

2006 ENGINE

Mechanical (H6DO) - Outback

GENERAL DESCRIPTION

SPECIFICATION

GENERAL SPECIFICATIONS

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)	89.2 x 80 (3.512 x 3.150)
	Displacement		cm ³ (cu in)	3,000 (183)
	Compression ratio			10.7
	Compression pressure (350 RPM 2 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 60°
			Close	ATDC 6°
	Valve clearance	mm (in)	Intake	0.20 ⁺⁰⁰⁴ _{-0.06} (0.0079 ⁺⁰⁰⁰¹⁶ _{-0.0024})
			Exhaust	0.35±0.05 (0.0138±0.020)
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	
NOTE:				
OL : Oversize US: undersize				

SIDE CLEARANCE SPECIFICATIONS

	Side clearance	mm (in)	Intake	Standard	0.075 - 0.135 (0.0030 - 0.0053)
			Exhaust	Standard	0.030 - 0.090 (0.0012 - 0.0035)
			HIGH	Standard	42.09 - 42.19 (1.6571 - 1.6610)

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Camshaft	Cam lobe height	mm (in)	Intake	LOW1	Standard	38.14 - 38.24 (1.5016 - 1.5055)
				LOW2	Standard	34.94 - 35.04 (1.3756 - 1.3795)
			Exhaust		Standard	41.65 - 41.75 (1.6398 - 1.6437)
	Cam base circle diameter	mm (in)	Intake	HIGH	Standard	32.00 (1.2598)
				LOW1	Standard	31.84 (1.2535)
			LOW2	Standard	31.84 (1.2535)	
	Journal O.D.	mm (in)	Exhaust		Standard	32.00 (1.2598)
			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	Flatness		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)			
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		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)
	Free length	mm (in)	Intake		Inner	39.55 (1.5571)
					Outer	41.18 (1.6213)
			Exhaust			46.32 (1.8236)

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Valve spring	Squareness		Intake		Inner	2.5°, 1.7 mm (0.067 in)	
					Outer	2.5°, 1.8 mm (0.071 in)	
			Exhaust			2.5°, 2.0 mm (0.079 in)	
Cylinder block	Standard height				mm (in)	202 (7.95)	
	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)		
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				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	Side clearance of large end		mm (in)		Standard	0.070 - 0.330 (0.0028 - 0.0130)	
	Oil clearance		mm (in)		Standard	0.016 - 0.043 (0.0006 - 0.0017)	
				Standard		1.490 - 1.506 (0.0587 -	

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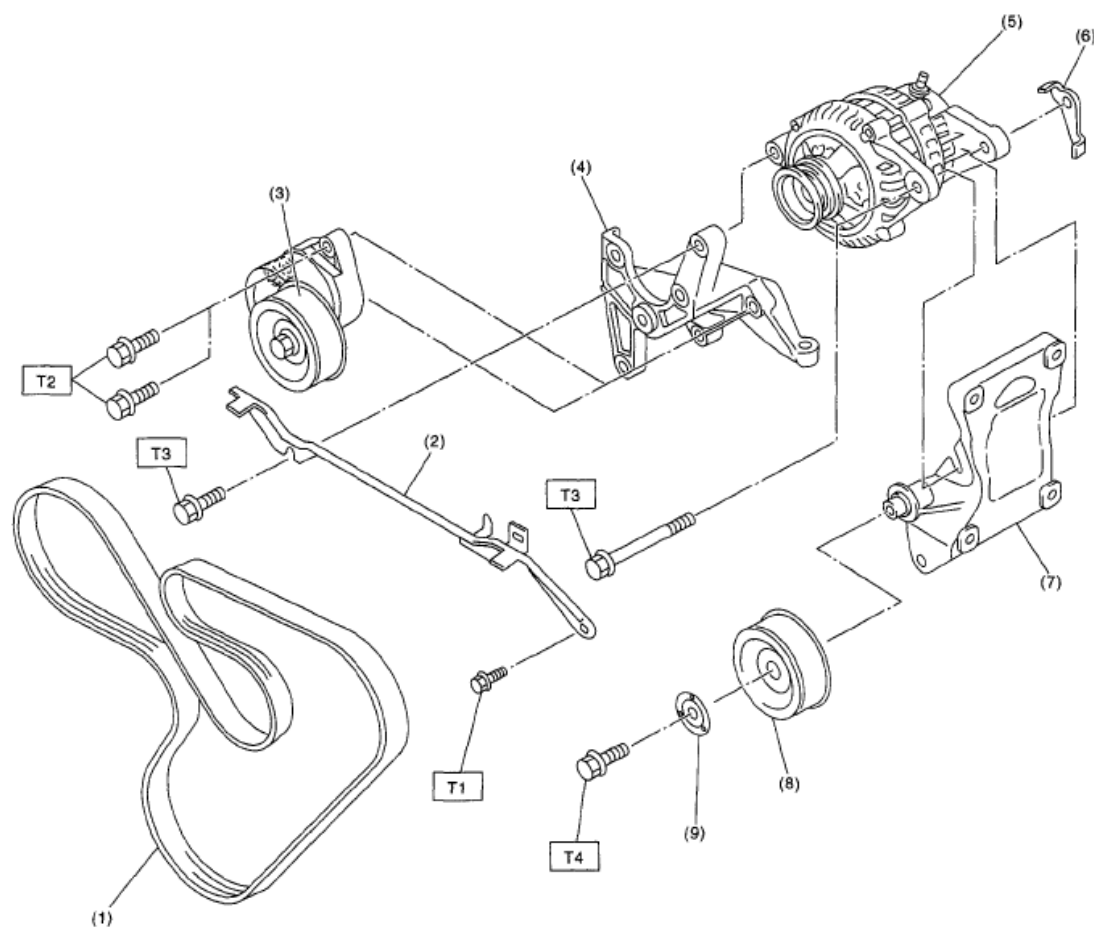
Bearing of large end	Bearing size (Thickness at center) mm (in)				0.0593)
				0.03 (0.0012) US	1.509 - 1.513 (0.0594 - 0.0596)
				0.05 (0.0020) US	1.519 - 1.523 (0.0598 - 0.0600)
				0.25 (0.0098) US	1.619 - 1.623 (0.0637 - 0.0639)
Bushing of small end	Clearance between piston pin and bushing		mm (in)	Standard	0 - 0.022 (0 - 0.0009)
Crankshaft	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)
	Crank journal outer diameter		#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)
			#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 -	

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Main bearing	Bearing size (Thickness at center)	mm (in)	#2, #4, #6		0.0797)
				0.25 (0.0098) US	2.121 - 2.124 (0.0835 - 0.0836)
				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)
OL : Oversize US: undersize					

COMPONENT**V-BELT**



ME-02020

- | | |
|---------------------------------|-------------------------|
| (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 | |

Tightening torque: N·m (kgf-m, ft-lb)

T1: 6.4 (0.65, 4.7)

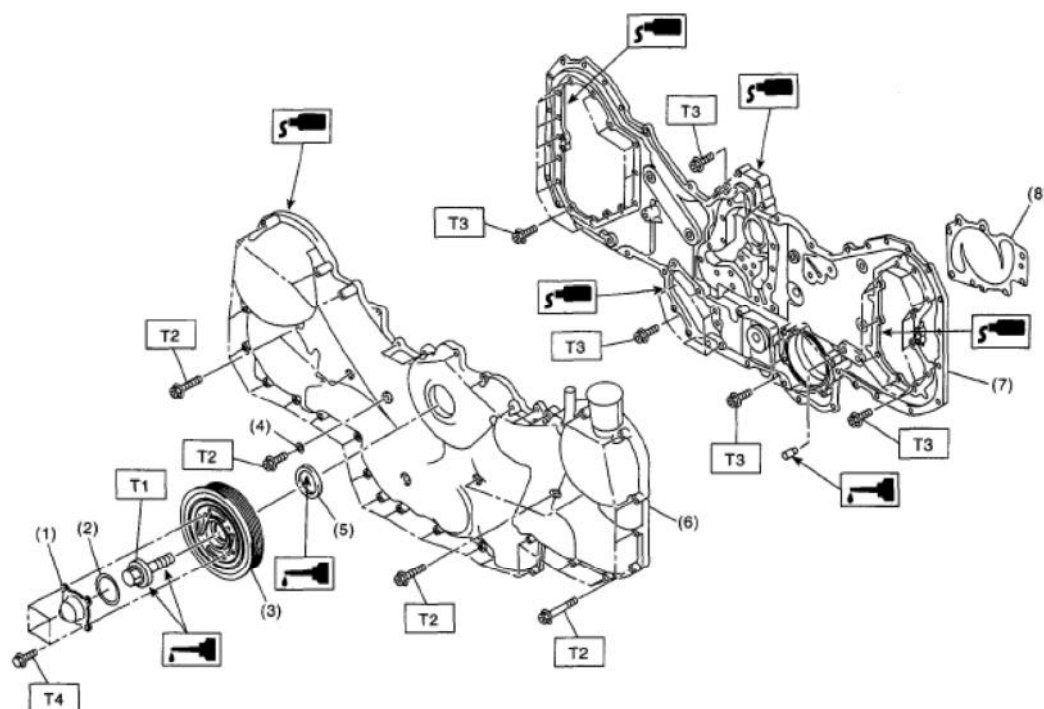
T2: 20 (2.0, 14)

T3: 25 (2.5, 18)

T4: 33 (3.4, 25)

Fig. 1: Exploded View Of V-Belt Components With Torque Specifications

TIMING CHAIN COVER



ME-02021

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

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

T1: Crank Pulley.

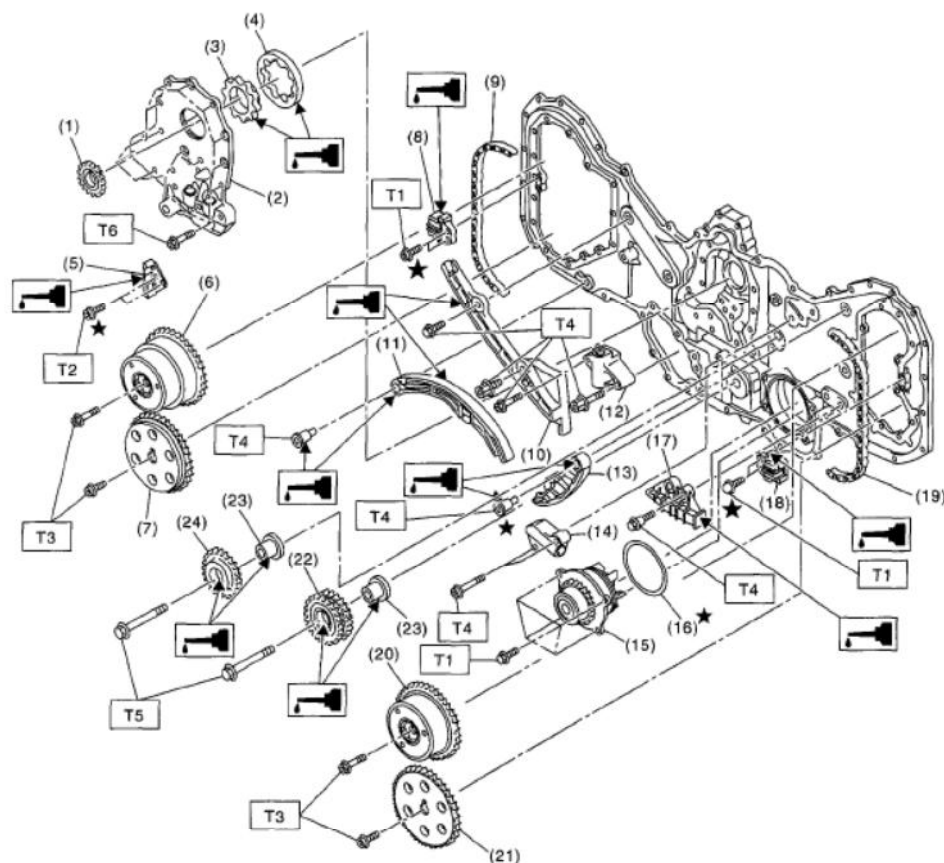
T2: Front Chain Cover.

T3: Rear Chain Cover.

T4: 6.4 (0.65, 4.7)

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

TIMING CHAIN



ME-02380

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

- (24) Idler sprocket (upper)

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

T1: 6.4 (0.65, 4.7)

T2: 7.8 (0.8, 5.8)

T3: **Cam**

Sprocket.>

T4: 16 (1.6, 12)

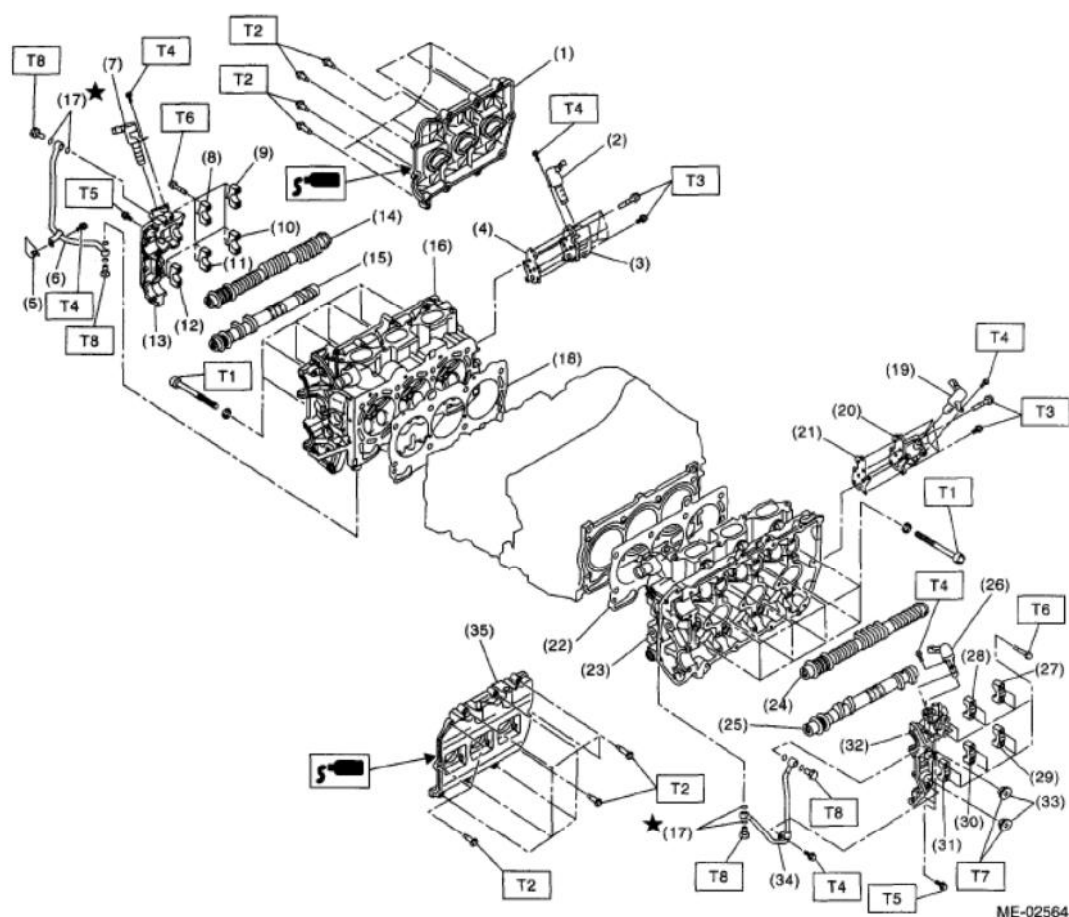
T5: 69 (7.0, 50.6)

T6: **Oil**

Pump.>

Fig. 3: Exploded View Of Timing Chain Components With Torque Specifications

CYLINDER HEAD AND CAMSHAFT



ME-02564

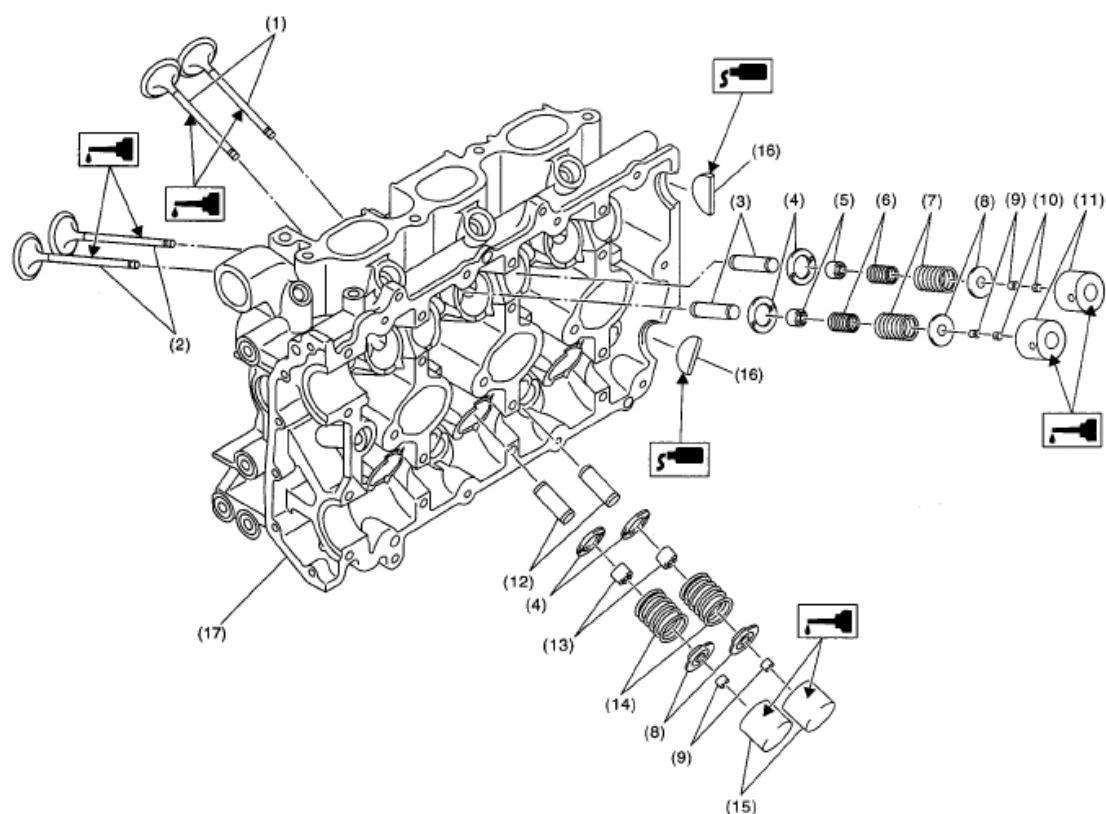
(1) Rocker cover (RH)	(16) Cylinder head (RH)	(31) Exhaust camshaft cap (Front LH)
(2) Oil switching solenoid valve (RH)	(17) Gasket	(32) Front camshaft cap (LH)
(3) Oil switching solenoid valve holder (RH)	(18) Cylinder head gasket (RH)	(33) Plug
(4) Oil switching solenoid valve gasket (RH)	(19) Oil switching solenoid valve (LH)	(34) Oil pipe (LH)
(5) Rear chain cover	(20) Oil switching solenoid valve holder (LH)	(35) Rocker cover (LH)
(6) Oil pipe (RH)	(21) Oil switching solenoid valve gasket (LH)	
(7) Oil flow control solenoid valve (RH)	(22) Cylinder head gasket (LH)	
(8) Intake camshaft cap (Center RH)	(23) Cylinder head (LH)	
(9) Intake camshaft cap (Rear RH)	(24) Intake camshaft (LH)	
(10) Exhaust camshaft cap (Rear RH)	(25) Exhaust camshaft (LH)	
(11) Exhaust camshaft cap (Center RH)	(26) Oil flow control solenoid valve (LH)	
(12) Exhaust camshaft cap (Front RH)	(27) Intake camshaft cap (Rear LH)	
(13) Front camshaft cap (RH)	(28) Intake camshaft cap (Center LH)	
(14) Intake camshaft (RH)	(29) Exhaust camshaft cap (Rear LH)	
(15) Exhaust camshaft (RH)	(30) Exhaust camshaft cap (Center LH)	

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

T1:	Cylinder
Head.>	
T2:	Cam-
shaft.>	
T3:	Oil
Switching Solenoid Valve.>	
T4:	6.4 (0.65, 4.7)
T5:	9.75 (1.0, 7.2)
T6:	16 (1.6, 12)
T7:	60 (6.1, 44)
T8:	29 (3.0, 21.4)

Fig. 4: Exploded View Of Cylinder Head And Camshaft Components With Torque Specifications

CYLINDER HEAD AND VALVE ASSEMBLY

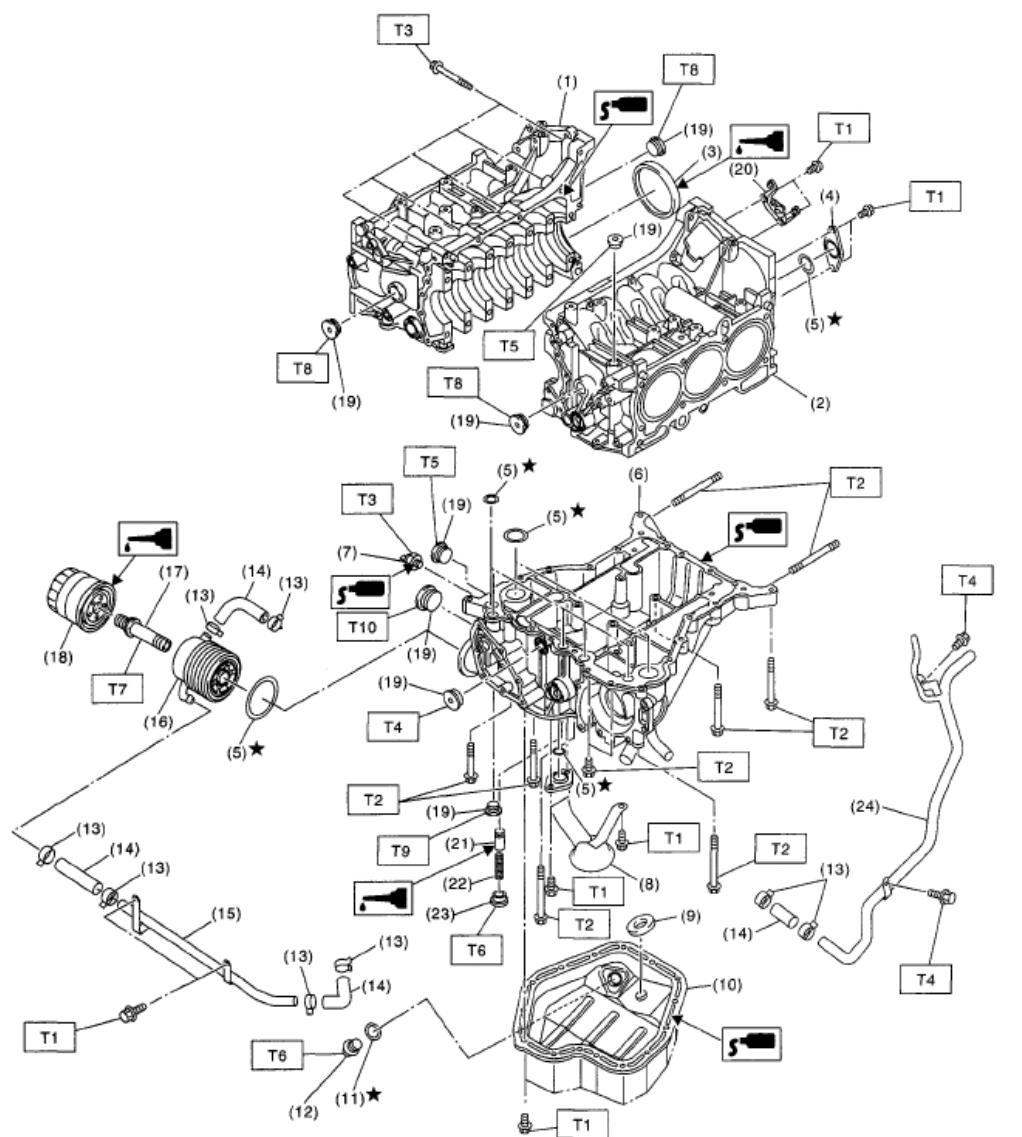


ME-02024

- | | | |
|----------------------------|----------------------------|------------------------------|
| (1) Exhaust valve | (7) Valve spring (Outer) | (13) Exhaust valve stem seal |
| (2) Intake valve | (8) Retainer | (14) Valve spring |
| (3) Intake valve guide | (9) Retainer key | (15) Valve lifter (Exhaust) |
| (4) Valve spring seat | (10) Shim | (16) Cylinder head plug |
| (5) Intake valve stem seal | (11) Valve lifter (Intake) | (17) Cylinder head |
| (6) Valve spring (Inner) | (12) Exhaust valve guide | |

Fig. 5: Exploded View Of Cylinder Head And Valve Assembly Components With Torque Specifications

CYLINDER BLOCK



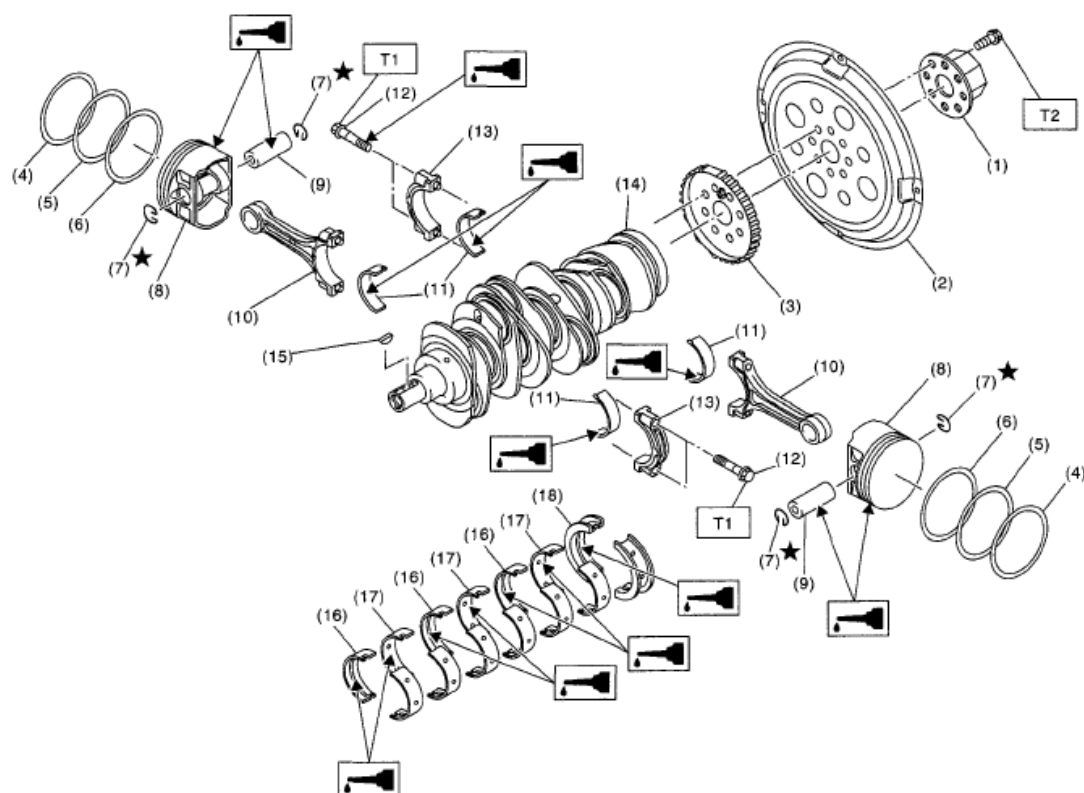
- (1) Cylinder block (RH)
- (2) Cylinder block (LH)
- (3) Rear oil seal
- (4) Service hole cover
- (5) O-ring
- (6) Oil pan upper
- (7) Oil pressure switch
- (8) Oil strainer
- (9) Magnet
- (10) Oil pan lower
- (11) Metal gasket
- (12) Drain plug

- (13) Clamp
- (14) Hose
- (15) Oil cooler pipe
- (16) Oil cooler
- (17) Connector
- (18) Oil filter
- (19) Plug
- (20) Crankshaft position sensor holder
- (21) Relief valve
- (22) Relief valve spring
- (23) Plug
- (24) Water pipe

Tightening torque: N·m (kgf-m, ft-lb)	
T1:	6.4 (0.65, 4.7)
T2:	18 (1.8, 13.3)
T3:	25 (2.5, 18.4)
T4:	16 (1.6, 12)
T5:	37 (3.8, 27)
T6:	44 (4.5, 33)
T7:	54 (5.5, 40)
T8:	70 (7.1, 52)
T9:	23 (2.3, 17)
T10:	90 (9.2, 67)

Fig. 6: Exploded View Of Cylinder Block Components With Torque Specifications

CRANKSHAFT AND PISTON



ME-02454

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

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

T1: 53 (5.4, 39)

T2: 81 (8.3, 60)

Fig. 7: Exploded View Of Crankshaft And Piston Components With Torque Specifications

ENGINE MOUNTING

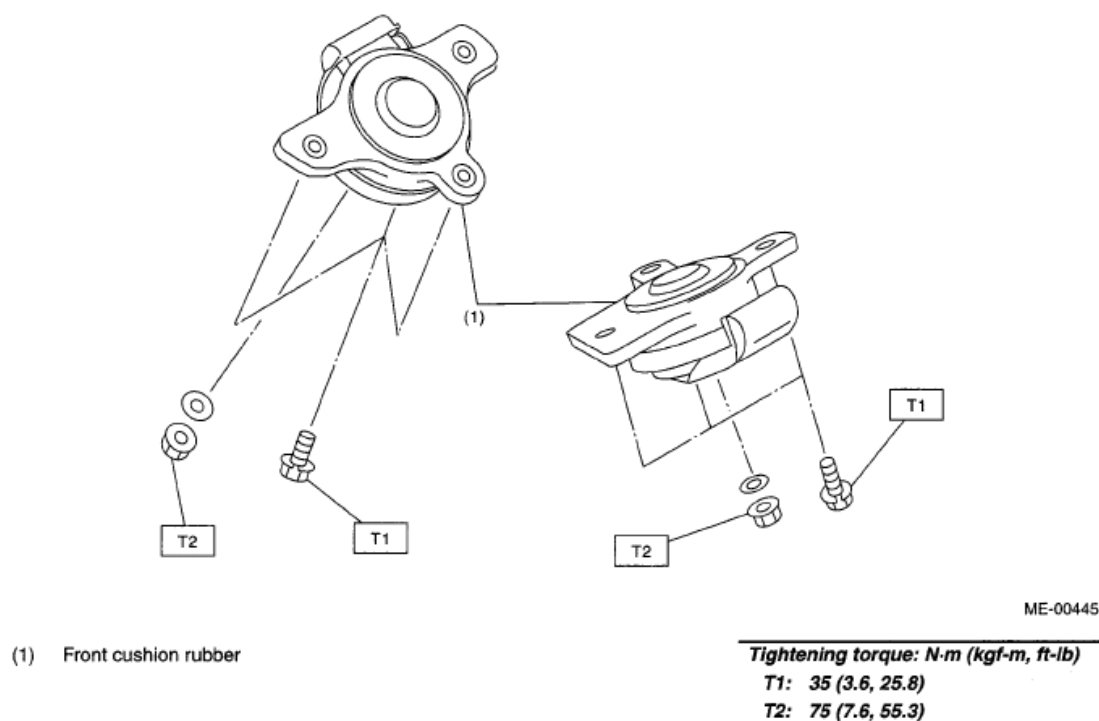


Fig. 8: Exploded View Of Engine Mounting Components With Torque Specifications

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 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.
- Be careful not to let oil, grease or coolant contact the timing belt, clutch disc and flywheel.
- All removed parts, if to be reused, should be reinstalled in the original positions and directions.
- Bolts, nuts and washers should be replaced with new parts as required.
- Even if necessary inspections have been made in advance, proceed with assembly work while making re-checks.

- Remove or install the engine in an area where chain hoists, lifting devices, etc. are available for ready use.
- Be sure not to damage coated surfaces of body panels with tools, or not to stain seats and windows with coolant or oil. Place a cover over fender, as required, for protection.
- Prior to starting work, prepare the following:

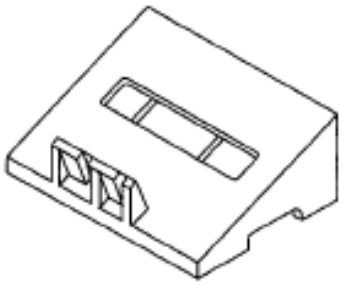
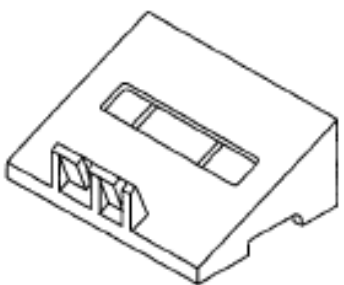
Service tools, clean cloth, containers to catch coolant and oil, wire ropes, chain hoist, transmission jacks, etc.

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

PREPARATION TOOL

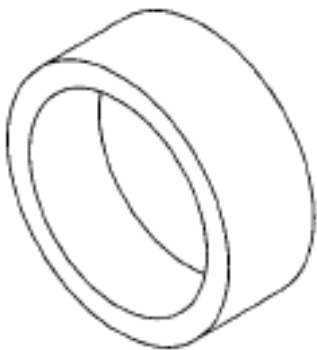
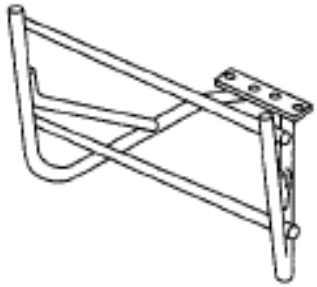
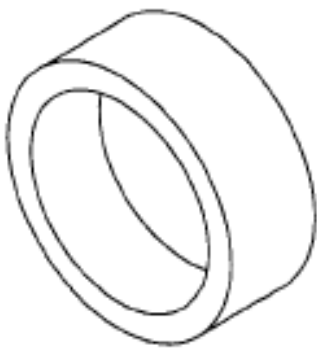
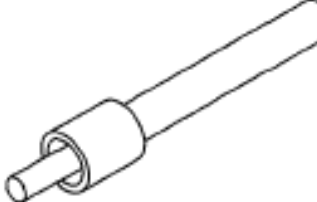
SPECIAL TOOL

SPECIAL TOOL REFERENCE CHART

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

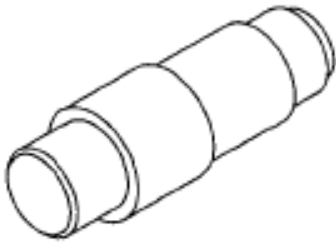
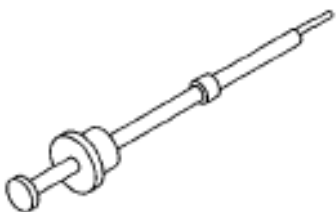
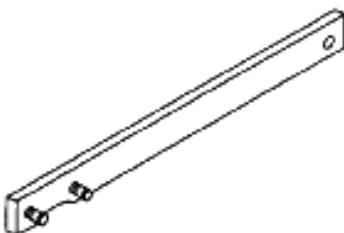
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 ST-498747300			
 ST18232AA000	18254AA000	PISTON GUIDE	Used for installing piston in cylinder.
 ST18254AA000	499585500	VALVE OIL SEAL GUIDE	Used for press-fitting of intake and exhaust valve guide oil seals.
 ST-499585500	18253AA000	PISTON PIN GUIDE	Used for installing piston pin, piston and connecting rod.
	18350AA000	CONNECTING ROD BUSHING	Used for removing and installing connecting rod bushing.

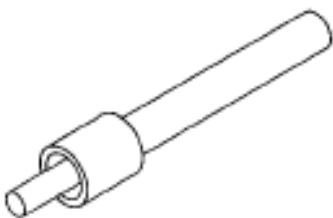
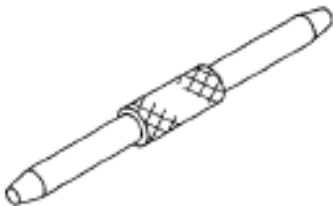
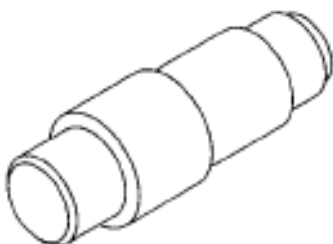
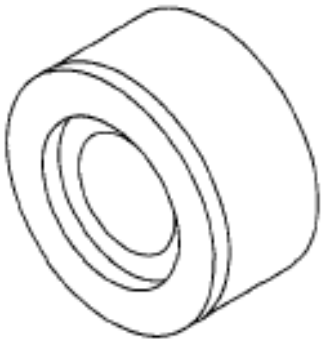
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 ST18253AA000		REMOVER AND INSTALLER	
 ST18350AA000	499097500	PISTON PIN REMOVER ASSY	Used for removing piston pin.
 ST-499097700	499977500	CAM SPROCKET WRENCH	Used for removing and installing intake cam sprocket.
 ST18231AA020	18231AA020	CAM SPROCKET WRENCH	Used for removing and installing exhaust cam sprocket.
	499587200	CRANKSHAFT OIL SEAL INSTALLER	• Used for installing crankshaft oil seal. • Used with CRANKSHAFT OIL SEAL GUIDE (499597100).

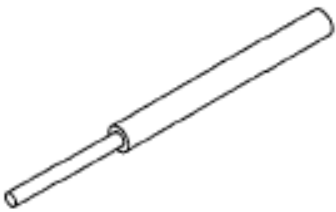
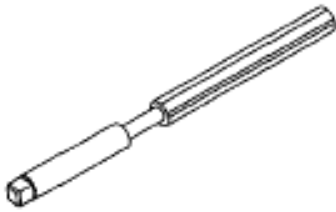
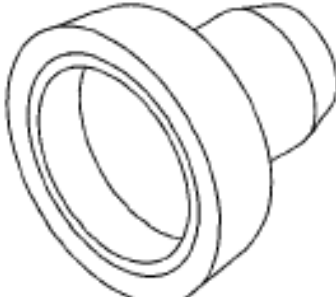
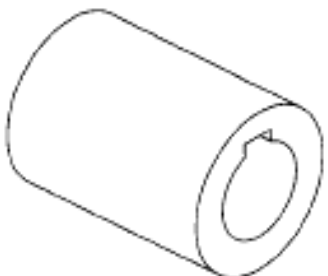
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 ST-498857100			
 ST-499017100	499597100	CRANKSHAFT OIL SEAL GUIDE	• Used for installing crankshaft oil seal. • Used with CRANKSHAFT OIL SEAL INSTALLER (499587200).
 ST-499037100	499718000	VALVE SPRING REMOVER	Used for removing and installing valve spring.
 ST18251AA040	18251AA040	VALVE GUIDE ADJUSTER	Used for installing valve guides.
	499765700	VALVE GUIDE REMOVER	Used for removing valve guides.

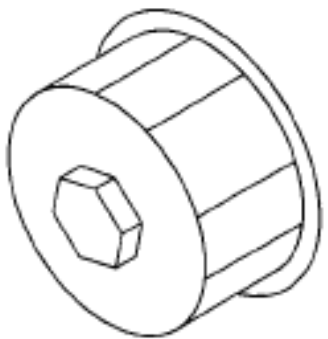
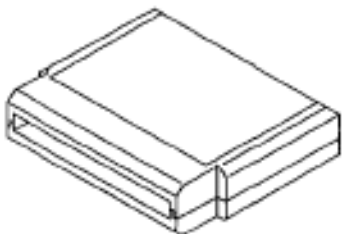
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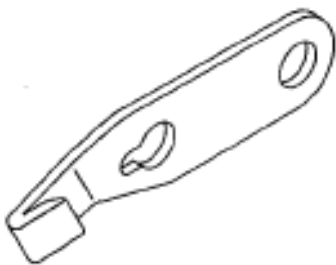
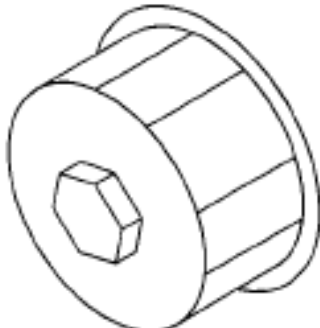
2006 ENGINE Mechanical (H6DO) - Outback

 ST-499765700			
 ST-499765900	499765900	VALVE GUIDE REAMER	Used for reaming valve guides.
 ST-499587200	499977100	CRANK PULLEY WRENCH	Used for stopping rotation of crank pulley when loosening/tightening crank pulley bolt.
 ST18252AA000	18252AA000	CRANKSHAFT SOCKET	Used for rotating crankshaft.
	498547000	OIL FILTER WRENCH	Used for removing and installing oil filter.

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 ST-498547000			
 ST18482AA010	18482AA010	CARTRIDGE	Troubleshooting for electrical system.
 ST22771AA030	22771AA030	SUBARU SELECT MONITOR KIT	Troubleshooting for electrical system.
 ST18233AA000	18233AA000	PISTON PIN SNAP RING PLIERS	Used for removing and installing snap ring of piston pin.
	498277200	STOPPER SET	Used for installing automatic transmission assembly to engine.

 ST-498497100			
 ST-498547000	42099AE000	CONNECTOR REMOVER	Used for disconnecting quick connector of the engine compartment.

GENERAL TOOL**GENERAL TOOL REFERENCE CHART**

TOOL NAME	REMARKS
Compression gauge	Used for measuring compression.

PROCEDURE

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

- Camshaft
- Cylinder head

COMPRESSION**INSPECTION**

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

1. After warming-up the engine, turn the ignition switch to OFF.

2. Make sure that the battery is fully charged.
3. Release the fuel pressure.

< Ref. to **RELEASING OF FUEL PRESSURE** , PROCEDURE, Fuel. >

4. Remove all the spark plugs. < Ref. to **REMOVAL** , Spark Plug. >
5. Check the starter motor for satisfactory performance and operation.
6. Hold the compression gauge tightly against the spark plug hole.

NOTE: When using a screw-in type compression gauge, the screw (put into cylinder head spark plug hole) should be less than 18 mm (0.71 in) long.

7. Fully open the throttle valve.
8. Crank the engine by means of the starter motor, and read the maximum value on the gauge when the pointer is steady.

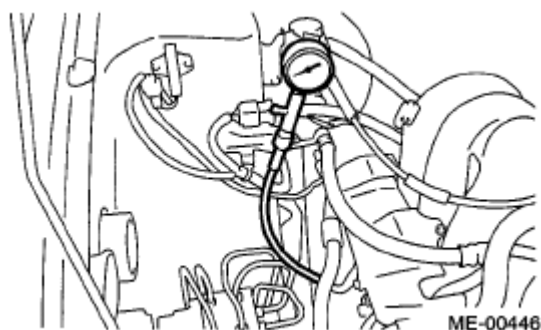


Fig. 9: Checking Engine Compression

9. 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/cm² , 185 - 213 psi)

Service limit:

1,128 kPa (11.5 kgf/cm² , 164 psi)

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. Stop the engine, and turn the ignition switch to OFF.
4. Insert the cartridge to the Subaru Select Monitor.
5. Connect the Subaru Select Monitor to the data link connector.
6. Turn the ignition switch to ON and Subaru Select Monitor switch to ON.
7. Select {Each System Check} in Main Menu.
8. Select {Engine Control System} in Selection Menu.
9. Select {Current Data Display & Save} in Engine Control System Diagnosis.
10. Select {Data Display} in Data Display Menu.
11. Start the engine, and read the engine idle speed.
12. 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 neutral]:

650±50 RPM

13. 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 neutral]:

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 General On-board Diagnosis Table under "Engine Control System". < Ref. to BASIC DIAGNOSTIC PROCEDURE . >

IGNITION TIMING

INSPECTION

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

1. Before checking the ignition timing, check the following item:
 1. Check the air cleaner element is free from clogging, spark plugs are in good condition, and hoses are connected properly.

2. Check the malfunction indicator light does not illuminate.
2. Warm-up the engine.
3. Stop the engine, and turn the ignition switch to OFF.
4. Insert the cartridge to the Subaru Select Monitor.
5. Connect the Subaru Select Monitor to the data link connector.
6. Turn the ignition switch to ON and Subaru Select Monitor switch to ON.
7. Select {Each System Check} in Main Menu.
8. Select {Engine Control System} in Selection Menu.
9. Select {Current Data Display & Save} in Engine Control System Diagnosis.
10. Select {Data Display} in Data Display Menu.
11. Start the engine and check the ignition timing at idle speed.

Ignition timing [BTDC/RPM]:

15°±8°/650

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

INTAKE MANIFOLD VACUUM

INSPECTION

1. Warm-up the engine.
2. Disconnect the brake vacuum hose from intake manifold, and then install the vacuum gauge.
3. Keep the engine at idle speed and read the vacuum gauge indication.

By observing the gauge needle movement, internal condition of the engine can be diagnosed as described below.

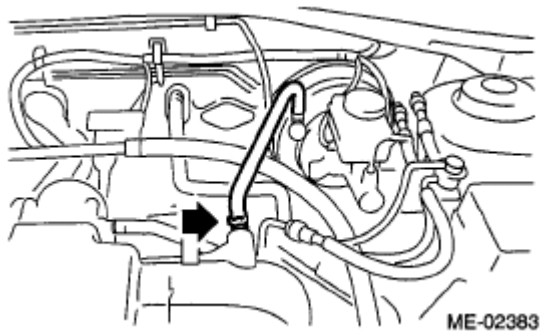


Fig. 10: Locating Brake Vacuum Hose

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

Less than -60.0 kPa (-450 mmHg, -17.72 in-Hg)

VACUUM PRESSURE SPECIFICATION

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 or throttle chamber idle adjustment

ENGINE OIL PRESSURE

INSPECTION

1. Remove the oil pressure switch from cylinder block. < Ref. to **REMOVAL** , Oil Pressure Switch. >
2. Connect the oil pressure gauge hose to cylinder block.
3. Connect the battery ground cable to the 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/cm² , 20 psi) or more (at 600 RPM)

500 kPa (5.1 kgf/cm² , 73 psi) or more (at 5,000 RPM)

CAUTION:

- If the oil pressure is out of specification, check oil pump, oil filter and lubrication line. < Ref. to **INSPECTION** , General Diagnostic Table. >
- If the oil pressure warning light is turned on and oil pressure is within specification, check the oil pressure switch. < Ref. to **INSPECTION** , General Diagnostic Table. >

5. After measuring the oil pressure, install the oil pressure switch. < Ref. to **INSTALLATION** , Oil Pressure Switch. >

Tightening torque:

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

FUEL PRESSURE**INSPECTION**

WARNING: Before removing the fuel pressure gauge, release the fuel pressure.

NOTE: If the fuel pressure is out of specification, check or replace the pressure regulator and pressure regulator vacuum hose.

1. Release the fuel pressure.

< Ref. to **RELEASING OF FUEL PRESSURE** , PROCEDURE, Fuel. >

2. Open the fuel filler flap lid, and remove the fuel filler cap.
3. Disconnect the fuel delivery hose and connect fuel pressure gauge.
4. Install the fuse of fuel pump to main fuse box.

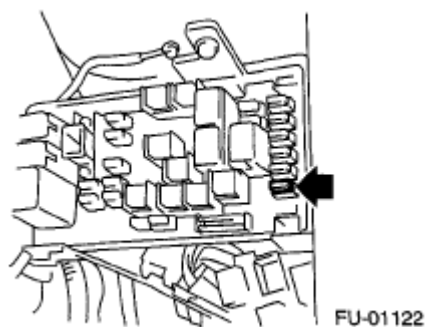


Fig. 11: Locating Fuel Pump Fuse

5. Start the engine.
6. Measure the fuel pressure while disconnecting pressure regulator vacuum hose from intake manifold.

Fuel pressure:

Standard: 333 - 363 kPa (3.4 - 3.7 kgf/cm² , 48 - 53 psi)

7. After connecting the pressure regulator vacuum hose, measure the fuel pressure.

Fuel pressure:

Standard: 279 - 309 kPa (2.85 - 3.15 kgf/cm² , 40 - 45 psi)

NOTE: The fuel pressure gauge registers 10 to 20 kPa (0.1 to 0.2 kgf/cm² , 1 to 3 psi) higher than standard values during high-altitude operations.

VALVE CLEARANCE

INSPECTION

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

1. Set the vehicle on a lift.
2. Remove the collector cover.
3. Disconnect the ground cable from battery.

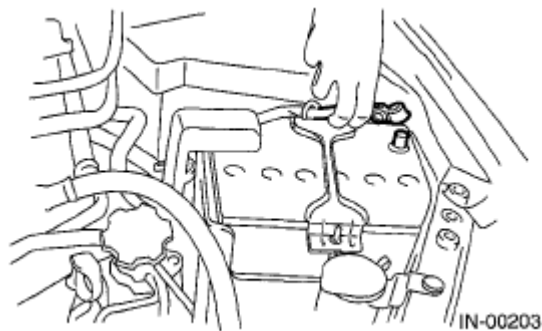


Fig. 12: Disconnecting Ground Cable From Battery

4. Lift-up the vehicle.
5. Remove the under cover.
6. Lower the vehicle.
7. When inspecting RH side cylinders:
 1. Remove the air intake duct and air cleaner case. < Ref. to **REMOVAL** , Air Intake Duct. > < Ref. to **REMOVAL** , Air Cleaner Case. >
 2. Remove the fuel tank protector (RH).

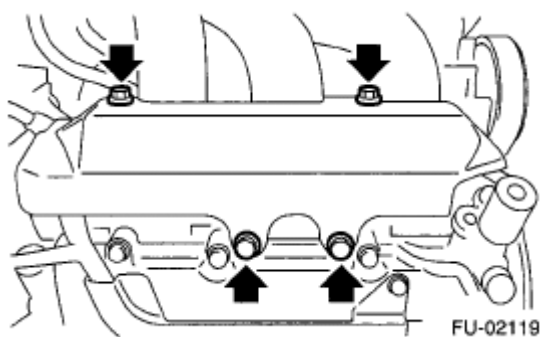


Fig. 13: Locating Fuel Tank Protector

3. Disconnect the connector of oil pressure switch.
4. Remove the ignition coil. < Ref. 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 rocker cover (LH).

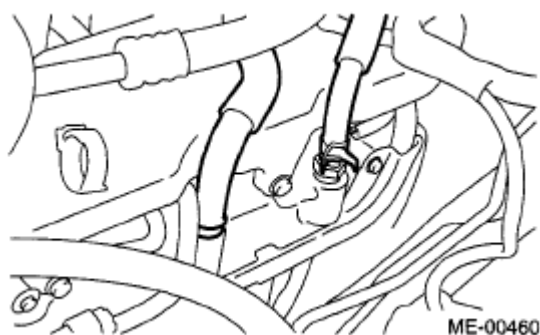


Fig. 14: Identifying PCV Hose And Blow-By Hose

3. Remove the fuel pipe protector (LH).

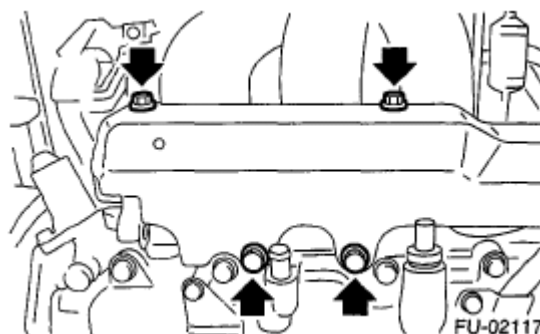
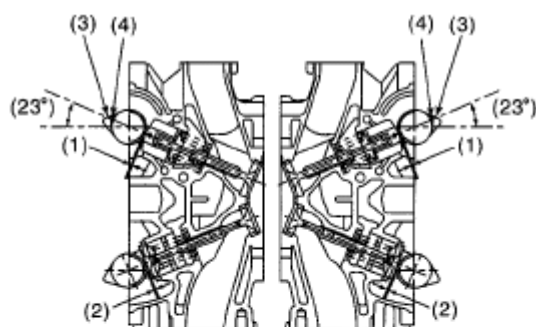


Fig. 15: Locating Fuel Pipe Protector

4. Remove the ignition coil. < Ref. 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.



ME-02565

- (1) Valve clearance (Intake side)
- (2) Valve clearance (Exhaust side)
- (3) High lift cam
- (4) Low lift cam

Fig. 16: Identifying Cam Positions

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

NOTE:

- Measure it within the range of $\pm 30^\circ$ from specified position shown in the figure.
- 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:**

$0.20^{+0.04}_{-0.06} \text{ mm } (0.007^{+0.0016}_{-0.0024} \text{ in})$

Exhaust:

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

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

clearance later on.

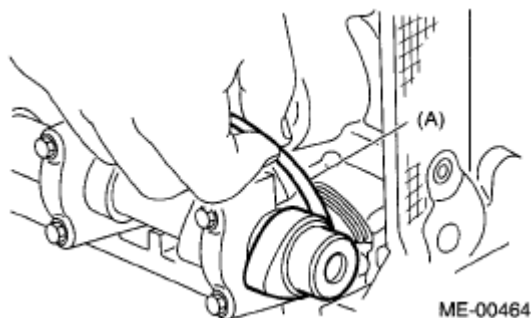


Fig. 17: Checking Valve Clearance

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

ADJUSTMENT

INTAKE SIDE

CAUTION:

- 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 then insert the valve lifter.

1. Measure all the valve clearances.

< Ref. to **INSPECTION**, Valve Clearance. >

NOTE:

Record each valve clearance after measurement.

2. Remove the camshaft. < Ref. to **REMOVAL**, Camshaft. >
3. Remove the valve lifter.
4. Remove the shim from valve lifter.
5. Check the thickness of the shim from the markings on the side of the shim that was removed.
6. Select a shim of suitable thickness from the following table using the measured valve clearance and shim thickness.

SHIM THICKNESS SPECIFICATION

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Unit: (mm)

$$S = (V + T) - 0.20$$

S: Required shim thickness

V: Measured valve clearance

T: Shim thickness to be used

SHIM THICKNESS SPECIFICATION

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)

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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)
13218AL530	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)

EXHAUST SIDE

CAUTION:

- 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.

< Ref. to **INSPECTION**, Valve Clearance. >

NOTE:

Record each valve clearance after measurement.

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

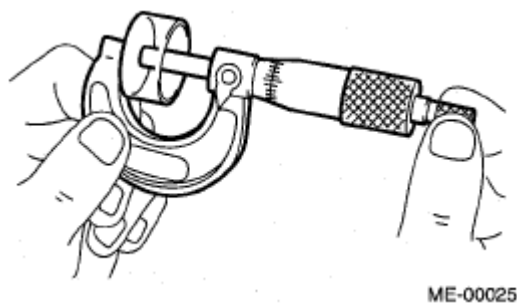


Fig. 18: Measuring Thickness Of Valve Lifter With Micrometer

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

VALVE LIFTER THICKNESS SPECIFICATION

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

VALVE LIFTER THICKNESS SPECIFICATION

Part No.	Thickness mm (in)
13228AD180	4.32 (0.1701)
13228AD190	4.34 (0.1709)
13228AD200	4.36 (0.1717)
13228AD210	4.38 (0.1724)

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13228AD220	4.40 (0.1732)
13228AD230	4.42 (0.1740)
13228AD240	4.44 (0.1748)
13228AD250	4.46 (0.1756)
13228AD260	4.48 (0.1764)
13228AD270	4.50 (0.1772)
13228AD280	4.52 (0.1780)
13228AD290	4.54 (0.1787)
13228AD300	4.56 (0.1795)
13228AD310	4.58 (0.1803)
13228AD320	4.60 (0.1811)
13228AC580	4.62 (0.1819)
13228AC590	4.63 (0.1823)
13228AC600	4.64 (0.1827)
13228AC610	4.65 (0.1831)
13228AC620	4.66 (0.1835)
13228AC630	4.67 (0.1839)
13228AC640	4.68 (0.1843)
13228AC650	4.69 (0.1846)
13228AC660	4.70 (0.1850)
13228AC670	4.71 (0.1854)
13228AC680	4.72 (0.1858)
13228AC690	4.73 (0.1862)
13228AC700	4.74 (0.1866)
13228AC710	4.75 (0.1870)
13228AC720	4.76 (0.1874)
13228AC730	4.77 (0.1878)
13228AC740	4.78 (0.1882)
13228AC750	4.79 (0.1886)
13228AC760	4.80 (0.1890)
13228AC770	4.81 (0.1894)
13228AC780	4.82 (0.1898)
13228AC790	4.83 (0.1902)
13228AC800	4.84 (0.1906)
13228AC810	4.85 (0.1909)
13228AC820	4.86 (0.1913)
13228AC830	4.87 (0.1917)
13228AC840	4.88 (0.1921)
13228AC850	4.89 (0.1925)
13228AC860	4.90 (0.1929)
13228AC870	4.91 (0.1933)

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	4.92 (0.1937)
13228AC890	4.93 (0.1941)
13228AC900	4.94 (0.1945)
13228AC910	4.95 (0.1949)
13228AC920	4.96 (0.1953)
13228AC930	4.97 (0.1957)
13228AC940	4.98 (0.1961)
13228AC950	4.99 (0.1965)
13228AC960	5.00 (0.1969)
13228AC970	5.01 (0.1972)
13228AC980	5.02 (0.1976)
13228AC990	5.03 (0.1980)
13228AD000	5.04 (0.1984)
13228AD010	5.05 (0.1988)
13228AD020	5.06 (0.1992)
13228AD030	5.07 (0.1996)
13228AD040	5.08 (0.2000)
13228AD050	5.09 (0.2004)
13228AD060	5.10 (0.2008)
13228AD070	5.11 (0.2012)
13228AD080	5.12 (0.2016)
13228AD090	5.13 (0.2020)
13228AD100	5.14 (0.2024)
13228AD110	5.15 (0.2028)
13228AD120	5.16 (0.2032)
13228AD130	5.17 (0.2035)
13228AD140	5.18 (0.2039)
13228AD150	5.19 (0.2043)
13228AD160	5.20 (0.2047)
13228AD170	5.21 (0.2051)
13228AD330	5.23 (0.2059)
13228AD340	5.25 (0.2067)
13228AD350	5.27 (0.2075)
13228AD360	5.29 (0.2083)
13228AD370	5.31 (0.2091)
13228AD380	5.33 (0.2098)
13228AD390	5.35 (0.2106)
13228AD400	5.37 (0.2114)
13228AD410	5.39 (0.2122)
13228AD420	5.41 (0.2130)
13228AD430	5.43 (0.2138)

	5.45 (0.2146)
13228AD450	5.47 (0.2154)
13228AD460	5.49 (0.2161)
13228AD470	5.51 (0.2169)
13228AD480	5.53 (0.2177)
13228AD490	5.55 (0.2185)
13228AD500	5.57 (0.2193)
13228AD510	5.59 (0.2201)

V-BELT

REMOVAL

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

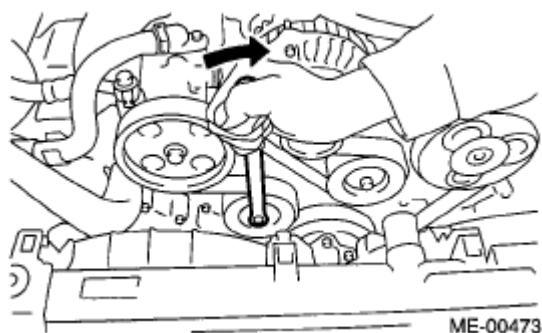
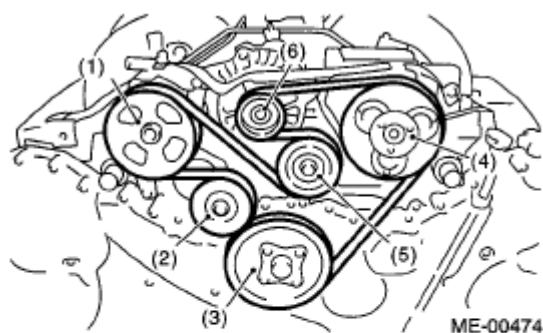


Fig. 19: Rotating Tool Clockwise

3. Remove the V-belt cover.

INSTALLATION

Install in the reverse order of removal.

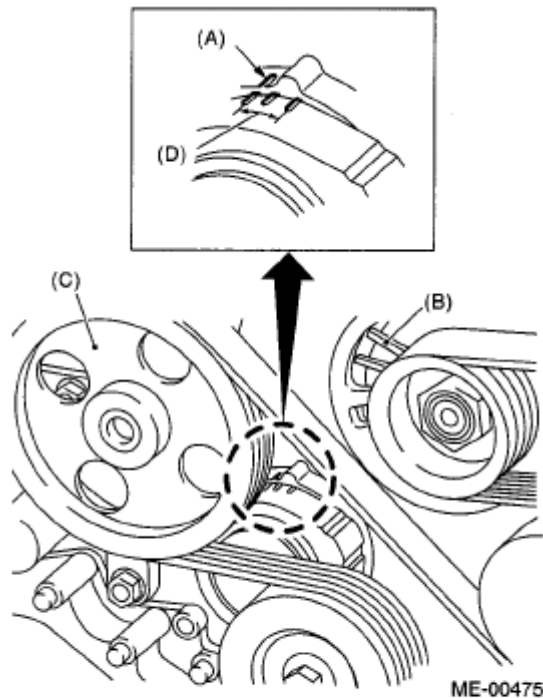


- (1) Power steering oil pump pulley
- (2) Belt tension adjuster ASSY
- (3) Crank pulley
- (4) A/C compressor
- (5) Belt idler
- (6) Generator

Fig. 20: Identifying Belt Tension Adjuster Assembly And Power Steering Oil Pump Assembly

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. 21: Identifying Automatic Belt Tension Indicator

ENGINE ASSEMBLY

REMOVAL

1. Set the vehicle on a lift.
2. Open the front hood fully and support with the front food stay.
3. Remove the collector cover.
4. Collect the refrigerant from A/C system. < Ref. to **PROCEDURE** , Refrigerant Recovery Procedure. >
5. Release the fuel pressure.

< Ref. to **RELEASING OF FUEL PRESSURE** , PROCEDURE, Fuel. >

6. Remove the fuel filler cap.
7. Disconnect the ground cable from battery.

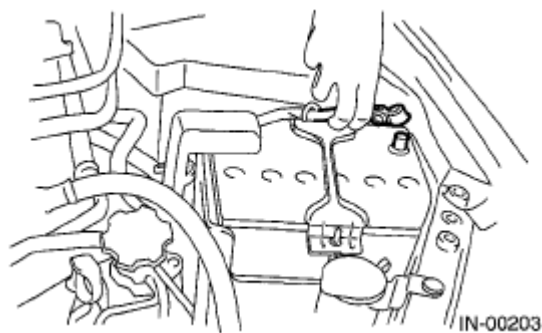


Fig. 22: Disconnecting Ground Cable From Battery

8. Remove the air intake duct, air cleaner case and air intake chamber.

< Ref. to **REMOVAL** , Air Intake Duct. > < Ref. to **REMOVAL** , Air Cleaner Case. > < Ref. to **REMOVAL** , Air Intake Chamber. >

9. Remove the radiator from vehicle. < Ref. to **REMOVAL** , Radiator. >
10. Remove the V-belts. < Ref. to **REMOVAL** , V-belt. >
11. Disconnect the A/C pressure hoses from A/C compressor. < Ref. to **REMOVAL** , Hose and Tube. >
12. Disconnect the following connector.
 1. Engine ground terminal

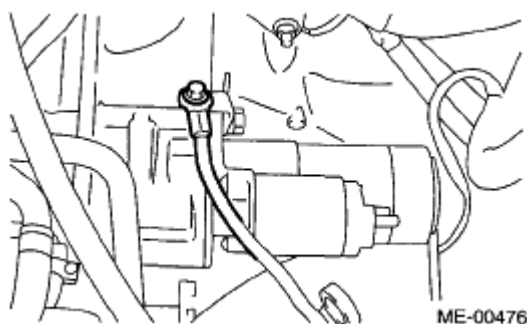


Fig. 23: Identifying Engine Grounding Terminal

2. Engine harness connectors

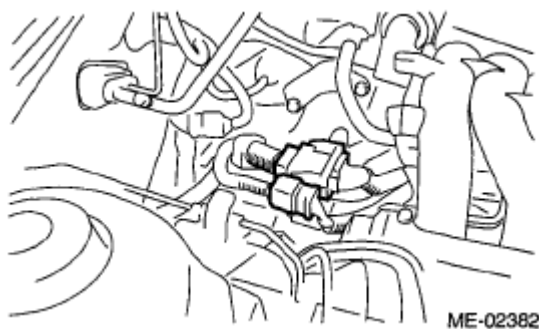


Fig. 24: Identifying Engine Harness Connectors

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

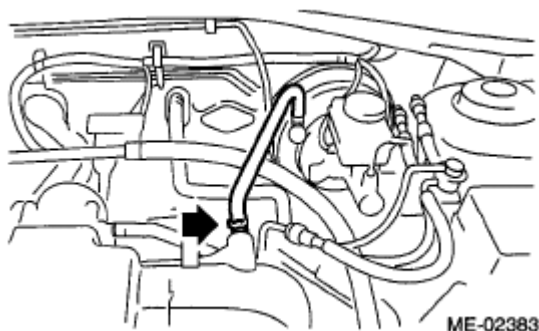
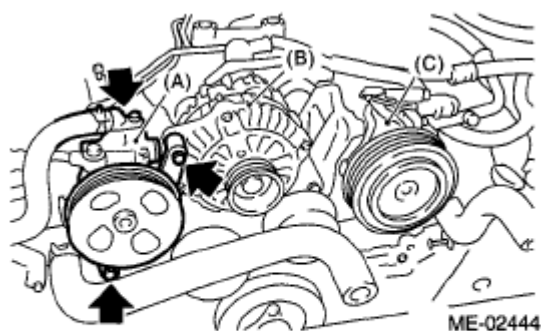


Fig. 25: Locating Brake Booster Vacuum Hose

2. Heater inlet and outlet hoses
3. Pressure regulator vacuum hose
14. Remove the power steering pump from the bracket.

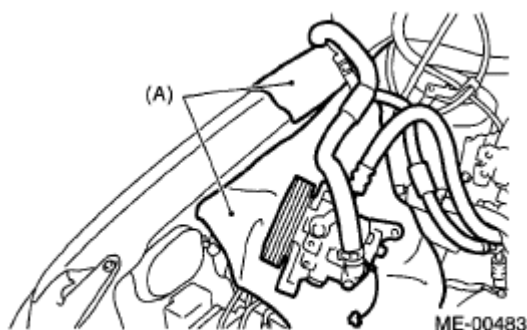
NOTE: **Do not disconnect the hose and pipe from the pump body.**



- (A) Power steering pump
- (B) Generator
- (C) A/C compressor

Fig. 26: Identifying Power Steering Pump And A/C Compressor

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



- (A) Cloth

Fig. 27: Identifying Cloth

15. Lift-up the vehicle.
16. Remove the under cover.
17. Remove the front exhaust pipe.

< Ref. to **REMOVAL** , Front Exhaust Pipe. >

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

18. Remove the ground cable.

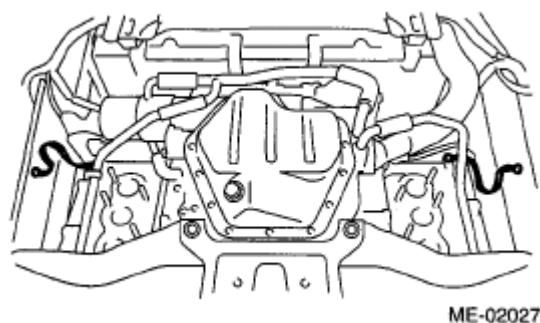


Fig. 28: Removing Ground Cable

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

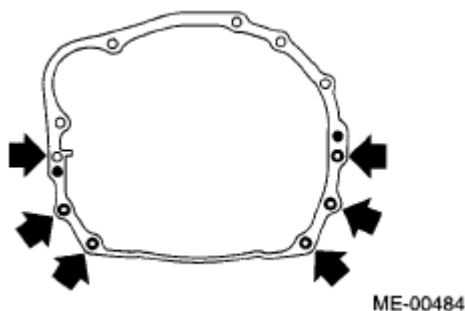


Fig. 29: Locating Transmission Lower Side Bolts

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

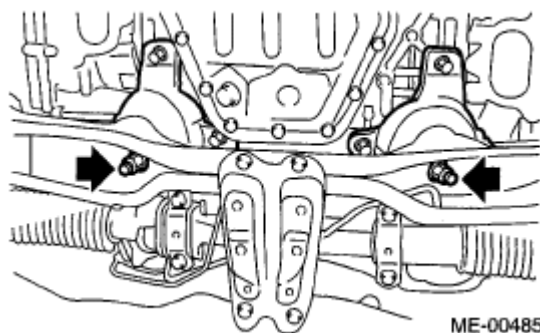


Fig. 30: Locating Front Cushion Rubber

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

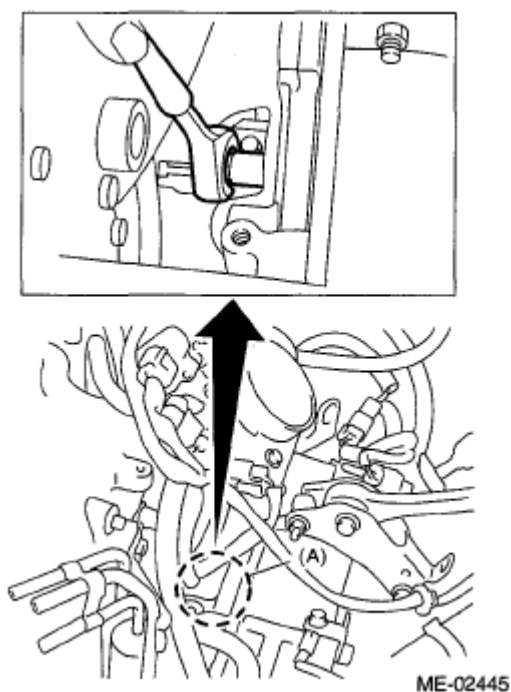


Fig. 31: Identifying Service Hole Plug

22. Remove the pitching stopper.

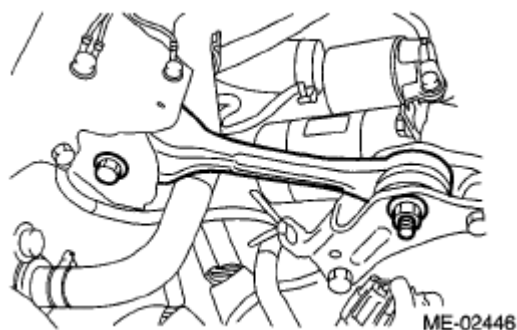


Fig. 32: Identifying Pitching Stopper

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

ST 42099AE000 CONNECTOR REMOVER

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

CAUTION:

- Collect fuel from the hose into container.
- Disconnect the hose with its end wrapped with cloth to prevent fuel from splashing.

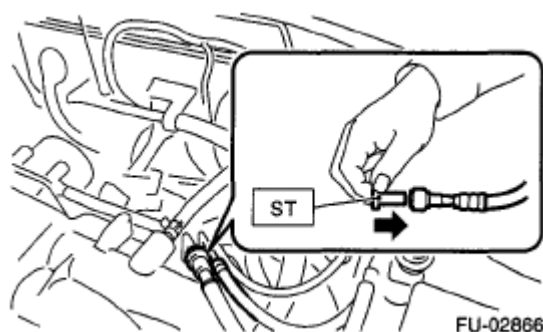


Fig. 33: Disconnecting Evaporation Hose From Pipe

24. Support the engine with a lifting device and wire ropes.
25. Support the transmission with a garage jack.

CAUTION: Doing this is very important because the transmission lowers for its own weight. This work is also of great importance for facilitating reinstallation.

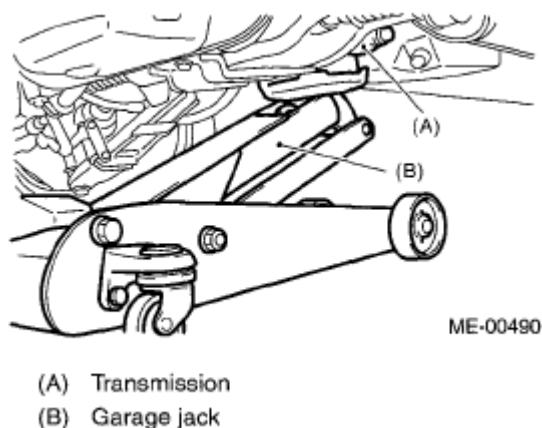


Fig. 34: Supporting Transmission With Garage Jack

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

26. Separation of engine and transmission:
 1. Remove the starter. < Ref. to **REMOVAL** , Starter. >
 2. Remove the bolts which hold upper side of transmission to engine.

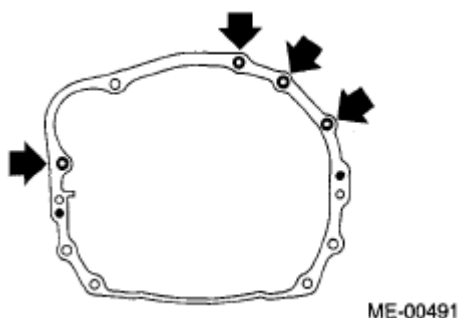


Fig. 35: Identifying Transmission Upper Side Bolts

27. Attach the ST to converter case.

ST 498277200 STOPPER SET

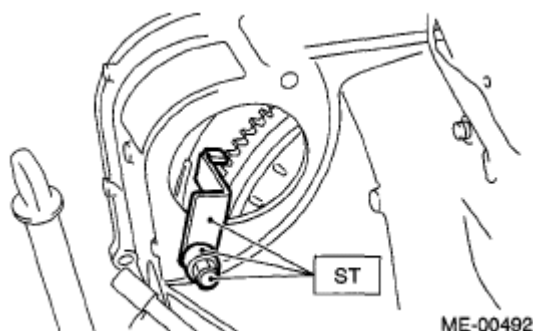


Fig. 36: Attaching ST To Converter Case

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

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

29. Remove the front cushion rubbers.

INSTALLATION

1. Install the front cushion rubbers.

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, 37 ft-lb)

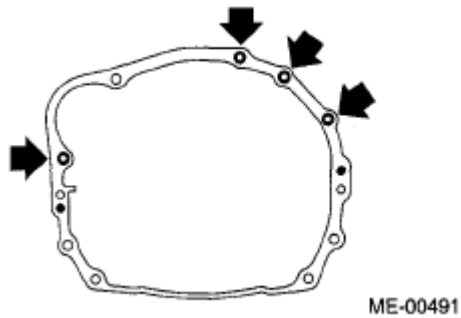


Fig. 37: Locating Transmission Upper Side Bolts

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

Tightening torque:

T1: 50 N.m (5.1 kgf-m, 37 ft-lb)

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

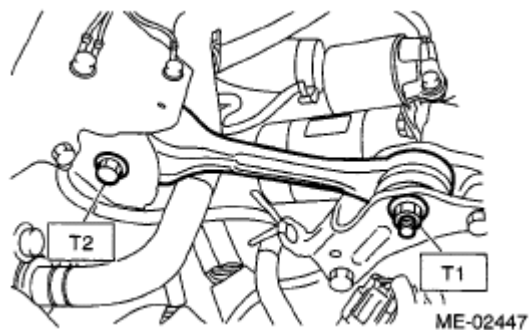


Fig. 38: Identifying Pitching Stopper

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. < Ref. 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.

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

Tightening torque:

25 N.m (2.5 kgf-m, 18 ft-lb)

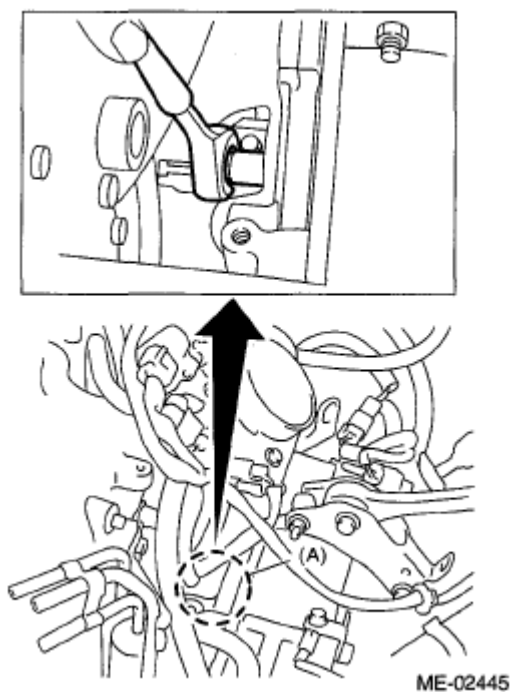


Fig. 39: Tightening Bolts

3. Install the service hole plug (A) to prevent getting foreign matter inside.
10. Install the power steering pump. < Ref. to **INSTALLATION** , Oil Pump. >
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, 37 ft-lb)

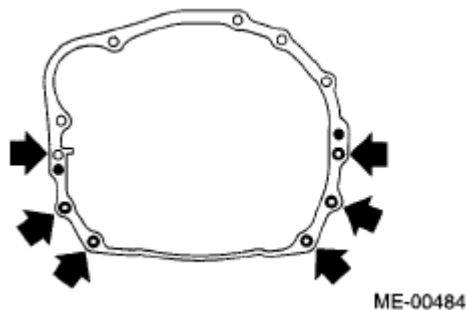


Fig. 40: Tightening Bolts And Nuts

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

Tightening torque:

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

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

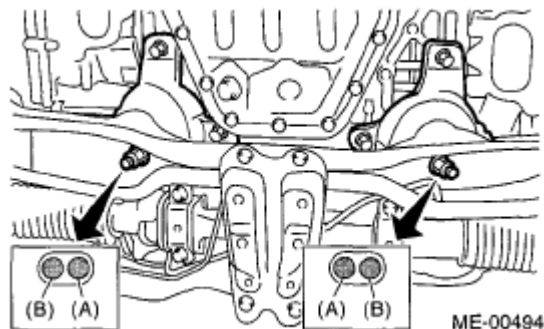


Fig. 41: Identifying Front Cushion Rubber Mounting Bolts And Locator

14. Install the front exhaust pipe.

< Ref. to **INSTALLATION** , Front Exhaust Pipe. >

NOTE:

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

15. Connect the ground cable.

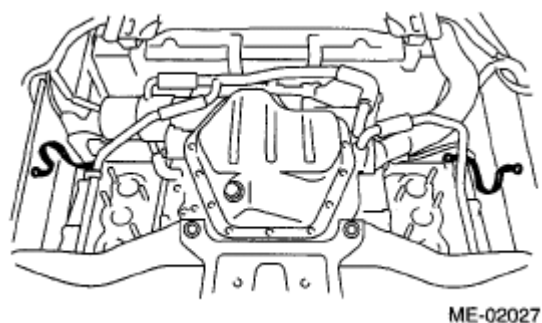


Fig. 42: Connecting Ground Cable

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 ground terminal

Tightening torque:

14 N.m (1.4 kgf-m, 10.1 ft-lb)

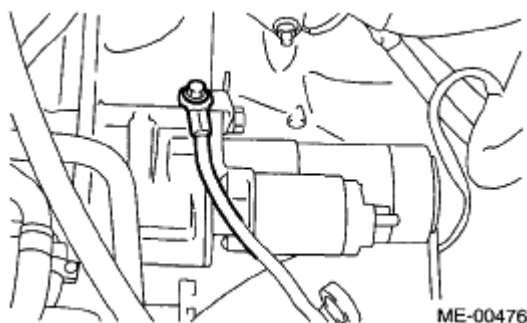


Fig. 43: Identifying Engine Grounding Terminal

2. Engine harness connectors

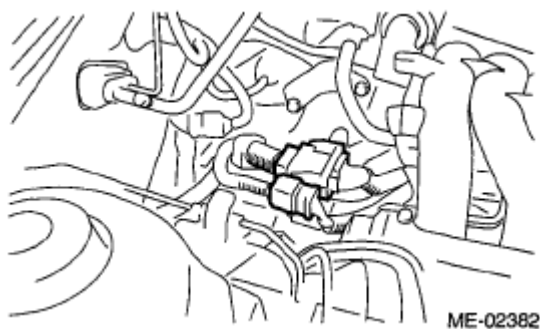


Fig. 44: Locating Engine Harness Connectors

3. Generator connector and terminal
4. A/C compressor connector
5. Power steering switch connector
20. Install the A/C pressure hoses.

< Ref. to **INSTALLATION** , Hose and Tube. >
21. Install the V-belts. < Ref. to **INSTALLATION**, V-belt. >
22. Install the radiator to vehicle. < Ref. to **INSTALLATION** , Radiator. >
23. Install the air intake duct, air cleaner case and air intake chamber. < Ref. to **INSTALLATION** , Air Intake Duct. > < Ref. to **INSTALLATION** , Air Cleaner Case. > < Ref. to **INSTALLATION** , Air Intake Chamber. >
24. Install the battery in the vehicle, and connect cables.
25. Fill engine coolant.

< Ref. to **FILLING OF ENGINE COOLANT** , REPLACEMENT, Engine Coolant. >
26. Check the ATF level and replenish it if necessary.

< Ref. to **INSPECTION** , Automatic Transmission Fluid. >
27. Charge the A/C system with refrigerant. < Ref. to **PROCEDURE** , Refrigerant Charging Procedure. >
28. Install the collector cover.
29. Remove the front hood stay, and close the front hood.
30. Take off 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. < Ref. 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 there are no cracks or other damages.

PREPARATION FOR OVERHAUL

REMOVAL

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

ST 18232AA000 ENGINE STAND

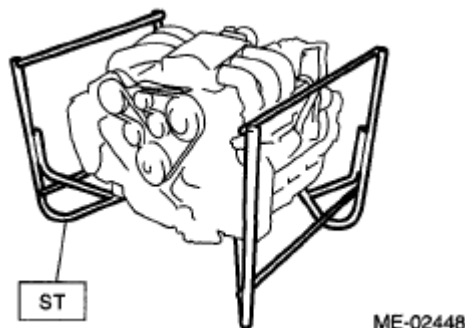


Fig. 45: Identifying ST 18232AA000 Engine Stand

3. Before servicing overhaul, remove the sensor, pipe and hose that installed to engine.
 1. Remove the intake manifold. < Ref. to **REMOVAL**, Intake Manifold. >
 2. Remove the generator. < Ref. to **REMOVAL**, Generator. >

3. Remove the A/C compressor. < Ref. to **REMOVAL** , Compressor. >
4. Disconnect the water pipe and hose.
5. Disconnect the engine harness.
6. Remove the spark plug. < Ref. to **REMOVAL** , Spark Plug. >
7. Remove the camshaft position sensor. < Ref. to **REMOVAL** , Camshaft Position Sensor. >
8. Remove the crankshaft position sensor. < Ref. to **REMOVAL** , Crankshaft Position Sensor. >
9. Remove the knock sensor. < Ref. to **REMOVAL** , Knock Sensor. >
10. Remove the engine coolant temperature sensor. < Ref. to **REMOVAL** , Engine Coolant Temperature Sensor. >
11. Remove the oil pressure switch. < Ref. to **REMOVAL** , Oil Pressure Switch. >
12. Remove the oil filter. < Ref. to **REMOVAL** , Engine Oil Filter. >
13. Remove the oil cooler. < Ref. to **REMOVAL** , Oil Cooler. >

CRANK PULLEY

REMOVAL

1. Remove the crank pulley cover.

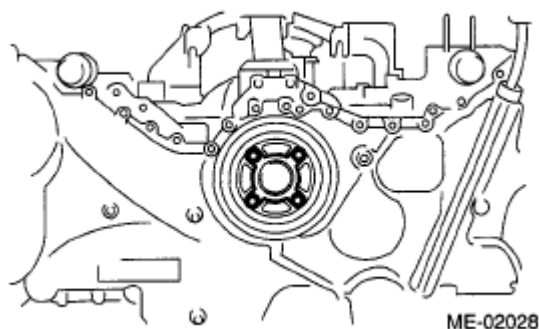


Fig. 46: Identifying Crank Pulley Cover

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

ST 499977100 CRANK PULLEY WRENCH

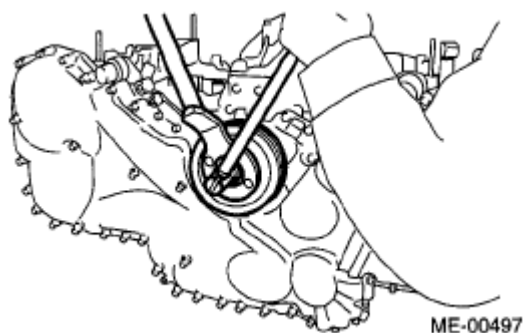


Fig. 47: Removing Crank Pulley Bolt Using Crank Pulley Wrench ST 499977100

3. 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 crank pulley 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 ft-lb)

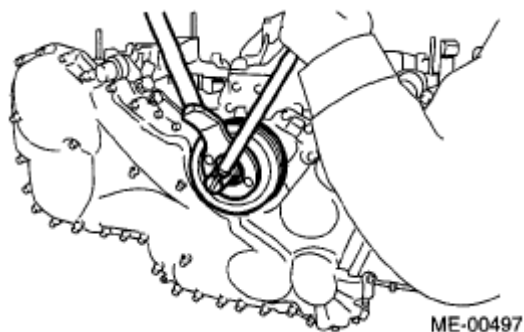


Fig. 48: Locating Crank Pulley Bolts

3. Install the crank pulley cover.

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

Tightening torque:

6.4 N.m (0.65 kgf-m, 4.7 ft-lb)

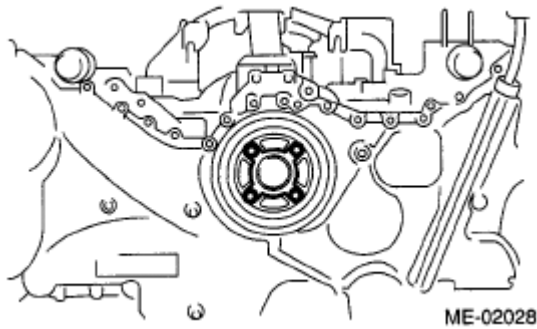


Fig. 49: Identifying Crank Pulley Cover

INSPECTION

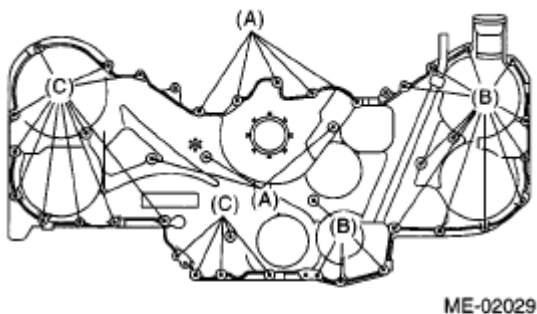
1. Check the crank pulley cover for oil and air leakage.
2. Check the crank pulley for looseness.

FRONT CHAIN COVER

REMOVAL

1. Remove the crank pulley. < Ref. to **REMOVAL**, Crank Pulley. >
2. 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. 50: Identifying Front Chain Cover Bolts

INSTALLATION

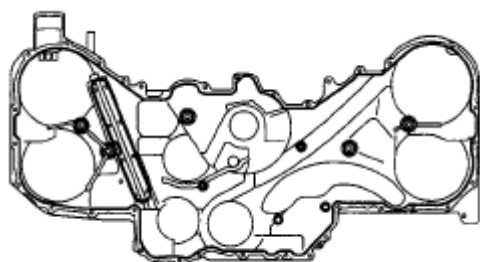
1. Remove the used liquid gasket from mating surface, and degrease it.
2. Apply liquid gasket to the mating surface of front chain cover.

Liquid gasket

THREE BOND 1280B (Part No. K0877YA018)

Applying liquid gasket diameter

$2.5 \pm 0.5 \text{ mm}$ ($0.098 \pm 0.020 \text{ in}$)

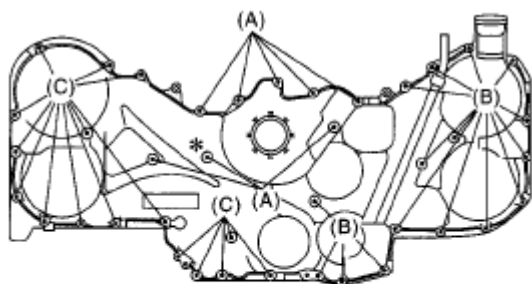


ME-02385

Fig. 51: Applying Liquid Gasket Diameter

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

CAUTION: Do not install the bolts in wrong place.



ME-02029

(A) M6 x 16

(B) M6 x 30

(C) M6 x 45

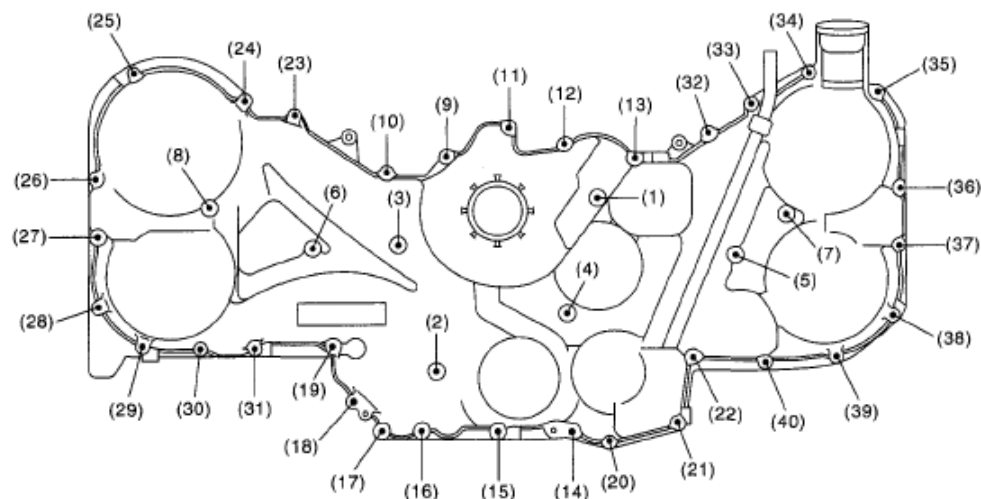
*: Sealing washer

Fig. 52: Identifying Front Chain Cover Bolts

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

Tightening torque:

6.6 N.m (0.67 kgf-m, 4.8 ft-lb)



ME-02031

Fig. 53: Tightening Sequence Of Bolts

5. Install the crank pulley. < Ref. to **INSTALLATION**, Crank Pulley. >

INSPECTION

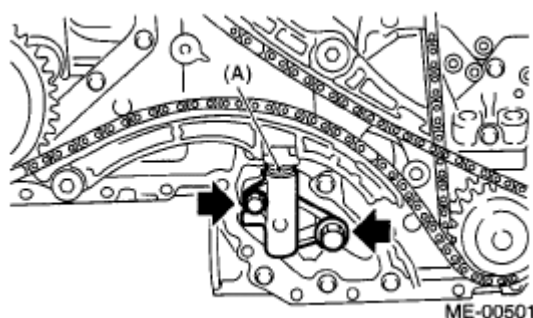
Check the cover surface for scratch and damage. Check for oil leakage on cover mating surface and installation part of crank pulley.

TIMING CHAIN ASSEMBLY

REMOVAL

1. Remove the crank pulley. < Ref. to **REMOVAL**, Crank Pulley. >
2. Remove the front chain cover. < Ref. to **REMOVAL**, Front Chain Cover. >
3. Remove the chain tensioner (RH).

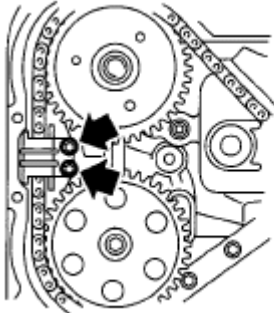
NOTE: Be careful not to come out the plunger (A).



ME-00501

Fig. 54: Locating Plunger

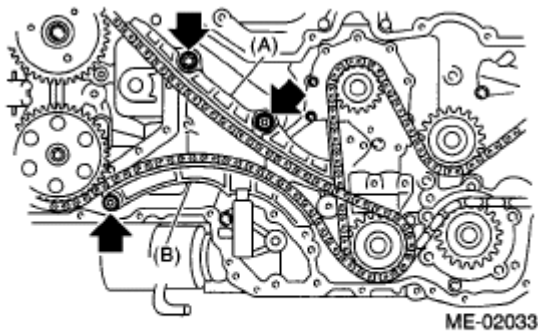
4. Remove the chain guide (RH: between cams).



ME-02032

Fig. 55: Locating Chain Guide

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



ME-02033

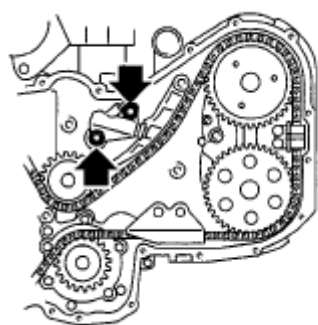
(A) Chain guide (RH)

(B) Chain tensioner lever (RH)

Fig. 56: Locating Chain Tensioner Lever

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

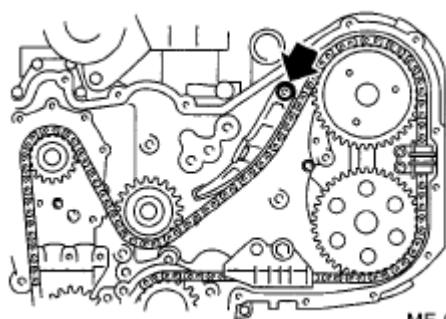
NOTE: Be careful not to come out the plunger.



ME-02034

Fig. 57: Locating Timing Chain And Chain Tensioner

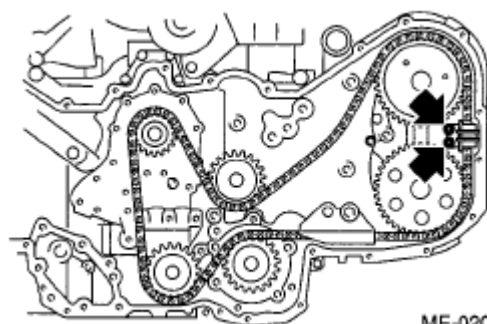
9. Remove the chain tensioner lever (LH).



ME-02035

Fig. 58: Locating Chain Tensioner Lever

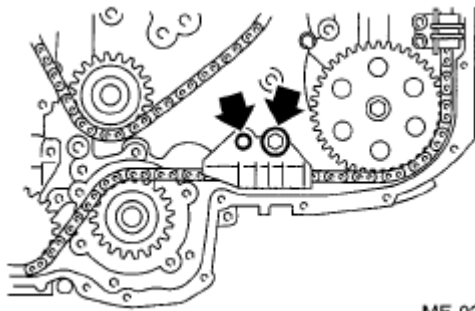
10. Remove the chain guide (LH: between cams).



ME-02036

Fig. 59: Locating Chain Guide

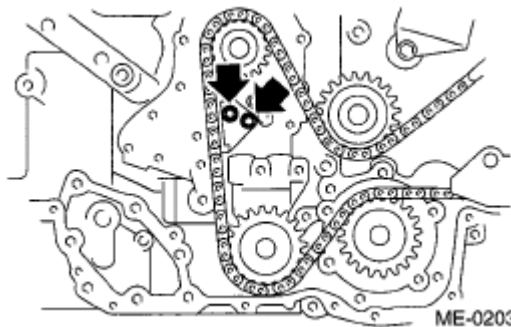
11. Remove the chain guide (LH)



ME-02037

Fig. 60: Locating Chain Guide (LH)

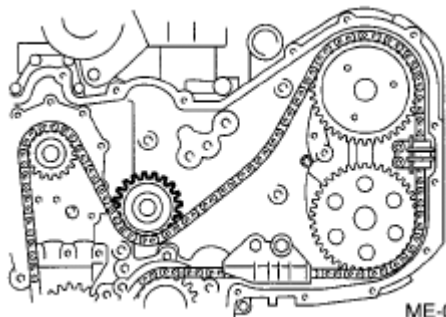
12. Remove the chain guide (center).



ME-02038

Fig. 61: Locating Chain Guide (Center)

13. Remove the idler sprocket (upper)



ME-02039

Fig. 62: Locating Idler Sprocket (Upper)

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

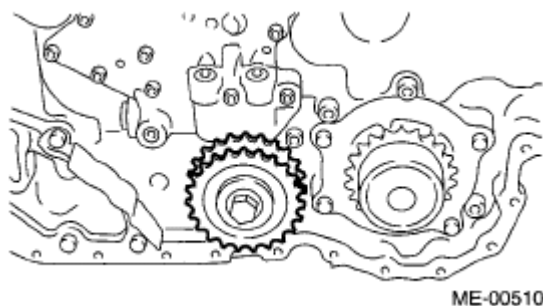


Fig. 63: Locating Idler Sprocket (Lower)

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. Preparation for chain tensioner installation

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.

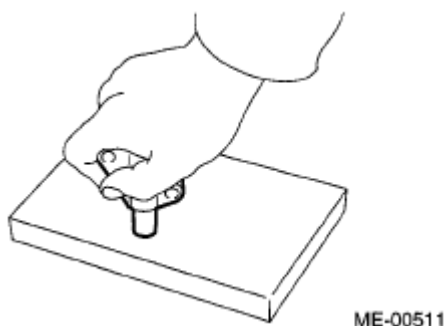
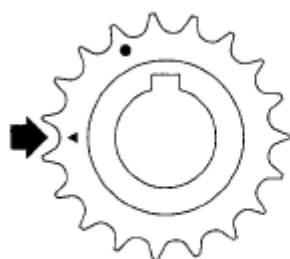


Fig. 64: Identifying Rubber Mat

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

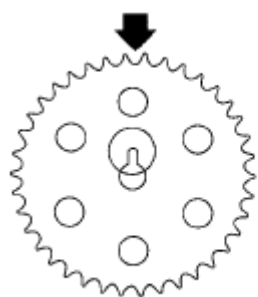
ST 18252AA000 CRANKSHAFT SOCKET



ME-02040

Fig. 65: Locating Crank Sprocket Mark

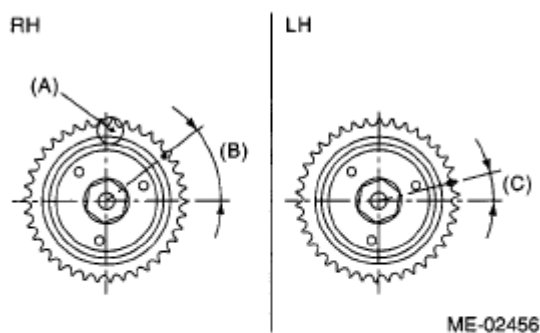
3. Align the key groove on exhaust cam sprocket to 12 o'clock position as shown in the figure.



ME-02041

Fig. 66: Locating Key Groove On Exhaust Cam Sprocket

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



ME-02456

- (A) Top mark
(B) 40°
(C) 15°

Fig. 67: Aligning Intake Cam Sprocket

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 timing chain installation.

6. Install the idler sprocket (lower).

Tightening torque:

69 N.m (7.0 kgf-m, 50.6 ft-lb)

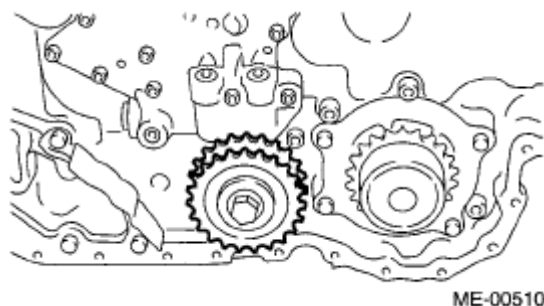


Fig. 68: Locating Idler Sprocket (Lower)

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

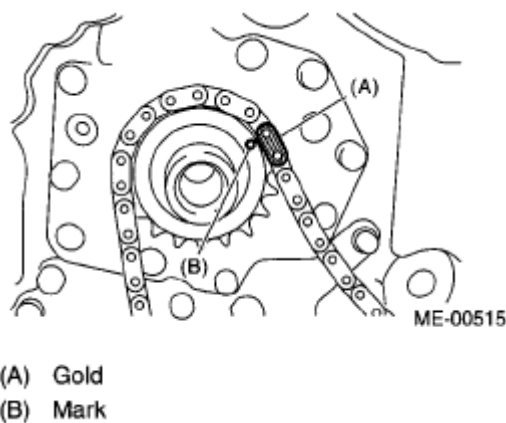


Fig. 69: Aligning Timing Mark On Crank Sprocket With Mark On Timing Chain

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.

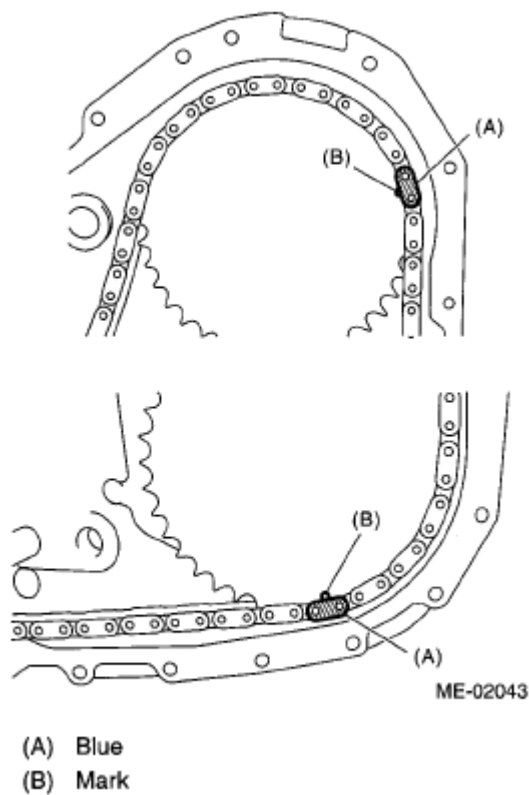


Fig. 70: Locating Timing Chain And Cam Sprocket

3. Install the chain idler (upper).

Tightening torque:

69 N.m (7.0 kgf-m, 50.6 ft-lb)

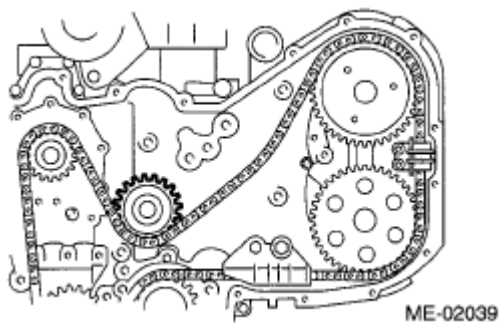


Fig. 71: Locating Chain Idler (Upper)

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

Tightening torque:

6.4 N.m (0.65 kgf-m, 4.7 ft-lb)

NOTE: Use a new installing bolt.

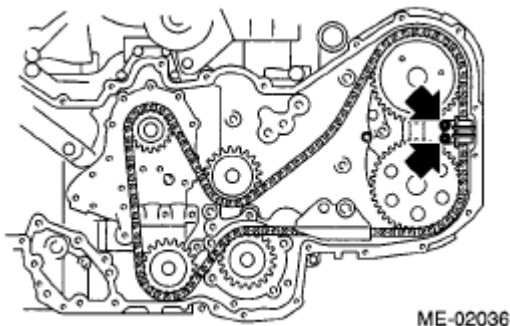


Fig. 72: Identifying Chain Guide

5. Install the chain guide (LH).

Tightening torque:

16 N.m (1.6 kgf-m, 12 ft-lb)

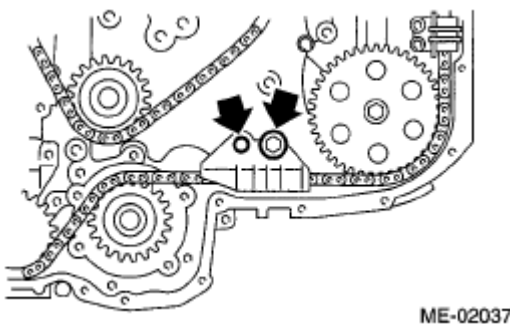


Fig. 73: Identifying Chain Guide (LH)

6. Install the chain tensioner lever (LH).

Tightening torque:

16 N.m (1.6 kgf-m, 12 ft-lb)

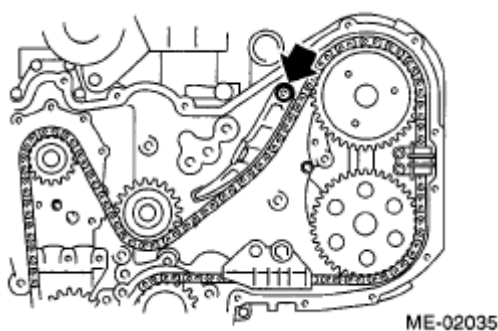


Fig. 74: Identifying Chain Tensioner Lever (LH)

7. Install the chain tensioner (LH).

Tightening torque:

16 N.m (1.6 kgf-m, 12 ft-lb)

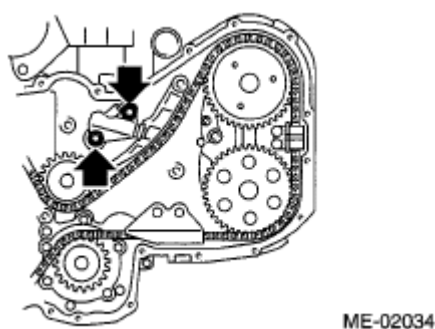
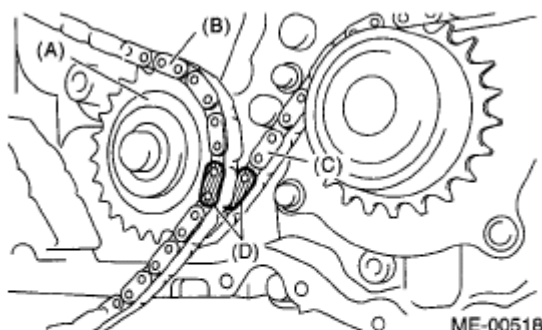


Fig. 75: Identifying Chain Tensioner (LH)

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

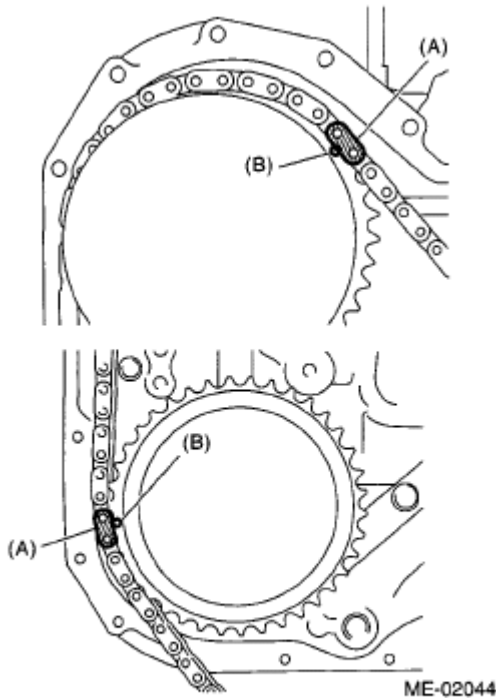


- (A) Idler sprocket (lower)
- (B) Timing chain (RH)
- (C) Timing chain (LH)
- (D) Blue

Fig. 76: Identifying Timing Chain (RH)

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.



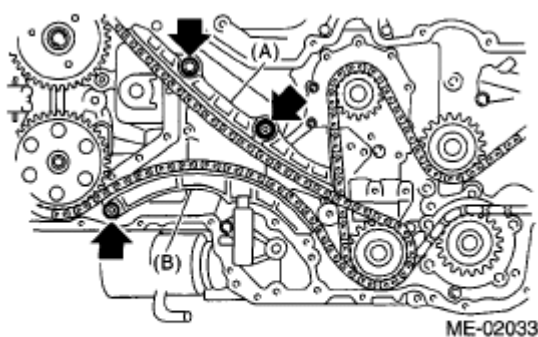
(A) Gold
(B) Mark

Fig. 77: Identifying Timing Chain And Cam Sprocket Mark

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

Tightening torque:

16 N.m (1.6 kgf-m, 12 ft-lb)



(A) Chain guide (RH)

(B) Chain tensioner lever (RH)

Fig. 78: Identifying Chain Tensioner Lever And Chain Guide

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

Tightening torque:

6.4 N.m (0.65 kgf-m, 4.7 ft-lb)

NOTE: Use a new installing bolt.

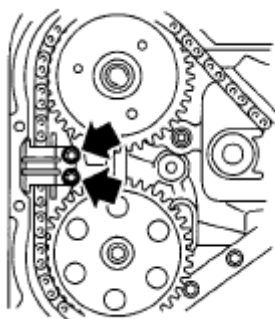


Fig. 79: Identifying Chain Guide

6. Install the chain tensioner (RH).

Tightening torque:

16 N.m (1.6 kgf-m, 12 ft-lb)

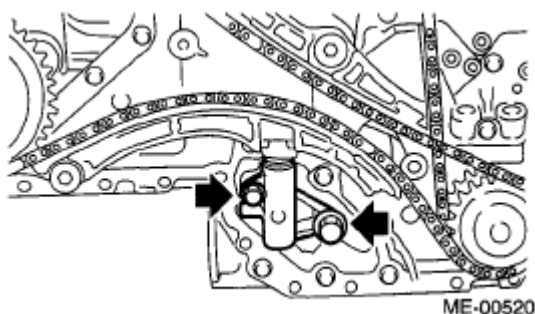


Fig. 80: Identifying Chain Tensioner (RH)

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, 5.8 ft-lb)

NOTE: Use a new installing bolt.

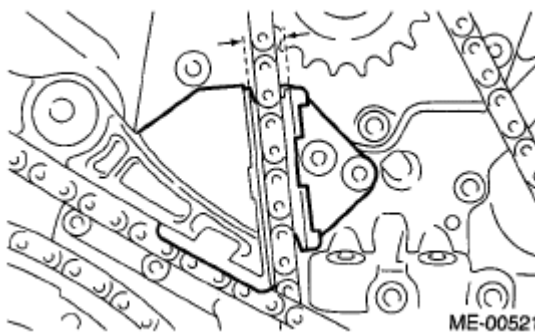


Fig. 81: Adjusting Clearance Between Chain Guide And Chain Guide

8. Check that each mark on the sprocket and timing chain is matched, and then draw out the stopper pin from chain tensioner.

CAM SPROCKET

REMOVAL

1. Remove the crank pulley. < Ref. to **REMOVAL**, Crank Pulley. >
2. Remove the front chain cover. < Ref. to **REMOVAL**, Front Chain Cover. >
3. Remove the timing chain assembly.

< Ref. to **REMOVAL**, Timing Chain Assembly. >

4. Remove the cam sprocket. To lock the camshaft, use the ST.

ST 499977500 CAM SPROCKET WRENCH

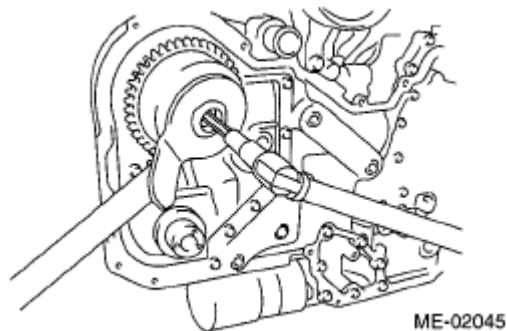


Fig. 82: Identifying ST 499977500 Cam Sprocket Wrench

ST 18231AA020 CAM SPROCKET WRENCH

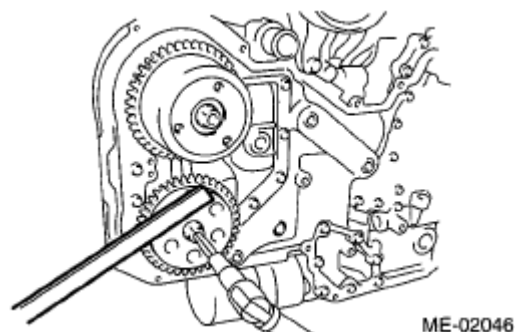


Fig. 83: Identifying ST 18231Aa020 Cam Sprocket Wrench

INSTALLATION

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

Tightening torque:

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

2. Further tighten the bolt.

Tightening angle:

Intake

45°±5°

Exhaust

$25^{\circ} \pm 5^{\circ}$

ST 499977500 CAM SPROCKET WRENCH

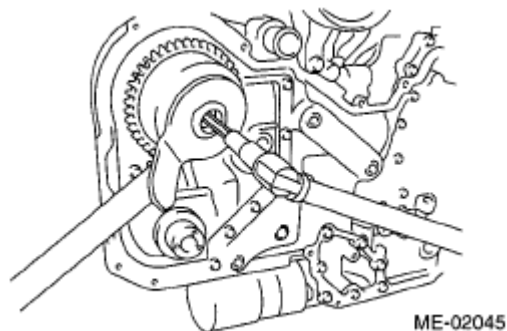


Fig. 84: Identifying ST 499977500 Cam Sprocket Wrench

ST 18231AA020 CAM SPROCKET WRENCH

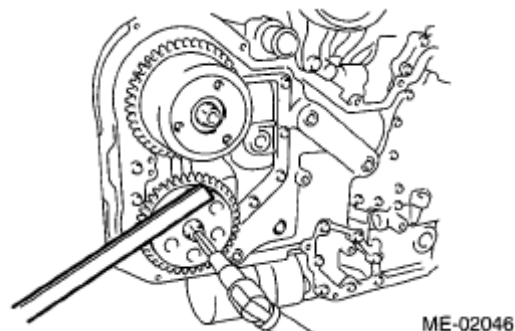


Fig. 85: Identifying ST 18231Aa020 Cam Sprocket Wrench

3. Install the timing chain assembly.

< Ref. to **INSTALLATION**, Timing Chain Assembly. >

4. Install the front chain cover.

< Ref. to **INSTALLATION**, Front Chain Cover. >

5. Install the crank pulley. < Ref. to **INSTALLATION**, Crank Pulley. >

INSPECTION

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

CRANK SPROCKET

REMOVAL

1. Remove the crank pulley. < Ref. to **REMOVAL**, Crank Pulley. >
2. Remove the front chain cover. < Ref. to **REMOVAL**, Front Chain Cover. >
3. Remove the timing chain assembly.

< Ref. to **REMOVAL**, Timing Chain Assembly. >

4. Remove the cam sprocket. < Ref. to **REMOVAL**, Cam Sprocket. >
5. Remove the crank sprocket (A).

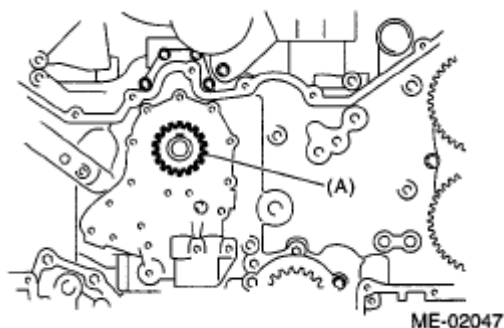


Fig. 86: Identifying Crank Sprocket

INSTALLATION

1. Install the crank sprocket (A).

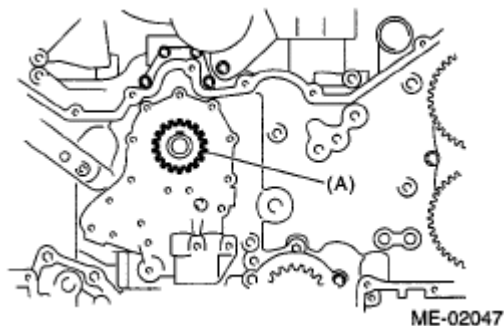


Fig. 87: Identifying Crank Sprocket

2. Install the cam sprocket. < Ref. to **INSTALLATION**, Cam Sprocket. >
3. Install the timing chain assembly.

< Ref. to **INSTALLATION**, Timing Chain Assembly. >

4. Install the front chain cover.

< Ref. to **INSTALLATION**, Front Chain Cover. >

5. Install the crank pulley. < Ref. to **INSTALLATION**, Crank Pulley. >

INSPECTION

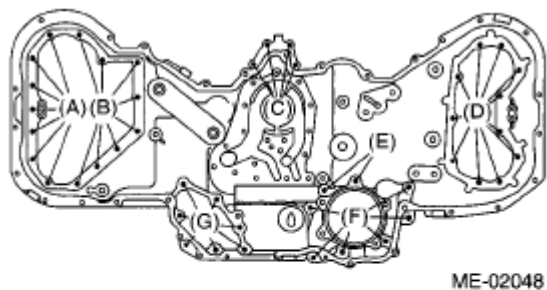
1. Check the crank sprocket teeth for abnormal wear and scratches.
2. Make sure there is no free play between crank sprocket and key.

REAR CHAIN COVER

REMOVAL

1. Remove the crank pulley. < Ref. to **REMOVAL**, Crank Pulley. >
2. Remove the front chain cover. < Ref. to **REMOVAL**, Front Chain Cover. >
3. Remove the timing chain. < Ref. to **REMOVAL**, Timing Chain Assembly. >
4. Remove the cam sprocket. < Ref. to **REMOVAL**, Cam Sprocket. >
5. Remove the crank sprocket.
6. Remove the oil pump. < Ref. to **REMOVAL**, Oil Pump. >
7. Remove the water pump. < Ref. to **REMOVAL**, Water Pump. >
8. 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. 88: Identifying Rear Chain Cover Bolts

INSTALLATION

NOTE: When replacing the rear chain cover, it is required to select the size. For details, refer to **INSPECTION** , Oil Pump.

NOTE: On the inner rotor, outer rotor and the rear chain cover, there are identification marks of A, B, or C in locations shown on the diagram. When replacing, use those with matching identification marks.

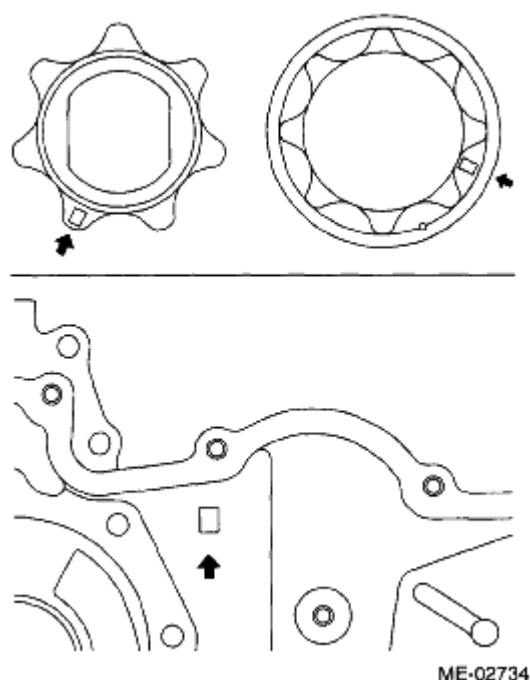


Fig. 89: Locating Matching Identification Marks

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

Liquid gasket

THREE BOND 1280B (Part No. K0877A018)

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)

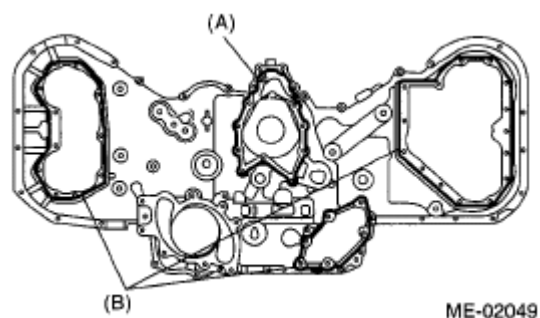
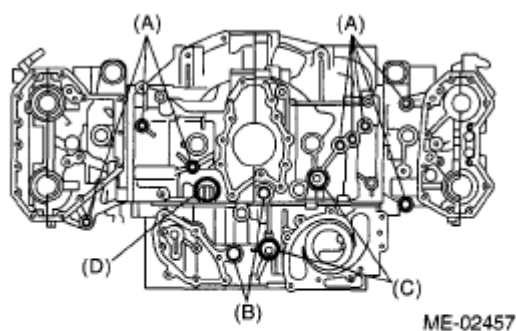


Fig. 90: Applying Liquid Gasket To Mating Surface Of Rear Chain Cover

3. Install the O-ring.

NOTE:

- Do not reuse the O-ring.
- Do not install the O-ring in wrong place.



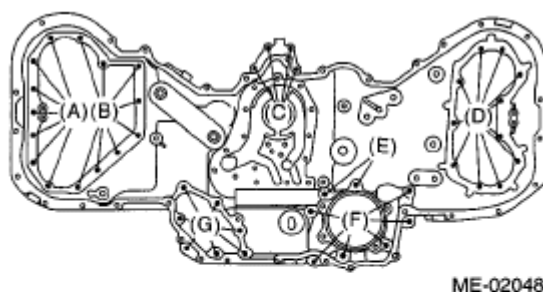
- (A) 14.2 × 1.9
(B) 19.2 × 2.4
(C) 25 × 2
(D) 31.2 × 1.9

Fig. 91: Identifying O-Ring

4. 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. 92: Identifying Rear Chain Cover Bolts

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

Tightening torque:

TIGHTENING TORQUE SPECIFICATION

(1) - (11)	9 N.m (0.9 kgf-m, 6.5 ft-lb)
(12) - (19)	20 N.m (2.0 kgf-m, 14 ft-lb)
(20) - (30)	9 N.m (0.9 kgf-m, 6.5 ft-lb)
(31) - (38)	12 N.m (1.2 kgf-m, 8.7 ft-lb)
(39) - (45)	9 N.m (0.9 kgf-m, 6.5 ft-lb)

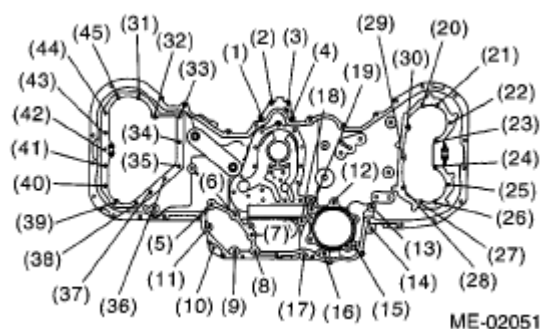


Fig. 93: Tightening Sequence Of Bolts

6. Install the water pump. < Ref. to **INSTALLATION** , Water Pump. >
7. Install the oil pump. < Ref. to **INSTALLATION** , Oil Pump. >
8. Install the crank sprocket.
9. Install the cam sprocket. < Ref. to **INSTALLATION** , Cam Sprocket. >

10. Install the timing chain. < Ref. to **INSTALLATION**, Timing Chain Assembly. >
11. Install the front chain cover.

< Ref. to **INSTALLATION**, Front Chain Cover. >

12. Install the crank pulley. < Ref. to **INSTALLATION**, Crank Pulley. >

CAMSHAFT

REMOVAL

1. Remove the crank pulley. < Ref. to **REMOVAL**, Crank Pulley. >
2. Remove the front chain cover. < Ref. to **REMOVAL**, Front Chain Cover. >
3. Remove the timing chain assembly.

< Ref. to **REMOVAL**, Timing Chain Assembly. >

4. Remove the cam sprocket.

< Ref. to **REMOVAL**, Cam Sprocket. >

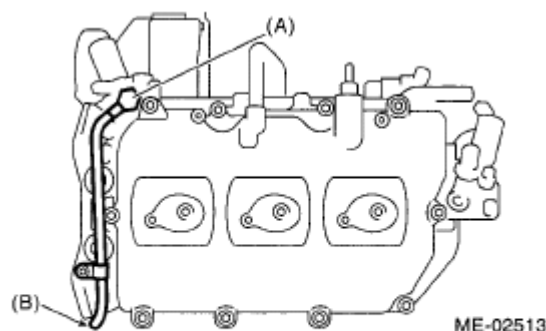
5. Remove the crank sprocket.

< Ref. to **REMOVAL**, Crank Sprocket. >

6. Remove the rear chain cover.

< Ref. to **REMOVAL**, Rear Chain Cover. >

7. Disconnect the oil pipe.



(A) Bolt without filter (with protrusion)

(B) Bolt with filter (without protrusion)

Fig. 94: Locating Oil Pipe

8. Remove the rocker cover (LH).

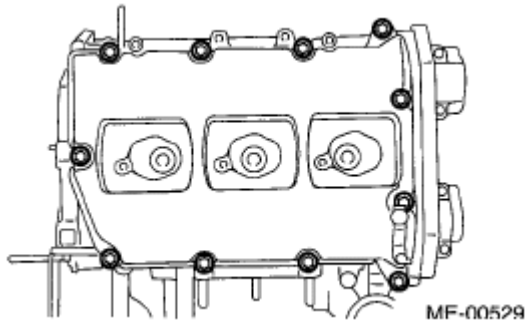


Fig. 95: Locating Rocker Cover (LH)

9. Remove the plugs (LH).

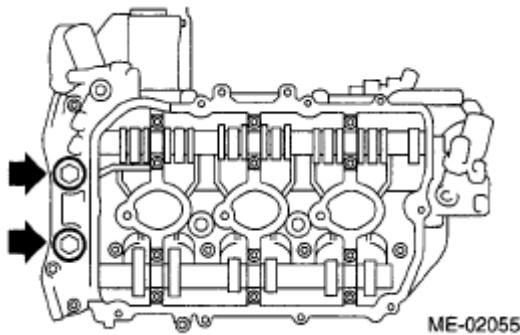


Fig. 96: Locating Plugs (LH)

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

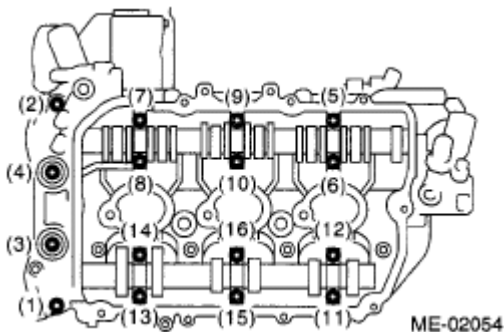


Fig. 97: Identifying Camshaft Cap Bolts

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

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

12. Similarly, remove the camshafts (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.

Liquid gasket:

THREE BOND 1280B (Part No. K0877YA018)

Applying liquid gasket diameter:

$2.0 \pm 0.5 \text{ mm}$ ($0.079 \pm 0.020 \text{ in}$)

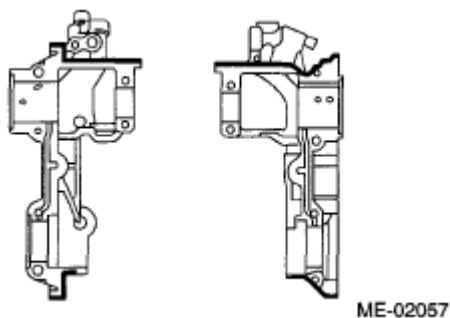


Fig. 98: Applying Liquid Gasket Diameter

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, 12 ft-lb)

(13) - (16): 9.75 N.m (1.0 kgf-m, 7.2 ft-lb)

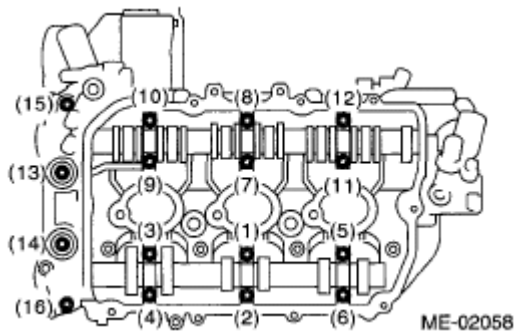


Fig. 99: Tightening Sequence Of Rocker Cover Bolts

3. Install the plugs.

Tightening torque:

60 N.m (6.1 kgf-m, 44 ft-lb)

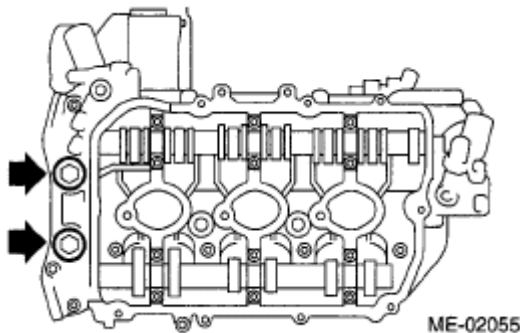


Fig. 100: Locating Plugs

4. Install the rocker cover.
 1. 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.

Liquid gasket:

THREE BOND 1280B (Part No. K0877YA018)

- LH side

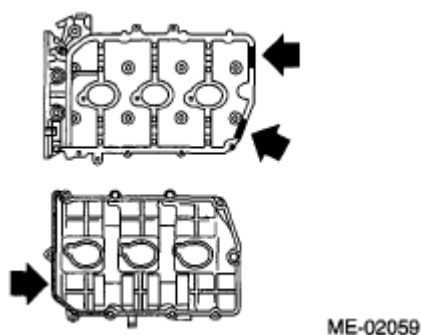


Fig. 101: Identifying Rocker Cover (LH Side)

- RH side

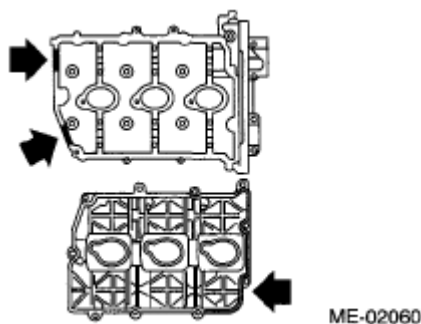


Fig. 102: Identifying Rocker Cover (RH Side)

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

Tightening torque:

6.4 N.m (0.65 kgf-m, 4.7 ft-lb)

- LH side

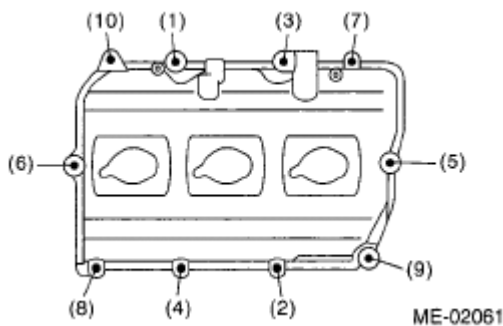


Fig. 103: Tightening Sequence Of Rocker Cover Bolts For LH Side

- RH side

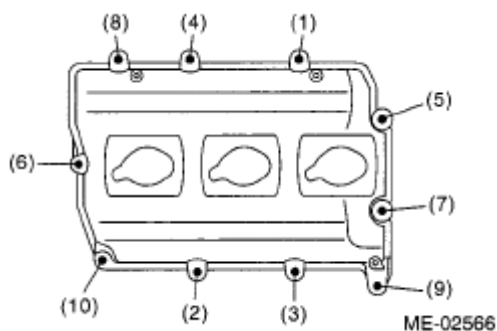


Fig. 104: Tightening Sequence Of Rocker Cover Bolts For RH Side

5. Connect the oil pipe.

CAUTION:

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

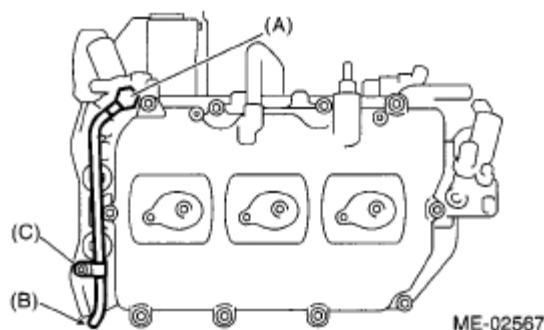
Tightening torque:

(A), (B)

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

(C)

6.4 N.m (0.65 kgf-m, 4.7 ft-lb)



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

Fig. 105: Identifying Oil Pipe

6. Install the rear chain cover. < Ref. to **INSTALLATION**, Rear Chain Cover. >

7. Install the crank sprocket.

< Ref. to **INSTALLATION**, Crank Sprocket. >

8. Install the cam sprocket.

< Ref. to **INSTALLATION**, Cam Sprocket. >

9. Install the timing chain assembly.

< Ref. to **INSTALLATION**, Timing Chain Assembly. >

10. Install the front chain cover.

< Ref. to **INSTALLATION**, Front Chain Cover. >

11. Install the crank pulley.

< Ref. to **INSTALLATION**, Crank Pulley. >

INSPECTION

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

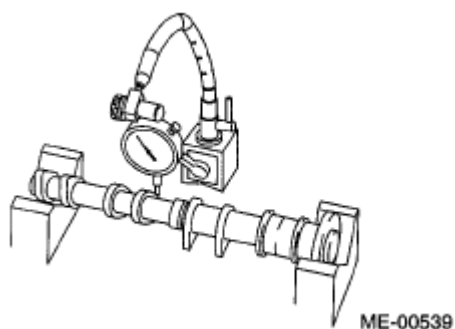


Fig. 106: Identifying Bend Of Camshaft

2. Check the journal for damage and wear. Replace if faulty.
3. Measure the outside diameter of camshaft journal. If the journal diameter is not within specification, check the oil clearance.

CAMSHAFT JOURNAL SPECIFICATION

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

4. Measurement of the camshaft journal oil clearance:
 1. Clean the bearing caps and camshaft journals.
 2. Place the camshafts on cylinder head. (Without installing the valve rocker.)

3. Place a plastigage across each camshaft journals.
4. Install the bearing cap.

NOTE: Do not turn the camshaft.

5. Remove the bearing caps.
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)

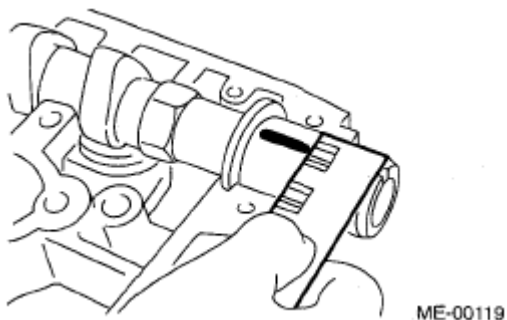


Fig. 107: Measuring Widest Point Of Plastigage

7. Completely remove the plastigage.
5. 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)

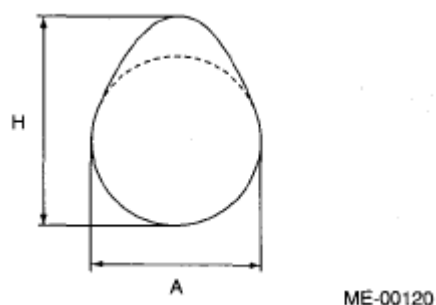
LOW1 38.14 - 38.24 mm (1.5016 - 1.5055 in)

LOW2 34.94 - 35.04 mm (1.3756 - 1.3795 in)

Exhaust

41.65 - 41.75 mm (1.6398 - 1.6437 in)

Cam base circle diameter A:

Intake**HIGH 32.0 mm (1.2598 in)****LOW1 31.84 mm (1.2535 in)****LOW2 31.84 mm (1.2535 in)****Exhaust****32.0 mm (1.2598 in)****Fig. 108: Checking Cam Height**

6. 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 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

1. Remove the crank pulley. < Ref. to **REMOVAL**, Crank Pulley. >
2. Remove the front chain cover. < Ref. to **REMOVAL**, Front Chain Cover. >
3. Remove the timing chain assembly.

< Ref. to **REMOVAL**, Timing Chain Assembly. >

4. Remove the cam sprocket.

< Ref. to **REMOVAL**, Cam Sprocket. >

5. Remove the crank sprocket.

< Ref. to **REMOVAL**, Crank Sprocket. >

6. Remove the rear chain cover.

< Ref. to **REMOVAL**, Rear Chain Cover. >

7. Remove the camshaft. < Ref. to **REMOVAL**, Camshaft. >

8. 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.

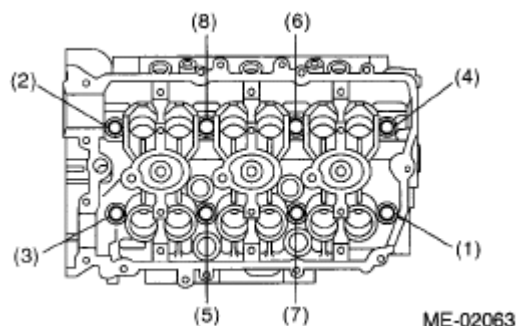


Fig. 109: Identifying Crank Sprocket

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

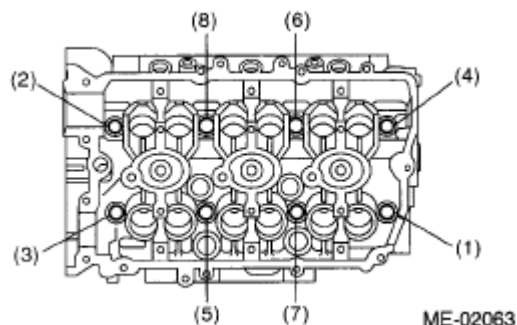


Fig. 110: Locating Cylinder Head Bolts

11. Remove the cylinder head gasket.

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

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

INSTALLATION

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

CAUTION:

- Use new cylinder head gaskets.
- Be careful not to scratch the mating surface of cylinder head and cylinder block.

2. Tighten the cylinder head bolts.
 1. Apply a coat of engine oil to washers and cylinder head bolt threads.
 2. Install the cylinder head to cylinder block, and then tighten the bolts with torque of 20 N.m (2.0 kgf-m, 14 ft-lb) in numerical sequence as shown in the figure.
 3. Tighten the bolts with torque of 50 N.m (5.1 kgf-m, 37 ft-lb) in numerical sequence as shown in the figure.
 4. Loosen all the bolts by 180° in reverse order of installation, and loosen again by 180° in the same order.
 5. Tighten the bolts with torque of 20 N.m (2.0 kgf-m, 14 ft-lb) in numerical sequence as shown in the figure.
 6. Tighten the bolts (1) - (4) with torque of 48 N.m (4.9 kgf-m, 35.4 ft-lb) in numerical sequence.
 7. Tighten the bolts (5) - (8) with torque of 44 N.m (4.5 kgf-m, 33 ft-lb) in numerical sequence.
 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.

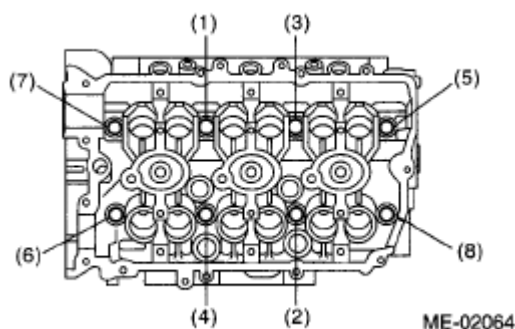


Fig. 111: Identifying Cylinder Head Bolts

3. Install the camshaft. < Ref. to **INSTALLATION**, Camshaft. >
4. Install the rear chain cover. < Ref. to **INSTALLATION**, Rear Chain Cover. >
5. Install the crank sprocket.

< Ref. to **INSTALLATION**, Crank Sprocket. >

6. Install the cam sprocket.

< Ref. to **INSTALLATION**, Cam Sprocket. >

7. Install the timing chain assembly.

< Ref. to **INSTALLATION**, Timing Chain Assembly. >

8. Install the front chain cover.

< Ref. to **INSTALLATION**, Front Chain Cover. >

9. Install the crank pulley.

< Ref. to **INSTALLATION**, Crank Pulley. >

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: **Keep all the removed parts in order for re-installing in their original positions.**

CAUTION:

- **Mark each valve to prevent confusion.**
- **Pay careful attention not to damage the lips of intake valve oil seals and exhaust valve oil seals.**

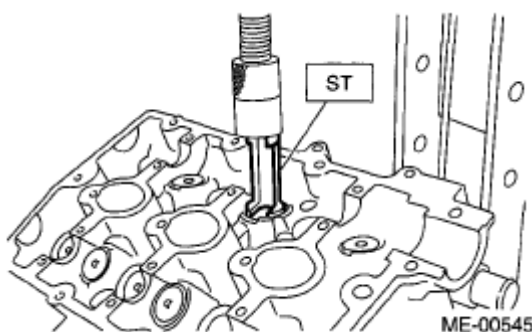


Fig. 112: Identifying Intake Valve Oil Seals And Exhaust Valve Oil Seals

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 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.

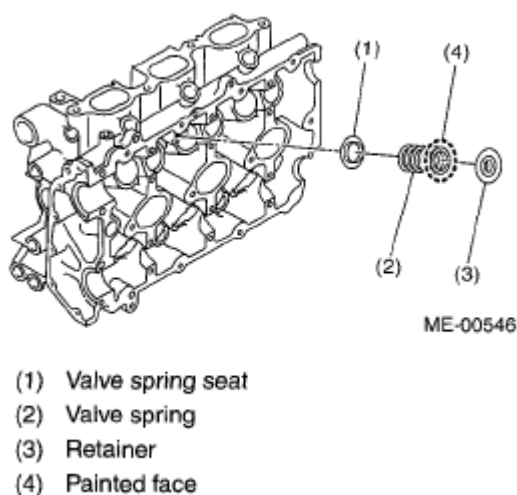


Fig. 113: Identifying Valve Spring And Retainer

4. Set the ST on valve spring.

ST 499718000 VALVE SPRING REMOVER

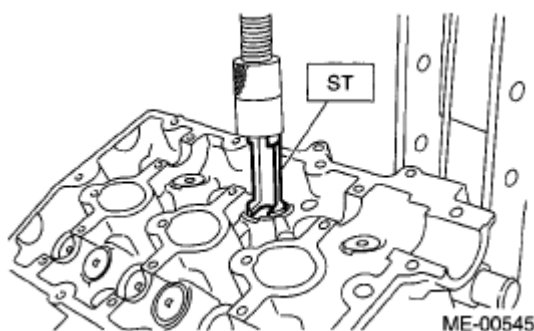


Fig. 114: Identifying ST 499718000 Valve Spring Remover

5. Compress the valve spring and fit the valve spring retainer key.
6. After installing, tap the valve spring retainers lightly with a wooden hammer for better seating.
2. Apply oil to the surface of valve lifter and valve shim.
3. Install the valve lifter and valve shim.

INSPECTION

CYLINDER HEAD

1. Make sure that no crack or other damages do not exist. In addition to visual inspection, inspect important areas using liquid penetrant tester. Check that there are no marks of gas leaking or water leaking on gasket installing surface.
2. Set the cylinder head on ST.

ST 18250AA010 CYLINDER HEAD TABLE

3. Measure the flatness of the cylinder head surface that mates with crankcase using a straight edge (A) and thickness gauge (B).

Flatness:

Standard

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 nuts can cause warping. When reinstalling, pay special attention to the torque so as to tighten evenly.

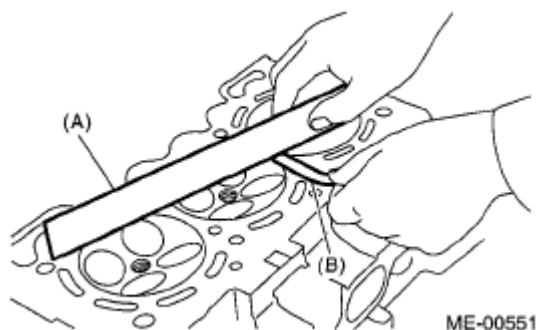


Fig. 115: Measuring Flatness Of Cylinder Head Surface

VALVE SEAT

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

Valve seat width W:

Intake

Standard

1.0 mm (0.039 in)

Exhaust

Standard

1.5 mm (0.059 in)

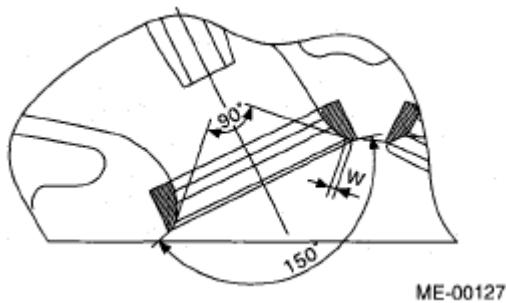


Fig. 116: Checking Valve Seat Width

VALVE GUIDE

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

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

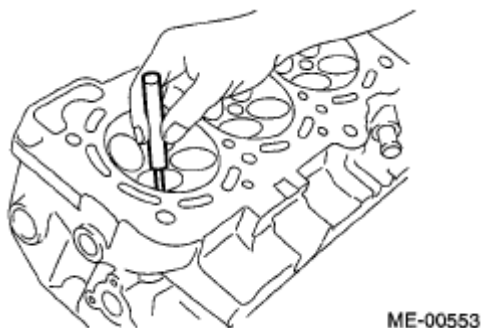


Fig. 117: Identifying ST1 18250Aa010 Cylinder Head Table And ST2 499765700 Valve Guide Remover

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

ST 18251AA040 VALVE GUIDE ADJUSTER

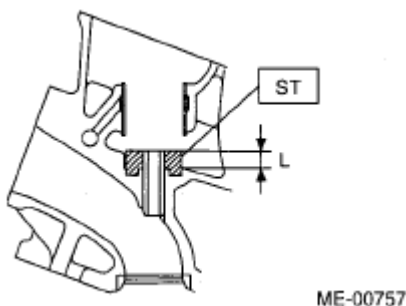


Fig. 118: Identifying Valve Guide Adjuster ST 18251AA020 On Cylinder Head

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

ST1 499765700 VALVE GUIDE REMOVER

ST2 18251AA040 VALVE GUIDE ADJUSTER

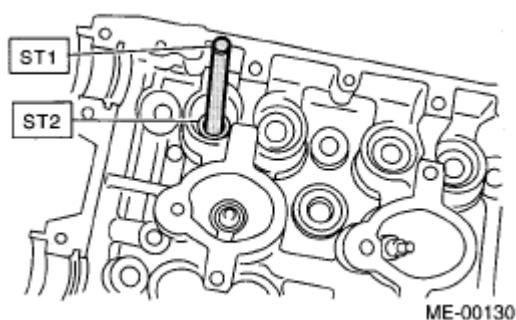


Fig. 119: Identifying Valve Guide Remover ST1 499767200 And Valve Guide Adjuster ST2 18251Aa020

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 reamer in valve guide, and rotate the reamer slowly clockwise while pushing it lightly. Bring the reamer back while rotating it clockwise. After reaming, clean the valve guide to remove chips.

ST 499765900 VALVE GUIDE REAMER

NOTE:

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

8. 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 valve, and replace if damaged, worn or deformed, or if "H" exceeds the standard, or offset wear occurs.

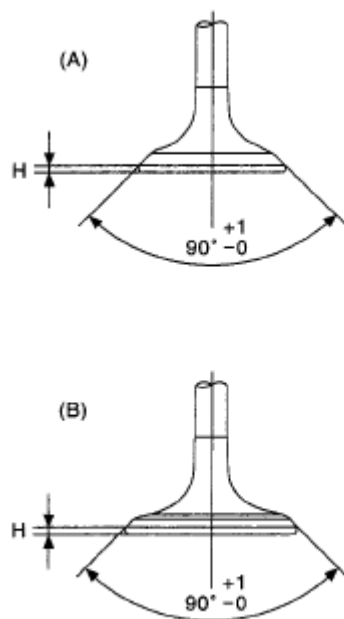
H:

Intake (A)

Standard

1.0 mm (0.039 in)

Exhaust (B)

Standard**1.2 mm (0.047 in)****Valve overall length:****Intake (A)****99.7 mm (3.925 in)****Exhaust (B)****105.2 mm (4.142 in)**

ME-02096

Fig. 120: Inserting Intake And Exhaust Valve

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

VALVE SPRING

- 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 SPECIFICATION

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)
		Outer	2.5°, 1.8 mm (0.071 in)
	Exhaust		2.5°, 2.0 mm (0.079 in)

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

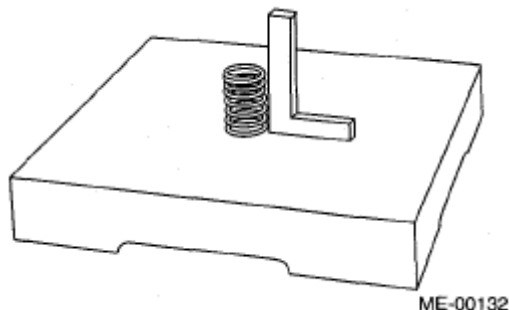


Fig. 121: Measuring Squareness Of Valve Spring

INTAKE AND EXHAUST VALVE OIL SEAL

In the following case, pinch and remove the oil seal from valve using pliers, and then replace it with a new part.

- When the lip is damaged.
- When the spring is out of the specified position.
- When readjusting the surfaces of intake valve and valve sheet.
- When replacing the intake valve guide.

- Set the cylinder head on ST1.
- Press-fit the oil seal to the specified dimension indicated in the figure using ST2.

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 or strike in.

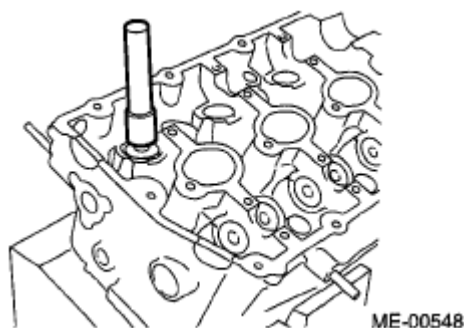


Fig. 122: Setting Cylinder Head On ST1

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)

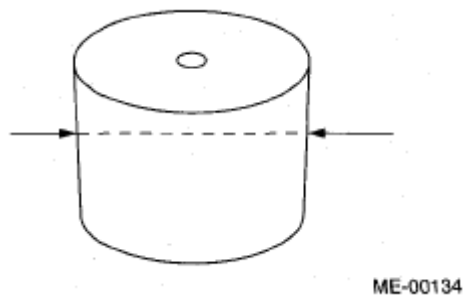


Fig. 123: Checking Outer Diameter Of Valve Lifter

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

Inner diameter:

32.994 - 33.016 mm (1.2990 - 1.2998 in)

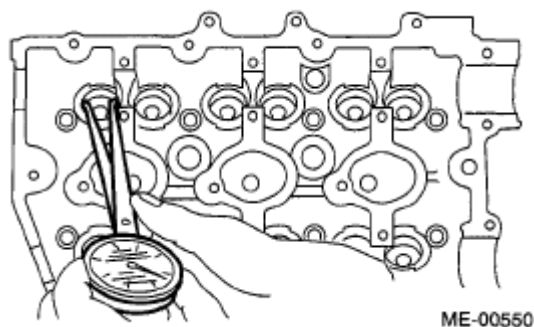


Fig. 124: Measuring Inner Diameter Of Valve Lifter Hole Of Cylinder Head

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 crank pulley. < Ref. to **REMOVAL**, Crank Pulley. >
2. Remove the front chain cover. < Ref. to **REMOVAL**, Front Chain Cover. >
3. Remove the timing chain assembly.

< Ref. to **REMOVAL**, Timing Chain Assembly. >

4. Remove the cam sprocket.

< Ref. to **REMOVAL**, Cam Sprocket. >

5. Remove the crank sprocket.

< Ref. to **REMOVAL**, Crank Sprocket. >

6. Remove the rear chain cover.

< Ref. to **REMOVAL**, Rear Chain Cover. >

7. Remove the camshaft. < Ref. to **REMOVAL**, Camshaft. >

8. Remove the cylinder head. < Ref. to **REMOVAL**, Cylinder Head. >
9. Remove the drive plate.

Using the ST, lock the crankshaft.

ST 498497100 CRANKSHAFT STOPPER

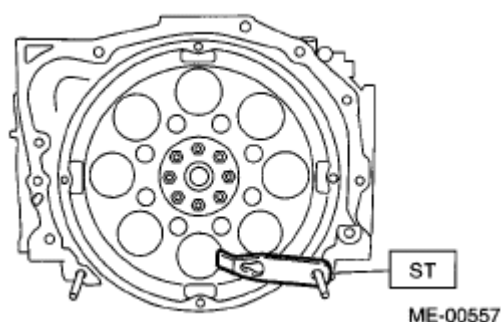


Fig. 125: Identifying ST 498497100 Crankshaft Stopper

10. Remove the crankshaft position sensor plate.

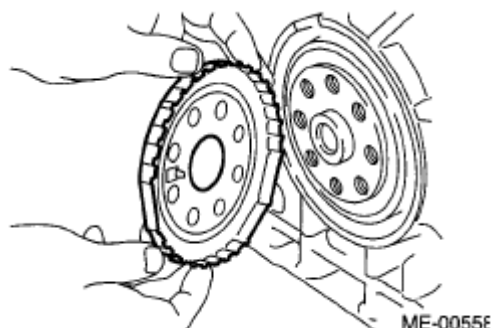


Fig. 126: Identifying Crankshaft Position Sensor Plate

11. Remove the crankshaft position sensor bracket.

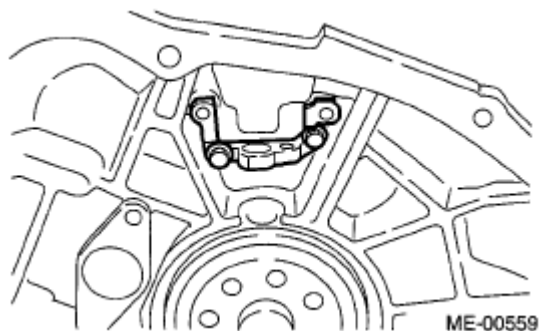


Fig. 127: Identifying Crankshaft Position Sensor Bracket

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

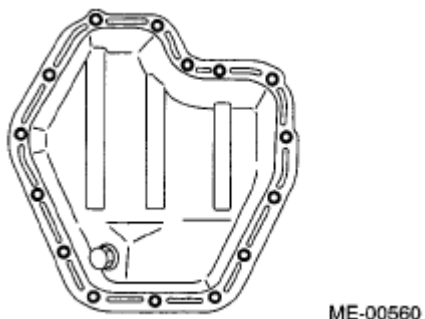


Fig. 128: Identifying Oil Pan

14. 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.

15. Remove the oil strainer.

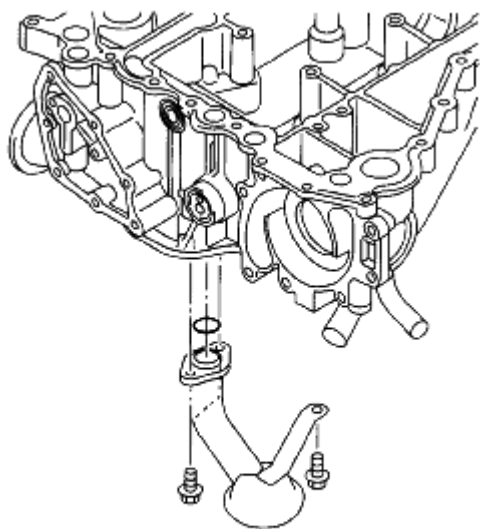
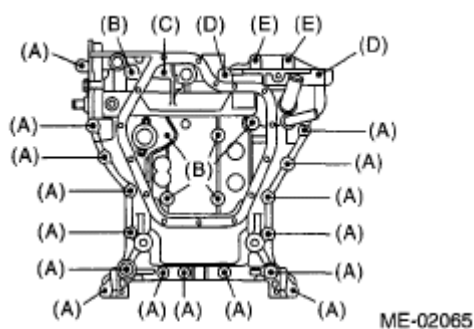


Fig. 129: Identifying Oil Strainer

16. 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
- (E) M8 × 24

Fig. 130: Identifying Oil Pan Bolts

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

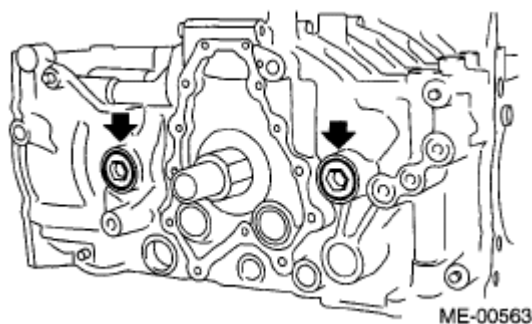


Fig. 131: Locating Service Hole Cover And Service Hole Plugs

18. 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

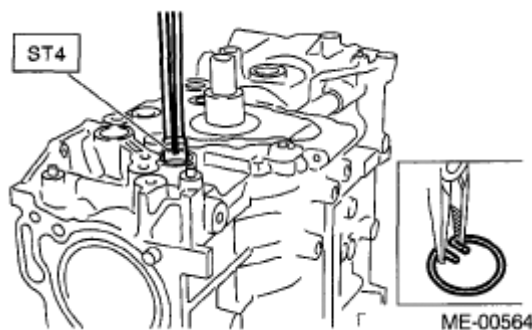


Fig. 132: Removing Piston Snap Ring Through Service Hole

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

ST 499097500 PISTON PIN REMOVER

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

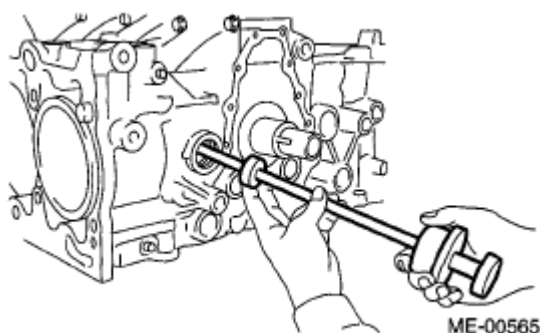


Fig. 133: Drawing Out Piston Pin From Pistons Using ST

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

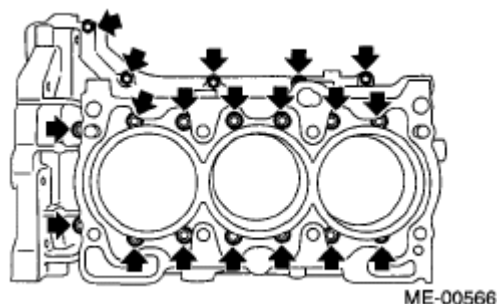


Fig. 134: Identifying Cylinder Block Bolts

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

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

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

NOTE:

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

26. 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 bearing and cylinder block before installation. Apply a coat of engine oil to crankshaft pins.

2. Position the crankshaft and connecting rod on #2, #4 and #6 cylinder block.
3. Apply liquid gasket to the mating surface of the #1, #3 and #5 cylinder blocks, and position it on #2, #4 and #6 cylinder blocks.

Liquid gasket:

Three bond 1215B (Part No. 004403007)

NOTE: Do not allow liquid gasket to run over to O-ring grooves, oil passages, bearing grooves, etc.

Applying liquid gasket diameter:

1.0±0.2 mm (0.039±0.008 in)

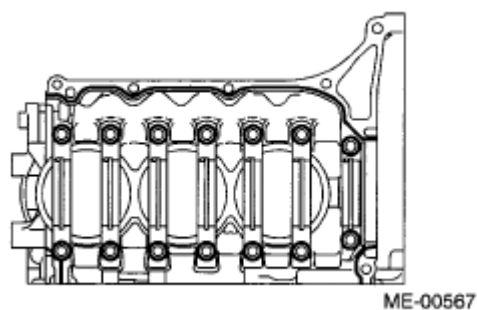


Fig. 135: Applying Liquid Gasket Diameter

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

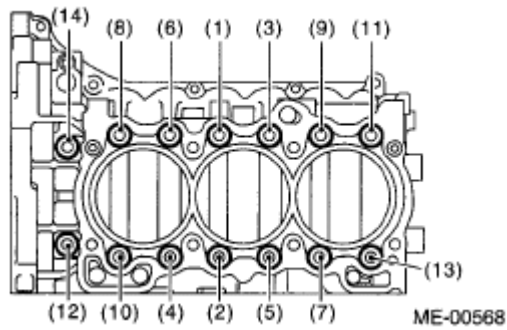


Fig. 136: Tightening Sequence Of Bolts

6. Retighten 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 ft-lb)

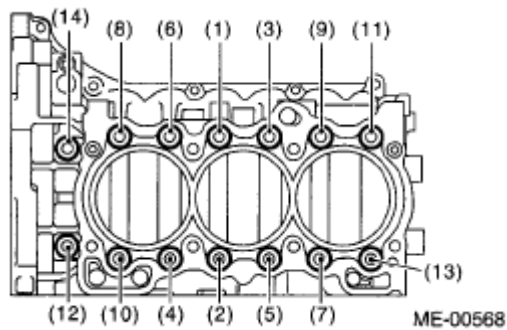


Fig. 137: Tightening Sequence Of Bolts

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

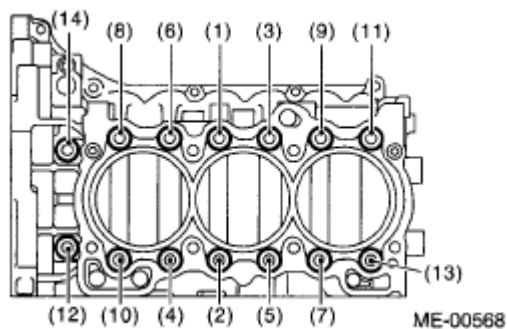


Fig. 138: Tightening Sequence Of Bolts

8. Install the upper bolt to cylinder block.

Tightening torque:

25 N.m (2.5 kgf-m, 18 ft-lb)

NOTE: Remove the liquid gasket which is running over to sealing surface between cylinder block and rear chain cover, cylinder block and oil pan upper, after tightening the bolts which combine the cylinder block.

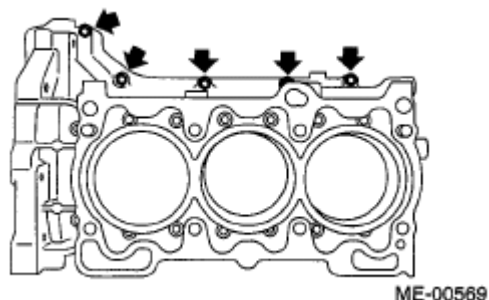


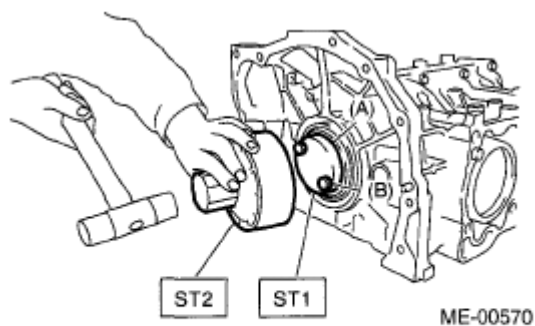
Fig. 139: Identifying Cylinder Block Bolts

9. Install the rear oil seal using ST1 and ST2.

ST1 499597100 CRANKSHAFT OIL SEAL GUIDE

ST2 499587200 CRANKSHAFT OIL SEAL INSTALLER

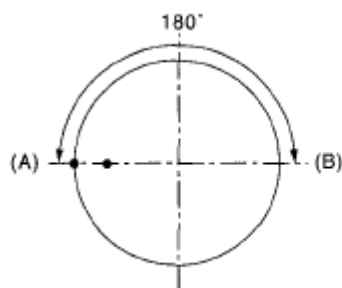
NOTE: Apply engine oil to the pressing-in portion.



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

Fig. 140: Applying Engine Oil To Pressing-In Portion

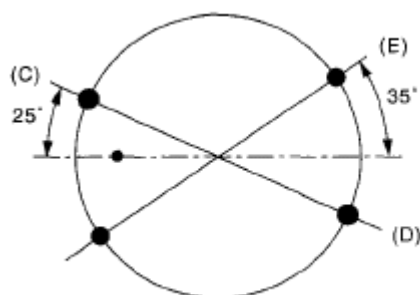
10. Position the top ring gap at (A) in the figure.
11. Position the second ring gap at (B).



ME-02066

Fig. 141: Identifying Second Ring

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.



ME-02067

Fig. 142: Identifying Lower Rail**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.

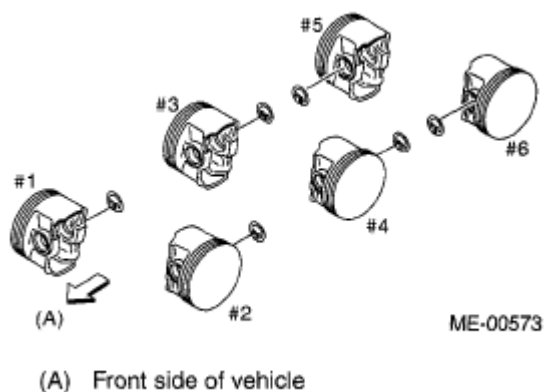


Fig. 143: Locating Snap Rings

16. Installing piston:

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

ST1 18252AA000 CRANKSHAFT SOCKET

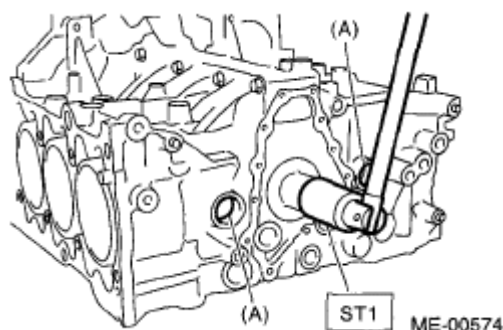


Fig. 144: Identifying Service Hole

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

ST2 18254AA000 PISTON GUIDE

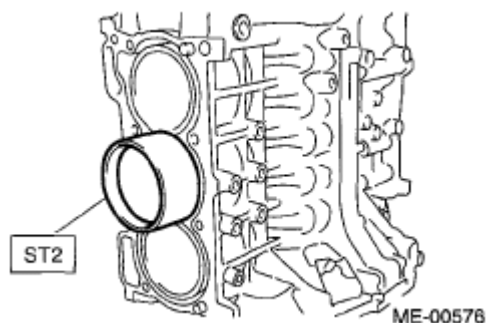
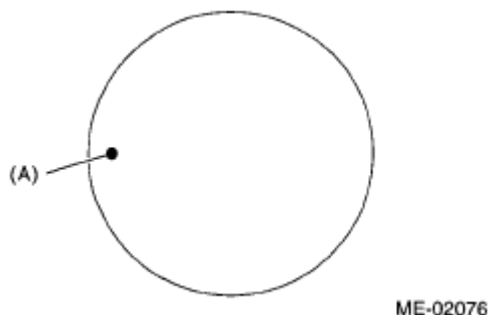


Fig. 145: Pressing Piston Into Cylinder

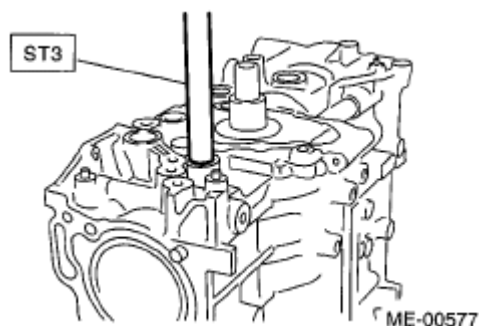
NOTE: Let the piston front mark (A) face towards the front of engine.

**Fig. 146: Identifying Piston Front Mark**

17. Installing piston pin:

1. Apply a thin 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 GUIDE

**Fig. 147: Identifying ST3 18253Aa000 Piston Guide**

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

ST4 18233AA000 PISTON PIN SNAP RING PLIERS

NOTE: Use new snap rings.

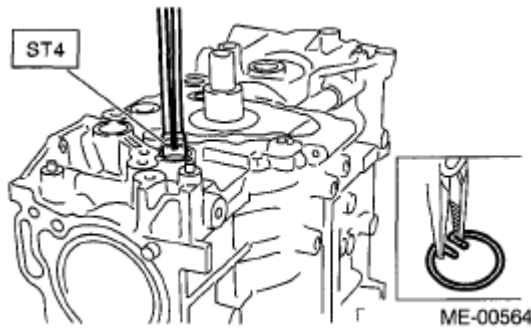


Fig. 148: Identifying Snap Rings

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.

Liquid gasket:

THREE BOND 1280B (Part No. K0877YA018)

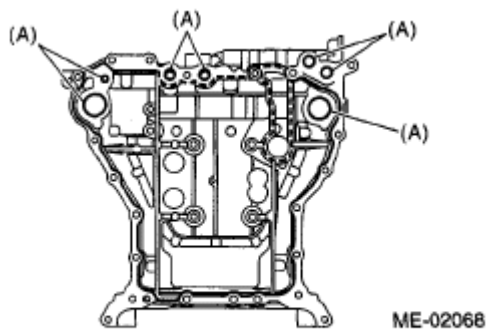
Applying liquid gasket diameter:

Full line part

3.0±1.0 mm (0.12±0.04 in)

Broken line part

1.0 mm (0.04 in)



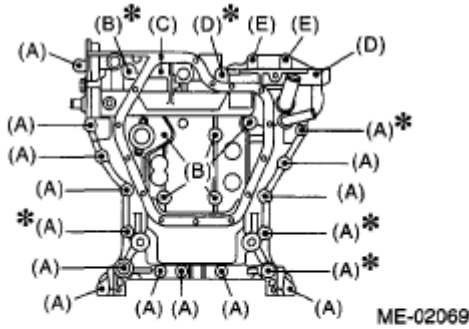
(A) O-ring

Fig. 149: Applying Liquid Gasket To Mating Surface Of Oil Pan Upper

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
- (E) M8 × 24
- *: Coating

Fig. 150: Locating Oil Pan Upper Bolts

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)

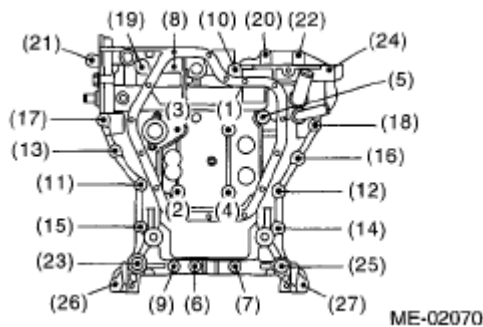


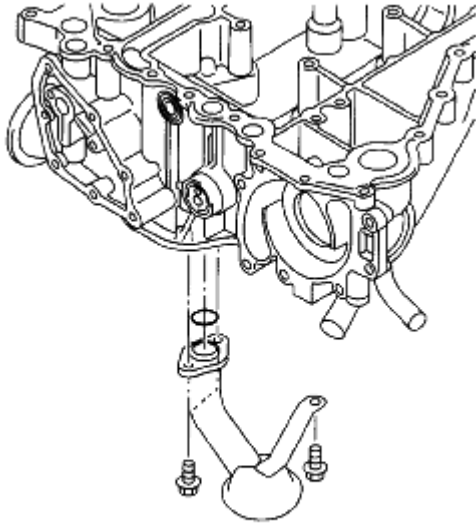
Fig. 151: Locating Oil Pan Upper Bolts

22. Install the oil strainer.

Tightening torque:

6.4 N.m (0.65 kgf-m, 4.7 ft-lb)

NOTE: Use new O-rings.



LU-02108

Fig. 152: Identifying O-Rings

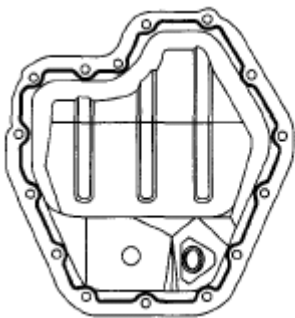
23. Apply liquid gasket to the matching surface of oil pan lower.

Liquid gasket:

THREE BOND 1280B (Part No. K0877YA018)

Applying liquid gasket diameter:

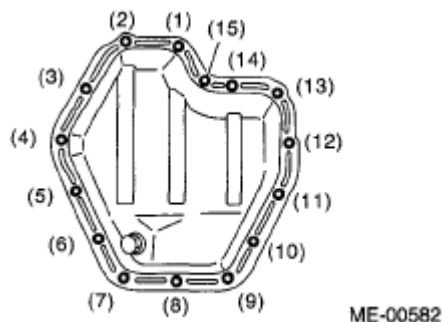
5.0±1.0 mm (0.20±0.04 in)



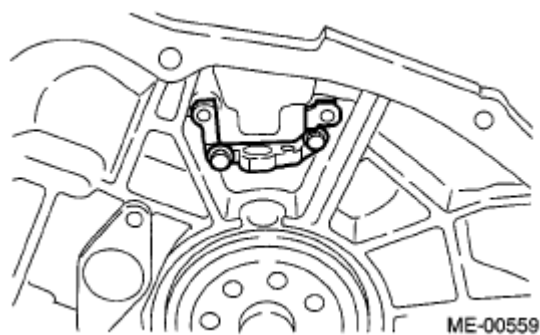
ME-00581

Fig. 153: Applying Liquid Gasket To Matching Surface Of Oil Pan Lower

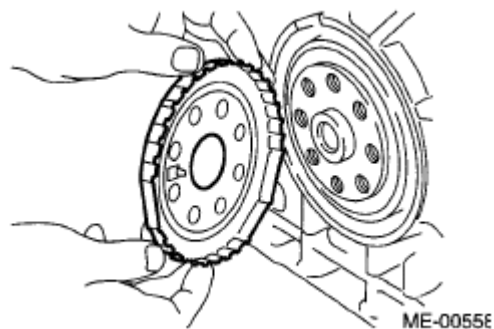
24. Tighten the oil pan lower installing bolts in the numerical order as shown in the figure.

Tightening torque:***6.4 N.m (0.65 kgf-m, 4.7 ft-lb)*****Fig. 154: Locating Oil Pan Lower Bolts**

25. Install the crankshaft sensor bracket.

Tightening torque:***6.4 N.m (0.65 kgf-m, 4.7 ft-lb)*****Fig. 155: Identifying Crankshaft Sensor Bracket**

26. Install the crankshaft sensor plate.

**Fig. 156: Locating Crankshaft Sensor Plate**

27. Install the drive plate.

To lock the crankshaft, use ST.

ST 498497100 CRANKSHAFT STOPPER

Tightening torque:

81 N.m (8.3 kgf-m, 60 ft-lb)

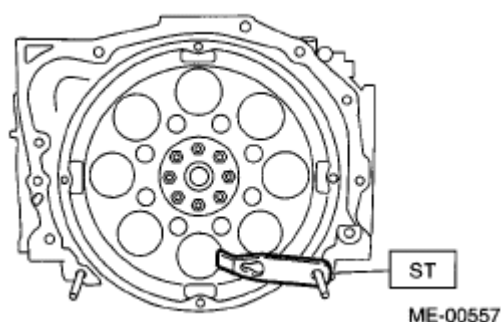


Fig. 157: Identifying Drive Plate

28. Install the cylinder head. < Ref. to **INSTALLATION**, Cylinder Head. >
29. Install the camshaft. < Ref. to **INSTALLATION**, Camshaft. >
30. Install the rear chain cover. < Ref. to **INSTALLATION**, Rear Chain Cover. >
31. Install the crank sprocket.

< Ref. to **INSTALLATION**, Crank Sprocket. >

32. Install the cam sprocket. < Ref. to **INSTALLATION**, Cam Sprocket. >
33. Install the timing chain assembly.

< Ref. to **INSTALLATION**, Timing Chain Assembly. >

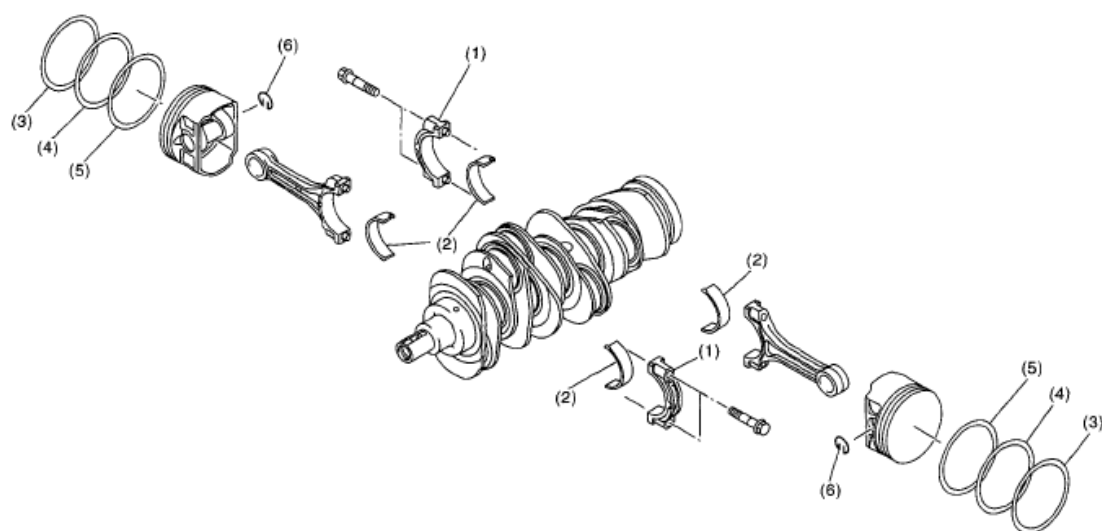
34. Install the front chain cover.

< Ref. to **INSTALLATION**, Front Chain Cover. >

35. Install the crank pulley.

< Ref. to **INSTALLATION**, Crank Pulley. >

DISASSEMBLY



ME-02097

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

Fig. 158: Exploded View Of Crankshaft Assembly Components

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 good order to prevent confusion.

5. Remove the snap ring.

ASSEMBLY

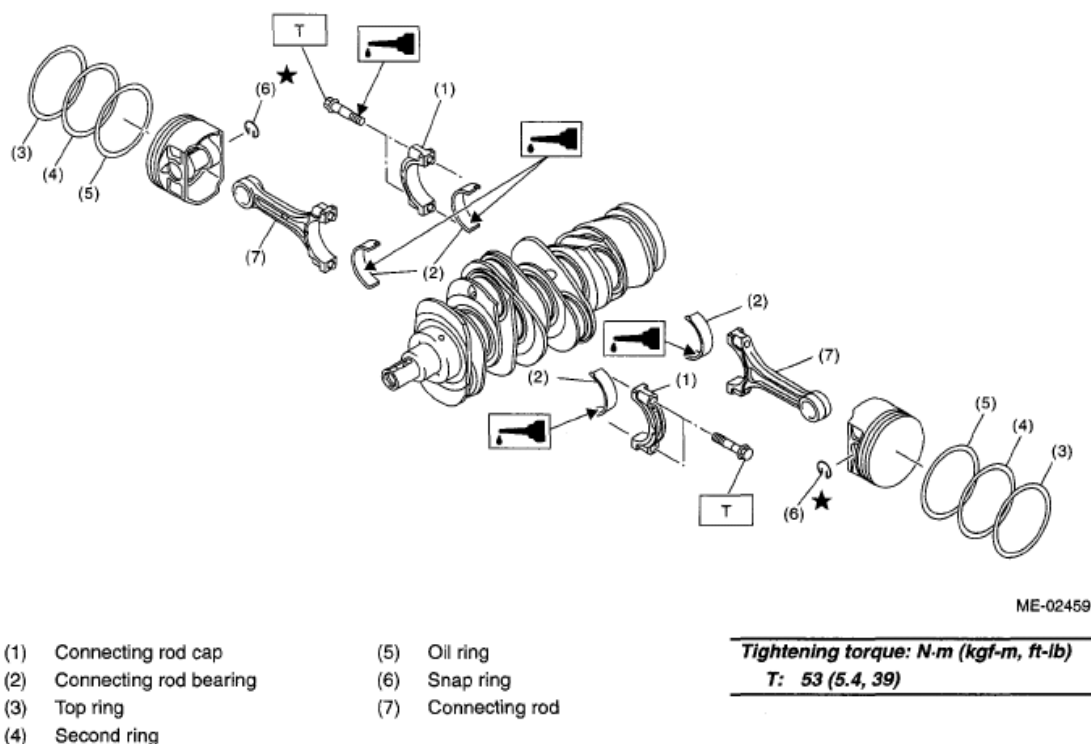


Fig. 159: Exploded View Of Crankshaft Assembly Components

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

NOTE: 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.

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

INSPECTION

CYLINDER BLOCK

1. Visually check for cracks and damage. Especially, inspect the important parts using liquid penetrant tester.
2. Check the oil passages for clogging.
3. Inspect the crankcase surface that mates with cylinder head for warping by using a straight edge.

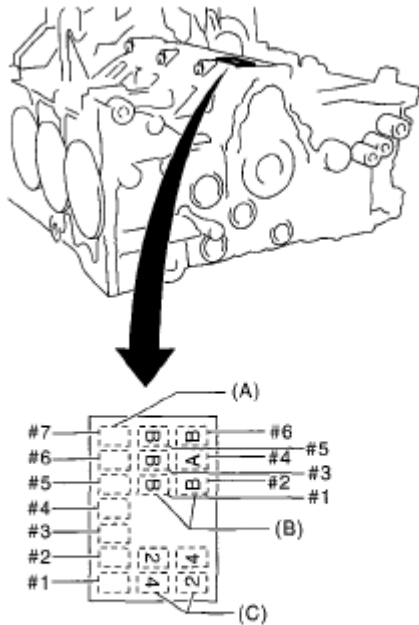
Standard height of cylinder block:***202 mm (7.95 in)*****CYLINDER AND PISTON**

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

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)***



ME-00585

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

Fig. 160: Identifying Standard Sized Pistons

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)

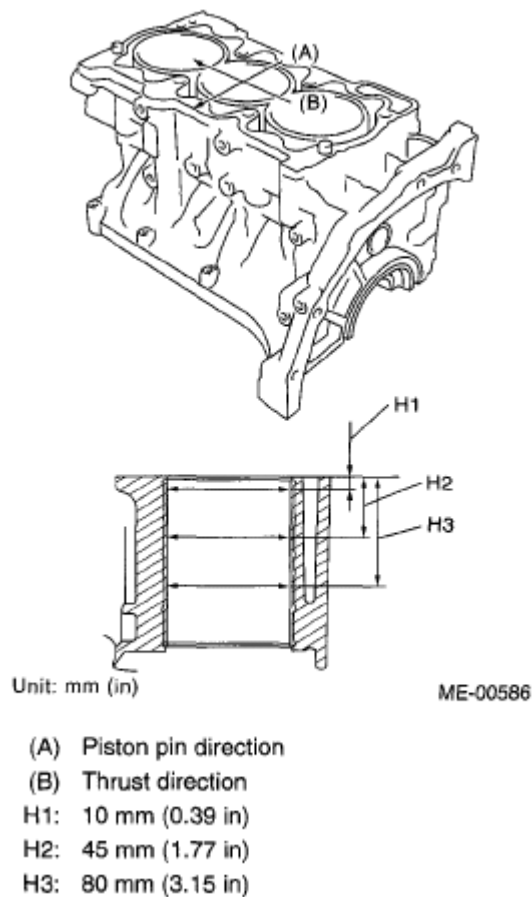


Fig. 161: Checking Inner Diameter Of Cylinder

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)

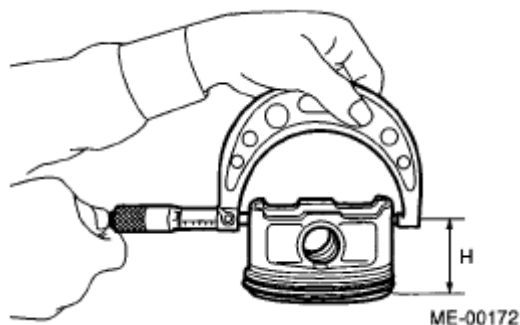


Fig. 162: Measuring Outer Diameter Of Piston

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, all other cylinders must be bored at the same time, and use oversize pistons. Do not perform boring on one cylinder only. Nor use an oversize piston for one cylinder only.

2. If the cylinder inner diameter exceeds 89.715 mm (3.5321 in) after boring and honing, replace the crankcase.

NOTE: Immediately after reboring, the cylinder diameter may differ from its real diameter due to temperature rise. Thus, pay attention to this when measuring the cylinder diameter.

PISTON AND PISTON PIN

1. Check the pistons and piston pins for damage, cracks and wear, and the piston ring grooves for wear and damage. Replace if faulty.
2. Measure the piston-to-cylinder clearance at each cylinder. < Ref. to **CYLINDER AND PISTON, INSPECTION**, Cylinder Block. > If any of the clearances is not within standard, replace the piston or bore the cylinder to use an oversize piston.
3. 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:

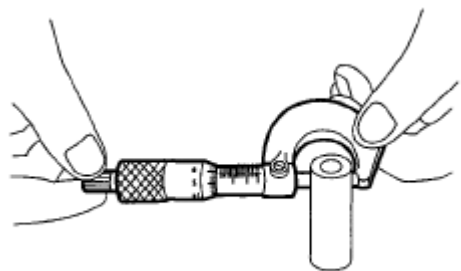
Standard

0.004 - 0.008 mm (0.0002 - 0.0003 in)



ME-00173

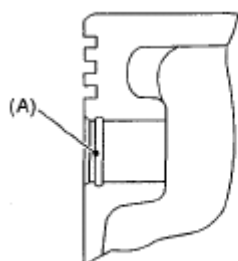
Fig. 163: Checking Clearance Between Piston Pin And Hole In Piston



ME-00174

Fig. 164: Checking Piston Pin

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



ME-00175

Fig. 165: Identifying Circlip Installation Groove On Piston

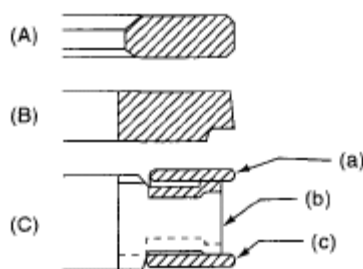
5. Check the piston pin snap ring for distortion, cracks and wear.

PISTON RING

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

CAUTION:

- Marks are displayed on the end of top and second rings. When installing the ring to piston, face this mark upward.
- Oil ring consists of the upper rail, expander and lower rail. When installing on the piston, be careful of the direction of each rail



ME-00591

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

Fig. 166: Identifying Piston Ring

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

PISTON RING GAP SPECIFICATION

	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)

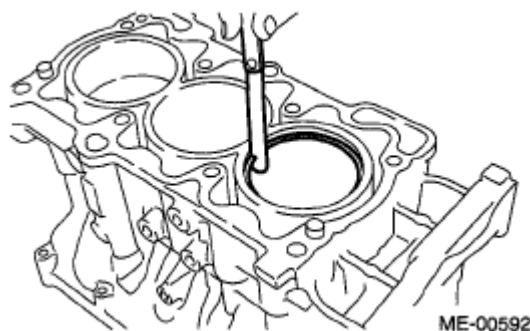


Fig. 167: Identifying Piston Ring And Oil Ring

3. Measure the clearance between piston ring and piston ring groove with a thickness gauge.

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

PISTON RING SPECIFICATION

		Standard mm (in)
Clearance between piston ring and piston ring groove	Top ring	0.040 - 0.080 (0.0016 - 0.0031)
	Second ring	0.030 - 0.070 (0.0012 - 0.0028)
Clearance between oil ring and oil ring groove		0.045 - 0.125 (0.0018 - 0.0049)

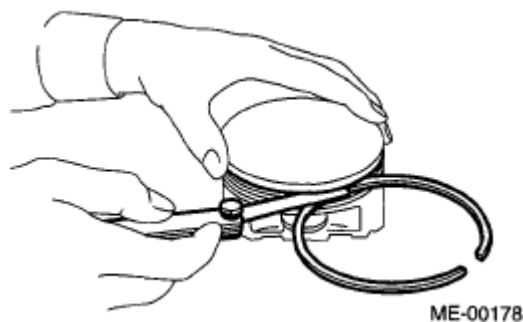
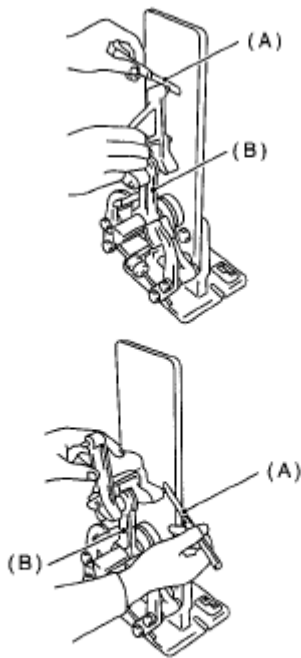


Fig. 168: Measuring Clearance Between Piston Ring And Piston Ring Groove With A Thickness Gauge

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.



ME-00179

- (A) Thickness gauge
- (B) Connecting rod

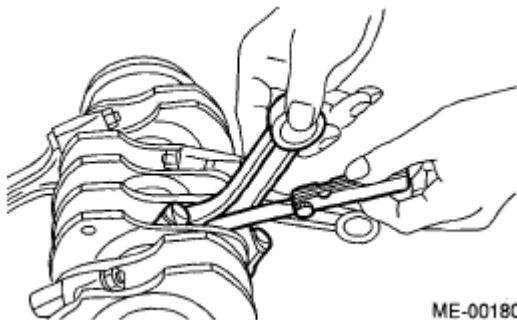
Fig. 169: Checking Connecting Rod Bend Or Twist Using Connecting Rod Aligner

3. Install the connecting rod fitted with bearing to crankshaft and measure the side clearance (thrust clearance). If the clearance exceeds the standard or uneven wear is found, replace the connecting rod.

Connecting rod side clearance:

Standard

0.070 - 0.330 mm (0.0028 - 0.0130 in)



ME-00180

Fig. 170: Checking Connecting Rod Side Clearance

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 **STANDARD BEARING SIZE (THICKNESS AT CENTER) SPECIFICATION** below.)

Connecting rod oil clearance:

Standard

0.016 - 0.043 mm (0.0006 - 0.0017 in)

STANDARD BEARING SIZE (THICKNESS AT CENTER) SPECIFICATION

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)

- Inspect the bushing at connecting rod small end, and replace if worn or damaged. Also measure the piston pin clearance at connecting rod small end.

Clearance between piston pin and bushing:

Standard

0 - 0.022 mm (0 - 0.0009 in)

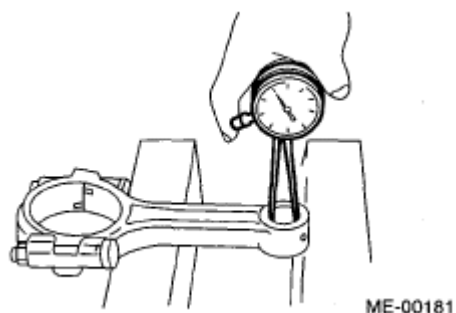


Fig. 171: Checking Clearance Between Piston Pin And Bushing

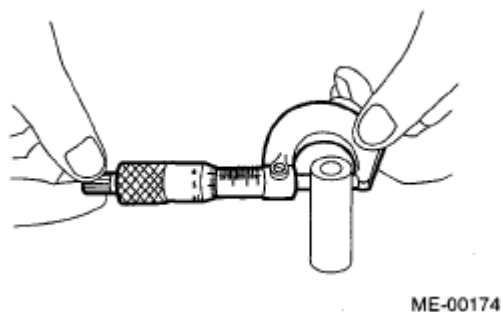


Fig. 172: Checking Piston Pin

7. Replacement procedure 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

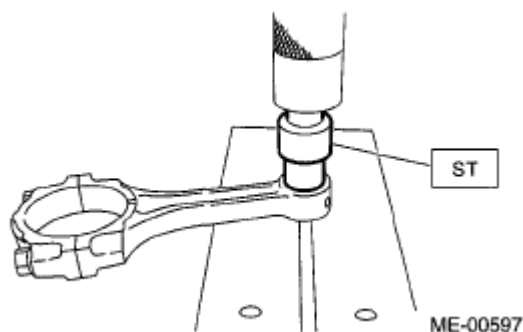


Fig. 173: Identifying ST 18350Aa000 Connecting Rod Bushing Remover And Installer

3. Make two 3 mm (0.12 in) holes in bushing. Ream the inside of bushing.
4. After completion of reaming, clean the bushing to remove chips.

CRANKSHAFT AND CRANKSHAFT BEARING

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

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.

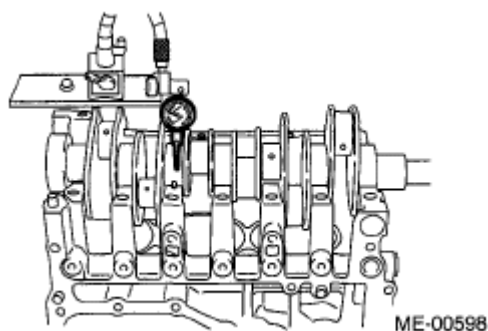


Fig. 174: Checking Crankshaft Bend Using Dial Gauge

- 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. 175: Checking Crank Journal And Crank Pin

CRANK JOURNAL AND CRANK PIN SPECIFICATION

		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)

- Measure the thrust clearance of crankshaft at center bearing. If clearance exceeds the standard, replace the bearing.

Crankshaft side clearance:

Standard

0.030 - 0.115 mm (0.0012 - 0.0045 in)

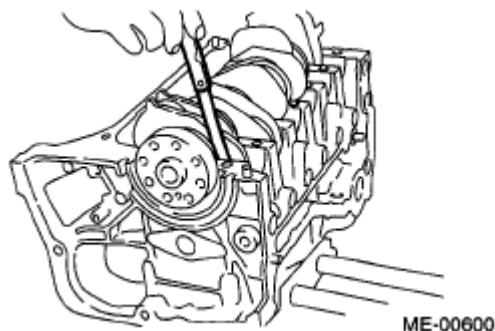


Fig. 176: Measuring Thrust Clearance Of Crankshaft

- Inspect individual crankshaft bearings for signs of flaking, seizure, melting and wear.
- 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 "Camshaft" for removal procedure. < Ref. to **REMOVAL**, Camshaft. >

INSTALLATION

Install in the reverse order of removal.

OIL SWITCHING SOLENOID VALVE

REMOVAL

1. Disconnect the ground cable from battery.

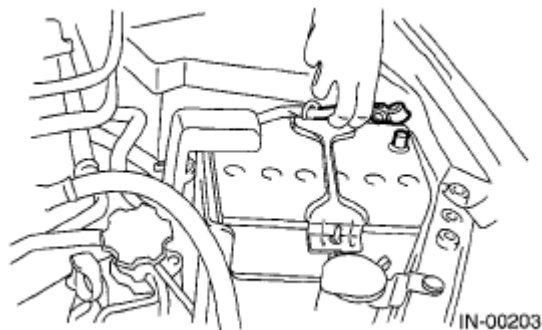


Fig. 177: Disconnecting Ground Cable From Battery

2. Remove the air intake chamber.

< Ref. to **REMOVAL** , Air Intake Chamber7. >

3. Disconnect the connector from the oil switching solenoid valve.

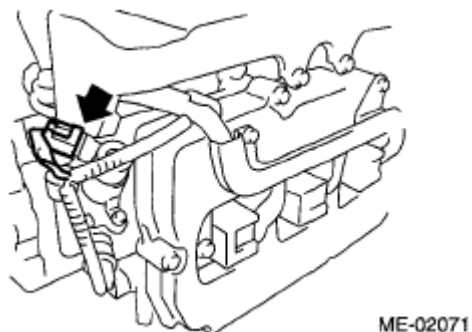


Fig. 178: Disconnecting Connector From Oil Switching Solenoid Valve

4. Remove the oil switching solenoid valve.

5. Remove the variable valve lift diagnosis oil pressure switch.

< Ref. to **REMOVAL** , Variable Valve Lift Diagnosis Oil Pressure Switch. >

6. Remove the oil temperature sensor.

< Ref. to **REMOVAL** , Oil Temperature Sensor. >

7. Remove the oil switching solenoid valve holder from the cylinder head.

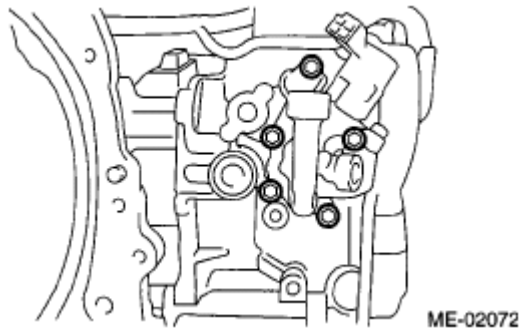


Fig. 179: Identifying Oil Switching Solenoid Valve Holder

INSTALLATION

1. Install the oil switching solenoid valve holder.

NOTE: Always use new gaskets.

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.

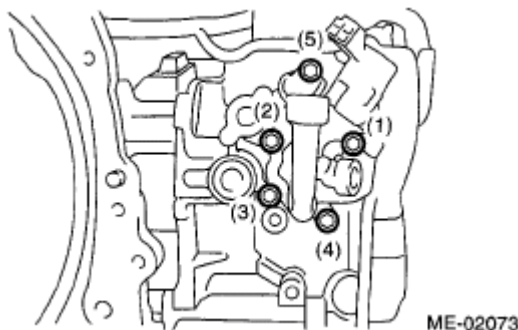


Fig. 180: Tightening Sequence Of Bolts

2. Install the oil temperature sensor.

< Ref. to **INSTALLATION** , Oil Temperature Sensor. >

3. Install the variable valve lift diagnosis oil pressure switch.

< Ref. to **INSTALLATION** , Variable Valve Lift Diagnosis Oil Pressure Switch. >

4. Install the oil switching solenoid valve.
5. Connect the connector to oil switching solenoid valve.

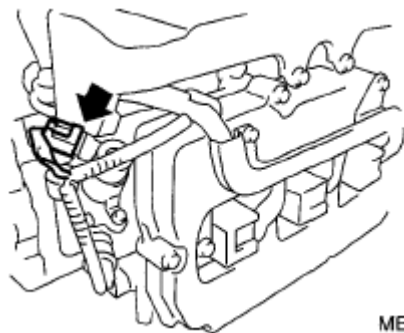


Fig. 181: Identifying Oil Switching Solenoid Valve

6. Install the air intake chamber.

< Ref. to **INSTALLATION** , Air Intake Chamber. >

INTAKE AND EXHAUST VALVE

SPECIFICATION

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

PISTON

SPECIFICATION

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

CONNECTING ROD

SPECIFICATION

Refer to "Cylinder Block" for removal and installation procedures of connecting rod.

< Ref. to **REMOVAL**, Cylinder Block. > < Ref. to **INSTALLATION**, Cylinder Block. >

CRANKSHAFT

SPECIFICATION

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

ENGINE TROUBLE IN GENERAL

INSPECTION

NOTE: "RANK" shown in the chart refers to the possibility of the cause of trouble in order "Very often" to "Rarely"

SYMPTOM REFERENCE

Symptom	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 or neutral switch	C
		Defective starter	B
	Battery	Improper connection of terminal	A
		Run-down battery	A
		Defective charging system	B
	Friction	Seizure of crankshaft and connecting rod bearing	C
		Seized camshaft	C
		Seized or stuck piston and cylinder	C
2) Initial combustion does not occur.	Starter	Defective starter	C
	Engine control system < Ref. to BASIC DIAGNOSTIC PROCEDURE . >		A
	Fuel line	Defective fuel pump and relay	A
		Lack of or insufficient fuel	B
	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

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	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
3) Initial combustion occurs.	Engine control system < Ref. to <u>BASIC DIAGNOSTIC PROCEDURE</u> . >		A
	Intake system	Defective intake manifold gasket	B
		Defective throttle body gasket	B
	Fuel line	Defective fuel pump and relay	C
		Clogged fuel line	C
		Lack of or insufficient fuel	B
	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
	Engine control system < Ref. to <u>BASIC DIAGNOSTIC PROCEDURE</u> . >		A
	Intake system	Loosened or cracked intake duct	B
		Loosened or cracked PCV hose	C
		Loosened or cracked vacuum hose	C
		Defective intake manifold gasket	B
		Defective throttle body gasket	B
		Dirty air cleaner element	C
	Fuel line	Clogged fuel line	C
		Lack of or insufficient fuel	B
	Chain	Trouble	B
		Defective timing	B

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

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	Lubrication system	Incorrect oil pressure	B
		Defective rocker cover gasket	C
	Cooling system	Over-heating	C
	Others	Evaporative emission control system malfunction	A
		Stuck or damaged throttle valve	B
3. Low output, hesitation and poor acceleration	Engine control system < Ref. to <u>BASIC DIAGNOSTIC PROCEDURE</u> . >		A
	Intake system	Loosened or cracked intake duct	A
		Loosened or cracked PCV hose	A
		Loosened or cracked vacuum hose	B
		Defective intake manifold gasket	B
		Defective throttle body gasket	B
		Defective PCV valve	B
		Loosened oil filler cap	B
		Dirty air cleaner element	A
	Fuel line	Defective fuel pump and relay	B
		Clogged fuel line	B
		Lack of or insufficient fuel	C
	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 < Ref. to <u>BASIC DIAGNOSTIC PROCEDURE</u> . >		A
		Loosened or cracked intake duct	A

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4. Surging	Intake system	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
	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 < Ref. to <u>BASIC DIAGNOSTIC PROCEDURE</u> . >		A
	Intake system	Loosened or cracked vacuum hose	A
	Others	Stuck or damaged throttle valve	A
6. Dieseling (Run-on)	Engine control system < Ref. to <u>BASIC DIAGNOSTIC PROCEDURE</u> . >		A
	Cooling system	Over-heating	B
	Others	Evaporative emission control system malfunction	B
	Engine control system < Ref. to <u>BASIC DIAGNOSTIC PROCEDURE</u> . >		A
	Intake system	Loosened or cracked intake duct	C
		Loosened or cracked PCV hose	C
		Loosened or cracked vacuum hose	B

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7. After burning in exhaust system		Defective PCV valve	B
		Loosened oil filler cap	C
	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 < Ref. to <u>BASIC DIAGNOSTIC PROCEDURE</u> . >		A
	Intake system	Loosened oil filler cap	B
	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

10. Excessive fuel consumption		Loosened oil drain plug or defective gasket	B
		Loosened oil pan fitting bolts or defective oil pan	B
	Engine control system < Ref. to BASIC DIAGNOSTIC PROCEDURE . >		A
	Intake system	Dirty air cleaner element	A
	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
A - Very often B - Sometimes C - Rarely			

ENGINE NOISE

INSPECTION

SYMPTOM 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 camshaft main bearing - Worn connecting rod bearing (large end)

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	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 spark plug • Improper gasoline
Clank when engine speed is between 1,000 and 2,000 RPM.	Sound is reduced when fuel injector connector of noisy cylinder is disconnected. ⁽¹⁾	• Worn crankshaft main bearing • Worn bearing at crankshaft end of connecting rod
Knocking sound when engine is operating under idling speed and engine is warm	Sound is reduced when fuel injector connector of noisy cylinder is disconnected. ⁽¹⁾	• Worn cylinder liner and piston ring • Broken or stuck piston ring • Worn piston pin and hole at piston end of connecting rod
	Sound is not reduced if each fuel injector connector is disconnected in turn. ⁽¹⁾	• Unusually worn valve lifter • Worn cam gear • Worn camshaft journal bore in cylinder head
Squeaky sound	-	Insufficient generator lubrication
Rubbing sound	-	Poor contact of generator brush and rotor
Gear scream when starting engine	-	• Defective ignition starter switch • Worn gear and starter pinion
Sound like polishing glass with a dry cloth	-	• 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 • Chain contacting with case/adjacent part
Valve noise	-	• Incorrect valve clearance • Trouble of valve lifter

NOTE:

(1) When disconnecting the fuel injector connector, the malfunction indicator light illuminates and DTC is stored in ECM memory. Therefore, perform the Clear Memory Mode < Ref. to

OPERATION , Clear Memory Mode. > and Inspection Mode < Ref. to **PROCEDURE** , Inspection Mode. > after connecting the fuel injector connector.