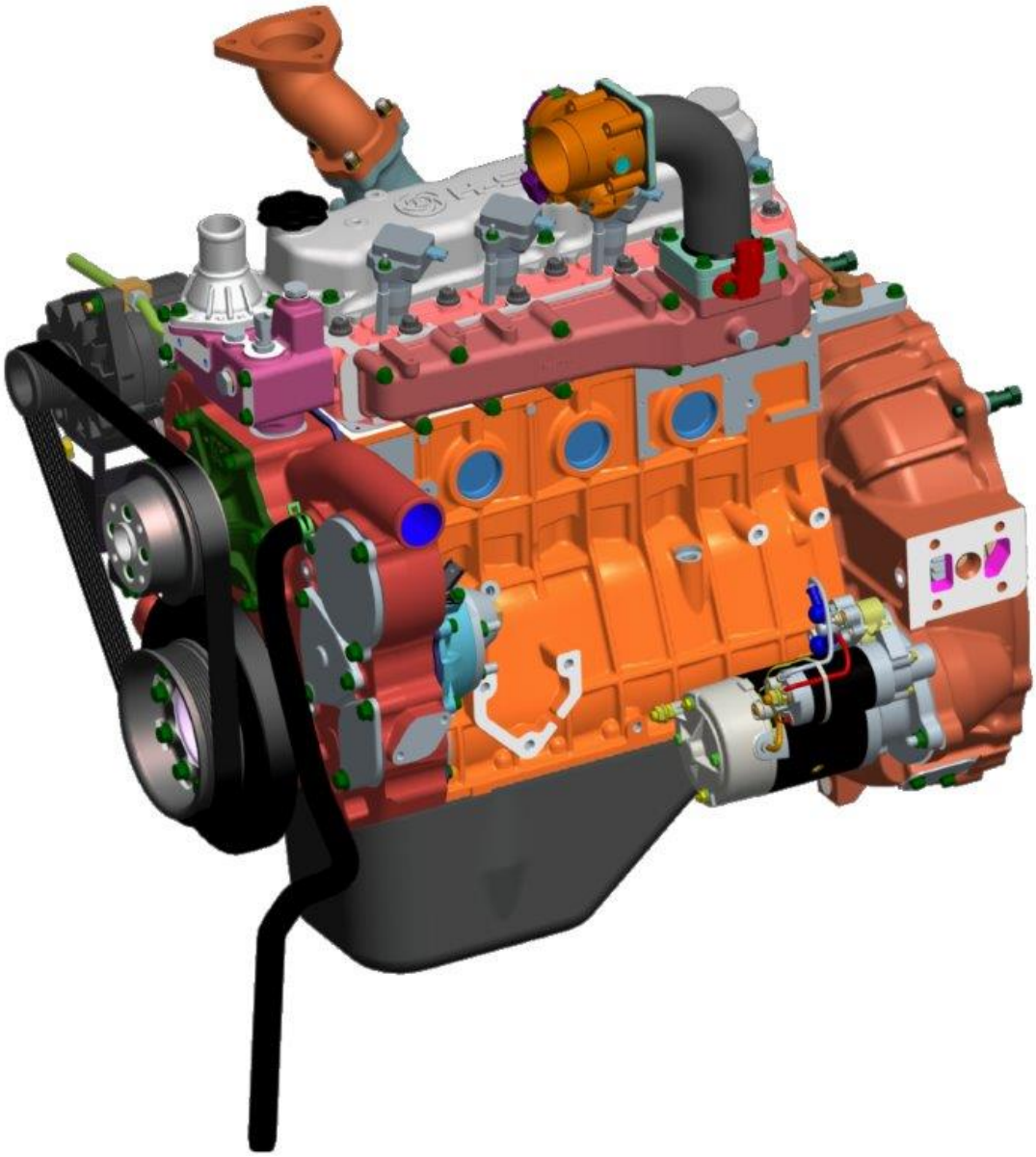
H4E4NG106 CNG BSIV ENGINE

Bharat Stage IV



ASHOK LEYLAND

MAR 2014

IMPORTANT PLEASE READ

In the Event of Serious Leak

On no account should a naked flame be used to detect a leak. Shut off all engines and electrical equipment in the immediate vicinity and leave off until the gas hazard is removed.

Smoking or naked lights must not be allowed. Extinguish all heaters, lights, gas rings, stoves and boilers in the immediate vicinity.

Move all people to a safe distance from the leak in an upwind or crosswind direction.

Unless the leakage is of minor nature or the leak can be quickly controlled by those present on site, the Fire Service and Police Department should be notified, advising them of the location. Material and volume involved.

Action in the Event of Fire

In the event of fire, expert help from the Fire Service must be sought immediately and the Police Department notified. Advice them of location material and quantity involved. Carry out the same precautions as under “SERIOUS LEAK”.

Do not attempt to extinguish flames other than by cutting off the flow of natural Gas. Control resulting fires with dry powder type extinguisher.

Fire extinguisher recommended: confirming to IS: 2171 of dry chemical powder type.

CONTENTS

GROUP - 16

HAE4NG106 CNG BSIV ENGINE

CONTENTS

GROUP - 16

HAE4NG106 CNG BSIV ENGINE

CONTENTS

GROUP - 16

HAE4NG106 CNG BSIV ENGINE

CONTENTS

GROUP - 16

HAE4NG106 CNG BSIV ENGINE

CONTENTS

GROUP - 16

HAE4NG106 CNG BSIV ENGINE

CONTENTS

GROUP - 16

HAE4NG106 CNG BSIV ENGINE

CONTENTS

GROUP - 16

HAE4NG106 CNG BSIV ENGINE

IMPORTANT

Experienced personnel should carry out any repair work on the aggregate and utmost cleanliness must be observed.

A dismantling of the aggregate should only be undertaken for the purpose of replacing or worn components. After the aggregate has been removed from the vehicle it should be thoroughly washed with a suitable cleansing liquid before it is opened.

Dismantling and assembly should be carried out on a clean work bench and the special tools, manufactured for this purpose to be used.

Any old sealing compound adhering to joint surfaces of parts and cover must be removed before the components are installed. Burrs or similar defects must be removed carefully with a oil stone.

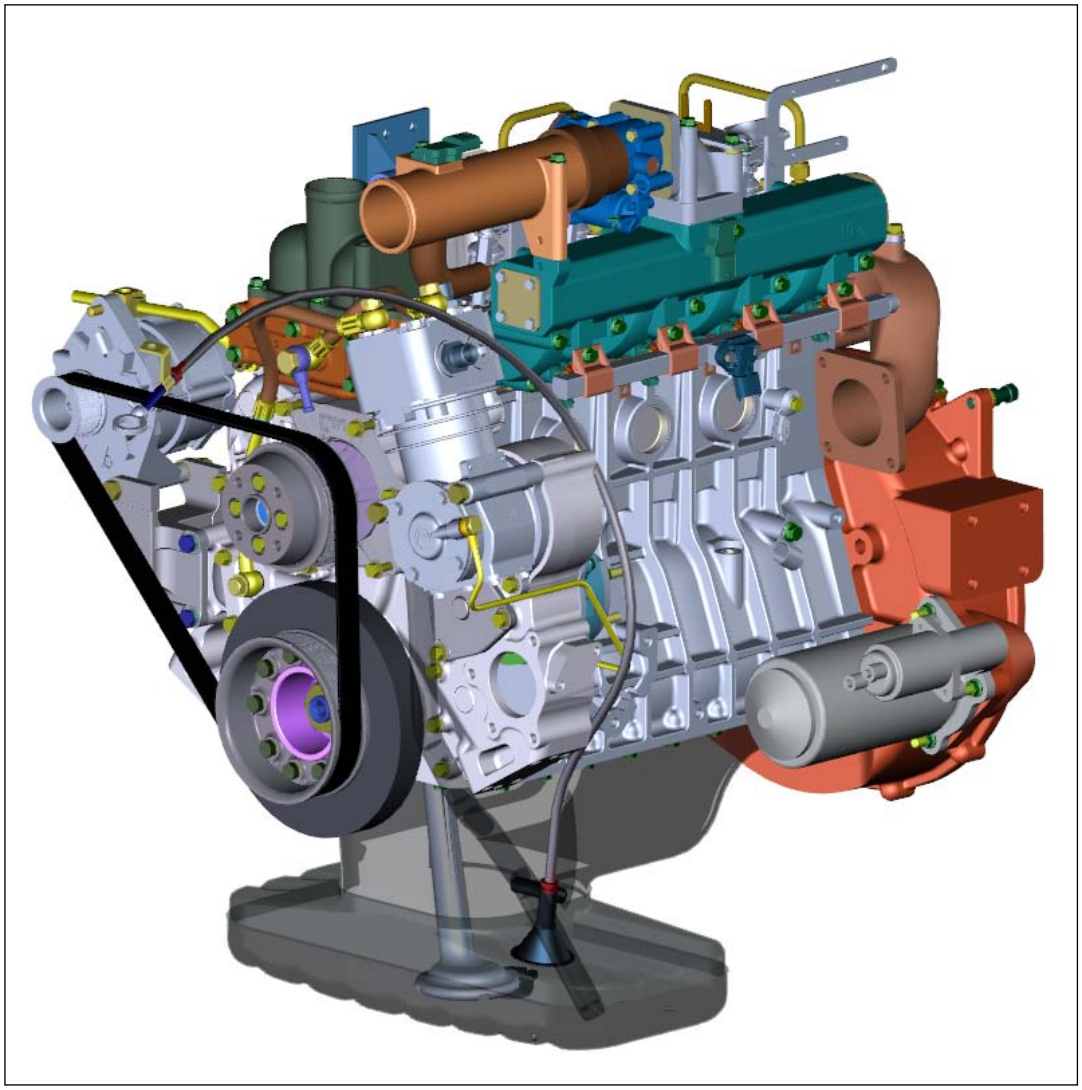
Damaged and badly worn components must be renewed.

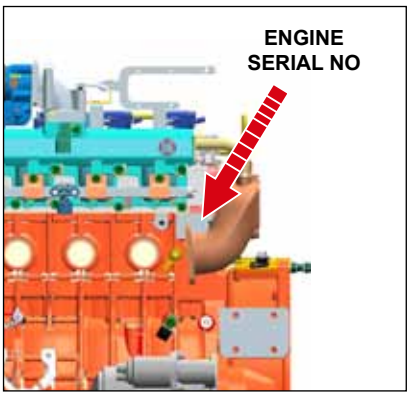
Sealing rings with rough, torn or hardened sealing lips must be renewed. Care must be taken that grease\sludge or other foreign matters do not obstruct oil holes and passages.

The tightening torque and adjustment data, given in the manual must be followed very strictly during the assembly of the aggregate. Tightening torque's for bolts and nuts, which are not contained in the table " tightening torque and adjustment data" can be obtained from standard specification tables.

16.0.5 Engine Type and Number

The engine no is stamped onto the crankcase on the left side rear top corner.





16.0.7 General Data

Description	HAE4NG106
Type $_{Text}$	H Series 4TI CNG BSIV Turbo Charged Engine
Bore and Stroke	104 x 113 mm
Piston displacement	3.839 ℓ
Max output	106 kW @ 2400 rpm
Max torque	450 Nm @ 1600 - 2000 rpm
Compression Ratio	11.5
Firing order	1-3-4-2
Direction of rotation	Counter clockwise viewed from flywheel.
Compression pressure	16 - 20 kg/cm² @ 280 rpm (with throttle kept in open position)
Idling revolution	700 ± 50 rpm
Max. revolution	2640 rpm
Valve Seat angle	
Intake	30°
Exhaust	45°
Valve Face Angle	
Intake	30°
Exhaust	45°
Valve Timing	
Intake opens	8° Before Top Dead Centre
Intake closes	48° After Bottom Dead Centre
Exhaust opens	60° Before Bottom Dead Centre
Exhaust closes	8° After Top Dead Centre
Valve clearance (when cold)	
Intake	0.30 mm
Exhaust	0.45 mm
Governing System	ECU control
Spark plug gap	0.3 ± 0.05 mm
Engine Oil Pump	
Type	Full forced Pressure feed by gear pump
Drive	By gear
Engine oil cooler	Multi plates type, water cooled
Coolant Pump	
Type	Forced circulation by volute pump
Drive	By Poly V-belt
Thermostat	Wax type, Bottom bypass system

16.0.8 Repair Data

Description	Specification (Measurements in mm) HAE4NG106	Measuring Device and Remarks
Crankcase		
Cylinder block flatness	0.05 (limit 0.1)	Straight edge rule and feeler gauge
Crankcase bore for cylinder liner fitment	Ref. section 15.0.13	W,X,Y,Z, punch marked on crank case LH side adjacent to each bore
Cylinder liner outside diameter	Ref. section 15.0.13	W,X,Y,Z, paint mark given on cylinder liner collar for identification
Interference fit of cylinder liner in crankcase bore Transition Fit	Transition fit	Selective assembly
Cylinder liner bore: Size	104.008 - 104.040 (limit 104.15)	Bore dial gauge (To be measured at 80 mm from top) stand
Liner projection	0.01 - 0.08	Dial gauge with magnetic
Block Top Surface to Crankshaft Centre	299.950 - 300	
Block Top Surface to sump face height	370	
Main journal dia	77.985 - 78.00	Micor meter
Cylinder counter bore depth	8.020 - 7.980	Vernier depth gauge
Cylinder counter bore dia	112.00 (+0.290 to 0.150)	Micro meter & bore dial gauge
Piston and Connecting Rod Assembly		
Piston diameter Standard size	103.960	Micrometer (measure at gudgeon pin axis)
Diametrical piston clearance (at skirt)	0.140 - 0.172	Feeler gauge
Piston ring Groove Width		
Top	2.57 - 2.59 (limit 3.10)	Micrometer
Second	2.03 - 2.05 (limit 2.14)	
Oil Ring	5.01 - 5.03 (limit 5.08)	
Piston ring width		
Top	2.47 - 2.49 (limit 2.32)	Micrometer
Second	1.97 - 1.99 (limit 1.88)	
Oil Ring	4.97 - 4.99 (limit 4.95)	
Piston ring side clearance in groove		
Top	0.08 - 0.12 (limit 0.7)	Feeler gauge
Second	0.04 - 0.08 (limit 0.2)	
Oil Ring	0.02 - 0.06 (limit 0.1)	
Piston Ring gap		
Top	0.30 - 0.45 (limit 1.2)	Feeler gauge
2nd	0.30 - 0.45 (limit 1.2)	
Oil	0.30 - 0.45 (limit 1.0)	
Maximum permissible piston weight difference per set	NIL	No need to check weight difference as pistons are serviced as set
Piston pin hole inside diameter	34.987 - 35.003 (limit 35.020)	Bore dial gauge
Gudgeon pin outside diameter	34.989 - 35.00 (limit 34.980)	Micrometer (Push fit in piston heated to 80°C)
Clearance between Piston pin and Piston pin hole	-0.013 - 0.014 (limit 0.04)	
Small end bush bore	35.015 - 35.025 (limit 35.07)	Bore dial gauge

16.0.8 Repair Data

Description	Specification (Measurements in mm) HAE4NG106	Measuring Device and Remarks
Diametrical clearance between gudgeon pin and con. rod small end bush bore Max. permissible clearance	0.015 - 0.036	Bore dial gauge and micrometer
	(limit 0.08)	
Interference fit of small end bush in connecting rod	0.035 - 0.092	Bore dial gauge and micrometer
Connecting rod centre to centre distance	181.480 - 181.520	
Connecting rod bend / twist limit	0.1 per 200	
Connecting rod big end dia	65.985 - 66	
Max. permissible connecting rod weight (gms) Grading	A : 1710 - 1750	Grades A, B, C, D, E are punched on big end of the connecting rod. An engine should have connecting rods of same grade.
	B : 1750 - 1790	
	C : 1790 - 1830	
	D : 1830 - 1870	
	E : 1870 - 1910	
Crankshaft		
Crankshaft journals and crankpin grinding dimensions	Ref. section 15.0.10	Micrometer
Surface hardness of journals and crankpins	269-311 BHN	Hardness Tester. No further heat treatment recommended
Maximum permissible run-out of centre journal	Ref. section 15.0.10	V-Blocks and dial gauge
Journals and crankpins	Ref. section 15.0.10	Micrometer
Crankshaft Bend	limit 0.04	
Crankshaft Main Bearing Cap roundness	0.06	
Main and thrust bearing shells Crankshaft end clearance	Ref. section 15.0.11	(Standard and undersize)
	0.05 - 0.22	Feeler gauge
Maximum permissible clearance	0.4 (limit)	
Diametrical clearance between main journal and bearing Maximum permissible clearance	0.039 - 0.09	Bore dial gauge and micrometer
	0.13 (limit)	
Main bearing inside diameter	77.985 - 78.00	Bore dial gauge
Main bearing spread	79.00 - 79.06	Vernier Calliper
Connecting rod big end bearings	Ref. section 15.0.12	(Standard and undersize)
Connecting rod side clearance	0.20 - 0.52 (limit 0.6)	Feeler gauge
Diametrical clearance between Connecting Rod Big End Bearing & Crank pin	0.031 - 0.082	Bore dial gauge and micrometer
	(limit 0.12)	
Connecting rod Big End bearing inside dia	65.985 - 66.00	Bore dial gauge
Connecting rod Big end ovality/taper	0.06	
Connecting rod big end bearing spread	67.05 - 67.55	Vernier caliper
Connecting rod bend/twist	limit 0.1 per 200	Fixture and feeler gauge
Connecting rod twist	limit 0.1 per 200	Fixture and feeler gauge
Flywheel face out	limit 0.15	Dial gauge

16.0.8 Repair Data

Description	Specification (Measurements in mm)	Measuring Device and Remarks
	HAE4NG106	
Cylinder Heads and Valves		
Cylinder head flatness	0.05 (limit 0.1)	Straight edge and feeler gauge
Cylinder head height	87.0 (limit 86.8)	Vernier caliper
Valve sink (Valve head depth below cylinder head face)		Dial gauge
Inlet	2.65 - 2.75	
Exhaust	2.37 - 2.47	
Valve stem diameter		
Inlet	8.95 - 8.97 (limit 8.9)	Micrometer
Exhaust	8.93 - 8.95 (limit 8.8)	
Intake and Exhaust Valve Guide dia	9.000 - 9.015	Internal micro meter
Diametrical valve stem clearance in guide		Plug gauge and Micrometer
Intake	0.035 - 0.068	
Exhaust	0.050 - 0.083	
Valve seat angle		
Intake	30° - 30° 15'	Bevel Protractor (for both inlet and exhaust)
Exhaust	45° - 45° 15'	
Valve seat seating depth on cylinder head		
Inlet	8.9 ± 0.1	
Exhaust	7.3 ± 0.1	
Valve seat thickness		
Inlet	7.5 - 7.7	
Exhaust	6.0 - 6.2	
Valve seat seating dia on cylinder head		
Inlet	46.5 (+0.016, - 0.0)	
Exhaust	41.0 (+0.10, - 0.0)	
Outer dia of valve seat		
Inlet	46.5 (+0.10 to +0.085)	
Exhaust	41.0 (+0.145 to 0.130)	
Valve angle		
Intake	29° 45' - 30°15'	Protractor (for both inlet and exhaust)
Exhaust	44° 45' - 45°15'	
Valve head diameter		
Inlet	45.3 - 45.5	Micrometer
Exhaust	39.8 - 40.0	
Maximum permissible out of true head face head to stem	0.03	Lathe and dial gauge
Interference fit of valve guide in cylinder head	0.010 - 0.039	Plug gauge and micrometer
Height of valve guide above spring seat	14.5	
Maximum permissible out of true of	0.030	
valve seat to guide		
Valve spring straightness	2.0 (limit)	Tri Square
Spring load	24.2 kg at 44.9 mm (limit 20.6 kg)	Valve spring scale (inlet and exhaust)
Valve stroke	12.3 - 12.4 mm	Depth gauge (inlet and exhaust)

16.0.8 Repair Data

Description	Specification (Measurements in mm) HAE4NG106	Measuring Device and Remarks
Timing		
Rocker arm shaft diameter	18.966 - 18.984	
Diametrical clearance between rocker	0.036 - 0.079	Plug gauge and micrometer
lever on rocker shaft	(limit 0.15)	
Push Rod Bend	0.3	Centres and dial gauge
Tappet Diameter	26.95 - 26.97	Micro meter
Tappet guide inside diameter	27.00 - 27.02	Internal micro meter
Diametrical tappet clearance in crankcase	0.025 - 0.071	Bore dial gauge and micrometer
bore Maximum permissible limit	0.1 (limit)	
Camshaft Bend	0.05 (limit)	Dial gauge and V blocks
Camshaft Cam lift (Intake)	6.8354	Vernier height gauge & V blocks
Camshaft Cam lift (Exhaust)	6.8933	Vernier height gauge & V blocks
Camshaft end play	0.10 - 0.18 (limit 0.3)	Dial gauge with magnetic base
Camshaft Journal Diameter		Micro meter
Journal 1	56.95 - 56.97 (limit 56.85)	
Journal 2	56.75 - 56.77 (limit 56.65)	
Journal 3	56.55 - 56.57 (limit 56.45)	
Camshaft Journal Bearing inside Diameter		Bore dial gaugeafter
pressing the bushes.		
Journal 1	57.0 (limit 57.070)	
Journal 2	56.8 (limit 56.870)	
Journal 3	56.6 (limit 56.670)	
Diametrical camshaft clearance in bushes Max. permissible clearance	0.03 - 0.12 0.15 (limit)	Internal measuring gauge and micrometer
Idler Shaft Diameter	49.95 - 49.975 (limit 49.94)	Micrometer
Idler Gear bushing inside Diameter	50.00 - 50.025 (limit 50.05)	Internal micro meter
Diametrical clearance between Idler Gear shaft and Bush	0.03 to 0.08 (limit 0.1)	Internal measuring gauge and micrometer
Idler Gear end play	0.04 - 0.10 (limit 0.15)	Dial gauge
Tooth Backlash between Crank gear & Idler gear	0.068 - 0.194	Feeler gauge or dial gauge
Tooth Backlash between Idler gear & Oil Pump gear	0.065 - 0.182 (limit 0.3)	Feeler gauge or dial gauge
Tooth Backlash between distributor drive gear & Idler gear	0.065 - 0.232	Feeler gauge or dial gauge
Tooth Backlash between Cam gear & Oil Pump gear	0.065 - 0.182 (limit 0.3)	Feeler gauge or dial gauge

16.0.8 Repair Data

Description	Specification (Measurements in mm)	Measuring Device and Remarks
	HAE4NG106	
Engine lubrication		
Max. oil pressure		
Full-load	4.5/4.8 kg/cm²	Pressure gauge
Idling	1.2/1.6 kg/cm²	Pressure gauge
Minimum oil pressure	1.0 kg/cm² (engine idling)	
Oil flow rate	21 - 24 l per minute at 4 kg/cm² at 1000 rpm	
Valve opening pressure: (Oil filter)		
Release valve	3.7 - 4.3 kg/cm²	Hydraulic pump with pressure
By-pass valve for paper element	4 kg/cm²	gauge
By-pass valve for heat exchanger	1.5 kg/cm²	
Oil Pump Gear Height	22.5	
Oil Pump gear Outer Diameter	49.2	
Oil Pump Gear Backlash (Drive & Driven)	0.09 - 0.21 (limit 0.30)	Feeler gauge
Drive Gear shaft Diameter	18.088 - 18.106 (limit 18.060)	Micro meter
Drive shaft Bushing inside Diameter	18.146 - 18.173 (limit 18.20)	Internal micro meter
Clearance between Drive Shaft & Bushing	0.040 - 0.085 (limit 0.1)	Bore dial gauge/Micro meter
Driven Gear shaft Diameter	17.979 - 17.997 (limit 17.970)	Micro meter
Driven Gear Inside Diameter	18.037 - 18.054 (limit 18.070)	Bore dial gauge/Internal micro meter
Clearance between driven gear and shaft	0.040 - 0.075 (limit 0.1)	Dial gauge
Oil Cooler air pressure testing	6 kg/cm²	
Cooling System		
Permissible maximum cooling temp.	95°C	Temperature gauge
Maximum water pump output	125 lpm @ 0.5 kg/cm²	Test tank
Distance between Impeller end face to shaft end face	9	Vernier caliper/ Depth gauge
Commencement of thermostat opening	74°C ± 2°C	Test tank thermometer & dial gauge
Thermostat working stroke at 95°C	10 mm or more	Test tank thermometer & dial gauge

16.0.10 Crank Shaft Journals and Crankpin Grinding Dimensions.

DESCRIPTION	mm
1. Std diameter of main journals	72.94 - 72.96
2. Std diameter of conrod journals	61.94 - 61.96
3. Fillet Radius main journal	3.00 - 3.50
4. Con. rod journal fillet radius	3.75 - 4.25
5. Wear limits	
Taper (across total width)	0.1
Ovality	0.1
Bend	0.04
Wear limit	0.2
Concentricity	0.03
Maximum permissible out of round	0.02
6. Available under sizes (only 4 under sizes)	0.25/0.50/0.75/1.00

16.0.11 Main and Thrust Bearing Shells Sizes

Under size	Crank pin	Main Journal
mm	mm	mm
0.25	61.69 - 61.71	72.69 - 72.71
0.50	61.44 - 61.46	72.44 - 72.46
0.75	61.19 - 61.21	72.19 - 72.21
1.00	60.94 - 60.96	71.94 - 71.96

Width of crank pin - 38.00 - 38.25 mm

NOTE

Correct by regrinding if worn unevenly more than 0.10 mm
Regrind if the wear is more than 0.2 mm
Replace crankshaft if wear is more than 1.2 mm

16.0.12 Connecting Rod Big End Bearings Sizes. (Thickness)

Under size (mm)	Thickness (mm)	Tolerance
STANDARD	2.00	-0.003 To -0.013
0.25	2.125	- do -
0.50	2.250	- do -
0.75	2.375	- do -
1.00	2.500	- do -

16.0.13 Crankcase Parent Bore / Cylinder Liner Outer Dia

Grade	Size (mm)	Grade	Size (mm)
W	107 + 0.0060 + 0	W	107 - 0.0125 - 0.0190
X	107 + 0.0125 + 0.0060	X	107 - 0.0060 - 0.0125
Y	107 + 0.0190 + 0.0125	Y	107 + 0 - 0.0060
Z	107 + 0.0250 + 0.0190	Z	107 + 0.0060 + 0.

NOTE

Interchangeability is allowed w.r.t. next oversize or undersize liners.

16.0.14 Recommended Coolant

GGulf Eurocool LL max 50 & Servo cool ALT Premixed coolant (AL Spec : JIS K 2234 - 94 Class 2 and Plus Plus)

Gulf Eurocool LL Max 50 & Servo cool ALT are pre mixed coolant (pre mixed with water at 50% ratio) and has been formulated with a view to offer extended service life. No addition of water is required.

The recommended coolant change interval is 200,000 kms or 2 years whichever is earlier. Gulf Eurocool Max 50 is available in convenient pack sizes of 1, 3, 20, 50 liters & also as 210 liter barrel.

NOTE

For topping up use only Gulf Eurocool LL Max 50 or Servo cool ALT directly. Do not dilute with plain or demineralised water for top up.

16.0.15 Recommended Lubricants

Use of correct grades of lubrication is most important to prevent the wear and tear of components. The charts show the oil grade recommended by AL.

			Co-branded Lubricant	Approved Lubricant	
Aggregate	**Ashok Leyland Specification**	**Ambient Temp. °C**	**Gulf Oil India**	**Indian Oil Corporation**	**Change Period (km)**
BHARAT STAGE II & III	"Low ash gas engine oil API CD/CF "	-15 and above	**Gulfco 1049 Max SAE 20W-50**	**Servo Pride GEO ALT 20W-50**	Oil change period every 10,000 km.

16.0.16 Filling Capacity

Aggregates	Maximum (ℓ)
H Series H4E4NG CNG Engine	
Lubricating Oil	12.5
Coolant	14.5

16.0.17 Liquid Gasket And Application Points

The engine use liquid gasket (Anabond 673) instead of conventional sheet gaskets. Apply liquid gasket, therefore, taking the following items into account.

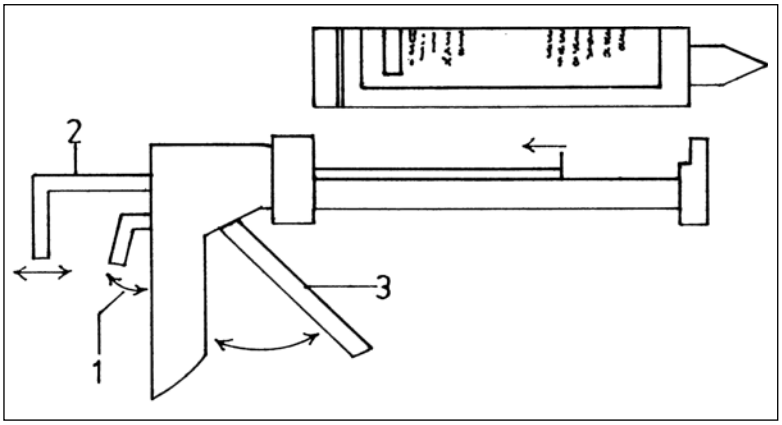
Liquid gasket application points and coating width

Parts Name	Application	Coating width
a) Oil pan	Flange face which mate with cylinder block and timing gear cover	3 - 4 (0.12 - 0.16)
b) Timing gear cover	Faces which mates with timing gear plate (flange face, boss face)	1.5 - 2.5 (0.06 - 0.10)
c) Flywheel housing	Faces which mate with cylinder block (flange face, boss face)	1.5 - 2.5 (0.06 - 0.10)
d) Oil cooler	Flange face which mates with cylinder block	1.5 - 2.5 (0.06 - 0.10)
e) Coolant pump	Flange face which mates with timing gear cover	1.5 - 2.5 (0.06 - 0.10)
f) Thermostat case	Flange face which mates with cylinder head	1.5 - 2.5 (0.06 - 0.10)
g) Intake pipe	Flange face which mates with intake manifold	1.5 - 2.5 (0.06 - 0.10)
h) Seal plate	Flange face which mates with power timing gear cover	1.5 - 2.5 (0.06 - 0.10)
I) Oil pipe	Flange face which mates with cylinder head	1.5 - 2.5 (0.06 - 0.10)
j) Camshaft end plate	Flange face which mates with cylinder block	1.5 - 2.5 (0.06 - 0.10)

Coating Liquid Gasket and parts Assembly Procedure

1. Completely remove old liquid gasket from each part and the respective mating part, and remove oil, water, and dirt using cloth.
2. Be careful not to apply excessive or insufficient liquid gasket. Also, be sure to overlap the start and end of each coating.
3. When assembling coated parts, be careful that there is no misalignment between mating parts. If there is any misalignment, coat the parts again.
4. Assemble the various parts within 20 minutes after applying liquid gasket. If more than 20 minutes have elapsed, remove the liquid gasket and apply it again.
5. After assembling the various parts wait for at least 15 minutes before starting the engine.

Applicator Gun



Loading Cartridge

Press lever 1 and simultaneously pull lever 2 back completely. Insert the cartridge. The open cartridge can be dispensed by pressing lever 3.

Unloading Cartridge

Press lever 1 and simultaneously pull lever 2 back completely - Remove cartridge from the gun.

NOTE

When removing the oil pan, the flange of the oil pan may sometimes become deformed preventing it from being reused. To prevent this, first insert plates with a thin edge at several points around the periphery of the oil pan, then remove the oil pan using a screwdriver.

16.0.18 Trouble Shooting

Fault	Possible Cause	Remedy
1. Engine not Starting	Starter motor not working	* Check for battery charge level. * Check starter motor condition. * Check starter kill system.
	Miss Spark / No spark / Erratic spark	* Check spark plug condition * Check other terminals for loose connection.
	Wrong or improper throttle wiring assembly	* Check throttle wiring assembly. * Check proper mounting of throttle.
	Insufficient gas pressure	* Refill gas
	Compression leak through spark plug sleeve	* Check compression pressure. * Check de-colourisation of spark plug porcelain part. * Check Metallic/Ceramic detachment of sparkplug. * Change spark plug if necessary.
2. Less pickup	**Fuel quantity insufficient/improper**	
	* Blocked air induction path.	Check & ensure proper air induction.
	* Defective closed loop circuit components	Check and replace if necessary.
	* Blocked / Melted catalytic convertor	Locate the fault in ignition system and replace catalytic convertor.
	* Clutch slip	Check clutch slip and rectify.
	* Compression pressure leak	Check compression pressure.
	* Metal/Ceramic detachment in spark plug.	Check and change spark plug if necessary.
	* Leakage through spark plug sleeve.	Change cylinder head.
	* Fault in ignition system.	Check and correct.
3. **Gas flow improper**	Regulator pressure reduction improper	* Change regulator, if necessary.
	* Blocked filter	- Clean filter with kerosene & compressed air.

16.8 TO TEST ENGINE COMPRESSION

Warm-up engine to normal operation temperature (approx\ 80°C). Disconnect spark plug connection and remove all six spark plugs.

Set the Adaptor Cylinder Compression with standard gauge compression on First cylinder.

Check valve clearance.

Keep the ignition key in switch OFF position and open the throttle fully. Since the air flow and fuel flow will be restricted with the throttle remain closed, there is a possibility of recording a low compression pressure. It is preferred to evacuate the gas pipe lines before the compression pressure testing.

Crank the engine approx 8 to 10 revolutions by actuating the starter motor. The battery must be in properly charged condition as to achieve a cranking speed of atleast 280 rpm. Keep engine stop cable in pulled in condition.

Repeat this procedure for all 6 cylinders.

Wet Compression Pressure Check

If the particular cylinder compression pressure is below 300 psi as per above dry check procedure, to locate fault with valve tightness or piston clearance repeat the compression pressure check after pouring few drops of engine oil thru spark plug hole. If low compression persists, the fault is with valve seats.

16.9 OPERATING INSTRUCTIONS

16.9.0 Precautions to be taken Before/ During Body Fabrication of CNG bus.

Cylinders are filled with CNG gas which is inflammable, it is therefore very important that the individual valves provided on each cylinder should be closed completely during the entire body building stage and can be opened only for moving the finished bus. The residual gas in the pipe line after closing the valves should be removed by running the engine for sufficient time.

In case of Gas leak at cylinder connections. Use teflon tape over the threads and tighten to arrest Gas leak.

Welding should never be done over the gas cylinders or anywhere near. Proper shielding of the gas cylinder should be done, so as to isolate welding sparks.

Provide flap doors on either side of the chassis to have access to the cylinder adaptors/pipe joints.

Provide openings at the gas filling points (size 250 mm x 250 mm)

Trap doors in floor with rubber sealing to provide access to tighten the cylinder strap nuts on either side.

Shielding guard (hinged) below cylinder piping and connection points for safety against flying stones to be given. These covers to be removable.

The four gas cylinder mounting cross bearers have to be integrated with bus body.

Fuel pipes to be supported from body structure members during body building wherever required.

Drilling of holes or welding on the main frame is not allowed.

During welding, disconnect the battery terminal and electronic ignition system.

Bonnet insulation inside - 40 mm fibre glass wool or PU foam and outside foam and rexine - to be ensured.

Body building structure material used should not carry leaking gas if any; e.g through pipes or hat section in to the passenger compartments. Proper sealing at the entry points need to be done.

There should not be any open holes on the floor to avoid any entry of leaking gas, if any. This is a safety precaution.

Provide suitable trap door for inspection of timing (using timing device). No cross bearers should come exactly over the timing windows.

Provide bigger bonnet to ensure better ventilation of the engine.

LH/RH louvers at front grille provided - to ensure air cleaner - air entry on LH and for ventilation for trigger box on RH side. Louvre arrangement should ensure no ingress of water.

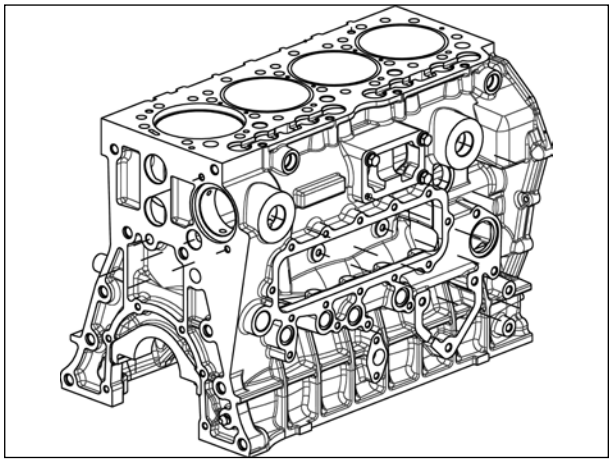
Front grille centre portion - louvre ventilation to fully cover radiator core area for efficient cooling.

In front grille opened position, water filling, oil filling and oil level checking, radiator removing should be accessible.

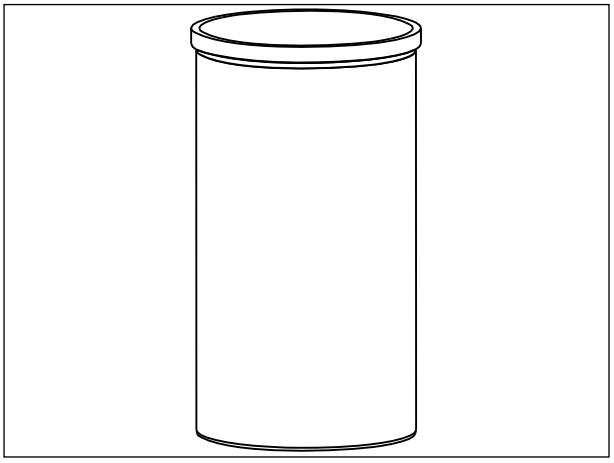
Body builder not to tamper with ignition system wiring.

High voltage wiring should not rub with body structure.

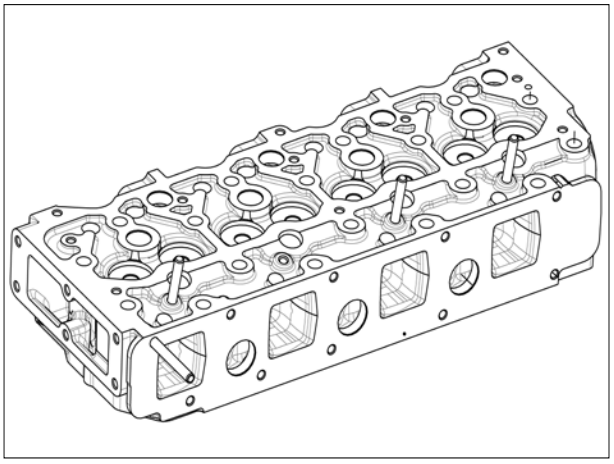
16.9.7 Description of Leading Engine Components



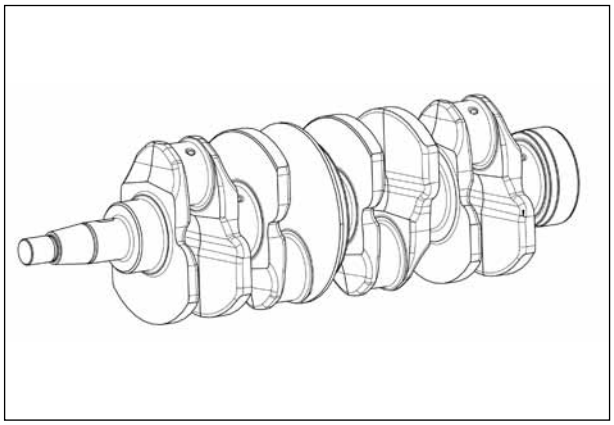
Cylinder Block - Made of high grade cast iron. Cylinders and the crankcase form an integral casting. The crankcase is enclosed from below by the oil sump.



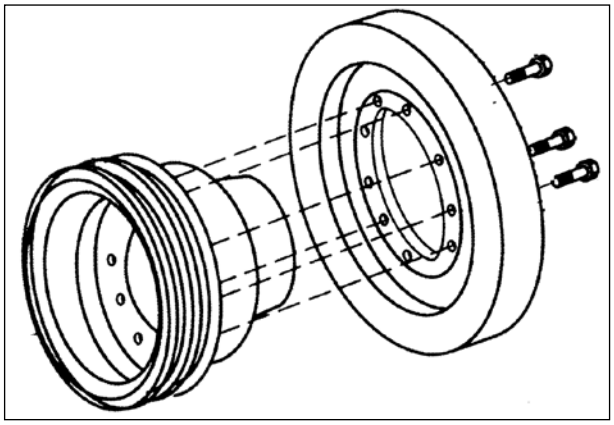
Cylinder Liners (dry, pre finished, hard, easy fit type) - Mild Interference Fit Liner is made of cast iron. There are four selectable sizes available i.e. W, X, Y, Z based on liner outer diameter.



Cylinder Head - made of high-grade cast iron, accommodating all cylinders, fitted with exchangeable, pre finished valve seats and valve guides.



Crankshaft - an alloy steel forging, mounted in five bearings with exchangeable shells. The main journals and crank-journals are induction hardened.

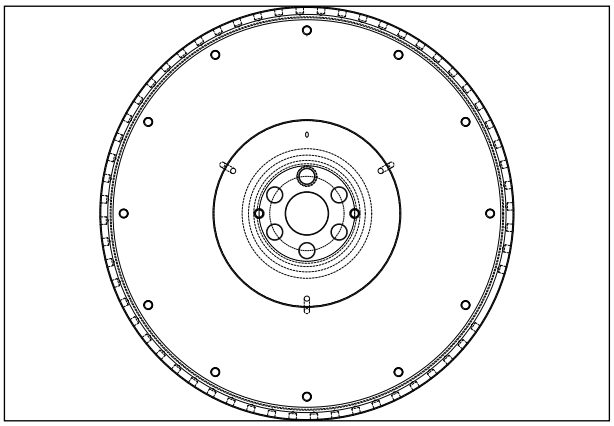


Vibration Damper - is mounted on the front end of the crankshaft. Care should be taken while handling the vibration damper.

Main and Small - End Bearing Shells - thin-walled, with aluminium and tin or lead bronze linings for sliding surfaces.

Camshaft - made of steel, mounted in the cylinder block in three exchangeable bearing bushes. Drive is supplied from the engine crankshaft through a gear train.

Valves - made of high-grade alloy steel. Valve stem seals prevent oil leakage into combustion chamber.

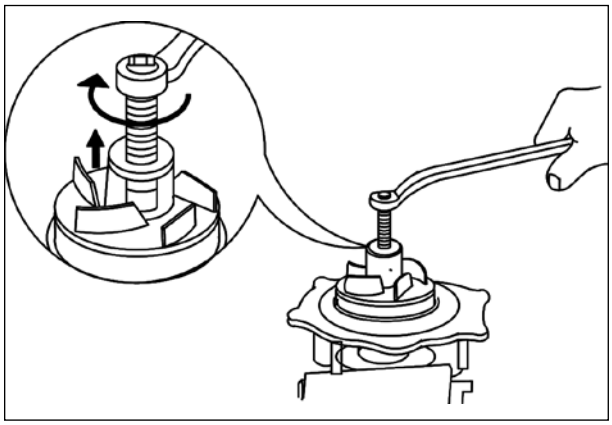


Flywheel - machined with 4 slots on the priphery to facilitate engine speed sensing by engine speed sensor. These slots are equispaced and dimensions are controlled to achieve perfect speed pulse output waveform from the speed sensor.

Flywheel housing - fitted with sensor mounting holder facilitates fitment of engine speed sensor over the flywheel for engine speed sensing. Aluminium is used for the holder as a non-magnetic base is required for the magnetic pulse pickup to avoid signal disturbances.

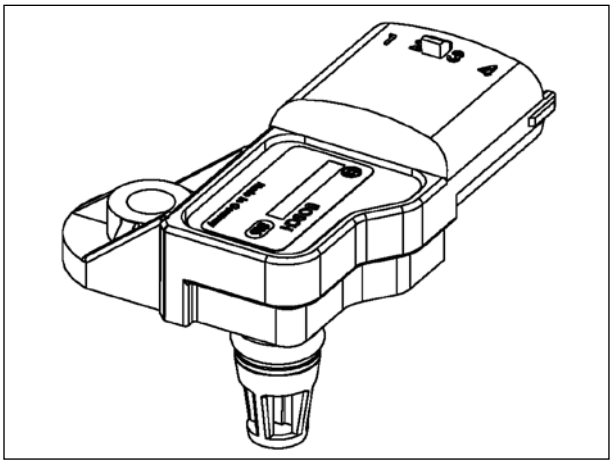
Valve Spring - made of spring steel, constant pitch coil type springs.

Electronic Control Unit (ECU) : The ECU is the heart of the system that compares the requirements thru sensors and the accelerator pedal movement with the fuel mappings already stored in the ECU and decides on the fuel delivery. It operates on 24V DC. Another function of ECU is the CAN communication to ACU.



Engine Coolant temperature sensor : It is a thermistor, mounted on coolant return line from cylinder head. It measures the engine operating temperature.

Engine speed sensor : Engine speed sensor is a inductive type sensor. It is mounted on the flywheel housing. Electric pulses are generated when the formed slots on the flywheel pass thro the sensor axis. The Electric pulse - Frequency (Sine Wave) generated by the sensor is proportional to the engine speed.



Engine Boost Pressure Sensor : Engine Boost Pressure sensor is mounted on the intake pipe before throttle to measure to boost pressure.

16.9.8 Trouble shooting

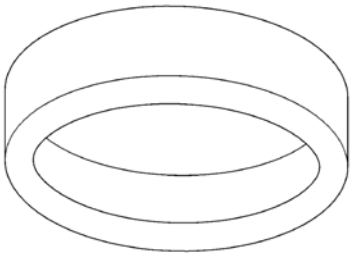
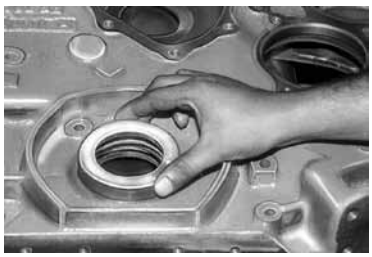
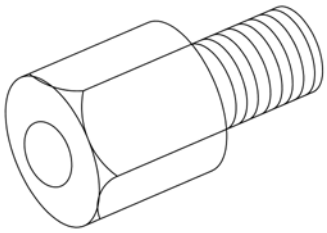
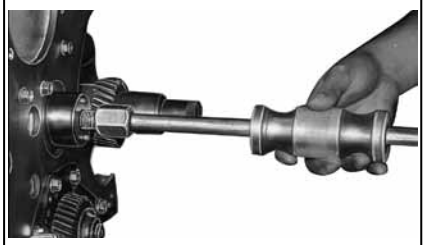
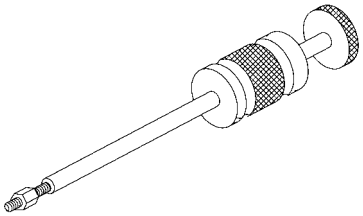
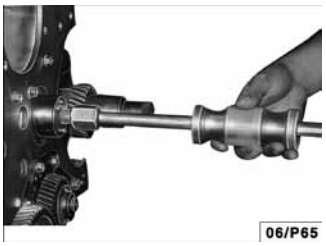
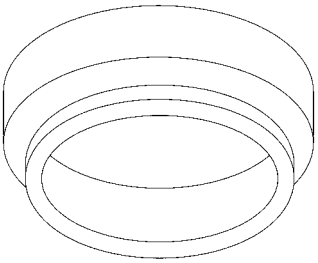
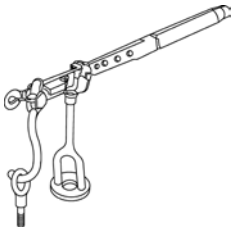
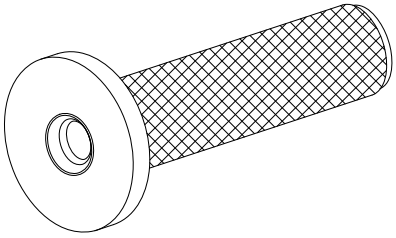
16.9.8.0 Engine

Symptom	Possible Cause	Remedy/Prevention
Engine overheating	Coolant	
	* Insufficient coolant	Add coolant
	* Defective thermostat	Replace the thermostat
	* Overflow of coolant due to leakage of exhaust into cooling system	Repair
	* Coolant leakage from cylinder head gasket	Replace gasket.
	* Defective coolant pump	Repair or replace.
	Radiator	
	* Clogged with rust and scale	Clean radiator.
	* Clogged with iron oxide due to leakage of exhaust into cooling system	Clean coolant passage and correct exhaust leakage.
	* Clogged radiator core due to mud or other debris	Clean radiator.
	* Defective radiator cap pressure valve	Replace radiator cap
	* In correct gap between radiator and fan	Correct the gap
	* Deration pipes blocked due to mud	Clean and use coolant.
	* CAC & Radiator fins out side for dust deposit.	Clean.
	* Malfunctioning of thermo sensing fan	Check and correct.
	Other problems	
	* Defective or deteriorated engine oil	Change engine oil.
	* Unsatisfactory operation of oil pump	Replace or repair
	* Insufficient oil	Add oil.
	* Brake drag	Repair or adjust.
Excessive oil consumption	Piston, cylinder liners and piston rings	
	* Wear of piston ring and cylinder liner	Replace piston rings and cylinder liner.
	* Worn, sticking or broken piston rings	Replace piston rings and cylinder liner.
	* Insufficient tension on piston rings	Replace piston rings and cylinder liner.
	* Unsuitable oil (viscosity too low)	Change oil as required and replace piston rings and cylinder liners.
	* Incorrectly fitted piston rings (upside down)	Replace piston rings.
	* Gaps of piston rings in line with each other	Reassemble piston rings.
	Valve and valve guides	
	* Worn valve stream	Replace valve and valve guide
	* Worn valve guide	Replace valve guides.
	* Incorrectly fitted valve stem seal	Replace the stem seal.
	* Excessive lubricant on rocker arm	Check clearance of rocker arm and shaft.

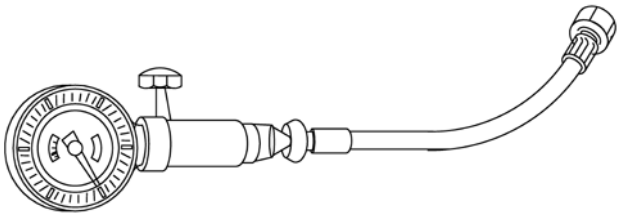
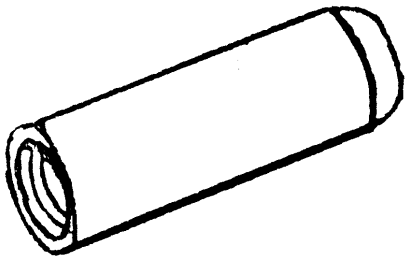
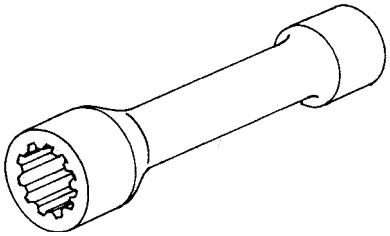
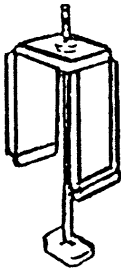
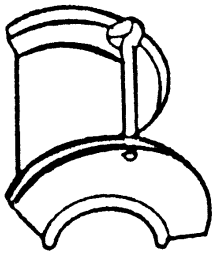
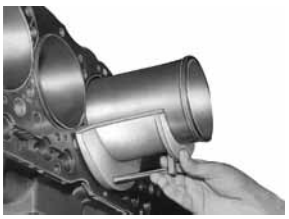
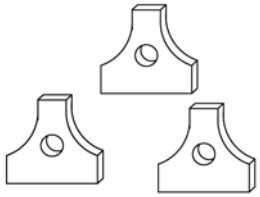
Symptom	Possible Cause	Remedy/Prevention
Excessive oil consumption	**Excess oil feed**	
	* Defective oil level gauge	Replace oil level gauge
	* Oil level too high	Drain excess oil.
	Other problems	
	* Overcooled engine (low temperature wear)	Warm up engine before moving vehicle. Check cooling system .
	* Oil leakage from miscellaneous parts	Repair.
Piston seizure	**Operation**	
	* Abrupt stoppage of engine after running at highspeed	Operate engine properly.
	* Hill climbing using unsuitable gear	Select suitable gear
	Oil	
	* Insufficient oil	Add oil.
	* Dirty oil	Change oil.
	* Poor quality oil	Replace with proper engine oil.
	* High oil temperature	Repair
	* Defective oil pump	Repair oil pump.
	* Reduced performance due to worn oil pump	Repair oil pump.
	* Suction strainer sucking air	Add oil and/or repair strainer.
	Abnormal combustion	See symptom:”Engine overheating”
	Coolant	See symptom:”Engine overheating”
Lack of power	**Intake**	
	* Clogged air cleaner	Replace element.
	Abnormal combustion	See symptom:”Piston Seizure”
	Piston, cylinder liners and piston rings	See symptom:”Excessive Oil Consumption”
	Other problems	
	* Breakage of turbine or blower	Repair
	* EGC system defective	Use diagnostic tool for trouble shooting and rectify.
	* CAN communication failure	Use diagnostic tool for trouble shooting and rectify.

Symptom	Possible Cause	Remedy/Prevention
Difficult starting engine	**Electrical system**	
	* Discharged battery	Charge battery
	* Defective wiring in starter circuit	Repair wiring of starter.
	* Loose or open-circuit battery cable	Tighten battery terminal connections or replace battery cable.
	Air cleaner	
	* Clogged element	Replace the element.
	Oil system	
	* Oil viscosity too high	Use proper viscosity oil, or install an oil immersion heater and warm up oil.
	Other problems	
	* Seized piston	Replace piston, piston rings ,and liner.
	* Seized bearing	Replace bearing and /or crankshaft
	* Reduced compression pressure	Overhaul engine
	* Ring gear damaged or worn pinion.	Replace the ring gear and/or starter
	* Check relays and fuses of EDC system	Replace defective parts.
Rough idling	**Engine**	
	* Improper valve clearance	Adjust valve clearance
	* Improper contact of valve seat	Replace or repair valve and valve seat.
	* Idling speed too low	Warm up engine.
	* Compression pressure of cylinders markedly different from one another	Overhaul engine

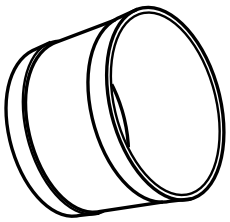
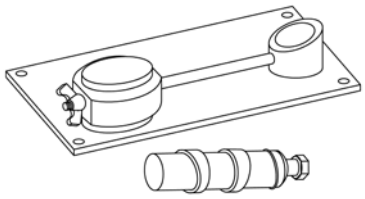
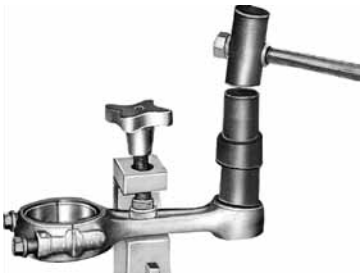
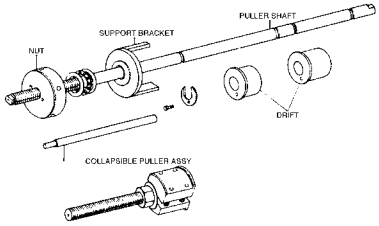
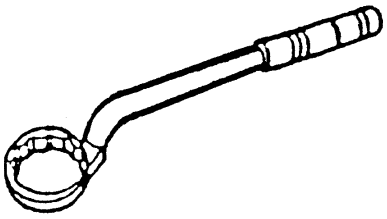
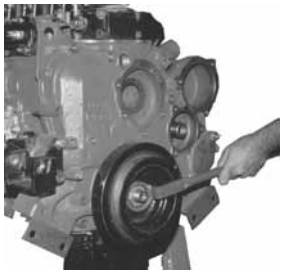
16.9.9 Special Tools

0102001 (3802) - Drift oil seal gear case 		To press oil seal on timing gear case
0102002 (3803) - Adapter idler gear spindle 		To be used with 0102003 - sliding hammer, to extract idler gear spindle
0102003 (3804) - Sliding hammer 		To remove idler gear spindle etc., With their respective adaptors
0102004 (3805) - Drift (1) oil seal flywheel hsg (4 mm step height) 		To press oil seal - crankshaft rear end in flywheel housing
0102005 (3806) - Compressor valve spring 		To assemble and disassemble inlet & exhaust valves
Z06DH0430025 - Drift valve stem seal 		To install valve stem seal.

16.9.9 Special Tools

0102021 (3801) - Gauge compression checking 		Check the compression pressure in each cylinder
0102009 (3811) - Drift valve guide 		To install valve guide
0102010 (3812) - Special socket cylinder head bolt 		To tighten cylinder head bolts after fixing rocker shaft assy.
0102011 (3813) - Extractor cylinder liner 		To extract cylinder liners.
0102012 (3814) - Guide cylinder liner 		To guide the cylinder liners while inserting it in to bore.
0102013 (3815) - Retainer cylinder liner (3 nos.) 		To hold the cylinder liners while removing the piston assembly

16.9.9 Special Tools

0102014 (3816) - Compressor piston ring 		To compress piston rings during assembly
0102017 (3836) - Drift & extractor con-rod bushes 		To extract and install connecting rod bushes
0102018 (3839) - Drift & extractor cam bushes 		To extract and install cam shaft bushes
0102019 (3840) - Wrench engine cranking 		To rotate the crankshaft

16.9.10 Factors Which Determine When an Engine Overhaul is Needed

The following factors determine the engine condition and the necessity of engine overhauling.

1. Low compression pressure.

Follow the procedure given below for measuring engine compression pressure.

a. Before measurement

Warm up the engine to operating temperature (bring the coolant temp to about 80°C)

Check and correct valve clearance.

Charge the battery fully.

b. Measurement

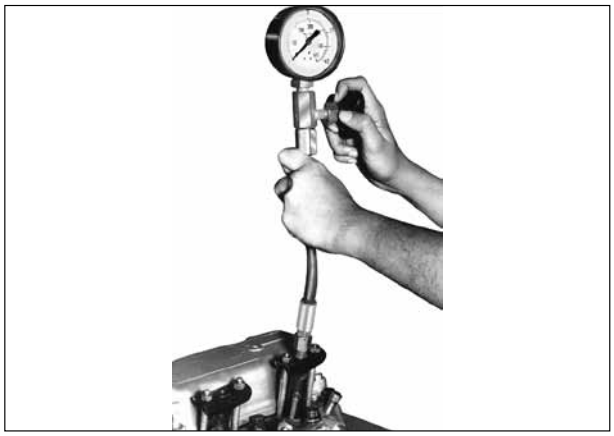
Remove the injector.

Install the gauge adapter (Special Tool 0102023) in the nozzle holder hole and connect compression gauge (Special Tool 0102021).

Keep the EDC reset switch in “OFF” position.

Crank the engine with the starter motor (ensure min. cranking speed of 280 rpm).

The gauge needle will start rising. Cranking should be continued until the needle in the gauge stops, without any further rising.



Note the reading. Loose gauge vent knob to ensure the needle returns to zero.

Repeat the procedure to the remaining cylinders.

Low compression pressure may be due to leakage past / thru piston rings / valves / blown cylinder head gasket.

To find out the exact point of leakage, a small amount of engine oil may be sprayed into the cylinder through nozzle hole and recheck the compression pressure.

If the compression pressure increases, wear in piston rings/cylinder bore is indicated. If it does not, leak is through the valves.

If compression pressure of adjacent cylinder is on lower side it may be due to cylinder head gasket.

Do not continuously operate the starter for more than 15 seconds at a time.

Measure the compression pressure for each cylinder. If the compression pressure is low, be sure to repeat the measuring.

Make sure no leakage through the sealing face.

C. Compression pressure (Recommended Values)

Minimum : 24 kg/cm² @ 280 rpm

Maximum : 29 - 32 kg/cm² @ 280 rpm

Pressure difference between each cylinders should be below 3 kg/cm²

2. Low oil pressure

Check the oil pressure warning lamp when the oil and coolant temperature is hot and at about 80°C.

a. If the warning lamp is lighted , check the oil level.

b. Check oil deterioration. If oil quality is poor, replace with a suitable grade oil.

c. Measure the oil pressure at coolant temperature about 80°C.

Standard oil pressure for Turbo engines

Idling : 1.0 kg/cm²
Max. : 4.8 kg/cm²

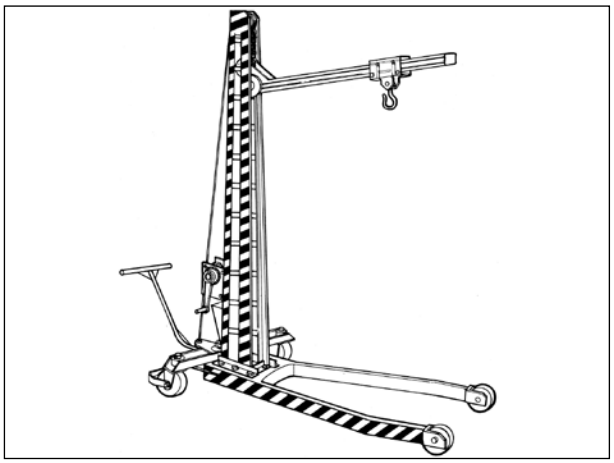
3. Other factors

a. Blow by gas increases.
b. Engine does not start easily.
c. Engine output decreases.
d. Fuel consumption increases.
e. Engine makes greater noise.
f. Excessive oil consumption.

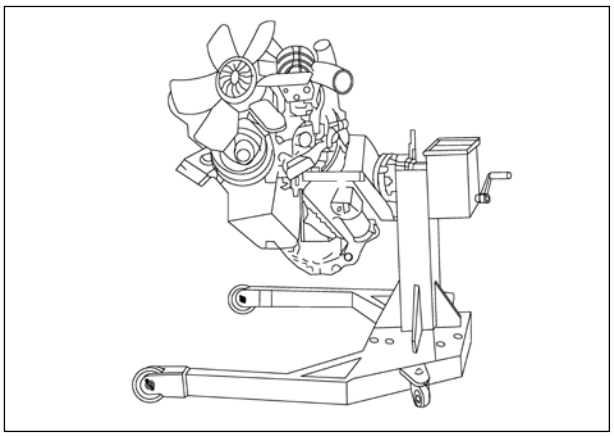
16.10 TO REMOVE AND REFIT ENGINE FROM VEHICLE

16.10.0 To Remove Engine

- Disconnect battery terminals and choke the wheels.
- Drain engine oil
- Drain the coolant and remove cooling system, radiator, pipes, hoses etc.
- Remove air intake system, turbo connection, charge air cooler, exhaust system and fuel pipe connections,
- Disconnect the clutch / gear linkage system.
- Remove gear box and clutch.
- Unscrew engine fixing bolts of the engine mounting pad.
- Fasten hoisting cable to the lifting eyes on right front and left rear of engine.



- Use multipurpose jip crane SME 11001 to lift the engine.
- Lift the engine slightly and move it outwards.
- Place the engine on suitable platform keeping in mind that the oil sump is not damaged.



NOTE

Use Engine stand of proper dimensions to keep the engine or use Special Maintenance Equipment, SME No. 01006.

- Engine should be thoroughly washed with a suitable cleaning liquid before it is dismantled.
- Dismantling and assembly should be carried out by experienced personal and atmost cleanliness must be observed. Special tools manufactured for this purpose to be used.

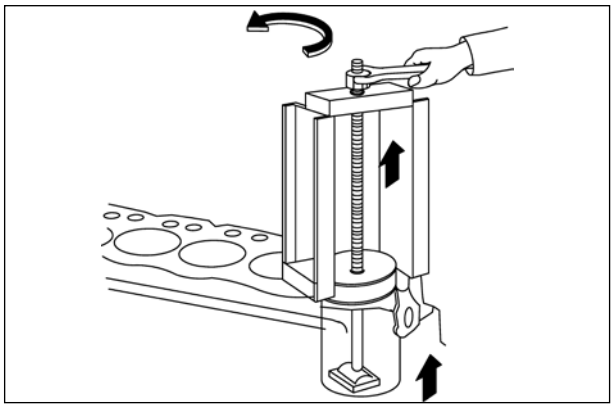
16.10.1 To Refit Engine

- The above mentioned procedure to be followed in reverse order.
- Ensure the alignment of the engine in the exact centre of the chassis frame.
- Before initial starting of the engine, check whether, gear box and cooling system have been filled with lubricants and coolants according to specifications.
- Ensure proper matching of connectors with respective sensors.

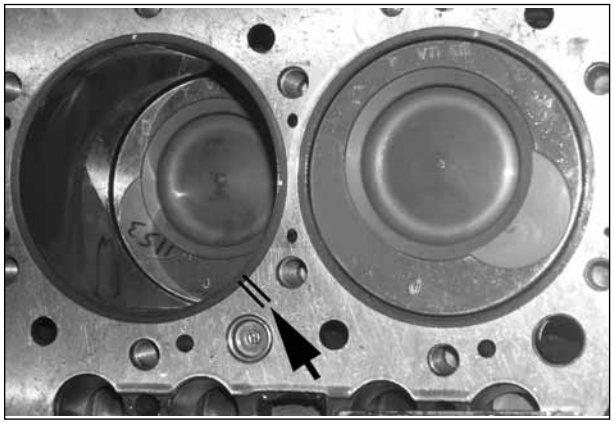
16.11 CRANKCASE

16.11.0 To Remove and Refit Cylinder Liners

Use Special Tool 0102011 - Extractor Cylinder Liner for removal of cylinder liners.



Liners are of mild interferance fit type. Special tool to be used for liner removal.

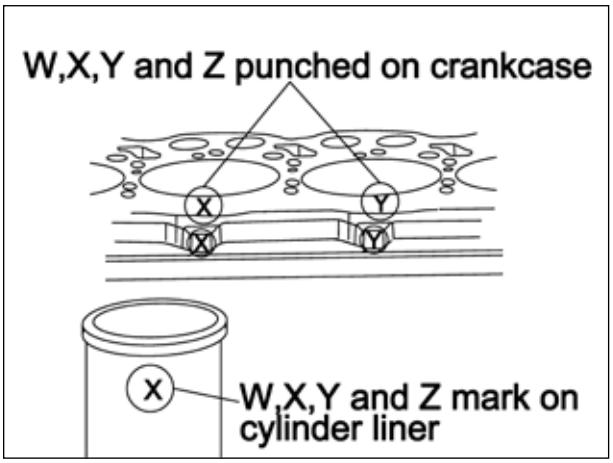


Incase you want to reuse the liner be sure to put matching marks with marker pen on the cylinder block and liner flange for repositioning.

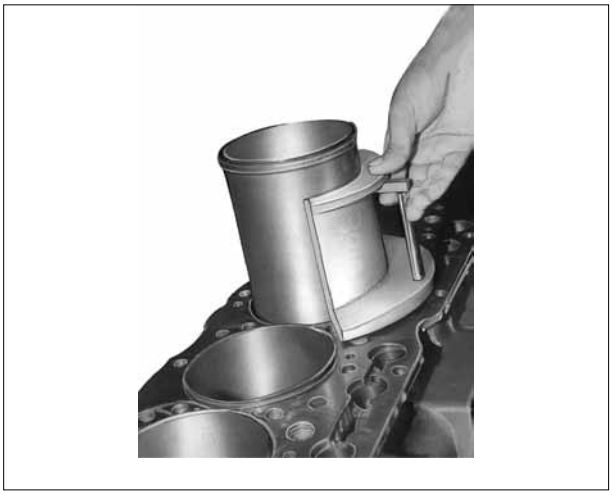
After removing the cylinder liners, put numbers on their periphery or arrange them in sequence.

Make sure that the liner grade mark has the same mark on the cylinder block.

There are 4 different grades of liners and cylinder block matches. Each liner has any one of the following markings W, X, Y or Z of the OD. These indicate the size of the O.D. of the liner.



Similarly, the matching I.D. markings of the cylinder bore is indicated by W, X, Y or Z on crank case LH side top for each Bore.

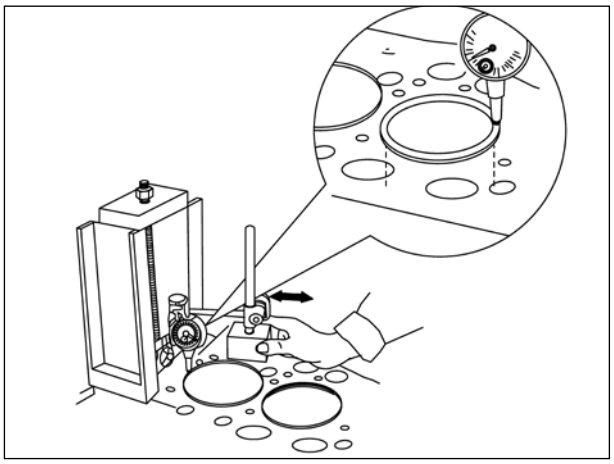


Apply a small amount of clean engine oil on the outer periphery of liner. The special tool should be used as liner is extremely thin and can easily get damaged. When reusing a liner, insert the liner in its original position aligning the markings marked before disassembly. Use Special Tool 0102012 - Guide Cylinder Liner.

Only Multi Layered Gasket (MLS) should be used along with Mild Interference liners (MIF).

Measure the projection of the cylinder liner.

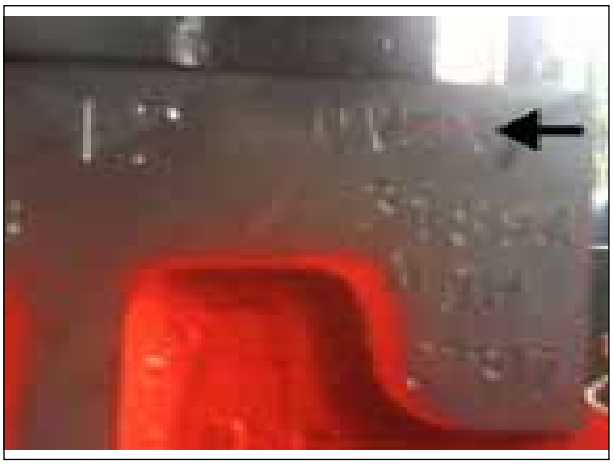
Fix Special Tool 0102013 - Retainer Cylinder Liner



Measure the amount of projection of the liner from the cylinder block with a dial gauge and magnetic stand.

MIF Liner Identification

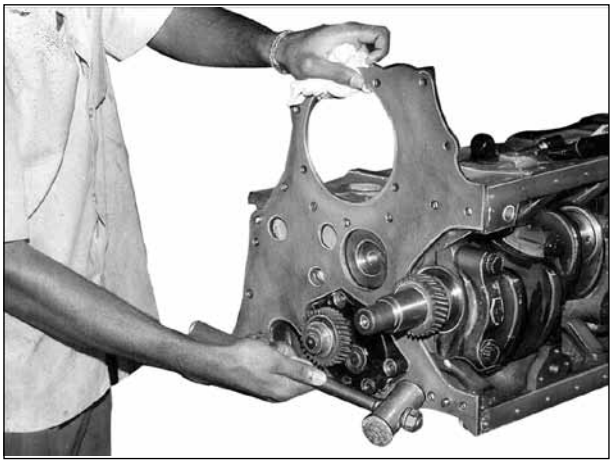
MIF liners can be identified by the absence of flame arrestors as shown above.



Cylinder blocks of engines with MIF liner will have "I" as prefix in block sl. no. for easy identification. (e.g OVHN 31894 is with out MIF liners and IOVHN 31894 is with MIF liners).

16.11.1 To Remove and Refit Timing Casing Cover and Back Plate

For BS III Engine, Identification mark is punched

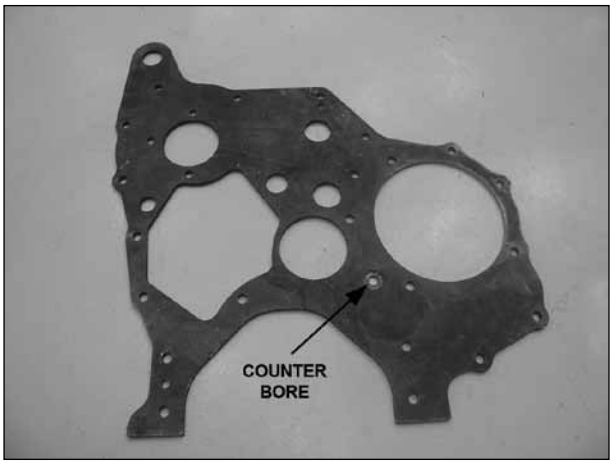


Backout fixing screws of the Timing back plate.

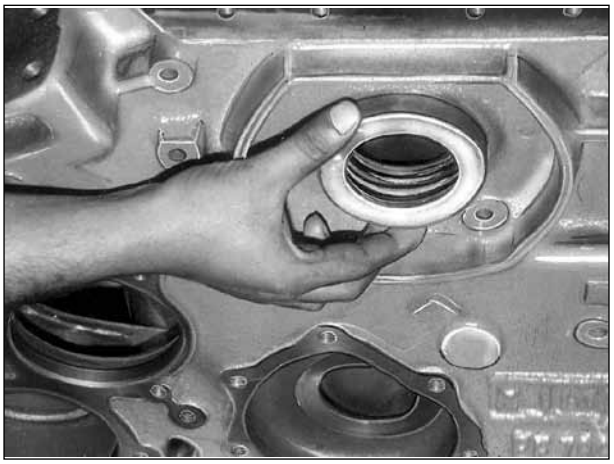
Take off the Timing back plate, taking care of both dowel pins. Before refitting, remove the old Liquid gasket material and clean front face of the crankcase.

Apply fresh liquid gasket (Anabond 683) with new gasket to crank case face of the Timing Back plate.

Screw down Timing Back plate with hex screws and spring washers.



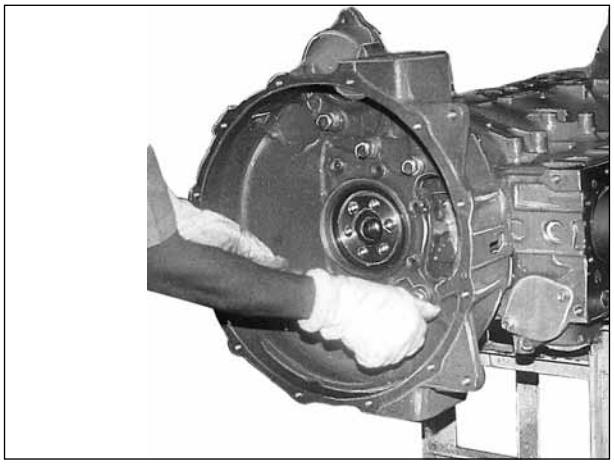
Timing back plate mounting bolt holes, in which one mounting hole is provided with a counter bore, use special bolt with a thread sealent (without washer).



Remove timing cover and Replace new oil seal using Special Tool 0102001 - Drift Oil Seal Gear Case.

Installation should only take place with engine in normal upright position.

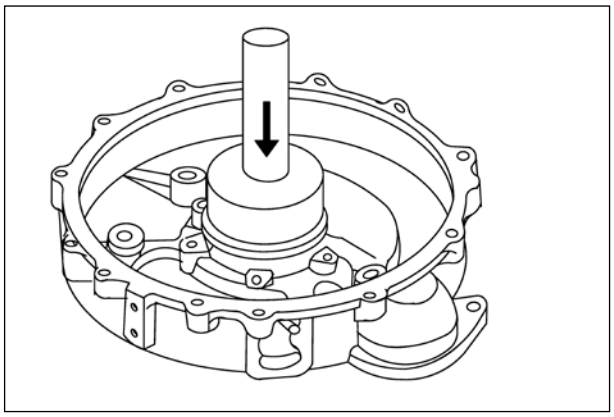
16.11.2 To Remove and Refit Flywheel Housing



Backout fixing screws of the flywheel housing. Start with M8 bolts (6 nos.) and then M14 bolts (8 nos.).

Take off the flywheel housing, taking care of rear main oil seal.

16.11.3 Install the Oil Seal in the Flywheel Housing



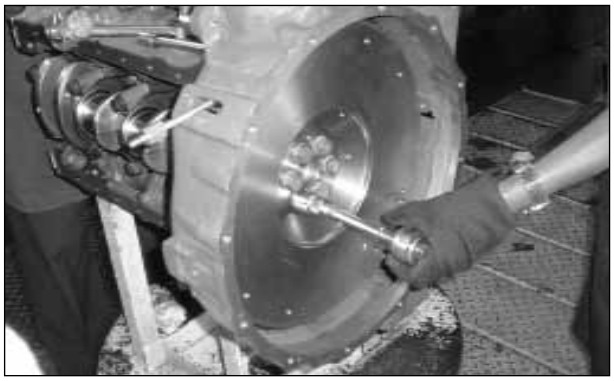
Using a special tool, press in the oil seal in the flywheel housing.

Special tool 0102004 : Drift for Oil Seal Flywheel Housing.

Before refitting, remove the old Liquid gasket material and clean rear face of the crankcase. Apply fresh Liquid gasket to inner side of the flywheel housing.

Fit flywheel housing and tighten it securely with hex screw. Start with M14 bolts (8 nos.) and M8 bolts (6 nos).

16.11.4 To Remove and Refit Flywheel



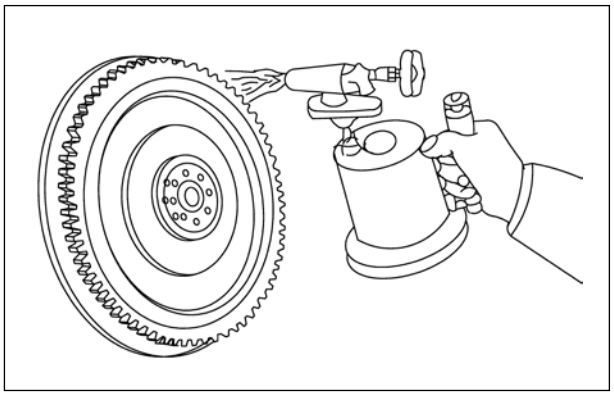
Backout fixing screws and remove flywheel.

Check ring gear, if necessary replace.

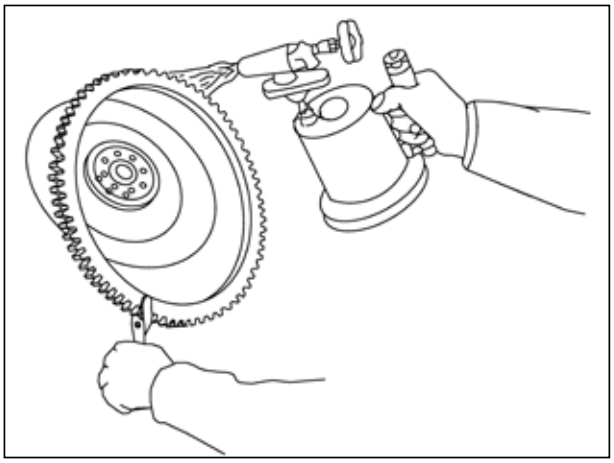
NOTE

Do not damage the slots on the flywheel

16.11.5 To Remove Ring Gear



- Heat the ring gear with a blow torch in a uniform manner (approx. 180°C).

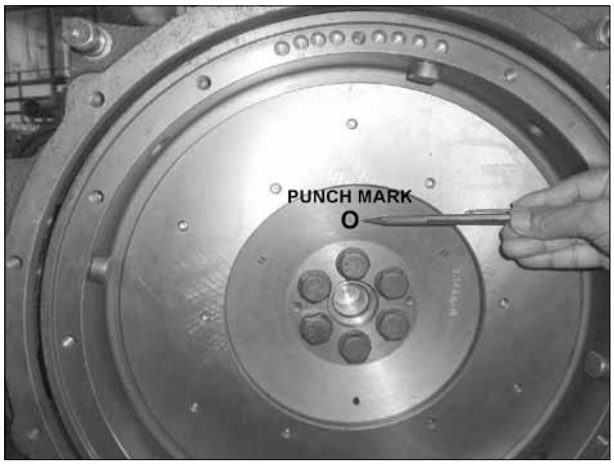


- Using a metal rod as pad and strike all around the ring gear in uniform manner and remove the ring gear.

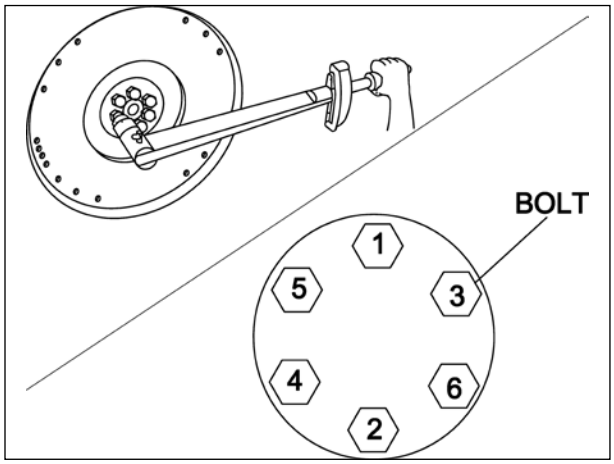
16.11.6 To Install Ring Gear

- Heat the ring gear uniformly using a blow torch (approx. 180°C).
- Drive the ring gear with its chamfered gear teeth facing the block onto the flywheel using a metal rod.

16.11.7 Install Flywheel



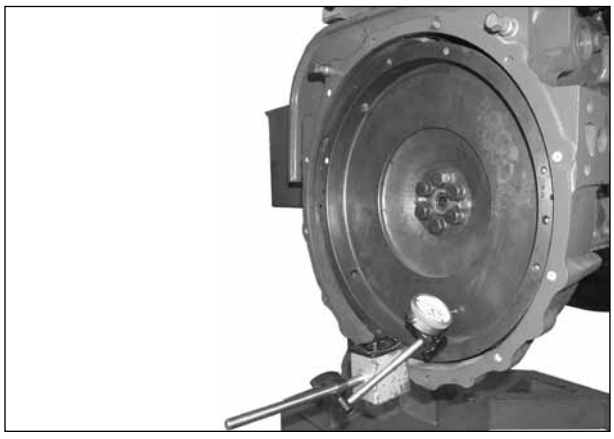
Align the 'O' mark on the flywheel and crankshaft collar knock pin.



Install the flywheel and tighten the bolts through several repetition of the tightening order so as to reach specified torque evenly and gradually then slacken and tighten them one by one to the specified torque as per sequence.

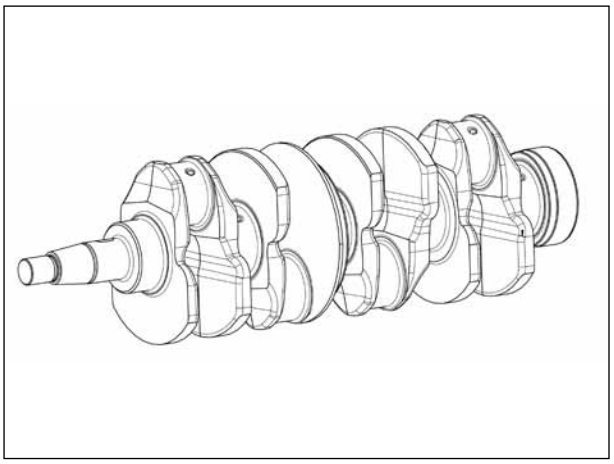
When tightening the bolt, apply engine oil to the threads and flywheel surface of the bolts.

Install the pilot bearing and stopper.



Check the flywheel faceout and it should be with in the recommended value.

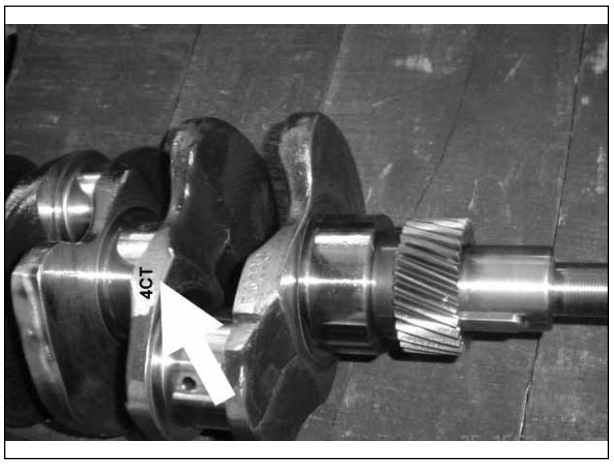
16.12 CRANKSHAFT



The crankshaft is supported by 5 main bearings.

Thrust is taken up by the thrust washer at the fourth journal.

Identification of engine crankshaft.

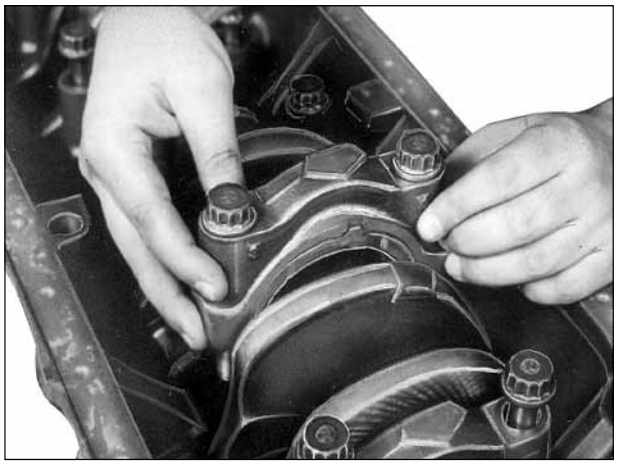


BS III 4Cylinder crankshaft is punch marked with 4CT on the first web.

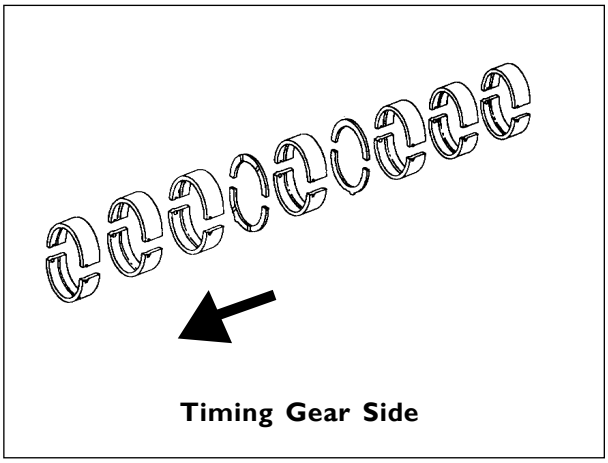
1St & 4th crank pin and 1st & 5th main journal fillets are induction hardened.

16.12.0 To Remove and Refit Crankshaft

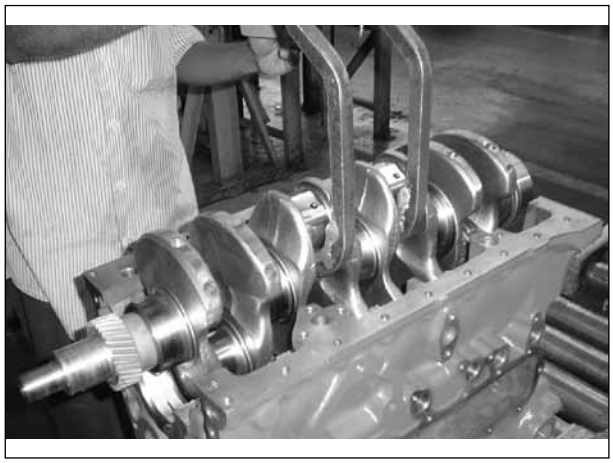
Backout collared bolts and remove bearing caps.



Remove thrust bearing cap (4th) last.

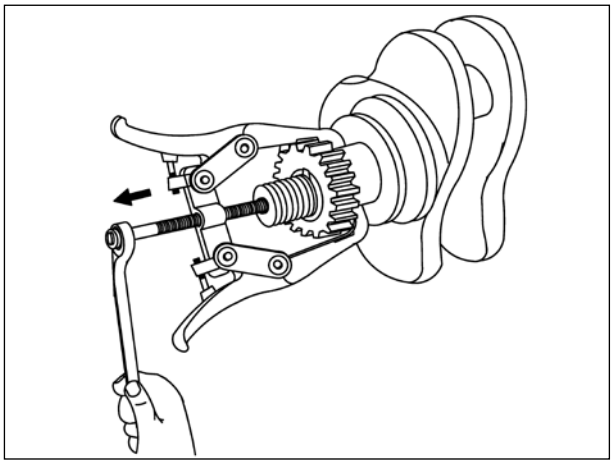


Arrange all the caps bearing and thrust washer in order. The bearing caps are match marked with the crankcase by the punch mark 1 - 5, commencing from timing gear side.



Lift the crankshaft out of the crankcase.

16.12.1 To Remove Crankshaft Gear

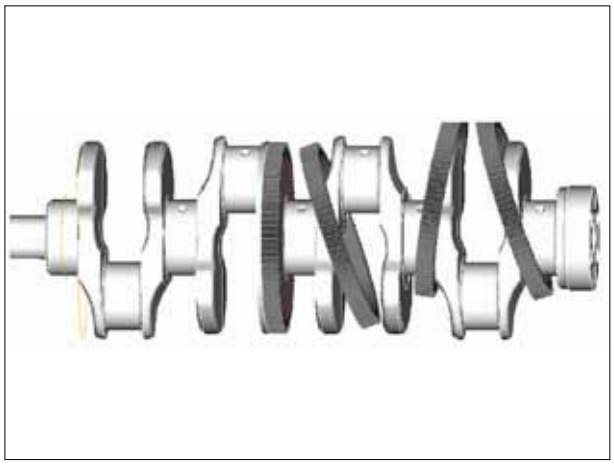


By using Conventional puller remove crankshaft gear from crankshaft.

16.12.2 To Refit the Crankshaft Gear

Heat the gear upto 130°C and fix it.

16.12.3 To Remove Ring Gear

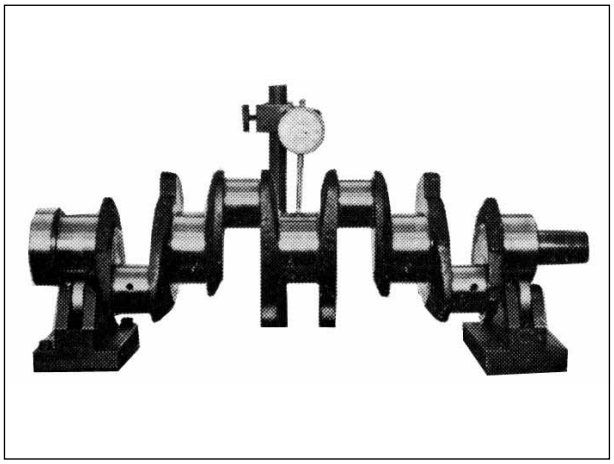


Pull out the ring gear as shown

16.12.4 To Refit Rim Gear

Heat the gear upto 130°C in a oven and fix it to the crank shaft matching the key way on the dowel in the crank shaft.

16.12.5 To Check Crankshaft Bend



Maximum permissible bend is 0.04 mm.

16.12.6 Installation

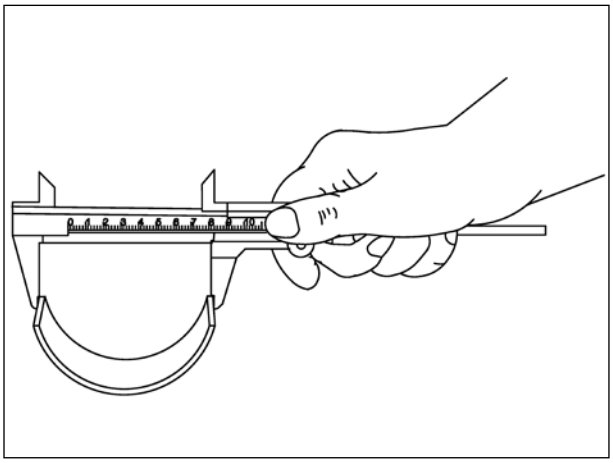
Clean crankcase, crankshaft and bearing shells by blowing compressed air through the lubrication holes.

16.12.7 To Renew Crankshaft Main & Connecting Rod Bearing and Check Main & Connecting Rod Bearing Spread

Hold the bearing shell without applying any pressure and measure the outside diameter.

Main bearing dimension : 79.00-79.60 mm

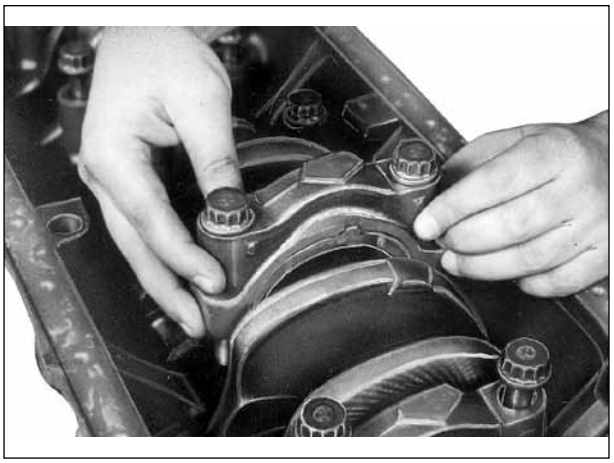
Connecting rod bearing dimension : 67.05 - 67.55 mm



Install the crankshaft, main bearing on the crankcase and bearing caps.

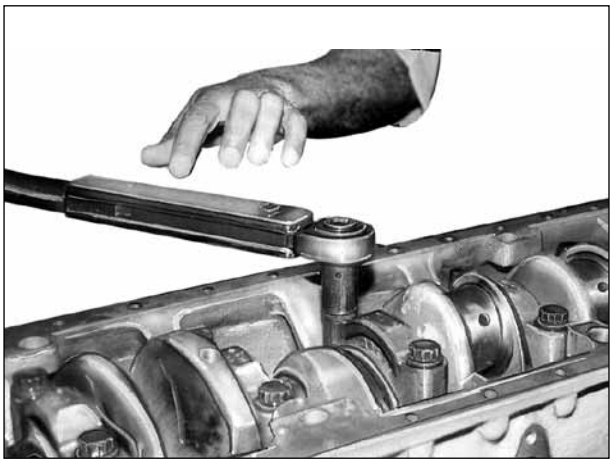
Lubricate crankshaft journals, bearing shells, cap bolt threads and under the bolt heads with the engine oil.

Carefully lower the crankshaft into position.

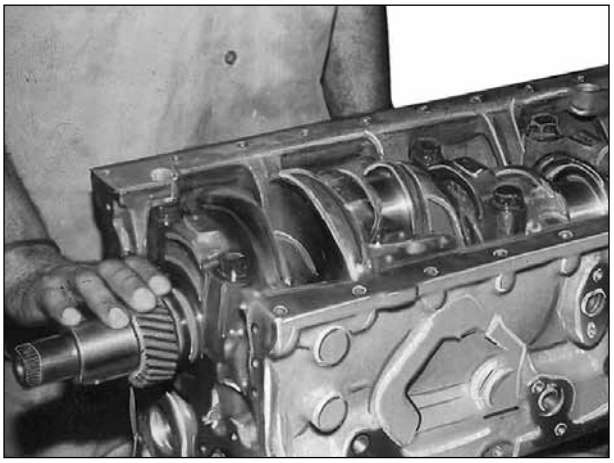


Fit bearing caps and starting off with the thrust bearing No.4, adhering to the match marks. Match ring gear & Mass Balancer gear marks. Connecting faces, of bearing caps and crankshaft should be perfectly clean.

Bearing cap set identification number is punched on the bearing cap and LH side rear end of the crankcase.



Tighten collared bolts uniformly in three stages in tightening order 3-2-4-1-5, to the recommended torque.



Do not attempt to rotate crankshaft before all bearing caps have been bolted down. The crankshaft must turn freely without binding i.e. a strong push by hand should make it turn atleast one revolution.

Check endplay of crankshaft as follows:

Force crankshaft in one axial direction and measure the gap between thrust bearing side and crank web face.

The initial end clearance with new thrust and main bearings should amount to 0.05 to 0.22 mm end clearance should not exceed 0.4 mm.

16.12.8 To Check and Grind Crankshaft

Clean crankshaft and blow out lubrication holes with compressed air, check journals and crankpins for cracks.

Check wear of crankshaft if wear is more than 1.2 mm from standard size, replace crankshaft.

No further heat treatment is recommended.

Support crankshaft at front and rear journals. The bend must not exceed 0.04 mm.

Check journals & crankpins for ovality, Taper.

Max. permissible ovality = 0 . 0 2 mm

Max. permissible Taper = 0 . 0 2 mm

Concentricity = 0.03 mm

Grind the crankshaft according to the available replacement bearing shells. This work may only be performed by experienced crankshaft grinders. For repair data of undersize big end bearings and main bearings refer section 16.0.7.

16.12.9 To Remove and Refit Crank Pulley

Backout the hex nut with box spanner.

Withdraw the crank pulley.

If found external damage, replace with new one.

Fit the new O ring on the inner dia of the hub.

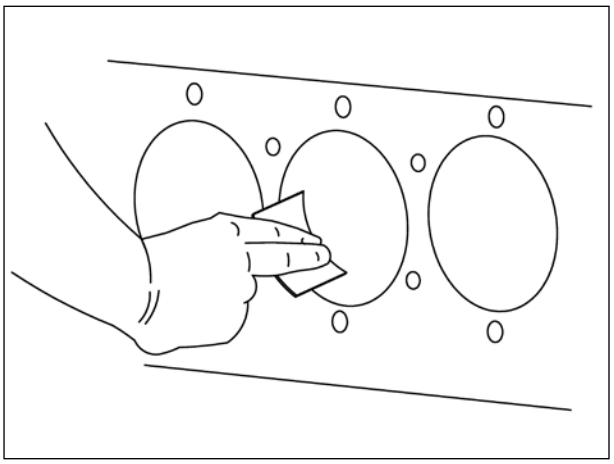
To refit crank pulley, reverse the procedure for removal.

16.13 PISTON AND CONNECTING RODS

16.13.0 To Remove Piston Assembly

Fix Special Tool 0102013 - Retainer Cylinder Liner to hold the liner.

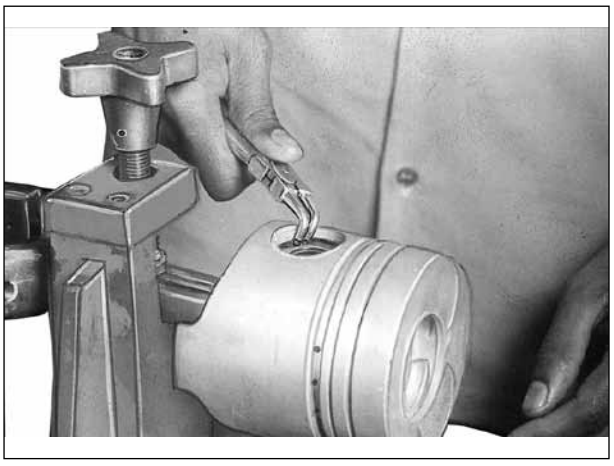
Backout connecting rod bolts and remove bearing cap.



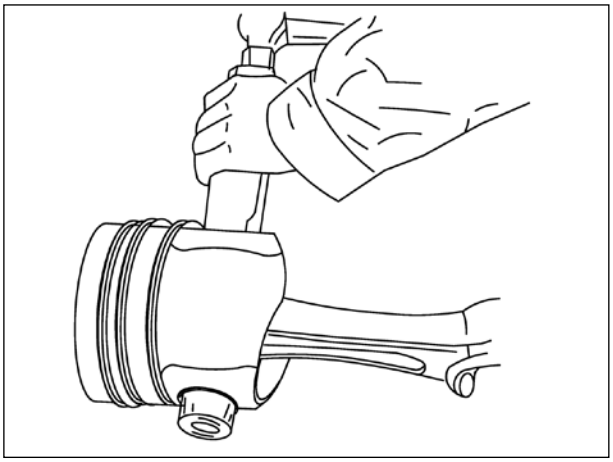
Scrape off carbon deposit from the upper end of the cylinder liner with the help of emery paper or scraper.

Extract all the pistons and connecting rod assemblies through top of the cylinders.

16.13.1 To Dismantle and Assemble Piston and connecting rod



Remove gudgeon pin circlip with the circlip plier.



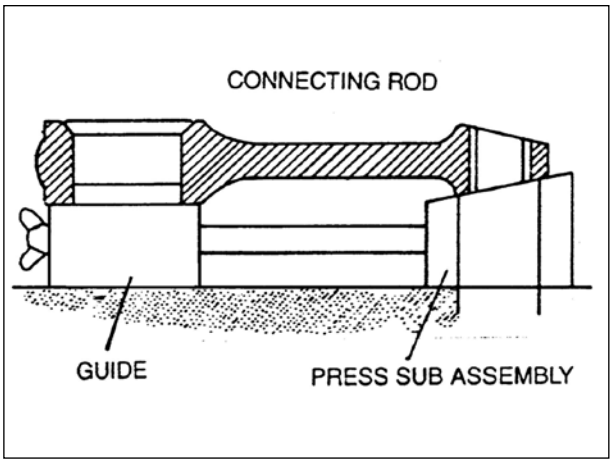
Place a copper drift on the pin and strike it out with the hammer.

16.13.2 Connecting Rod Bush

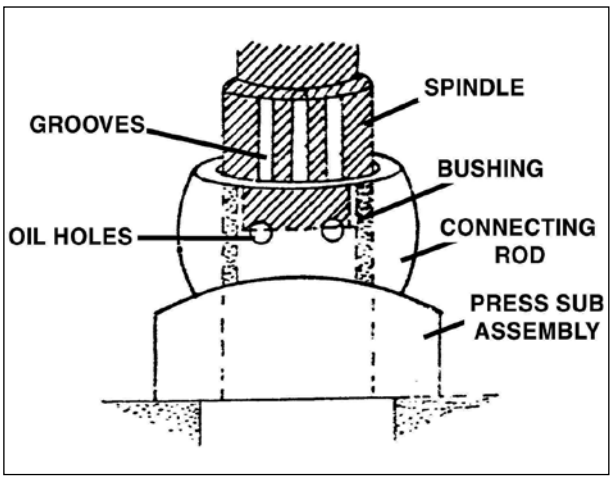
16.13.2.0 To Remove Bush

Using a special tool 0102017 - Drift and extractor.

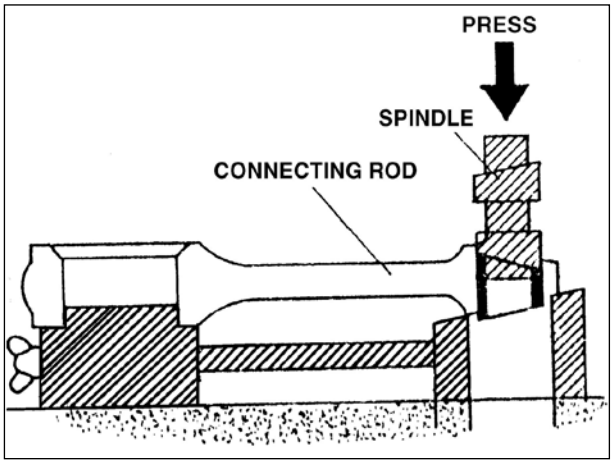
Align supporting surfaces of the guide and press sub assembly flush on the flat plain.



Set the connecting rod assembly without crank pin bearing on the guide and press assembly.

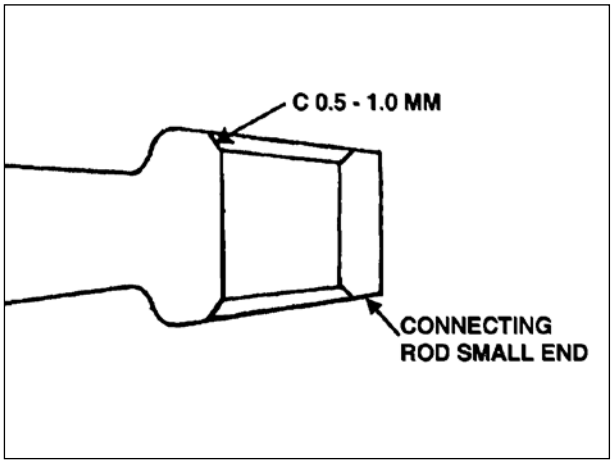


Install the spindle into the bushing. Align the grooving of the spindle with the oil hole of the bush.



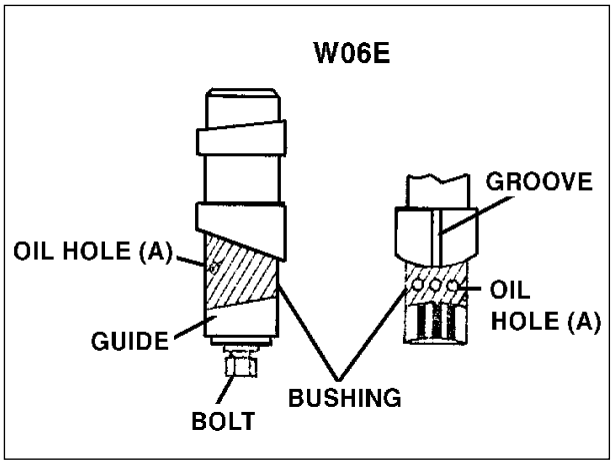
Using a hydraulic press, remove the bush slowly and smoothly.

16.13.2.1 Installation of Connecting Rod Bush



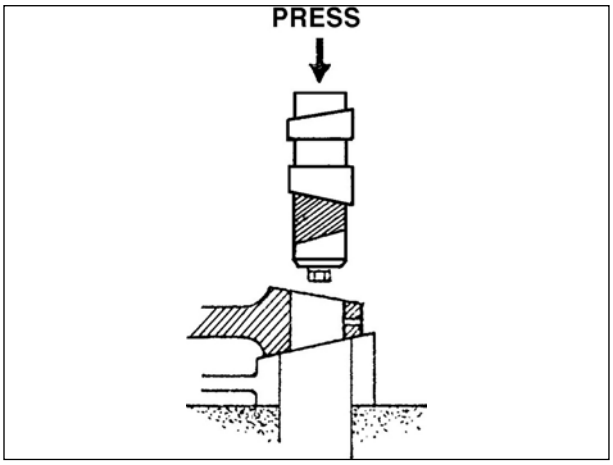
Chamfer one edge of the bush hole at the small end of the connecting rod uniformly by C 0.5 - 1.0 mm.

Set the bush and guide on the spindle then secure them with the bolt.



Be sure to slip the bushing over the spindle in the proper direction, so that oil hole 'A' will later align with the rifle hole in the connecting rod.

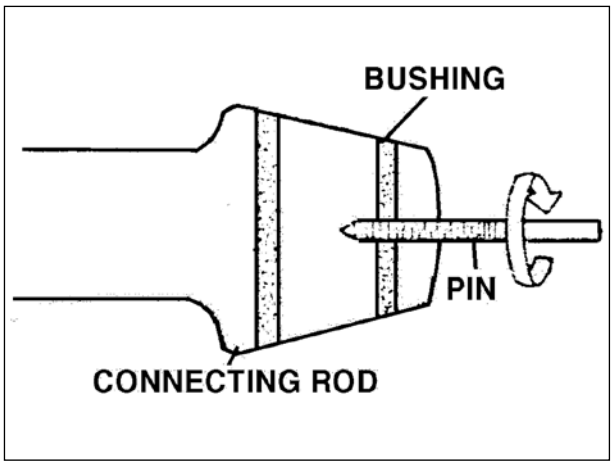
lubricate the bush guide and bush bore on the connecting rod.



Align oil hole 'B' in the bushing with the rifle hole of the connecting rod.

Always operate the press slowly and smoothly.

16.13.2.2 Inspect the Bushing Position after Installation

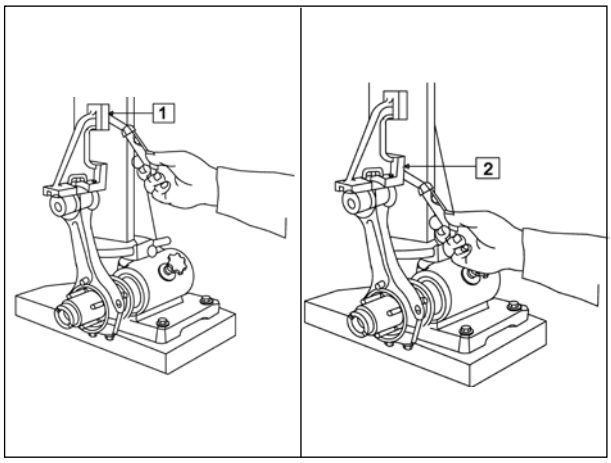


Make sure that the oil holes of the bushing and connecting rod are aligned.

Insert a pin of 3 mm dia into the hole at the end of the connecting rod, and make sure that the pin fully goes in.

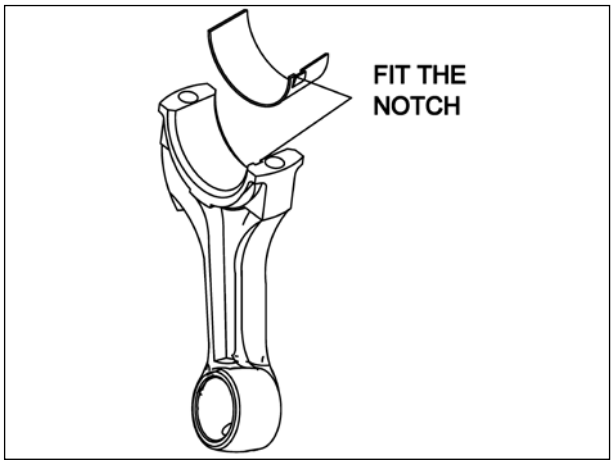
If there is any deviation in the alignment of the oil holes correct it with a drill of 3 mm dia. If drilling is carried out, take care to remove the machined burrs clears off the connecting rod small end bore and oil holes.

16.13.2.3 Check for Bend of Connecting Rod



Check for bend of connecting rod by means of bend checking tool and feeler gauge. The permissible tolerance is 0.1 measured at the distance of 200 mm from the longitudinal axis of connecting rod.

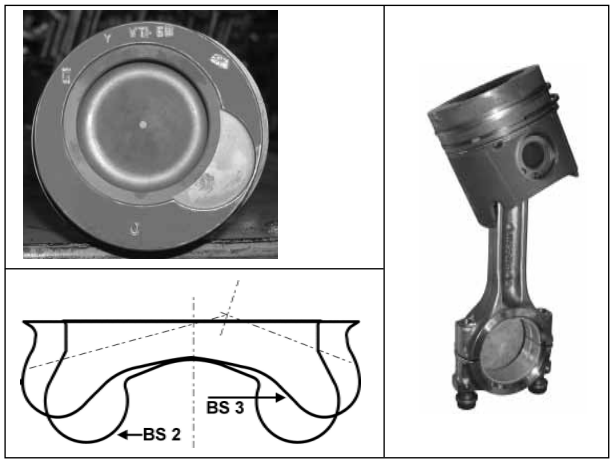
16.13.2.4 Install Connecting Rod Bearing



Confirm the notch are aligned both in the connecting rod and bearing.

16.13.3 Piston and Piston Rings

16.13.3.0 Piston General



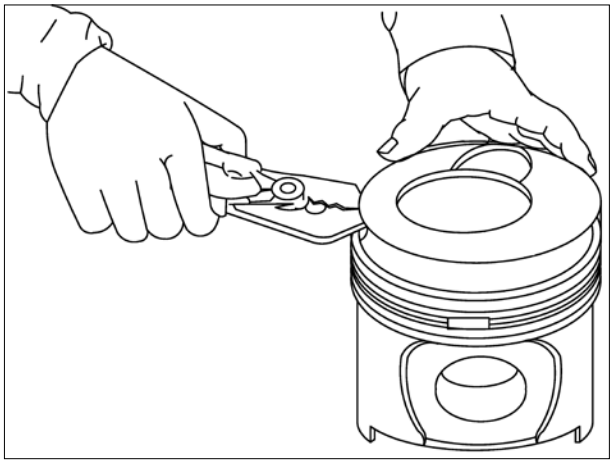
The piston combustion chamber is of shallow type for faster and more efficient combustion.

The piston consists of two compression Ring grooves, one oil scraper ring groove and crown face with a valve pocket.

Max. difference in the weight of the piston in an engine set of 4 pistons should not exceed 5 gms.

Weight group identification mark is punched on the piston crown.

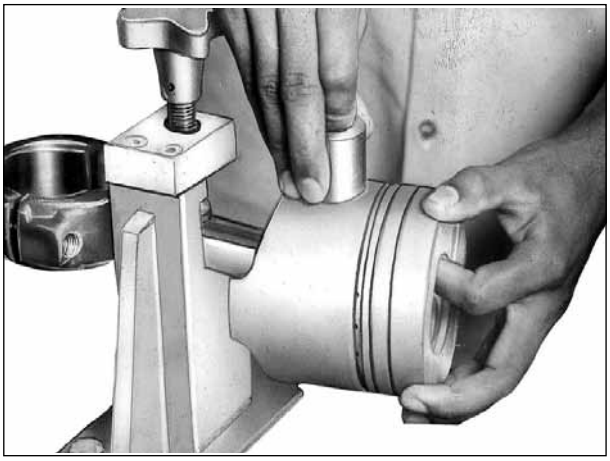
16.13.3.1 To Remove Piston rings



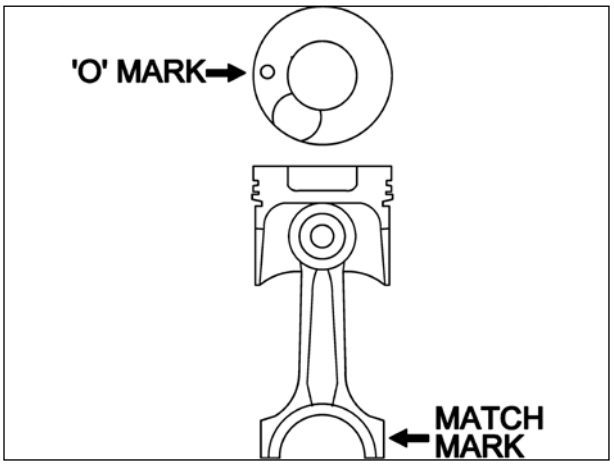
Remove compression rings and oil scraper rings with the aid of piston ring plier.

Remove carbon deposits from piston ring grooves.

16.13.3.2 Assemble Piston and Connecting Rod

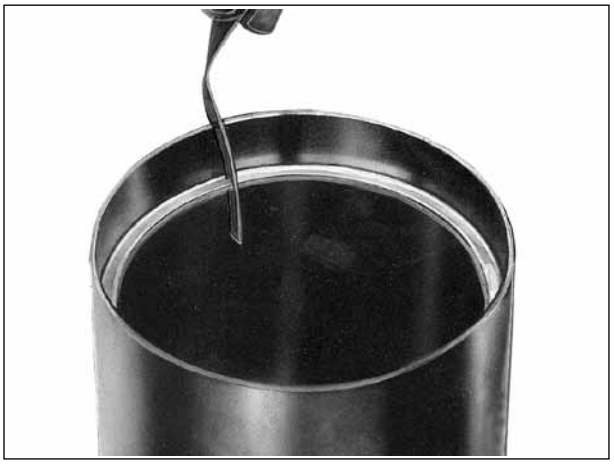


Heat the piston to approximately 80°C temperature. Insert the gudgeon pin into the piston with connecting rod.



O mark on the piston top and and connecting rod match mark should remain opposite to each other, while assembling the piston to connecting rod.

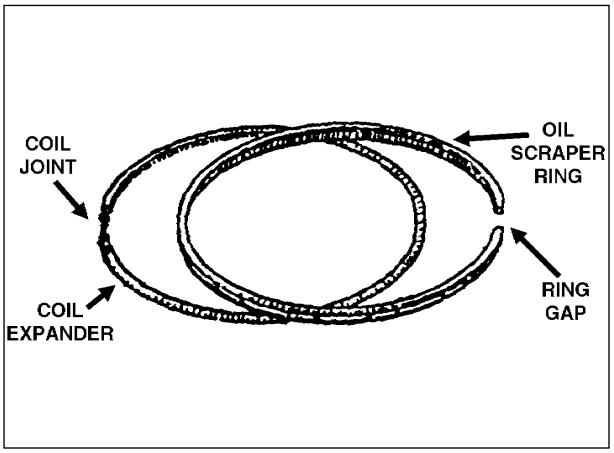
16.13.3.3 Install Piston Rings



Before fitting new piston rings, check each ring gap separately by inserting the ring into the cylinder bore at right angles and measure the ring gap (Butt clearance) with a feeler gauge.

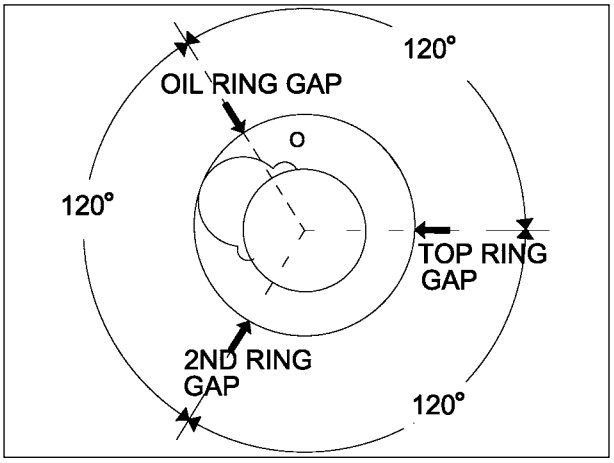
Apply oil over the piston ring. use a piston ring expander while fitting the piston rings.

Install the piston ring in sequence viz; oil ring, second ring and top ring with the identification mark at the top of the ring facing upwards.



Connect the ends of the coil expander and then fit the coil inside the piston ring after ensuring that the gap of the piston ring is 180° away from the joint of the coil. Coil expander and piston scraper ring are supplied together.

Check the lateral clearance of the piston rings.



Stagger the piston ring gaps so that they are not in line, approximately at 120° away from each other.

16.13.3.4 Installation

Lubricate piston, piston rings, cylinder bore and con rod bearing with engine oil.

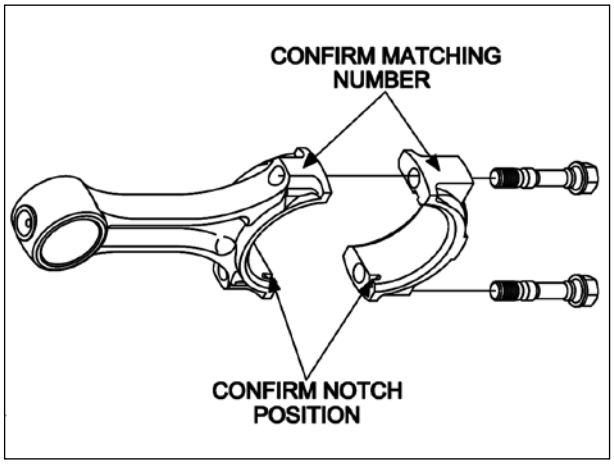
Displace the piston ring gaps relative to each other by 120°.

Make sure that 'O' mark on the piston top is on the tappet side, when fitted.

Rotate crankshaft so that the crankpin of the respective piston is in B.D.C. position.

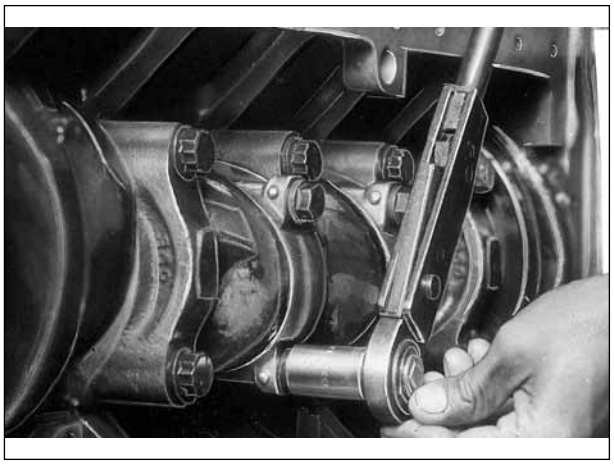
Insert piston with connecting rod assembly into the cylinder bore compressing the piston rings by means of Special Tool 0102014 - Compressor Piston Ring.

Push the piston into the crankcase until the big end bearing is seated on the crankpin.



Align the punch mark on the connecting rod and cap.

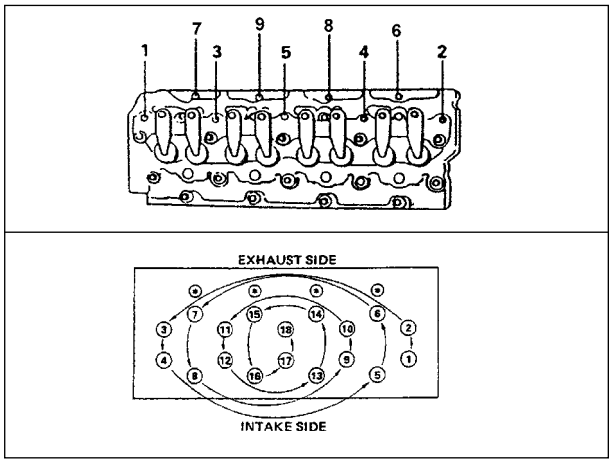
Fit bearing cap with bearing, taking care that the bearing halves are seated properly in the connecting rod and cap.



Tighten con rod bolts alternatively to recommended torque.

16.14 CYLINDER HEAD ASSEMBLY

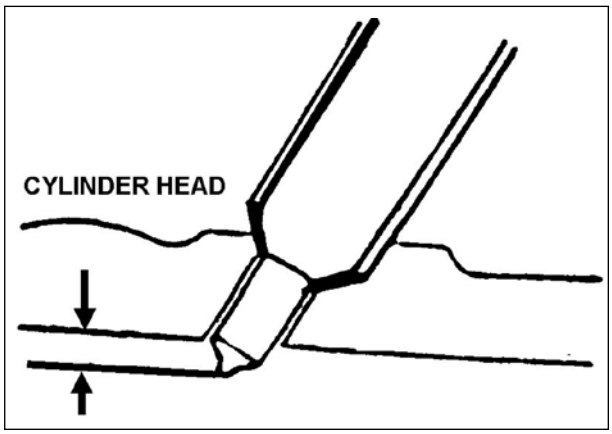
16.14.0 To Remove Cylinder Head



Loosen the cylinder head bolts / rocker arm support bolts as per sequence shown. Start with M10 bolts and then M12 bolts.

Using a special tool 0102010 - Wrench Cylinder Head Bolt

Lift the cylinder head from the dowels on the cylinder block and place it on wooden blocks (supporting on both the ends) to avoid nozzle tip damage.

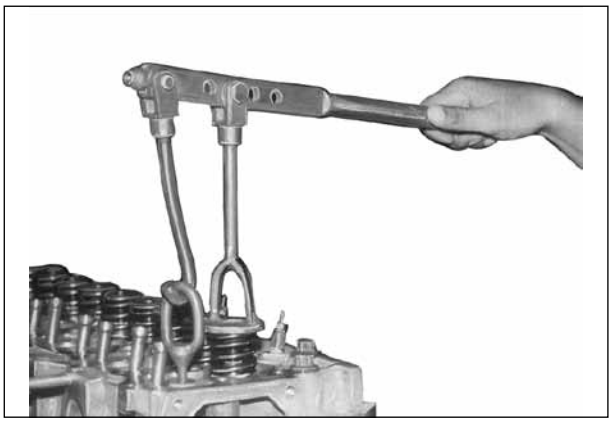


Nozzle protrusion from the cylinder head surface is 2 ± .a2mm.

Ensure that all the nozzles are removed from the cylinder head.

Remove the valve split cone lock, collar and spring from cylinder head.

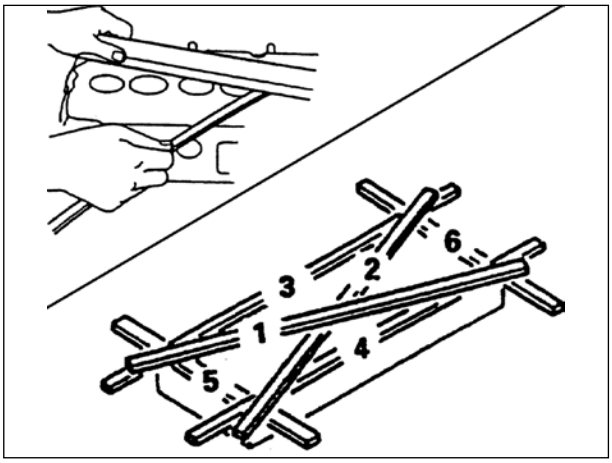
Remove coolant sensor from the cylinder head.



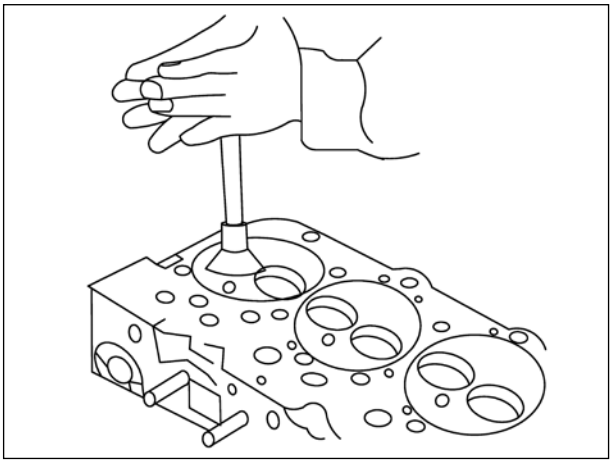
Using Special Tool 0102005 - Compressor Valve Spring, remove the exhaust and inlet valves.

Before removal of all valves, punch the serial nos of cylinder numbers on the valve face, to avoid mixing of valves.

Clean the cylinder head, valves, spring and all other parts thoroughly with the suitable solvent.

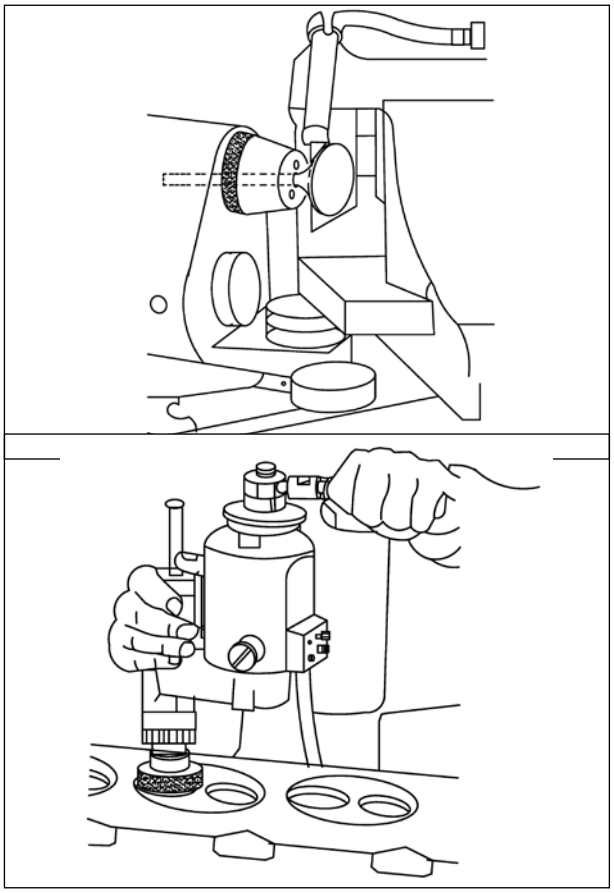


Check cylinder head surface unevenness.
Hand lap valve and valve seat.



Lightly apply lapping compound to the valve face. Install the valve with a Valve Lapping Tool, tap and rotate valve against the seat.

16.14.1 To Grind Valves and Valve Seats



Grinding of valves and valve seats should only be performed when handlapping does not result in proper seating.

Any conventional valve grinding machine can be used.

After grinding, always recheck the valve sink.

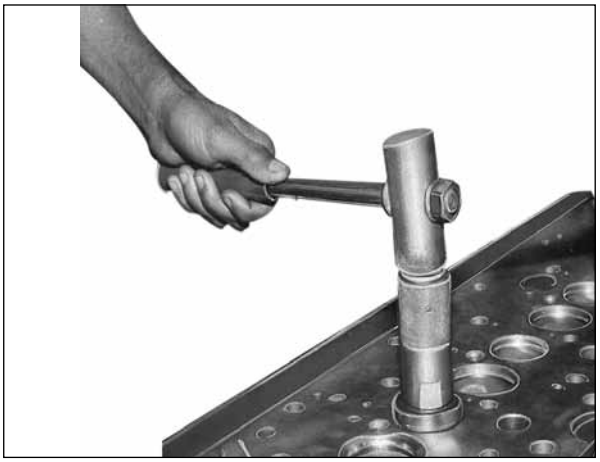
For repair data refer section 16.0.3.

16.14.2 To Remove Valve Seat

Cut the circumference of a valve head at three places with a grinder and install it into seat and weld valve to seat. Then to remove, drive out valve and seat with a hammer and a brass block.

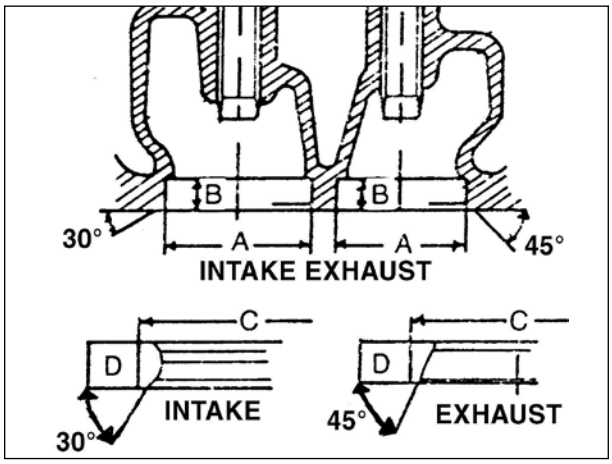
16.14.3 Valve Seat Installation

Heat the cylinder head to about 80° - 100°C with hot water. On the other hand, cool the valve seat with dry ice or liquid nitrogen for about 30 minutes.



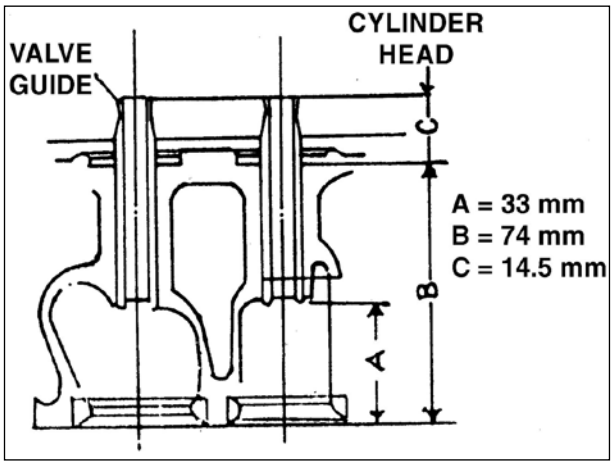
Hold the seat with pincers and place it into the heated cylinder head.

Valve seat section machining specifications



		Intake (mm)	Exhaust (mm)
Cylinder Head Dimension	A	46.500 - 46.516	41.000 - 41.016
	B	8.8 - 9.0	7.2 - 7.4
Valve Seat Dimension	C	46.630 - 46.645	41.130 - 41.145
	D	7.5 - 7.7	6.0 - 6.2

16.14.3.0 To Check the Valve Guide



The Valve guide may require replacement if stem to valve guide clearance exceeds

Intake - 0.035 - 0.068 mm

Exhaust - 0.050 - 0.083 mm

16.5.3.1 To Renew Valve Guide

Remove the valve stem seal.

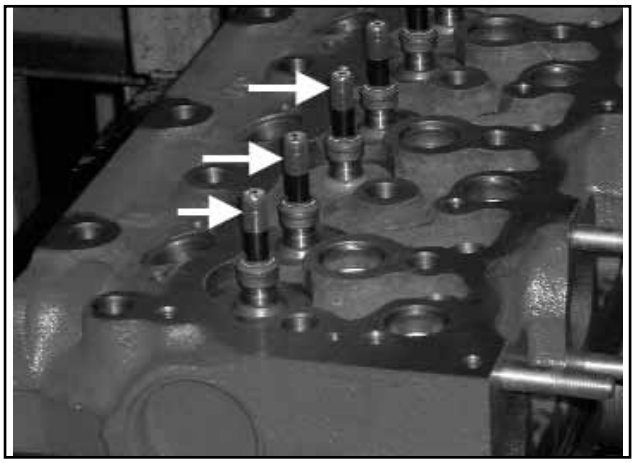
Using a brass rod and hammer, drive out the valve guide.

Install the valve guide.

Special Tool 0102009 - Drift Valve Guide.

Apply engine oil lightly to the valve guide outer circumference before installation.

16.14.3.2 To Refit Valve and Valve Stem Seals



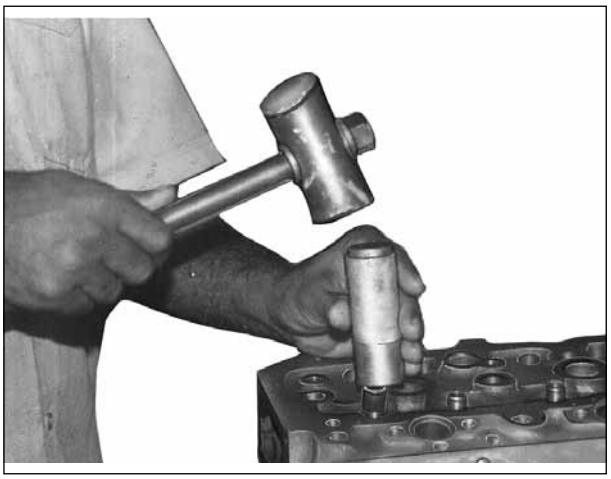
Install the valves, lower spring seat and stem seals.

Use fitment sleeve for valve guide seal to part no. X1102160.

Then apply engine oil to the lip of the stem seal and install the stem seals.

Remove and scrap the fitment sleeve.

Drive the special tool until it hits the lower spring seat.



Special Tool 0102006 - Drift Valve Stem Seal.

16.5.3.3 To Check Valve Springs

Check valve springs on a valve spring scale for re-usability

Valve spring

straightness = 2.0 mm

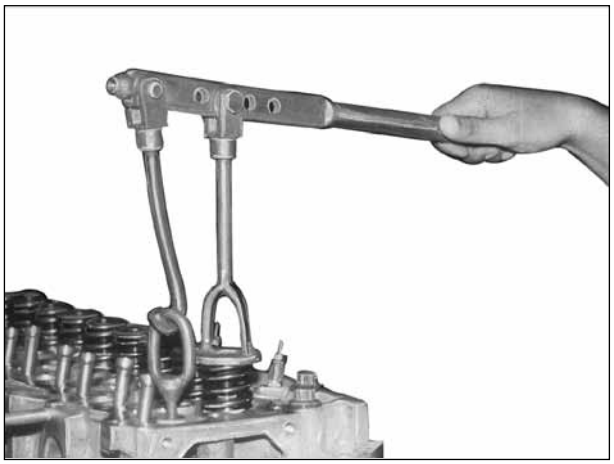
Setting load

Outer = 27.4 ± 1.4 kg at 45.5 mm
Inner = 8.8 ± 0.4 kg at 43.0 mm

16.14.4 To Assemble the Cylinder Head

Apply engine oil to contact surface of all the parts. Make sure that the valves are installed in the respective cylinders.

Valve springs are constant pitch in place of progressive spring (Equal pitch coil).



Press valve spring and collar to install split cone lock.

Using Special Tool 0102005 - Compressor Valve Spring.

Install the Cylinder Head

Install the cylinder head gasket, always use new cylinder head gasket. After cleaning the surfaces of the cylinder head, cylinder block and head gasket free from dirt, water and grease.

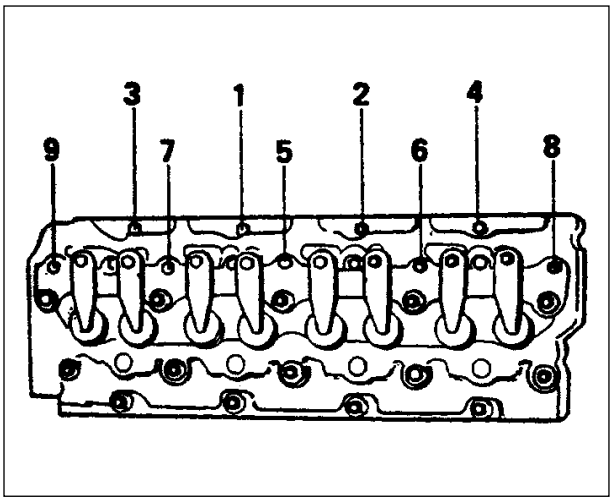
Fit 8 numbers valve tappets on to the cylinder block after applying the oil to the tappet bores on the cylinder block.

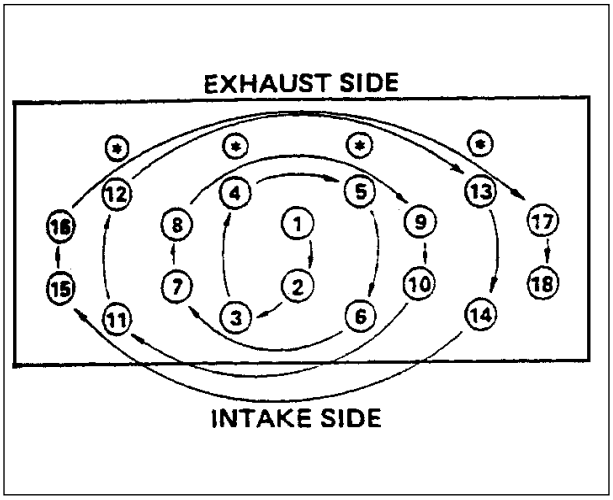
Ensure fitment of two dowel pins on the cylinder block top, to locate cylinder head and gasket.

Install the cylinder head over the dowels on the cylinder block.

Insert push rod in correct position.

NOTE **Only Multi Layered Gasket (MLS) should be used along with Mild Interference liners (MIF).**





Recommend to replace the existing bolts with new with new cylinder head bolts while reassembly.

Apply oil on bolt thread and bolt head seating area.

Tighten the cylinder head bolts in two stages as per tightening sequence and recommended torque. Start with M12 bolts and then M10 bolts.

Mount the rocker arm assembly on the cylinder head, make sure that the push rods interlock with the adjusting screws.

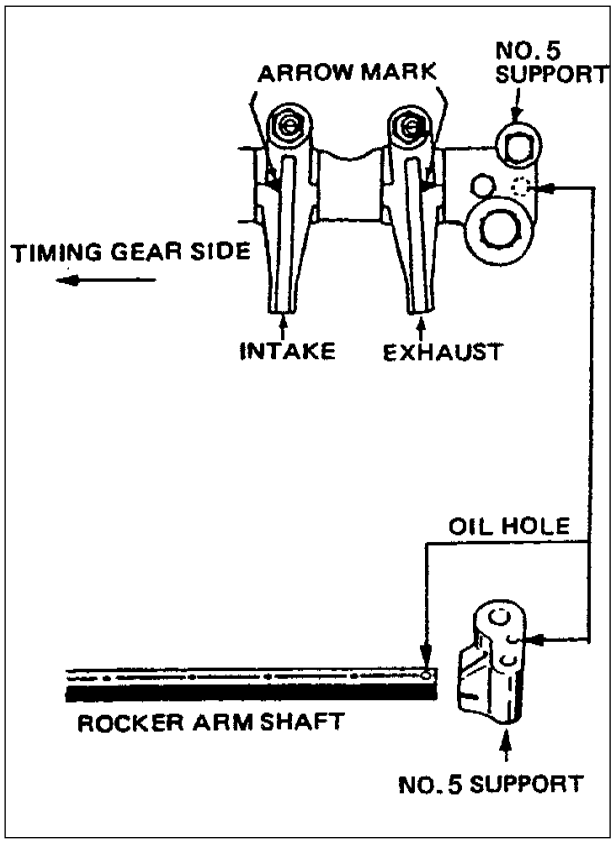
16.15 TIMING

16.15.0 To Remove and Refit Rocker Levers

Backout fixing bolt and remove rocker shaft assembly.

Reassemble rocker arm assy. in the order as follows:-

Bracket, Inlet valve lever, Spacer, Exhaust valve lever, Bracket . . . ,



Confirm that oil hole of rocker arm assembly No.5 support aligns with shaft oil hole.

Improper installation will result in seizure of the entire valve assembly.

16.15.1 To Remove, Refit and Check Push Rod and Tappets

Remove push rods and tappets.

Check out of true (bend) of push rods between centres.

Maximum permissible out of true = 0.3 mm.

Examine push rod ends for wear. Replace if necessary and check rocker lever and tappet lubrication in this case.

Check diametral clearance of tappet in crankcase bore and inspect sliding surface and push rod seat for wear.

If necessary replace worn out parts.

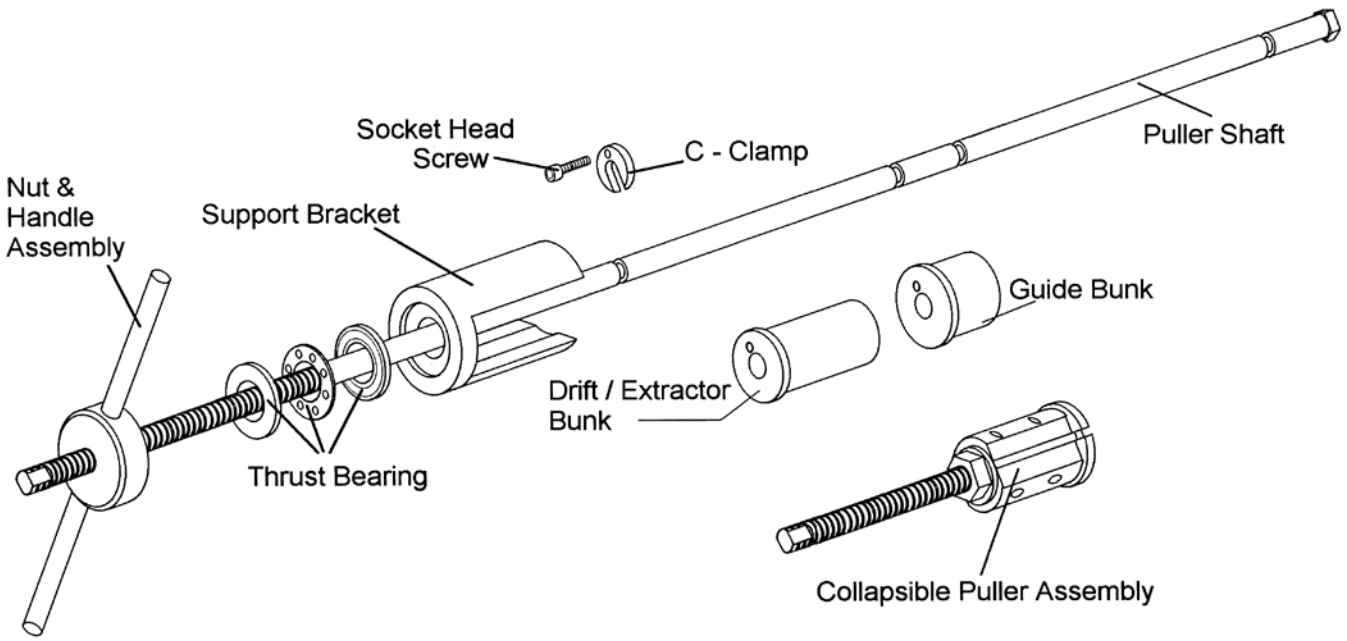
To refit push rods and tappets, reverse the procedure for removal.

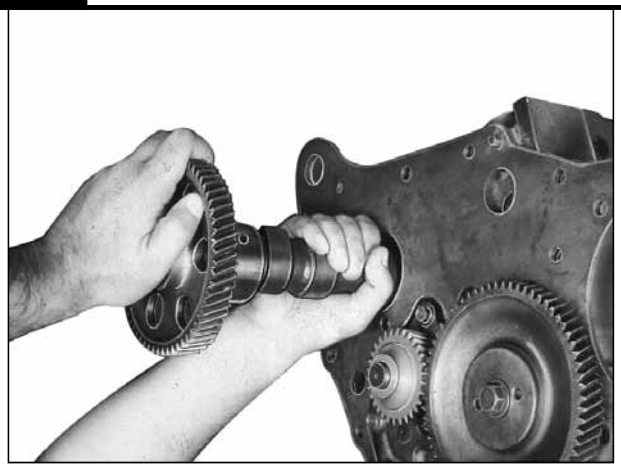
16.15.2 To Remove and Refit Camshaft

Unscrew 2 Nos Hex screws of 12mm size from camshaft holding flange through opening provided in camshaft gear.

Do not unscrew camshaft drive gear holding bolt and try to pull the gear using puller.

Extract camshaft after removing push rods and tappets.





Pull out the camshaft slowly turning it, so that the bearings are not damaged.

16.15.3 Removal and Replacement of Camshaft Bushes

Use Special Tool 0102018 - Drift & Extractor Camshaft Bushes to remove and refit camshaft bushes.

Extraction

The cylinder block is designed with minimum aperture, the camshaft bushes are not approachable from the LH side or bottom side of the engine.

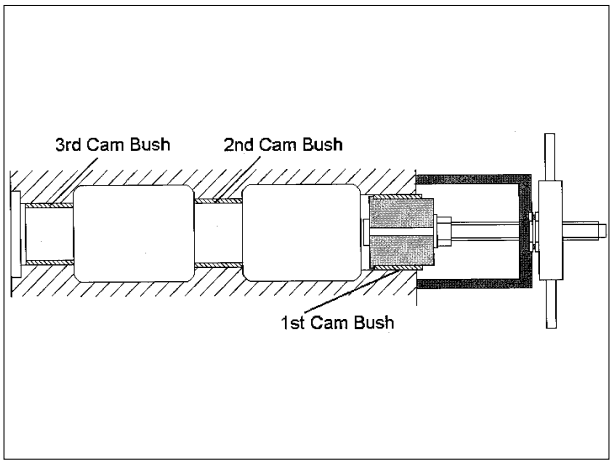
Hence the parent bores of camshaft bushes in the cylinder block have been machined in different diameters to facilitate the removal and re-fitment of the bushes. For this reason, the diameters of the camshaft bearing journals are in descending order.

16.15.3.0 Camshaft Bush Dimensions (in mm)

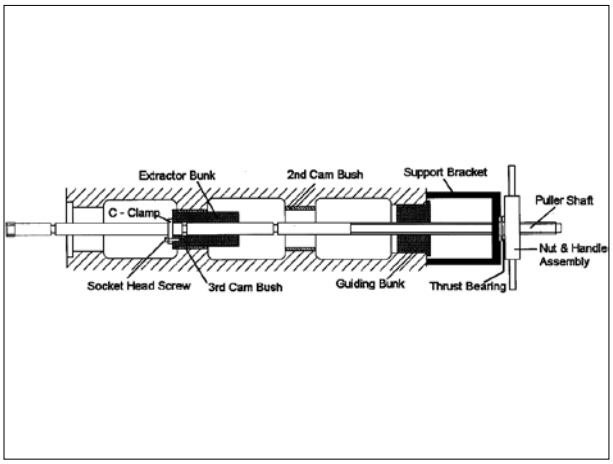
Parent bore diameter		
First Bush	-	60
Second Bush	-	59.8
Third Bush	-	59.6
Bush inner diameter		
First Bush	-	57
Second Bush	-	56.8
Third Bush	-	56.6

16.15.4.1 Removal of bushes

Proceed in the following manner to remove the camshaft bushes.

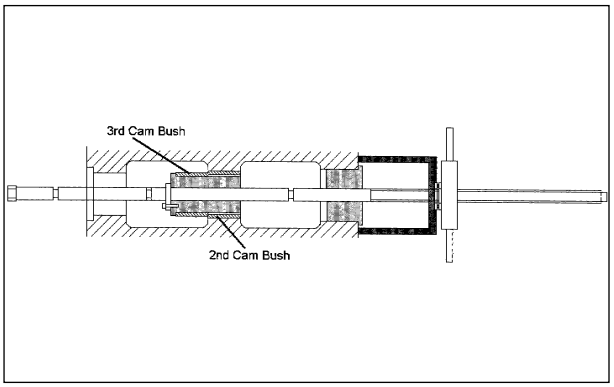


1. Remove the 1st bush using collapsible puller assembly and support bracket from front.
2. Compress the collapsible puller and insert the same in to the bush until the collapsible bunk expands and holds the bush snugly.
3. Lightly tighten the nut next to the collapsible bunk so that the bunk does not collapse when the bush is being pulled out.
4. Place the support bracket and thrust bearing in place and using the nut and handle assembly, pull out the bush.



5. Fix the extractor bunk on the appropriate groove on the puller shaft, insert the puller shaft from rear side of the engine carefully locating the bunk inside the 3rd bush.
6. Arrange the guiding bunk, support bracket, thrust bearing and nut & handle assembly at the front end of the engine on the puller shaft and extract the 3rd bush.

The 3rd bush will be in between the 3rd and 2nd parent bores of the camshaft bushes now.

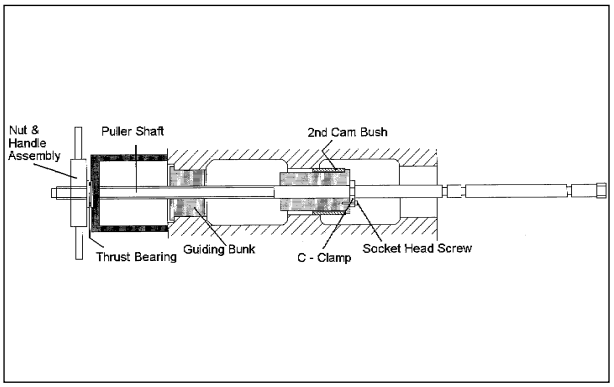


7. Guide the extractor bunk along with the extracted 3rd bush in to the 2nd bush and continue to rotate the nut & handle assembly until the 2nd bush is extracted.

8. Take out the puller arrangement along with the 2nd and 3rd bushes carefully through the 1st bush parent bore of the camshaft.

16.15.5 Installation:

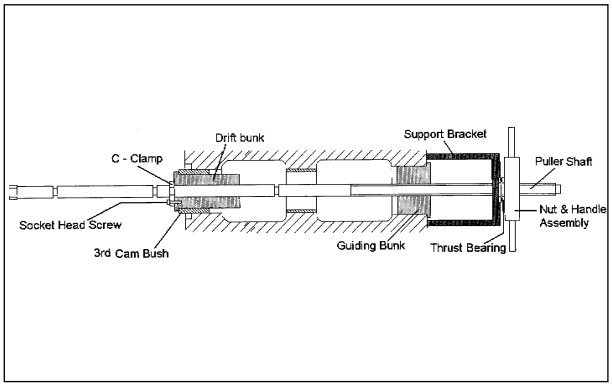
The camshaft bushes are pre-finished; hence handle them carefully.



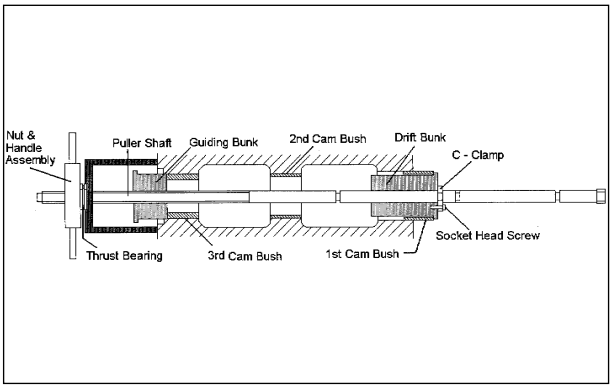
1. Place the 2nd camshaft bush on the drift bunk.

   Insert the puller from the front side of the engine until the front portion of the drift bunk sufficiently enters the 2nd camshaft bush parent bore.

   Arrange the guide bunk, support bracket, thrust bearing and nut & handle assembly at the rear end of the cylinder block as shown and tighten the nut & handle assembly until the 2nd camshaft bush is in its place.



2. Remove the puller from the cylinder block and fix the drift bunk in the appropriate groove as shown in figure. Place the 3rd camshaft bush on the bunk and insert the puller shaft from rear end of cylinder block until the front end of the drift bunk is sufficiently inside the parent bore of the 3rd camshaft bush as shown in figure. Arrange the guide bunk, support bracket, thrust bearing and nut & handle assembly at the front end of the cylinder block as shown and tighten the nut & handle assembly until the 3rd camshaft bush is in its place. Check for the alignment of oil holes. When the bush is in its place, it would be about 2 mm inside the parent bore.



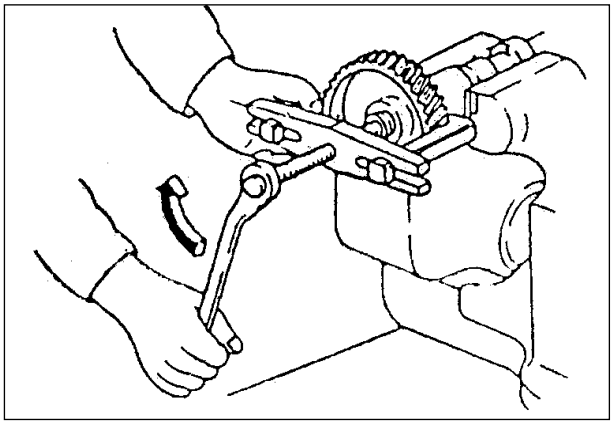
4. Remove the puller from the cylinder block and place the 1st gear bush on the drift bunk. Insert the puller from front end until the front portion of drift bunk is sufficiently inside the parent bore of 1st camshaft bush parent bore.

   Arrange the support bracket, thrust bearing, nut & handle assembly and the guide bunk (in about 2 mm space provided by bush) at the front end of the cylinder block as shown in the figure, at rear and tighten the nut & handle assembly until the 1st camshaft bush is in its place.

To refit camshaft reverse the procedure for removal.

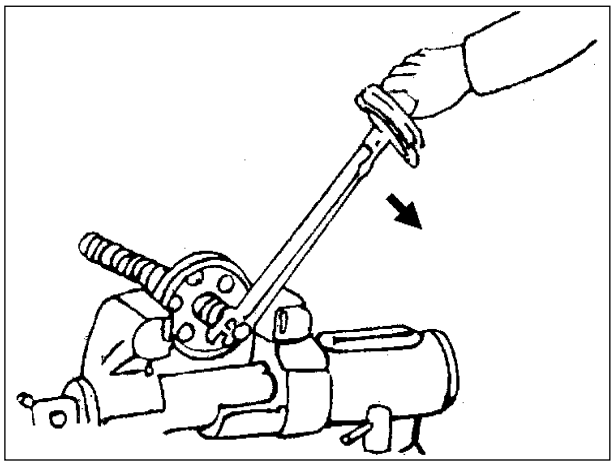
If necessary, remove the camshaft gear

Hold the camshaft assembly with a suitable vice through wooden supports.



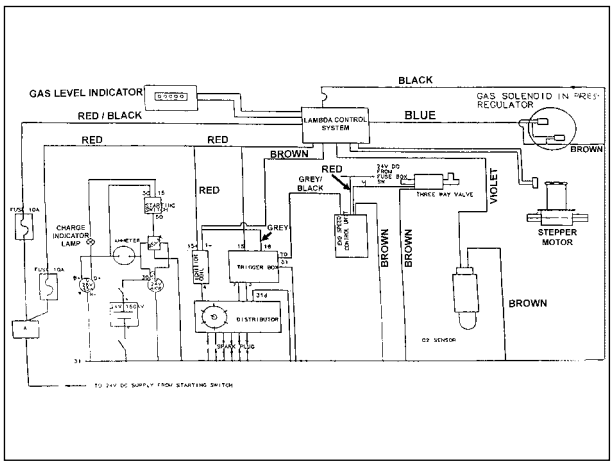
Remove the nut, then using a gear puller, remove the gear.

16.15.6 Install the camshaft gear on the shaft



Install the camshaft bearing with a thrust bearing. When installing the gear to the camshaft, heat the gear in hot water (approx. 100°C), then install the gear on the camshaft by using a press. When tightening the bolts, apply engine oil to the threads and bearing surface of the bolt.

16.15.7 To Refit the Camshaft



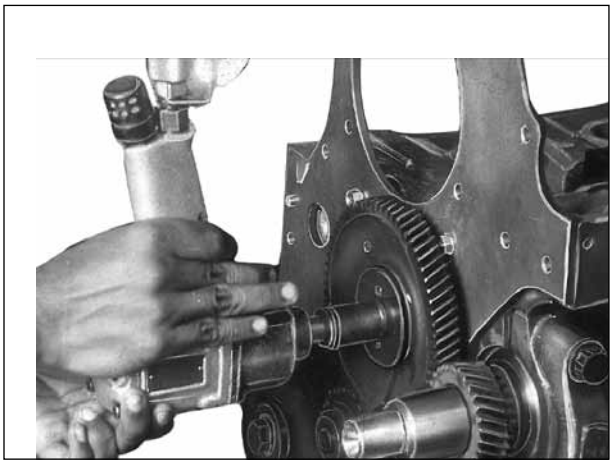
'E2' punch mark is punched on the rear end of the camshaft.

Set the no. 1 piston to Top Dead Centre of the compression stroke.

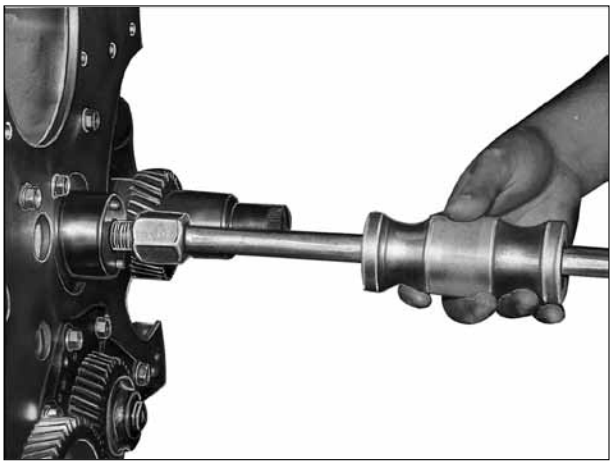
Lubricate all journals of the camshaft and insert the camshaft assembly into the cylinder block, by slowly turning, so that the bearing will not be damaged.

Align the camshaft timing gear matching mark with the oil pump gear mark.

16.15.8 To Remove and Refit Intermediate Timing Gear

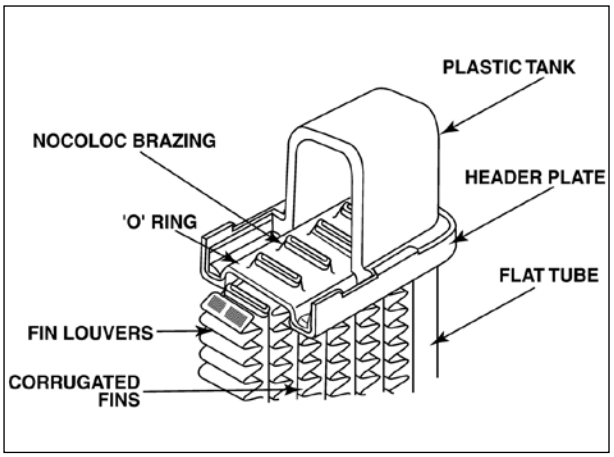


Backout fixing bolt and remove it with thrust washer, withdraw intermediate gear.



To remove the spindle use special tool 0102003 - Sliding Hammer and special tool 0102002 - Adaptor Idler Gear Shaft.

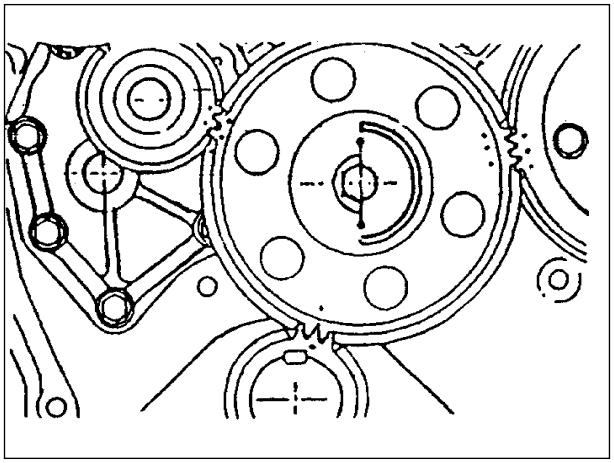
16.15.9 Install the Idler Gear Shaft (Spindle)



Install idler gear shaft with thrust plate using a plastic hammer.

Make sure that the two oil holes is facing downward (oil pan side) so that it does not become clogged due to accumulation of sludge and other foreign material in the oil.

16.15.10 Install the Idler Gear



Install the Idler gear, be sure that the matching marks of the crankshaft gear, oil pump drive gear and idler gears are aligned correctly.

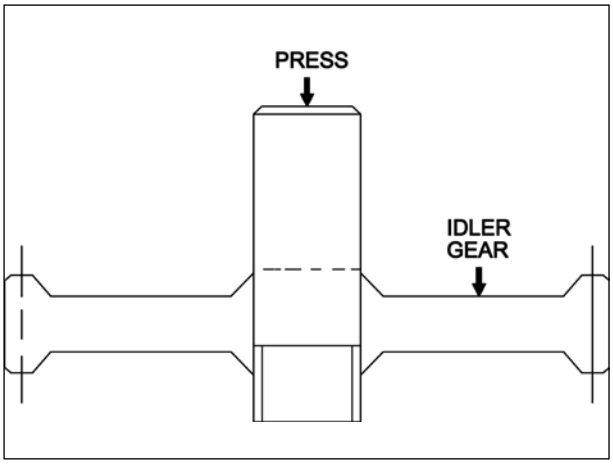
Check end play within 0.040 - 0.095 mm.

Ensure backlash - 0.068 - 0.194 mm.

Tightening torque procedure for idler gear bolt

- Apply oil on bolt thread and face
- Initial torque by 100 Nm, then loosen the bolt.
- Then torque the bolt to 40 Nm + 60° - 65°

16.15.11 To Re-bush Intermediate Gear



Press out the worn bush with a suitable drift.

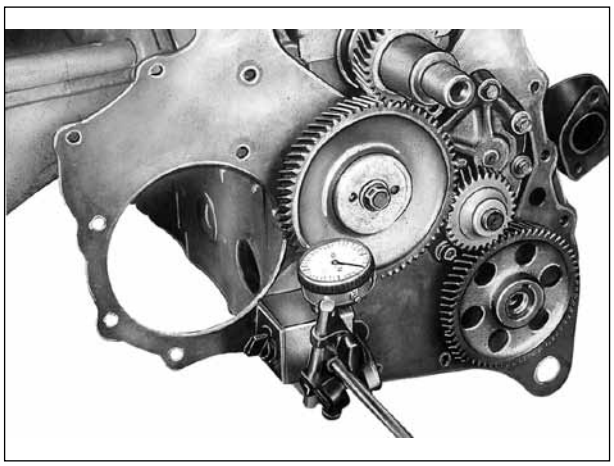
Drive in the new bush.

The replacement bush is supplied finished.

Max. oil clearance

between spindle and bush = 0.1 mm

Intermediate gear endplay = 0.15 mm

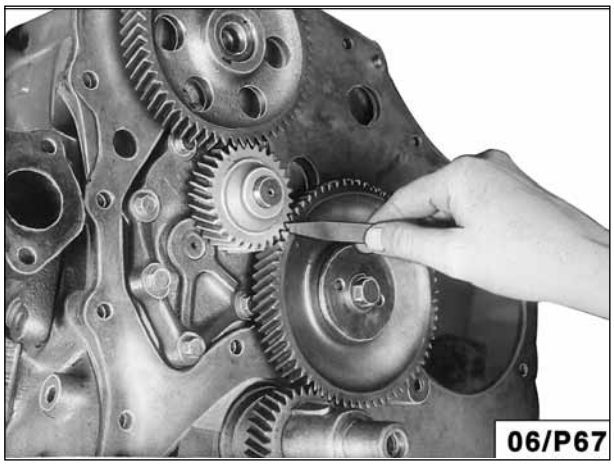


Bush internal diameter = 50.00 mm

Spindle dia = 49.95-49.97 mm

16.15.12 To Position Timing Gears for Valve Timing.

16.15.13 Timing Gear Backlash Checking

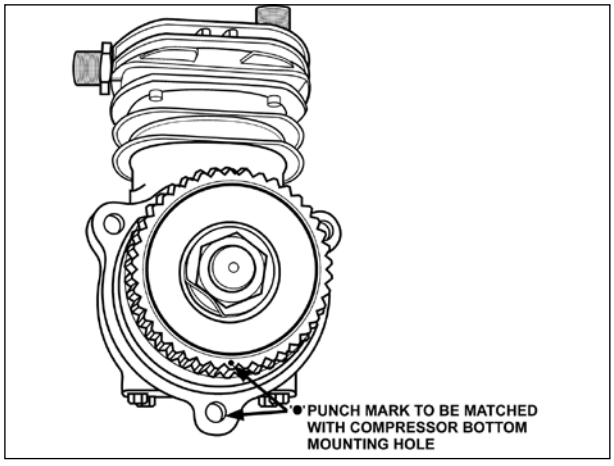


Check tooth backlash with feeler gauge.

Backlash between driving gear and intermediate gear, should be with in the recommended values.

Max. limit = 0.3 mm.

16.15.14 To Fit Air Compressor



While assembling, keep engine first cylinder at TDC, align '•' punch mark on the gear teeth with the bottom mounting hole, then assemble the compressor and tighten the mounting bolts.

16.15.0 To Adjust the Valve Clearance

Method for determining if the No. 1 or No.6 piston is at the Top Dead Center on compression stroke.

Turning the crankshaft, align the mark "1-6" on the flywheel pointer on the flywheel housing.

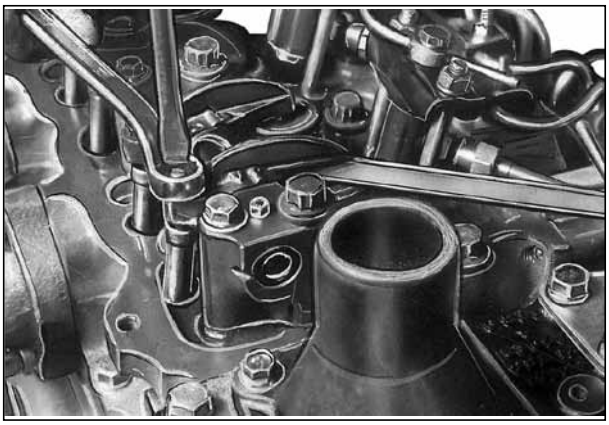
In this position either the No. 1 or No. 6 piston is at the top dead center on compression stroke.

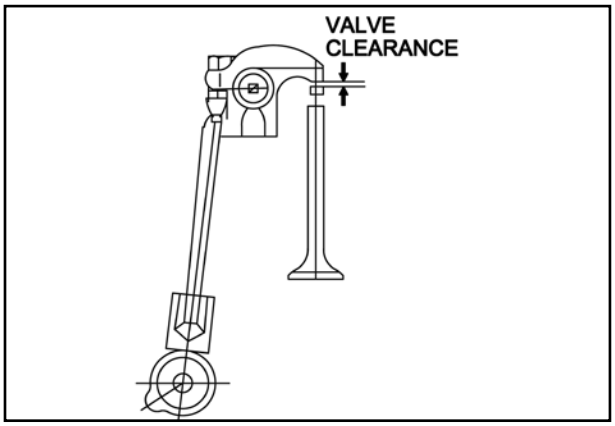
If both No. 1 intake and exhaust rocker arms can be moved easily by hand, the No. 1 piston is at top dead center on compression stroke.

With the No. 1 piston positioned at top dead center on compression stroke, adjust the No. 1 valve clearance using a feeler gauge.

The feeler gauge should move with a very slight pull.

Valve clearance





To adjust the other cylinder valves, by turning the crankshaft clockwise 120° (viewed from the front side). Adjust the valve clearance for each cylinder as per firing order.

16.15.01 To Adjust the Valve Clearance

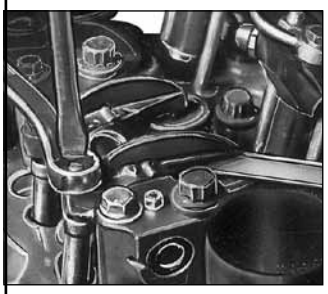
Method for determining if the No. 1 or No.4 piston is at the Top Dead Center on compression stroke.

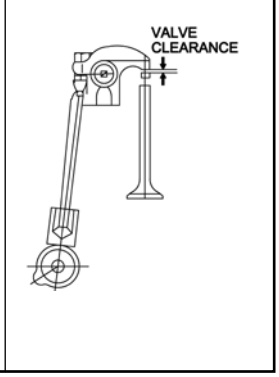
* Turning the crankshaft, align the mark "1-4" on the flywheel pointer on the flywheel housing.
* In this position either the No. 1 or No. 4 piston is at the top dead center on compression stroke.

If both No. 1 intake and exhaust rocker arms can be moved easily by hand, the No. 1 piston is at top dead center on compression stroke.

With the No. 1 piston positioned at top dead center on compression stroke, adjust the No. 1 valve clearance using a feeler gauge.

The feeler gauge should move with a very slight pull.





To adjust the other cylinder valves, by turning the crankshaft clockwise 180° (viewed from the front side). Adjust the valve clearance for each cylinder as per firing order.

16.16 ENGINE LUBRICATION

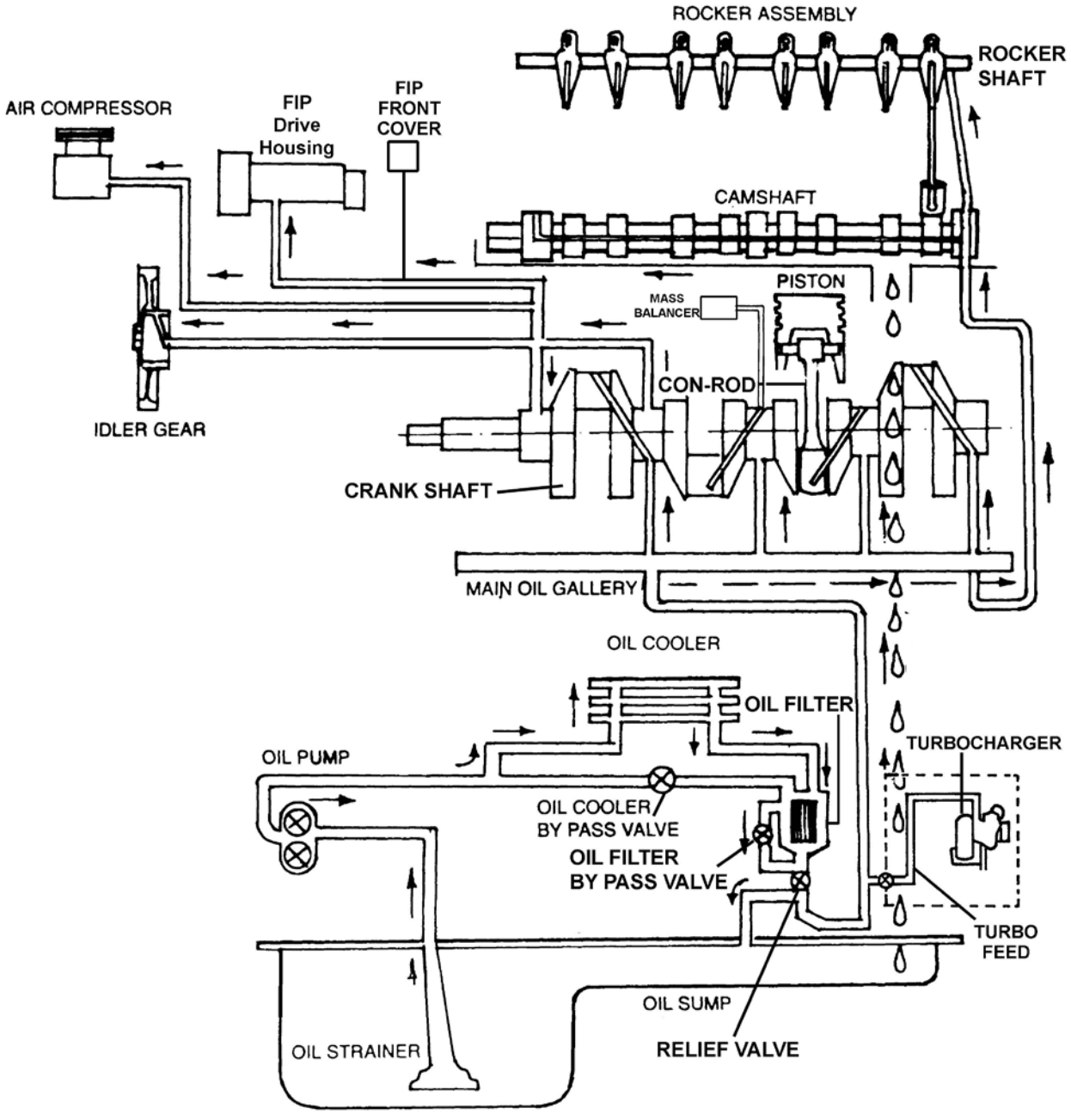
16.16.0 Design and Operation

The diagram illustrates the arrangement of the equipment, and the flow of oil through the systems.

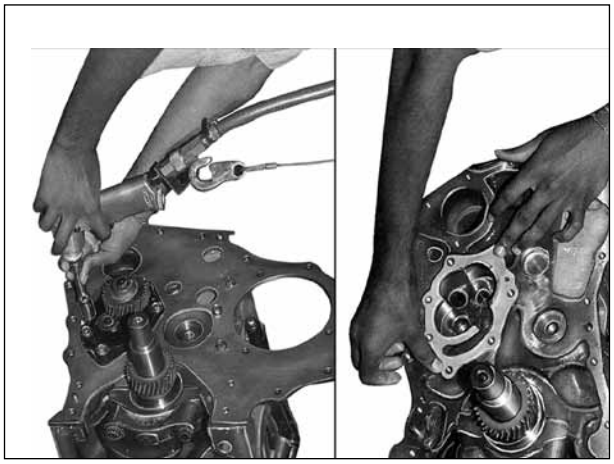
The engine is arranged for forced feed lubrication. The oil pump supplies the lubricating oil for engine.

The oil pump is located within timing gear cover and driven by Intermediate gear, the oil pump gear in turn drives the engine camshaft.

The oil pump forces the oil from the sump to the oil cooler. The oil is then filtered through full flow paper type oil filter, there are by pass valves for cooler and filter respectively. After cleaning the oil passes to the main gallery via oil pressure relief valve it is forced through oil ducts to the crankshaft and camshaft bearings. The connecting rod big end bearings are supplied with lubricant from the crankshaft main bearings, through inclined oil ducts. The lubricating oil rises from the camshaft bearing No. 3 to the rocker shaft assembly. The intermediate gear pin is lubricated from the 1st main Journal Bearing & Aux. gallery. This oil also lubricates the other timing gears.

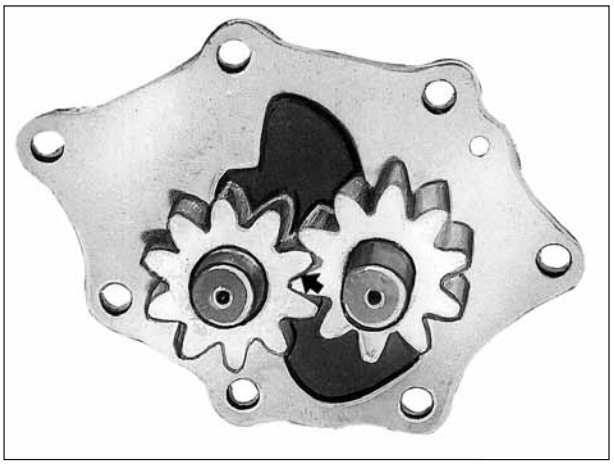


16.16.1 To Remove and Refit Oil Pump



Remove oil pump from front face of Crank case after removing intermediate gear and camshaft.

16.16.2 To Overhaul Oil Pump



Check Gear backlash between oil pump gears specification is 0.09 - 0.21 mm (limit - 0.30 mm).

Replace the gear if Backlash exceeds the limit.

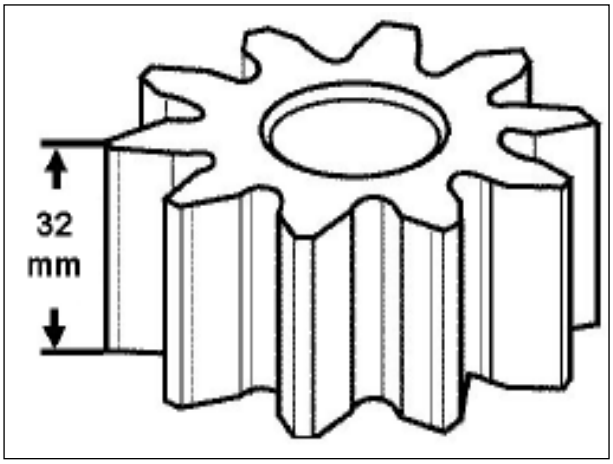
Drive gear shaft diameter to drive gear Bushing Inner diameter clearance should not exceed 0.040 mm - 0.085 mm, If found excess by measuring the Drive gear shaft and Bushing inner dia separately. The drive gear shaft diameter dimension - 18.088 - 18.106 mm (limit 18.06 mm).

Check clearance between driven gear and shaft 0.040 - 0.075 mm (limit - 0.1mm). Replace gear or shaft whichever is worn excessively.

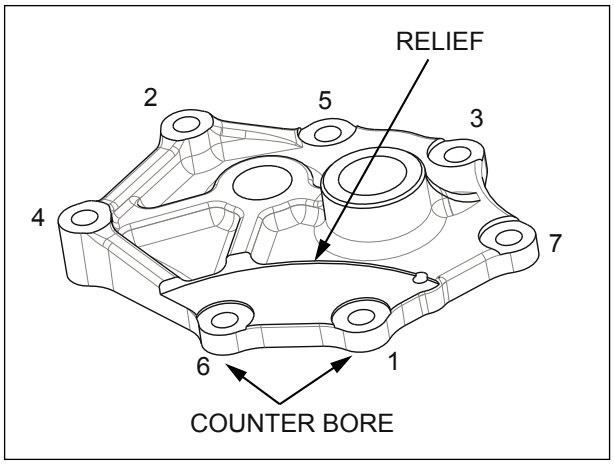
Driven gear Shaft Diameter 17.979 - 17.997mm (Limit 17.970 mm). Driven gear inside diameter 18.037 - 18.054 mm (Limit 18.070 mm).

Ensure height of the oil pump gear is between 32 to 32.4mm.

16.16.3 To Refit the Oil Pump



The oil pump assembly is fixed by means of 7 screws, two of which are located at the counter sunk area.

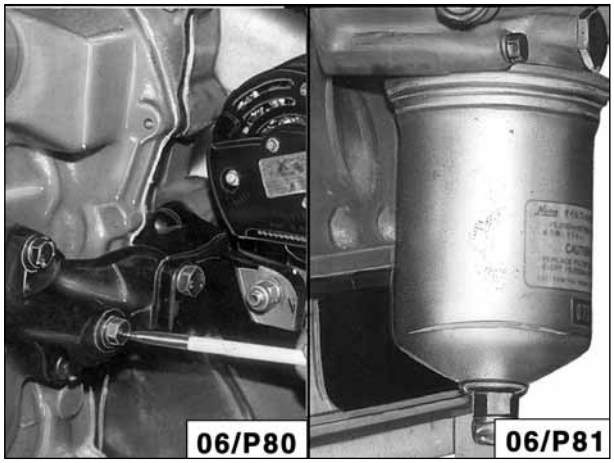


The bolts used at these 2 locations have controlled head thicknesses and are to be fitted using thread sealant and without washers. Tightening sequence of the oil pump.

Make sure adequate clearance between idler gear and oil pump cover, in view of the increased width of idler gear.

16.16.4 To Overhaul Oil Cooler and Filter Assy

16.16.4.0 To Remove

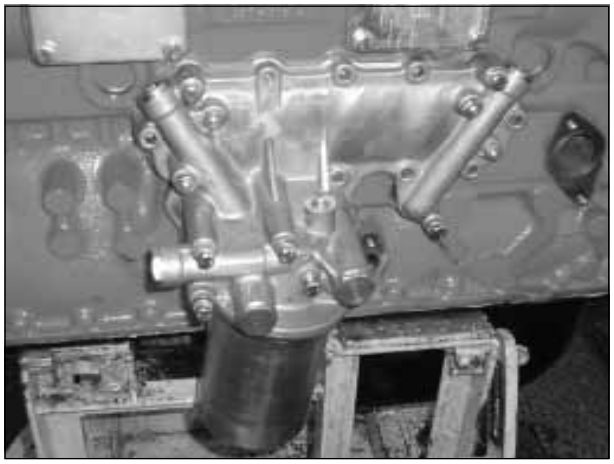


Remove the entire assy of oil cooler and oil filter from engine after draining coolant from cylinder block and oil from filter drain plug.

NOTE

All Bolts are of 13 mm size, But of Varied length. Be careful to identify the bolts to its original place during reassembly. Remove & refit O-rings 4 nos during reassembly

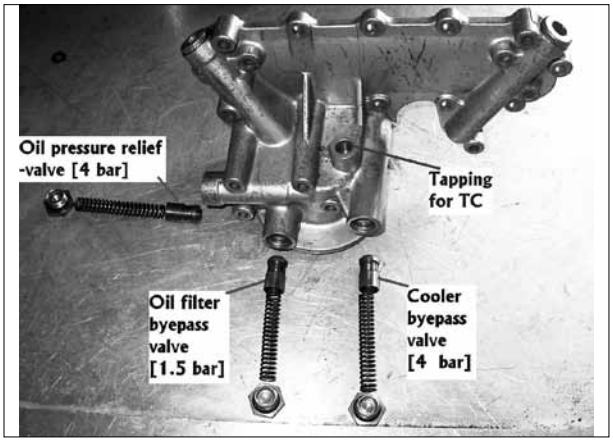
16.16.4.1 To Overhaul Assembly



Clean the oil filter head and oil cooler plate.

Clean the oil cooler.

Assemble the oil cooler by-pass valve.



Assemble the oil filter by-pass valve.

Assemble oil pressure regulator valve.

Assemble oil pressure gauge adaptor.

Assemble the oil cooler on the oil cooler plate.

Replace the `O' ring at oil filter centre bolt and position the bolt in oil filter bowl.

Replace the ‘O’ ring on the top of filter bowl.

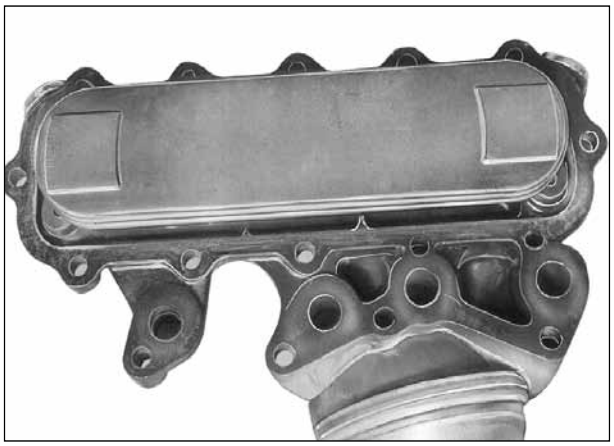
Refit the spring and the plate washer in the bowl.

Fit a new oil filter element, washer, sealing ring facing upwards.

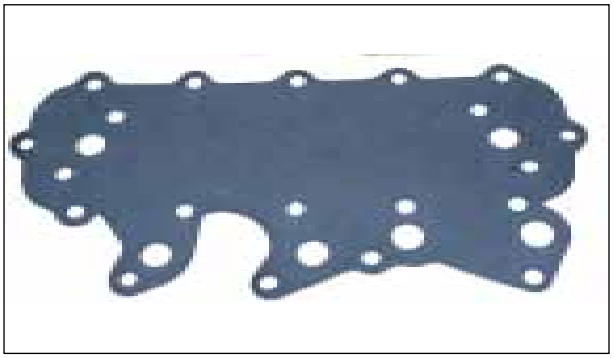
Fit filter bowl with filter element to the filter head tighten the centre bolt.

Also tighten the drain plug.

16.16.4.2 To Refit Oil Cooler



Clean the gasket sealing faces thoroughly.

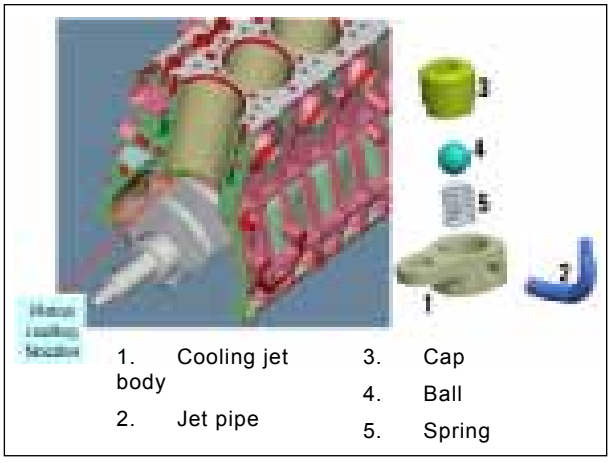


For oil cooler / oil filter assembly a compressed asbestos gasket is used.

This will prevent oil cooler casing from direct contact with coolant, in turn aluminium surface erosion.

Install Oil Cooler with filter.

16.16.4.3 Engine Piston Cooling Nozzle

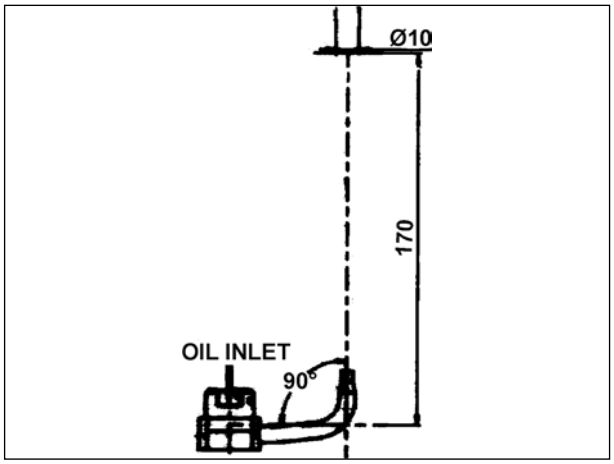


1. Cooling jet body
2. Jet pipe
3. Cap
4. Ball
5. Spring

In order to improve the piston crown cooling of engines, Piston Cooling Nozzles are fitted. This arrangement is expected to improve the cooling of the piston crown.

The piston cooling nozzles are mounted directly on the main oil gallery. These nozzles are set to operate at oil pressures 1.5 ksc and above.

16.16.4.4 Inspection Method for Piston Cooling Nozzle



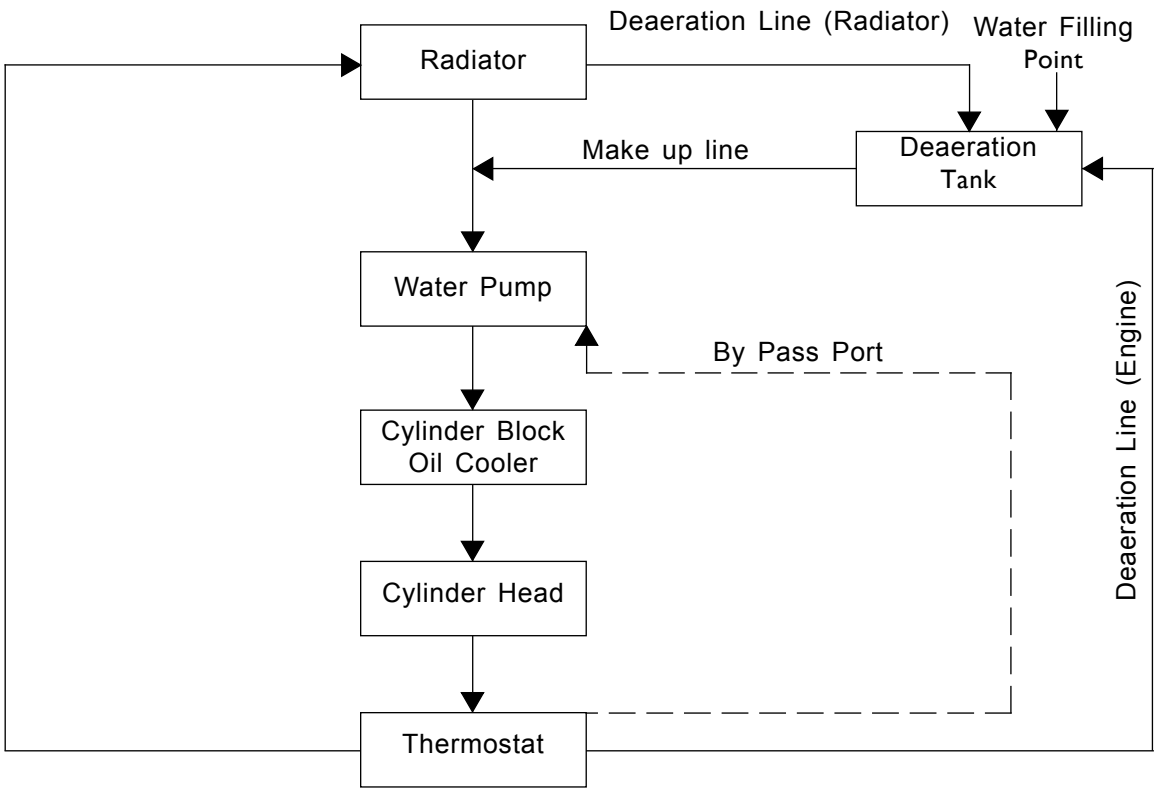
* At a pressure of 4 bar, the oil jet from the nozzle should penetrate a hole of dia 10 mm placed at a height of 170 mm.
* At 1.5 bar, no oil should flow out of the nozzle.
* When pressure is increased to 2.75 bar oil jet should issue from nozzle.

While complete / semi overhauling of the engine in the field the following care to be taken.

* Do not assemble the engine with non – PCN piston which will cause damage to the piston, cooling nozzles etc.
* Care to be taken while installing piston assembly along with connecting rod. If the connecting rods are not properly directed towards crank pins, will damage piston cooling nozzle.
* Nozzle should be free from dust and dirt while assembling
* Position of Piston cooling nozzle is taken care by the reamed mounting hole in the crankcase.
* In case any damage noticed on the piston cooling nozzle, **the same should be replaced with a new one**. Please do not try to repair, as it will lead to improper installation with respect to angle and pressure.

16.17 COOLING SYSTEM

COOLING SYSTEM



16.17.0 General

The engine is water cooled, and forced circulated by a water pump.

The coolant, drawn by the pump from the radiator or the thermostat control by-pass enters the crankcase and oil cooler. It is then passed to the cylinder head. The coolant returns to the radiator via thermostat housing.

During vehicle operation the thermostat functions to maintain the operating temperature of 80° to 85°C.

The thermostat installed in the cooling system controls not only the flow of coolant to the radiator but also regulates the by-pass flow alternately i.e when it allows the coolant to flow back to the radiator it closes the by pass fully and vice versa.

The sensing unit of the coolant temperature is provided at thermostat housing. It shows the engine coolant outlet temperature.

16.17.1 To Flush Cooling System

Flushing of the cooling system might become necessary because of impurities in the coolant itself.

The cooling system may also be clogged by rust deposits, grease or other impurities in the coolant. This should be removed by flushing the system several times with hot water containing a grease dissolving agent.

Let the engine run when flushing the system.

NOTE

Make sure that solution does not contain any acid as even the smallest amount of it in the cleaning fluid is likely to affect the cooling system unfavourably.

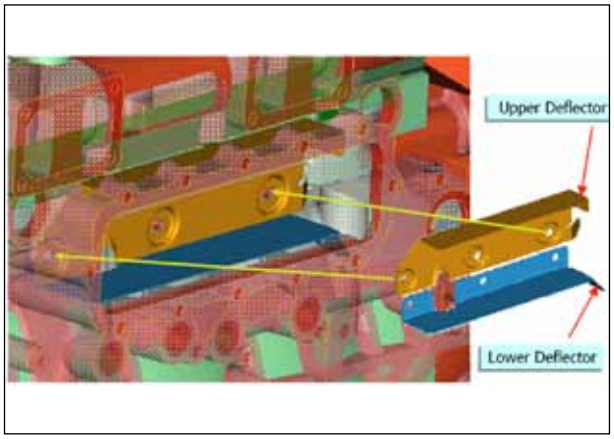
Having drained off the solvents, flush the system several times whilst the engine is running.

The use of hard water fosters the formation of fur which may be removed with aid of an acid free solvent. The fur removing agent must not be aggressive to copper brass and zinc materials used in the cooling systems.

Also flush the cooling system several times after application of a fur solvent.

Should lime has deposited too heavily in the radiator tubes remove radiator and have it cleaned mechanically by a specialised workshop.

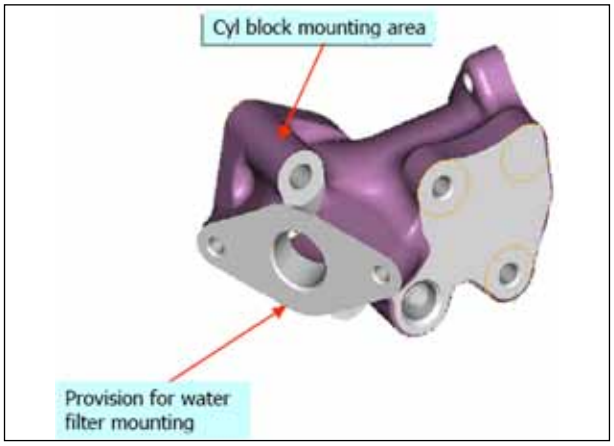
16.17.2 Baffle Plate



Baffle plates are provided for increasing the oil cooler efficiency by guiding the water through the oil cooler plates.

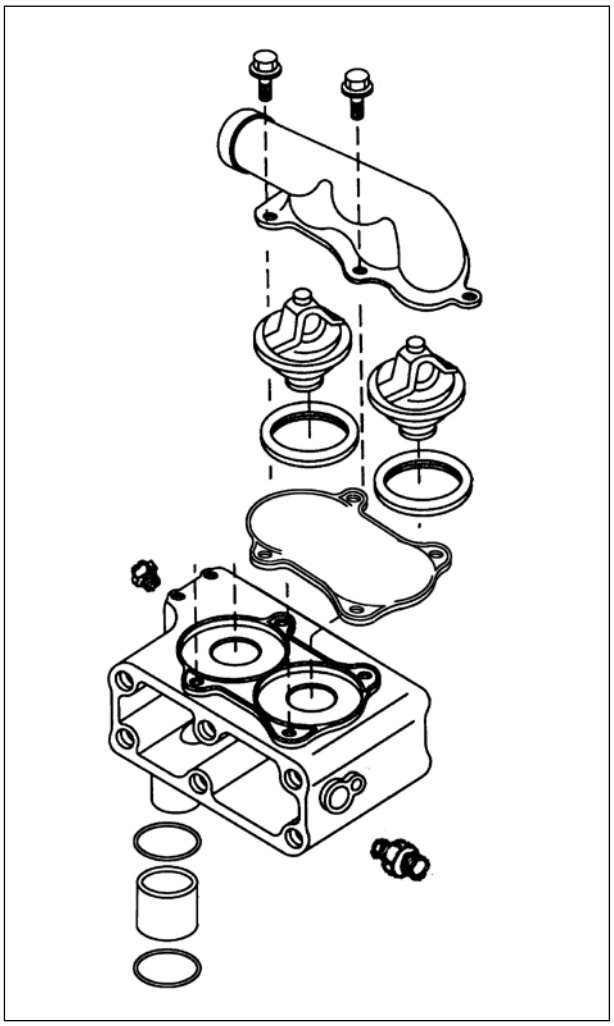
These plates are fitted behind the cooler plates.

16.17.3 Pipe Coolant Pump Outlet



The flow area on the coolant pump outlet is increased to suit higher flow rate and a provision for water filter mounting is provided.

16.17.8 Thermostat



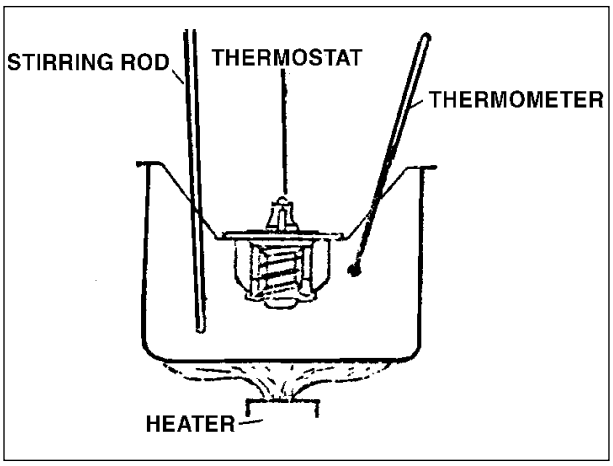
Thermostat housing is modified for accommodating twin thermostat (parallel) of current engine to achieve recommended flow restrictions.

Consequently thermostat cover is also modified for accomodating twin thermostat and position changed from vertical to horizontal.

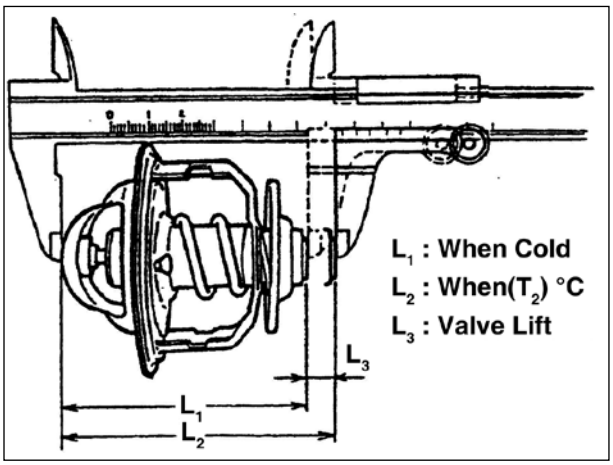
16.17.9 To Test Thermostat

Remove hose connection and take out thermostat.

Inspection of thermostat function



Place the thermostat in hot water and check the valve opening temperature and valve lift. The thermostat valve opening temperature is punched on the thermostat seat, and it should be confirmed.



Check commencement of opening. This is the temperature at which the stroke of the thermostat has risen to 0.1 mm in a gradually heated water bath.

Commencement of opening = 82°C ± 2°C.

Measure the stroke with the aid of special device and vernier calliper.

Check full working stroke.

Working stroke = 7.5 mm at 95°C

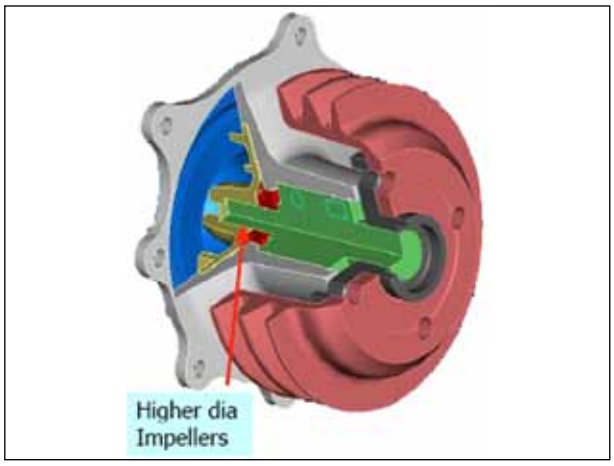
Install the thermostat

Remove the water and dirt adhering to the thermostat casing.

Replace the gasket without fail, if it is corroded, damaged or flattened.

Before install the casing cover apply the liquid gasket or the casing joint.

16.17.10 To Remove and Refit Water Pump



Drain off coolant collecting it in a clean container if anti-freeze has been added.

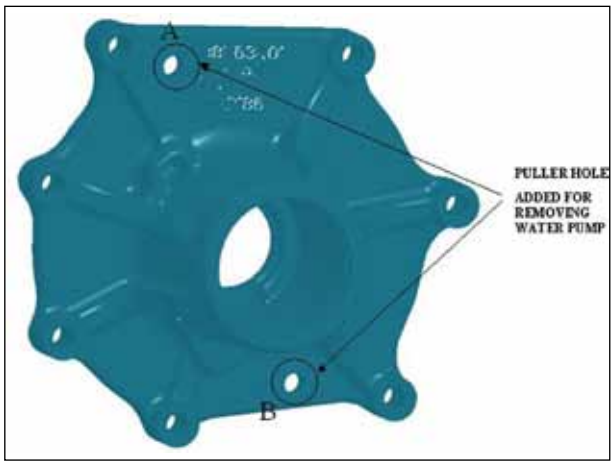
Unscrew fan and remove V belt for water pump fan and alternator.

Remove hose connection from water pump and backout attaching bolts.

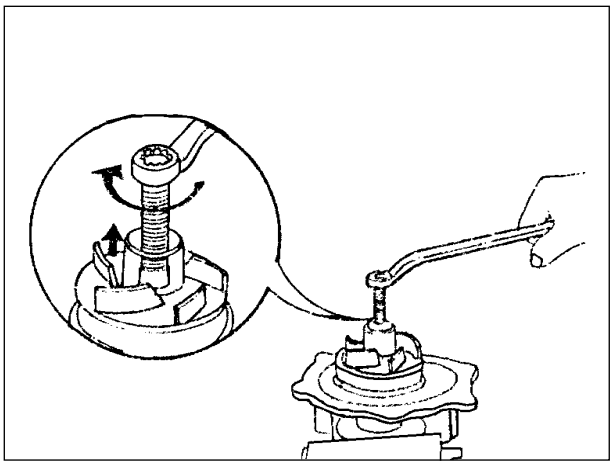
To refit water pump reverse the procedure for removal.

16.17.11 To Overhaul Water Pump

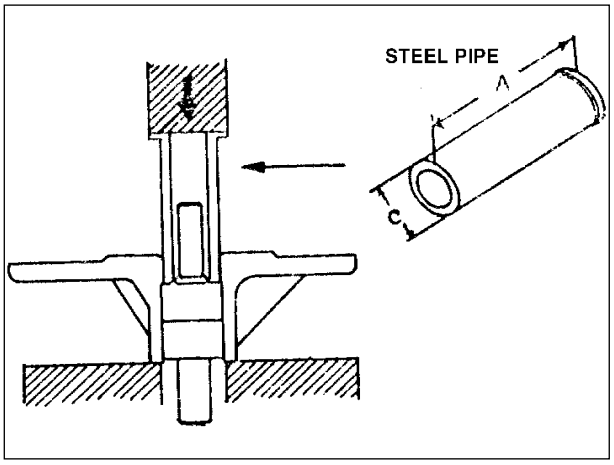
Dismantling



Unscrew water pump mounting Hex screws, remove water pump by screwing in two 10 mm dia, 1.5 mm pitch bolts in the water pump casing at locations A and B.

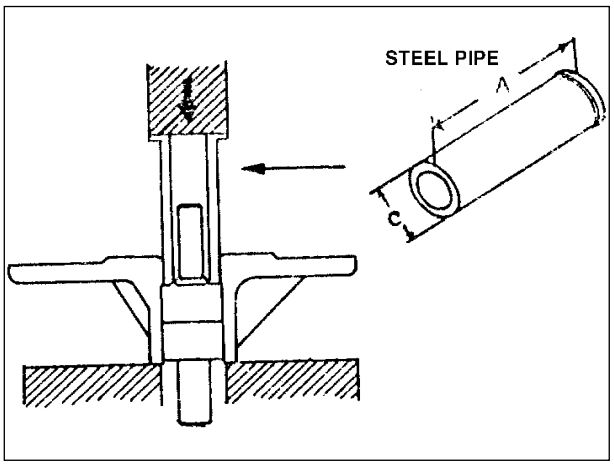


Remove the water pump vane from shaft by screwing in a bolt of 10 mm dia, 1.5 mm pitch.



Using a conventional puller remove the pulley from the shaft.

Remove the circlip before removing the shaft and the bearing.



Using a steel pipe and press, remove the water pump shaft along with sealed bearings from water pump body.

To install new water pump seal apply a little liquid

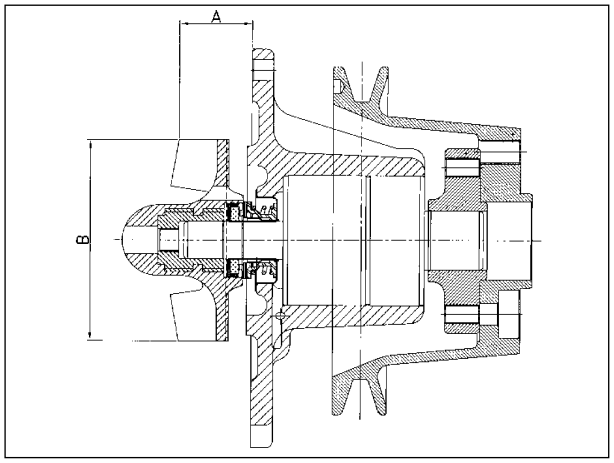
sealant to the water pump seal outer circumference and water pump body. Install the slinger and coolant seal.

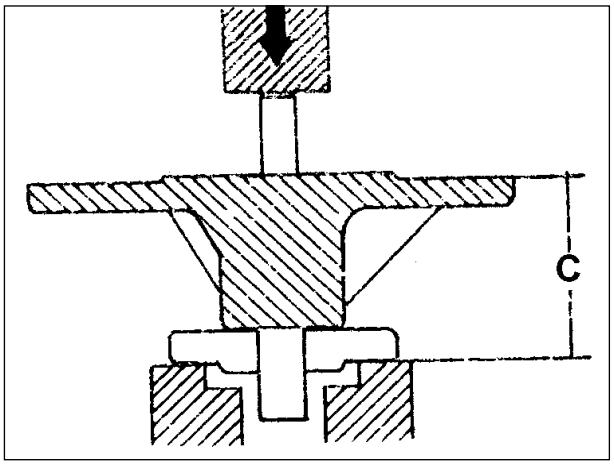
To install Vane. (Impeller)

Using a press install the Vane to the shaft.

Apply a little engine oil to the seal face.

Maintain distance between water pump mounting face to impeller outer dia end tip.





Model	Dimension (in mm)		
	A	B	C
HA4CTI3N	17	100 dia	95

Refit the water pump assy after applying fresh liquid sealant over clean surface.

Using a press install the pulley drive flange. For distance from water pump installation face to flange outer face.

16.10.12 To Remove and Refit Fan Belt - To adjust fan belt tension

Loosen the necessary fasteners, slacken the pulleys & remove the old belt.

Check pulley grooves for wear / damage and replace the pulley if required

Clean the pulley grooves for debris and ensure not to apply oil or grease on the pulley grooves.

Check alignment of the pulleys.

Misalignment of pulleys will produce noise & shorten the belt life.

Mount the belt over pulleys and ensure that the belt ribs are seated in the respective pulley grooves.

Tension the belt and tighten all the fasteners.

Run the engine for 3 to 5 minutes with the applied tension to allow the belt to seat in the respective pulley grooves properly. Reset tension.

Apply initial belt tension of 700N by adjusting the alternator position.

To ensure the applied tension, measure it in the middle of span between water-pump pulley and alternator using electronic type tension gauge.

Verify the initial tension after running the engine for 24 hours

Tensioning of fan belt

A tight belt results in rapid wear of

a) Fan belt

b) Alternator and Water pump bearings

A loose fan belt result in

a) Squeaking noise

b) An undercharged battery

c) Engine overheating

Belt tension Procedure

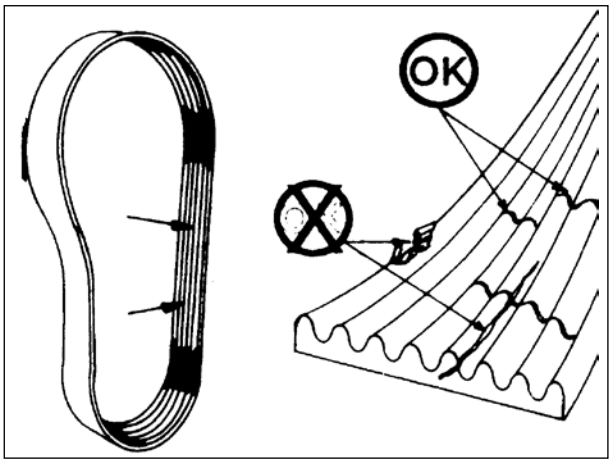
- Hold the sensing head steadily across the belt span within 5~10 mm distance above the top surface of the belt.
- Tap the belt gently near the mid span using a rod or with similar tool to cause the belt span to vibrate.
- Check the required tension display on the LCD panel of the Tension Meter.
- If a reading is not obtained, check the sensing head for correct positioning and ensure that it is positioned properly.
- Repeat the same procedure to recheck.

DO's:

- Check belt tension at regular intervals and adjust as needed.
- Check for any abnormal wear and damage in pulleys / Belt
- Check for pulley alignment
- Make belts free of fluffs and dirt.

DON'Ts:

- Don't over tension the belt
- Don't apply oil/grease or paint on pulley grooves
- Don't fix the belt improperly aligned
- Don't use worn out belts
- Don't pry the belt using sharp tools.



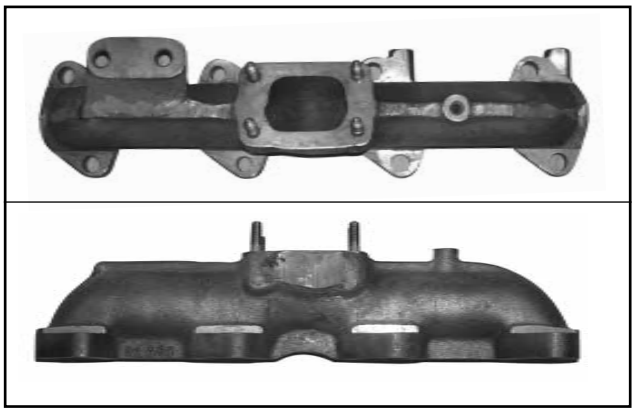
Visually inspect the belt.

NOTE

Replace the belt if it is frayed or pieces of material missing or longitudinal cracks intersect with transverse cracks.

16.18 EXHAUST AND INTAKE MANIFOLD

16.18.0 To Remove and Refit Exhaust Manifold

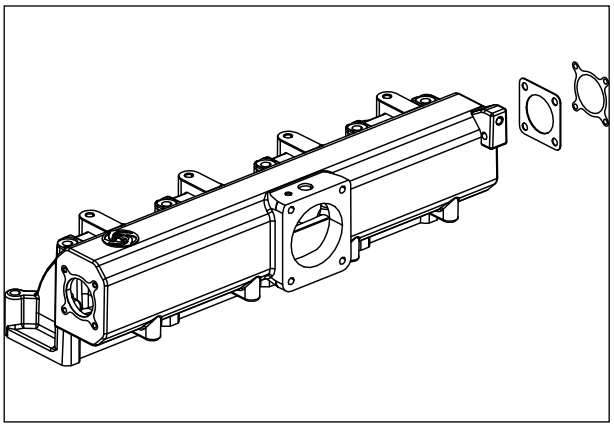


Disconnect front exhaust pipe from the turbocharger outlet elbow.

Backout manifold attaching screws from cylinder heads and remove the exhaust manifold taking care of the gaskets.

To refit manifold, reverse the procedure for removal.

16.18.1 To Remove and Refit Intake Manifold



Backout fixing screws and remove the vertical intake pipe. Backout manifold attaching screws from cylinder head and remove intake manifold.

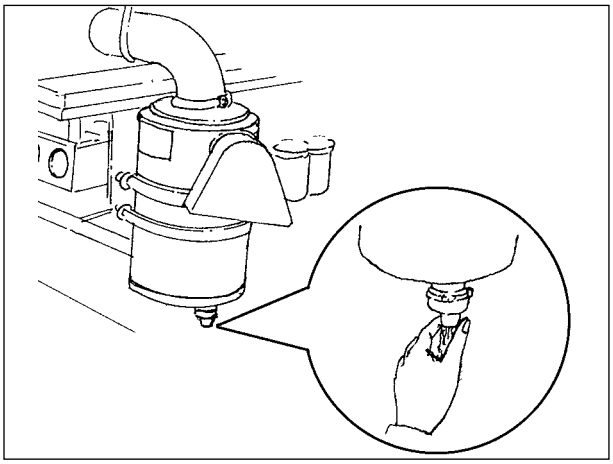
Clean thoroughly inlet manifold gasket sealing face and refit new gasket.

To refit intake manifold, reverse the procedure for removal.

NOTE

Use liquid gasket. Take care that the gasket does not get in to the inside surfaces. Tighten down the attaching screws evenly.

16.18.2 Maintenance and Servicing of Dry Type Air cleaner



Maintenance of Air cleaner plays a major role in engine performance and life. Poor air cleaner maintenance will result in complaints like excess liner wear, high engine oil consumption, excess blow by and poor pick up.

Maintenance and Servicing

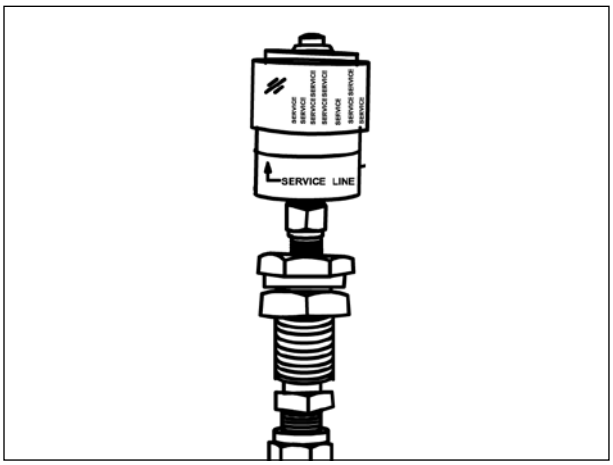
Following maintenance recommendations need to be strictly followed.

- Remove dust deposit weekly by squeezing the dust evacuator valve.
- Replace dust evacuator valve immediately if it is torn, cracked, remains open or missing.
- Never operate the engine, if the restriction indicator is either broken or missing.

NOTE

Do not clean the air filter elements.

- Replace primary filter element as soon as vacuum indicator shows red band.



- Replace the secondary filter element at the time of every third replacement of the primary filter element.

CAUTION

The wing nut should be tightened with hand alone. Excessive tightening would damage the air cleaner.

16.19 ALUMINIUM RADIATORS AND CHARGE AIR COOLER

16.19.0 Service Instruction

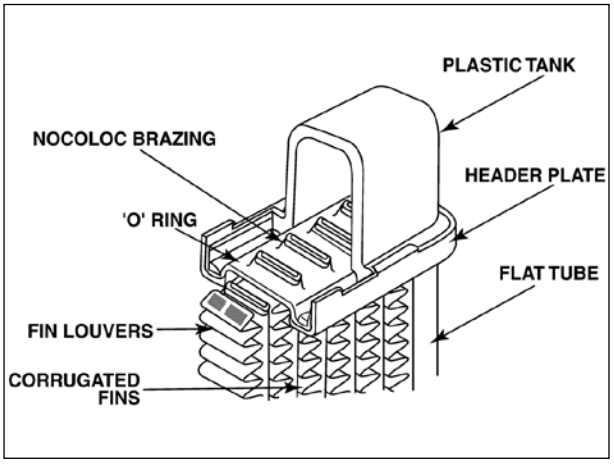
16.19.0.0 Introduction

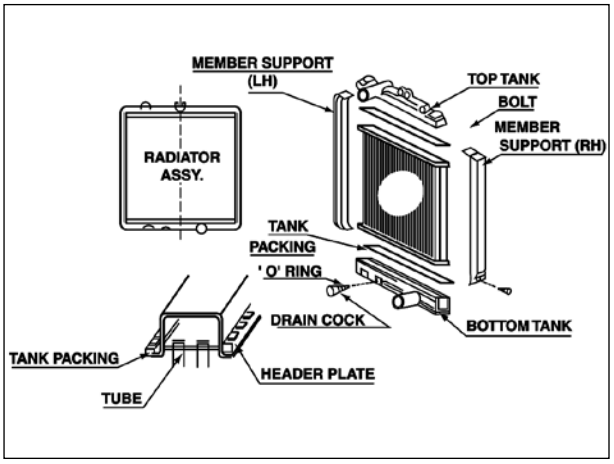
This manual explains the procedure for servicing (specifically, the sealing of leakages) of aluminium radiators fitted with plastic tanks that may damage in actual usage due to improper handling before installation on the vehicle.

The procedure covers the following aspects of servicing:-

* Leakage spot detection
* Sealing Techniques and the tools required
* Confirmation of proper sealing

16.19.0.1 Details of Radiator





A typical radiator is shown for reference.

Users are requested to get themselves familiar with all the parts and the assembly of radiator before undertaking the servicing.

16.19.0.2 Servicing Kit

The radiator servicing kit consists of following items:-

* Screw Driver
* Monkey Plier
* Sealant resin and hardener containers (Araldite Standard of M/s Ciba Geigy make or on equivalent Epo x y based system)
* Alumaseal container
* Araldite applicator
* Brush

Araldite rapid may be used in place of Araldite standard for faster drying and curing of seal.

16.19.0.3 Procedure for Servicing

Removal of radiator from vehicle -

* Allow the coolant in the radiator to reach to the room temperature.
* Drain the coolant from radiator completely by unscrewing the drain cock.
* Remove all the mounting fasteners, attachments like shroud, hoses etc.
* Take out the radiator from the vehicle carefully without damaging the core.

Radiator core and plastic tanks are susceptible to cracking due to impact and deformation. Handle carefully.

Detection of Leakage Spot –

* Connect the inlet of the radiator to air supply at the gauge pressure of 1.5 bar.
* Seal all other outlet points.
* Dip the radiator completely in a clean water tank.
* Tilt the radiator and shake it vigorously to let the air bubbles trapped at the clinching area to escape.
* Observe carefully for one minute and locate the source of air leakage on the radiator from the direction of air bubbles that are coming out of the radiator.

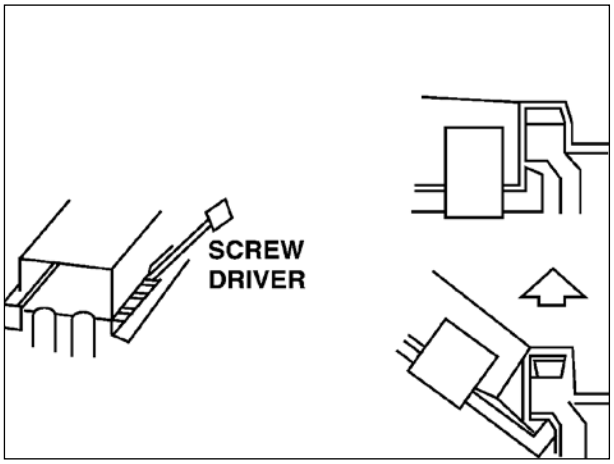
Do not use the water tank that is used for copper radiators.

Sealing the leakage spot –

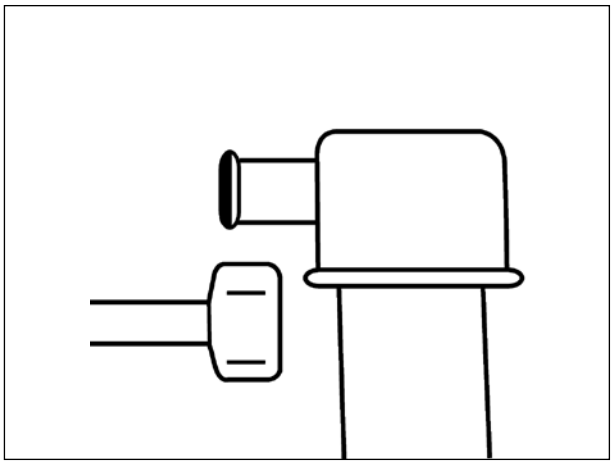
Following procedures shall be adopted for arresting leakages at different locations of the radiator.

Replacement of Plastic tank –

* Take out the member supports using 13 size spanner



* Release the clinch projections of header plate using screw driver.
* After making all the clinching projections up, take out the tank from its seat in header plate while grasping the outlet.

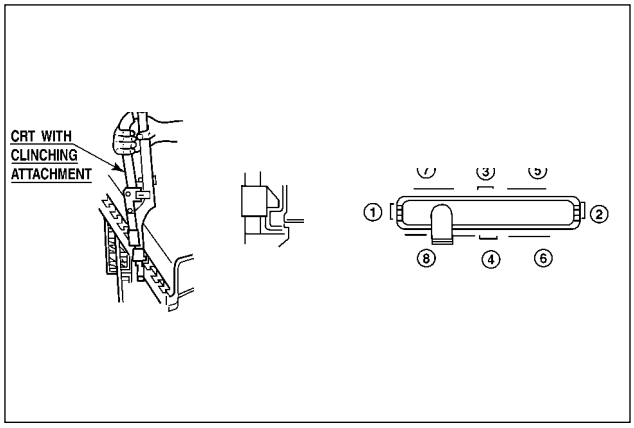


* In case, it takes more effort, pat the tank with rubber or plastic hammer lightly.
* Take off the tank packing.
* Clean the area of the header plate where the tank sits, thoroughly.
* Insert new tank packing in the place without twisting.
* Insert new tank (top or bottom) as applicable.

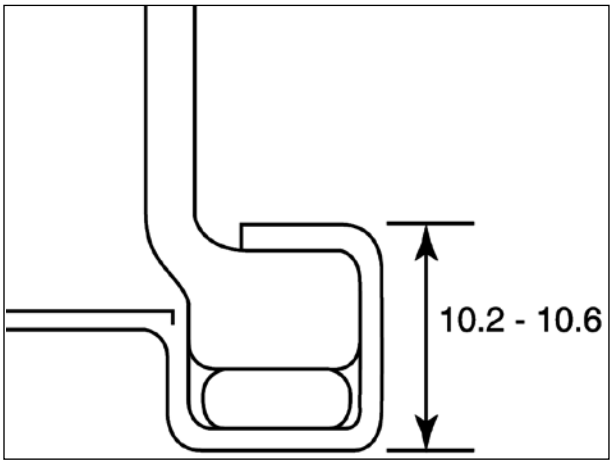
NOTE **If the source of leakage is at the base of the tank, i.e. area between header plate and tank there is no need to replace the tank.**

CAUTION **Tank packing shall be replaced, every time, the tank is taken off for servicing.**

* If gap is found between the clinching projections of header plate and tank, softly hammer the projections.
* Clinch the header plate projections with monkey plier.



* The sequence of clinching should be followed as illustrated in the figure.



* After clinching, confirm the dimension.

CAUTION **If any of the clinching projections is broken during the clinching or releasing process, discontinue the servicing and replace the entire radiator by a new one.**

* Fix the member supports and tighten the bolts properly wherever applicable.

Bottom Type pipe, Drain Cock and Pressure Cap –

Bottom Type pipe -

* Take out the Bottom Type pipe using 10 size spanner.
* Remove the ‘O’ ring.
* Clean the seat of Bottom Type pipe and the ‘O’ ring groove.
* Insert a new ‘O’ ring.
* Fit the Bottom Type pipe back, ensuring proper tightness of the bolts.

Drain Cock

* Unscrew the drain cock.
* Remove the 'O' ring.
* Clean the 'O' ring groove.
* Insert a new 'O' ring.
* Screw the drain cock back.

Pressure Cap –

* Replace the pressure cap with a new one, if leakage is through if after cleaning the filler neck.

NOTE **Always use recommended radiator pressure cap.**

Radiator Core –

Different procedure of sealing shall be followed for minor and major leaks in the radiator core.

Minor Leaks : Leak spots which are very minute, are to be sealed in following manner.

* Install the radiator onto the vehicle as explained in section 16.10.0.4.
* Pour the contents of alumaseal in the radiator.
* Fill proper quantity of coolant liquid.
* Run the engine in idling for more than 20 minutes to detect leakage, if any.

Major Leaks: Procedure of sealing major leaks in the radiator is as follows :

* Wash the core with clean water and brush provided in the kit to remove dirt, dust etc.
* To remove the greasy spot on the core, apply thinner with cotton swab and take off the grease.
* Dry the core using a dryer.

CAUTION **Drying by heating must be avoided.**

* Mix adequate quantity of Araldite resin and hardener in the ratio of 1:1 and stir it thoroughly.
* Apply the mixture immediately at the leakage spot with the applicator.
* If required, apply the mixture to dry and harden under the shade at room temperature for 10-12 hour.
* Allow the mixture to dry and harden under the shade at room temperature for 10-12 hour.
* Araldite Rapid of M/s Ciba Geigy dries and hardens within one hour and hence users may use it to minimize the down time.
* Silver colour paint may be used for touching up the araldite spots and impart the aluminium type appearance.

CAUTION **Do not damage the fins during the process.**

Confirm that fins are set properly, if disturbed during the process.

As the Araldite is inflammable, do not dry it by heating.

Proper cleaning of radiator core is must for proper setting of Araldite or else it will come off.

Confirmation of Proper Sealing

* After the sealing work is over, assemble the radiator properly.
* Subject the assembled radiator to leakage test.

NOTE **If the problem of leakage persists, it is advisable to replace the radiator with new one.**

16.19.0.4 Radiator Installation

* Ensure that all the openings of the radiator are closed properly except the inlet.
* Install the radiator on the vehicle ensuring proper alignment, damping etc. as applicable.
* Connect the inlet and outlet pipes and clamp them.
* Fit the fan shroud.

Fill the radiator with proper quantity of fresh coolant as recommended.

16.19.0.5 Do's and Don'ts

Do's

Always use the clinching tool for removing and refitting the radiator tanks.

Always drain the radiator fully before removing it from vehicle.,

Always refill the radiator with coolant recommended by the manufacturer.

Always check tank packing before reassembly of tank to core.

Don'ts

Never open the pressure cap when the radiator is hot.

Don't use acid for cleaning the tubes and tanks.

Don't use manual force for cleaning clogged tubes.

16.21 Tightening Torque Specification

	kgm	lb.ft	Nm	Max. allowed No. of tightening
Liner Pressing Special Tool	5 - 6	36 - 42	49 - 59	
Main Bearing Cap Bolts	14 ± 1.5 90° ± 5°	103 ± 11 90° ± 5°	140 ± 15 90° ± 5°	4
Flywheel Housing Fitting Bolts (13 mm bolt)	1.9 - 2.6	14 - 18	19 - 26	
Flywheel Housing Fitting Bolts (22 mm bolt)	11 - 13	80 - 94	108 - 128	
Flywheel Fitting Bolts	10 ± 1 60° ± 5°	73 ± 7.3 60° ± 5°	100 ± 10 60° ± 5°	3
Connecting Rod Cap Bolts	10 ± 1 60° ± 5°	73 ± 7.3 60° ± 5°	100 ± 10 60° ± 5°	3
Timing Gear Plate Bolts	1.9 - 2.6	14 - 18	19 - 26	
Oil Pump Assembly Fitting Bolts	1.9 - 2.6	14 - 18	19 - 26	
Camshaft Drive Gear Fitting Bolt	10 ± 1 60° ± 5°	73 ± 7.3 60° ± 5°	100 ± 10 60° ± 5°	4
Camshaft Thrust Plate Fitting Bolts	1.9 - 2.6	14 - 18	19 - 26	
Idler Gear Fitting Bolt	10.2 ± 10 90° ± 5°	73.8 ± 7.3 90° ± 5°	100 ± 10 120° ± 5°	4
Timing Gear Cover Fitting Bolts	1.9 - 2.6	14 - 18	19 - 26	
Crankshaft Pulley Fitting Nut	56 ± 12	405.7 ± 88.5	550 ± 120	
Oil Strainer Fitting Bolts	1.9 - 2.6	14 - 18	19 - 26	
Oil Pan Fitting Bolts	1.9 - 2.6	14 - 18	19 - 26	
Oil Pan Drain Plug	4 - 5	29 - 32	39 - 49	
FIP Drive gear bolt	3.7 - 4.5	26 - 32	36 - 44	
Timer cover Mounting on Timing Casing	1.9 - 2.6	14 - 18	19 - 26	
Air Compressor Fitting Bolts	4.5 - 5.0	33 - 36	44 - 49	
Alternator Bracket	4.5 - 5.0	33 - 36	44 - 49	
Alternator Supporting Bolt & Nut.	4.5 - 5.0	33 - 36	44 - 49	
Fan Belt Adjusting Bracket	4.5 - 5.0	33 - 36	44 - 49	
Water Jacket Elbow	4.5 - 5.0	33 - 36	44 - 49	
Water Drain Plug on Elbow	4.5 - 5.0	33 - 36	44 - 49	
Centre Bolt - Oil Filter	4 - 5	29 - 32	39 - 49	
Oil Cooler Element Fitting Nuts	1 - 1.5	8 - 5	10 -15	
Oil Cooler Assembly Fitting Bolts	1.9 - 2.6	14 - 18	19 - 26	
Water Pump Assembly Fitting Bolts	1.9 - 2.6	14 - 18	19 - 26	
Water Pump Pulley Bolt	1.9 - 2.6	14 - 18	19 - 26	
Fan to Spacer Bolts	2.0 - 3.0	15 - 21	20 - 29	
Cooling Fan Fitting Bolts	1.5 - 2.2	11 - 16	15 - 22	
Cylinder Head Bolts (Shorter Bolts)	7.1 ± 0.5 & 150° ± 5°	52 ± 4 & 150° ± 5°	70 ± 5 & 150° ± 5°	
Cylinder Head Longer Bolts (Rocker Bolts)	7.1 ± 0.5 & 180° ± 5°	52 ± 4 & 180° ± 5°	70 ± 5 & 180° ± 5°	

16.21 Tightening Torque Specification

	kgm	lb.ft	Nm	Max. allowed No. of tightening
Rocker Shaft Locking Bolts	0.6 - 0.7	4 - 5	6 -7	
Rocker Shaft Assembly Fitting Bolts	1.9 - 2.6	14 - 18	19 - 26	
Rocker Shaft Assembly Main Bolts	13 - 14	94 - 102	128 - 137	
Rocker Arm Adjusting Screw Nuts	1.9 - 2.6	14 - 18	19 - 26	
Thermostat Case	4.5 - 5.0	33 - 36	44 - 49	
Thermostat Cover	1.9 - 2.6	14 - 18	19 - 26	
Exhaust Manifold	4.5 - 5.0	33 - 36	44 - 49	
Turbocharger	4.5 - 5.0	33 - 36	44 - 49	
Inlet Manifold Fitting Bolts	1.9 - 2.6	14 - 18	19 - 26	
Cylinder Head Cover Bolts	1.3 - 1.8	10 - 13	13 - 18	
Exhaust Elbow	1.9 - 2.6	14 - 18	19 - 26	

16.22 MAINTENANCE SCHEDULE

Sl no	ACTIVITY	PDI	Daily	Weekly	Monthly	Every km X 1000	Remarks
A	General						
1	Check and adjust valve clearance on cold engine					80	
2	Check and tighten front and rear engine mounting					80	
3	Check and tighten cylinder head bolts for correct torque in correct sequence					80	
4	Check vibration pulley for any damages and replace if necessary					80	
B	Lubrication system						
1	Check and top up engine oil if necessary. Also check oil leakages at the time of top up			✓			
2	Change engine oil and oil filter element					10	
3	Clean oil cooler					80	
4	Check engine oil pressure (min. 1 kg/cm² at idling and 80°C engine temperature)	✓	✓				
C	Cooling System						
1	Visually inspect cooling fan / drive for any damages and replace/rectify		✓			40	
2	Inspect fan clutch / hub for dust if necessary clean				✓	20	
3	Check and tight fan mounting bolts	✓				80	
4	Check coolant level and top up if necessary . Also check for coolant leakages at the time of top up		✓				
5	Check radiator hoses and clamps for leakages and tightness	✓			✓	80	
6	Check fan belt tension / condition and adjust / replace if necessary	✓				40	
7	Check radiator stay rod and radiator mounting bolts	✓				40	
8	Drain cooling system and fill recommended coolant	Every 2,00,000 km					
9	Replace cooling system hoses, clips and radiator rubber pads for radiator mounting & stay rod. To be replaced along with coolant change.						

Sl no	ACTIVITY	PDI	Daily	Weekly	Monthly	Every km X 1000	Remarks
D	**CNG System**						
1	Check all the CNG pipe line (including gland nut) and fittings for leak with detergent free soap solution or methane gas detector and ensure tightness if necessary.				✓		
2	Check for free operation of cylinder valves.				✓		
3	Check operation of fuel indicating gauge.				✓		
4	Check condition of fuel filling valve.				✓		
5	Check lambda probe efficiency & replace the sensor if necessary					160	
6	Check and service the pressure regulator if necessary					120	
7	Drain the Low pressure gas filter					10	
8	Check and replace catridge of Low pressure gas filter					36	
9	Check gas tank mounting strap for tightness					40	or once in 5 months whichever is earlier
10	Check gas tank strap rubber packing for any defects/ cracks and replace if necessary					40	
E	**Ignition System**						
1	Check for proper fitment of ignition coil.				✓		
2	Replace spark plug (Mandatory as per manufacturers recommendation)					90	
F	**Air Intake and Exhaust**						
1	Check vacuum indicator and replace primary filter element whenever the vacuum indicator shows redband		✓				
2	Replace air cleaner secondary filter element - At the time of every third replacement of primary filter element						
3	Check air inlet hose for any puncture/damage		✓			40	
4	Check for any blockage / breakage at rainhood assembly		✓			40	
5	Check Turbocharger mounting	✓			✓	40	
6	Check charge air cooler for any blockage of fins and clean the cooler if necessary	✓				20	
7	Check charge air cooler hoses for any damage	✓			✓	40	

Sl no	ACTIVITY	PDI	Daily	Weekly	Monthly	Every km X 1000	Remarks
8	Check exhaust manifold and silencer for leaks and tightness	✓				40	
9	Check intake and exhaust manifold mounting fasteners	✓				40	First at 20,000 kms and subse-quently every 40,000 kms.
10	Check for Exhaust leak in the Upstream of Catalytic Convertor					8	
11	Check and ensure that Silencer is not choked					8	
12	Inspect Catalytic Convertor for any physical damage externally					8	
13	Ensure that Engine exhaust Pipe and Catalytic conver-tor mountings are firm in its position.					8	
G	**Bosch System**						
1	Check tightness of engine speed sensors and clean the sensor tip for any dirt/dust deposits					40	
2	Check functioning of Malfunction indicator lamp (MIL)		✓				
3	Check tightness of all mating connectors and ensure they are connected properly					40	
4	Check and secure wiring harness away from high tem-perature zones on the engine/vehicle					40	
5	Check functioning of ECU and sensors with diagnostic tool	✓				80	