Engine Workshop Manual AJ with Variable Valve Timing

FOREWORD

This manual explains the disassembly, inspection, repair, and reassembly procedures for the above-indicated engine. In order to do these procedures safely, quickly, and correctly, you must first read this manual and any other relevant service materials carefully.

The infomation in this manual is current up to September, 2002. Any changes that occur after that time will not be reflected in this particular manual. Therefore, the contents of this manual may not exactly match the mechanism that you are currently servicing.

Mazda North American Operations
U.S.A.

CONTENTS

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GENERAL INFORMATION

00
SECTION

00–00 GENERAL INFORMATION

HOW TO USE THIS MANUAL

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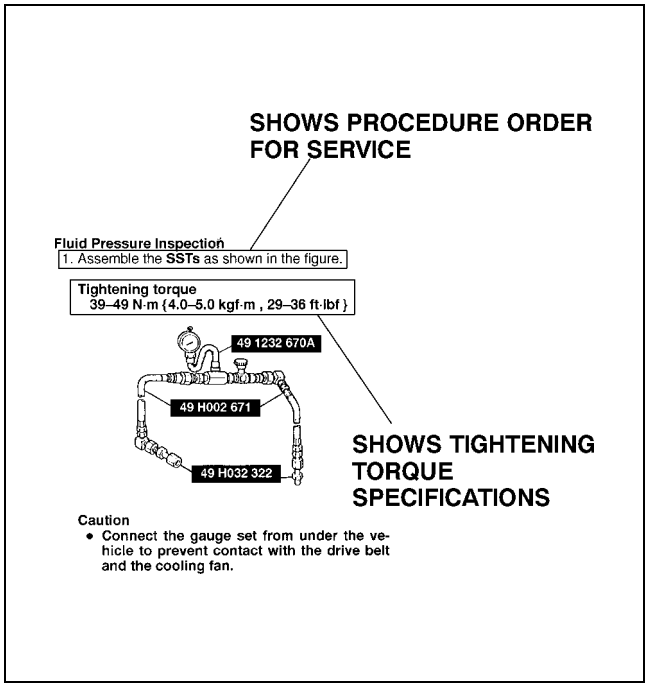
Range of Topics

- This manual contains procedures for performing all required service operations. The procedures are divided into the following five basic operations:
  i. Removal/Installation
  ii. Disassembly/Assembly
  iii. Replacement
  iv. Inspection
  v. Adjustment
- Simple operations which can be performed easily just by looking at the vehicle (i.e., removal/installation of parts, jacking, vehicle lifting, cleaning of parts and visual inspection) have been omitted.

Service Procedure

Inspection, adjustment

- Inspection and adjustment procedures are divided into steps. Important points regarding the location and contents of the procedures are explained in detail and shown in the illustrations.



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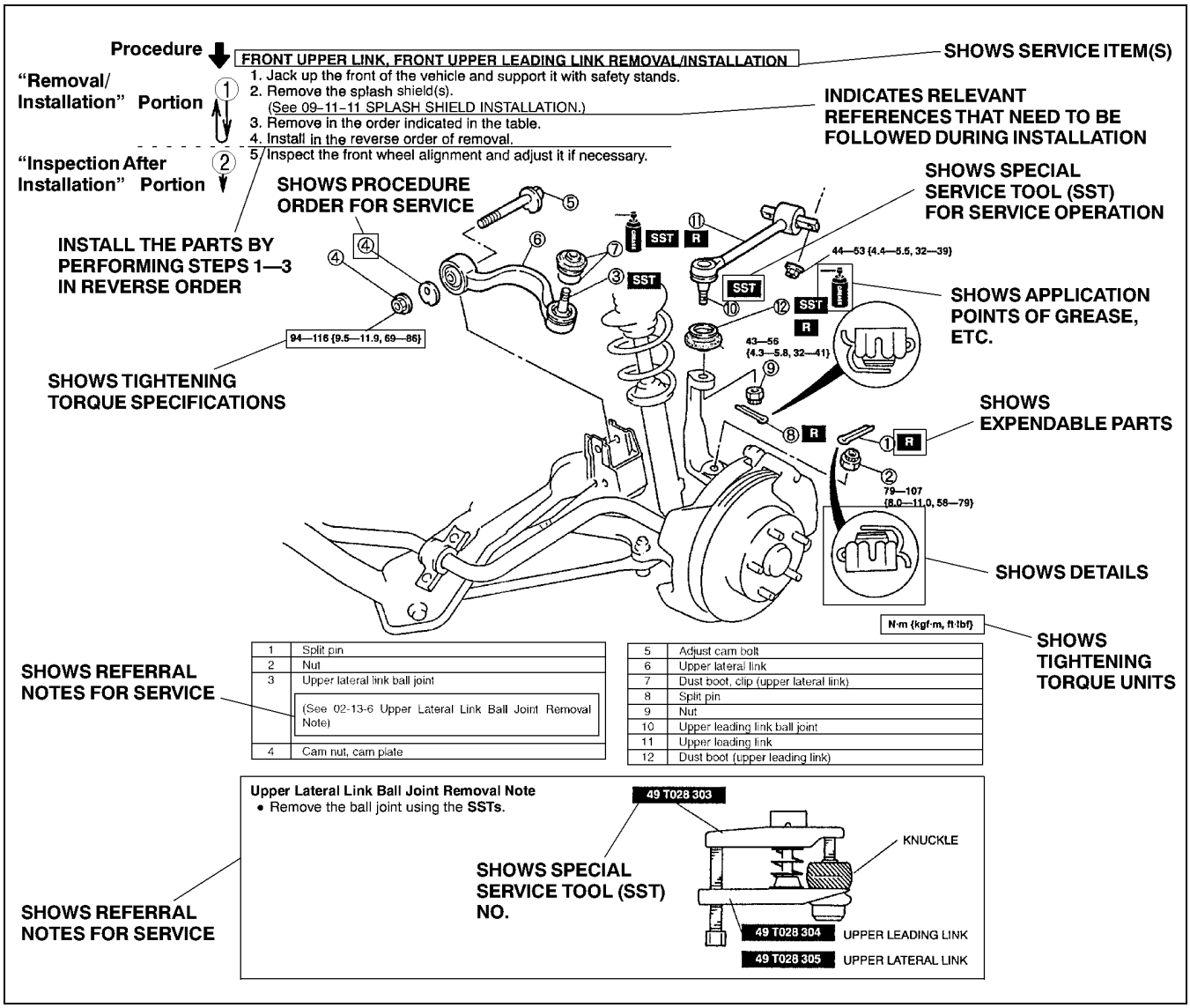
Repair procedure

1. Most repair operations begin with an overview illustration. It identifies the components, shows how the parts fit together and describes visual part inspection. However, only removal/installation procedures that need to be performed methodically have written instructions.
2. Expendable parts, tightening torques and symbols for oil, grease, and sealant are shown in the overview illustration. In addition, symbols indicating parts requiring the use of special service tools or equivalent are also shown.
3. Procedural steps are numbered and the part that is the main point of that procedure is shown in the illustration with the corresponding number. Occasionally, there are important points or additional information concerning a procedure. Refer to this information when servicing the related part.



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Symbols

- There are eight symbols indicating oil, grease, fluids, sealant and **SST** or equivalent use. These symbols show application points or use of these materials during service.

Symbol	Meaning	Kind
	Apply oil	New, appropriate engine oil or gear oil
	Apply brake fluid	New, appropriate brake fluid
	Apply automatic transaxle/transmission fluid	New, appropriate automatic transaxle/ transmission fluid
	Apply grease	Appropriate grease
	Apply sealant	Appropriate sealant
	Apply petroleum jelly	Appropriate petroleum jelly
	Replace part	O-ring, gasket, etc.
	Use SST or equivalent	Appropriate SST or equivalent

Advisory Messages

You'll find several **Warnings**, **Cautions**, **Notes**, **Specifications** and **Upper and Lower Limits** in this manual.

Warning

- **A Warning indicates a situation in which serious injury or death could result if the warning is ignored.**

Caution

- **A Caution indicates a situation in which damage to the vehicle could result if the caution is ignored.**

Note

- A **Note** provides added information that will help you to complete a particular procedure.

UNITS

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Electric current	A (ampere)
Electric power	W (watt)
Electric resistance	ohm
Electric voltage	V (volt)
Length	mm (millimeter)
	in (inch)
Negative pressure	kPa (kilo pascal)
	mmHg (millimeters of mercury)
	inHg (inches of mercury)
Positive pressure	kPa (kilo pascal)
	kgf/cm^2 (kilogram force per square centimeter)
	psi (pounds per square inch)
Number of revolutions	rpm (revolutions per minute)
Torque	N·m (Newton meter)
	kgf·m (kilogram force meter)
	kgf·cm (kilogram force centimeter)
	ft·lbf (foot pound force)
	in·lbf (inch pound force)
Volume	L (liter)
	US qt (U.S. quart)
	Imp qt (Imperial quart)
	ml (milliliter)
	cc (cubic centimeter)
	cu in (cubic inch)
	fl oz (fluid ounce)
Weight	g (gram)
	oz (ounce)

Conversion to SI Units (Système International d'Unités)

- All numerical values in this manual are based on SI units. Numbers shown in conventional units are converted from these values.

Rounding Off

- Converted values are rounded off to the same number of places as the SI unit value. For example, if the SI unit value is 17.2 and the value after conversion is 37.84, the converted value will be rounded off to 37.8.

Upper and Lower Limits

- When the data indicates upper and lower limits, the converted values are rounded down if the SI unit value is an upper limit and rounded up if the SI unit value is a lower limit. Therefore, converted values for the same SI unit value may differ after conversion. For example, consider 2.7 kgf/cm^2 in the following specifications:

  210—260 kPa {2.1—2.7 kgf/cm^2, 30—38 psi}
  270—310 kPa {2.7—3.2 kgf/cm^2, 39—45 psi}

- The actual converted values for 2.7 kgf/cm^2 are 264 kPa and 38.4 psi. In the first specification, 2.7 is used as an upper limit, so the converted values are rounded down to 260 and 38. In the second specification, 2.7 is used as a lower limit, so the converted values are rounded up to 270 and 39.

FUNDAMENTAL PROCEDURES

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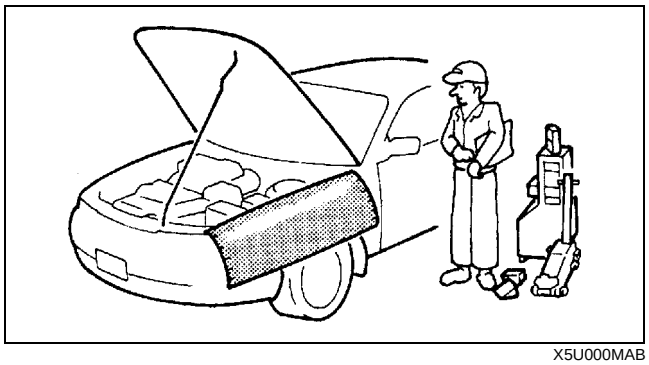
Preparation of Tools and Measuring Equipment

- Be sure that all necessary tools and measuring equipment are available before starting any work.



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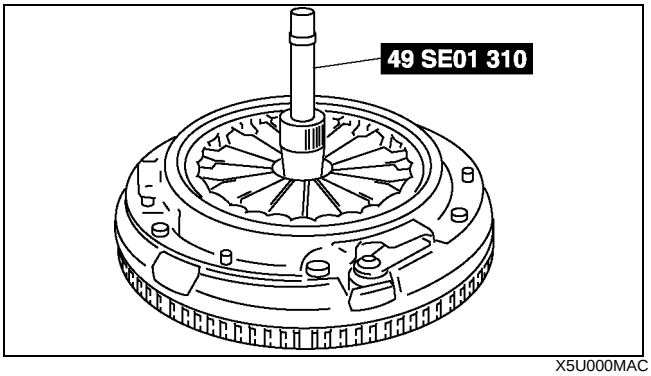
Special Service Tools

- Use special service tools or equivalent when they are required.



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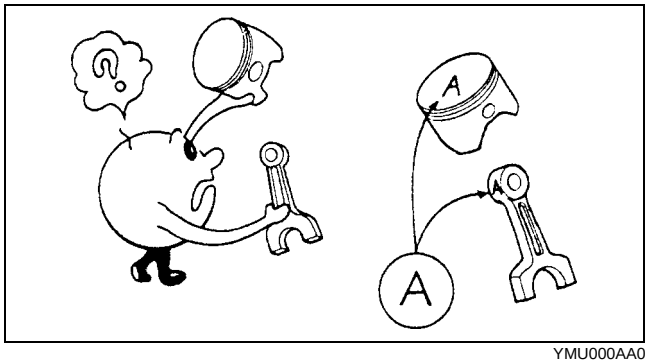
Disassembly

- If the disassembly procedure is complex requiring many parts to be disassembled, all parts should be disassembled in a way that will not affect their performance or external appearance and identified so reassembly can be performed easily and efficiently.



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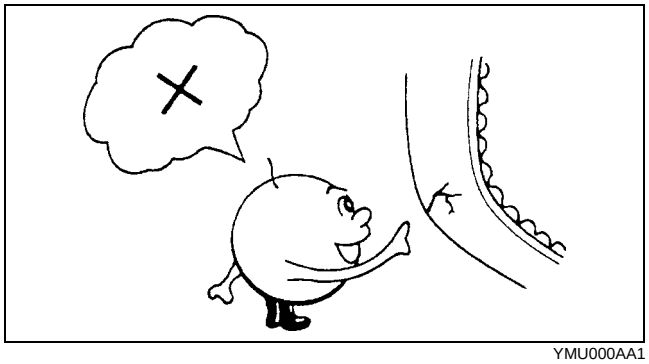
Inspection During Removal, Disassembly

- When removed, each part should be carefully inspected for malfunctioning, deformation, damage and other problems.



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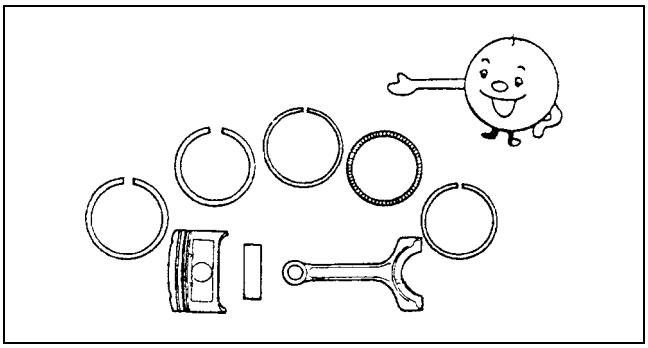
Arrangement of Parts

- All disassembled parts should be carefully arranged for reassembly.
- Be sure to separate or otherwise identify the parts to be replaced from those that will be reused.



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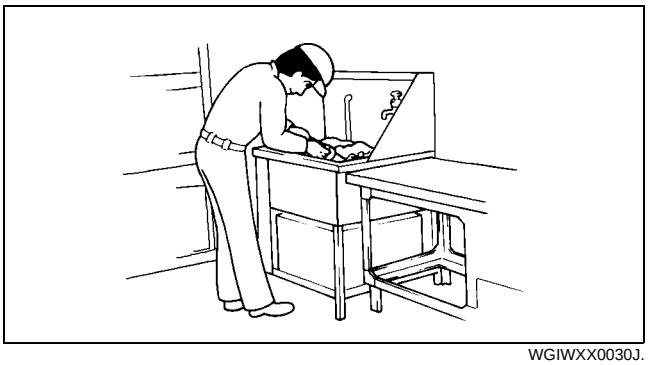
Cleaning of Parts

- All parts to be reused should be carefully and thoroughly cleaned in the appropriate method.

Warning

- **Using compressed air can cause dirt and other particles to fly out causing injury to the eyes. Wear protective eye wear whenever using compressed air.**



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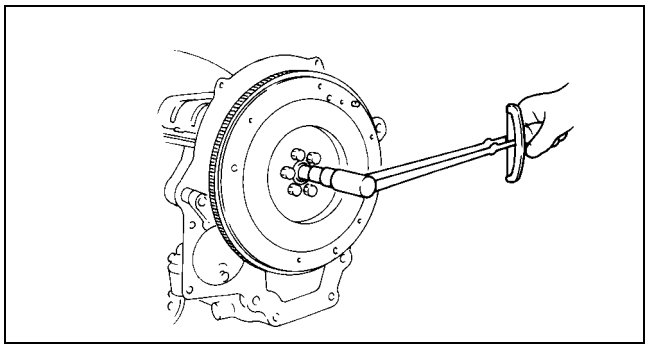
Reassembly

- Standard values, such as torques and certain adjustments, must be strictly observed in the reassembly of all parts. If removed, these parts should be replaced with new ones:
  - — Oil seals
  - — Gaskets
  - — O-rings
  - — Lockwashers
  - — Cotter pins
  - — Nylon nuts

Depending on location:

- Sealant and gaskets, or both, should be applied to specified locations. When sealant is applied, parts should be installed before sealant hardens to prevent leakage.
- Oil should be applied to the moving components of parts.
- Specified oil or grease should be applied at the prescribed locations (such as oil seals) before reassembly.



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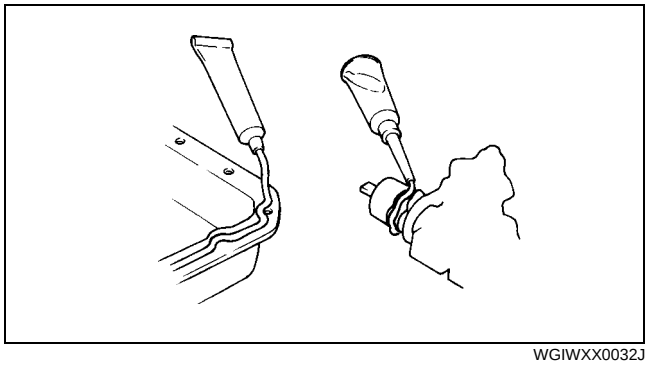

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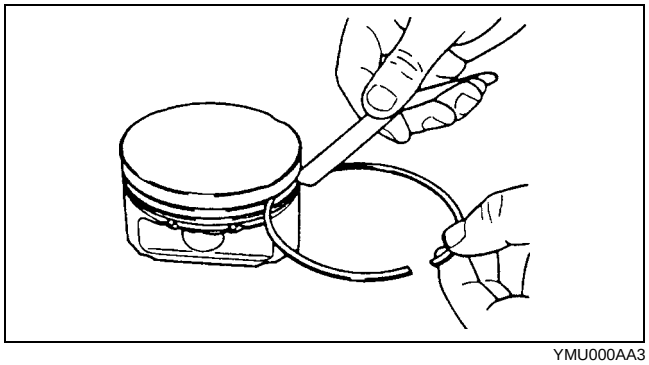
Adjustment

- Use suitable gauges and testers when making adjustments.



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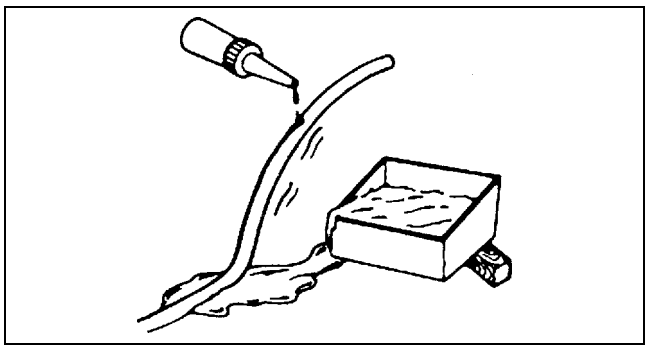
Rubber Parts and Tubing

- Prevent gasoline or oil from getting on rubber parts or tubing.



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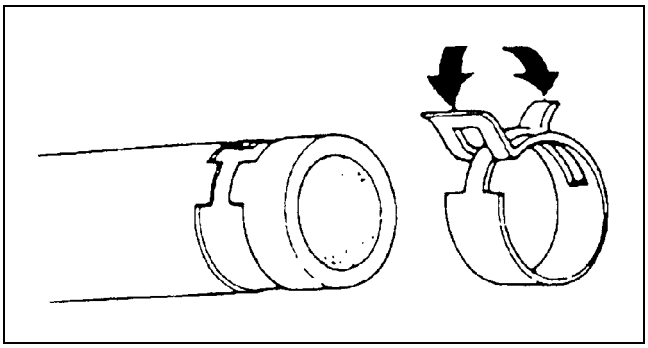
Hose Clamps

- When reinstalling, position the hose clamp in the original location on the hose and squeeze the clamp lightly with large pliers to ensure a good fit.



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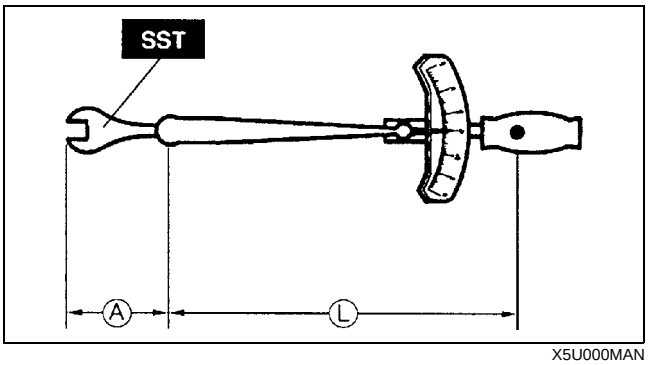
Torque Formulas

- When using a torque wrench-**SST** or equivalent combination, the written torque must be recalculated due to the extra length that the **SST** or equivalent adds to the torque wrench. Recalculate the torque using the following formulas. Choose the formula that applies to you.

Torque Unit	Formula
N·m	N·m × [L/(L+A)]
kgf·m	kgf·m × [L/(L+A)]
kgf·cm	kgf·cm × [L/(L+A)]
ft·lbf	ft·lbf × [L/(L+A)]
in·lbf	in·lbf × [L/(L+A)]

A : The length of the **SST** or equivalent past the torque wrench drive.
L : The length of the torque wrench.



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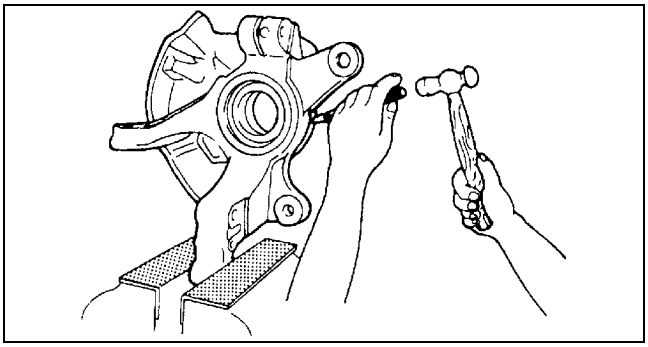
Vise

- When using a vise, put protective plates in the jaws of the vise to prevent damage to parts.



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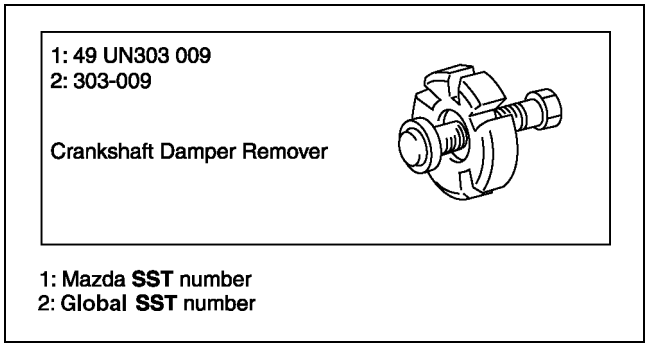
SST

- Some global **SST** or equivalent are used as **SSTs** necessary for engine repair. Note that these **SSTs** are marked with global **SST** numbers.
- **SST** numbers are indicated in two ways, as shown in the follwing examples.
  - — 01–60 section: Both MAZDA and global **SST** numbers are indicated for reference.
  - — Except 01–60 section: Either only the MAZDA **SST** number or both the MAZDA **SST** and global **SST** numbers are shown.

Example (01-60 section)



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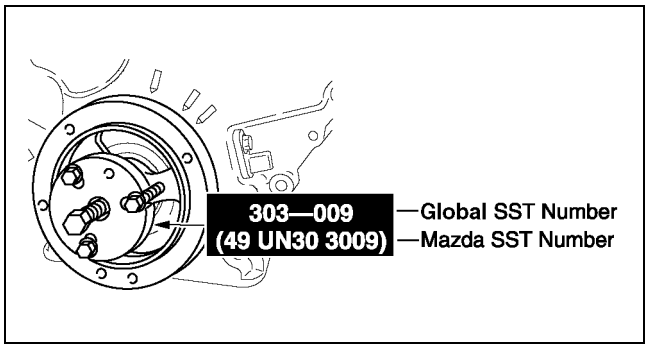
Example (except 01-60 section)



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ELECTRICAL SYSTEM

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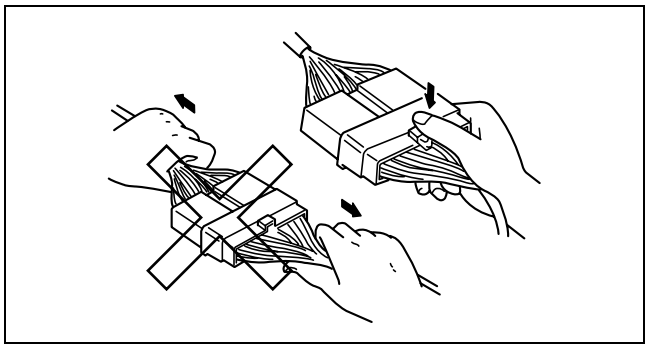
Connectors

Disconnecting connectors

- When disconnecting two connectors, grasp the connectors, not the wires.
- Connectors can be disconnected by pressing or pulling the lock lever as shown.



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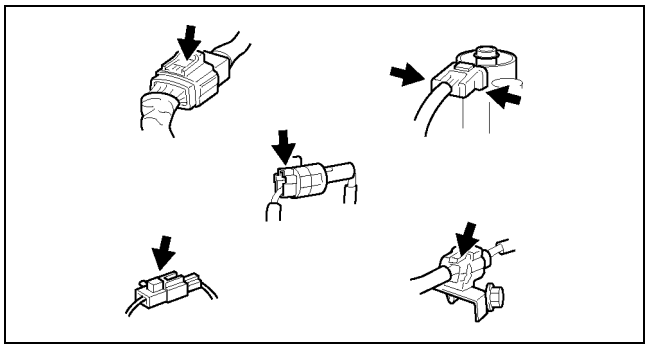

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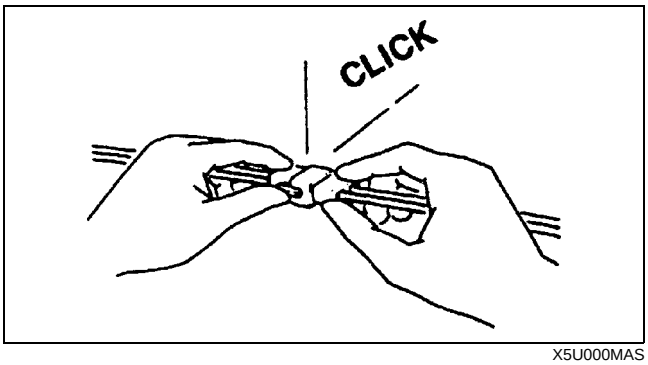
Locking connector

- When locking connectors, listen for a click indicating they are securely locked.



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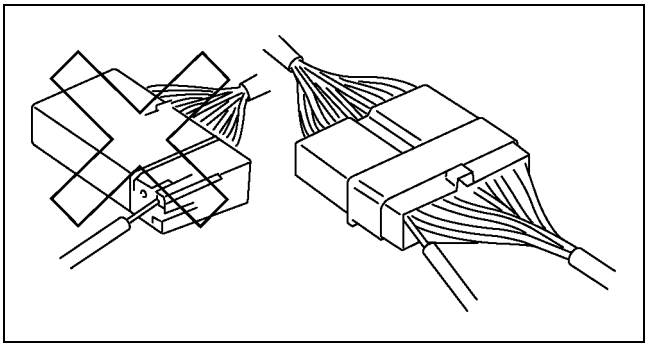
Inspection

- When a tester is used for inspecting continuity or measuring voltage, insert the tester probe from the wiring harness side.
- Inspect the terminals of waterproof connectors from the connector side since they cannot be accessed from the wiring harness side.

Caution

- **To prevent damage to the terminal, wrap a thin wire around the lead before inserting into terminal.**



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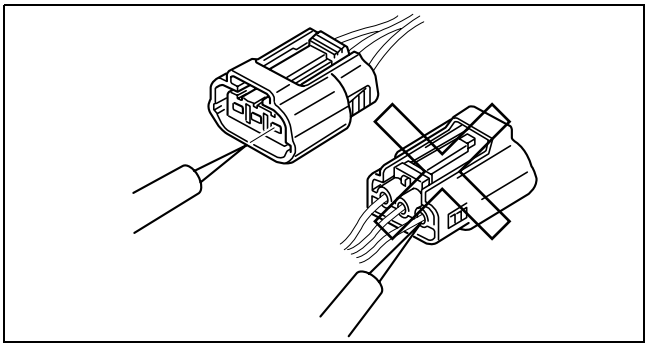

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SAE STANDARDS

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- In accordance with new regulations, SAE (Society of Automotive Engineers) standard names and abbreviations are now used in this manual. The table below lists the names and abbreviations that have been used in Mazda manuals up to now and their SAE equivalents.

SAE Standard		Remark		SAE Standard		Remark
Abbreviation	Name			Abbreviation	Name	
AP	Accelerator Pedal			MAP	Manifold Absolute Pressure	
ACL	Air Cleaner			MAF sensor	Mass Air Flow Sensor	
A/C	Air Conditioning			MFL	Multiport Fuel Injection	
BARO	Barometric Pressure			OBD	On-board Diagnostic System	
B+	Battery Positive Voltage			OL	Open Loop	
CMP sensor	Camshaft Position Sensor			OC	Oxidation Catalytic Converter	
CAC	Charge Air Cooler			O2S	Oxygen Sensor	
CLS	Closed Loop System			PNP	Park/Neutral Position	
CTP	Closed Throttle Position			PSP	Power Steering Pressure	
CPP	Clutch Pedal Position			PCM	Powertrain Control Module	#3
CIS	Continuous Fuel Injection System			PAIR	Pulsed Secondary Air Injection	Pulsed injection
CKP sensor	Crankshaft Position Sensor					
DLC	Data Link Connector			AIR	Secondary Air Injection	Injection with air pump
DTM	Diagnostic Test Mode	#1				
DTC	Diagnostic Test Code(s)					
DI	Distributor Ignition			SAPV	Secondary Air Pulse Valve	
DLI	Distributorless Ignition			SFI	Sequential Multiport Fuel Injection	
EI	Electronic Ignition	#2				
ECT	Engine Coolant Temperature			3GR	Third Gear	
EM	Engine Modification			TWC	Three Way Catalytic Converter	
EVAP	Evaporative Emission			TB	Throttle Body	
EGR	Exhaust Gas Recircuilation			TP sensor	Throttle Position Sensor	
FC	Fan Control			TCC	Torque Converter Clutch	
FF	Flexible Fuel			TCM	Transmission (Transaxle) Control Module	
4GR	Fourth Gear					
GEN	Generator			TR	Transmission (Transaxle) Range	
GND	Ground			TC	Turbocharger	
HO2S	Heated Oxygen Sensor	With heater		VSS	Vehicle Speed Sensor	
				VR	Voltage Regulator	
IAC	Idle Air Control			VAF sensor	Volume Air Flow Sensor	
IAT	Intake Air Temperature			WU-TWC	Warm Up Three Way Catalytic Converter	#4
KS	Knock Sensor					
MIL	Malfunction Indicator Lamp			WOT	Wide Open Throttle	

#1 : Diagnostic trouble codes depend on the diagnostic test mode.
#2 : Controlled by the PCM
#3 : Device that controls engine and powertrain
#4 : Directly connected to exhaust manifold

ABBREVIATIONS

B6U000000011101

CKP	Crankshaft position
EX	Exhaust
HLA	Hydraulic lash adjuster
IN	Intake
LH	Left hand
OCV	Oil control valve
P/S	Power steering
RH	Right hand
SST	Special service tool

ENGINE

01
SECTION

01–10 MECHANICAL

ENGINE OVERHAUL SERVICE WARNING

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Warning

- **Continuous exposure to USED engine oil has caused skin cancer in laboratory mice. Protect your skin by washing with soap and water immediately after this work.**

ENGINE MOUNTING

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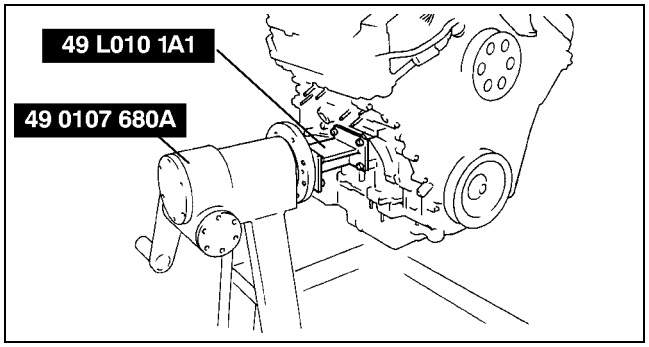
1. Install the **SST** (engine hanger) to the cylinder block holes as indicated in the figure, and tighten the **SSTs** (bolts).
2. Mount the engine on the **SST** (engine stand).
3. Drain the engine oil into a container.
4. Inspect the seal rubber of the oil pan drain plug and make sure there are no cracks or damage.
   - If necessary, replace the oil pan drain plug.
5. Clean the flange surface (seal rubber) of the drain plug, then install the plug.

Tightening torque
22—30 N·m {2.2—3.1 kgf·m, 16—22 ft·lbf}



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ENGINE DISMOUNTING

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1. Dismount in the reverse order of mounting.

TIMING CHAIN DISASSEMBLY

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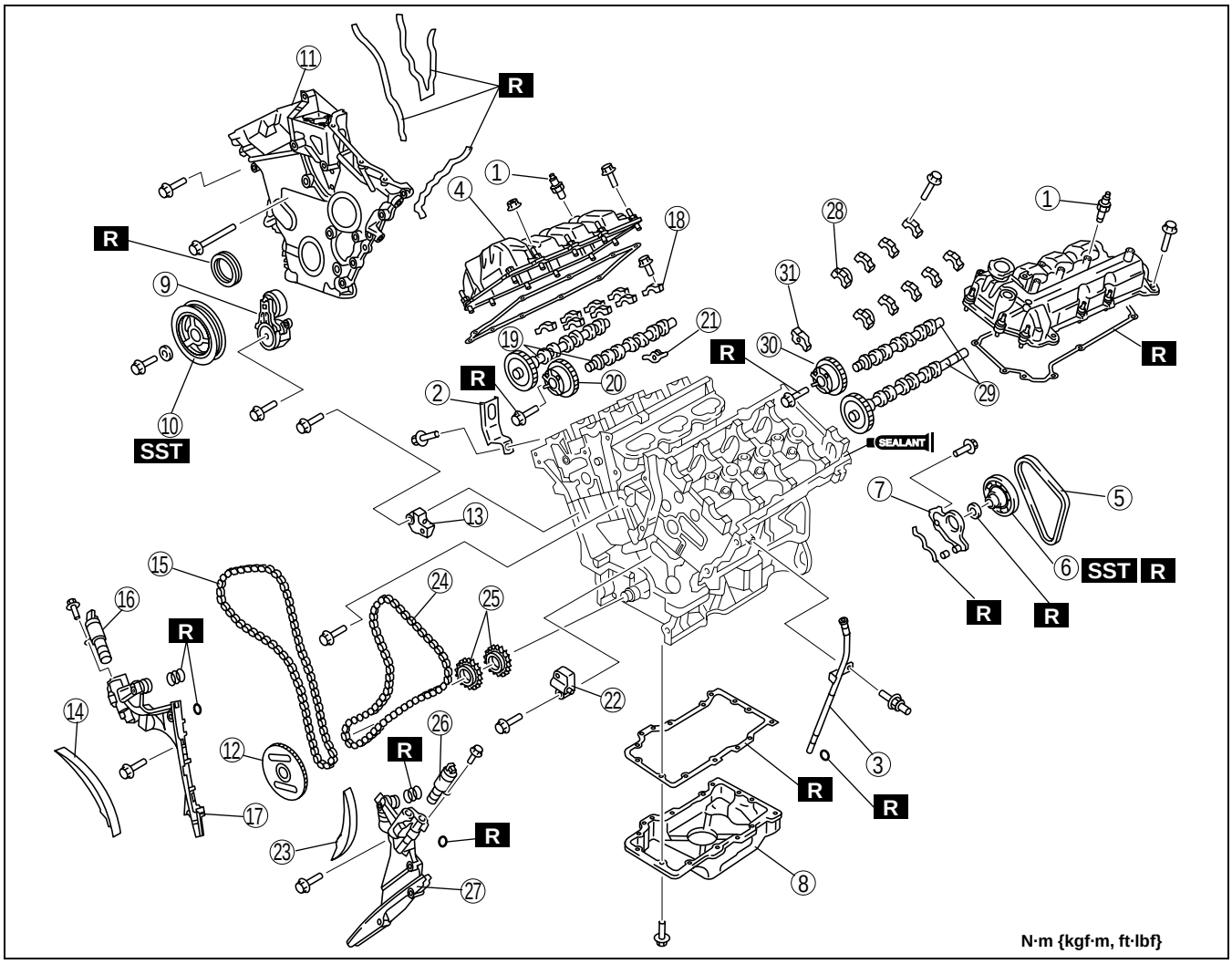
1. Disassemble in the order indicated in the table.



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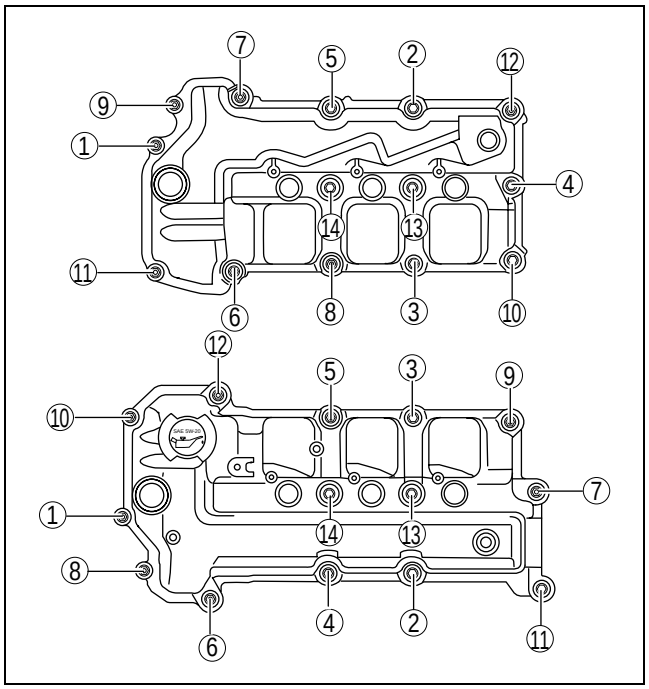
1	Spark plug
2	Engine hanger
3	Oil level gauge, pipe
4	Cylinder head cover (See 01–10–4 Cylinder Head Cover Disassembly Note)
5	Water pump drive belt (See 01–10–4 Water Pump Drive Belt Disassembly Note)
6	Water pump drive pulley (See 01–10–4 Water Pump Drive Pulley Disassembly Note)
7	Camshaft oil seal housing (See 01–10–5 Camshaft Oil Seal Housing Disassembly Note)
8	Oil pan (See 01–10–5 Oil Pan Disassembly Note)
9	Auto tensioner
10	Crankshaft pulley (See 01–10–6 Crankshaft Pulley Disassembly Note)
11	Engine front cover (See 01–10–6 Engine Front Cover Disassembly Note)
12	CKP sensor pulse wheel
13	Chain tensioner (RH) (See 01–10–7 Chain Tensioner (RH) Disassembly Note)
14	Tensioner arm (RH)

15	Timing chain (RH)
16	Oil control valve (OCV)
17	Chain guide (RH)
18	Camshaft cap (RH) (See 01–10–7 Camshaft Cap (RH) Disassembly Note)
19	Camshaft (RH)
20	Variable valve timing actuator (RH) (See 01–10–8 Variable Valve Timing Actuator Disassembly Note)
21	Rocker arm (RH)
22	Chain tensioner (LH) (See01–10–8 Chain Tensioner (LH) Disassembly Note)
23	Tensioner arm (LH)
24	Timing chain (LH)
25	Crankshaft timing sprocket
26	Oil control valve (OCV)
27	Chain guide (LH)
28	Camshaft cap (LH) (See 01–10–8 Camshaft Cap (LH) Disassembly Note)
29	Camshaft (LH)
30	Variable valve timing actuator (LH) (See 01–10–8 Variable Valve Timing Actuator Disassembly Note)
31	Rocker arm (LH)

Cylinder Head Cover Disassembly Note

1. Remove the cylinder head cover bolts in the order indicated in the figure.



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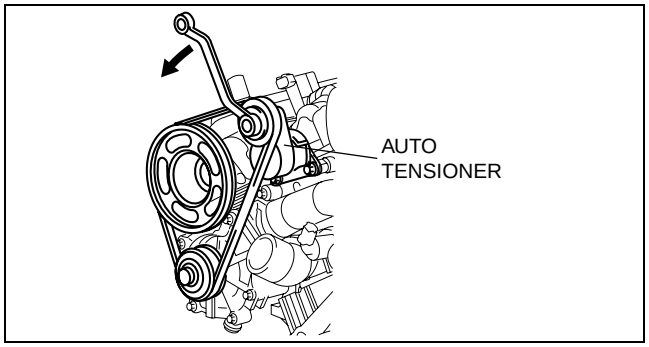
Water Pump Drive Belt Disassembly Note

1. Rotate the belt tensioner counterclockwise to release the drive belt tension and remove the belt.



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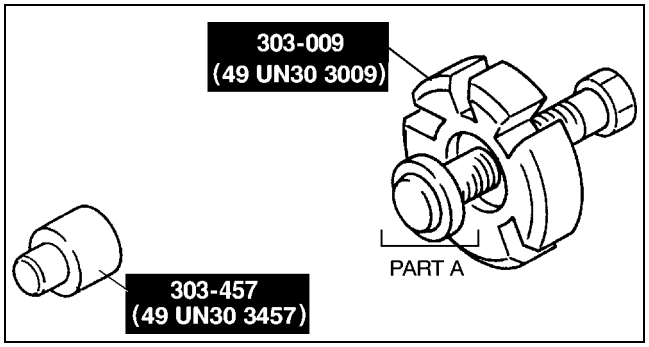
Water Pump Drive Pulley Disassembly Note

1. Replace part A of the **SST** [303-009 (49 UN30 3009)] with the **SST** [303-457 (49 UN30 3457)].



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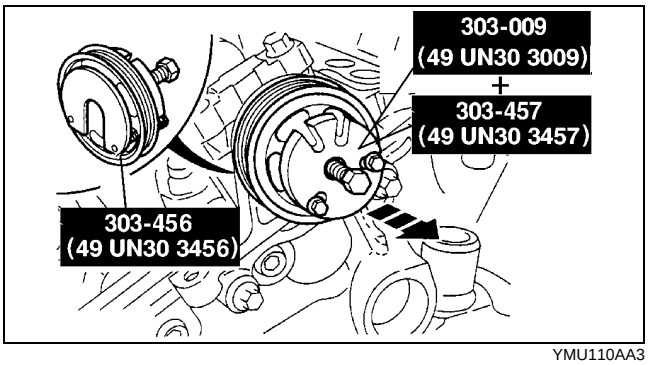
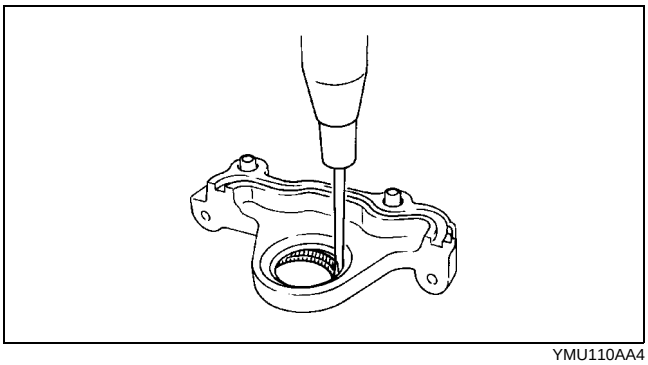
2. Remove the water pump pulley using the **SSTs**.



YMU110AA3

Camshaft Oil Seal Housing Disassembly Note

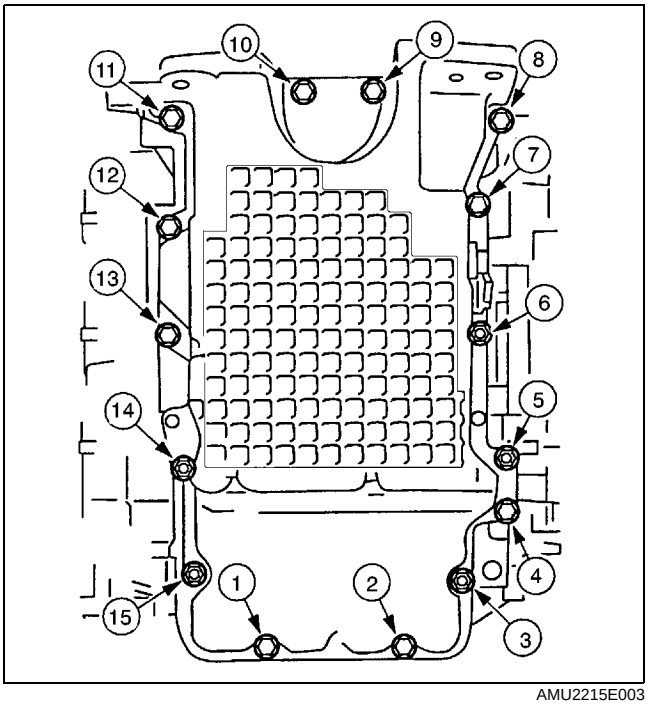
1. Remove the oil seal using a screwdriver.



YMU110AA4

Oil Pan Disassembly Note

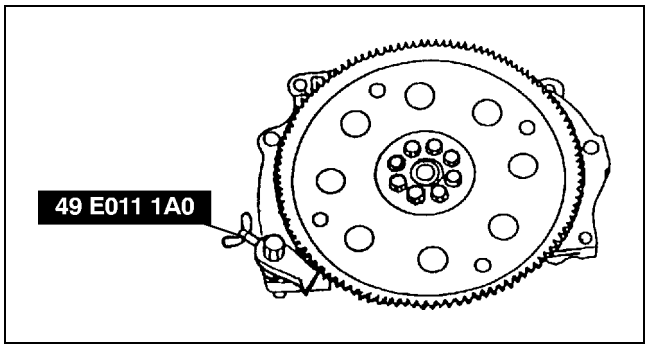
1. Remove the oil pan bolts and studs in the order indicated in the figure.



AMU2215E003

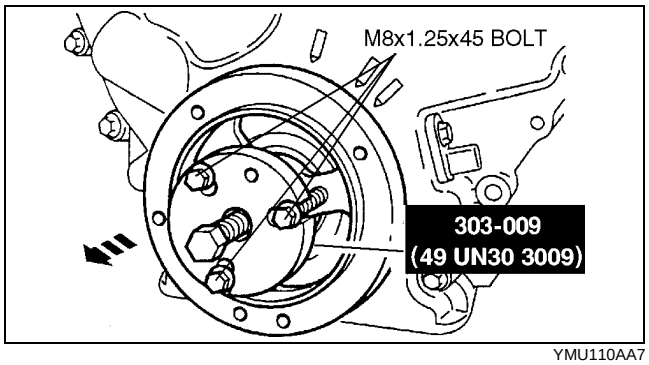
Crankshaft Pulley Disassembly Note

1. Hold the the flywheel (MTX) or the drive plate (ATX) using the **SST**.
2. Remove the crankshaft pulley lock bolt.



YMU110AA6

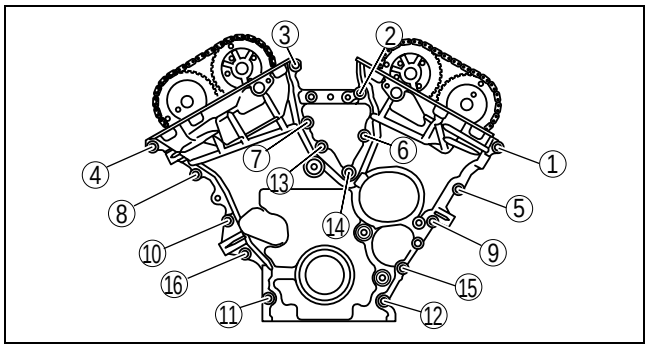
3. Remove the crankshaft pulley using the **SST** and three bolts **(M8 × 1.25 × 45)**.



YMU110AA7

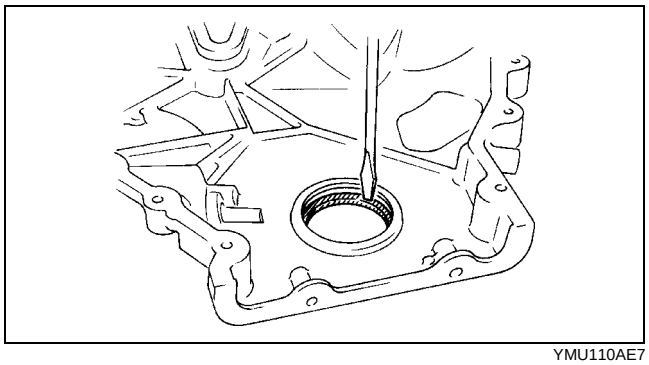
Engine Front Cover Disassembly Note

1. Remove the engine front cover bolts and studs in the order indicated in the figure.



B6U2215W117

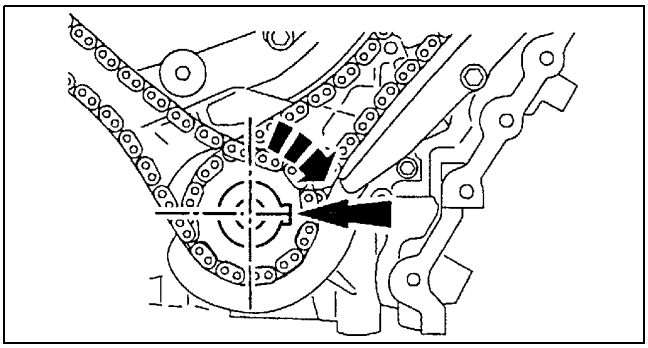
2. Remove the oil seal using a screwdriver.



YMU110AE7

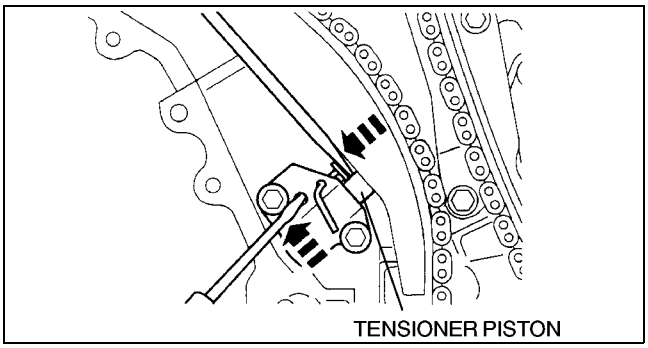
Chain Tensioner (RH) Disassembly Note

1. Before removing chain tensioner (RH), turn the crankshaft clockwiswe to position the crankshaft keyway in the **3 o'clock** position. (camshafts (RH) are in the neutral position.)
2. Hold the timing chain tensioner ratchet lock mechanism away from the ratchet stem with a thin screwdriver.
3. Slowly press the tensioner piston.



YMU110WAL

4. Hold the tensioner piston with a **1.5 mm {0.06 in}** wire or paper clip.



YMU110ACC

Camshaft Cap (RH) Disassembly Note

1. Before removing the camshaft cap, inspect the following.
   (1) Camshaft end play (See 01–10–18 CAMSHAFT END PLAY INSPECTION.)
   (2) Camshaft journal oil clearance (See 01–10–18 CAMSHAFT OIL CLEARANCE INSPECTION.)

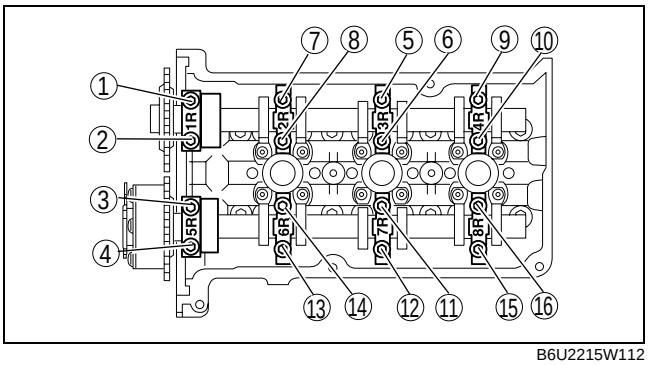
Caution

- **Remove the camshaft bearing thrust caps 1R and 5R first. Do not loosen any of the other bolts until the thrust caps are removed, or damage to the thrust caps may occur.**

Note

- The camshaft bearing caps are numbered to make sure they are assembled in their original positions. When removed, keep the bearing caps with the cylinder head from where they were removed. Do not mix the caps.

2. Remove the camshaft cap bolts in the order indicated in the figure, loosening in several passes.



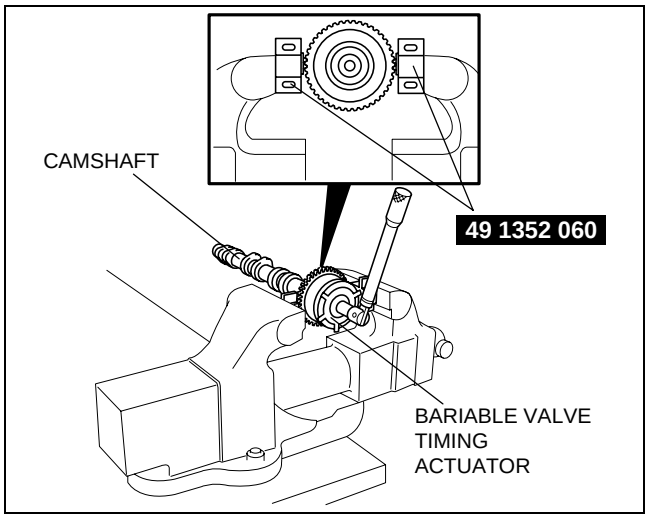
B6U2215W112

Variable Valve Timing Actuator Disassembly Note

Caution
- **The variable valve timing actuator cannot be disassembled because it is a precision unit.**

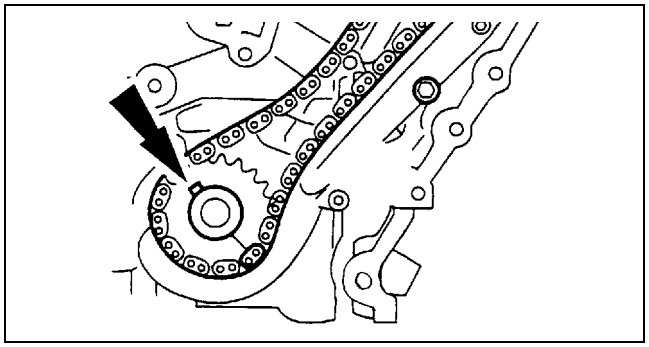
Note
- The variable valve timing actuator camshaft sprocket is integrated with the variable valve timing actuator and cannot be disassembled.

1. Secure the camshaft sprocket in a vise using the **SST**.
2. Loosen the variable valve timing actuator tightening bolt.
3. Remove the variable valve timing actuator.



B6U2225W012

Chain Tensioner (LH) Disassembly Note
1. Before removing chain tensioner (LH), turn the crankshaft clockwise **1 and 2/3 turns** to position the crankshaft keyway in the **11 o'clock** position. (camshafts (LH) are in the neutral position.)
2. Press and hold the tensioner piston by following Step 4 to 6 in Chain Tensioner (RH) Disassembly Note. (See 01–10–7 Chain Tensioner (RH) Disassembly Note.)

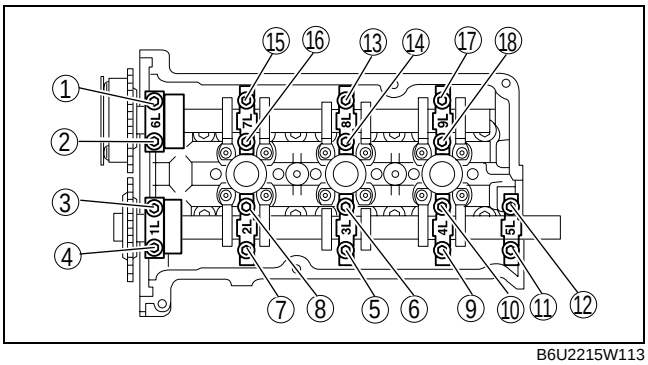

YMU110AAD

Camshaft Cap (LH) Disassembly Note
1. Before removing the camshaft cap, inspect the following.
   (1) Camshaft end play (See 01–10–18 CAMSHAFT END PLAY INSPECTION.)
   (2) Camshaft journal oil clearance (See 01–10–18 CAMSHAFT OIL CLEARANCE INSPECTION.)

Caution
- **Remove the camshaft bearing thrust caps 1L and 6L first. Do not loosen any of the other bolts until the thrust caps are removed, or damage to the thrust caps may occur.**

Note
- The camshaft bearing caps are numbered to make sure they are reassembled in their original position. When removed, keep the bearing caps with the cylinder head from where they were removed. Do not mix the caps.

2. Remove the camshaft cap bolts in the order indicated in the figure, loosening in several passes.

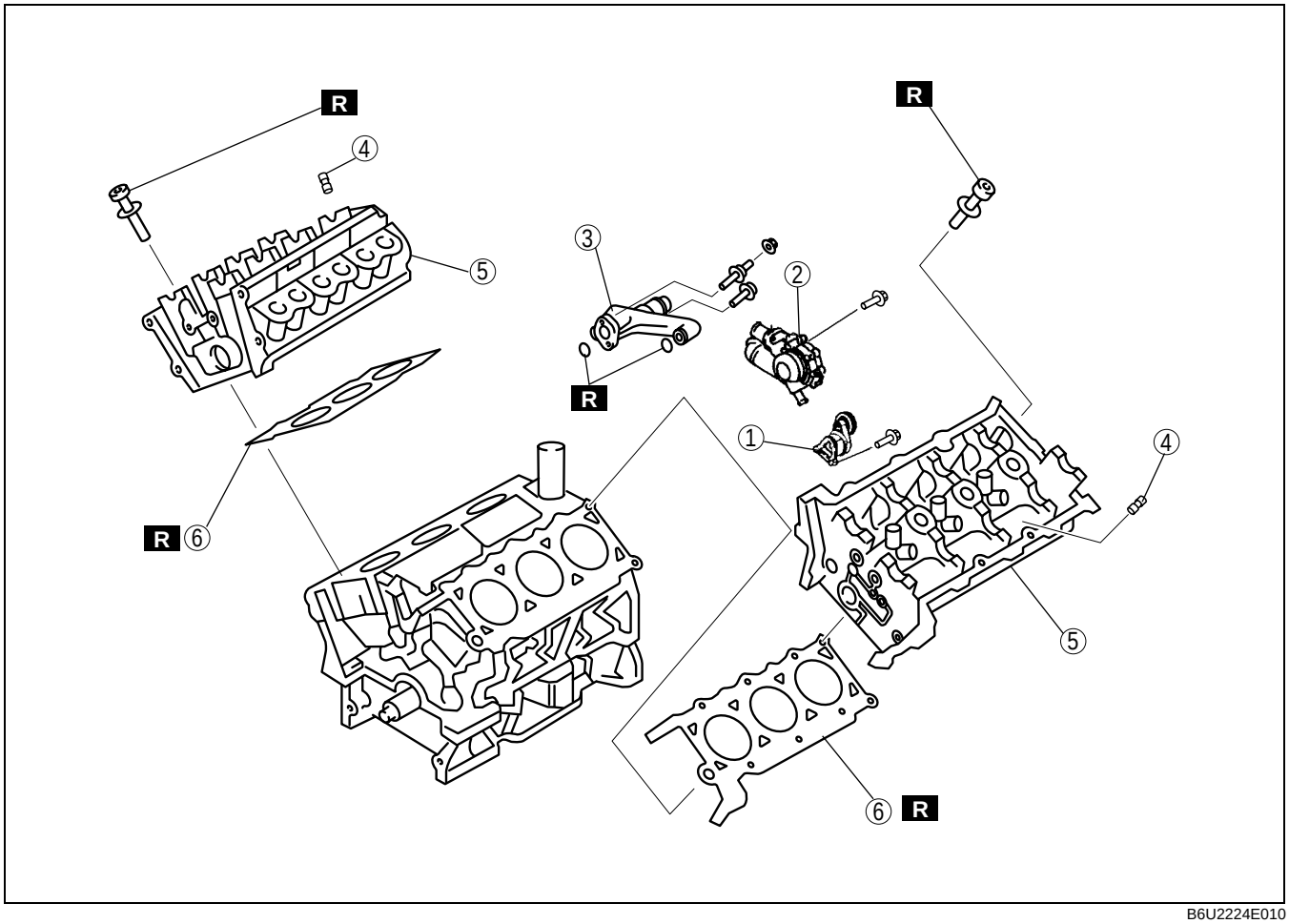


B6U2215W113

CYLINDER HEAD DISASSEMBLY(I)

B6U011010100101

1. Disassemble in the order indicated in the table.



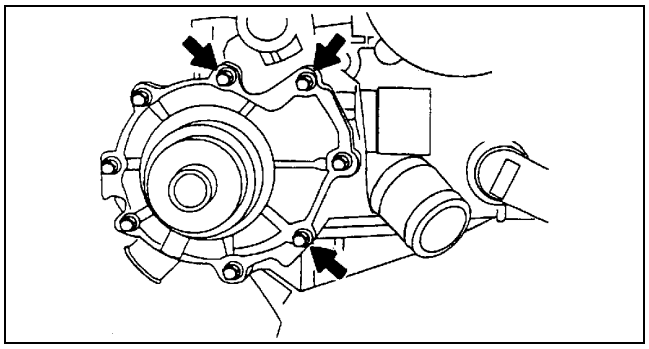
B6U2224E010

1	Water pump drive belt tensioner
2	Water pump (See 01–10–10 Water Pump Disassembly Note)
3	Water bypass tube

4	HLA
5	Cylinder head (See 01–10–10 Cylinder Head Disassembly Note)
6	Cylinder head gasket

Water Pump Disassembly Note

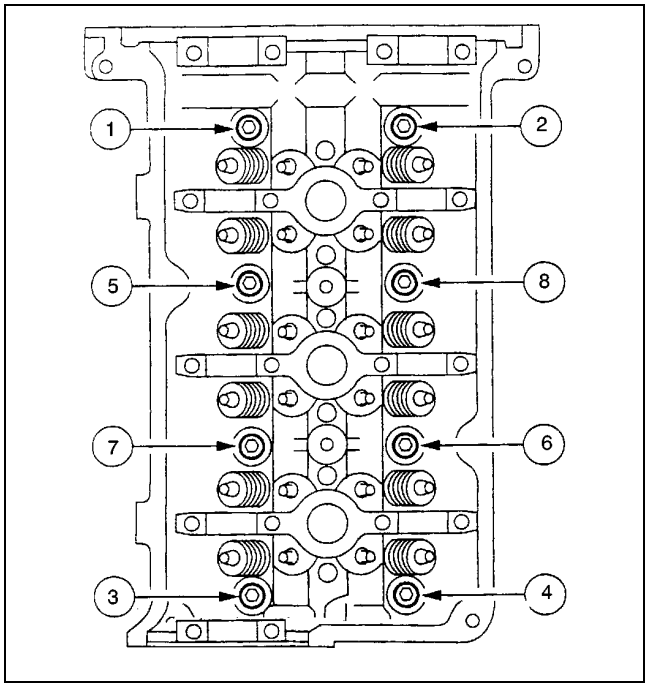
1. Remove the water pump mounting bolts as shown.



YMU110ACD

Cylinder Head Disassembly Note

1. Remove the cylinder head bolts in the order indicated in the figure, loosening in several passes.



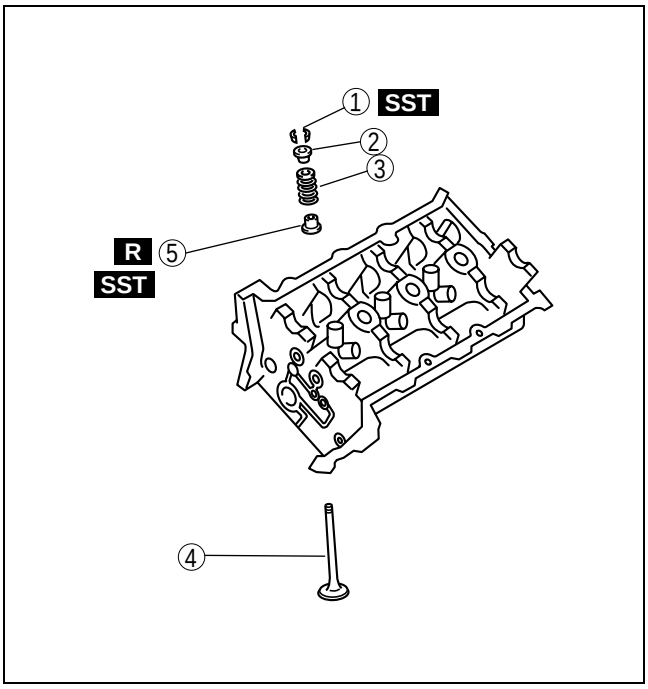
B6U2224E003

CYLINDER HEAD DISASSEMBLY(II)

1. Disassemble in the order indicated in the table.

1	Valve keeper (See 01–10–11 Valve Keeper Disassembly Note)
2	Upper valve spring seat
3	Valve spring
4	Valve
5	Valve seal (See 01–10–11 Valve Seal Disassembly Note)

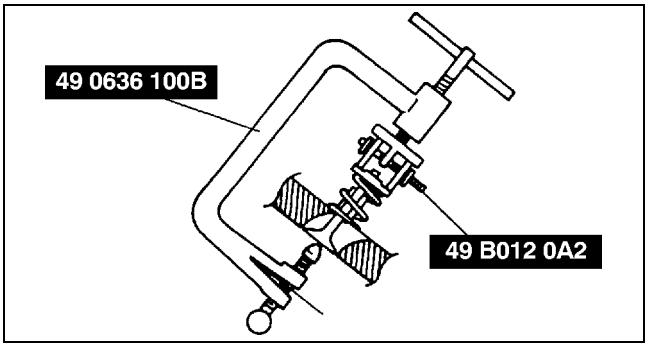
B6U011010100102



B6U2224E011

Valve Keeper Disassembly Note

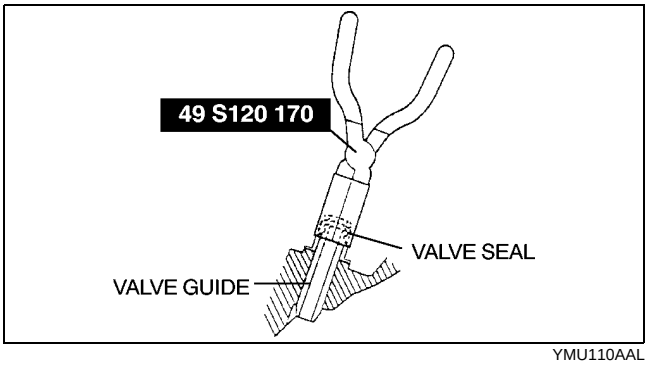
1. Remove the valve keeper using the **SSTs**.



YMU110AAK

Valve Seal Disassembly Note

1. Remove the valve seal using the **SST**.

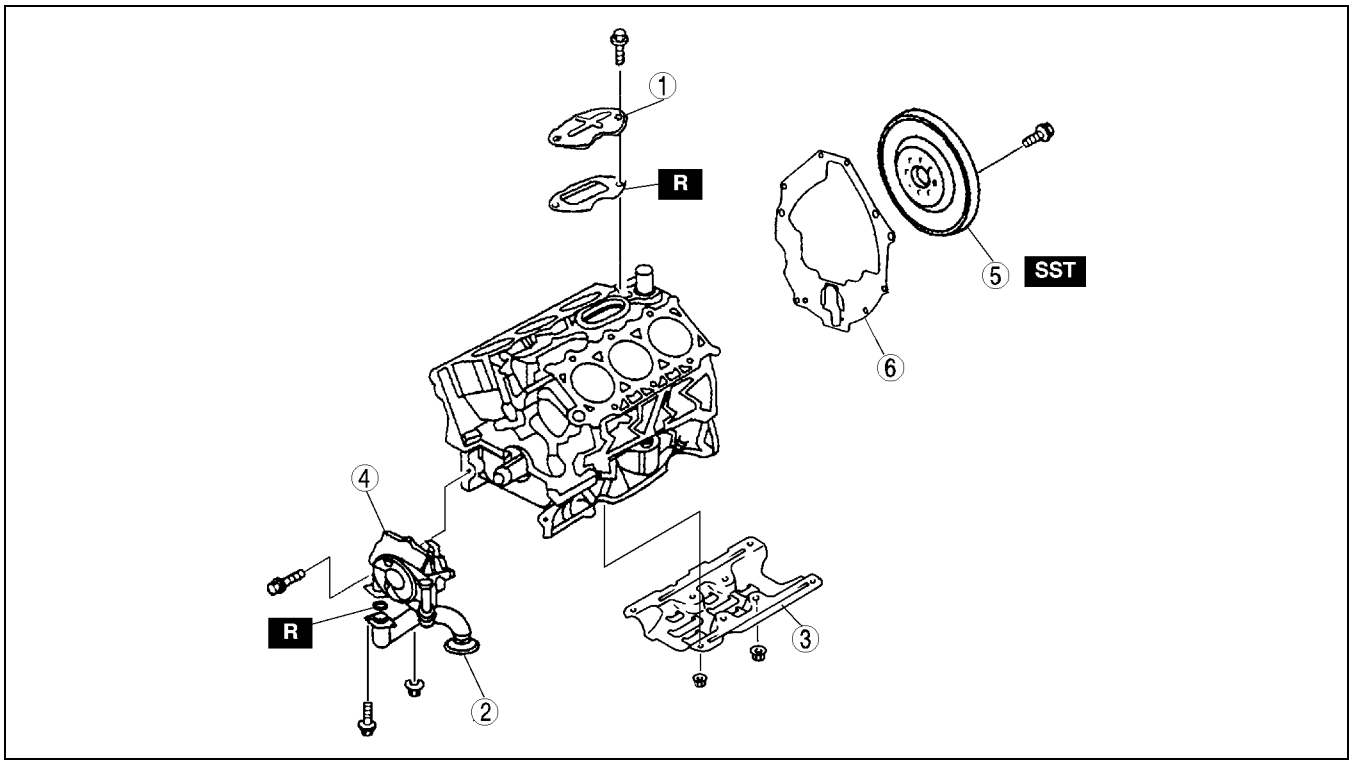


YMU110AAL

CYLINDER BLOCK DISASSEMBLY(I)

B6U011010300101

1. Disassemble in the order indicated in the table.

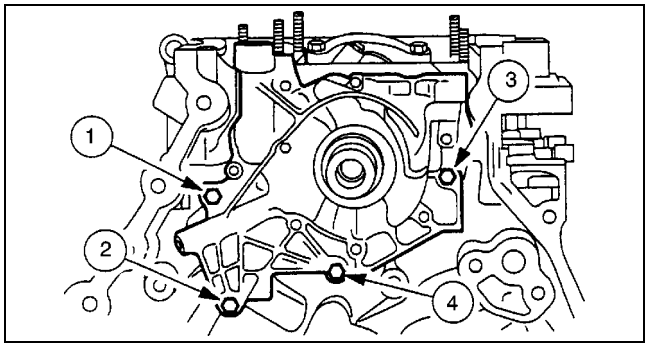


B6U2224E001

1	Plate
2	Oil strainer
3	Oil baffle
4	Oil pump (See 01–10–12 Oil Pump Disassembly Note)
5	Flywheel (MTX), Drive plate (ATX) (See 01–10–13 Flywheel (MTX), Drive Plate (ATX) Disassembly Note)
6	End plate

Oil Pump Disassembly Note

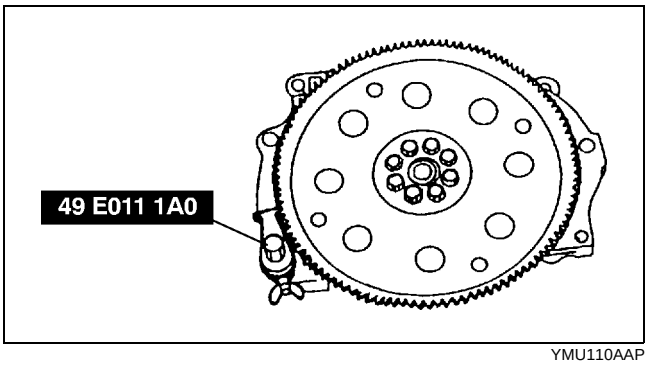
1. Remove the bolts in the order indicated in the figure.



YMU110AAN

Flywheel (MTX), Drive Plate (ATX) Disassembly Note

1. Hold the flywheel (MTX) or the drive plate (ATX) using the **SST**.
2. Remove the bolts, loosening in several passes.

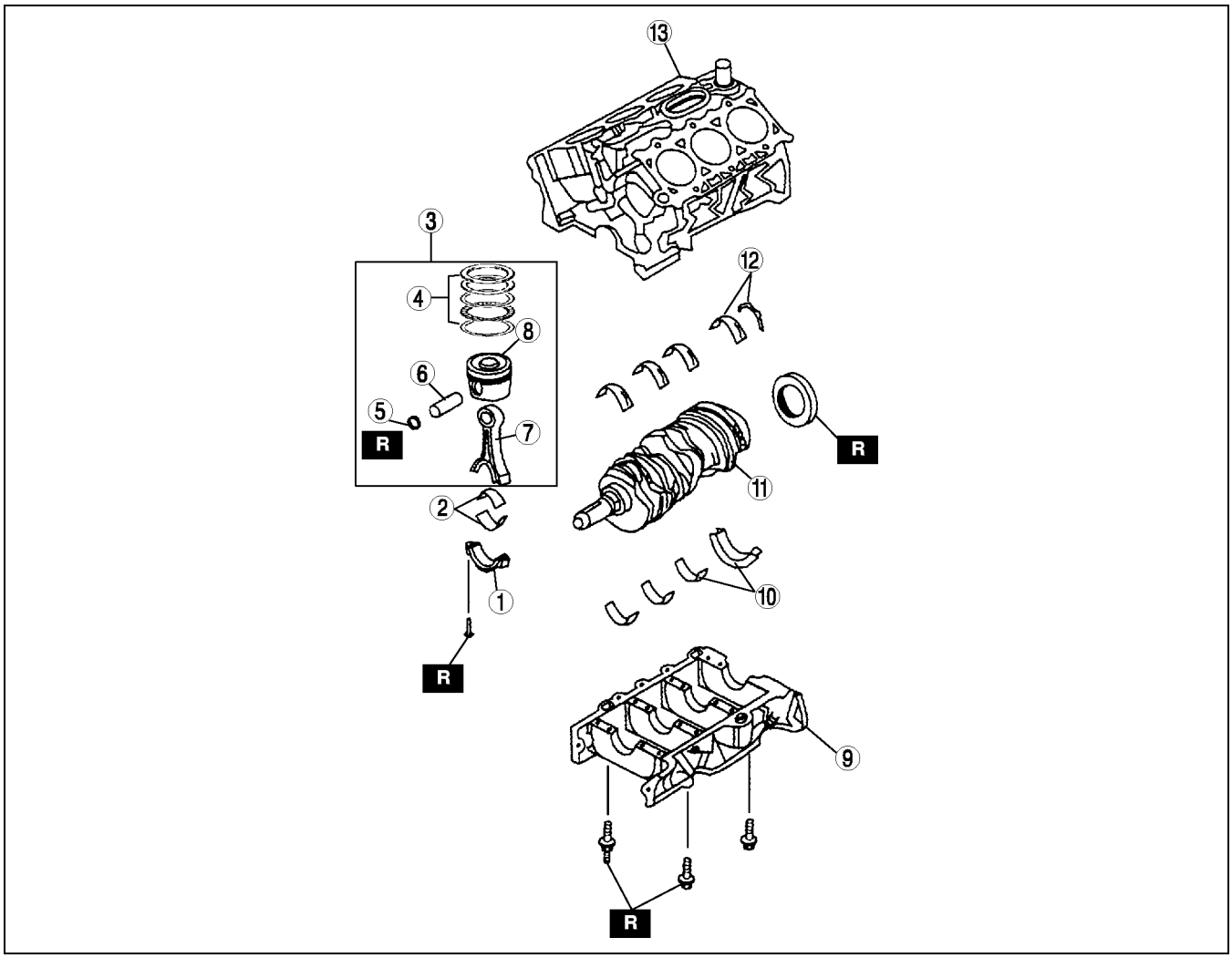


YMU110AAP

CYLINDER BLOCK DISASSEMBLY(II)

B6U011010300102

1. Disassemble in the order indicated in the table.



YMU110AAQ

1	Connecting rod cap (See 01–10–14 Connecting Rod Cap Disassembly Note)
2	Connecting rod bearing
3	Connecting rod, piston (See 01–10–14 Connecting Rod, Piston Disassembly Note)
4	Piston ring
5	Snap ring
6	Piston pin (See 01–10–14 Piston Pin Disassembly Note)

7	Connecting rod
8	Piston
9	Lower cylinder block (See 01–10–14 Lower Cylinder Block Disassembly Note)
10	Lower main bearing, thrust bearing
11	Crankshaft
12	Upper main bearing, thrust bearing
13	Upper cylinder block

Connecting Rod Cap Disassembly Note

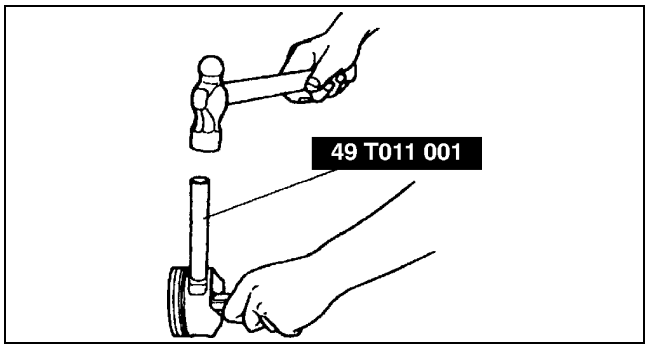
1. Before removing the connecting rod cap, inspect the connecting rod side clearance. (See 01–10–25 CONNECTING ROD SIDE CLEARANCE INSPECTION.)
2. Remove the connecting rod bolt from the connecting rod cap by tapping the bolt with a plastic hammer.

Connecting Rod, Piston Disassembly Note

1. Before removing the connecting rod and piston, inspect the connecting rod oil clearance. (See 01–10–25 CONNECTING ROD OIL CLEARANCE INSPECTION/REPAIR.)

Piston Pin Disassembly Note

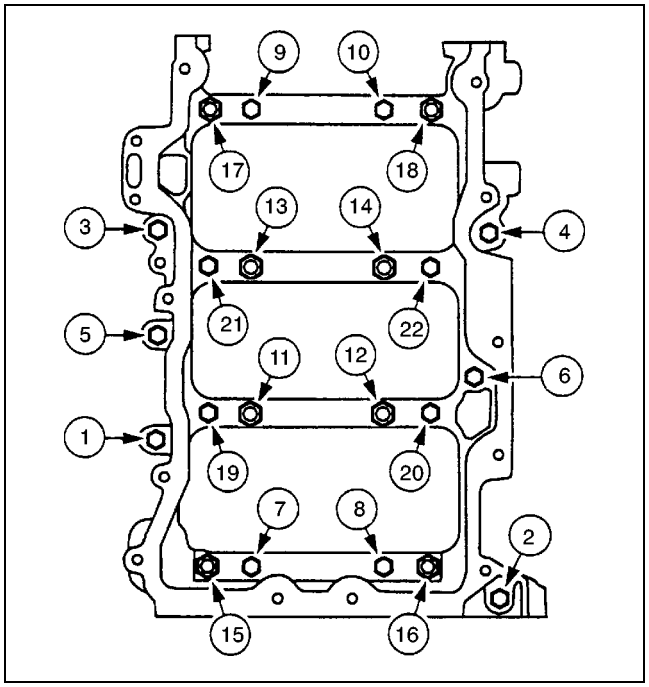
1. Remove the piston pin using the **SST**.



YMU110AAR

Lower Cylinder Block Disassembly Note

1. Before removing the lower cylinder block, inspect the crankshaft end play. (See 01–10–24 CRANKSHAFT END PLAY INSPECTION.)
2. Remove the lower cylinder block bolts in the order indicated in the figure in, loosening several passes.



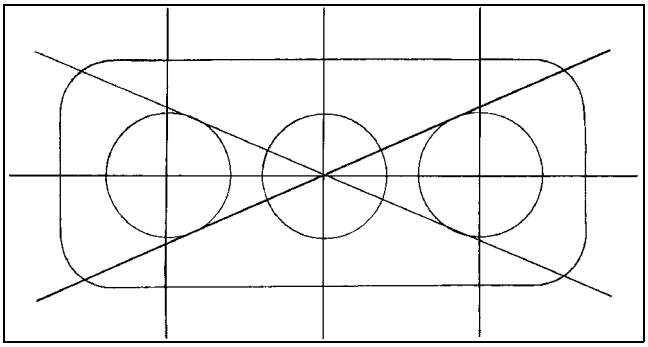
AMU2224E002

CYLINDER HEAD INSPECTION

B6U011010100103

1. Carry out color contrast penetration examination on the cylinder head surface.
   - Replace the cylinder head if necessary.
2. Inspect for the following and replace if necessary.
   (1) Camshaft end play (See 01–10–18 CAMSHAFT END PLAY INSPECTION.)
   (2) Camshaft journal oil clearance (See 01–10–18 CAMSHAFT OIL CLEARANCE INSPECTION.)
3. Measure the cylinder head for distortion in the six directions as indicated in the figure.
   - If the cylinder head distortion exceeds the maximum, replace the cylinder head. Do not attempt to repair the cylinder head by milling or grinding.

   Maximum distortion
   0.08 mm {0.0031 in}



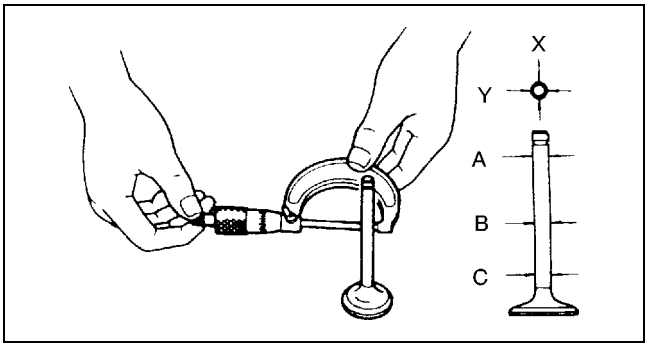
YMU110AD0

VALVE, VALVE GUIDE INSPECTION

B6U011012111101

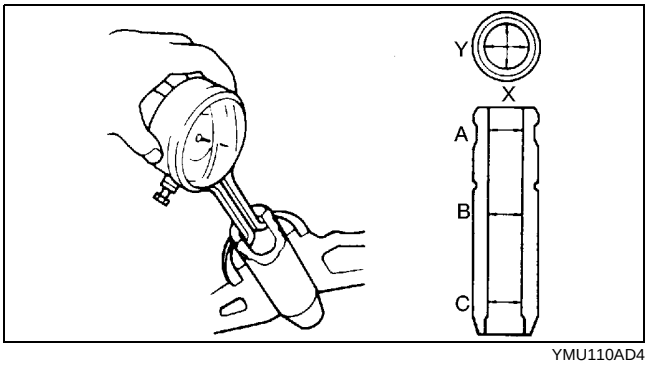
1. Measure the stem diameter of each valve in X and Y directions at the three points (A, B, and C) as indicated in the figure.
   - If not as specified, replace the valve.

   Standard diameter
   IN: 5.975—5.995 mm {0.2352—0.2360 in}
   EX:5.950—5.970 mm {0.2343—0.2350 in}



YMU110AD3

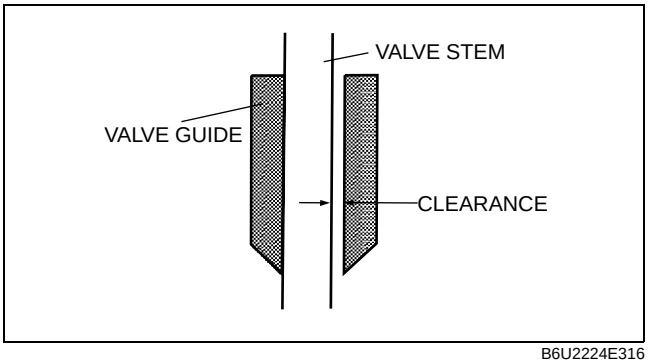
2. Measure the inner diameter of each valve guide in X and Y directions at the three points (A, B, and C) as indicated in the figure.



YMU110AD4

3. Calculate the valve stem to guide clearance by subtracting the outer diameter of the valve stem from the inner diameter of the corresponding valve guide.
   - If not as specified, replace the valve and/or the valve guide.

   Standard clearance
   IN: 0.020—0.069 mm {0.0008—0.0027 in}
   EX: 0.045—0.094 mm {0.0018—0.0037 in}



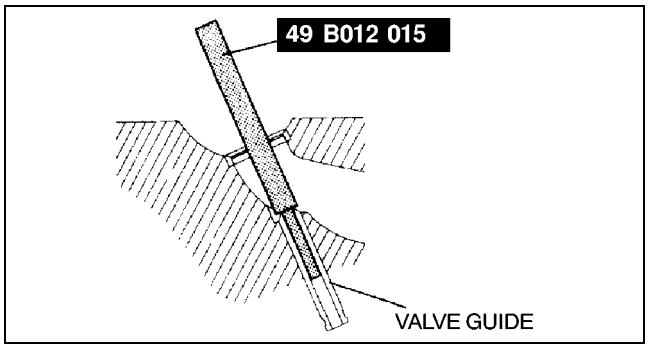
B6U2224E316

VALVE GUIDE REPLACEMENT

B6U011010280101

Valve Guide Removal

1. Remove the valve guide from the combustion chamber side using the **SST**.



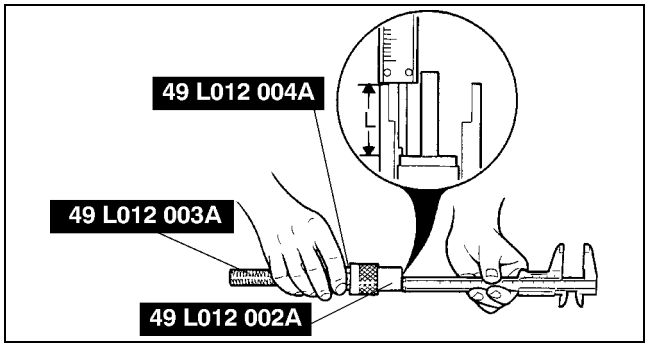
YMU110AD6

Valve Guide Installation

1. Assemble the **SSTs** so that depth **L** is as specified.

   Depth L
   IN: 13.4—14.2 mm {0.528—0.559 in}
   EX: 13.4—14.2 mm {0.528—0.559 in}

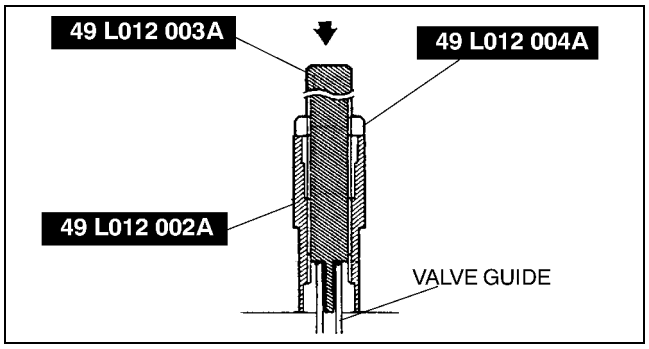
2. Tap the valve guide in from the side opposite the combustion chamber until the **SSTs** contact the cylinder head.



YBR2224A040

3. Verify that the valve guide projection height is within the specification.

   Standard height
   IN: 13.4—14.2 mm {0.528—0.559 in}
   EX: 13.4—14.2 mm {0.528—0.559 in}



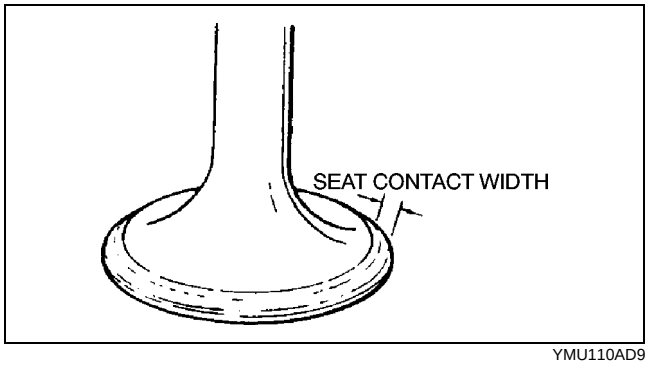
YBR2224A041

VALVE SEAT INSPECTION/REPAIR

B6U011010102101

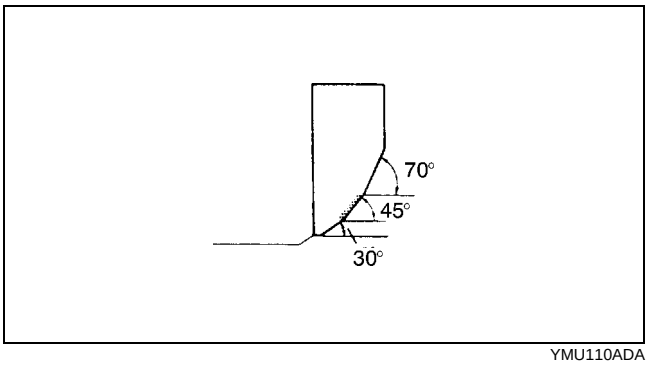
1. Measure the seat contact width.
   - If not as specified, resurface the valve seat using a **45**° valve seat cutter and/or resurface the valve face.

   Standard width
   IN: 1.1—1.4 mm {0.043—0.055 in}
   EX: 1.4—1.7 mm {0.056—0.066 in}



YMU110AD9

2. Verify that the valve seating position is at the center of the valve face.
   - If the seating position is too high, correct the valve seat using a **70**° cutter, and then **45**° cutter.
   - If the seating position is too low, correct the valve seat using **30**° cutter, and then **45**° cutter.



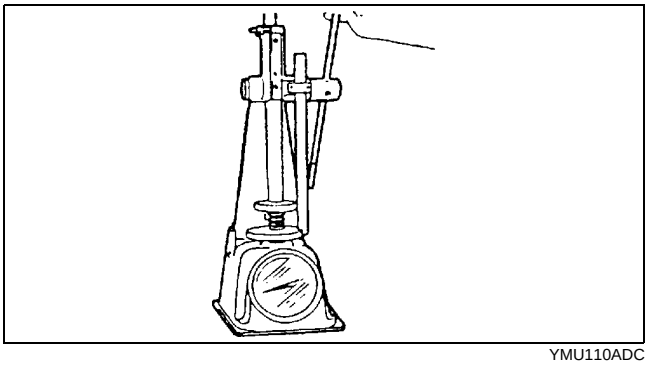
YMU110ADA

VALVE SPRING INSPECTION

B6U011012125101

1. Apply pressing force to the pressure spring and inspect the spring height.
   - If not as specified, replace the valve spring.

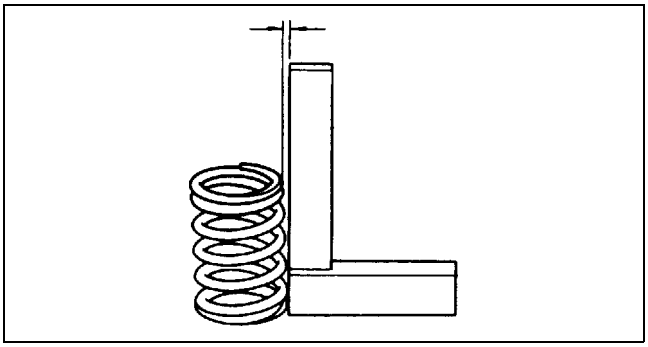
   Pressing force
   680 N {69.3 kgf, 152 lbf}
   Standard height
   30.19 mm {1.189 in}



YMU110ADC

2. Measure the amount of off- square on the valve spring.
   - If not as specified, replace the valve spring.

   Valve spring maximum off-square
   1% (0.468 mm {0.00184 in})



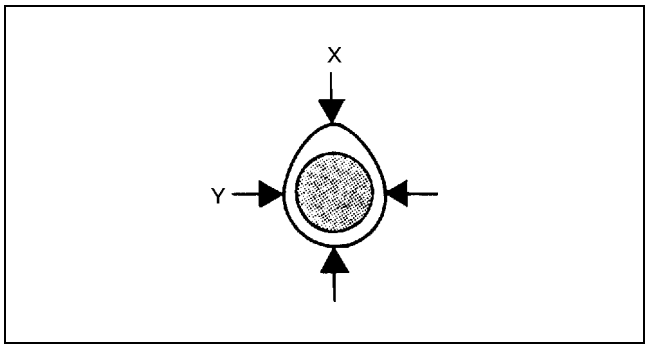
YMU110ADD

CAMSHAFT INSPECTION

B6U011012420101

1. Measure the cam lobe height at the two points as indicated in the figure to calculate the gap between X and Y.
   - If not as specified, replace the camshaft.

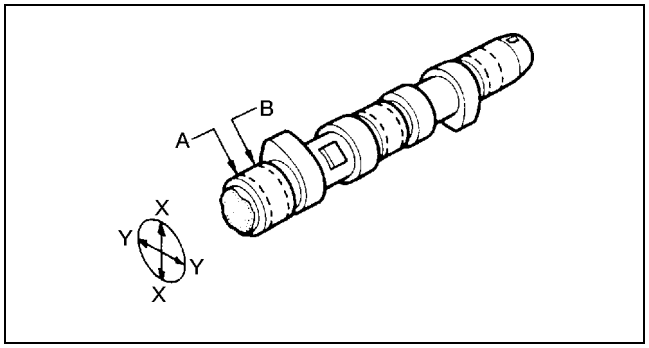
   Standard height
   IN: 4.79 mm {0.189 in}
   EX: 4.79 mm {0.189 in}



YMU110ADF

2. Measure the journal diameters in X and Y directions at the two points (A and B) as indicated in the figure.
   - If not as specified, replace the camshaft.

   Standard diameter
   26.936—26.962 mm {1.0604—1.0615 in}



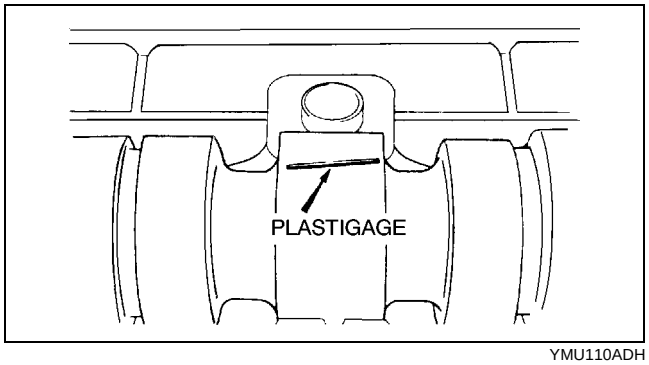
YMU110ADG

CAMSHAFT OIL CLEARANCE INSPECTION

B6U011012420102

1. Position plastigage atop the journals in the axial direction.
2. Install the camshaft cap. (See 01–10–40 Timing Chain (LH) Assembly Note.) (See 01–10–41 Timing Chain (RH) Assembly Note.)
3. Remove the camshaft cap. (See 01–10–7 Camshaft Cap (RH) Disassembly Note.) (See 01–10–8 Camshaft Cap (LH) Disassembly Note.)
4. Measure the oil clearance.
   - If the oil clearance exceeds the maximum clearance, replace the cylinder head.

   Standard clearance
   0.025—0.076 mm {0.0010—0.0029 in}
   Maximum clearance
   0.121 mm {0.00476 in}



YMU110ADH

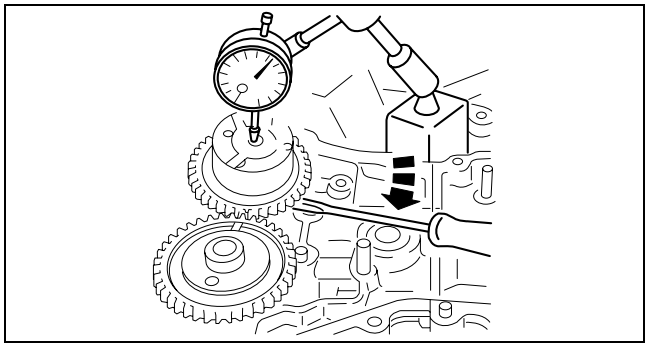
CAMSHAFT END PLAY INSPECTION

B6U011012420103

1. Measure the camshaft end play.
   - If the camshaft end play exceeds the maximum end play, replace the cylinder head or camshaft.

   Standard end play
   0.025—0.165 mm {0.0010—0.0064 in}
   Maximum end play
   0.190 mm{0.00748 in}

2. Remove the camshaft cap. (See 01–10–7 Camshaft Cap (RH) Disassembly Note.) (See 01–10–8 Camshaft Cap (LH) Disassembly Note.)



B6U2217E001

HYDRAULIC LASH ADJUSTER (HLA) INSPECTION

B6U011012100101

1. Measure the diameter of each HLA bore.

   Standard diameter
   16.018—16.057 mm {0.63063—0.63216 in}

2. Measure the diameter of each HLA.

   Standard diameter
   15.988—16.000 mm {0.62945—0.62992 in}

3. Calculate the clearance between the HLA and the related HLA bores.
   - If the clearance exceeds the maximum clearance, replace the cylinder head or the HLA.

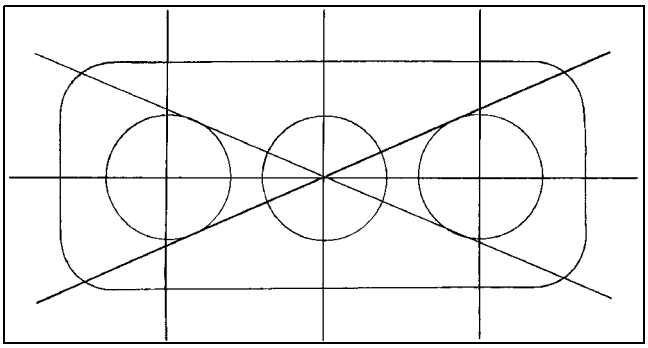
   Standard clearance
   0.018—0.069 mm {0.0008—0.0027 in}
   Maximum clearance
   0.16 mm {0. 0063 in}

CYLINDER BLOCK INSPECTION

B6U011010300103

1. Measure the distortion of the cylinder block top surface in the six directions as indicated in the figure.
   - If not as specified, replace the cylinder block.

   Cylinder block maximum distortion
   0.08 mm {0.0031 in}



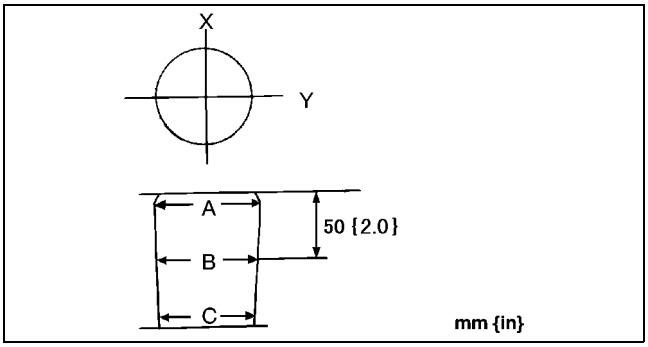
YMU110AD0

2. Measure the cylinder bores in X and Y directions at **50 mm {2.0 in}** below the top surface.
   - If the difference between measurements A and C exceeds the maximum taper, replace the cylinder block.
   - If the difference between measurements X and Y exceeds the maximum distortion, replace the cylinder block.

   Cylinder bore
   89.000—89.030 mm {3.5039—3.5051 in}

   Maximum taper
   0.020 mm {0.00079 in}

   Off-round
   0.020 mm {0.00079 in}



YMU110ADL

WATER INLET TUBE INSTALLATION

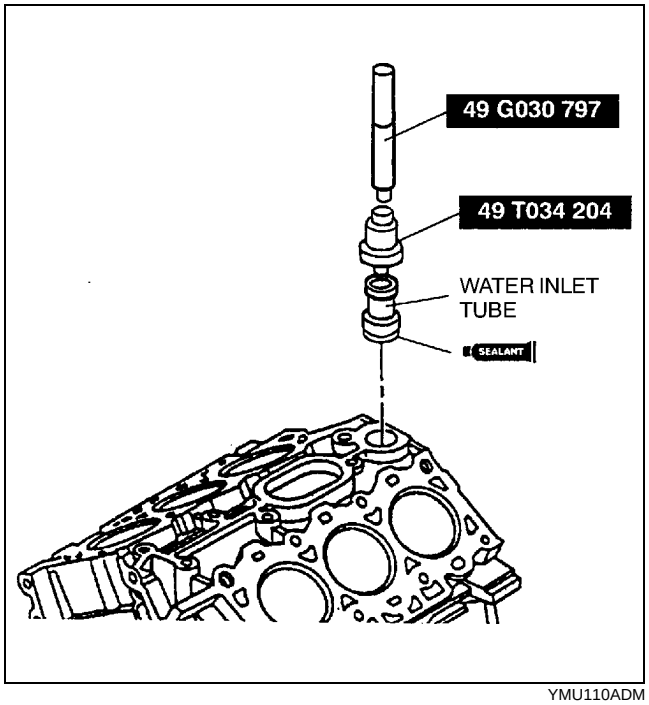
B6U011002000104

Note
- When replacing a cylinder block that has no water inlet tube.

1. Apply silicone sealant to the water inlet tube as indicated in the figure.

   Thickness
   2.0 mm {0.079 in}

2. Install the water inlet tube using the **SST**.



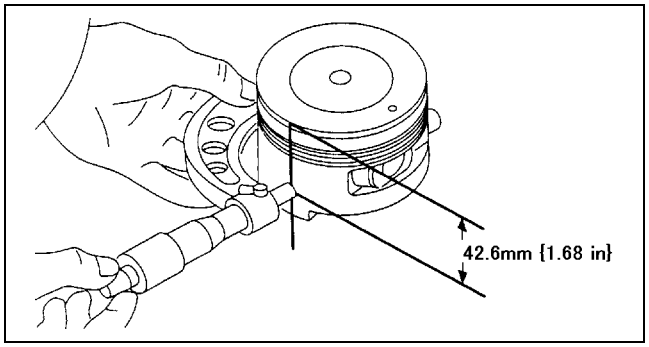
YMU110ADM

PISTON INSPECTION

B6U011011010101

1. Measure the outer diameter of each piston at a right angle **(90°)** to the piston pin, **42.6 mm {1.68 in}** below the top of the piston.
   - If the piston diameter is below the standard diameter, replace the piston.

   Piston diameter
   88.990—89.030 mm {3.5036—3.5051 in}



AMU2224E003

PISTON CLEARANCE INSPECTION

B6U011011010102

1. Measure the piston-to-cylinder clearance.
   - If not as specified, replace the piston or the cylinder block.
     — If the piston is replaced, the piston rings must also be replaced.

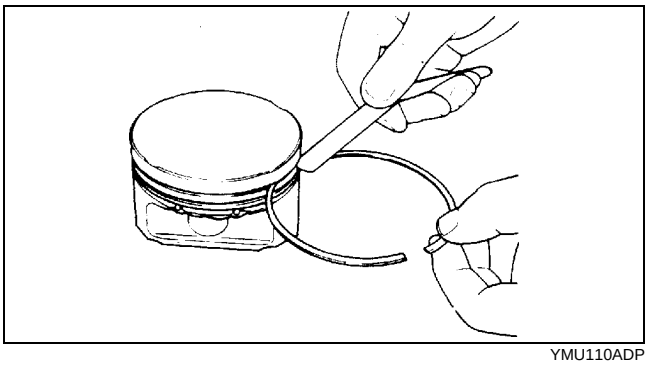
   Standard clearance
   0.012—0.022 mm {0.0004—0.0008 in}

PISTON RING CLEARANCE INSPECTION

B6U011011010103

1. Measure the piston ring-to-ring groove clearance around the entire circumference.
   - If the piston ring-to-ring groove clearance exceeds the maximum clearance, replace the piston and piston ring.

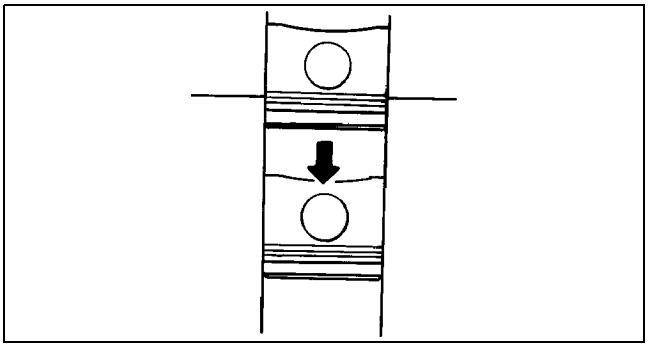
   Standard clearance
   Top: 0.040—0.075 mm {0.0016—0.0029 in}
   Second: 0.040—0.085 mm {0.0016—0.0033 in}
   Maximum clearance
   0.10 mm {0.0039 in}



YMU110ADP

2. Insert the piston ring into the cylinder by hand and use the piston to push it to the bottom of the ring travel.
3. Measure each piston ring end gap with a feeler gauge.
   - If the piston ring end gap exceeds the maximum end gap, replace the piston ring.

   Standard end gap
   Top: 0.10—0.25 mm {0.004—0.009 in}
   Second: 0.27—0.42 mm {0.011—0.016 in}
   Oil (side rail): 0.15—0.65 mm {0.006—0.025 in}
   Maximum end gap
   Top: 0.50 mm {0.019 in}
   Second: 0.65 mm {0.025 in}
   Oil (side rail): 0.90 mm {0.035 in}



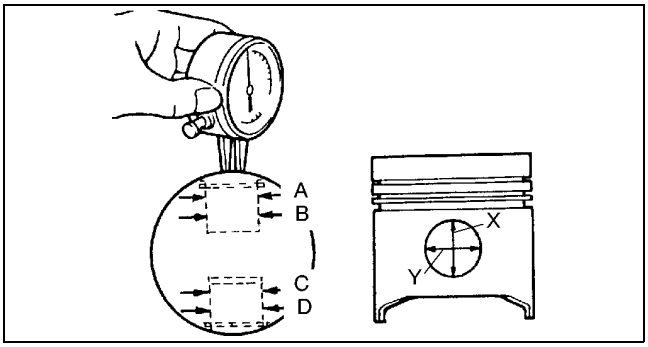
YMU110ADQ

PISTON PIN CLEARANCE INSPECTION

B6U011011010104

1. Measure each piston pin bore diameter in X and Y directions at the four points (A, B, C and D) as indicated in the figure.

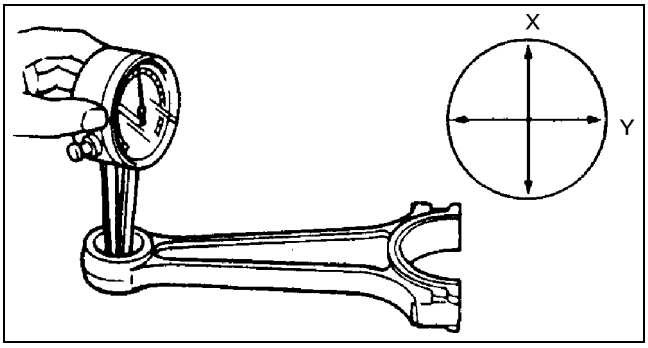
   Standard diameter
   21.008—21.012 mm {0.82709—0.82724 in}



YMU110ADR

2. Measure each connecting rod small end inner diameter in X and Y directions as indicated in the figure.

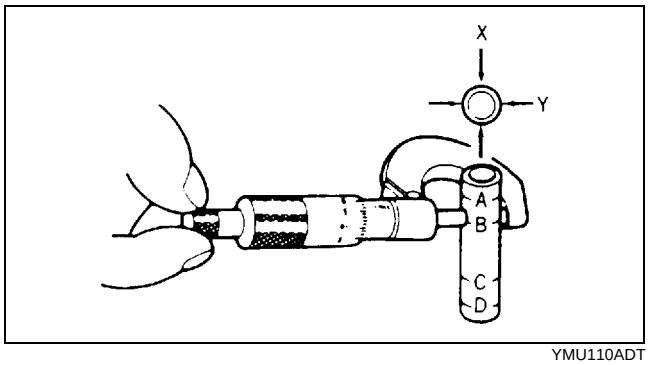
   Standard diameter
   21.017—21.031 mm {0.82744—0.82799 in}



YMU110ADS

3. Measure each piston pin diameter in X and Y directions at the four points (A, B, C and D) as indicated in the figure.

   Standard diameter
   21.011—21.013 mm {0.82721—0.82728 in}



YMU110ADT

4. Calculate the piston pin-to-piston pin bore clearance.
   - If not as specified, replace the piston and/or piston pin.

   Standard clearance
   –0.005—0.001 mm {–0.00019—0.00003 in}

5. Calculate small end-to-piston pin clearance of the connecting rod.
   - If small end-to-piston pin clearance of the connecting rod exceeds the maximum clearance, replace the connecting rod or piston pin.

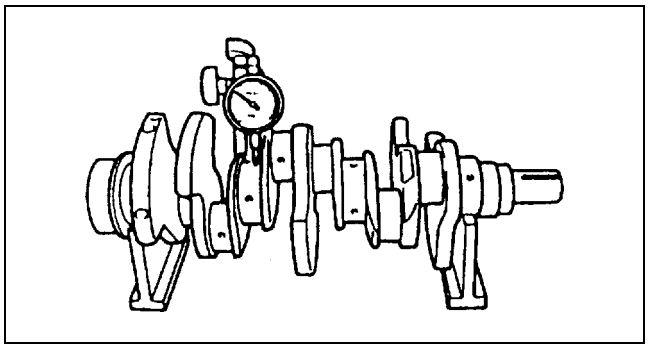
   Standard clearance
   0.004—0.020 mm {0.00016—0.00078 in}
   Maximum clearance
   0.035 mm {0.0013 in}

CRANKSHAFT INSPECTION

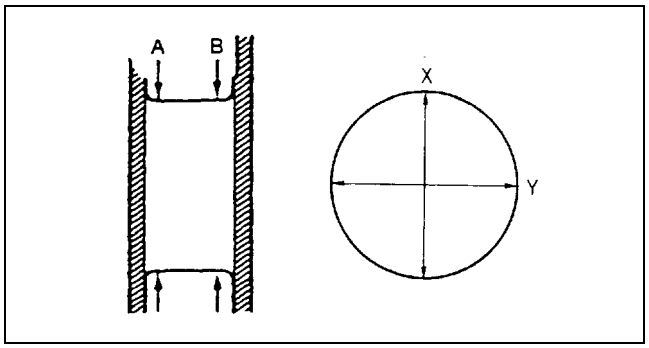
B6U011011301101

1. Measure the crankshaft runout.
   - If the crankshaft runout exceeds the maximum runout, replace the crankshaft.

   Maximum runout
   0.05 mm {0.0019 in}


YMU110ADU

2. Measure the journal diameter in X and Y directions at the two points (A and B) as indicated in the figure.
   - If not as specified, replace the crankshaft or grind the journal and install the undersize bearing.



YMU110ADV

Main journal

mm {in}

Bearing size	Standard diameter
Standard	62.968—62.992 {2.4791—2.4799}
0.25 {0.01} undersize	62.718—62.742 {2.4693—2.4701}

Crank pin

mm {in}

Bearing size	Standard diameter
Standard	49.970—49.990 {1.9674—1.9681}
0.02 {0.0008} undersize	49.950—49.970 {1.9666—1.9673}
0.05 {0.0020} undersize	49.920— 49.940 {1.9654—1.9661}
0.25 {0.01} undersize	49.720—49.740 {1.9575—1.9582}

CRANKSHAFT OIL CLEARANCE INSPECTION/REPAIR

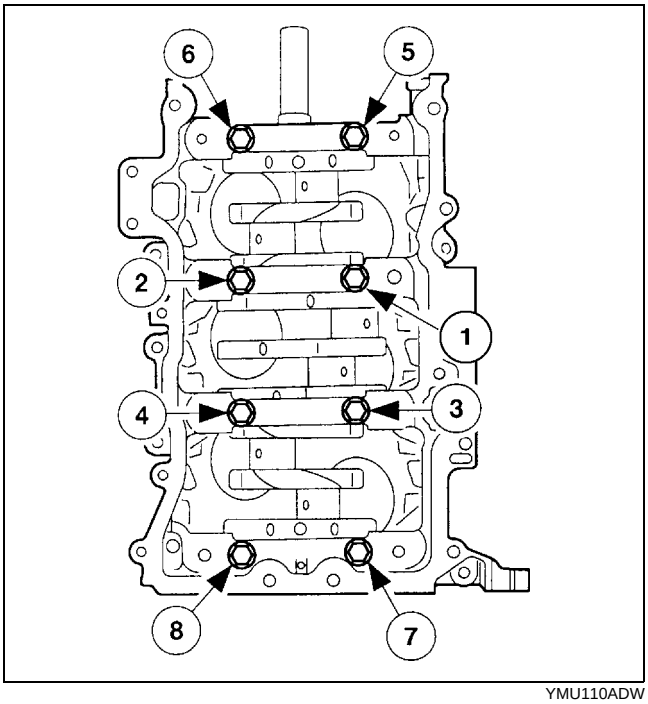
B6U011011301102

Caution
- **Because the bolts are pliant bolts, they cannot reused. Use new bolts for inspection. The bolts may be reused for assembly.**

1. Install the upper main bearing and crankshaft.
2. Position a plastigage atop the journals in the axial direction.
3. Install the lower mainbearing and lower cylinder block, and tighten the bolts in the order indicated in the figure.

   Tightening torque
   37—43 N·m {3.7—4.4kgf·m, 27—31 ft·lbf}

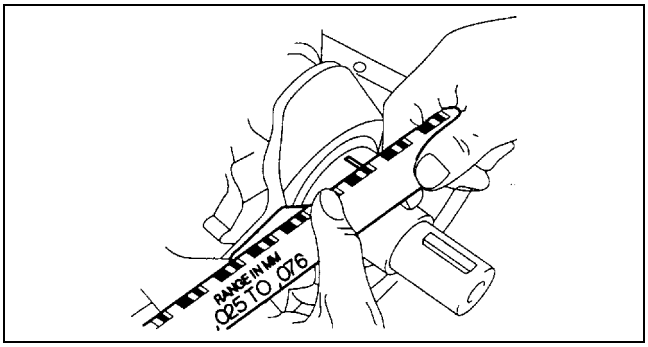
4. Tighten the bolts by turning each **85**° **— 95**° in the sequence as indicated in the figure.
5. Loosen the bolts in the reverse order of tightening.



YMU110ADW

6. Measure the main journal oil clearance.
   - If the clearance exceeds the maximum, replace the main bearing using the main bearing selection table or grind the main journal and install the undersize bearings so that the specified oil clearance is obtained.

   Standard clearance
   0.025—0.045 mm {0.0010—0.0017 in}
   Maximum clearance
   0.050 mm {0.0019 in}

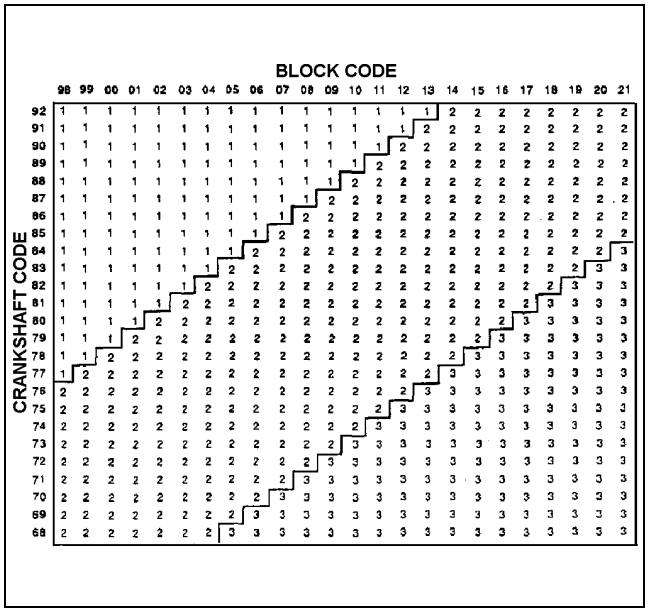


YMU110ADX

mm {in}

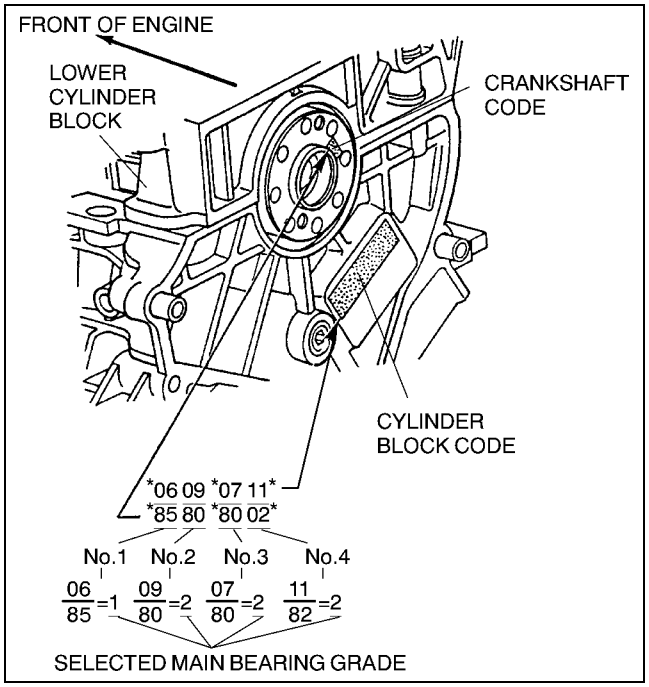
Bearing size	Grade	Bearing thickness	
		Upper:No.1,2,3,4 Lower: No.1,2,3	Lower: No.4
Standard	1	2.494—2.500 {0.09819—0.09842}	2.492—2.498 {0.09812—0.09834}
	2	2.498—2.504 {0.09835—0.09858}	2.496—2.502 {0.09827—0.09850}
	3	2.502—2.508 {0.09851—0.09873}	2.5000—2.5006 {0.09843—0.09844}
0.25 {0.01} undersize	–	2.623—2.629 {0.10327—0.10350}	2.621—2.627 {0.10319—0.10342}

Main bearing selection table



B6U2224E119

Example of main bearing selection



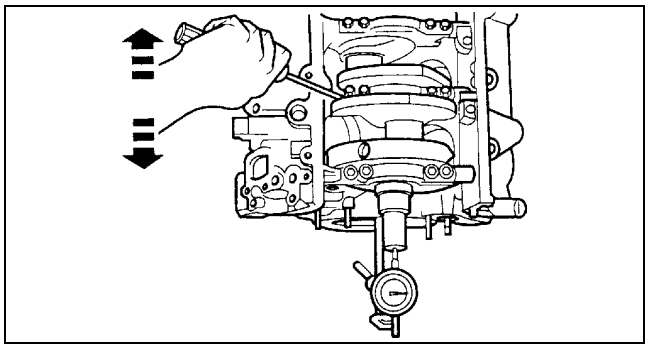
YMU110AE6

CRANKSHAFT END PLAY INSPECTION

1. Measure the crankshaft end play.
   - If not as specified, replace the thrust bearing and No.4 lower main bearing or crankshaft so that the specified end play is obtained.

Standard end play
0.110—0.232 mm {0.00434—0.00913 in}

B6U011011301103



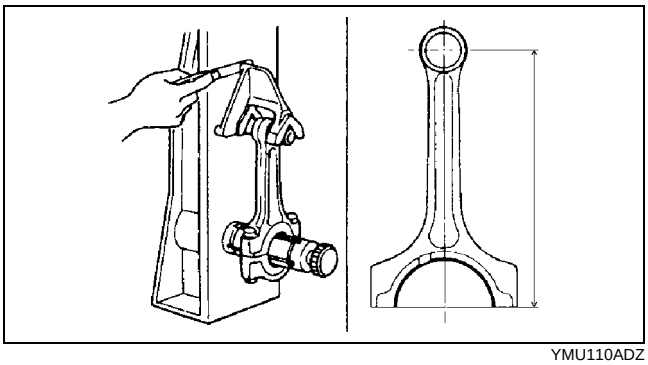
YMU110ADY

CONNECTING ROD INSPECTION

B6U011011211101

1. Measure each connecting rod for bending and distortion.
   - If not as specified, replace the connecting rod.

Bending
0.038 mm {0.0014 in}max./25 mm {0.98 in}
Distortion
0.050 mm {0.0019 in}max./25 mm {0.98 in}
Center-to-center distance
138.06—138.14 mm {5.4355—5.4385 in}



YMU110ADZ

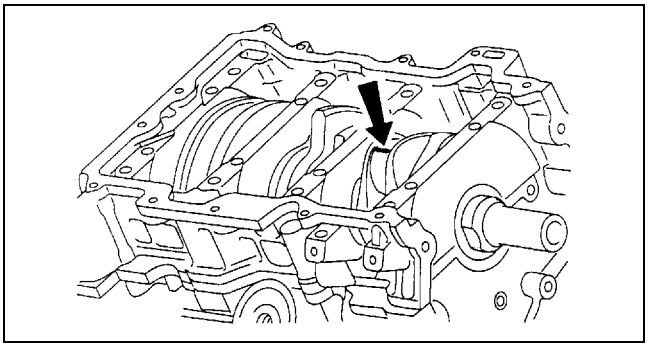
CONNECTING ROD OIL CLEARANCE INSPECTION/REPAIR

B6U011011211102

Caution
- **Because the bolts are pliant bolts, they cannot reused. Use new bolts for inspection. The bolts may be reused for assembly.**

1. Position plastigage atop the journals in the axial direction.
2. Install the connecting rod bearing and connecting rod cap. (See 01–10–32 Connecting Rod Cap Assembly Note.)
3. Remove the connecting rod cap.
4. Measure the connecting rod oil clearance.
   - If not as specified, replace the connecting rod bearing or grind the crankpin and use undersize bearings so that the specified clearance is obtained.

Standard clearance
0.028—0.066 mm {0.0012—0.0025 in}



YMU110AE0

mm {in}

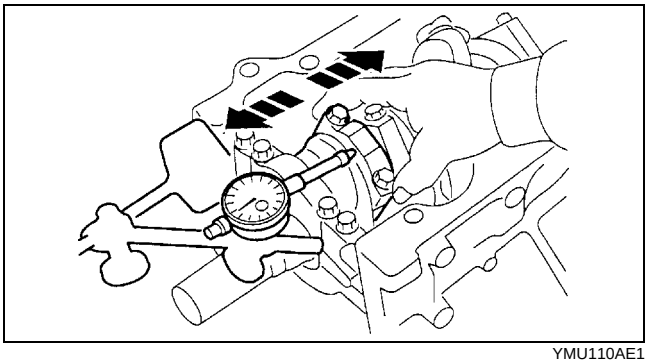
Bearing size	Bearing thickness
Standard	1.500—1.506 {0.0591—0.0593}
0.02 {0.0008} undersize	1.510—1.516 {0.0595—0.0596}
0.05 {0.002} undersize	1.525—1.531 {0.0601—0.0602}
0.25 {0.01} undersize	1.625—1.631 {0.0640—0.0642}

CONNECTING ROD SIDE CLEARANCE INSPECTION

B6U011011211103

1. Measure the connecting rod large end side clearance.
   - If the connecting rod side clearance exceeds the maximum clearance, replace the connecting rod and cap.

Standard clearance
0.10—0.30 mm {0.004—0.011 in}
Maximum clearance
0.35 mm {0.013 in}



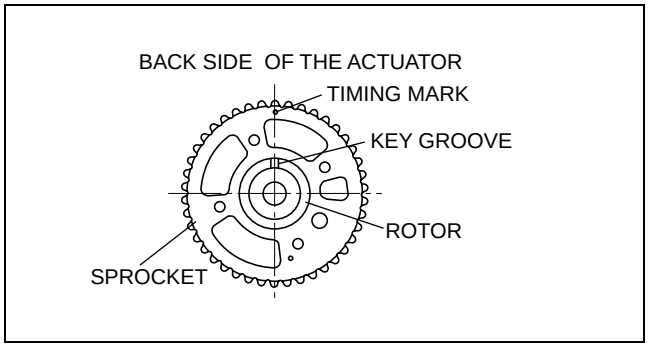
YMU110AE1

VARIABLE VALVE TIMING ACTUATOR INSPECTION

B6U011000142101

Caution
- **The variable valve timing actuator cannot be disassembled because it is a precision unit.**

1. Confirm that the key groove of the rotor and the timing mark of the sprocket at the variable valve timing actuator are aligned and fitted.
   - If the timing mark and the key groove are not aligned, rotate the rotor toward the bulb timing retard position by hand until they are in place.
   - If the rotor and sprocket are not secured even though their timing mark and the key groove are aligned, replace the variable valve timing actuator.



B6U2224E002

OIL CONTROL VALVE (OCV) INSPECTION

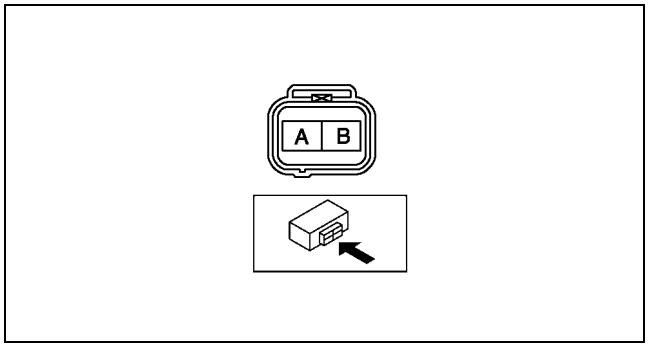
B6U011014420101

Coil Resistance Inspection

1. Disconnect the negative battery cable.
2. Disconnect the oil control valve (OCV) connector.
3. Measure the resistance between terminals A and B using an ohmmeter.
   - If not as specified, replace the oil control valve (OCV).

Specification
7.05—7.95 ohms

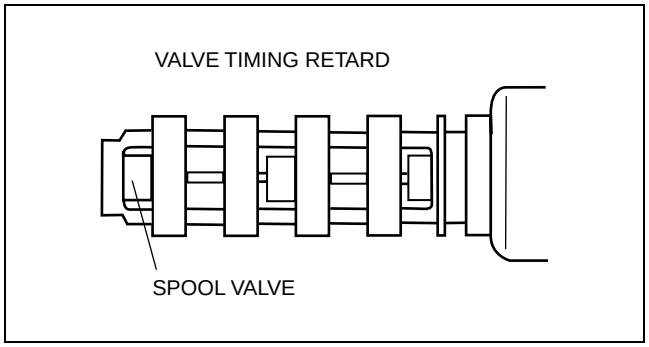
4. Connect the oil control valve (OCV) connector.



A6A2226W101

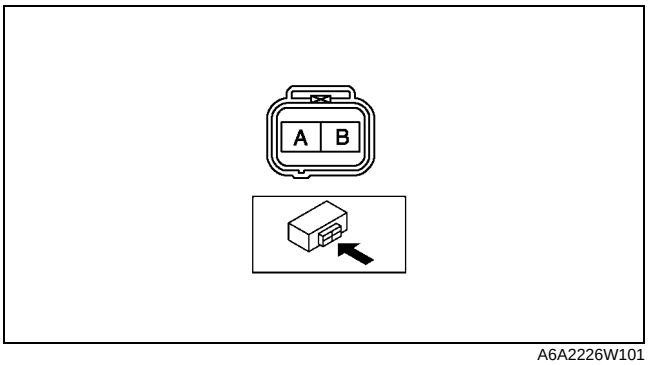
Spool Valve Operation Inspection

1. Disconnect the negative battery cable.
2. Remove the oil control valve (OCV).
3. Verify that the spool valve in the oil control valve (OCV) is in the maximum valve timing retard position as indicated in the figure.
   - If not as specified, replace the oil control valve (OCV).
4. Verify that the battery is fully charged.
   - If not as specified, recharge the battery.



B6U2424E001

5. Apply battery positive voltage between the oil control valve (OCV) terminals and verify that the spool valve operates and moves to the maximum valve timing advance position.

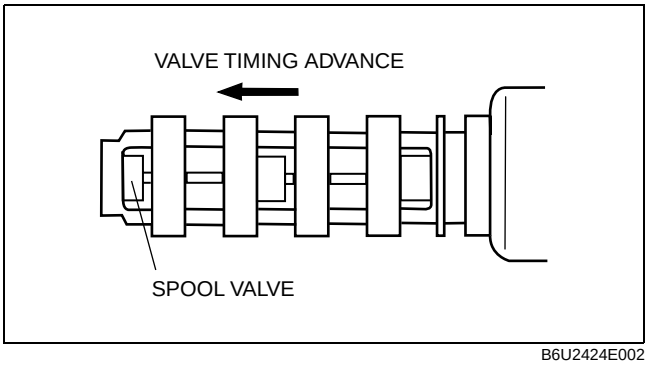


A6A2226W101

- If not as specified, replace the oil control valve (OCV).

Note

- When applying battery positive voltage between the oil control valve (OCV) terminals, the connection can be either of the following:
  - — Positive battery cable to terminal A, negative battery cable to terminal B
  - — Positive battery cable to terminal B, negative battery cable to terminal A



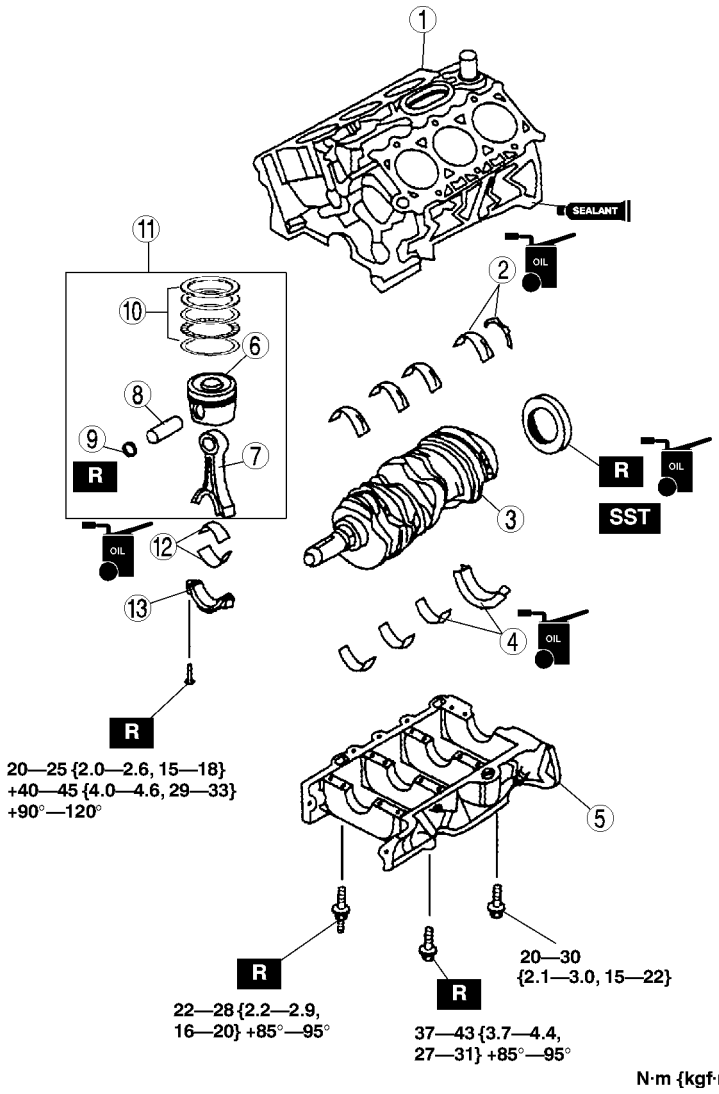
B6U2424E002

6. Stop applying battery positive voltage and verify that the spool valve returns to the maximum valve timing retard position.
   - If not as specified, replace the oil control valve (OCV).

CYLINDER BLOCK ASSEMBLY(I)

B6U011010300104

1. Assemble in the order indicated in the table.



YMU110AAT

1	Upper cylinder block
2	Upper main bearing, thrust bearing
3	Crankshaft
4	Lower main bearing, thrust bearing
5	Lower cylinder block (See 01–10–29 Lower Cylinder Block Assembly Note)
6	Piston
7	Connecting rod
8	Piston pin (See 01–10–31 Piston Pin Assembly Note)

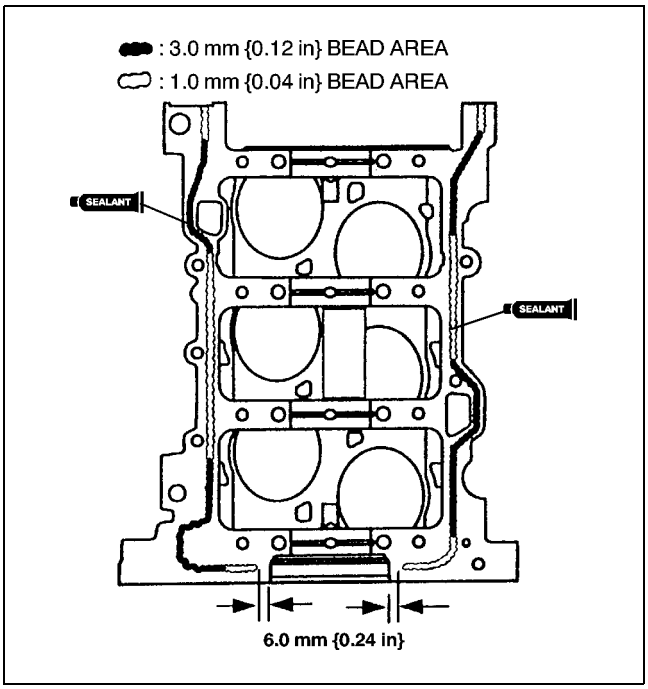
9	Snap ring
10	Piston ring (See 01–10–31 Piston Ring Assembly Note)
11	Piston, connecting rod (See 01–10–31 Piston, Connecting Rod Assembly Note)
12	Connecting rod bearing
13	Connecting rod cap (See 01–10–32 Connecting Rod Cap Assembly Note)

Lower Cylinder Block Assembly Note

1. Apply a continuous bead of silicone sealant to the upper cylinder block as indicated in the figure.

Caution

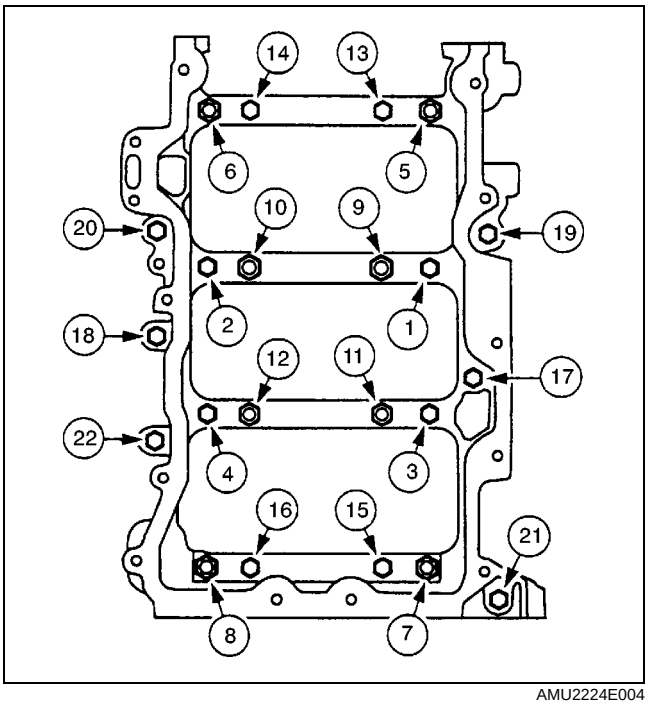
- **Because bolts 1—16 are pliant bolts, they cannot be reused. Replace bolts 1—8 with new bolts and use bolts 9—16 installed during inspection when assembling the lower cylinder block.**



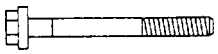
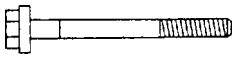
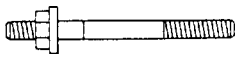
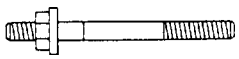
YMU110AAU

2. Install the lower cylinder block bolts in the order indicated in the figure.

Tightening torque
3.0—5.0 N·m {30—51 kgf·cm, 27—44 in·lbf}

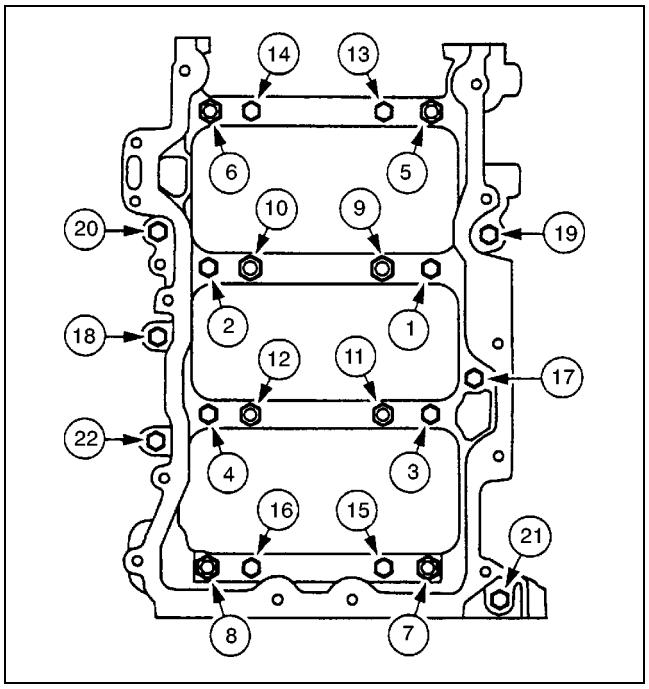


AMU2224E004

Hole No.	Bolt	Description
18, 19, 20, 21, 22		M8×1.25×79.3 bolt
1, 2, 3, 4, 17		M8×1.25×96 bolt
13, 14, 15, 16		M10×1.5×106.5 bolt
5, 6, 7, 8		M8×1.25×96 stud/M6×1.0×18
9, 10, 11, 12		M10×1.5×106.8/ M8×1.25×21.5 stud

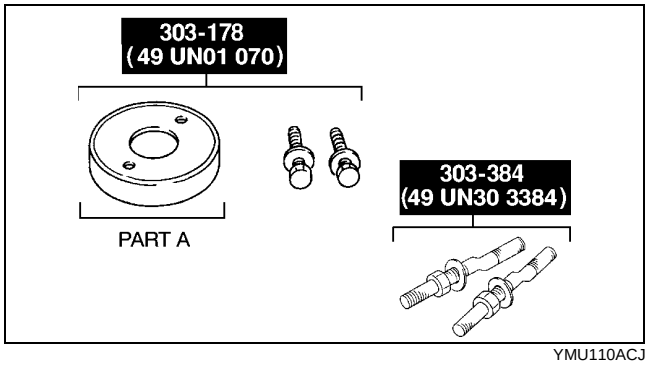
3. Push crankshaft forward and then rearward to seat the crankshaft thrust washer.

4. Tighten the lower cylinder block bolts in the order indicated in the figure in four steps.
   (1) Bolts 1-8: tighten to **22—28 N·m {2.2—2.9 kgf·m, 16—20 ft·lbf}**.
   (2) Bolts 9-16: tighten to **37—43 N·m {3.7—4.4 kgf·m, 27—31 ft·lbf}**.
   (3) Bolts 1-16: tighten **85°—95°**.
   (4) Bolts 17-22: tighten to **20—30 N·m {2.1—3.0 kgf·m, 15—22 ft·lbf}**.
   (5) Verify that the crankshaft rotates freely.



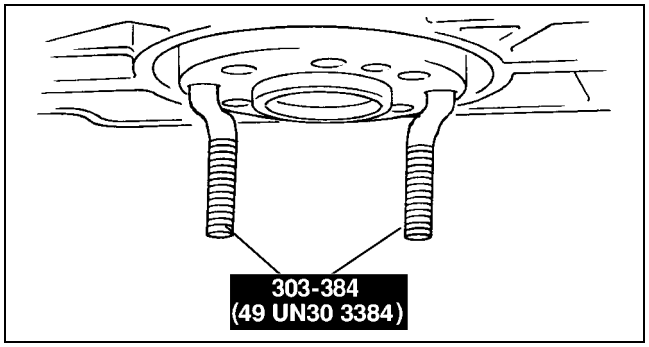
AMU2224E004

5. Assemble rear oil seal with part A of the **SST** [303-178 (49 UN01 070)] and the **SST** [303-384 (49 UN30 3384)].



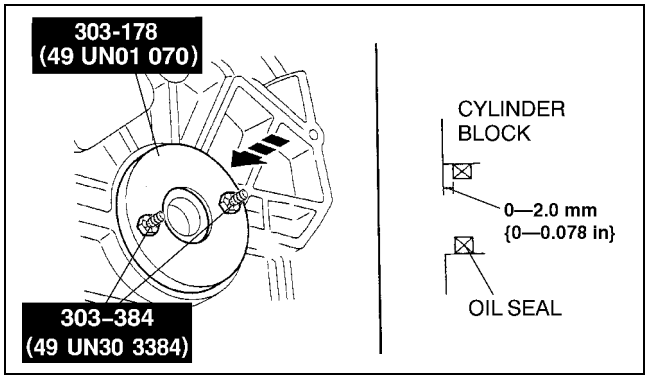
YMU110ACJ

   (1) Install the studs of the **SST** as indicated in the figure.
   (2) Apply clean engine oil to the oil seal.
   (3) Push the oil seal slightly in by hand.



YMU110ACK

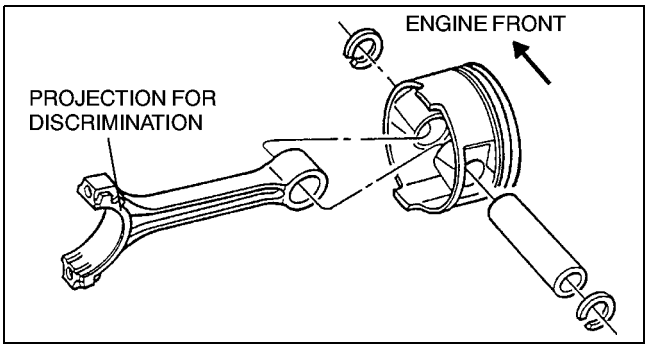
   (4) Install part A of the **SST** [303-178 (49 UN01 070)] and compress the oil seal with the nuts of the **SST** [303-384 (49 UN30 3384)].



ZMU0110W010

Piston Pin Assembly Note

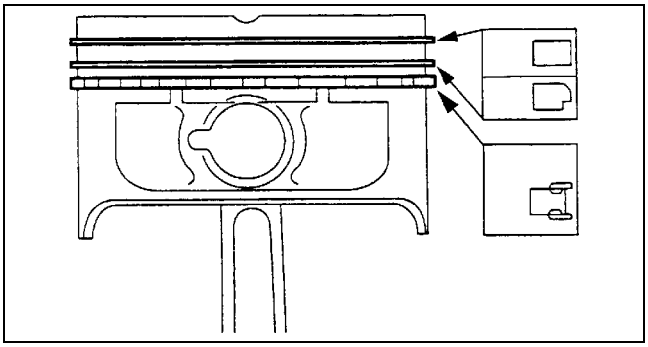
1. Assemble the piston pin so that connecting rod's projection for discrimination faces the opposite side of the arrow mark on the piston (rear side of the engine).
2. Apply clean engine oil to the piston pin.
3. Install the piston pin until the pin contacts the clip.
   - If the pin cannot be installed easily, heat the piston.



YMU110AAW

Piston Ring Assembly Note

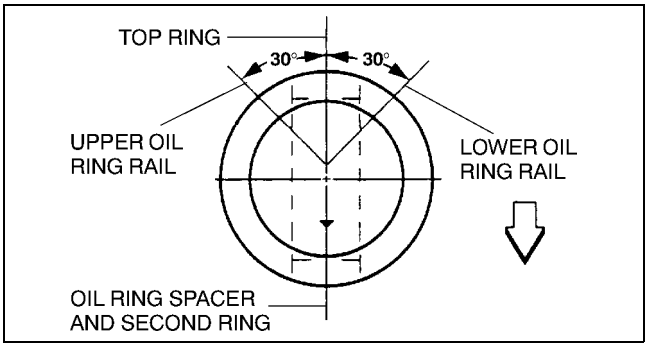
1. Install the two oil control ring segments and spacer.
2. Verify that the second ring is installed with the scraper face side downward.
3. Install the top ring.



YMU110AAX

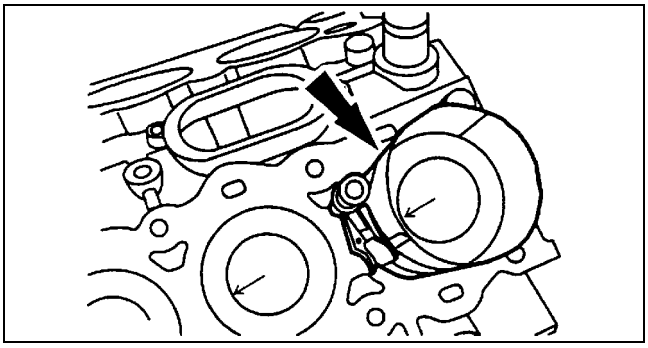
Piston, Connecting Rod Assembly Note

1. Position the end gap of each ring as indicated in the figure.



YMU110AAY

2. Insert the piston and connecting rod into the cylinder with the arrow mark to front of the engine.



YMU110AAZ

Connecting Rod Cap Assembly Note

Caution
- **Because the connecting rod bolts are pliant bolts, they cannot be reused. Use the bolts installed during inspection when assembling the connecting rod cap.**

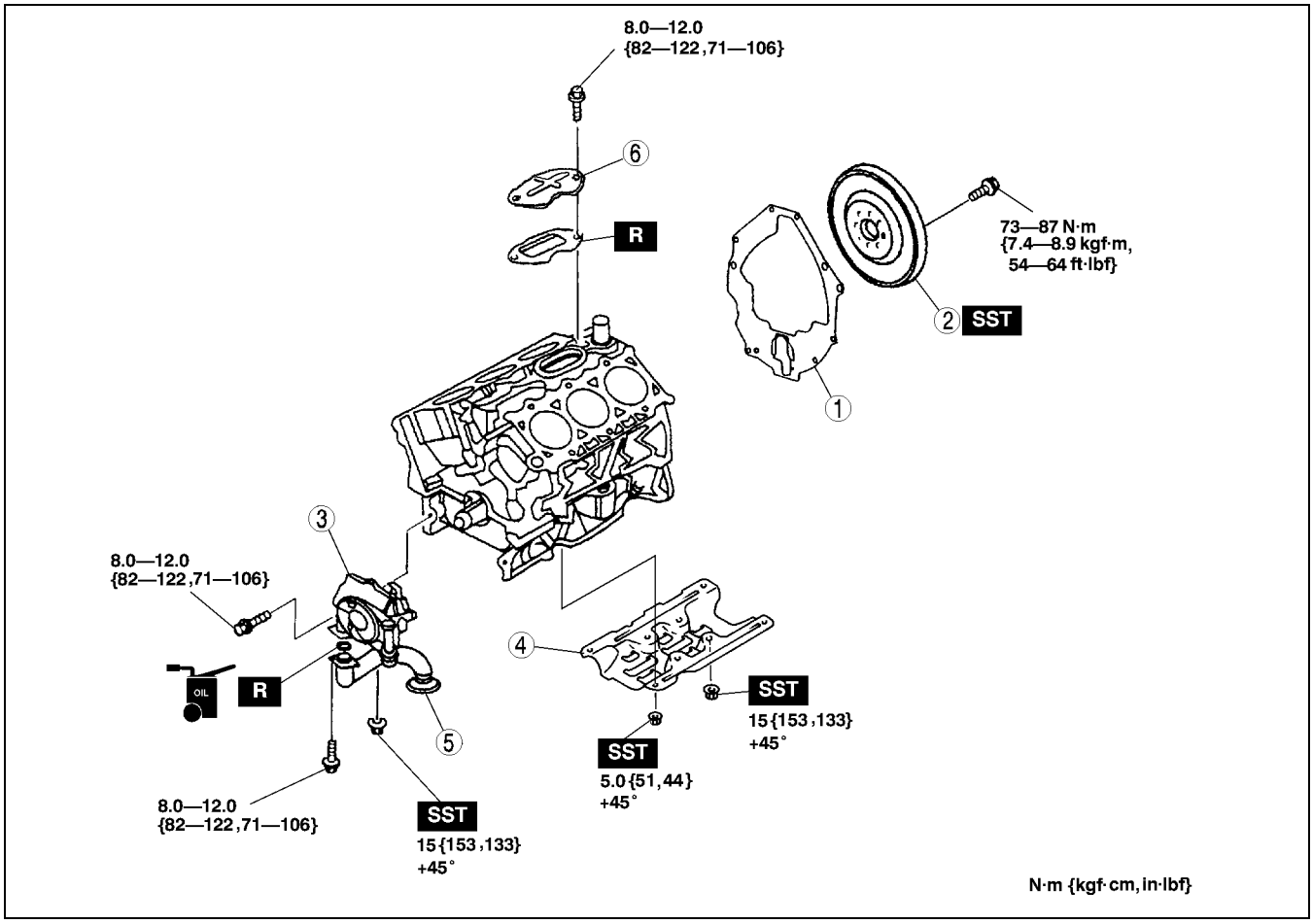
Note
- When assembling the connecting rods and connecting rod caps, it is imperative that bearing slots and tangs be located on the same side of the connecting rods.

1. Install the connecting rod bolts to the connecting rod cap by tapping the bolt with a plastic hammer.
2. Tighten the connecting rod bolts in three steps.
   (1) Tighten to **20—25 N·m {2.0—2.6 kgf·m, 15—18 ft·lbf}**.
   (2) Tighten to **40—45 N·m {4.0—4.6 kgf·m, 29—33 ft·lbf}**.
   (3) Tighten **90°—120°**.

CYLINDER BLOCK ASSEMBLY(II)

B6U011010300105

1. Assemble in the order indicated in the table.



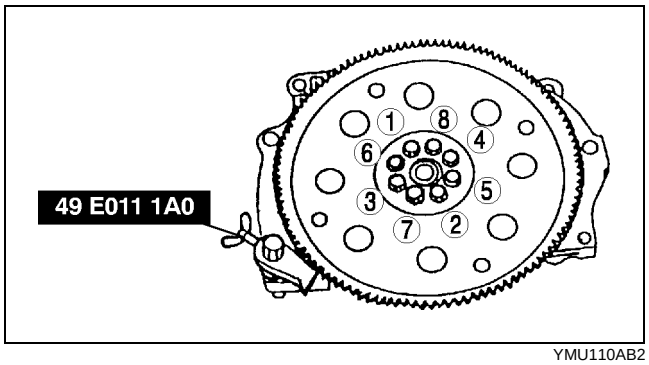
B6U2224E005

1	End plate
2	Flywheel (MTX), Drive plate (ATX) (See 01–10–34 Flywheel (MTX), Drive Plate (ATX) Assembly Note)
3	Oil pump (See 01–10–34 Oil Pump Assembly Note)

4	Oil baffle (See 01–10–34 Oil Baffle Assembly Note)
5	Oil strainer (See 01–10–34 Oil Strainer Assembly Note)
6	Plate

Flywheel (MTX), Drive Plate (ATX) Assembly Note

1. Hold the flywheel (MTX) or the drive plate (ATX) using the **SST**.
2. Tighten the bolts in the order indicated in the figure in several passes.

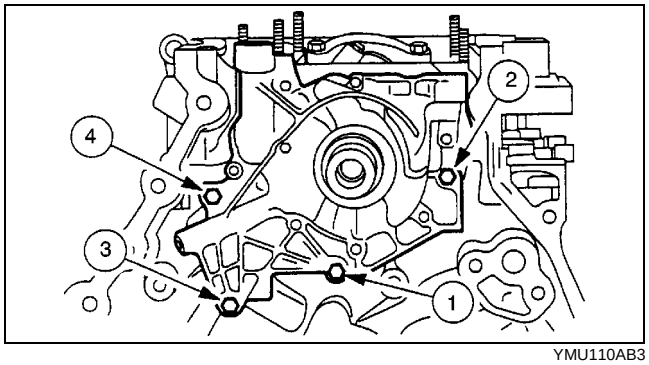


YMU110AB2

Oil Pump Assembly Note

1. Tighten the bolts in the order indicated in the figure.

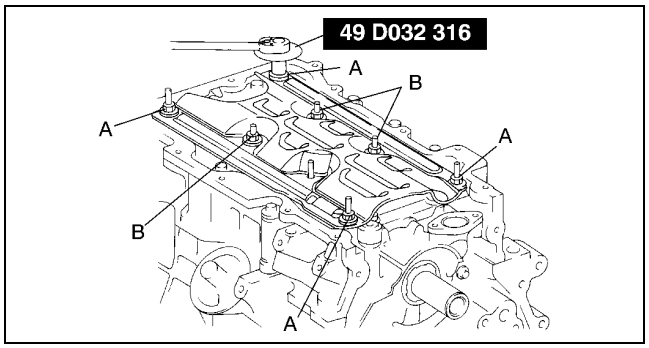
   Tightening torque
   8.0—12.0 N·m {82—122 kgf·cm, 71—106 in·lbf}



YMU110AB3

Oil Baffle Assembly Note

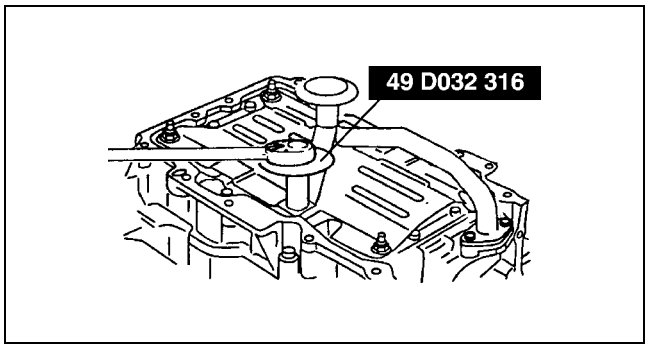
1. Tighten the nuts in two steps.
   (1) Tighten nuts A to **5.0 N·m {51.0 kgf·cm, 44.3 in·lbf}**, then nuts B to **15.0 N·m {153 kgf·cm, 133 in·lbf}**.
   (2) Tighten **45** ° using the **SST**.



ZME2224E001

Oil Strainer Assembly Note

1. Tighten the bolts.
2. Tighten the nut in two steps.
   (1) Tighten to **15.0 N·m {153 kgf·cm, 133 in·lbf}**.
   (2) Tighten **45** ° using the **SST**.



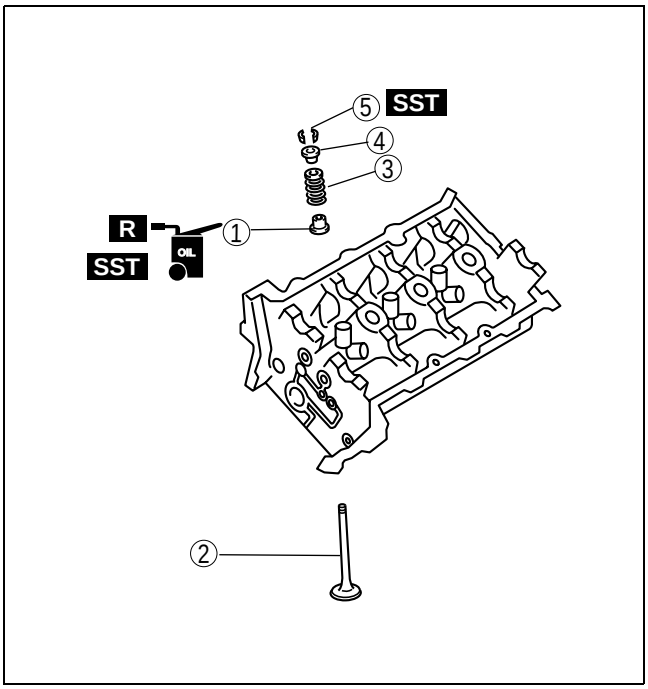
YMU110AB4

CYLINDER HEAD ASSEMBLY(I)

B6U011010100104

1. Assemble in the order indicated in the table.

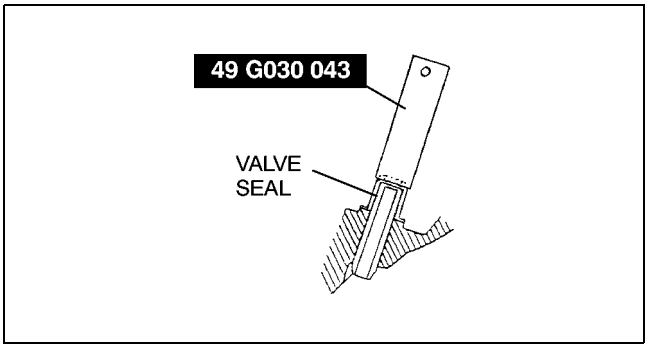
1	Valve seal (See 01–10–35 Valve Seal Assembly Note)
2	Valve
3	Valve spring
4	Upper valve spring seat
5	Valve keeper (See 01–10–35 Valve Keeper Assembly Note)



B6U2224E012

Valve Seal Assembly Note

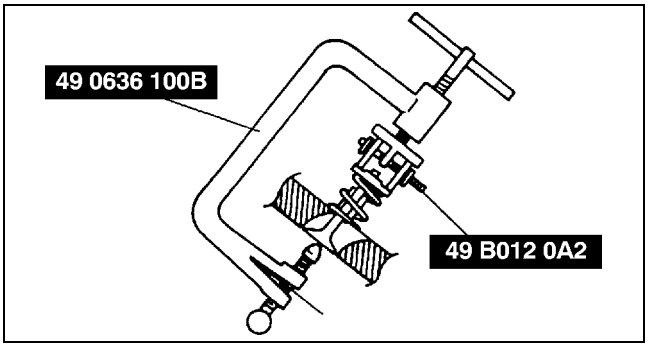
1. Press the valve seal onto the valve guide by hand.
2. Lightly tap the **SST** using a plastic hammer.



YMU110AB6

Valve Keeper Assembly Note

1. Install the valve keeper using the **SSTs**.

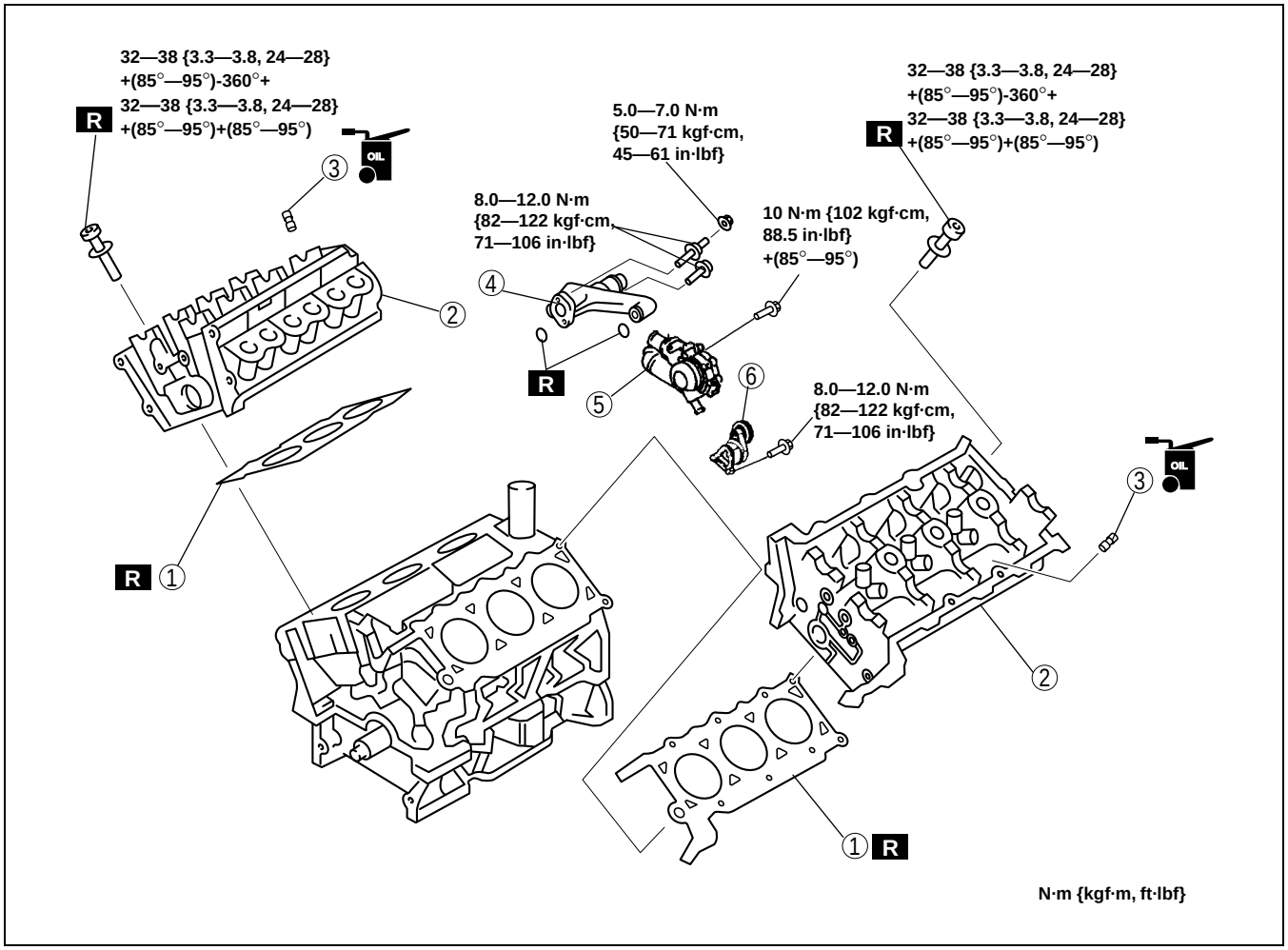


YMU110AAK

CYLINDER HEAD ASSEMBLY(II)

B6U011010100105

1. Assemble in the order indicated in the table.



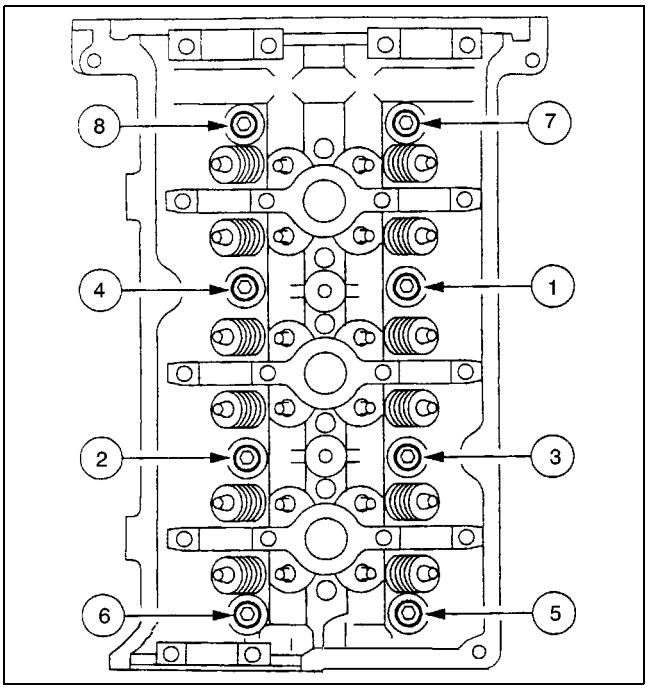
B6U2224E107

1	Cylinder head gasket
2	Cylinder head (See 01–10–37 Cylinder Head Assembly Note)
3	HLA

4	Water bypass tube
5	Water pump (See 01–10–37 Water Pump Assembly Note)
6	Water pump drive belt tensioner

Cylinder Head Assembly Note

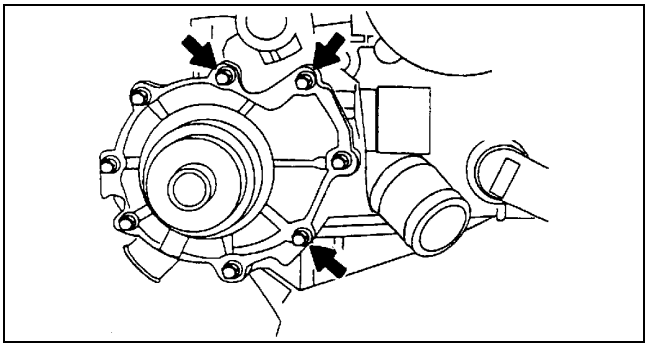
1. Tighten the cylinder head bolts in the order indicated in the figure in six steps.
   (1) Tighten to **32— 38N·m {3.2 —3.9kgf·m, 23—28 ft·lbf}**.
   (2) Tighten **85**°**—95**°.
   (3) Loosen **360**° (one full turn) in reverse order.
   (4) Tighten to **32— 38N·m {3.2 —3.9kgf·m, 23—28 ft·lbf}**.
   (5) Tighten **85**°**—95**°.
   (6) Tighten **85**°**—95**°.



B6U110AB8

Water Pump Assembly Note

1. Install new bolts and tighten them in two steps.
   (1) Tighten to **10.0 N·m {102 kgf·cm, 88.5 in·lbf}**.
   (2) Tighten **85**°**—95**°.

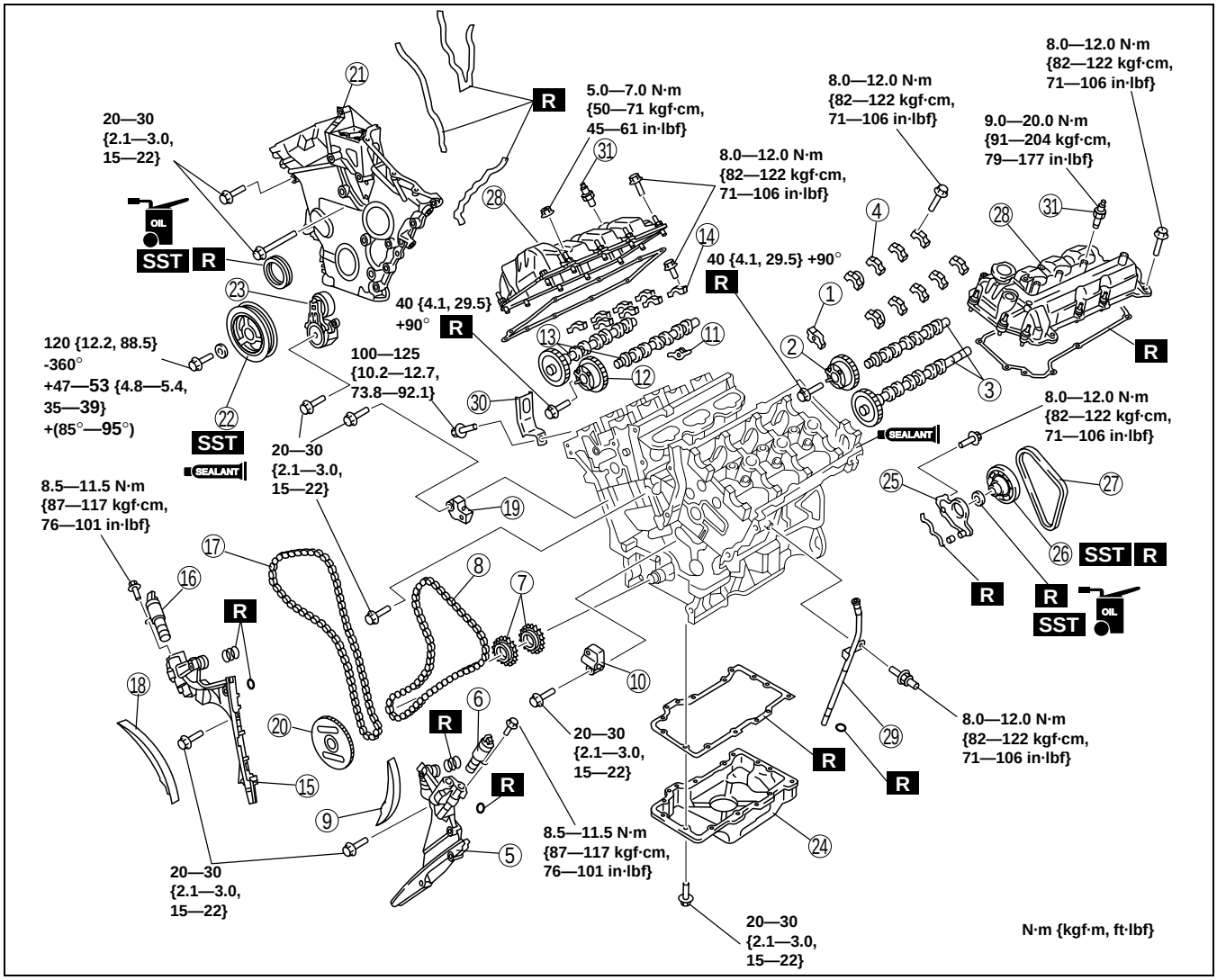


YMU110ACD

TIMING CHAIN ASSEMBLY

B6U011012201102

1. Assemble in the order indicated in the table.



B6U2216E103

1	Rocker arm (LH)
2	Variable valve timing actuator (LH) (See 01–10–39 Variable Valve Timing Actuator Assembly Note)
3	Camshaft (LH) (See 01–10–39 Camshaft (LH) Assembly Note)
4	Camshaft cap (LH)
5	Chain guide (LH) (See 01–10–40 Chain Guide (LH, RH) Assembly Note)
6	Oil control valve (OCV)
7	Crankshaft timing sprocket
8	Timing chain (LH) (See 01–10–40 Timing Chain (LH) Assembly Note)
9	Tensioner arm (LH)
10	Chain tensioner (LH)
11	Rocker arm (RH)
12	Variable valve timing actuator (RH) (See 01–10–39 Variable Valve Timing Actuator Assembly Note)
13	Camshaft (RH) (See 01–10–40 Camshaft (RH) Assembly Note)

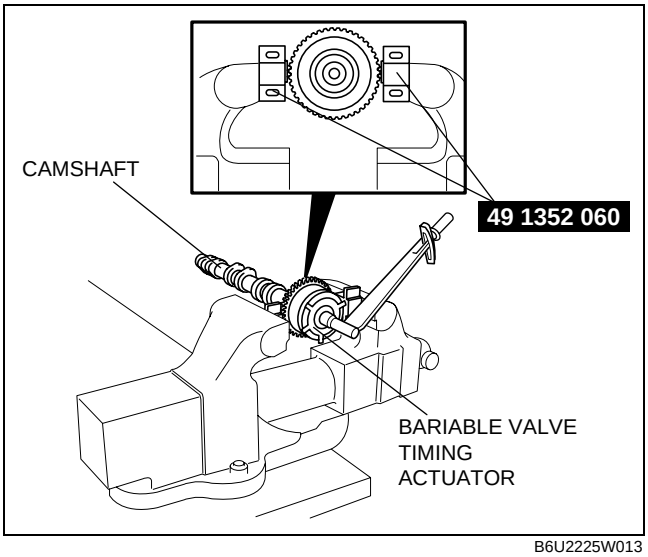
14	Camshaft cap (RH)
15	Chain guide (RH) (See 01–10–40 Chain Guide (LH, RH) Assembly Note)
16	Oil control valve (OCV)
17	Timing chain (RH) (See 01–10–41 Timing Chain (RH) Assembly Note)
18	Tensioner arm (RH)
19	Chain tensioner (RH)
20	CKP sensor pulse wheel (See 01–10–42 Crankshaft Position (CKP) Sensor Pulse Wheel Assembly Note)
21	Engine front cover (See 01–10–42 Engine Front Cover Assembly Note)
22	Crankshaft pulley (See 01–10–43 Crankshaft Pulley Assembly Note)
23	Auto tensioner
24	Oil pan (See 01–10–44 Oil Pan Assembly Note)
25	Camshaft oil seal housing (See 01–10–45 Camshaft Oil Seal Housing Assembly Note)

26	Water pump drive pulley (See01–10–45 Water Pump Drive Pulley Assembly Note)
27	Water pump drive belt

28	Cylinder head cover (See 01–10–46 Cylinder Head Cover Assembly Note)
29	Oil level gauge, pipe
30	Engine hanger
31	Spark plug

Variable Valve Timing Actuator Assembly Note

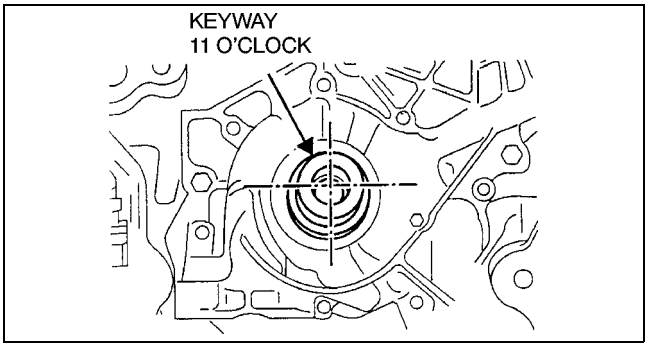
1. Install the variable valve timing actuator using a new tightening bolt.
2. Secure the camshaft sprocket in a vise using the **SST**.
3. Tighten the variable valve timing actuator tightening bolt in two steps.
   (1) Tighten to **40 N·m {4.1 kgf·m, 29.5 ft·lbf}**.
   (2) Tighten **90**°.



B6U2225W013

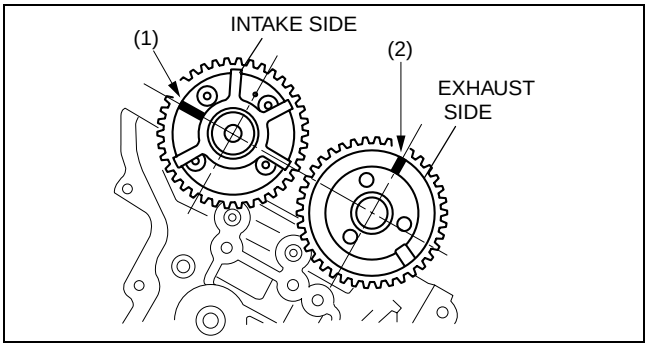
Camshaft (LH) Assembly Note

1. Turn the crankshaft clockwise to position the crankshaft keyway in the **11 o'clock** position.



YMU110ABB

2. Install the camshafts (LH).
   (1) Position the intake camshaft so that the mark is at **9 o'clock** direction.
   (2) Position the exhaust camshaft so that the mark is at **12 o'clock** direction.



B6U2215E001

Caution

- **Do not install thrust caps 1L and 6L at this time, or damage to the thrust caps may occur.**

Note

- Tighten the camshafts caps at specified torque after assembling the timing chain.
- The camshaft bearing caps are numbered to make sure they are assembled in their original positions.

3. Hand tighten the camshaft (LH) caps in their original positions.

Chain Guide (LH, RH) Assembly Note

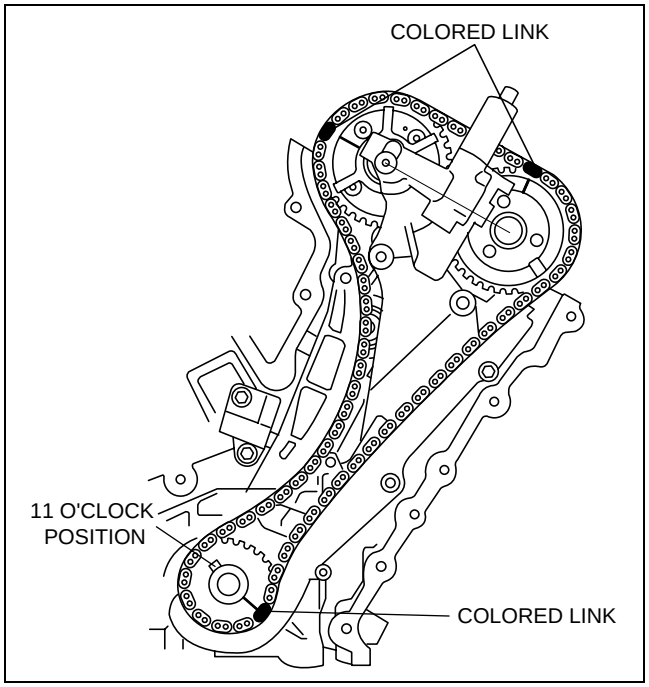
1. The chain guide should be installed to the actuator and allowed to hang freely when the bolts are installed. Do not hold the the chain guide in an upward position when the bolts are installed. The actuator causes a wear O-ring and this installation method will allow that wear to continue.

Timing Chain (LH) Assembly Note

1. Install the timing chain (LH) by aligning the colored links on the timing chain (LH) with the marks on the timing sprockets.

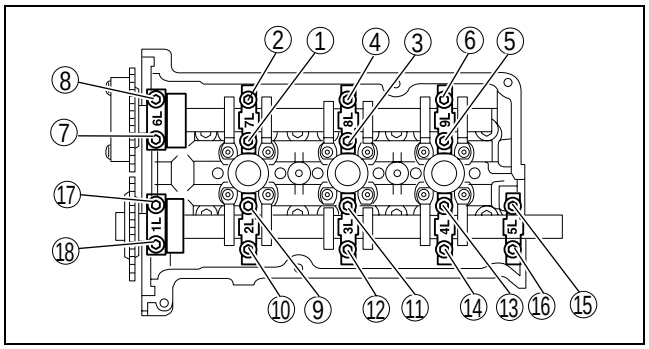
   Caution
   - **Install the camshaft bearing thrust caps after installing the other bearing caps, or damage to the thrust caps may occur.**

2. Align the camshaft end play using the camshaft bearing thrust caps 1L and 6L, and tighten the other bearing caps.



B6U2215E002

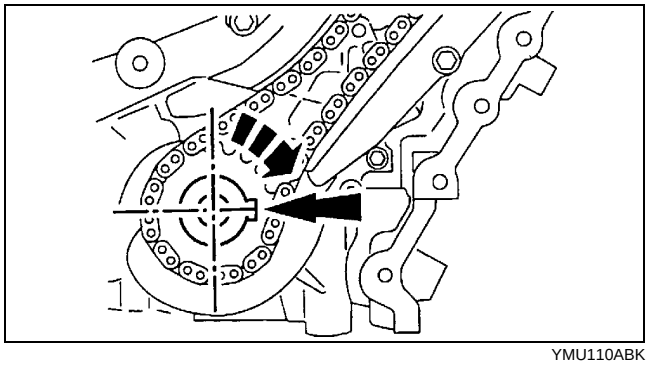
3. Tighten the bearing caps in the order indicated in the figure in several passes.



B6U2215W107

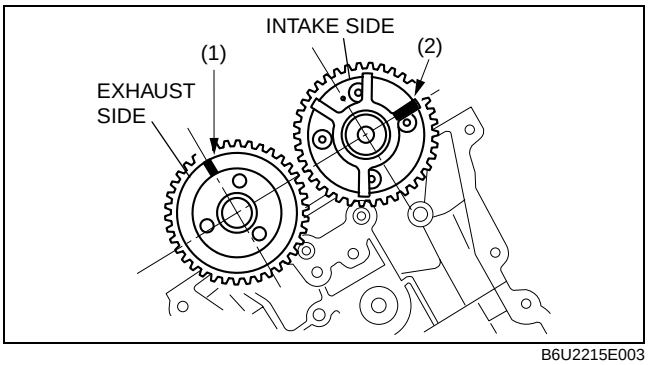
Camshaft (RH) Assembly Note

1. Turn the crankshaft clockwise to position the crankshaft keyway in the **3 o'clock** position.



YMU110ABK

2. Install the camshafts (RH).
   (1) Position the exhaust camshaft so that the mark is at **12 o'clock** direction.
   (2) Position the intake camshaft so that the mark is at **3 o'clock** direction.



B6U2215E003

Caution
- **Do not install thrust caps 1R and 5R at this time, or damage to the thrust caps may occur.**

Note
- Tighten the camshafts caps at specified torque after assembling the timing chain.
- The camshaft bearing caps are numbered to make sure they are assembled in their original positions.

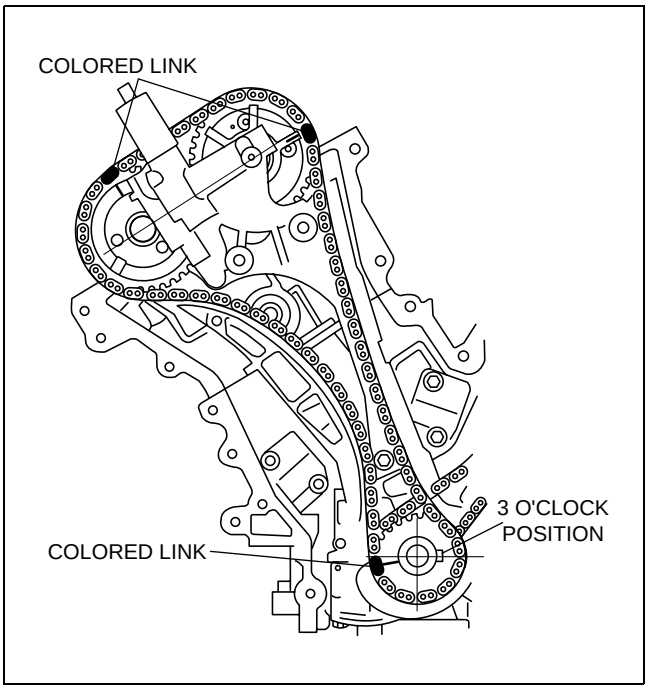
3. Hand tighten the camshaft caps (RH) in their original positions.

Timing Chain (RH) Assembly Note

1. Install the timing chain (RH) by aligning the colored links on the timing chain (RH) with the marks on the timing sprockets.

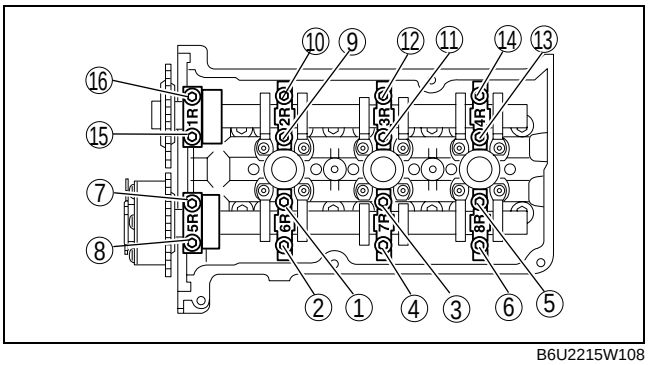
Caution
- **Install the camshaft bearing thrust caps after installing the other bearing caps, or damage to the thrust caps may occur.**

2. Align the camshaft end play using the camshaft bearing thrust caps 1R and 5R, and tighten the other bearing caps.



B6U2215E004

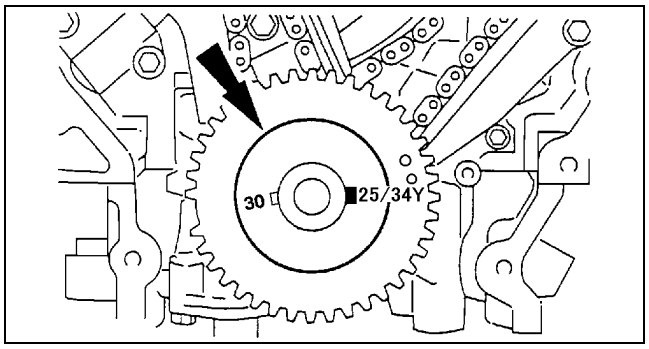
3. Tighten the bearing caps in the order indicated in the figure in several passes.
4. Install the chain tensioner and remove the retaining wire.



B6U2215W108

Crankshaft Position (CKP) Sensor Pulse Wheel Assembly Note

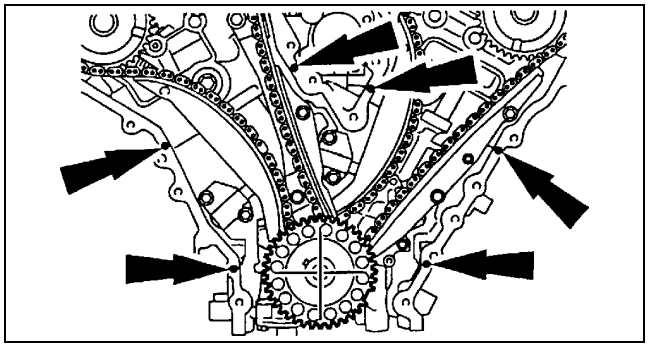
1. Using the keyway marked 25/34Y (orange paint stripe), install the rotor with the indentation towards the front.



AMU2215W006

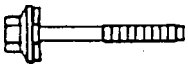
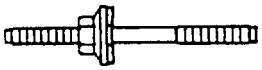
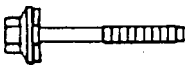
Engine Front Cover Assembly Note

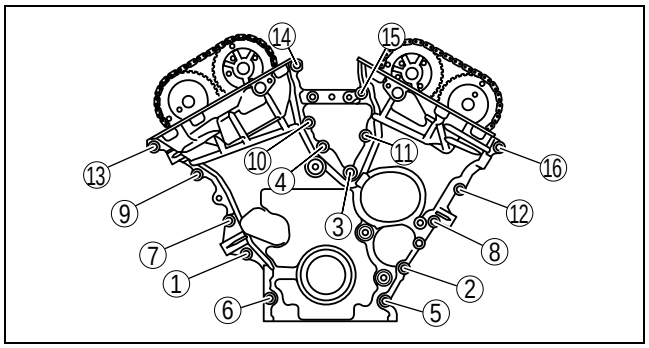
1. Apply a **6 mm {0.24 in}** dot of silicon sealant as indicated in the figure (mating faces).



YMU110ABR

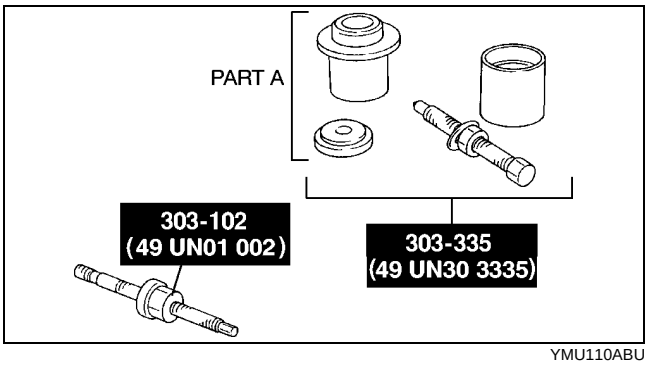
2. Tighten the bolts and studs in the order indicated in the figure.

Hole No.	Bolt	Description
2, 5, 6, 7, 9, 12,		M8×1.25×51.8 bolt
3, 4, 14		M8×1.25×64 stud
1, 8, 13, 16		M6×1.0×20/ M8×1.25 stud
10, 11, 15,		M8×1.25×115 bolt



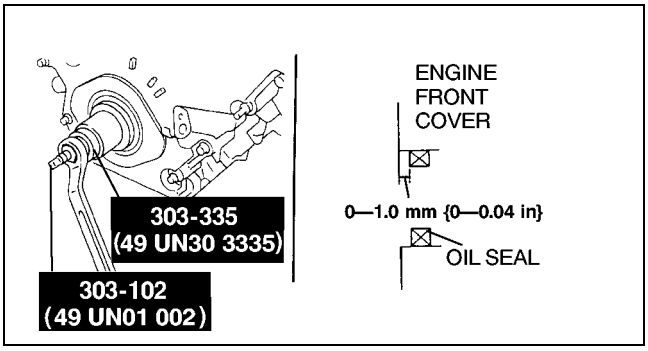
B6U2215W116

3. Assemble the front oil seal using part A of the **SST** [303-335 (49 UN30 3335)] and the **SST** [303-102 (49 UN01 002)] in the following order.



YMU110ABU

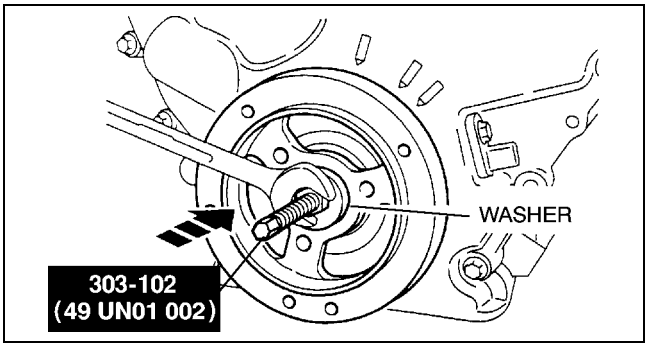
(1) Apply clean engine oil to the new oil seal.
(2) Push the oil seal slightly in by hand.
(3) Compress the oil seal using the **SSTs**.



YMU110ACQ

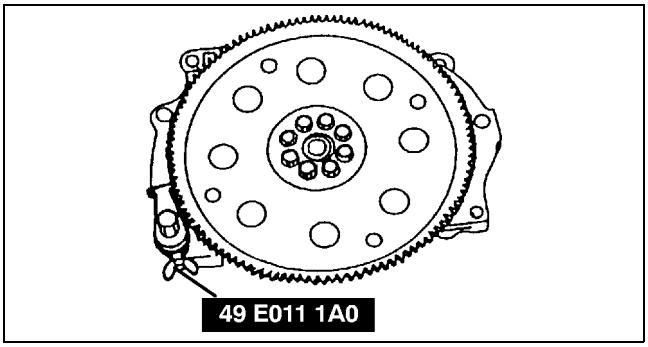
Crankshaft Pulley Assembly Note

1. Using the silicone sealant, seal the keyway in the crankshaft pulley.
2. Install the crankshaft pulley using the **SST** and washer of crankshaft pulley lock bolt washer.



YMU110ABV

3. Hold the flywheel (MTX) or the drive plate (ATX) using the **SST**.
4. Tighten the crankshaft pulley lock bolt in four steps.
   (1) Tighten to **120 N·m {12.2 kgf·m, 88.5 ft·lbf}**.
   (2) Loosen **360**° (one full turn) in reverse order.
   (3) Tighten **47—53 N·m {4.8—5.4 kgf·m, 35—39 ft·lbf}**.
   (4) Tighten **85°—95°**.

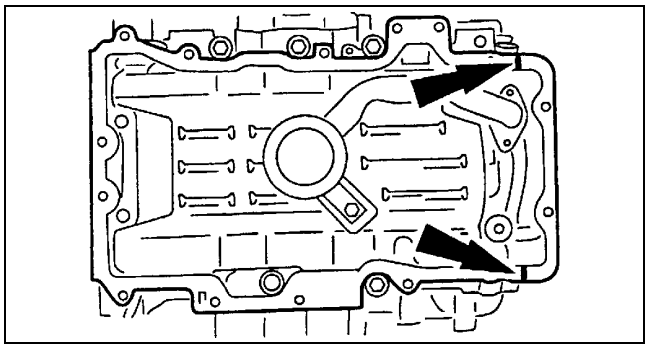


YMU110ABW

Oil Pan Assembly Note

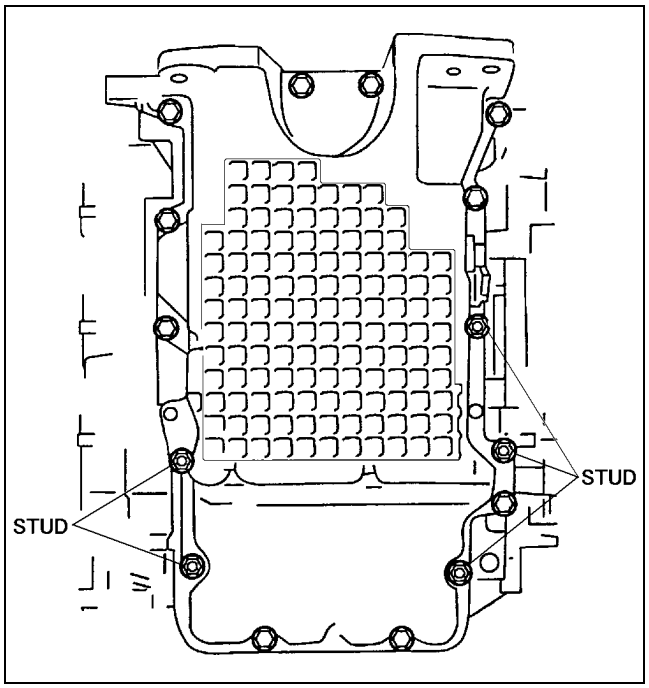
1. Apply silicone sealant to the mating faces as indicated in the figure.

   Dot diameter
   10 mm {0.39 in}



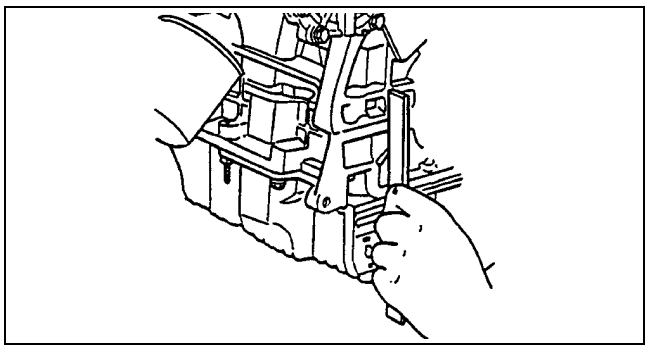
YMU110ABY

2. Install the oil pan with a new gasket.
3. Install the bolts and studs as indicated in the figure.



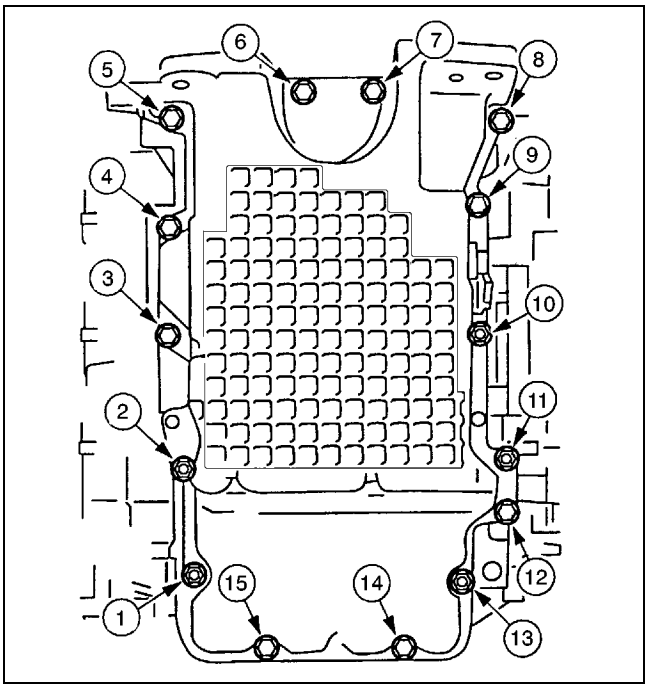
AMU2215E004

4. Align the cylinder block and the rear face of the oil pan using the straight edge.



YMU110ACS

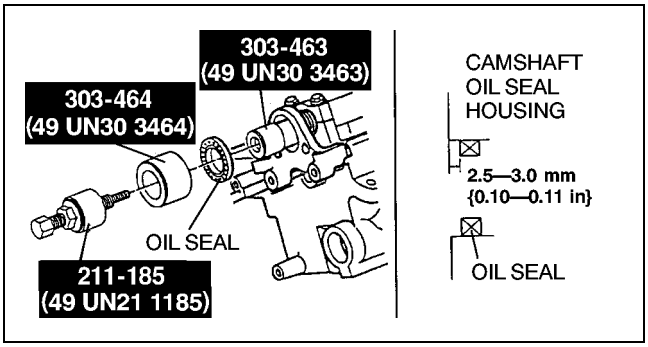
5. Tighten the bolts and studs in the order indicated in the figure.



AMU2215E005

Camshaft Oil Seal Housing Assembly Note

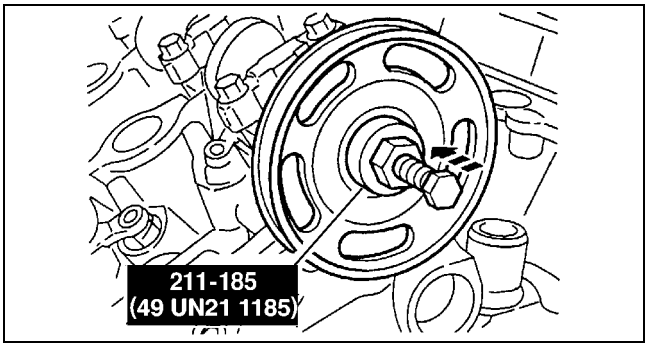
1. Apply clean engine oil to the oil seal.
2. Install the camshaft oil seal using the **SSTs**.



YMU110AC1

Water Pump Drive Pulley Assembly Note

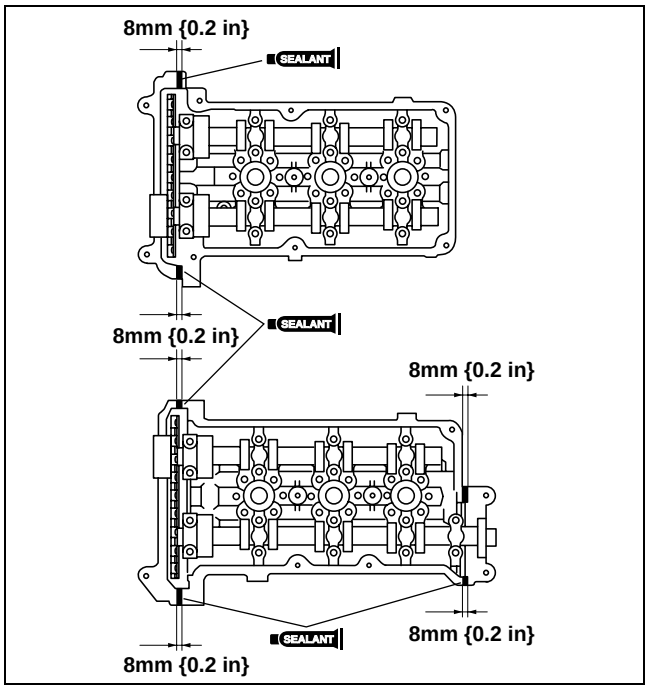
1. Install the new water pump pulley using the **SST**.



YMU110AC2

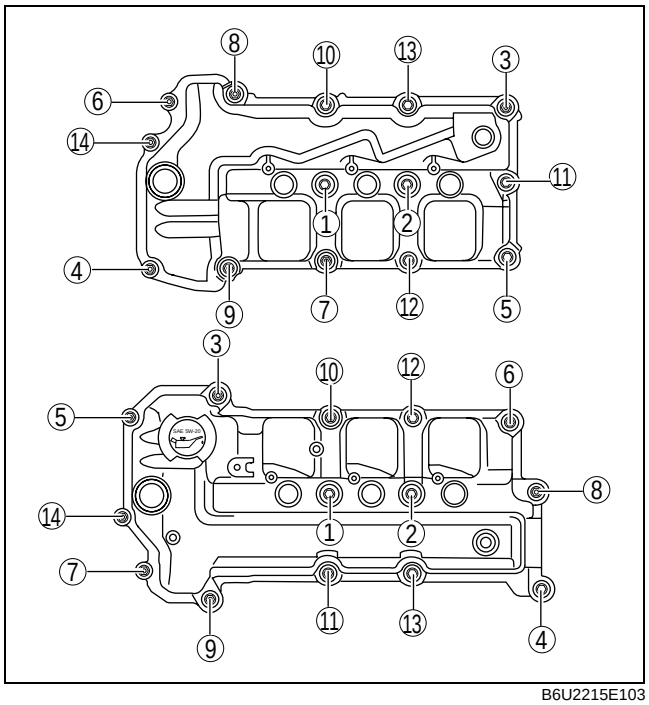
Cylinder Head Cover Assembly Note

1. Apply silicone sealant to the mating faces as indicated in the figure.
2. Install the cylinder head cover with a new gasket.



B6U2215E106

3. Tighten the bolts in the order indicated in the figure.



B6U2215E103

01–50 TECHNICAL DATA

ENGINE TECHNICAL DATA

B6U015001001101

Item				Engine
				AJ
Cylinder head				
Cylinder head gasket contact surfaces distortion	(mm {in})	Maximum		0.08 {0.0031}
Valve and valve guide				
Valve stem diameter	(mm {in})	Standard	IN	5.975—5.995 {0.2352—0.2360}
			EX	5.950—5.970 {0.2343—0.2350}
Valve stem to guide clearance	(mm {in})	Standard	IN	0.020—0.069 {0.0008—0.0027}
			EX	0.045—0.094 {0.0018—0.0037}
Valve guide projection height	(mm {in})	Standard	IN	13.4—14.2 {0.528—0.559}
			EX	13.4—14.2 {0.528—0.559}
Valve seat				
Valve seat contact width	(mm {in})	Standard	IN	1.1—1.4 {0.043—0.055}
			EX	1.4—1.7 {0.056—0.066}
Valve seat angle	(°)		IN	45
			EX	45
Valve spring				
Pressing force at valve spring height H	(mm {in})	680 N {69.3 kgf,152 lbf}		30.19 {1.189}
Off-square	(mm {in})	Maximum		1% (0.468 {0.00184})
Camshaft				
Cam lobe height	(mm {in})	Standard	IN	4.79 {0.189}
			EX	4.79 {0.189}
Journal diameter	(mm {in})	Standard		26.936—26.962 {1.0604—1.0615}
Journal oil clearance	(mm {in})	Standard		0.025—0.076 {0.0010—0.0029}
		Maximum		0.121 {0.00476}
End play	(mm {in})	Standard		0.025—0.165 {0.0010—0.0064}
		Maximum		0.190 {0.00748}
HLA				
HLA bore diameter	(mm {in})	Standard		16.018—16.057 {0.63063—0.63216}
HLA diameter	(mm {in})	Standard		15.988—16.000 {0.62945—0.62992}
HLA-to-HLA bore oil clearance	(mm {in})	Standard		0.018—0.069 {0.0008—0.0027}
		Maximum		0.16 {0.0063}
Cylinder block				
Distortion	(mm {in})	Maximum		0.08 {0.0031}
Cylinder bore diameter [Measure the cylinder bore at 50 mm {2.0 in} below the top surface]	(mm {in})	Standard		89.000—89.030 {3.5039—3.5051}
Taper	(mm {in})	Maximum		0.020 {0.00079}
Off-round	(mm {in})	Maximum		0.020 {0.00079}
Piston				
Piston diameter [Measured at 90° to pin bore axis and 42.6 mm{1.68 in} below the top of piston]	(mm {in})	Standard		88.990—89.030 {3.5036—3.5051}
Piston-to-cylinder clearance	(mm {in})	Standard		0.012—0.022 {0.0004—0.0008}

Item				Engine
				AJ
Piston ring				
Piston ring-to-ring groove clearance	(mm {in})	Standard	Top	0.040—0.075 {0.0016—0.0029}
			Second	0.040—0.085 {0.0016—0.0033}
		Maximum		0.10 {0.0039}
End gap (measured in cylinder)	(mm {in})	Standard	Top	0.10—0.25 {0.004—0.009}
			Second	0.27—0.42 {0.011—0.016}
			Oil (rail)	0.15—0.65 {0.006—0.025}
		Maximum	Top	0.50 {0.019}
			Second	0.65 {0.025}
			Oil (rail)	0.90 {0.035}
Piston pin				
Piston pin diameter	(mm {in})	Standard		21.011—21.013 {0.82721—0.82728}
Piston pin bore diameter	(mm {in})	Standard		21.008—21.012 {0.82709—0.82724}
Connecting rod-to-piston pin clearance	(mm {in})	Standard		0.004—0.020 {0.00016—0.00078}
		Maximum		0.035 {0.0013}
Piston pin bore-to-piston pin clearance	(mm {in})	Standard		–0.005—0.001 {–0.00019—0.00003}
Connecting rod and connecting rod bearing				
Length (center to center)	(mm {in})	Standard		138.06—138.14 {5.4355—5.4385}
Bending	(mm {in})	Maximum		0.038 {0.0014}/25 {0.98}
Distortion	(mm {in})	Maximum		0.050 {0.0019}/25 {0.98}
Connecting rod small end inner diameter	(mm {in})	Standard		21.017—21.031 {0.82744—0.82799}
Connecting rod side clearance	(mm {in})	Standard		0.10—0.30 {0.004—0.011}
		Maximum		0.35 {0.013}
Connecting rod bearing size	(mm {in})	Standard		1.500—1.506 {0.0591—0.0593}
		0.02 {0.0008} undersize		1.510—1.516 {0.0595—0.0596}
		0.05 {0.0020} undersize		1.525—1.531 {0.0601—0.0602}
		0.25 {0.0100} undersize		1.625—1.631 {0.0640—0.0642}
Connecting rod bearing oil clearance	(mm {in})	Standard		0.028—0.066 {0.0012—0.0025}
Crankshaft				
Crankshaft runout	(mm {in})	Maximum		0.05 {0.0019}
Main journal diameter	(mm {in})	Standard		62.968—62.992 {2.4791—2.4799}
		0.25 {0.01} undersize		62.718—62.742 {2.4693—2.4701}
Main journal oil clearance	(mm {in})	Standard		0.025—0.045 {0.0010—0.0017}
		Maximum		0.050 {0.0019}
Main bearing size	(mm {in})	Standard	Grade 1	Upper No.1,2,3,4; Lower No.1,2,3: 2.494—2.500 {0.09819—0.09842} Lower No.4: 2.492—2.498 {0.09812—0.09834}
			Grade 2	Upper No.1,2,3,4; Lower No.1,2,3: 2.498—2.504 {0.09835—0.09858} Lower No.4: 2.496—2.502 {0.09827—0.09850}
			Grade 3	Upper No.1,2,3,4; Lower No.1,2,3: 2.502—2.508 {0.09851—0.09873} Lower No.4: 2.5000—2.5006 {0.09843—0.09844}
		0.25 {0.01} undersize		Upper No.1,2,3,4; Lower No.1,2,3: 2.623—2.629 {0.10327—0.10350} Lower No.4: 2.621—2.627 {0.10319—0.10342}

Item			Engine
			AJ
Crank pin journal diameter	(mm {in})	Standard	49.970—49.990 {1.9674—1.9681}
		0.02 {0.0008} undersize	49.950—49.970 {1.9666—1.9673}
		0.05 {0.0020} undersize	49.920—49.940 {1.9654—1.9661}
		0.25 {0.0100} undersize	49.720—49.740 {1.9575—1.9582}
Crankshaft end play	(mm {in})	Standard	0.110—0.232 {0.00434—0.00913}
Camshaft oil seal			
Pushing distance of the camshaft oil seal [from the edge of the oil seal housing]	(mm {in})		2.5—3.0 {0.10—0.11}
Front oil seal			
Pushing distance of the front oil seal [from the edge of the engine front cover]	(mm {in})		0—1.0 {0—0.04}
Rear oil seal			
Pushing distance of the rear oil seal [from the edge of the cylinder block]	(mm {in})		0—2.0 {0—0.08}
Oil control valve (OCV)			
Resistance	(ohm)		7.05—7.95

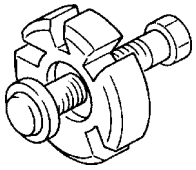
01–60 SERVICE TOOLS

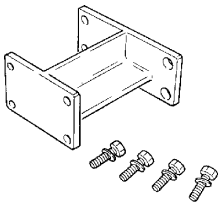
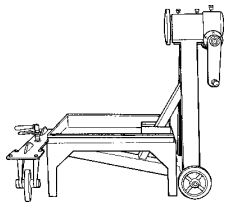
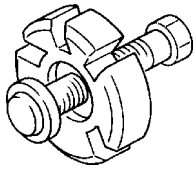
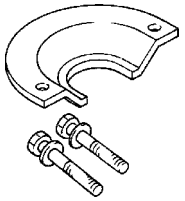
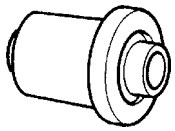
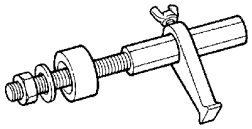
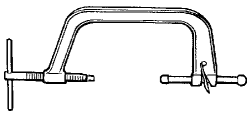
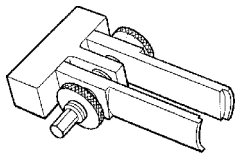
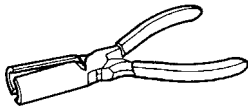
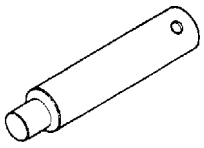
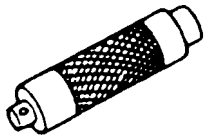
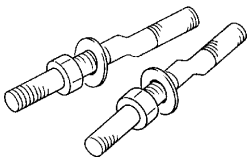
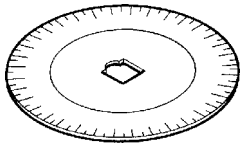
ENGINE SST

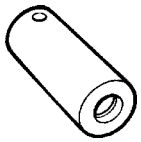
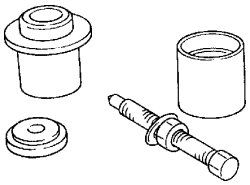
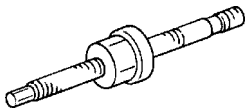
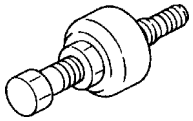
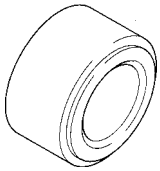
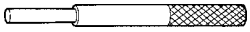
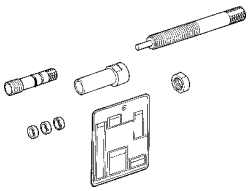
B6U016001001101

1: Mazda SST number
2: Global SST number

Example

1:49 UN30 3009 2:303-009 Crankshaft damper remover	

1.49 L010 1A1 2. – Engine hanger set 	1.49 0107 680A 2. – Engine stand 	1.49 UN30 3009 2.303-009 Crankshaft damper remover 
1.49 UN30 3457 2.303-457 Shaft protector 	1.49 UN30 3456 2.303-456 Water pump pulley plate 	1.49 T034 204 2. – Attachment (Part of 49 T034 2A1) 
1.49 E011 1A0 2. – Ring gear brake set 	1.49 0636 100B 2. – Valve spring lifter arm 	1.49 B012 0A2 2. – Pivot 
1.49 S120 170 2. – Valve seal remover 	1.49 T011 001 2. – Piston pin installer 	1.49 G030 797 2. – Handle (Part of 49 G030 795) 
1.49 UN01 070 2.303-178 Crankshaft seal installer 	1.49 UN30 3384 2.303-384 Rear crankshaft adapter bolts 	1.49 D032 316 2. – Protractor 

1.49 G030 043 2. – Guide (Part of 49 G030 040) 	1.49 UN30 3335 2.303-335 Crankshaft seal installer/aligner 	1.49 UN01 002 2.303-102 Crankshaft damper replacer 
1.49 UN21 1185 2.211-185 Pump pulley replacer 	1.49 UN30 3464 2.303-464 Camshaft seal replacer 	1.49 UN30 3463 2.303-463 Camshaft seal protector 
1.49 B012 015 2. – Valve guide installer 	1.49 L012 0A0B 2. – Valve seal and valve guide installer set 	1.49 1352 060 2. – Ring gear brake