switch	(19)	Plug
(8)	Oil strainer	(20)	Crankshaft position sensor holder
(9)	Magnet	(21)	Relief valve
(10)	Oil pan lower	(22)	Relief valve spring
(11)	Metal gasket	(23)	Plug
(12)	Drain plug	(24)	Water pipe

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: 18 (1.8, 13.3)

T3: 25 (2.5, 18.4)

T4: 16 (1.6, 11.8)

T5: 37 (3.8, 27.3)

T6: 44 (4.5, 32.5)

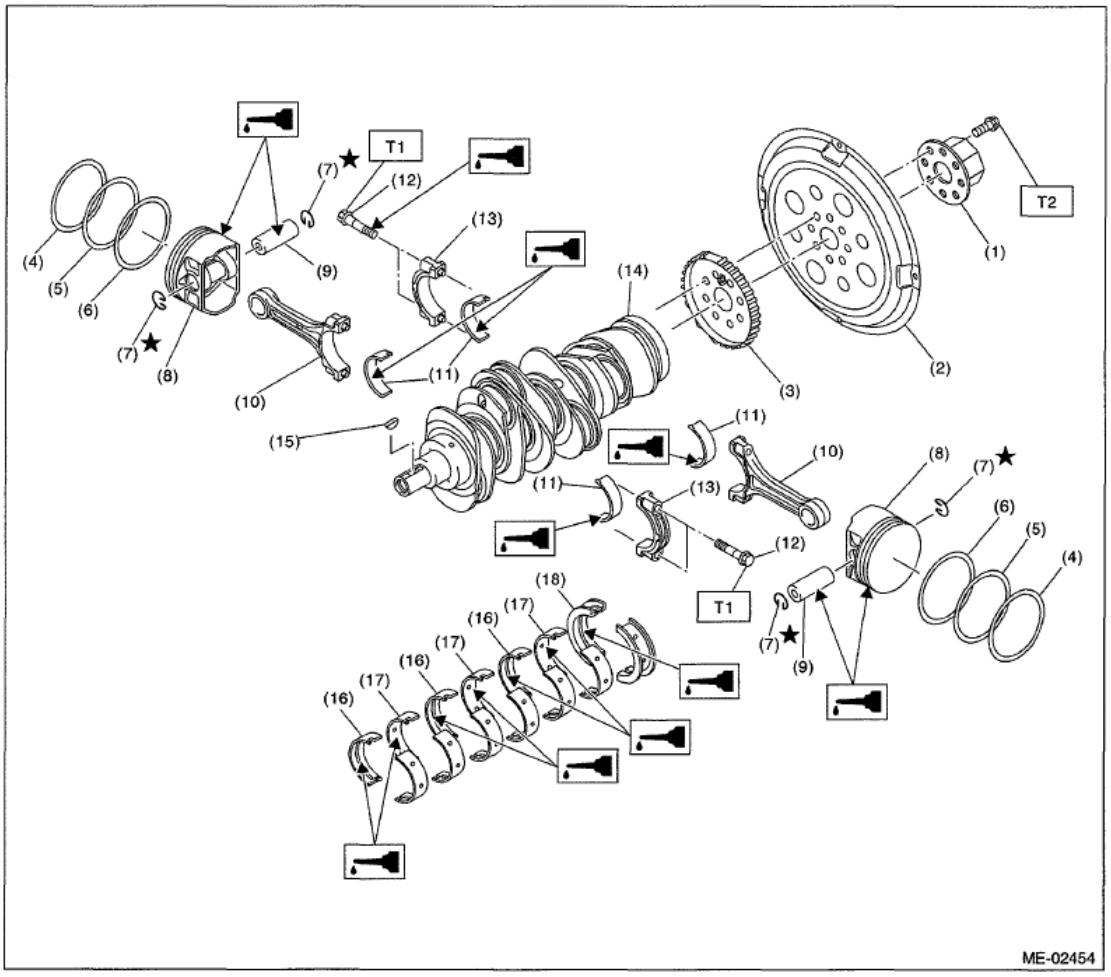
T7: 54 (5.5, 39.8)

T8: 70 (7.1, 51.6)

T9: 23 (2.3, 17.0)

T10: 90 (9.2, 66.4)

CRANKSHAFT AND PISTON



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

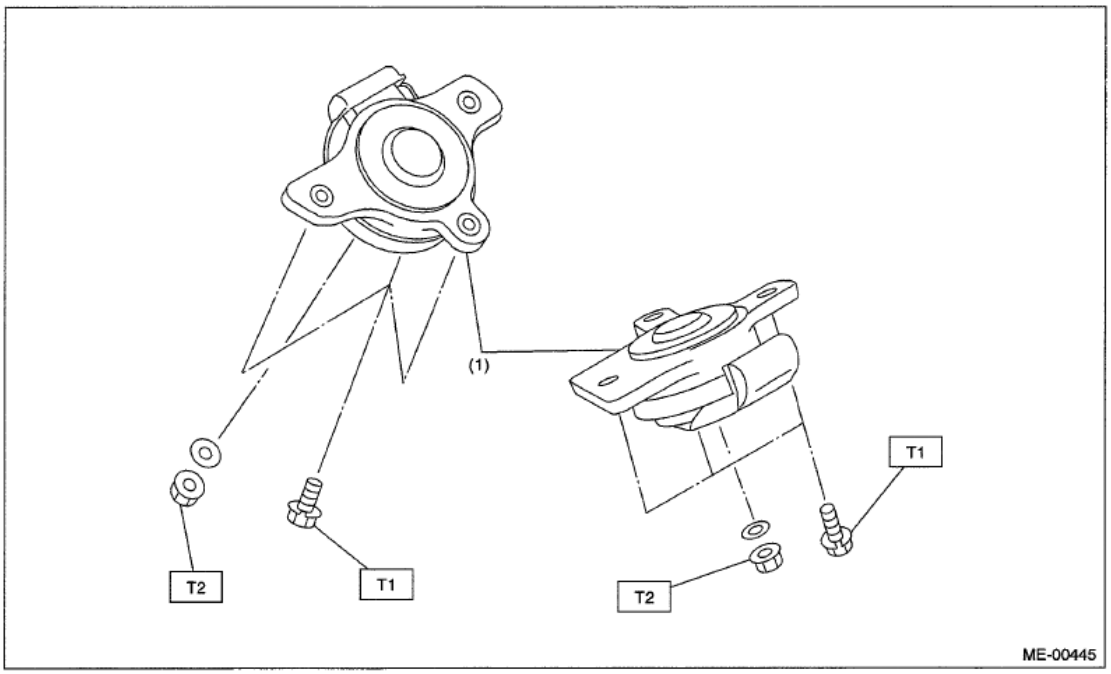
Fig. 7: Identifying Crankshaft And Piston Components
Courtesy of SUBARU OF AMERICA, INC.

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

T1: 53 (5.4, 39.1)

T2: 81 (8.3, 59.7)

ENGINE MOUNTING



(1) Front cushion rubber

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

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

T1: 35 (3.6, 25.8)

T2: 85 (8.7, 62.7)

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.
- 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:

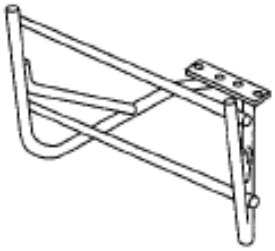
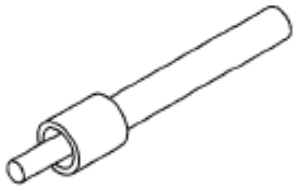
  Service tools, clean cloth, containers to catch coolant and oil, wire ropes, chain hoist, transmission jacks, etc.

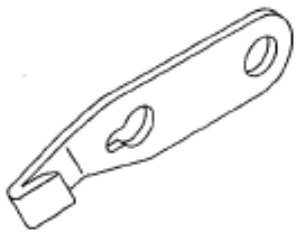
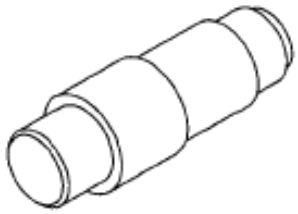
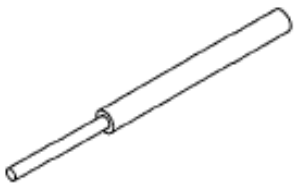
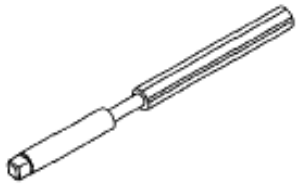
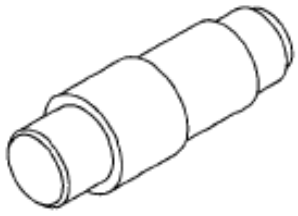
- Lift up or lower the vehicle when necessary. Make sure to support the correct positions.

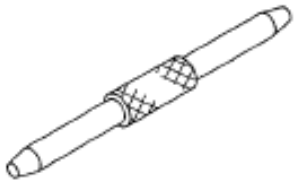
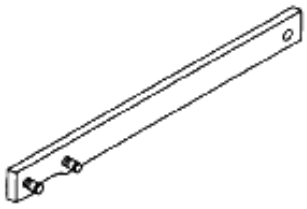
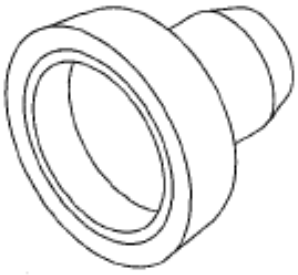
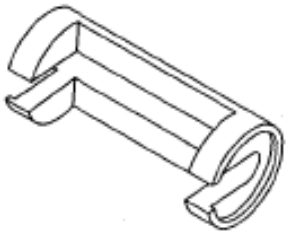
PREPARATION TOOL

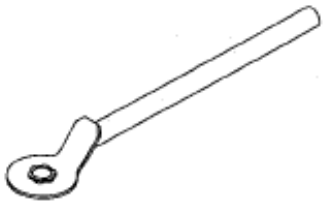
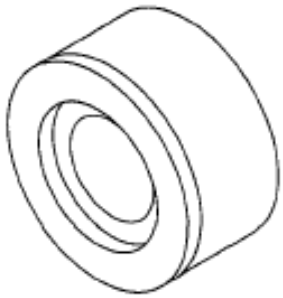
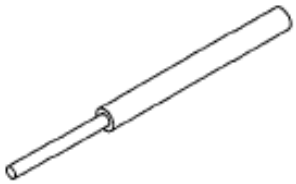
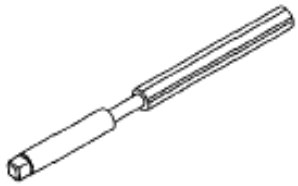
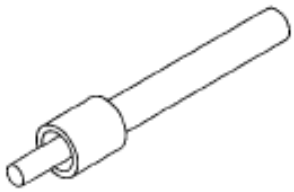
SPECIAL TOOL

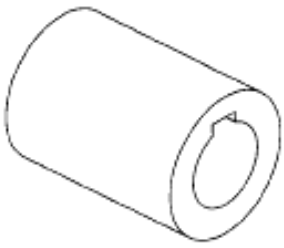
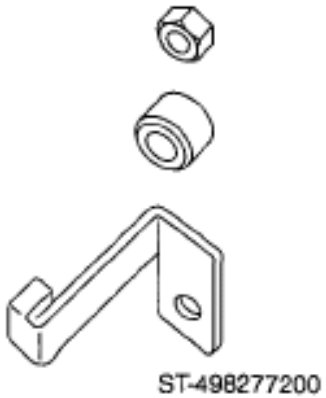
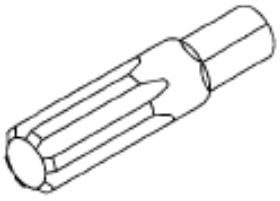
SPECIAL TOOL DESCRIPTION

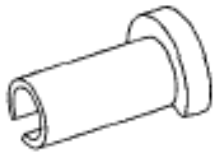
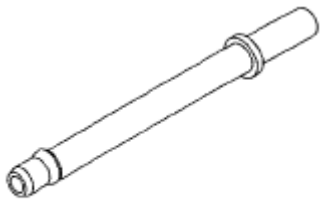
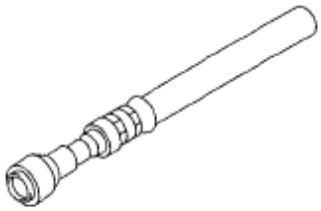
ILLUSTRATION	TOOL NUMBER	DESCRIPTION	REMARKS
 ST18232AA000	18250AA010	CYLINDER HEAD TABLE	• Used for replacing valve guides. • Used for removing and installing valve spring.
 ST-499585500	18232AA000	ENGINE STAND	Used for disassembling and assembling engine.
	498497100	CRANKSHAFT	Used for removing and installing

 ST-498497100		STOPPER	the drive plate.
 ST18350AA000	18254AA000	PISTON GUIDE	Used for installing piston in cylinder.
 ST-499765700	499585500	VALVE OIL SEAL GUIDE	Used for press-fitting of intake and exhaust valve guide oil seals.
 ST-499765900	18253AA000	PISTON PIN GUIDE	Used for installing piston pin, piston and connecting rod.
 ST18350AA000	18350AA000	CONNECTING ROD BUSHING REMOVER AND INSTALLER	Used for removing and installing connecting rod bushing.

 ST-499597100	499097700	PISTON PIN REMOVER ASSY	Used for removing piston pin.
 ST-499017100	499977500	CAM SPROCKET WRENCH	Used for removing and installing intake cam sprocket.
 ST18231AA020	18231AA020	CAM SPROCKET WRENCH	Used for removing and installing exhaust cam sprocket.
 ST-499587200	499587200	CRANKSHAFT OIL SEAL INSTALLER	• Used for installing crankshaft oil seal. • Used together with the CRANKSHAFT OIL SEAL GUIDE (499597100).
 ST-499718000	499597100	CRANKSHAFT OIL SEAL GUIDE	• Used for installing crankshaft oil seal. • Used together with the CRANKSHAFT OIL SEAL INSTALLER (499587200).

 ST-499977500	499718000	VALVE SPRING REMOVER	Used for removing and installing valve spring.
 ST18251AA040	18251AA040	VALVE GUIDE ADJUSTER	Used for installing valve guides.
 ST-499765700	499765700	VALVE GUIDE REMOVER	Used for removing valve guides.
 ST-499765900	499765900	VALVE GUIDE REAMER	Used for reaming valve guides.
 ST-498857100	499977100	CRANK PULLEY WRENCH	Used to stop rotation of the crank pulley when loosening or tightening crank pulley bolts.

 ST18252AA000	18252AA000	CRANKSHAFT SOCKET	Used for rotating crankshaft.
 ST1B022XU0	1B022XU0	SUBARU SELECT MONITOR III KIT	Used for troubleshooting the electrical system.
 ST18233AA000	18233AA000	PISTON PIN SNAP RING PLIERS	Used for removing and installing snap ring of piston pin.
 ST-498277200	498277200	STOPPER SET	Used for installing automatic transmission assembly to engine.
 ST-499057000	499057000	TORX PLUS®	Used for removing and installing the drive plate.

 ST42099AE000	42099AE000	QUICK CONNECTOR RELEASE	Used for disconnecting quick connector of the engine compartment.
 ST18471AA000	18471AA000	FUEL PIPE ADAPTER	Used for measuring fuel pressure.
 ST42075AG690	42075AG690	FUEL HOSE	• Used for measuring fuel pressure. • This is the SUBARU genuine part.

GENERAL TOOL

GENERAL TOOL REFERENCE

TOOL NAME	REMARKS
Compression gauge	Used for measuring compression.
Timing light	Used for measuring ignition timing.
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.

PROCEDURE

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

- V-belt
- Timing chain
- Camshaft

- Cylinder head

COMPRESSION

INSPECTION

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

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

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

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

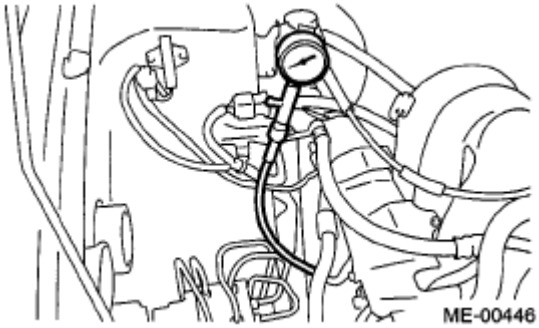


Fig. 9: Checking Compression
Courtesy of SUBARU OF AMERICA, INC.

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)

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. Warm up the engine.
3. Read the engine idle speed using Subaru Select Monitor. Refer to **READ CURRENT DATA FOR ENGINE (NORMAL MODE)** , OPERATION, Subaru Select Monitor.
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]:

    650±50 RPM

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

    Idle speed [A/C ON and gears in P or N range]:

    770±50 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 BASIC DIAGNOSTIC PROCEDURE .

IGNITION TIMING

INSPECTION

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

METHOD WITH SUBARU SELECT MONITOR

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

    Ignition timing [BTDC/RPM]:

    15° ±8°/650

    If the timing is not correct, check the ignition control system. Refer to **BASIC DIAGNOSTIC PROCEDURE** .

METHOD WITH TIMING LIGHT

1. Before checking the ignition timing, check the following item:
    1. Check the air cleaner element is free from clogging, spark plugs are in good condition, and hoses are connected properly.
    2. Check the malfunction indicator light does not illuminate.
2. Warm up the engine.
3. Stop the engine, and turn the ignition switch to OFF.
4. Remove the air cleaner case. Refer to **REMOVAL** , Air Cleaner Case.
5. Connect the timing light to the power wire of #1 ignition coil.
6. Install the air cleaner case. Refer to **INSTALLATION** , Air Cleaner Case.
7. Start the engine, aim the timing light to the crank pulley, and check the ignition timing by the crank pulley indicator.

    Ignition timing [BTDC/RPM]:

    15°±8°/650

    If the timing is not correct, check the ignition control system. Refer to **BASIC DIAGNOSTIC PROCEDURE** .

INTAKE MANIFOLD VACUUM

INSPECTION

1. Warm up 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.

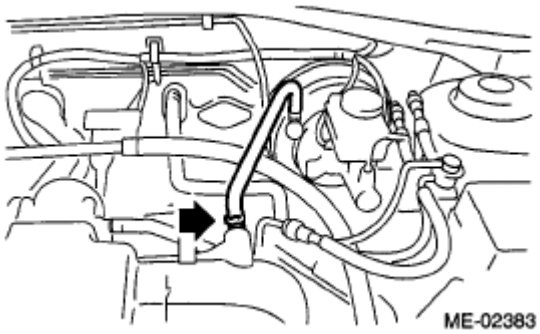


Fig. 10: Locating Brake Booster Vacuum Hose
Courtesy of SUBARU OF AMERICA, INC.

Vacuum pressure (at idling, A/C OFF):

Less than -60.0 kPa

(-450 mmHg, -17.72 inHg)

VACUUM PRESSURE REFERENCE

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

ENGINE OIL PRESSURE

INSPECTION

1. Remove the oil pressure switch from the cylinder block. Refer to **REMOVAL** , Oil Pressure Switch.
2. Connect the oil pressure gauge hose to the cylinder block.
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:

   135 kPa (1.4 kgf/cm^2 , 20 psi) or more

   (at 600 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 oil pump, oil filter and lubrication line. Refer to **INSPECTION** , Engine Lubrication System Trouble in General.
   - If the oil pressure warning light is ON and oil pressure is within specification, check the oil pressure switch. Refer to **INSPECTION** , Engine Lubrication System Trouble in General.
5. After measuring the oil pressure, install the oil pressure switch. Refer 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: Check or replace the fuel pump and fuel delivery line if the fuel pressure is out of the standard.

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

      ST1 42099AE000 QUICK CONNECTOR RELEASE

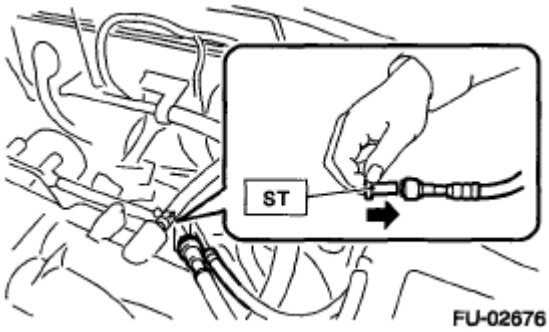


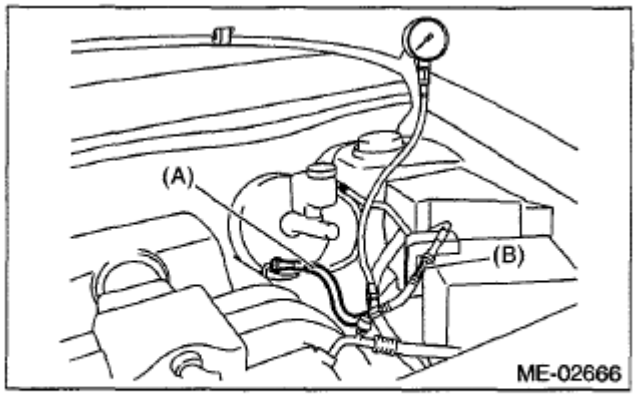
Fig. 11: Disconnecting Fuel Delivery Hose Using ST1
Courtesy of SUBARU OF AMERICA, INC.

2. Connect the fuel pressure gauge with ST2 and ST3.

NOTE: ST2 is a SUBARU genuine part.

ST2 42075AG690 FUEL HOSE

ST3 18471AA000 FUEL PIPE ADAPTER



(A) ST2
(B) ST3

Fig. 12: Connecting Fuel Pressure Gauge With ST2 And ST3
Courtesy of SUBARU OF AMERICA, INC.

5. Start the engine.
6. 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

NOTE: **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 the battery.

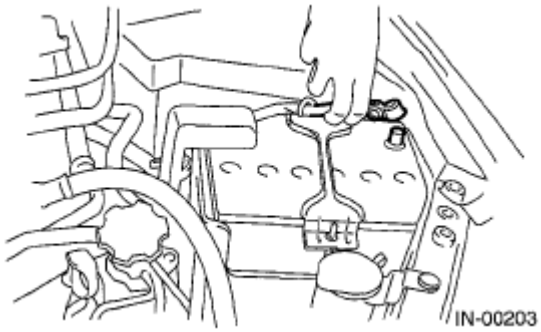


Fig. 13: Disconnecting Ground Cable From Battery
Courtesy of SUBARU OF AMERICA, INC.

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. Refer to **REMOVAL** , Air Intake Duct. Refer to **REMOVAL** , Air Cleaner Case.
    2. Remove the fuel pipe protector (RH).

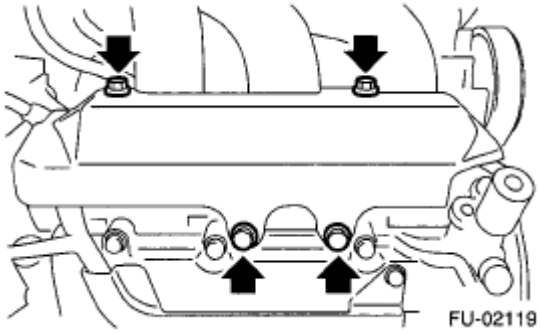


Fig. 14: Locating Fuel Pipe Protector Bolts (RH)
Courtesy of SUBARU OF AMERICA, INC.

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

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).

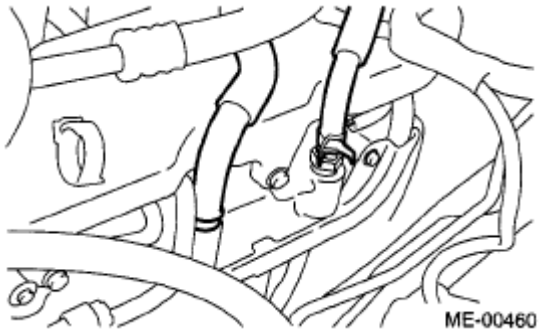


Fig. 15: Identifying PCV Hose And Blow-By Hose
Courtesy of SUBARU OF AMERICA, INC.

   3. Remove the fuel pipe protector (LH).

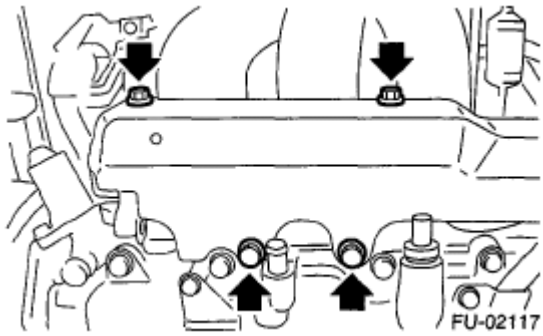
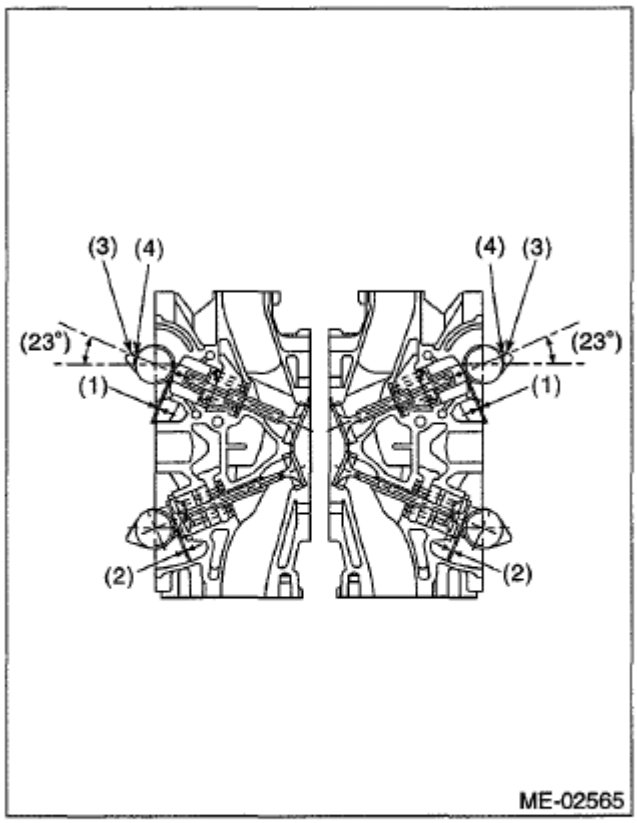


Fig. 16: Locating Fuel Pipe Protector Bolts (LH)

Courtesy of SUBARU OF AMERICA, INC.

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

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)
(3) High lift cam
(4) Low lift cam

Fig. 17: 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.**
- **Measure it in low lift cam for intake side.**
- **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)

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

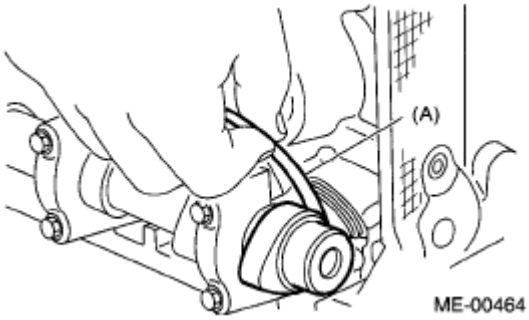


Fig. 18: Measuring Clearance Of Intake Valve And Exhaust Valve Using Thickness Gauge
Courtesy of SUBARU OF AMERICA, INC.

11. If necessary, adjust the valve clearance. Refer 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.

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.**
- **When installing the valve lifter, align the anti-rotation of valve lifter with groove on cylinder head, and insert the valve lifter.**

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

NOTE: Record each valve clearance after measurement.

2. Remove the timing chain assembly. Refer to **REMOVAL**, Timing Chain Assembly.
3. Remove the cam sprocket. Refer to **REMOVAL**, Cam Sprocket.
4. Remove the camshaft. Refer to **REMOVAL**, Camshaft.
5. Remove the valve lifter.
6. Remove the shim from valve lifter.
7. Check the thickness of the shim from the markings on the side of the shim that was removed.
8. Select a shim of suitable thickness from the following table using the measured valve clearance and shim thickness, and install it.

THICKNESS REFERENCE

Unit: mm (in)
S = (V + T) - 0.20 (0.0079)
S: Required shim thickness V: Measured valve clearance T: Shim thickness to be used

THICKNESS REFERENCE

Part No.	Thickness mm (in
13218AK890	1.92 (0.0756)
13218AK900	1.94 (0.0764)
13218AK910	1.96 (0.0772)
13218AK920	1.98 (0.0780)
13218AK930	2.00 (0.0787)
13218AK940	2.02 (0.0795)
13218AK950	2.04 (0.0803)
13218AK960	2.06 (0.0811)
13218AK970	2.07 (0.0815)
13218AK980	2.08 (0.0819)
13218AK990	2.09 (0.0823)
13218AL000	2.10 (0.0827)
13218AL010	2.11 (0.0831)
13218AL020	2.12 (0.0835)
13218AL030	2.13 (0.0839)
13218AL040	2.14 (0.0843)
13218AL050	2.15 (0.0846)
13218AL060	2.16 (0.0850)
13218AL070	2.17 (0.0854)
13218AL080	2.18 (0.0858)
13218AL090	2.19 (0.0862)
13218AL100	2.20 (0.0866)
13218AL110	2.21 (0.0870)

13218AL120	2.22 (0.0874)
13218AL130	2.23 (0.0878)
13218AL140	2.24 (0.0882)
13218AL150	2.25 (0.0886)
13218AL160	2.26 (0.0890)
13218AL170	2.27 (0.0894)
13218AL180	2.28 (0.0898)
13218AL190	2.29 (0.0902)
13218AL200	2.30 (0.0906)
13218AL210	2.31 (0.0909)
13218AL220	2.32 (0.0913)
13218AL230	2.33 (0.0917)
13218AL240	2.34 (0.0921)
13218AL250	2.35 (0.0925)
13218AL260	2.36 (0.0929)
13218AL270	2.37 (0.0933)
13218AL280	2.38 (0.0937)
13218AL290	2.39 (0.0941)
13218AL300	2.40 (0.0945)
13218AL310	2.41 (0.0949)
13218AL320	2.42 (0.0953)
13218AL330	2.43 (0.0957)
13218AL340	2.44 (0.0961)
13218AL350	2.45 (0.0965)
13218AL360	2.46 (0.0969)
13218AL370	2.47 (0.0972)
13218AL380	2.48 (0.0976)
13218AL390	2.49 (0.0980)
13218AL400	2.50 (0.0984)
13218AL410	2.51 (0.0988)
13218AL420	2.52 (0.0992)
13218AL430	2.53 (0.0996)
13218AL440	2.54 (0.1000)
13218AL450	2.55 (0.1004)
13218AL460	2.56 (0.1008)
13218AL470	2.57 (0.1012)
13218AL480	2.58 (0.1016)
13218AL490	2.59 (0.1020)
13218AL500	2.60 (0.1024)
13218AL510	2.61 (0.1028)
13218AL520	2.62 (0.1032)

	2.64 (0.1039)
13218AL540	2.66 (0.1047)
13218AL550	2.68 (0.1055)
13218AL560	2.70 (0.1063)
13218AL570	2.72 (0.1071)
13218AL580	2.74 (0.1079)
13218AL590	2.76 (0.1087)

9. Install the camshaft. Refer to **INSTALLATION**, Camshaft.
10. Install the cam sprocket. Refer to **INSTALLATION**, Cam Sprocket.
11. Install the timing chain assembly. Refer to **INSTALLATION**, Timing Chain Assembly.
12. Measure all valve clearance again at this time. If the valve clearance is not correct, repeat the procedure over again from the first step.
13. After measuring, install the related parts in the reverse order of removal.

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 the valve clearances. Refer to **INSPECTION**, Valve Clearance.

NOTE: Record each valve clearance after measurement.

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

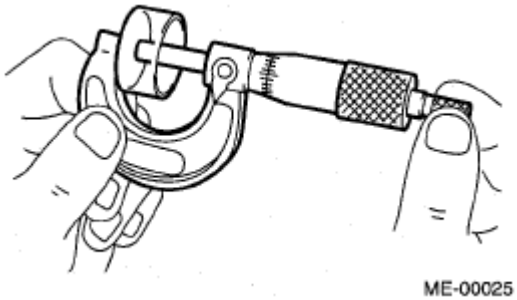


Fig. 19: Measuring Thickness Of Valve Lifter Using Micrometer
Courtesy of SUBARU OF AMERICA, INC.

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

THICKNESS REFERENCE

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

THICKNESS REFERENCE

Part No.	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)
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)
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)

	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}

6. Install the camshaft. Refer to **INSTALLATION**, Camshaft.
7. Install the cam sprocket. Refer to **INSTALLATION**, Cam Sprocket.
8. Install the timing chain assembly. Refer to **INSTALLATION**, Timing Chain Assembly.
9. Measure all valve clearance again at this time. If the valve clearance is not correct, repeat the procedure over again from the first step.
10. After measuring, 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. Open the front hood fully and support with the front hood stay.
3. Remove the collector cover.
4. Collect the refrigerant from A/C system. Refer to **PROCEDURE** , Refrigerant Recovery Procedure.

5. Release the fuel pressure. Refer to **RELEASING OF FUEL PRESSURE** , PROCEDURE, Fuel.
6. Remove the fuel filler cap.
7. Remove the battery from vehicle. Refer to **REMOVAL** , Battery.
8. Remove the air intake duct, air cleaner case and air intake chamber. Refer to **REMOVAL** , Air Intake Duct. Refer to **REMOVAL** , Air Cleaner Case. Refer to **REMOVAL** , Air Intake Chamber.
9. Remove the radiator from vehicle. Refer to **REMOVAL** , Radiator.
10. Remove the V-belts. Refer to **REMOVAL**, V-belt.
11. Disconnect the A/C pressure hoses from A/C compressor. Refer to **REMOVAL** , Hose and Pipe.
12. Disconnect the engine ground terminals.

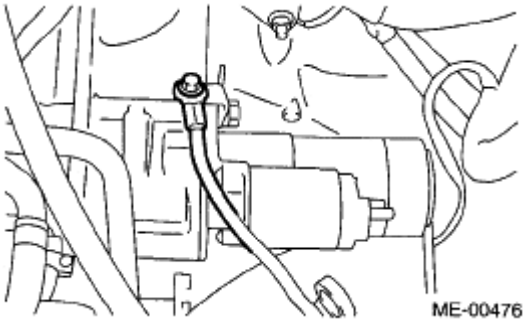


Fig. 20: Identifying Engine Grounding Terminal
Courtesy of SUBARU OF AMERICA, INC.

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

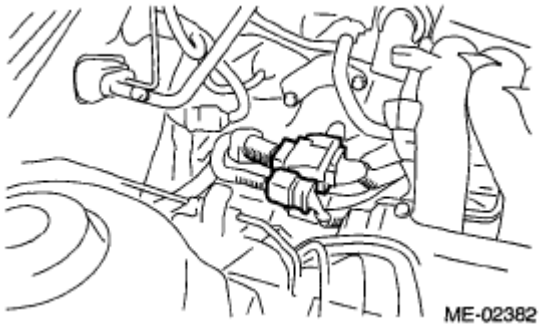


Fig. 21: Identifying Engine Harness Connectors
Courtesy of SUBARU OF AMERICA, INC.

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

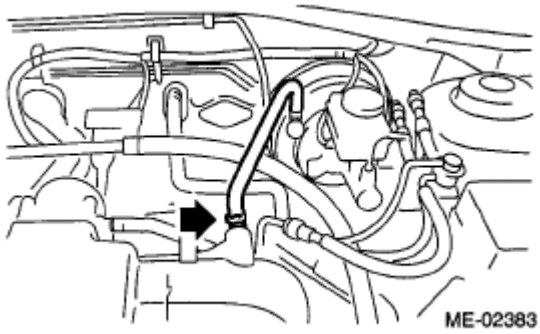


Fig. 22: Locating Brake Booster Vacuum Hose
Courtesy of SUBARU OF AMERICA, INC.

2. Heater inlet and outlet hoses
3. Pressure regulator vacuum hose

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

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

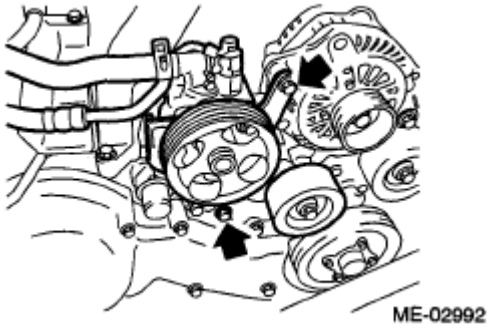


Fig. 23: Locating Power Steering Pump Bracket Bolts
Courtesy of SUBARU OF AMERICA, INC.

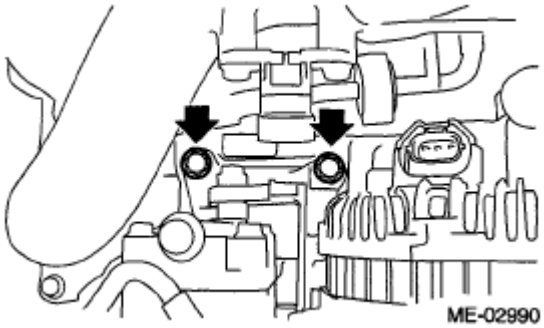
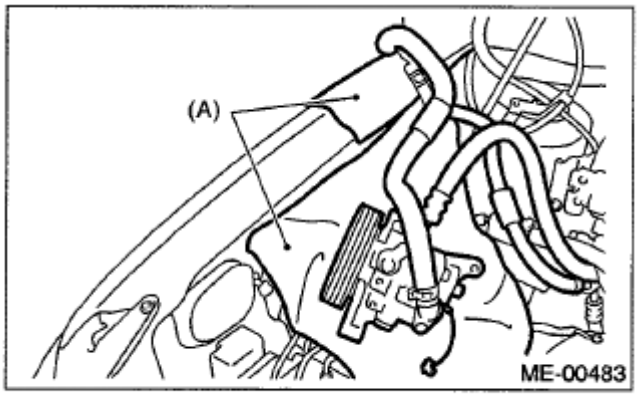


Fig. 24: Locating Power Steering Pump Bolt
Courtesy of SUBARU OF AMERICA, INC.

16. Place the power steering pump on the right side wheel apron.



(A) Cloth

Fig. 25: Placing Power Steering Pump On Right Side Wheel Apron
Courtesy of SUBARU OF AMERICA, INC.

17. Lift up the vehicle.
18. Remove the under cover.
19. Remove the front exhaust pipe. Refer to **REMOVAL** , Front Exhaust Pipe.

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

20. Remove the ground cable.

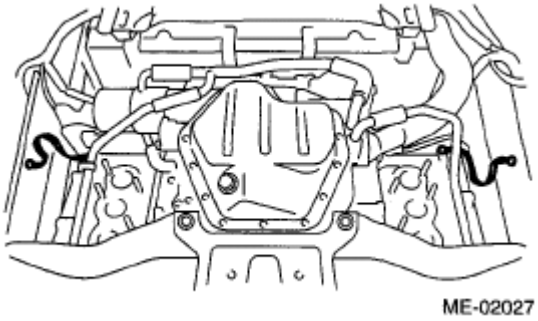


Fig. 26: Identifying Ground Cable
Courtesy of SUBARU OF AMERICA, INC.

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

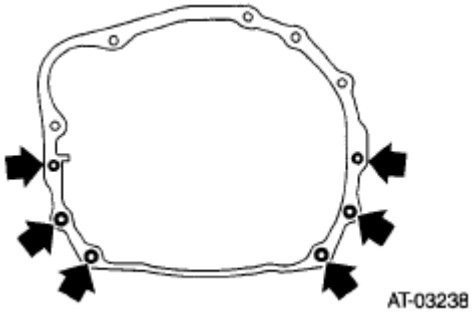


Fig. 27: Locating Transmission Lower Side Bolts And Nuts
Courtesy of SUBARU OF AMERICA, INC.

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

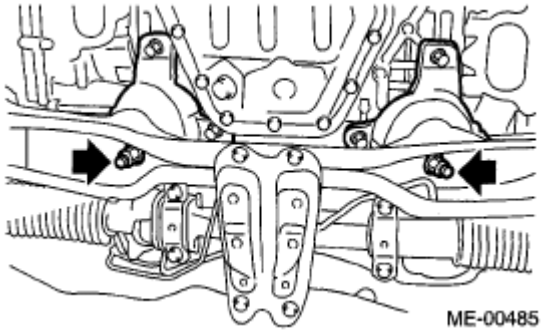


Fig. 28: Locating Front Crossmember Nuts
Courtesy of SUBARU OF AMERICA, INC.

23. Lower the vehicle.
24. Separate the torque converter clutch from drive plate.
    1. Remove the service hole plug (A).
    2. Remove the bolts which hold torque converter clutch to drive plate.
    3. Remove other bolts while rotating the crankshaft using socket wrench.

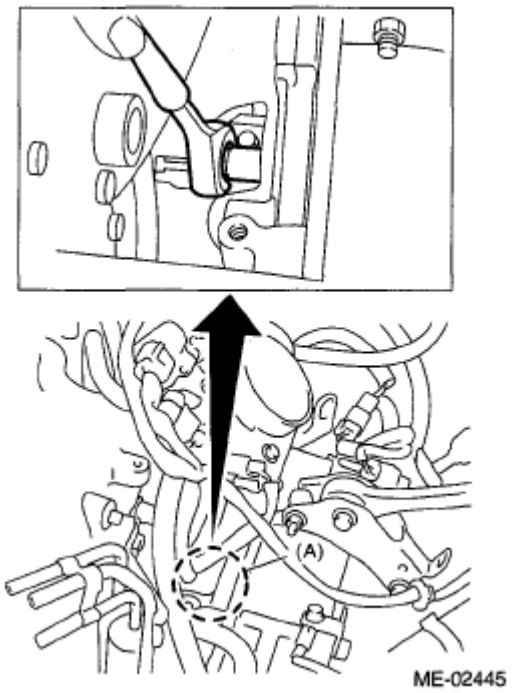


Fig. 29: Separating Torque Converter Clutch From Drive Plate
Courtesy of SUBARU OF AMERICA, INC.

25. Remove the pitching stopper.

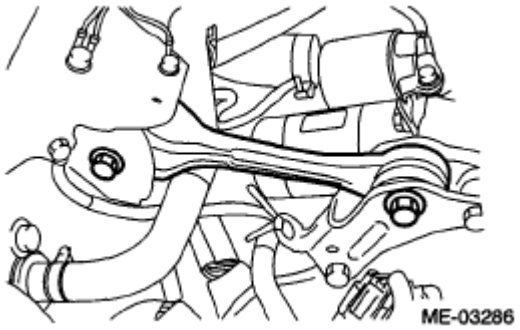


Fig. 30: Identifying Pitching Stopper
Courtesy of SUBARU OF AMERICA, INC.

26. Disconnect the fuel delivery hose and evaporation hose.

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

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

ST 42099AE000 QUICK CONNECTOR RELEASE

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

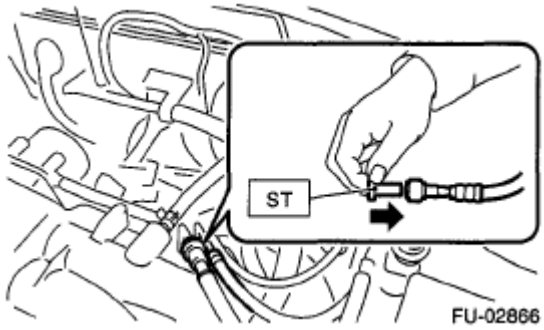
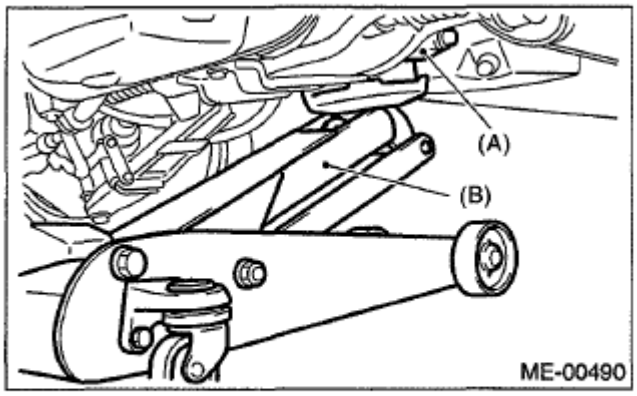


Fig. 31: Disconnecting Connector Of Fuel Pipe
Courtesy of SUBARU OF AMERICA, INC.

27. Support the engine with a lifting device and wire ropes.
28. 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. 32: Supporting Transmission With Garage Jack
Courtesy of SUBARU OF AMERICA, INC.

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

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

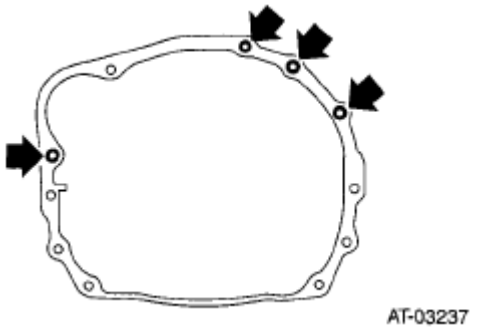


Fig. 33: Locating Transmission Upper Side Bolts
Courtesy of SUBARU OF AMERICA, INC.

30. Attach the ST to the converter case.

    ST 498277200 STOPPER SET

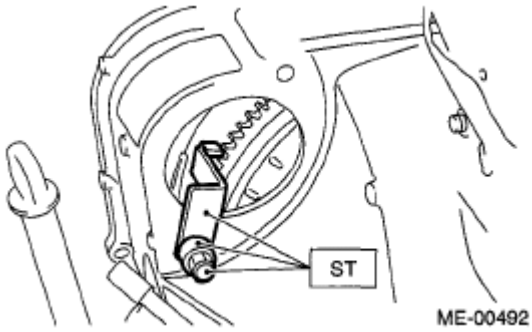


Fig. 34: Attaching ST To Converter Case
Courtesy of SUBARU OF AMERICA, INC.

31. Remove the engine from vehicle.
    1. Slightly raise the engine.
    2. Raise the transmission with garage jack.
    3. Slowly move the engine away from engine compartment.

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

32. Remove the engine mounting.

INSTALLATION

1. Install the engine mounting.

   Tightening torque:

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

2. 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.

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

Tightening torque:

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

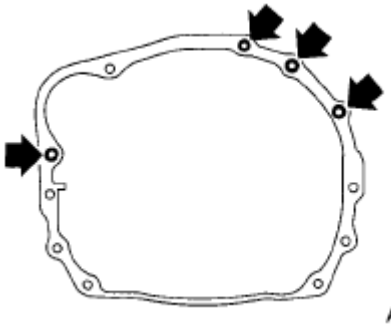


Fig. 35: Locating Transmission Upper Side Bolts
Courtesy of SUBARU OF AMERICA, INC.

4. Remove the lifting device and wire ropes.
5. Remove the garage jack.
6. Install the pitching stopper.

Tightening torque:

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

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

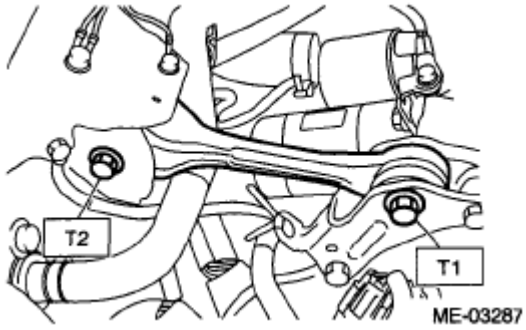


Fig. 36: Identifying Pitching Stopper
Courtesy of SUBARU OF AMERICA, INC.

7. 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

8. Install the starter. Refer to **INSTALLATION** , Starter.
9. 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)

    3. Install the service hole plug (A) to prevent getting foreign matter inside.

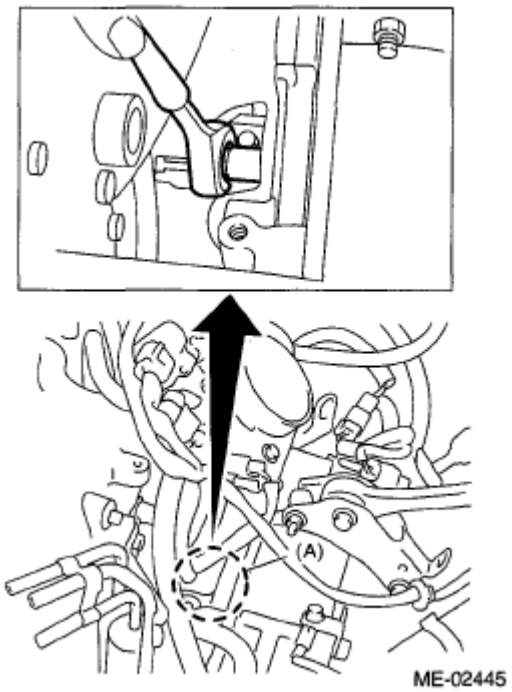


Fig. 37: Separating Torque Converter Clutch From Drive Plate
Courtesy of SUBARU OF AMERICA, INC.

10. 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)

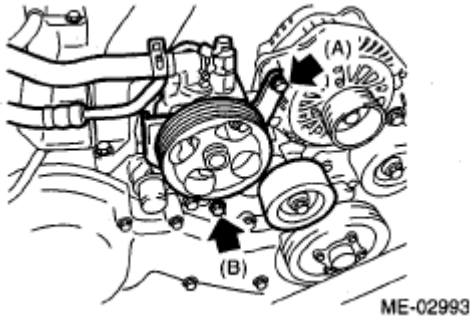


Fig. 38: Locating Power Steering Pump Bracket Bolts
Courtesy of SUBARU OF AMERICA, INC.

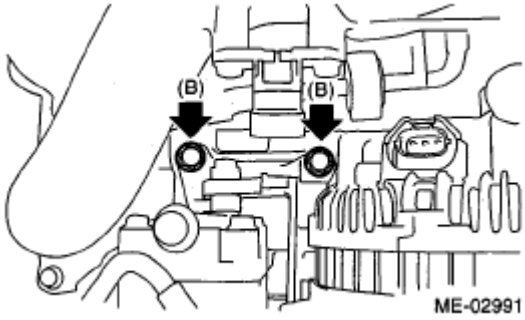


Fig. 39: Locating Power Steering Pump Bolts
Courtesy of SUBARU OF AMERICA, INC.

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

Tightening torque:

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

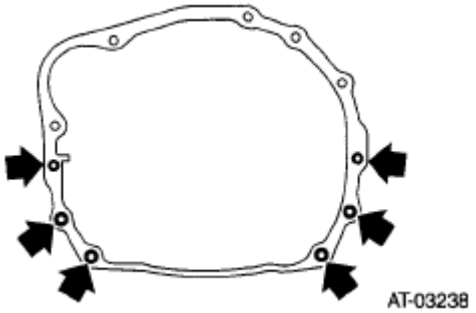


Fig. 40: Locating Transmission Lower Side Bolts And Nuts
Courtesy of SUBARU OF AMERICA, INC.

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

Tightening torque:

85 N.m (8.7 kgf-m, 62.7 ft-lb)

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

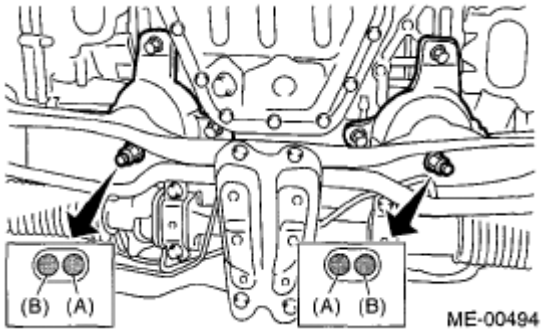


Fig. 41: Identifying Front Cushion Rubber Mounting Bolts And Locator
Courtesy of SUBARU OF AMERICA, INC.

14. Install the front exhaust pipe. Refer 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.**

15. Connect the ground cable.

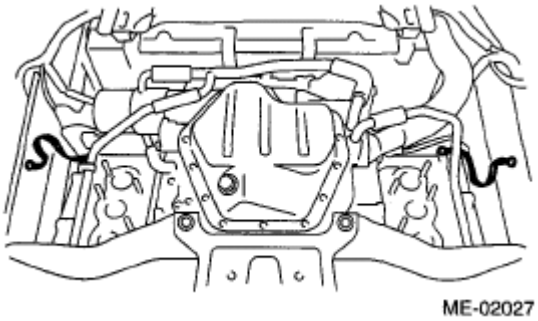


Fig. 42: Identifying Ground Cable
Courtesy of SUBARU OF AMERICA, INC.

16. Install the under cover.
17. Lower the vehicle.
18. Connect the following hoses.
    1. Fuel delivery hose and evaporation hose
    2. Heater inlet and outlet hoses
    3. Brake booster vacuum hose
    4. Pressure regulator vacuum hose
19. Connect the following connectors.
    1. Engine harness connectors

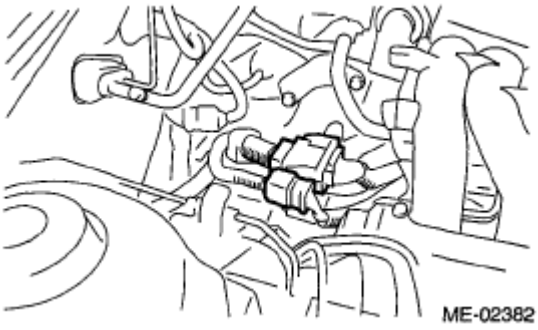


Fig. 43: Identifying Engine Harness Connectors
Courtesy of SUBARU OF AMERICA, INC.

    2. Generator connector and terminal
    3. A/C compressor connector
    4. Power steering switch connector
20. Install the engine ground terminals.

Tightening torque:

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

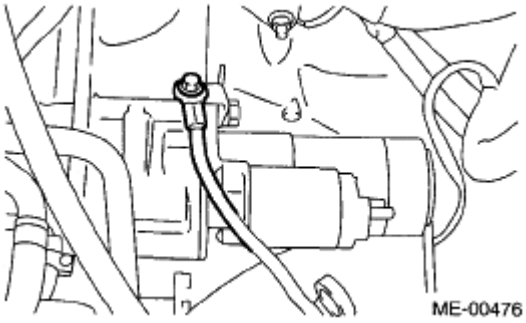


Fig. 44: Identifying Engine Grounding Terminal
Courtesy of SUBARU OF AMERICA, INC.

21. Install the A/C pressure hoses. Refer to **INSTALLATION** , Hose and Pipe.
22. Install the V-belts. Refer to **INSTALLATION**, V-belt.
23. Install the radiator to vehicle. Refer to **INSTALLATION** , Radiator.
24. Install the air intake duct, air cleaner case and air intake chamber. Refer to **INSTALLATION** , Air Intake Duct. Refer to **INSTALLATION** , Air Cleaner Case. Refer to **INSTALLATION** , Air Intake Chamber.
25. Install the battery to the vehicle. Refer to **INSTALLATION** , Battery.
26. Fill engine coolant. Refer to **FILLING OF ENGINE COOLANT** , REPLACEMENT, Engine Coolant.
27. Check the ATF level and replenish it if necessary. Refer to **INSPECTION** , Automatic Transmission Fluid.
28. Charge the A/C system with refrigerant. Refer to **PROCEDURE** , Refrigerant Charging Procedure.
29. Install the collector cover.
30. Remove the front hood stay, and close the front hood.
31. 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

REMOVAL

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

INSTALLATION

Install in the reverse order of removal.

Tightening torque:

Engine mounting:

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. Refer to **REMOVAL**, Engine Assembly.
2. Set the engine on ST.

   ST 18232AA000 ENGINE STAND

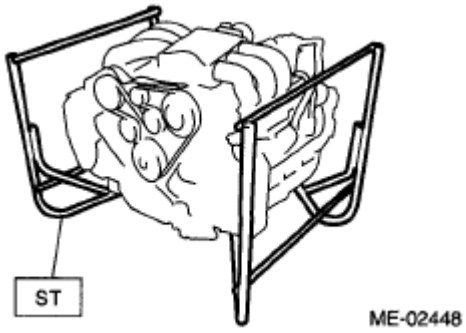


Fig. 45: Setting Engine On ST
Courtesy of SUBARU OF AMERICA, INC.

3. Before servicing overhaul, remove the sensor, pipe and hose that installed to engine.
   1. Remove the intake manifold. Refer to **REMOVAL** , Intake Manifold.
   2. Remove the generator. Refer to **REMOVAL** , Generator.
   3. Remove the A/C compressor. Refer to **REMOVAL** , Compressor.
   4. Disconnect the water pipe and hose.
   5. Disconnect the engine harness.
   6. Remove the spark plug. Refer to **REMOVAL** , Spark Plug.
   7. Remove the camshaft position sensor. Refer to **REMOVAL** , Camshaft Position Sensor.
   8. Remove the crankshaft position sensor. Refer to **REMOVAL** , Crankshaft Position Sensor.
   9. Remove the knock sensor. Refer to **REMOVAL** , Knock Sensor.
   10. Remove the engine coolant temperature sensor. Refer to **REMOVAL** , Engine Coolant Temperature Sensor.

11. Remove the oil pressure switch. Refer to **REMOVAL** , Oil Pressure Switch.
12. Remove the oil filter. Refer to **REMOVAL** , Engine Oil Filter.
13. Remove the oil cooler. Refer 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.

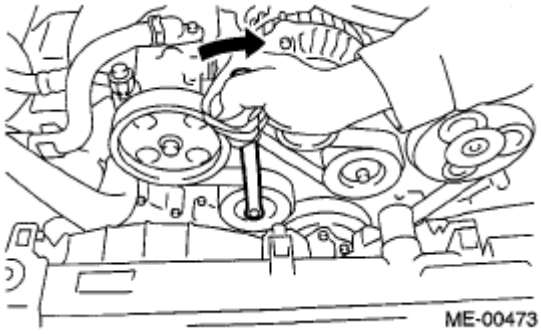
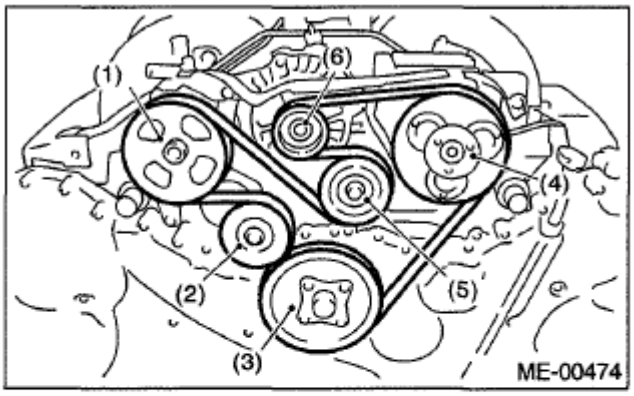


Fig. 46: Loosening V-Belt
Courtesy of SUBARU OF AMERICA, INC.

INSTALLATION

Install in the reverse order of removal.

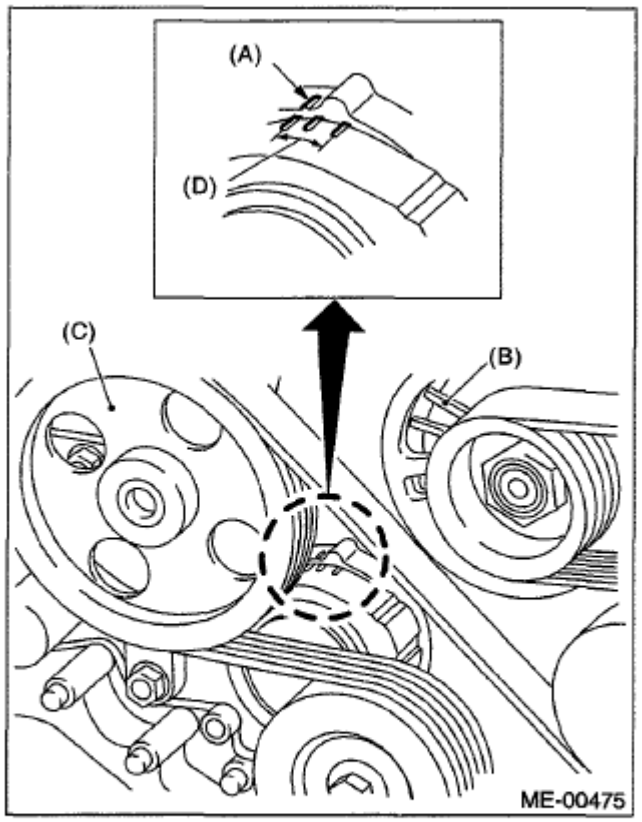


(1) Power steering oil pump pulley
(2) Belt tension adjuster ASSY
(3) Crank pulley
(4) A/C compressor pulley
(5) Belt idler
(6) Generator pulley

Fig. 47: 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).



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

Fig. 48: Positioning Of 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-belts. Refer to **REMOVAL**, V-belt.
2. Remove the crank pulley cover.

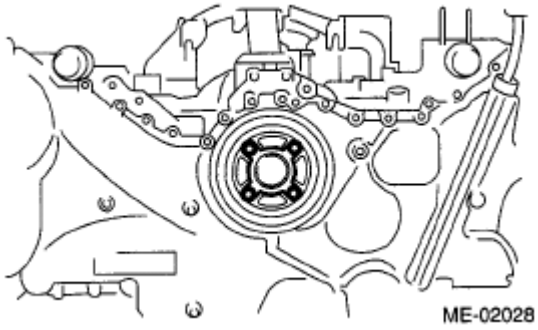


Fig. 49: Identifying Crank Pulley Cover
Courtesy of SUBARU OF AMERICA, INC.

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

   ST 499977100 CRANK PULLEY WRENCH

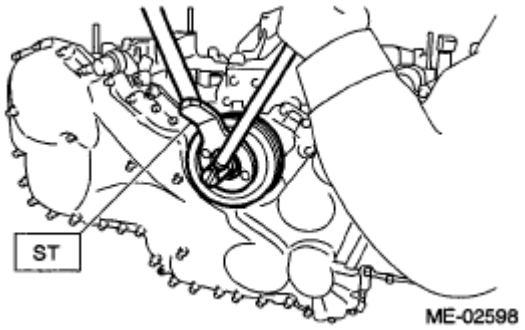


Fig. 50: Removing Crank Pulley Bolt
Courtesy of SUBARU OF AMERICA, INC.

4. Remove the crank pulley.

INSTALLATION

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

   ST 499977100 CRANK PULLEY WRENCH

   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.

      Tightening torque:

      178 N.m (18.1 kgf-m, 131.3 ft-lb)

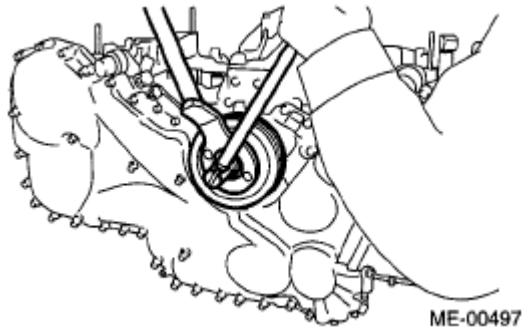


Fig. 51: Tightening Crank Pulley Bolts
Courtesy of SUBARU OF AMERICA, INC.

3. Install the crank pulley cover.

NOTE: Use new O-rings.

Tightening torque:

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

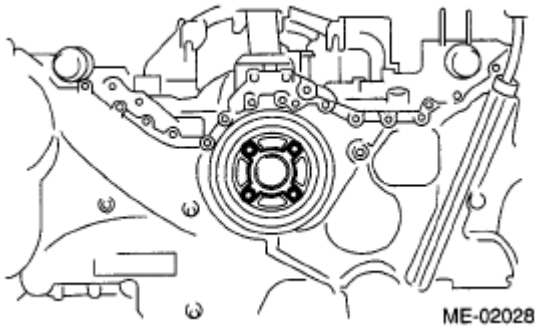


Fig. 52: Identifying Crank Pulley Cover
Courtesy of SUBARU OF AMERICA, INC.

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

INSPECTION

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

FRONT CHAIN COVER

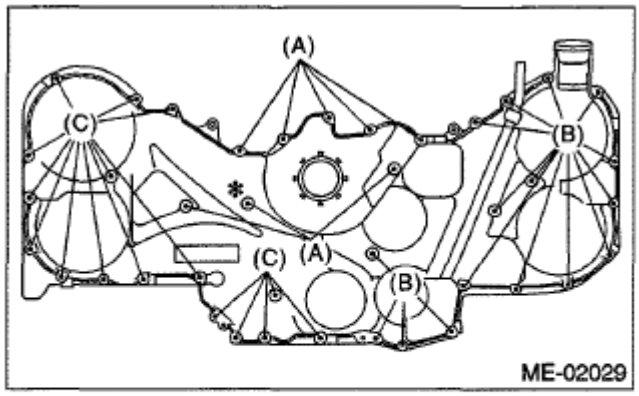
REMOVAL

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

body.

1. Remove the V-belts. Refer to **REMOVAL**, V-belt.
2. Remove the crank pulley. Refer to **REMOVAL**, Crank Pulley.
3. Remove the bolts which install oil pipe (RH) onto the front chain cover.
4. Remove the front chain cover.

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



(A) M6 × 16
(B) M6 × 30
(C) M6 × 45
*: Sealing washer

Fig. 53: Identifying Chain Cover Bolt In Tightening Sequence
Courtesy of SUBARU OF AMERICA, INC.

INSTALLATION

1. Remove the used liquid gasket from mating surface, and degrease it.
2. Apply liquid gasket to the mating surface of front chain cover.

NOTE: Install within 5 minutes after applying liquid gasket.

Liquid gasket:

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

Applying liquid gasket diameter

2.5±0.5 mm (0.098±0.020 in)

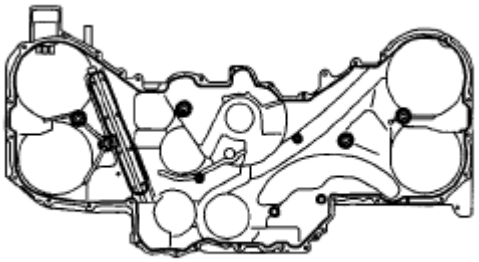
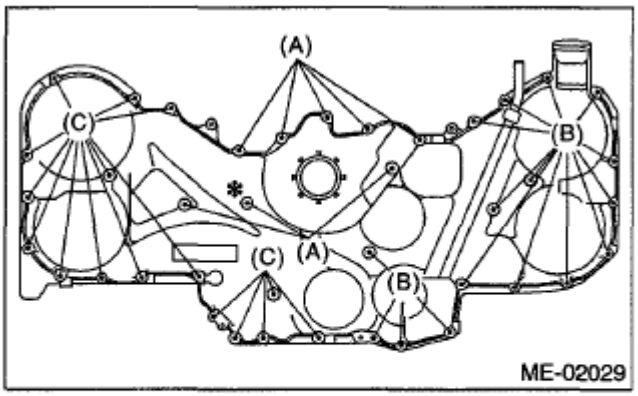


Fig. 54: Identifying Liquid Gasket Applying Area On Mating Surface Of Front Chain Cover
Courtesy of SUBARU OF AMERICA, INC.

3. Install the front chain cover. Temporarily tighten the bolts.

CAUTION: Do not install the bolts in wrong place.



(A) M6 × 16
(B) M6 × 30
(C) M6 × 45
*: Sealing washer

Fig. 55: Identifying Chain Cover Bolt In Tightening Sequence
Courtesy of SUBARU OF AMERICA, INC.

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

Tightening torque:

6.6 N.m (0.7 kgf-m, 4.9 ft-lb)

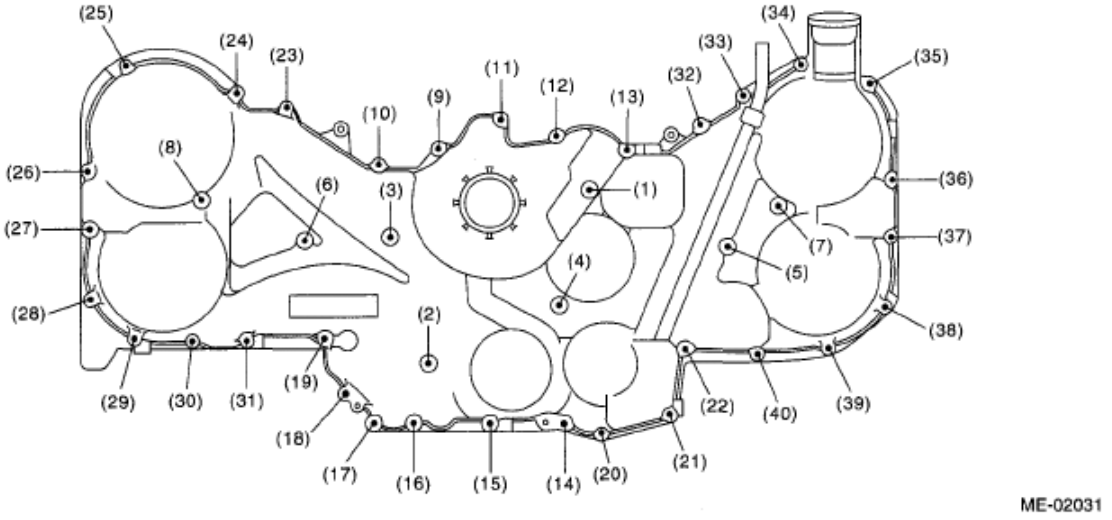


Fig. 56: Identifying Bolts In Tightening Sequence
Courtesy of SUBARU OF AMERICA, INC.

5. Tighten the bolts which install oil pipe (RH) onto the front chain cover.

   Tightening torque:

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

6. Install the crank pulley. Refer to **INSTALLATION**, Crank Pulley.
7. Install the V-belts. Refer to **INSTALLATION**, V-belt.

INSPECTION

Check the cover surface for scratch and damage. Check for oil leakage on cover mating surface and installation part of crank pulley.

TIMING CHAIN ASSEMBLY

REMOVAL

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

1. Remove the V-belts. Refer to **REMOVAL**, V-belt.
2. Remove the crank pulley. Refer to **REMOVAL**, Crank Pulley.
3. Remove the front chain cover. Refer to **REMOVAL**, Front Chain Cover.
4. Remove the chain tensioner (RH).

NOTE: Be careful not to let the plunger (A) pops out.

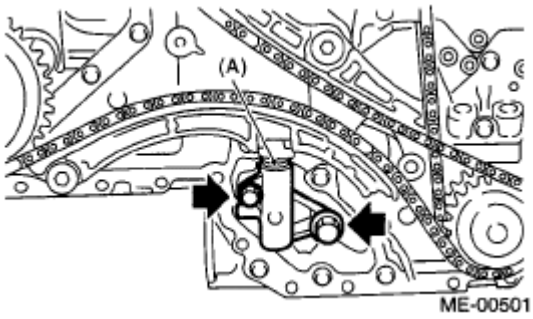


Fig. 57: Identifying Plunger
Courtesy of SUBARU OF AMERICA, INC.

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

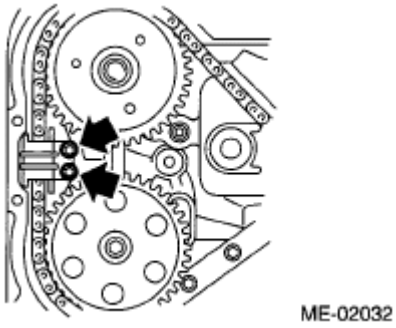
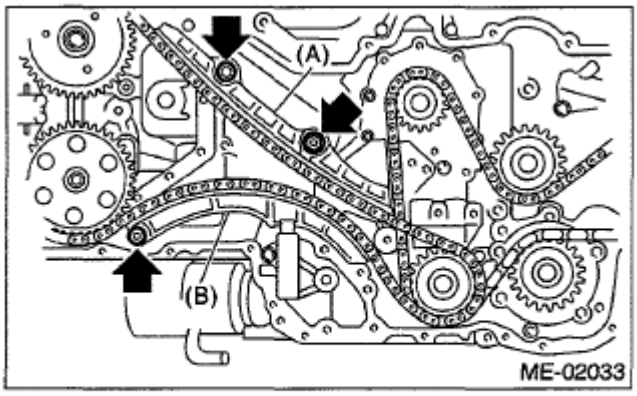


Fig. 58: Locating Chain Guide Bolts
Courtesy of SUBARU OF AMERICA, INC.

6. Remove the chain guide (RH).
7. Remove the chain tensioner lever (RH).



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

Fig. 59: Identifying Chain Guide (RH) And Chain Tensioner Lever (RH)
Courtesy of SUBARU OF AMERICA, INC.

8. Remove the timing chain (RH).
9. Remove the chain tensioner (LH).

NOTE: Be careful not to let the plunger pops out.

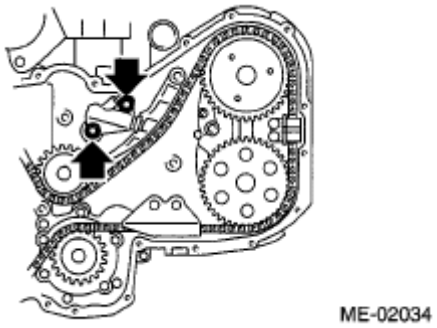


Fig. 60: Locating Chain Tensioner Bolts (LH)
Courtesy of SUBARU OF AMERICA, INC.

10. Remove the chain tensioner lever (LH).

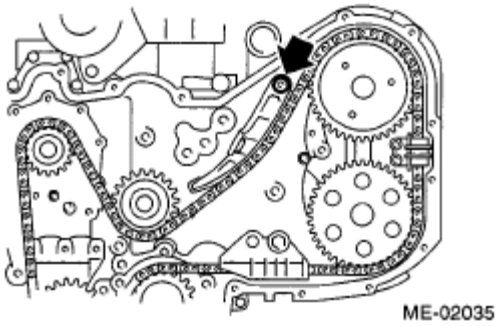


Fig. 61: Locating Chain Tensioner Lever Bolt (LH)
Courtesy of SUBARU OF AMERICA, INC.

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

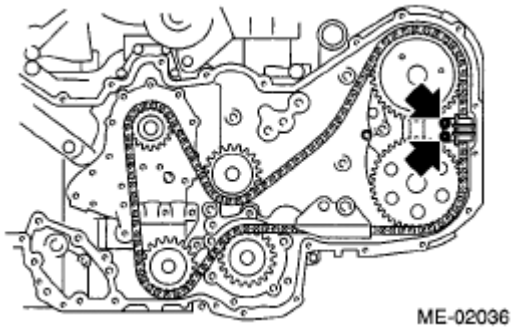


Fig. 62: Locating Chain Guide Bolts

Courtesy of SUBARU OF AMERICA, INC.

12. Remove the chain guide (LH).

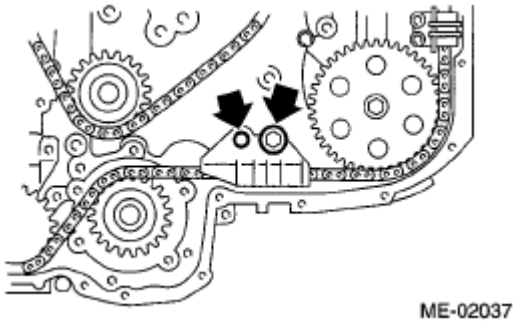


Fig. 63: Locating Chain Guide Bolts (LH)
Courtesy of SUBARU OF AMERICA, INC.

13. Remove the chain guide (center).

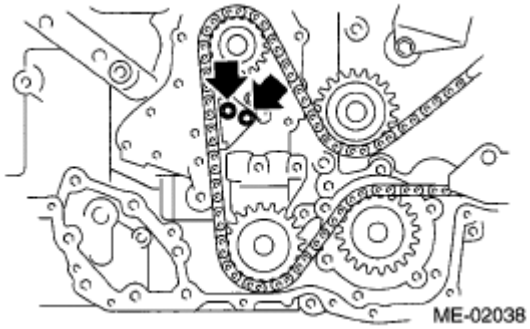


Fig. 64: Locating Chain Guide (Center)
Courtesy of SUBARU OF AMERICA, INC.

14. Remove the idler sprocket (upper).

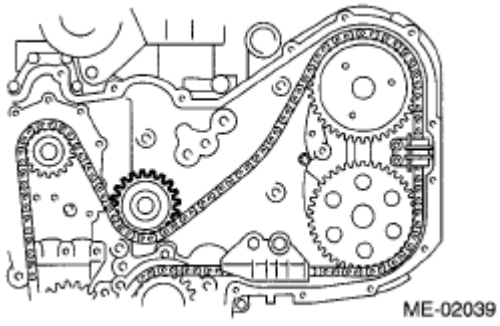


Fig. 65: Identifying Idler Sprocket (Upper)
Courtesy of SUBARU OF AMERICA, INC.

15. Remove the timing chain (LH).
16. Remove the idler sprocket (lower).

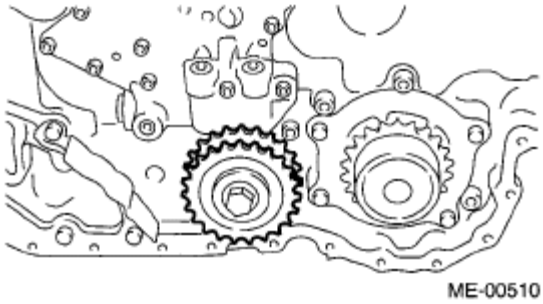


Fig. 66: Identifying Idler Sprocket (Lower)
Courtesy of SUBARU OF AMERICA, INC.

INSTALLATION

NOTE:
- **Be careful that the foreign matter is not into or onto assembled component during installation.**
- **Apply engine oil to the chain guide, chain tensioner lever and idler sprocket when installing.**

1. Prepare to attach the chain tensioner.
    1. Insert the screw, spring pin and tension rod into tensioner body.
    2. While depressing the tensioner onto rubber mat, twist it to shorten tension rod. Then insert the thin pin into the hole between tension rod and tension body to keep it.

NOTE: Work on the rubber mat or other anti-skid materials.

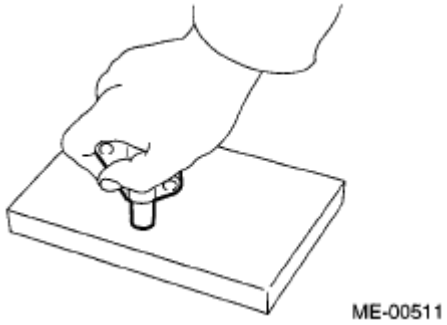


Fig. 67: Inserting Screw, Spring Pin And Tension Rod Into Tensioner Body
Courtesy of SUBARU OF AMERICA, INC.

2. Using the ST, align the 'Top mark" on crank sprocket to 9 o'clock position as shown in the figure.

ST 18252AA000 CRANKSHAFT SOCKET

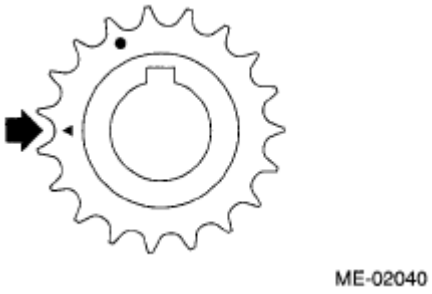


Fig. 68: Locating Top Mark On Crank Sprocket
Courtesy of SUBARU OF AMERICA, INC.

3. Align the key groove on exhaust cam sprocket to 12 o'clock position as shown in the figure.

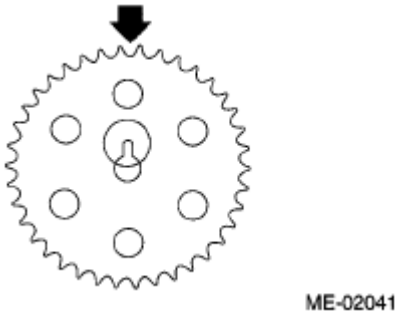
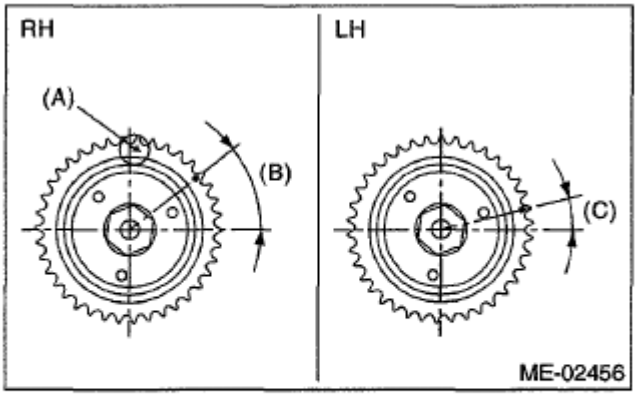


Fig. 69: Locating Key Groove On Exhaust Cam Sprocket
Courtesy of SUBARU OF AMERICA, INC.

4. Align the intake cam sprocket as shown in the figure.



(A) Top mark
(B) 40°
(C) 15°

Fig. 70: Positioning Of Intake Cam Sprocket
Courtesy of SUBARU OF AMERICA, INC.

5. Turn the crank sprocket clockwise, align the "Top mark" to 12 o'clock position. (Piston #1 is in TDC position)

NOTE: Do not rotate the crank shaft and cam sprocket before completing the installation of timing chain.

6. Install the idler sprocket (lower).

Tightening torque:

69 N.m (7.0 kgf-m, 50.9 ft-lb)

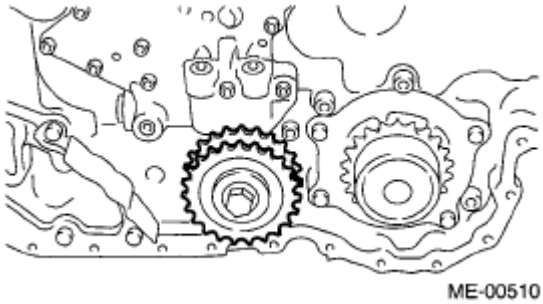
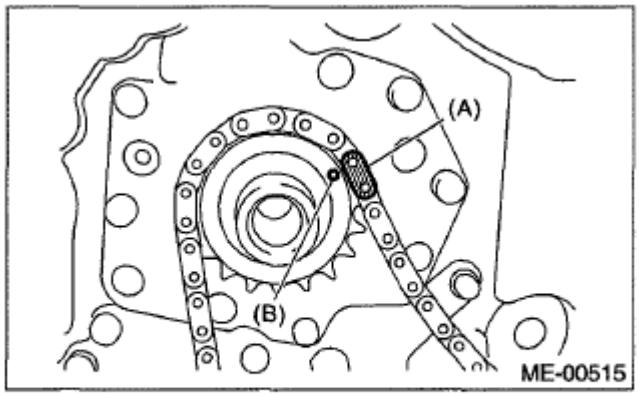


Fig. 71: Identifying Idler Sprocket (Lower)
Courtesy of SUBARU OF AMERICA, INC.

7. Install the timing chain (LH).
   1. Align the timing mark (B) on the crank sprocket with mark (A) on the timing chain (LH).



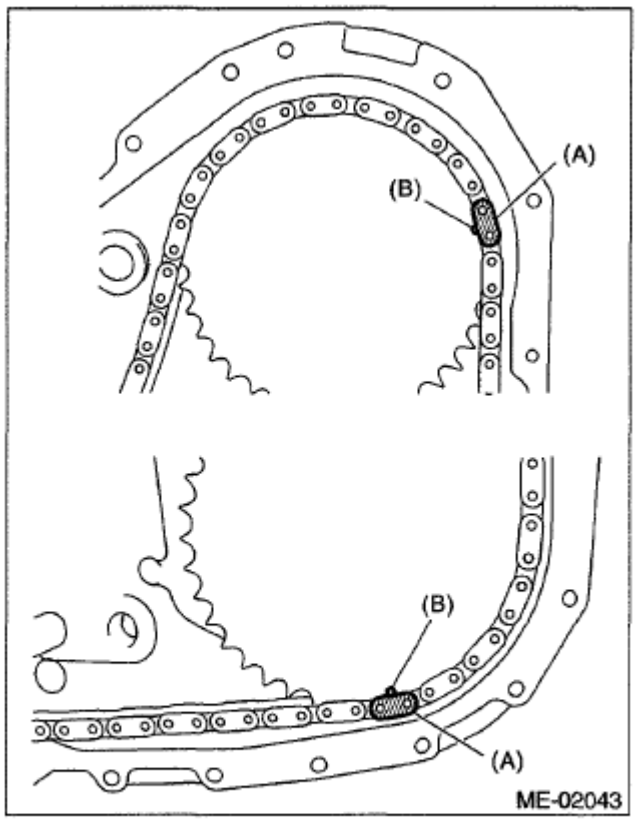
(A) Gold
(B) Mark

Fig. 72: Identifying Timing Mark On Crank Sprocket And Timing Chain (LH)
Courtesy of SUBARU OF AMERICA, INC.

   2. Install the timing chain (LH) to the idler sprocket (lower), water pump, exhaust cam sprocket (LH)

and intake cam sprocket (LH) in this order.

NOTE: Check that the mark on timing chain (A) and cam sprocket (B) is aligned as same as aligned on crank sprocket.



(A) Blue
(B) Mark

Fig. 73: Identifying Mark On Timing Chain And Cam Sprocket
Courtesy of SUBARU OF AMERICA, INC.

3. Install the idler sprocket (upper).

Tightening torque:

69 N.m (7.0 kgf-m, 50.9 ft-lb)

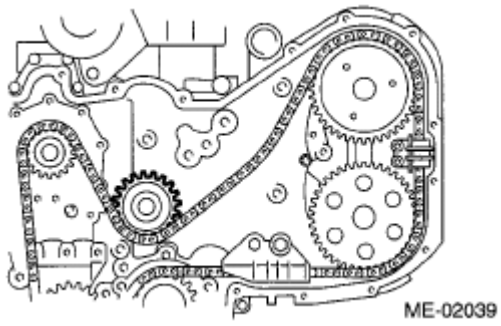


Fig. 74: Identifying Idler Sprocket (Upper)
Courtesy of SUBARU OF AMERICA, INC.

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

   Tightening torque:

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

   NOTE: Use a new installing bolt.

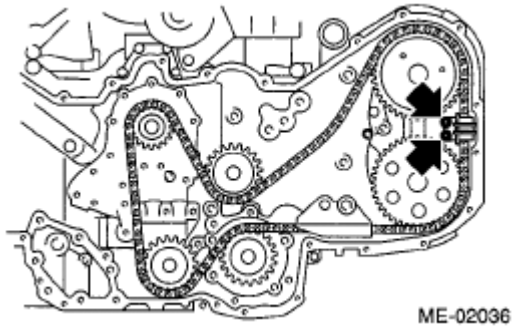


Fig. 75: Locating Chain Guide Bolts
Courtesy of SUBARU OF AMERICA, INC.

5. Install the chain guide (LH).

   Tightening torque:

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

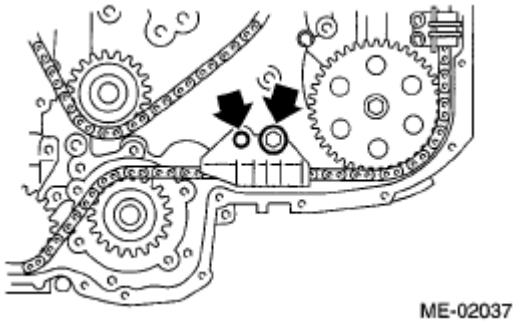


Fig. 76: Locating Chain Guide Bolts (LH)
Courtesy of SUBARU OF AMERICA, INC.

6. Install the chain tensioner lever (LH).

   Tightening torque:

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

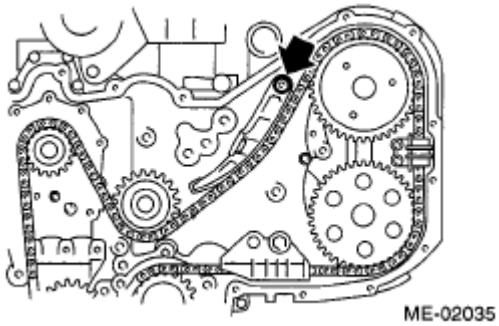


Fig. 77: Locating Chain Tensioner Lever Bolt (LH)
Courtesy of SUBARU OF AMERICA, INC.

7. Install the chain tensioner (LH).

   Tightening torque:

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

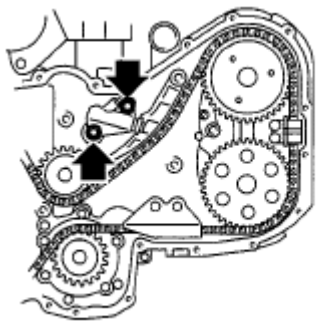
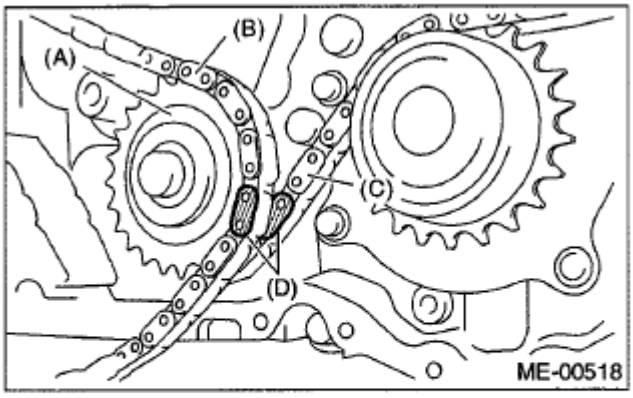


Fig. 78: Locating Chain Tensioner Bolts (LH)
Courtesy of SUBARU OF AMERICA, INC.

8. Install the timing chain (RH).
    1. Align the marks of timing chain LH and RH on the idler sprocket (lower).

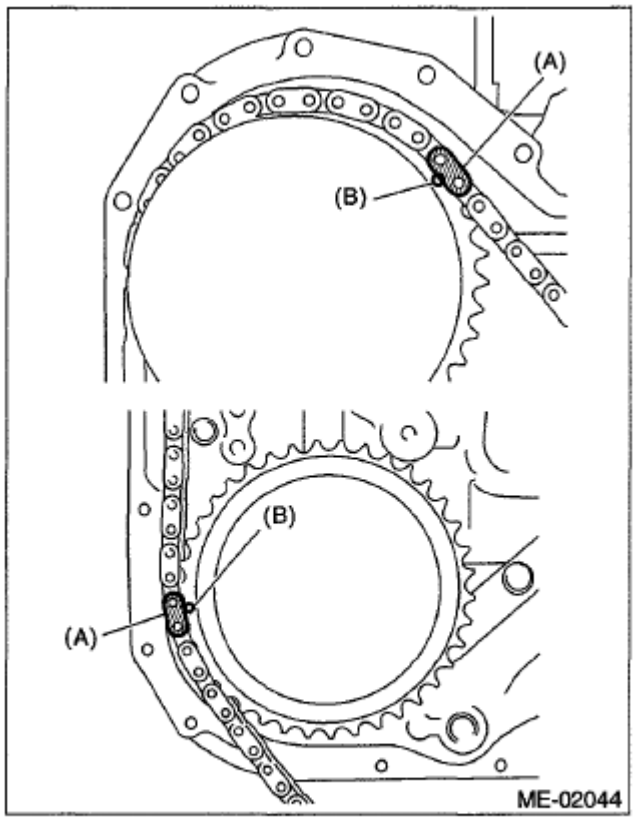


(A) Idler sprocket (lower)
(B) Timing chain (RH)
(C) Timing chain (LH)
(D) Blue

Fig. 79: Identifying Marks Of Timing Chain LH And RH On Idler Sprocket (Lower)
Courtesy of SUBARU OF AMERICA, INC.

    2. Install the timing chain (RH) to the intake cam sprocket (RH) and exhaust cam sprocket (RH) in this order.

NOTE: Check that the mark on timing chain (A) and cam sprocket (B) is aligned as same as aligned on crank sprocket.



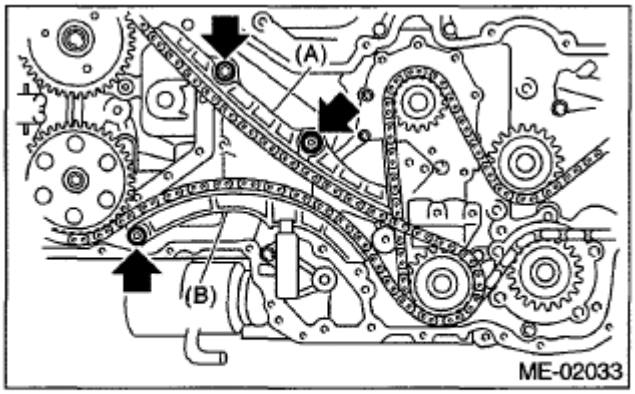
(A) Gold
(B) Mark

Fig. 80: Identifying Mark On Timing Chain And Cam Sprocket
Courtesy of SUBARU OF AMERICA, INC.

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

Tightening torque:

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



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

Fig. 81: Identifying Chain Guide (RH) And Chain Tensioner Lever (RH)
Courtesy of SUBARU OF AMERICA, INC.

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

   Tightening torque:

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

   NOTE: Use a new installing bolt.

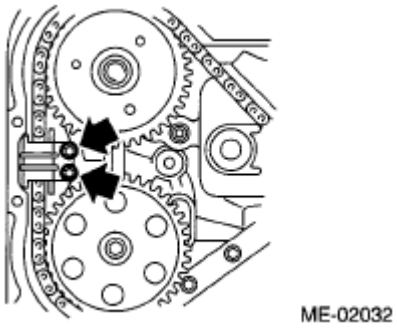


Fig. 82: Locating Chain Guide Bolts
Courtesy of SUBARU OF AMERICA, INC.

6. Install the chain tensioner (RH).

   Tightening torque:

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

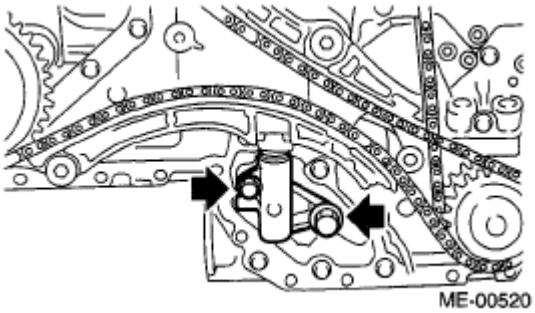


Fig. 83: Locating Chain Tensioner Bolts (RH)
Courtesy of SUBARU OF AMERICA, INC.

7. Adjust the clearance between chain guide (RH) and chain guide (center) within 8.4 - 8.6 mm (0.331 - 0.339 in). Install the chain guide (center).

   Tightening torque:

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

   NOTE: Use a new installing bolt.

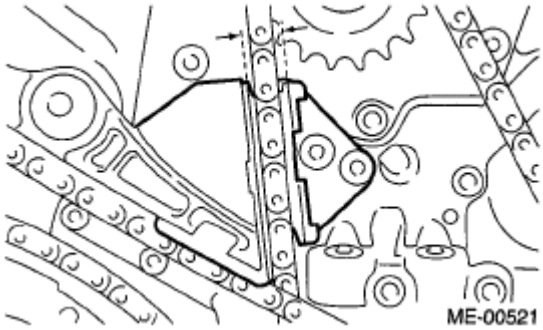


Fig. 84: Identifying Clearance Between Chain Guide (RH) And Chain Guide (Center)
Courtesy of SUBARU OF AMERICA, INC.

8. Check that each mark on the sprocket and timing chain is matched, and then draw out the stopper pin from chain tensioner.
9. Install the front chain cover. Refer to **INSTALLATION**, Front Chain Cover.
10. Install the crank pulley. Refer to **INSTALLATION**, Crank Pulley.
11. Install the V-belts. Refer to **INSTALLATION**, V-belt.

CAM SPROCKET

REMOVAL

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

body.

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

   ST 499977500 CAM SPROCKET WRENCH

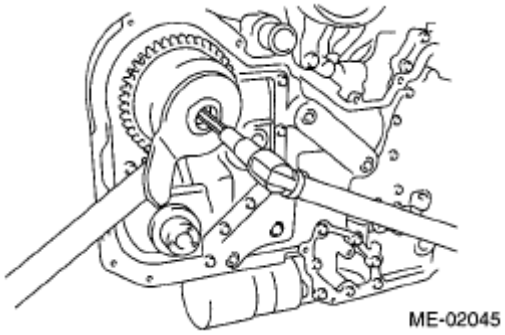


Fig. 85: Identifying ST 499977500 Cam Sprocket Wrench
Courtesy of SUBARU OF AMERICA, INC.

ST 18231AA020 CAM SPROCKET WRENCH

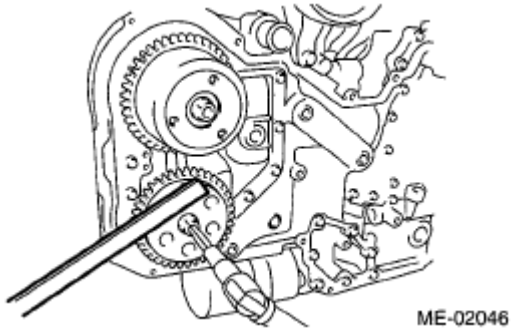


Fig. 86: Identifying ST 18231Aa020 Cam Sprocket Wrench
Courtesy of SUBARU OF AMERICA, INC.

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 bolts.

   Tightening angle:

   Intake side

   45°±5°

   Exhaust side

   25°±5°

   ST 499977500 CAM SPROCKET WRENCH

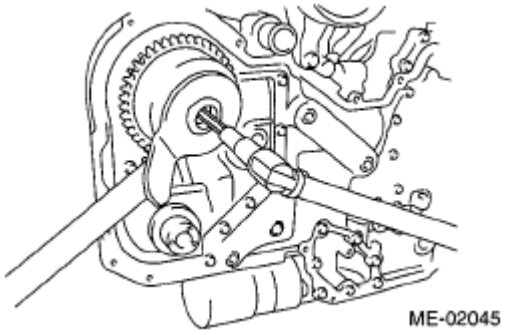


Fig. 87: Identifying ST 499977500 Cam Sprocket Wrench
Courtesy of SUBARU OF AMERICA, INC.

   ST 18231AA020 CAM SPROCKET WRENCH

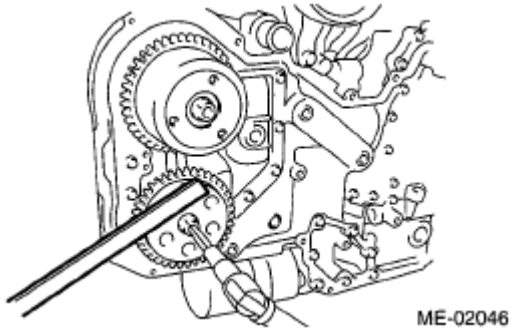


Fig. 88: Identifying ST 18231Aa020 Cam Sprocket Wrench
Courtesy of SUBARU OF AMERICA, INC.

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

INSPECTION

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

CRANK SPROCKET

REMOVAL

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

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

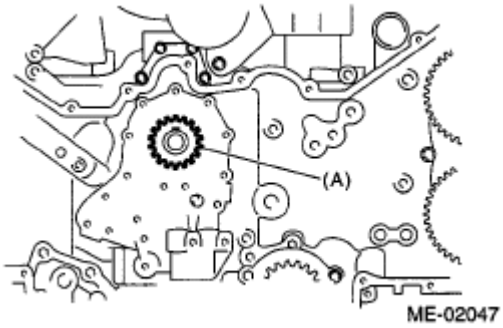


Fig. 89: Identifying Crank Sprocket
Courtesy of SUBARU OF AMERICA, INC.

INSTALLATION

1. Install the crank sprocket (A).

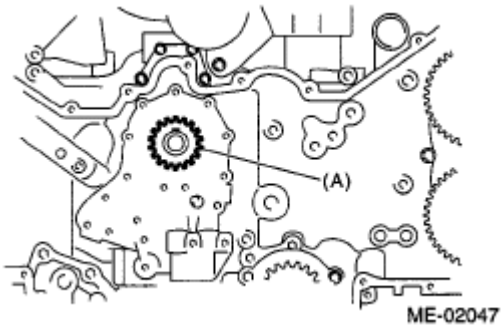


Fig. 90: Identifying Crank Sprocket
Courtesy of SUBARU OF AMERICA, INC.

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

INSPECTION

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

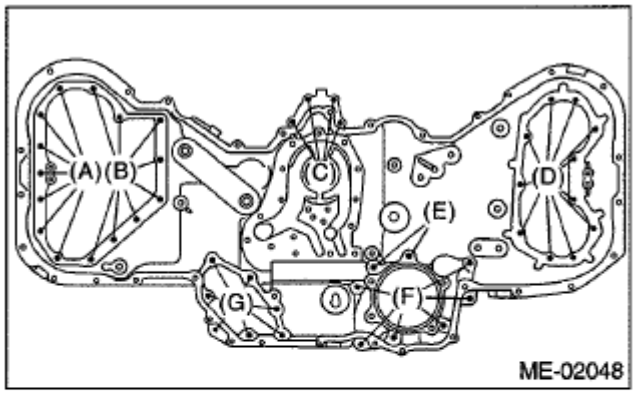
REAR CHAIN COVER

REMOVAL

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

1. Remove the V-belts. Refer to **REMOVAL**, V-belt.
2. Remove the crank pulley. Refer to **REMOVAL**, Crank Pulley.
3. Remove the front chain cover. Refer to **REMOVAL**, Front Chain Cover.
4. Remove the timing chain. Refer to **REMOVAL**, Timing Chain Assembly.
5. Remove the cam sprocket. Refer to **REMOVAL**, Cam Sprocket.
6. Remove the crank sprocket. Refer to **REMOVAL**, Crank Sprocket.
7. Remove the oil pump. Refer to **REMOVAL** , Oil Pump.
8. Remove the water pump. Refer to **REMOVAL** , Water Pump.
9. Remove the rear chain cover.

NOTE: Installation bolt has seven different sizes. To prevent the confusion in installation, keep these bolts on container individually.



(A) M6 × 14
(B) M6 × 18 (Silver)
(C) M6 × 30
(D) M6 × 18
(E) M8 × 40
(F) M8 × 30
(G) M6 × 22

Fig. 91: [Identifying Water Pump Bolts]
Courtesy of SUBARU OF AMERICA, INC.

INSTALLATION

NOTE: When replacing the rear chain cover, it is required to select the size. Refer to INSPECTION , Oil Pump.

1. Remove the used liquid gasket from mating surface, and degrease it.
2. Apply liquid gasket to the mating surface of rear chain cover.

NOTE: Install within 5 minutes after applying liquid gasket.

Liquid gasket:

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

Applying liquid gasket diameter

(A) 1.0±0.5 mm (0.039±0.020 in)

(B) 3.0±1.0 mm (0.118±0.039 in)

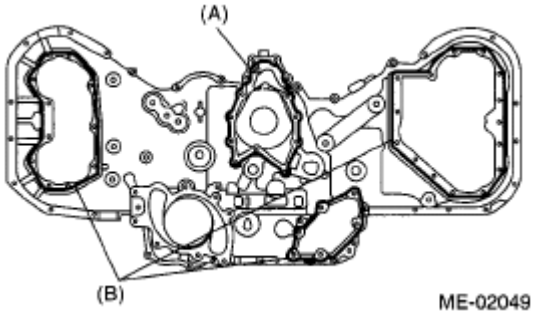
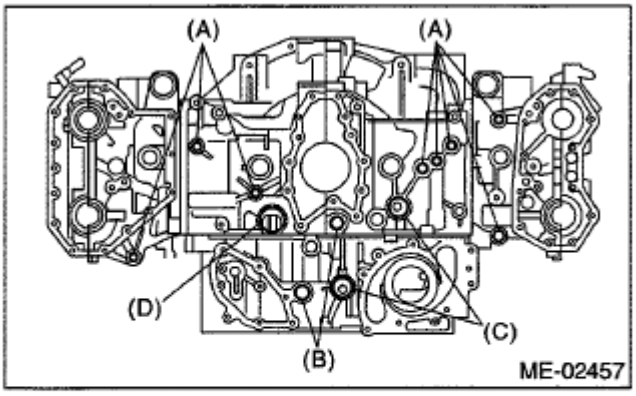


Fig. 92: Identifying Liquid Gasket Applying Area On Mating Surface Of Rear Chain Cover
Courtesy of SUBARU OF AMERICA, INC.

3. Install the O-ring.

NOTE:
- **Use new O-rings.**
- **Do not install the O-ring in wrong place.**



(A) 14.2 × 1.9
(B) 19.2 × 2.4
(C) 25 × 2
(D) 31.2 × 1.9

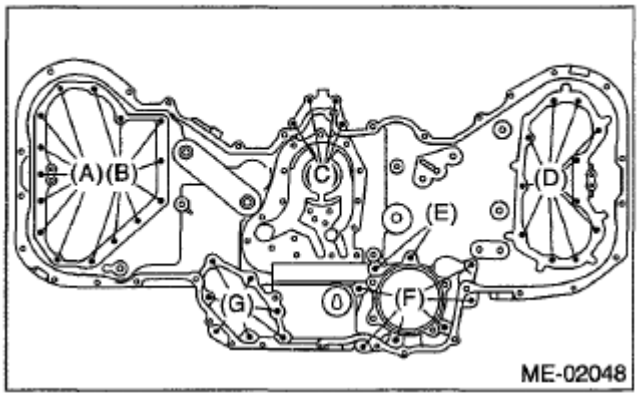
Fig. 93: Identifying O-Rings And Bolts
Courtesy of SUBARU OF AMERICA, INC.

4. Install the water pump gasket.

NOTE: Use a new gasket.

5. Temporarily tighten the rear chain cover.

NOTE: Do not install the bolts in wrong place.



(A) M6 × 14
(B) M6 × 18 (Silver)
(C) M6 × 30
(D) M6 × 18
(E) M8 × 40
(F) M8 × 30
(G) M6 × 22

Fig. 94: Identifying Rear Chain Cover Bolts
Courtesy of SUBARU OF AMERICA, INC.

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

Tightening torque:

BOLTS TORQUE

(1) - (11)	9 N.m (0.9 kgf-m, 6.6 ft-lb)
(12) - (19)	20 N.m (2.0 kgf-m, 14.8 ft-lb)
(20) - (30)	9 N.m (0.9 kgf-m, 6.6 ft-lb)
(31) - (38)	12 N.m (1.2 kgf-m, 8.9 ft-lb)
(39) - (45)	9 N.m (0.9 kgf-m, 6.6 ft-lb)

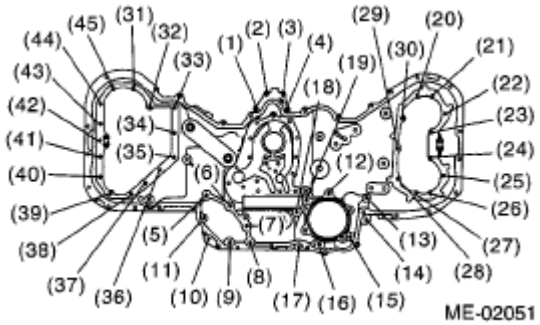


Fig. 95: Identifying Rear Chain Cover Bolts In Tightening Sequence
Courtesy of SUBARU OF AMERICA, INC.

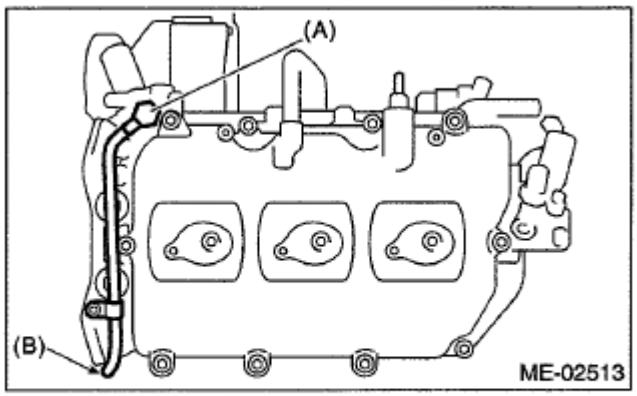
7. Install the water pump. Refer to **INSTALLATION** , Water Pump.
8. Install the oil pump. Refer to **INSTALLATION** , Oil Pump.
9. Install the crank sprocket. Refer to **INSTALLATION**, Crank Sprocket.
10. Install the cam sprocket. Refer to **INSTALLATION**, Cam Sprocket.
11. Install the timing chain. Refer to **INSTALLATION**, Timing Chain Assembly.
12. Install the front chain cover. Refer to **INSTALLATION**, Front Chain Cover.
13. Install the crank pulley. Refer to **INSTALLATION**, Crank Pulley.
14. Install the V-belts. Refer to **INSTALLATION**, V-belt.

CAMSHAFT

REMOVAL

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

1. Remove the V-belts. Refer to **REMOVAL**, V-belt.
2. Remove the crank pulley. Refer to **REMOVAL**, Crank Pulley.
3. Remove the front chain cover. Refer to **REMOVAL**, Front Chain Cover.
4. Remove the timing chain assembly. Refer to **REMOVAL**, Timing Chain Assembly.
5. Remove the cam sprocket. Refer to **REMOVAL**, Cam Sprocket.
6. Remove the crank sprocket. Refer to **REMOVAL**, Crank Sprocket.
7. Remove the rear chain cover. Refer to **REMOVAL**, Rear Chain Cover.
8. Disconnect the oil pipe.



(A) Bolt without filter (without protrusion)
(B) Bolt with filter (with protrusion)

Fig. 96: Identifying Oil Pipe Bolts
Courtesy of SUBARU OF AMERICA, INC.

9. Remove the rocker cover (LH).

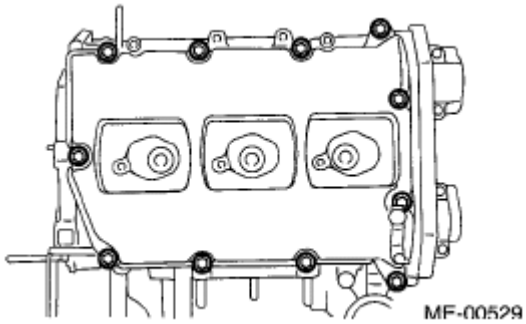


Fig. 97: Identifying Rocker Cover (LH)
Courtesy of SUBARU OF AMERICA, INC.

10. Remove the plugs (LH).

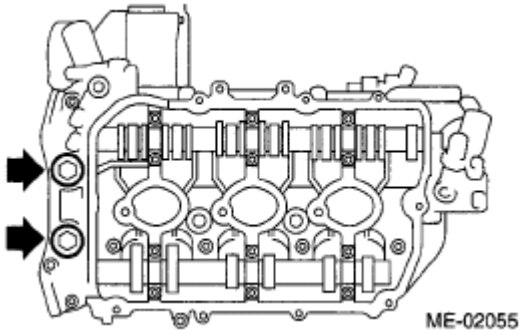


Fig. 98: Locating Plugs (LH)
Courtesy of SUBARU OF AMERICA, INC.

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

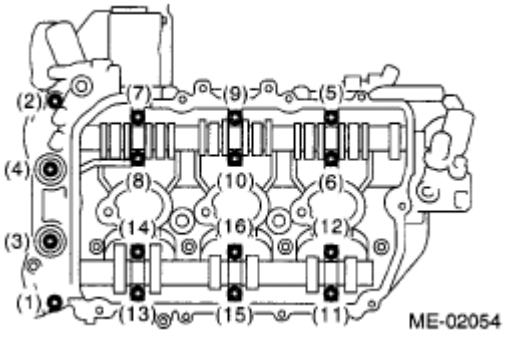


Fig. 99: Identifying Camshaft Cap Bolts In Loosening Sequence
Courtesy of SUBARU OF AMERICA, INC.

12. Remove the camshaft caps and camshaft (LH).

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

13. Similarly, remove the camshaft (RH) and related parts.

INSTALLATION

1. Apply engine oil to camshaft journals, and install the camshaft.
2. Install the camshaft cap.
    1. Apply liquid gasket sparingly to back side of 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 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)

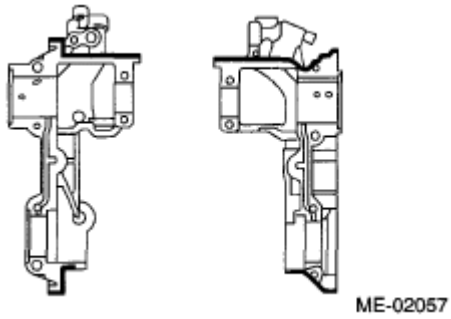


Fig. 100: Identifying Liquid Gasket Applying Area On Back Side Of Front Camshaft Cap
Courtesy of SUBARU OF AMERICA, INC.

2. Apply engine oil to cap bearing surface, and install the cap to camshaft.
3. Tighten the rocker cover 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)

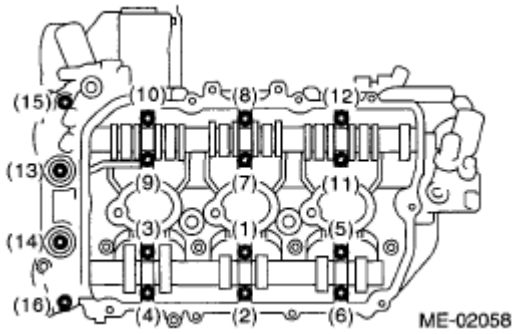


Fig. 101: Identifying Rocker Cover Bolts In Tightening Sequence
Courtesy of SUBARU OF AMERICA, INC.

3. Install the plugs.

   Tightening torque:

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

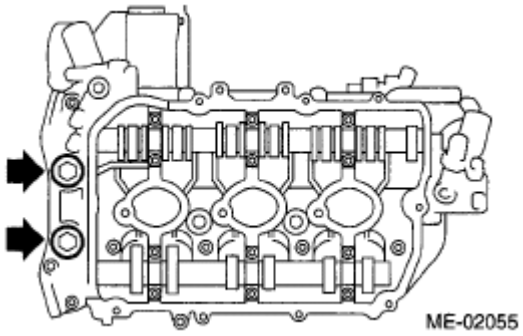


Fig. 102: Locating Plugs (LH)
Courtesy of SUBARU OF AMERICA, INC.

4. 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 within 5 minutes after applying liquid gasket.

Liquid gasket:

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

- LH side

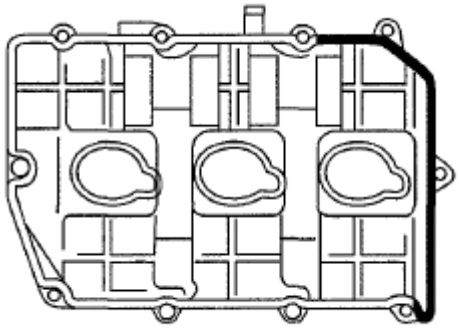


Fig. 103: Identifying Liquid Gasket Applying Area On Mating Surface Of Cylinder Head And Rocker Cover (LH Side)
Courtesy of SUBARU OF AMERICA, INC.

- RH side

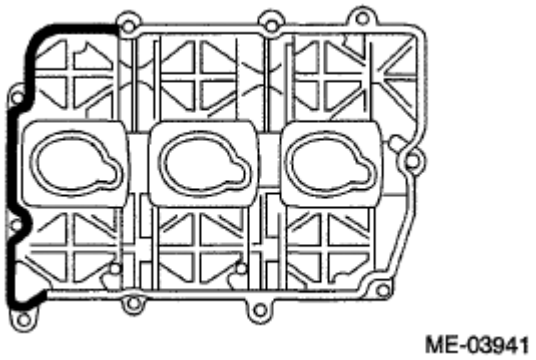


Fig. 104: Identifying Liquid Gasket Applying Area On Mating Surface Of Cylinder Head And Rocker Cover (RH Side)
Courtesy of SUBARU OF AMERICA, INC.

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

Tightening torque:

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

- LH side

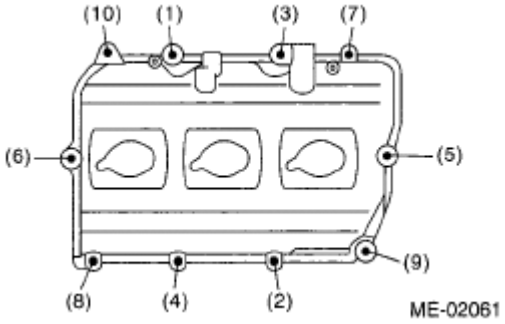


Fig. 105: Identifying Rocker Cover Bolts Tightening Sequence (LH Side)
Courtesy of SUBARU OF AMERICA, INC.

- RH side

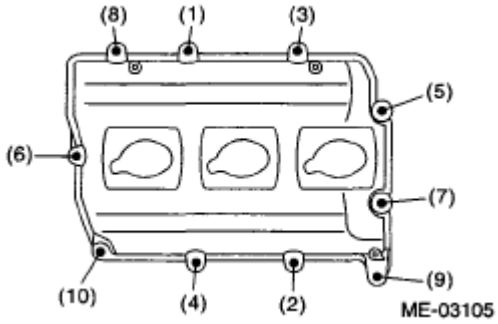


Fig. 106: Identifying Rocker Cover Bolts Tightening Sequence (RH Side)
Courtesy of SUBARU OF AMERICA, INC.

5. Connect the oil pipe.

NOTE:

- **Be careful not to mistake the location of (A) and (B).**
- **Use a new gasket.**

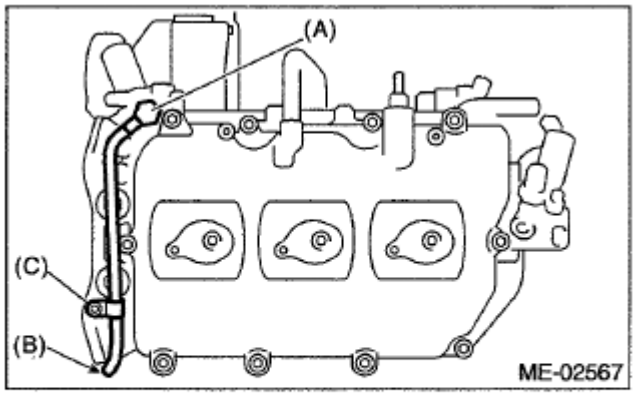
Tightening torque:

(A), (B)

29 N.m (3.0 kgf-m, 21.4 ft-lb)

(C)

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



(A) Bolt without filter (without protrusion)
(B) Bolt with filter (with protrusion)
(C) Oil pipe bolt

Fig. 107: Identifying Oil Pipe Bolts
Courtesy of SUBARU OF AMERICA, INC.

6. Install the rear chain cover. Refer to **INSTALLATION**, Rear Chain Cover.
7. Install the crank sprocket. Refer to **INSTALLATION**, Crank Sprocket.
8. Install the cam sprocket. Refer to **INSTALLATION**, Cam Sprocket.
9. Install the timing chain assembly. Refer to **INSTALLATION**, Timing Chain Assembly.
10. Install the front chain cover. Refer to **INSTALLATION**, Front Chain Cover.
11. Install the crank pulley. Refer to **INSTALLATION**, Crank Pulley.
12. Install the V-belts. Refer to **INSTALLATION**, V-belt.

INSPECTION

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

   Service limit:

   0.020 mm (0.00079 in)

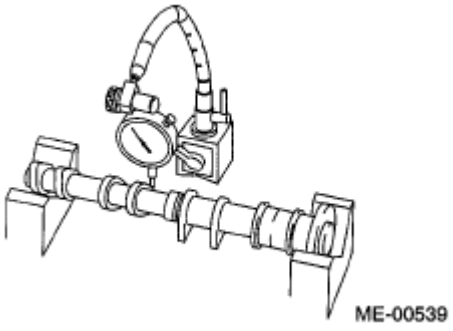


Fig. 108: Measuring Bend Of Camshaft

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 REFERENCE

	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 camshaft on the cylinder head. (Do not attach the valve rockers.)
   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)

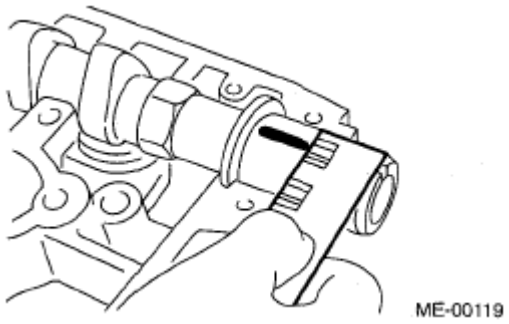


Fig. 109: Measuring Widest Point Of Plastigage On Journal
Courtesy of SUBARU OF AMERICA, INC.

   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

HIGH 42.09 - 42.19 mm (1.6571 - 1.6610 in)

LOW1 38.14 - 38.24 mm (1.5016 - 1.5055 in)

LOW2 38.14 - 38.24 mm (1.5016 - 1.5055 in)

Exhaust

40.45 - 40.55 mm (1.5925 - 1.5965 in)

Cam base circle diameter A:

Standard

Intake

HIGH 32.00 mm (1.2598 in)

LOW1 31.84 mm (1.2535 in)

LOW2 31.84 mm (1.2535 in)

Exhaust

32.00 mm (1.2598 in)

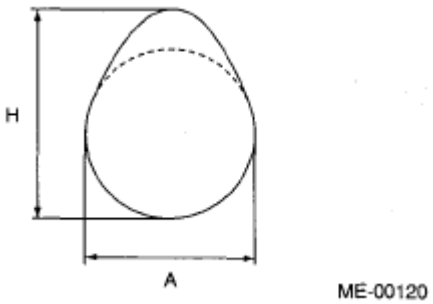


Fig. 110: Identifying Cam Base Circle Diameter
Courtesy of SUBARU OF AMERICA, INC.

7. Measure the side clearance of the camshaft with a dial gauge. If the side clearance exceeds the standard or there is offset wear, 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

0.030 - 0.090 mm (0.0012 - 0.0035 in)

CYLINDER HEAD

REMOVAL

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

1. Remove the V-belts. Refer to **REMOVAL**, V-belt.
2. Remove the crank pulley. Refer to **REMOVAL**, Crank Pulley.
3. Remove the front chain cover. Refer to **REMOVAL**, Front Chain Cover.
4. Remove the timing chain assembly. Refer to **REMOVAL**, Timing Chain Assembly.
5. Remove the cam sprocket. Refer to **REMOVAL**, Cam Sprocket.
6. Remove the crank sprocket. Refer to **REMOVAL**, Crank Sprocket.
7. Remove the rear chain cover. Refer to **REMOVAL**, Rear Chain Cover.
8. Remove the camshaft. Refer to **REMOVAL**, Camshaft.
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.

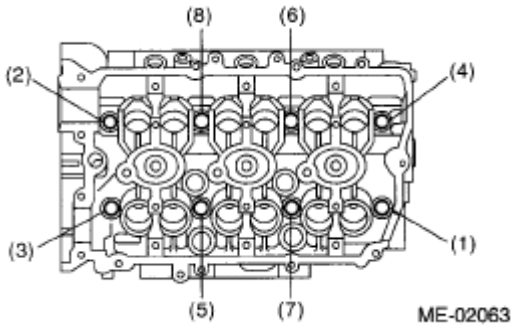


Fig. 111: Identifying Cylinder Head Bolts In Loosening Sequence
Courtesy of SUBARU OF AMERICA, INC.

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

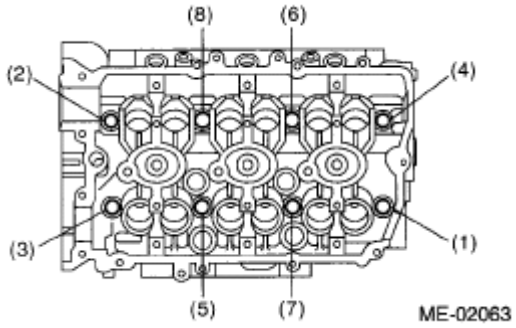


Fig. 112: Identifying Cylinder Head Bolts In Loosening Sequence
Courtesy of SUBARU OF AMERICA, INC.

12. Remove the cylinder head gasket.

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

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

INSTALLATION

1. Install the cylinder head and gaskets on cylinder block.

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

NOTE: Use new cylinder head gaskets.

2. Tighten the cylinder head bolts.
    1. Apply a thin coat of engine oil to washers and cylinder head bolt threads.
    2. Mount the cylinder head onto the cylinder block, then tighten the bolts with a torque of 20 N.m (2.0 kgf-m, 14.8 ft-lb) in the order indicated in the figure.
    3. Tighten the bolts with a torque of 50 N.m (5.1 kgf-m, 36.9 ft-lb) in the order indicated in the figure.
    4. Loosen all the bolts by 180° in the reverse order of installing, and loosen them further by 180°.
    5. Tighten the bolts with a torque of 20 N.m (2.0 kgf-m, 14.8 ft-lb) in the order indicated in the figure.
    6. Tighten the bolts (1) - (4) in the order indicated with a torque of 48 N.m (4.9 kgf-m, 35.4 ft-lb).
    7. Tighten the bolts (5) - (8) in the order indicated with a torque of 44 N.m (4.5 kgf-m, 32.5 ft-lb).
    8. Tighten all bolts 90° in the numerical order as shown in the figure.
    9. Tighten the bolt (1) - (4) by 45° in the numerical order.

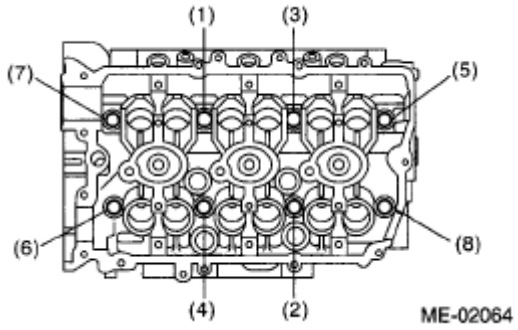


Fig. 113: Identifying Cylinder Head Bolts In Tightening Sequence
Courtesy of SUBARU OF AMERICA, INC.

3. Install the camshaft. Refer to **INSTALLATION**, Camshaft.
4. Install the rear chain cover. Refer to **INSTALLATION**, Rear Chain Cover.
5. Install the crank sprocket. Refer to **INSTALLATION**, Crank Sprocket.
6. Install the cam sprocket. Refer to **INSTALLATION**, Cam Sprocket.
7. Install the timing chain assembly. Refer to **INSTALLATION**, Timing Chain Assembly.
8. Install the front chain cover. Refer to **INSTALLATION**, Front Chain Cover.
9. Install the crank pulley. Refer to **INSTALLATION**, Crank Pulley.
10. Install the V-belts. Refer to **INSTALLATION**, V-belt.

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.**
- **For removal and installation procedures of the valve guide, intake valve oil seal and exhaust valve oil seal, refer to VALVE GUIDE, INSPECTION, Cylinder Head. Refer to INTAKE AND EXHAUST VALVE OIL SEAL, INSPECTION, Cylinder Head.**

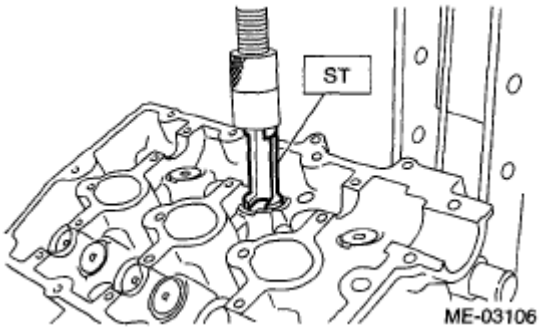


Fig. 114: Identifying ST 499718000 Valve Spring Remover
Courtesy of SUBARU OF AMERICA, INC.

ASSEMBLY

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

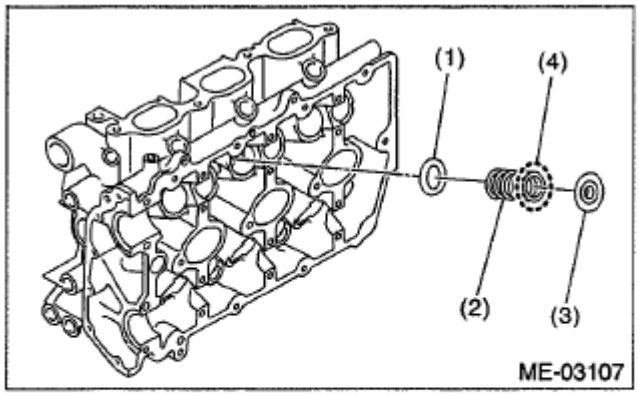
       ST 18250AA010 CYLINDER HEAD TABLE

    2. Coat the stem of each valve with engine oil and insert the valve into the 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.**
       - **For the valve spring on intake side, install two of them (inner and outer).**
       - **Install the valve spring with the painted side facing to retainer.**



(1) Valve spring seat
(2) Valve spring
(3) Retainer
(4) Painted face

Fig. 115: Identifying Valve Spring Seat, Valve Spring And Retainer
Courtesy of SUBARU OF AMERICA, INC.

4. Set the ST on valve spring.

   ST 499718000 VALVE SPRING REMOVER

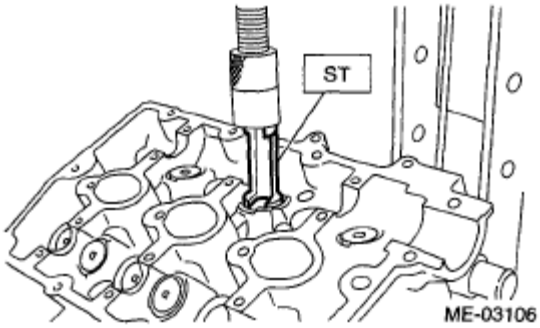


Fig. 116: Identifying ST 499718000 Valve Spring Remover
Courtesy of SUBARU OF AMERICA, INC.

5. Compress the valve spring and fit the valve spring retainer key.
6. After installing, tap the valve spring retainers lightly with a plastic hammer for better seating.

2. Apply oil to the surface of valve lifter and valve shim.
3. Install the valve lifter and valve shim.

INSPECTION

CYLINDER HEAD

1. Check for cracks or damage. Use liquid penetrant tester on the important sections to check for fissures. 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. Inspect the cylinder head surface that mates with cylinder block for warping by using a straight edge (A) and thickness gauge (B). If the warping exceeds the limit, replace the cylinder head.

   Warping 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.

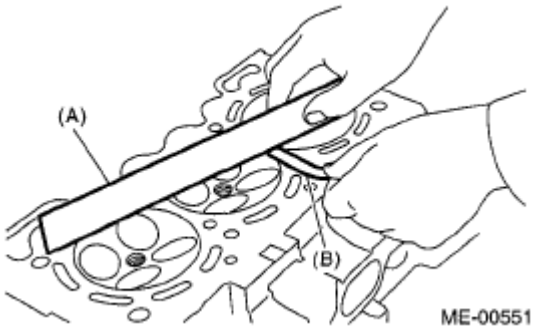


Fig. 117: Inspecting Cylinder Head Surface
Courtesy of SUBARU OF AMERICA, INC.

VALVE SEAT

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

Valve seat width W:

Standard

Intake

1.0 mm (0.039 in)

Exhaust

1.5 mm (0.059 in)

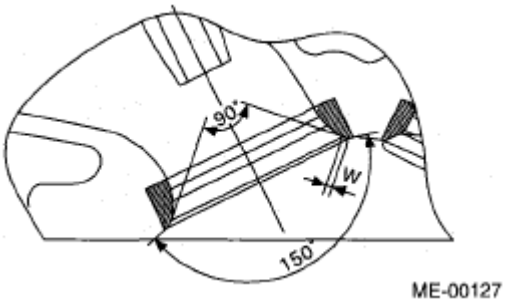


Fig. 118: Identifying Valve Seat Width
Courtesy of SUBARU OF AMERICA, INC.

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 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

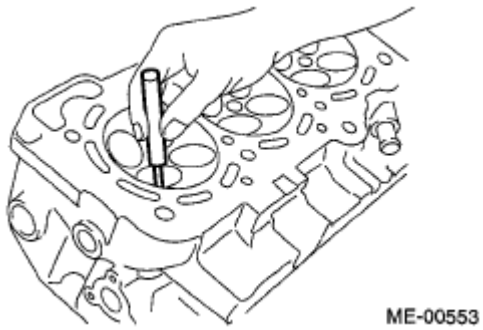


Fig. 119: Inserting ST2 Into Valve Guide
Courtesy of SUBARU OF AMERICA, INC.

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

   ST 18251AA040 VALVE GUIDE ADJUSTER

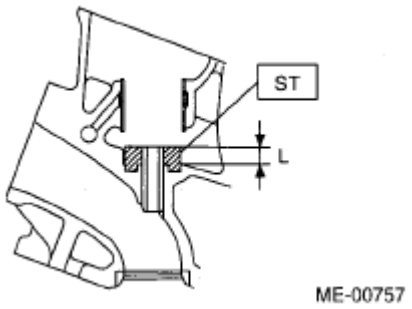


Fig. 120: Identifying ST 18251Aa040 Valve Guide Adjuster
Courtesy of SUBARU OF AMERICA, INC.

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

ST1 499765700 VALVE GUIDE REMOVER

ST2 18251AA040 VALVE GUIDE ADJUSTER

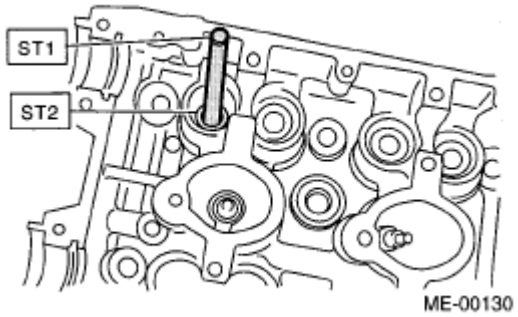


Fig. 121: Identifying ST1 499765700 Valve Guide Remover And ST2 18251Aa040 Valve Guide Adjuster
Courtesy of SUBARU OF AMERICA, INC.

6. Check the valve guide protrusion.

   Valve guide protrusion L:

   11.4 - 11.8 mm (0.449 - 0.465 in)

7. Ream the inside of valve guide using ST. Put the ST in valve guide, and rotate the ST slowly clockwise while pushing it lightly. Bring the ST back while rotating it clockwise.

   ST 499765900 VALVE GUIDE REAMER

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

8. After reaming, clean the valve guide to remove chips.
9. Recheck the contact condition between valve and valve seat after replacing the valve guide.

INTAKE AND EXHAUST VALVE

1. Inspect the flange and stem of the valve, and replace if damaged, worn, or deformed, or if "H" is outside of the standard.

   Head edge thickness H:

   Standard

Intake (A)

1.0 mm (0.039 in)

Exhaust (B)

1.2 mm (0.047 in)

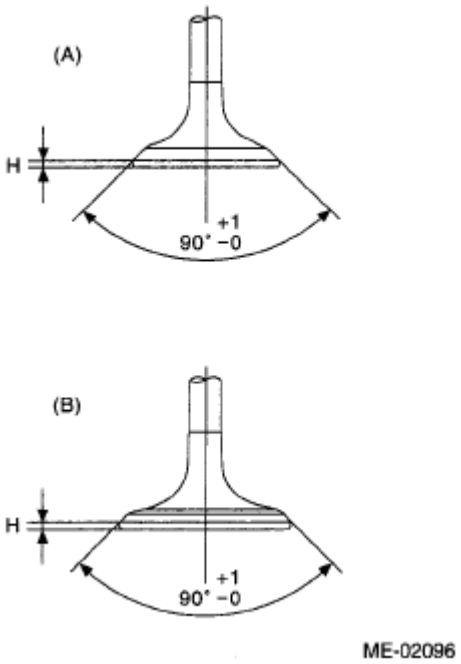


Fig. 122: Identifying Head Edge Thickness
Courtesy of SUBARU OF AMERICA, INC.

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

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

Valve overall length:

Intake

99.7 mm (3.925 in)

Exhaust

105.2 mm (4.142 in)

VALVE SPRING

1. Check the valve springs for damage, free length, and tension. Replace the valve spring if it is not within the standard value presented in the table.

VALVE SPRING LENGTH REFERENCE

Free length mm (in)	Intake	Inner	39.55 (1.5571)
		Outer	41.18 (1.6213)
	Exhaust		46.32 (1.8236)
Squareness	Intake	Inner	2.5°, 1.7 mm (0.067 in) or less
		Outer	2.5°, 1.8 mm (0.071 in) or less
	Exhaust		2.5°, 2.0 mm (0.079 in) or less

2. To measure the squareness of the valve spring, stand the valve spring on a surface plate and measure its deflection at the top of the spring using a try square.

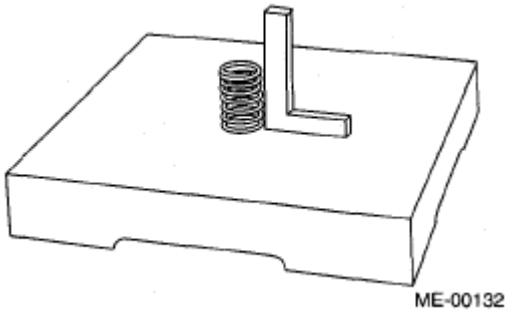


Fig. 123: Measuring Deflection Of Spring Using Try Square
Courtesy of SUBARU OF AMERICA, INC.

INTAKE AND EXHAUST VALVE OIL SEAL

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

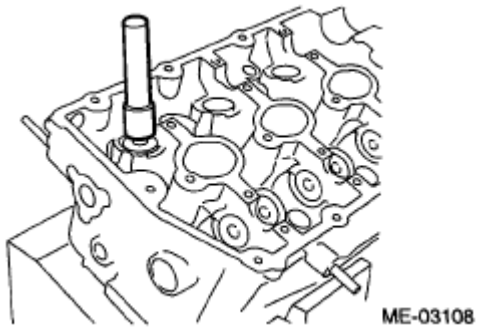


Fig. 124: Pressing Oil Seal Using ST2
Courtesy of SUBARU OF AMERICA, INC.

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)

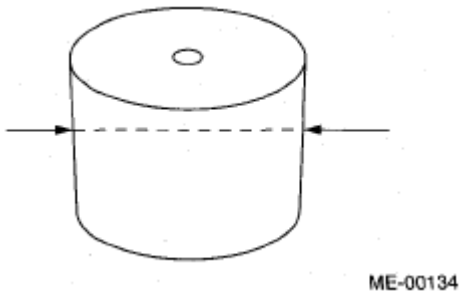


Fig. 125: Identifying Outer Diameter Of Valve Lifter
Courtesy of SUBARU OF AMERICA, INC.

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

   Inner diameter:

   32.994 - 33.016 mm (1.2990 - 1.2998 in)

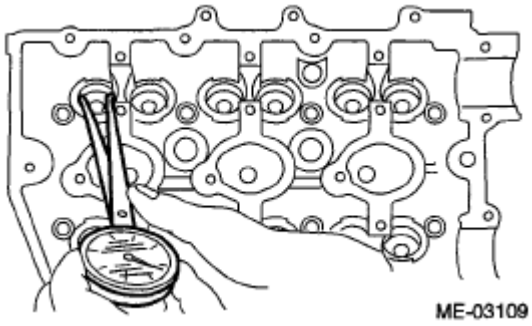


Fig. 126: Measuring Inner Diameter Of Valve Lifter Hole Of Cylinder Head
Courtesy of SUBARU OF AMERICA, INC.

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

Standard:

0.019 - 0.057 mm (0.0007 - 0.0022 in)

CYLINDER BLOCK

REMOVAL

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

1. Remove the V-belts. Refer to **REMOVAL**, V-belt.
2. Remove the crank pulley. Refer to **REMOVAL**, Crank Pulley.
3. Remove the front chain cover. Refer to **REMOVAL**, Front Chain Cover.
4. Remove the timing chain assembly. Refer to **REMOVAL**, Timing Chain Assembly.
5. Remove the cam sprocket. Refer to **REMOVAL**, Cam Sprocket.
6. Remove the crank sprocket. Refer to **REMOVAL**, Crank Sprocket.
7. Remove the rear chain cover. Refer to **REMOVAL**, Rear Chain Cover.
8. Remove the camshaft. Refer to **REMOVAL**, Camshaft.
9. Remove the cylinder head. Refer to **REMOVAL**, Cylinder Head.
10. Use the ST to lock the crankshaft, and remove the drive plate.

    ST1 498497100 CRANKSHAFT STOPPER

    ST2 499057000 TORX PLUS®

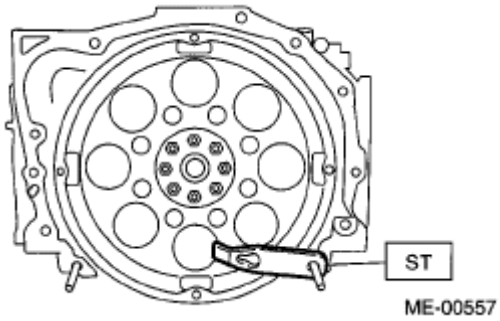


Fig. 127: Identifying ST On Drive Plate
Courtesy of SUBARU OF AMERICA, INC.

11. Remove the crankshaft position sensor plate.

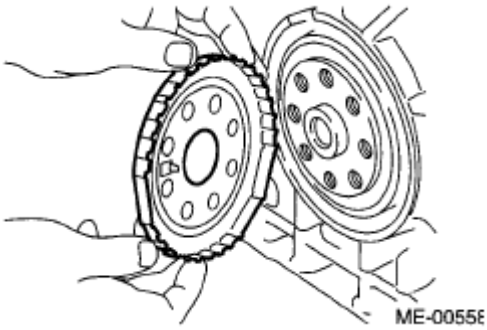


Fig. 128: Identifying Crankshaft Position Sensor Plate
Courtesy of SUBARU OF AMERICA, INC.

12. Remove the crankshaft position sensor bracket.

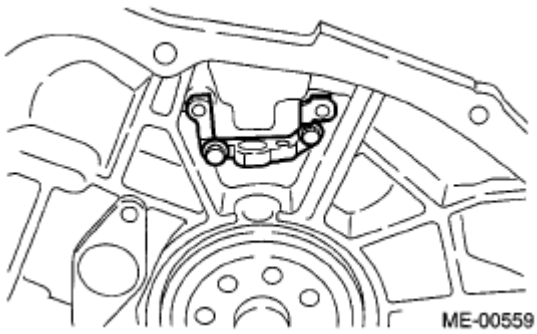


Fig. 129: Identifying Crankshaft Position Sensor Bracket
Courtesy of SUBARU OF AMERICA, INC.

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

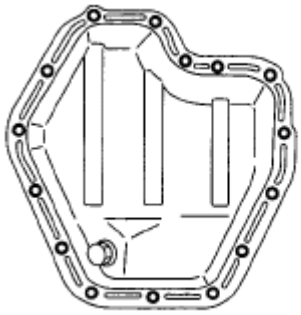


Fig. 130: Identifying Oil Pan Bolts
Courtesy of SUBARU OF AMERICA, INC.

15. Insert an oil pan cutter blade between cylinder block-to-oil pan clearance and remove the oil pan.

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

16. Remove the oil strainer.

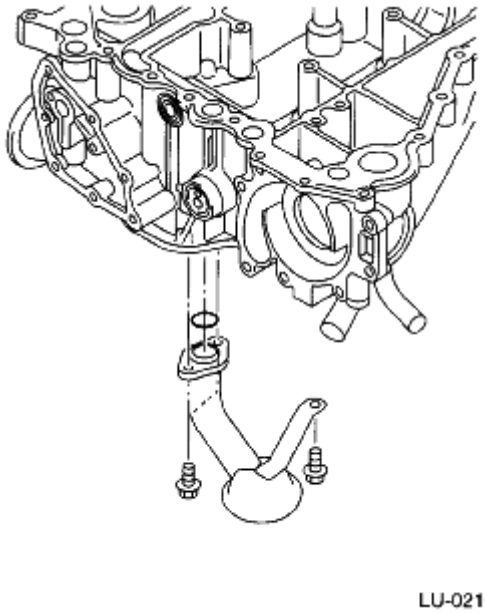
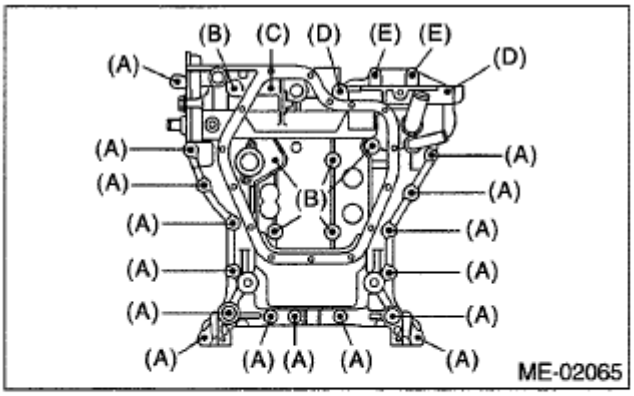


Fig. 131: Identifying Oil Strainer And O-Rings
Courtesy of SUBARU OF AMERICA, INC.

17. Remove the bolts which install oil pan upper onto cylinder block.

NOTE: Installation bolt has five different sizes. To prevent the confusion in installation, keep these bolts on container individually.



(A) M8 × 40
(B) M8 × 65
(C) M8 × 85
(D) M8 × 130.5
(E) M8 × 24

Fig. 132: Identifying Oil Pan Upper Bolts
Courtesy of SUBARU OF AMERICA, INC.

18. Remove the service hole cover and service hole plugs using a hexagon wrench.

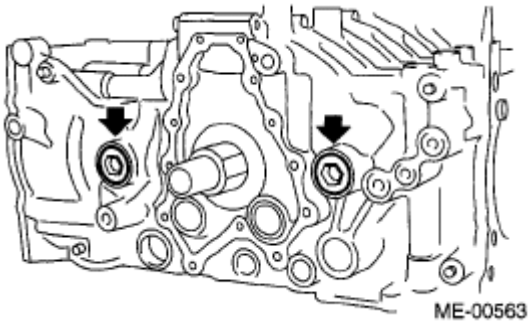


Fig. 133: Locating Service Hole Plugs
Courtesy of SUBARU OF AMERICA, INC.

19. Rotate the crankshaft to bring #1 and #2 pistons to bottom dead center position, then, using the ST, remove the piston snap ring through service hole of #1 and #2 cylinders.

ST 18233AA000 PISTON PIN SNAP RING PLIERS

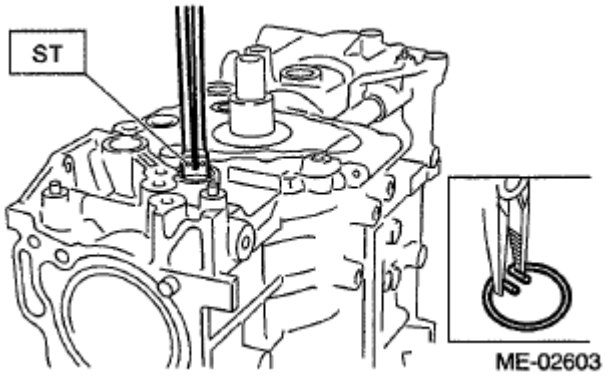


Fig. 134: Removing Piston Snap Ring
Courtesy of SUBARU OF AMERICA, INC.

20. Draw out the piston pin from #1 and #2 pistons using ST.

    ST 499097700 PISTON PIN REMOVER ASSY

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

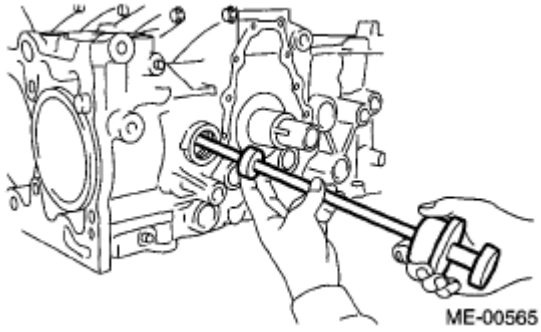


Fig. 135: Removing Piston Pin From Piston
Courtesy of SUBARU OF AMERICA, INC.

21. Similarly remove the piston pins from #3, #4, #5, and #6 pistons.
22. Remove the cylinder block connecting bolts.

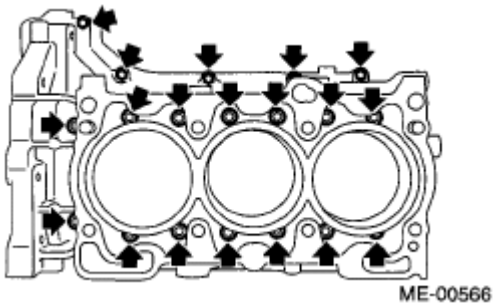


Fig. 136: Locating Cylinder Block Connecting Bolts
Courtesy of SUBARU OF AMERICA, INC.

23. Separate the cylinder block (LH) and (RH).

NOTE: When separating the cylinder block, do not allow the connecting rod to fall or damage the cylinder block.

24. Remove the rear oil seal.
25. Remove the crankshaft together with connecting rod.
26. Remove the crankshaft bearings from cylinder block using a hammer handle.

NOTE:
- **Be careful not to confuse the crankshaft bearing combination.**
- **Press the bearing at the end opposite to locking lip.**

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

NOTE: Be careful not to confuse the original combination of piston and cylinder.

INSTALLATION

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

   ST 18232AA000 ENGINE STAND

NOTE: Remove oil on the mating surface of cylinder block before installation. Apply a coat of engine oil to the bearing and crankshaft journal.

2. Position the crankshaft on the cylinder block (RH).
3. Apply liquid gasket to the mating surfaces of cylinder block (RH), and position the cylinder block (LH).

NOTE:
- **Do not allow liquid gasket to run over to oil passages, bearing grooves, etc.**
- **Install 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)

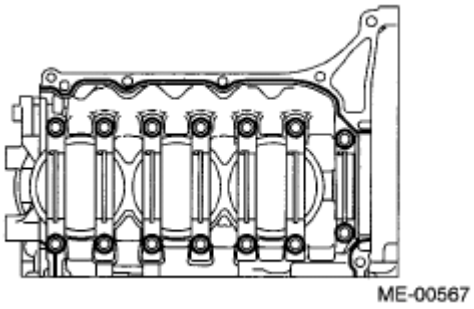


Fig. 137: Identifying Liquid Gasket Applying Area On Mating Surfaces Of Cylinder Block
Courtesy of SUBARU OF AMERICA, INC.

4. Apply a coat of engine oil to the washer and bolt thread.
5. Tighten all bolts in the numerical order as shown in the figure.

Tightening torque:

(1) - (11), (13):25 N.m (2.5 kgf-m, 18.4 ft-lb)

(12), (14):20 N.m (2.0 kgf-m, 14.8 ft-lb)

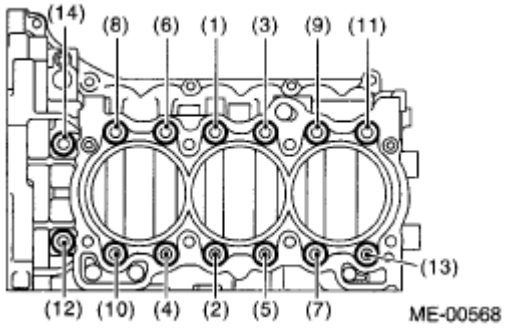


Fig. 138: Identifying Cylinder Head Bolts In Tightening Sequence
Courtesy of SUBARU OF AMERICA, INC.

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

Tightening torque:

(1) - (11), (13): 25 (2.5 kgf-m, 18.4 ft-lb)

(12), (14): 20 N.m (2.0 kgf-m, 14.8 ft-lb)

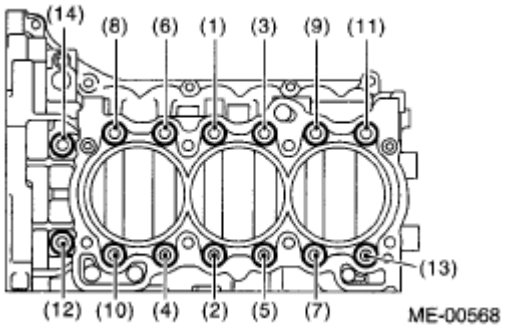


Fig. 139: Identifying Cylinder Head Bolts In Tightening Sequence
Courtesy of SUBARU OF AMERICA, INC.

7. Tighten all bolts 90° - 110° in the numerical order as shown in the figure.

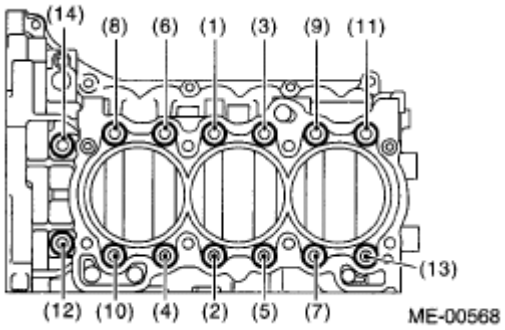


Fig. 140: Identifying Cylinder Head Bolts In Tightening Sequence
Courtesy of SUBARU OF AMERICA, INC.

8. 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 rear chain cover and oil pan upper.

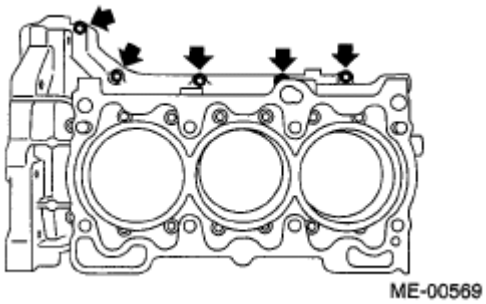


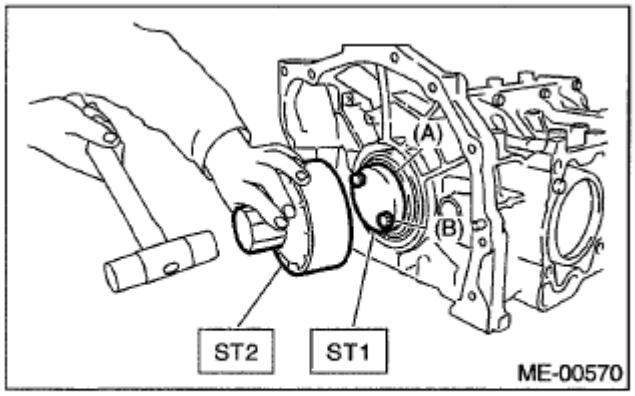
Fig. 141: Locating Cylinder Block Upper Bolt
Courtesy of SUBARU OF AMERICA, INC.

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

NOTE: Use 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. 142: Installing Rear Oil Seal Using ST1 And ST2
Courtesy of SUBARU OF AMERICA, INC.

10. Position the top ring gap at (A) in the figure.
11. Position the second ring gap at (B).

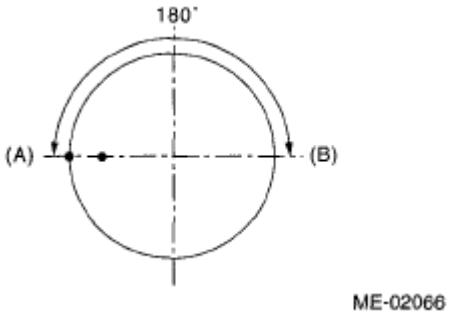


Fig. 143: Positioning Of Second Ring Gap And Top Ring Gap
Courtesy of SUBARU OF AMERICA, INC.

12. Position the upper rail gap at (C) in the figure.
13. Position the expander gap at (D) in the figure.

14. Position the lower rail gap at (E) in the figure.

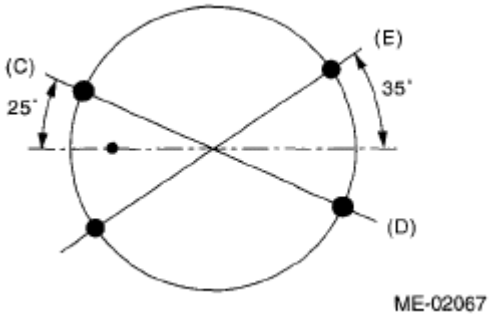


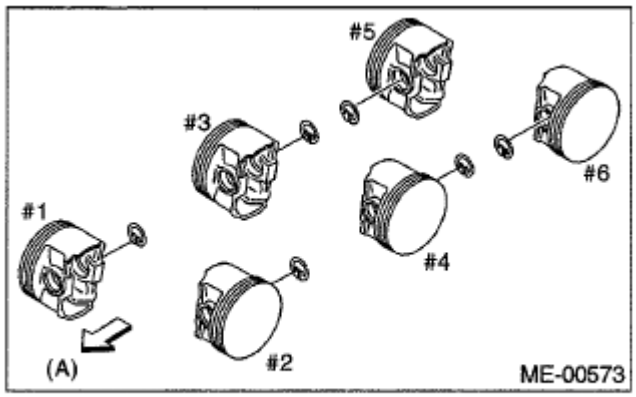
Fig. 144: Positioning Lower Rail Gap, Expander Gap And Upper Rail Gap
Courtesy of SUBARU OF AMERICA, INC.

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

15. Install the snap ring.

Install the snap rings in the piston holes located opposite to the service holes in cylinder block when positioning all pistons in corresponding cylinders.

NOTE: Use new snap rings.



(A) Front side of vehicle

Fig. 145: Positioning Of Pistons In Cylinders
Courtesy of SUBARU OF AMERICA, INC.

16. Installing piston:
    1. Using ST1, turn the crankshaft so that #3 and #4 connecting rod small ends are set on the service hole (A).

ST1 18252AA000 CRANKSHAFT SOCKET

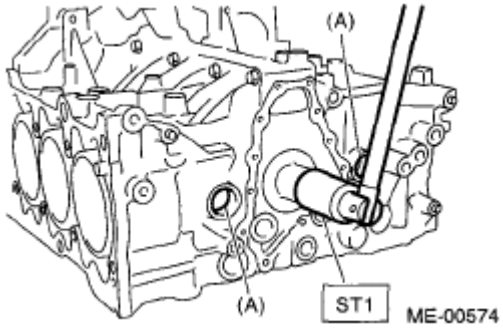


Fig. 146: Turning Crankshaft
Courtesy of SUBARU OF AMERICA, INC.

2. Apply a thin coat of engine oil to piston and cylinder.
3. Using ST2, press-fit the piston into cylinder.

ST2 18254AA000 PISTON GUIDE

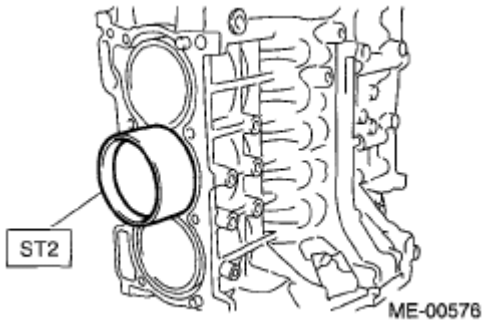


Fig. 147: Pressing Piston Into Cylinder Using ST2
Courtesy of SUBARU OF AMERICA, INC.

NOTE: Let the piston front mark (A) face towards the front of engine.

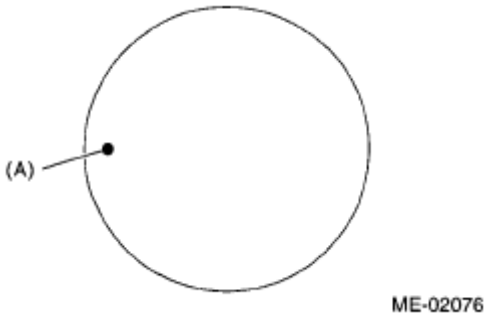


Fig. 148: Identifying Piston Front Mark
Courtesy of SUBARU OF AMERICA, INC.

17. Installing piston pin:
    1. Apply a coat of engine oil to ST3 before insertion, and then insert it into the service hole to align piston pin hole with connecting rod small end.

       ST3 18253AA000 PISTON PIN GUIDE

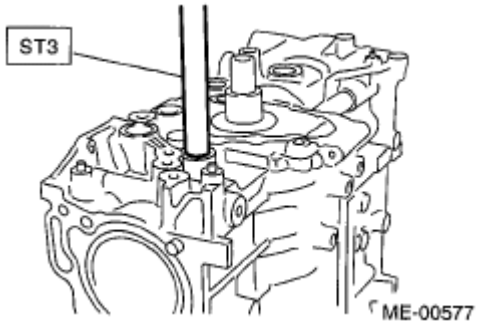


Fig. 149: Installing Piston Pin
Courtesy of SUBARU OF AMERICA, INC.

    2. Apply a coat of engine oil to piston pin, and insert the piston pin into piston and connecting rod through service hole.
    3. Using ST4, install the snap ring.

       ST4 18233AA000 PISTON PIN SNAP RING PLIERS

       NOTE: Use new snap rings.

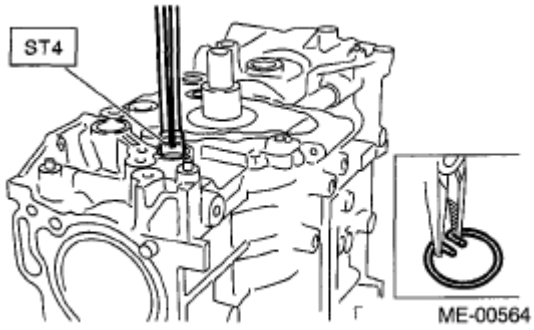


Fig. 150: Installing Snap Ring Using ST4
Courtesy of SUBARU OF AMERICA, INC.

    4. Similarly install the #1, #2, #5 and #6 pistons.
18. Install the service hole plug and O-ring.

    NOTE: Use new O-rings.

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

NOTE: Install within 5 minutes after applying liquid gasket.

Liquid gasket:

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

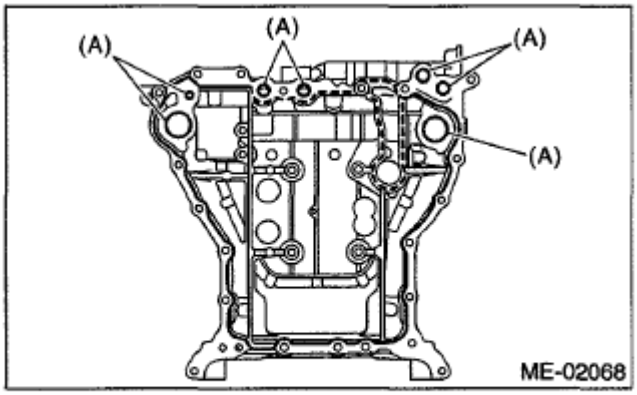
Applying liquid gasket diameter:

Full line part

3.0±1.0 mm (0.12±0.04 in)

Broken line part

1.0 mm (0.04 in)



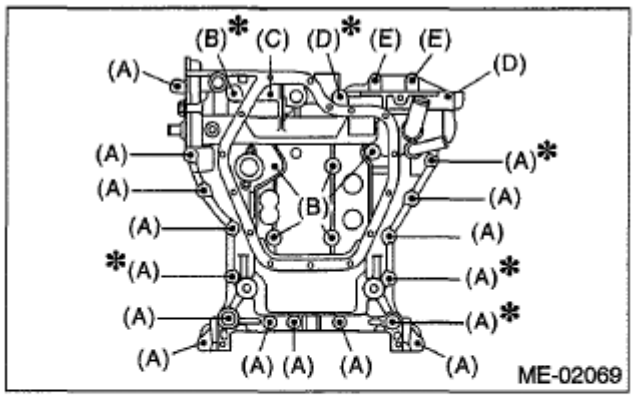
(A) O-ring

Fig. 151: Identifying Liquid Gasket Applying Area On Mating Surface Of Oil Pan Upper
Courtesy of SUBARU OF AMERICA, INC.

NOTE: Use new O-rings.

20. Temporarily tighten the oil pan upper.

NOTE: Do not install the bolts in wrong place.



(A) M8 × 40
(B) M8 × 65
(C) M8 × 85
(D) M8 × 130.5
(E) M8 × 24
*: Coating

Fig. 152: Identifying Oil Pan Upper Bolts
Courtesy of SUBARU OF AMERICA, INC.

21. 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)

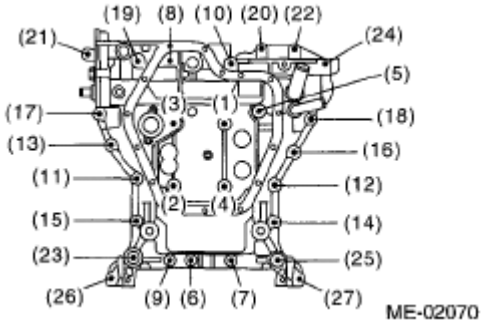


Fig. 153: Identifying Oil Pan Upper Bolts In Tightening Sequence
Courtesy of SUBARU OF AMERICA, INC.

22. Install the oil strainer.

Tightening torque:

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

NOTE: Use new O-rings.

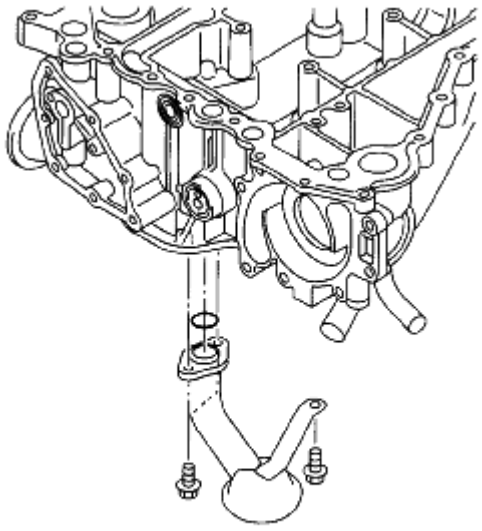


Fig. 154: Identifying Oil Strainer And O-Rings
Courtesy of SUBARU OF AMERICA, INC.

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

NOTE: Install 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)

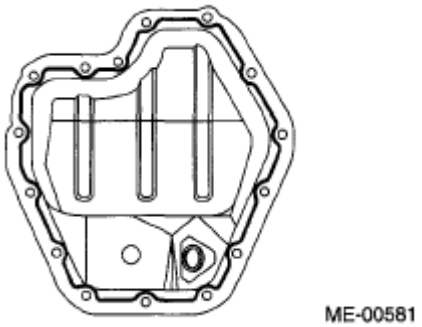


Fig. 155: Identifying Liquid Gasket Applying Area On Matching Surface Of Oil Pan Lower
Courtesy of SUBARU OF AMERICA, INC.

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

    Tightening torque:

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

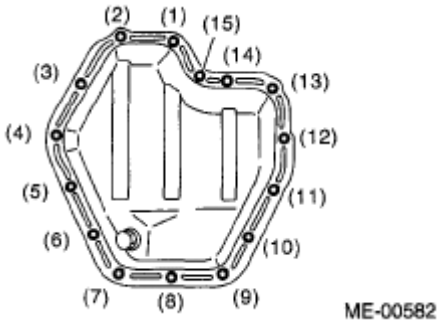


Fig. 156: Identifying Oil Pan Lower Bolts In Tightening Sequence
Courtesy of SUBARU OF AMERICA, INC.

25. Attach the crankshaft position sensor holder.

    Tightening torque:

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

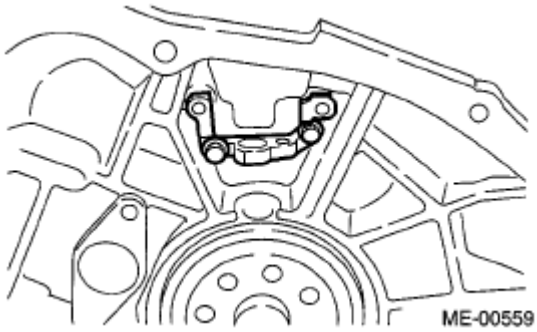


Fig. 157: Identifying Crankshaft Position Sensor Holder
Courtesy of SUBARU OF AMERICA, INC.

26. Install the crankshaft sensor plate.

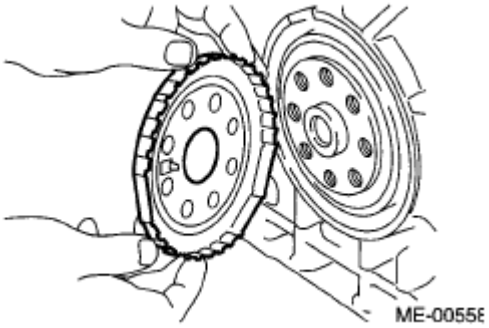


Fig. 158: Identifying Crankshaft Position Sensor Plate
Courtesy of SUBARU OF AMERICA, INC.

27. Use the ST to lock the crankshaft, and install the drive plate.

    ST1 498497100 CRANKSHAFT STOPPER

    ST2 499057000 TORX PLUS®

    Tightening torque:

    81 N.m (8.3 kgf-m, 59.7 ft-lb)

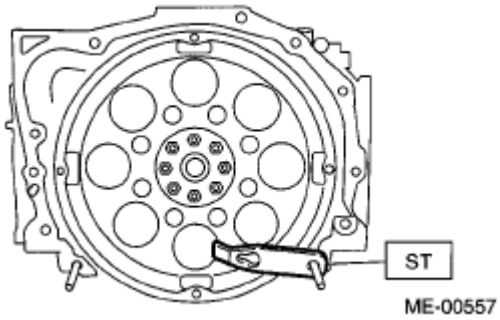
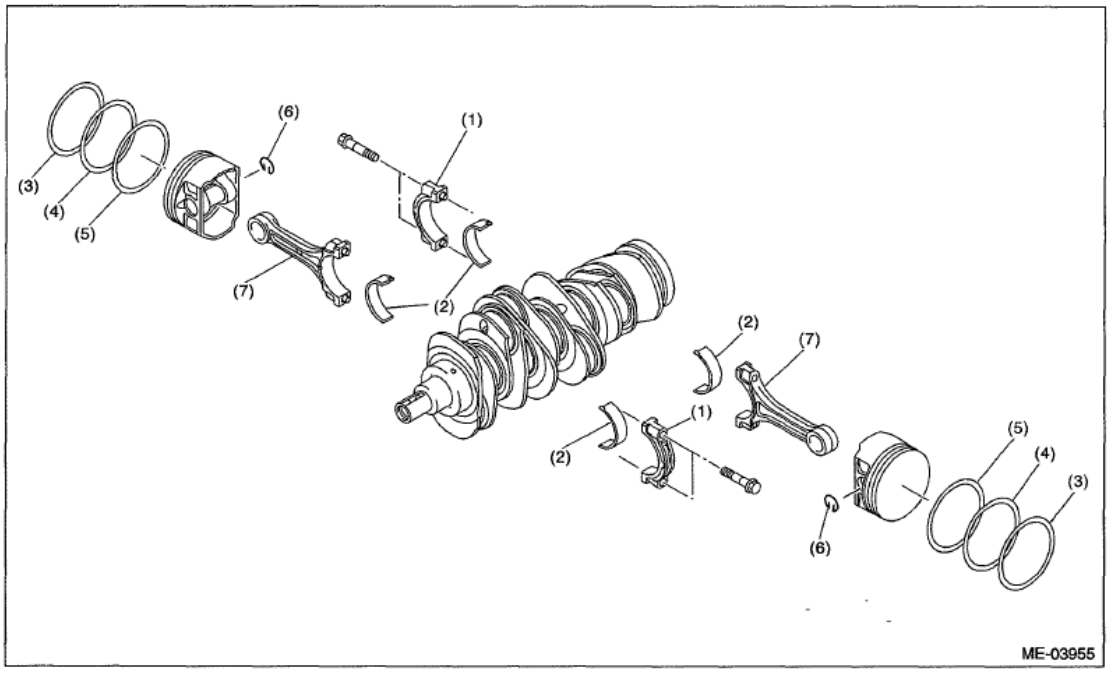


Fig. 159: Identifying ST On Drive Plate
Courtesy of SUBARU OF AMERICA, INC.

28. Install the cylinder head. Refer to **INSTALLATION**, Cylinder Head.
29. Install the camshaft. Refer to **INSTALLATION**, Camshaft.
30. Install the rear chain cover. Refer to **INSTALLATION**, Rear Chain Cover.
31. Install the crank sprocket. Refer to **INSTALLATION**, Crank Sprocket.
32. Install the cam sprocket. Refer to **INSTALLATION**, Cam Sprocket.
33. Install the timing chain assembly. Refer to **INSTALLATION**, Timing Chain Assembly.
34. Install the front chain cover. Refer to **INSTALLATION**, Front Chain Cover.
35. Install the crank pulley. Refer to **INSTALLATION**, Crank Pulley.
36. Install the V-belts. Refer to **INSTALLATION**, V-belt.

DISASSEMBLY



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

Fig. 160: Identifying Connecting Rod Cap, Connecting Rod Bearing, Snap Ring, Top Ring, Oil Ring And Connecting Rod
Courtesy of SUBARU OF AMERICA, INC.

1. Remove the connecting rod cap.
2. Remove the connecting rod bearing.

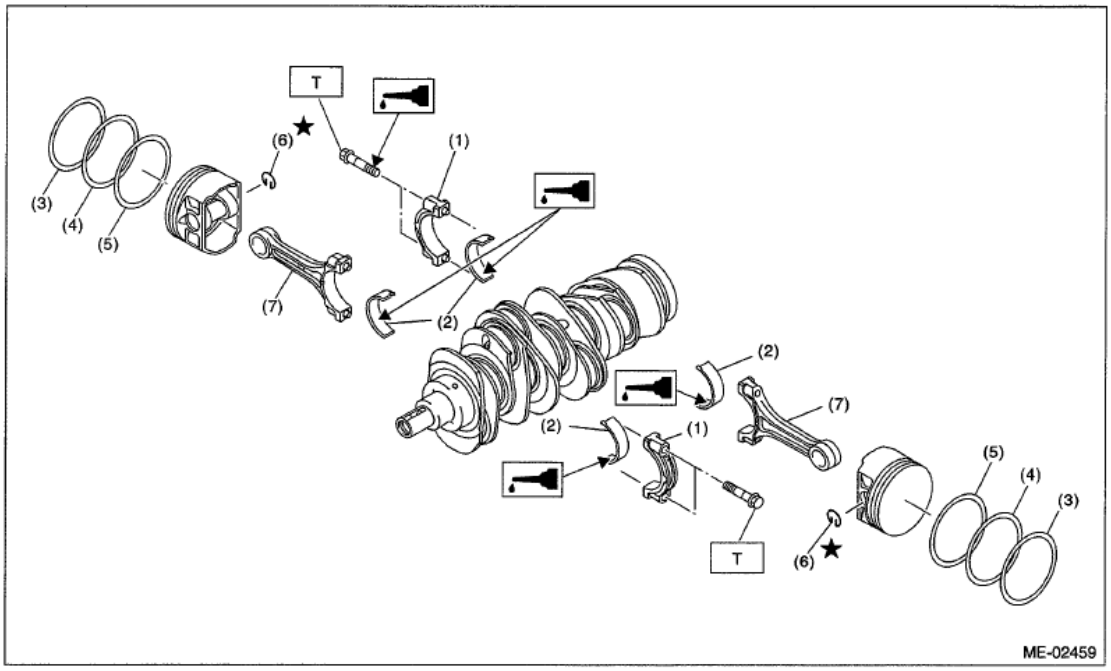
NOTE: Arrange the removed connecting rod, connecting rod cap and bearing in order, to prevent confusion.

3. Remove the piston rings using piston ring expander.
4. Remove the oil ring by hand.

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

5. Remove the snap ring.

ASSEMBLY



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

Fig. 161: Identifying Connecting Rod Cap, Connecting Rod Bearing, Snap Ring, Top Ring, Oil Ring, Second Ring And Connecting Rod
Courtesy of SUBARU OF AMERICA, INC.

1. Apply oil to the surface of the connecting rod bearings, and install the bearings on the connecting rods and connecting rod caps.
2. Position each connecting rod with the marking side facing forward.
3. Install the connecting rod cap. Make sure the arrow mark on connecting rod cap facing front during installation.

CAUTION:
- **Each connecting rod has its own mating cap. Make sure that they are assembled correctly by checking their matching number.**
- **When tightening the connecting rod bolts, apply oil on the threads and flange end.**

Tightening torque:

53 N.m (5.4 kgf-m, 39.1 ft-lb)

4. Install the oil ring spacer, upper rail and lower rail by hand.
5. Install the second ring and top ring using piston ring expander.

INSPECTION

CYLINDER BLOCK

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

   Warping 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.

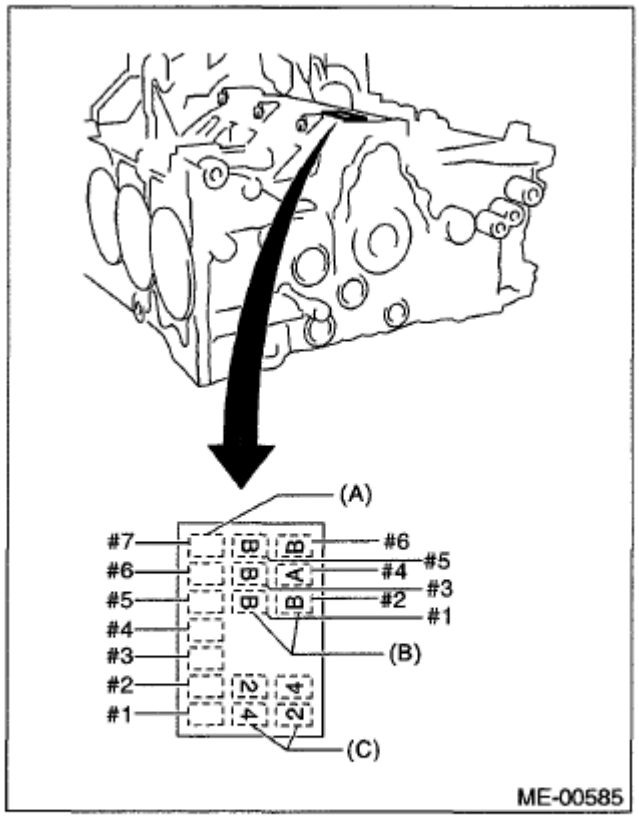
NOTE:

- **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: 89.205 - 89.215 mm (3.5120 - 3.5124 in)

B: 89.195 - 89.205 mm (3.5116 - 3.5120 in)



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

Fig. 162: 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).

   Cylindrically:

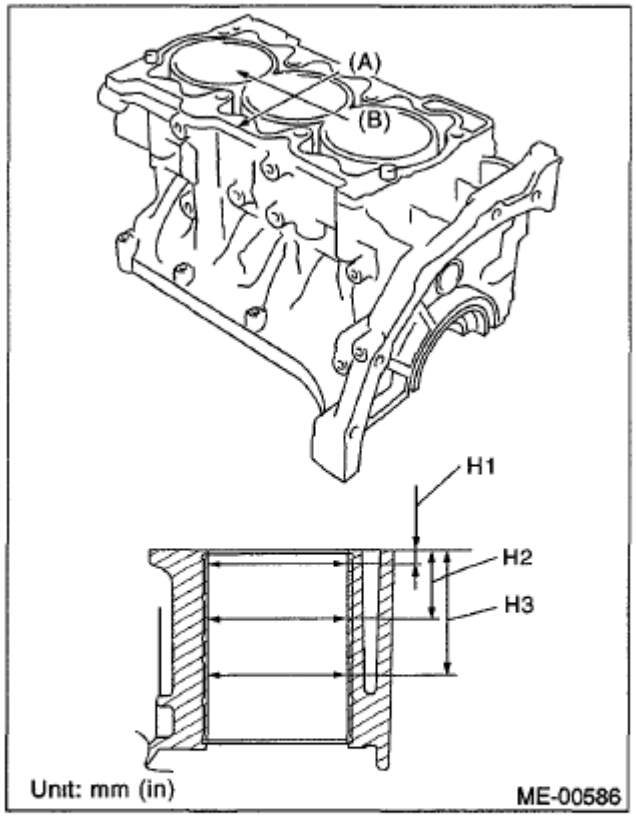
   Standard

   0.030 mm (0.0012 in)

   Out-of-roundness:

   Standard

0.010 mm (0.0004 in)



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

Fig. 163: Identifying Inner Diameter Of Cylinder In Both Thrust And Piston Pin Directions
Courtesy of SUBARU OF AMERICA, INC.

3. When the piston is to be replaced due to general or cylinder wear, 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: 89.205 - 89.215 mm (3.5120 - 3.5124 in)

B: 89.195 - 89.205 mm (3.5116 - 3.5120 in)

0.25 mm (0.0098 in) oversize

89.445 - 89.465 mm (3.5215 - 3.5222 in)

0.50 mm (0.0197 in) oversize

89.695 - 89.715 mm (3.5313 - 3.5321 in)

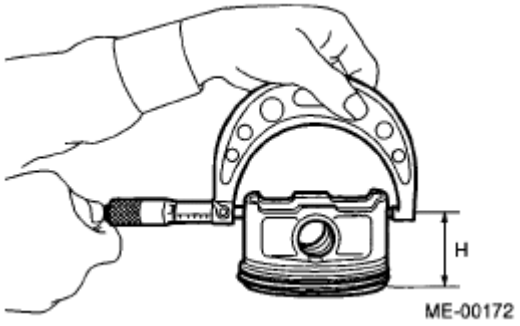


Fig. 164: Measuring Outer Diameter Of Piston
Courtesy of SUBARU OF AMERICA, INC.

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 cylindrically, out-of-roundness, 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, other cylinders must be bored at the same time, and replaced with oversize pistons.**

- **Do not perform boring on one cylinder only. Do not replace only a single cylinder for an oversize piston.**

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

   Cylinder inner diameter boring limit (diameter):

   To 89.715 mm (3.5321 in)

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

   Standard clearance between piston pin and hole in piston:

   Standard

   0.004 - 0.008 mm (0.0002 - 0.0003 in)

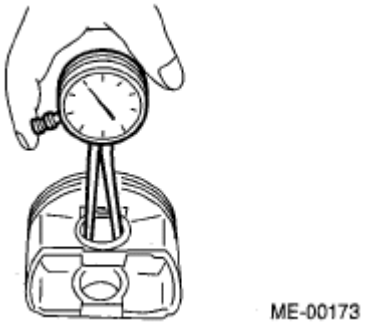


Fig. 165: Checking Clearance Of Piston
Courtesy of SUBARU OF AMERICA, INC.

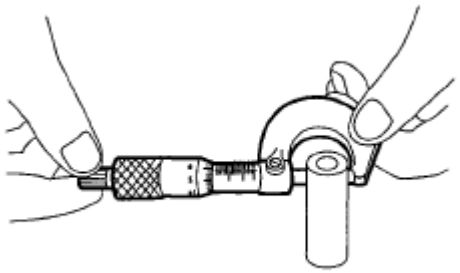


Fig. 166: Checking Clearance Of Piston Pin
Courtesy of SUBARU OF AMERICA, INC.

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

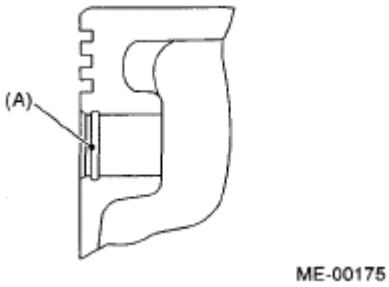


Fig. 167: Identifying Snap Ring Installation Groove On Piston
Courtesy of SUBARU OF AMERICA, INC.

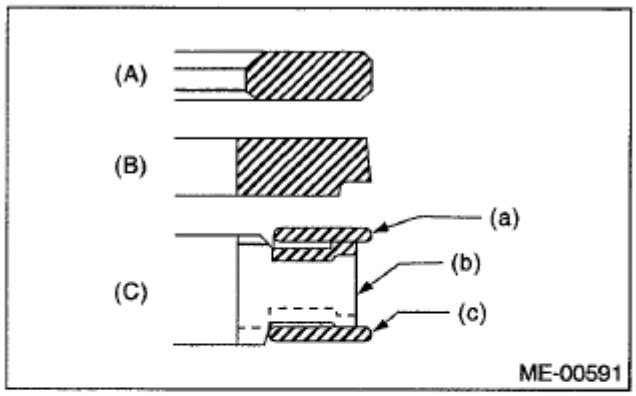
5. Check the piston pin snap ring for distortion, cracks and wear.

PISTON RING

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

NOTE:

- **The top ring and second ring have the mark to determine the direction to install on them. When installing the ring to piston, face this mark to the top side.**
- **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. 168: Identifying Top Ring, Second Ring, Oil Ring, Upper Rail, Expander And Lower Rail
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.

PISTON RING GAP REFERENCE

		Standard mm (in)
Piston ring gap	Top ring	0.20 - 0.35 (0.0079 - 0.0138)
	Second ring	0.35 - 0.50 (0.0138 - 0.0197)
	Oil ring	0.20 - 0.60 (0.0079 - 0.0236)

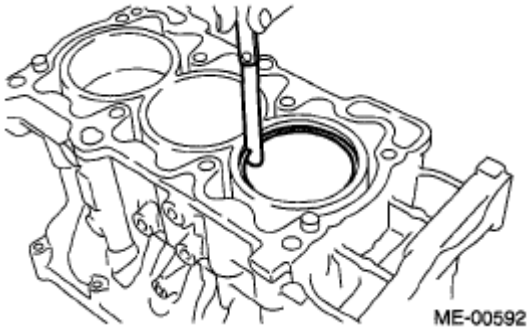


Fig. 169: Measuring Piston Ring Gap With Thickness Gauge
Courtesy of SUBARU OF AMERICA, INC.

3. Fit the piston ring straight into the piston ring groove, then measure the clearance between piston ring and

piston ring groove with a thickness gauge.

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

PISTON RING REFERENCE

		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		0.045 - 0.125 (0.0018 - 0.0049)

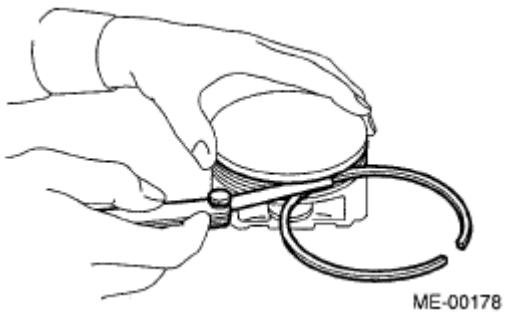
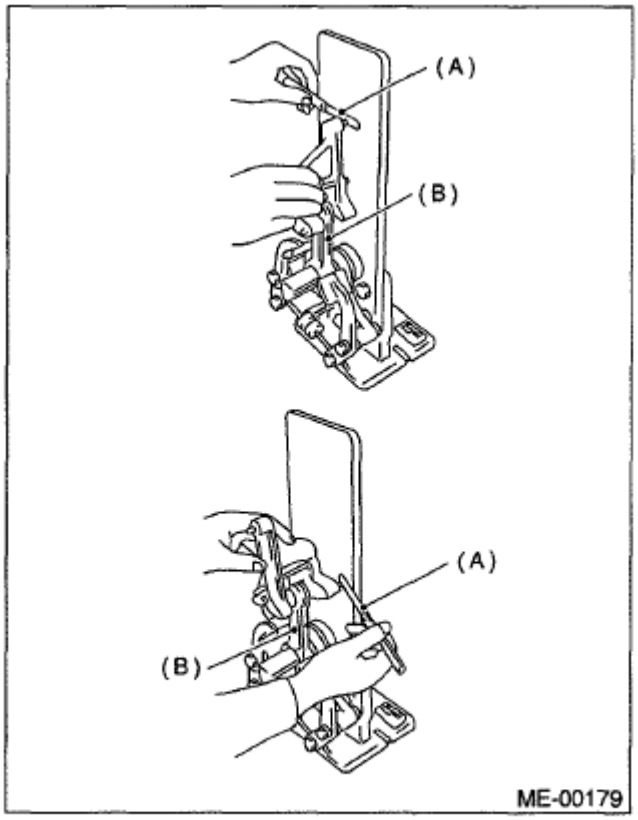


Fig. 170: Measuring Clearance Between Piston Ring And Piston Ring Groove
Courtesy of SUBARU OF AMERICA, INC.

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.



(A) Thickness gauge
(B) Connecting rod

Fig. 171: Checking Connecting Rod For Bend Or 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 thrust clearance exceeds the standard or uneven wear is found, replace the connecting rod.

Connecting rod thrust clearance:

Standard

0.070 - 0.330 mm (0.0028 - 0.0130 in)

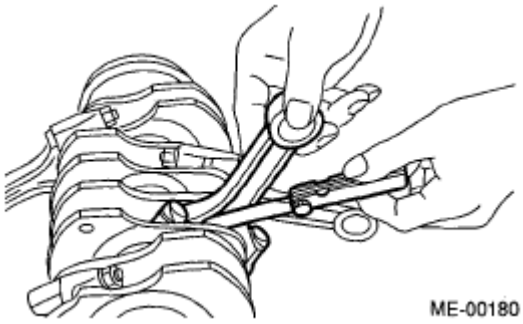


Fig. 172: Measuring Connecting Rod Thrust Clearance
Courtesy of SUBARU OF AMERICA, INC.

4. Inspect the connecting rod bearing for scar, peeling, seizure, melting, wear, etc.
5. Measure the oil clearance on each connecting rod bearing using 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)

CONNECTING ROD OIL CLEARANCE REFERENCE

		Unit: mm (in)
Bearing	**Bearing size (Thickness at center)**	**Outer diameter of crank pin**
Standard	1.490 - 1.506 (0.0587 - 0.0593)	51.984 - 52.000 (2.0466 - 2.0472)
0.03 (0.0012) undersize	1.509 - 1.513 (0.0594 - 0.0596)	51.954 - 51.970 (2.0454 - 2.0461)
0.05 (0.0020) undersize	1.519 - 1.523 (0.0598 - 0.0600)	51.934 - 51.950 (2.0446 - 2.0453)
0.25 (0.0098) undersize	1.619 - 1.623 (0.0637 - 0.0639)	51.734 - 51.750 (2.0368 - 2.0374)

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

Clearance between piston pin and bushing:

Standard

0 - 0.022 mm (0 - 0.0009 in)

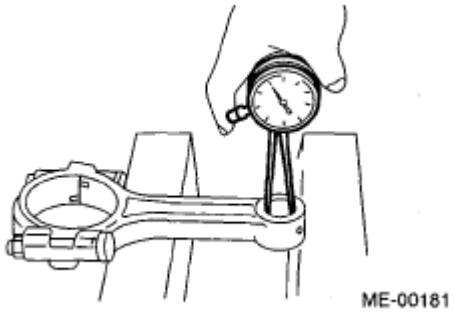


Fig. 173: Measuring Piston Pin Clearance At Connecting Rod Small End
Courtesy of SUBARU OF AMERICA, INC.

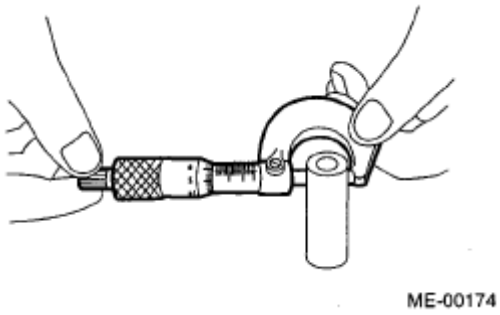


Fig. 174: Measuring Bushing Clearance At Connecting Rod Small End
Courtesy of SUBARU OF AMERICA, INC.

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

       ST 18350AA000 CONNECTING ROD

       BUSHING REMOVER AND INSTALLER

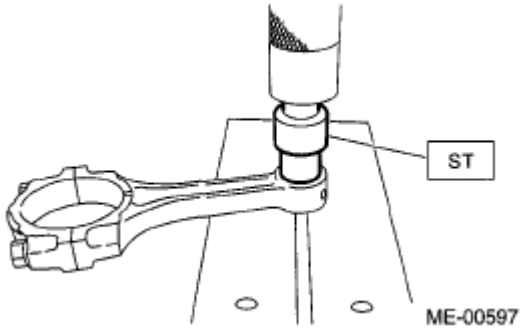


Fig. 175: Pressing Bushing With ST
Courtesy of SUBARU OF AMERICA, INC.

    3. Make two 3 mm (0.12 in) holes in the pressed bushing by aligning with the pre-manufactured holes

on the connecting rod, and ream the inside of the bushing.

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

CRANKSHAFT AND CRANKSHAFT BEARING

1. Clean the crankshaft completely, and check it for cracks using liquid penetrant tester. 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 #5 crankshaft bearing on cylinder block, position the crankshaft on these bearings, and then check the crankshaft bend using a dial gauge.

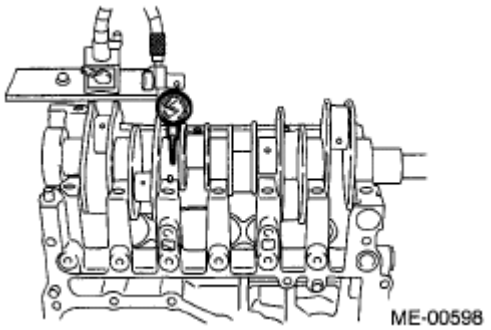


Fig. 176: Checking Crankshaft For Bend
Courtesy of SUBARU OF AMERICA, INC.

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

Cylindrically

0.006 mm (0.0002 in)

Fig. 177: Inspecting Crank Journal And Crank Pin
Courtesy of SUBARU OF AMERICA, INC.

CRANK JOURNAL DIAMETER REFERENCE

Unit: mm (in)

		Crank journal diameter		Crank pin outer diameter
		#1,#3, #5, #7	#2, #4, #6	
Standard	Journal O.D.	63.992 - 64.008 (2.5194 - 2.5200)		51.984 - 52.000 (2.0466 - 2.0472)
	Bearing size (Thickness at center)	1.992 - 2.005 (0.0784 - 0.0789)	1.996 - 2.009 (0.0786 - 0.0791)	1.490 - 1.506 (0.0587 - 0.0593)
0.03 (0.0012) undersize	Journal O.D.	63.962 - 63.978 (2.5182 - 2.5188)		51.954 - 51.970 (2.0454 - 2.0461)
	Bearing size (Thickness at center)	2.011 - 2.014 (0.0792 - 0.0793)	2.015 - 2.018 (0.0793 - 0.0794)	1.509 - 1.513 (0.0594 - 0.0596)
0.05 (0.0020) undersize	Journal O.D.	63.942 - 63.958 (2.5174 - 2.5180)		51.934 - 51.950 (2.0446 - 2.0453)
	Bearing size (Thickness at center)	2.021 - 2.024 (0.0796 - 0.0797)	2.025 - 2.028 (0.0797 - 0.0798)	1.519 - 1.523 (0.0598 - 0.0600)
0.25 (0.0098) undersize	Journal O.D.	63.742 - 63.758 (2.5095 - 2.5102)		51.734 - 51.750 (2.0368 - 2.0374)
	Bearing size (Thickness at center)	2.121 - 2.124 (0.0835 - 0.0836)	2.125 - 2.128 (0.0837 - 0.0838)	1.619 - 1.623 (0.0637 - 0.0639)

4. Measure the thrust clearance of crankshaft at center bearing by using thickness gauge. If the thrust clearance is not within the standard, replace the bearing.

Crankshaft thrust clearance:

Standard

0.030 - 0.115 mm (0.0012 - 0.0045 in)

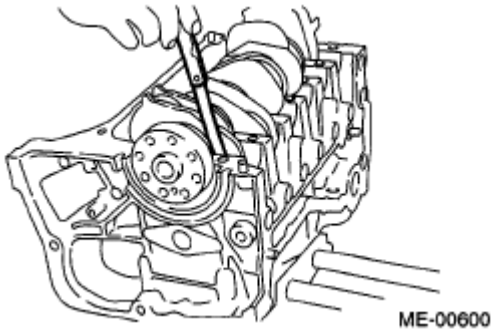


Fig. 178: Measuring Thrust Clearance Of Crankshaft Center Bearing
Courtesy of SUBARU OF AMERICA, INC.

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

Oil flow control solenoid valve is a unit with camshaft cap. Refer to **REMOVAL**, Camshaft.

INSTALLATION

Install in the reverse order of removal.

OIL SWITCHING SOLENOID VALVE

REMOVAL

1. Disconnect the ground cable from the battery.

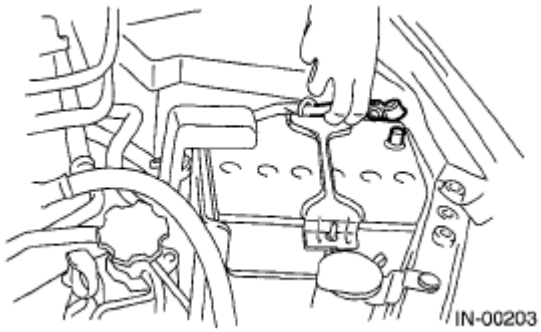


Fig. 179: Disconnecting Ground Cable From Battery
Courtesy of SUBARU OF AMERICA, INC.

2. Remove the air intake chamber. Refer to **REMOVAL** , Air Intake Chamber.
3. Disconnect the connector from the oil switching solenoid valve.

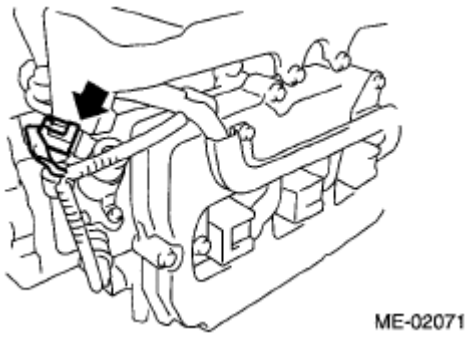


Fig. 180: Locating Oil Switching Solenoid Valve Connector
Courtesy of SUBARU OF AMERICA, INC.

4. Remove the oil switching solenoid valve.
5. Remove the variable valve lift diagnosis oil pressure switch. Refer to **REMOVAL** , Variable Valve Lift Diagnosis Oil Pressure Switch.
6. Remove the oil temperature sensor. Refer to **REMOVAL** , Oil Temperature Sensor.
7. Remove the oil switching solenoid valve holder from the cylinder head.

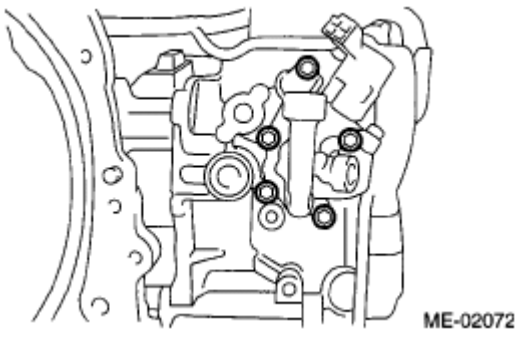


Fig. 181: Identifying Oil Switching Solenoid Valve Holder

Courtesy of SUBARU OF AMERICA, INC.

INSTALLATION

1. Install the oil switching solenoid valve holder.

NOTE: Use a new gasket.

1. Temporarily tighten the bolts by tightening torque of 5 - 10 N.m (0.5 - 1.0 kgf-m, 3.7 - 7.4 ft-lb) in order shown in the figure.
2. Tighten the bolts by tightening torque of 10±0.5 N.m (1.0±0.05 kgf-m, 7.4±0.37 ft-lb) in order shown in the figure.

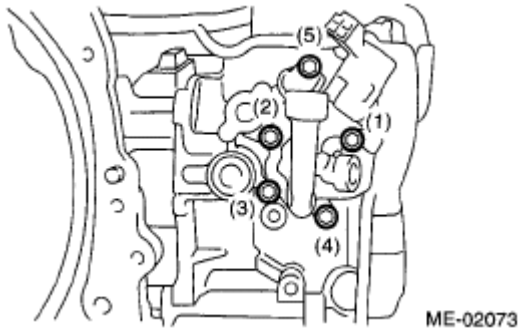


Fig. 182: Identifying Holder Bolts In Tightening Sequence
Courtesy of SUBARU OF AMERICA, INC.

2. Install the oil temperature sensor. Refer to **INSTALLATION** , Oil Temperature Sensor.
3. Install the variable valve lift diagnosis oil pressure switch. Refer to **INSTALLATION** , Variable Valve Lift Diagnosis Oil Pressure Switch.
4. Install the oil switching solenoid valve.
5. Connect the connector to the oil switching solenoid valve.

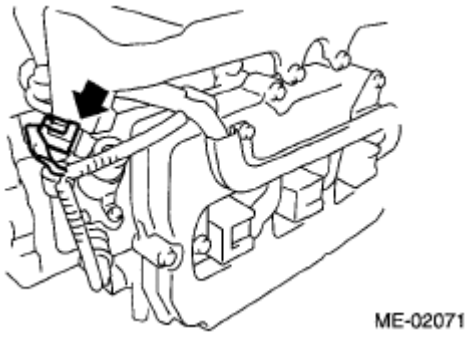


Fig. 183: Locating Oil Switching Solenoid Valve Connector
Courtesy of SUBARU OF AMERICA, INC.

6. Install the air intake chamber. Refer to **INSTALLATION** , Air Intake Chamber.

7. Connect the ground cable to battery.

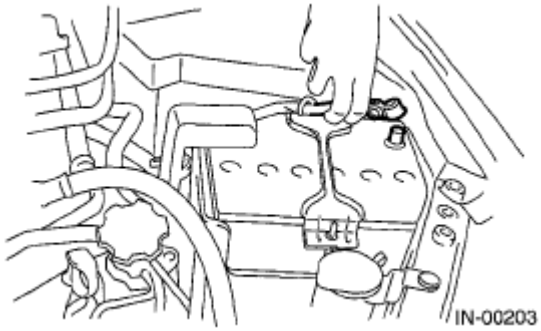


Fig. 184: Disconnecting Ground Cable From Battery
Courtesy of SUBARU OF AMERICA, INC.

INTAKE AND EXHAUST VALVE

SPECIFICATION

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

PISTON

SPECIFICATION

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

CONNECTING ROD

SPECIFICATION

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

CRANKSHAFT

SPECIFICATION

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

ENGINE TROUBLE IN GENERAL

INSPECTION

NOTE: The "RANK" shown in the chart shows the possibilities of the cause of trouble

in order from "Very often" to "Rarely".

A - Very often

B - Sometimes

C - Rarely

SYMPTOMS 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 the terminal	A
		Run-down battery	A
		Defective charging system	B
	Friction	Seizure of crankshaft and connecting rod bearing	C
		Seized camshaft	C
		Seized or stuck piston and cylinder	C
2) Initial combustion does not occur.	Starter	Defective starter	C
	Engine control system Refer to **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
		Trouble of valve lifter	C
		Trouble of valve lifter. In case noise occurs with valve moving, or when the harness involved to the oil switching	B

		solenoid valve, variable valve lift diagnosis oil pressure switch and variable valve lift has trouble in a past.	
3) Initial combustion occurs.	Engine control system Refer 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
		Trouble of valve lifter	C
		Trouble of valve lifter. (In case noise occurs with valve moving. Or the harness involved to oil switching solenoid valve, variable valve lift diagnosis oil pressure switch and variable valve lift has trouble in a past.)	B
4) Engine stalls after initial combustion.	Engine control system Refer to **BASIC DIAGNOSTIC PROCEDURE** .		A
	Intake system	Loosened or cracked intake duct	B
		Loosened or cracked PCV hose	C
		Loosened or cracked vacuum hose	C
		Defective intake manifold gasket	B
		Defective throttle body gasket	B
		Dirty air cleaner element	C
	Fuel line	Clogged fuel line	C
		Lack of or insufficient fuel	B
	Timing chain	Trouble	B
		Defective timing	B
		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

	Compression	Incorrect valve timing	B
		Improper engine oil (low viscosity)	B
		Trouble of valve lifter	C
		Trouble of valve lifter. (In case noise occurs with valve moving. Or the harness involved to oil switching solenoid valve, variable valve lift diagnosis oil pressure switch and variable valve lift has trouble in a past.)	B
2. Rough idle and engine stall	Engine control system Refer 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 piston	B
		Incorrect valve timing	A
		Improper engine oil (low viscosity)	B
		Trouble of valve lifter	C
		Trouble of valve lifter. (In case noise occurs with valve moving. Or the harness involved to oil switching solenoid valve, variable valve lift diagnosis oil pressure switch and variable valve lift has trouble in a past.)	B
	Lubrication system	Incorrect oil pressure	B
		Defective rocker cover gasket	C
	Cooling system	Over-heating	C
	Others	Evaporative emission control system malfunction	A
		Stuck or damaged throttle valve	B
	Engine control system Refer to **BASIC DIAGNOSTIC PROCEDURE** .		A
		Loosened or cracked intake duct	A

3. Low output, hesitation and poor acceleration	Intake system	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
		Trouble of valve lifter	C
		Trouble of valve lifter. (In case noise occurs with valve moving. Or the harness involved to oil switching solenoid valve, variable valve lift diagnosis oil pressure switch and variable valve lift has trouble in a past.)	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 Refer 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	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

4. Surging	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
		Trouble of valve lifter	C
		Trouble of valve lifter. (In case noise occurs with valve moving. Or the harness involved to oil switching solenoid valve, variable valve lift diagnosis oil pressure switch and variable valve lift has trouble in a past.)	B
	Cooling system	Over-heating	B
	Others	Evaporative emission control system malfunction	C
5. Engine does not return to idle.	Engine control system Refer to **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 Refer to **BASIC DIAGNOSTIC PROCEDURE** .		A
	Cooling system	Over-heating	B
	Others	Evaporative emission control system malfunction B	
7. After burning in exhaust system	Engine control system Refer 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
	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
		Trouble of valve lifter	C
		Trouble of valve lifter. (In case noise occurs with valve	

		moving. Or the harness involved to oil switching solenoid valve, variable valve lift diagnosis oil pressure switch and variable valve lift has trouble in a past.)	B
	Lubrication system	Incorrect oil pressure	C
	Cooling system	Over-cooling	C
	Others	Evaporative emission control system malfunction	C
8. Knocking	Engine control system Refer to **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
		Trouble of valve lifter	C
		Trouble of valve lifter. (In case noise occurs with valve moving. Or the harness involved to oil switching solenoid valve, variable valve lift diagnosis oil pressure switch and variable valve lift has trouble in a past.)	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
10. Excessive fuel consumption	Engine control system Refer to **BASIC DIAGNOSTIC PROCEDURE** .		A
	Intake system	Dirty air cleaner element	A
	Timing chain	Defective timing	B
	Compression	Incorrect valve clearance	B
		Loosened spark plug or defective gasket	C
		Loosened cylinder head bolt or defective gasket	C
		Improper valve sealing	B
		Defective valve stem	C
		Worn or broken valve spring	C
		Worn or stuck piston rings, cylinder and piston	B
		Incorrect valve timing	B

		Trouble of valve lifter	C
		Trouble of valve lifter. (In case noise occurs with valve moving. Or the harness involved to oil switching solenoid valve, variable valve lift diagnosis oil pressure switch and variable valve lift has trouble in a past.)	B
	Lubrication system	Incorrect oil pressure	C
	Cooling system	Over-cooling	C

ENGINE NOISE

INSPECTION

POSSIBLE CAUSE REFERENCE

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 crankshaft 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 heat range of spark plug • Improper octane value of gasoline
Clank when engine speed is between 1,000 and 2,000 RPM.	Noise is reduced when fuel injector connector of noisy cylinder is disconnected. ((1))	• Worn crankshaft main bearing • Worn connecting rod bearing (large end)
	Noise is reduced when fuel injector connector of noisy cylinder is	• Worn cylinder liner and piston ring • Broken or stuck piston ring

Knocking sound when engine is operating under idling speed and engine is warm	disconnected. ((1))	• 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 • Timing chain contacting with adjacent part
Valve noise	-	• Incorrect valve clearance • Trouble of valve lifter

(1) When disconnecting the fuel injector connector, the malfunction indicator light illuminates and DTC is stored in ECM memory. Therefore, perform the Clear Memory Mode Refer to **OPERATION** , Clear Memory Mode. and Inspection Mode Refer to **PROCEDURE** , Inspection Mode. after connecting the fuel injector connector.

