SERVICE MANUAL

MODEL

J13, J15 & J16 SERIES

ENGINES

SECTION EM

ENGINE MECHANICAL

EM

GENERAL DESCRIPTION

CONTENTS

J13, J15 AND J16 ENGINES

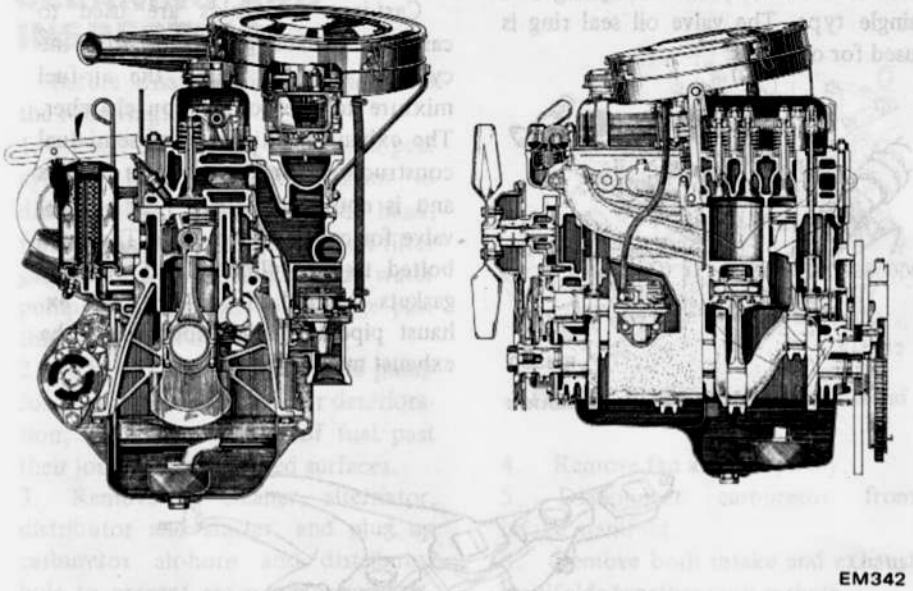
- O.H.V. type valve mechanism
- Deep skirt, cast-iron cylinder block with cast-in cylinders
- Cast-iron cylinder head including bathtub type combustion chambers
- Fully counter balanced crankshaft with 3 main bearing journals
- 2-barrel, downdraft carburetor for thorough air-fuel mixing

The exhaust manifold is of semi-dual construction for the bonnet type models. For caball type models, the exhaust manifold is equipped with the heat control valve.

Since the J15 is a bored-out version of the J13, and the J16 is a length-ened-version of the J15. The way in which they are serviced is seldom different except that some technical data must be adjusted.

Engine major data

Engine Model		J13	J15	J16
Displacement	cc (cu in)	1,299 (79.3)	1,483 (90.5)	1,567 (95.6)
Bore x stroke	mm (in)	73 x 77.6 (2.87 x 3.06)	78 x 77.6 (3.07 x 3.06)	78 x 82 (3.07 x 3.23)
Compression Ratio		8.2	8.3	8.3
Ignition timing B.T.D.C.	rpm	8°/600	8°/600	8°/600

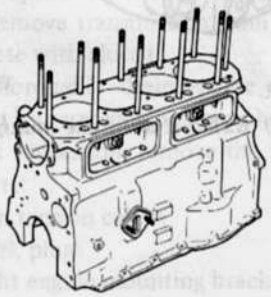


EM342

Fig. EM-1 Cross sectional view (J15 engine-bonnet type models)

CYLINDER BLOCK

The crankshaft is a fully counter balanced, 3-bearing type designed to turn out smooth, dependable power. Water is forced through the water jackets to deprive the cylinders of unwanted combustion heat. The engine identification marks "T01" for the J15 and J16 and "B34" for the J13 are embossed on the right rear of the engine block.

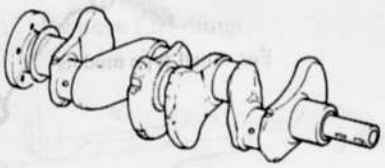


EM343

Fig. EM-2 Cylinder block

CRANKSHAFT

The crankshaft is of special steel forging with 3 main bearing journals. To provide balance, 4 counter (balance) weights are provided just opposite the cranks. The main bearing journals and connecting rod journals (crank pins) are case hardened and finished to extreme smoothness for increased wear resistance. The crankshaft has drilled passages through which oil can flow to the main bearings to lubricate and at the same time to cool the bearings. The center main bearing is equipped with thrust washers to take up end thrust of the crankshaft.



EM344

Fig. EM-3 Crankshaft

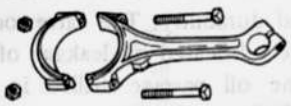
PISTON AND CONNECTING ROD

The pistons are made of aluminum alloy casting. It is Autothermic type to assure perfect roundness when heated to operating temperature. The piston pin is a full floating fit to the piston while it is press fitted to the connecting rod small end. The connecting rod is a special steel forging. On the J13, the piston pin is bolted to the small end to prevent it from working out of place during operation. The cylinder walls are lubricated by oil squirted from the oil jets located at the connecting rod big ends.

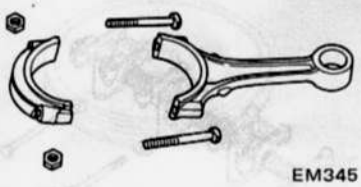
EM347

Fig. EM-4 Piston

J13



J15, J16

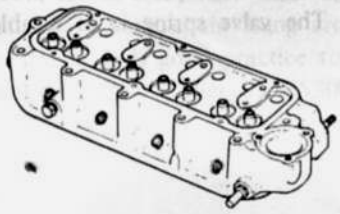


EM345

Fig. EM-5 Connecting rod

CYLINDER HEAD

The cylinder head is made of steel casting. It contains bathtub type combustion chambers. A special sintered alloy valve seat is installed on the exhaust valve. It is press-fitted.

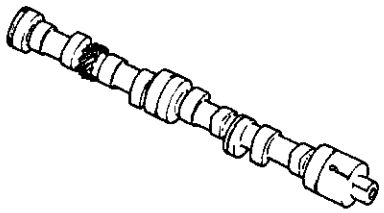


EM346

Fig. EM-6 Cylinder head

CAMSHAFT

The camshaft is of special steel casting and is supported by 3 main bearings. The cam lobes are case hardened and finished to extreme smoothness for increased wear resistance.

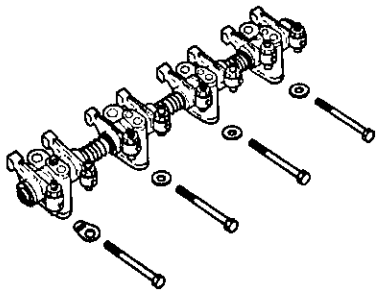


EM348

Fig. EM-7 Camshaft

ROCKER SHAFT

The rocker shaft is made of carbon steel; it is also case hardened for increased durability. The valve rocker arms are lubricated by leakage of oil from the oil passage drilled in the rocker shaft.

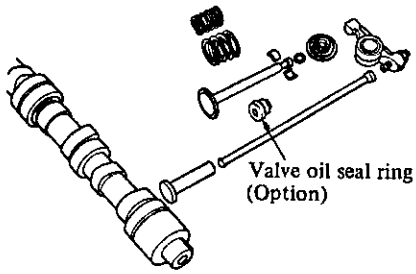


EM349

Fig. EM-8 Rocker shaft assembly

VALVE MECHANISM

The valve train consists of the camshaft, push rod, valve rocker arm, and valve; motion is transmitted through these four parts in the order listed. The valve spring is of double spring type, inner and outer. Only for the A321 models, the valve spring is of single type. The valve oil seal ring is used for option.



EM350

Fig. EM-9 Valve mechanism

MANIFOLDS

Cast-iron manifolds are used to carry the exhaust gases away from the cylinders and to admit the air-fuel mixture to the combustion chamber. The exhaust manifold is of semi-dual construction for bonnet type models and is equipped with a heat control valve for caball type models. These are bolted to the cylinder head with the gaskets inserted in between. The exhaust pipe is flange mounted to the exhaust manifold.

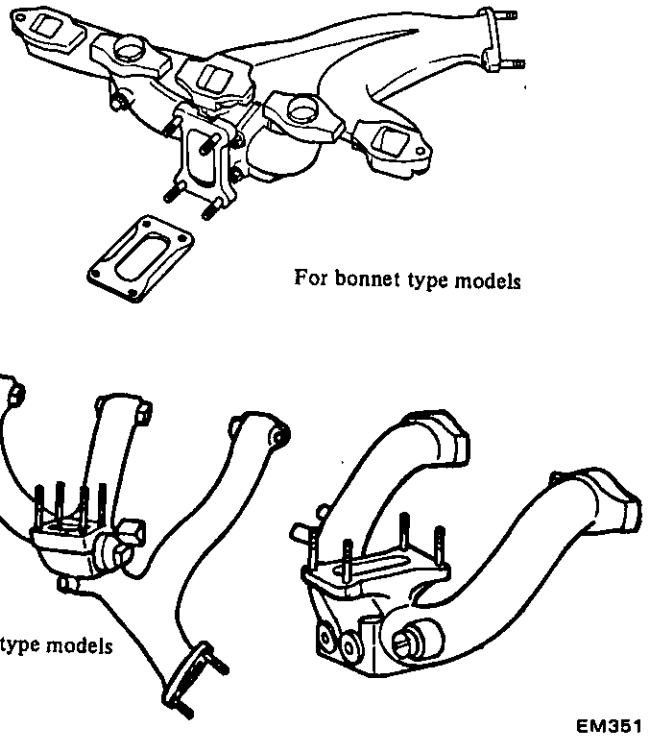


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Fig. EM-10 Exhaust & Intake manifolds

ENGINE DISASSEMBLY

CONTENTS

PRELIMINARY CLEANING AND INSPECTING

Before disassembling engine, note the following:

1. Fuel, oil or water may leak past cylinder head and block. Prior to disassembling, check cylinder head, front chain cover, oil pan and oil filter gaskets and crankshaft and water pump seals for signs of leakage past their gasketed surfaces.
2. Check carburetor and fuel pump for condition; fuel hoses for deterioration, cracks or leakage of fuel past their jointed or connected surfaces.
3. Remove air cleaner, alternator, distributor and starter, and plug up carburetor air-horn and distributor hole to prevent entry of foreign matter.
4. Wipe dust and mud off engine.
5. Inspect block, rocker cover, front chain cover, oil pan and all other outer parts for visual defects and broken or missing parts such as bolts and nuts.
6. Test all pipings and electrical circuits for discontinuity or broken or damaged insulation.

DISASSEMBLY

To remove engine from vehicle, refer to related topic under "Engine Removal and Installation" in Chassis and Body Service Manual, Section ER.

1. Remove transmission from engine complete with clutch.
2. Thoroughly drain engine oil and coolant by removing bottom plugs.
3. In succession, remove the following parts:

- High tension cables
- Spark plugs
- Right engine mounting bracket
- Oil filter bracket and oil filter
- Oil pressure switch
- Oil level gauge
- Fan belt

After above steps have been completed, attach Engine Attachment ST05280000 to right side of engine. With the use of an overhead hoist and lifting cable, hoist engine up away from the engine carrier and place it down in Engine Stand ST0501S000. The engine attachment is common to the J13, J15 and J16 engines. To remove oil filter, use Oil Filter Wrench ST19320000.

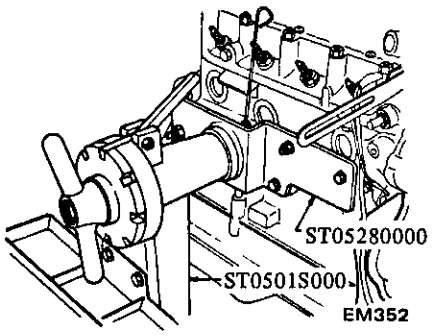

Fig. EM-11 Engine on engine stand

4. Remove fan and fan pulley.
5. Disconnect carburetor from intake manifold.
6. Remove both intake and exhaust manifolds together with gaskets.

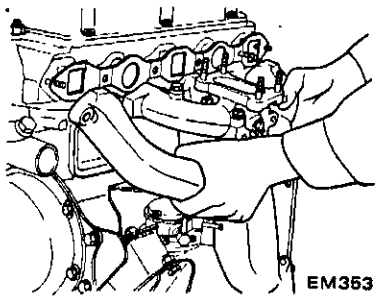

Fig. EM-12 Removing intake and exhaust manifolds

7. Remove fuel pump.

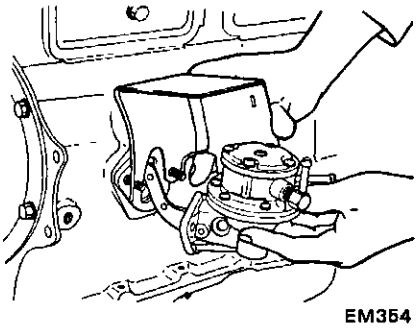

Fig. EM-13 Removing fuel pump

8. Back off bolts and remove left hand engine mounting bracket.
9. Back off bolts securing water outlet; remove water outlet and thermostat.
10. Remove water pump together with gasket.

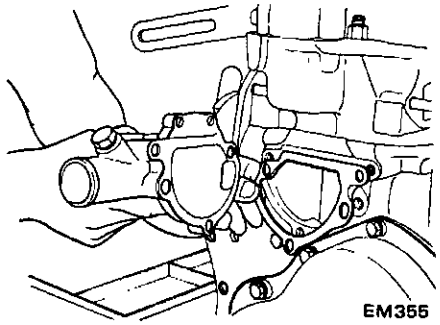

Fig. EM-14 Removing water pump

11. Back off bolts securing carnkshaft pulley in position: remove crankshaft pulley.

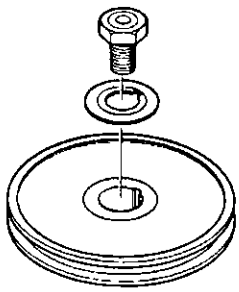

Fig. EM-15 Removing crank pulley

12. Applying suitable wrench, unscrew bolts which hold timing chain cover in place; take off cover together with gasket.
13. Remove timing chain tensioner.
14. Back off bolts which secure camshaft gear to camshaft; remove camshaft washer. At the same time, take out oil thrower on crankshaft side.
15. Remove camshaft and crankshaft gears with chain hung around gear teeth. It is good practice to use Crankshaft Gear Puller ST16530000.

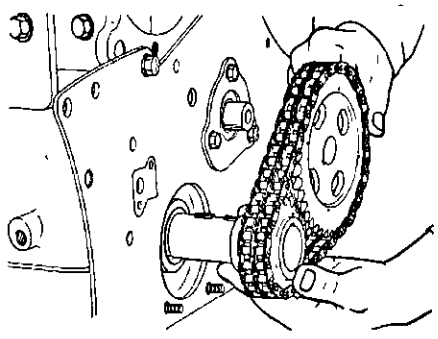

Fig. EM-16 Removing timing chain

16. Remove camshaft and crankshaft keys from key-ways in gears (two for crankshaft and one for camshaft).
17. Straighten tabs of lock washers and back off bolts securing flywheel to flange end of crankshaft rear. Flywheel can then be taken out. Be careful not to drop it. At this stage of disassembly, remove engine rear plate together with gasket.
18. Back off bolts which hold rocker cover to the top of cylinder head; remove rocker cover together with gasket under cover.
19. Back off valve rocker shaft bracket bolts and cylinder head stud nuts in two or three progressive steps and in sequence shown.

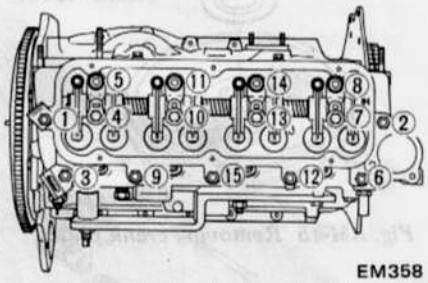

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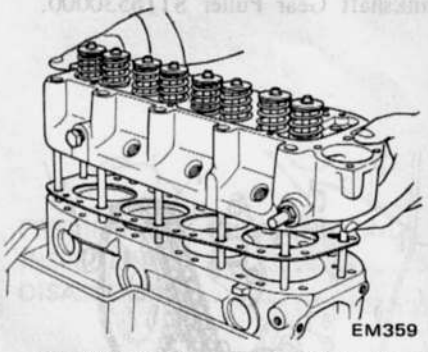
Fig. EM-17 Rocker shaft bracket bolt and cylinder head nut loosening sequence

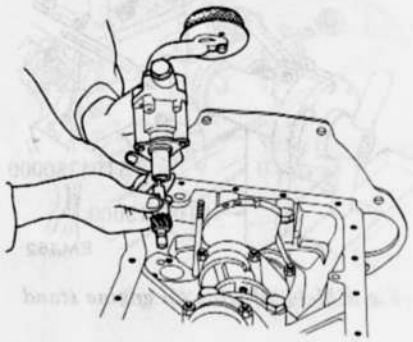
20. Take off valve rocker shaft assembly from cylinder head.
21. Lift out push rods from holes in cylinder head.
22. Lift cylinder head straight up away from engine block together with gasket under head. Every caution should be taken not to damage threads of stud bolts while head is being lifted.



EM359

Fig. EM-18 Removing cylinder head

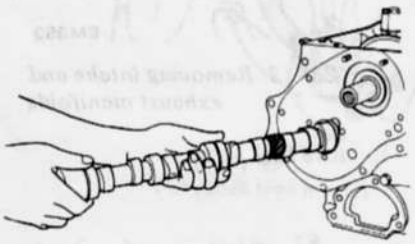
23. Invert engine block 180° so that oil pan is facing up; remove bolts which secure oil pan to engine block. Remove oil pan together with gasket.
24. Remove oil pump with oil strainer assembly and oil pump drive spindle by backing off bolts which secure it to engine block.



EM360

Fig. EM-19 Removing oil pump and oil pump drive spindle

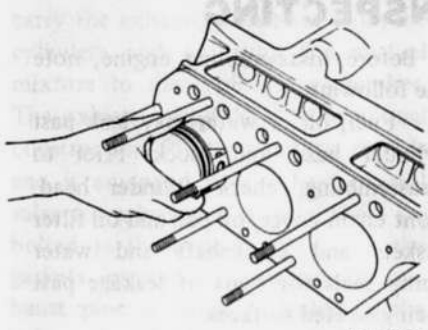
25. Free camshaft locating plate; withdraw camshaft toward the front of engine. When removing shaft, exercise care not to damage camshaft bearings as well as cam lobes, which would make them unfit for further service.



EM361

Fig. EM-20 Withdrawing camshaft

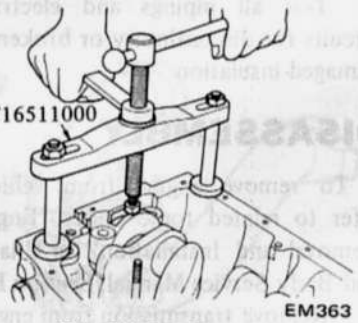
26. Pull out valve lifters from block.
27. Remove front plate by backing off bolts securing it to engine block.
28. Rotate engine block on engine stand for easy access to pistons.
29. Remove bolts which hold connecting rod caps in place; separate connecting rod caps together with bearing inserts. Push connecting rod and piston assembly out top of cylinder with a bar or handle end of a hammer. Avoid damaging piston rings when removing piston and connecting rod. Place all disassembled parts in part rack in correct order so that they can be reinstalled in their original locations.



EM362

Fig. EM-21 Withdrawing piston and connecting rod assembly

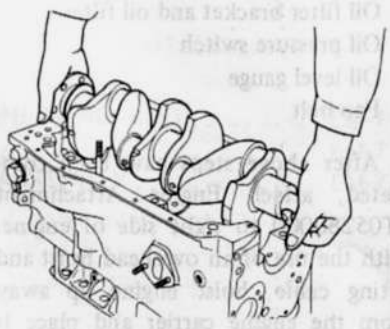
30. Back off bolts holding crankshaft bearing caps to engine block saddles; separate caps off saddles together with thrust washers and bearings. It is necessary to use Crankshaft Main Bearing Cap Puller ST16511000 when removing center and rear bearing caps.



EM363

Fig. EM-22 Removing main bearing cap

31. Remove crankshaft and main bearings. Make sure to place them in correct order in parts rack, so that they can be installed in their original locations.



EM364

Fig. EM-23 Removing crankshaft

PISTON AND CONNECTING ROD

1. Remove piston rings from around piston using Piston Ring Expander EM03500000.

Note: Exercise caution in removing piston rings. Excessive spreading of rings will cause damage and render them unfit for further service due to breakage or relaxed tension.

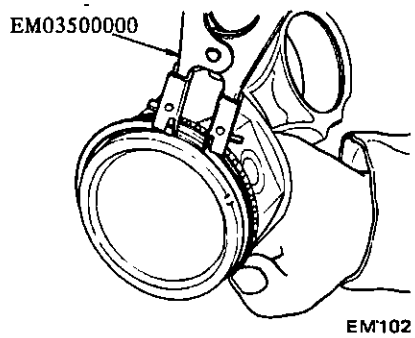


Fig. EM-24 Removing piston ring

2. Remove piston pin with Piston Pin Press Stand ST13060000 under press (J15 and J16).

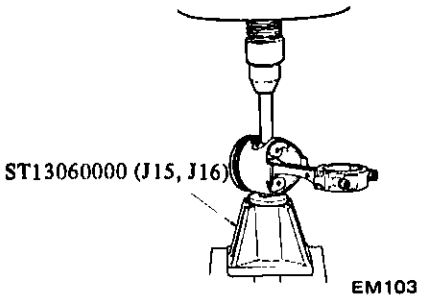


Fig. EM-25 Removing piston pin (J15 and J16)

3. Using suitable wrench, back off bolt securing piston pin in place. Using Piston Pin Press Stand ST13040000, remove pin under press (J13).

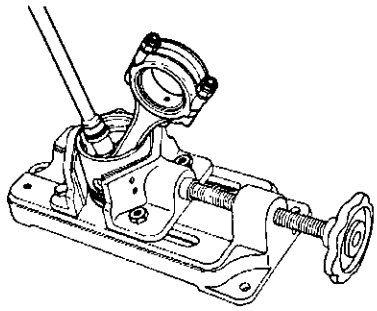


Fig. EM-26 Removing piston pin bolt (J13)

Note: Be sure to place removed pins in correct order in part rack so that they can be reinstalled in the same pistons from which they were removed.

CYLINDER HEAD

Compress valve springs with Valve Lifter ST12070000. Remove rubber rings, valve collets, spring retainers, valve springs, valve oil seal rings (option) and valves. Place removed parts in correct order in parts rack so that they can be reinstalled in their original locations.

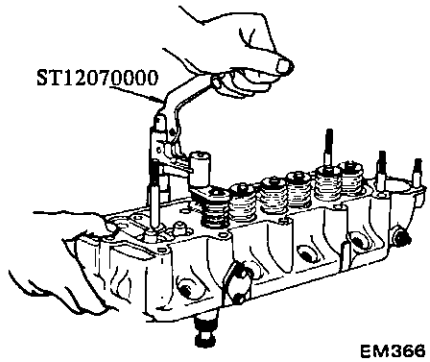


Fig. EM-27 Removing valve

VALVE ROCKER ASSEMBLY

Withdraw cotter pins from each end of rocker shaft; remove valve rocker, valve rocker bracket and spring in order listed. The rearmost bracket has a set screw which secures rocker shaft in place to prevent it from working loose during operation.

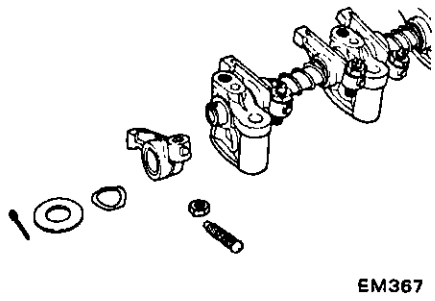


Fig. EM-28 Disassembling rocker assembly

INSPECTION AND REPAIR

CONTENTS

PREPARATION FOR INSPECTION

1. Before cleaning, check for signs of water and oil leaks in cylinder block and head.
2. Clean oil and carbon deposits from all parts. They should be clean from gasket or sealant.
3. Clean all oil holes with solvent and dry with compressed air. Make sure that they are not restricted.

Head surface flatness

	Standard mm (in)	Maximum allowable limit mm (in)
Transverse warpage on gasket contacting face	0.1 (0.0039)	0.2 (0.0079)
Surface grinding limit	1.5 (0.0591)	

CYLINDER HEAD AND VALVE

CHECKING CYLINDER HEAD MATING FACE

1. Make a visual check for cracks and flaws.
2. Measure the surface of cylinder head (on cylinder block side) for warpage. If it is found to be beyond the limit designated below, regrind the affected surface with a surface grinder.

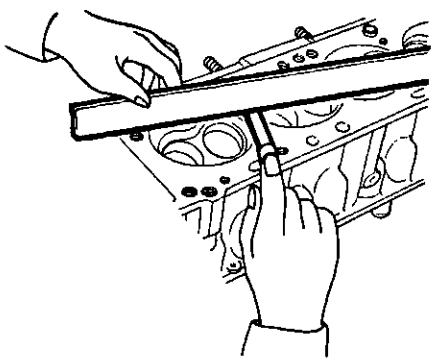


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Fig. EM-29 Checking cylinder head surface

Surface grinding limit

The grinding limit of cylinder head is available by the cylinder block grinding in an engine..

Depth of cylinder head grinding is "A"

Depth of cylinder block grinding is "B"

The limit is following;

A+B = 2.0 mm (0.0784 in)

VALVE ASSEMBLY

1. Check each intake and exhaust

valve for worn, damaged or deformed valve caps or stems. Correct or replace defective valves.

2. Valve face or valve stem end surface should be refaced by using a valve grinder.

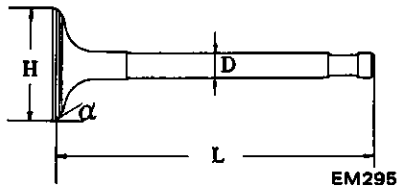


Fig. EM-30 Intake and exhaust valve dimensions

Unit: mm (in)

H	Valve head diameter	J13	In.	34.8 to 35.0 (1.370 to 1.378)
			Ex.	29.9 to 30.1 (1.177 to 1.185)
		J15 J16	In.	37.8 to 38.0 (1.488 to 1.496)
			Ex.	31.9 to 32.1 (1.256 to 1.264)
L	Valve length	J13	In.	109.35 to 109.65 (4.3051 to 4.3169)
			Ex.	108.55 to 108,85 (4.2736 to 4.2854)
		J15 J16	In. & Ex.	109.35 to 109.65 (4.3051 to 4.3169)
D	Valve stem diameter		In. & Ex.	8.680 to 8.693 (0.3417 to 0.3422)
	Valve seat angle		In. & Ex.	45°30′

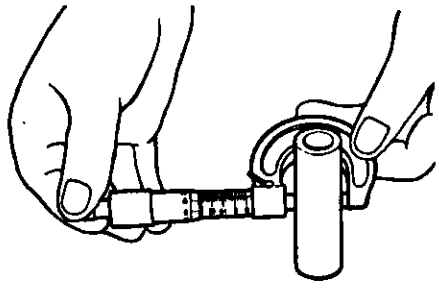


Fig. EM-31 Measuring stem diameter

Note: When valve head has been worn down to 0.5 mm (0.0197 in) in thickness, replace the valve.

Grinding allowance for the valve stem end surface is 0.5 mm (0.0197 in) or less.

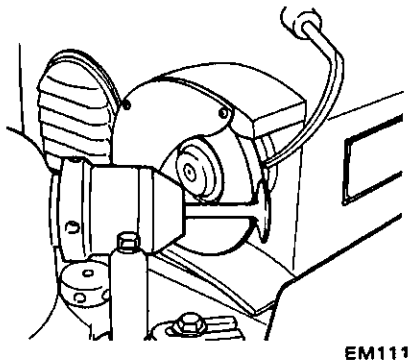


Fig. EM-32 Regrinding valve face

VALVE LIFTER AND PUSH ROD

Valve lifter

Check valve lifters for excessive wear on the face that contacts with cam lobe. The end that contacts push rod should also be smooth. Replace with new ones if worn beyond repair.

Correct valve lifter to lifter hole clearance is 0.016 to 0.052 mm (0.0006 to 0.0020 in).

Push rod

1. Inspect push rod for excessive wear on the face that contacts with valve rocker ball end (spherical face). The face that contacts with valve lifter should also be smooth, replacing those worn or damaged beyond repair.
2. Check push rod for bend or twist with a dial gauge or on a surface plate.

Unit: mm (in)

Maximum allowable bend	0.05 (0.0020)
Maximum allowable twist	0.2 (0.0079) at center

VALVE SPRING

1. Check valve spring for squareness using a steel square and surface plate. If spring is out of square "S" in Figure EM-33 beyond specified limit, replace with new ones.

Valve spring specifications

		620, T20	A321
		J13, J15 and J16	J13 and J15
Valve spring length		Double spring type	Single spring type
Outer	mm (in)	52 (2.047)	47.1 (1.854)
Inner	mm (in)	50 (1.969)	
Valve spring pressed length (valve open)			
Outer	mm/kg (in/lb)	30.7/47.8 (1.209/105)	30.7/70.6 (1.209/156)
Inner	mm/kg (in/lb)	28.7/21.3 (1.130/47)	
Valve spring assembled height (valve close)			
Outer	mm/kg (in/lb)	38.9/29.0 (1.531/64)	38.9/35.4 (1.016/78)
Inner	mm/kg (in/lb)	36.9/13.1 (1.453/29)	
Out of square ("S")			
Outer	mm (in)	1.6 (0.063)	1.6 (0.063)
Inner	mm (in)	1.2 (0.047)	

2. Measure free length and tension of each spring. If the measured value exceeds the specified limit, replace spring.

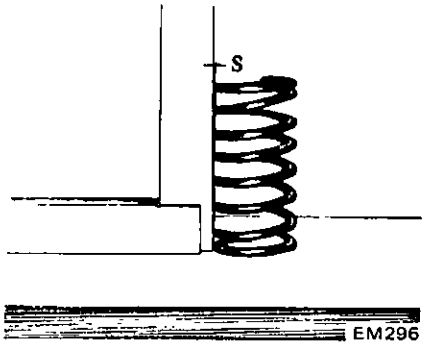


Fig. EM-33 Measuring spring squareness

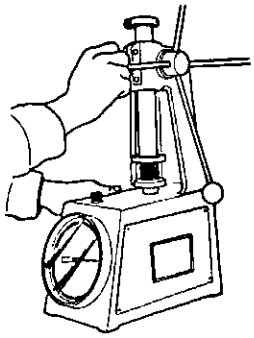


Fig. EM-34 Measuring spring tension

ROCKER ARM AND VALVE ROCKER PIVOT

1. Check rocker arm for sign of wear or damage to rocker shaft hole, replacing those worn or damaged beyond limits. Correct oil clearance between rocker arm and rocker shaft is 0.01 to 0.05 mm (0.0004 to 0.0020 in).
2. Check rocker arm for wear or damage to the end that contacts with valve stem end. The face that contacts with push rod should also be inspected for roughness. Replace if worn or damaged beyond repair.

VALVE GUIDE

Measure clearance between valve guide and valve stem. If the clearance exceeds the designated limit, replace the worn parts or both valve and valve guide.

In this case, it is essential to determine if such a clearance has been caused by a worn or bent valve stem or by a worn valve guide.

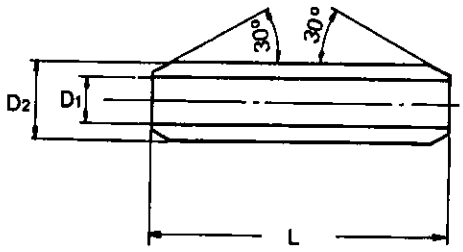


Fig. EM-35 Intake and exhaust valve guide dimensions (for Service)

Valve guide dimensions (for Service) Unit: mm (in)

D_1	Valve guide inner diameter	In. & Ex.	7.6 to 7.8 (0.299 to 0.307)
D_2	Valve guide outer diameter	In. & Ex.	14.313 to 14.326 (0.5635 to 0.5640)
L	Valve guide length	In.	47.6 (1.874)
		Ex.	56.0 (2.205)

As an emergency expedient, push valve in valve guide and move to the left and the right. If its tip deflects about 0.2 mm (0.0079 in) or more, the clearance between stem and guide exceeds the maximum limit of 0.1 mm (0.0039 in).

Note: Valve should be moved in parallel with rocker arm. (Generally, a large amount of wear occurs in this direction.)

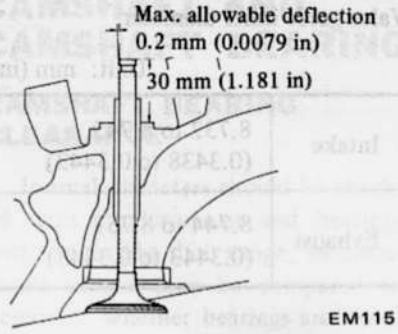


Fig. EM-36 Measuring clearance between valve stem and valve guide

Valve guide specifications

		Intake	Exhaust	Wear limit
Valve guide hole diameter	mm (in)	14.281 to 14.300 (0.5622 to 0.5630)		—
Guide to guide hole interference	mm (in)	0.013 to 0.045 (0.0005 to 0.0018)		—
Valve guide inner diameter	mm (in)	8.732 to 8.745 (0.3438 to 0.3443)	8.744 to 8.757 (0.3443 to 0.3448)	—
Valve stem outer diameter	mm (in)	8.680 to 8.693 (0.3417 to 0.3422)		—
Guide to stem clearance	mm (in)	0.039 to 0.065 (0.0015 to 0.0026)	0.051 to 0.077 (0.0020 to 0.0030)	0.10 (0.0039)

Replacement of valve guide

1. To remove old guides, use a drift and drive them out of combustion chamber side toward rocker cover. Heating cylinder head will facilitate the operation.

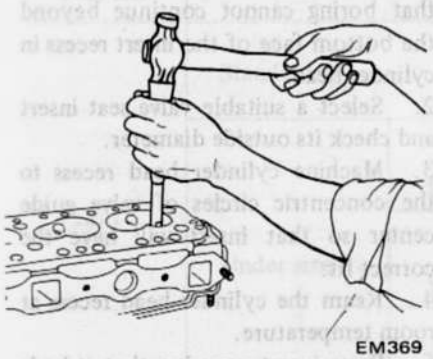


Fig. EM-37 Driving valve guide out from cylinder head

2. New guides should be installed to proper depth and reamed to size of normal room temperatures. Standard diameter of hole to which guide is fitted is 14.281 to 14.300 mm (0.5622 to 0.5630 in).

3. When installing new guides with an arbor press, it is recommended to heat cylinder head to about 80°C (176°F). Then, press them into place in valve guide holes from rocker cover side. Guides must be installed to proper depth so that height above valve spring seat is 15.5 to 15.9 mm (0.610 to 0.626 in) as shown in Figure EM-38. Interference between valve guide and guide hole should be held within 0.013 to 0.045 mm (0.0005 to 0.0018 in).

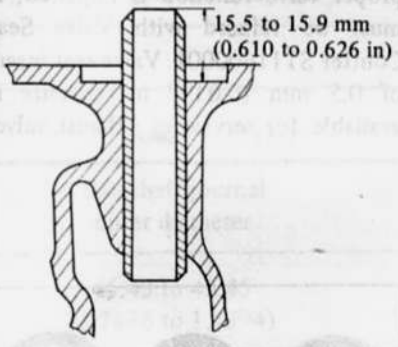


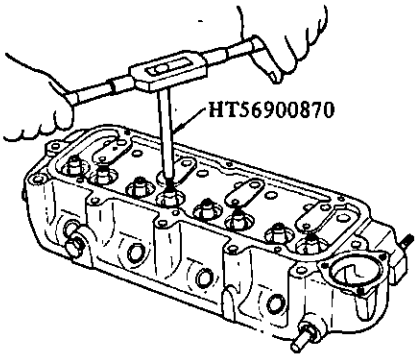
Fig. EM-38 Installing valve guide

4. Ream the bore with valve guide pressed in, using Valve Guide Reamer HT56900870.

Valve guide inner diameter

Unit: mm (in)

Intake	8.732 to 8.745 (0.3438 to 0.3443)
Exhaust	8.744 to 8.757 (0.3443 to 0.3448)



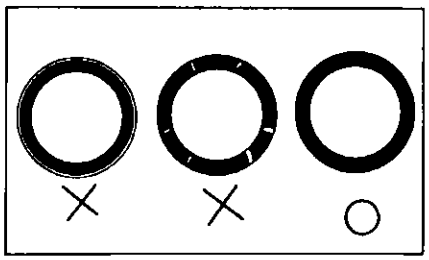
EM371

Fig. EM-39 Reaming valve guide

5. Correct valve seat surface with new valve guide as the axis.

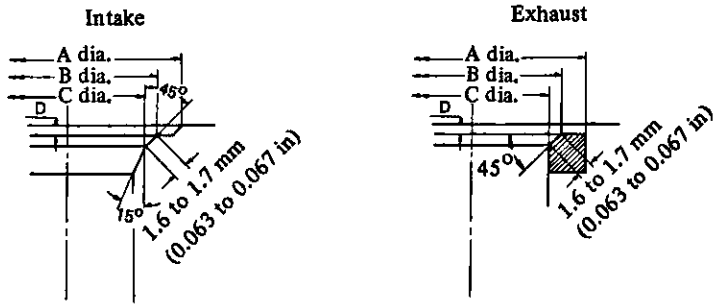
VALVE SEAT

When a valve seat is badly damaged or worn excessively to a point where proper valve function is impaired, it must be refaced with Valve Seat Coutter ST11600001. Valve seat insert of 0.5 mm (0.0197 in) oversize is available for service in exhaust valve.



EM372

Fig. EM-40 Valve seat contacting face



Unit: mm (in)

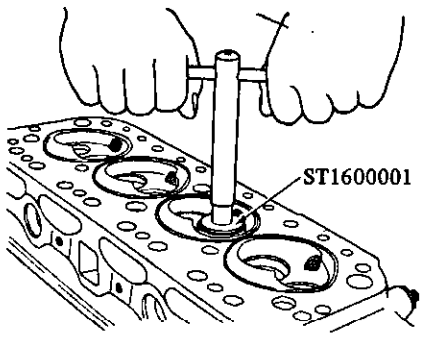
		J13	J15, J16
Intake	A	40 (1.575)	40 (1.575)
	B	34.5 (1.358)	37.5 (1.476)
	C	32.2 (1.268)	35.2 (1.386)
	D	0.2 to 0.4 (0.0079 to 0.0157)	0.2 to 0.4 (0.0079 to 0.0157)
Exhaust	A	32.5 (1.280)	35 (1.378)
	B	29.4 (1.157)	31.6 (1.244)
	C	26.8 (1.055)	29.0 (1.142)
	D	1.0 to 1.2 (0.0394 to 0.0472)	0.2 to 0.4 (0.0079 to 0.0157)

EM375

Fig. EM-41 Valve seat dimensions

Regrinding valve seats

1. When valve seat is found to be wide beyond specifications, it should be narrowed with a 45-degree grinding cutter.
2. Width of valve seat should then be adjusted to 1.6 to 1.7 mm (0.063 to 0.067 in) by making upper and lower cuts as shown in Figure EM-42. To do this, use a 15-degree grinding cutter.



EM373

Fig. EM-42 Grinding valve seat with grinding cutter

3. Apply small amount of fine grinding compound to valve contacting face and put valve into guide. Lap valve against its seat until proper valve seating is obtained. Remove valve and then clean valve and valve seat.

Replacing valve seat insert

1. Old insert can be removed by boring out until it collapses. The machine depth stop should be set so that boring cannot continue beyond the bottom face of the insert recess in cylinder head.
2. Select a suitable valve seat insert and check its outside diameter.
3. Machine cylinder head recess to the concentric circles of valve guide center so that insert will have the correct fit.
4. Ream the cylinder head recess at room temperature.
5. Press insert ensuring that it beds on the bottom face of its recess.

6. Valve seats newly fitted should be cut or ground at the specified dimensions as shown in Figure EM-41.

7. Lap valve against its seat, following above mentioned procedure.

Unit: mm (in)

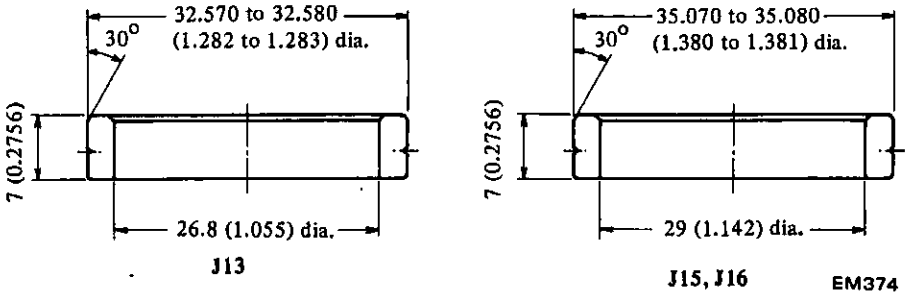


Fig. EM-43 Standard exhaust valve seat dimensions

Cylinder head recess diameter

Unit: mm (in)

		J13	J15 and J16
Exhaust	For standard insert	32.500 to 32.516 (1.2795 to 1.2802)	35.000 to 35.016 (1.3780 to 1.3786)
	For service insert	33.00 to 33.016 (1.2992 to 1.2998)	35.500 to 35.516 (1.3976 to 1.3983)

Interference fit mm (in)	Exhaust	0.054 to 0.080 (0.0021 to 0.0031)

CAMSHAFT AND CAMSHAFT BEARING

CAMSHAFT BEARING CLEARANCE

Journal diameters should be checked with a micrometer and bearings with an inside dial gauge. Measurements should then be compared to determine whether bearings are worn. If found worn beyond 0.18 mm (0.007 in), replace with new ones. In press-fitting a new bearing, make certain that oil holes in block and bearing are properly aligned.

Camshaft journal to bearing clearance

Unit: mm (in)

	Front	Center	Rear
Camshaft journal diameter	45.434 to 45.447 (1.7887 to 1.7892)	43.897 to 43.910 (1.7282 to 1.7287)	41.218 to 41.231 (1.6228 to 1.6233)
Bearing inner diameter	45.474 to 45.484 (1.7903 to 1.7907)	43.948 to 43.961 (1.7302 to 1.7307)	41.257 to 41.267 (1.6243 to 1.6247)
Bearing clearance	0.027 to 0.050 (0.0011 to 0.0020)	0.038 to 0.064 (0.0015 to 0.0025)	0.026 to 0.049 (0.0010 to 0.0019)
Bearing clearance limit	0.18 (0.0071)		

Camshaft journal to bearing specifications

Unit: mm (in)

Bearing position	Size		Bearing thickness	Camshaft journal outer diameter
Front	Standard		1.57 to 1.59 (0.0618 to 0.0626)	45.43 to 45.45 (1.7886 to 1.7894)
	Under size	0.25 (0.0098)	1.69 to 1.71 (0.0665 to 0.0673)	45.18 to 45.20 (1.7787 to 1.7795)
		0.50 (0.0197)	1.82 to 1.84 (0.0717 to 0.0724)	44.93 to 44.95 (1.7689 to 1.7697)
		0.75 (0.0295)	1.94 to 1.96 (0.0764 to 0.0772)	44.68 to 44.70 (1.7591 to 1.7598)

Bearing position	Size		Bearing thickness	Camshaft journal outer diameter
Center	Standard		1.57 to 1.59 (0.0618 to 0.0626)	43.89 to 43.91 (1.7279 to 1.7287)
	Under size	0.25 (0.0098)	1.69 to 1.71 (0.0665 to 0.0673)	43.64 to 43.66 (1.7181 to 1.7189)
		0.50 (0.0197)	1.82 to 1.84 (0.0717 to 0.0724)	43.39 to 43.41 (1.7083 to 1.7091)
		0.75 (0.0295)	1.94 to 1.96 (0.0764 to 0.0772)	43.14 to 43.16 (1.6984 to 1.6992)
Rear	Standard		1.57 to 1.59 (0.0618 to 0.0626)	41.21 to 41.23 (1.6224 to 1.6232)
	Under size	0.25 (0.0098)	1.69 to 1.71 (0.0665 to 0.0673)	40.96 to 40.98 (1.6126 to 1.6134)
		0.50 (0.0197)	1.82 to 1.84 (0.0717 to 0.0724)	40.71 to 40.73 (1.6028 to 1.6035)
		0.75 (0.0295)	1.84 to 1.96 (0.0764 to 0.0772)	40.46 to 40.48 (1.5929 to 1.5937)

VALVE TIMING

This diagram will apply to all cylinders. If any valve is found beyond specifications, one possibility is that cam lobe is worn or damaged excessively, calling for replacement of camshaft.

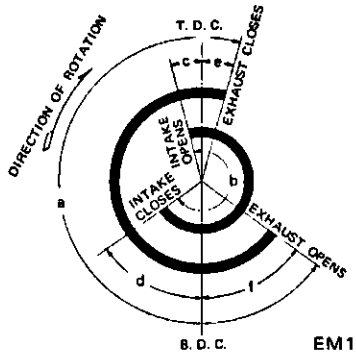


Fig. EM-44 Valve timing diagram

	a	b	c	d	e	f
J13	244	244	14	50	12	52
J15, J16	252	252	18	54	16	56

CAMSHAFT ALIGNMENT

1. Check camshaft, camshaft journal and cam surface for bend, wear or damage. If defects are beyond limits, replace affected parts.
2. A bent valve is one-half of the reading obtained when camshaft is turned one full revolution with a dial gauge applied to the center journal.

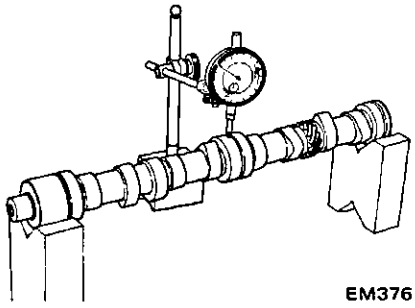


Fig. EM-45 Measuring camshaft bend

3. Camshaft end play can be checked by installing camshaft, camshaft locating plate and camshaft gear in their respective positions. End play will then be indicated with a dial gauge or a feeler gauge. If end play exceeds 0.35 mm (0.0138 in), replace locating plate.

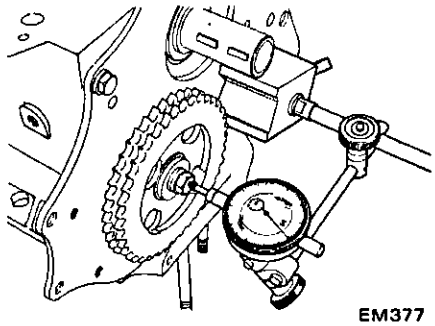


Fig. EM-46 Measuring camshaft end play

Camshaft specifications

			Standard	Wear/repair limit
Camshaft bend	mm (in)		Less than 0.03 (0.0012)	0.05 (0.0020)
Camshaft lobe height	mm (in)	J13	37.60 to 37.70 (1.4803 to 1.4842)	37.40 (1.4724)
		J15 J16	37.605 to 37.650 (1.4805 to 1.4823)	37.35 (1.4705)
Camshaft end play	mm (in)		0.05 to 0.29 (0.0020 to 0.0114)	0.35 (0.0138)

CYLINDER BLOCK

1. Check flatness of block gasket surface with a straight edge and a feeler gauge at two diagonal and five longitudinal positions.
2. Place the straight edge along diagonal lines of block plane and the longitude, and inspect for level using a feeler gauge.

	Standard	Limit
Surface flatness mm (in)	Less than 0.05 (0.0020)	0.10 (0.0039)

Surface grinding limit

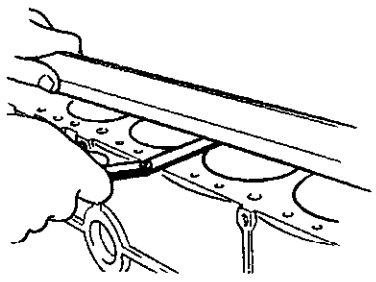
The grinding limit of cylinder block is available by the cylinder head grinding in an engine.

Depth of cylinder head grinding is "A"

Depth of cylinder block grinding is "B"

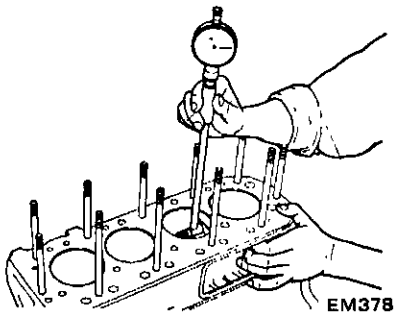
The limit is:

A + B = 2.0 mm (0.0784 in)



EM303

Fig. EM-47 Checking cylinder block syrface



EM378

Fig. EM-48 Measuring cylinder bore diameter

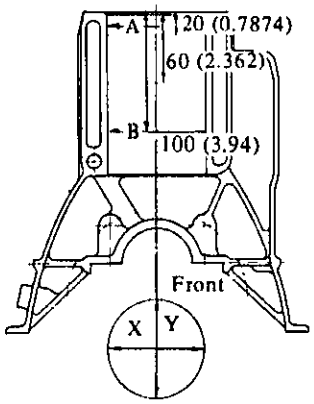
3. Using a bore gauge, measure cylinder bore for out-of-round or taper. If out-of-round or taper is excessive, rebore the cylinder walls by means of a boring machine. Measurement should be taken along bores for taper and around bores for out-of-round. See Figure EM-49.

Out-of-round X-Y
Taper A-B

4. When wear, taper or out-of-round is minor and within the limit, remove the step at the topmost portion of cylinder using a ridge reamer or other similar tool.

HOW TO MEASURE CYLINDER BORE

A bore gauge is used. Measure cylinder bore at top, middle and bottom positions toward A and B directions as shown in Figure EM-49 and record the measured values.



Unit: mm (in)

EM125

Fig. EM-49 Cylinder bore measuring positions

Cylinder bore specifications

		Standard		Wear limit
		J13	J15, J16	
Cylinder bore mm (in)	Inner diameter	73.000 to 73.050 (2.8740 to 2.8760)	77.950 to 78.000 (3.0689 to 3.0709)	0.15 (0.0059)
	Out-of-round	0.020 (0.0008)		0.1 (0.0039)
	Taper	0.02 (0.0008)		
Difference cylinder bore between cylinders on one engine	mm (in)	0.02 (0.0008)		

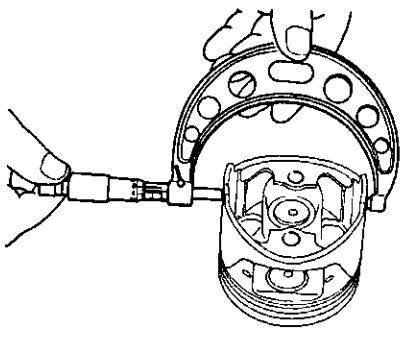
CYLINDER BORING

1. When any cylinder needs boring, all other cylinders must also be bored at the same time.
2. Determine piston oversize according to the amount of wear of cylinder.

Oversize pistons specifications Unit: mm (in)

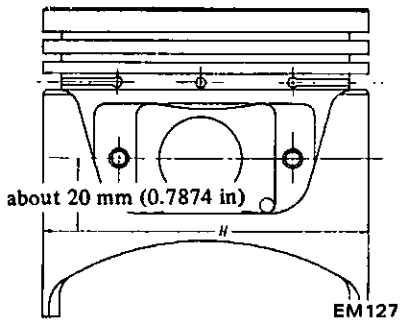
		J13	J15, J16
Standard size		72.987 to 73.037 (2.8735 to 2.8755)	77.935 to 77.985 (3.0683 to 3.0703)
Over size	0.50 (0.0197)	73.467 to 73.517 (2.8924 to 2.8944)	78.415 to 78.465 (3.0872 to 3.0892)
	1.00 (0.0394)	73.967 to 74.017 (2.9121 to 2.9140)	78.915 to 78.965 (3.1069 to 3.1089)
	1.50 (0.0591)	74.467 to 74.517 (2.9318 to 2.9337)	79.415 to 79.465 (3.1266 to 3.1285)

3. The size to which cylinders must be honed is determined by adding to the largest piston diameter (at piston skirt in thrust direction) piston-to-cylinder clearance.



EM126

Fig. EM-50 Measuring piston diameter



EM127

Fig. EM-51 Measuring piston skirt diameter

Rebored size calculation

D = A + B − C = A + [0.005 to 0.025 mm (0.0002 to 0.0010 in)]

Where,

D: Honed diameter
A: Skirt diameter as measured
B: Piston-to-wall clearance
C: Machining allowance [0.02 mm (0.0008 in)]

Note: To prevent strain due to cutting heat, bore the cylinders in the order of 2-4-1-3.

4. Do not cut too much out of cylinder bore at one time. Cut 0.05 mm (0.0020 in) or so at a time.
5. Measurement of cylinder bore just machined requires the utmost care since it is expanded by cutting heat.
6. As a final step, cylinders should be honed to size.
7. Measure the finished cylinder bore for out-of-round or tapered part.
8. Measure piston to cylinder clearance.

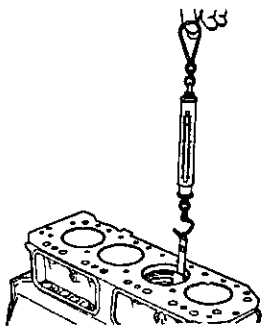
This clearance can be checked easily by using a feeler gauge and a spring balance hooked on feeler gauge, measuring the amount of force requir-

ed to pull out gauge from between piston and cylinder.

Notes:

a. When measuring the clearance, slowly pull the feeler gauge straight upward.

b. It is recommended that piston and cylinder be heated to 20°C (68°F).



EM379

Fig. EM-52 Measuring piston fit in cylinder

Note: If cylinder bore has worn beyond the wear limit, use-cylinder liner.

Undersize cylinder liners are available.

Interference fit of cylinder liner in cylinder block should be 0.08 to 0.09 mm (0.0031 to 0.0035 in).

	J13	J15, J16
Standard clearance mm (in)	0.023 to 0.043 (0.0009 to 0.0017)	0.025 to 0.045 (0.0010 to 0.0018)
Feeler gauge mm (in)	0.04 (0.0016)	
Extracting force kg (lb)	0.5 to 1.5 (1.1 to 3.3)	

Cylinder liner for service

Unit: mm (in)

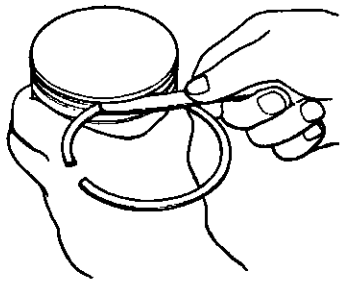
	J13		J15, J16	
	Outside diameter	Inner diameter	Outside diameter	Inner diameter
4.0 (0.1575) Undersize	77.00 to 77.05 (3.0315 to 3.0335)	72.45 to 72.55 (2.8524 to 2.8563)	81.95 to 82.00 (3.2264 to 3.2283)	77.45 to 77.55 (3.0492 to 3.0531)
4.5 (0.1772) Undersize	77.50 to 77.55 (3.0512 to 3.0531)		82.45 to 82.50 (3.2461 to 3.2480)	
5.0 (0.1969) Undersize	78.00 to 78.05 (3.0709 to 3.0728)		82.95 to 83.00 (3.2657 to 3.2677)	

PISTON, PISTON PINS AND PISTON RINGS

1. Remove carbon from piston and ring grooves with a carbon scraper and a curved steel wire. The wire will be useful in cleaning bottom land of ring groove. Clean out oil slots in bottom land of oil ring groove.

2. Check for damage, scratches and wear. Replace if such a defect is detected.

3. Measure the side clearance of rings in ring grooves as each ring is installed. Clearance with new pistons and rings should be as follows.

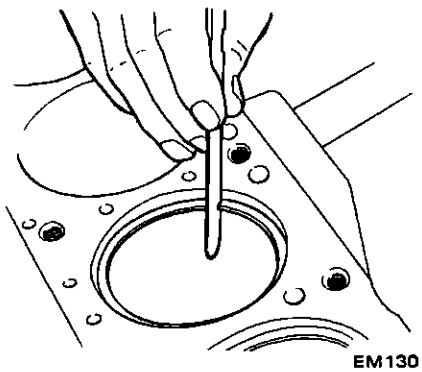


EM129

Fig. EM-53 Measuring piston ring side clearance

4. Push ring into cylinder with a piston so as to place it squarely in cylinder; measure ring gap with a feeler gauge.

Ring should be placed to diameter at upper or lower limit of ring travel.



EM130

Fig. EM-54 Measuring ring gap

Notes:

a. When piston ring only is to be replaced, without cylinder bore being corrected, measure the gap at the bottom of cylinder where the wear is minor.
Proper ring fit in ring groove is very important for proper performance and long life. A sticky ring causes blow-by or oil-up, resulting in premature wear on ring and cylinder wall. If it is too loose, this accelerates wear on sides of ring groove to aggravate ring play.

b. Oversize piston rings are available. [0.5 mm (0.0197 in), 1.0 mm (0.0394 in) oversize].

Side clearance Unit: mm (in)

	Standard	Wear limit
	J13, J15 and J16	
Top ring	0.036 to 0.076 (0.0014 to 0.030)	0.1 (0.0039)
Second ring	0.036 to 0.076 (0.0014 to 0.030)	

Ring gap Unit: mm (in)

	Standard		Wear limit
	J13	J15, J16	
Top ring	0.20 to 0.33 (0.0079 to 0.0130)	0.20 to 0.35 (0.0079 to 0.0138)	1.0 (0.0394)
Second ring	0.20 to 0.33 (0.0079 to 0.0130)	0.14 to 0.29 (0.0055 to 0.0114)	
Oil ring	0.30 to 0.90 (0.0118 to 0.0354)	0.3 to 0.9 (0.0118 to 0.0354)	

Oversize piston ring outer diameter Unit: mm (in)

		J13	J15, J16
Standard		73.00 (2.8740)	77.95 (3.0689)
Oversize	0.50 (0.0197)	73.50 (2.8937)	78.45 (3.0886)
	1.00 (0.0394)	74.00 (2.9134)	78.95 (3.1083)
	1.50 (0.0591)	74.50 (2.9331)	79.45 (3.1279)

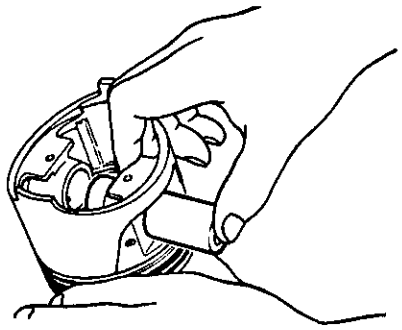


Fig. EM-55 Piston pin fitting

5. Measure piston pin hole in relation to the outer diameter of pin. If wear exceeds the limit, replace piston pin together with piston on which it is installed.

6. Determine the fitting of piston pin into piston pin hole to such an extent that it can be finger pressed at room temperature. This piston pin must be a tight press fit into connecting rod.

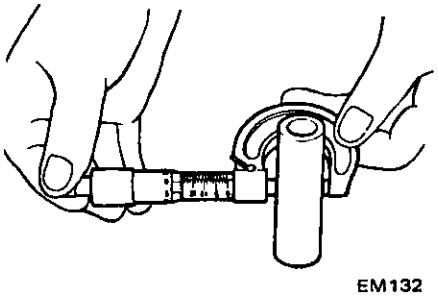


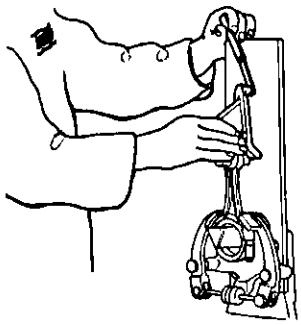
Fig. EM-56 Measuring piston pin diameter

Unit: mm (in)

	J13	J15, J16
Piston pin outside diameter	17.447 to 17.452 (0.6869 to 0.6871)	20.993 to 20.998 (0.8265 to 0.8267)
Piston pin hole diameter	17.453 to 17.460 (0.6871 to 0.6874)	21.001 to 21.008 (0.8268 to 0.8271)
Piston pin to piston clearance	0.001 to 0.013 (0.00004 to 0.0005)	0.003 to 0.015 (0.00012 to 0.00059)
Interference fit of piston pin to connecting rod	Bolt clamp	0.015 to 0.033 (0.00059 to 0.00130)

CONNECTING ROD

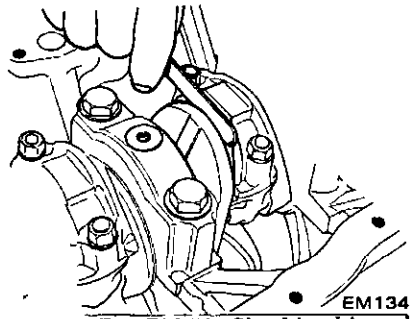
1. If a connecting rod has any flaw on both sides of the thrust face and the large end, correct or replace it.



EM133

Fig. EM-57 Checking rod alignment

2. Check connecting rod for bend or torsion using connecting rod aligner. If bend or torsion exceeds the limit, correct or replace.
3. When replacing connectig rod, select rod so that weight difference between new and old ones is within 6 gr (0.2116 oz).
4. Install connecting rods with bearings on to corresponding crank pins and measure the thrust clearance. If the measured value exceeds the limit, replace connecting rod.



EM134

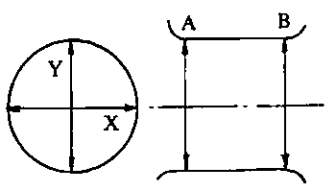
Fig. EM-58 Checking big end play

J13, J15 and J16	Standard	Maximum
Connecting rod bend or torsion (per 100 mm or 3.94 in length) mm (in)	0.03 (0.0012)	0.1 (0.0039)
Connecting rod big end play mm (in)	0.20 to 0.3 (0.0079 to 0.0118)	0.5 (0.0197)

CRANKSHAFT

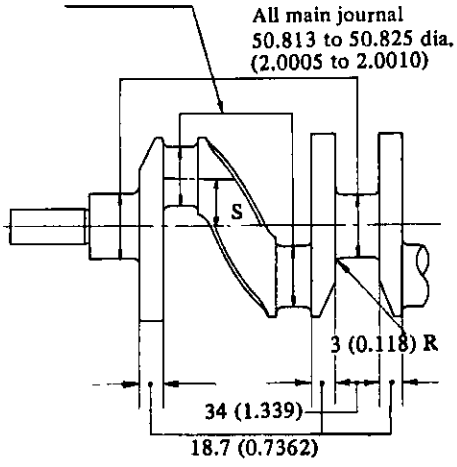
1. Whenever crankshaft is removed from engine, it should be cleaned thoroughly in a suitable solvent. After cleaning, check crankshaft journal and crank pin for score, bias wear or cracks. Repair or replace as required. If defects are minor, dress with fine crocus cloth.
2. Check with micrometer journals and crank pins for taper and out-of-round. Measurement should be taken along journals for taper and around journals for out-of-round. See Figure EM-59 for detailed information.

Out-of-round X-Y
Taper A-B



Unit: mm (in)

	S
J13, J15	38.8 (1.528)
J16	41.0 (1.646)



EM380

Fig. EM-59 Crankshaft and journal dimension

If journals or crank pins are tapered or out-of-round beyond limits, replace with a new shaft.

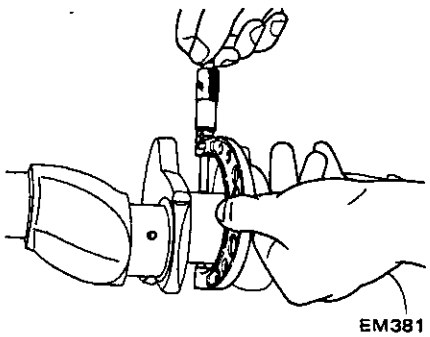

EM381

Fig. EM-60 Measuring journal diameter

3. Crankshaft can be checked for bend by placing it on V-blocks and using a dial gauge with its indicating finger resting on center journal.

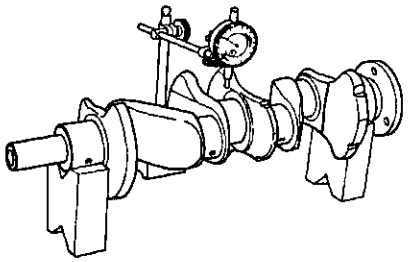

EM382

Fig. EM-61 Checking crankshaft bend

J13, J15 and J16	Standard	Maximum
Taper and out-of-round of journal and crank pin mm (in)	less than 0.01 (0.0004)	0.03 (0.0012)

J13, J15 and J16	Standard	Maximum
Crankshaft bend mm (in)	less than 0.03 (0.0012)	0.05 (0.0020)

Note: When measuring bend, use a dial gauge. Bend value is half of the reading obtained when crankshaft is turned one full revolution with a dial guage attahced to its center journal.

4. After regrinding crankshaft, finish it to the necessary size indicated in the list on page EM-21 by using an adequate undersize bearing according to the extent of required repair.

5. After grinding journals or crankpins, crankshaft should be checked for end play. This can be done by installing shaft in engine block with main bearings and bearing caps torqued to 10 to 11 kg-m (72 to 80 ft-lb). Without disturbing above setting, bar crankshaft as far endwise as possible and insert a feeler gauge in clearance between block and center main bearing.

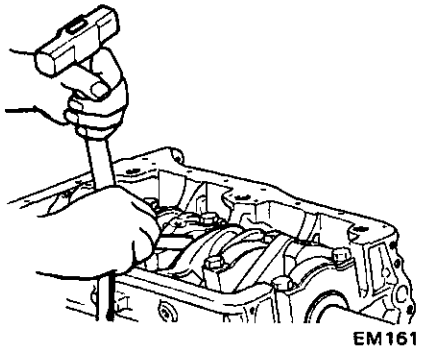

EM161

Fig. EM-62 Checking crankshaft end play

	Standard	Wear limit
Crankshaft free end play mm (in)	0.05 to 0.20 (0.0020 to 0.0079)	0.3 (0.0118)

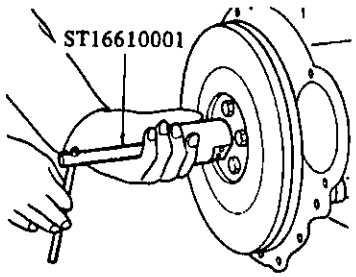
If end play exceeds service limits above, replace thrust washers with those that give proper crankshaft end play.

Thrust washer thickness (Upper and lower) mm (in)	
1	2.235 to 2.286 (0.0880 to 0.0900)
2	2.286 to 2.337 (0.0900 to 0.0920)
3	2.337 to 2.388 (0.0920 to 0.0940)
4	2.388 to 2.438 (0.0940 to 0.0960)

6. At the rear end of crankshaft, check crankshaft pilot bushing for wear or damage. Replace it if defect is detected.

To replace crankshaft rear pilot bushing proceed as follows:

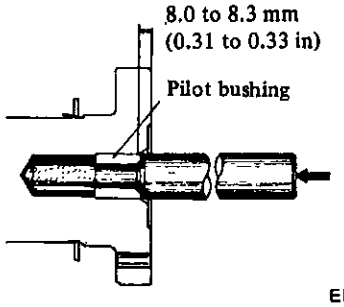
(1) Pull out bushing using Pilot Bushing Puller ST16610001.



CL088

Fig. EM-63 Pulling out pilot bushing

(2) Before installing a new bushing, thoroughly clean bushing hole. Press fit bushing so that its height above flange end is 8.0 to 8.3 mm (0.315 to 0.327 in). Do not oil bushing.



EM404

Fig. EM-64 Press-fitting new pilot bushing

BUSHING AND BEARING

MEASUREMENT OF CONNECTING ROD BEARING CLEARANCE

1. Check connecting rod bearing for wear, scores or pitting, replacing those found beyond maximum limits.
2. Measure clearance between connecting rod journal and bearing to determine if it is within specified limits.

Bearing oil clearance

	Standard	Maximum
Connecting rod clearance (big end) mm (in)	0.011 to 0.052 (0.0004 to 0.0020)	0.10 (0.0039)

To measure clearance, proceed as follows:

(1) Before measuring, journals and bearings should be wiped clean of oil or dust.

(2) Place a strip of plastigage lengthwise on journal. Install bearing on journal and tighten to 2.5 to 3.5 kg-m (18 to 25 ft-lb).

(3) Loosen bolts securing cap in place. Compare flattened width with a special scale supplied with the plastigage envelope. If difference between maximum and minimum width in a strip exceeds 0.03 mm (0.0012 in), it is an indication that journal is worn locally, calling for further service.

Note: Do not turn crankshaft with plastigage installed.

3. If measurement reveals that oil clearance exceeds 0.10 mm (0.0039 in), use correct undersize bearing.

Connecting rod bearing and journal specifications

Unit: mm (in)

		Bearing thickness	Connecting rod journal outer diameter (crank pin)
Standard		1.83 to 1.84 (0.0720 to 0.0724)	47.64 to 47.65 (1.8756 to 1.8760)
Under size	0.08 (0.0031)	1.86 to 1.87 (0.0732 to 0.0736)	47.58 to 47.59 (1.8732 to 1.8736)
	0.12 (0.0047)	1.89 to 1.90 (0.0744 to 0.0748)	47.52 to 47.53 (1.8709 to 1.8713)
	0.25 (0.0098)	1.95 to 1.96 (0.0768 to 0.0772)	47.40 to 47.41 (1.8661 to 1.8665)
	0.50 (0.0197)	2.08 to 2.09 (0.0819 to 0.0823)	47.14 to 47.15 (1.8559 to 1.8563)
	0.75 (0.0295)	2.20 to 2.21 (0.0866 to 0.0870)	46.90 to 46.91 (1.8465 to 1.8468)
	1.00 (0.0394)	2.33 to 2.34 (0.0917 to 0.0921)	46.64 to 46.65 (1.8362 to 1.8366)

Note: Since bearings are of precision insert type, it is not necessary to file bearing caps or to grind bearing surfaces with an emery cloth to correct bearing clearance.

MEASUREMENT OF MAIN BEARING CLEARANCE

Thoroughly clean all bearings. Check for scratches, scores, or wear, replacing those found beyond limits.

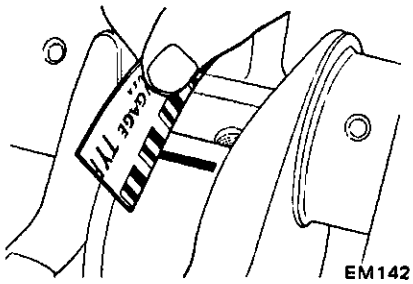
Bearing oil clearance

	Standard	Maximum
Main bearing clearance mm (in)	0.02 to 0.05 (0.0008 to 0.0020)	0.10 (0.0039)

To measure oil clearance, proceed as follows:

1. Crankshaft journals and bearings should be wiped clean of oil and any other foreign materials such as dust and dirt before they can be measured for oil clearance.
2. Use plastigage, placing it lengthwise on journal. Install bearing and bearing cap in position and tighten to 10 to 11 kg-m (72 to 80 ft-lb) tension.
3. Remove cap and measure width of plastigage flattened by comparing with a special scale printed on plastigage envelope.

Note Do not turn crankshaft while plastigage is installed.



EM142

Fig. EM-65 Measuring main bearing oil clearance

When new bearings are used, bearing fit, or more specifically, oil clearance should always be inspected. If if exceeds 0.10 mm (0.0039 in) (maximum), correct undersize bearings should be selected or journals should be ground to fit next undersize bearings.

Note: Since bearings are of precision insert type, it is not necessary to file bearing caps or to grind bearing surfaces with an emery cloth to correct bearing clearance.

Main bearing and journal specifications

Unit: mm (in)

		Bearing thickness	Crankshaft journal outer diameter
Standard		1.822 to 1.835 (0.0717 to 0.0722)	50.81 to 50.82 (2.000 to 2.001)
Under size	0.25 (0.0098)	1.947 to 1.960 (0.0767 to 0.0772)	50.57 to 50.59 (1.991 to 1.992)
	0.50 (0.0197)	2.072 to 2.085 (0.0816 to 0.0821)	50.31 to 50.33 (1.9807 to 1.9815)
	0.75 (0.0295)	2.197 to 2.210 (0.0865 to 0.0870)	50.07 to 50.09 (1.971 to 1.972)
	1.00 (0.0394)	2.322 to 2.335 (0.0914 to 0.0919)	49.81 to 49.83 (1.961 to 1.962)

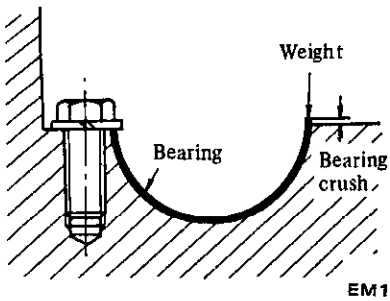
FITTING BEARINGS

Bearings are manufactured with crush to make them fit snugly into their bores. To measure this, proceed as follows:

1. Properly set main bearing in main bearing cap recess or cylinder block bearing recess.
2. Lock one side of the bearing and press the other side till the bearing back surface is completely flush against the recess.

Press weight:
about 500 kg (1,100 lb)

3. Then, measure bearing crush "H" with a feeler gauge. See Figure EM-66. The standard bearing crush value is 0 to 0.05 mm (0 to 0.0020 in).



EM143

Fig. EM-66 Checking bearing crush

MISCELLANEOUS COMPONENTS

CRANKSHAFT SPROCKET AND CAMSHAFT SPROCKET

1. Check crankshaft and camshaft sprockets for wear or scores on sprocket teeth. Replace if worn or damaged beyond limits.
2. Install camshaft sprocket and check to determine that gear run out is held within 0.1 mm (0.0039 in). If above, replace.

CHAIN AND CHAIN TENSIONER

1. Check chain for stepped wear, scratches or other problems to roller links. Replace if necessary.
2. Check chain tensioner for wear, breakage or any other defects which would interfere with proper chain function. Replace if necessary.

FLYWHEEL

1. Check ring gear. If found to be worn or damaged excessively, replace.
2. Clutch contacting face of flywheel should be smooth. If it is worn, damaged or roughened beyond limits, repair or replace.
3. Measure flywheel for run out. This can be checked with a dial gauge, by rotating it in either direction with indicating finger resting on flywheel face farthest from center. If run out exceeds 0.05 mm (0.0020 in), replace flywheel.

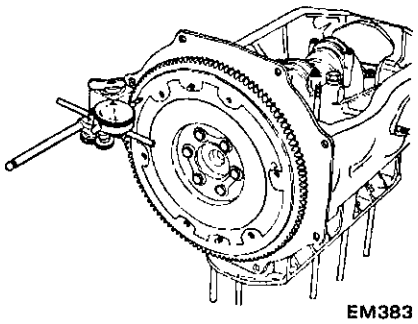


Fig. EM-67 Measuring flywheel run out

Note: Removal and installation of ring gear requires use of a hydraulic press. It is also necessary to heat ring gear as this expands it, thus facilitating removal and installation. Do not heat ring gear to more than 300°C (572°F). To do so could result in impaired hardness of ring gear.

FRONT COVER OIL SEAL

First check front cover of oil seal for deflected wiping edge or oil leakage. If it is deflected or there is any sign of oil leak, replace with a new seal. When installing a new seal, pay particular attention to mounting directions.

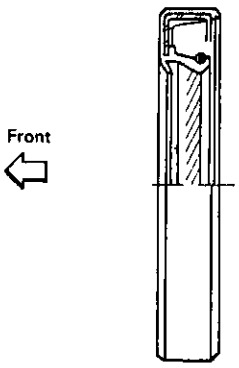


Fig. EM-68 Installing oil seal

Notes:

a. It is good practice to renew oil seal whenever engine is overhauled.
b. Apply lithium grease to wiping edge of oil seal.

ENGINE ASSEMBLY

CONTENTS

PRECAUTION

Before assembling engine, observe the following precautions:

1. Clean all disassembled parts with clean solvent. All oil holes in crankshaft, camshaft, valve rocker shaft, etc. should be cleaned thoroughly to remove all traces of grinding chips or lint. Always use clean solvent.
2. In general, used gaskets, packings and oil seals should be replaced with new ones.
3. Under no circumstances should lockwashers be reused.
4. Place bolts, nuts and washers back in their original parts or places from which they were removed.
5. Most packings serve best when liquid packing is applied to their sealing surfaces. When designated, use suitable liquid packing to eliminate possibility of water, oil and gas leak.
6. Prior to assembling, all sliding surfaces should be oiled liberally.
7. Proper tightening is essential to successful performance of all vehicle repairs. It is also important to follow correct sequence of tightening in pulling up cylinder head. Be on the alert at all times to the amount of clearance permitted.

8. Cleanliness of tools or parts such as work bench used in making a repair is essential. When setting up a job every precaution should be taken that tools or parts are free of dirt, mud and oil. Do not work in dust and grit, for they are primary cause of wear in any engine.

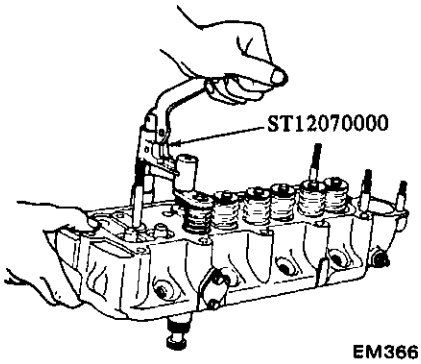
CYLINDER HEAD

Use Valve Lifter ST12070000, to install intake and exhaust valves, valve springs, valve spring retainers, valve collets and rubber rings to cylinder head in the order listed.

Notes:

a. **Do not interchange valves between cylinders, for their sliding or seating surfaces have undergone wearing-in or have been lapped at assembly, forming specific contact with their mating parts.**

b. **Check to be sure that valves are properly seated on valve seats without foreign particles stuck in between.**

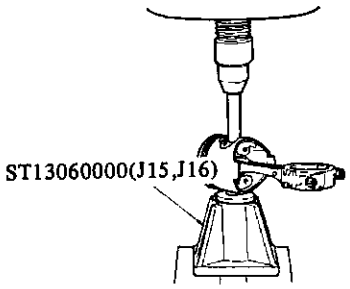


EM366

Fig. EM-69 Installing valve

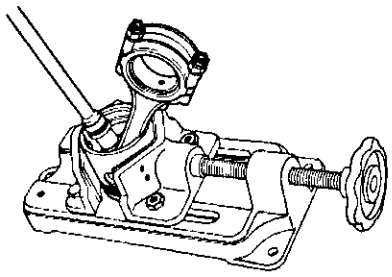
PISTON AND CONNECTING ROD

1. Heat piston to 20°C (68°F); assemble connecting rod, piston pin and piston together by hand. On the J13, tighten connecting rod small end bolt to 2.5 to 3.5 kg-m (18 to 25 ft-lb) using a suitable torque wrench.



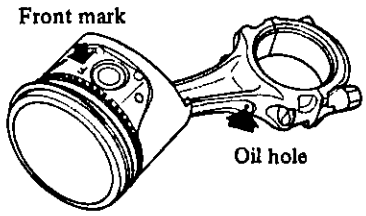
EM156

Fig. EM-70 Installing piston pin



EM365

Fig. EM-71 Tightening small end bolt (J13)



EM321

Fig. EM-72 Assembling piston and connecting rod

Notes:

a. **For the J15 and J16 engine piston is pressed into connecting rod, and fitting force is from 0.5 to 1.5 tons; the aid of Piston Pin Press Stand ST13060000 (J15, J16) or ST13040000 (J13) is necessary. When pressing piston pin in connecting rod, apply engine oil to pin and small end of connecting rod.**

b. **All pistons are marked with a notch in piston head and "F" mark around piston pin hole. Be sure to install pistons in cylinders with these marks facing toward front of engine.**

c. **Connecting rod should be installed with bottom oil jet placed on right side.**

d. **Do not give direct hammer blows to piston pin when fitting it into place in piston.**

2. To install piston with piston rings properly spaced around it, use Piston Ring Expander EM03500000. Every caution should be taken that rings are not interchanged between ring grooves in piston.

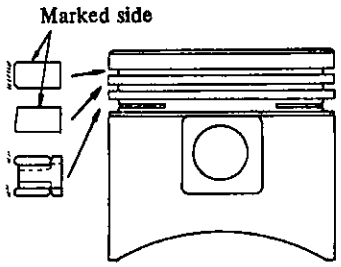
Be sure to install compression rings with surfaces having marked end toward piston head:

Notes:

a. **Top ring is chromium-plated on liner contacting face.**

b. **Second ring has larger taper surface than top ring.**

c. **In the combined oil ring, upper rail is the same as lower one.**



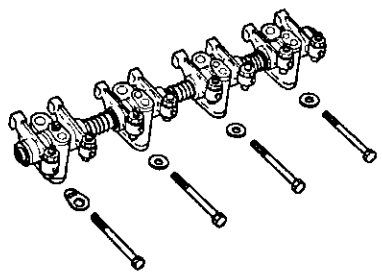
EM168

Fig. EM-73 Installing piston ring

3. Install connecting rod bushing in big end half and cap. Make sure that dust and dirt are not carried in between their mating clearance.

VALVE ROCKER SHAFT ASSEMBLY

Install parts, as shown in Figure EM-74, in place on rocker shaft; secure with cotter pins on both ends of rocker shaft. Install set screw in hole in rearmost bracket and tighten to prevent shaft from working loose during operation.

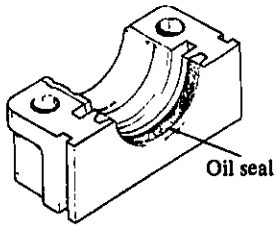


EM349

Fig. EM-74 Assembling valve rocker shaft assembly

ASSEMBLING ENGINE

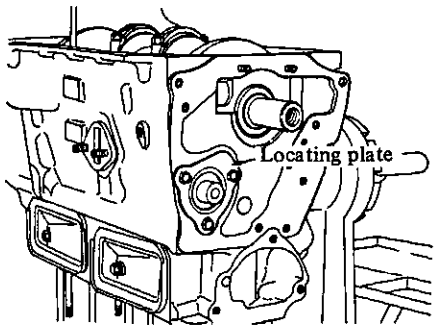
1. The first step in engine assembly is to bolt Engine Attachment ST05280000 to right hand side of cylinder block. Next, install another Engine Stand ST0501S000 in block.
2. Thoroughly clean groove in oil seal housing of crankshaft rear bearing; place oil seal in groove with finger and thumb. Using an oil seal replacer (guide), lightly tap with a hammer until oil seal is installed correctly. Trim seal flush with ends of housing block. Install oil seal in rear bearing cap as above.



EM385

Fig. EM-75 Installing crankshaft rear oil seal

3. Apply a light coat of engine oil to sliding surfaces of valve lifters; insert lifters in holes in cylinder block. To install camshaft, be sure to coat sliding surfaces of camshaft bushings with a light coat of engine oil. Insert camshaft in cylinder block from front side of engine, exercising care not to damage camshaft bushings. Torque locating plate to 0.5 to 0.8 kg-m (3.6 to 5.8 ft-lb) using a suitable torque wrench.

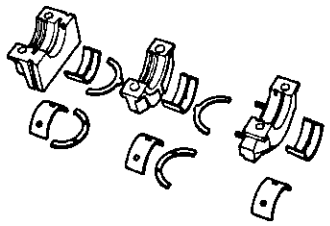


EM386

Fig. EM-76 Installing locating plate

4. Clean main bearing shells, bearing saddles and bearing caps. Place shell halves in bearing saddles in cylinder block; place other halves in bearing caps. Next, install thrust washers on each side of center bearing. Make certain that lug on each half of shell fits in a notch in bearing saddle and bearing cap.

Note: Thrust washers should be installed with side oil grooves facing toward outer side of bearing cap.

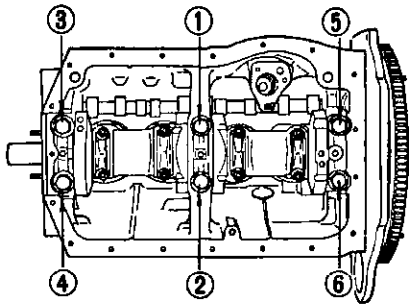


EM387

Fig. EM-77 Main bearing caps and bearings

5. Liberally apply clean engine oil to bearing shells; place crankshaft on shells in cylinder block.
6. To install main bearing caps, be sure that arrow mark in cap head is placed toward front of engine. Install thrust washers on each side of center main bearing cap. Main bearing cap bolts should be tightened in the sequence as shown and in three to four steps gradually. After above steps have been completed, check to determine that crankshaft turns freely.

Main bearing cap tightening torque:
10 to 11 kg-m
(72 to 80 ft-lb)

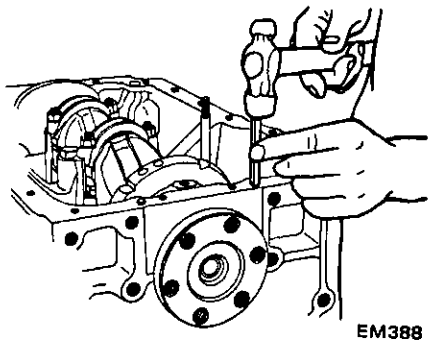


EM404

Fig. EM-78 Torque sequence of cap bolts

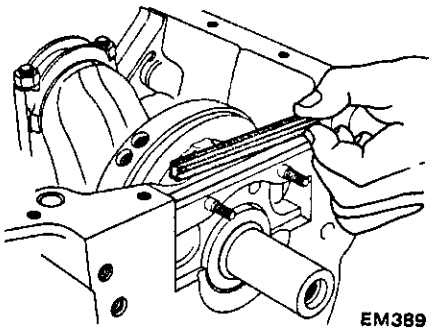
Note: Apply liquid packing to bearing saddle touching ends of rear main bearing cap.

7. Install rear bearing side seal and front seal. Prior to installing, apply adhesive to these seals. Be careful not to damage sealing lips which could result in oil leak.



EM388

Fig. EM-79 Driving rear bearing side oil seal



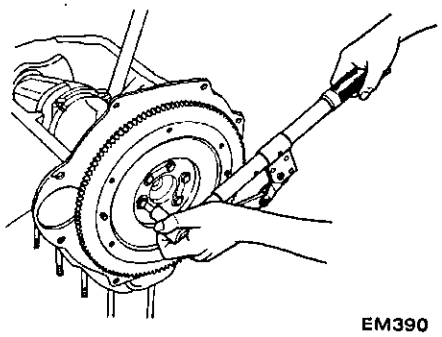
EM389

Fig. EM-80 Installing front seal

8. Install engine rear plate and gasket and tighten bolts to specified torque.

9/16" bolt	3.0 to 4.0 kg-m (22 to 29 ft-lb)
1/2" bolt	0.9 to 1.5 kg-m (6.5 to 11 ft-lb)

9. Position flywheel in place on flange end of crankshaft; install and tighten attaching bolts to 4.0 to 5.0 kg-m (29 to 36 ft-lb). Bend ends of lockwashers up against sides of attaching bolts to secure installation.

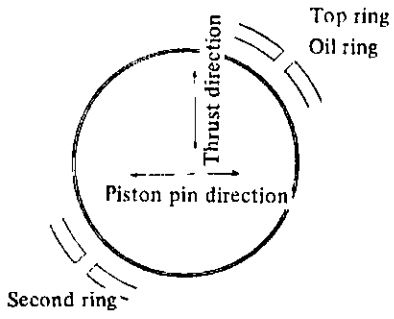


EM390

Fig. EM-81 Installing flywheel

Note: Always use new lockwashers and tighten them up against bolts securely.

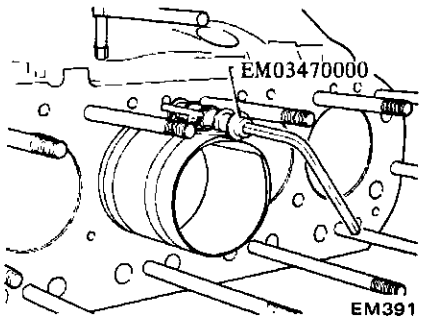
10. Using Piston Ring Compressor EM03470000, install pistons so they are below top of cylinders. Notes in installing pistons:
(1) Marking "F" in piston head should be placed toward the front of engine.
(2) Each connecting rod is numbered, begining at the front of engine. Piston and connecting rod assemblies should be installed in respective cylinder so that number on rod corresponds with cylinder number.
(3) Piston ring end gaps should be staggered 180° apart from each other, being careful not to locate them in thrust and piston pin directions.



EM165

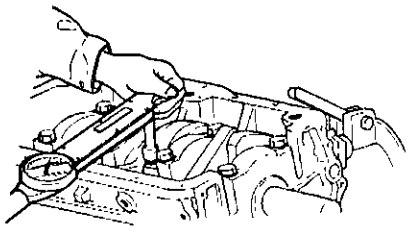
Fig. EM-82 Piston ring direction

(4) Numbers on connecting rod and bearing cap must be on the same side with oil jets properly pointed. Refer to Note "c" under the paragraph "Piston and Connecting Rod." Install connecting rod caps with light engine oil on both journal and bushing contacting surfaces. Draw them up to 2.8 to 3.5 kg-m (20 to 25 ft-lb); install pal nuts to secure the installation.



EM391

Fig. EM-83 Installing piston



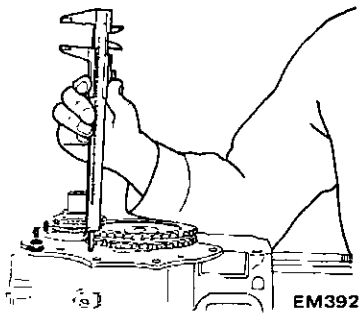
EM166

Fig. EM-84 Tightening connecting rod cap

11. Install engine front plate with gasket under it and tighten bolts to specified torque.

7/16" bolt	0.5 to 1.0 kg-m (3.6 to 7.2 ft-lb)
1/2" bolt	0.9 to 1.5 kg-m (6.5 to 11 ft-lb)

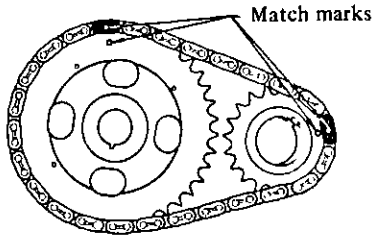
12. Install crankshaft sprocket, camshaft sprocket and chain in the following manner:
(1) Insert keys in keyways. Temporarily install both crankshaft and camshaft sprockets and check to see that they are flush with each other. If difference in height falls below 0.5 mm (0.020 in), place a 0.15 mm (0.0059 in) washer under crankshaft sprocket.



EM392

Fig. EM-85 Measuring sprocket height

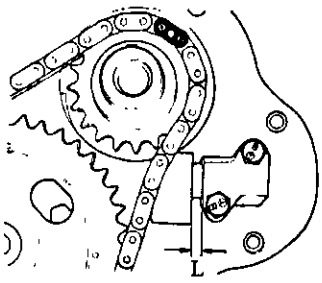
(2) After above step has been completed, install crankshaft sprocket, chain and camshaft sprocket with their markings properly aligned. Oil sprocket teeth and chain with light engine oil. Tighten camshaft sprocket bolt to 4.0 to 5.0 kg-m (29 to 36 ft-lb) by means of a suitable torque wrench.



EM393

Fig. EM-86 Aligning markings

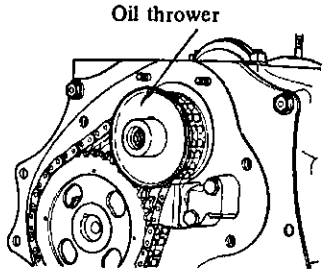
13. Install chain tensioner. Correct projection "L" of spindle is below 15 mm (0.591 in). Replace spindle when it is found to be over this limit.



EM394

Fig. EM-87 Installing chain tensioner

14. Install oil thrower in front of camshaft sprocket correctly.



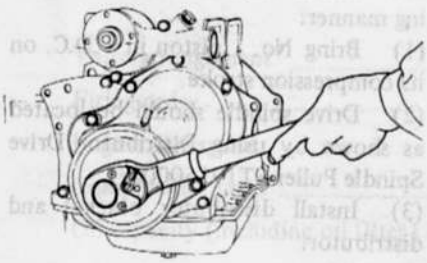
EM395

Fig. EM-88 Installing oil thrower

15. Install front (chain) cover with gasket inserted in between. At this time, coat gasket surface and gasket

contact surface of engine block with suitable liquid packing before installing gasket. Apply a lithium grease to wiping edge of front cover oil seal.

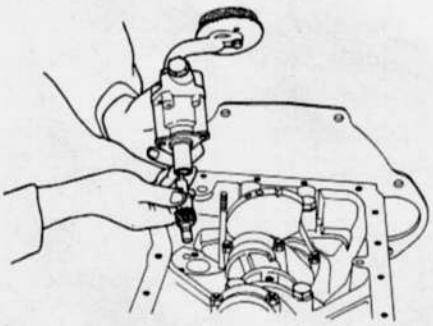
16. Install and tighten crankshaft pulley to 12 to 14 kg-m (87 to 101 ft-lb) torque. Be sure to bend locking tab of lockwasher to secure the installation.



EM396

Fig. EM-89 Installing crankshaft pulley

17. Install oil pump drive spindle and oil pump assembly with gasket placed under them. Correct tightening is 1.2 to 1.8 kg-m (8.7 to 13 ft-lb).



EM397

Fig. EM-90 Installing oil pump

18. At this stage, oil pan should be installed to flanged end of engine block with gasket inserted in between. Tightening should be performed in criss-cross pattern to 0.5 to 1.0 kg-m (3.6 to 7.2 ft-lb) tension.

19. The next step in engine assembly is to install cylinder head and rocker shaft assembly.

(1) Position cylinder head in place on top of engine block. Do not forget to install gasket between head and block.

Note: Coat gasket surface of engine block with suitable liquid packing before installing gasket. Also apply same liquid packing to cylinder head on surface in which push rod holes are cast out.

(2) Insert push rods.

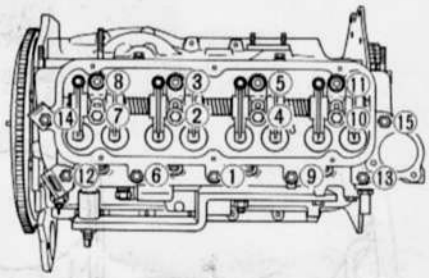
(3) Position rocker shaft assembly on top of cylinder head.

(4) Tighten cylinder head stud nuts and valve rocker shaft bracket bolts at the same time.

Cylinder head stud nut	5.0 to 6.0 kg-m (36 to 43 ft-lb)
Rocker shaft bracket bolt	2.0 to 3.0 kg-m (15 to 22 ft-lb)

In tightening, note the following:

- Tightening should be made in two or three steps, finally torquing to specifications.
- Tightness of nuts and bolts should be rechecked after engine has been operated for several minutes; if necessary, retighten.

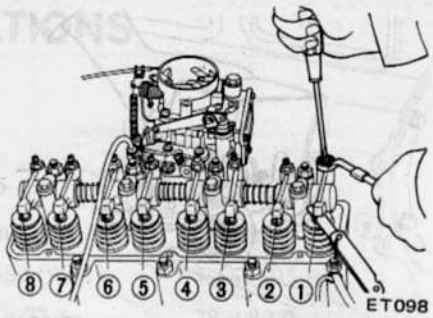


EM398

Fig. EM-91 Tightening sequence

20. After valve-tappet clearnace has been adjusted properly, install valve rocker cover. Correct valve-tappet clearance is 0.35 mm (0.0138 in) for both intake and exhaust valves when engine is hot. To achieve this, first set clearance to 0.35 mm (0.0138 in) when engine is cold. After engine has been assembled, run it for at least several minutes and recheck clearance. For details, refer to "Adjusting intake and exhaust valve clearance" in ET section.

	Intake and Exhaust Valves
Valve-tappet clearance (hot) mm (in)	0.35 (0.0138)

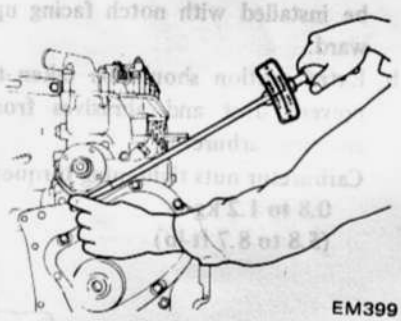


ET098

Fig. EM-92 Adjusting valve-tappet clearance

21. Install side cover. Tighten bolts which hold it in place to 0.4 to 0.8 kg-m (2.9 to 5.8 ft-lb) torque.

22. Install water pump assembly with gasket placed under it. Coat gasket surface with suitable liquid packing before installing gasket. Install and tighten attaching bolts to specifications. It should be between 1.2 and 1.8 kg-m (8.7 to 13 ft-lb).



EM399

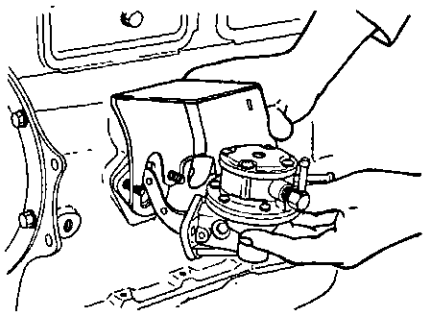
Fig. EM-93 Installing water pump

23. Install thermostat and water outlet. Do not forget to install gasket.

EM400

Fig. EM-94 Installing thermostat and water outlet

24. Coat cylinder block to fuel pump mounting faces with suitable liquid packing and position gasket on fuel pump mounting face of block; install pump and tighten to 1.2 to 1.8 kg-m (8.7 to 13 ft-lb) tension using a suitable torque wrench. Heat shield plate should be installed simultaneously.



EM354

Fig. EM-95 Installing fuel pump

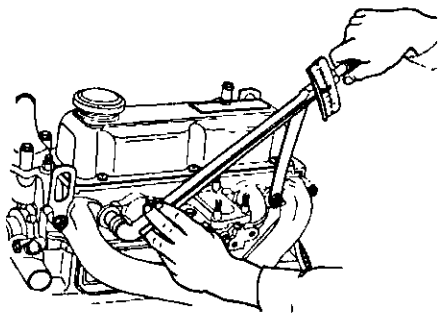
25. Position intake and exhaust manifolds on cylinder block; install bolts which secure manifolds and torque to 1.7 to 2.3 kg-m (12 to 17 ft-lb). Next, install carburetor and air cleaner. Engine slinger and air cleaner support should also be tightened together with manifolds.

Notes:

a. **Carburetor insulating gasket should be installed with notch facing upward.**

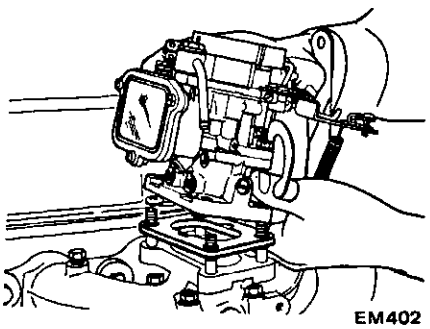
b. **Extra caution should be taken to prevent dust and abrasives from entering carburetor.**

Carburetor nuts tightening torque:
0.8 to 1.2 kg-m
(5.8 to 8.7 ft-lb)



EM401

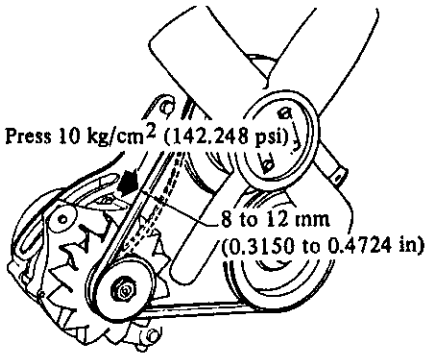
Fig. EM-96 Installing manifold



EM402

Fig. EM-97 Installing carburetor assembly

26. Install alternator bracket, adjusting bar, alternator, fan pulley, fan and fan belt in that order. Then, check to be sure that deflection of fan belt is held within 8 to 12 mm (0.315 to 0.472 in) when thumb pressure is applied midway between pulleys.



ET075

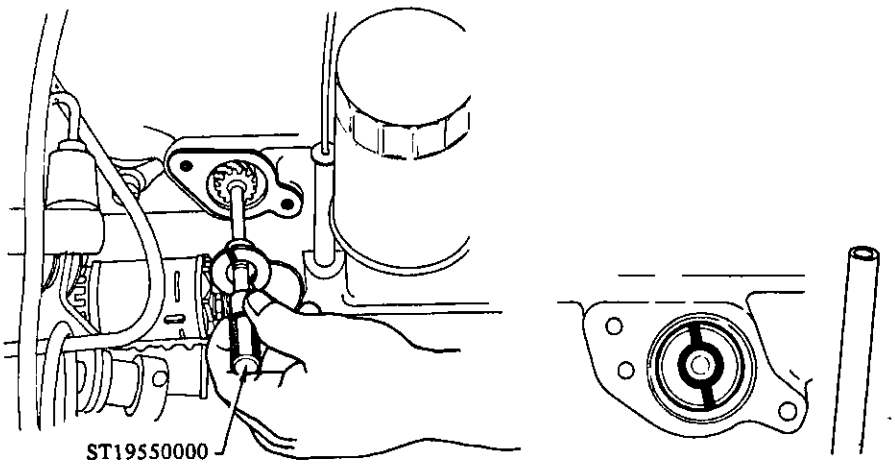
Fig. EM-98 Measuring deflection of fan belt

27. Position oil filter bracket in place with gasket placed under it; tighten to 1.6 to 2.4 kg-m (12 to 17 ft-lb) using a suitable torque wrench.
28. Fasten oil filter on oil filter bracket by hand.

Note: Do not overtighten filter, or oil leakage may occur.

29. Install distributor in the following manner:
(1) Bring No. 1 piston in T.D.C. on its compression stroke.
(2) Drive spindle should be located as shown by using Distributor Drive Spindle Puller ST19550000.
(3) Install distributor bracket and distributor.

Note: Be careful not to drop drive spindle into oil pan.



EM403

Fig. EM-99 Mounting direction of distributor drive spindle

30. Install spark plugs, high tension cables, oil pressure switch and oil level gauge.
31. Install fuel pipes and vacuum hose.

All pipes and hoses should be clamped securely, being careful not to allow them to interfere with adjacent or surrounding parts.
32. Fill with engine oil to specified level.
33. Using an overhead hoist and lifting cable, hoist engine up away from engine stand and then down onto engine carrier. Install clutch assembly, starting motor and engine mountings.

SERVICE DATA AND SPECIFICATIONS

GENERAL SPECIFICATIONS

		J13	J15	J16
Engine model		J13	J15	J16
Cylinder arrangement		4 in line	4 in line	4 in line
Displacement	cc (cu in)	1,299 (79.3)	1,483 (90.5)	1,567 (95.6)
Bore x stroke	mm (in)	73 x 77.6 (2.87 x 3.06)	78 x 77.6 (3.07 x 3.06)	78 x 82.0 (3.07 x 3.23)
Valve arrangement		O.H.V.	O.H.V.	O.H.V.
Firing order		1–3–4–2	1–3–4–2	1–3–4–2
Engine idle speed	rpm	600	600	600
Compression ratio		8.2	8.3	8.3
Oil capacity (including oil filter)				
Liters (U.S. qt., Imp. qt.)		3.4 to 4.4 (3⅝, 4⅝ to 4⅝, 3⅞)		

TIGHTENING TORQUE

Model	J13	J15	J16
Cylinder head stud nut kg-m (ft-lb)	5.0 to 6.0 (36 to 43)		
Rocker shaft bracket bolt kg-m (ft-lb)	2.0 to 3.0 (14 to 22)		
Connecting rod big end nuts kg-m (ft-lb)	2.8 to 3.5 (20 to 25)		
Connecting rod small end bolt kg-m (ft-lb)	2.5 to 3.5 (18 to 25)	—	
Flywheel fixing bolts kg-m (ft-lb)	4.0 to 5.0 (29 to 36)		
Main bearing cap bolts kg-m (ft-lb)	10 to 11 (72 to 80)		
Camshaft sprocket bolt kg-m (ft-lb)	4.0 to 5.0 (29 to 36)		
Oil pan bolts kg-m (ft-lb)	0.5 to 1.0 (3.6 to 7.2)		
Oil pump bolts kg-m (ft-lb)	1.2 to 1.8 (8.7 to 13)		
Oil pan drain plug kg-m (ft-lb)	2.0 to 3.0 (14.5 to 21.7)		
Locating plate bolts kg-m (ft-lb)	0.5 to 0.8 (3.6 to 5.8)		
Carburetor nuts kg-m (ft-lb)	0.8 to 1.2 (5.8 to 8.7)		
Manifold nuts kg-m (ft-lb)	1.7 to 2.3 (12 to 17)		
Fuel pump nuts kg-m (ft-lb)	1.2 to 1.8 (8.7 to 13.0)		
Crank pulley bolt kg-m (ft-lb)	12 to 14 (87 to 101)		
Engine front plate bolts kg-m (ft-lb)			
7/16" bolts	0.5 to 0.9 (3.6 to 6.5)		
1/2" bolts	0.9 to 1.5 (6.5 to 11)		
Engine rear plate bolts kg-m (ft-lb)			
9/16" bolts	3.0 to 4.0 (22 to 29)		
1/2" bolts	0.9 to 1.5 (6.5 to 11)		

Model	J13	J15	J16
Water pump bolts kg-m (ft-lb)	1.2 to 1.8 (8.7 to 13)		
Oil filter bolts kg-m (ft-lb)	1.6 to 2.4 (12 to 17)		
Side cover bolt kg-m (ft-lb)	0.4 to 0.8 (2.9 to 5.8)		

SPECIFICATIONS

Model	J13	J15	J16
a) Valve mechanism			
Valve clearance (hot) Intake and exhaust mm (in)	0.35 (0.0138)		
Valve head dia. mm (in)			
–Intake	34.9 (1.3740)	37.9 (1.4921)	
–Exhaust	30.0 (1.1811)	32.0 (1.2598)	
Valve stem dia. mm (in)			
Intake and exhaust	8.680 to 8.693 (0.3417 to 0.3422)		
Valve length mm (in)			
–Intake	109.35 to 109.65 (4.305 to 4.317)	109.35 to 109.65 (4.305 to 4.317)	
–Exhaust	108.55 to 108.85 (4.274 to 4.285)	109.35 to 109.65 (4.305 to 4.317)	
Valve spring free length mm (in)	Model 620, T20 (J13, J15 and J16)		Model A321 (J13, J15)
–Outer	52 (2.047)		
–Inner	50 (1.969)		47.1 (1.854)
Valve spring pressured length (valve open) mm/kg (in/lb)			
–Outer	30.7/47.8 (1.209/105)		30.7/70.6 (1.209/156)
–Inner	28.7/21.3 (1.130/47)		
Valve spring assembled height (valve close) mm/kg (in/lb)			
–Outer	38.9/29.0 (1.531/64)		38.9/35.4 (1.531/78)
–Inner	36.9/13.1 (1.453/29)		

Model	J13	J15	J16
Valve spring effective turns mm (in)	Model 620, T20 (J13, J15 and J16)		Model A321 (J13, J15)
–Outer	4.5 (0.1772)		3.75 (0.1476)
–Inner	6.5 (0.2559)		
Valve spring wire dia. mm (in)			
–Outer	4.0 (0.1575)		4.5 (0.1772)
–Inner	2.8 (0.1102)		
Valve spring coil dia. mm (in)			
–Outer	25.2 (0.9921)		25.2 (0.9921)
–Inner	18.4 (0.7244)		
Valve guide length mm (in)			
–Intake	47.6 (1.874)		
–Exhaust	56.0 (2.205)		
Valve guide height from head surface mm (in)	15.5 to 15.9 (0.610 to 0.626)		
Valve guide inner dia. mm (in)			
–Intake	8.732 to 8.745 (0.3438 to 0.3443)		
–Exhaust	8.744 to 8.757 (0.3443 to 0.3448)		
Valve guide outer dia. mm (in)			
Intake and exhaust	14.313 to 14.326 (0.5635 to 0.5640)		
Valve guide to stem clearance mm (in)			
–Intake	0.039 to 0.065 (0.0015 to 0.0026)		
–Exhaust	0.051 to 0.077 (0.0020 to 0.0030)		
Valve guide interference fit mm (in)	0.013 to 0.045 (0.0005 to 0.0018)		
Valve seat width mm (in)			
Intake and exhaust	1.6 to 1.7 (0.0630 to 0.0669)		
Valve seat angle			
Intake and exhaust	45°		
Valve seat interference fit mm (in)			
exhaust	0.054 to 0.080 (0.0021 to 0.0031)		

Model	J13	J15	J16
b) Camshaft and timing chain			
Camshaft end play mm (in)	0.05 to 0.29 (0.0020 to 0.0114)		
Camshaft lobe height mm (in)	6.15 (0.2421)		
Camshaft journal dia. (standard size) mm (in)			
–Front	45.434 to 45.447 (1.7887 to 1.7892)		
–Center	43.897 to 43.910 (1.7282 to 1.7287)		
–Rear	41.218 to 41.231 (1.6228 to 1.6233)		
Camshaft bend mm (in)	Less than 0.03 (0.0012)		
Camshaft journal to bearing clearance mm (in)			
–Front	0.027 to 0.050 (0.0011 to 0.0020)		
–Center	0.038 to 0.064 (0.0015 to 0.0025)		
–Rear	0.026 to 0.049 (0.0010 to 0.0019)		
Camshaft bearing inner dia. mm (in)			
–Front	45.474 to 45.484 (1.7903 to 1.7907)		
–Center	43.948 to 43.961 (1.7302 to 1.7307)		
–Rear	41.257 to 41.267 (1.6243 to 1.6247)		
c) Rocker arm lever ratio	1.4		
d) Connecting rod			
Center distance mm (in)	142.67 (5.617)		139.85 (5.506)
Bearing material	F500	F770	
Bearing thickness (S.T.D.) mm (in)	1.83 to 1.84 (0.0720 to 0.0724)		
Big end play mm (in)	0.20 to 0.30 (0.0079 to 0.0118)		
Connecting rod bearing clearance mm (in)	0.011 to 0.052 (0.0004 to 0.0020)		
Connecting rod bend or torsion (per 100 mm or 2.937 in) mm (in)	Less than 0.03 (0.0012)		

Model	J13	J15	J16
e) Crankshaft and main bearing			
Journal dia. mm (in)	50.813 to 50.825 (2.0005 to 2.0010)		
Journal taper & out-of-round mm (in)	Less than 0.01 (0.0004)		
Crankshaft free end play mm (in)	0.05 to 0.20 (0.0020 to 0.0079)		
Wear limit of dittoed play mm (in)	0.3 (0.0118)		
Crank pin dia. mm (in)	47.640 to 47.652 (1.8756 to 1.8761)		
Crank pin taper & out-of-round mm (in)	Less than 0.01 (0.0004)		
Main bearing material	F770		
Main bearing thickness (S.T.D.) mm (in)	1.822 to 1.835 (0.0717 to 0.0722)		
Main bearing clearance mm (in)	0.02 to 0.05 (0.0008 to 0.0020)		
Wear limit of dittoed clearance mm (in)	0.10 (0.0039)		
Crankshaft bend mm (in)	Less than 0.03 (0.0012)		
f) Piston			
Piston dia. –S.T.D. mm (in)	72.987 to 73.037 (2.8735 to 2.8755)	77.935 to 77.985 (3.0683 to 3.0763)	
0.50 (0.0197) Oversize	73.467 to 73.517 (2.8924 to 2.8944)	78.415 to 78.465 (3.0871 to 3.0892)	
1.00 (0.0394) Oversize	73.967 to 74.017 (2.9121 to 2.9140)	78.915 to 78.965 (3.1069 to 3.1089)	
1.5 (0.0591) Oversize	74.467 to 74.517 (2.9318 to 2.9337)	79.415 to 79.465 (3.1266 to 3.1285)	
Ellipse difference mm (in)	0.07 to 0.17 (0.0028 to 0.0067)		

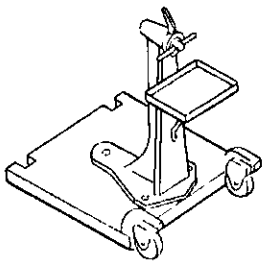
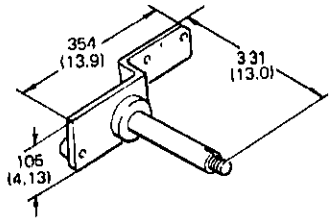
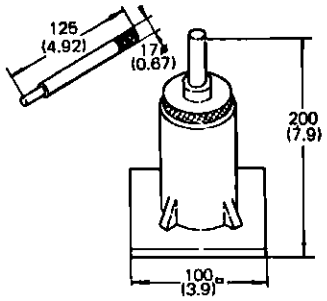
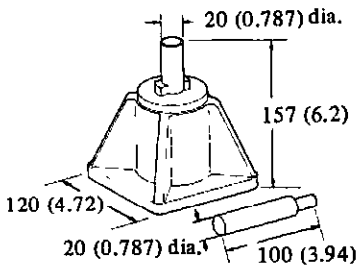
Model	J13	J15	J16
Ring groove width			
–Top		2.0 (0.0787)	
–Second		2.0 (0.0787)	
–Oil		4.0 (0.1575)	
Piston to bore clearance mm (in)	0.023 to 0.043 (0.0009 to 0.0017)	0.025 to 0.045 (0.0010 to 0.0018)	
Piston pin hole off-set mm (in)	0	0.95 to 1.05 (0.0374 to 0.0413)	
Piston pin hole diameter mm (in)	17.453 to 17.460 (0.6871 to 0.6874)	21.001 to 21.008 (0.8268 to 0.8271)	
g) Piston pin			
Pin dia. mm (in)	17.447 to 17.452 (0.6869 to 0.6871)	20.993 to 20.998 (0.8265 to 0.8267)	
Pin length mm (in)	65.23 to 65.48 (2.5681 to 2.5780)	66.40 to 66.55 (2.6142 to 2.6240)	
Piston pin to piston clearance mm (in)	0.001 to 0.013 (0.00004 to 0.00051)	0.003 to 0.015 (0.00012 to 0.00059)	
Interference fit of piston pin to connecting rod bushing mm (in)	Bolt clamp	0.015 to 0.033 (0.0006 to 0.0013)	
h) Piston ring			
Ring height mm (in)			
–Top		1.984 (0.0781)	
–Second		1.984 (0.0781)	
Side clearance mm (in)			
–Top		0.036 to 0.076 (0.0014 to 0.0030)	
–Second		0.036 to 0.076 (0.0014 to 0.0030)	
Ring gap mm (in)			
–Top	0.20 to 0.33 (0.0079 to 0.0130)	0.20 to 0.35 (0.0079 to 0.0138)	
–Second	0.20 to 0.33 (0.0079 to 0.0130)	0.14 to 0.29 (0.0055 to 0.0114)	
–Oil		0.30 to 0.90 (0.0118 to 0.0354)	

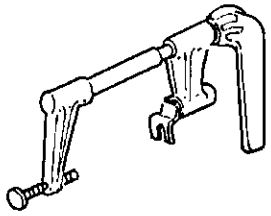
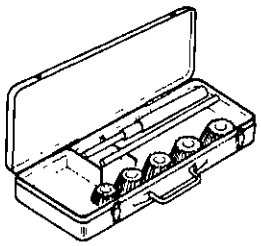
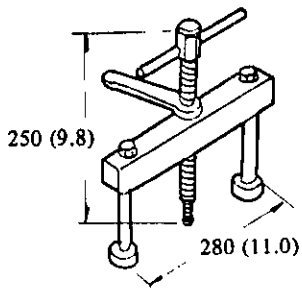
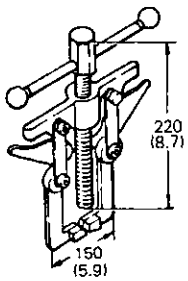
TROUBLE DIAGNOSES AND CORRECTIONS

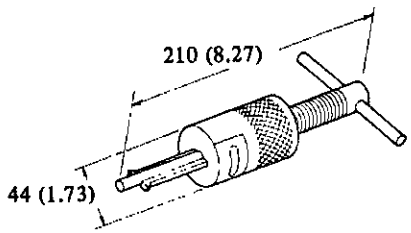
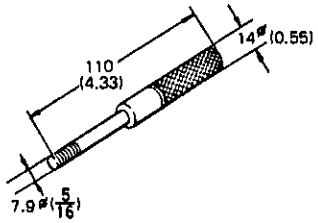
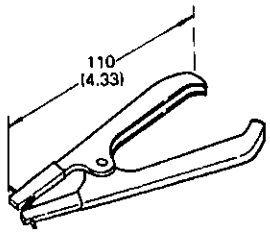
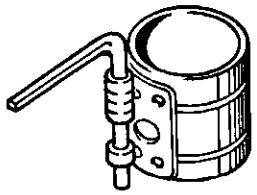
Condition	Probable cause	Corrective action
I. Noisy engine		
Knocking of crankshaft and bearing.	Loose main bearing.	Replace.
	Seized bearing.	Replace.
	Bent crankshaft.	Repair or replace.
	Uneven wear of journal.	Correct.
	Excessive crankshaft end play.	Replace center bearing.
Piston and connecting rod knocking	Loose bearing.	Replace.
	Seized bearing.	Replace.
	Loose piston pin.	Replace pin or bushing.
	Loose piston in cylinder.	Recondition cylinder.
	Broken piston ring.	Replace.
	Improper connecting rod alignment.	Realign.
Camshaft knocking	Loose bearing.	Replace.
	Excessive axial play.	Replace bearing thrust plate.
	Rough gear teeth.	Repair.
	Broken cam gear.	Replace.
Timing chain noise	Improper chain tension.	Adjust.
	Worn and/or damaged chain.	Replace.
	Worn sprocket.	Replace.
	Worn and/or broken tension adjusting mechanism.	Replace.
	Excessive camshaft and bearing clearance.	Replace.
Camshaft and valve mechanism knocking	Improper valve clearance.	Adjust.
	Worn adjusting screw.	Replace.
	Worn rocker face.	Replace.
	Loose valve stem in guide.	Replace guide.
	Weakened valve spring.	Replace.
	Seized valve.	Repair or replace.
Water pump knocking	Improper shaft end play.	Replace.
	Broken impeller.	Replace.
II. Other mechanical troubles		
Sticking valve.	Improper valve clearance.	Adjust.
	Insufficient clearance between valve stem and guide.	Clean stem or ream guide.
	Weakened or broken valve spring.	Replace.
	Seized or damaged valve stem.	Replace or clean.
	Poor fuel quality.	Use better fuel.

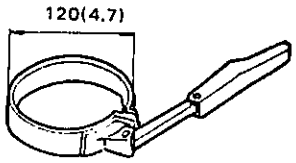
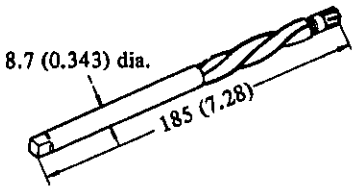
Condition	Probable cause	Corrective action
Seized valve seat	Improper valve clearance.	Adjust.
	Weakened valve spring.	Replace.
	Thin valve head edge.	Replace valve.
	Narrow valve seat.	Reface.
	Overheating	Repair or replace.
	Over speeding.	Drive within proper speed.
	Sticking valve guide.	Repair.
Excessively worn cylinder and piston	Shortage of engine oil.	Add or replace oil.
	Dirty engine oil.	Clean crankcase, replace oil and oil filter element.
	Poor quality of oil.	Use right oil.
	Overheating.	Repair or replace.
	Faulty assembly of piston with connecting rod.	Repair or replace.
	Improper piston ring clearance.	Adjust.
	Broken piston ring.	Replace.
	Dirty air cleaner.	Clean.
	Too rich mixture.	Adjust.
	Engine over run.	Drive at proper speeds.
	Sticking choke valve.	Clean and adjust.
	Overchoking.	Start correctly.
Defective connecting rod	Shortage of engine oil.	Add oil.
	Low oil pressure.	Correct.
	Poor quality of engine oil.	Use right oil.
	Rough surface of crankshaft.	Grind and replace bearing.
	Clogged oil passage.	Clean.
	Bearing wear or eccentricity.	Replace.
	Improper bearing assembly.	Correct.
	Loose bearing.	Replace.
	Connecting rod alignment incorrect.	Repair or replace.
Defective crankshaft bearing	Shortage of engine oil.	Add or replace.
	Low oil pressure.	Correct.
	Poor quality of engine oil.	Use right oil.
	Crankshaft journal worn or out-of-round.	Repair.
	Clogged oil passage in crankshaft.	Clean.
	Bearing wear or eccentricity.	Replace.
	Improper bearing assembly.	Correct.
	Eccentric crankshaft or bearing.	Replace.

SPECIAL SERVICE TOOLS

No.	Tool number & tool name	Description Unit: mm (in)	For use on	Reference page or figure No.
1.	ST0501S000 Engine stand assembly ST05011000 Engine stand ST05012000 Base	This engine stand assembly is used for disassembling or assembling engine block or differential carrier throughout 360° in all directions.  SE184	All models	Page EM-5 Page EM-25 Fig. EM-11
2.	ST05280000 Engine attachment	This engine attachment is installed to engine stand ST0501S000 in disassembling or assembling engine.  SE286	J13 J15 J16	Page EM-5 Page EM-25 Fig. EM-11
3.	ST13040000 Piston pin press stand	For removing and installing the piston pin.  SE302	J13	Page EM-7 Page EM-24
4.	ST13060000 Piston pin press stand	This tool is used with a press to drive pin into, or out of, connecting rod.  SE188	J15 J16 L20A	Page EM-7 Fig. EM-25 Page EM-24 Fig. EM-70

No.	Tool number & tool name	Description Unit: mm (in)	For use on	Reference page or figure No.
5.	ST12070000 Valve lifter	This tool is used to compress valve spring by the combined action of its cam and lever, thereby facilitating the removal or installation of collect (for general use).  SE194	All models	Page EM-7 Page EM-24 Fig. EM-69
6.	ST11600001 Valve seat cutter set	This valve seat cutter set is used to or refinish a valve seat.  SE193	J13 J15 J16 P	Page EM-12 Fig. EM-42
7.	ST16511000 Crankshaft main bearing cap puller	This tool is used to remove the cap from main bearing. When using this tool, turn its adapter into the threaded hole in main bearing cap.  SE190	J13 J15 J16 All L-Series	Page EM-6 Fig. EM-22
8.	ST16530000 Crankshaft gear puller	This tool is used to remove camshaft and crankshaft gears with chain hung around gear teeth.  SE287	J13 J15 J16 H20 H30	Page EM-5

No.	Tool number & tool name	Description Unit: mm (in)	For use on	Reference page or figure No.
9.	ST16610001 Pilot bush puller	This tool is used to push pilot bush out of place.  SE191	J13 J15 J16 L13 L14 L16 L18 L20A G18	Page EM-20 Fig. EM-63
10.	ST19550000 Distributor drive spindle puller	This tool is used to remove and install distributor drive spindle.  SE288	J13 J15 J16	Page EM-28 Fig. EM-99
11.	EM03500000 Piston ring expander	This tool is used to remove and install the piston rings.  SE289	All models	Page EM-7 Page EM-24
12.	EM03470000 Piston ring compressor	This tool is used to compress piston rings while piston is being inserted into cylinder.  SE199	All models	Page EM-26

No.	Tool number & tool name	Description Unit: mm (in)	For use on	Reference page or figure No.
13.	ST19320000 Oil filter wrench	This tool is used to take oil filter out of place. In tightening the filter, do not use this filter, to prevent excess tightening.  SE197	All models	Page EM-5
14.	HT56900870 Valve guide reamer	The reamer is used for finishing the bore of new guide.  SE303	J13 J15 J16	Fig. EM-39 Page EM-11