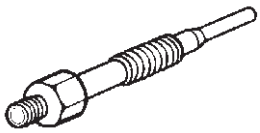
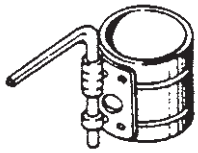
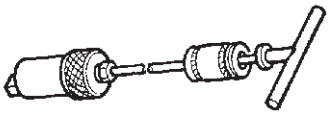
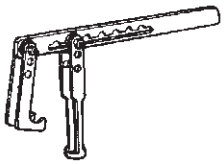
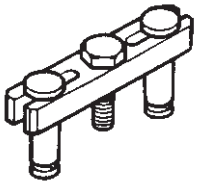
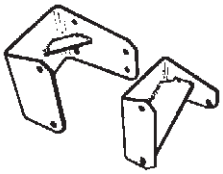
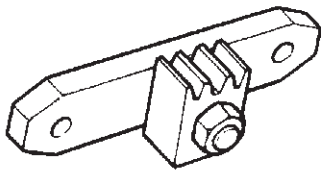
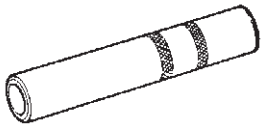
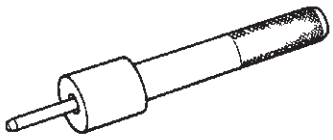
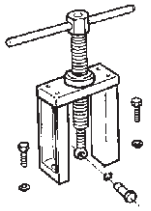
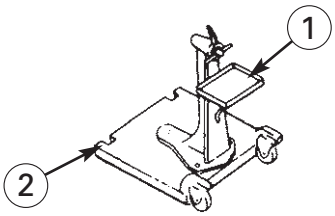
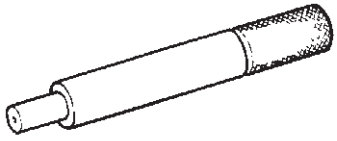
ENGINE MECHANICALS

SECTION EM

CONTENTS

REFERENCE NUMBER	NAME	ENGINE APPLICATION	
		LD-23	BD-30 Ti
ED 196-01000	Adapter for pressure gauge 	-	X
EM 034 - 70000	Piston ring compressor 	X	X
KV 101 - 07900	Valve guide sealing ring extractor 	X	X
KV 101-092S0	Valve spring compressor 	X	-
KV 101 - 09300	Injection pump pinion blocking device 	-	X
KV 111 - 01110	Valve seat extractor 	-	X
KV 111 - 03000	Injection pump drive gear extractor 	-	X
KV 111 - 03200	Engine trestle coupling 	-	X

REFERENCE NUMBER	NAME	ENGINE APPLICATION	
		LD-23	BD-30 Ti
KV 111-033S0	Crankshaft blocking device 	-	X
KV 111 - 03400	Valve oil seal tool 	-	X
KV 111 - 03900	Valve guide inserter 	-	X
KV 111 - 04010	Cylinder liner tool 	-	X
KV 111-045S0	Camshaft bushes replacement set 	-	X
ST 050 - 1S000	Engine trestle assembly 1. ST-050-11000 Engine support 2. ST-050-12000 Base 	X	-
ST 110 - 32000	Valve guide reamer Diameter = 8 mm (0.315 inches) 	X	X
ST 110 - 33000	Valve guide punch 	-	X

REFERENCE NUMBER	NAME	ENGINE APPLICATION	
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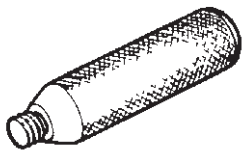
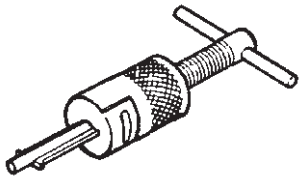
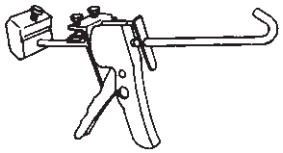
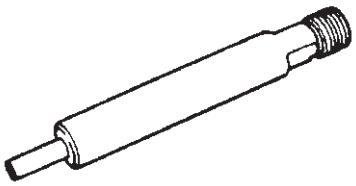
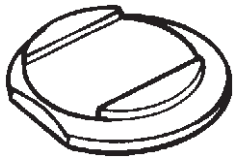
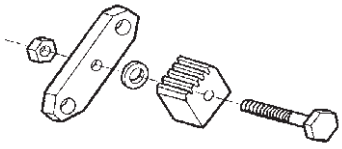
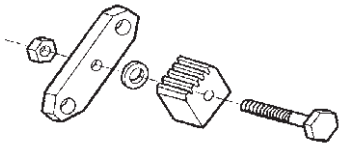
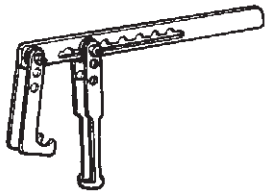
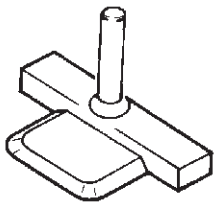
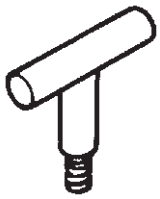
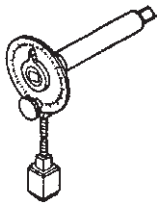
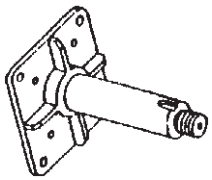
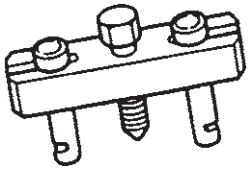
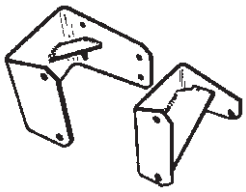
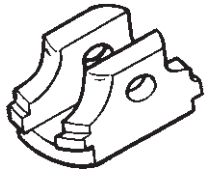
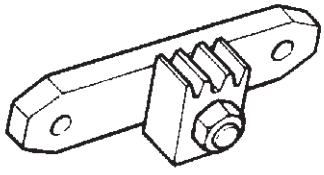
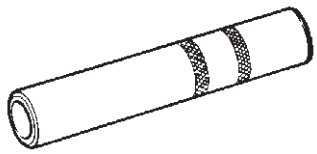
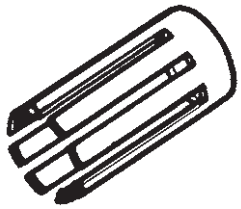
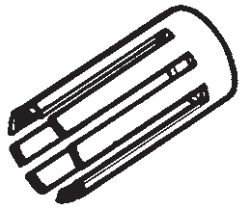
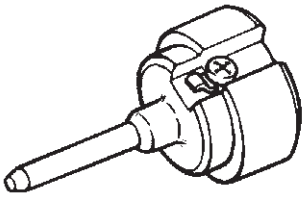
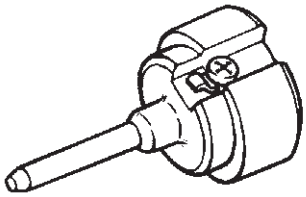
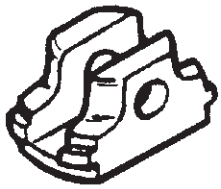
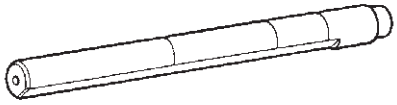
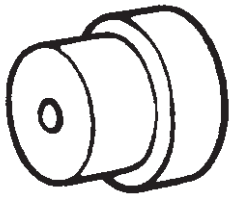
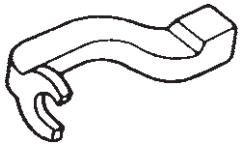
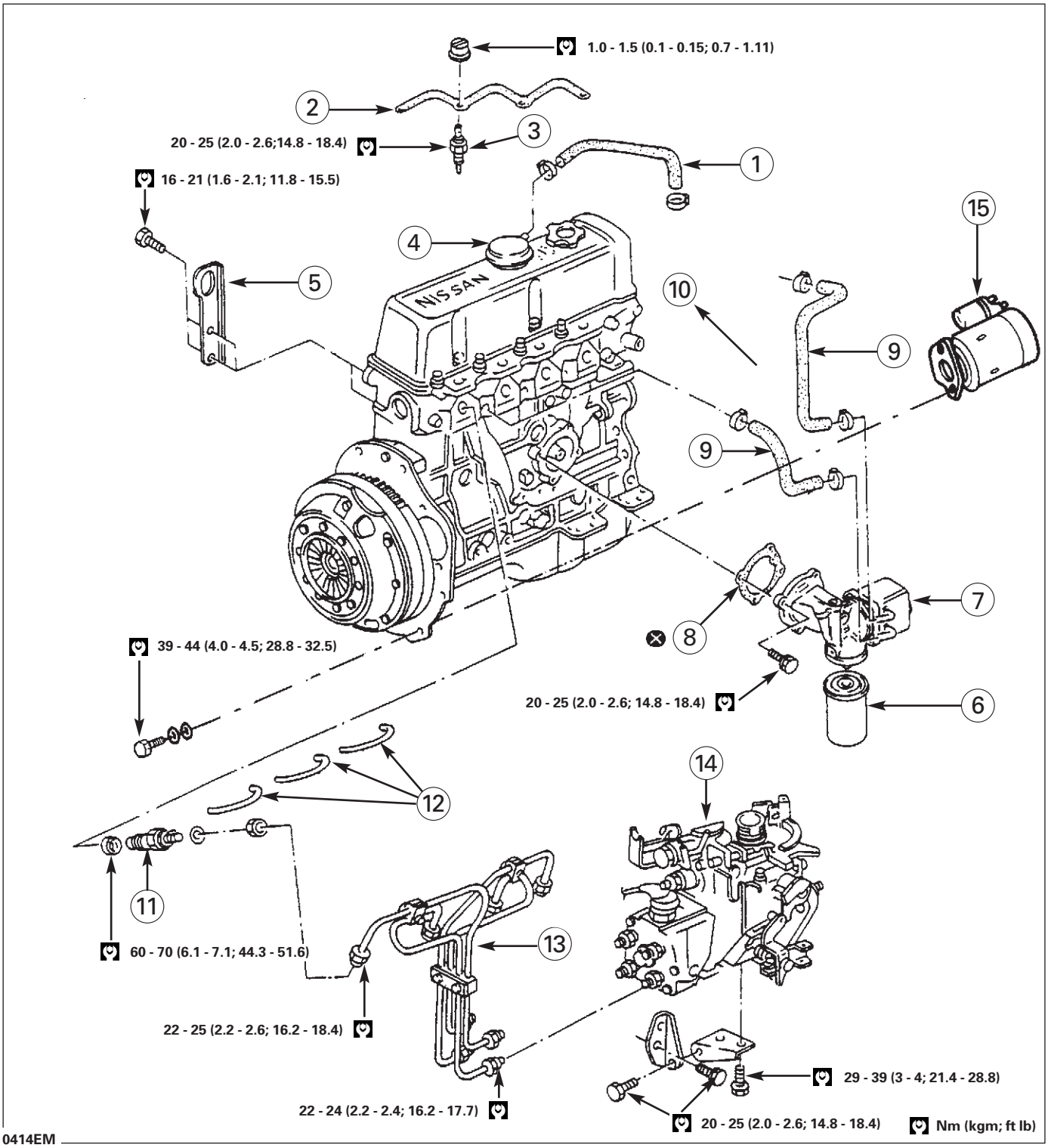
ST 152 - 43000	Valve seat mandrel 	-	X
ST 166 - 10001	Timer extractor 	-	X
WS 399 - 30000	Tube squeezer. For squeezing the sealant paste tube 	X	X
ED 196 - 00800	Adapter for pressure gauge 	-	X
KV 111 - 04030	Installation adapter 	-	X
KV 101 - 05630	Crankshaft blocking device 	-	X
KV 101 - 056S0	Crown gear stop 	X	-
KV 101 - 09210	Valve spring compressor 	-	X

REFERENCE NUMBER	NAME	ENGINE APPLICATION	
		LD-23	BD-30 Ti
KV 101 - 11100	Gasket cutter 	-	X
KV 101 - 11200	Adapter 	-	X
KV 101 - 12100	Adapter for angular tightening 	X	-
KV 111 - 01900	Engine trestle shaft 	X	-
KV 111 - 02900	Pulley extractor 	X	-
KV 111 - 03200	Engine trestle coupling 	-	X
KV 111 - 03310	Stop plate 	-	X
KV 111- 033S0	Crankshaft blocking device 	-	X

REFERENCE NUMBER	NAME	ENGINE APPLICATION	
		LD-23	BD-30 Ti
KV 111 - 03400	Valve oil seal tool 	-	X
KV 111 - 03620	Adapter (Inlet) 	-	X
KV 111 - 03620	Adapter (Exhaust) 	-	X
KV 111 - 03810	Adapter (Inlet) 	-	X
KV 111 - 03820	Adapter (Exhaust) 	-	X
KV 111 - 04110	Disassembly adapter 	-	X
KV 111 - 04510	Replacement bar 	-	X
KV 111 - 04520	Guide plate 	-	X

REFERENCE NUMBER	NAME	ENGINE APPLICATION	
		LD-23	BD-30 Ti
KV 111 - 04530	Adapter (bearing 1) 	-	X
KV 112 - 26582	Cold timing solenoid 	-	X
ST 106 - 40001	Rocker adjustment spanner (valve clearances) 	X	-

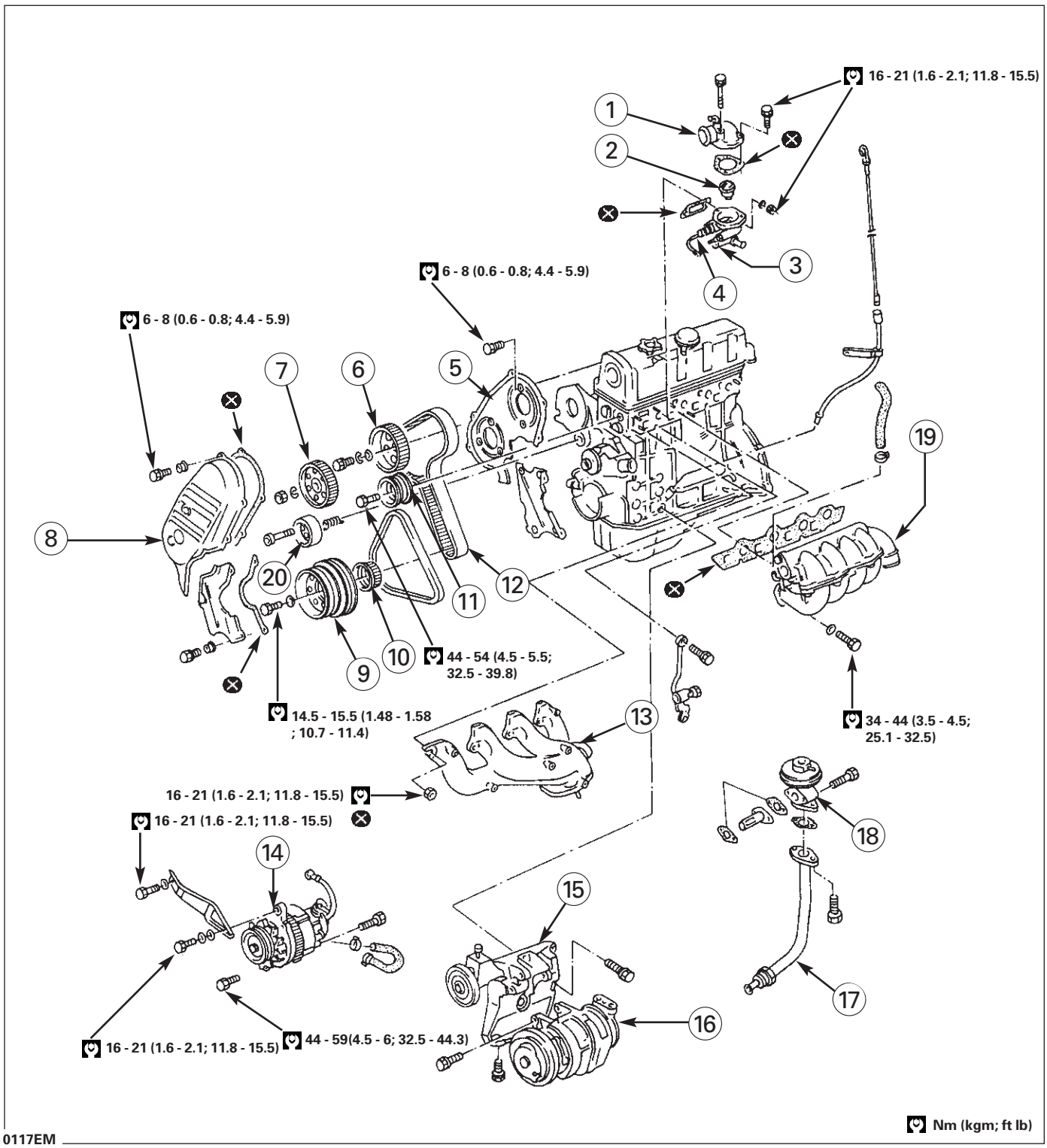
Right side



COMPONENTS

1. Breather pipes:
2. Pre-heating glow plug connector plate
3. Pre-heating glow plug
4. Sump breather
5. Engine removal bracket
6. Oil filter
7. Oil cooler
8. Oil cooler gasket
9. Oil cooler pipe
10. To water pump outlet pipe
11. Injector
12. Return pipes
13. Injection pipes
14. Injection pump
15. Starter motor

Left side

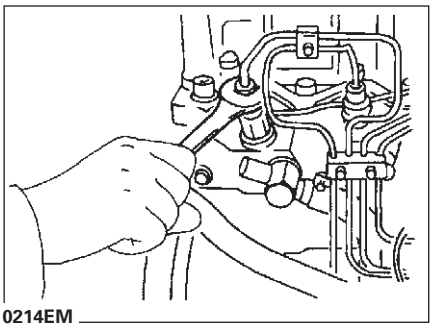


COMPONENTS

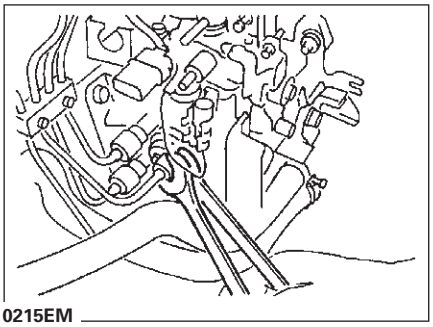
1. Water outlet
2. Thermostat
3. Thermostat housing
4. Water temperature sensor
5. Rear cover
6. Toothed camshaft pulley
7. Toothed injection pump pulley
8. Dust guard
9. Crankshaft stabilising pulley
10. Toothed crankshaft pulley
11. Idler pulley
12. Timing belt
13. Exhaust manifold
14. Alternator
15. Compressor bracket
16. Compressor
17. EGR tube
18. EGR valve
19. Inlet manifold
20. Tension pulley

CHECKING THE COMPRESSION PRESSURE

1. Start the engine and allow it to run until it reaches its normal operating temperature.
2. Disconnect the injection pipes on the injector end and just loosen them on the pump end. Remove the clamps from the injection pipes.
   - **Use two spanners to prevent the feed bracket on the side of the pump from coming off.**

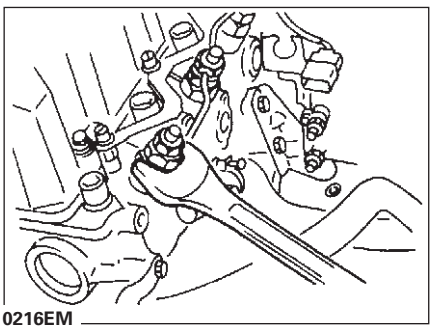


0214EM



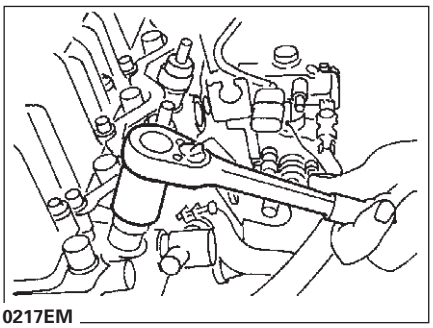
0215EM

3. Disconnect the return pipes.



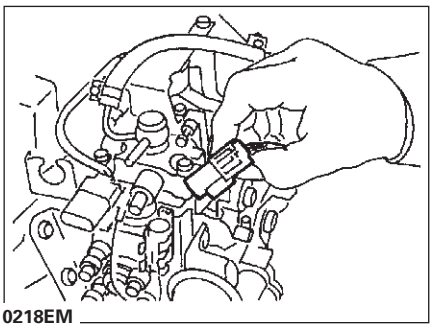
0216EM

4. Remove all the injectors, using a suitable tool to withdraw them from their housings.

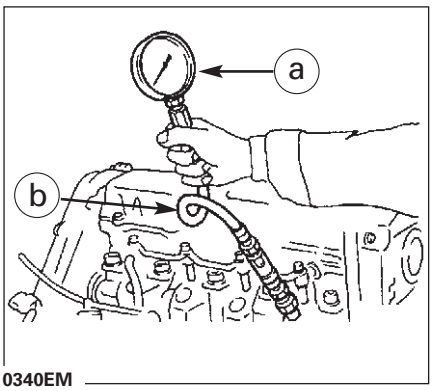


0217EM

5. Disconnect the connector on the fuel cut-off solenoid valve.



0218EM



0340EM

6. Fit a pressure gauge (a) into the injector hole of the cylinder to be tested, using a suitable adapter pipe (b) and measure the compression pressure.

Compression pressure gauge adapter in injector hole:
15 - 20 Nm (1.5 - 2 kgm, 11.1 - 14.8 ft lb)

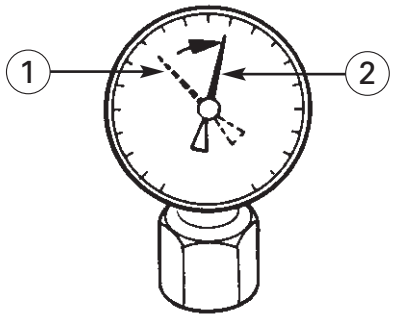
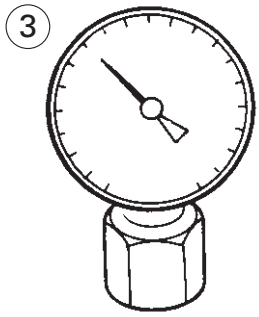
7. Start the engine and take a pressure reading
   - **Always use a fully-charged battery to obtain a correct reading.**
   - **The reading must be made as quickly as possible.**

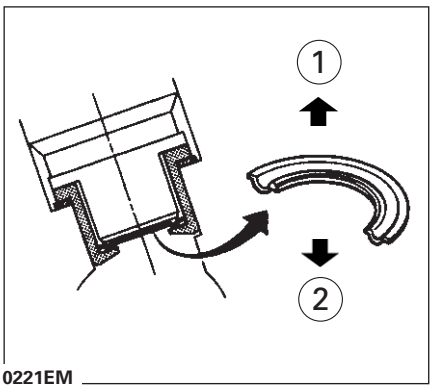
Compression pressure

	Unit				Reading at rpm
	kPa	bar	kg/cm^2	psi	
Standard	3090	31.4	32	456	200
Minimum	2450	24.52	25	356	
Limit of difference between cylinders:	490	4.9	5	71	

8. If the compression value in one or more cylinders is below the specified values, pour approximately 3 cc (0.026 Imp qt) of oil into the injector hole and repeat the reading.

   Refer the test results to the following table.

Pressure gauge reading during tests	Fault-finding
 0219EM	**1. First reading (Point 7)** **2. Second reading (Point 8)** • The rings are worn or damaged.
 0220EM	**3. Reading remains unaltered at points 7 and 8** • If the pressure in two adjacent cylinders is low, and adding oil does not cause the pressure to rise, there is a leak in the gasket between both cylinders. This problem may be caused by the presence of oil or water in the combustion chambers. • Valve seized • The surface of the valve seating is not correct.



0221EM

9. Change the gaskets on the injectors and re - fit the injectors.

The new gaskets must be fitted as shown in the figure.

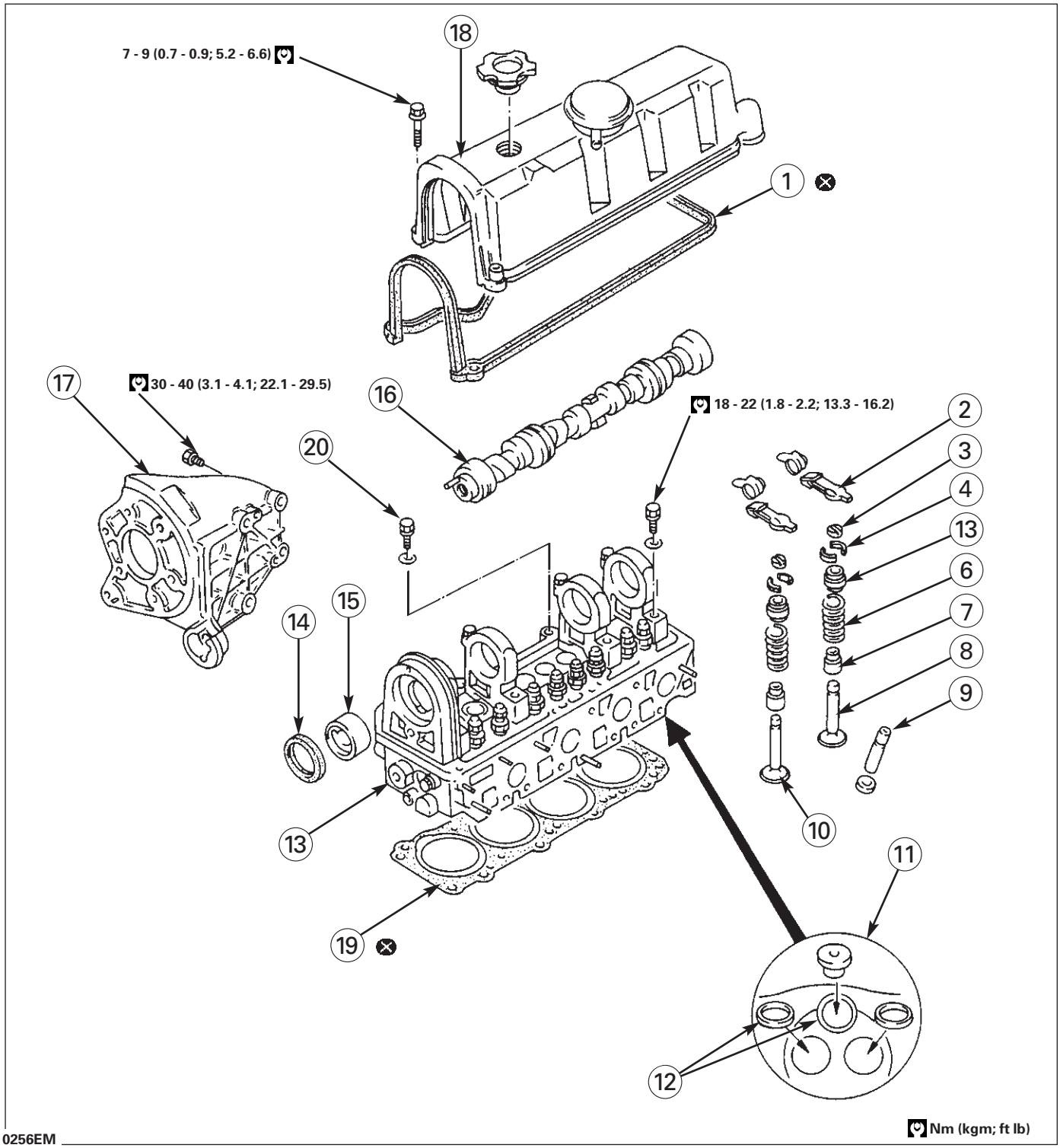
Injector tightening torque:
60 - 70 Nm (6.1 - 7.1 kgm; 44.3 - 51.6 ft lb)

1. Injector side

2. Combustion chamber side

10. Fit the return and injection pipes (See “CYLINDER HEAD - Assembly - Injection pipes” in this section).

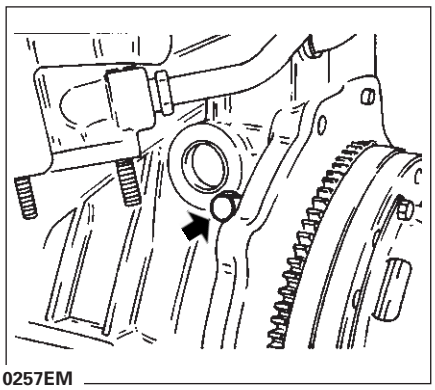
Exploded view



COMPONENTS

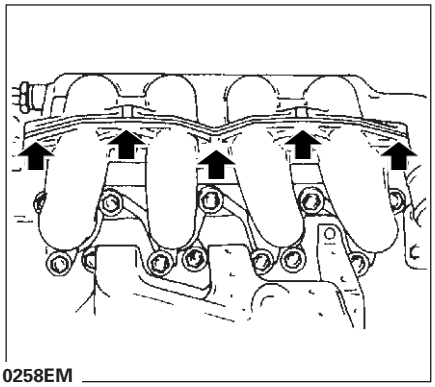
1. Rocker cover gasket
2. Rocker
3. Shim
4. Sleeve
5. Spring retainer
6. Spring
7. Valve oil seal
8. Inlet valve
9. Valve guide
10. Exhaust valve
11. Combustion chamber
12. Seat
13. Cylinder head
14. Oil seal
15. Spacer
16. Camshaft
17. Injection pump bracket
18. Rocker cover
19. Cylinder head gasket
20. See "CYLINDER HEAD - Installation - Tightening procedure"

CYLINDER HEAD - Removal



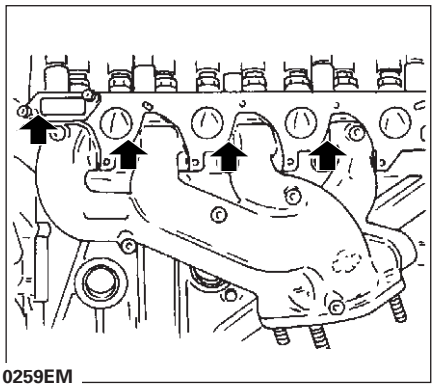
0257EM

1. Disconnect the exhaust manifold from the front part of the exhaust pipe.
2. Drain the engine coolant by removing the cylinder block drain plug.
3. Remove the water hoses and the air inlet duct.
4. Remove the timing belt.
   See “DISASSEMBLY - Timing belt” in this section.
5. Remove the gears, the camshaft, the pipe and the EGR valve.



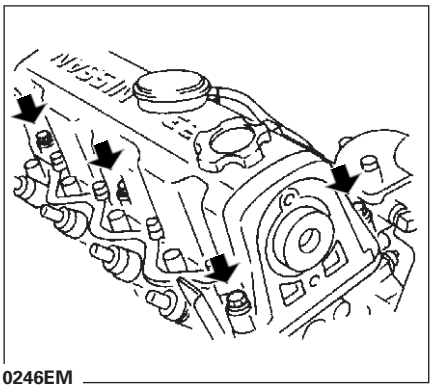
0258EM

6. Remove the protective screen from the exhaust manifold.
7. Remove the inlet manifold.



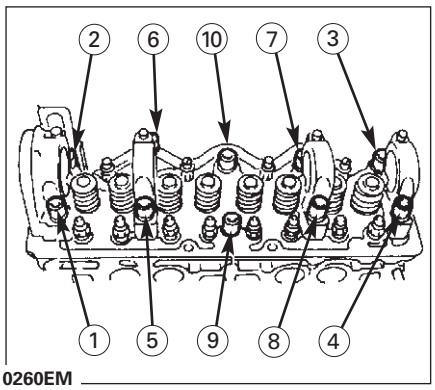
0259EM

8. Remove the exhaust manifold and the thermostat box.
9. Disconnect the injection pipes.
   See “CHECKING THE COMPRESSION PRESSURE - Checking the compression in the cylinders” in this section.



0246EM

10. Remove the rocker cover
    Remove the bolts fixing the cover to the cylinder head.



0260EM

11. Remove the cylinder head from the engine block.

    Loosen the bolts joining the cylinder head to the block in the order shown in the figure.

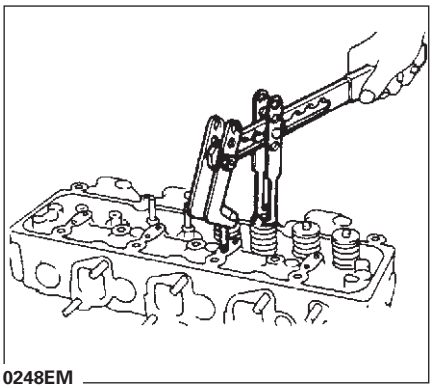
    - **The bolts must be loosened in two or three steps.**
    - **If disassembly is carried out in the incorrect order, the cylinder head may warp or crack.**

    For the disassembly, inspection and assembly of the cylinder head, see the appropriate sections in this section.

CYLINDER HEAD - Disassembly

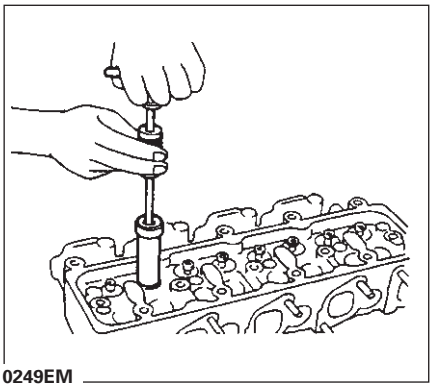
- **See "CYLINDER HEAD - Disassembly" for disassembly of the cylinder head**

1. Remove the pre-heating glow plugs bracket.
2. Remove the valve parts using suitable tools.
   - **Keep each valve and its components together and mark them so that they can be re-fitted in their original positions.**



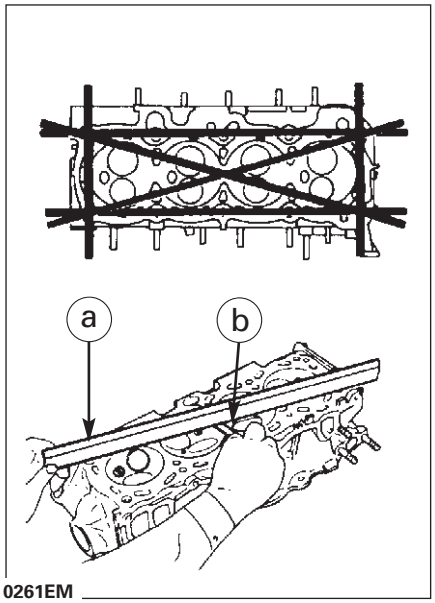
0248EM

3. Remove the valve oil seals using a suitable tool.
   - **See "CHECKING THE COMPRESSION PRESSURE - Valve stem oil seal"**



0249EM

Cylinder head distortion and wear



0261EM

1. Check visually for cracks or deformations.
2. Clean the surface of the cylinder head and measure the distortion with a flat, rigid ruler (a) and a feeler gauge (b). Make several measurements in different points as shown in the figure.

   Permitted deformation of cylinder head surface:

   Standard: Less than 0.05 mm (0.002 inches)
   Limit: 0.1 mm (0.004 inches)

   If it exceeds the specified limit, change the cylinder head or grind it flat.

   Grinding limit:

   The grinding limit for the cylinder head depends on the degree of grinding carried out to the cylinder block.

   When:

   "A" is the amount of grinding required for the cylinder head and "B" is the amount of grinding required for the cylinder block; the maximum limit is estimated as follows:

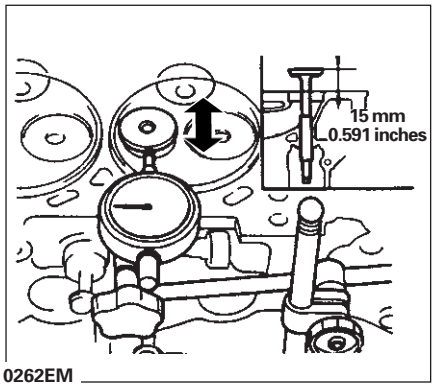
   A+B = 0.1 mm (0.004 inches)

   - **After grinding, check that the camshaft turns freely by hand. If any resistance is felt, the cylinder head must be replaced.**

     Nominal height of cylinder head:
     89.4 - 89.6 mm (3.52 - 3.53 inches)

Valves

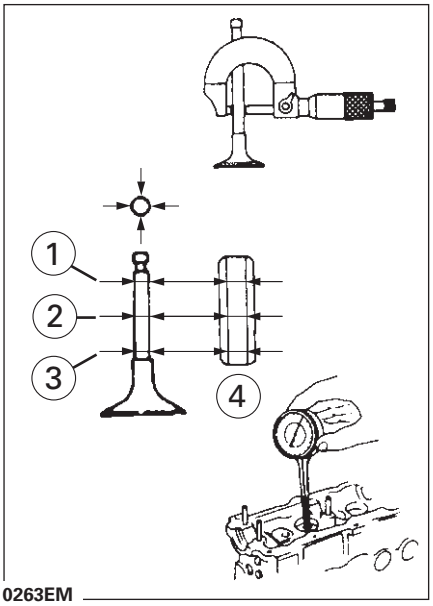
VALVE GUIDE CLEARANCE



0262EM

1. Measure the bending across the cylinder head, as shown in the illustration.
   - **Raise the valve 15 mm (0.591 inches) above the cylinder head.**

   Valve bending limit (total dial gauge reading):
   0.1 mm (0.004 inches)



0263EM

2. If the limit is exceeded, check the clearance between the valve and its guide.
   a) Measure the diameter of the valve stem and the inner diameter of the valve guide, as shown in the figure.
   b) Check that the clearance is within specifications.

      Limit of clearance between valve stem and guide:
      0.1 mm (0.004 inches)

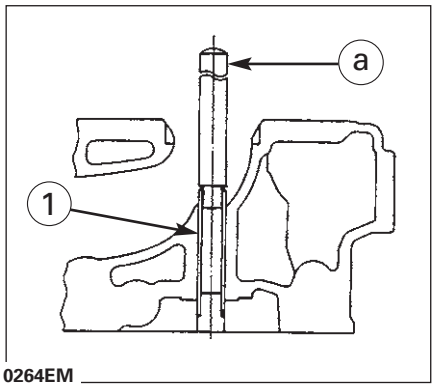
   c) If the limit is exceeded, replace the valve or valve guide.

1. Upper part
2. Centre
3. Lower part
4. Valve guide

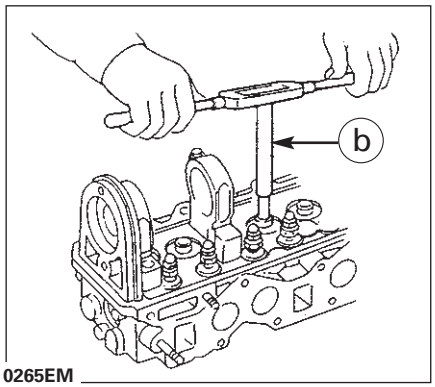
Valves (cont'd)

REPLACEMENT OF VALVE GUIDE

1. Heat the cylinder head in oil to 150 - 160°C (302 - 320°F)
2. Remove the valve guide (1) using a press or a hammer and suitable tool (a).



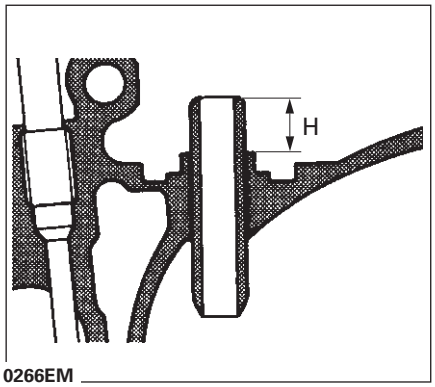
0264EM



0265EM

3. Ream out the valve guide housing in the cylinder head using a suitable tool (b).

   Reaming dimensions (service parts):
   Finished diameter: 12.223 - 12.234 mm (0.48 - 0.482 inches).



0266EM

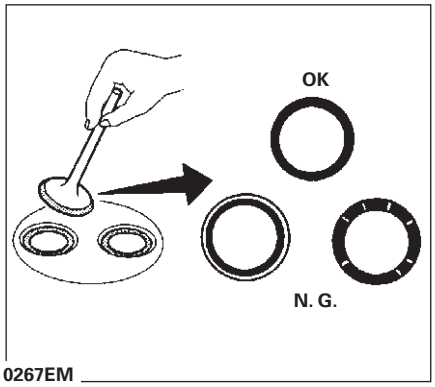
4. Heat the cylinder head to 150 - 160°C (302 - 320°F) and fit the valve guide to the dimension H as shown.

   Dimension H for fitting guide in cylinder head:
   H: 13.0 - 13.1 mm (0.512 - 0.516 inches)

5. Valve guide reaming

   Reaming dimensions:
   8.000 - 8.018 mm (0.315 - 0.316 inches)

VALVE SEATS

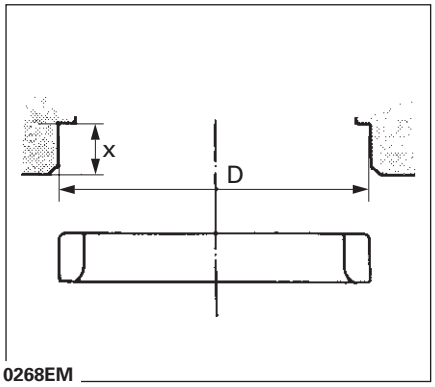


0267EM

1. Check that the valve seats have no pitting on the contact surface with the valve. Grind or change them if the wear is excessive. Grind the valve seat.
   - **When repairing a valve seat, first check the wear of the valve and valve guide. If they are worn, replace them. Then grind the seat.**
   - **Milling must be performed with both hands to ensure uniformity.**
2. Check the contact of the valve with its seat. Cover the valve with marking compound. If the contact is not correct, grind the valve seat. If the mark of the valve appears through 360 of the face, the stem and valve are concentric; otherwise, grind or change the valve.

Valves (cont'd)

VALVE SEAT REPLACEMENT



0268EM

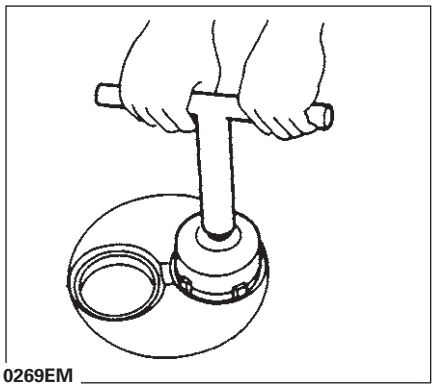
1. Old valve seats may be removed by routing them until they break.
   The depth stop of the machine must be set so that it cannot continue further than the surface supporting the seat in the cylinder head.
2. Machine the housing in the cylinder head.

   Diameter D for grinding valve seats:
   Inlet: 38.6 - 38.8 mm (1.51 - 1.52 inches)
   Exhaust: 31.6 - 31.8 mm (1.24 - 1.25 inches)
   Height X:
   Inlet: 9.5±0.15 mm (0.374±0.006 inches)
   Exhaust: 10.1±0.15 mm (0.398 ± 0.006 inches)

The grinding must be carried out in concentric circles around the centre of the valve guide so that the valve seats correctly.

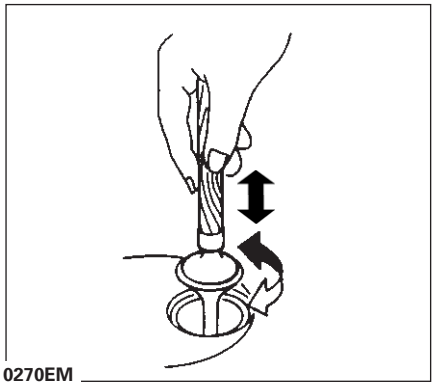
3. Heat the cylinder head to 150 - 160°C (302 - 320°F) and fit the seat by pressing it fully home.
4. Fit the new valve seats.

When the valve seat is changed, the valve must also be changed.

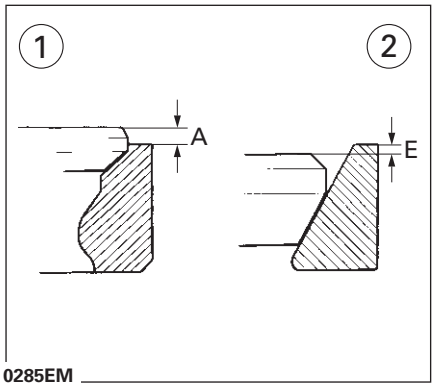

0269EM

5. Rout or grind the valve seat using a suitable tool with the dimensions specified in "CHARACTERISTICS AND TECHNICAL DATA".

The cut must be made with both hands to ensure a uniform and concentric finish.


0270EM

6. Apply a small amount of fine emery compound to the valve's contact surface and fit the valve into its guide.
   - **Grind the valve in its seat until it seats correctly.**
   - **Remove the valve and clean both it and its seat.**



0285EM

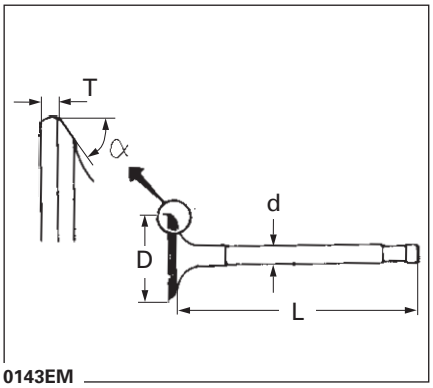
7. Check that the valves seat correctly in their housings.

   inlet valve (1) seating position
   Dimension "A" = 0.2±0.12 mm (0.008 ± 0.005 inches)

   Exhaust valve (2) seating position
   Dimension E = 0.33±0.14 (0.013±0.006 inches)

Valves (cont'd)

VALVE DIMENSIONS

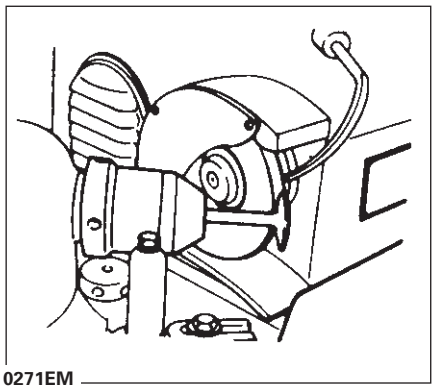


0143EM

1. Check the dimensions of each valve according to those stated in "CHARACTERISTICS AND TECHNICAL DATA"
2. Correct or change any defective valve.

   When the thickness "T" of the valve head has worn to within 0.5 mm (0.02 inches), replace the valve.

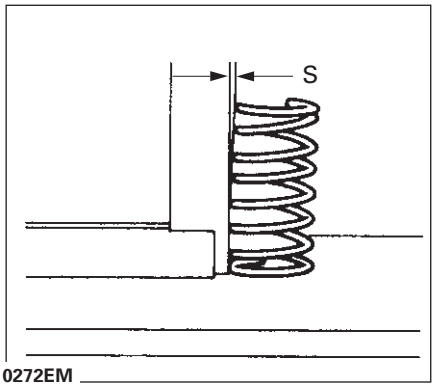
T. (thickness margin)


0271EM

3. The face of the valve or the surface of the end of the valve stem must be ground using a manual grinder.

The permitted grinding limit for the end of the stem is 0.5 mm (0.02 inches) or less.

STRAIGHTNESS OF VALVE SPRINGS



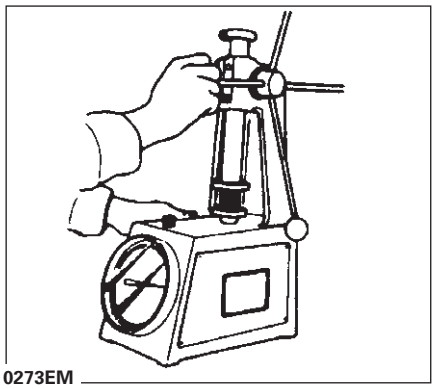
0272EM

Check the straightness of the valve springs using a steel set square and a flat surface.

If the deformation S of the spring exceeds the specified limit, change it for a new one.

Straightness defect: permitted maximum
Less than 2.5 mm (0.1 inches)

VALVE SPRING LOAD PRESSURE


0273EM

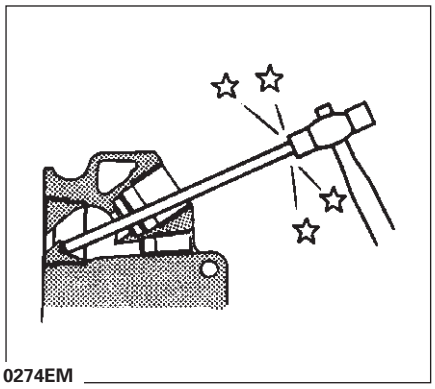
Measure the free length and pressure of each spring once fitted. If the value exceeds the specified limit, change the spring. See "CHARACTERISTICS AND TECHNICAL DATA"

Combustion chambers

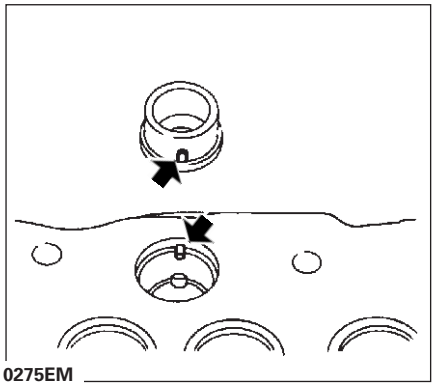
REPLACING THE COMBUSTION CHAMBERS

Generally the combustion chambers should not be changed.
However, if they are cracked or badly damaged, they must be changed.

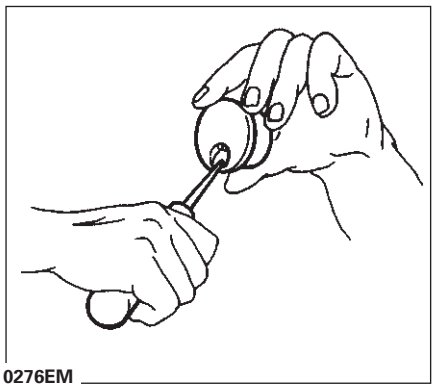
1. Heat the cylinder heat in oil to 150 - 160°C (302 - 320°F).
2. Remove the combustion chamber, taking care not to damage the cylinder head.
   - **Take care not to damage the inside of the injector hole.**


0274EM

3. Fit the combustion chamber.
   a) Heat the cylinder head to 150 - 160°C (302 - 320°F) in oil.
   b) Align the centring stud on the combustion chamber with the notch in the cylinder head and fit it into the cylinder head using a nylon mallet.


0275EM

   c) Clean the auxiliary channel before fitting the combustion chamber. See illustration.

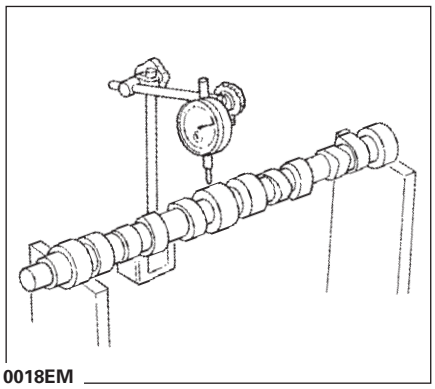

0276EM

Camshaft

VISUAL CHECK OF CAMSHAFT

Check whether the camshaft shows signs of deterioration, deformation or wear.

CAMSHAFT SAG



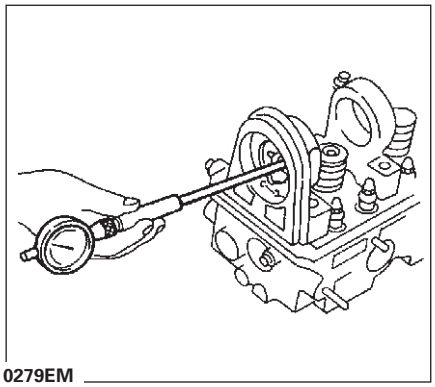
0018EM

1. Measure the alignment of the camshaft at its central journal.

   Camshaft bending limit (total dial gauge reading):
   Limit: 0.05 mm (0.002 inches)

2. Replace the camshaft if it exceeds the specified limit.

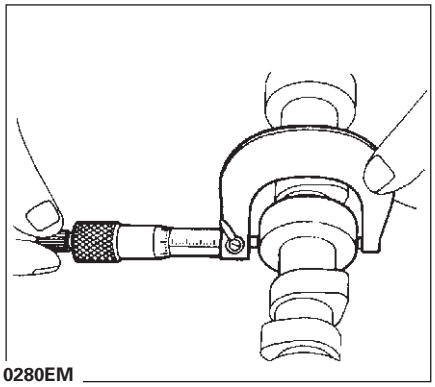
CLEARANCE BETWEEN THE CAMSHAFT BEARING AND JOURNAL



0279EM

1. Use a micrometer to measure the inner diameter (A) of the camshaft bearing.
2. Use a suitable calliper to measure the outer diameter (B) of the camshaft hub.

Clearance between camshaft bearing and hub (A-B)
Normal = 0.020 - 0.109 mm (0.001 - 0.004 inches)
Limit: Less than 0.15 mm (0.006 inches)



0280EM

3. Measure the outer diameter of the camshaft journal.

   Standard outer diameter:
   47.949 - 47.962 mm (1.88 - 1.89 inches)

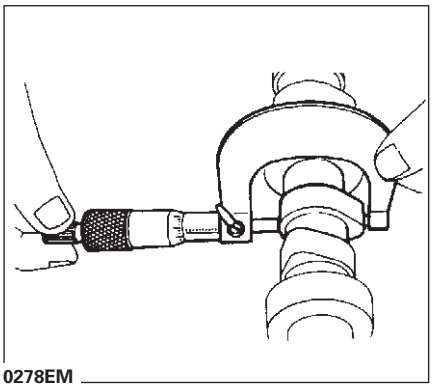
If the clearance exceeds the limit, replace the camshaft and/or the cylinder head.

Standard clearance:
0.038 - 0.067 mm (0.001 - 0.002 inches)
Limit: 0.1 mm (0.004 inches)

Do not remove the camshaft supports. If they are removed, the free rotation of the camshaft must be checked once they are re-fitted.

Camshaft (cont'd)

CAMSHAFT CAM HEIGHT.

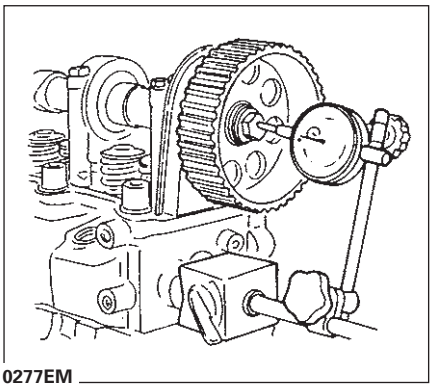

0278EM

1. Measure the camshaft cam height.

   Standard cam height:
   inlet
   39.95 - 40.00 mm (1.57 - 1.58 inches)
   Exhaust
   40.30 - 40.35 mm (1.58 - 1.59 inches)
   Cam height wear limit:
   0.15 mm (0.006 inches)

2. If the wear exceeds the limit, replace the camshaft.

CAMSHAFT END PLAY:

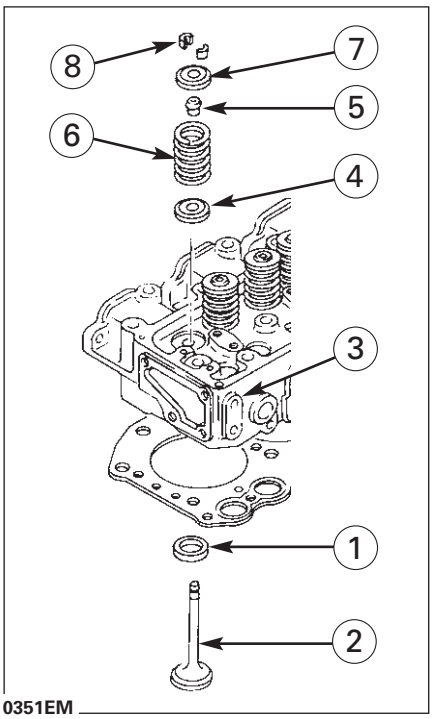

0277EM

1. Fit the camshaft into the cylinder head.
2. Tighten the bracket bolts to the specified torque.
3. Measure the camshaft end play.

Bolts fixing camshaft supports:
18 - 22 Nm (1.8 - 2.2 kgm; 13.3 - 16.2 ft lb)

End play:
Standard
0.08 - 0.38 mm (0.003 - 0.015 inches)

CYLINDER HEAD - Assembly



0351EM

1. Assemble the valve components as follows:
   a) Insert the valve guides and valve seat (1) into their housings in the cylinder head.

      See "CYLINDER HEAD - Inspection - replacement of valve seat" in this section.

   b) Fit the valve (2) into its housing.

      • **Take care not to swap the inlet and exhaust valves.**

      • **Before fitting the valve, oil it with new engine oil.**

   c) Rotate the cylinder head (3) by 180°.

   d) Fit the spring seat (4).

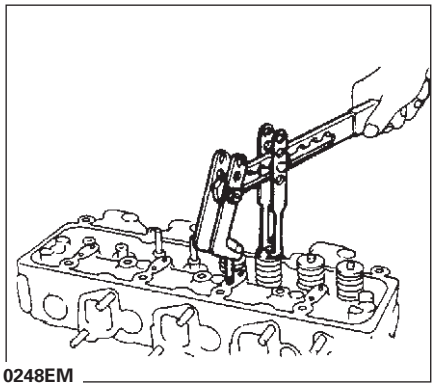
   e) Fit the oil seal (5).

      See "REPLACEMENT OF OIL SEALS - Valve oil seals" in this section.

      • **Always use a new oil seal.**

   f) Fit the valve spring (6) with its painted side facing the cylinder head.

   g) Fit the spring cap (7).



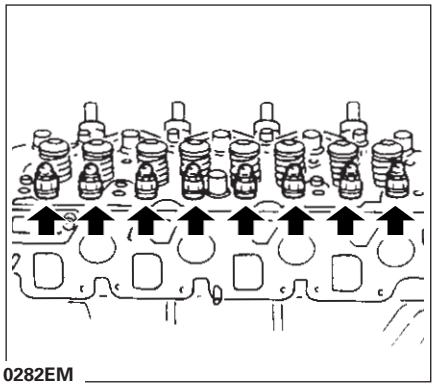
0248EM

   h) Compress the spring with a suitable tool.

   i) Fit the split cones (8) and release the pressure on the spring.

2. Fit the cylinder head onto the engine block.
   See "CYLINDER HEAD - Assembly" in this section.

3. Fit the rocker pivots.
   Thread the pivots together with the lock nuts into the bearing.



0282EM

Cylinder head gasket

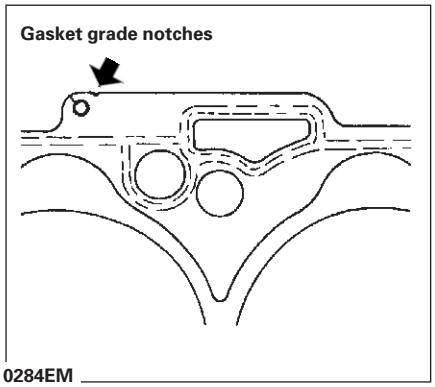
- Fit a new cylinder head gasket, selecting one as follows:

SELECTION OF CYLINDER HEAD GASKET.

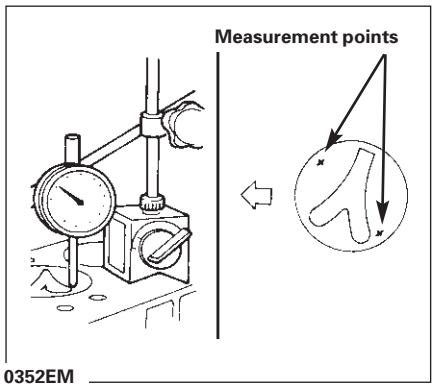
- Two cases may arise:
  - **a) Only the cylinder head gasket is changed.**
  - **b) The cylinder block, cylinder head, pistons, connecting rod or crankshaft is changed or repaired**
- Follow the correct process for the specific case.

a) Only the cylinder head gasket is changed.

1. Fit a gasket that is identical to the one used previously. See Table A.



0284EM



0352EM

b) The cylinder block, cylinder head, pistons, connecting rod or crankshaft is changed or repaired.

- Select the cylinder head gasket as follows:

> • **IMPORTANT NOTE: In the following process, all measurements must be made in millimetres, never in inches.**

1. Measure the height of the piston at TDC with respect to the surface of the cylinder block.
   a) Set piston 1 to TDC. Keep it in this position and measure the height with respect to the surface of the cylinder block at two points. See the figure.
   b) Calculate the average value of the two points measured.
   c) Repeat this process for all the other pistons.

   Take care to measure the height at 2 points for each cylinder, as shown in the figure.
   d) Calculate the average of all the values for all the pistons, measured at point (b) and round of the result.
   e) Determine the correct gasket using Table A.

TABLE A

Gasket classification	Average piston height in mm	Gasket thickness mm	Number of notches in the gasket
A	Less than 0.60	1.25	None
B	0.60 - 0.65	1.30	1
C	0.65 - 0.70	1.35	2
D	More than 0.70	1.40	3

Cylinder head gasket

SELECTION OF CYLINDER HEAD GASKET (cont'd)

f) Check that the average value of the height of each piston with respect to the surface of the cylinder block, measured in step (b), is greater than the thickness of the selected gasket plus 0.05 mm.

If so, use a gasket that is one grade thicker; otherwise, us the gasket selected in step (e).

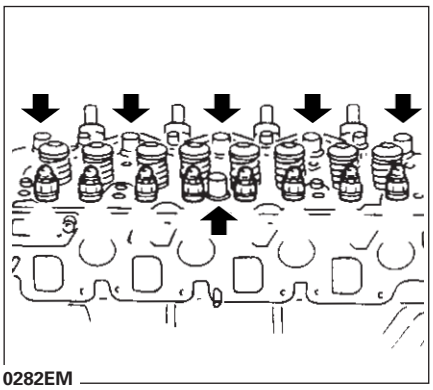
Unit: mm

Step	Piston / Item	1		2		3		4	
1.	Point	M1	M2	M1	M2	M1	M2	M1	M2
2.	Value (a)	0.67	0.68	0.69	0.65	0.63	0.68	0.68	0.71
2.	Value (b)	0.675		0.67		0.655		0.695	
3.	Value (d)	0.67375							
4.	Value (d) rounded	0.67*							
5.	Gasket thickness (temporary)	1.35 (Type C)							
6.	X: Maximum thickness of selected gasket: 0.70 (Class C) Incremented thickness of selected gasket: 0.70+0.05 = 0.75 Y: Maximum average height value= 0.695 (in step 2) The ratio between "X" and "Y" is: "X > Y".**								
7.	Thickness of selected gasket (final): 1.35 (Class C)								

* **Rounding of the thousandths digit.**
Value less than 5: Keep the hundredths value.
Value greater than 5: increase the hundredths value by 0.01 mm.

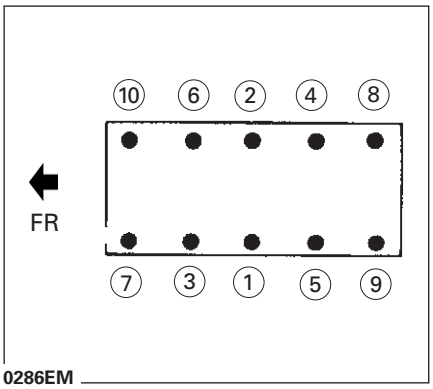
** **If "X<Y", use the gasket with the next higher value to the one selected.**

Fitting the cylinder head assembly into the cylinder block



0282EM

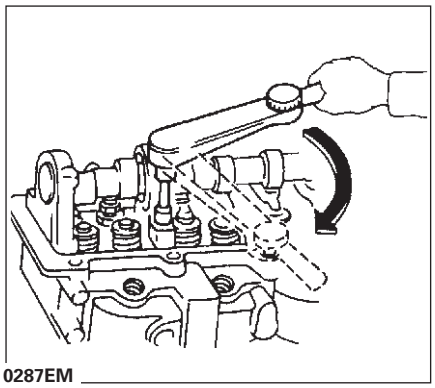
1. Place the cylinder head onto the cylinder block, with the selected head gasket, and fit the bolts as shown in the figure.
   - **Check that piston 1 is at TDC on its compression stroke.**
   - **The cylinder head bolts must not be used more than three times. Replace them in case of doubt.**



0286EM

2. Tighten the cylinder head bolts in the order shown in the figure and following the "Cylinder head bolt tightening procedure" below.
   - **Trim off the excess part of the cylinder head gasket once the cylinder head has been fitted and tightened down.**

Fitting the cylinder head assembly into the cylinder block (cont'd)


0287EM

3. Procedure for tightening the cylinder head bolts

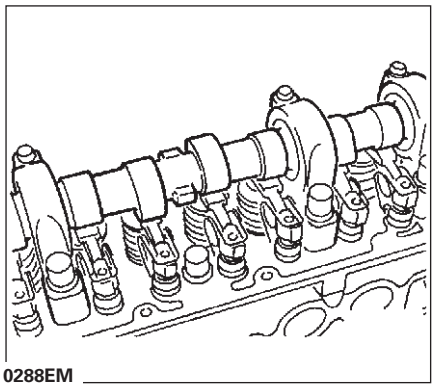
   Lubricate the bolt threads and seating surfaces of the bolt heads with clean engine oil.
   Tighten the bolts progressively in the following steps.

   1) Tighten to 100 Nm (10.2 kgm; 73.8 ft lb)

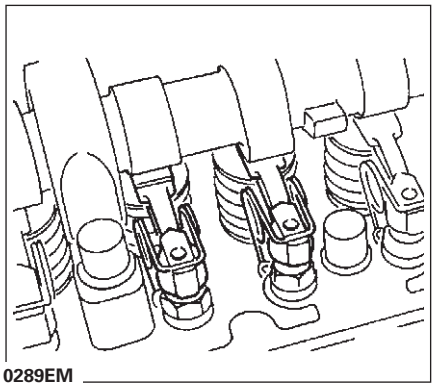
   2) Tighten by turning the bolt head through 90°.

   3) Retighten by turning the bolt head through a further 90°.

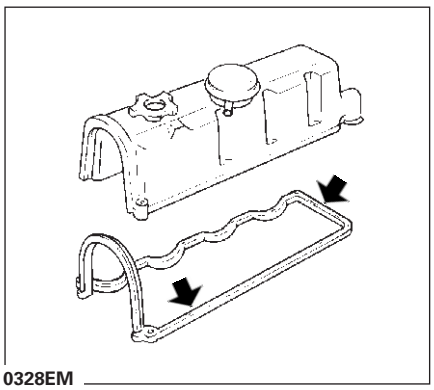
   The resulting torque should be:
   157 - 206 Nm (16 - 21 kgm; 115.8 - 151.9 ft lb)


0288EM

4. Fit the camshaft supports and camshaft to the cylinder head.
   - **Do not damage the interiors of the camshaft bearings.**
   - **Place cylinder 1 at TDC on its compression stroke.**

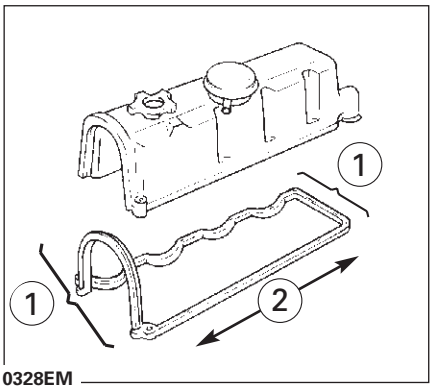

0289EM

5. Fit the rockers and their springs.


0328EM

6. Apply a layer of sealant paste approx. 1 mm (0.039 inches) thick to the gasket groove on the rocker cover and fit the cover.

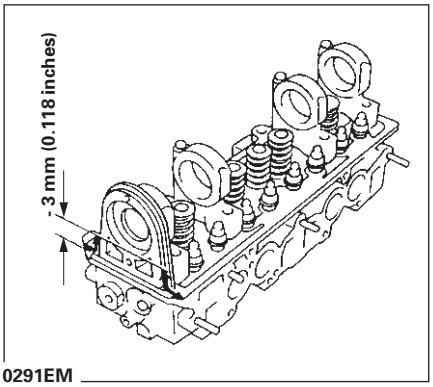
Fitting the cylinder head assembly into the cylinder block (cont'd).



0328EM

7. Place and fit the rocker cover in the order shown in the figure.

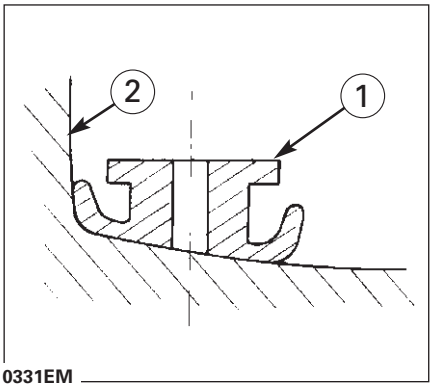
   First fit the areas of the front and rear ends (1). Then, pressing from the centre (2) to the ends, fit the rocker cover gasket.



0291EM

8. Fit the rocker cover.

   Apply a layer of sealant paste approx. 1 mm (0.039 inches) thick and 3 mm (0.118 inches) wide to the corners of the front camshaft support before fitting the rocker cover.

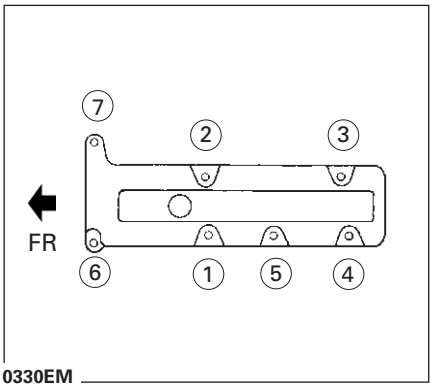


0331EM

9. Fit the special rocker cover washers as shown in the figure.

1. Washer fitting position.

2. Rocker cover



0330EM

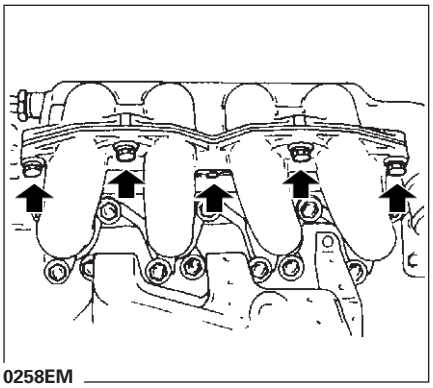
10. Manually insert the rocker cover fixing bolts, following the order shown in the figure.

    Tighten the bolts, following the same order, to the specified torque.

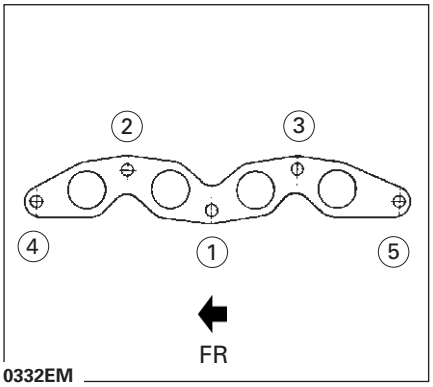
Rocker cover bolts:
7 - 9 Nm (0.7 - 0.9 kgm; 5.2 - 6.6 ft lb)

Fitting the manifolds

FITTING THE INLET MANIFOLD


0258EM

1. Thoroughly clean the seating face of the manifold on the cylinder head.
   - **Fit a new gasket every time the manifold is removed.**

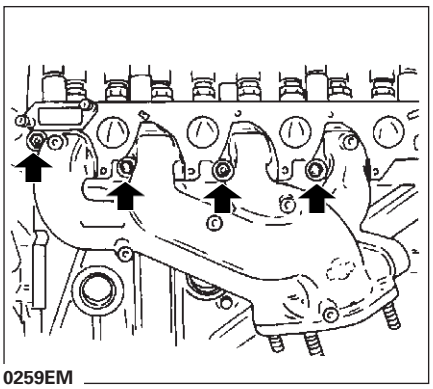


0332EM

2. Tighten the bolts in the order shown in the figure.

Bolts and nuts fixing inlet manifold:
16 - 21 Nm (1.6 - 2.1 kgm; 11.8 - 15.5 ft lb)

FITTING THE EXHAUST MANIFOLD AND THE THERMOSTAT COVER ASSEMBLY.

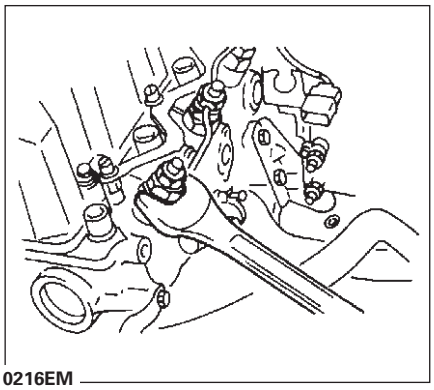

0259EM

1. Thoroughly clean the seating face of the manifold on the cylinder head.
   - **Fit new gaskets at each disassembly.**

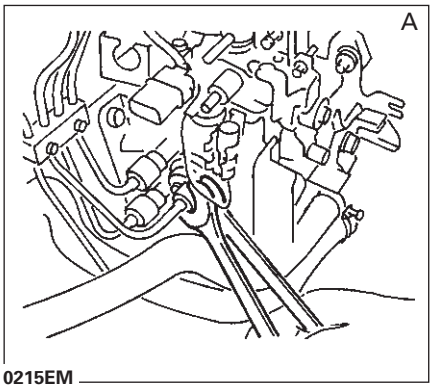
Exhaust manifold bolts:
16 - 21 Nm (1.6 - 2.1 kgm; 11.8 - 15.5 ft lb)

Nuts and bolts on thermostat box:
16 - 21 Nm (1.6 - 2.1 kgm; 11.8 - 15.5 ft lb)

Fit the injection pipes.


0216EM

1. Connect the excess fuel pipes to the injectors.

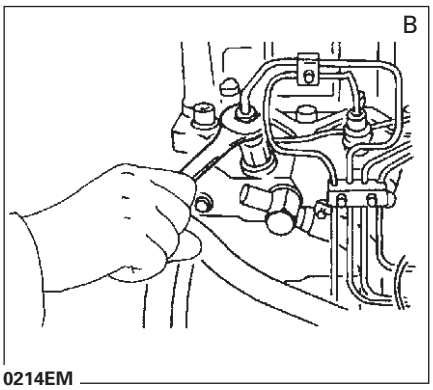


0215EM

2. Fit the injection pipes.

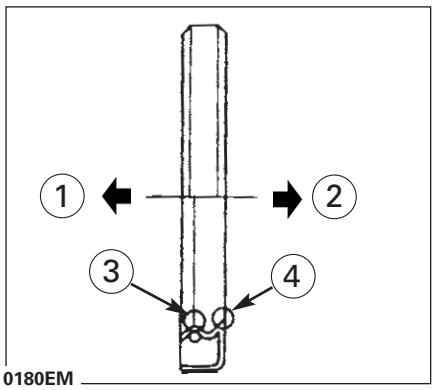
Injection pipes:
22 - 25 Nm (2.2 - 2.6 kgm, 16.2 - 18.4 ft lb)

A: Pump side



0214EM

B: Engine side

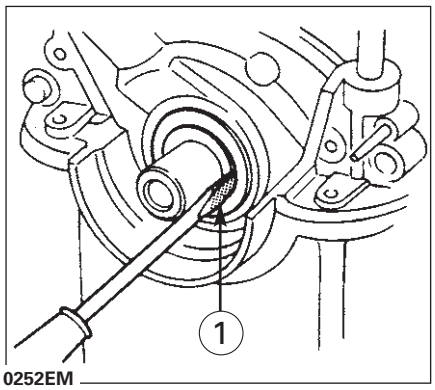


0180EM

Precautions for fitting all seals

- **When fitting a new seal, ensure that it is fitted in the correct position.**
- **It is recommended that the front and rear oil seals be replaced whenever the engine is disassembled.**
- **Clean away any excess oil after fitting.**

1. Engine interior
2. Engine exterior
3. Oil seal lip
4. Dust guard lip

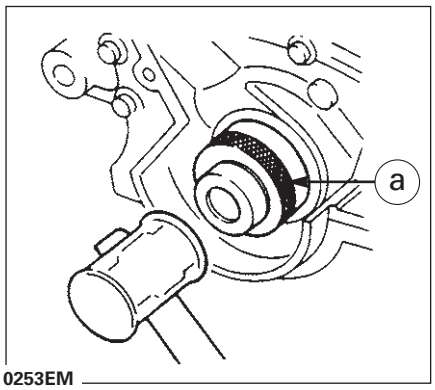


0252EM

Front crankshaft oil seal

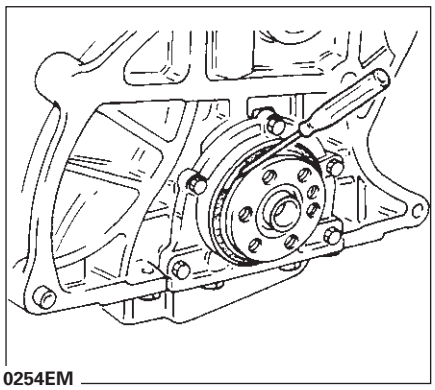
- **It is recommended that the front and rear oil seals be replaced whenever the engine is disassembled.**

1. Remove the following components from the engine.
   - Radiator shroud
   - Fan
   - Timing belt
   - Cover of the toothed crankshaft pulley.
   - Rear crankshaft oil seal
   - **Take care not to damage the seal seating surface.**



0253EM

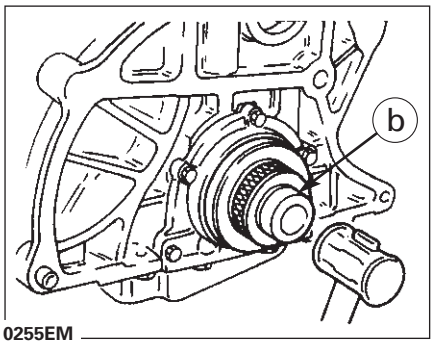
2. Apply engine oil to the new seal and fit the seal into its housing using a suitable tool (a).


0254EM

Rear sealing ring of the crankshaft

- **It is recommended that the front and rear oil seals be replaced whenever the engine is disassembled.**

1. Remove the following components of the engine:
   - Gearbox assembly
   - Clutch assembly
   - Engine flywheel and the rear plate.
   - Oil seal
   - **Take care not to damage the seal seating surface.**



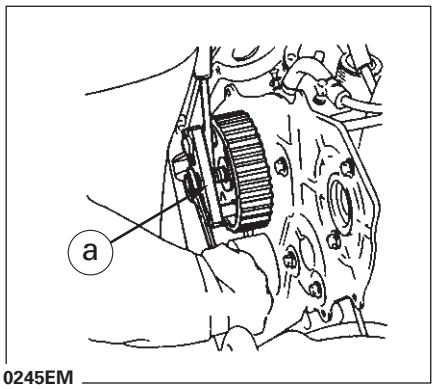
0255EM

2. Apply engine oil to the new seal and fit the seal using a suitable tool (b).

See “ASSEMBLY - Cylinder block - Rear crankshaft oil seal” in this section.

Valve oil seal

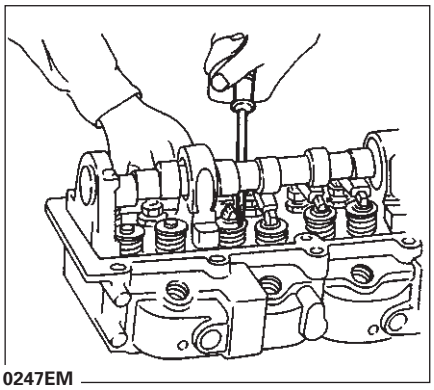
Removal and Fitting



0245EM

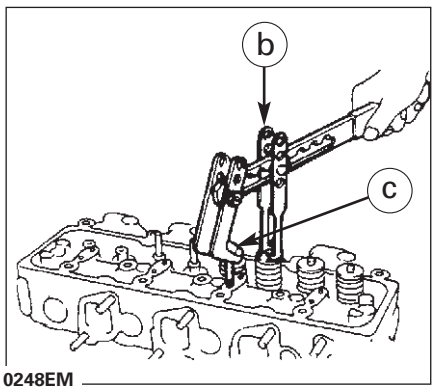
1. Remove the timing belt. See “TIMING BELT - Removal” in this section.
2. Remove the toothed camshaft and injection pump pulleys and the tensioner and idler pulleys.

   If the pulleys are difficult to remove, use an extractor (a)


0247EM

3. Remove the rocker cover and breather pipe.

   See “CYLINDER HEAD - Disassembly” in this section.
4. Remove the rocker springs.
5. Remove the rockers and the valve split-cones.
6. Remove the camshaft supports and the camshaft.

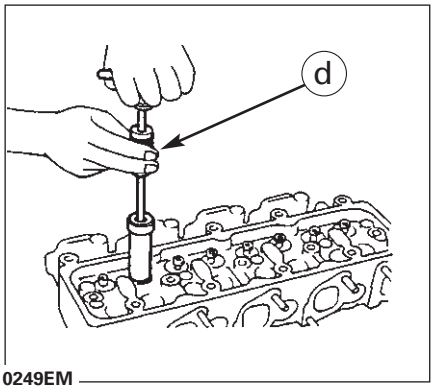


0248EM

7. Replace the valve seal using the special tools (b) and (c) as described below.
   - **When replacing the valve seal, place the corresponding piston at TDC to prevent the valve from dropping into the cylinder.**

   a) Place piston 1 at TDC.

   b) Remove the valve springs and the old seals from the valves of cylinders 1 and 4.



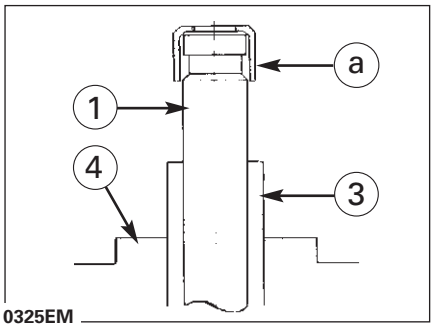
0249EM

   c) Use the special tool (d) to fit the new valve seals to cylinders 1 and 4. as shown in the figures below. Re-fit the valve springs (with the painted side inside the cylinder head)

   d) Place piston 2 at TDC.

   e) Change the valve seals for cylinders 2 and 3. following the same steps as for 1 and 4.

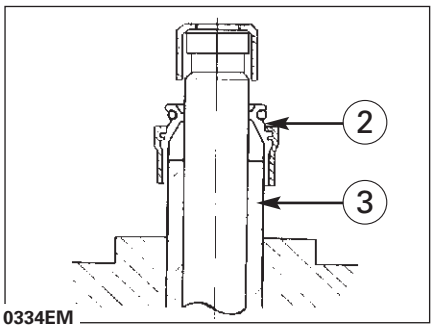
Valve seal installation sequence



0325EM

a) Fit the valve (1) into the valve guide (3) in the cylinder head (4).

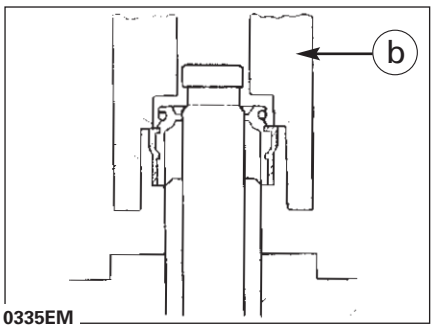
b) Fit the installation guide (a) onto the valve.



0334EM

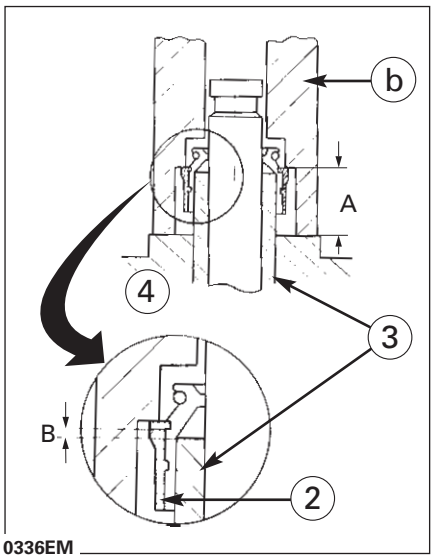
c) Apply engine oil to the seal.

d) Slide the seal (2) until it touches the valve guide (3).



0335EM

e) Remove the installation guide (a) and insert the fitting tool (b), guiding it with the valve, until it reaches the seal.



0336EM

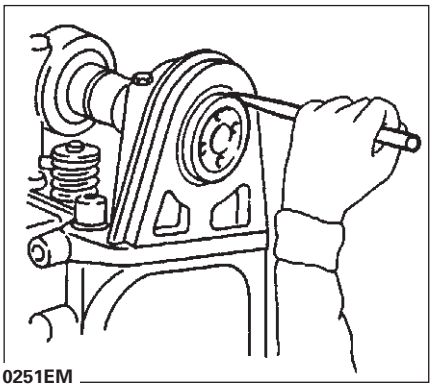
f) Press the seal (2) onto the valve guide (3) until the tool touches the cylinder head (4).

The installation tool (b) must be designed so that its dimension A allows the valve seal (2) to be fitted to the specified dimension B when it touches the cylinder head.

Dimension B, clearance between seal (2) and valve guide (3):
0.6 - 0.8 mm (0.024 - 0.031 inches)

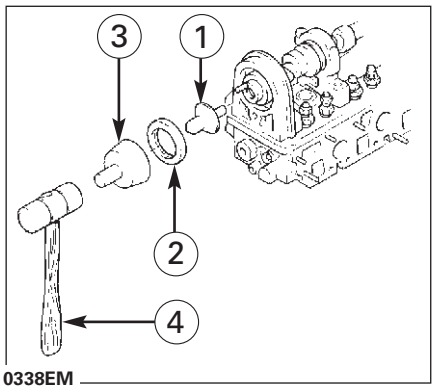
REPLACEMENT OF OIL SEALS

Camshaft seal



0251EM

1. Remove the timing belt, toothed wheels and rear covers.
2. Remove the oil seal with a suitable tool.

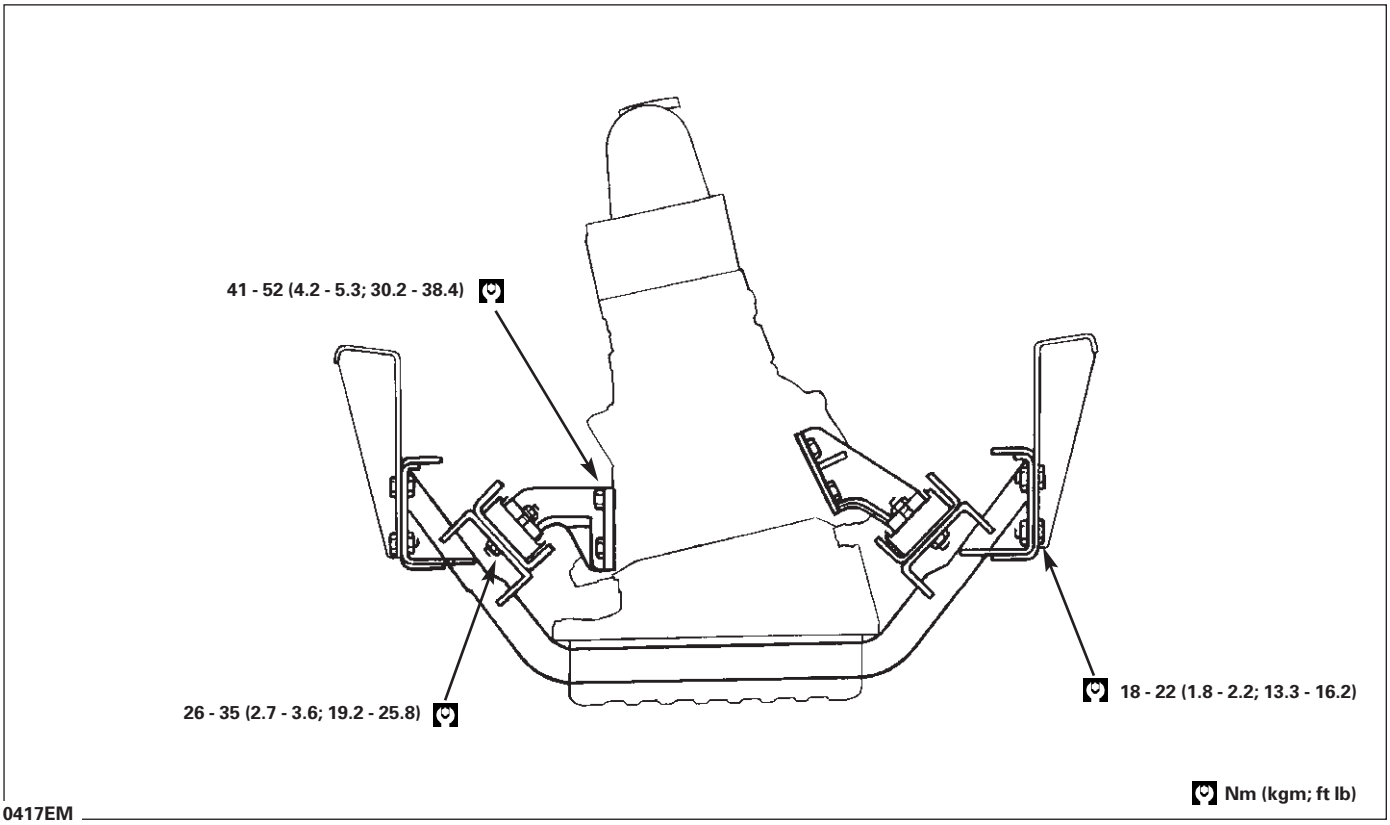


0338EM

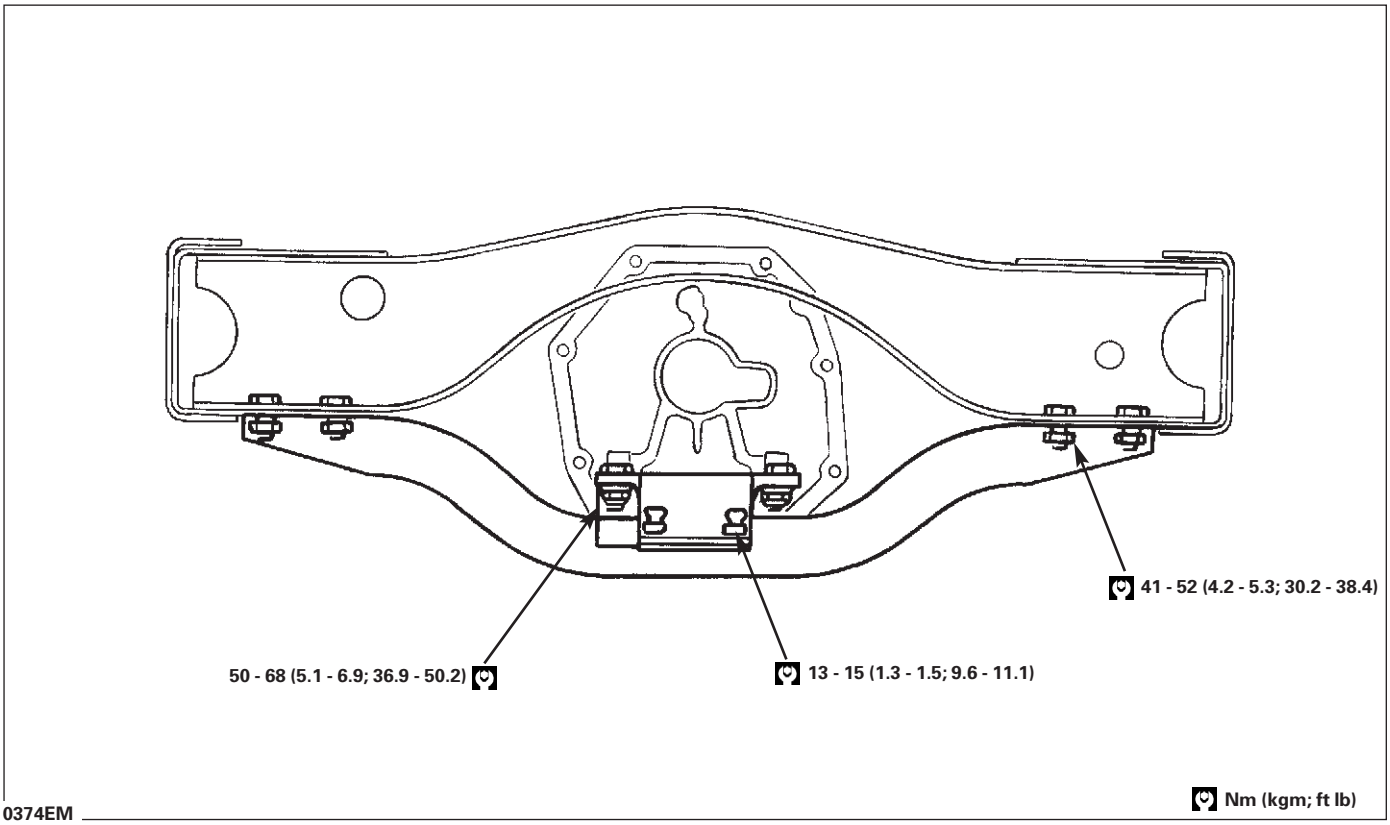
3. Fit the new seals (2) with the special tools (1) and (3), as shown in the figure.
   - **Ensure that the seals are correctly positioned.**

1. Central guide of seal
2. Seal
3. Outer guide of seal
4. Nylon mallet

ENGINE BRACKETS



0417EM



0374EM

WARNING:

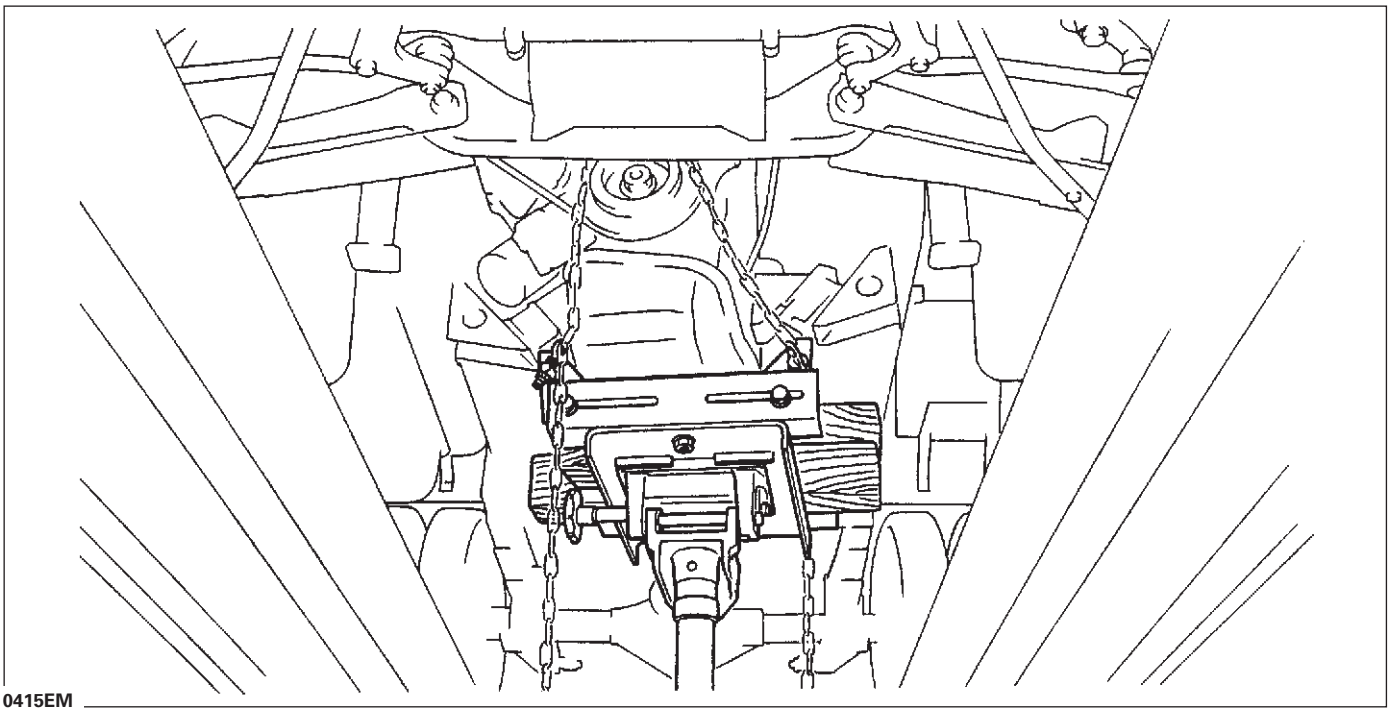
- **Park the vehicle on a flat floor, apply the parking brake and chock the rear wheels.**
- **Do not remove engine until the exhaust system has totally cooled.**
- **Before disconnecting the fuel pipe, ensure that the pressure in the system has been released.**
- **Ensure that the engine and transmission are lowered and raised safely.**

CAUTION

- **When raising or lowering the engine, take care not to hit it against nearby parts, especially the accelerator cable covering, brake pipes and brake master cylinder.**
- **When raising the engine, always use the engine slings safely.**

DISASSEMBLY

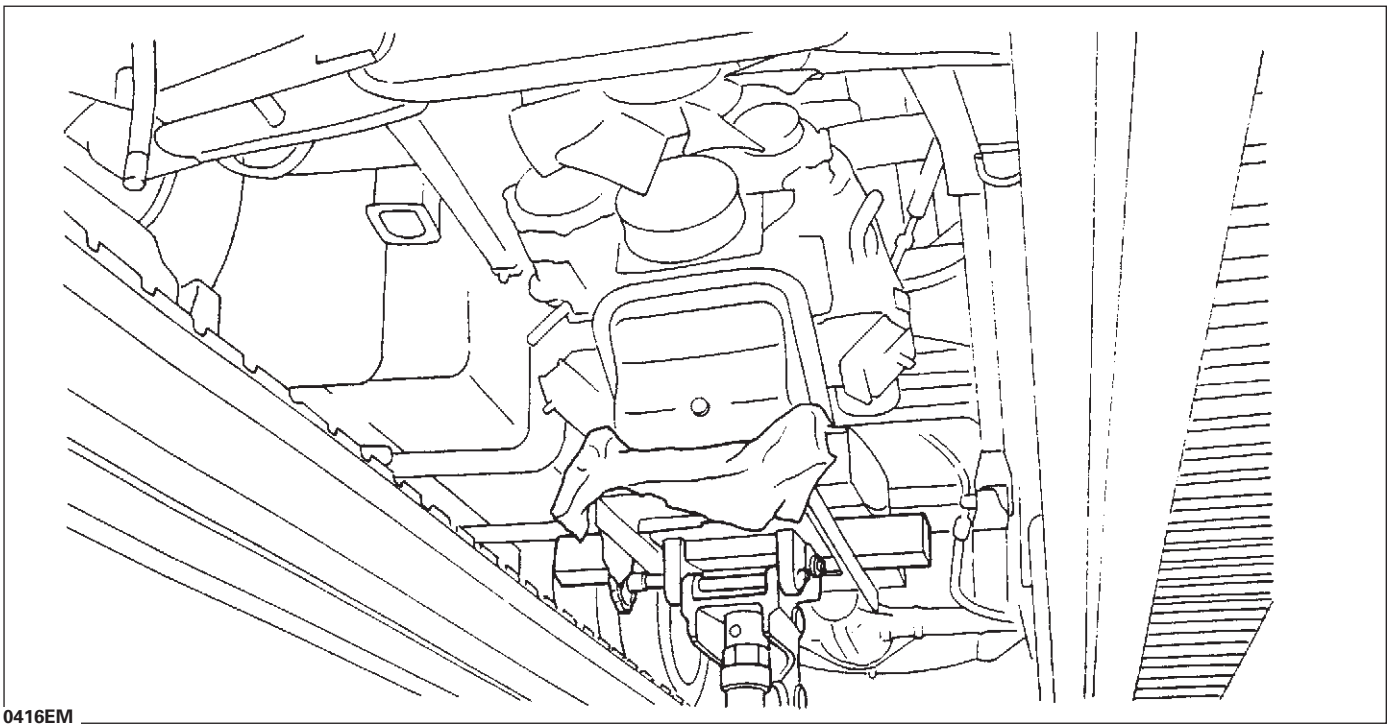
1. Remove the driver's seat.
2. Raise the passenger seat.
3. Disconnect the gear shift lever.
4. Use a hoist or crane to support the engine by the rear sling.
5. Drain the cooling system.
6. Disconnect the vacuum hoses, fuel pipes, cables, circuits, connectors and the rest.
7. Remove the radiator and cooling fan from its housing.
8. Remove the drive belts and the alternator.
9. Remove the front exhaust pipe.
10. Remove the gearbox (see section MT in this manual)
11. Raise the engine sufficiently to be able to remove the nuts on the engine brackets.
12. Remove one end of the steering drive bar.
13. Remove the cross member from the engine brackets.
14. Use a hydraulic jack to lower the engine, supporting it also with the hoist or crane.
15. Remove the engine by moving it very carefully to avoid it hitting any nearby parts.
16. Remove the rear sling.
17. Remove the engine.



0415EM

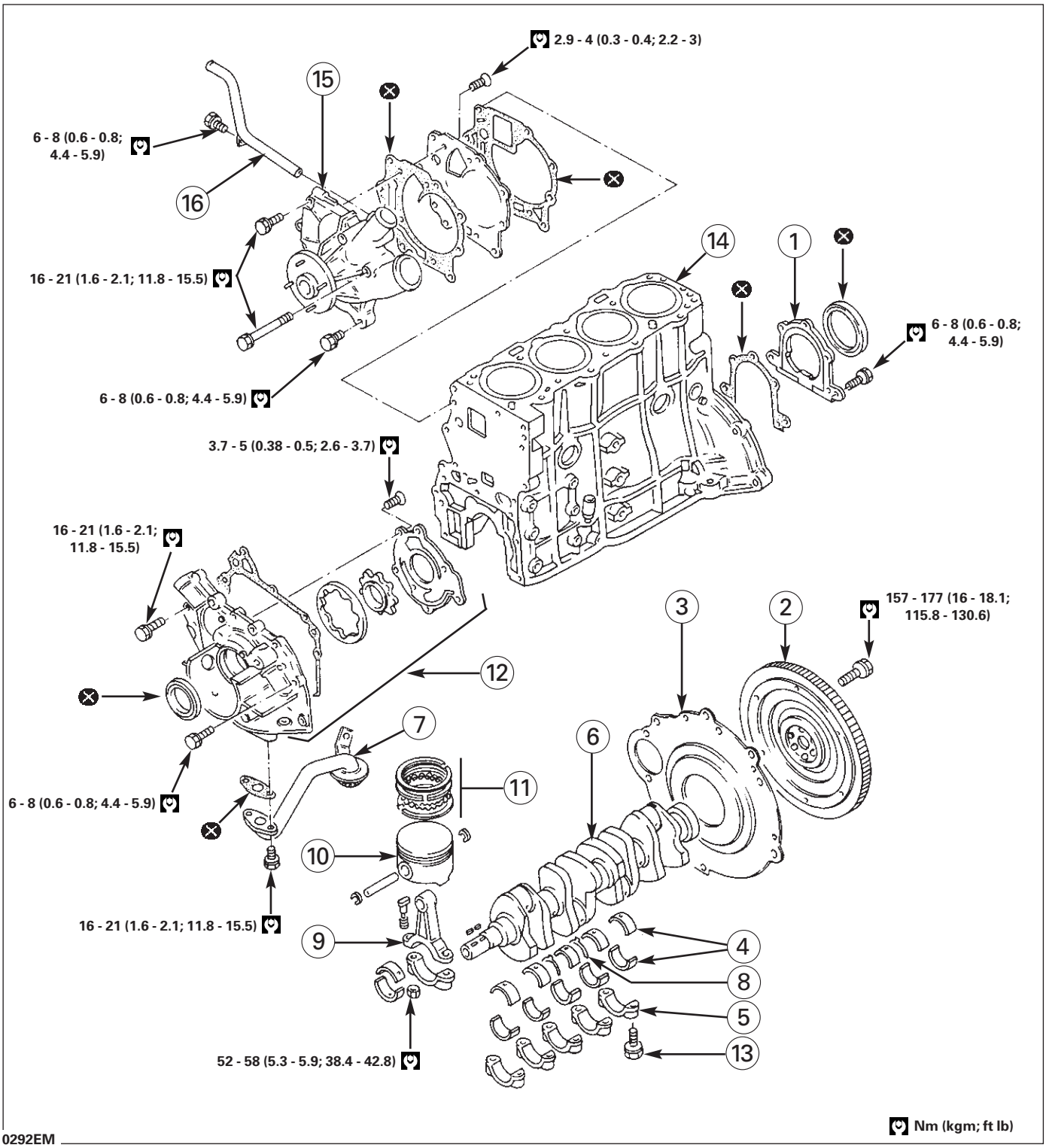
INSTALLATION

1. Temporarily fit the engine mountings and brackets to the engine.
2. Carefully raise the engine with a suitable jack.
3. Installation is carried out be reversing the removal process.



0416EM

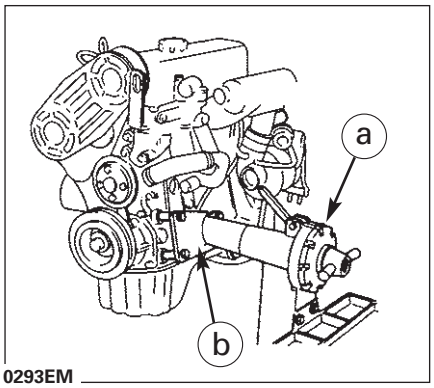
Exploded view



COMPONENTS

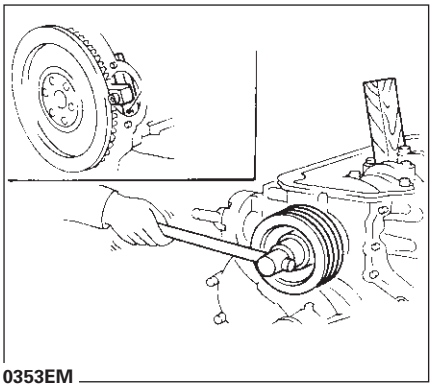
1. Oil seal bracket
2. Flywheel
3. Rear plate
4. Main bearing
5. Bearing caps
6. Crankshaft
7. Oil filter and breather pipe
8. Thrust washer
9. Connecting rod
10. Piston
11. Piston rings
12. Oil pump
13. See "CRANKSHAFT" "CYLINDER BLOCK - Assembly"
14. Cylinder block
15. Water pump
16. Pipe to oil cooler

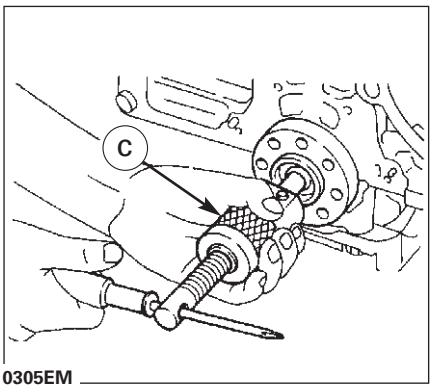
Pistons and crankshaft



0293EM

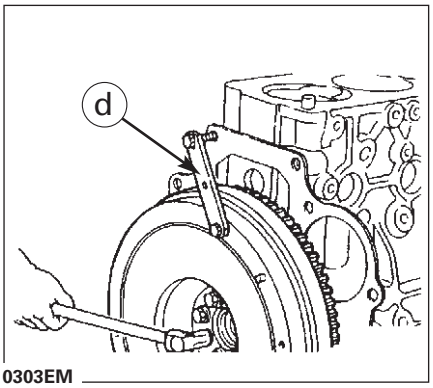
1. Remove the oil filter.
2. Place the engine on the supports (a) and (b).
3. Drain the cooling system and the oil from the engine sump.
4. Remove the drive belts
5. Remove the timing belt.
   See “TIMING - Removal” in this section.
6. Remove the water pump.
7. Remove the alternator.
8. Remove the cylinder head.
   See “CYLINDER HEAD - Disassembly” in this section.
9. Remove the sump and oil pump.
   See “OIL SUMP - Removal” in this section.
10. Remove the crankshaft pulley.
    - **Block the crankshaft by fixing the flywheel with a suitable tool or by inserting a wooden wedge between the crankshaft and the cylinder block to prevent the crankshaft from turning.**


0353EM



0305EM

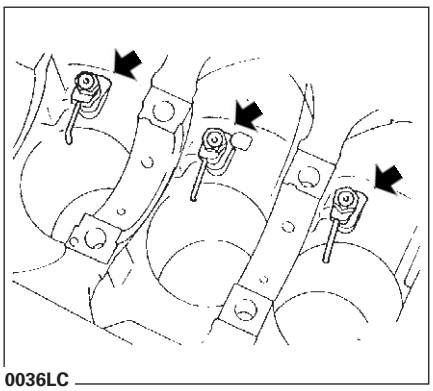
11. Remove the pilot bearing from the crankshaft using a suitable tool (c).



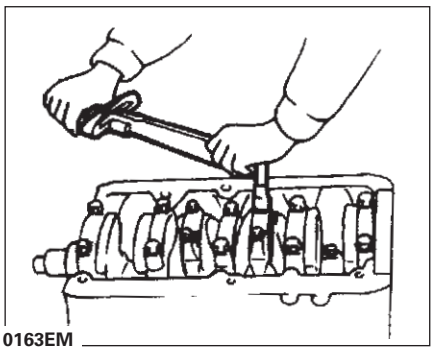
0303EM

12. Use the special tool (d) to block the crankshaft while the flywheel and fixing bolts are removed.
13. Loosen the bolts fixing the bracket of the rear crankshaft seal and remove the bracket and seal together. Discard the seal and gasket.

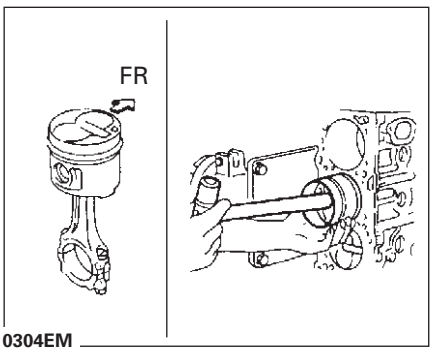
Pistons and crankshaft (cont'd)


0036LC

14. Remove the piston cooling oil jets.

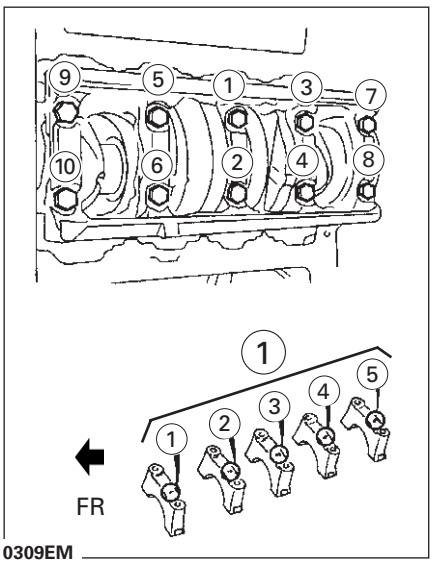

0163EM

15. Remove the connecting rod caps.



0304EM

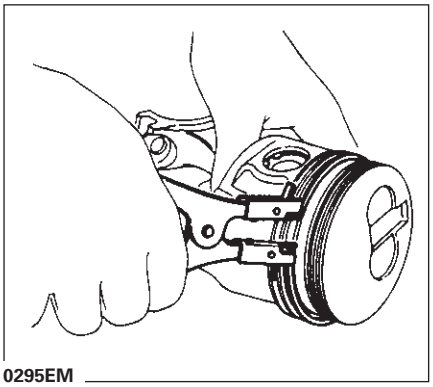
16. Remove the piston/connecting rod assemblies from the cylinder block.
    - **Take care not to damage the cylinder wall with the connecting rod when you withdraw it.**



0309EM

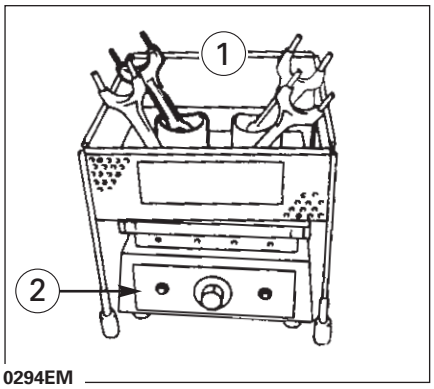
17. Remove the bolts fixing the bearing caps.
    - **Loosen the bolts in the order shown in the figure:**
    - **Before disassembling the pin which joins the piston to the connecting rod, heat the piston to 60 - 70°C (140 - 158°F), or use a press with a suitable tool.**
18. Remove the crankshaft from the cylinder block.

Pistons and crankshaft (cont'd)



0295EM

19. Remove the piston rings with a suitable tool.



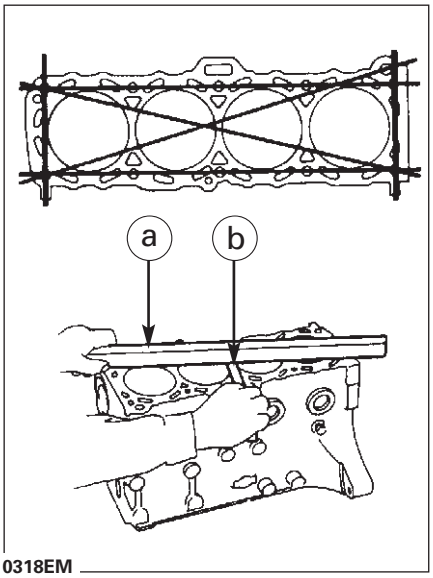
0294EM

20. Remove the piston and connecting rod assemblies.
    - **Before disassembling the pin which joins the piston to the connecting rod, heat the piston to 60 - 70°C (140 - 158°F), or use a press with a suitable tool.**

1. Pistons and connecting rods

2. Heater

Cylinder block distortion and wear



0318EM

1. Check visually for cracks or deformations.
2. Clean the surface of the cylinder block and measure the distortion with a flat, rigid ruler (a) and a feeler gauge (b), making several measurements at different points, as shown in the figure.

   Standard:
   Less than 0.05 mm (0.002 inches)

   Limit:
   0.2 mm (0.008 inches)

   If it exceeds the specification, grind it flat.

   The limit for grinding the cylinder block depends on the grinding of the cylinder head.

   The depth for grinding the cylinder head is "A".

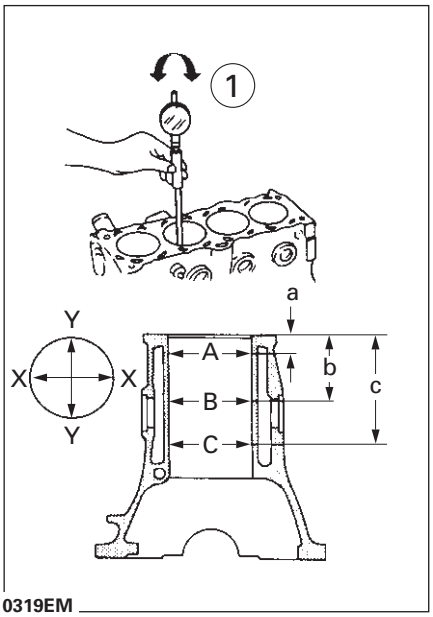
   The depth for grinding the cylinder block is "B".

   The maximum limit is:
   A+B = 0.1 mm (0.004 inches)

   Replace the cylinder block if necessary.

Cylinders

Cylinder bore



0319EM

1. Check for scratches or dents. Re-bore the cylinder if any faults are found.
2. Use an interior dial gauge to measure the internal diameter of the cylinder at various points, as shown in the figure, to check for ovalling and coning.

   Inner diameter of cylinders:

   See "TECHNICAL DATA AND CHARACTERISTICS".

   Wear limit = 0.2 mm (0.008 inches)

   Ovalling limit (X - Y) = 0.020 mm (0.001 inches)

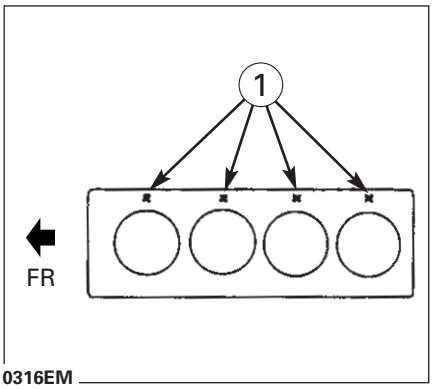
   Coning limit (A - B, A - C, B - C): = 0.020 mm (0.001 inches)

1. Move the gauge as shown in the drawing; take the minimum reading.

a. 20 mm (0.78 inches)

b. 60 mm (2.362 inches)

c. 100 mm (3.937 inches)



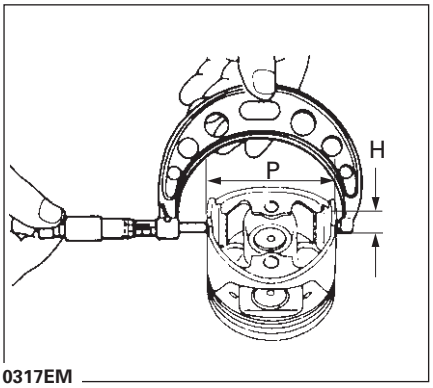
0316EM

- **If a piston or the cylinder block is replaced with a new one, select a piston matching the grade number of the piston to be replaced, marked on the upper surface of the cylinder block.**

1. Piston grade number

Cylinders (cont'd)

Cylinder re-boring



0317EM

1. The dimension to which the cylinders must be re-bored is calculated by adding the clearance between the piston and cylinder to the piston diameter.

   Height "H" at piston skirt:

   Approximately 39.73 mm (1.564 inches)

   Calculation of re-boring dimension

   D = P + R - T = P + [0.087 - 0.103 mm (0.0034 - 0.004 inches)]

   Where,

   D: Re-boring diameter

   P: Piston skirt diameter

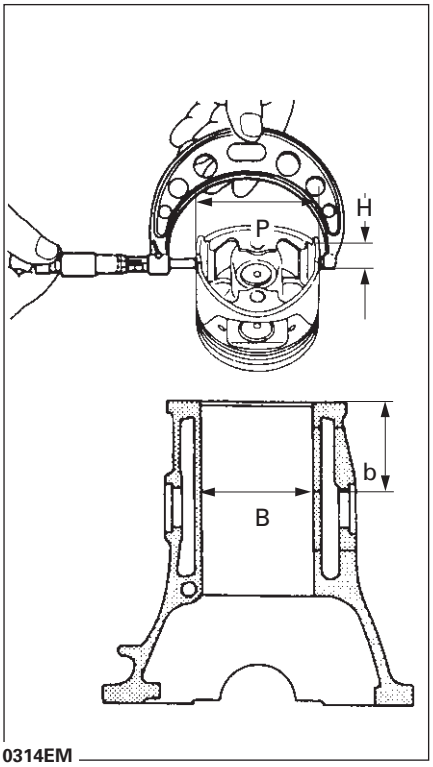
   R: Clearance between piston and cylinder wall

   T: Re-boring tolerance 0.02 mm (0.001 inches)

2. Fit the bearing caps and tighten them to the specified torque to avoid deformation of the cylinders during final assembly.
3. Re-bore the cylinders in the sequence 1-3-4-2.
   - **Do not remove too much material from the cylinder walls at one pass. Remove only about 0.05 mm (0.002 inches) each time.**
4. Re-bore the cylinders to the required dimension (see "TECHNICAL DATA AND CHARACTERISTICS"
   - **Use clean, sharp stones of the appropriate grade.**
   - **The boring cross-over angle should be about 45°.**
5. Check for ovalling and coning in the re-bored cylinders.
   - **Great care must be taken when measuring the diameter of a cylinder that has just been re-bored since it will have expanded due to the heat generated during re-boring.**

Pistons

Clearance between piston and cylinder wall



0314EM

1. Measure the diameters of the piston and the cylinder bore.

   PISTON: **Diameter "P" of the piston (measured at distance "H" from the piston skirt, approximately)**

   H = 39.73 mm (1.564 inches)

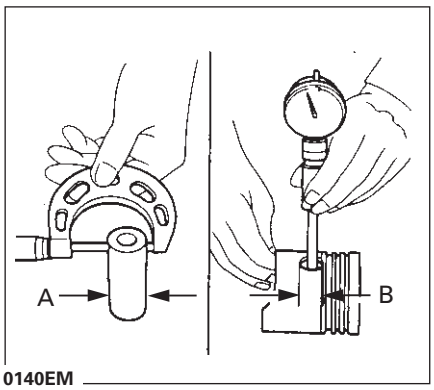
   See "TECHNICAL DATA AND CHARACTERISTICS".

   CYLINDER: **Diameter "B" of the cylinder (measured at distance "b" from the top of the block, approximately**

   b= 60 mm (2.362 inches)

2. Check that the clearance between the piston and the cylinder wall is within the specified limits.

   Clearance (B - P) = 0.107 - 0.123 mm (0.004 - 0.005 inches)



0140EM

Pistons (cont'd)

Clearance between piston and piston pin

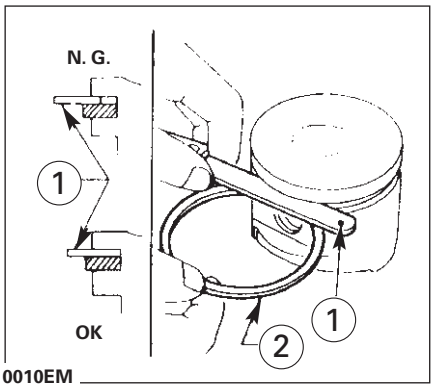
1. Measure the outer diameter of the piston pin and the inner diameter of the piston eye.
2. Calculate the piston pin's clearance in the piston:

Outer diameter "A" of gudgeon pin: 25.995 - 26.000 (1.023 - 1.025 inches) mm

Piston eye diameter "B" = 26.003 - 26.008 mm (1.024 - 1.025 inches)

Clearance (B - A) :0.003 - 0.013 mm (0.0001 - 0.0051 inches)

Spare parts are available as sets of pistons and rings.



0010EM

Side clearance between rings and piston

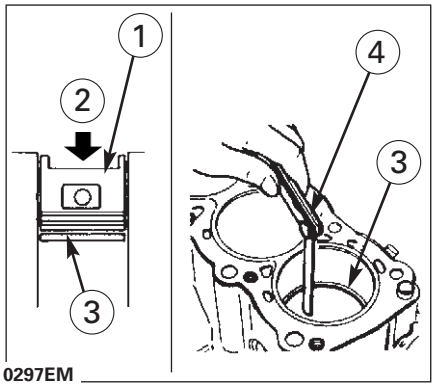
	Standard		Limit	
	mm	inches	mm	inches
Upper ring	0.09 - 0.122	0.004 - 0.005	0.2	0.008
2nd ring	0.04 - 0.072	0.002 - 0.003	0.15	0.006
Oil ring	0.03 - 0.065	0.001 - 0.002	0.1	0.004

1. Feeler gauge

2. Piston ring

Clearance between piston ring ends

	Standard		Limit	
	mm	inches	mm	inches
Upper ring	0.3 - 0.5	0.012 - 0.02	0.85	0.033
2nd ring	0.6 - 0.85	0.024 - 0.033	1.2	0.047
Oil ring	0.25 - 0.5	0.01 - 0.02	0.85	0.033



0297EM

If the piston ring is beyond the specified limit, replace it. If the clearance still exceeds the limit with a new ring, grind the cylinder and use an over-sized piston and ring.

See "TECHNICAL DATA AND CHARACTERISTICS".

1. Piston

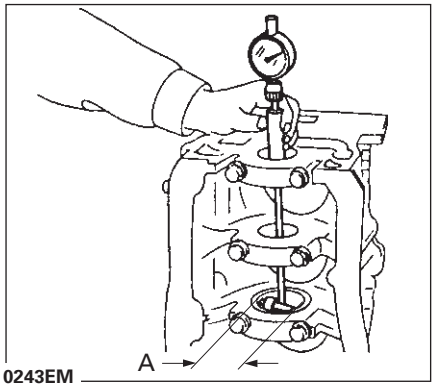
2. Press fit

3. Piston ring

4. Feeler gauge

Bearings clearance

Main bearings and crankshaft supports.

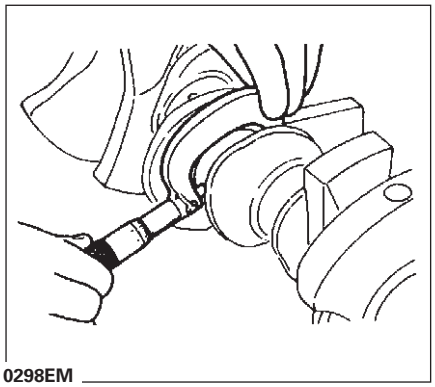


0243EM

1. Fit the main bearing shells into the cylinder block and bearing caps, respectively.
2. Fit the bearing caps with their shells into the cylinder block.
3. Tighten all the bolts on the bearing caps to the specified torque in the correct order and in two or three steps:

   Crankshaft bearing caps bolts
   74 - 83 Nm (7.5 - 8.5 kgm; 54.6 - 61.2 ft lb)

4. Measure the inner diameter "A" of each main bearing with an interior micrometer.


0298EM

5. Measure the outer diameter "Dm" of each crankshaft journal with a micrometer.

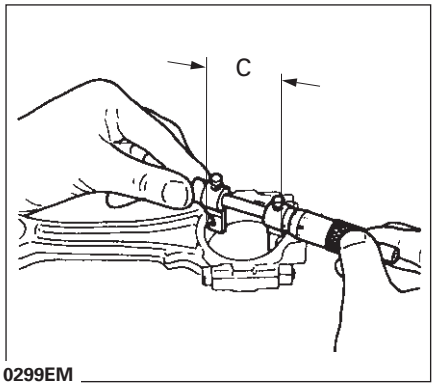
   Diameter of the crankshaft supports
   See "TECHNICAL DATA AND CHARACTERISTICS".

6. Calculate the clearance of the main bearings and crankshaft supports.

   Clearance between the main bearings and crankshaft supports:
   Standard: 0.041 - 0.076 mm (0.0016 - 0.003 inches)

   - **Replace the main bearings if the clearance exceeds the specified limit.**
   - **If any crankshaft journal is worn or faulty, replace the crankshaft and main bearings.**

Connecting rod big end bearing and crankshaft pin.



0299EM

1. Fit the bearing shells on the connecting rods and caps, respectively.
   - **Oil the bolt and nut threads.**
2. Fit the caps to the connecting rods.

   Nuts and bolts fixing connecting rod caps:
   52 - 58 Nm (5.3 - 5.9 kgm; 38.4 - 42.8 ft lb)

3. Measure the inner diameter "C" of the bearing with an interior micrometer.
4. Measure the outer diameter "Dp" of each crankshaft pin with an exterior micrometer.

   Diameter of crankshaft pins.
   See "TECHNICAL DATA AND CHARACTERISTICS".

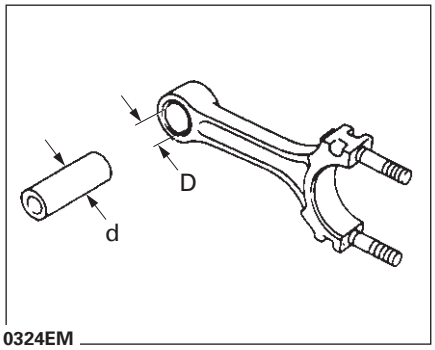
   Calculate the clearance of the crankshaft connecting rod bearings.

   Clearance between the big end bearings and crankshaft pins:
   Standard: 0.041 - 0.076 mm (0.0016 - 0.003 inches)

   - **Replace the big end bearings if the clearance exceeds the specified limit.**
   - **If any crankshaft pin is worn or faulty, replace the crankshaft and the big end bearings.**

Bearings clearance (cont'd)

LITTLE END BEARING AND GUDGEON PIN



0324EM

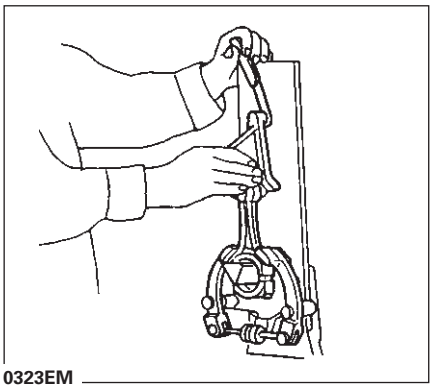
1. Measure the inner diameter "D" of the little end bearing with an interior micrometer.
2. Measure the outer diameter "d" of the piston pin with a micrometer.
3. Calculate the clearance of the little end bearing and gudgeon pin.

Clearance between the little end bearing and gudgeon pin:
0.025 - 0.043 mm (0.001 - 0.0017 inches)

• Replace the little end bearings if the clearance exceeds the specified limit.

Connecting rod

BENDING AND TWISTING OF THE CONNECTING ROD

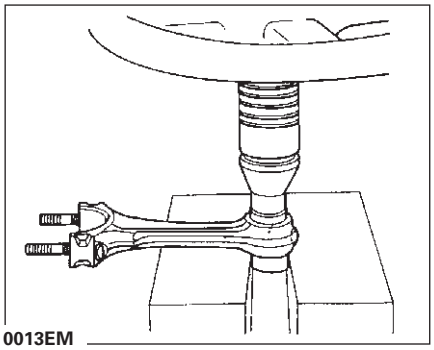

0323EM

Bending and twisting [for every 100 mm (3.94 inches) of length]:

Bending: Less than 0.025 mm (0.001 inches)

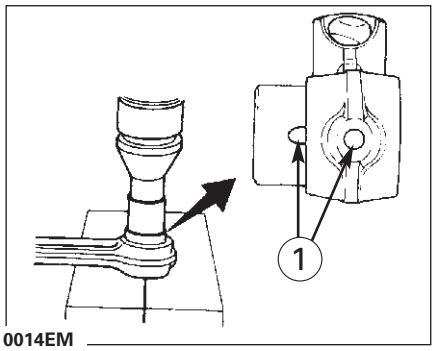
Twisting: Less than 0.025 mm (0.001 inches)

Replacing the little end bearing


0013EM

1. Remove the little end bearing with a suitable tool.

Do not damage the surface of the little end housing.



0014EM

2. Fit new little end bearings. Insert them so that they are flush with the surface of the connecting rod.

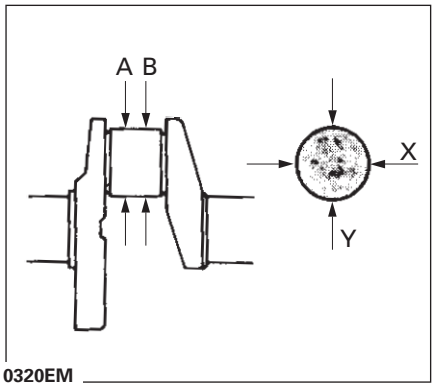
Check that the lubrication holes (1) are correctly aligned.

3. Ream out the little end bearing, after fitting it into its housing.

Inner diameter of little end bearing
Size of finish: 26.025 - 26.038 mm (1.024 - 1.025 inches)

Crankshaft

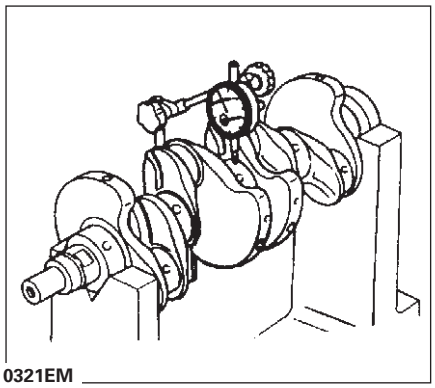
CHECKING THE JOURNALS



0320EM

1. Check that the crankshaft pins and journals are not scratched, worn or cracked. Minor defects can be corrected with fine emery paper.
2. Use a micrometer to check the crankshaft pins and journals for coning and ovalling.

   Ovalling: Less than 0.006 mm (0.0002 inches)
   Coning: Less than 0.006 mm (0.0002 inches)


0321EM

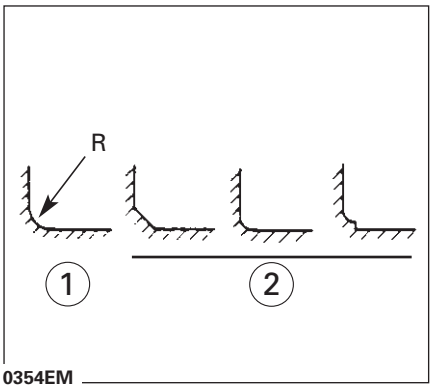
3. Check the eccentricity of the crankshaft.

   Eccentricity (total dial gauge reading):
   Less than 0.07 mm (0.003 inches)

GRINDING THE JOURNALS AND CRANKPINS

When using smaller main bearings and big ends, the journals and crankpins must be ground to match the bearings.

R: Crankpin = 3.0 mm (0.118 inches)
Journal: 3.5 mm (0.138 inches)



0354EM

CAUTION

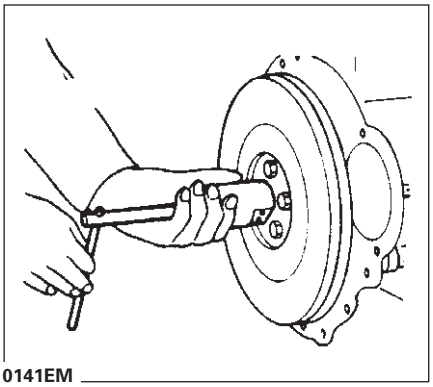
- **Take care not to widen the support surface of the journals and crankpins.**
- **Do not grind the crankshaft counterweight.**

1. Correct

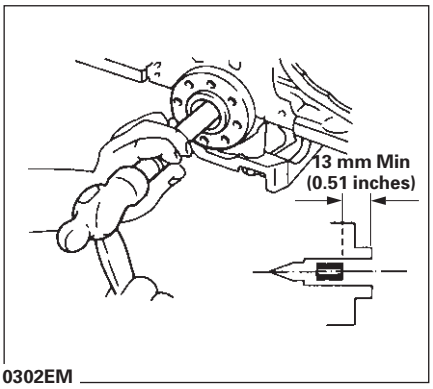
2. Incorrect

Crankshaft

PILOT BEARING


0141EM

1. Inspect the pilot bearing and replace if necessary.
   Remove the pilot bearing using a suitable special tool.



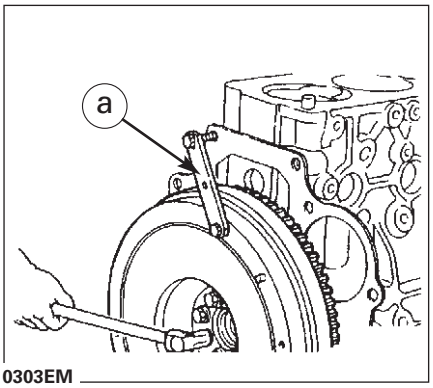
0302EM

2. Fit the new pilot bearing using the suitable special tool.
   Fit it as shown in the figure.

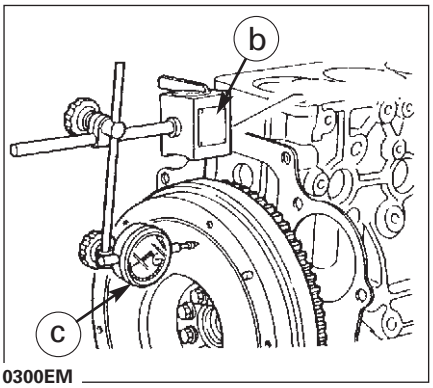
FLYWHEEL

1. Fit the rear plate.
2. Use the special tool (a) to block the crankshaft while the flywheel is fitted to it; tighten the fixing bolts to the specified torque in an alternative order.

Bolts fixing engine flywheel:
157 - 177 Nm (16 - 18.1 kgm, 115.8 - 130.6 ft lb)



0303EM



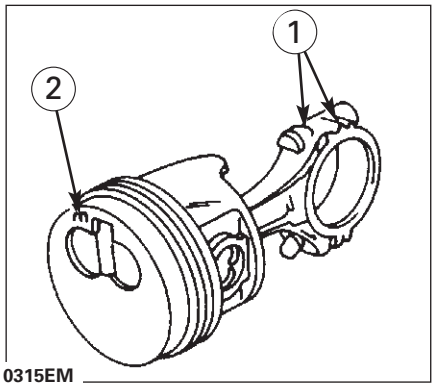
0300EM

3. Fit a magnetic base (b) with a dial gauge (c) and check the warping of the flywheel.

Flywheel warp (total dial gauge reading)
Less than 0.15 mm (0.006 inches)

Pistons and connecting rods

ASSEMBLE THE PISTON AND CONNECTING ROD

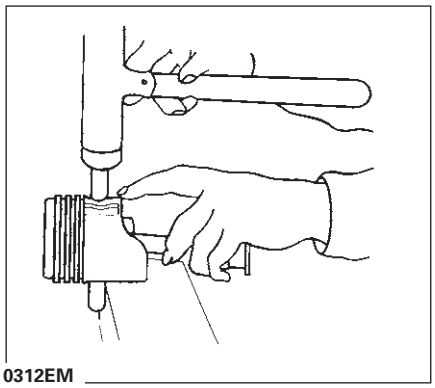


0315EM

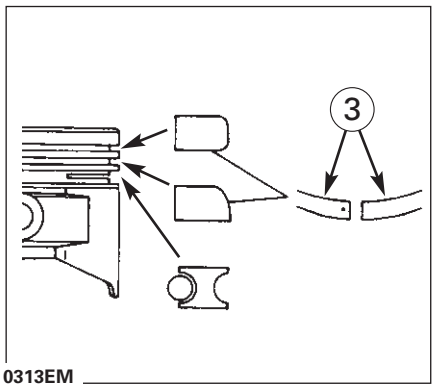
- **The numbers marked on the connecting rod and cap match each cylinder. Take care not to mix them up, including the direction of the cap and connecting rod.**

1. Cylinder number

2. Grade mark


0312EM

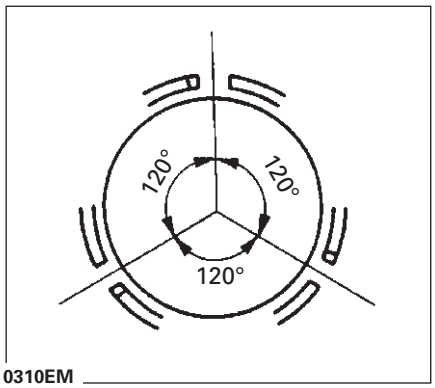
1. Fit a new spring washer in one end of the piston pin eye in the piston.
2. Fit the gudgeon pin into the piston and connecting rod
   - **When inserting the gudgeon pin in the connecting rod, heat the piston with a heater or water (approximately 60 to 70°C (140 to 158 F)) and apply clean, new engine oil to the gudgeon pin and the little end bearing.**
3. Fit a new spring washer in the other end of the gudgeon pin.
   - **After assembly, ensure that the piston rocks smoothly.**



0313EM

4. Open the piston rings and fit them using a suitable tool.
   - **Only open the rings enough for them to fit into the slots in the piston.**
   - **Ensure that the manufacturer's mark faces upward.**

3. Marked side facing upward

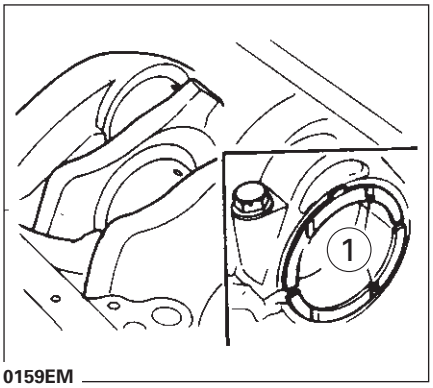


0310EM

- **Fit the segments in the piston in the orientation shown in the figure.**

Crankshaft

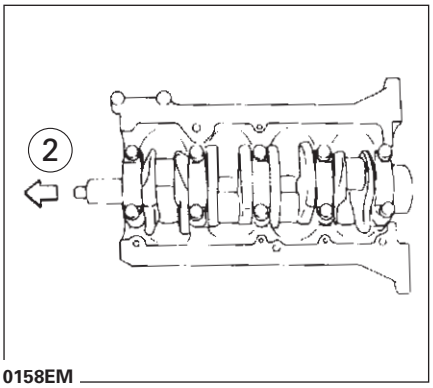
1. Fit the upper bearing shells into their housings in the upper part of the crankshaft seatings in the cylinder block.
   - **The upper bearing shells have a lubrication hole and slot not found on the lower ones.**
   - **If the crankshaft, cylinder block or bearings are to be re-used, the main bearing clearance must be checked.**
2. Fit the upper crankshaft thrust washers to the central crankpin.
   - **Place the thrust washers so that the lubrication slots face the crankshaft, not the cap.**
   - **Only the central bearing has thrust washers.**
   - **The central main bearings are wider than the others.**
   - **The other main bearings are all of the same size.**
   - **A single main bearing cannot be changed by itself; the entire set of 5 must be replaced together.**



0159EM

1. Oil ring

3. Fit the crankshaft in its housing.
   - **Apply new engine oil to the crankshaft journals and crankpins.**
4. Fit the lower shells into their caps.
   Fit the lower thrust washers into the central bearing.
5. Fit the crankshaft bearing caps with the number facing towards the front of the cylinder block.
   - **Apply engine oil to the main bearing caps and the cylinder block contact surfaces.**
6. Fit the rear sealing ring of the crankshaft
   - **Apply new engine oil to the contact surface of the rear oil seal and crankshaft.**

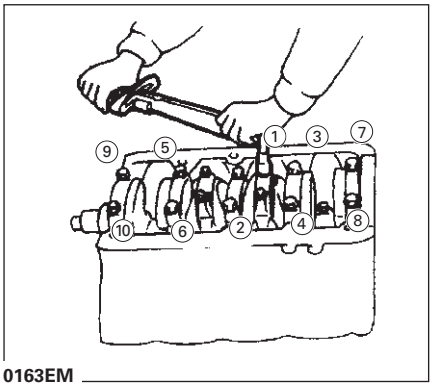


0158EM

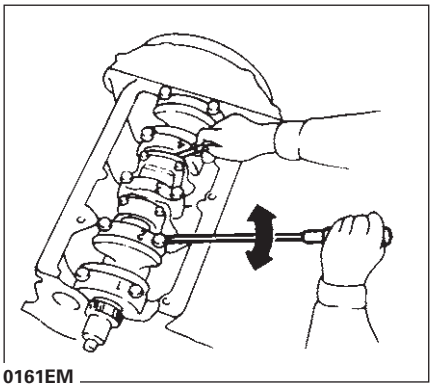
2. Front part

7. Gradually tighten the crankshaft caps in two or three steps, in the order shown in the figure.

   Journal cap bolts:
   167 - 177 Nm (17.0 - 18.1 kgm; 123.2 - 130.6 ft lb)
   - **After tightening the caps, check that the crankshaft turns smoothly.**



0163EM


0161EM

Crankshaft (cont'd)

8. Measure the crankshaft longitudinal play at the central bearing.

Crankshaft end play:

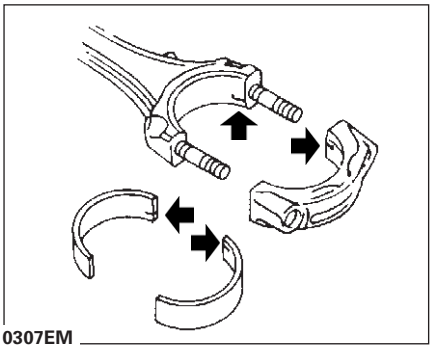
Standard:
0.16 - 0.36 mm (0.006 - 0.014 inches)

Limit:
0.3 mm (0.012 inches)

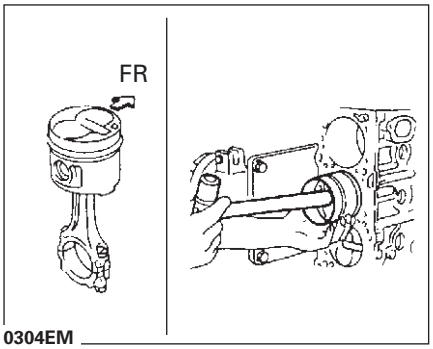
If it exceeds the specified limit, loosen the bolts fixing the caps, remove the caps, remove the crankshaft and replace the thrust washers. Retighten the caps. Check the lengthwise play of the crankshaft again.

- **See "TECHNICAL DATA AND CHARACTERISTICS".**

Fitting the piston and connecting rod assemblies into the cylinder block

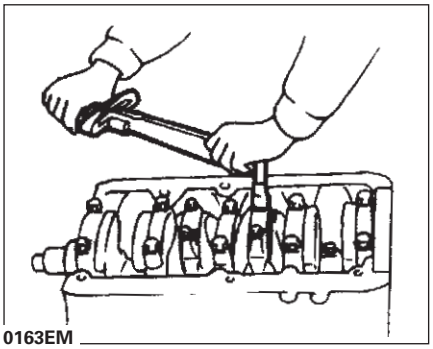

0307EM

1. Fit the connecting rod bearing shells into the connecting rods and caps. See "CYLINDER BLOCK - Inspection" in this section.
   - **Fit the bearings so that the positioning notch in the connecting rod aligns with the lug on the shell.**
   - **Apply engine oil to the surfaces of the connecting rod bearing and the crankpins.**



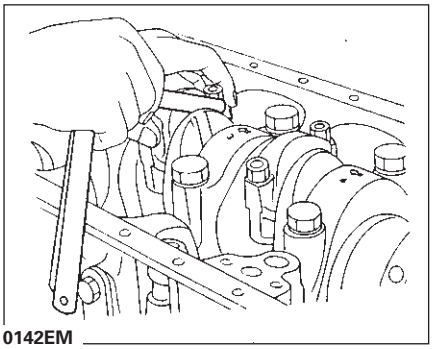
0304EM

2. Fit the piston and connecting rod assemblies into the cylinder block.
   - **Fit them into their cylinders using a suitable tool.**
   - **Take care not to damage the cylinder wall with the connecting rod.**
   - **Apply engine oil to the cylinder wall, piston and bearing.**
   - **Fit the piston so that the reference mark on the piston faces the front of the engine.**


0163EM

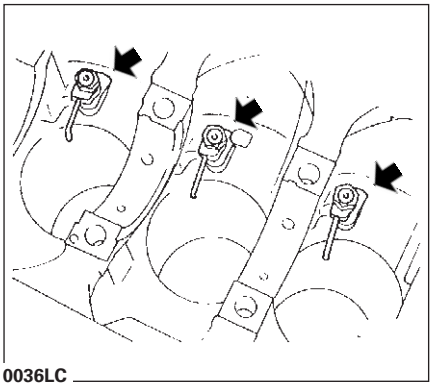
3. Fit the connecting rod caps.
   - **Apply engine oil to the thread of the nut fixing the cap.**
   - **Tighten the cap nuts to the specified torque.**

   Nuts fixing connecting rod caps:
   52 - 58 Nm (5.3 - 5.9 kgm; 38.4 - 42.8 ft lb)


0142EM

4. Measure the connecting rod side clearance:

   Connecting rod side clearance (end play of the big end):
   Standard: 0.15 - 0.4 mm (0.006 - 0.016 inches)
   - **If it exceeds the specified limit, replace the connecting rod and/or crankshaft.**


0036LC

5. Fit the piston cooling oil jets.

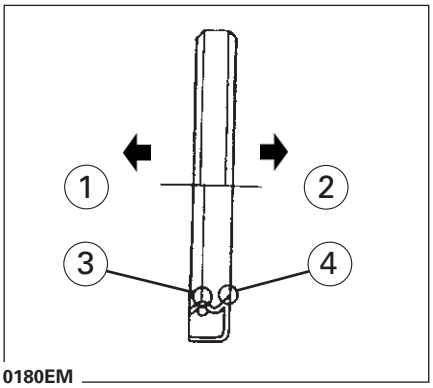
   Fixing of oil jets in engine block:
   29 - 39 Nm (3.0 - 4.0 kgm; 21.4 - 28.8 ft lb)

   NOTE: When fitting the oil jet, ensure that it does not interfere with the connecting rod. Replace the jet if it is deformed.

6. Remove the oil sump.

   See "OIL SUMP - Fitting" in this section.

Rear sealing ring of the crankshaft



0180EM

Never re-use a seal; always fit a new one after every disassembly of the engine.

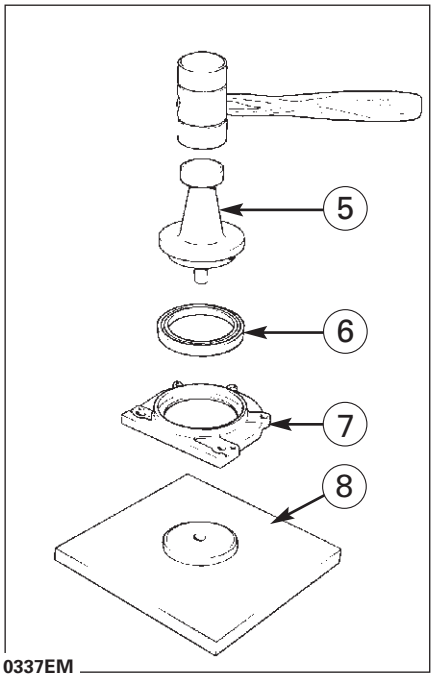
Ensure that the seal is fitted the right way round in the bracket, as shown in the figure.

1. Engine interior

2. Engine exterior

3. Seal lip

4. Dust guard lip



0337EM

Use a special tool to insert the seal into the bracket in order to prevent damage to the seal lips.

Apply soapy paste around the outer diameter of the seal to facilitate its insertion into the rear crankshaft seal bracket.

1. Fit the bracket and seal assembly into its housing; always use a new gasket.
2. place the bolts fixing the rear crankshaft seal bracket to the cylinder block, tightening them crosswise and following the steps given below to prevent tensions and possible distortions, with their consequent leaks of oil through the seal.

   a) Insert the bolts by hand without tightening them.

   b) Tighten them to the specified torque in the above mentioned order

   Bolts fixing rear crankshaft seal bracket to cylinder block:
   6 - 8 Nm (0.6 - 0.8 kgm; 4.4 - 5.9 ft lb)

   - **Trim off the part of the gasket protruding from the rear seal bracket.**

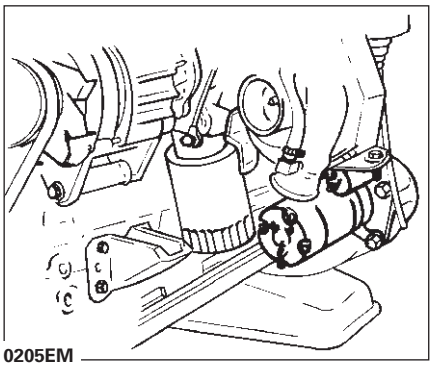
5. Tool

6. Seal

7. Seal bracket

8. Tool base

Starter motor


0205EM

1. Place the starter motor in its housing and fix it with bolts.

   Bolts fixing starter motor:
   39 - 44 Nm (4.0 - 4.5 kgm; 28.8 - 32.5 ft lb)

Oil cooler

See Oil Cooler - ENGINE LUBRICATION SYSTEM - in Section LC of this manual.

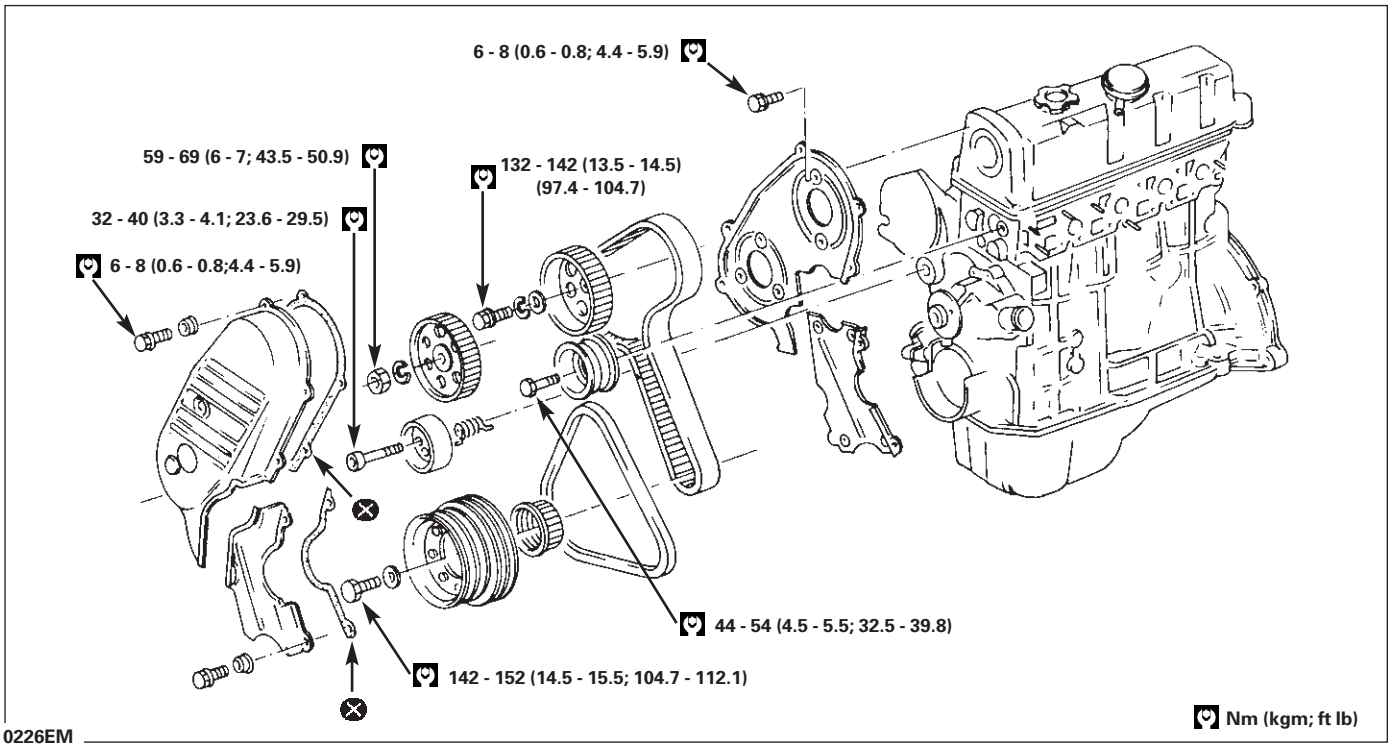
Timing belt

CAUTION

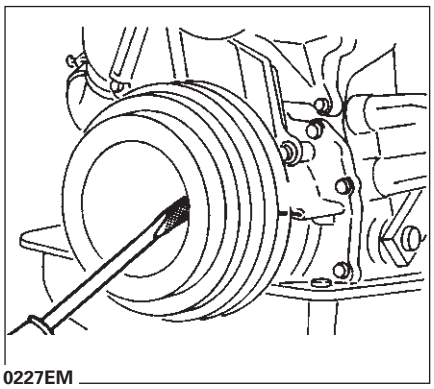
a. **Do not twist or bend the timing belt.**

b. **After removing the timing belt, do not turn the crankshaft or camshaft separately since the valves will hit the piston heads.**

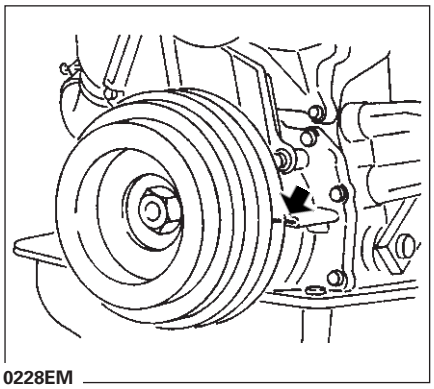
c. **Ensure that the timing belt, toothed camshaft pulley, toothed crankshaft pulley and belt tensioners are free of oil and coolant.**



0226EM

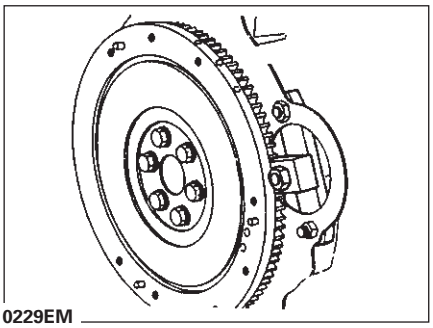

0227EM

1. Remove the crankshaft pulley dust guard.

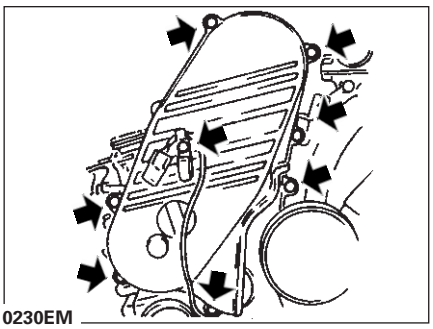

0228EM

2. Place piston 1 at TDC on its compression stroke by aligning the marks.

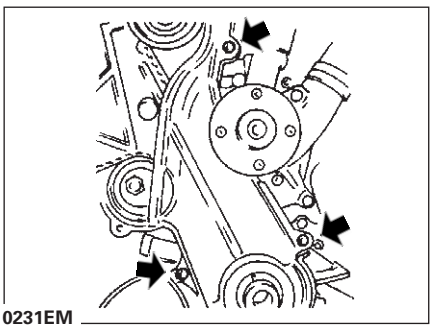
Timing belt (cont'd)

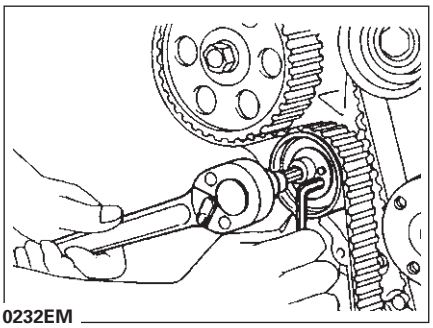

0229EM

3. Remove the starter motor and fit the crown gear stop, using the fixing holes.
4. Remove the crankshaft pulley bolt.
5. Remove the crankshaft pulley using an extractor.
   - **Ensure that the extractor jaws are correctly fitted; only fit them to the rear side of the pulley.**

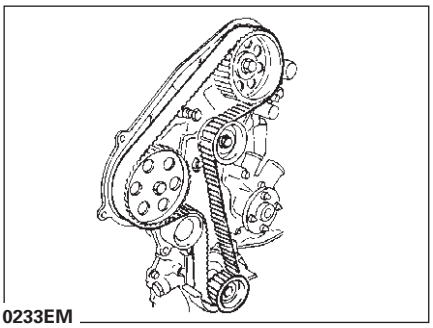

0230EM

6. Remove the timing belt covers.


0231EM


0232EM

7. Remove the timing belt.
   a) Loosen the bolt on the tension pulley, turn the pulley to the right and tighten the bolt.

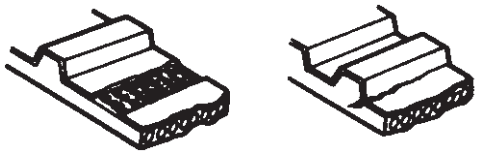
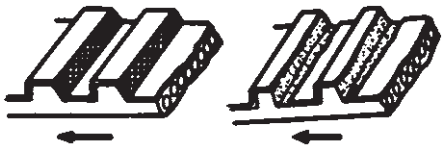

0233EM

   b) Remove the timing belt with the toothed crankshaft pulley.

Timing belt (cont'd)

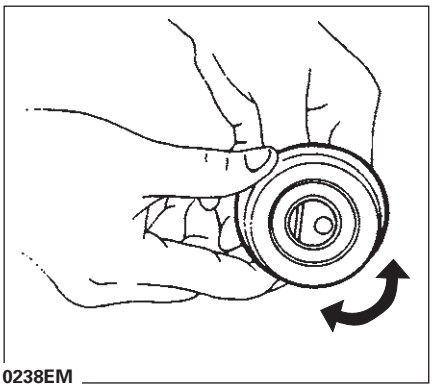
Inspection

Visually check the state of the timing belt and replace it if faults are found.

SYMPTOM	FAULT	PROBABLE CAUSE
Broken tooth/cracked tooth root.	 0234EM	• Camshaft seizure • Injection pump seizure. • Damage to the camshaft, crankshaft oil seal or camshaft oil seal.
Rear surface cracked/worn.	 0235EM	• Seizure of tensioner. • Engine overheating • Interference with the belt cover.
Side surface worn.	 • The edges of the belt are worn and rounded. • The structural threads are worn and visible. 0236EM	• Belt badly fitted. • Bad fitting of the upper or lower timing cover.
Worn teeth.	 • The tooth surface material is worn. • The tooth material is frayed, the rubber layer is worn or discoloured (white) or the pattern is worn and has disappeared. 0237EM	• Belt cover incorrectly closed. • Coolant leaks in the water pump. • The camshaft is not operating correctly. • The injection pump is not operating correctly. • Belt too tight.
Oil, coolant or water on the belt.		• Oil seals incorrectly fitted. • Coolant leaks in the water pump. • Belt cover incorrectly closed.

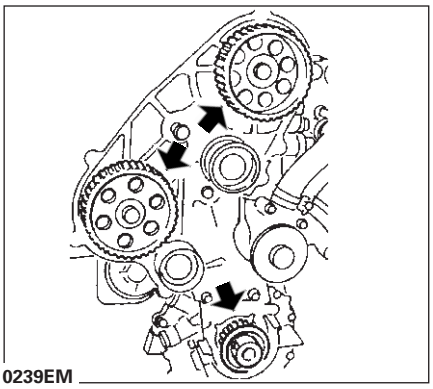
Timing belt (cont'd)

Belt tension pulley, tension spring and idler pulley


0238EM

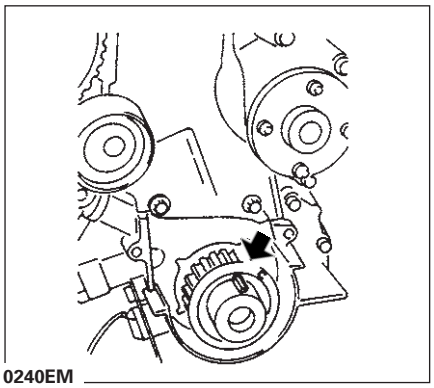
1. Check that the belt tension pulley and idler pulley rotate smoothly.
2. Check the state of the tension spring.

Toothed crankshaft and camshaft pulleys

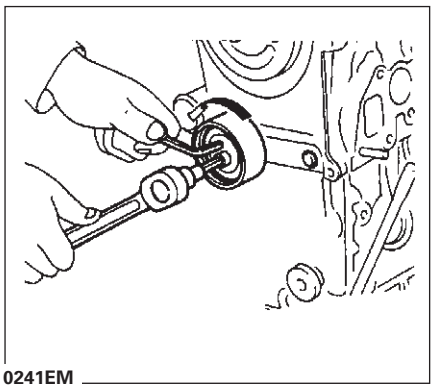

0239EM

1. Check that the teeth have not deteriorated.

Timing belt

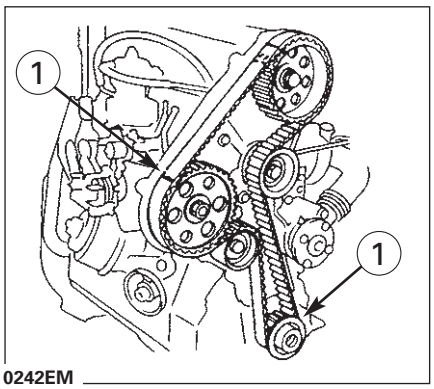

0240EM

1. Check that piston 1 is at TDC on its compression stroke.


0241EM

2. Fit the tensioner and the return spring.
   - **Temporarily tighten the bolts so that the tensioner is in the extreme outer position.**
3. Fit the idler pulley and tighten the bolt to the specified torque:

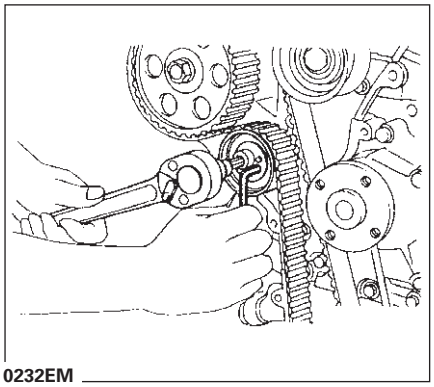
   44 - 54 Nm (4.5 - 5.5 kgm; 32.5 - 39.8 ft lb)



0242EM

4. Fit the timing belt with the toothed crankshaft pulley.
   a) Align the white lines on the timing belt with the marks stamped on the toothed camshaft pulley, toothed injection pump pulley and toothed crankshaft pulley.
   b) Position the arrow on the timing belt so it faces the belt cover (front part of engine).

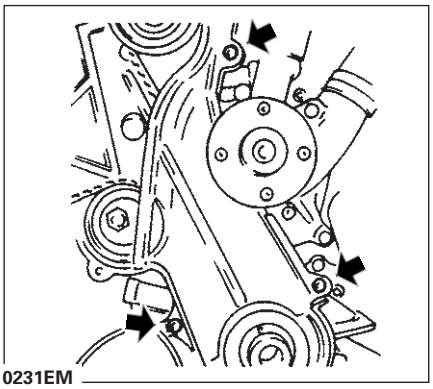
1. Alignment marks


0232EM

5. Adjust the timing belt tension.
   a) Loosen the tensioner lock nut to apply tension to the timing belt. The pulley must return completely under its own power.
   b) Turn the crankshaft two turns to the right to apply the specified tension to the timing belt. Ensure that piston 1 is at TDC on its compression stroke.
   c) Tighten the tensioner lock nut while holding the tension pulley with the hexagonal spanner to prevent changes to the tension.

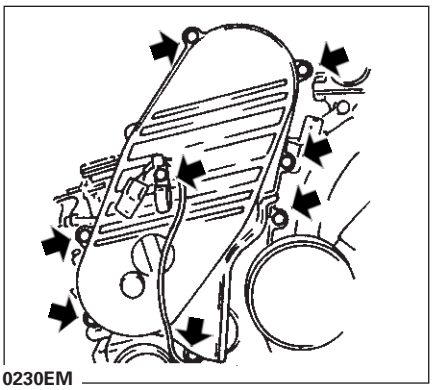
   Belt tension:
   294.2 - 343.2 N (30 - 35 kg; 66 - 77 lb)

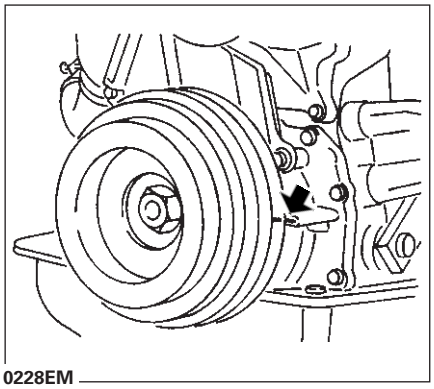
Timing belt (cont'd)


0231EM

6. Fit the upper and lower timing covers to the engine and fix them with their bolts.

Cover bolts:
6 - 8 Nm (0.6 - 0.8 kgm; 4.4 - 5.9 ft lb)

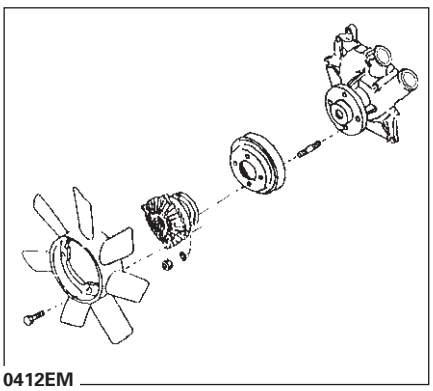

0230EM


0228EM

7. Fit the crankshaft pulley with the marks aligned and tighten the pulley stud.

Nut fixing pulley:
142 - 152 Nm (14.5 - 15.5 kgm; 104.7 - 112.1 ft lb)

See sections EF and EC for aligning the timing marks.


0412EM

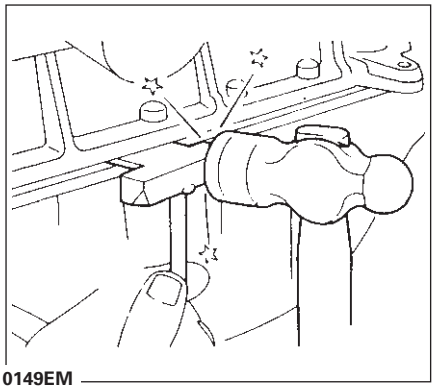
8. Fit the crankshaft pulley dust cover; replace it if it is damaged.

Nuts and bolts fixing viscous clutch and adapter to crankshaft pulley:
3 - 4 Nm (0.3 - 0.4 kgm; 2.2 - 3 ft lb)

9. Fit the fan to the viscous clutch.

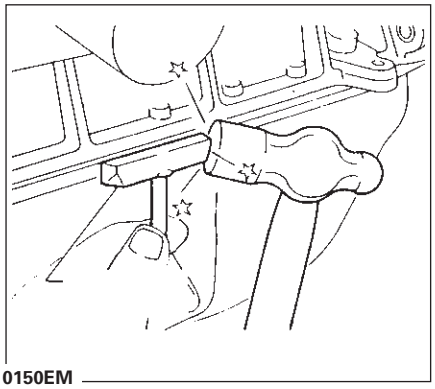
Bolts fixing fan to viscous clutch:
3 - 4 Nm (0.3 - 0.4 kgm; 2.2 - 3 ft lb)

1. Drain the engine oil.
2. Remove the oil dipstick tube.
3. Loosen and remove the bolts fixing the sump to the block.
4. Remove the sump. Move and pull the sump well. If it is difficult to release the sump from the block, proceed as follows:
   a) Insert the gasket cutter between the cylinder block and the oil sump.
      - **Do not damage the oil pump gasket with the cutter, nor the part of the seal of the rear oil gasket since this would damage the aluminium contact surfaces.**
      - **Do not insert a screwdriver or it will damage the oil sump stud.**



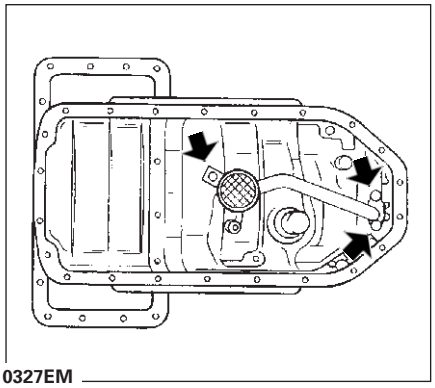
0149EM

   b) Slide the tool, tapping it sideways with a mallet, and remove the oil sump.



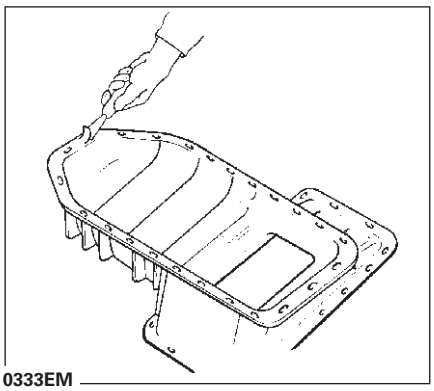
0150EM

5. Remove the inlet tube and filter.



0327EM

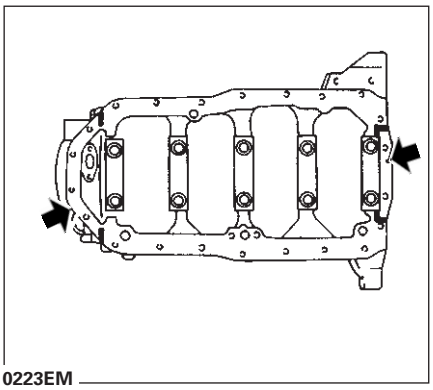
OIL SUMP - Fitting



0333EM

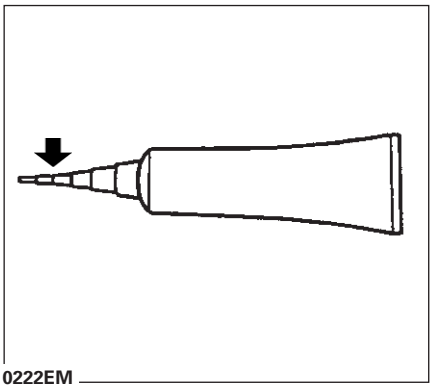
1. Before fitting the sump, remove all traces of the old sealant from the surface with a scraper.

   Also remove all traces of old sealant paste from the contact surface on the cylinder block.



0223EM

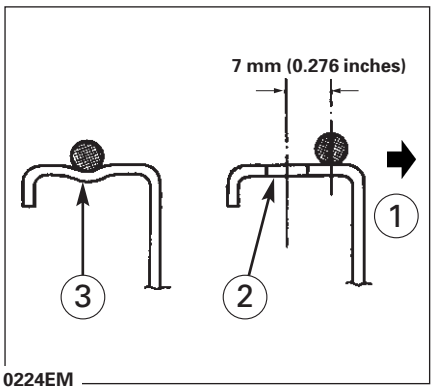
2. Apply sealant paste to the points shown in the figure.



0222EM

Ensure that the sealant paste is 4.0 to 4.5 mm (0.157 - 0.177 inches) wide.

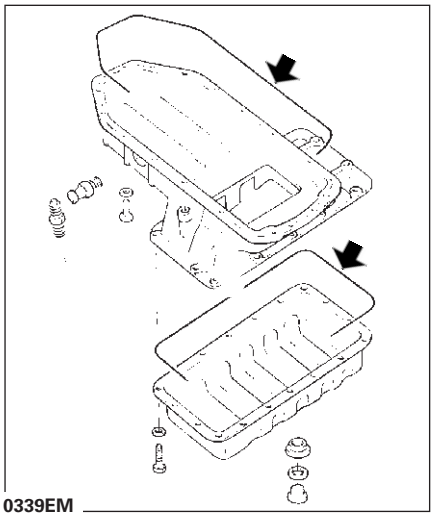
- **Cut the tube where shown to obtain approximately the required width of sealant paste.**
- **Use original sealant paste or its equivalent.**



0224EM

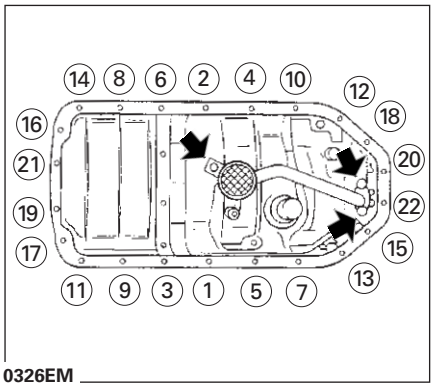
3. Apply the sealant paste to the internal contact surface, as shown in the figure.

1. Interior side
2. Stud orifice
3. Groove


0339EM

4. Apply a continuous line of sealant paste to the contact surfaces of the sump and adapter plate.

   Fitting must be carried out within 5 minutes of application.



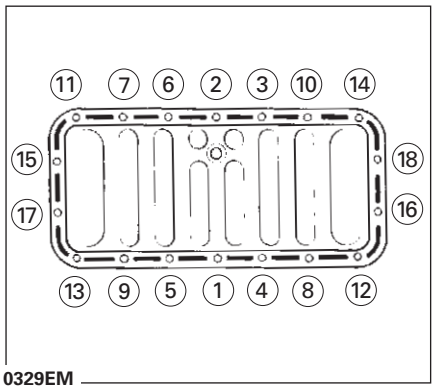
0326EM

5. Fit the adapter plate and breather pipe. Tighten the nuts in the order shown.

   Breather pipe bolts, pump side:
   16 - 21 Nm (1.6 - 2.1 kgm; 11.8 - 15.5 ft lb)

   Bolts on filter side (bracket):
   6 - 8 Nm (0.6 - 0.8 kgm; 4.4 - 5.9 ft lb)

   Bolts fixing adapter plate:
   6-8 Nm (0.6-0.8 kgm; 4.4-5.9 ft lb)



0329EM

6. Fit the sump and tighten the bolts in the order shown in the figure.

   Wait for at least 30 minutes before filling with engine oil.

   Sump bolts:
   6 - 8 Nm (0.6 - 0.8 kgm; 4.4 - 5.9 ft lb)

General features

Engine model		LD-23
Cylinder layout		Vertical in line
Capacity	cm^3 ($inches^3$)	2283 (139.31)
Bore x stroke	mm (inches)	86 x 96 (3.386 x 3.78)
Valve layout		OHC.
Ignition order		1-3-4-2 (Indirect)
Number of piston rings	Compression	2
	Oil	1
Number of crankshaft journals		5
Compression ratio		22.7 : 1

COMPRESSION PRESSURE

	Unit				Reading at rpm
	kPa	bar	kg/cm^2	psi	
Standard	3090	31.4	32	456	200
Minimum	2450	24.5	25	356	
Limit of difference between cylinders	4990	4.9	5	71	

Technical data

CYLINDER HEAD

Maximum permitted deformation in cylinder head surface

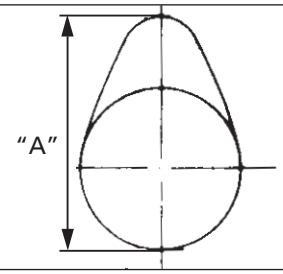
Unit: mm (inches)

Standard	Less than 0.05 (0.002)
Limit	0.1 (0.004)
Nominal height of cylinder head	89.4 - 89.6 (3.52 - 3.53)

Camshaft and camshaft bearings

Unit: mm (inches)

	Standard	Limit
Clearance between journal and bearing (lubrication clearance)	89.4 - 89.6 (3.52 - 3.53)	
Diameter of camshaft journal	47.949 - 47.962 (1.887 - 1.888)	0.1 (0.004)
Inner diameter of camshaft bearing	48 - 48.016 (1.888 - 1.890)	
Camshaft sag (Total gauge reading)	Less than 0.02 (0.001)	0.05 (0.002)

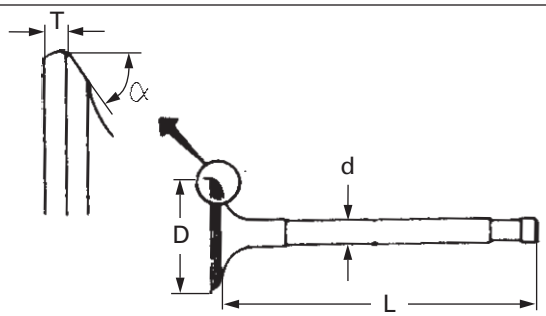


0145EM

Height "A" of the cam	inlet	39.95 - 40 (1.573 - 1.575)
	Exhaust	40.3 - 40.35 (1.587 - 1.588)

Valves

Unit: mm (inches)



0143EM

Diameter "D" of valve head	Inlet	41.4 - 41.6 (1.63 - 1.638)
	Exhaust	33.0 - 33.2 (1.299 - 1.307)
Length "L" of valve	Inlet	118.27 - 118.83 (4.656 - 4.678)
	Exhaust	117.33 - 117.77 (4.619 - 4.637)
Diameter "d" of valve stem	Inlet	7.965 - 7.980 (0.313 - 0.314)
	Exhaust	7.945 - 7.960 (0.312 - 0.313)
Angle " α " of valve seat	Inlet	53°±15′
	Exhaust	45°30′±15′
Valve grinding width "T"		0.5 (0.02)
Valve stem end grinding limit		0.5 (0.02)
Valve clearance (when hot)	Inlet	0.25 (0.01)
	Exhaust	0.3 (0.012)

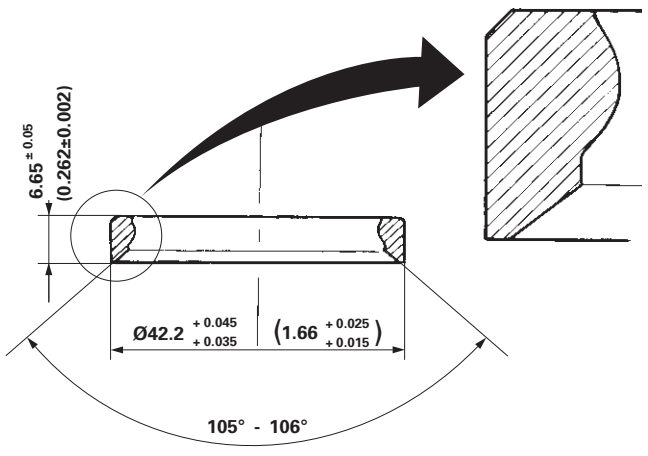
Valve guide

Unit: mm (inches)

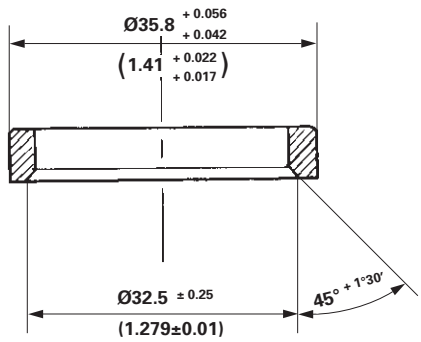
		Standard	Service
Valve guide outer diameter		12.023 - 12.034 (0.473 - 0.474)	12.223 - 12.234 (0.481 - 0.482)
Valve guide interior diameter (finished)		8 - 8.018 (0.315 - 0.316)	
Diameter of valve guide housing in cylinder block		11.985 - 11.996 (0.471 - 0.472)	12.185 - 12.196 (0.479 - 0.480)
		Standard	**Service**
Clearance between stem and guide in cylinder head	inlet	0.02 - 0.053 (0.001 - 0.002)	0.1 (0.004)
	Exhaust	0.04 - 0.073 (0.002 - 0.003)	
Allowable valve bending limit		0.1 (0.004)	

Valve spring

Free length	mm (inches)	51.5 (2.027)
Height when compressed	mm/N (mm/kg; inches/lb)	30.0/512 (30.0/52.3; 1.181/23.72)
Height when fitted/pressure	mm/N (mm/kg; inches/lb)	40/226 (40/23; 1.575/0.096)
Maximum permitted deformation of spring	mm (inches)	2.5 (0.098)



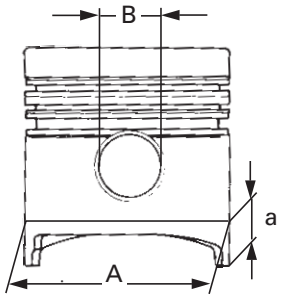
0290EM



0322EM

Pistons

Unit: mm (inches)



0151EM

		Standard	Limit
Diameter "A" of piston:	"A"	86.885 - 86.893 (3.420 - 3.421)	87.475 - 87.493 (3.443 - 3.445)
	"B"	86.893 - 86.901 (3.421 - 3.421)	
	"C"	86.901 - 86.909 (3.421 - 3.422)	
	"D"	86.909 - 86.917 (3.422 - 3.422)	
	"E"	86.917 - 86.925 (3.422 - 3.422)	
Dimension "a" from piston skirt		39.73 (1.564)	
Diameter "B" of gudgeon pin hole		26.003 - 26.008 (1.023 - 1.024)	

Piston ring

Unit: mm (inches)

		Standard	Limit
Natural clearance	Upper	0.09 - 0.122 (0.003 - 0.005)	0.2 (0.008)
	Second	0.04 - 0.072 (0.003 - 0.005)	0.15 (0.006)
	Lubrication	0.03 - 0.065 (0.003 - 0.005)	0.1 (0.004)
End gap	Upper	0.3 - 0.5 (0.012 - 0.02)	0.85 (0.033)
	Second	0.6 - 0.85 (0.024 - 0.033)	1.2 (0.047)
	Lubrication	0.25 - 0.5 (0.01 - 0.02)	0.85 (0.033)

Gudgeon pins

Unit: mm (inches)

	Standard	Limit
Diameter of gudgeon pin	25.995 - 26 (1.023 - 1.024)	
Clearance between piston pin and piston	0.003 - 0.013 (0.0001 - 0.0005)	
Clearance between piston pin and connecting rod	0.025 - 0.043 (0.001 - 0.002)	

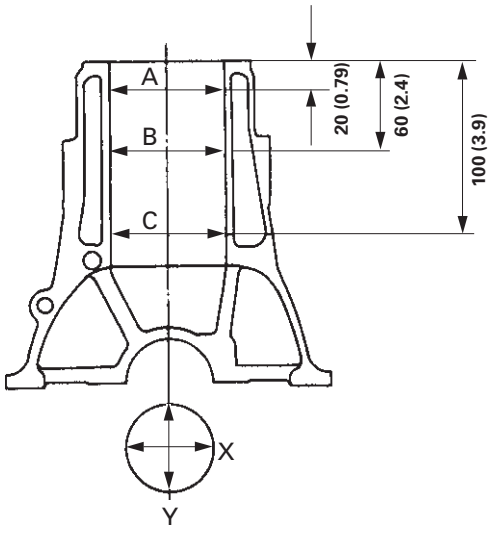
CONNECTING RODS

Unit: mm (inches)

	Standard	Limit
Bending permitted [for every 100 mm, 3.94 inches, of length]:	Less than 0.025 (0.001)	
Permitted twisting	Less than 0.025 (0.001)	
Inner diameter of connecting rod bearing	26.025 - 26.038 (1.024 - 1.025)	
Side clearance	—	0.6 (0.024)

CYLINDER BLOCK

Unit: mm (inches)

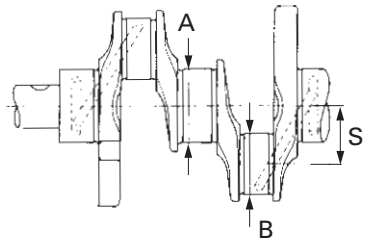


0301EM

		Standard	Limit
Flatness of block surface:		Less than 0.05 (0.002)	0.1 (0.004)
Cylinder bore	"A"	87 - 87.008 (3.425 - 3.426)	
	"B"	87.008 - 87.016 (3.426 - 3.426)	
	"C"	87.016 - 87.024 (3.426 - 3.426)	
Ovalling	(X -Y)	Less than 0.02 (0.001)	0.02 (0.001)
Coning	(A-B, A-C, B-C)	Less than 0.02 (0.001)	0.02 (0.001)
Clearance between piston and cylinder		0.107 - 0.123 (0.004 - 0.005)	
Extraction force of feeler gauge (with a 0.06 mm (0.002 inches) gauge)	N (kg, lb)	5.9 - 11.8 (0.6 - 1.2; 1.32 - 2.65)	
Inner diameter of main journal		66.657 - 66.667 (2.624 - 2.625)	

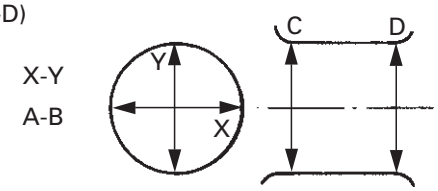
Crankshaft

Unit: mm (inches)



0146EM

Ovalling X-Y
Coning (C-D)



0155EM

	Standard	Limit
Diameter of main support journal "A"	62.943 - 62.956 (2.478 - 2.478)	
Diameter of crankpin "B"	62.943 - 62.956 (2.478 - 2.478)	
Distance "S"	46.00 (1.8054)	
Ovalling (X-Y)	Less than 0.01 (0.0004)	0.02 (0.0008)
Coning (C-D)	Less than 0.01 (0.0004)	0.02 (0.0008)
Crankshaft eccentricity	0 - 0.03 (0 - 0.0012)	0.1 (0.004)
Longitudinal play	0.06 - 0.25 (0.0023 - 0.01)	0.4 (0.0157)

MAIN BEARINGS

Permitted clearance of main bearings and big end bearings

Unit: mm (inches)

	Standard	Limit
Main bearing clearance	0.041 - 0.076 (0.0016 - 0.003)	0.12 (0.005)
Connecting rod bearing clearance	0.032 - 0.07 (0.0012 - 0.0027)	

Oversized main bearings available

Unit: mm (inches)

	Diameter of crankshaft journal
Standard	62.943 - 62.956 (2.478 - 2.479)
0.25 (0.01)	62.693 - 62.706 (2.4682 - 2.4687)
0.5 (0.02)	62.443 - 62.456 (2.4584 - 2.4589)

Oversized big end bearings available

Unit: mm (inches)

	Diameter of crankshaft journal
Standard	53.961 - 53.974 (2.1244 - 2.1250)
0.25 (0.01)	53.711 - 53.724 (2.1146 - 2.1151)
0.5 (0.02)	53.461 - 53.474 (2.1048 - 2.1053)

MISCELLANEOUS PARTS

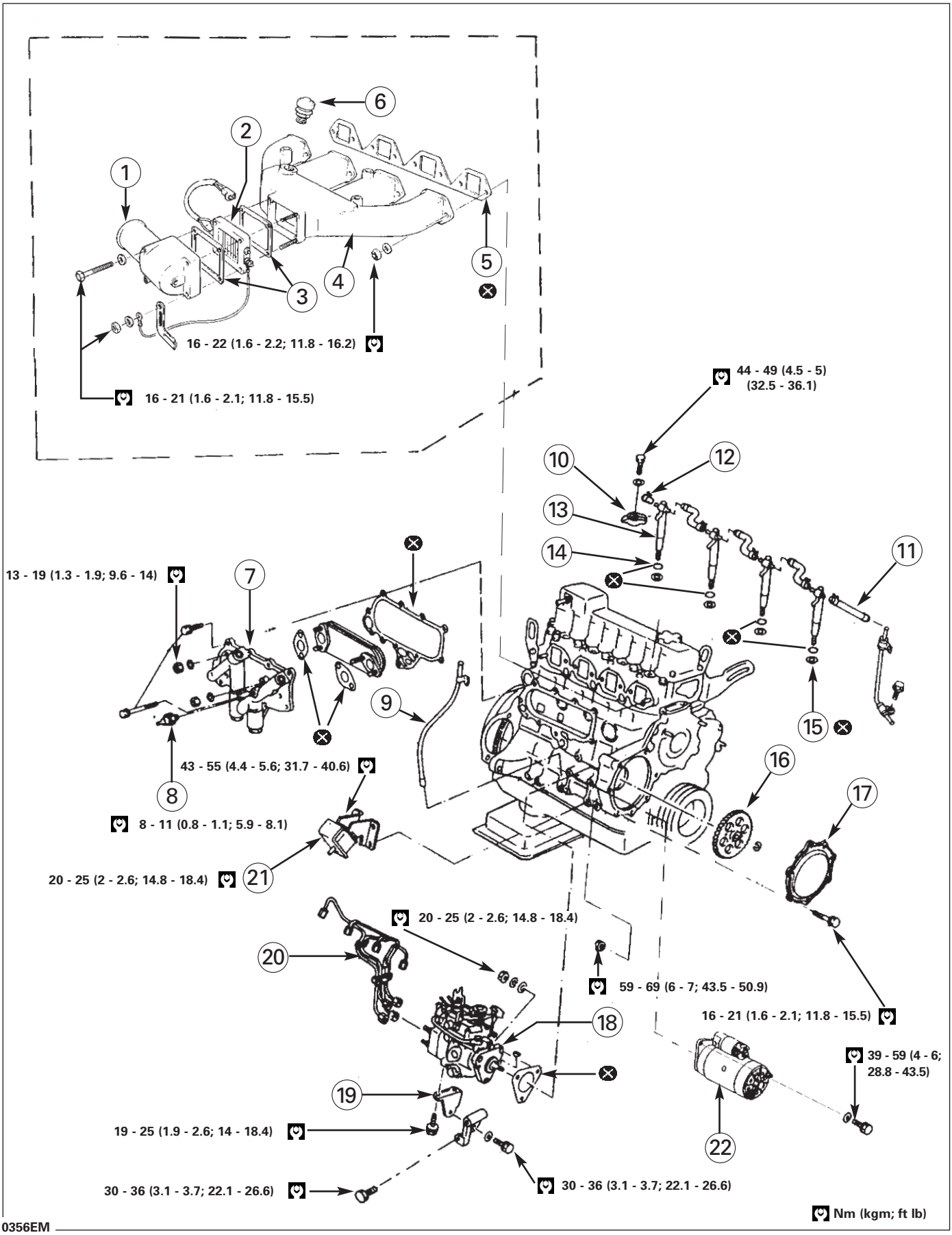
Unit: mm (inches)

Flywheel Warping (total compressor reading)	Less than 0.15 (0.006)

TIGHTENING TORQUES

COMPONENT		Nm	kgm	ft lbs
Injectors to cylinder head		60 - 70	6.1 - 7.1	44.3 - 51.6
Injection pipe to injector connectors		22 - 25	2.2 - 2.6	16.2 - 18.4
Injection pipe to injection pump connectors		22 - 24	2.2 - 2.4	16.2 - 17.7
Bolts fixing injection pump bracket to cylinder block:		20 - 25	2 - 3	14.8 - 18.4
Bolts fixing injection pump to bracket		29 - 39	3 - 4	21.4 - 28.8
Nuts and bolta fixing oil cooler		20 - 25	2.0 - 2.6	14.8 - 18.4
Bolts fixing engine transport slings:		16 - 21	1.6 - 2.1	11.8 - 15.5
Pre-heating glow plugs to cylinder block:		20 - 25	2.0 - 2.6	14.8 - 18.4
Nuts fixing connection plate to glow plugs		1 - 1.5	0.1 - 0.2	0.7 - 1.8
Bolts fixing timing cover:		6 - 8	0.6 - 0.8	4.4 - 5.9
Nut fixing the crankshaft pulley		142 - 152	14.5 - 15.5	104.7 - 112.1
Bolts fixing timing idler pulley:		44 - 54	4.5 - 5.5	32.5 - 39.8
Nuts fixing exhaust manifold:		16 - 21	1.6 - 2.1	11.8 - 15.5
Bolts fixing alternator to tensioning arch		16 - 21	1.6 - 2.1	11.8 - 15.5
Bolts fixing alternator to its bracket		44 - 59	4.5 - 6	32.5 - 43.5
Bolts fixing inlet manifold:		16 - 21	1.6 - 2.1	11.8 - 15.5
Bolts fixing rear cover		6 - 8	0.6 - 0.8	4.4 - 5.9
Nuts and bolts fixing thermostat cover:		16 - 21	1.6 - 2.1	11.8 - 15.5
Rocker cover bolts		7 - 9	0.7 - 0.9	5.2 - 6.6
Bolts fixing the injection pump bracket		30 - 40	3.1 - 4.1	22.1 - 29.5
Sequence for tightening bolts fixing cylinder head to cylinder block:	First step	100	10.2	73.8
	Second step	Tighten by 90°		
	Third step	Tighten another 90°		
	Resulting torque	157 - 206	16 - 21	115.8 - 151.9
Bolts fixing rocker shaft brackets		18 - 22	1.8 - 2.2	13.3 - 16.2
Nuts and bolts fixing viscous clutch to pulley:		3 - 4	0.3 - 0.4	2.2 - 3
Bolts fixing fan to viscous clutch		3 - 4	0.3 - 0.4	2.2 - 3
Bolts fixing engine bracket to cylinder block:		41 - 52	4.2 - 5.3	30.2 - 38.4
Nuts fixing front engine bracket to SilentBloc		26 - 32	2.7 - 3.3	19.2 - 23.6
Nuts fixing rear engine bracket to SilentBloc		13 - 18	1.3 - 1.8	9.6 - 13.3
Bolts fixing rear engine bracket to gearbox		60 - 68	6.1 - 6.9	44.3 - 50.2
Bolt fixing oil cooler hose		6 - 8	0.6 - 0.8	4.4 - 5.9
Bolts fixing water pump		16 - 21	1.6 - 2.1	11.8 - 15.5
Bolts fixing bearing caps		167 - 22	17 - 2.2	123.2 - 16.2
Nuts fixing connecting rod caps		52 - 58	5.3 - 5.9	38.4 - 42.8
Bolts fixing crankshaft flywheel		157 - 177	16.0 - 18.1	115.8 - 130.6
Nuts fixing oil jets		29 - 39	3 - 4	21.4 - 28.8
Bolts fixing rear seal bracket		6 - 8	0.6 - 0.8	4.4 - 5.9
Bolts blocking timing belt tensioner		32 - 40	3.3 - 4.1	23.6 - 29.5
Breather pipe bolts, pump side:		16 - 21	1.6 - 2.1	11.8 - 15.5
Breather pipe bolts, filter side (bracket):		6 - 8	0.6 - 0.8	4.4 - 5.9
Bolts fixing breather pipe adapter plate:		6 - 8	0.6 - 0.8	4.4 - 5.9
Bolts fixing oil sump to cylinder block:		6 - 8	0.6 - 0.8	4.4 - 5.9
Oil level sensor		16 - 21	1.6 - 2.1	11.8 - 15.5
Bolts fixing starter motor		39 - 54	4 - 5.5	28.8 - 39.8
Valve clearance adjuster lock nuts		49 - 59	5.0 - 6.0	36.1 - 43.5

Right side

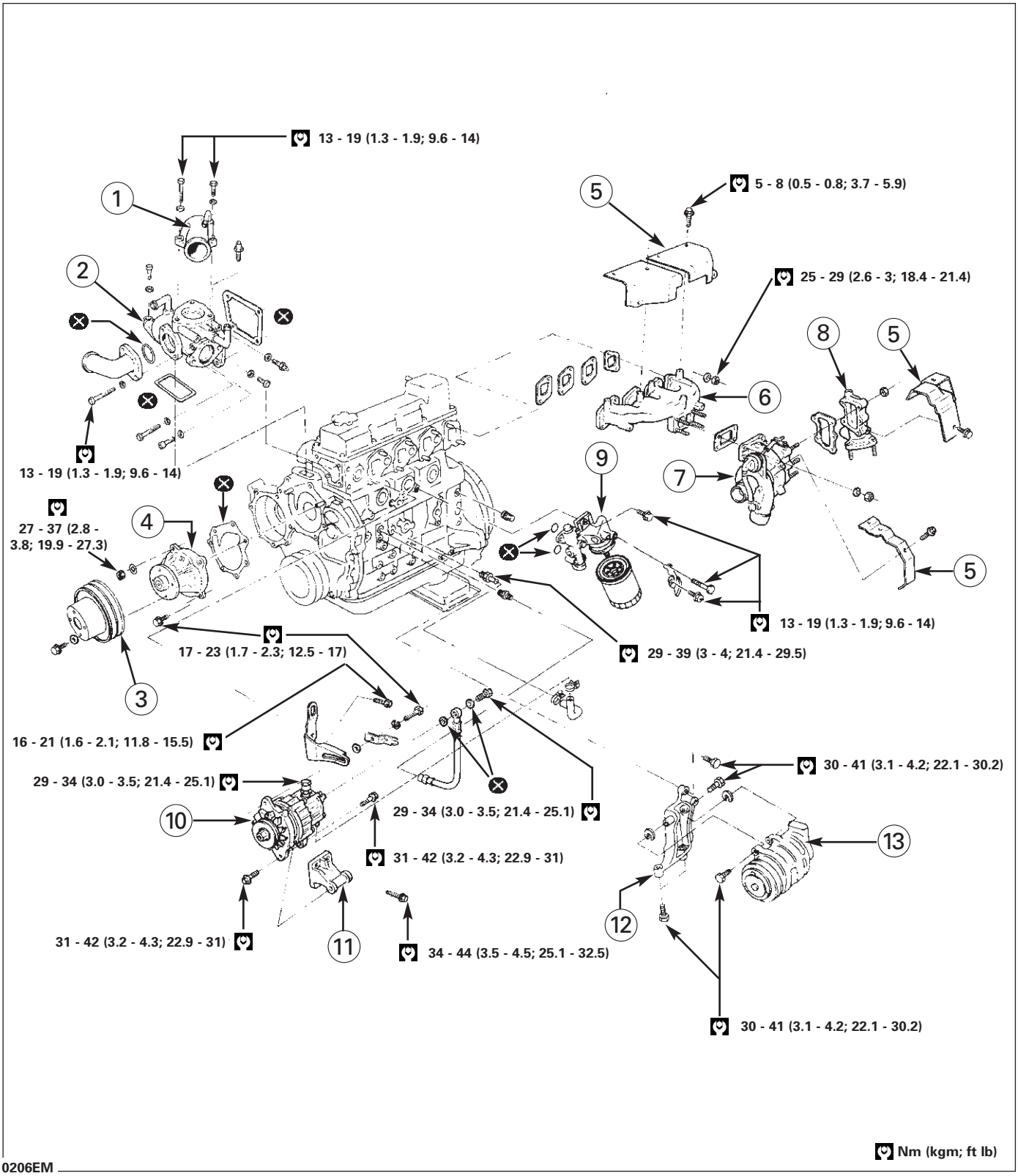


0356EM

Components

1. Metal pipe
2. Air heater
3. Gasket
4. Inlet manifold
5. Gasket
6. Discharge valve
7. Oil cooler
8. Oil pressure switch
9. Oil dipstick guide
10. Injector flange
11. Injector overflow pipe
12. Overflow pipe cap
13. Injector assembly
14. O-ring
15. Sealing washer
16. Injection pump drive gear
17. Injection pump gear cover
18. Injection pump
19. Injection pump brackets
20. Injection pipes
21. Elastic engine bracket
22. Starter motor

Left side

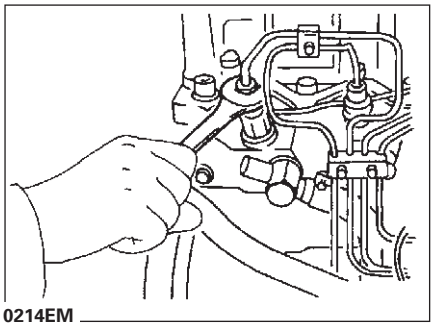


0206EM

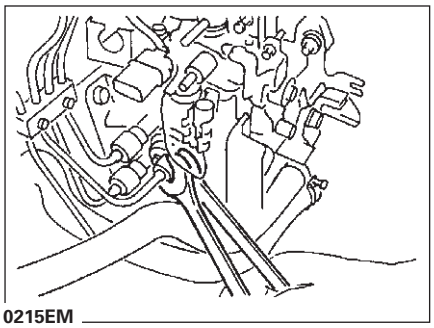
COMPONENTS

1. Water outlet hose
2. Thermostat box
3. Water pump pulley
4. Water pump
5. Protective plates
6. Exhaust manifold
7. Super Charger
8. Gas outlet duct
9. Oil filter and bracket
10. Alternator
11. Alternator bracket
12. Air conditioning compressor bracket
13. Air conditioning compressor

1. Start the engine and allow it to run until it reaches its normal operating temperature. Then stop it.
2. Disconnect the injection pipes on the injector end and just loosen them on the pump end. Remove the clamps from the injection pipes.
   - **Use two spanners to prevent the feed bracket on the side of the pump from coming off.**

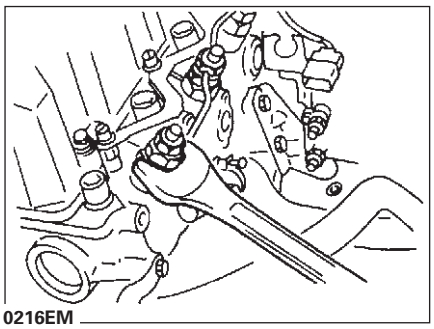


0214EM



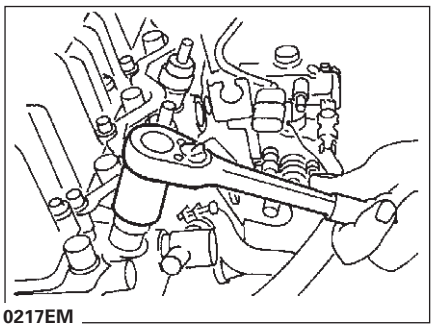
0215EM

3. Disconnect the return pipes.



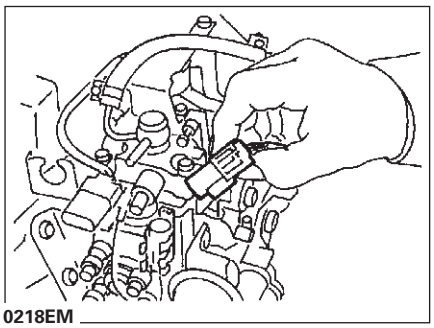
0216EM

4. Remove all the injectors using a suitable tool.



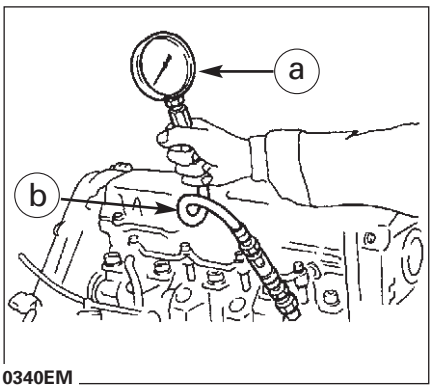
0217EM

5. Disconnect the connector on the fuel cut-off solenoid valve.



0218EM

CHECKING THE COMPRESSION PRESSURE



0340EM

6. Fit a pressure gauge (a) and adapter (b) suitable for measuring the compression pressure into the injector hole of the cylinder to be checked.

   Compression pressure gauge adapter for injector hole:
   15 - 20 Nm (1.5 – 2 kgm, 11.1 – 14.8 ft lb)

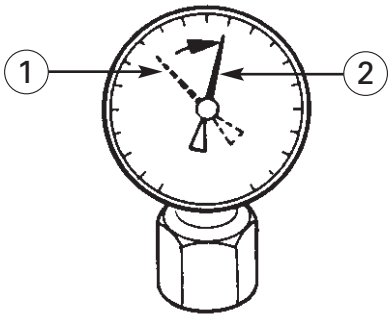
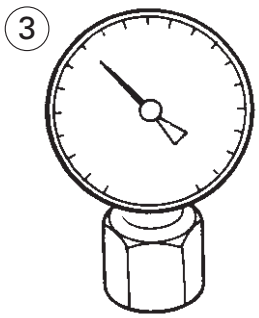
7. Start the engine and take a pressure reading
   - **Always use a fully-charged battery to obtain a correct reading.**
   - **The reading must be made as quickly as possible.**

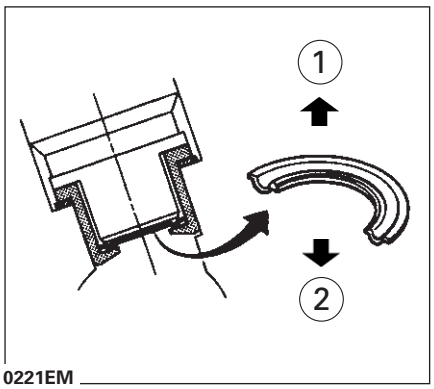
Compression pressure

	Unit				Reading at rpm
	kPa	bar	kg/cm^2	psi	
Standard	2942	29.42	30	427	
Minimum	2452	24.52	25	356	300

8. If the compression value in one or more cylinders is below the specified values, pour approximately 3 cc (0.026 Imp qt) of oil into the injector hole and repeat the reading.

   Refer the test results to the following table.

Pressure gauge reading during tests	Fault-finding
 0219EM	**1. First reading (Point 7)** **2. Second reading (Point 8)** • The rings are worn or damaged.
 0220EM	**3. Reading remains unaltered at points 7 and 8** • If the pressure in two adjacent cylinders is low, and adding oil does not cause the pressure to rise, there is a leak in the gasket between both cylinders. This problem may be caused by the presence of oil or water in the combustion chambers. • Valve seized • The seating contact surface of the valve is not correct.



0221EM

9. Change the gaskets on the injectors and re-fit the injectors.
   The new gaskets must be fitted as shown in the figure.

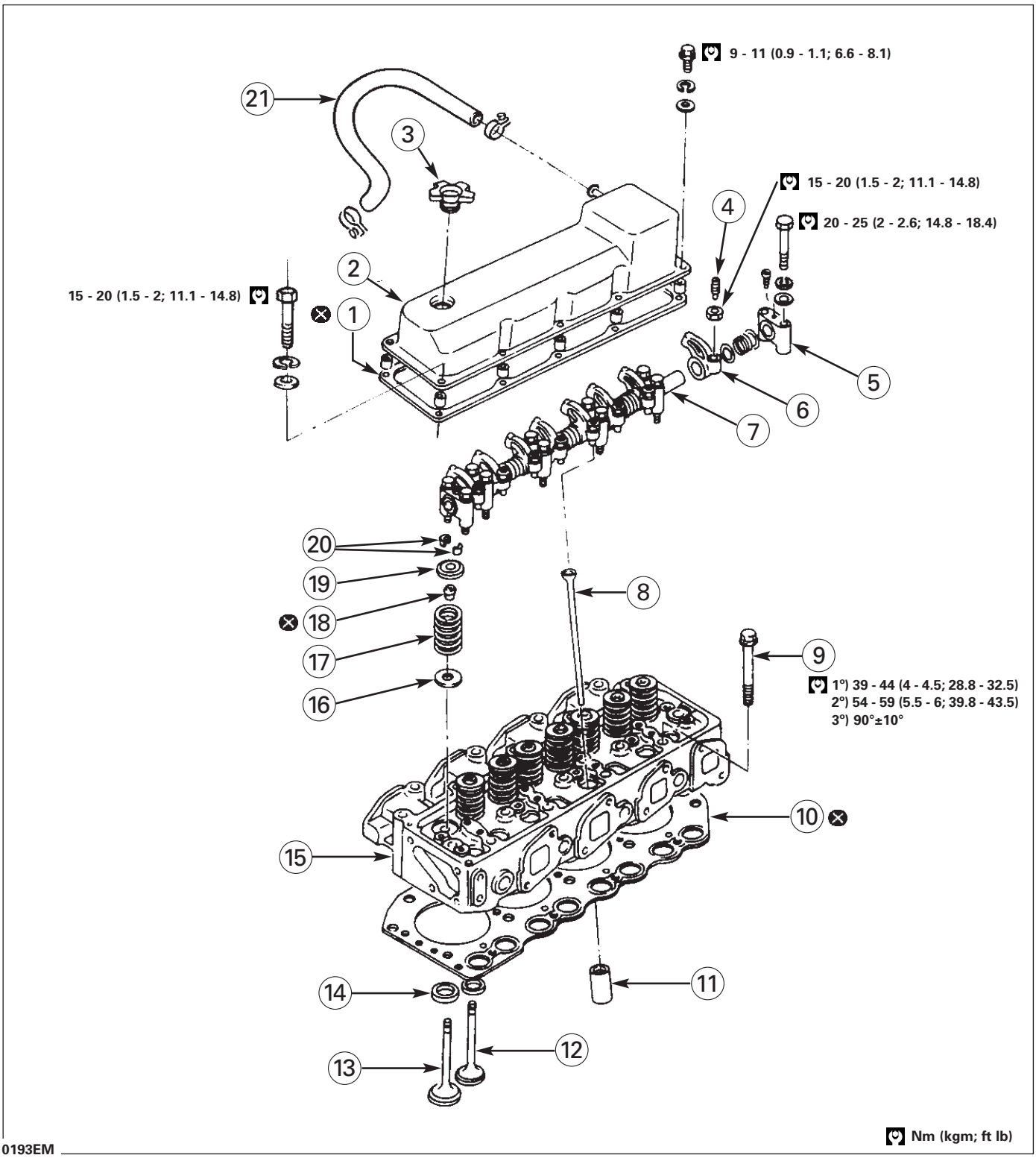
   Tighten the flanges fixing the injectors.
   44 - 49 Nm (4.5 - 5 kgm; 32.5 - 36.1 ft lb)

1. Injector side

2. Combustion chamber side

10. Fit the return and injection pipes.
    See “CYLINDER HEAD - Assembly - Injection pipes” in this section.

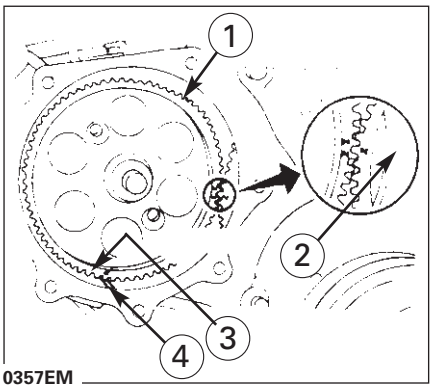
Exploded view



COMPONENTS

1. Rocker cover gasket
2. Rocker cover
3. Oil filler cap
4. Rocker adjustment screw
5. Rocker shaft bracket
6. Rocker
7. Rocker shaft
8. Push rod
9. Cylinder head bolt
10. Cylinder head gasket
11. Push rod
12. Inlet valve
13. Exhaust valve
14. Valve seat
15. Cylinder head
16. Spring seat
17. Valve spring
18. Valve oil seal
19. Spring cap
20. Split cones
21. Pipe for recycling gases to inlet manifold

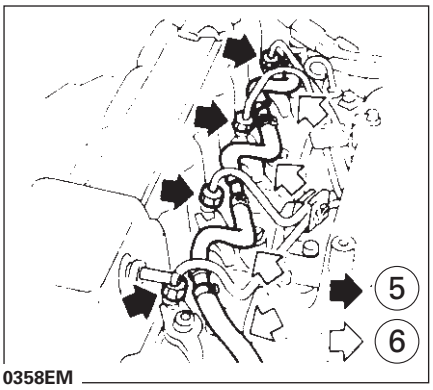
1. Place piston 1 at TDC of its compression stroke.
2. If the engine is in the vehicle.
   - Drain the water from the engine by removing the drain plugs on the block and radiator.
   - Remove the starter motor.
   - Remove the transmission shaft.
   - Remove the inlet manifold.
   - Remove the alternator.
   - Disconnect the radiator hoses.
   - Disconnect the fuel pipes.



0357EM

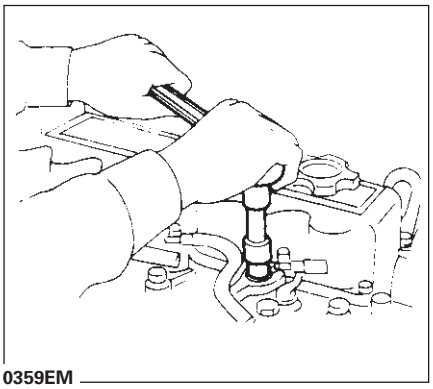
1. Injection pump gear
2. Idler gear
3. Point marked
4. Alignment marks

3. Remove the injection (5) and return pipes (6).



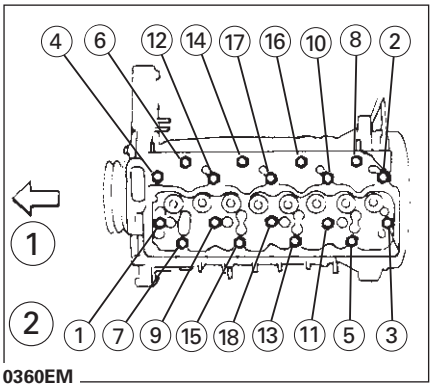
0358EM

4. Remove the injectors, and their O-rings and sealing washers.
5. Remove the rocker cover
6. Remove the rocker shaft assembly
7. Remove the pushrods


0359EM

8. Remove the bolts fixing the cylinder head in the order shown in the figure.
   Remove the cylinder head.
   - **If the bolts are removed in the incorrect order, the cylinder head may warp or crack.**
   - **The bolts must be loosened in two or three steps.**

   For the disassembly, inspection and fitting of the cylinder head, see the corresponding items in this section.



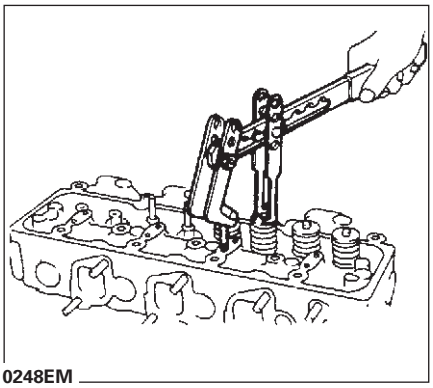
0360EM

1. Engine front
2. Loosen in numeric order.

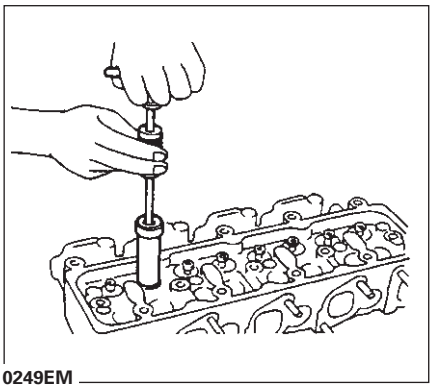
CYLINDER HEAD - Disassembly

- **See "CYLINDER HEAD - Removal" for the removal of the cylinder head**

1. Remove the pre-heating glow plugs bracket.
2. Remove the valve parts using a suitable tool.
   - **Keep each valve and its components together and mark them so that they can be re-fitted in their original positions.**

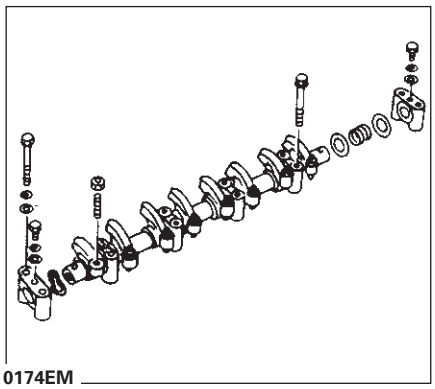


0248EM



0249EM

3. Remove the valve oil seals using a suitable tool.
   - **See "REPLACEMENT OF OIL SEALS" in this section.**

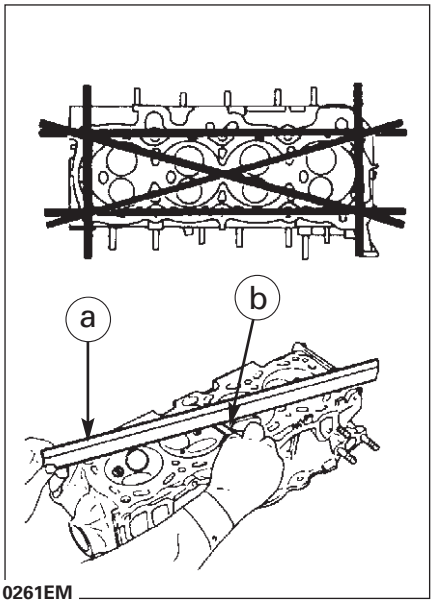


0174EM

4. Disassembly of rocker shaft
   a) Remove the bolts fixing the rocker shaft.
   b) Remove the rocker shaft and its supports.

   If the rocker shaft supports are difficult to remove, dip it in oil at 70°C (158°F) for a few minutes and then remove it.

Cylinder block distortion and wear



0261EM

1. Check visually for cracks or deformations.
2. Clean the surface of the cylinder head and measure the distortion with a flat, rigid ruler (a) and a feeler gauge (b). Make several measurements in different points as shown in the figure.

   Flatness of cylinder head surface:

   Less than 0.07 mm (0.003 inches)

   If it exceeds the specified limit, change the cylinder head or grind it flat.

   Grinding limit:

   The grinding limit for the cylinder head depends on the degree of grinding carried out to the cylinder block.

   When:

   "A" is the amount of grinding required for the cylinder head and "B" is the amount of grinding required for the cylinder block; the maximum limit is calculated as follows:

   A+B = 0.07 mm (0.003 inches)

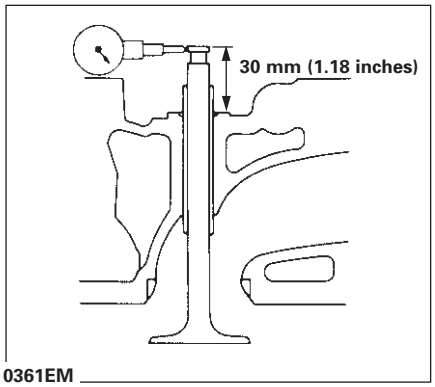
   - **After grinding, check that the camshaft turns freely by hand. If any resistance is felt, the cylinder head must be replaced.**

     Nominal height of cylinder head:

     89.6 - 89.8 mm (3.527 - 3.535 inches)

Valves

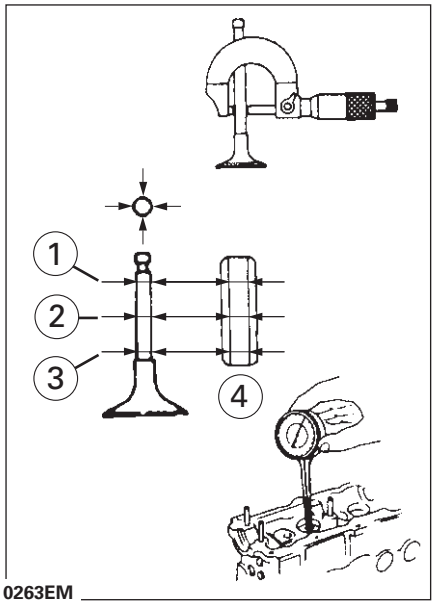
VALVE GUIDE CLEARANCE



0361EM

1. The valve guide clearance must be measured parallel to the rocker arm. (Generally there is much wear in this direction.)

   Clearance between stem and guide
   Limit:
   Inlet: 0.15 mm (0.006 inches)
   Exhaust: 0.2 mm (0.008 inches)
   Maximum permitted deviation:
   (Gauge reading)
   Inlet: 0.3 mm (0.012 inches)
   Exhaust: 0.04 mm (0.016 inches)



0263EM

2. If the limit is exceeded, check the clearance between the valve and its guide.
   a) Measure the diameter of the valve stem and the inner diameter of the valve guide, as shown in the figure.
   b) Check that the clearance is within specifications.

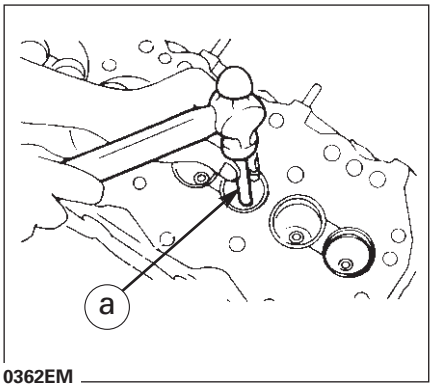
      Limit of clearance between valve stem and guide:
      Inlet: 0.15 mm (0.006 inches)
      Exhaust: 0.2 mm (0.008 inches)

   c) If the limit is exceeded, replace the valve or valve guide.

1. Upper part
2. Centre
3. Lower part
4. Valve guide

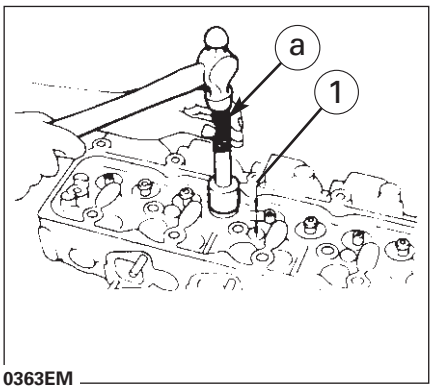
Valves (Cont'd)

REPLACEMENT OF VALVE GUIDE



0362EM

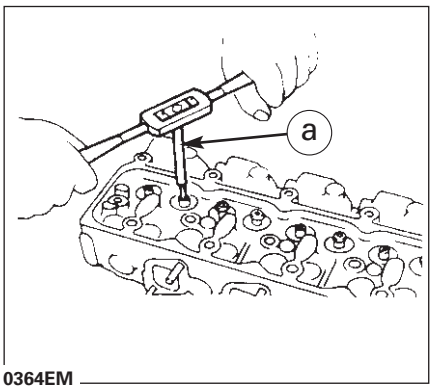
1. Remove the valve guide in a press at a pressure of 20 kN (2 t) or with a hammer and suitable tool (a).



0363EM

2. For servicing, insert the valve guide in the cylinder head using a suitable tool (a) until the guide stands out by 13 mm (0.512 inches).

1. Guide projection 13 mm (0.512 inches)

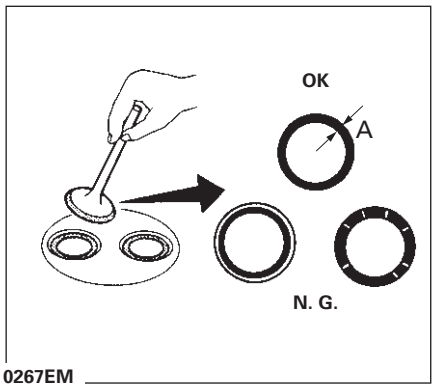


0364EM

3. Ream the valve guide using a suitable tool (a).

Finished diameter
8.000 - 8.015 mm (0.315 - 0.316 inches)

VALVE SEATS



0267EM

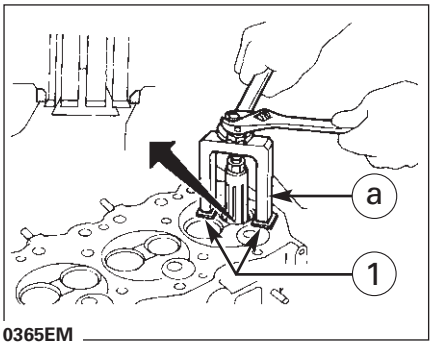
1. Check that the valve seats have no pitting on the contact surface with the valve. Grind or change them if the wear is excessive. Grind the valve seat.
   - **When repairing a valve seat, first check the wear of the valve and valve guide. If they are worn, replace them. Then grind the seat.**
2. Check the contact of the valve with its seat. Cover the valve with marking compound. If the contact is not correct, grind the valve seat. If the mark of the valve appears through 360 of the face, the stem and valve are concentric.

   Otherwise, grind or change the valve.

   A. Width of contact valve seat/guide = 2.1 mm (0.083 inches)

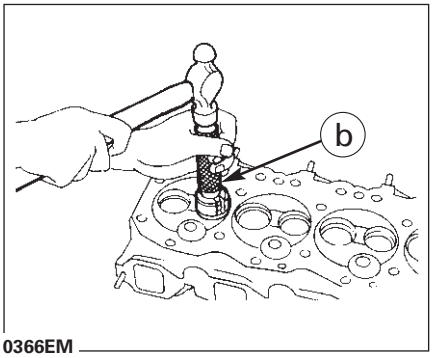
Valves (Cont'd)

REPLACEMENT OF VALVE SEATS



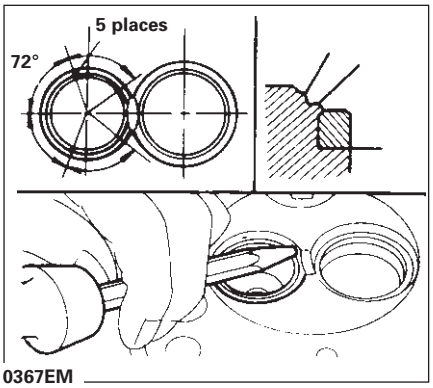
0365EM

1. Drill out the old seats until they break off or remove them with the special tool (a).
   - **Fit a copper seat (1) between the contact area of the tool and the cylinder head.**



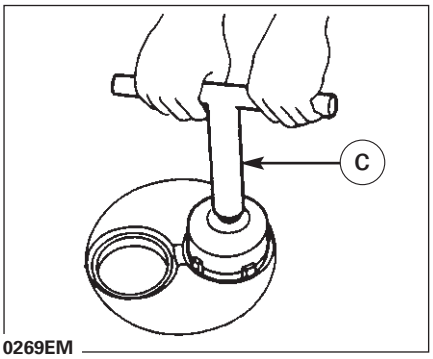
0366EM

2. Place the valve seats in dry ice and allow them to cool for five minutes.
   - **Do not touch the cold seats with the hand.**
3. Heat the cylinder head to 80°C (176°F)
4. Fit the new, previously-cooled seats into their housings in the cylinder head, using a suitable tool (b).



0367EM

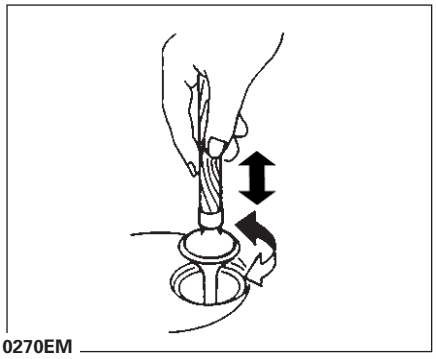
5. Fit the seat into the cylinder head, pressing it at five points (equidistant, at approx. 72°), using a suitable punch.
   - **When using the punch to fit the valve seat in the cylinder head, choose five points other than those used previously.**



0269EM

6. Mill or grind the valve seat using a suitable tool (c) with the dimensions specified in "TECHNICAL DATA AND CHARACTERISTICS".

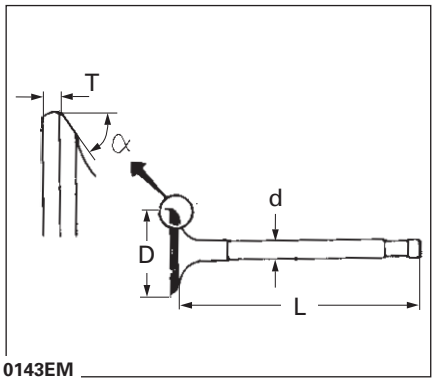
   The cut must be made with both hands to ensure a uniform and concentric finish.


0270EM

7. Apply a small amount of fine emery compound to the valve's contact surface in its guide.
   - **Grind the valve in its seat until it seats correctly.**
   - **Remove the valve and clean both the valve and its seat.**
8. Check that the valves seat correctly in their housings.

Valves (cont'd)

VALVE DIMENSIONS

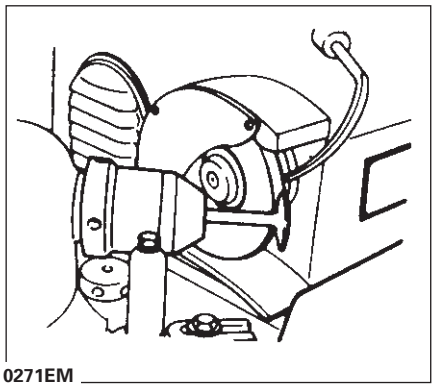


0143EM

1. Check the dimensions of each valve according to those stated in "CHARACTERISTICS AND TECHNICAL DATA"
2. Correct or change any defective valve.

   When the thickness "T" of the valve head has worn to within 1 mm (0.039 inches), replace the valve.

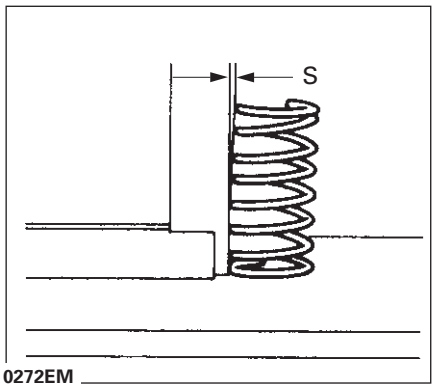
T. (thickness margin)


0271EM

3. The face of the valve or the surface of the end of the valve stem must be ground using a manual grinder.

The permitted grinding limit for the end of the stem is 0.2 mm (0.008 inches) or less.

STRAIGHTNESS OF VALVE SPRINGS



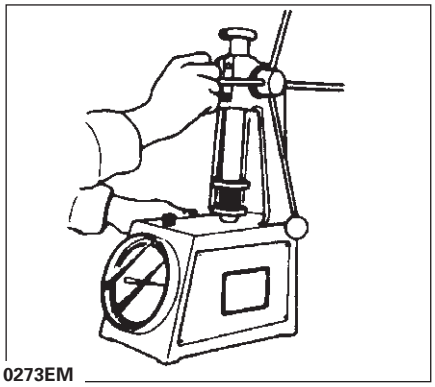
0272EM

Check the straightness of the valve springs using a steel set square and a flat surface.

If the deformation S of the spring exceeds the specified limit, change it for a new one.

Maximum permitted straightness defect:
Less than 2.5 mm (0.098 inches)

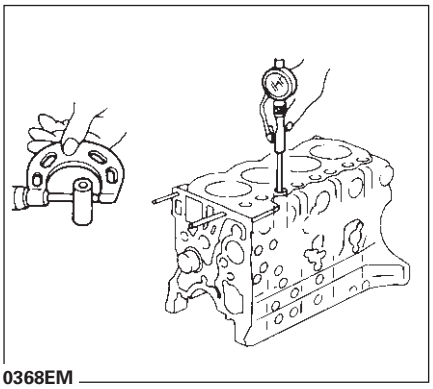
VALVE SPRING LOAD PRESSURE


0273EM

Measure the free length and pressure of each spring. If the value exceeds the specified limit, change the spring. See "TECHNICAL DATA AND CHARACTERISTICS".

Tappets and pushrods

PUSHRODS


0368EM

1. Check the faces of the pushrods for excessive wear.
2. Replace them with new ones if they are worn beyond repair.

a. The end of the pushrod must be smooth.

b. Clearance between pushrod and its hole

Normal: 0.03 - 0.073 mm (0.0012 - 0.003 inches)
Limit: Less than 0.2 mm (0.008 inches)

Outer diameterof pushrod "A":
Normal: 25.96 - 25.97 mm (1.022 - 1.023 inches)

Diameter of pushrod hole in cylinder head:
Normal: 26 - 26.033 mm (1.023 - 1.025 inches)

PUSHRODS

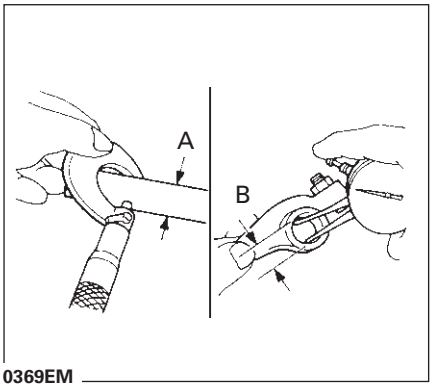
1. Inspect the pushrods for excessive wear on their faces.
2. Check the faces of the pushrods for excessive wear.
3. Check whether the pushrods are curved, using a dial gauge.

Maximum permitted curvature

(Total gauge reading):
Less than 0.3 mm (0.012 inches)

Limit: 0.5 mm (0.02 inches)

Rocker shaft and rockers



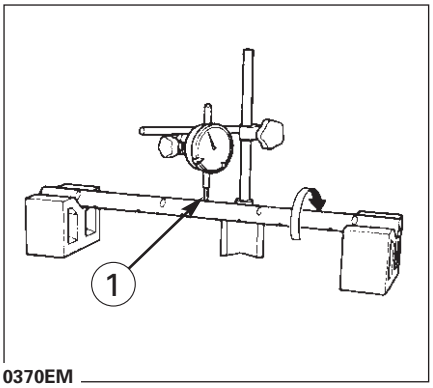
0369EM

1. Check the rockers, supports and shaft for dents, wear or deformation. Replace them if necessary.
2. Check the clearance between rockers and shaft. If it exceeds the specified value, replace the rockers or the shaft.

Specified clearance:
0.014 - 0.056 mm (0.0005 - 0.0022 inches)
Limit: Less than 0.15 mm (0.006 inches)

External diameter of rocker shaft "A"
Normal: 19.979 - 20 mm (0.786 - 0.787 inches)

Inner diameter of rocker shaft "B"
Normal: = 20.014 - 20.035 mm (0.788 - 0.789 inches)

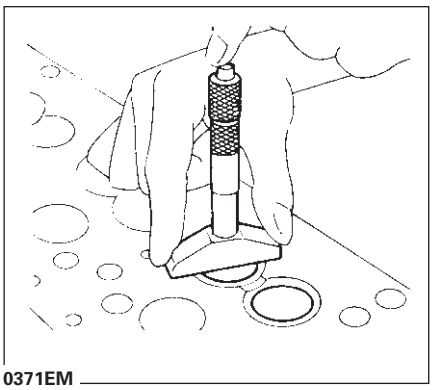


0370EM

3. Check the centre of the rocker shaft for curvature. If the curvature is within the specified limit, straighten it; otherwise, replace it.

Rocker shaft curvature

(Total gauge reading):
Limit: Less than 0.3 mm (0.012 inches)

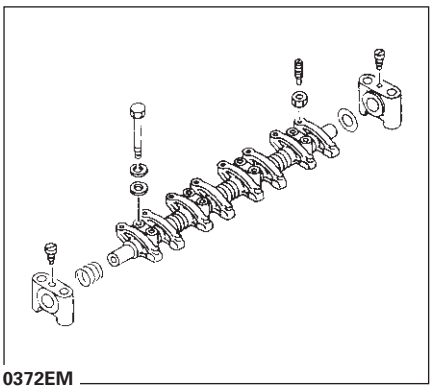

0371EM

Measuring the distance between the cylinder head and the valves

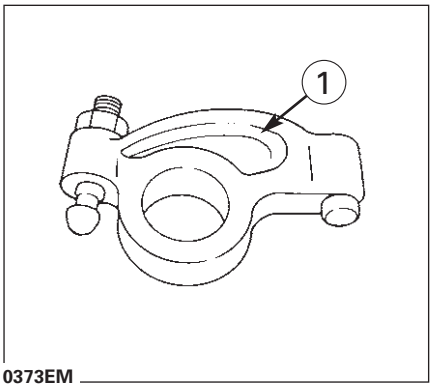
Measure the distance between the surface of the cylinder head and the inlet and exhaust valves. If it exceeds the specified distance, replace the valve(s) or seat(s).

Specified distance:

Standard	**Inlet: 1 ± 0.2 mm (0.039±0.008 inches)** **Exhaust: 1 ± 0.2 mm (0.039±0.008 inches)**
Limit	**Less than 1.25 mm (0.049 inches) for inlet and exhaust valves.**


0372EM

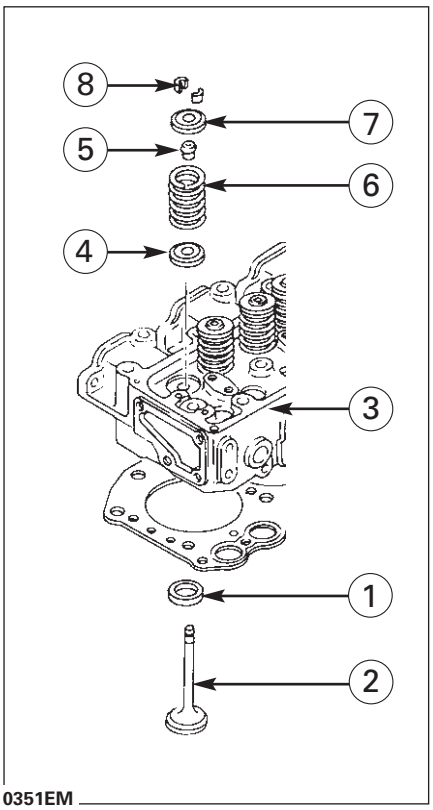
1. Assemble the rocker shaft



0373EM

• **Rocker identification.**

(1) Identification mark (on the rocker)	Work with the valve of:
B	Inlet
C	Exhaust



0351EM

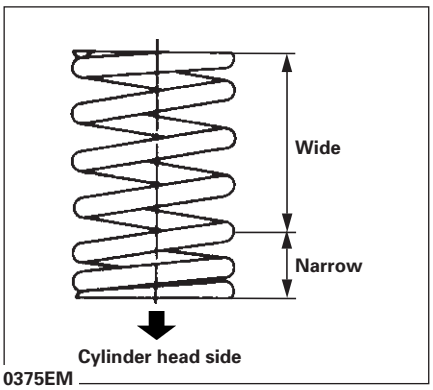
2. Assemble the valve components as follows:
   a) Insert the valve guides and the valve seat (1) in their housings in the cylinder head.

   See "CYLINDER HEAD - Inspection - Replacement of valve seat" in this section.

   b) Fit the valve (2) into its housing.
      • **Take care not to swap the inlet and exhaust valves around.**
      • **Before fitting the valve, oil it with new engine oil.**
   c) Turn the cylinder head through 180° (3).
   d) Fit the spring seat (4).
   e) Fit the oil seal (5).

      See "REPLACEMENT OF OIL SEALS - Valve oil seals" in this section.

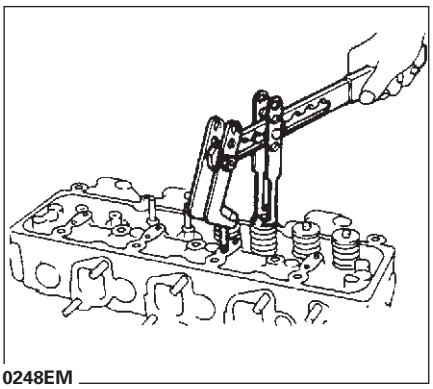
      • **Always use a new oil seal.**



0375EM

f) Fit the valve spring (6)

Fit the valve spring with its narrow side facing the interior of the cylinder head.


0248EM

g) Fit the spring cap (7).

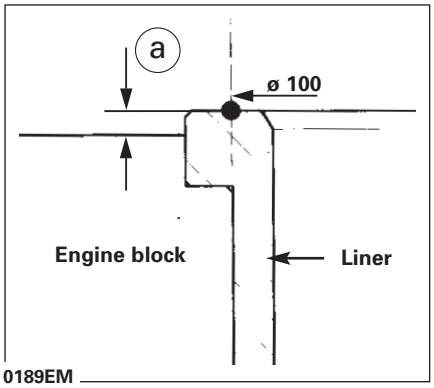
h) Press the spring with a suitable tool.

i) Fit the split cones (8) and release the pressure on the spring.

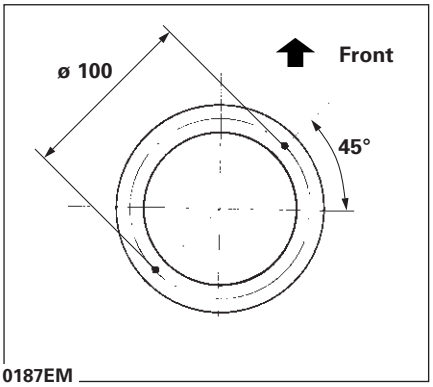
3. Fit the cylinder head onto the engine block.
   See “CYLINDER HEAD - Assembly” in this section.

Cylinder head gasket

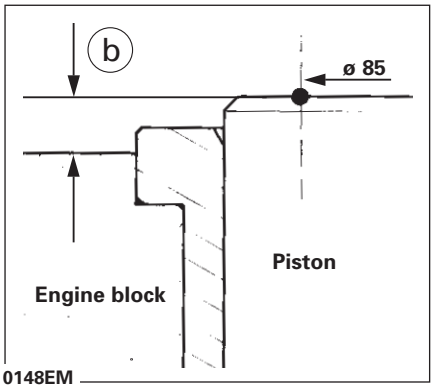
SELECTION OF CYLINDER HEAD GASKET.



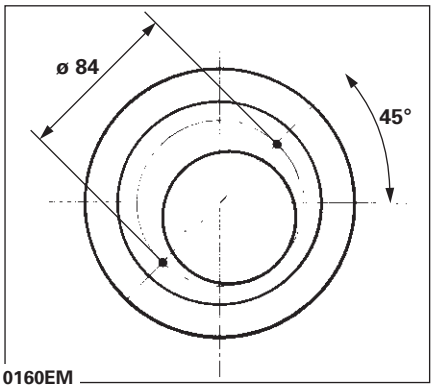
0189EM



0187EM



0148EM



0160EM

- **IMPORTANT NOTE: In the following process, all measurements must be made in millimetres, never in inches.**

NOTE: Scrap the disassembled cylinder head gasket. Fit a new one with each disassembly.

1. Measure the distance "a" (the difference in height between the upper face of the lining and the cylinder block) for piston 1. This measurement must be made at two points on the lining, as shown in the figure.

2. With piston 1 at TDC, measure the distance "b" (difference in height between the piston at TDC and the upper face of the engine block). This measurement must be made at two points on the lining, as shown in the figure.

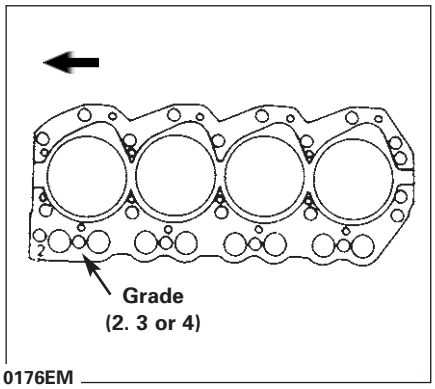
3. Calculate the average measurement of the four taken in points 1 and 2. by adding the two "b" measurements and then adding the two "a" measurements and dividing each by two. The difference between both values, distance H, is the value for piston 1.

$$\frac{(b1)+(b2)}{2} - \frac{(a1)+(a2)}{2} = H$$

4. Repeat points 1, 2 and 3 for the other pistons.

Cylinder head gasket

Selection of cylinder head gasket



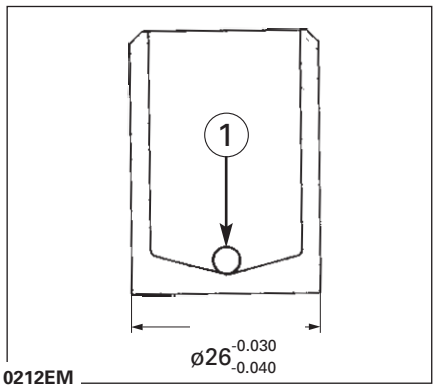
0176EM

5. Take the largest of the calculated H dimensions and use the following table to select the cylinder head gasket.

Unit: mm

Maximum value of H	Gasket to use	
	Grade	Thickness
<0.44	2	1.2
0.44 - 0.49	3	1.25
>0.49	4	1.3

NOTE: The grade of each cylinder head gasket is marked on it. Place the side with this marking upward.

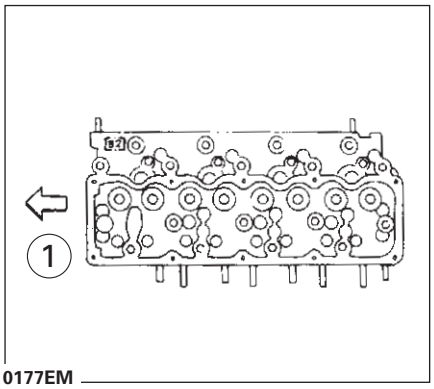


0212EM

6. Apply oil and place the push rods in their housings

1. Lubrication holes (2)

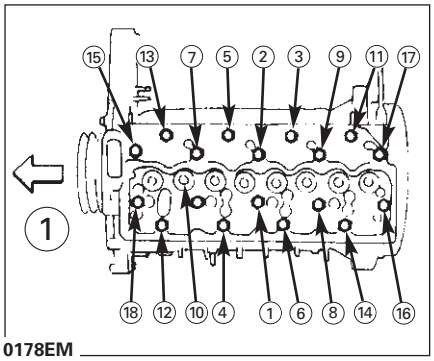
Fitting the cylinder head assembly into the cylinder block



0177EM

1. Place the cylinder head onto the cylinder block with the selected head gasket.
   - **Check that piston 1 is at TDC on its compression stroke.**
   - **The cylinder head bolts must not be used more than three times. Replace them in case of doubt.**

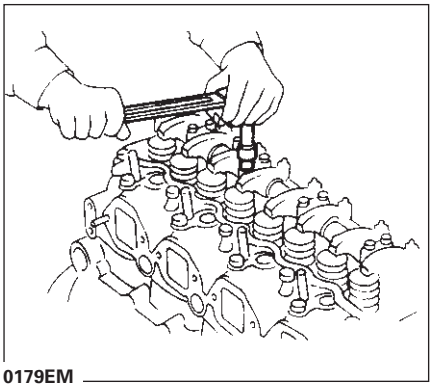
1. Front part



0178EM

2. Tighten the cylinder head bolts as shown in the figure and following the "Cylinder head bolts tightening procedure" in point 3 below.

1. Front part



0179EM

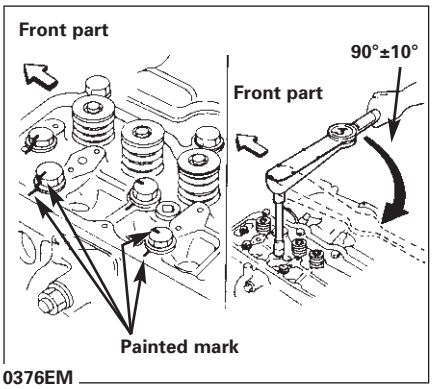
3. Procedure for tightening the cylinder head bolts.

   Lubricate the bolt threads and seating surfaces of the bolt heads with clean engine oil.

   Tighten the bolts progressively in the following steps.

   a) Tighten to: 39 - 44 Nm (4 - 4.5 kgm; 28.8 - 32.5 ft lb)

   b) Tighten to: 54 - 59 Nm (5.5 - 6 kgm; 39.8 - 43.5 ft lb)



0376EM

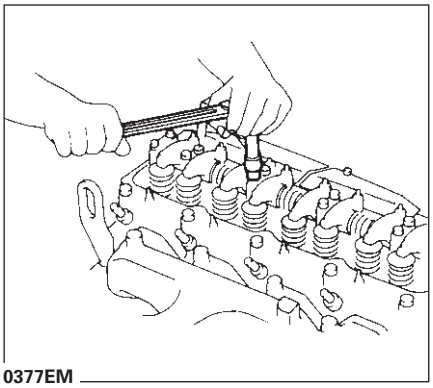
   c) Mark the heads of the bolts and their supporting point on the cylinder head so that both marks align and are facing the exhaust manifold. See the figure.

   d) Turn all the bolts in the above order by 90°±10° clockwise

   e) Check that the marks painted on each bolt faces to the vehicle's front.

NOTE: Check that all the bolts are tightened to 127 - 157 Nm (13 - 16 kgm; 93.7 - 115.8 ft lb) and if not, all the cylinder head bolts must be loosened, in the reverse order for tightening, and re-tightened in the tightening order. If, after this second attempt, tightening faults are still present, all components - bolts, threads, etc - must be checked and any faulty ones rejected.

Fitting the cylinder head assembly into the cylinder block (cont'd).

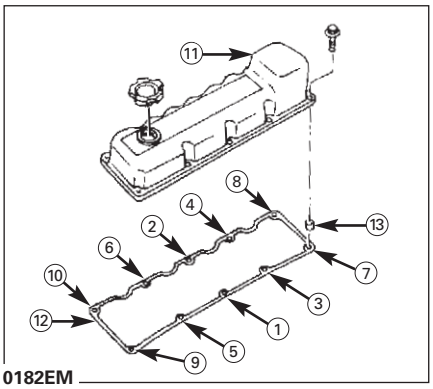


0377EM

4. Apply clean engine oil and fit the pushrods.
5. Fit the rocker shaft.

Bolts fixing rocker shaft support:
20 - 25 Nm (2 - 2.6 kgm; 14.8 - 18.4 ft lb)

6. Temporarily adjust the inlet and exhaust valve clearances.
See section MA for adjustment.



0182EM

7. Fit the rocker cover (11) with a new gasket (12) and spacers (13).

NOTE: Never forget any spacer; the lack of one of these may cause oil leaks .

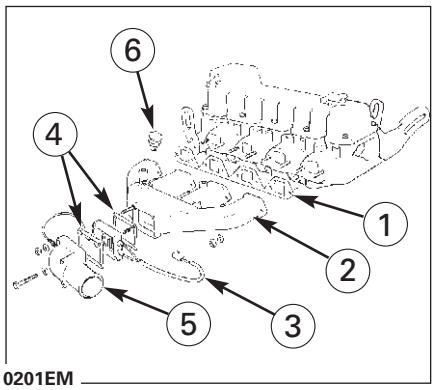
Tighten the rocker cover bolts in the order shown in the figure.

Rocker cover bolts (except bolt 9):
9 - 11 Nm (0.9 - 1.1 kgm; 6.6 - 8.1 ft lb)

Bolt 9:
15 - 20 Nm (1.5 - 2 kgm; 11.1 - 14.8 ft lb)

Manifolds

FITTING THE INLET MANIFOLD.



0201EM

1. Thoroughly clean the seating face of the manifold on the cylinder head.
   - **Fit a new gasket every time the manifold is removed.**
2. Fit the gasket (1) and fit the manifold (2) in place.
   Fit and tighten the nuts and bolts fixing the inlet manifold:

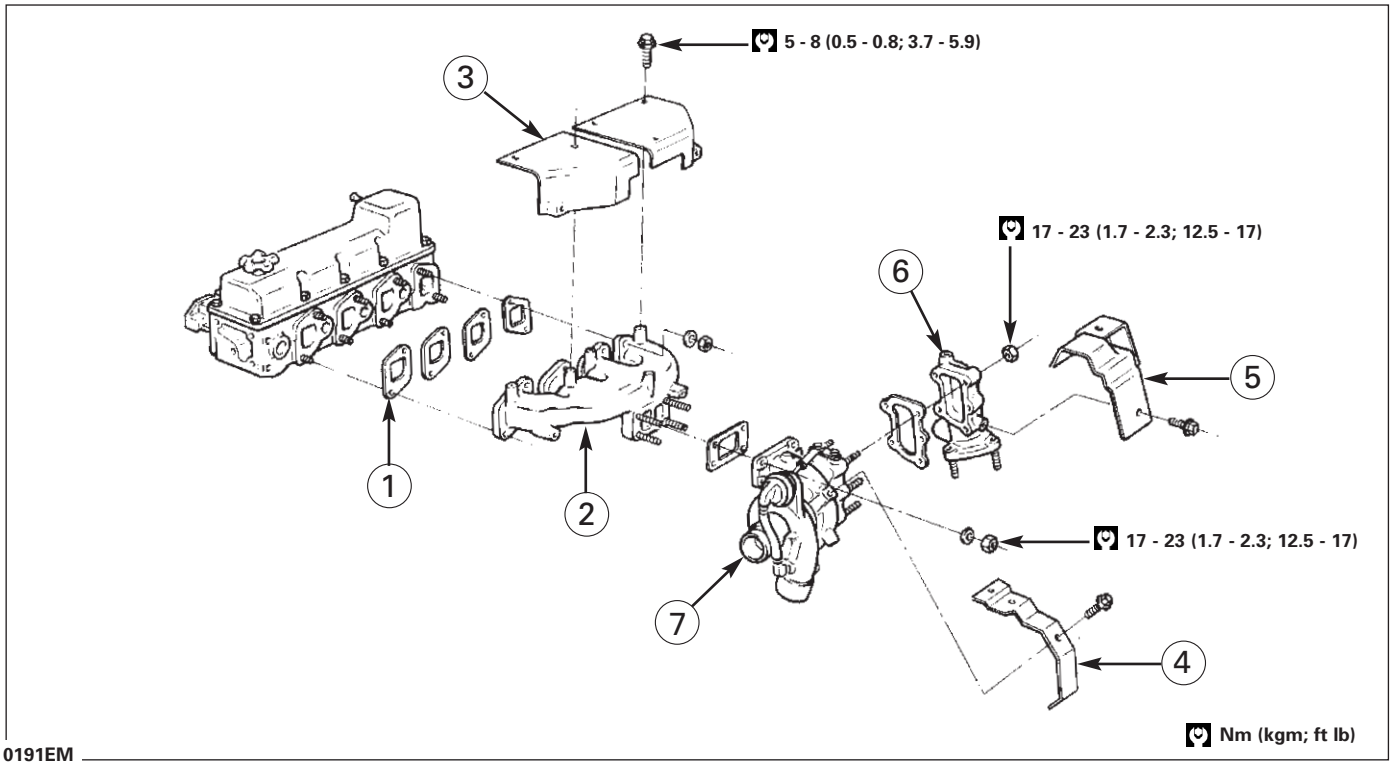
   Bolts and nuts fixing inlet manifold:
   16 - 22 Nm (1.6 - 2.2 kgm; 11.8 - 16.2 ft lb)
3. Clean the seating face of the air heater (3).
   Fit a new gasket (4) and fit the heater in its correct position.
   Fit a new gasket (4) and fit the air inlet manifold (5) in place.
   Fit and tighten the nuts and bolts fixing the inlet manifold:

   Bolts and nuts fixing heater to inlet manifold:
   16 - 21 Nm (1.6 - 2.1 kgm; 11.8 - 15.5 ft lb)
4. Connect the heater connector (3) to the electrical system.
5. Fit the discharge valve (6). Apply Teflon liquid.
   This valve prevents over-pressure in the engine air inlet. The valve must open at the following pressure:

   Inlet manifold air discharge valve opening pressure (with an air flow of 20 l/min): 92 - 106 kPa (0.92 - 1.06 bar; 0.94 - 1.08 kg/cm^2; 13.34 - 15.37 psi).

Manifolds (Cont'd)

FITTING THE EXHAUST MANIFOLD



0191EM

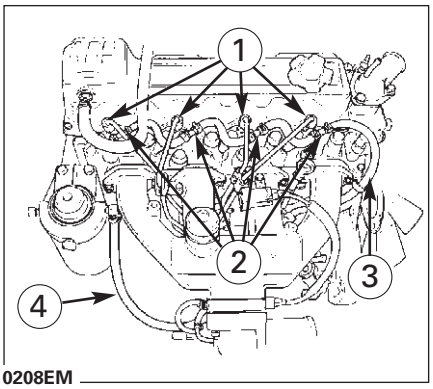
1. Gaskets between exhaust manifold and cylinder head
2. Exhaust manifold
3. Protective plate on exhaust manifold.
4. Protective plate on turbo-charger
5. Protective plate on gas outlet
6. Gas outlet connection
7. Super-charger

1. Thoroughly clean the seating face of the exhaust manifold on the cylinder head.
   - **Fit a new gasket every time the manifold is removed.**
   - **The gaskets are all the same but each must be fitted in a specific position. As the figure shows, the gasket for cylinder 4 must be rotated by 180° with respect to the others.**
2. Fit a new set of gaskets (1) and fit the manifold (2) in place.

   Fit and tighten the nuts and bolts fixing the exhaust manifold.

   Bolts and nuts fixing exhaust manifold:
   25 - 29 Nm (2.6 - 3 kgm; 18.4 - 21.4 ft lb)

Fit the injection pipes.



0208EM

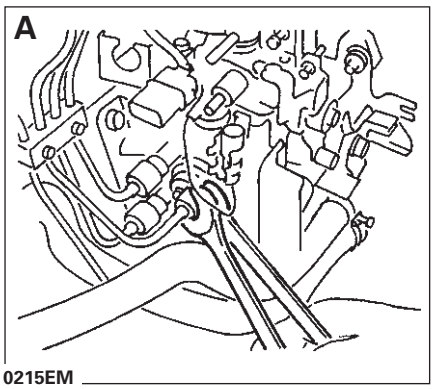
1. Fit the injectors (1) with their new washers and O-rings and fit the fixing flanges.

Injectors to cylinder head
44 - 49 Nm (4.5 - 5 kgm; 32.5 - 36.1 ft lb)

2. Connect the fuel return pipes (2) to the injectors.

1. Injection pipes:
2. Return pipe
3. Excess fuel pipe to pump
4. Pipe from filter to pump

3. Connect the return pipes (3) from the injectors to the pump and the pipe from the filter to the injection pump (4).

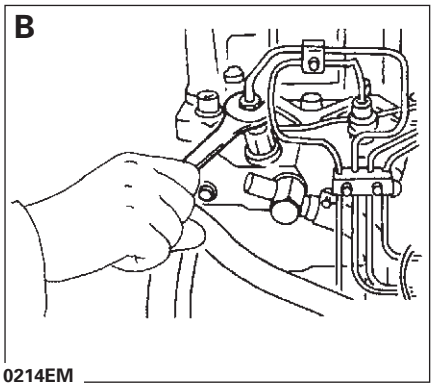


0215EM

4. Connect the injection pipes to the injectors and to the pump.
   - Manually fit the connectors without tightening them or forcing them.
   - Firstly tighten the connections on the side of the injectors, starting with those of cylinders 2 and 3.

Injection pipes to injectors and to pump:
20 - 25 Nm (2 - 2.6 kgm; 14.8 - 18.4 ft lb)

A: Pump side



0214EM

B: Engine side

Removal and Fitting

Do not disassemble the turbo-charger

1. Drain the water from the engine.
2. Remove the following parts:
   - **Air intake duct and pipes**
   - **Air inlet**
   - **Heat shields**
   - **Front exhaust pipe.**
   - **Oil pipes**
   - **Water pipes**
3. Remove the turbo-charger from the exhaust manifold:
4. Remove the bolts fixing the turbo-charger to its bracket.
   - **Change all the gaskets whenever the turbo-charger is removed.**

Inspection

Condition 1: Low engine power

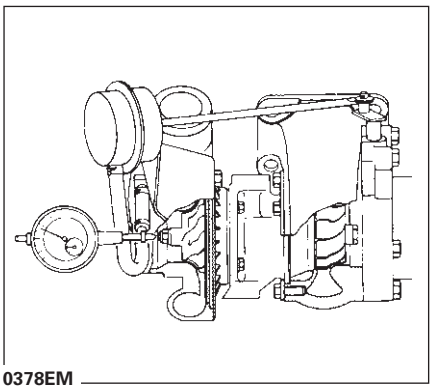
Probable cause	Correction
Air leak at the connection between the compressor casing and the inlet pipe/suction hose, or inlet pipe and exhaust manifold.	Correct the connection
Exhaust gas leak at the connection of the turbine rotor casing and the exhaust manifold, connection pipe and exhaust outlet.	Correct the connection or change the gasket
By-pass valve stuck in open position	Replace the turbo-charger
Shaft crankpin or bearing seized or worn	
Front axle	
Residues behind the turbine rotor	
Broken turbine rotor	
Shaft crankpin or bearing seized or worn	

Condition 2: Excessively high engine power

Probable cause	Correction
Rubber pipe on by-pass valve disconnected or broken	Repair or replace the rubber pipe
By-pass valve stuck in closed position	Replace the turbo-charger
Broken actuator diaphragm	

Inspection (Cont'd)

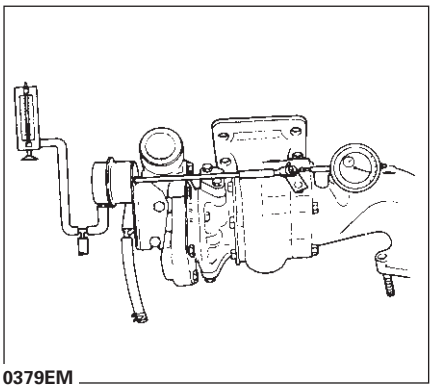
Condition 3: Excessively high oil consumption or light blue smoke in exhaust gases	
Probable cause	**Correction**
Oil leak in oil duct connection	Correct the connection
Oil leak through turbine oil seal	Replace the turbo-charger
Oil leak through compressor oil seal	
Shaft crankpin or bearing worn	



0378EM

1. Check the turbine rotor and the compressor as follows:
   - **Visually inspect for cracks, sticking, deformations or other damage.**
   - **Turn the rotors to ensure that they spin freely without abnormal noises or friction.**
   - **Measure the axial play.**

   Play (axial):
   0.013 - 0.097 mm (0.0005 - 0.0038 inches)



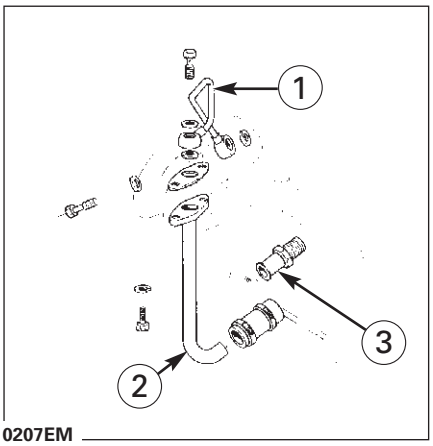
0379EM

2. Check the operation of the by-pass valve actuator.
   - **Move the by-pass valve to ensure that it is not stuck or scratched.**
   - **Measure the longitudinal play of the by-pass valve actuator.**

   Do not apply a pressure of more than 93.3 kPa (0.933 mbar; 0.95 kg/cm^2; 13.5 psi) to the actuator diaphragm.

   Stroke/pressure of by-pass valve actuator:

   1 mm (0.039 inches)/ 101.5±2.0 kPa (0.995 - 1.035 bar; 1.015 - 1.056 kg/cm^2; 14.428 - 15.008 psi)



0207EM

Nuts fixing turbo-charger to exhaust manifold:
Nuts fixing gas outlet connection to turbo-charger:

Fixing of oil inlet pipe (1) to turbo-charger and to oil filter:
17 - 23 Nm (1.7 - 2.3 kgm; 12.5 - 17 ft lb)

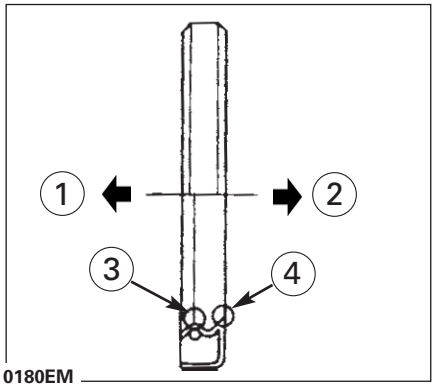
Fixing of turbo-charger oil outlet pipe (2):
14 - 21 Nm (1.4 - 2.1 kgm; 10.3 - 15.5 ft lb)

Fixing of oil inlet pipe (3) to cylinder block:
29 - 39 Nm (3 - 4 kgm; 21.4 - 28.8 ft lb)

Bolts fixing protective plates:
5 - 8 Nm (0.5 - 0.8 kgm; 3.7 - 5.9 ft lb)

REPLACEMENT OF OIL SEALS

PRECAUTIONS WHEN FITTING ALL SEALS

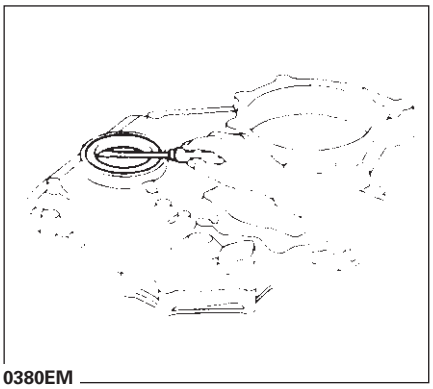


0180EM

- **When fitting a new seal, ensure that it is fitted in the correct position.**
- **It is recommended that the front and rear oil seals be replaced whenever the engine is disassembled.**
- **Clean away any excess oil after fitting.**

1. Engine interior
2. Engine exterior
3. Oil seal lip
4. Dust guard lip

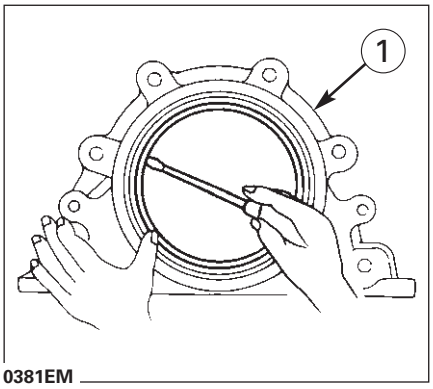
FRONT CRANKSHAFT OIL SEAL


0380EM

- **It is recommended that the front and rear oil seals be replaced whenever the engine is disassembled.**

1. Remove the following components of the engine:
   - Radiator shroud
   - Fan
   - Drive belts
   - Crankshaft pulley
   - Crankshaft oil seal
   - **Take care not to damage the seal seating surface.**
2. Apply clean engine oil to the new seal and fit the seal using a suitable tool.

REAR CRANKSHAFT OIL SEAL

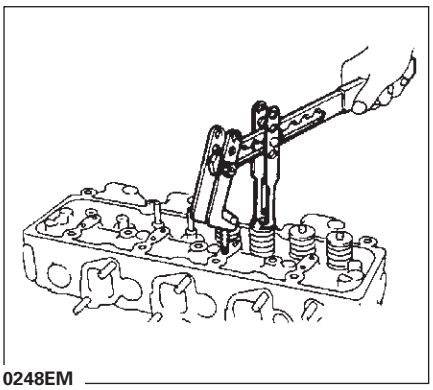


0381EM

- **It is recommended that the front and rear oil seals be replaced whenever the engine is disassembled.**

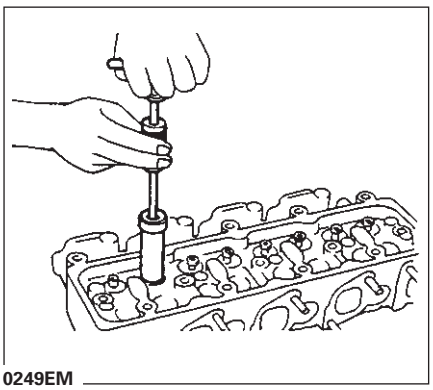
1. Remove the following components of the engine:
   - Gearbox assembly
   - Clutch casing
   - Engine flywheel and the rear plate.
   - Oil seal bracket (1)
   - Oil seal
   - **Take care not to damage the seal seating surface.**
2. Apply new engine oil to the new seal and fit the seal using a suitable tool.
   See “ASSEMBLY - Cylinder block - Rear crankshaft oil seal” in this section.

Valve oil seals



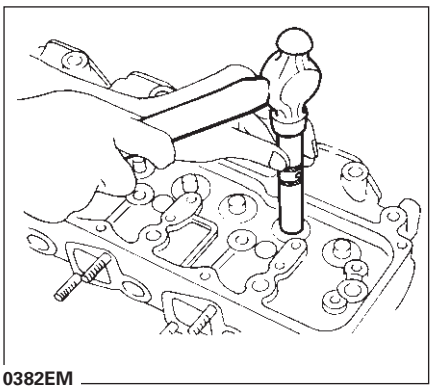
0248EM

1. Remove the following components of the engine, using suitable tools:
   a) Rocker cover
   b) Rocker shaft
   c) Spring of corresponding valve.
   The corresponding piston must be at TDC to prevent the valves from dropping.



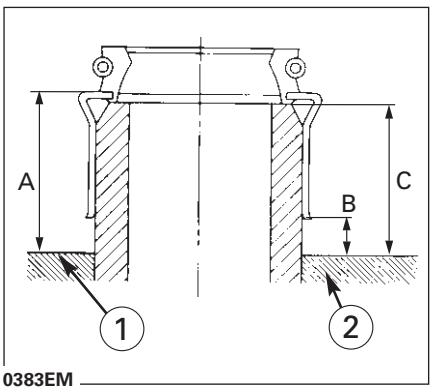
0249EM

2. Remove the valve oil seals using a suitable tool.



0382EM

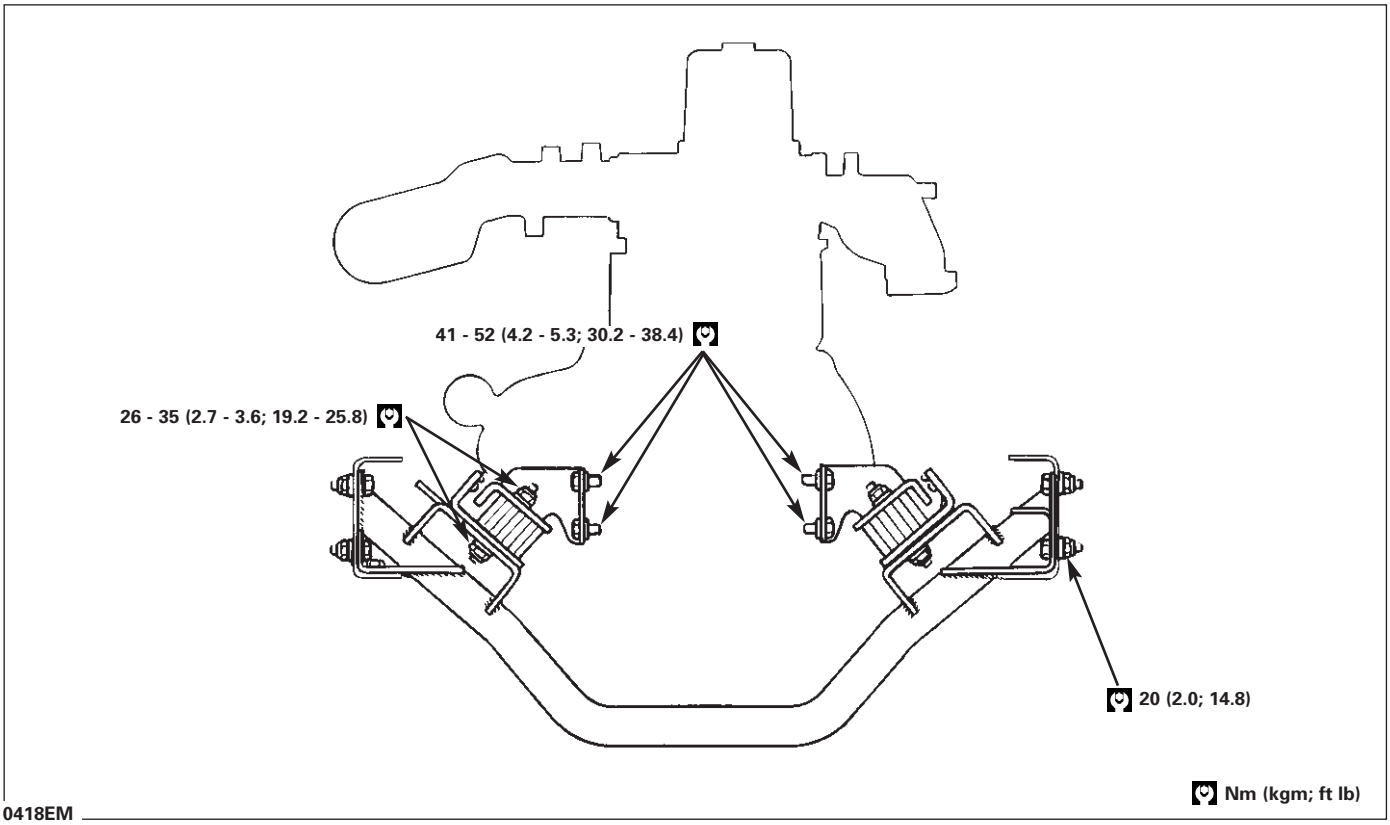
3. Lubricate the new seal with clean engine oil and fit it into its housing, in the position shown in the figure, using a suitable tool.



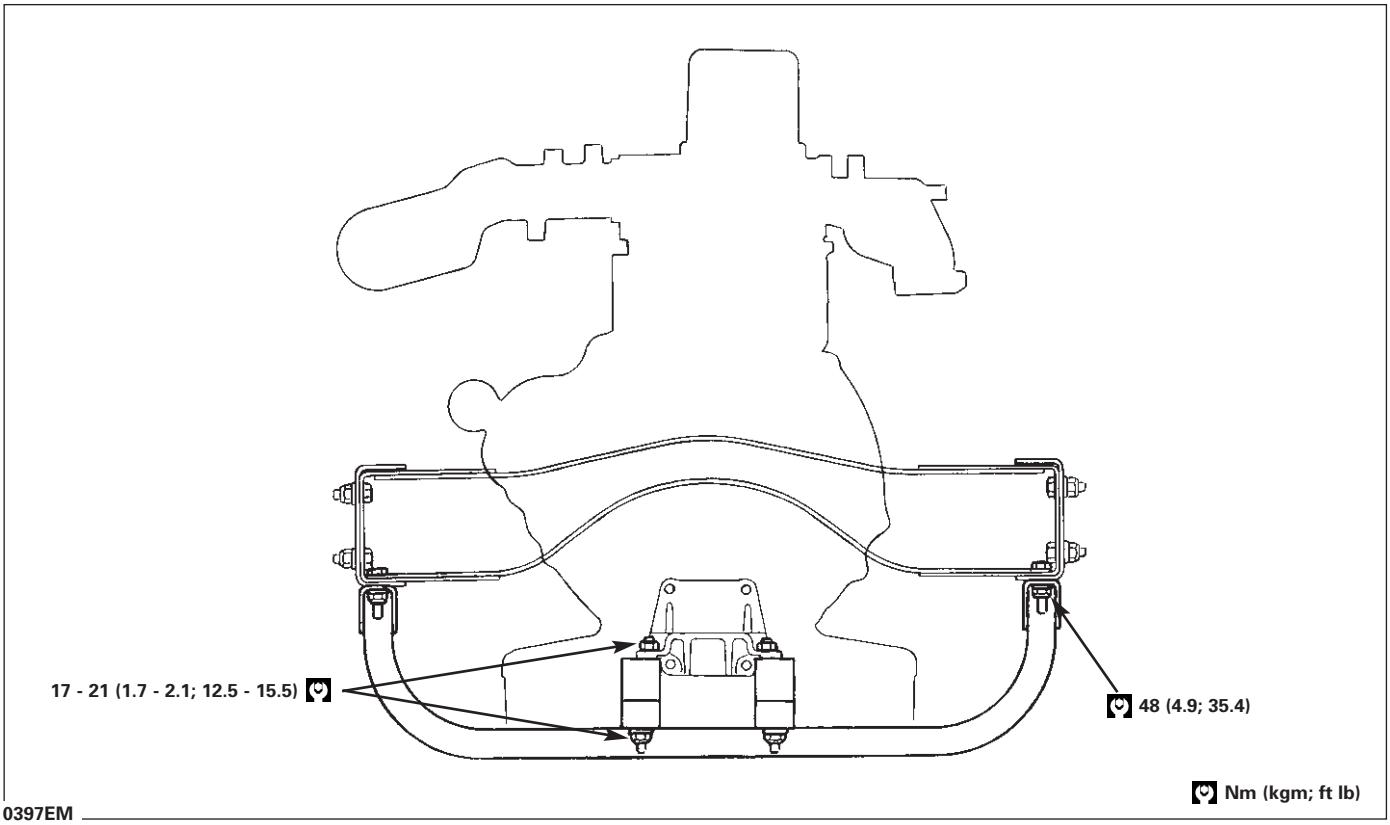
0383EM

A = 17.5±0.2 (0.689±0.008 inches)
B= 5.6 - 6 mm (0.22 - 0.236 inches)
C = 15.8 - 16.2 mm (0.622-0.638 inches).
1. Seat washer
2. Cylinder head

Engine brackets



0418EM



0397EM

WARNING:

- **Park the vehicle on a flat floor, apply the parking brake and chock the rear wheels.**

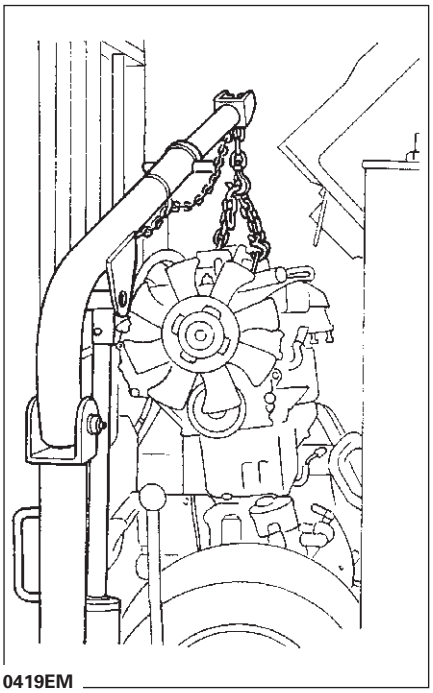
  Do not remove engine until the exhaust system has totally cooled.
- **Before disconnecting the fuel pipe, ensure that the pressure in the system has been released.**
- **Raise the engine and transmission safely.**

CAUTION

- **When raising or lowering the engine, take care not to hit it against nearby parts, especially the accelerator cable covering, brake pipes and brake master cylinder.**
- **When raising the engine, always use the engine slings safely.**

REMOVAL

1. Disconnect the battery earth strap.
2. Empty the cooling system, collecting the liquid in a suitable container.
3. Tilt the cab and fix it (tilt cab models only)
4. Remove the front exhaust pipe.
5. Remove the starter motor
6. Remove the radiator.
7. Remove the alternator.
8. Remove the air conditioning compressor and tie it to the bodywork with wire. (Do not remove the pipes from the compressor.)
9. Remove the upper studs from the clutch casing.
10. Support the transmission with a hydraulic jack.
11. Support the engine with a hydraulic jack.
12. Remove the nuts fixing the engine brackets to the chassis.
13. Make sure there is no component or hose, pipe or cable preventing the removal of the engine.
14. Remove the engine by moving it very carefully to avoid it or the crane hitting the cab or any nearby parts.

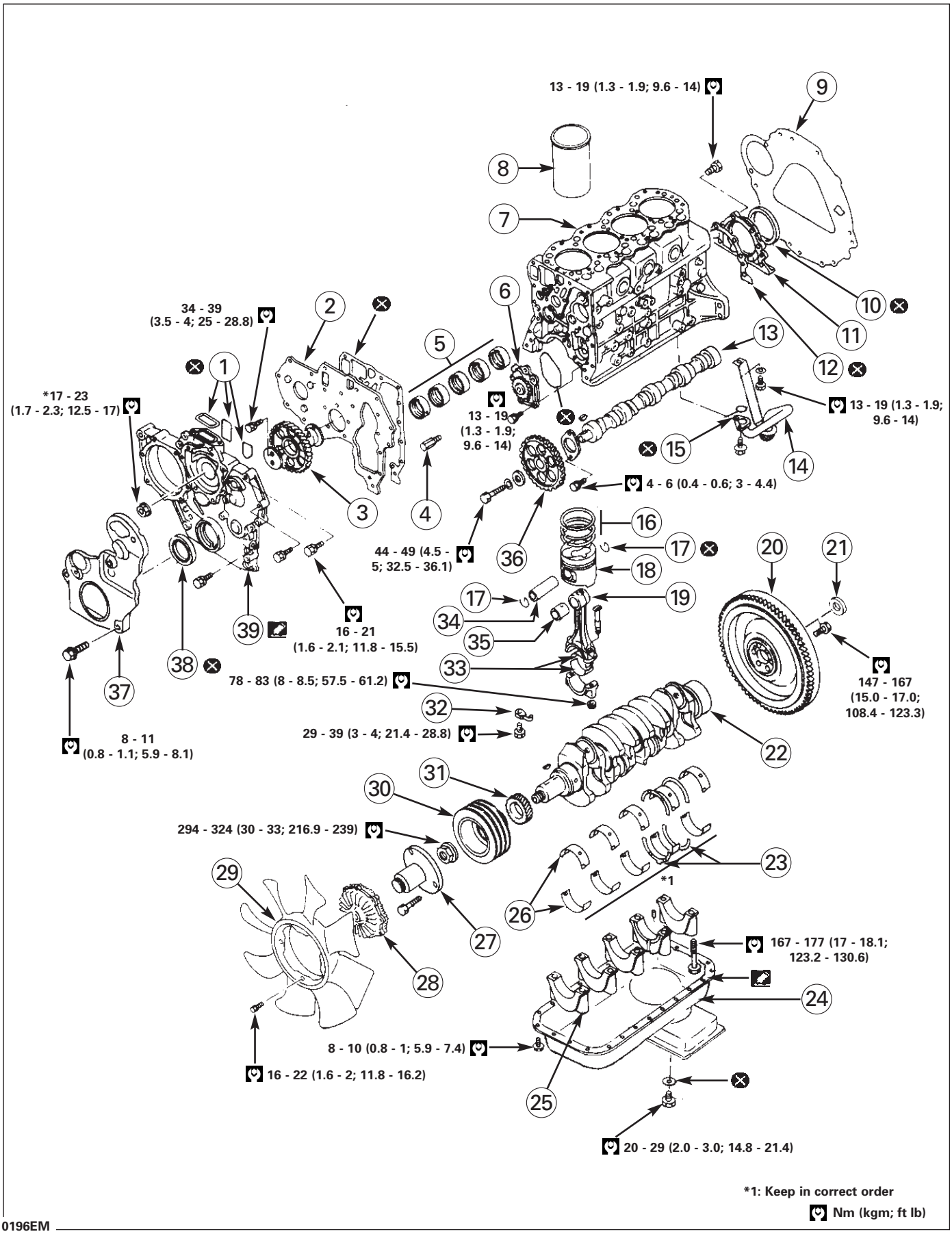


0419EM

INSTALLATION

1. Re-fit by reversing the removal process.

Exploded view

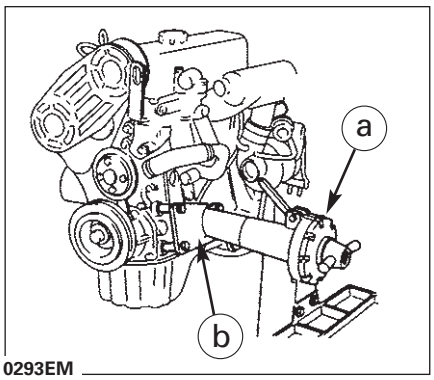


0196EM

COMPONENTS

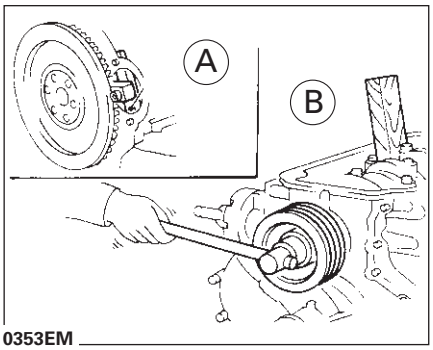
1. Timing plate rubber gaskets
2. Front plate
3. Idler gear
4. Oil supply to gears
5. Camshaft bearings
6. Oil pump
7. Cylinder block
8. Cylinder liner
9. Rear plate
10. Rear oil seal
11. Rear oil seal bracket
12. Rear oil seal bracket gasket
13. Camshaft
14. Oil strainer
15. Oil strainer gasket
16. Piston rings
17. Gudgeon pin retainer clip
18. Piston
19. Connecting rod
20. Flywheel
21. Primary shaft pilot bearing
22. Crankshaft
23. Thrust washers
24. Engine oil sump
25. Journal caps
26. Main bearings
27. Coupler between viscous clutch and crankshaft pulley
28. Viscous clutch
29. Fan
30. Crankshaft pulley
31. Crankshaft gear
32. Piston cooling oil jet
33. Big end bearings
34. Pin
35. Little end bearings
36. Camshaft gear
37. Soundproof cover
38. Front oil seal
39. Timing cover

Pistons and crankshaft



0293EM

1. Oil filter removal
2. Place the engine on the engine supports a and b.
3. Drain the cooling system and the engine oil.
4. Remove the drive belts
5. Remove the thermostat box
6. Remove the alternator.
7. Remove the cylinder head.
   See “CYLINDER HEAD - Removal” in this section.
8. Remove the sump and oil pump.
   See “OIL SUMP - Removal” in this section.

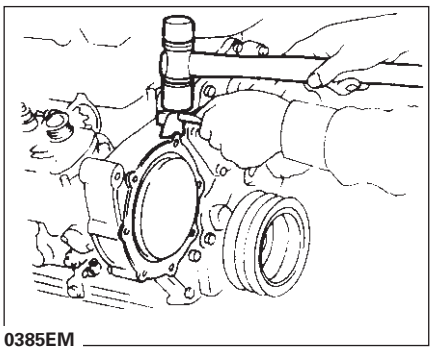


0353EM

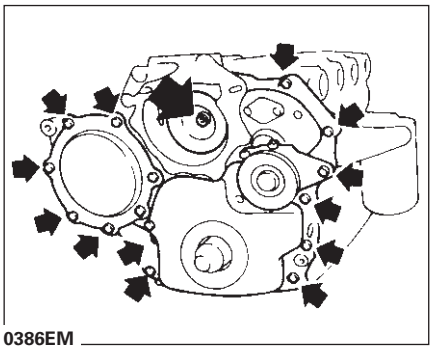
9. Remove the crankshaft pulley.
   - **Block the crankshaft by fixing the flywheel with a suitable tool or by inserting a wooden wedge between the crankshaft and the cylinder block to prevent the crankshaft from turning.**

A. Method A: using a tool.

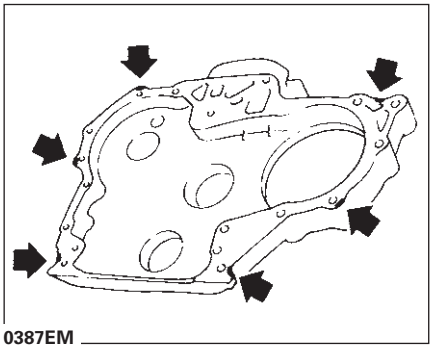
B. Method B: using a wooden wedge


0385EM

10. Remove the injection pump gear cover.


0386EM

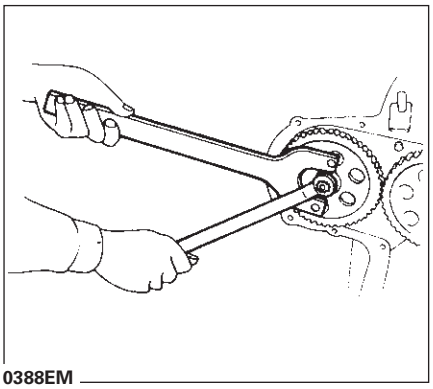
11. Remove the water pump.
12. Remove the timing cover.


0387EM

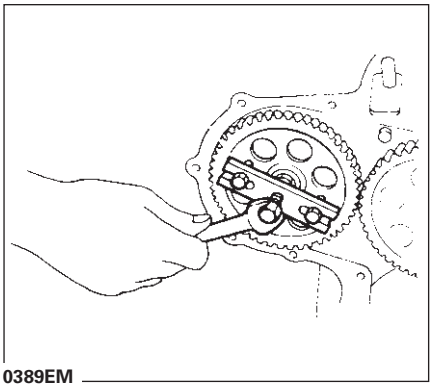
- **If it is difficult to remove the timing cover because of the Teflon liquid, separate it with a suitable tool, taking care not to damage any part.**

Pistons and crankshaft (Cont'd)

13. Remove the injection pump drive gear, using a special tool.

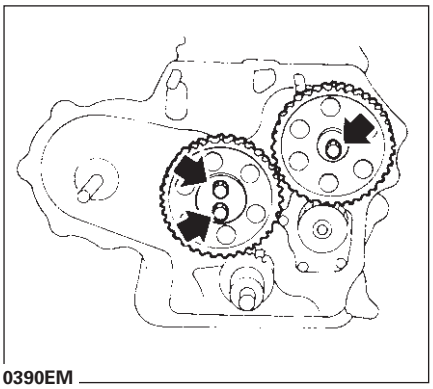


0388EM



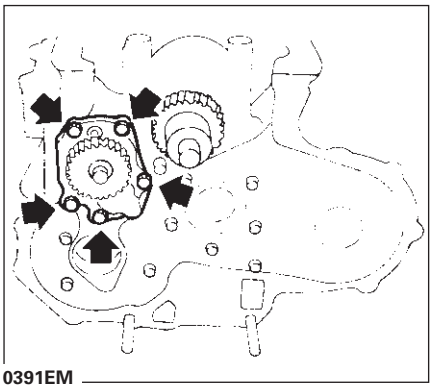
0389EM

14. Remove the idler gear and its shaft.
15. Remove the camshaft gear, the camshaft and the pushrods.



0390EM

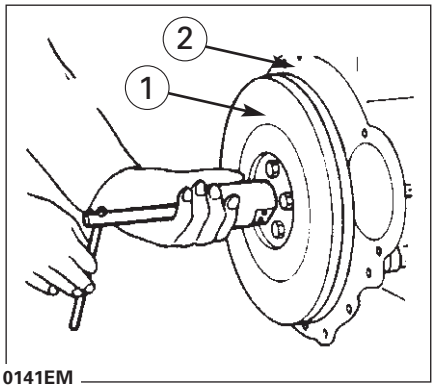
16. Remove the oil pump.



0391EM

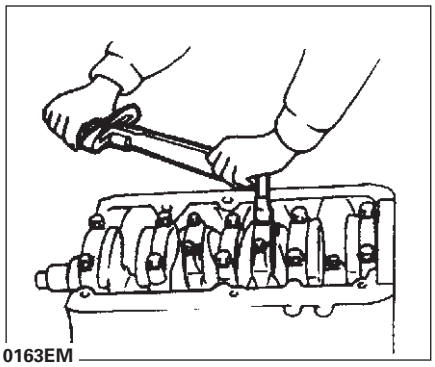
17. Remove the crankshaft gear.

Pistons and crankshaft (Cont'd)

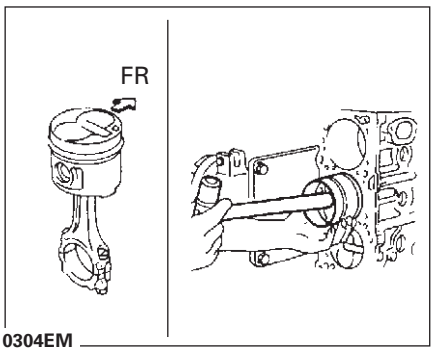


0141EM

18. Remove the pilot bearing from the flywheel using a suitable special tool.
19. Remove the flywheel (1) and the rear plate (2).

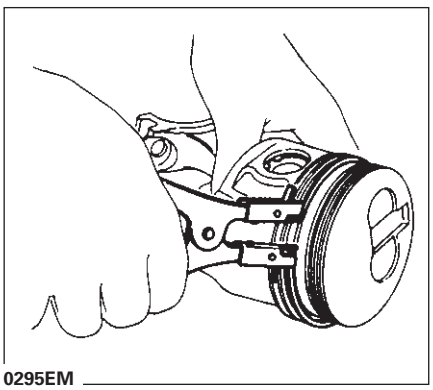

0163EM

20. Remove the connecting rod caps.



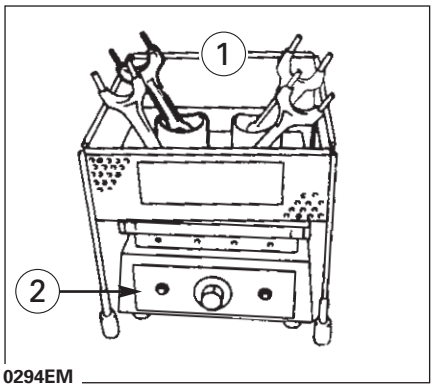
0304EM

21. Remove the piston/connecting rod assemblies from the cylinder block.
    - **Take care not to damage the cylinder wall with the connecting rod when you withdraw it.**


0295EM

22. Remove the piston rings with a suitable tool.

Pistons and crankshaft (Cont'd)

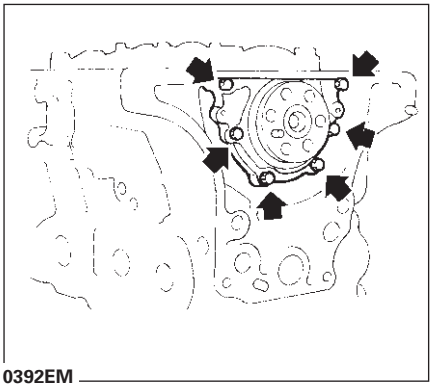


0294EM

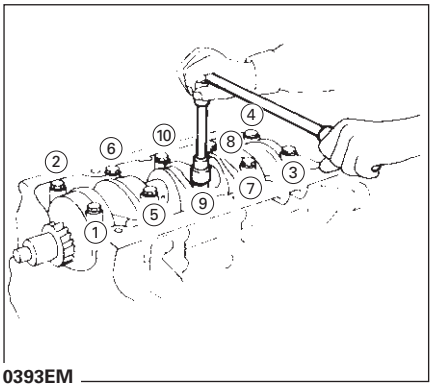
23. Remove the piston/connecting rod assemblies.
    - **Before disassembling the gudgeon pin, heat the piston to 60 - 70°C (140 - 158°F), or use a press with a suitable tool.**

1. Pistons and connecting rods

2. Heater


0392EM

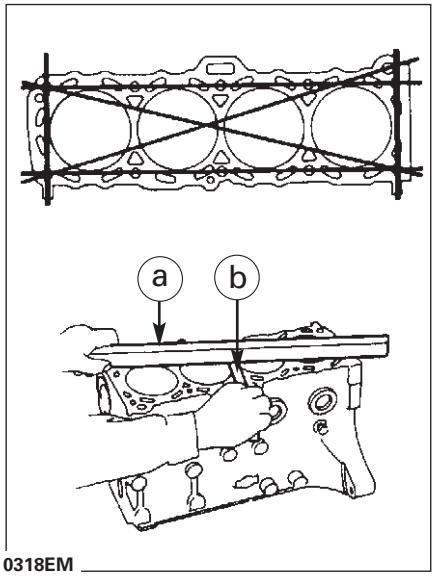
24. Remove the rear crankshaft seal bracket



0393EM

25. Remove the bolts fixing the bearing caps.
    - **Loosen the bolts in the order shown in the figure:**
    - **Before disassembling the pin which joins the piston to the connecting rod, heat the piston to 60 - 70°C (140 - 158°F), or use a press with a suitable tool.**

Cylinder block distortion and wear



0318EM

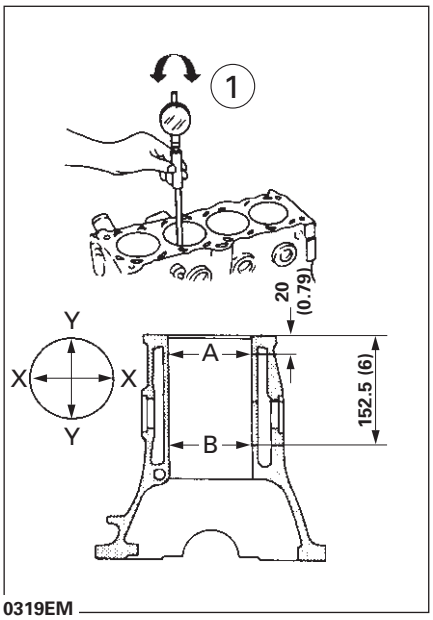
1. Check visually for cracks or deformations.
2. Clean the surface of the cylinder block and measure the warping with a flat, rigid ruler (a) and a feeler gauge (b), making several measurements in different points as shown in the figure.

   Standard:
   Less than 0.05 mm (0.002 inches)

   Limit:
   0.2 mm (0.008 inches)

Liners

WEAR



0319EM

1. Check for scratches or dents and re-bore the liner if any faults are found.
2. Use an interior dial gauge to measure the interior diameter of the liner at various points, as shown in the figure, to check for ovalling and coning.

   Inner diameter of liners:

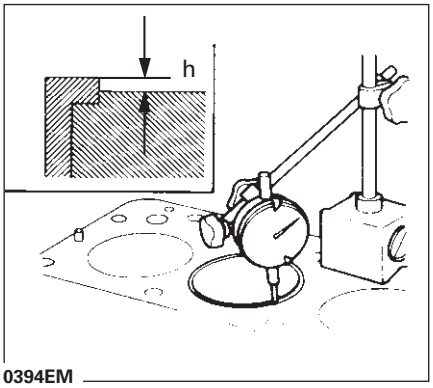
   See "TECHNICAL DATA AND CHARACTERISTICS".

   Wear limit = 0.2 mm (0.008 inches)

   Ovalling limit (X - Y) = 0.07 mm (0.003 inches).

   Coning limit (A - B) = 0.2 mm (0.008 inches)

1. Move the gauge as shown in the drawing. Take the minimum reading.



0394EM

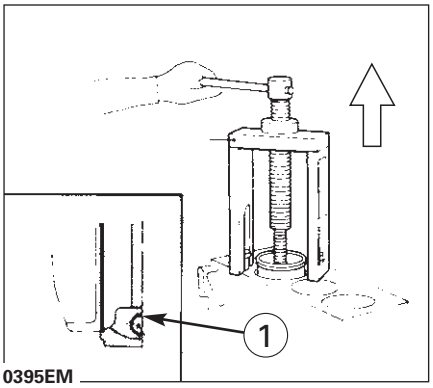
3. Check the height "h" of the cylinder liner with respect to the surface of the cylinder block.

   Height "h": Standard: 0.02 - 0.09 mm (0.001 - 0.004 inches)

   Maximum permitted deviation in each cylinder:
   Less than 0.05 mm (0.002 inches)

Liners (Cont'd)

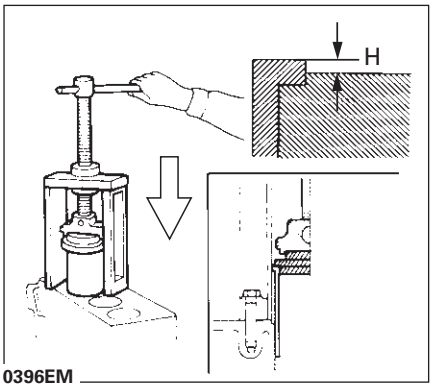
CHANGING THE LINERS



0395EM

1. Remove the liner using a suitable tool.

1. Adapter

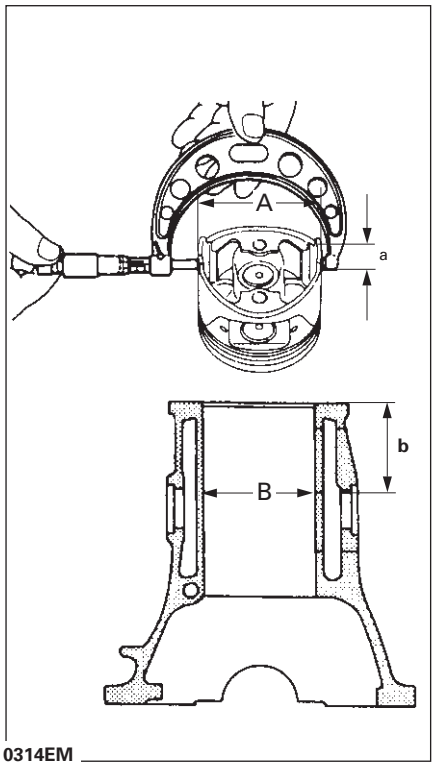


0396EM

2. Fit the new liner into the cylinder block using a suitable tool.
3. Check that the height "h" between the new liner and the surface of the cylinder block is within the specified limits.
   See "CYLINDER BLOCK - Inspection - Liners - Wear" in this section.

Pistons

CLEARANCE BETWEEN PISTON AND CYLINDER LINER



0314EM

1. Measure the diameter of the piston and the liner.

   PISTON: Diameter "A" of piston (measured at the distance "a" from the upper face of the piston, approximately)

   a = 63.5 mm (2.5 inches)

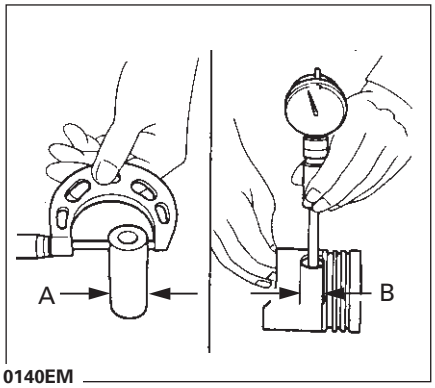
   See "TECHNICAL DATA AND CHARACTERISTICS".

2. Check that the clearance between the piston and the liner wall is within the specified limit.

   Clearance (B - A) = 0.043 - 0.077 mm (0.0017 - 0.003 inches)

Pistons (Cont'd)

CLEARANCE BETWEEN PISTON AND GUDGEON PIN



0140EM

1. Measure the outer diameter of the gudgeon pin and the inner diameter of the piston eye.
2. Calculate the gudgeon pin's clearance in the piston:

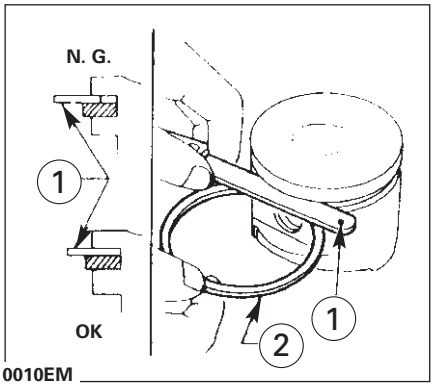
   Exterior diameter of gudgeon pin = 29.993 - 30 mm (1.18 - 1.181 inches)

   Piston eye diameter = 29.997 - 30.005 mm (1.18 - 1.181 inches)

   Clearance (B - A): 0.003 - 0.012 mm (0.00012 - 0.00047 inches)

   Spare parts are available as sets of pistons and rings.

SIDE CLEARANCE BETWEEN RINGS AND PISTON



0010EM

	Standard		Limit	
	mm	inches	mm	inches
Upper ring	0.06 - 0.1	0.002 - 0.004	0.5	0.02
2nd ring	0.04 - 0.08	0.002 - 0.003	0.3	0.012
Oil ring	0.02 - 0.06	0.0008 - 0.002	0.15	0.006

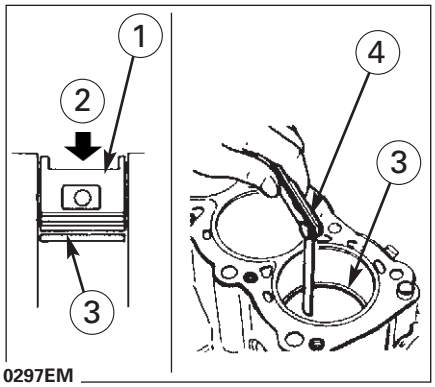
1. Feeler gauge

2. Piston ring

CLEARANCE BETWEEN PISTON RING ENDS:

Unit: mm (inches)

	Production	Service	Limit
Upper ring	0.3 - 0.45 (0.012 - 0.018)	0.04 - 0.6 (0.002 - 0.024)	1.5 (0.059)
2nd ring	0.2 - 0.35 (0.008 - 0.014)	0.3 - 0.5 (0.012 - 0.02)	
Oil ring	0.15 - 0.35 (0.006 - 0.014)	0.3 - 0.5 (0.012 - 0.02)	



0297EM

If the piston ring is beyond the specified limit, replace it. If the clearance still exceeds the limit with a new ring, grind the cylinder and use an over-sized piston and ring.

See "TECHNICAL DATA AND CHARACTERISTICS".

1. Piston

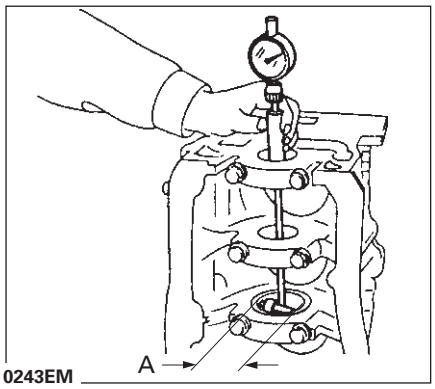
2. Press fit

3. Piston ring

4. Feeler gauge

Bearing clearance

MAIN BEARINGS AND CRANKSHAFT JOURNALS

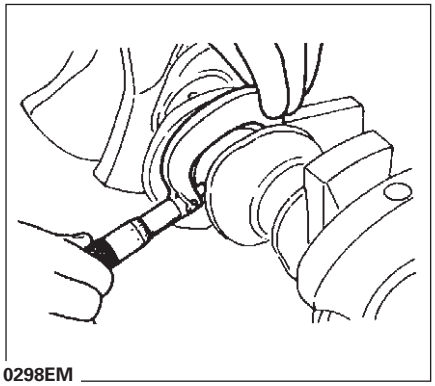


0243EM

1. Fit the main bearing shells into the cylinder block and bearing caps, respectively.
2. Fit the bearing caps with their shells into the cylinder block.
3. Tighten the bolts fixing the bearing caps in the correct order and in two or three steps.

   Crankshaft bearing cap bolts
   167 - 177 Nm (17 - 18.1 kgm; 123.2 - 130.6 ft lb)

4. Measure the outer diameter "A" of each main bearing with an interior micrometer.


0298EM

5. Measure the outer diameter "Dm" of each crankshaft journal with a micrometer.

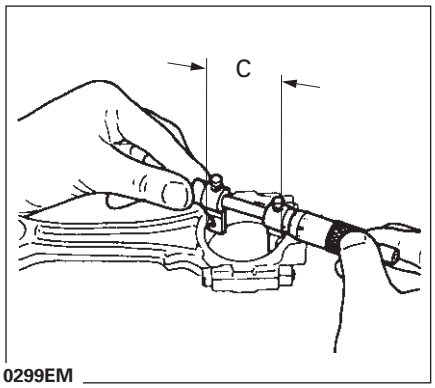
   Diameter of crankshaft journals
   See "TECHNICAL DATA AND CHARACTERISTICS".

6. Calculate the clearance of the main bearings and crankshaft journals.

   Clearance between the main bearings and crankshaft journals:
   Standard: 0.041 - 0.076 mm (0.0016 - 0.003 inches)

   - **Replace the main bearings if the clearance exceeds the specified limit.**
   - **If any crankshaft journal is worn or faulty, replace the crankshaft and main bearings.**

BIG END BEARINGS AND CRANKPINS



0299EM

1. Fit the bearing shells on the connecting rods and caps, respectively.
   - **Oil the bolt and nut threads.**
2. Fit the caps to the connecting rods.

   Nuts and bolts fixing big end caps:
   78 - 83 Nm (8 - 8.5 kgm; 57.5 - 61.2 ft lb)

3. Measure the inner diameter "C" of the bearing with an interior micrometer.
4. Measure the outer diameter "Dp" of each crankpin with a micrometer.

   Diameter of crankpin:
   See "TECHNICAL DATA AND CHARACTERISTICS".

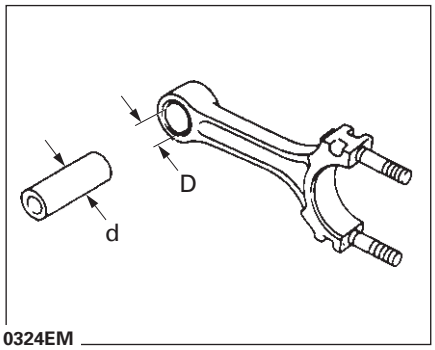
   Calculate the clearance of the crankshaft connecting rod bearings.

   Clearance between big end bearings and crankpins.
   Standard: 0.035 - 0.081 mm (0.0014 - 0.0032 inches)
   Maximum permitted limit: Less than 0.15 mm (0.006 inches)

   - **Replace the big end bearings if the clearance exceeds the specified limit.**
   - **If any crankpin is worn or faulty, replace the crankshaft and the connecting rod bearings.**

Bearing clearance (Cont'd)

LITTLE END BEARING AND GUDGEON PIN



0324EM

1. Measure the inner diameter "D" of the little-end bearing with an interior micrometer.
2. Measure the outer diameter "d" of the gudgeon pin with a micrometer.
3. Calculate the clearance between the little end bearing and the gudgeon pin

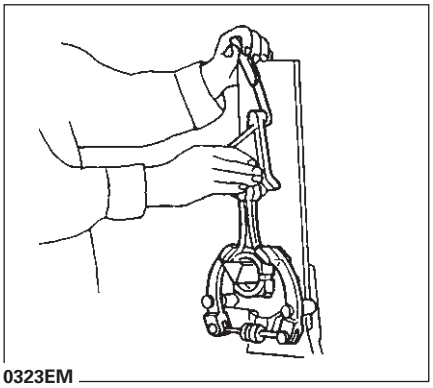
Clearance between the little end bearing and gudgeon pin:

Standard: 0.025 - 0.045 mm (0.001 - 0.0018 inches)
Limit: 0.15 mm (0.006 inches)

- **Replace the little end bearings if the clearance exceeds the specified limit.**

Connecting rod

BENDING AND TWISTING OF THE CONNECTING ROD

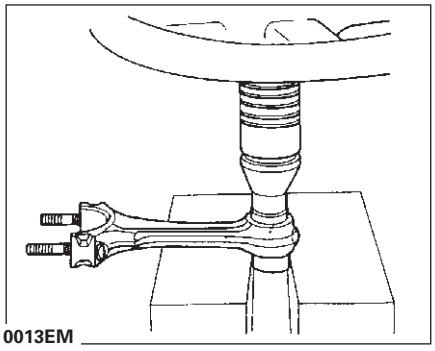

0323EM

Bending and twisting [for every 100 mm (3.94 inches) of length]:

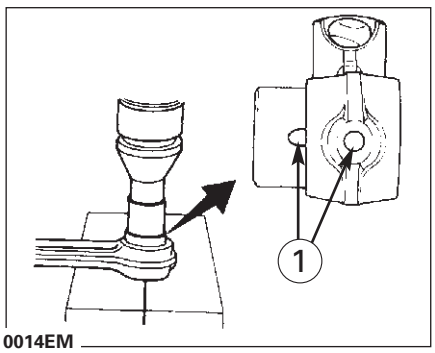
Bending: Less than 0.075 mm (0.003 inches)

Twisting: Less than 0.075 mm (0.003 inches)

REPLACING THE LITTLE END BEARING


0013EM

1. Remove the little end bearing with a suitable tool.
   - **Do not damage the surface of the little end bearing.**



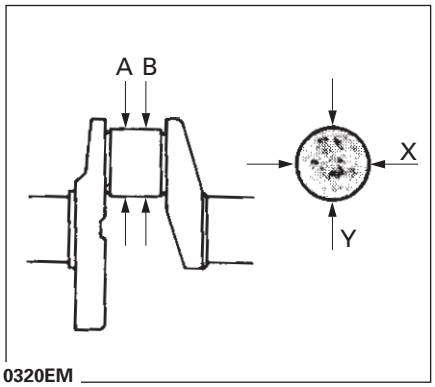
0014EM

2. Fit the new little end bearings. Insert them so that they are flush with the surface of the connecting rod.
   - **Check that the lubrication holes (1) are correctly aligned.**
3. Ream the little end bearing when it is fitted into its housing.

Inner diameter of little end bearing
Finished size: 30.025 - 30.038 mm (1.182 - 1.183 inches)

Crankshaft

CHECKING THE JOURNALS

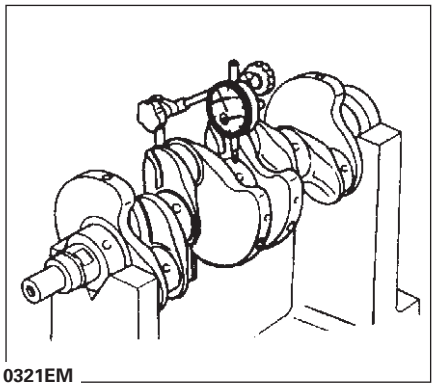


0320EM

1. Check that the crankshaft pins and journals are not scratched, worn or cracked. Minor defects can be corrected with fine emery paper.
2. Use a micrometer to check the crankshaft pins and journals for coning and ovalling.

Ovalling (X-Y): **Less than 0.001 mm (0.0004 inches)**
Limit: 0.02 mm (0.001 inches)

Coning (A-B): **Less than 0.001 mm (0.0004 inches)**
Limit: 0.02 mm (0.001 inches)


0321EM

3. Check the eccentricity of the crankshaft.

Eccentricity (total dial gauge reading)

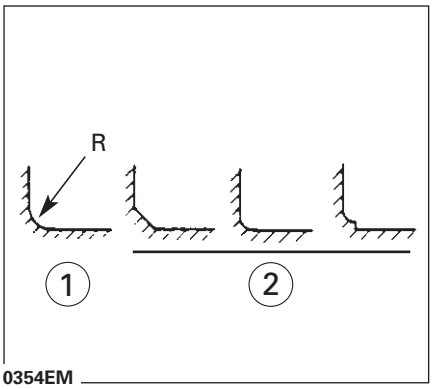
Standard: 0 - 0.03 mm (0 - 0.012 inches)

Limit: 0.1 mm (0.004 inches)

GRINDING JOURNALS AND CRANKPINS

When using smaller main bearings and big ends, the journals and crankpins must be ground to fit the bearings.

R: Crankpins = 3.0 mm (0.118 inches)
Journal = 3.5 mm (0.138 inches)



0354EM

CAUTION

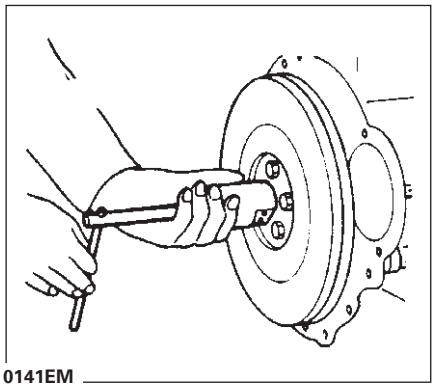
- **Take care not to widen the support surface of the journals and crankpins.**
- **Do not grind the crankshaft counterweight.**

1. Correct

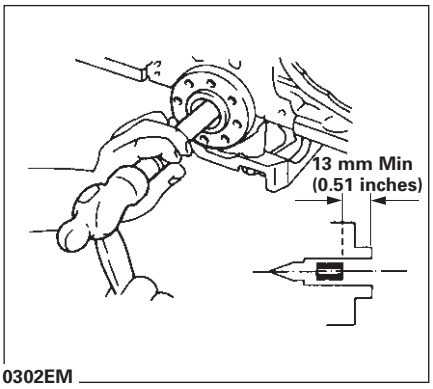
2. Incorrect

Crankshaft

PILOT BEARING


0141EM

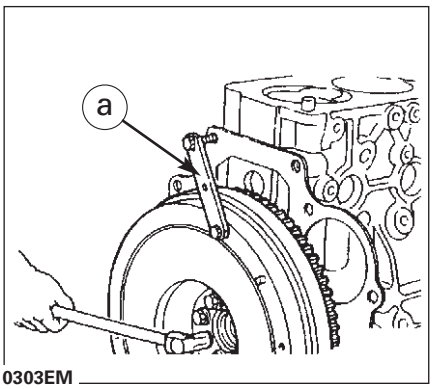
1. Inspect the pilot bearing and replace if necessary.
   Remove the pilot bearing using a suitable tool.



0302EM

2. Fit the new pilot bearing using a suitable tool.
   Fit it as shown in the figure.
   - **Insert it fully into its housing.**
   - **Before fitting the new bearing, clean its housing.**
   - **Place liquid gasket on the pilot bearing housing.**

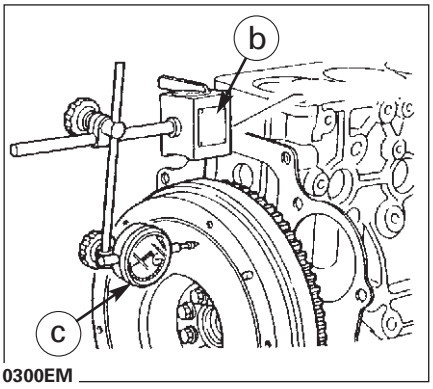
Flywheel



0303EM

1. Fit the rear plate.
2. Use the special tool (a) to block the crankshaft while the flywheel is fitted to it; tighten the fixing bolts to the specified torque in an alternative order.

   Bolts fixing engine flywheel:
   147 - 167 Nm (15 - 17 kgm, 108.4 - 123.2 ft lb)

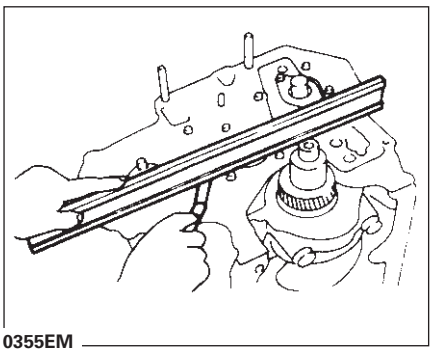


0300EM

3. Fit a magnetic base (b) with a dial gauge (c) and check the warping of the flywheel.

   Flywheel warp (total dial gauge reading)
   Less than 0.1 mm (0.004 inches)

FRONT PLATE

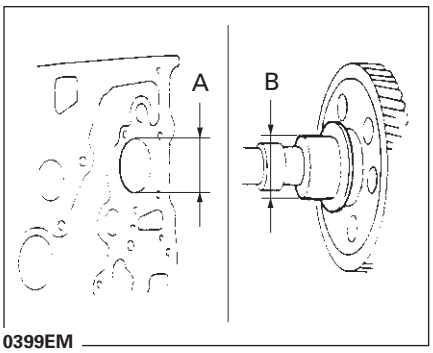

0355EM

Check the warp of the front plate. If it exceeds the service limit, grind or replace it.

Limit of warp:
0.2 mm (0.008 inches)

Camshaft and camshaft bearing

CAMSHAFT BEARING CLEARANCE



0399EM

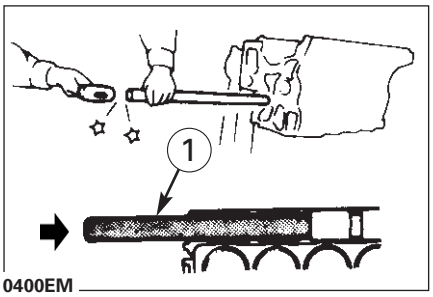
Measure the inner diameter of the camshaft (A) and the outer diameter of the camshaft supports (B).

Clearance between camshaft support and bearing

Standard:
0.020-0.109 mm (0.001 - 0.00429 inches)

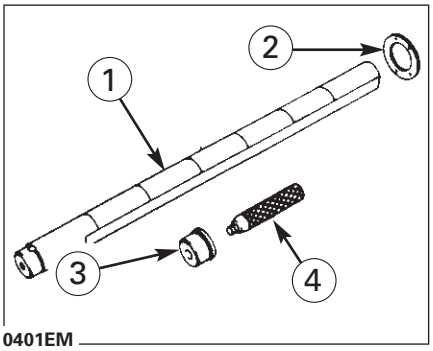
Limit:
Less than 0.15 mm (0.006 inches)

REPLACEMENT OF CAMSHAFT BEARINGS



0400EM

1. Remove the rear cap of the camshaft. Using a suitable tool, remove the camshaft bearings from the cylinder block. If necessary, break the bearings to remove them..



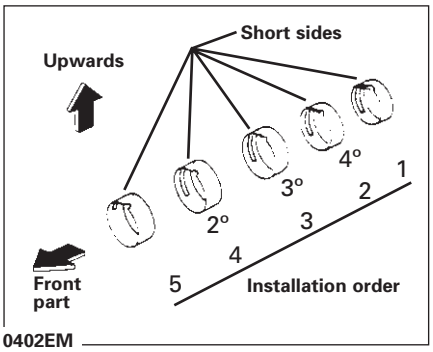
0401EM

2. Using suitable tools, fit the camshaft bearings as follows:

   a) Fit the camshaft bearings in the following order: “Rear”, “4”, “3”, “2” and “Front”.

      All the bearings must be fitted from the front.

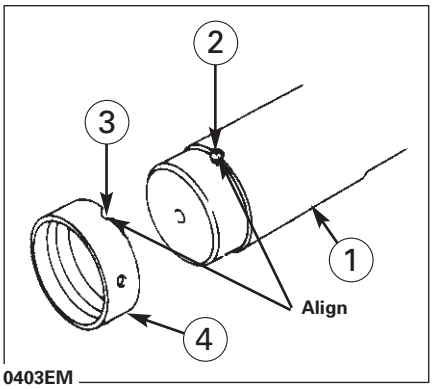
   b) Fit with the cut upwards and facing the front of the engine.



0402EM

REPLACEMENT OF CAMSHAFT BEARINGS (Cont'd)

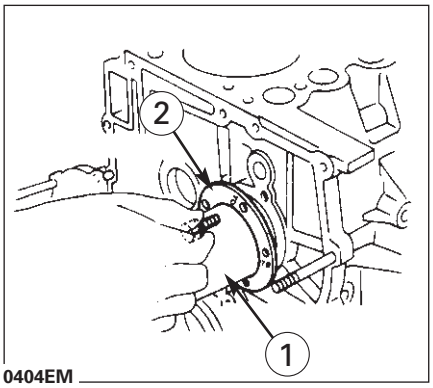
REPLACEMENT OF CAMSHAFT BEARINGS (Cont'd)



0403EM

c) Rear camshaft bearing

Align the notch (3) of the rear bearing with the recess (2) in the replacement bar (1) before fitting.



0404EM

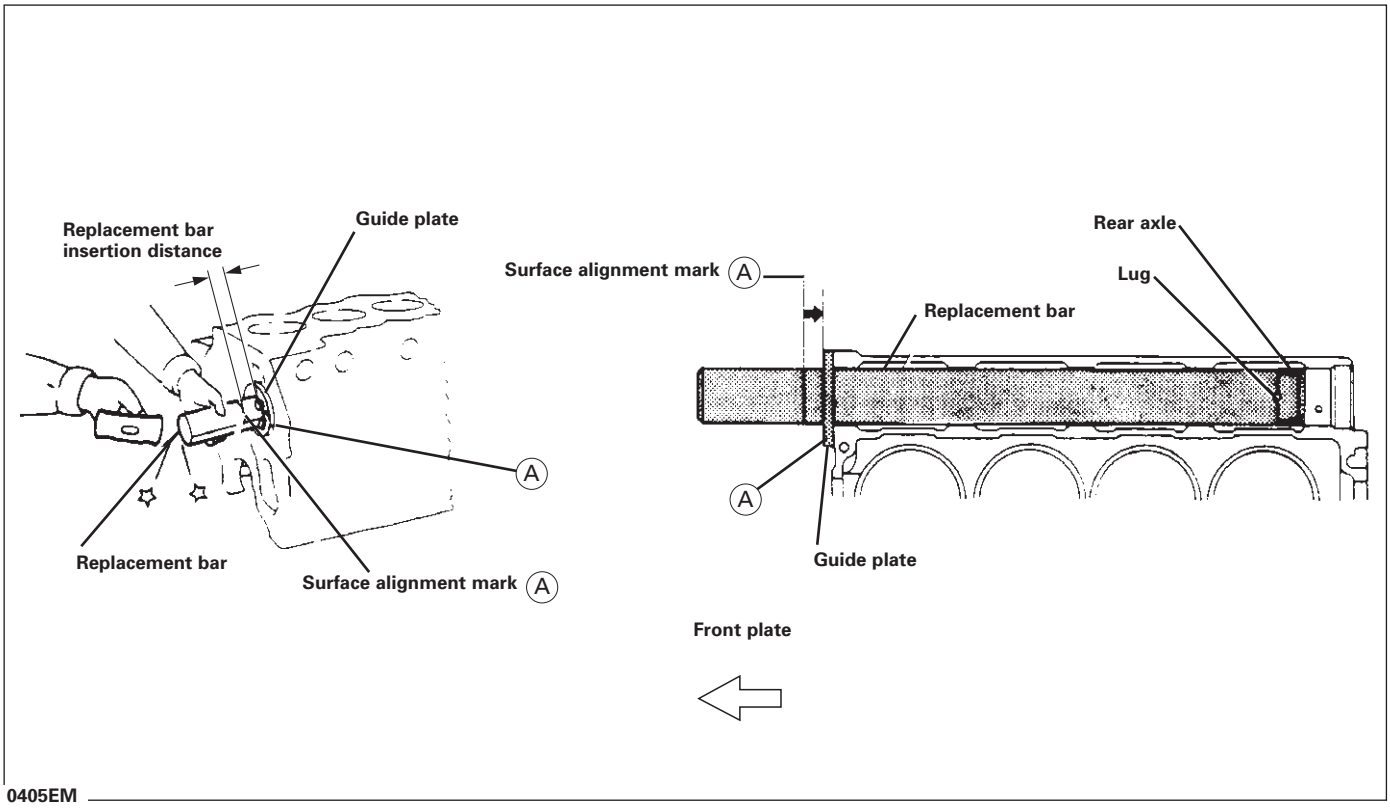
Insert the rear bearing into the cylinder block with the replacement bar (1).

Fit the guide plate (2) with the bolt holes (on the side marked "TD") facing the upper part of the cylinder block. Tighten the bolts.

Insert the replacement bar until the alignment mark on the bar is aligned with the end of the guide plate.

Remove the replacement assembly.

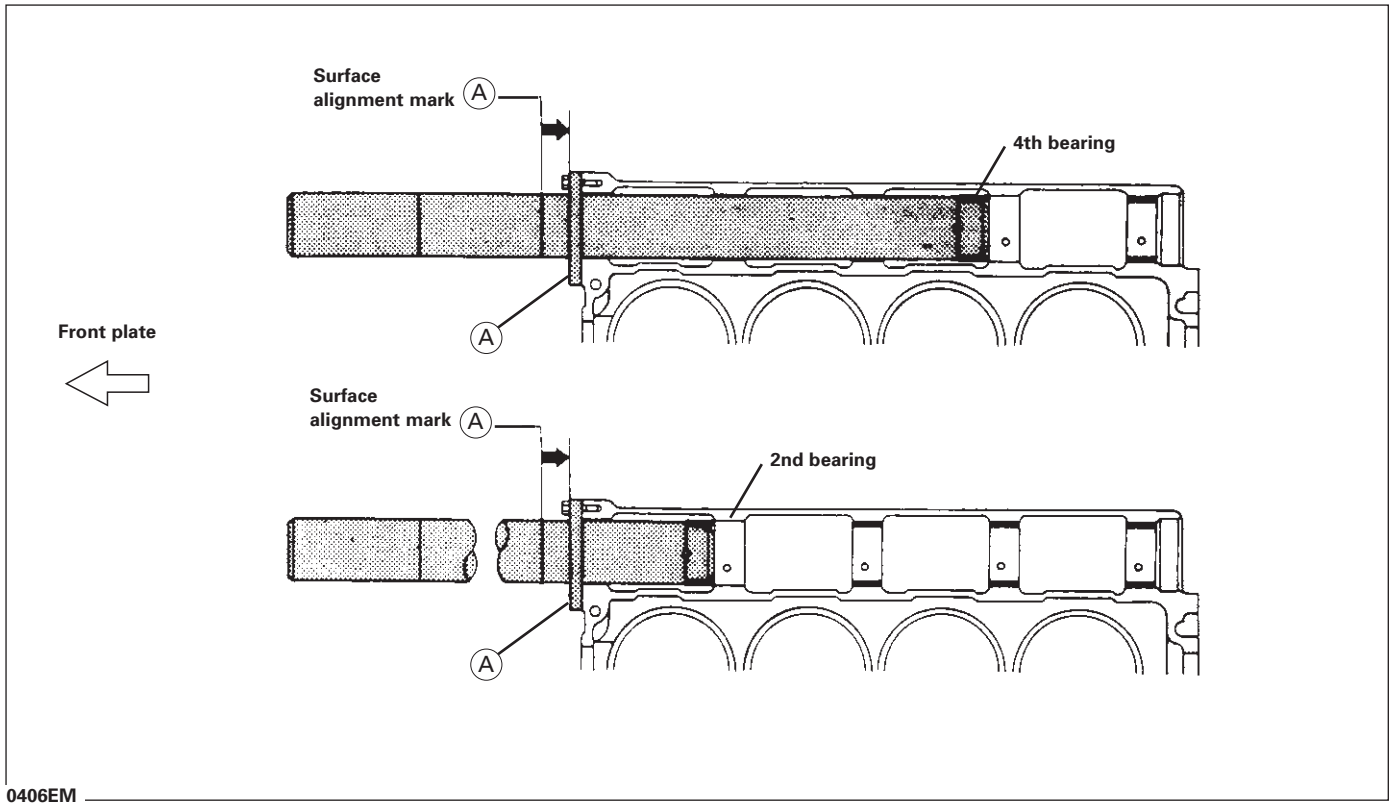
After fitting, check that the oil hole in the camshaft bearing aligns with the oil hole in the cylinder block.



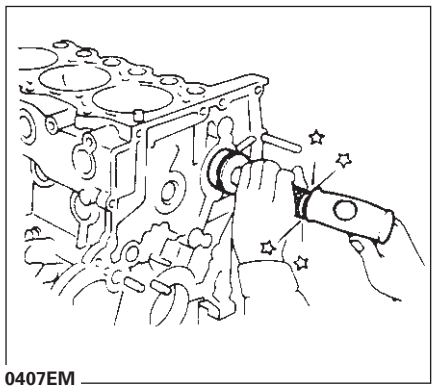
0405EM

REPLACEMENT OF CAMSHAFT BEARINGS (Cont'd)

REPLACEMENT OF CAMSHAFT BEARINGS (Cont'd)



0406EM



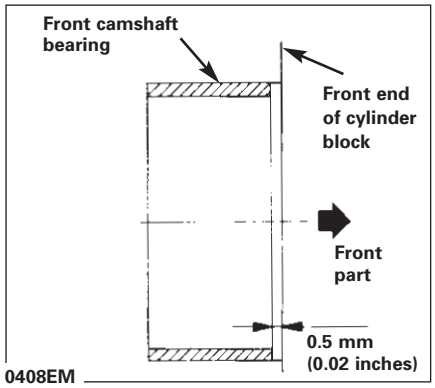
0407EM

d) Camshaft bearings 4, 3 and 2

Fit in the same way as the rear camshaft bearing.

e) Front camshaft bearing

Using the adapter for the 1st bearing, fit the front camshaft bearing so that the oil hole in the cylinder block aligns with the oil hole in the bearing.

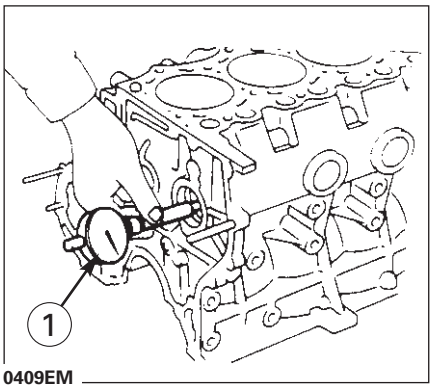


0408EM

When fitting the front camshaft bearing, ensure that it is 0.5 mm (0.020 inches) from the front edge of the cylinder block.

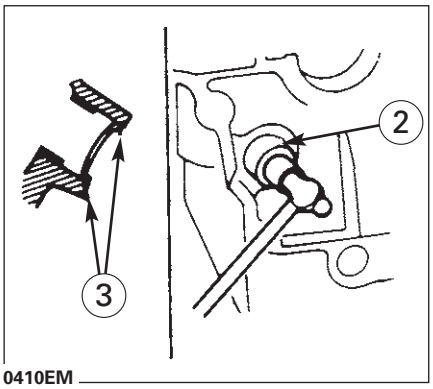
REPLACEMENT OF CAMSHAFT BEARINGS (cont'd)

REPLACEMENT OF CAMSHAFT BEARINGS (Cont'd)



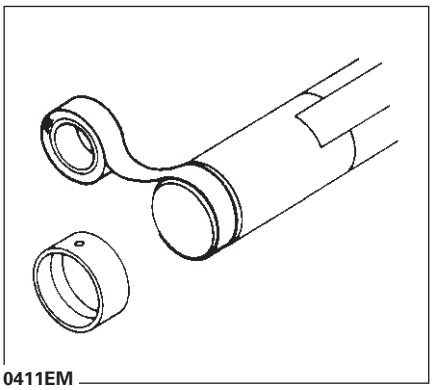
0409EM

3. Check the clearance of the camshaft bearings using an interior dial gauge (1).

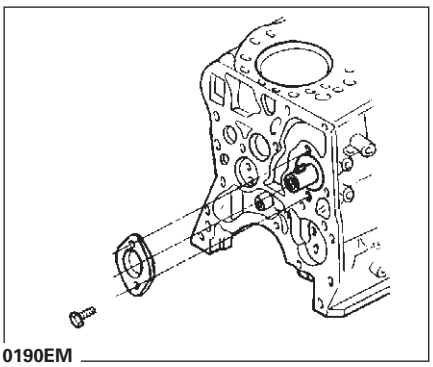


0410EM

4. Fit a new plug in the rear camshaft housing, using a suitable punch (2).
   - **Apply Teflon liquid (3).**


0411EM

When fitting bearings 4 to 2 into the replacement bar, use adhesive tape on the bar to prevent it from moving.

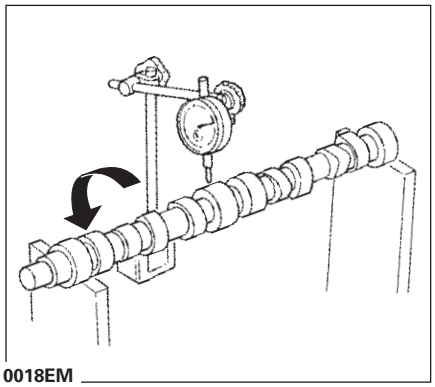

0190EM

5. Fit the camshaft thrust washer.
   - **Fit the thrust washer with the bevel facing outward. Fix it with bolts.**

Bolts fixing camshaft thrust washer:
4 - 6 Nm (0.4 - 0.6 kgm; 3 - 4.4 ft lb)

REPLACEMENT OF CAMSHAFT BEARINGS (cont'd)

CHECKING THE CAMSHAFT


0018EM

1. Check whether the surfaces of the camshaft supports and the cams are bent, worn or damaged.

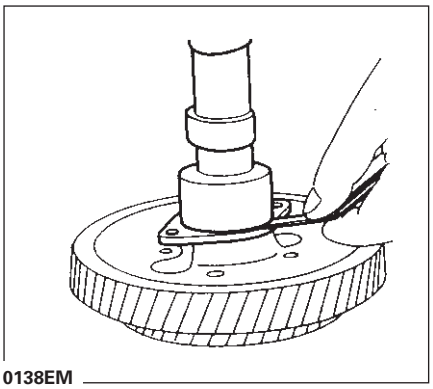
   Replace if necessary.

2. Measure the curvature of the camshaft at its central journal.

   If the curvature exceeds the specified limit, repair or replace the camshaft.

   Camshaft curvature

   Standard: Less than 0.02 mm (0.001 inches)
   Limit: Less than 0.06 mm (0.002 inches)


0138EM

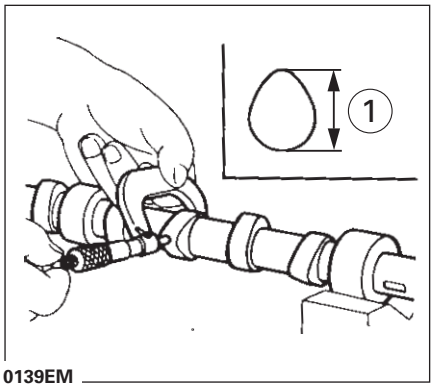
3. Measure the longitudinal play of the camshaft between the installation plate and the gearing.

   Replace the camshaft installation plate if the specified value is exceeded.

   Camshaft longitudinal play:

   Standard
   0.08 - 0.28 mm (0.003 - 0.011 inches)

   Limit
   Less than 0.5 mm (0.02 inches)



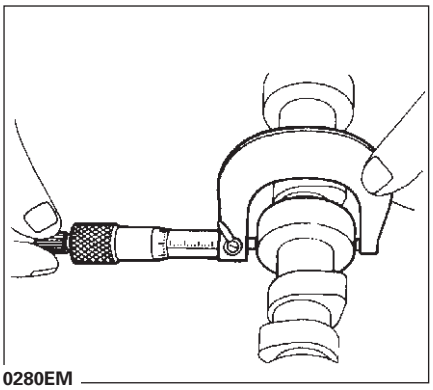
0139EM

4. Measure the height (1) of the cams. If they exceed the specified limit, replace the camshaft.

   Cam height:

   Standard: Inlet and exhaust
   41.88 - 41.92 mm (1.649 - 1.65 inches)

   Limit: Inlet and exhaust
   Less than 41.4 mm (1.63 inches)


0280EM

5. Measure the outer diameter of the camshaft support journals.

   Standard outer diameter:

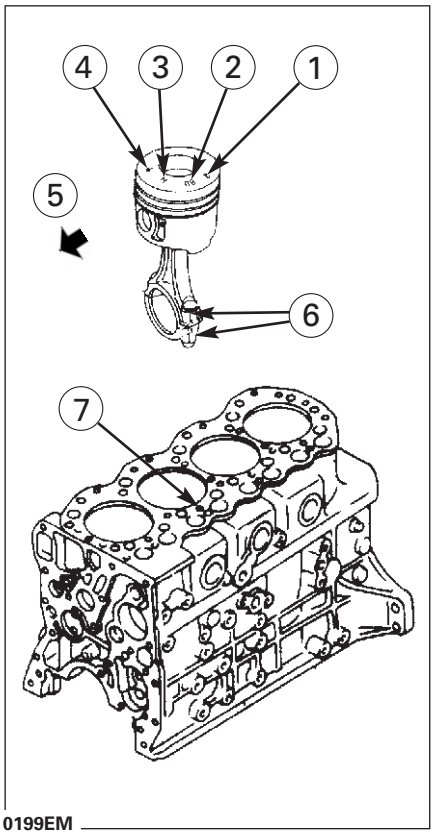
Front bearing	**50.721 - 50.74 mm (1.997 - 1.998 inches)**
2nd	**50.521 - 50.54 mm (1.989 - 1.990 inches)**
3rd	**50.321 - 50.34 mm (1.981 - 1.982 inches)**
4th	**50.121 - 50.14 mm (1.973 - 1.974 inches)**
Rear	**49.921 - 49.94 mm (1.965 - 1.966 inches)**

Clearance between camshaft bearing journals and support bearings

Standard: 0.002 - 0.109 mm (0.001 - 0.0429 inches)

Limit: Less than 0.15 mm (0.006 inches)

- **If the clearance exceeds the specified limit, replace the camshaft and the support bearings.**
- **Check that the camshaft turns smoothly.**



0199EM

1. Letter of classification by weight
2. BD. Piston for BD-30 Ti engine
3. Piston grade
4. Arrow pointing to engine front.
5. Engine front
6. Two marks:
   - Letter of classification by weight
   - Cylinder number
7. Liner grade (on cylinder block)

Pistons and connecting rods

CLASSIFICATION OF PISTONS BY WEIGHT AND DIAMETER

1. The pistons have the following marks on their upper face:
   (1)- A letter indicating the piston's classification by weight.
   (2)- Two letters, BD, identify the piston as belonging to the BD-30 Ti engine.
   (3)- A number identifying the piston by its diameter.
   (4)- An arrow which must always point to the front of the engine when fitted.

Classification by weight		
Letter (1)	**g**	**oz**
A	805 - 810	28.39 - 28.57
B	810 - 815	28.57 - 28.74
C	815 - 820	28.74 - 28.92
D	820 - 825	28.92 - 29.09
E	825 - 830	29.09 - 29.27
F	830 - 835	29.27 - 29.45

Classification by diameters	
Number/Grade	**Diameter mm (inches)**
1	95.94 - 95.95 (3.77 - 3.78)
2	95.95 - 95.96 (3.78 - 3.79)
3	95.96 - 95.97 (3.79 - 3.8)

The grade numbers of pistons fitted to the same engine must match those on the cylinder block next to each liner and all must have the same weight classification. This system allows the diameters of pistons and liners to be adjusted to maintain the permitted clearance limits while avoiding large variations in weight between the pistons of the same engine, thus achieving minimal dynamic imbalance.

CLASSIFICATION OF CONNECTING RODS BY WEIGHT

Liner grade		Piston to be installed	
Marking next to each lining (7)		**Piston grade (3)**	**Weight letter (1)**
Cylinder 1	2	2	Any, as long
Cylinder 2	2	2	as it is
Cylinder 3	1	1	the same
Cylinder 4	3	3	for all

1. Connecting rods have two marks on the big end and cap.
   - A letter indicates the connecting rod classification by weight.
   - A number showing the cylinder in which the connecting rod must be mounted.

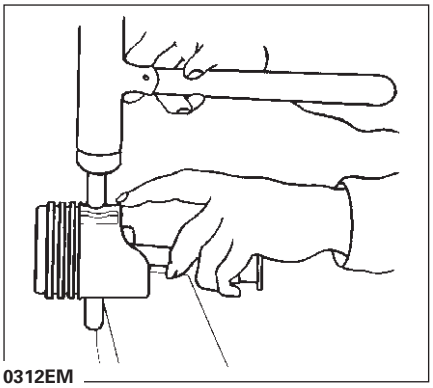
   The connecting rods fitted to the same engine must have the same letter to ensure minimal weight variations and minimal dynamic imbalance.

   The cylinder number on the connecting rod must match the number of the cylinder in which the connecting rod and piston are to be installed.

ASSEMBLE THE PISTON AND CONNECTING ROD

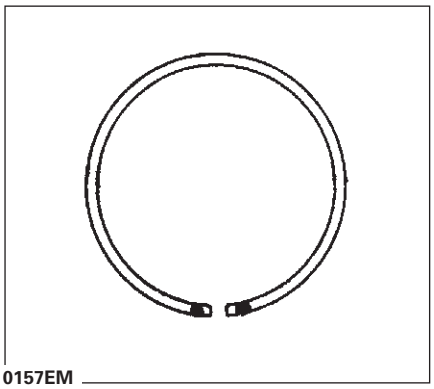
a. Take into account the notes in the previous section regarding installation combinations for pistons and connecting rods.

b. If the fifth mark (the arrow showing the installation position of the piston) cannot be found, install the piston so that the indent in the combustion chamber corresponding to the inlet valve (the larger of the two indents) faces the front of the engine.



0312EM

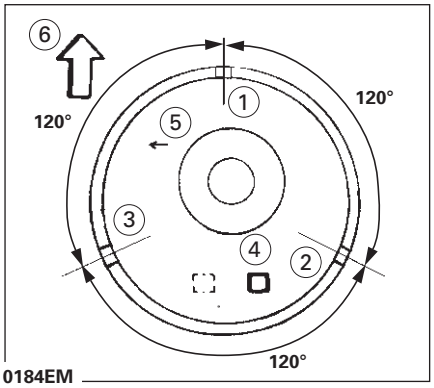
1. Fit a new spring washer in one end of the gudgeon pin eye in the piston.
2. Insert the gudgeon pin into the piston and connecting rod.
   - **When inserting the gudgeon pin in the connecting rod, heat the piston with a heater or water at 60 to 70°C (140 to 158°F) and apply clean, new engine oil to the gudgeon pin and the little end bearing.**
3. Fit a spring washer in the other end of the piston eye.
   - **After assembly, ensure that the piston rocks smoothly.**



0157EM

4. Open the piston rings and fit them using a suitable tool.
   - **Only open the rings enough for them to fit into the slots in the piston.**
   - **Ensure that the manufacturer's mark faces upward.**

Fit the first ring with its opening aligned with the gudgeon pin, and then fit the other rings with their openings staggered at 120°.

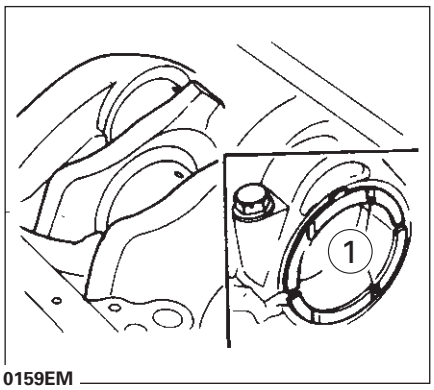


0184EM

1. Positioning of ends of ring 1 (upper)
2. Positioning of ends of ring 2
3. Positioning of ends of ring 3 (oil)
4. Piston classification
5. Identification mark
6. Engine front

Crankshaft

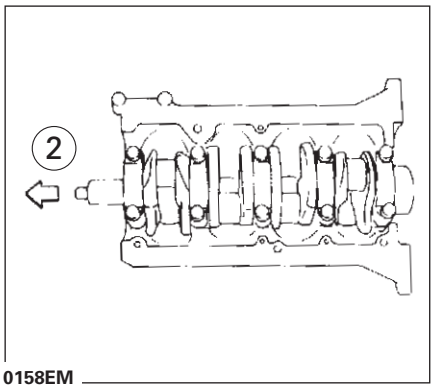
1. Fit the upper bearing shells into their housings in the upper part of the crankshaft seatings in the cylinder block.
   - **The upper bearing shells have a lubrication hole and slot not found on the lower ones.**
   - **If the crankshaft, cylinder block or bearings are to be re-used, the main bearing clearance must be checked.**
2. Fit the top crankshaft thrust washers to centre crankpin.
   - **Place the thrust washers so that the lubrication slots face the crankshaft, not the cap.**
   - **The thrust washers are fitted to bearing 4.**
   - **The central main bearings are wider than the others.**
   - **The other main bearings are all of the same size.**
   - **A single main bearing cannot be changed by itself; the entire set of 5 must be replaced together.**



0159EM

1. Oil slot

3. Fit the crankshaft in its housing.
   - **Apply new engine oil to the crankshaft journals and crankpins.**
4. Fit the lower bearing shells in their caps.
   Fit the bottom crankshaft thrust washers to crankpin 4 counting from the front of the block.
5. Fit the crankshaft bearing caps with the number facing the front of the cylinder block.
   - **Apply new engine oil to the main bearing caps and the cylinder block contact surfaces.**
6. Fit the rear sealing ring of the crankshaft
   - **Apply new engine oil to the contact surface of the rear oil seal and crankshaft.**

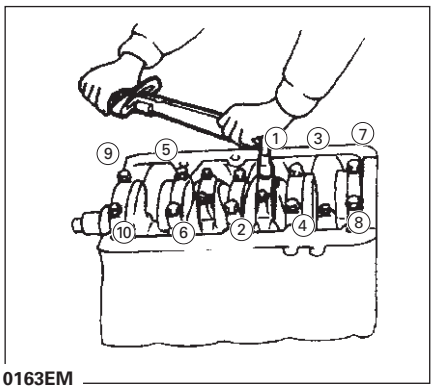


0158EM

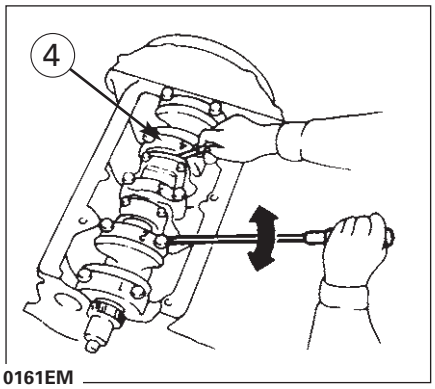
2. Front part

7. Gradually tighten the bolts fixing the caps in two or three steps. Follow the order shown in the figure.

   Journal cap bolts:
   167 - 177 Nm (17 - 18.1 kgm; 123.2 - 130.6 ft lb)
   - **After tightening the caps, check that the crankshaft turns smoothly.**



0163EM



0161EM

Crankshaft (cont'd)

8. Measure the crankshaft longitudinal play at crankpin 4 (4).

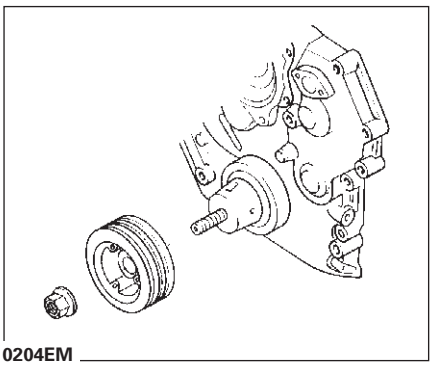
   Crankshaft end play:

   Standard:
   0.06 - 0.249 mm (0.0023 - 0.0098 inches)

   Limit:
   0.4 mm (0.016 inches)

   If it exceeds the specified limit, loosen the bolts fixing the caps, remove the caps, remove the crankshaft and replace the thrust washers. Retighten the caps. Check the lengthwise play of the crankshaft again.

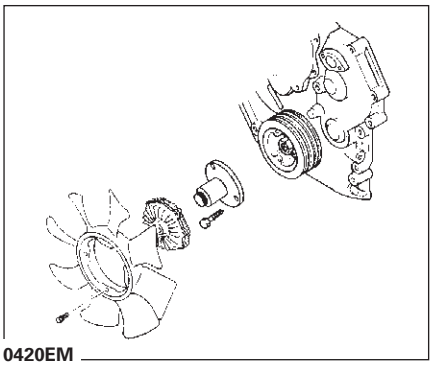
   - **See "TECHNICAL DATA AND CHARACTERISTICS".**


0204EM

CRANKSHAFT PULLEY

1. Oil the lip of the seal in the timing cover and the pulley contact area.
2. Position the pulley on the crankshaft, guiding it with a keyway
3. Fit the nut fixing the pulley. Hold the rear of the crankshaft and tighten the nut to the specified torque

   Nut fixing pulley:
   294 - 324 Nm (30 - 33 kgm; 216.9 - 239 ft lb)


0420EM

VISCOUS CLUTCH AND FAN

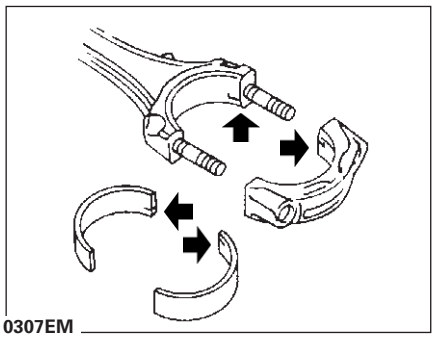
1. Fit the viscous clutch adapter.

   Bolt fixing viscous clutch adapter:
   31 - 37 Nm (3.2 - 3.8 kgm; 22.9 - 27.3 ft lb)

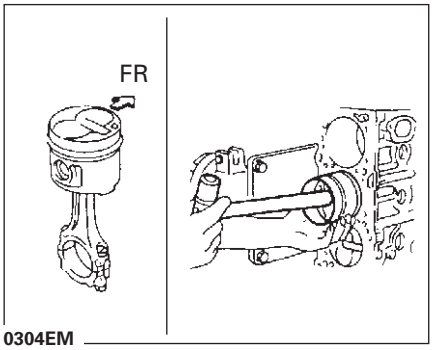
2. Fit the fan and viscous clutch to the adapter on the crankshaft pulley.

   Bolt fixing fan and viscous clutch:
   16 - 22 Nm (1.6 - 2 kgm; 11.8 - 16.2 ft lb)

FITTING THE PISTON AND CONNECTING ROD ASSEMBLY INTO THE CYLINDER BLOCK

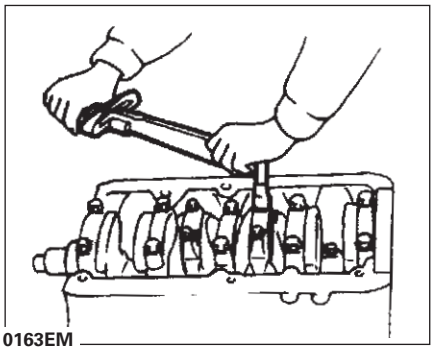

0307EM

1. Fit the connecting rod bearing shells into the connecting rods and caps. See "CYLINDER BLOCK - Inspection" in this section.
   - **Fit the bearings so that the notch in the connecting rod aligns with the lug on the bearing.**
   - **Apply engine oil to the surfaces of the connecting rod bearing and the crankpins.**



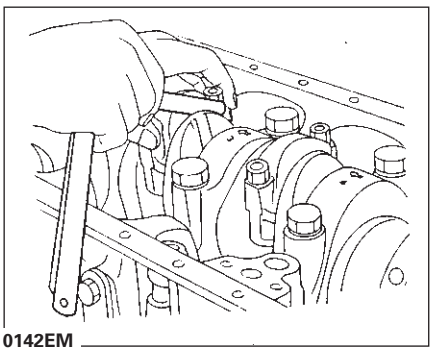
0304EM

2. Fit the piston and connecting rod assemblies into the cylinder block.
   - **Fit them into their cylinders using a suitable tool.**
   - **Take care not to damage the cylinder wall with the connecting rod.**
   - **Apply engine oil to the cylinder wall, piston and bearing.**
   - **Fit the piston so that the reference mark on the piston faces the front of the engine.**


0163EM

3. Fit the connecting rod caps.
   - **Apply engine oil to the thread of the nut fixing the cap.**
   - **Tighten the cap nuts to the specified torque.**

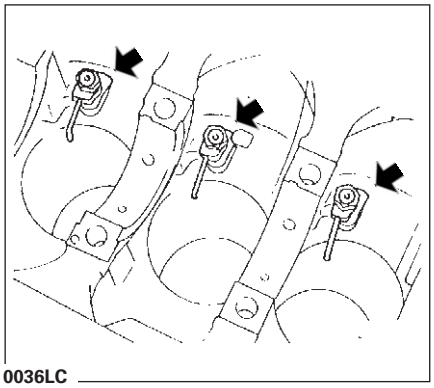
   Nuts fixing connecting rod caps:
   78 - 83 Nm (8 - 8.5 kgm; 57.5 - 61.2 ft lb)


0142EM

4. Measure the connecting rod side clearance:

   Connecting rod side clearance (end play of the big end):
   Standard: 0.01 - 0.22 mm (0.004 - 0.009 inches)
   Limit: 0.22 mm (0.009 inches)

   - **If it exceeds the specified limit, replace the connecting rod and/or crankshaft.**


0036LC

5. Fit the piston cooling oil jets.

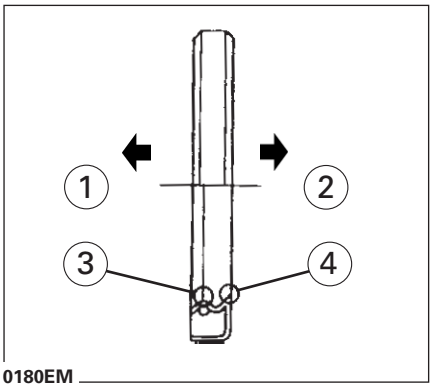
   Fixing of oil jets in engine block:
   29 - 39 Nm (3.0 - 4.0 kgm; 21.4 - 28.8 ft lb)

   NOTE: When fitting the oil jet, ensure that it does not interfere with the connecting rod. Replace the jet if it is deformed.

6. Remove the oil sump.

   See "OIL SUMP - Fitting" in this section.

Rear sealing ring of the crankshaft



0180EM

Never re-use a seal; always fit a new one after every disassembly of the engine.

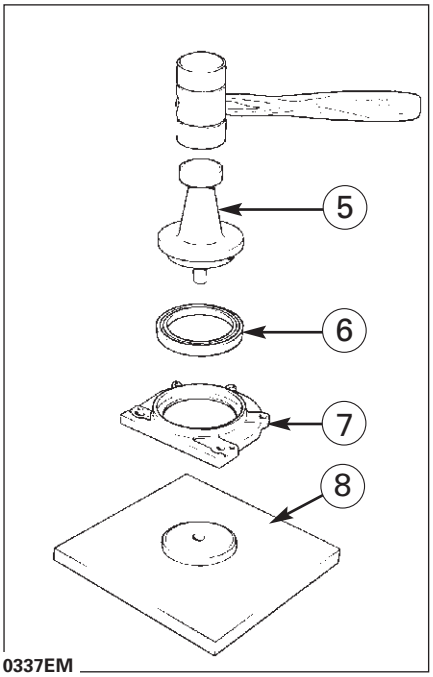
Ensure that the seal is fitted the right way round in the bracket, as shown in the figure.

1. Engine interior

2. Engine exterior

3. Seal lip

4. Dust guard lip



0337EM

Use a special tool to insert the seal into the bracket in order to prevent damage to the seal lips.

Apply soapy paste around the outer diameter of the seal to facilitate its insertion into the rear crankshaft seal bracket.

1. Fit the bracket and seal assembly into its housing; always use a new gasket.
2. Place the bolts fixing the rear crankshaft seal bracket to the cylinder block, tightening them crosswise and following the steps given below to prevent tensions and possible distortions, with their consequent leaks of oil through the seal.

   a) Insert the bolts by hand without tightening them.

   b) Tighten them to the specified torque in the above mentioned order

   Bolts fixing rear crankshaft seal bracket to cylinder block
   13 - 19 Nm (1.3 - 1.9 kgm; 9.6 - 14 ft lb)

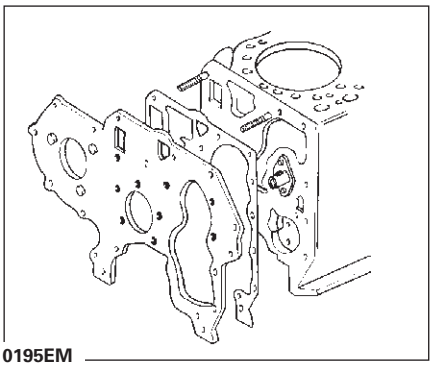
   - **Trim off the part of the gasket protruding from the rear seal bracket.**

5. Tool

6. Seal

7. Seal bracket

8. Tool base


0195EM

Timing

1. Fit the front block plate.
   - Offer up the gasket to the front face of the cylinder block, positioning it with the centerers and studs on the block.
   - Fit the plate and fix it with its bolts.
   - Trim off the part of the gasket protruding from the timing plate or cylinder block.

   Bolts fixing front plate to block:
   17 - 23 Nm (1.7 - 2.3 kgm; 12.5 - 17 ft lb)

   - Turn the crankshaft until cylinder 1 is at 0.8 mm (0.031 inches) before TDC on its compression stroke.
2. Fit the camshaft gear (2).
   - Position it using the key. Fix it with the central bolt

   Fixing of camshaft gear:
   44 - 49 Nm (4.5 - 5 kgm; 32.5 - 36.1 ft lb)

   - Check the axial play of the gear

   Axial play of camshaft gear:
   0.08 - 0.028 mm (0.003 - 0.0011 inches)
3. Fit the idler gear hub.
   - Position with the lubrication hole facing the cylinder head.
   - Dip the gear hub in clean engine oil.
4. Fit the idler gear (1).
   - Align the point marked on the idler gear with the centre of the two points marked on the camshaft gear.

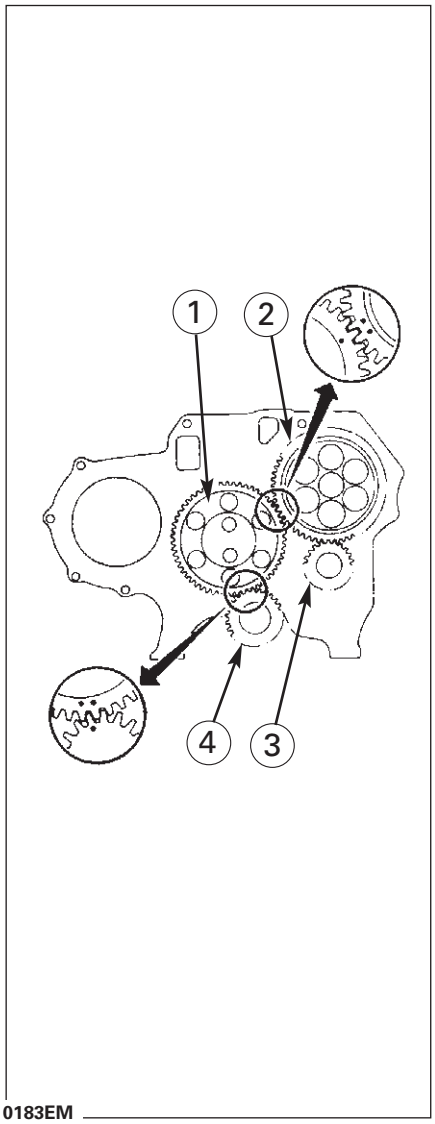
   Bolts fixing idler gear:
   34 - 39 Nm (3.5 - 4.0 kgm; 25.1 - 28.8 ft lb)

   - Check the axial play of the idler gear and tightening washer.

   Idler gear axial play:
   0.03 - 0.14 mm (0.001 - 0.006 inches)

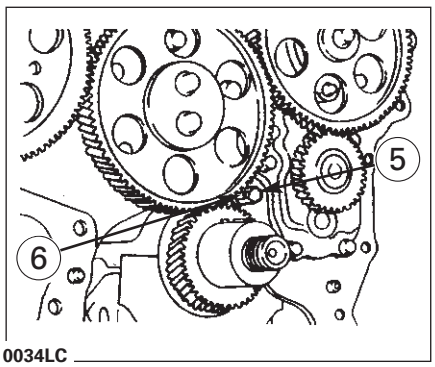
   Clearance between teeth of idler gear and camshaft gear:
   0.06 - 0.12 mm (0.002 - 0.005 inches)
5. Fit the crankshaft gear (4).
   - Using the key as a guide, position it so that the point marked on the crankshaft gear aligns with the centre of the two points marked on the idler gear.

   NOTE: Do not turn the crankshaft until the injector pump has been set up.



0183EM

1. Idler gear
2. Camshaft gear
3. Oil pump gear
4. Crankshaft gear



0034LC

6. Fit the gear oil jet.
   - Place the jet (5) in its housing, positioned so that the oil outlet (6) faces the union between the idler gear and the crankshaft.
   - Oil the gears with clean engine oil.

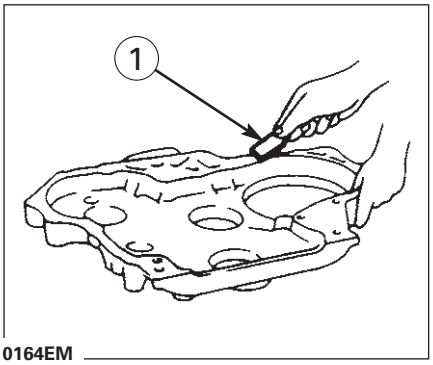
5. Oil supply to gears
6. Oil outlet

Timing (Cont'd)

FITTING AND SETTING UP THE INJECTION PUMP

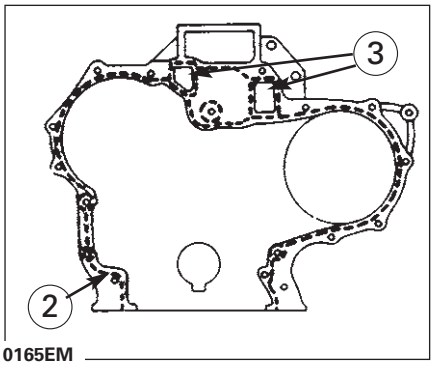
See "INJECTION PUMP - Installation - Setting up" in sections EF & EC of this manual.

TIMING COVER



0164EM

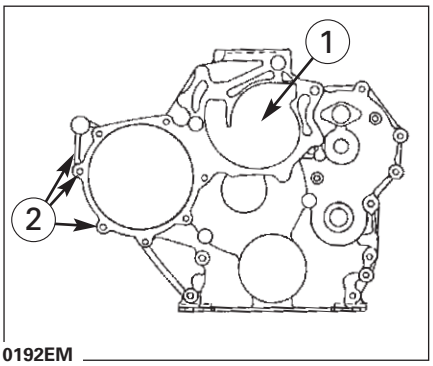
1. Fit the timing cover.
   - Use a rasp to clean all remains of Teflon liquid from the cover and the front block plate (1). Clean both contact surfaces.



0165EM

   - Fit new O-rings in the water conduits (3) from the cylinder block to the thermostat box. Fix the O-rings to the block with two spots of grease.
   - Apply a continuous line of Teflon liquid, about 3 mm (0.118 inches) wide to the surface of the front face. Take special care to prevent Teflon liquid from entering the water conduits.
   - The Teflon liquid must be applied between the holes of the cover and the inner part of the joint surface, as shown in the adjacent figure.
   - Do not allow more than 5 minutes to elapse between applying the Teflon liquid and fitting the timing cover. If more time elapses, the Teflon liquid must be removed and the application process re-started.

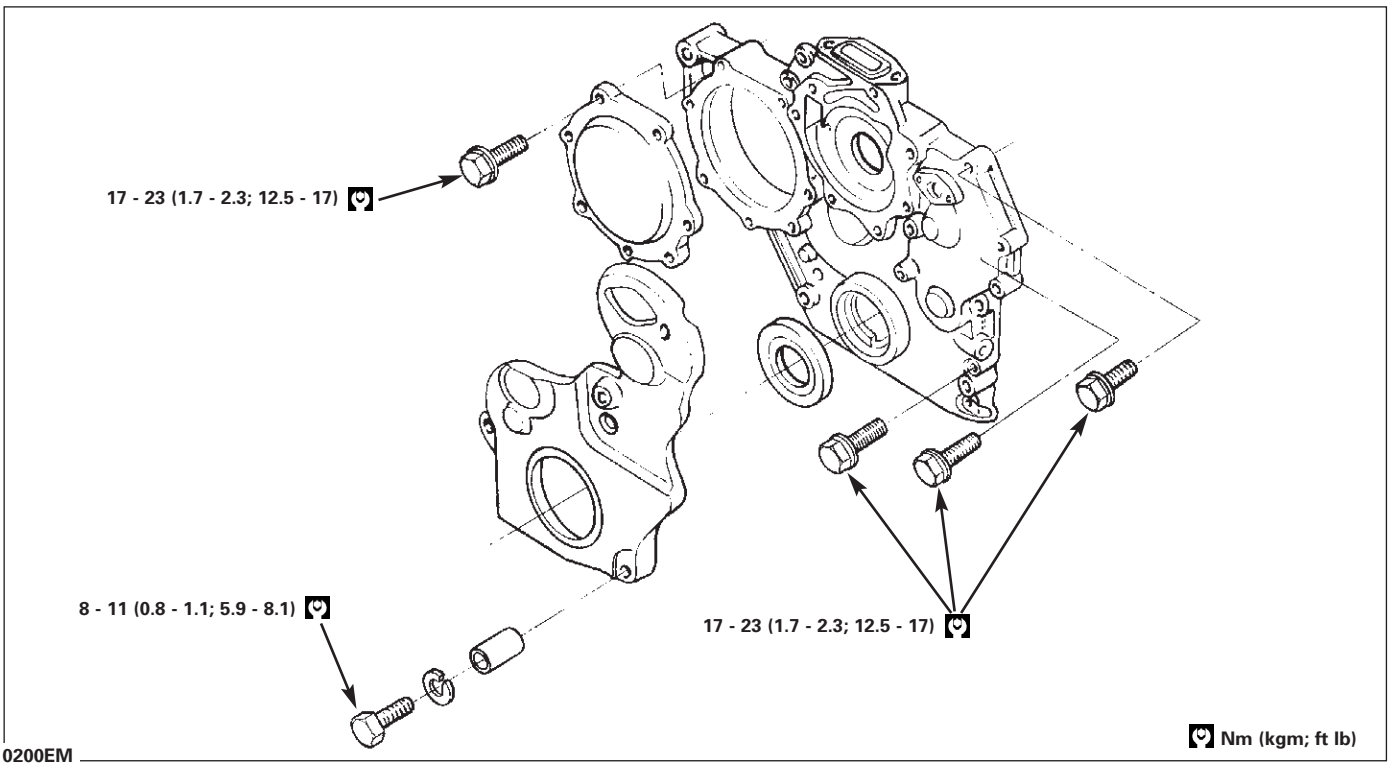
2. Location for the application of Teflon liquid



0192EM

2. Offer up the timing cover on its housing on the front cover of the cylinder block. Position it with the guides and fix it with its nuts and bolts.
   - Put bolts in the places marked in the figure.
   - 3 nuts must be fitted in the points marked (1).
   - In the 3 points marked (2), the bolts must be placed in the head in the side of the cylinder block.

Nuts and bolts fixing timing cover:
17 - 23 Nm (1.7 - 2.3 kgm; 12.5 - 17 ft lb)



0200EM

SOUNDPROOF COVER

3. Position the soundproof cover on the timing cover
   Insert the bolts fixing the soundproof cover. Do not forget the Grover washer and spacer for each bolt.

   Bolts fixing the sound-proof cover:
   8 - 11 Nm (0.8 - 1.1 kgm; 5.9 - 8.1 ft lb)

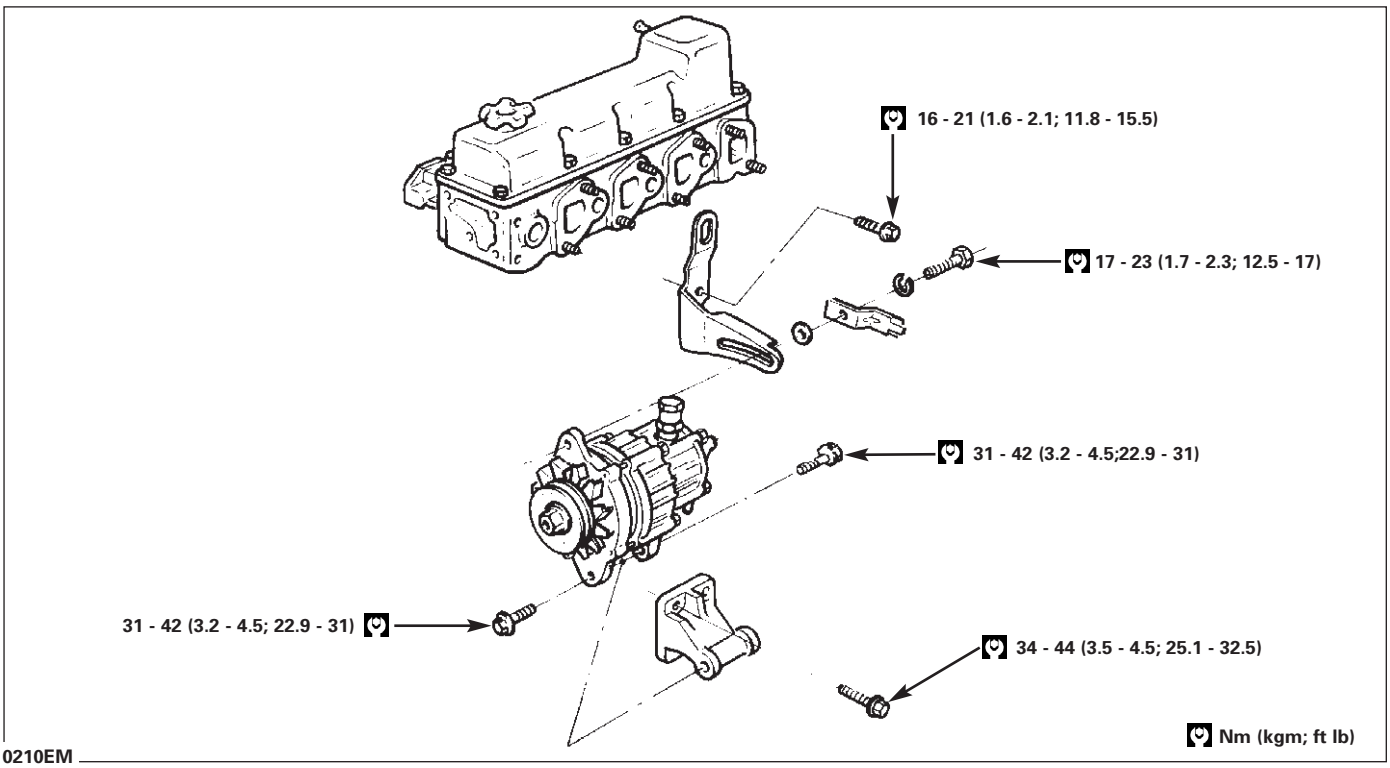
INJECTION PUMP GEAR COVER

4. Fit the injection pump gear cover.
   - Use a rasp to remove all remains of Teflon liquid from the sound-proof and timing covers. Clean both contact surfaces.
   - Apply a continuous line of Teflon liquid, some 3 mm (0.118 inches) wide and 150 mm (5.9 inches) in diameter, to the inner face of the gear cover.
   - Offer up the gear cover to its housing. The cover has an arrow on it which must point upward.

   Do not allow more than 5 minutes to elapse between applying the liquid gasket and fitting it to the engine. If more time elapses, the liquid gasket must be removed and the application process re-started.

   - Tighten the bolts fixing the gear cover.

   Bolts fixing the injection pump gear cover:
   16 - 21 Nm (1.6 - 2.1 kgm; 11.8 - 15.5 ft lb)



0210EM

ALTERNATOR

1. Fit the alternator bracket to the left side of the block and fix it with its bolts.

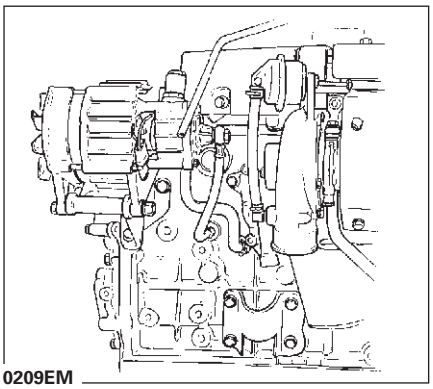
   Bolts fixing alternator bracket:
   34 - 44 Nm (3.5 - 4.5 kgm; 25.1 - 32.5 ft lb)

2. Place the alternator into its housing.
   Hand-insert the bolts fixing the alternator to its bracket.

3. Fit the belt. Tension the alternator and fix it with the bolt on the tensioning arch. Tighten the bolts fixing it to the bracket, starting with the one at the front of the engine.

   Bolts fixing alternator to bracket:
   31 - 42 Nm (3.2 - 4.5 kgm; 22.9 - 31 ft lb)

   Bolts fixing alternator to tensioning arch:
   17 - 23 Nm (1.7 - 2.3 kgm; 12.5 - 17 ft lb)



0209EM

4. Connect the depressor lubrication pipes.
   Oil return pipe, depressor to block (apply sealant to connector with block).

   Oil return pipe to block:
   31 - 42 Nm (3.2 - 4.3 kgm; 22.9 - 31 ft lb)

   - Oil inlet pipe of block to depressor (apply sealant to connector with block).

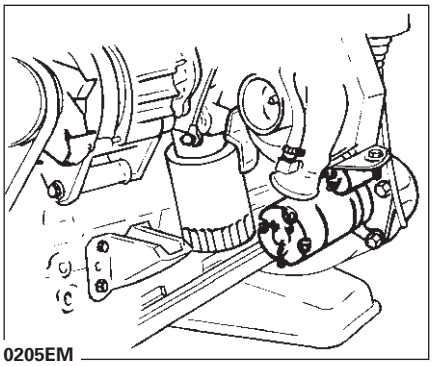
   Oil inlet pipe on depressor

   (depressor side)
   19-27 Nm (1.9-2.8 kgm; 14 - 19.9 ft lb)

   (block side)
   31 - 42 Nm (3.2 - 4.3 kgm; 22.9 - 31 ft lb)

   Bolt fixing suction outlet connector:
   29 - 34 Nm (3.0 - 3.5 kgm; 21.4 - 25.1 ft lb)

5. Connect the connector and the battery charge cable.


0205EM

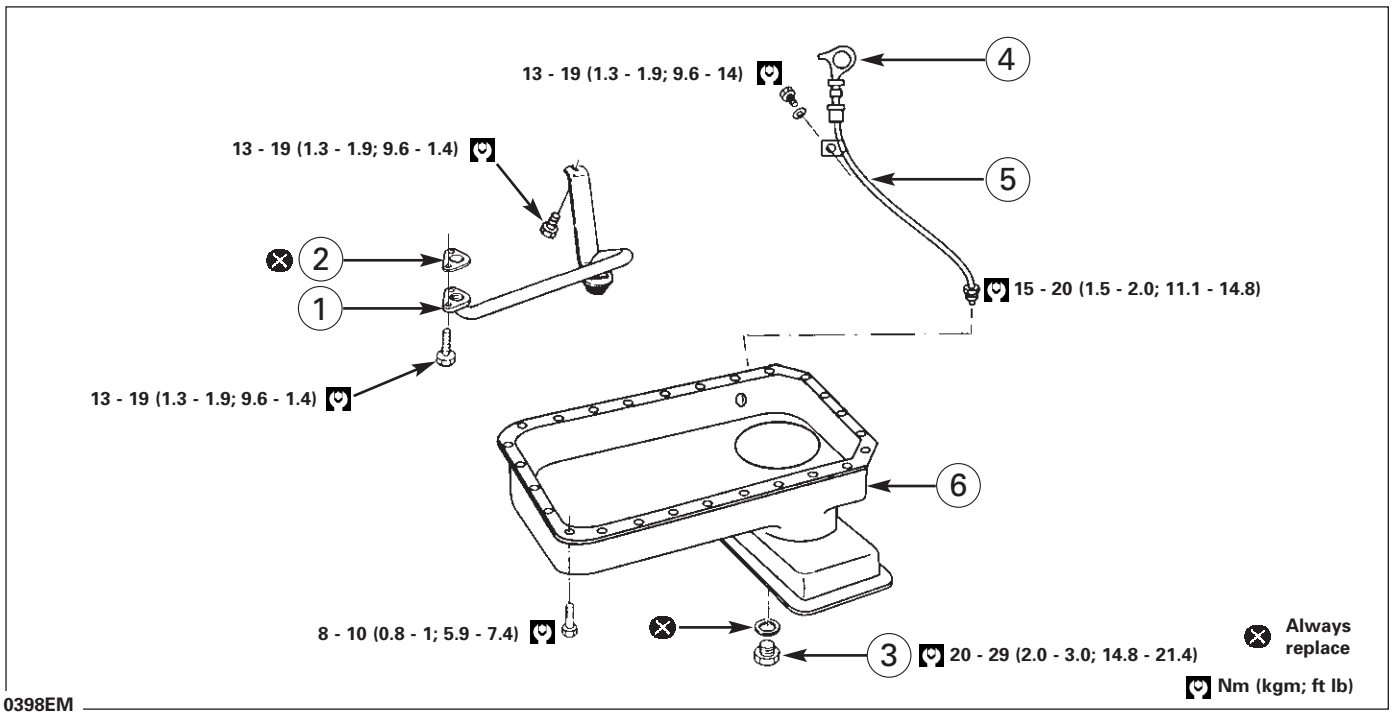
STARTER MOTOR

1. Place the starter motor in its housing and fix it with bolts.

Bolts fixing starter motor:
39 - 44 Nm (4.0 - 4.5 kgm; 28.8 - 32.5 ft lb)

OIL COOLER

See Oil Cooler - ENGINE LUBRICATION SYSTEM - in Section LC of this manual.



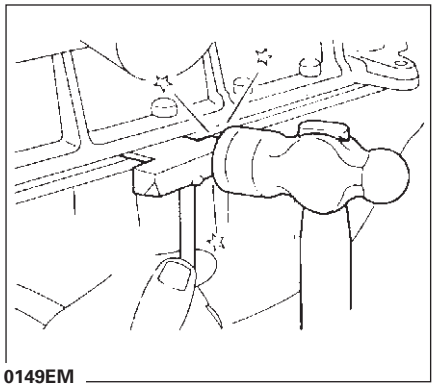
0398EM

1. Suction pipe and filter
2. Suction pipe gasket
3. Drain plug
4. Oil level dipstick
5. Oil level dipstick tube
6. Oil sump

1. Drain the engine oil.
2. Remove the oil dipstick tube.
3. Loosen and remove the bolts fixing the sump to the block.
4. Remove the sump. Move and pull the sump well. If it is difficult to release the sump from the block, insert the special tool as follows:

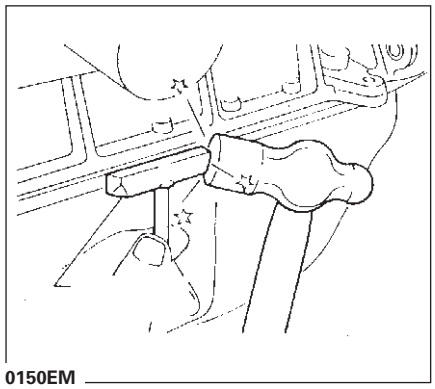
   a) Insert the tool between the sump and the cylinder block.

   - **Do not insert the gasket cutter into the inlet pipe and filter or into the rear oil seal, since this would damage the aluminium contact surfaces.**
   - **Do not insert a screwdriver or it will damage the oil sump stud.**



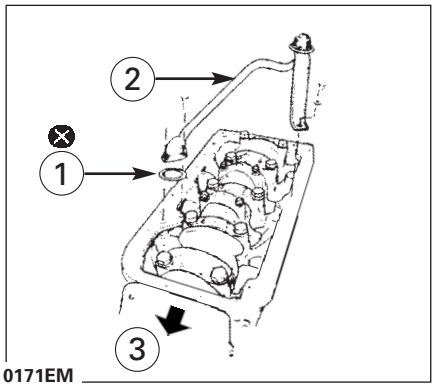
0149EM

   b) Slide the tool, tapping it with a mallet, and remove the oil sump.



0150EM

5. Remove the inlet tube and filter.



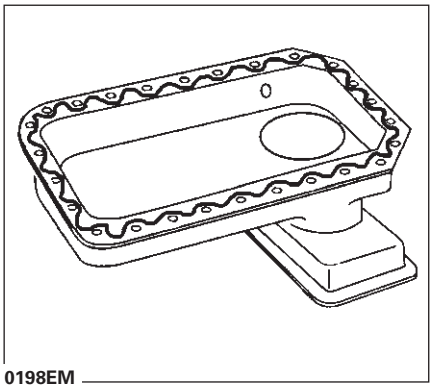
0171EM

1. Fit the inlet pipe and filter (2). Fit a new gasket (1).

   Bolts fixing inlet tube:
   13 - 19 Nm (1.3 - 1.9 kgm; 9.6 - 14 ft lb)

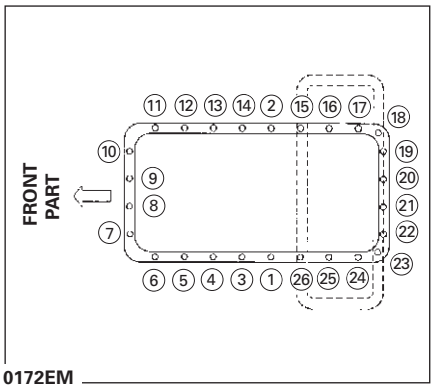
2. Remove all traces of old sealant from the sump stud and block surface. Degrease the contact surfaces.

3. Engine block front



0198EM

3. Apply Teflon liquid to the sump seating face. See figure.
4. Fit the sump and align the bolt holes.
   Ensure that there are no interferences between the sump and the inlet pipe or front piece.



0172EM

Sump bolts tightening sequence

5. Insert the bolts into the block and tighten them in the numeric sequence described in the figure. On finishing the tightening, re-tighten the four central bolts. 1, 2, 3 and 4.

   Bolts fixing sump to block:
   8 - 10 Nm (0.8 - 1 kgm; 5.9 - 7.4 ft lb)

6. Fit the oil dipstick tube.

   Oil dipstick tube connector to sump:
   15 - 20 Nm (1.5 - 2 kgm; 11.1 - 14.8 ft lb)

   Bolt fixing oil dipstick tube to inlet manifold:
   13 - 19 Nm (1.3 - 1.9 kgm; 9.6 - 14 ft lb)

   - Do not fill with oil until at least 30 minutes have elapsed after fitting the Teflon liquid.
   - Do not allow more than 5 minutes to elapse between applying the Teflon liquid and installing the sump, otherwise the oil gasket must be cleaned off and the process repeated.

General features

Engine model		BD-30 Ti
Cylinder layout		Vertical in line
Capacity	cm^3 ($inches^3$)	2953 (180.192)
Bore x stroke	mm (inches)	96 x 102 (3.779 x 4.016)
Valve layout		O.H.V.
Ignition order		1-3-4-2 (Direct)
Piston ring number	Compression	2
	Oil	1
Number of crankshaft journals		5
Compression ratio		17.2 : 1

COMPRESSION PRESSURE

	Unit				Reading at rpm
	kPa	bar	kg/cm^2	psi	
Standard	2942	29.42	30	427	300
Minimum	2452	24.52	25	356	

Technical data

CYLINDER HEAD

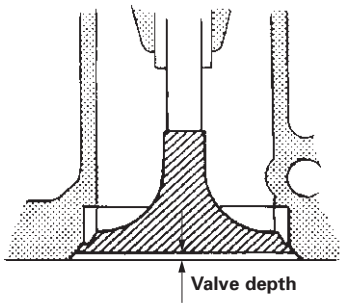
Maximum permitted warping of cylinder head surface

Unit: mm (inches)

Standard	Less than 0.07 (0.003)
Limit	0.2 (0.008)
Nominal height of cylinder head	89.7 (3.53)

Depth of valve with respect to cylinder head

Unit: mm (inches)



0413EM

	Standard	Service
Inlet	0.8 - 1.2 (0.031 - 0.047)	Less than 1.25 (0.049)
Exhaust		

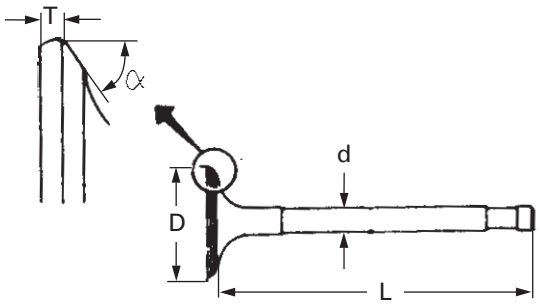
Rocker shaft and rockers

Unit: mm (inches)

	Standard	Limit
Exterior diameter of the rocker shaft.	19.979 - 20 (0.786 - 0.787)	–
Maximum permitted rocker shaft play:	0 - 0.1 (0 - 0.004)	Less than 0.3 (0.012)
Interior diameter of rocker shaft housing	20.014 - 20.035 (0.788 - 0.789)	–
Clearance between rocker shaft and housing	0.014 - 0.056 (0.0005 - 0.0022)	0.15 (0.006)

Valves

Unit: mm (inches)



0143EM

Diameter "D" of valve head	Inlet	43.4 - 43.6 (1.709 - 1.716)
	Exhaust	37.9 - 38.1 (1.492 - 1.5)
Length "L" of valve	Inlet	117 (4.606)
	Exhaust	
Diameter "d" of valve stem	Inlet	7.965 - 7.980 (0.313 - 0.314)
	Exhaust	7.945 - 7.960 (0.312 - 0.313)
Angle "α" of valve seat	Inlet	45° - 45°30'
	Exhaust	
Valve grinding width "T"		1.0 (0.039)
Valve stem end grinding limit		0.2 (0.008)
Valve clearance (when hot)	Inlet	0.25±0.03 (0.009±0.001)
	Exhaust	

VALVE GUIDE

Unit: mm (inches)

		Standard	Service
Valve guide outer diameter		12.0.33 - 12.044 (0.4737 - 0.4742)	–
Valve guide interior diameter (finished)		8 - 8.015 (0.315 - 0.316)	
Diameter of valve guide housing in cylinder block		12 - 12.011 (0.4724 - 0.4728)	
Valve guide interference adjustment		0.022 - 0.044 (0.0009 - 0.0017)	
		Standard	**Service**
Clearance between stem and guide	Inlet	0.023 - 0.053 (0.0009 - 0.0021)	0.15 (0.006)
	Exhaust	0.04 - 0.07 (0.0016 - 0.0027)	0.2 (0.008)
Allowable valve bending limit	Inlet	0.3 (0.012)	
	Exhaust	0.4 (0.016)	

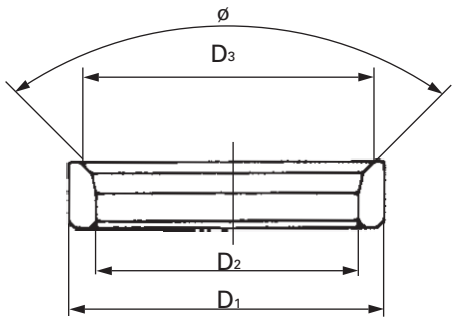
VALVE SPRING

Free length	mm (inches)	53.4 (2.102)
Height when compressed	mm/N (mm/kg; inches/lb)	31.8/751.2 (31.8/76.6; 1.252/34.24)
Maximum permitted deformation of spring	mm (inches)	2.5 (0.098)

Valves

VALVE SEATS

Unit: mm (inches)



0167EM

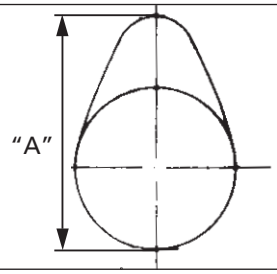
Inlet	Outer diameter "D1"		44.535 - 44.545 (1.7533 - 1.7537)
	Interior diameter "D2"		38.4±38.6 (1.5118±1.5197)
	Seat diameter "D3"		41.7 - 41.9 (1.6417 - 1.6496)
	Cylinder head housing diameter.		44.5 - 44.515 (1.752 - 1.7525)
	Angle "ø" of valve seat		89° - 91°
Exhaust	Outer diameter "D1"	Standard	39.535 - 39.545 (1.5565 - 1.5569)
		0.2 (Oversize)	39.735 - 39.745 (1.5644 - 1.5648)
		0.4 (Oversize)	39.935 - 39.945 (1.5722 - 1.5726)
	Interior diameter "D2"		32.9 - 33.1 (1.295±1.303)
	Interior diameter "D3":		36.95±37.05 (1.4547±1.4587)
	Cylinder head housing diameter.	Standard	39.495 - 39.51 (1.5549 - 1.5555)
		0.2 (Oversize)	39.695 - 39.71 (1.5628 - 1.5634)
		0.4 (Oversize)	39.895 - 39.91 (1.5707 - 1.5713)
	Angle "ø" of valve seat		89° - 90°

Cylinder block and liner

CAMSHAFT AND CAMSHAFT BEARINGS

Unit: mm (inches)

		Standard	Limit
Clearance between journal and bearing (lubrication clearance)		0.02 - 0.109 (0.001 - 0.0429)	Less than 0.15 (0.006)
Diameter of camshaft journal			
	Front	50.721 - 50.740 (1.9907 - 1.9915)	
	2°	50.521 - 50.540 (1.9829 - 1.9836)	
	3°	50.321 - 50.340 (1.9750 - 1.9758)	
	4°	50.121 - 50.140 (1.9672 - 1.9679)	
	Rear	49.921 - 49.940 (1.9593 - 1.9601)	
Camshaft sag (Total gauge reading)		Less than 0.02 (0.001)	Less than 0.06 (0.002)
Camshaft end play:		0.08 - 0.28 (0.003 - 0.011)	Less than 0.5 (0.02)

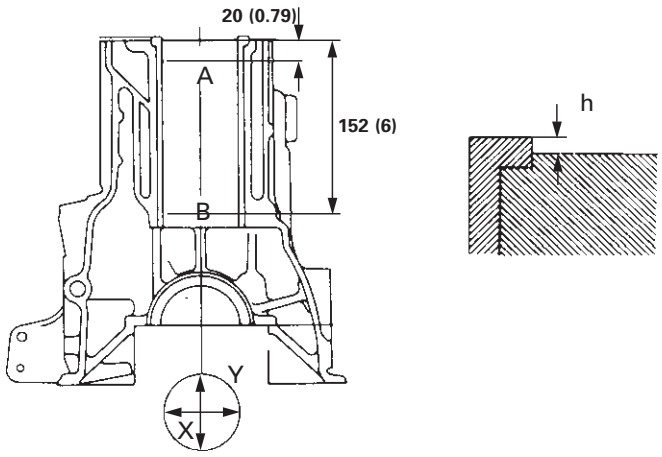


0145EM

Height "A" of the cam	Inlet	41.88 - 41.92 (1.649 - 1.65)	41.4 (1.63)
	Exhaust		

Cylinder block and liner (Cont'd)

Unit: mm (inches)

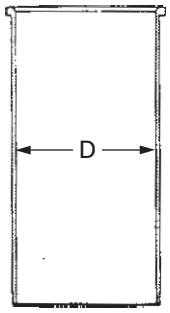


0384EM

		Standard	Limit
Warping of block surface		Less than 0.05 (0.002)	0.2 (0.008)
Diameter of liner housing in block		99 - 99.02 (3.8856 - 3.8864)	
Inner diameter of liner	Class 1	96 - 96.01 (3.7678 - 3.7682)	
	Class 2	96.01 - 96.02 (3.7682 - 3.7686)	
	Class 3	96.02 - 96.03 (3.7686 - 3.769)	
Ovalling	(X -Y)	Less than 0.07 (0.003)	
Coning	(A - B)	Less than 0.2 (0.008)	
Height "h" of liner with respect to the block surface		0.02 - 0.09 (0.001 - 0.003)	
Maximum permitted deviation in each cylinder		Less than 0.05 (0.002)	

LINERS

Unit: mm (inches)



0168EM

Diameter of cylinder liner (service)*	96.05 - 96.07 (3.7698 - 3.7706)

*Before fitting into the cylinder block.

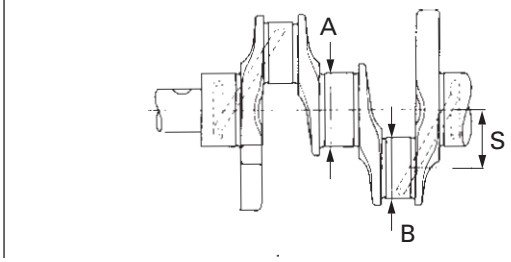
TAPPETS AND PUSHRODS

Unit: mm (inches)

	Standard	Limit
Outer diameter of tappet	25.960 - 25.970 (1.022 - 1.0224)	–
Diameter of pushrod hole in cylinder block	26 - 26.033 (1.0236 - 1.0249)	–
Clearance between pushrod and housing	0.03 - 0.073 (0.001 - 0.003)	Less than 0.2 (0.008)
Maximum permitted deformation of push rod	Less than 0.3 (0.012)	Less than 0.5 (0.02)

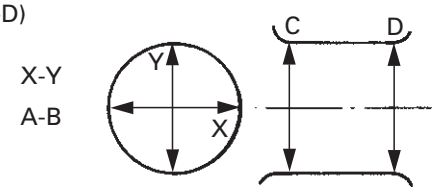
CRANKSHAFT

Unit: mm (inches)



0146EM

Ovalling X-Y
Coning (C-D)



0155EM

	Standard	Limit
Diameter of camshaft main journal "A"	70.907 - 70.920 (2.791 - 2.792)	
Diameter of crankpin "B"	56.913 - 56.926 (2.24 - 2.241)	
Distance "S"	51.00 (1.811)	
Ovalling (X-Y)	Less than 0.01 (0.0004)	0.02 (0.001)
Coning (C-D)		
Crankshaft eccentricity	0 - 0.03 (0 - 0.0012)	0.1 (0.004)
Longitudinal play	0.06 - 0.249 (0.0023 - 0.0098)	0.4 (0.016)

OVER-SIZED MAIN AND BIG END BEARINGS AVAILABLE

Permitted clearance in main and big end bearings

Unit: mm (inches)

	Standard	Limit
Main bearing clearance	0.035 - 0.087 (0.0014 - 0.0034)	Less than 0.15 (0.006)
Clearance of big end and crankpin bearings.	0.035 - 0.081 (0.0014 - 0.0032)	
Clearance between the gudgeon pin and the little end bearing	0.025 - 0.045 (0.001 - 0.0018)	

Over-sized main bearings available

Unit: mm (inches)

	Diameter of crankshaft journal
Standard	70.907 - 70.92 (2.7916 - 2.7921)
0.25 (0.01)	70.657 - 70.670 (2.7818 - 2.7823)
0.5 (0.02)	70.407 - 70.420 (2.7720 - 2.7724)
0.75(0.03)	70.157 - 70.17 (2.7621 - 2.7626)
1 (0.039)	69.907 - 69.92 (2.752 - 2.753)

Over-sized big end bearings available

Unit: mm (inches)

	Diameter of the crankpin
Standard	56.913 - 56.926 (2.2407 - 2.2412)
0.25 (0.01)	56.663 - 56.676 (2.2308 - 2.2313)
0.5 (0.02)	56.413 - 56.426 (2.221 - 2.2215)
0.75(0.03)	56.163 - 56.176 (2.2111 - 2.2116)
1 (0.039)	55.913 - 55.926 (2.2013 - 2.2018)

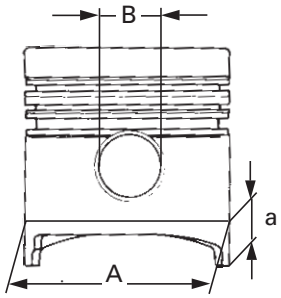
THRUST WASHERS AVAILABLE

Over-sized thrust washers available

Unit: mm (inches)

		Diameter of the crankpin
Standard	Stamped with mark A	2.275 - 2.325 (20.0896 - 0.0915)
	B	2.3 - 2.35 (0.09 - 0.092)
	C	2.325 - 2.375 (0.091 - 0.093)
Oversized	0.2 (0.008)	2.475 - 2.525 (0.0974 - 0.0994)
	0.4 (0.016)	2.675 - 2.725 (0.1053 - 0.1073)

PISTONS



0151EM

		Standard	Limit
Diameter "A" of piston:	Grade 1	95.940 - 95.95 (3.7772 - 3.7775)	
	Grade 2	95.95 - 95.96 (3.7775 - 3.7779)	
	Grade 3	95.96 - 95.97 (3.7779 - 3.7783)	
Measurement "a" from top of piston		63.5 (2.5)	
Diameter "B" of gudgeon pin hole		29.997 - 30.005 (1.18 - 1.181)	

Piston ring

Unit: mm (inches)

		Standard	Limit
Natural clearance	Upper	0.06 - 0.1 (0.002 - 0.004)	0.5(0.02)
	Second	0.04 - 0.08 (0.002 - 0.003)	0.3 (0.012)
	Lubrication	0.02 - 0.06 (0.001 - 0.002)	0.15 (0.006)
Separation between piston ring ends (production)	Upper	0.03 - 0.45 (0.012 - 0.018)	1.5 (0.059)
	Second	0.2 - 0.35 (0.008 - 0.014)	
	Lubrication	0.15 - 0.35 (0.006 - 0.014)	
Clearance between piston ring ends (Service):	Upper	0.04 - 0.6 (0.016 - 0.024)	
	Second	0.3 - 0.5 (0.012 - 0.02)	
	Lubrication		

Gudgeon pins

Unit: mm (inches)

	Standard	Limit
Diameter of gudgeon pin	29.993 - 30 (1.1772 - 1.1774)	
Clearance between gudgeon pin and piston	-0.003 - 0.012 (0.00012 - 0.00047)	
Clearance between gudgeon pin and little end bearing	0.025 - 0.045 (0.001 - 0.0018)	0.15 (0.006)

CONNECTING RODS

Unit: mm (inches)

	Standard	Limit
Permitted bending [for every 100 mm (3.94 inches) of length]	Less than 0.075 (0.03)	
Permitted twisting		
Inner diameter of little end bearing	30.025 - 30.038 (1.182 - 1.183)	
Side clearance	0.1 - 0.22 (0.004 - 0.009)	0.22 (0.009)

MISCELLANEOUS PARTS

Unit: mm (inches)

Gear cluster	Play in each gear	Standard	0.06 - 0.12 (0.002 - 0.005)
		Limit	0.2 (0.008)
Flywheel	Warping (total dial gauge reading)		Less than 0.1 (0.004)
Front plate	Limit of warp		0.2 (0.008)

TIGHTENING TORQUES

COMPONENT		Nm	kgm	ft lbs
Bolts fixing air inlet heater to inlet manifold		16 - 21	1.6 - 2.1	11.8 - 15.5
Bolts and nuts fixing inlet manifold:		16 - 22	1.6 - 2.2	11.8 - 16.2
Bolts fixing injection pump		20 - 25	2 - 2.6	14.8 - 18.4
Bolts fixing the injection pump bracket		30 - 36	3.1 - 3.7	22.1 - 26.6
Bolts fixing lower part of injection pump to bracket on block		30 - 36	3.1 - 3.7	22.1 - 26.6
Bolts fixing injection pump to lower bracket		19 - 25	1.9 - 2.6	14 - 18.4
Bolts fixing air conditioning compressor to block:		30 - 41	3.1 - 4.2	22.1 - 30.2
Bolts fixing air conditioning compressor to bracket		30 - 41	3.1 - 4.2	22.1 - 30.2
Nuts fixing injection pump drive gear		59 - 69	6.0 - 7	43.5 - 50.9
Injection pump drive gear cover bolts		44 - 49	4.5 - 5	32.5 - 36.1
Injection pipe connectors to injectors		20 - 25	2 - 2.6	14.8 - 18.4
Injection pipe connectors to injection pump		20 - 25	2 - 2.6	14.8 - 18.4
Injectors to cylinder head		44 - 49	4.5 - 5	32.5 - 36.1
Nut fixing fuel return pipe to injectors.		29 - 39	3 - 4	21.4 - 28.8
Bolts fixing rear engine slings		16 - 21	1.6 - 2.1	11.8 - 15.5
Bolts and nuts fixing exhaust manifold		16 - 22	1.6 - 2.2	11.8 - 16.2
Nuts fixing exhaust manifold to cylinder block		25 - 29	2.6 - 3	18.4 - 21.4
Bolts fixing alternator bracket to cylinder block		34 - 44	3.5 - 4.5	25.1 - 32.5
Bolts fixing alternator to its bracket		34 - 44	3.5 - 4.5	25.1 - 32.5
Bolts fixing alternator to tensioning arch		17 - 23	1.7 - 2.3	12.5 - 17
Bolts fixing depressor outlets		29 - 34	3 - 3.5	21.4 - 25.1
Oil inlet pipe on depressor (compressor side)		19 - 27	1.9 - 2.8	14 - 19.9
Oil inlet pipe on depressor (block side)		31 - 42	3.2 - 4.3	22.9 - 3
Bolts fixing cylinder head to cylinder block	First step	39 - 49	4 - 5	28.8 - 36.1
	Second step	54 - 59	5.5 - 6	39.8 - 43.5
	Third step	90°±10°		
	Resulting torque	127 - 157	13 - 16	93.7 - 115.8
Bolts fixing rocker shaft support		20 - 25	2 - 2.6	14.8 - 18.4
Lock nuts on rocker adjustment screws		15 - 20	1.5 - 2	11.1 - 14.8
Bolts fixing rocker cover (except no. 9):		9 - 11	0.9 - 1.1	6.6 - 8.1
Rocker cover bolt no. 9		15 - 20	1.5 - 2	11.1 - 14.8
Bolts fixing engine bracket to cylinder block:		41 - 59	4.2 - 5.3	30.2 - 38.4
Nuts fixing front engine bracket to SilentBloc		26 - 32	2.7 - 3.3	19.2 - 23.6
Nuts fixing rear engine bracket to SilentBloc		17 - 20	1.7 - 2	12.5 - 14.8
Bolts fixing rear bridge support to chassis		39 - 49	4 - 5	28.8 - 36.1
Nuts and bolts fixing timing cover		17 - 23	1.7 - 2.3	12.5 - 17
Bolts fixing timing soundproof cover		8 - 11	0.8 - 1.1	5.9 - 8.1
Idler gear bolts:		34 - 39	3.5 - 4	25.1 - 28.8
Bolts fixing the injection pump gear cover		16 - 21	1.6 - 2.1	11.8 - 15.5
Nuts fixing oil jets		29 - 39	3 - 4	21.4 - 28.8
Nuts fixing connecting rod caps		78 - 83	8 - 8.5	57.5 - 61.2
Nut fixing the crankshaft pulley		294 - 324	30 - 33	216.9 - 239
Bolts fixing crankshaft flywheel		147 - 167	15 - 17	108.4 - 123.2
Bolts fixing front plate to block:		17 - 23	1.7 - 2.3	12.5 - 17
Bolts fixing bearing caps		167 - 177	17 - 18.1	123.2 - 130.6
Bolts fixing camshaft drive gear		44 - 49	4.5 - 5	32.5 - 36.1
Bolts fixing injection pump drive gear		59 - 69	6 - 7	43.5 - 50.9
Bolts fixing camshaft thrust washer:		4 - 6	0.4 - 0.6	3 - 4.4
Bolts fixing rear seal bracket		13 - 19	1.3 - 1.9	9.6 - 14
Bolts fixing viscous clutch adapter to pulley		31 - 37	3.2 - 3.8	22.9 - 27.3

COMPONENT	Nm	kgm	ft lbs
Bolts fixing fan to viscous clutch	16 - 22	1.6 - 2.2	11.8 - 16.2
Bolts fixing starter motor	39 - 59	4 - 6	28.8 - 43.5
Bolts fixing oil filter inlet pipe	13 - 19	1.3 - 1.9	9.6 - 14
Bolts fixing sump to cylinder block	8 - 10	0.8 - 1	5.9 - 7.4
Bolt fixing oil dipstick tube to inlet manifold	13 - 19	1.3 - 1.9	9.6 - 14