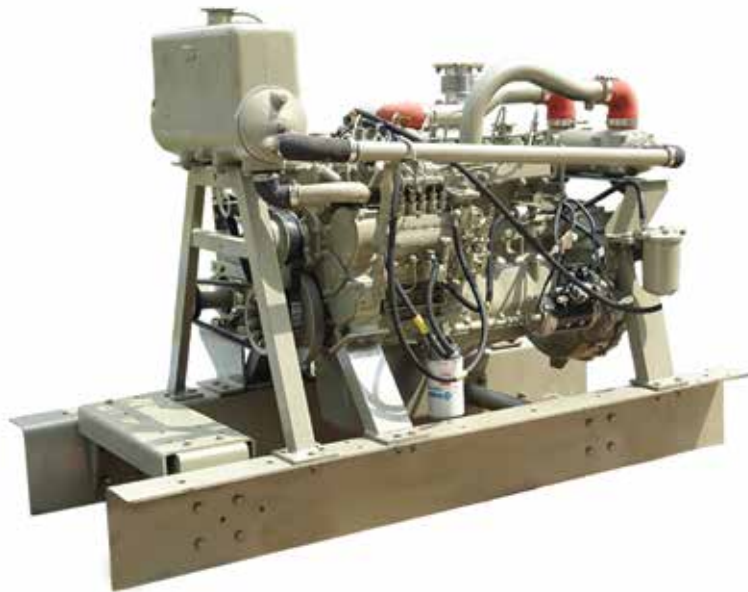




HA6ETI SERVICE MANUAL

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FOREWORD

This Service Manual contains specifications, data and instructions on the correct methods of carrying out dismantling, assembling and repair work on **HA6ETI Engine**.

By using this Manual and the appropriate special tools, it is possible to execute repairs within the specified time. Adhering to the safety instructions will protect operators from accidents. Before starting any repair work, ensure the availability of safety measures in good order. Check and wear prescribed safety-wear required by safety regulations, i.e., goggles, helmet, hand gloves and safety shoes. Check all tools, material handling equipments before using them.

In accordance with Ashok Leyland Limited (the Company's) policy of continuous product improvements, the company reserves the right to change the procedures, material, specifications, dimensions or design referred to in this Booklet, at any time and without prior notice. Relevant changes would be updated through our service circulars, If found necessary.

Care has been taken to include as much useful information as possible. Every reasonable effort has been made to ensure that this booklet is accurate. The Informations, Data and Procedures given in this manual are indicative in nature and not binding.

Ashok Leyland Limited,
Power Solutions Business
No.1, Sardar Patel Road Guindy
Chennai - 600 032.



ASHOK LEYLAND

PUB. NO. PSB-HA6ETI: SEP'16

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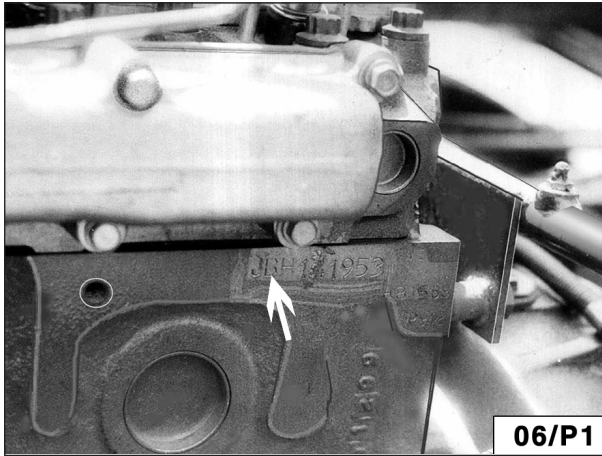


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**1.0 GENERAL****1.0.0 Engine Type and Number**

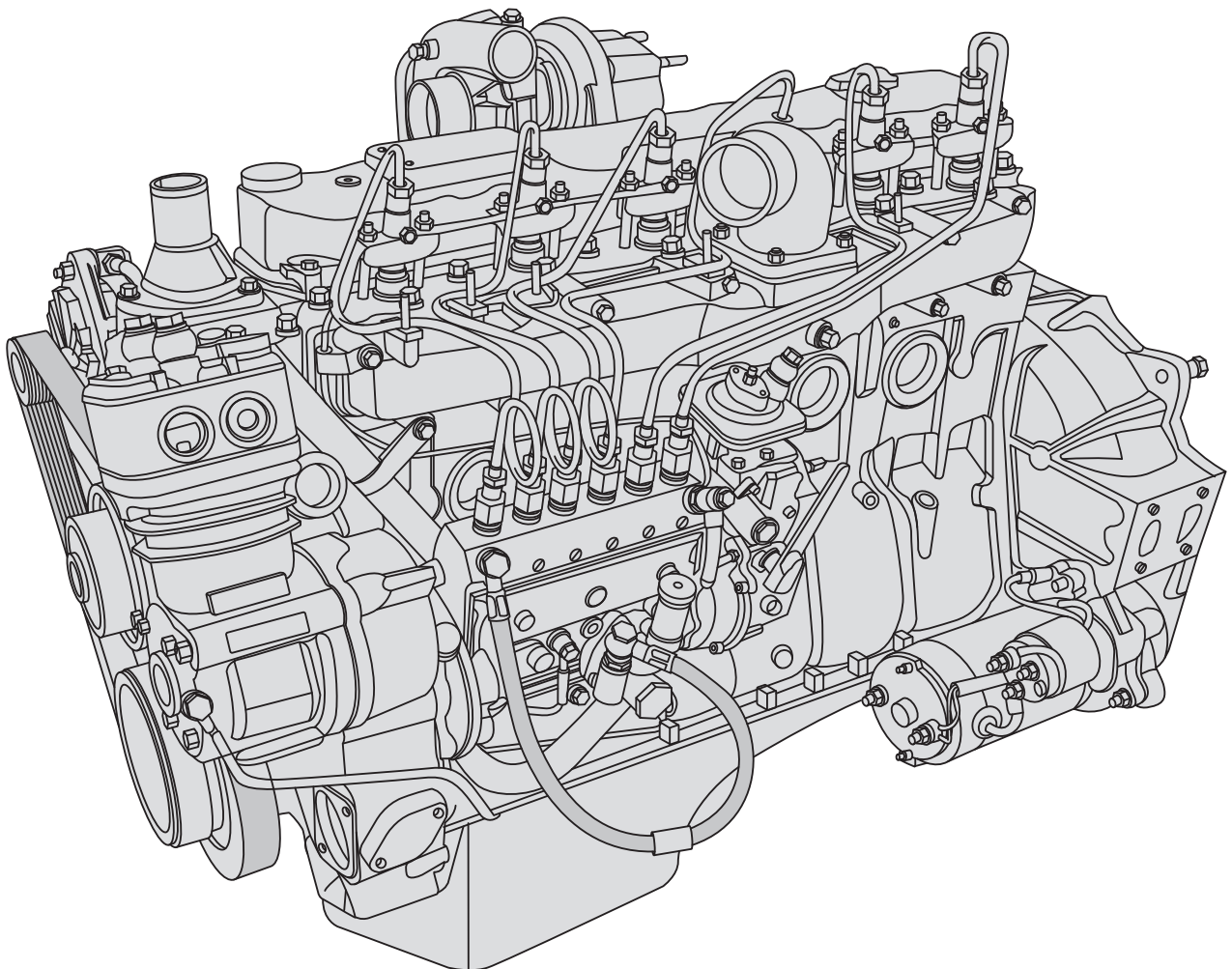
The engine serial no is stamped onto the crankcase on the left side rear top corner.

1.0.1 Design and Operation

6 Cylinder, water cooled 4 stroke Diesel Engine with direct fuel injection into a shallow combustion chamber arranged in the crown.

Another characteristics is the special shape and arrangement of the intake ducts in the cylinder head which allows the air to enter only from one direction. Upon entering, the air is given a swirling motion causing the fuel to mix, which is injected through a multi hole nozzle into the combustion chamber. Combustion is initiated at the end of compression stroke.

The shape of the combustion chamber allows full use of the energy contained in the fuel, because the cooling surfaces are comparatively small in relation to the volume of the combustion chamber whilst the air swirls ensures that air and fuel are mixed uniformly.



Representative Diagram



1.0.2 General Data

Description	HA6ETIC3RD	HA6ETIC3RU	HA6ETIC3RS	ALM6ETI	ALM6ETI-MK1
Type	Diesel four stroke, 6 cylinder, Water cooled direct injection, in-line overhead valve.				
Aspiration	Turbocharged with inter cooler				
Max output	101HP @ 2200 rpm	133HP @ 2220, 2300, 2400 rpm	160HP @ 2200, 2300 rpm	151 - 160HP @ 2000, 2400 rpm	172 - 180HP @ 2000, 2400 rpm
Max torque	450NM @ 1400 - 1600 rpm	475NM @ 1700 - 1900 rpm	590NM @ 1700 - 1900 rpm	550NM @ 1600 rpm	660NM @ 1600 rpm
Bore & Stroke (mm)	104 X 113				
Displacements (ltrs.)	5.759				
Compression Ratio	17.5 : 1				
Firing order	1-4-2-6-3-5				
Direction of rotation	Counter clockwise viewed from flywheel.				
Compression pressure	30.5 - 33.5 kg/cm² @ 280 rpm				
Idling revolution	600 - 900 rpm				
FuelInjectionEquipment	In line pump with manifold compensator				
Injection pipe (OD x ID x Length)	6.35 x 1.8 x 600 (mm)				
Valve Timing					
Intake opens	18° Before Top Dead Centre		9° Before Top Dead Centre		
Intake closes	30° After Bottom Dead Centre		55° After Bottom Dead Centre		
Exhaust opens	57° Before Bottom Dead Centre		42° Before Bottom Dead Centre		
Exhaust closes	15° After Top Dead Centre		45° After Top Dead Centre		
Valve clearance (when cold)					
Intake	0.30 mm				
Exhaust	0.45 mm				
Engine Oil Pump					
Type	Full forced Pressure feed by gear pump				
Drive	By timing gears				
Engine oil cooler	Plates type				
Injection Nozzle					
Type	Multi hole nozzle type				
Valve opening pressure	250 - 258 bar				
Coolant Pump					
Type	Centrifugal pump				
Drive	Poly-V Belt				
Thermostat	Single thermostat wax type (bottom bypass) opens at 82° ± 2°C				
Injection timing (Flywheel Travel)	9.75° ± 15' BTDC	9° ± 15' BTDC	9° ± 15' BTDC	11.5° ± 0.5° BTDC	10.5° ± 0.5° BTDC
Turbocharger	With waste Gate & Without waste Gate				


1.0.3 Repair Data

DESCRIPTION	SPECIFICATION (Measurements in mm)	MEASURING DEVICE AND REMARKS
Crankcase		
Cylinder block flatness	0.05 (limit 0.1)	
Crankcase bore for cylinder liner fitment	Refer section 14.0.8	W,X,Y,Z, punch marked on crank case LH side adjacent to each bore
Cylinder liner outside diameter	Refer section 14.0.8	W,X,Y,Z, paint mark given on cylinder liner collar for identification
Fitment of cylinder liner in crankcase bore	Interference Fit liner	Selective assembly (Only MLS gasket to be used).
Cylinder liner bore: Size	104.008 - 104.040 (limit 104.15)	Bore dial gauge (To be measured at 80 mm from top)
Liner projection	0.01 - 0.08	
Block Top Surface to Crankshaft Centre	299.950 - 300.05	
Block Top Surface to sump face height	369.9 - 370.1	
Main journal dia	77.985 - 78.00	
Cylinder counter bore depth	8.020 - 7.980	
Cylinder counter bore dia	112.00 (+0.290 to 0.150)	
Crank Assembly		
Piston diameter Standard size	103.826 - 103.858	Micrometer (measure at skirt area perpendicular to pin axis)
Diametral piston clearance (at skirt)	0.140 - 0.172	Feeler gauge
Piston ring Groove Width		
Top	—	
Second	2.55 - 2.57 (limit 2.70)	Slip gauge
Oil Ring	3.020 - 3.040 (limit 3.08)	
Piston ring width		
Top	—	
Second	2.47 - 2.49 (limit 2.32)	Micrometer
Oil Ring	2.97 - 2.99 (limit 2.95)	
Piston ring side clearance in groove		
Top	0.08 - 0.12 (limit 0.7)	
Second	0.06 - 0.10 (limit 0.2)	Feeler gauge
Oil Ring	0.025 - 0.065 (limit 0.1)	
Piston Ring gap		
Top	0.30 - 0.45 (limit 1.2)	
2nd	0.30 - 0.45 (limit 1.2)	Feeler guage
Oil	0.25 - 0.45 (limit 1.2)	
Maximum permissible piston weight difference per set	5 g	
Piston pin hole inside diameter	36.998 - 37.003 (limit 37.030)	Bore dial gauge
Gudgeon pin outside diameter	36.989 - 36.994 (limit 36.980)	Micrometer (Push fit in piston heated to 80°C)



DESCRIPTION	SPECIFICATION (Measurements in mm)	MEASURING DEVICE AND REMARKS
Clearance between Piston pin and Piston pin hole	0.004 - 0.014 (limit 0.040)	
Small end bush bore	37.015 - 37.025 (limit 37.07)	Bore dial gauge
Diametral clearance between gudgeon pin and con. rod small end bush bore Max. permissible clearance	0.021 - 0.036 (limit 0.08)	Bore dial gauge and micrometer
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	
Crankshaft journals and crankpin grinding dimensions	Refer section 14.0.5	Micrometer
Surface hardness of journals and crankpins	269-311 BHN	Hardness Tester. No further heat treatment recommended
Maximum permissible run-out of centre journal	limit 0.4	V-Blocks and dial gauge
Crankshaft Main Bearing Cap roundness	0.06	
Crankshaft end play Maximum permissible clearance	0.05 - 0.22 0.4 (limit)	Feeler gauge
Diametral clearance between main journal and bearing Maximum permissible clearance	0.039 - 0.09 0.13 (limit)	Bore dial gauge and micrometer
Main bearing inside diameter	77.98 - 78.00	Bore dial gauge
Main bearing spread	79.00 - 79.06	Vernier Calliper
Connecting rod side clearance	0.20 - 0.52 (limit 0.6)	Feeler gauge
Diametral clearance between Connecting Rod Big End Bearing & Crank pin	0.031 - 0.082 (limit 0.12)	Bore dial gauge and micrometer
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
Connecting rod weight		
Group A	1790 - 1830 grams	All the connecting rods should be from the same group in an Engine.
Group B	1831 - 1870 grams	
Group C	1871 - 1910 grams	
Group D	1911 - 1950 grams	
Group E	1951 - 1990 grams	
Flywheel face out	limit 0.15	Dial gauge



DESCRIPTION	SPECIFICATION (Measurements in mm)	MEASURING DEVICE AND REMARKS
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
Nozzle protrusion from cylinder head surface	2.1 - 2.5	
Valve sink (Valve head depth below cylinder head face)		Dial gauge
Inlet	0.05 - 0.35	
Exhaust	(-) 0.47 - (-) 0.77	
Valve stem diameter		Micrometer
Inlet	8.95 - 8.97 (limit 8.9)	
Exhaust	8.93 - 8.95 (limit 8.8)	
Intake and Exhaust Valve Guide dia	9.000 - 9.015	Internal micro meter
Diametral valve stem clearance in guide		Plug gauge and Micrometer
Intake	0.032 - 0.065	
Exhaust	0.050 - 0.083	
Valve seat angle		Bevel Protractor (for both inlet and exhaust)
Intake	30° - 30° 15'	
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		Protractor (for both inlet and exhaust)
Intake	29° 45' - 30° 15'	
Exhaust	44° 45' - 45° 15'	
Valve head diameter:		Micrometer.
Inlet	45.3 - 45.5	
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 - 15.00	
Maximum permissible out of true of valve seat to guide	0.030	
Valve spring straightness	2.0 (limit)	Tri Square
Spring load	44.9 @ 24.2 kg (limit 20.6 kg)	Valve spring scale (inlet and exhaust)
Valve stroke	12.3 - 12.4	Depth gauge (inlet and exhaust)



DESCRIPTION	SPECIFICATION (Measurements in mm)	MEASURING DEVICE AND REMARKS
Timing		
Rocker arm shaft diameter	18.966 - 18.984	
Diametral clearance between rocker lever on rocker shaft	0.036 - 0.079 (limit 0.15)	Plug gauge and micrometer
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
Diametral tappet clearance in crankcase bore Maximum permissible limit	0.025 - 0.071 0.1 (limit)	Bore dial gauge and micrometer
Camshaft Bend	0.05 (limit)	Dial gauge and V blocks
Camshaft Cam lift (Intake)	6.8433 - 6.9433	Vernier height gauge & V blocks
Camshaft Cam lift (Exhaust)	6.7854 - 6.8854	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)	
Journal 4	56.35 - 56.37 (limit 56.25)	
Camshaft Journal Bearing inside Dia after pressing the bushes.		Bore dial gauge
Journal 1	57.0 (limit 57.070)	
Journal 2	56.8 (limit 56.870)	
Journal 3	56.6 (limit 56.670)	
Journal 4	56.4 (limit 56.470)	
Diametral camshaft clearance in bushes Max. permissible clearance	0.03 - 0.12 0.15 (limit)	Internal measuring gauge and micrometer
Idle Shaft Diameter	49.95 - 49.975 (limit 49.94)	Micrometer
Idle Gear bushing inside Diameter	50.00 - 50.025 (limit 50.05)	Internal micro meter
Diametral clearance between Idle Gear shaft and Bush	0.03 to 0.08 (limit 0.1)	Internal measuring gauge and micrometer
Idle 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 Injection Pump 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



DESCRIPTION	SPECIFICATION (Measurements in mm)	MEASURING DEVICE AND REMARKS
Engine lubrication		
Max. oil pressure:		
Full-load	4.5/4.8 kg/cm ²	Pressure gauge
Idling	1.2/1.6 kg/cm ²	Pressure gauge
Minimum oil pressure	1.0 kg/cm ² (engine idling)	
Oil flow rate	29.4 ℓ per minute at 4 kg/cm ² at 1000 rpm	
Valve opening pressure: (Oil filter)		
Oil Pressure Relief valve	3.7 - 4.3 kg/cm ²	Hydraulic pump with pressure gauge
By-pass valve for paper element	1.5 kg/cm ²	
By-pass valve for heat exchanger	4 kg/cm ²	
Oil pump gear height	32.00 - 32.04	
Oil pump gear outer dia	48.84 - 49.00	
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	0.09 - 0.21 (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	0.09 - 0.21 (limit 0.1)	Dial gauge
Oil Cooler air pressure testing	6 kg/cm ²	
Cooling System		
Permissible maximum cooling temp.	95°C	Temperature gauge
Maximum water pump output	216 lpm @ 0.65 kg/cm ²	
Commencement of thermostat opening	82°C ± 2°C at 0.1 mm travel	Test tank thermometer & dial gauge
Thermostat working stroke at 95°C	10 mm or more	Test tank thermometer & dial gauge



1.0.4 Tightening Torques	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 & 90° ± 5°	103 ± 8 & 90° ± 5°	140 ± 10 & 90° ± 5°	4
Flywheel Housing Fitting Bolts (M8 x 1.25 - 16 mm long)	1.9 - 2.6	14 - 18	19 - 26	
Flywheel Housing Fitting Bolts (M14 x 2 - 45 mm long)	11 - 13	80 - 94	108 - 128	
Flywheel Mounting Bolts (Without Crankshaft Adaptor)	10 ± 1 60° ± 5°	73 ± 7.3 60° ± 5°	100 ± 10 60° ± 5°	3
Crankshaft to Flywheel Adaptor bolt	10 ± 1 & 60° ± 5°	73 ± 7.3 & 60° ± 5°	100 ± 10 & 60° ± 5°	
Flywheel Mounting Bolts (With Crankshaft Adaptor)	12 - 13	85 - 92	115 - 125	
Connecting Rod Cap Bolts (Fracture Spilt Conrod)	4 & 120° ± 5°	30 & 120° ± 5°	40 & 120° ± 5°	3
Connecting Rod Cap Bolts (Non - Fracture Spilt Conrod)	4 & 68° ± 3°	30 & 68° ± 3°	40 & 68° ± 3°	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	
Idle Gear Fitting Bolt	10 ± 1 120° ± 5°	73 ± 7.3 120° ± 5°	100 ± 10 120° ± 5°	4
Timing Gear Cover Fitting Bolts	1.9 - 2.6	14 - 18	19 - 26	
Crankshaft Pulley S/A Mounting Nut	48	347	470	
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	5.5 - 6.5	40 - 47	53 - 63	
FIP Drive gear bolt	3 - 3.5	21 - 25	32 - 34	
FIP Mounting on Timing Casing	1.9 - 2.6	14 - 18	19 - 26	
FIP Fuel Injector Banjo	2.0 - 2.5	15 - 18	20 - 25	
Fuel Outlet Orifice Adaptor	2.5 - 3.0	18 - 22	25 - 30	
High Pressure Pipe Cap Nut	2.0 - 2.5	15 - 18	20 - 25	
Injector Leak of Pipe Screws	0.5 - 0.7	3.7 - 5	5 - 7	
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	
Centre Bolt - Oil Filter	4-5	29 - 32	39 - 49	
Oil Cooler Element Fitting Nuts	1 - 1.5	8 - 10	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 Bolt (M12) (Shorter bolt) - Marusan gasket	7.1 - 7.3 & 150° - 152°	52 - 53 & 150° - 152°	70 - 72 & 150° - 152°	
Cylinder Head Bolt (M12) (Longer bolt) - Marusan gasket	7.1 - 7.3 & 180° - 182°	52 - 53 & 180° - 182°	70 - 72 & 180° - 182°	
Cylinder Head Bolts (M10)	4.5 - 5.0	33 - 36	44 - 49	
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	7.1-7.3 & 180° -182°	52 - 53 & 180° - 182°	70 - 72 & 180° - 182°	
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	
Injector Pipe Clip fasteners	0.5 - 1.0	3.7 - 7.2	5 - 10	
Exhaust Manifold	4.5 - 5.0	33 - 36	44 - 49	
Inlet Manifold Fitting Bolts	1.9 - 2.6	14 - 18	19 - 26	
Cylinder Head Cover Bolts	1.9 - 2.6	14 - 19	18 - 25	
PC Nozzle Mounting Cap Screw	1.6 - 1.8	12 - 14	16 - 18	
Speed sensor screw	0.6 - 1.0	4 - 7.2	6 - 10	
Fan Mounting Bolts	2 - 3	15 - 21	20 - 30	
Starter Motor - Nut	4.5 - 5	33 - 36	44 - 49	


1.0.5 Crank Shaft Main Journals and Crank Journals 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

1.0.6 Main and Crank Journals Grinding 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

1.0.7 Connecting Rod Big End Bearing Shell 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 -

1.0.8 Crankcase Parent Bore and Cylinder Liner Outer Dia
Crankcase Parent Bore

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

Cylinder Liner Outer Dia

Grade	Size (mm)
W	107 + 0.014 + 0.008
X	107 + 0.020 + 0.014
Y	107 + 0.026 + 0.020
Z	107 + 0.032 + 0.026

NOTE

Interchangeability is allowed w.r.t. next oversize or undersize liners. Only Multi Layered Gasket (MLS) should be used along with Interference Liners.

**1.0.9 Fuel Oil (High Speed Diesel)**

Users are recommended to obtain their fuel supplies from a source which can be depended upon to maintain a consistent standard of quality and service.

Fuel should be free from water and dirt, care should be taken by the user to protect fuel from contamination.

1.0.9.0 Fuel Specifications - as per IS 1460 : 2000 (Bharat Stage III)

i).	Acidity, inorganic	...	Nil
ii).	Acidity, total mg.of KOH/g (Max.)	...	0.20
iii).	Ash, percent by Mass (Max.)	...	0.01
iv).	Carbon residue (Ramsbottom) on 10 percent residue, percent by Mass, Max	...	0.30
v).	Cetane Number (Minimum)	...	51
vi).	Cetane index (Minimum)	...	46
vii).	Pour point (Max.)	...	3°C for Winter & 15°C for Summer
viii).	Copper Strip Corrosion for 3 hours @ 100°C., Max., rating	...	Not worse than No.1
ix).	Distillation, percent v/v, recovered:		
	a) at 350°C, Min	...	85
	b) at 370°C, Min	...	95
x).	Flash point (Min.)		
	a) Abel, °C, Min	...	35
	b) Pensky-Martens, °C, Min	...	66
xi.	Kinematic viscosity, cSt, @ 40°C	...	2.0 to 4.5
xii.	Sediment, percent by mass (Max.)	...	0.05
xiii.	Density; at 15°C., kg/m ³	...	820 - 845
xiv.	Total Sulphur, percent by mass (Max.)	...	0.035
xv.	Water content percent by mass (Max.)	...	0.020
xvi.	Cold Filter Plugging Point (CFPP) max	...	6°C for Winter and 18°C for Summer
xvii.	Total Sediments mg per 100 ml. (max)	...	1.6
xviii.	Total contaminations (Particulate matter) mg/kg. (max)	...	24
xix.	Oxidation stability, g/m ³ , (max)	...	25
xx.	Polycyclic Aromatic Hydrocarbon (PAH), percent by mass, Max	...	11
xxi.	Lubricity, corrected wear scar diameter (wsd) 1.4) at 60°C, microns, Max	...	460

Emission Levels (g/kWh)

Pollutant	BS II 2001	BS III 2005	BS IV 2010
NOx	7.00	5.00	3.50
CO	4.00	2.10	1.50
HC	1.10	0.66	0.46
PM	0.15	0.10	0.02

1.0.10 Recommended coolant

The proper selection and use of coolant are very important to prevent corrosion of the cooling system and clogging of the radiator. Replace coolant as per the maintenance schedule.

RECOMMENDED COOLANT

Gulf Leypower Coolant 5000 is the pre mixed coolant and has been formulated with a view to offer extended service life. No addition of water is required.

For coolant change interval, refer Maintenance Schedule. Gulf Leypower Coolant 5000 is available as pre mixed packs.

**CAUTION**

For topping up use only Gulf Leypower Coolant 5000 directly. Do not dilute with plain or demineralised water for top up.

1.0.11 Recommended Lubricants

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

Aggregate	Min. Ambient Temp. °C	Approved Lubricant
		Gulf Oil India
HA6ETI Engine	-20	Leypower XLL Diesel Engine Oil

Note: Do not mix lubricants of different brands/grades.

1.0.12 Filling Capacity

Aggregates	Qty (ltrs.)
Engine	16
Cooling system	As per application



1.0.13 Liquid Gasket and Application Points

Use liquid gasket (Anabond 673/Loctite 587) instead of conventional sheet gaskets. The following are the liquid gasket application points.

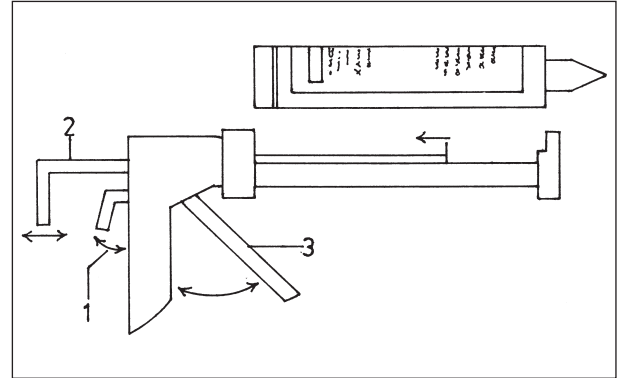
Liquid gasket application points and coating width

Parts Name	Application	Coating width
a) Oil pan	Flange face which mate with cylinder block, timing gear cover and flywheel housing	1.5 - 2.5 mm
b) Timing gear cover	Faces which mates with timing gear plate (flange face, boss face)	
c) Flywheel housing	Faces which mate with cylinder block (flange face, boss face)	
d) Coolant pump	Flange face which mates with timing gear cover	
e) Thermostat case	Flange face which mates with cylinder head	
f) Camshaft end plate	Flange face which mates with cylinder block	

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.

1.0.14 Description of Leading Engine Components

Cylinder Block (PCN) - 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 - 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 seven bearings with exchangeable shells. The main journals and crank-joints are induction hardened.

Vibration Damper (Poly - V) - is mounted on the front end of the crankshaft. Care should be taken while handling the vibration damper. Use proper special tool while extracting the damper pulley.

Alfin Pistons - made of special grade aluminium alloy with cast iron insert to form the first compression ring seat. The combustion chamber design is shallow type for better combustion efficiency and reduction in soot emissions.

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 four 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.

Valve Spring - made of spring steel, constant pitched coil.



1.0.15 Special Tools

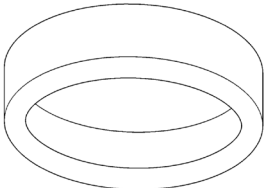
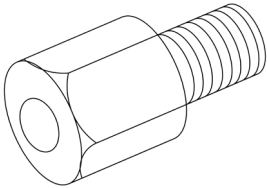
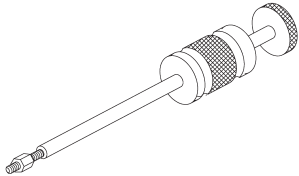
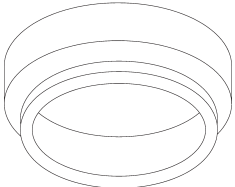
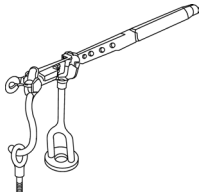
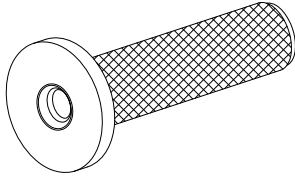
FIG. No	PART NUMBER	TOOL DESCRIPTION	FIGURE	APPLICATION
1	P2607047	Drift oil seal gear case	 3802 (0102001)	To Press Oil Seal On Timing Gear Case
2	P2607147	Adapter idler gear spindle	 3803 (0102002)	To Be Used With P2607247 - Sliding Hammer, To Extract Idler Gear Spindle
3	P2607247	Sliding hammer	 3804 (0102003)	To Remove Injectors, Idler Gear Spindle Etc., With Their Respective Adaptors
4	P2607347	Drift oil seal flywheel hsg	 3805 (0102004)	To Press Oil Seal - Crankshaft Rear End In Flywheel Housing
5	P2607447	Compressor valve spring	 3806 (0102005)	To Assemble And Disassemble Inlet & Exhaust Valves
6	P2608247	Drift valve stem seal	 3807 (Z06DH0430025)	To Install Valve Stem Seal.



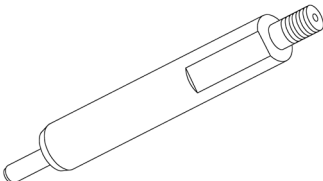
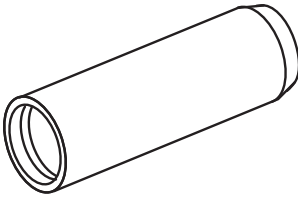
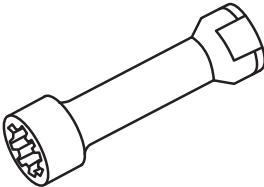
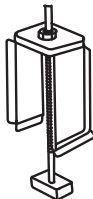
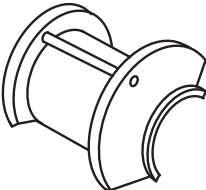
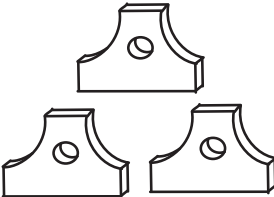
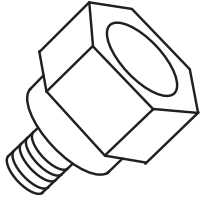
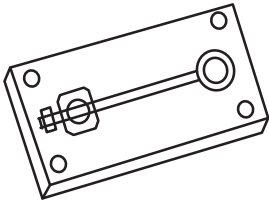
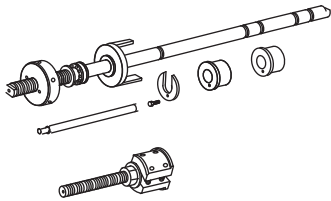
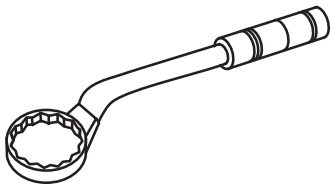
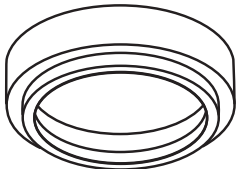
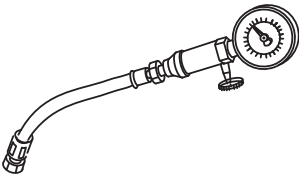
FIG. No	PART NUMBER	TOOL DESCRIPTION	FIGURE	APPLICATION
7	P2613247	Adapter compression checking	 3822 (0102023)	To Be Used With P2600441 - Gauge Compression Checking, To Check The Compression Pressure Of Each Cylinder
8	P2608947	Drift valve guide	 3811 (0102009)	To install valve guide
9	P2607747	Special socket cylinder head bolt	 3812 (0102010)	To tighten cylinder head bolts after fixing rocker shaft assy.
10	P2607847	Extractor cylinder liner	 3813 (0102011)	To extract cylinder liners.
11	P2607947	Guide cylinder liner	 3814 (0102012)	To guide the cylinder liners while inserting it in to bore.
12	P2608047	Retainer cylinder liner (3 nos.)	 3815 (0102013)	To hold the cylinder liners while removing the piston assembly

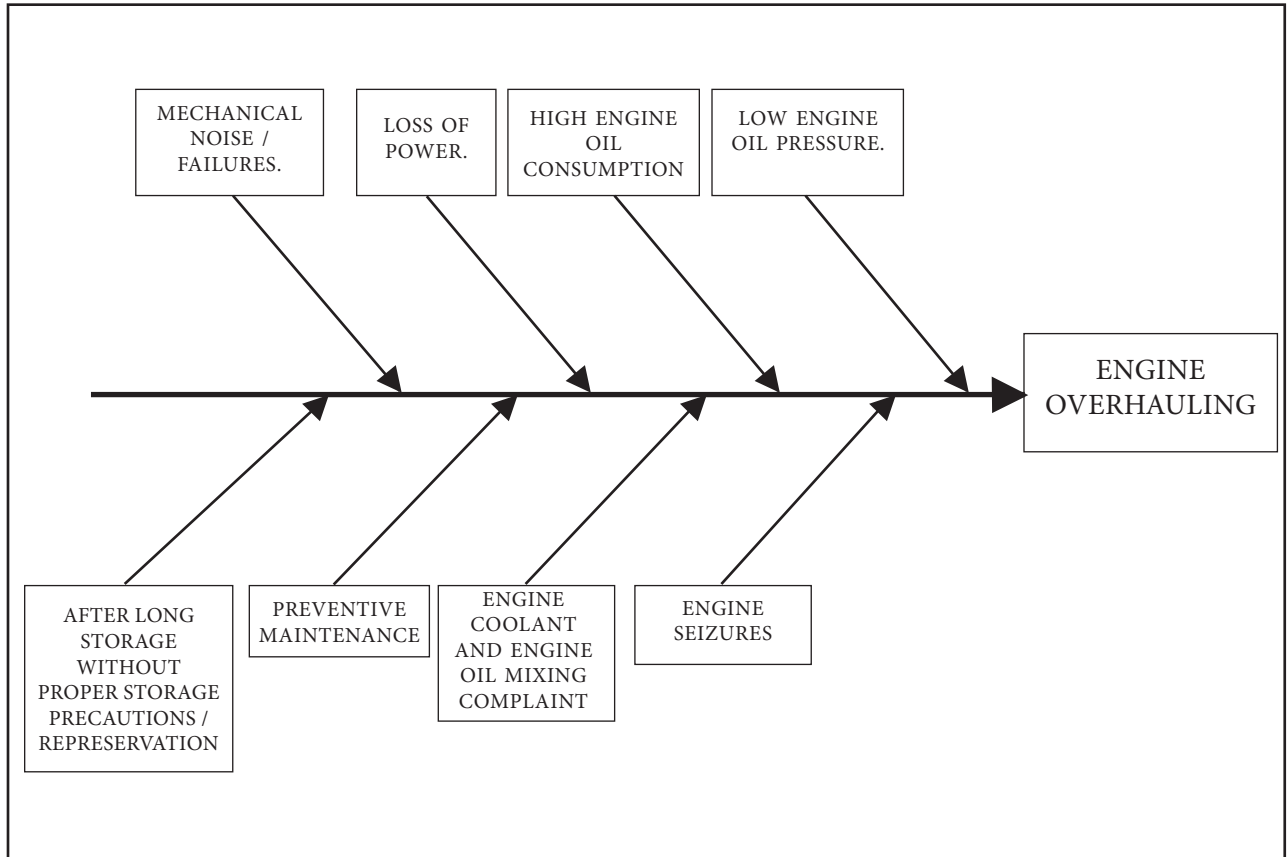


FIG. No	PART NUMBER	TOOL DESCRIPTION	FIGURE	APPLICATION
13	P2610647	Compressor piston ring	 3816 (0102014)	To compress piston rings during assembly
14	P2608347	Adapter Injector Removal	 3818	To be used with P2607247 - sliding hammer, to remove injectors
15	P2608147	Drift & extractor con-rod bushes	 3836 (0102017)	To extract and install connecting rod bushes
16	P2609147	Drift & extractor cam bushes	 3839 (0102018)	To Extract and install cam shaft bushes
17	P2609247	Wrench engine cranking	 3840 (0102019)	To rotate the crankshaft
18	P2610747	Drift oil seal flywheel Hsg,(6.0mm height)	 3842	To press oil seal - crankshaft rear end in flywheel housing
19	P2600441	Gauge compression checking	 3801 (0102021)	Check the compression pressure in each cylinder

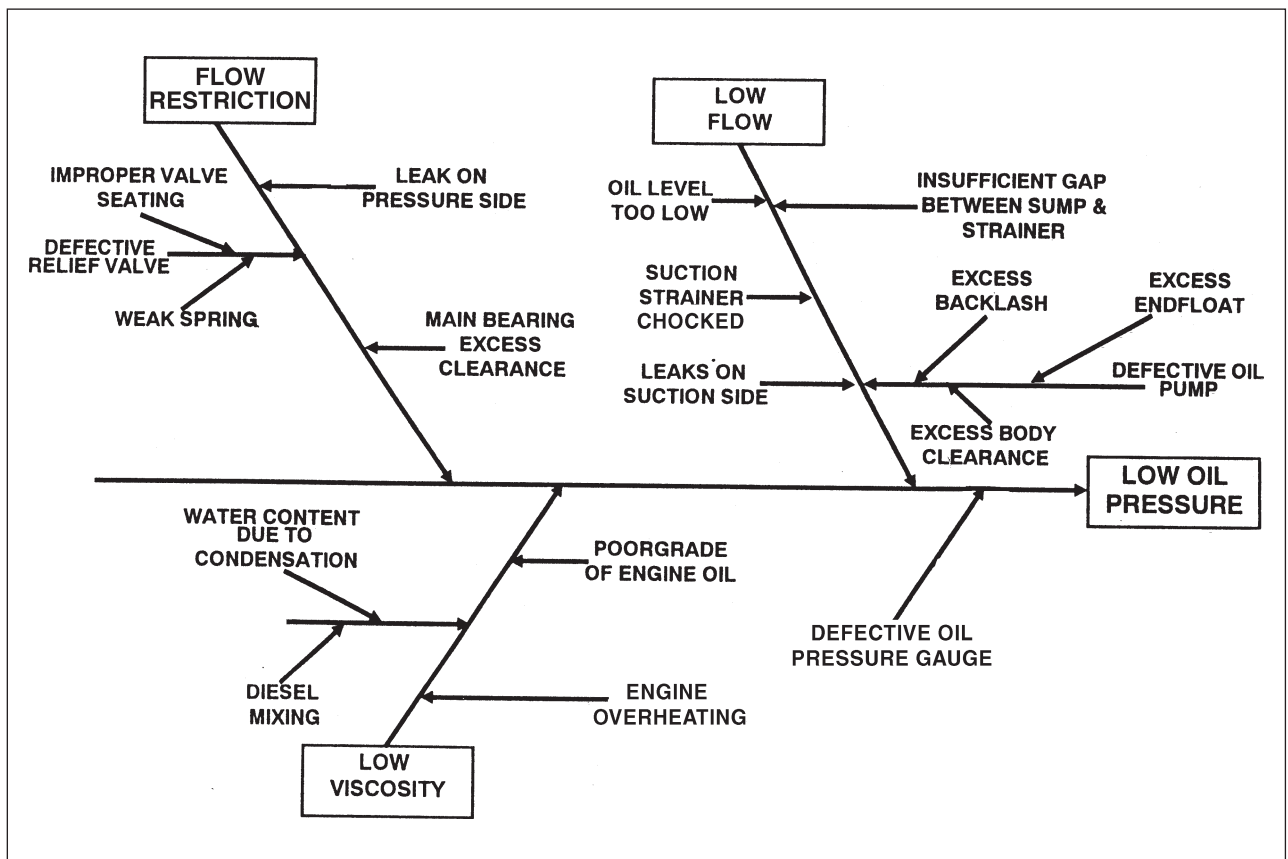


1.0.16 Engine Preliminary Checks

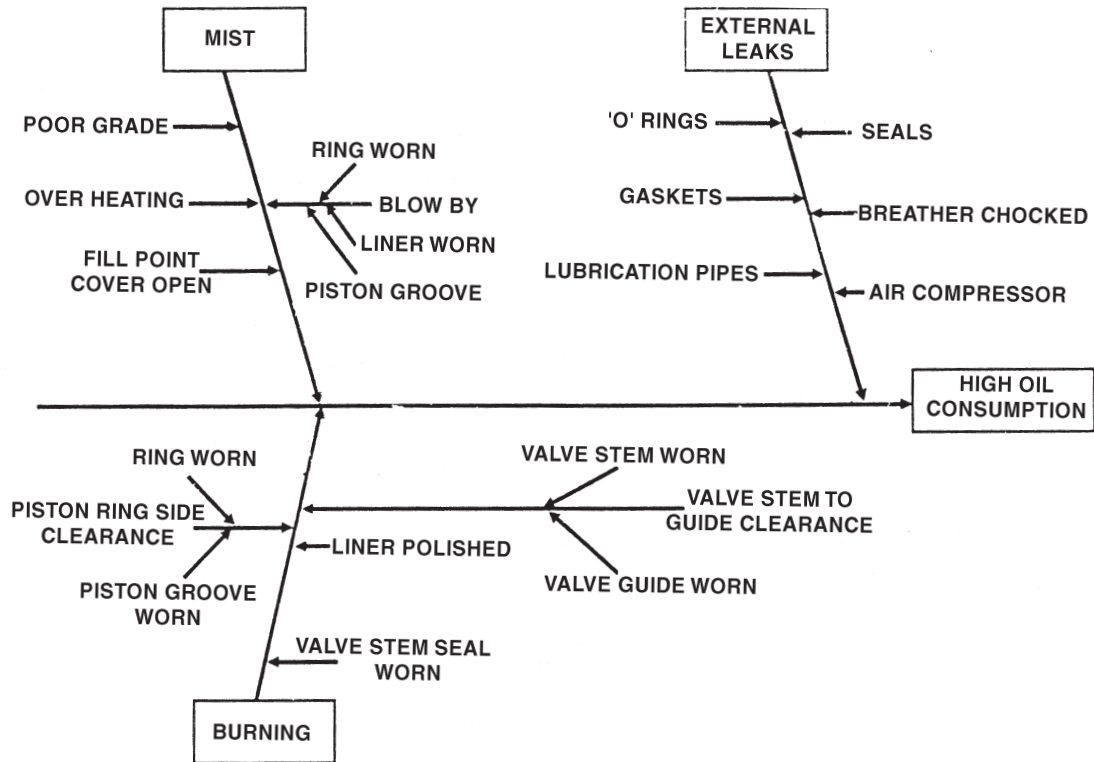
It is mandatory to carryout few preliminary checks on engine before dismounting the engine from the Equipment. The following cause and effects can lead to overhauling decision.



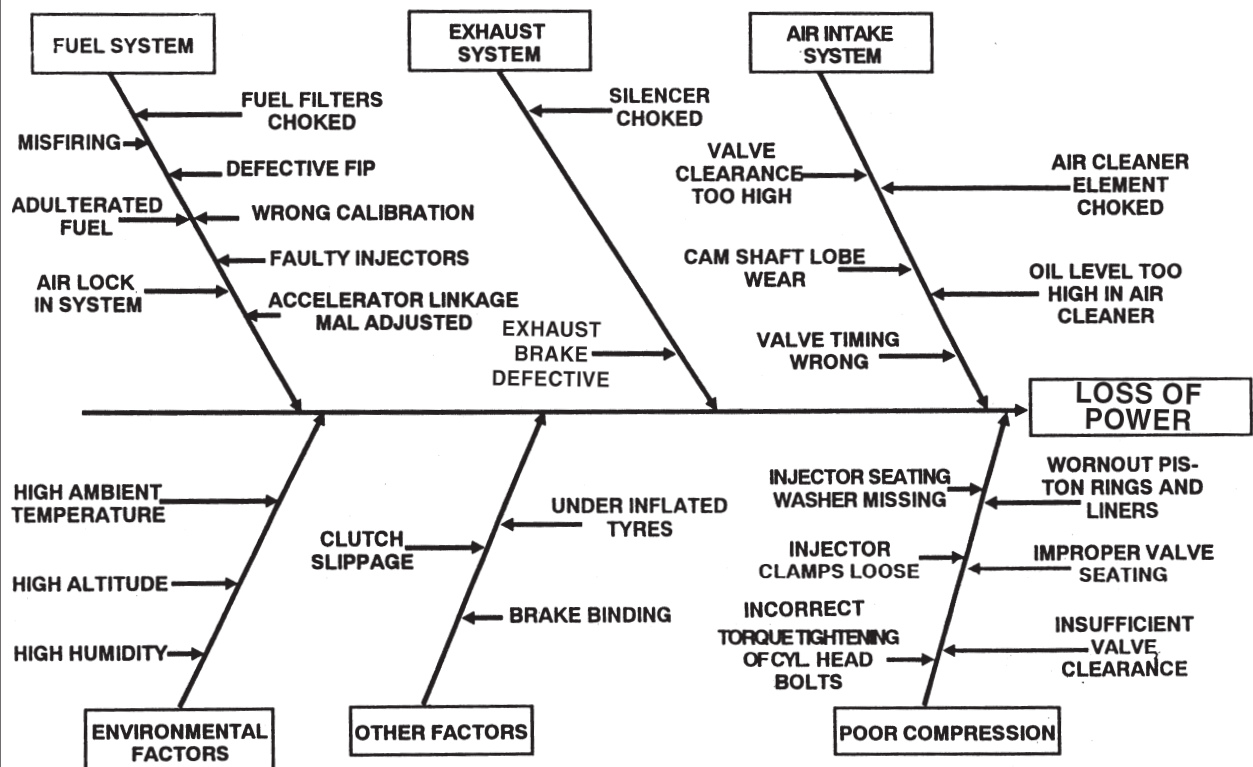
Engine Overhauling



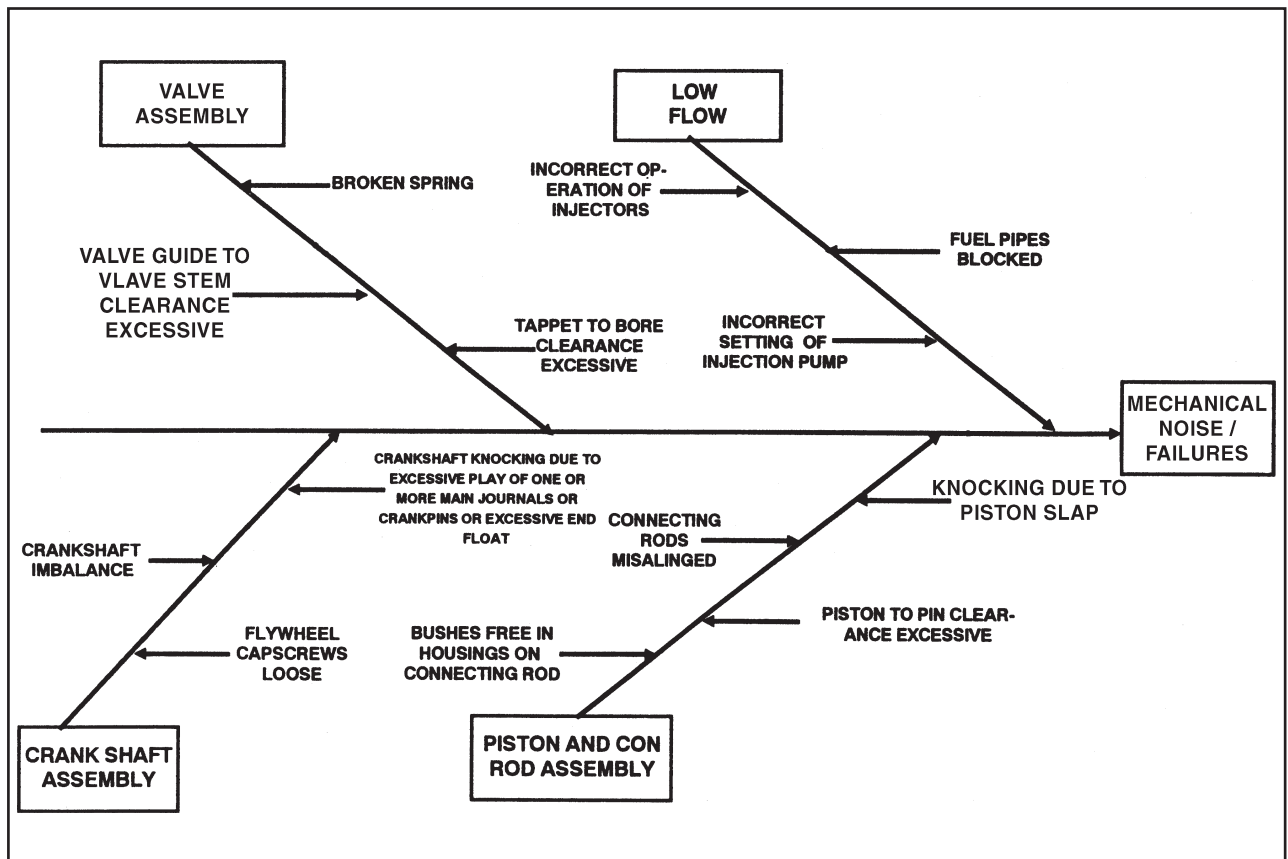
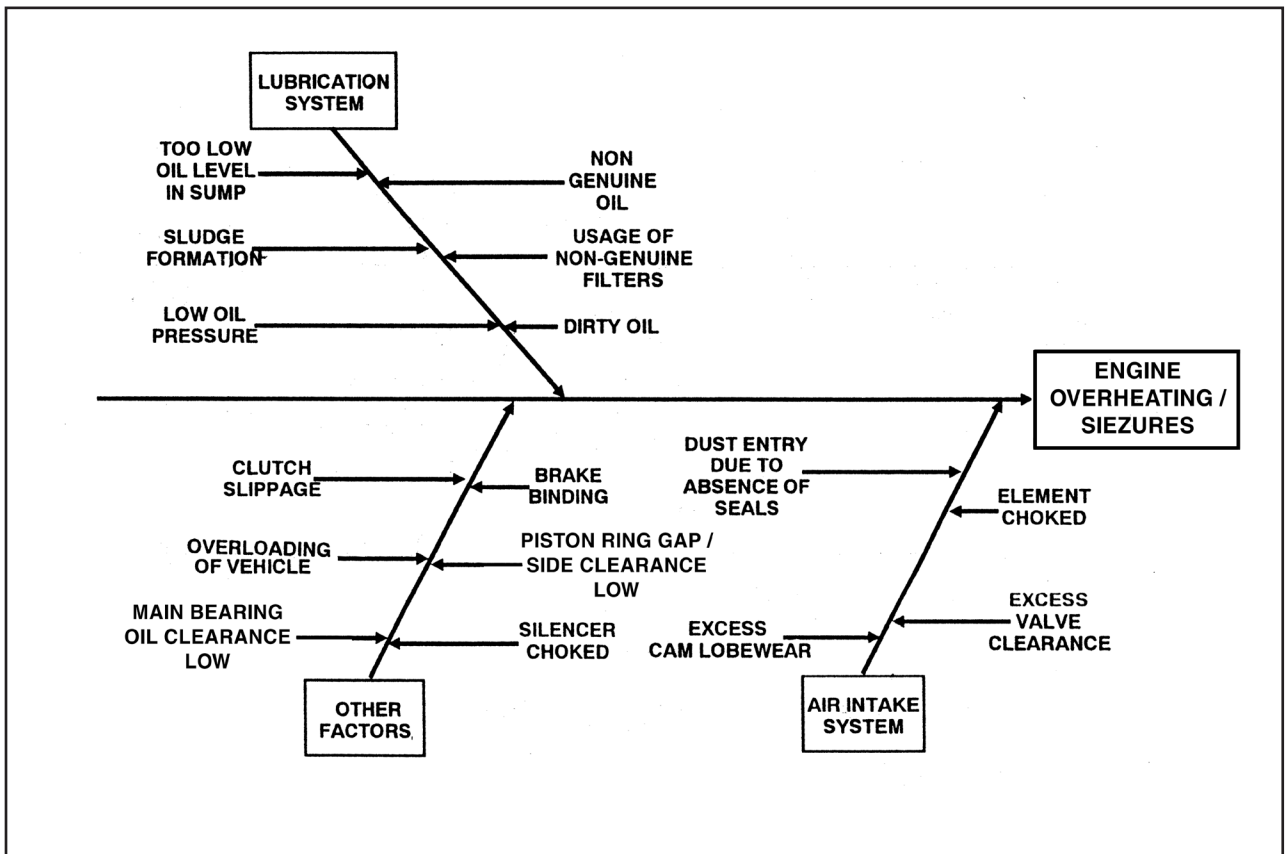
Low Engine Oil Pressure

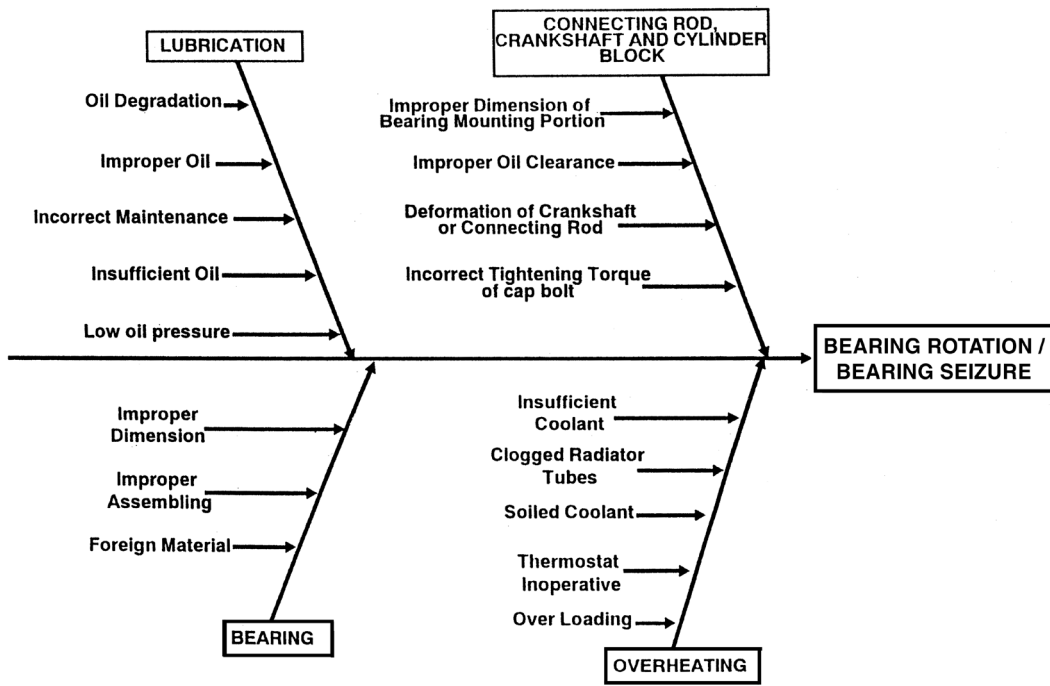


High Oil Consumption



Loss of Power


Mechanical Noise / Failures

Engine Overheating / Seizures



Bearing Rotation / Bearing Seizures

1.0.17 To Test Engine Compression

Use **Special Tool 0102007 - Adaptor Engine Compression** with **Special Tool P2600441 - Gauge Compression Checking**. (Use Adaptor Cylinder Compression in place of nozzle).



Warm-up engine to normal operation temperature (approx 80°C). Disconnect fuel delivery pipes and remove all six injectors.

NOTE

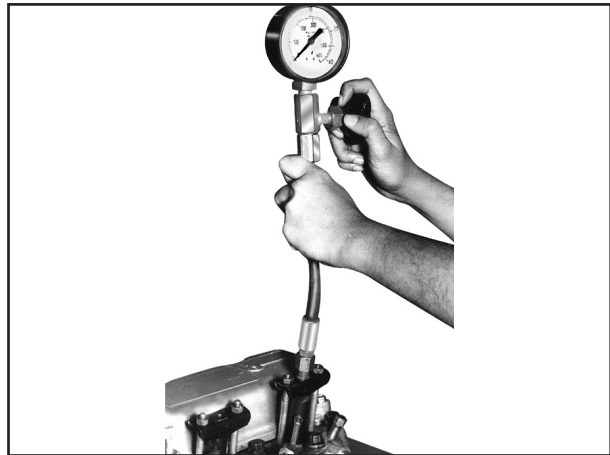
Use Special Tool 0102015 - Adaptor Injector Removal with **Special Tool P2607247 - Sliding Hammer**, if injector extraction is difficult.

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

Check valve clearance, if necessary adjust as per recommendation.

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.

Compression pressure kg/cm² @ 280 rpm

	HA6ETI
Minimum	24 kg/cm ²

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

If compression pressure is found below minimum recommendation engine requires reconditioning.

In the last case it will be necessary to check valve tightness, condition of piston clearance of the respective cylinder.

Wet Compression Pressure Check

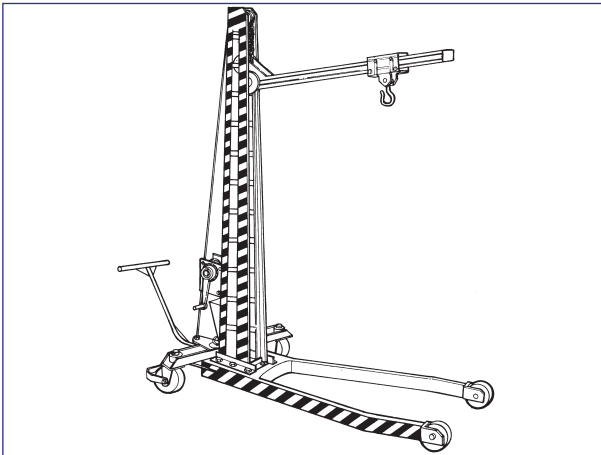
If the particular cylinder compression pressure is below 300 psi as per above dry check procedure, to locate fault with valve tightness or piston clearance repeat the compression pressure check after pouring few drops of engine oil thru Injector hole. If low compression persists, the fault is with valve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



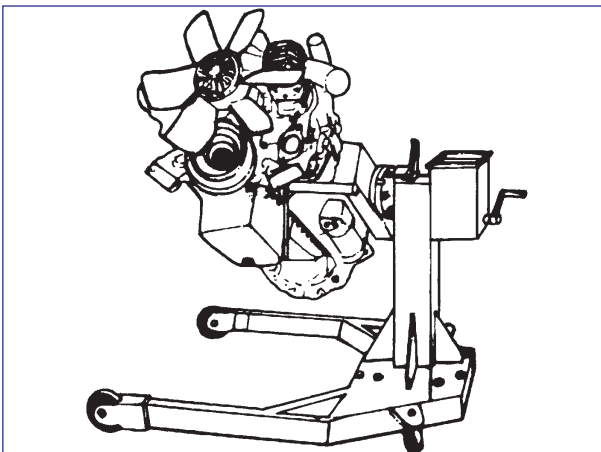
1.1 TO REMOVE AND REFIT ENGINE FROM EQUIPMENT

1.1.0 To Remove Engine

- Disconnect battery terminals
- 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 electrical connection from fuel shut off solenoid.
- 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 utmost cleanliness must be observed. Special tools manufactured for this purpose to be used.

1.1.1 To Refit Engine

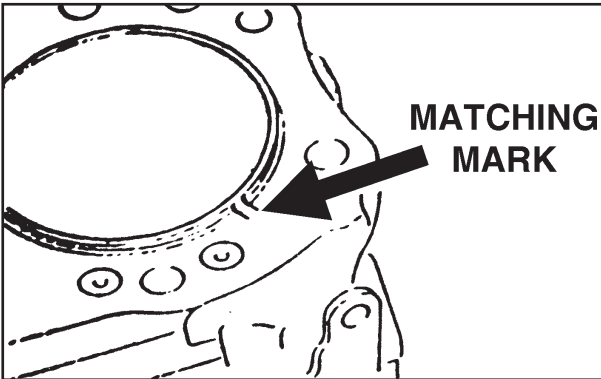
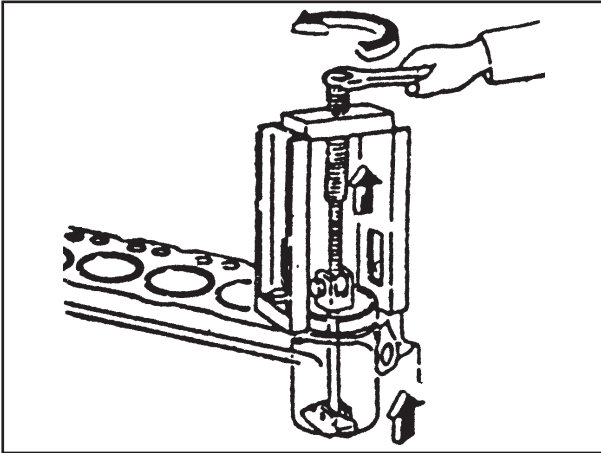
- The above mentioned procedure to be fitted back in reverse order.
- Ensure the alignment of the engine in the exact centre of the chassis frame.
- Before initial starting of the engine, check whether, engine oil, gear box oil and coolant level are verified.



1.2 CRANKCASE

1.2.0 To Remove and Refit Cylinder Liners

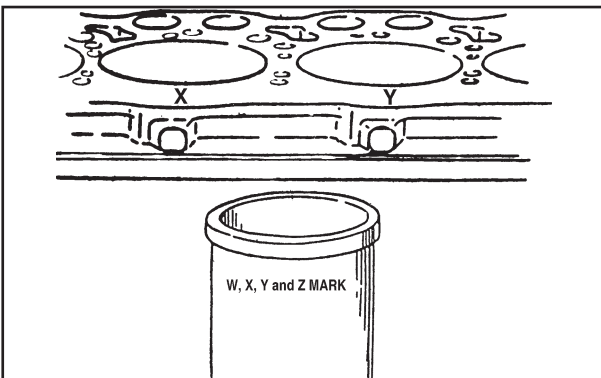
Use Special Tool P2607847 - Extractor Cylinder Liner for removal of cylinder liners.



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.

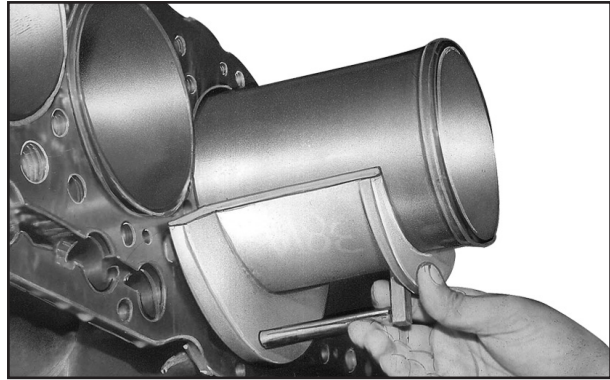
Make sure that the liner grade mark has the same mark on the cylinder block.



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 O.D. 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.

Gently press the liner with hand.

Place a plate of dia 107 mm and thickness 15 mm of PTFE material over the liner top and gently tap with nylon mallet at the centre to drive the liner into the bore.

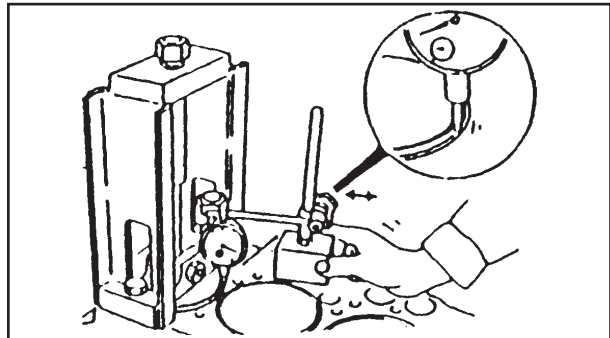


When reusing a liner, insert the liner in its original position aligning the markings marked before disassembly. Use Special Tool P2607947 - Guide Cylinder Liner.

NOTE

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

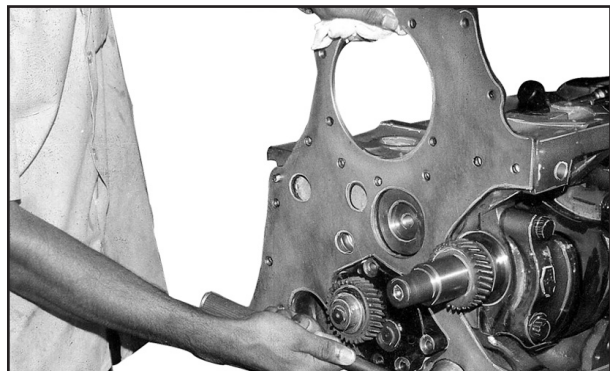
Measure the projection of the cylinder liner.



Fix Special Tool P2608047 - Retainer Cylinder Liner and measure the amount of projection of the liner from the cylinder block with a dial gauge and magnetic stand.

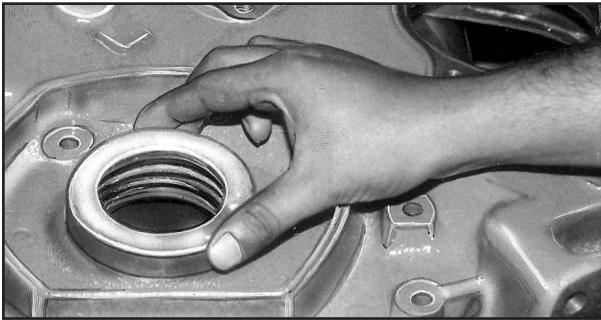
Refer data for liner projection.

1.2.1 To Remove and Refit Timing Casing Cover and Back Plate



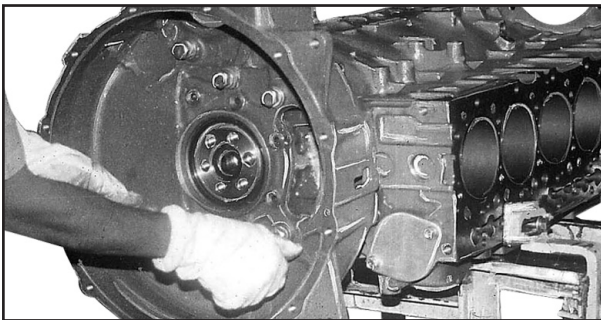


Backout fixing screws of the Timing back plate.
Take off the Timing back plate, taking care of both dowel pins. Before refitting, remove the old Liquid gasket material and clean front face of the crankcase.
Apply fresh liquid gasket (Anabond 683) with new gasket to crank case face of the Timing Back plate.
Screw down Timing Back plate with hex screws and spring washers.



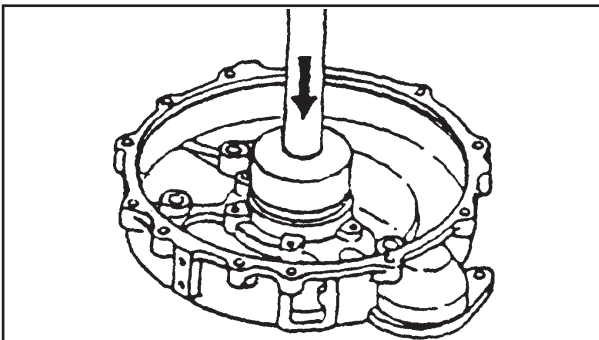
Remove timing cover and Replace new oil seal using Special Tool P2607047 - Drift Oil Seal Gear Case.
Installation should only take place with engine in normal upright position.

1.2.2 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.

1.2.3 Install the Oil Seal in the Flywheel Housing



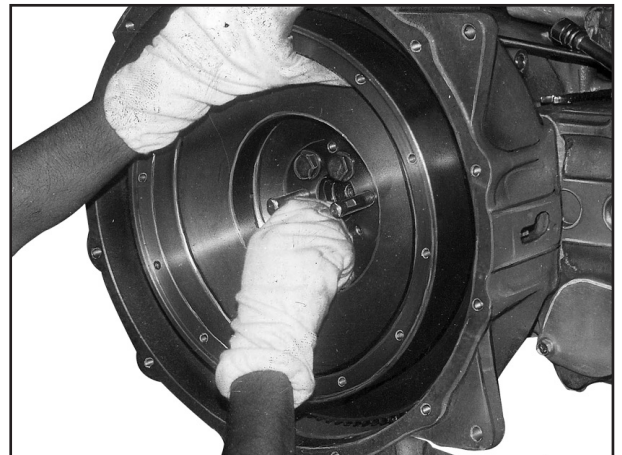
Using a special tool, press in the oil seal in the flywheel housing.
Special tool P2607347 : Drift for Oil Seal Flywheel Housing.
Before refitting, remove the old Liquid gasket material and clean rear face of the crankcase. Apply fresh Liquid gasket to inner side of the flywheel housing.
Fit flywheel housing and tighten it securely with hex screw. Start with M14 bolts (8 nos.) and M8 bolts (6 nos.).

1.2.4 Install Crankshaft Adaptor (as Applicable)



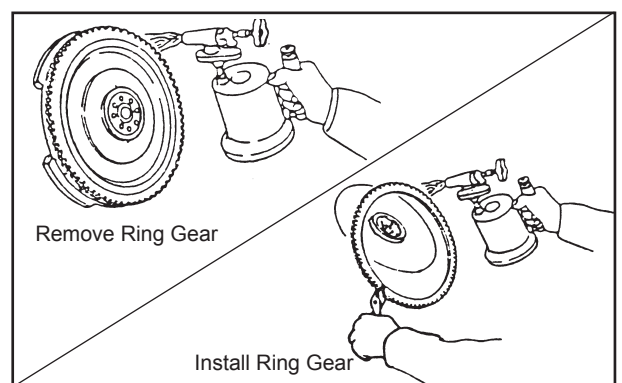
Align crankshaft adaptor dowel hole with crankshaft collar and engage crankshaft adaptor mounting capscrews. Torque the mounting capscrew as per the specified torque.

1.2.5 To Remove and Refit Flywheel



Backout fixing screws and remove flywheel. **Fig - 11**
Check ring gear, if necessary replace.

1.2.6 To Remove Ring Gear



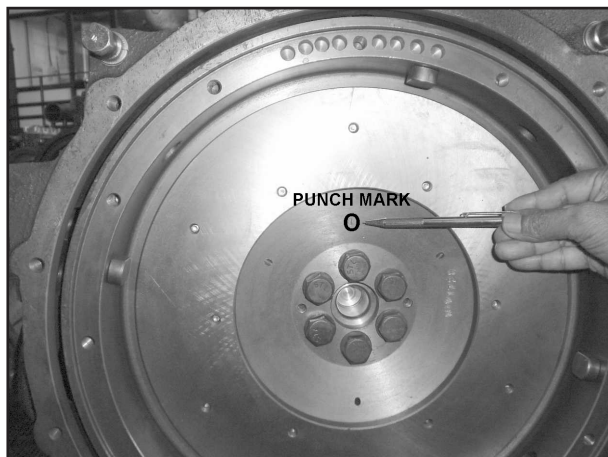
- Heat the ring gear with a blow torch in a uniform manner (approx. 180°C).
- Using a metal rod as pad and strike all around the ring gear in uniform manner and remove the ring gear.

1.2.7 To Install Ring Gear

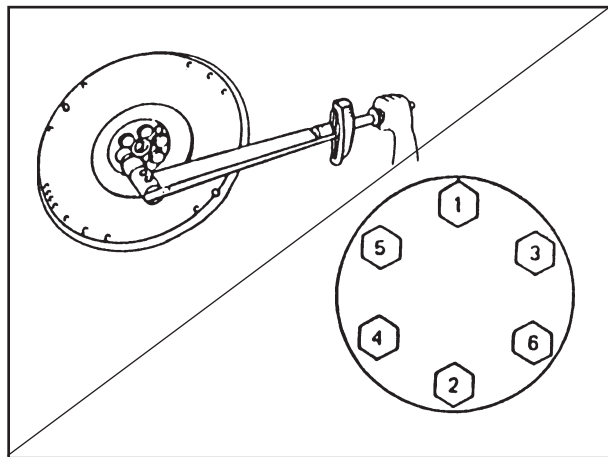
- Heat the ring gear uniformly using a blow torch (approx. 180°C).
- Drive the ring gear with its chamfered gear teeth facing the block onto the flywheel using a metal rod.



1.2.8 Install Flywheel



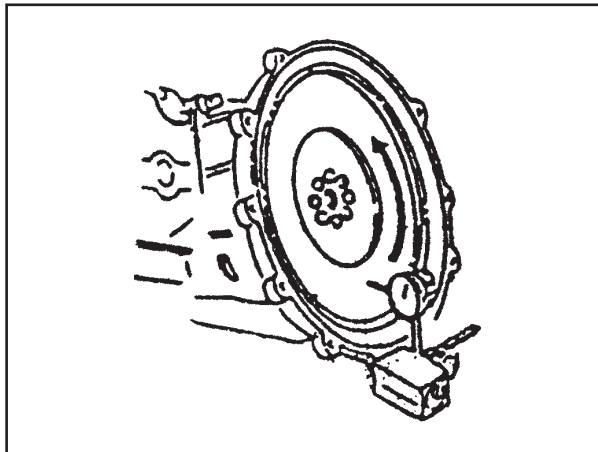
Align the 'O' mark on the flywheel and crankshaft collar knock pin.



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 by 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 runout as per recommendation.

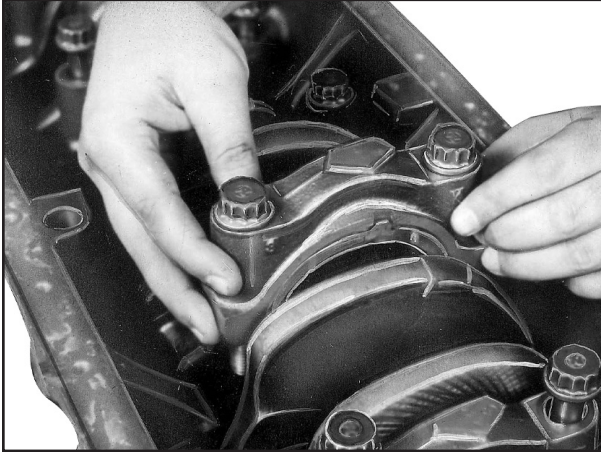


1.3 CRANKSHAFT

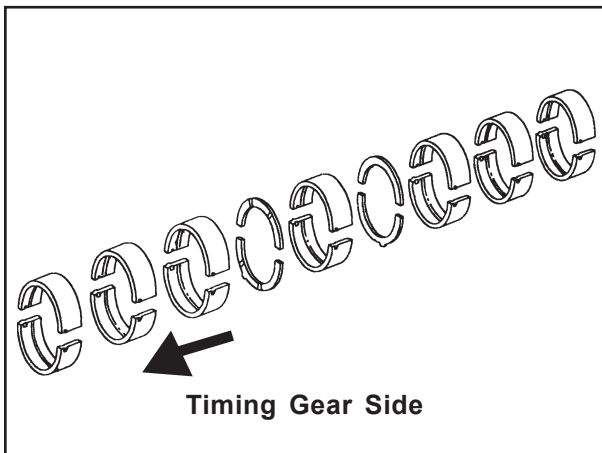
The crankshaft is supported by 7 main bearings.
Thrust is taken up by the thrust washer at the fourth journal.

1.3.0 To Remove and Refit Crankshaft

Backout collared bolts and remove bearing caps.

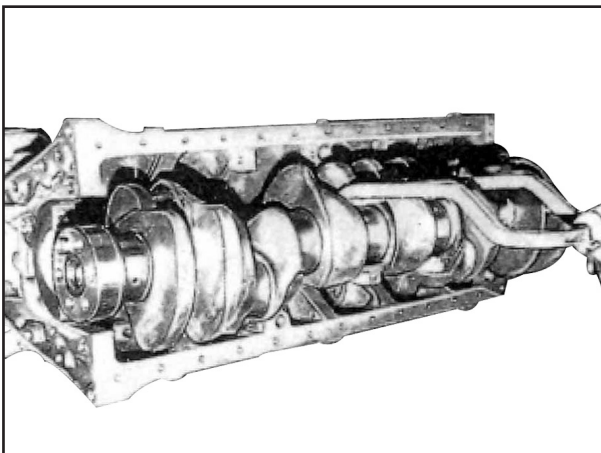


Remove thrust bearing cap (4th) last.



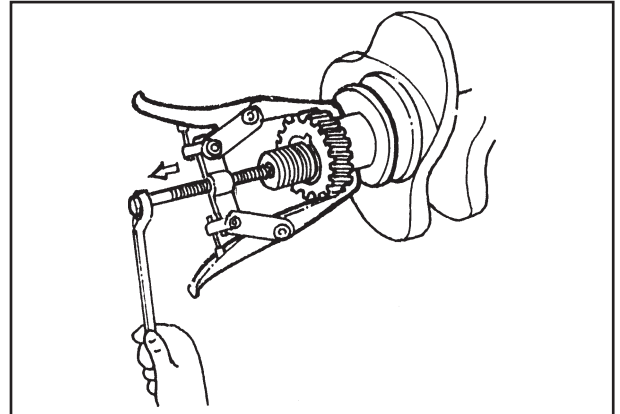
Arrange all the caps bearing and thrust washer in order.

The bearing caps are match marked with the crankcase by punch marking 1 to 7, commencing from timing gear side.



Lift the crankshaft out of the crankcase.

1.3.1 To Renew Crankshaft Gear

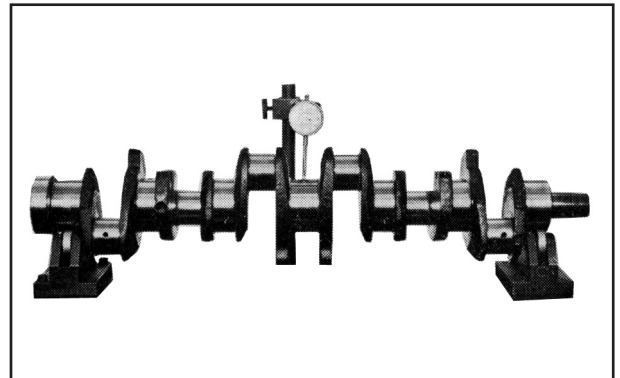


By using Conventional puller remove crankshaft gear from crankshaft.

1.3.2 To Refit the Crankshaft Gear

Heat the gear upto 130°C and fix it.

1.3.3 To Check Crankshaft Bend



Maximum permissible bend is 0.04 mm.

1.3.4 Installation

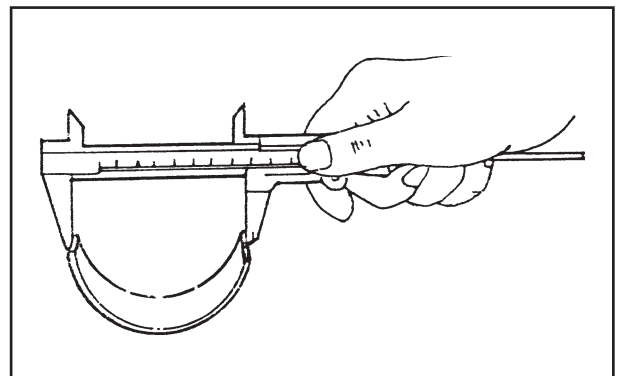
Clean crankcase, crankshaft and bearing shells by blowing compressed air through the lubrication holes.

1.3.5 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

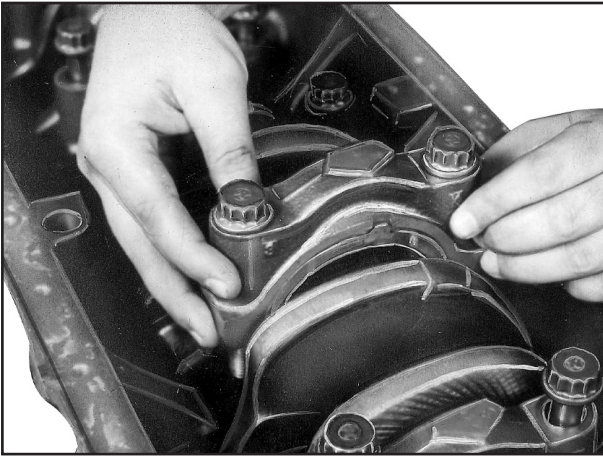
Connecting rod bearing dimension : 67.05 - 67.55 mm



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

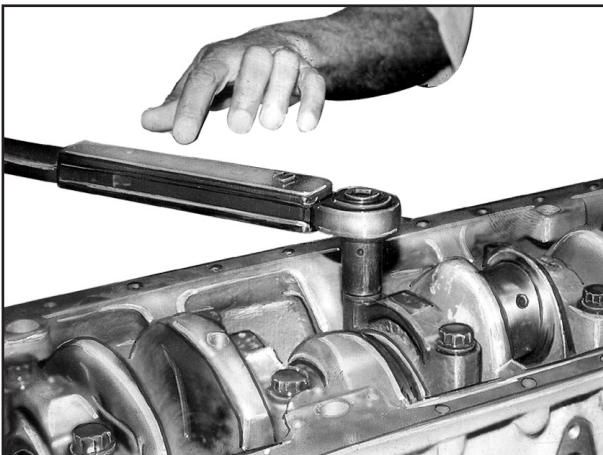


Lubricate crankshaft journals, bearing shells, cap bolt threads and under the bolt heads with the engine oil. Carefully lower the crankshaft into position.

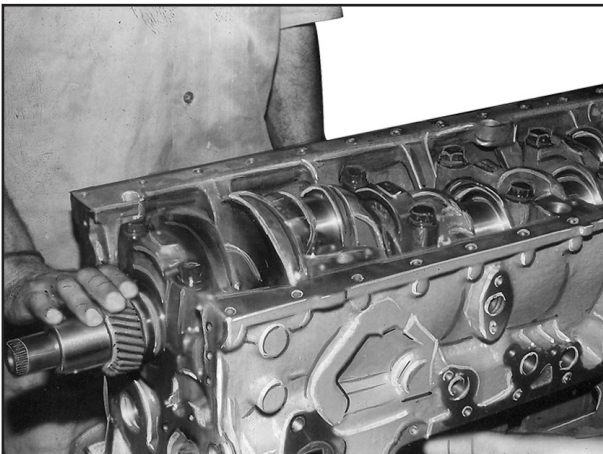


Fit bearing caps and starting off with the thrust bearing No.4, adhering to the match marks. Connecting faces, of bearing caps and crankshaft should be perfectly clean.

Bearing cap set identification no punched on the bearing cap and LH side rear end of the crankcase.



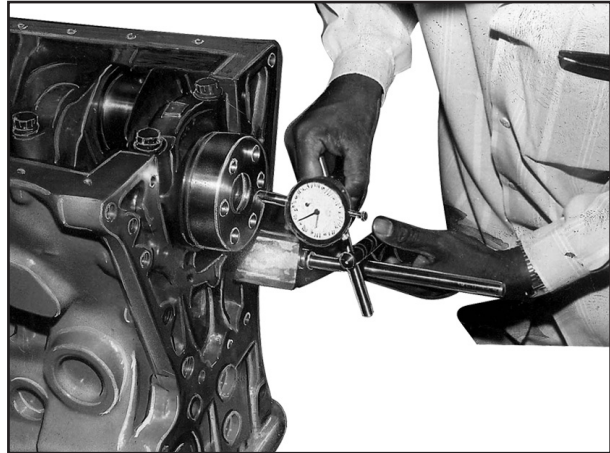
Tighten cap collared bolts uniformly in the three stages in tightening order 4-5-3-6-2-7-1.



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 and end clearance should not exceed 0.4 mm.

1.3.6 To Check and Grind Crankshaft

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

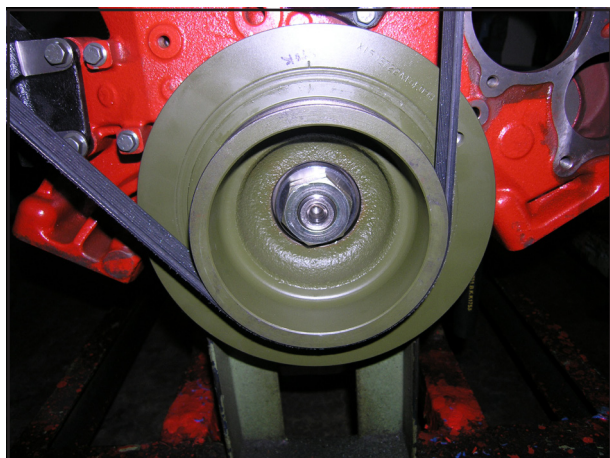
Check wear of crankshaft if wear is more than 1.2 mm from standard size, replace crankshaft.

No further heat treatment is recommended.

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

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 14.0.7.

1.3.7 To Remove and Refit Vibration Damper



Backout the hex nut with box spanner 46 mm.

Withdraw the vibration damper.

If found externally damaged, replace with new one.

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

To refit vibration damper reverse the procedure for removal.

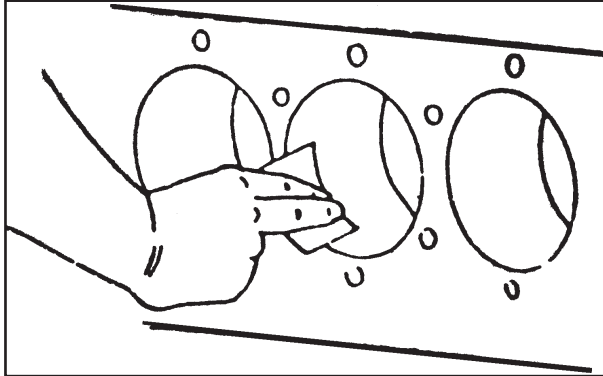


1.4 PISTON AND CONNECTING RODS

1.4.0 To Remove Piston Assembly

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

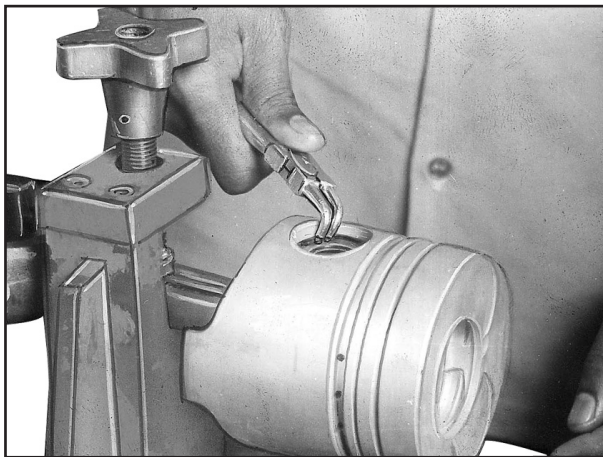
Backout connecting rod bolts and remove bearing cap.



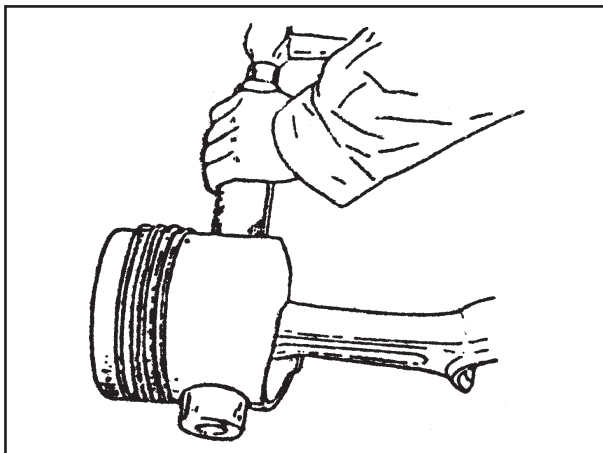
Scrape off carbon deposit from the upper end of the cylinder liner with the help of emery paper or scraper.

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

1.4.1 To Dismantle and Assemble Piston and connecting rod



Remove gudgeon pin circlip with the circlip plier.



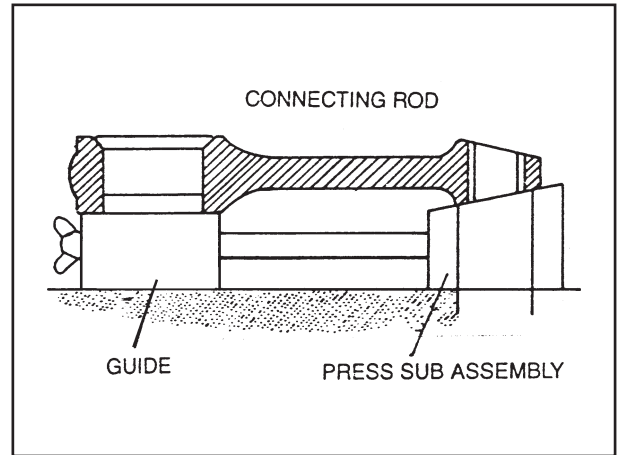
Place a copper drift on the pin and strike it out with the hammer.

1.4.2 Connecting Rod Bush

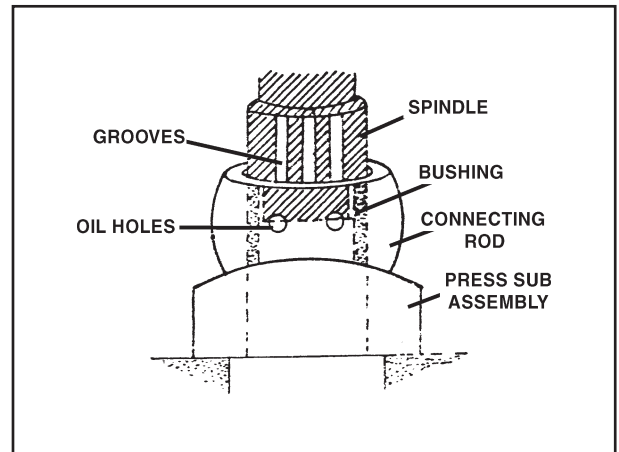
1.4.2.0 To Remove Bush

Using a special tool P2608147 - Drift and extractor.

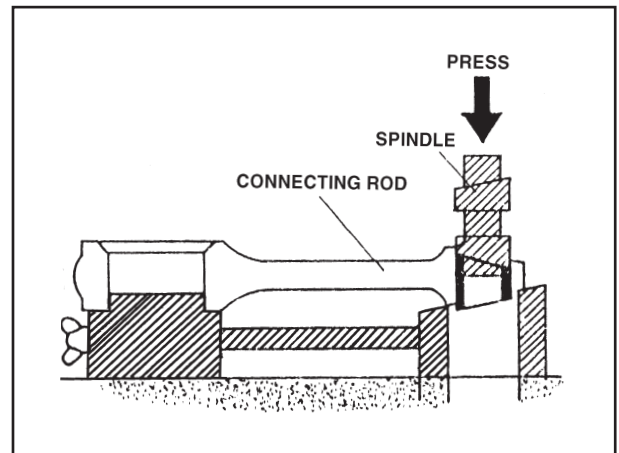
Align supporting surfaces of the guide and press sub assembly flush on the flat plain.



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



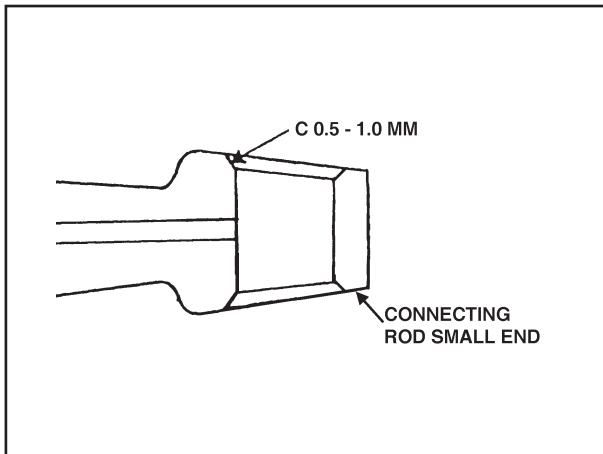
Install the spindle into the bush. Align the grooving of the spindle with the oil hole of the bush.



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

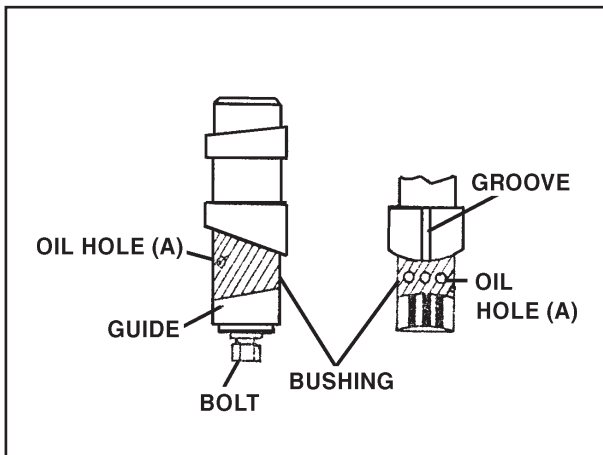


1.4.2.1 Installation of Connecting Rod Bush



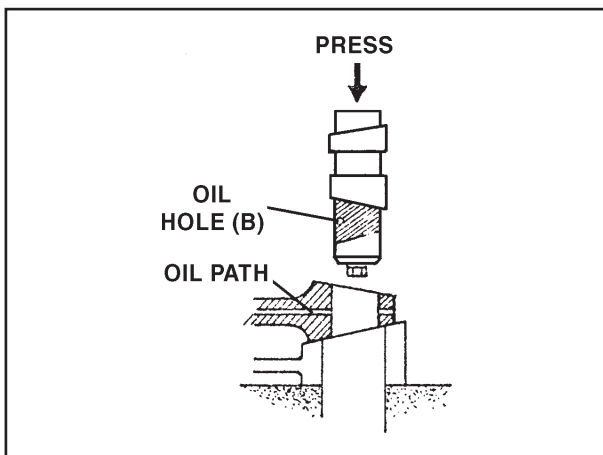
Chamfer one edge of the bush hole at the small end of the connecting rod uniformly by C 0.5 - 1.0 mm.

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.

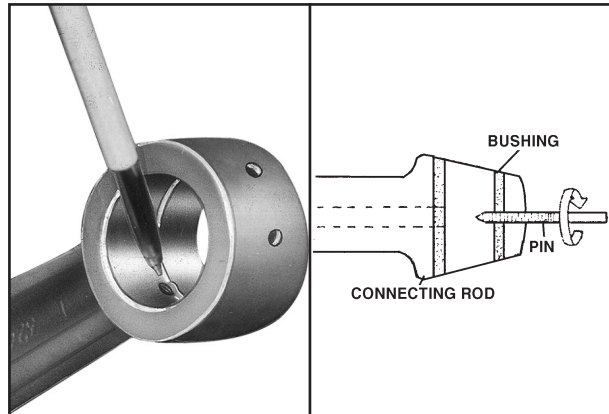
lubricate the bush guide and bush bore on the connecting rod.



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

Always operate the press slowly and smoothly.

1.4.2.2 Inspect the Bushing Position after Installation

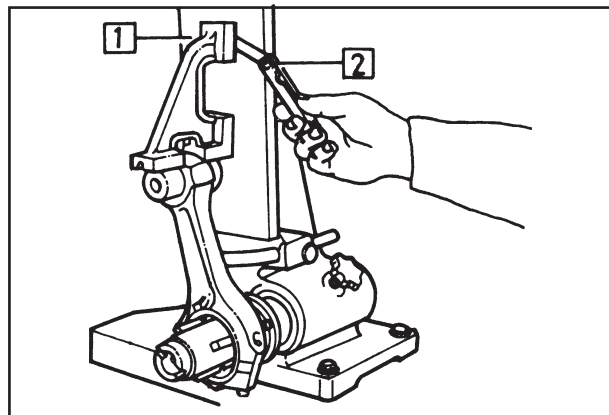


Make sure that the oil holes of the bushing and connecting rod are aligned. **Fig - 10**

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.

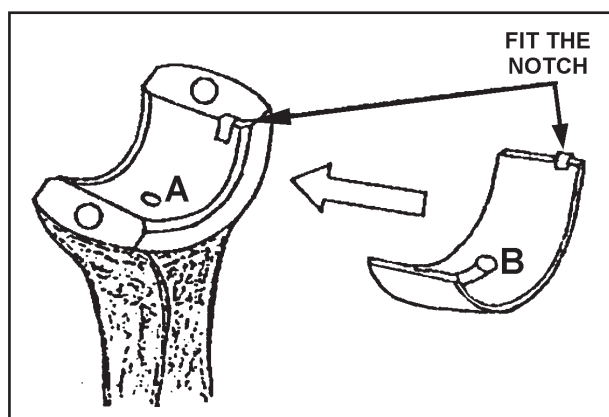
If there is any deviation in the alignment of the oil holes correct it with a drill of 3 mm dia. If drilling is carried out, take care to remove the machined burrs clears off the connecting rod small end bore and oil holes.

1.4.2.3 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. **Fig - 11**

1.4.2.4 Install the Connecting Rod Bearing



Confirm the oil hole A & B are in line. **Fig - 12**



1.4.3 Piston and Piston Rings

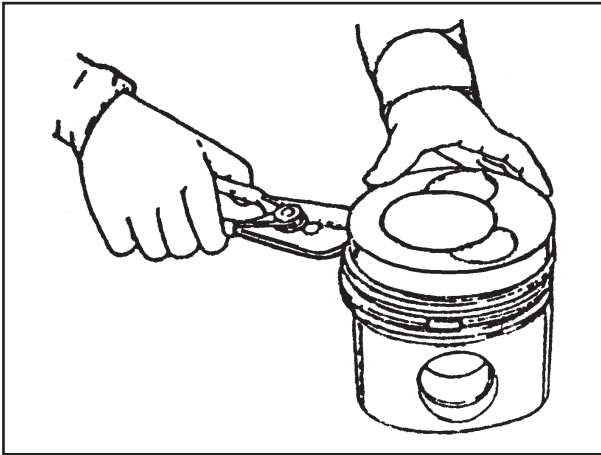
1.4.3.0 Piston General

The piston combustion chamber is of re-entrant type for faster and more efficient combustion. The piston consists of two compression Ring grooves, one oil scraper ring groove and crown face with valve pockets.

Max. difference in the weight of the piston is an engine set of 6 pistons not to exceed 5 gms.

Weight group identification mark punched on the piston crown.

1.4.3.1 To Remove Piston rings

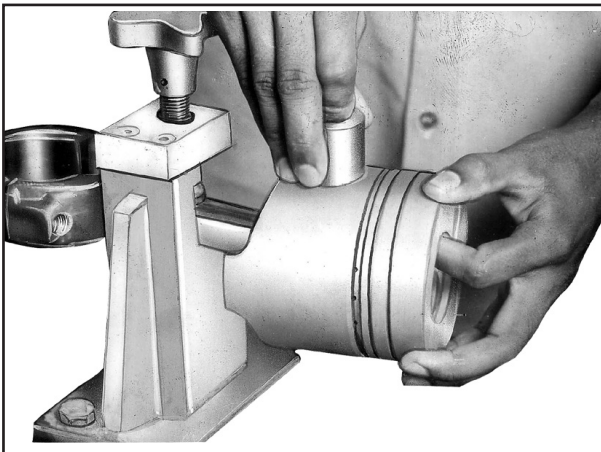


Remove compression rings and oil scraper rings with the aid of piston ring plier.

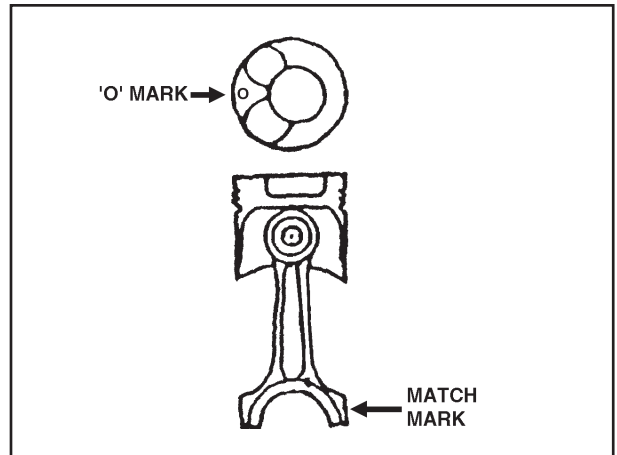
Remove carbon deposits from piston ring grooves.

1.4.3.2 Assemble Piston and Connecting Rod

Heat the piston to approximately 80°C temperature.

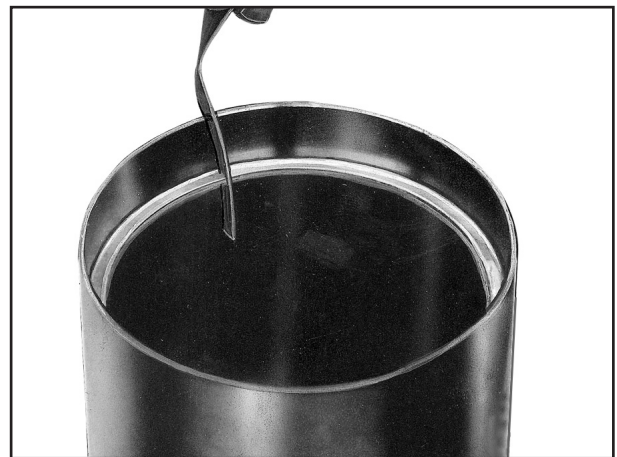


Insert the gudgeon pin into the piston with connecting rod.



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

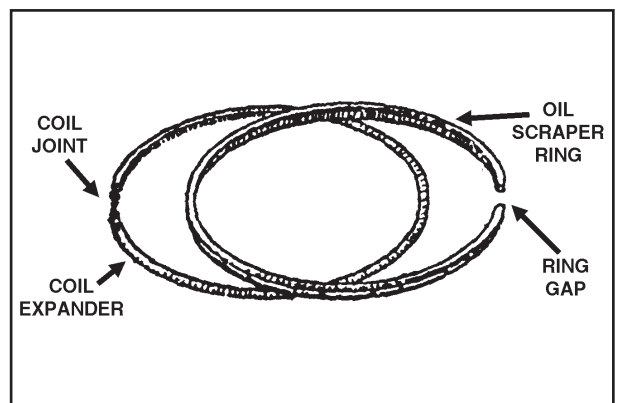
1.4.3.3 Install Piston rings



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 with a feeler gauge.

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

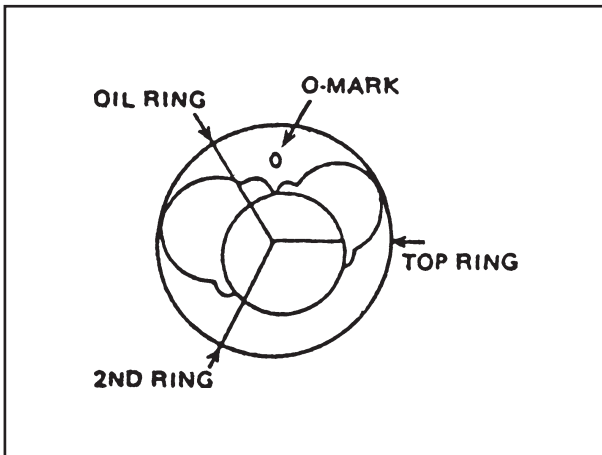
Install the piston ring in sequence viz; oil ring, second ring and top ring with the identification mark at the top of the ring facing upwards.



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 side clearance of the piston rings.



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

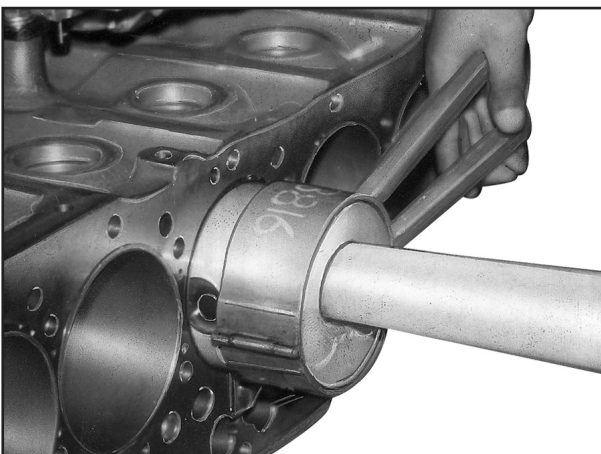
1.4.3.4 Installation

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

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

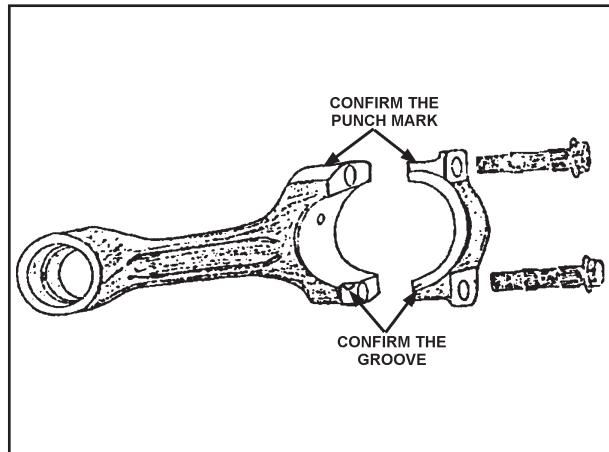
Make sure that 'O' mark on the piston top is on the tappet side, when fitted.

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

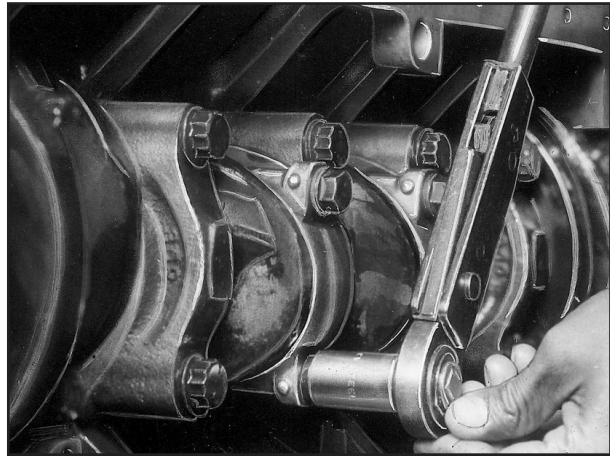


Insert piston with connecting rod assembly into the cylinder bore compressing the piston rings by means of Special Tool P2610647 - Compressor Piston Ring.

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.

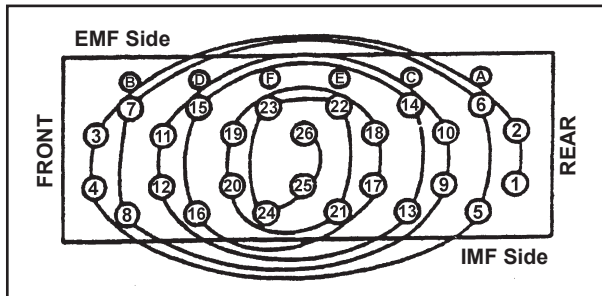
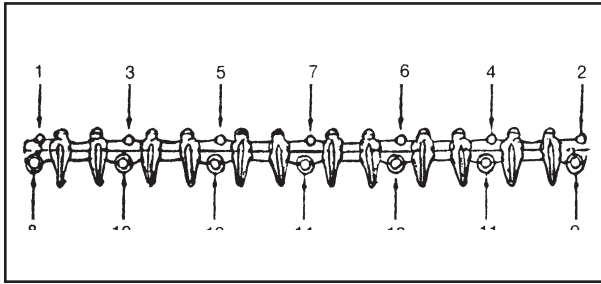


Fit bearing cap with bearing, taking care that the bearing halves are seated properly in the connecting rod and cap. Tighten con rod bolts alternatively to recommended torque. Check Connecting rod end play.



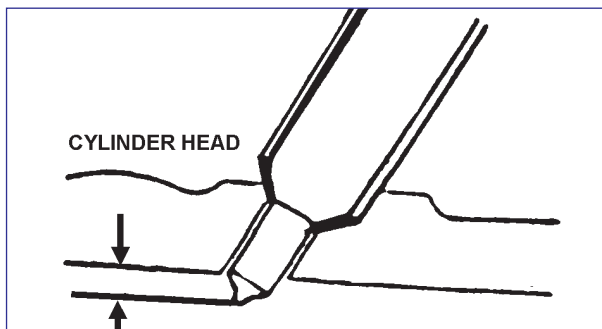
1.5 CYLINDER HEAD ASSEMBLY

1.5.0 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.

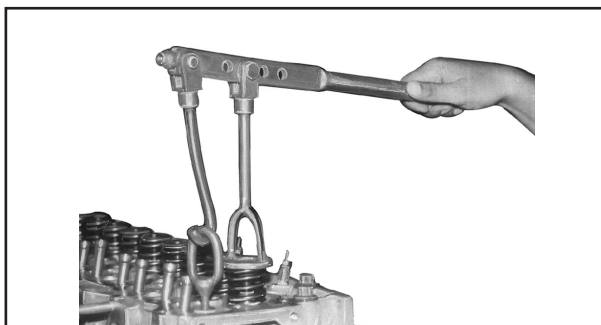
Using a special tool P2607747 - Wrench Cylinder Head Bolt



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 2.3 ± 0.2 mm.

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

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



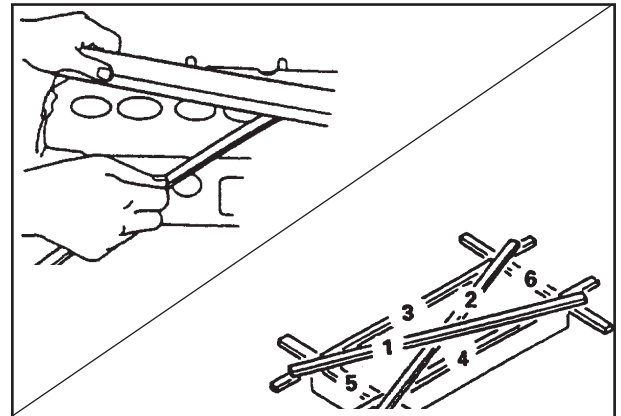
Using Special Tool P2607447 - Compressor Valve Spring.

Remove the inlet and exhaust valves.

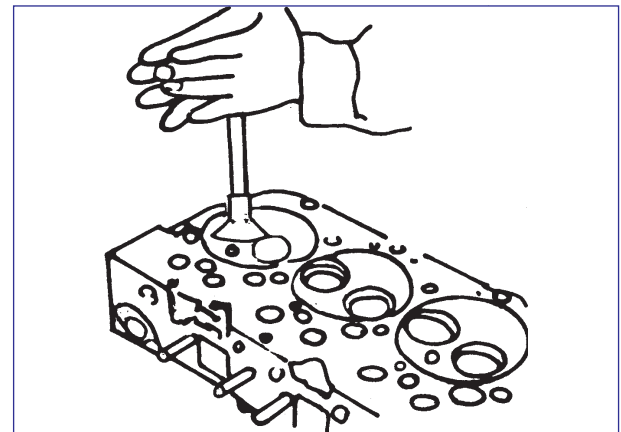
Before removal of all valves, punch the serial nos of cylinder numbers on the valve face, to avoid mixing of valves.

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

Check cylinder head surface unevenness as indicated in the diagram.

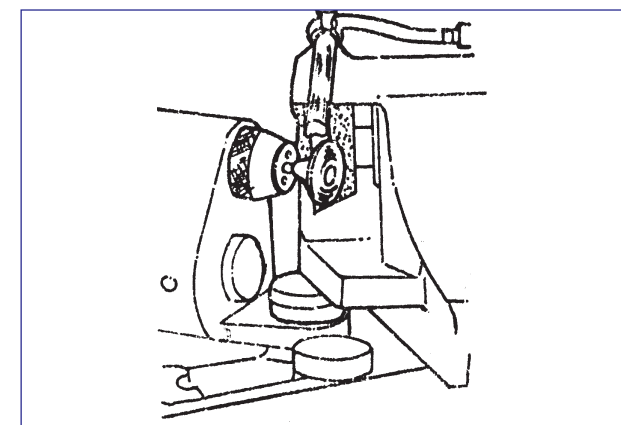


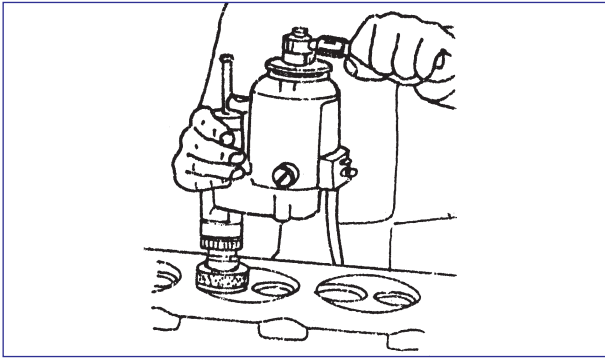
Hand lap valve and valve seat.



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

1.5.1 To Grind Valves and Valve Seats





NOTE

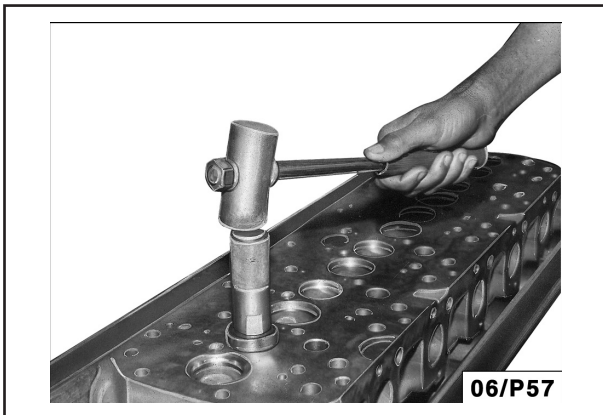
Grinding of valves and valve seats should only be performed when handlapping does not result in proper seating. Any conventional valve grinding machine can be used.

After grinding, always recheck the valve sink.
For repair data refer section 14.0.3.

1.5.2 To Refit the Valve Seat and To Check and Reface Valve Seat

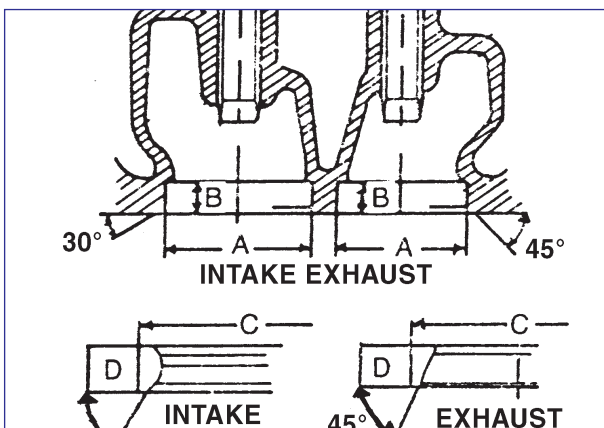
Cut the circumference of a valve head at three places with a grinder and install it into seat and weld valve to seat. Then drive out valve and seat with a hammer and a brass block.

1.5.3 Valve Seat Installation



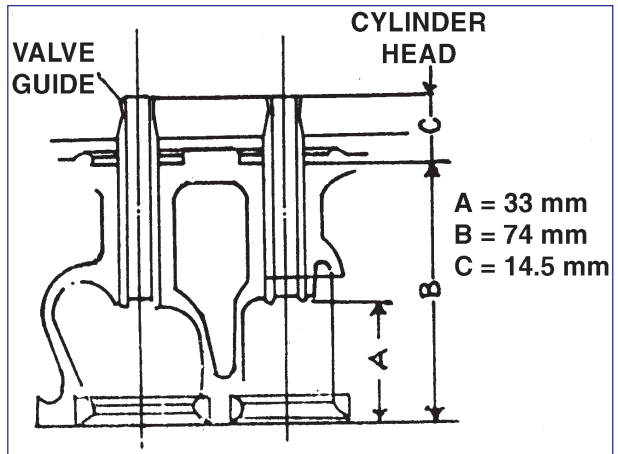
Heat the cylinder head to about 80° - 100°C with hot water. On the other hand, cool the valve seat with dry ice or liquid nitrogen for about 30 minutes. Hold the seat with pincers and place it into the heated cylinder head.

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

1.5.3.0 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

1.5.3.1 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 P2608947 - Drift Valve Guide.

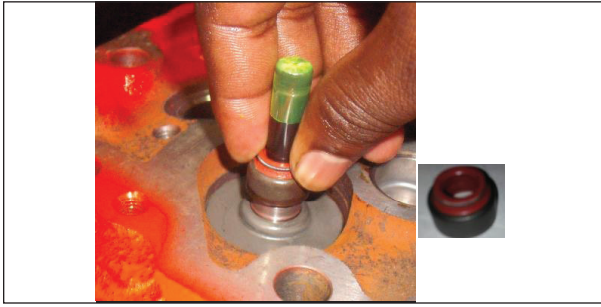
NOTE

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

1.5.3.2 To Refit Valve and Valve Stem Seals



Install the valves and lower spring seat.
Use plastic sleeve (X1102160) before inserting the valve stem seal to avoid oil seal lip damage.



Apply engine oil to the lip of the valve stem seal and insert by hand force.

Remove and scrap the fitment sleeve.



Use correct tool to ensure proper seating of valve Stem Seal on guide.

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

Special Tool P2608247 - Drift Valve Stem Seal.

1.5.3.3 To Check Valve Springs

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

Valve spring straightness= 2.0 mm

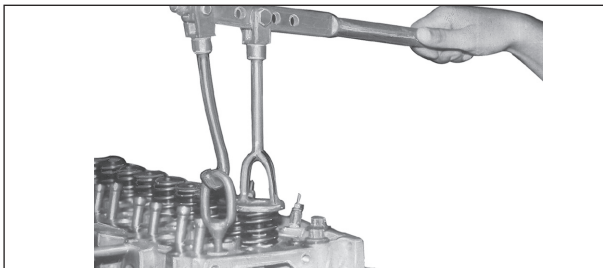
Setting load = 26.5kg at 45.5mm limit 24.6mm

1.5.4 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, if the same valves were used.

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 P2607447 - Compressor Valve Spring. Install the Cylinder Head

NOTE

Only (Multi Layered Gasket) MLF gasket should be used along with Interference Liners

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

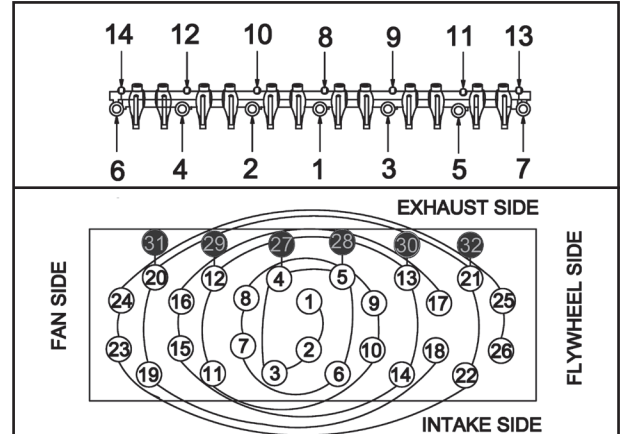
Fit 12 numbers valve lifters on to the cylinder block after applying the oil to the tappet bores on the cylinder block.

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

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

Insert push rod in correct order.

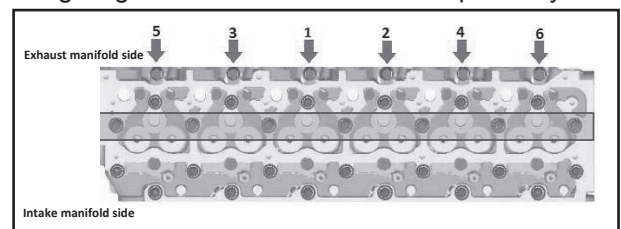
Spiral Tightening Sequence indicating with bolt number



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

Procedure for Yield point tightening of Cylinder head mounting bolts:

- Ensure the cleanliness of the mating components before assembly.
- Dip the cylinder head mounting bolt in oil to the length of 30mm minimum to ensure availability of oil on the threads of bolt and also apply oil on the bolt head before inserting into cylinder head
- Locate and fix 3-4 threads of the cylinder head bolts by hand.
- Tighten the bolts as per the sequence given below:
- Apply a pre-torque of 120Nm. (88 lb-ft)
- Loosen the bolt by 360° (i.e. one complete turn).
- Re-tighten the bolts by applying a torque of 70Nm. (52lb-ft)
- The long and the short Cylinder head bolts to be angle tightened to 180° and 150° respectively.



The 6 numbers M10 bolts are to be tightened in the sequence shown above.

CAUTION

Retightening of cylinder head bolt is not recommended.

Only one reuse of the Cylinder head bolts is accepted, thereafter replace new.

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



1.6 TIMING

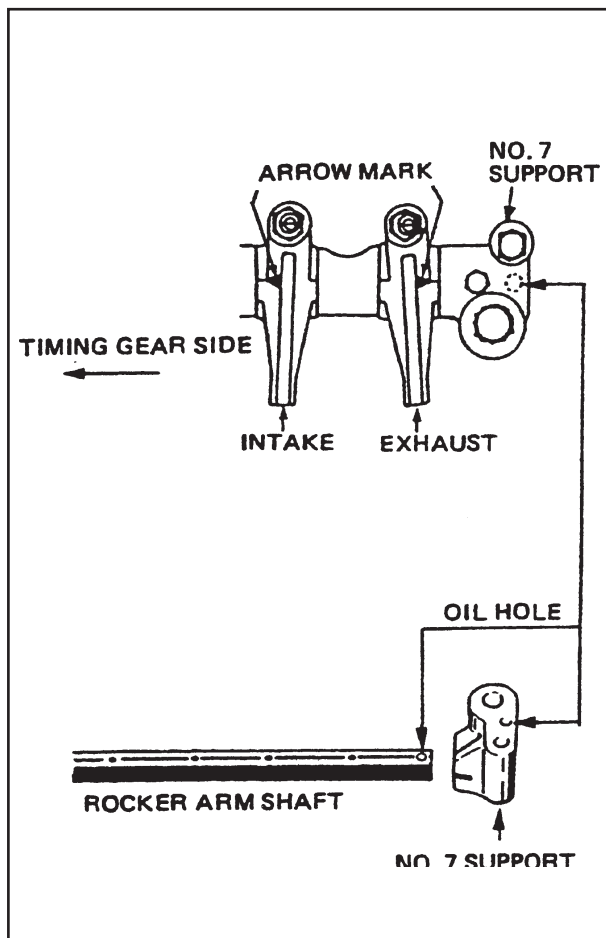
1.6.0 To Remove and Refit Rocker Levers

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.7 support aligns with shaft oil hole.



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

1.6.1 To Remove, Refit and Check Push Rod and Tappets

Remove push rods and tappets.

Check out of true 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.

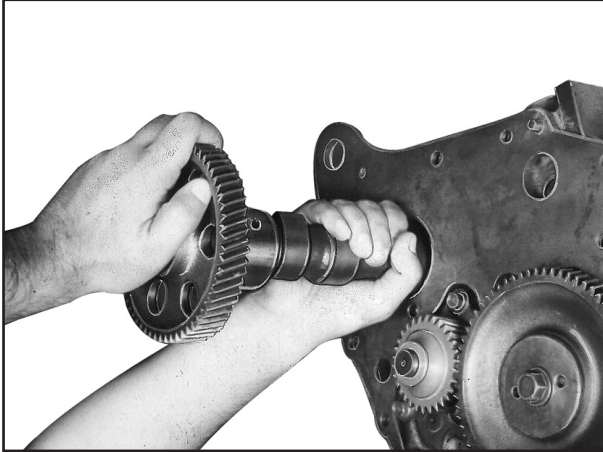


1.6.2 To Remove and Refit Camshaft

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.

1.6.3 Removal and Replacement of Camshaft Bushes

Use Special Tool P2609147 - 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.

1.6.4 Camshaft Bush Dimensions (in mm)

Parent bore diameter

First Bush - 60

Second Bush - 59.8

Third Bush - 59.6

Fourth Bush - 59.8

Bush inner diameter

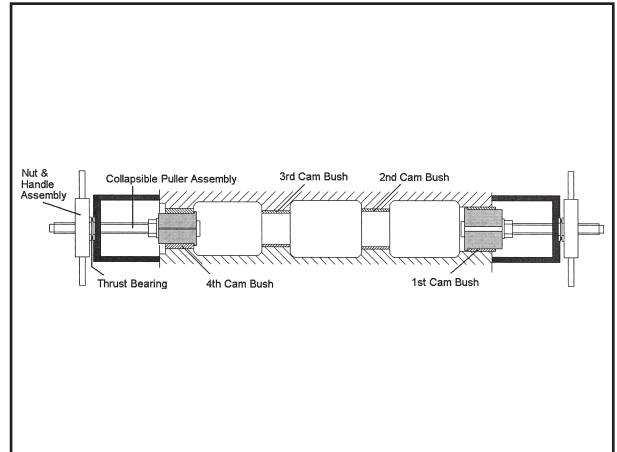
First Bush - 57

Second Bush - 56.8

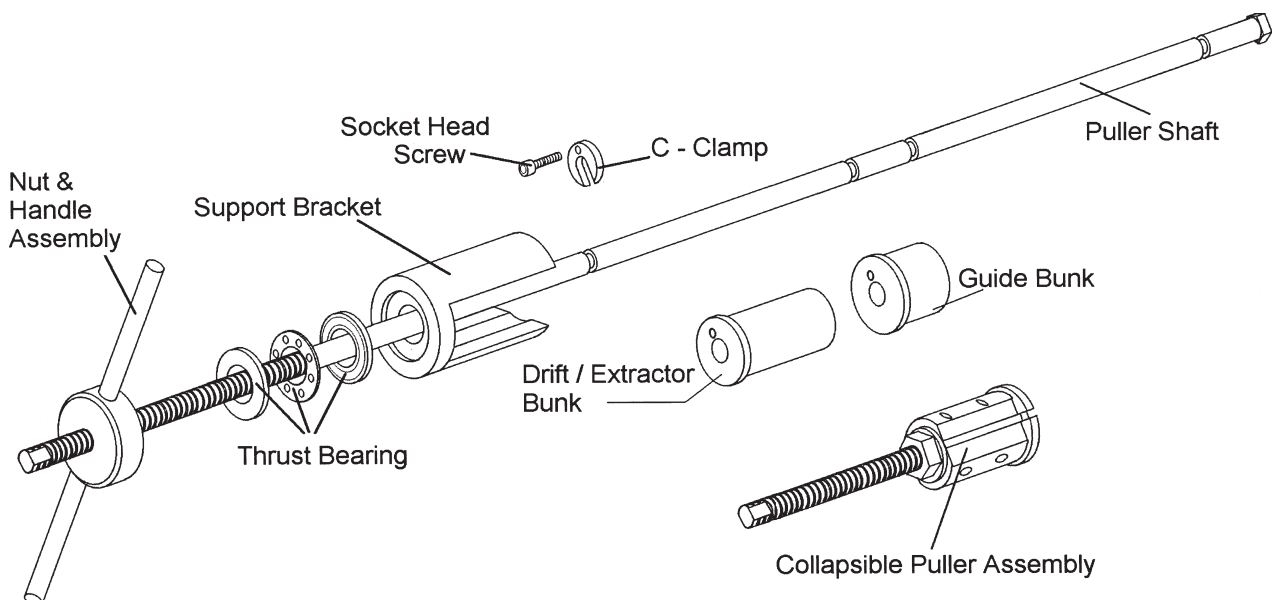
Third Bush - 56.6

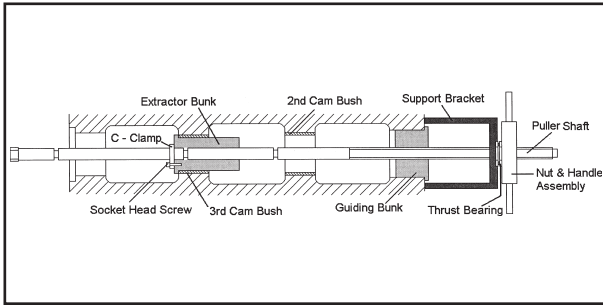
Fourth Bush - 56.4

Proceed in the following manner to remove the camshaft bushes.

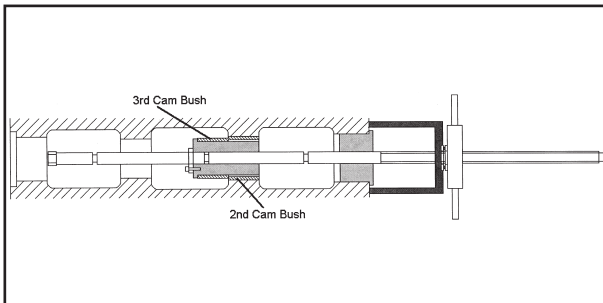


1. Remove the 1st and 4th bushes one after one using collapsible puller assembly and support bracket from front and rear respectively.
2. Compress the collapsible puller and insert the same in to the bush until the collapsible bunk expands and holds the bush snugly.
3. Lightly tighten the nut next to 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.





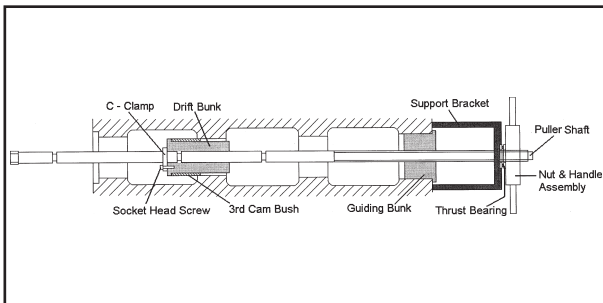
5. Fix the extractor bunk on the appropriate groove on the puller shaft, insert the puller shaft from rear side of the engine carefully locating the bunk inside the 3rd bush.
6. Arrange the guiding bunk, support bracket, thrust bearing and nut & handle assembly at the front end of the engine on the puller shaft and extract the 3rd bush. The 3rd bush will fall between the 3rd and 2nd parent bores of the camshaft bushes now.



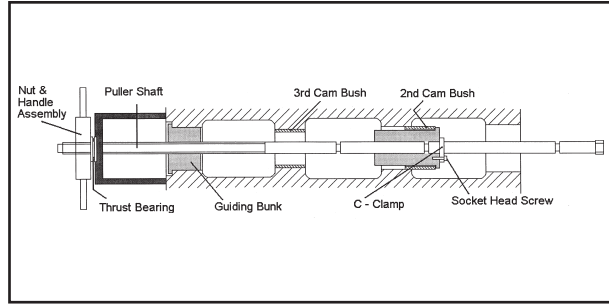
7. Guide the extractor bunk along with the extracted 3rd bush in to the 2nd bush and continue to rotate the nut & handle assembly until the 2nd bush is extracted.
8. Take out the puller arrangement along with the 2nd and 3rd bushes carefully through the 1st bush parent bore of the camshaft.

1.6.5 Installation:

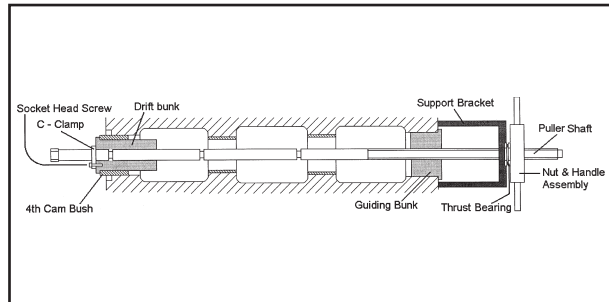
The camshaft bushes are pre-finished; hence handle them carefully.



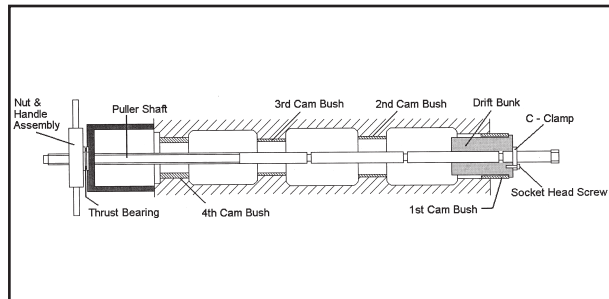
1. Fix the drift bunk on the puller shaft in the appropriate groove on the longer puller shaft as shown. Place the 3rd camshaft bush on the extractor and carefully insert the puller shaft from rear of the engine until the front portion of the drift bunk sufficiently enters the 3rd camshaft bush parent bore. 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.



2. Remove the puller from the cylinder block and place the 2nd camshaft bush on the drift bunk. Insert the puller from the front side of the engine until the front portions of the drift bunk sufficiently enter 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.



3. Remove the puller from the cylinder block and fix the drift bunk in the appropriate groove as shown in figure. Place the 4th camshaft bush on the bunk and insert the puller shaft from rear end of cylinder block until the front end of the bunk is sufficiently inside the parent bore of the 4th camshaft bush as shown. 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 and handle assembly until the 4th 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.



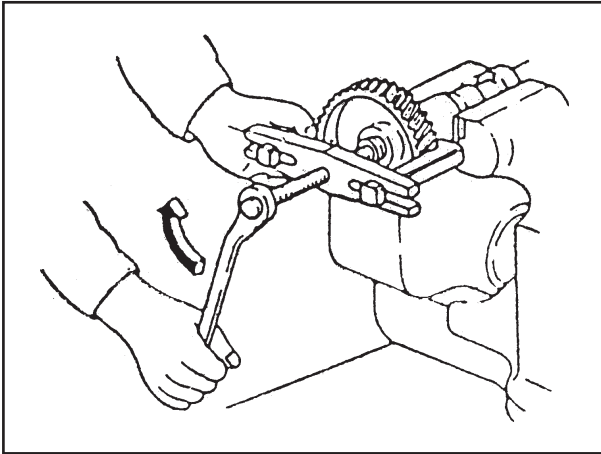
4. Remove the puller from the cylinder block and place the 1st gear bush on the drift bunk. Insert the puller from front end until the front portion is sufficiently inside the parent bore of 1st camshaft bush parent bore. Arrange the support bracket, thrust bearing and nut & handle assembly at the front end of the cylinder block as shown in the figure, centralize the puller shaft at the rear and tighten the nut & handle assembly until the 1st camshaft bush is in its place.



To refit camshaft reverse the procedure for removal.

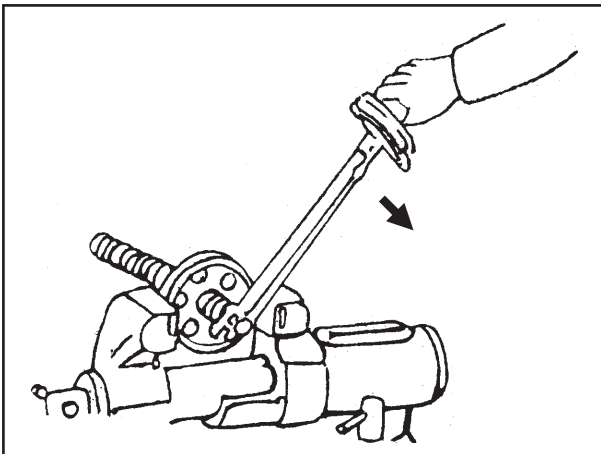
If necessary, remove the camshaft gear

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



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

1.6.6 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.

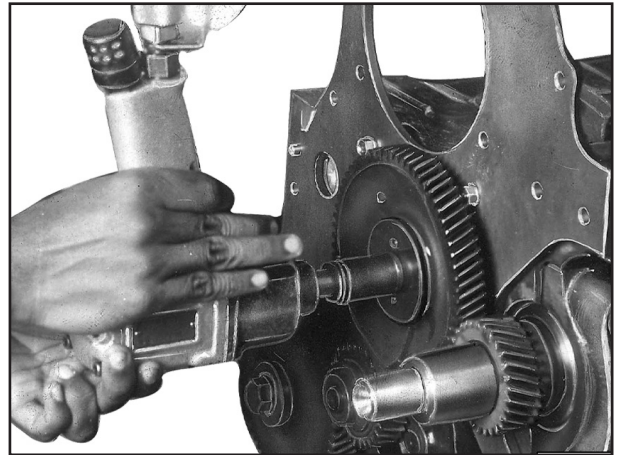
1.6.7 To Refit the Camshaft

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

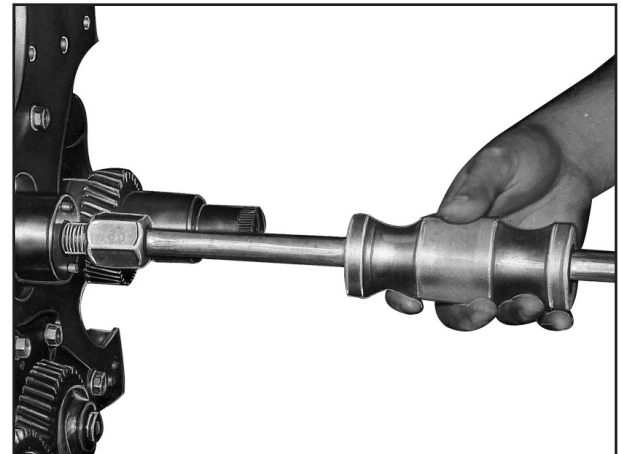
Lubricate all journals of the camshaft and insert the camshaft assembly into the cylinder block, by slowly turning, so that the bearing will not be damaged.

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

1.6.8 To Remove and Refit Intermediate Timing Gear

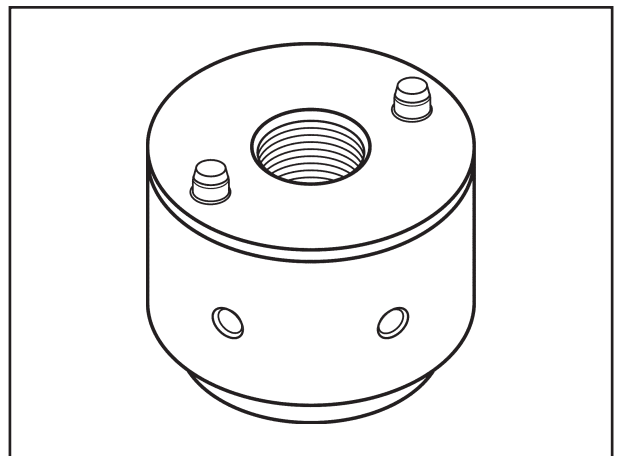


Backout fixing bolt and remove it with thrust washer, withdraw intermediate gear.



To remove the spindle use special tool P2607247 - Sliding Hammer and special tool P2607147 - Adaptor Idler Gear Shaft.

1.6.9 Install the Idler Gear Shaft (Spindle)

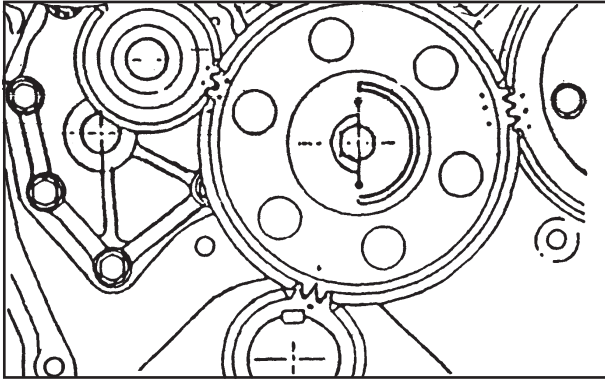


Install idler gear shaft with thrust plate using a plastic hammer.

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.



1.6.10 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.

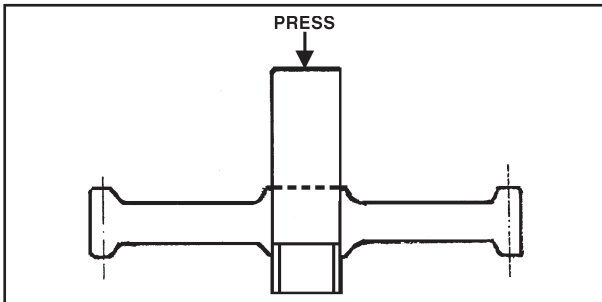
Check end play within 0.040 - 0.095 mm.

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 $100 \text{ Nm} + 120^\circ \pm 5^\circ$

1.6.11 To Re-bush Intermediate Gear



Press out the worn bush with a suitable drift.
Drive in the new bush.

NOTE

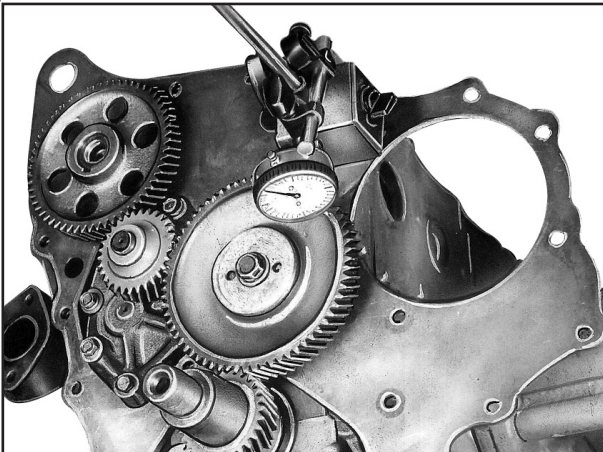
The replacement bush is supplied finished.

Max. oil clearance between spindle and bush = 0.1 mm

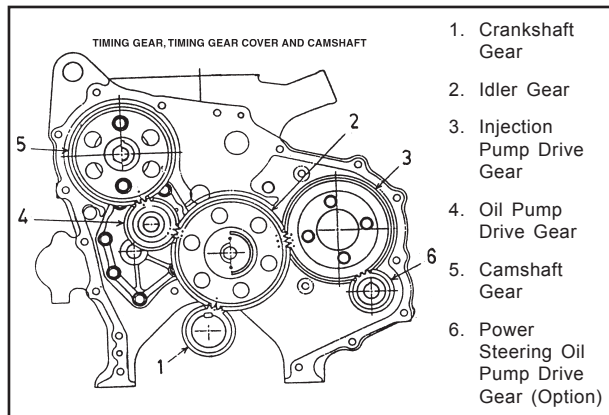
Intermediate gear endplay = 0.15 mm

Bush internal diameter = 50.00 mm

Spindle dia = 49.95-49.97 mm

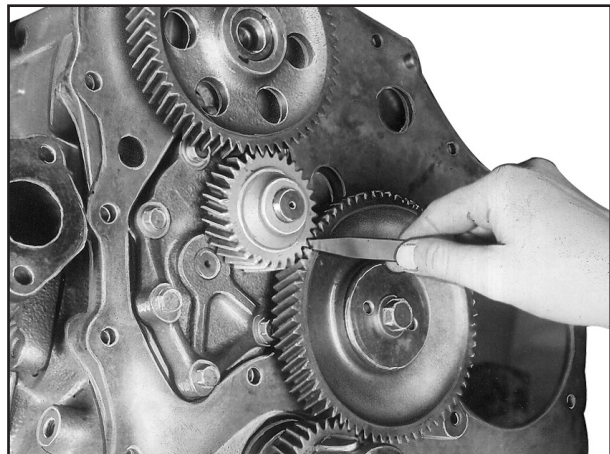


1.6.12 To Position Timing Gears for Valve Timing and FIP Timing



The gear train to be matched as per matching punch marks on gear circumference.

1.6.13 Timing Gear Backlash Checking

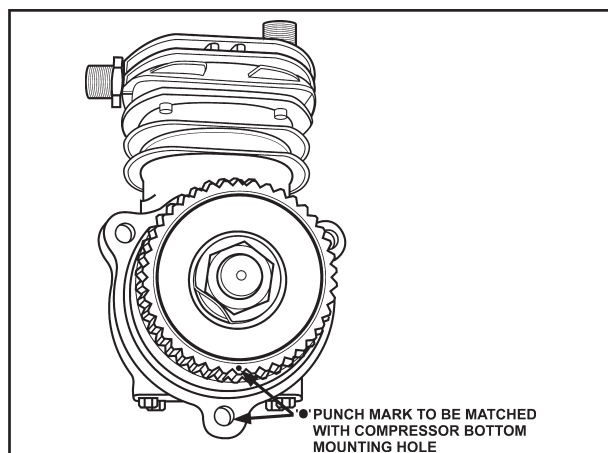


Check tooth backlash with feeler gauge.

Backlash between driving gear and intermediate gear.

Max. limit = 0.3 mm.

1.6.14 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.

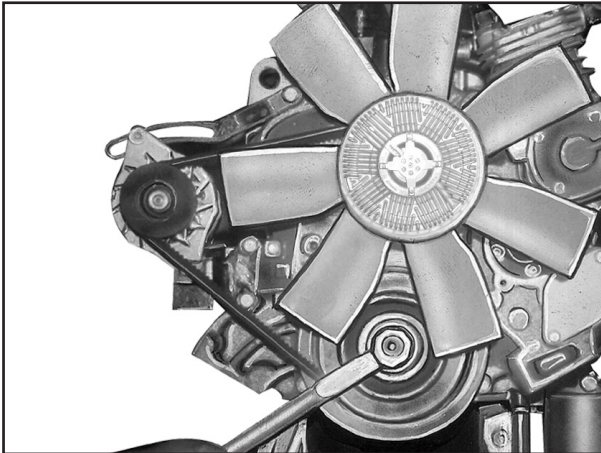


1.6.15 To Remove and Refit Fuel Injection Pump and To Adjust the Injection Timing

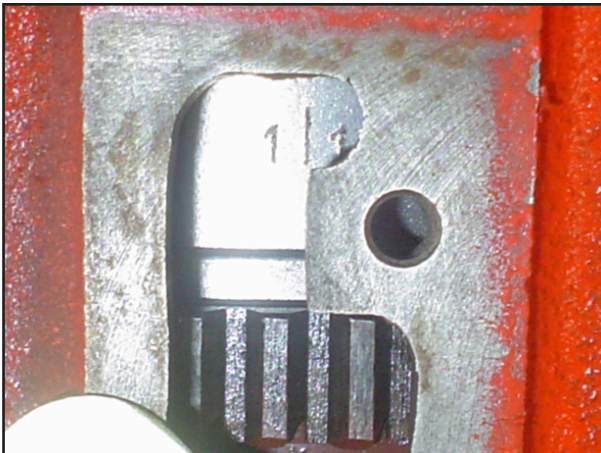
Use special Tool P2609247 - Wrench for Engine Cranking.

A. Removal of FIP from Engine:

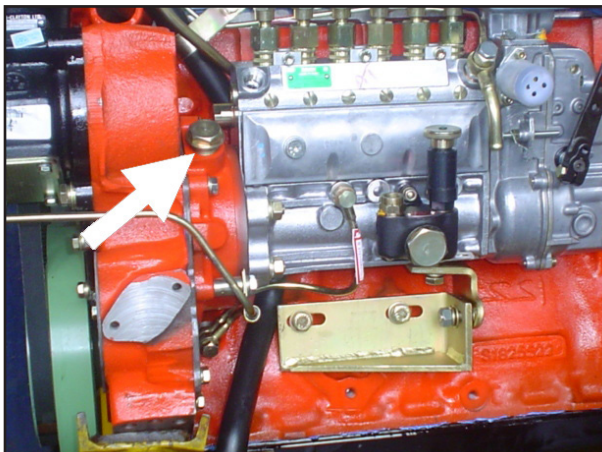
1. Isolate battery.
2. Remove high pressure pipe connections, remove over flow pipe and boost compensator pipe. Remove the FIP support bracket.
3. Remove the front cover case bearing holder.



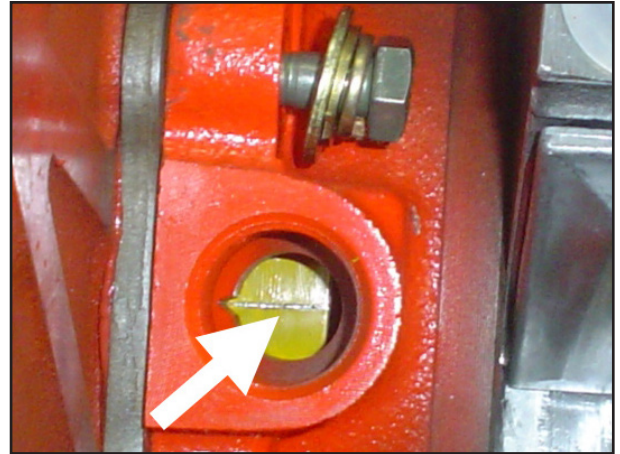
4. Rotate the engine clockwise direction viewing from the front of the engine.



Align the ING mark on the flywheel with the timing pointer on the flywheel housing. Also ensure that the first cylinder at the end of the compression stroke.



5. Remove the plug from the timer hole.



6. Check the injection timing mark on the timer is aligned with the timer cover pointer.
7. Loosen and remove the mounting bolts of the FIP from the timing casing. Remove the FIP.

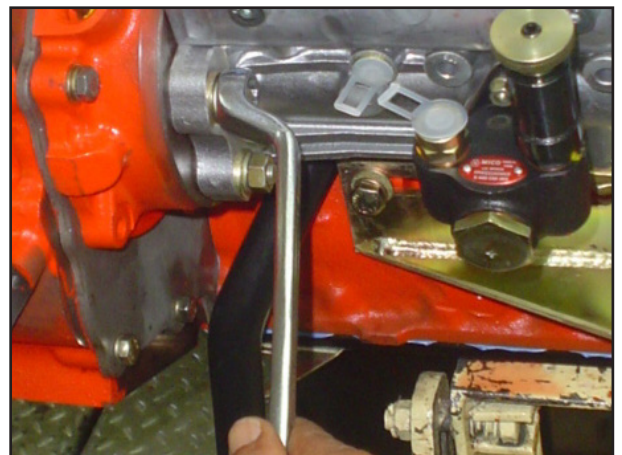
C. To Refit the Fuel Injection Pump and adjusting the Fuel Injection Timing

1. Bring the no.1 cylinder at TDC on compression stroke.
2. Align ING mark on the engine flywheel with the timer pointer on the engine flywheel by rotating the engine clockwise direction (viewing from the front of the engine). Also ensure that the first cylinder at the end of the compression stroke.

NOTE

Engine should not be rotated anticlockwise direction to align ING mark.

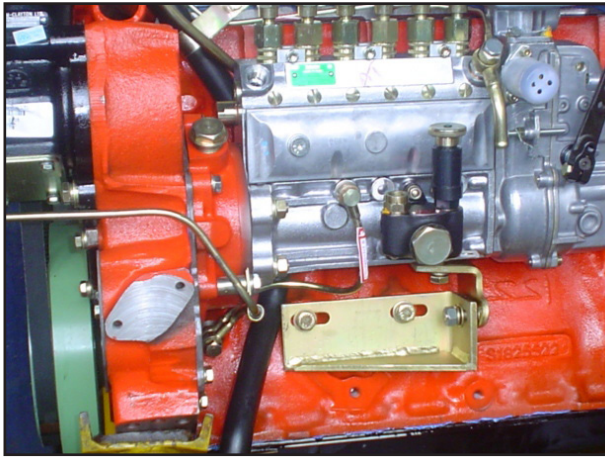
3. Check the FIP mounting Gasket.
4. Fit the FIP onto the engine aligning the injection pump drive gear.
5. Fix the FIP mounting bolts onto the timing case and tighten.
6. Check the injection timing mark on the timer is aligned with the timer cover pointer.



7. If not adjust the injection timing mark, by loosening the four mounting bolts of the injection pump drive gear and align the mark.

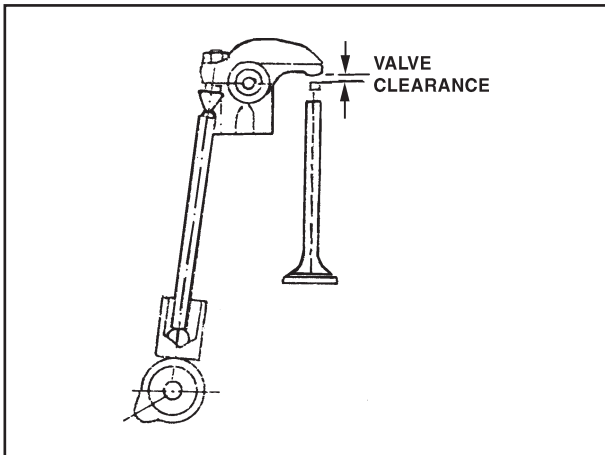
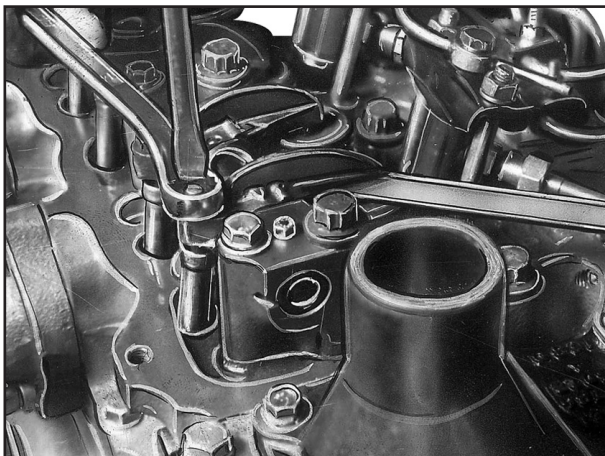


8. Tighten the injection pump drive gear mounting bolts (If loosened).
9. Fix the timer hole plug and front bearing casing cover and tighten.



10. Refit the injector pipe connections, overflow pipe and boost compensator pipe, lub oil pipe connections and FIP support brackets.

1.6.16 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.

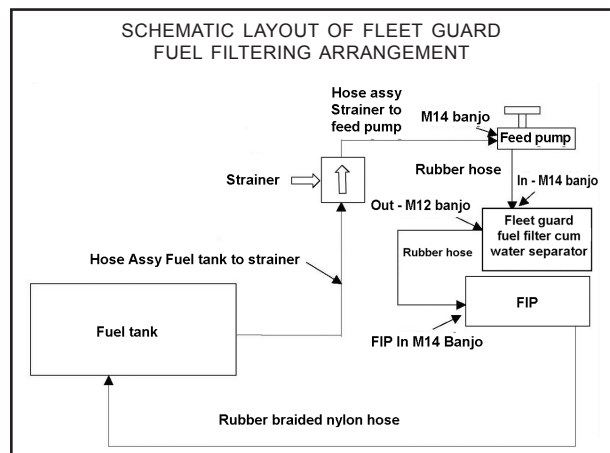
Valve clearance -

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.

1.6.17 Fuel Filters

Effective fuel filtration is absolutely essential for trouble free operation of the fuel injection equipment. Fuel filters have been designed to retain even the smallest of the impurities and protect the extremely sensitive precision parts of the injection pump and nozzle from damage.

1.6.18 Fuel Filter cum Water separator (Fleet Guard Make)



Fleet guard fuel filtering system consists of a strainer (Fitted before feed pump) and a fuel filter cum water separator (fitted at pressure side before FIP).

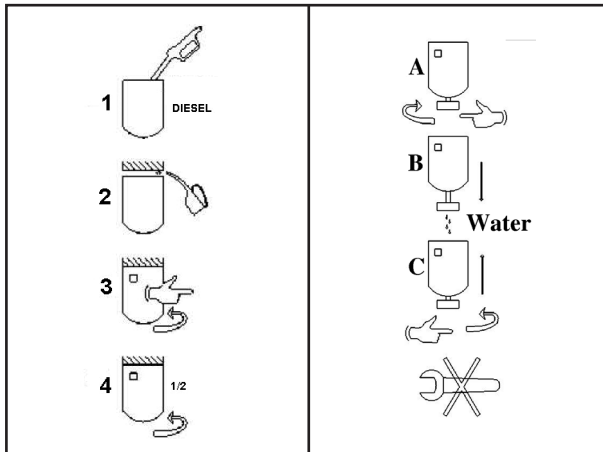
For ease of identification, fuel in and out ports are embossed clearly on the filter-head.

Further, as a mistake proofing, the fuel in port is provided with M14 size and fuel out port is provided with M12 size threads.

Maintenance

Fuel filter must be replaced at regular intervals for efficient operation.

For replacement period refer Maintenance Schedule.


Renewal procedure for Fuel Filter cum Water separator.


Renewal of
Fuel Filter cum water
separator

Draining Water from
Water Separator

- Remove old filter using a filter wrench.
- Clean filter base and ensure that all the old gasket material is completely removed.
- Check the filter mounting adaptor for tightness.
- Install spud/thread seal.
- Apply a thin coat of clean engine oil to the gasket sealing surface of the new filter. Press the gaskets firmly into the gasket retainer groove while lubricating the sealing gasket. Do Not Use Grease.
- Carefully read the installation instructions printed on the outside of the filter to determine the number of turns the filter must be rotated past gasket contact for proper installation and gasket compression.
- Pre-fill the new filter with clean fuel.
- Spin on the new filter until the sealing gasket makes contact with the sealing surface on the fuel filter head.
- Mark a reference point on the filter and head to identify the point that the sealing gasket first makes contact with the sealing surface of the head.
- Rotate the filter the number of turns past gasket contact indicated by the installation instructions printed on the side of the filter canister.
- Start the engine and check for fuel leakage around the sealing gasket and filter assembly.

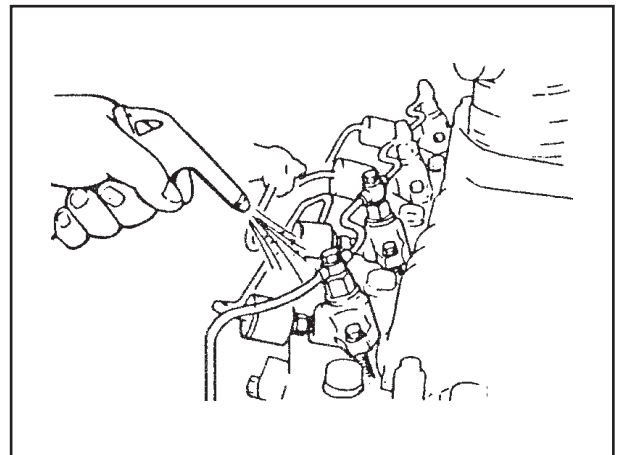
Procedure for draining water

Drain water from the unit as per the instructions provided on the component (See right side picture).

- Rotate the drain cock anti-clockwise (as shown in the instructions printed on the outside of the filter)
- Drain the water till the fuel starts to flow.
- Rotate the drain cock clockwise the number of turns as indicated by the installation instructions printed on the side of the filter canister.
- Start the engine and check for fuel leakage around the sealing gasket and filter assembly.
- Never use a spanner for rotating the drain cock.


CAUTION

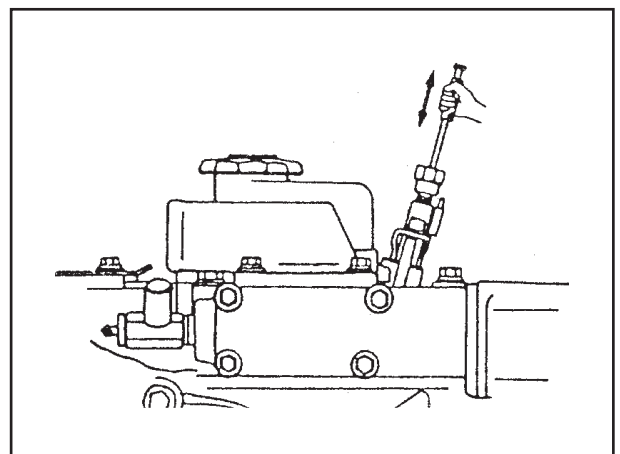
Drain water daily or as and when required depending upon the prevailing condition. Drain cock should be hand tightened fully. Never use any spanner.

1.6.19 To Remove and Refit Injector Nozzle


Clean the surrounding area of the nozzle and fuel line connections.

Remove injector pipes, clean and cover both the ends of the pipes to prevent entry of the dirt.

Remove nozzle assembly.



Use a special tools 0102015 - Adaptor Injector Removal and P2607247 - Sliding Hammer.



1.6.19.0 Cleaning

**IMPORTANT**

Drain water daily or as and when required depending upon the prevailing condition. Drain cock should be hand tightened fully. Never use any spanner.

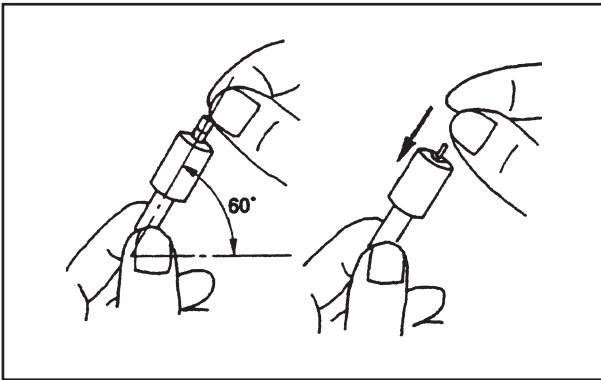
To Clean nozzles

Use ultrasonic cleaning equipment.

Ultrasonic cleaning is a safe and effective way of cleaning the nozzles.

Ultrasonic cleaning equipment consists of generator capable of generating electrical energy at an ultrasonic frequency and a 'transducerized tank' which holds the cleaning solution and the parts to be cleaned. The Ultrasonic frequency waves are transmitted to the cleaning solution contained in the tank, which dislodges the dirt and soot.

The main objective of using this equipment is to clean the spray holes of the nozzles especially the DSLA type in which the ball profile is soft.

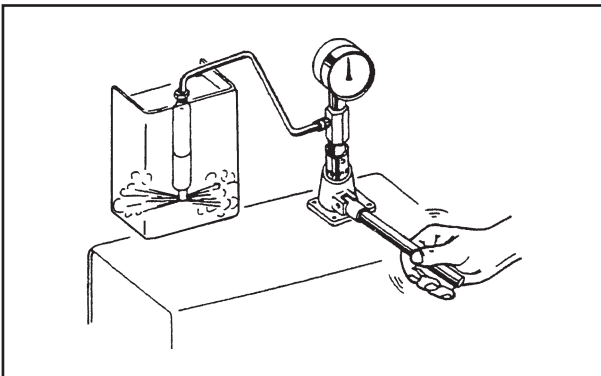
1.6.19.1 Test the nozzle sinking

Wash the nozzle with the diesel then immerse it in diesel oil.

Slide the needle inside the nozzle and ensure moves smoothly. The needle should fall under its own weight when withdraw vertically about 1/3rd and released. If its motion is sluggish, replace the nozzle with new one.

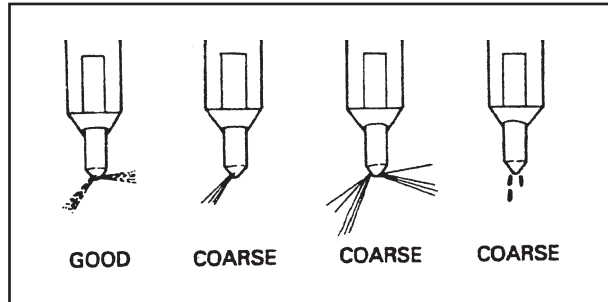
Adjust the injection pressure.

Connect the nozzle holder with a nozzle tester and move the lever at the rate of about 50 - 60 strokes per minute.

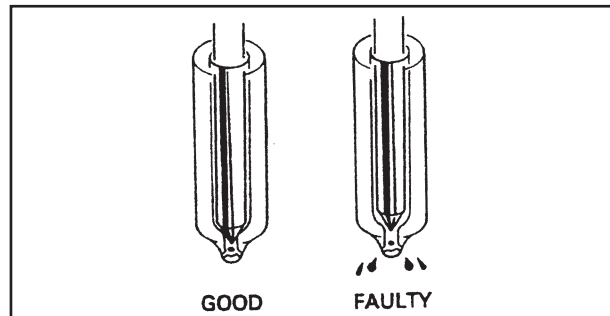


Adjust the injection pressure as recommended.

If the injection pressure is not within specifications, readjust the injection pressure with the shims.

1.6.19.2 Test the spray profile

In case of the new nozzle, operate the lever at the rate of 30 - 60 strokes per minute and for a used nozzle, operate the lever at the rate of 15 - 60 strokes per minute.

1.6.19.3 Test the fuel leakage (Dribbling)

When checking for fuel leakage from the nozzle, apply a pressure of about 10 - 20 kg/cm², to lower than correct injection pressure to the nozzle. If there is no leakage, the nozzle is normal.

1.6.19.4 Install the nozzle holder assembly.

Fit the new nozzle washer.

Tight the nozzle holder bolts alternatively right and left, tightening the bolts gradually until the specified torque is reached evenly [Torque 150 kgcm (11 lb.ft.)].



1.7 ENGINE LUBRICATION

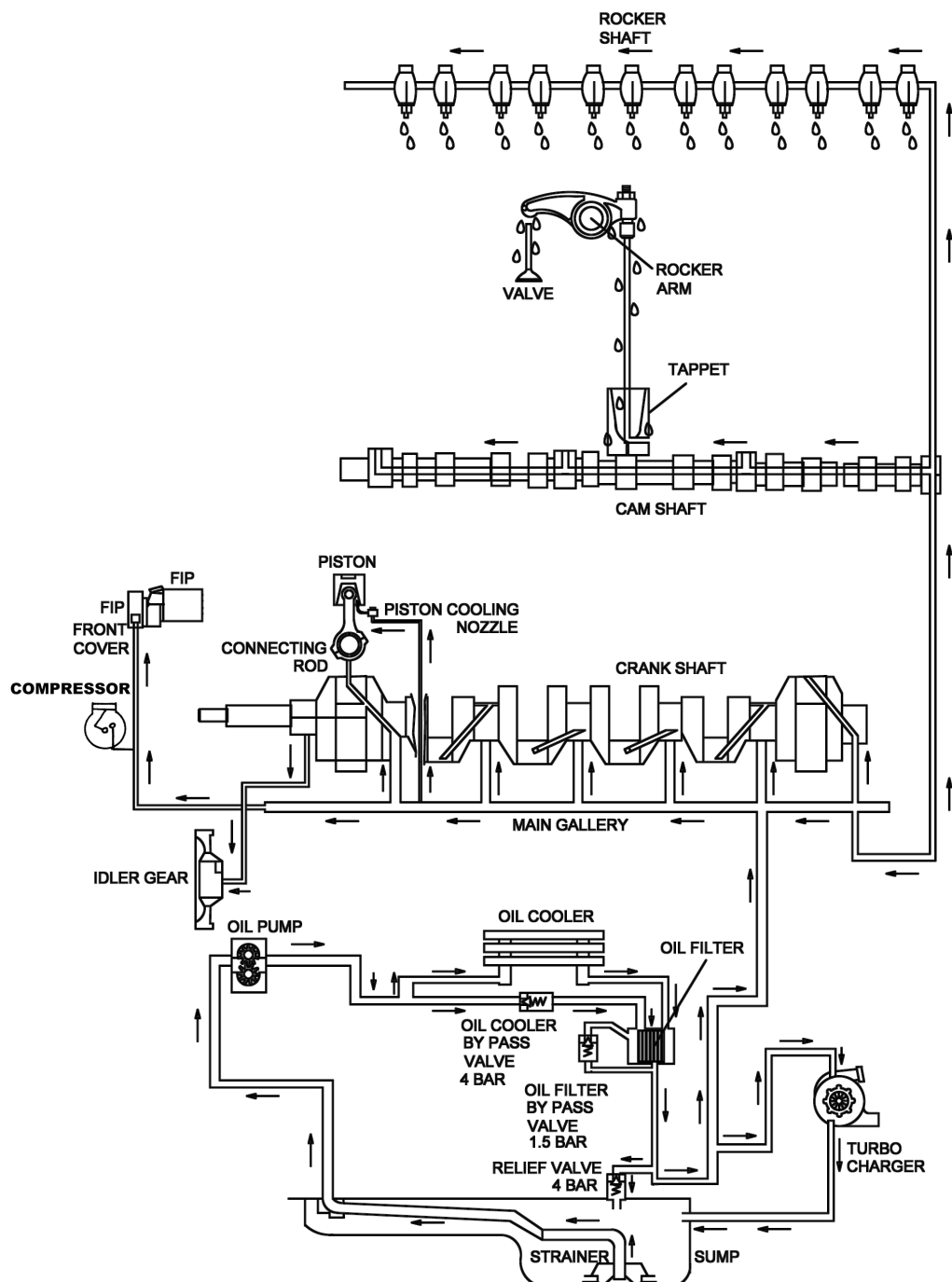
1.7.0 Design and Operation

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.

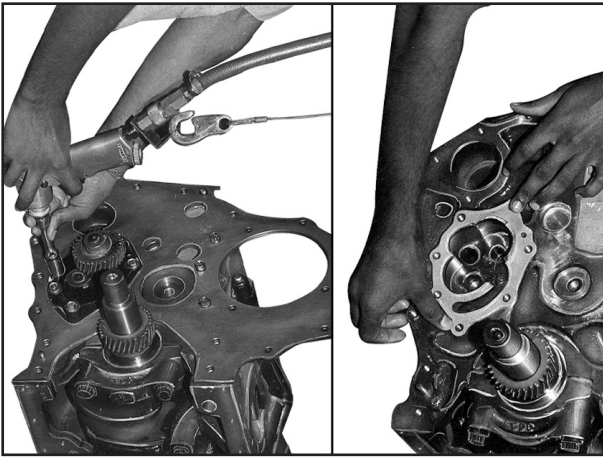
The oil pump forces the oil from the sump to the oil cooler. The oil is then filtered through full flow paper type oil filter,

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.6 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. The lubricating oil for the injection pump and Air compressor is tapped off from the duct feeding 1st main journal and carried to the injection pump and Air compressor by the pipe arranged outside the crankcase.



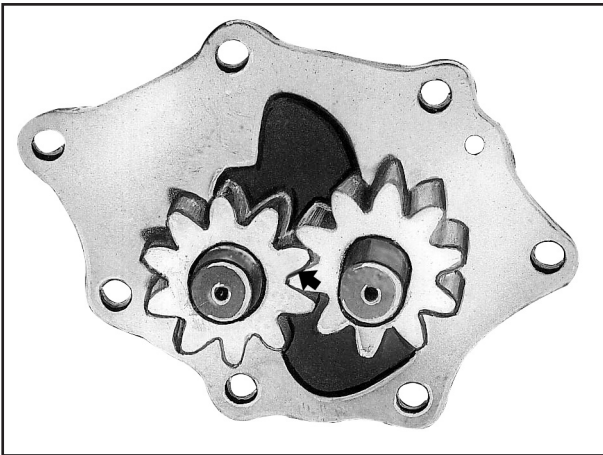


1.7.1 To Remove and Refit Oil Pump



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

1.7.2 To Overhaul Oil Pump



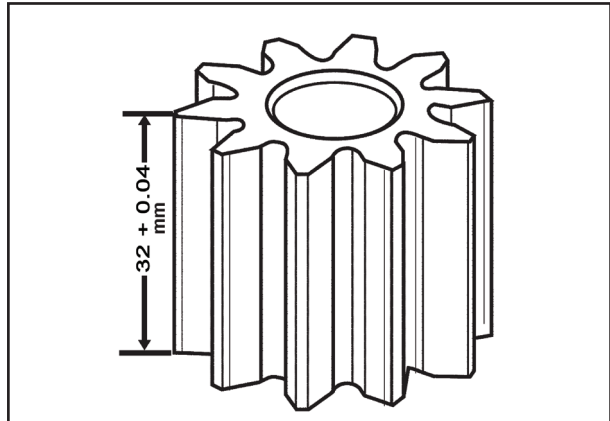
Check Gear backlash between oil pump gears standard 0.09 - 0.21 mm (limit - 0.30 mm).



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).

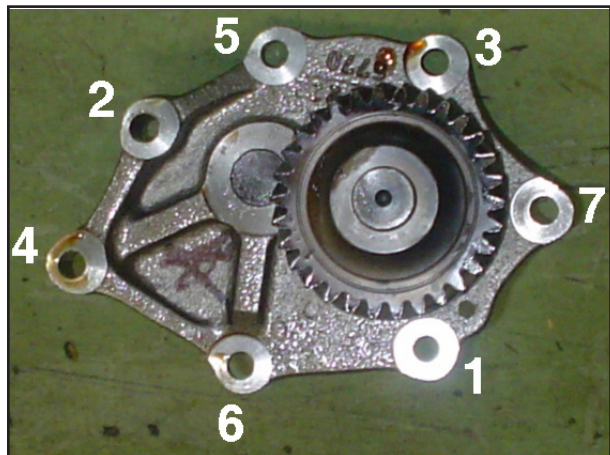
Check clearance between driven gear and shaft 0.040 - 0.075 mm (limit - 0.1mm). Replace gear or shaft whichever is worn excessively.

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 32 + 0.04 mm.

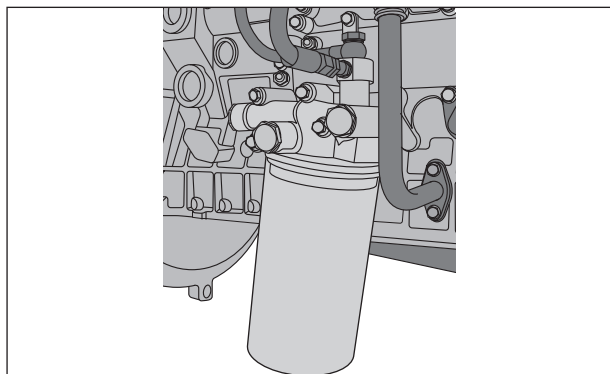
1.7.3 To Refit the Oil Pump



The oil pump assembly is fixed by means of 7 screws, Tightening sequence of the oil pump.

1.7.4 To Overhaul Oil Cooler and Filter Assy

1.7.4.0 To Remove



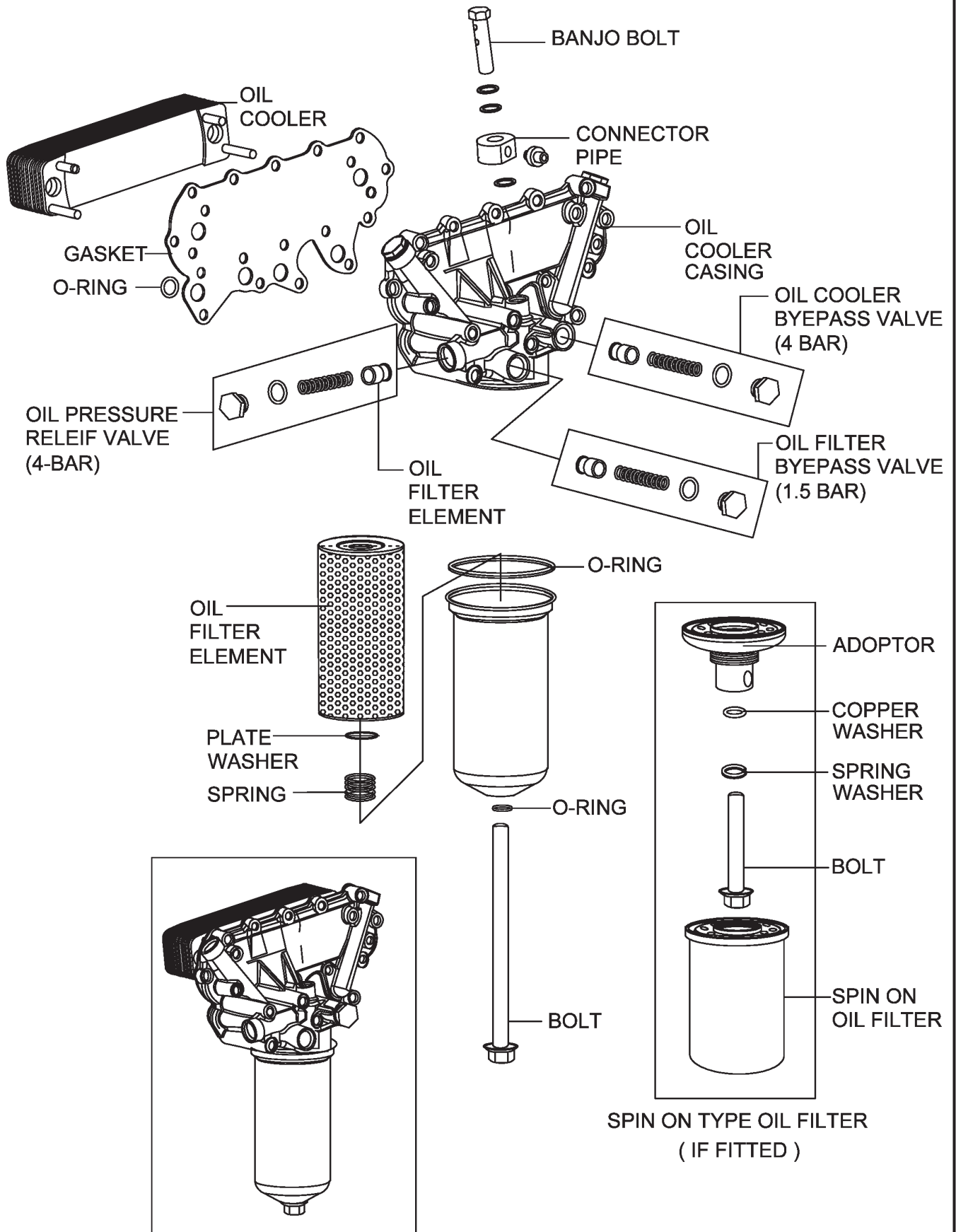
Remove the entire assy of oil cooler and oil filter from engine after draining coolant from cylinder block and oil from the oil filter

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



OIL COOLER AND OIL FILTER ASSEMBLY





Clean the oil filter head and oil cooler plate.

Clean the oil cooler.

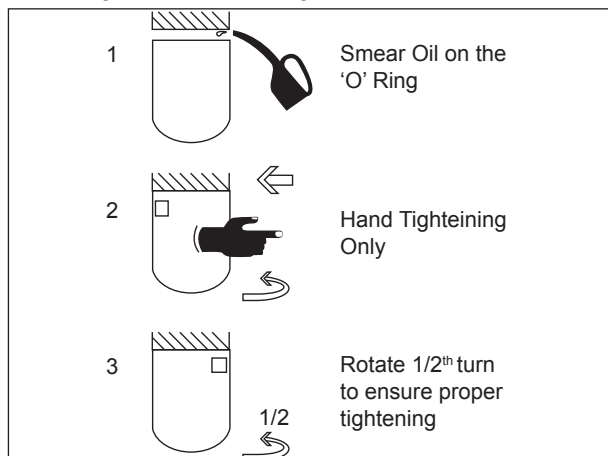
Assemble the oil cooler by-pass valve.

Assemble the oil filter by-pass valve.

Assemble oil pressure regulator valve.

Assemble oil pressure gauge adaptor.

Renewal procedure for spin on oil filter



Remove the old filter using a filter wrench. Clean filter base (adaptor) and ensure that all the old washer is removed.

Check the filter mounting adaptor for tightness.

Apply thread seal.

Apply thin coat of clean engine oil to the washer sealing surface of the new filter. Do not use grease.

Carefully read the installation instructions printed on the outside of the filter to determine the number of turns the filter must be rotated past washer contact for proper installation and washer compression.

Pre-fill the new filter with clean engine oil.

Spin on the new filter until the washer makes contact with the sealing surface on the filter head.

Mark a reference point on the filter and head to identify the point that the sealing washer first makes contact with the sealing surface of the head.

Rotate the filter by 1/2th number of turns past washer contact.

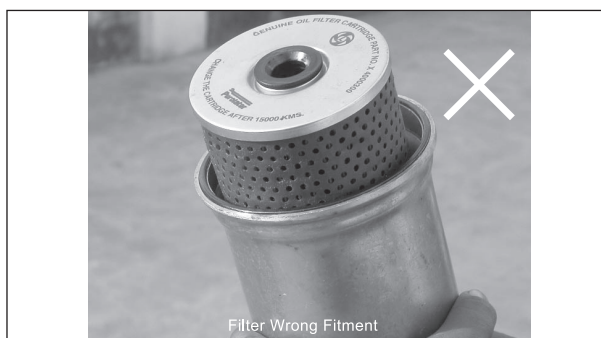
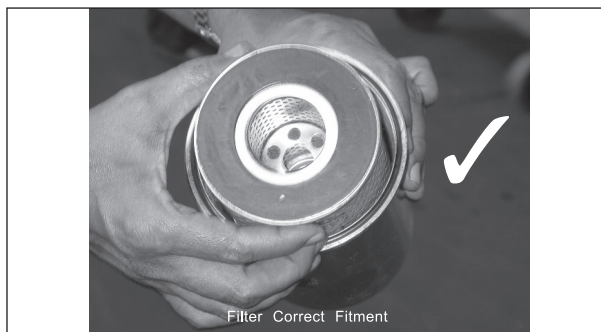
Start the engine and check for oil leakage around the sealing washer and filter assembly.

If fitted with cartridge type oil filter

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.

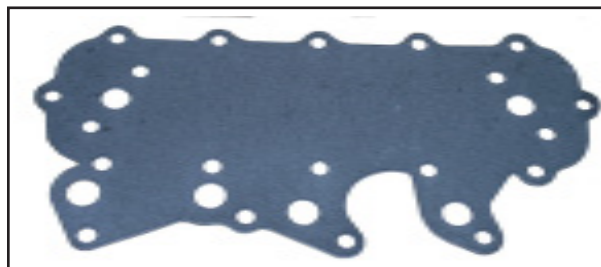
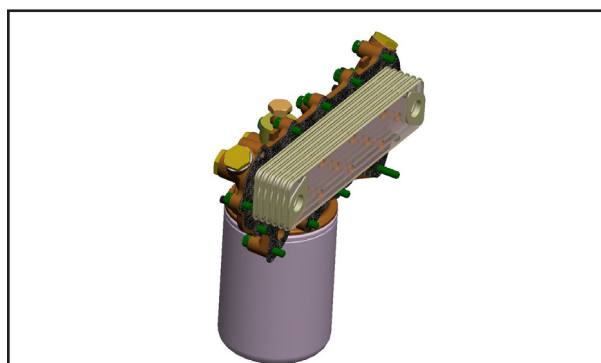
Refit the spring and the plate washer in the bowl.



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.

1.7.4.1 To Refit Oil Cooler



Clean the gasket sealing faces thoroughly.

* 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.



1.7.4.2 Cleaning Guidelines for Oil Mist Separator (DE5810)

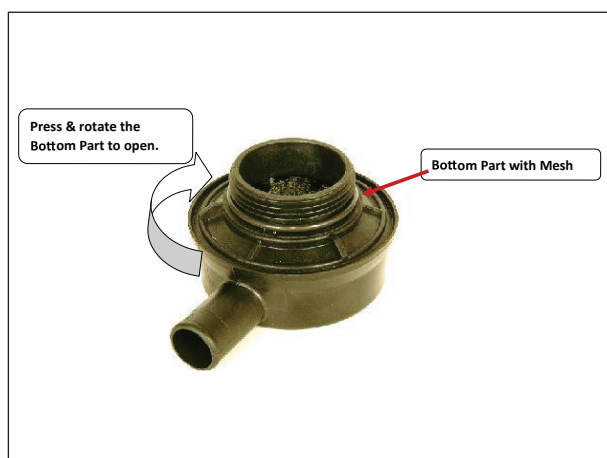
Along with the gases being filtered through the Breather, there are also traces of oil, moisture and grease that can build up and cause problems. A clogged valve can lead to reduced fuel efficiency, and if it is unable to open properly, it can also damage the engine. This is why it is important to clean the valve regularly.

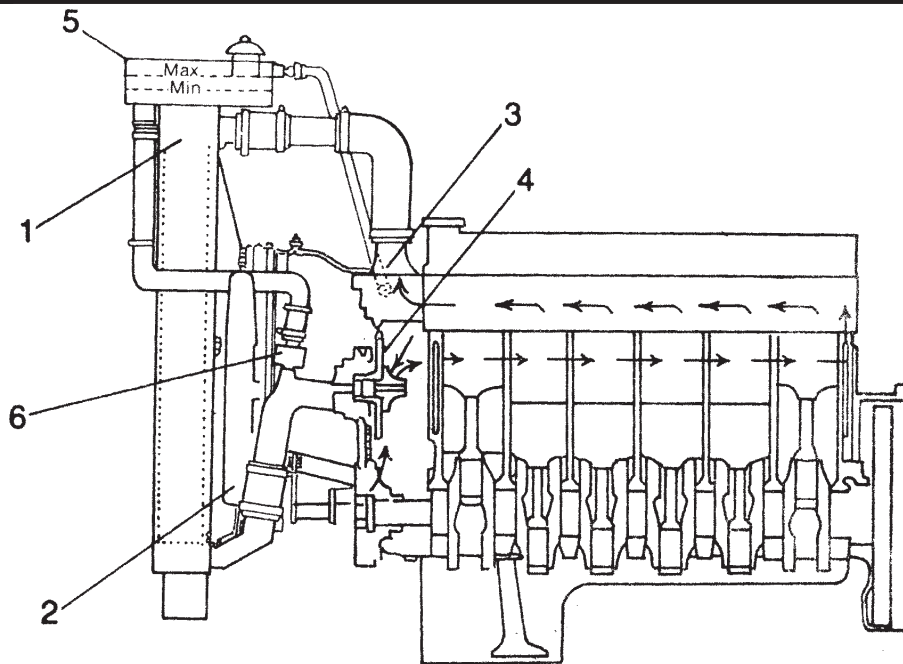
It is Recommended that Breather Valve be cleaned/ replaced after 500/1000 hours of operation based on Condition.

Due to obstruction, clogging can take place due to varnish built up and deposits of burnt oil, grease and gum.

This section has instructions for doing cleaning operation.

1. Carefully pull the hose off of the top of the Breather valve & remove the valve from the adaptor. Then press rotate the bottom part of Breather.
2. a.) Spray a liberal coating of engine degreaser or carburetor cleaner (mixture of various solvents available with 3M and other companies) on the mesh fitted in the bottom part with container nozzle.
b.) Alternately, if nozzle fitted can is not available then immerse the Bottom part with wire mesh in the loose fluid to initiate cleaning action
3. Blow the wire mesh with compressed air.
4. If varnish build up is observed on the suction side, clean it with solvent & brush. Use compressed air after cleaning to blow off debris/wastes.
5. After cleaning, fit the Bottom part with the Breather Valve.
6. Check and replace "O" Ring if damaged.
7. Reconnect the rubber hose to the top of the Breather valve.





1. Radiator
2. Cooling Fan
3. Thermostat
4. Coolant Pump
5. De-aeration Tank
6. Non-return valve

Water pump : Heavy Duty sealed 55 mm dia integral shaft bearing

1.8 COOLING SYSTEM

1.8.0 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 Engine operation the thermostat functions to maintain the operating temperature of 80° to 95°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.

NOTE

Make sure that the rate of filling of coolant is moderate so as to avoid air traps which are likely to cause cylinder head gasket failure.

1.8.1 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.

1.8.2 External Cleaning of Radiator

The radiator tubes/fins may be cleaned by washing them with using a suitable hot cleaning solutions such as 0.5ℓ of HP Radiator cleaner (supplied by M/s Hindustan Petroleum corporation).

A 5% caustic soda solution (sodium hydroxide) may also be used for this purpose. In addition, the radiator fins can be blown from the inside with air or water with less than 2 kg/cm² pressure.



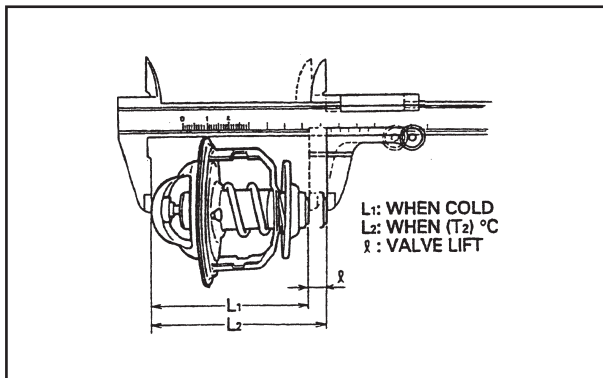
1.8.3 To Test Thermostat



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 = $82^{\circ}\text{C} \pm 2^{\circ}\text{C}$ @ 0.1 mm travel.

Measure stroke with the aid of special device and dial gauge.

Check full working stroke.

Working stroke = 10 mm or more at 95°C

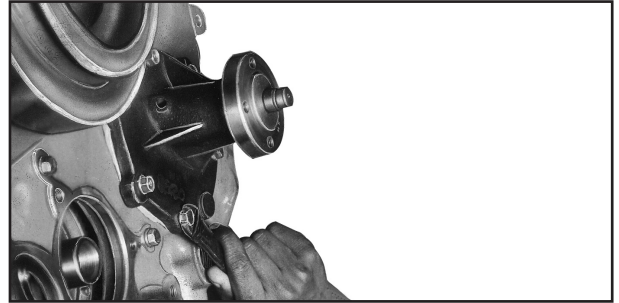
Install the thermostat

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.

1.8.4 To Remove and Refit Water Pump



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

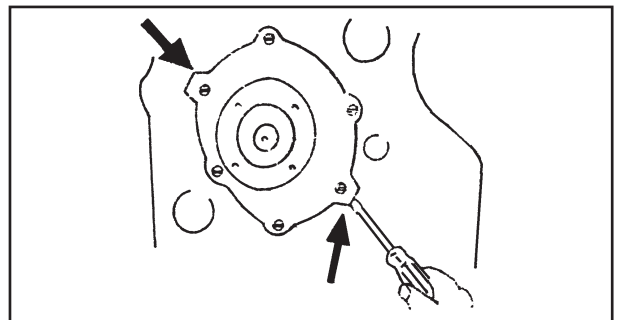
Unscrew fan and remove V belt for water pump fan and alternator.

Remove hose connection from water pump and backout attaching bolts.

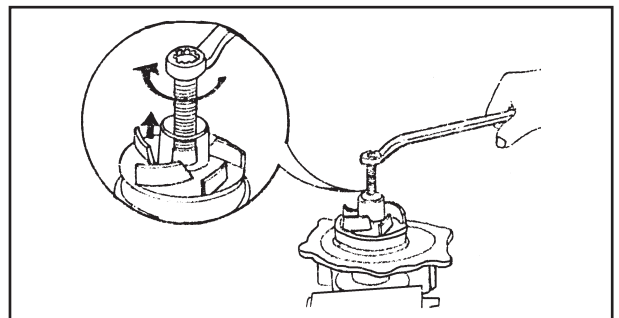
To refit water pump reverse the procedure for removal.

1.8.5 To Overhaul Water Pump

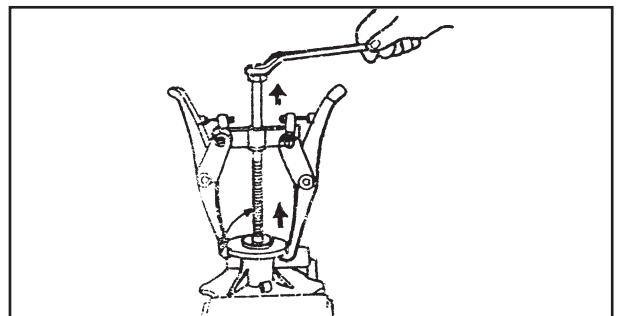
Dismantling



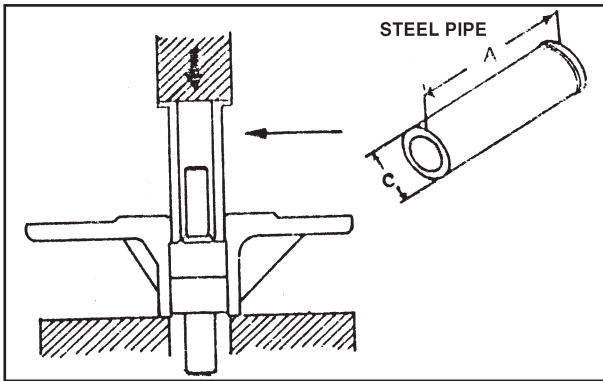
Unscrew water pump mounting Hex screws, remove water pump by prying loose with screw driver at the 2 points on the flange.



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.



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.

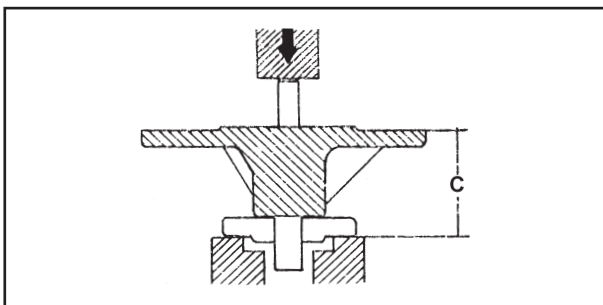
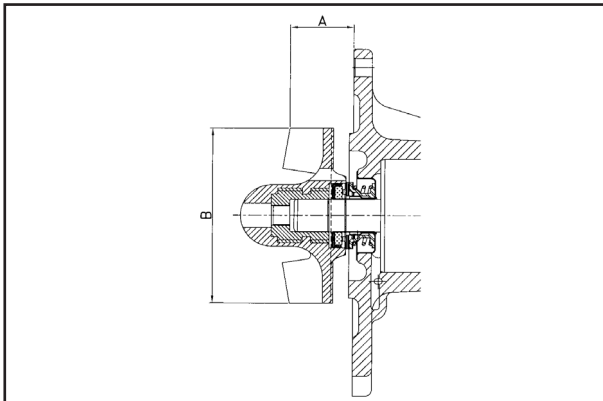
To install Vane. (Impeller)

Using a press install the Vane to the shaft.

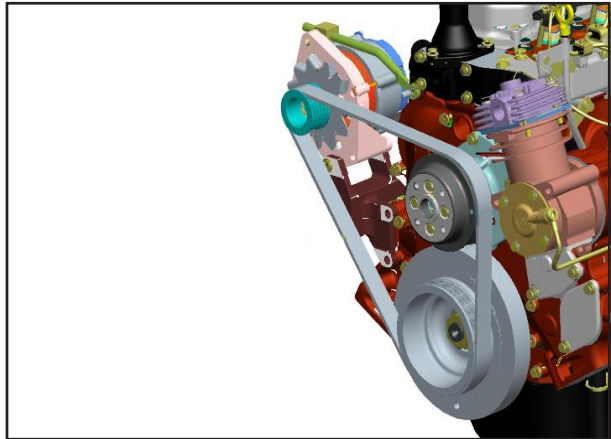
NOTE

Apply a little engine oil to the seal face.

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



1.8.6 To Remove and Refit Fan Belt - To adjust fan belt tension (Poly V belt arrangement)



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.

NOTE

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

Model	Dimension (in mm)		
	A	B	C
HA6ETI	20.8 ± 0.2	85	90

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.

**Belt tension Procedure**

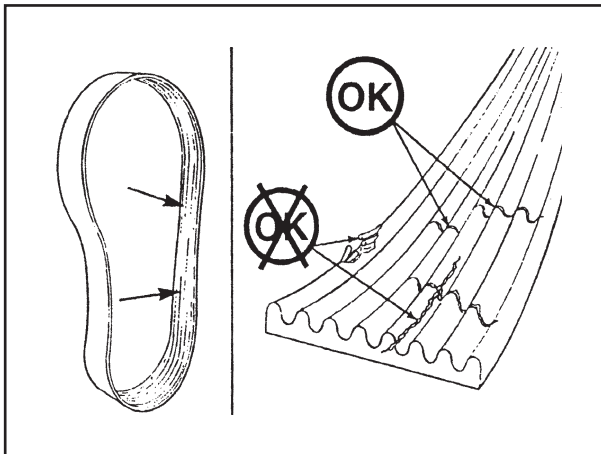
- Hold the sensing head steadily across the belt span within 5~10 mm distance above the top surface of the belt.
- Tap the belt gently near the mid span using a rod or with similar tool to cause the belt span to vibrate.
- Check the required tension display on the LCD panel of the Tension Meter.
- If 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.



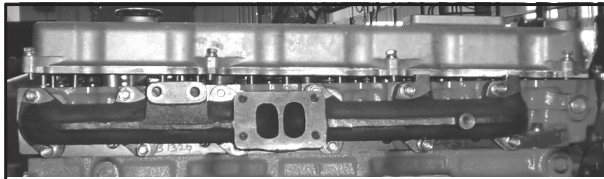
Visually inspect the belt.

 NOTE

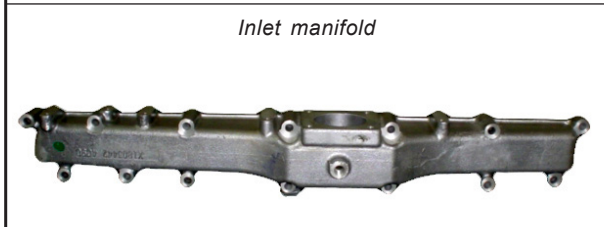
Replace the belt if it is frayed or pieces of material missing or longitudinal cracks intersect with transverse cracks.



1.9 EXHAUST AND INTAKE MANIFOLD



Exhaust manifold



Inlet manifold

1.9.0 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.

1.9.1 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.

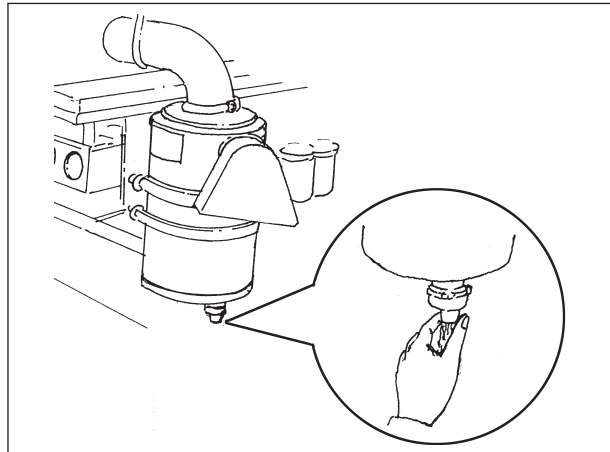
To refit intake manifold, reverse the procedure for removal.



NOTE

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

1.9.2 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.

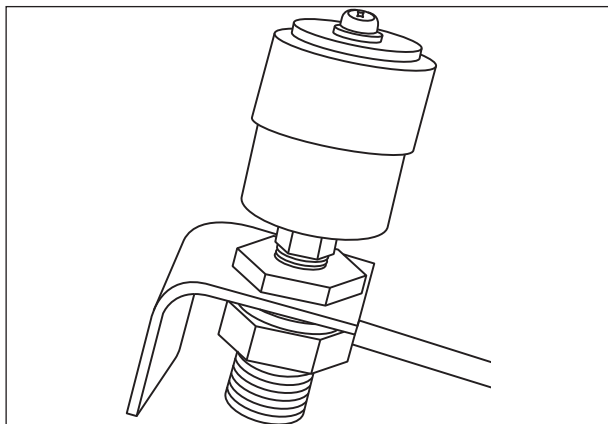
- Remove dust deposit weekly by squeezing the dust evacuator valve.
- Replace dust evacuator valve immediately if it is torn, cracked, remains open or missing.
- Never operate the engine, if the restriction indicator is either broken or missing.



CAUTION

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.

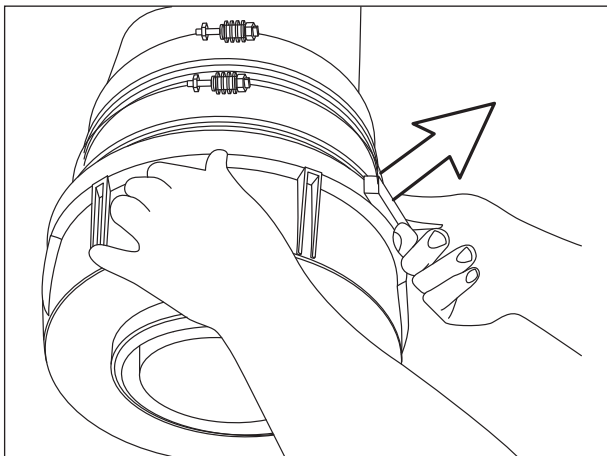


NOTE

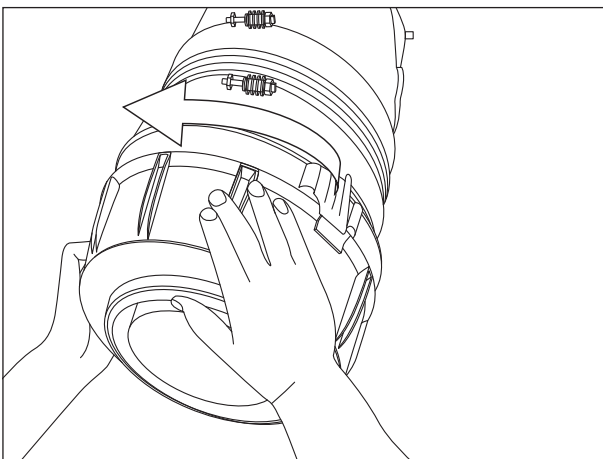
The wing nut should be tightened with hand alone. Excessive tightening would damage the air cleaner.



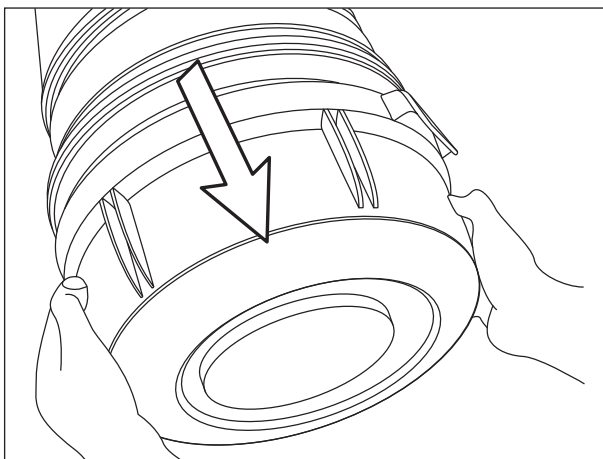
1.9.3 Guidelines for replacing Opti air filter



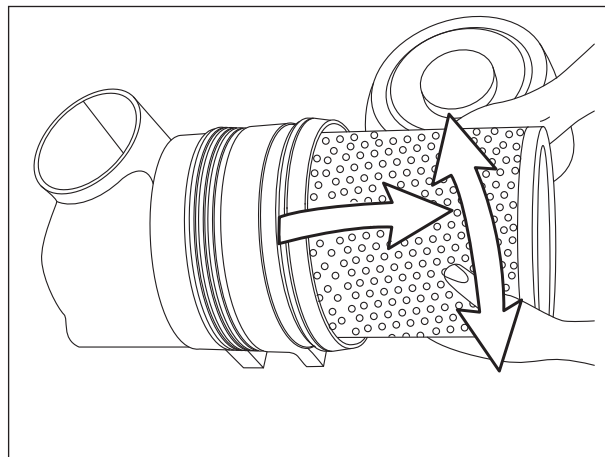
1. Lift the lever as indicated on the cover label



2. Twist the cover to the left in the open position

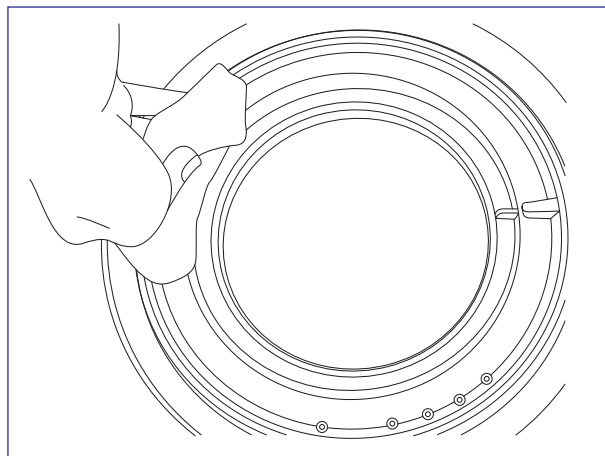


3. Remove the cover

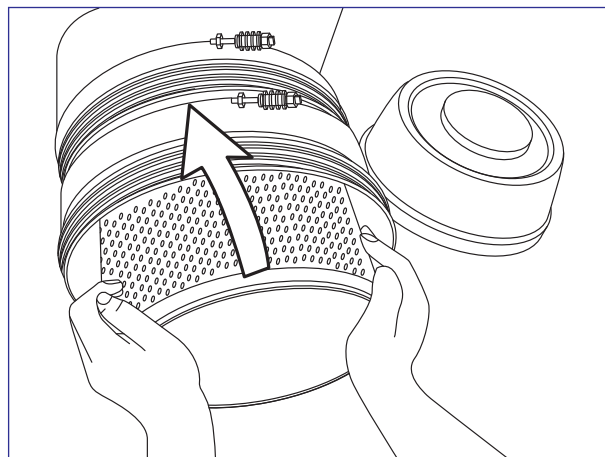


4. Twist the end of the filter to disengage the seal. Gently remove the filter element from the housing. Inspect the element for the foreign material on the sealing surface and potential marks of dust at the clean air side.

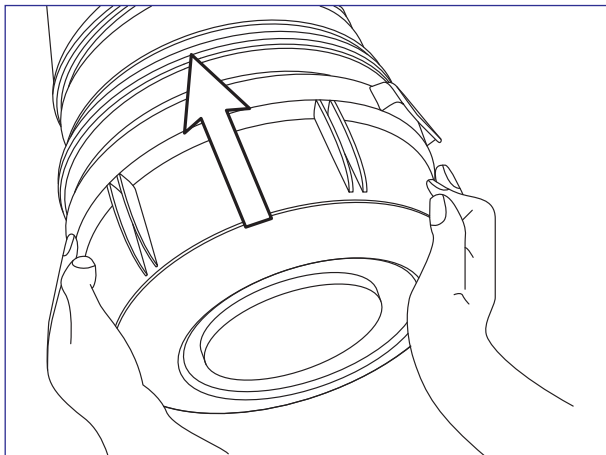
Repeat the above step at the time of change interval for safety element.



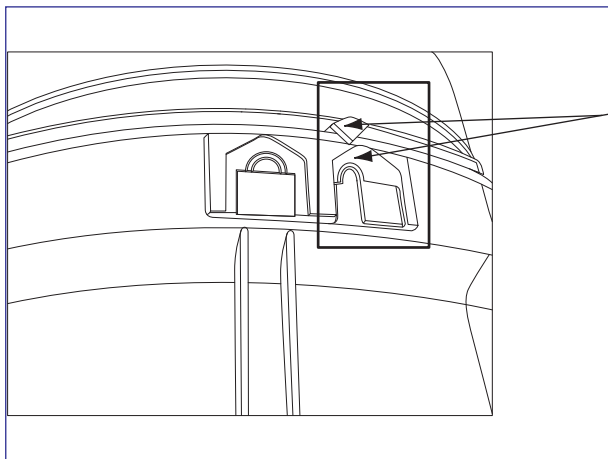
5. Thoroughly clean the sealing surface and the inside of the housing.



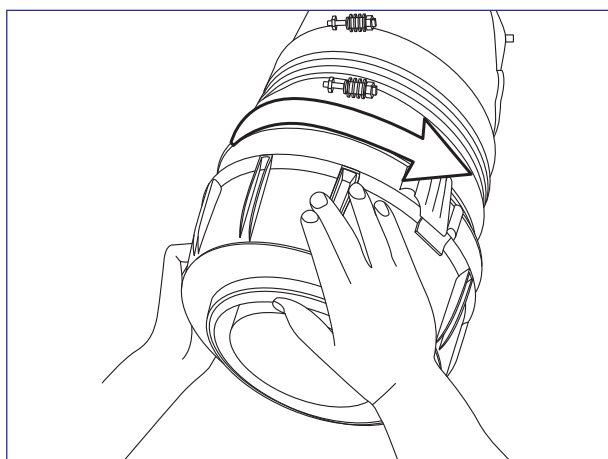
6. Insert the new element in the housing



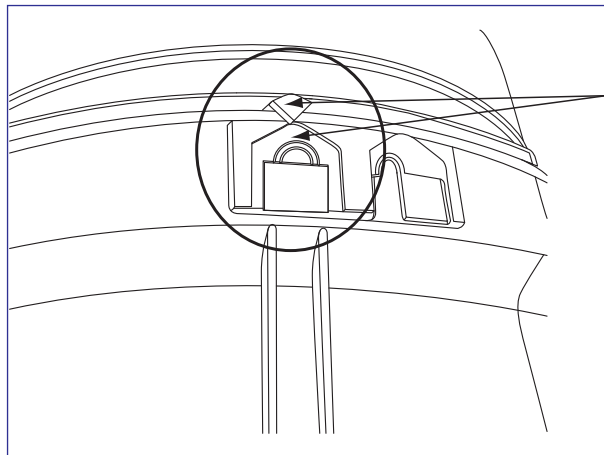
7. Place the cover back on the housing. Make sure dust evacuator valve is oriented downwards.



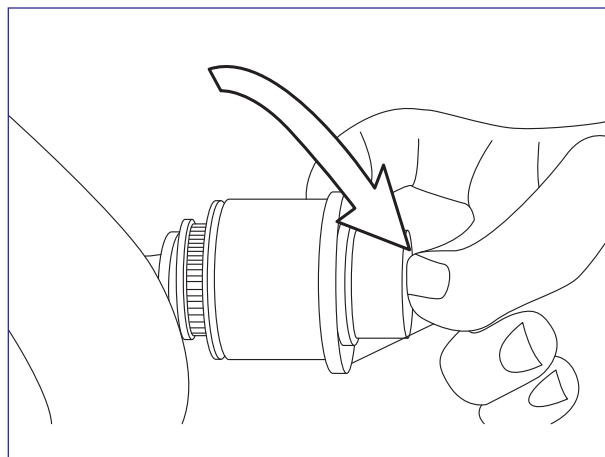
Also unlocked symbol marking on end cover should match with the marking on air cleaner housing.



8. Twist the cover to the right and put into the closed position.



Ensure that the arrow mark on air cleaner housing matches with the locked symbol on air cleaner end cap.



9. Once the elements have been changed, make sure that you reset the restriction indicator.



IMPORTANT

Never pull the latch

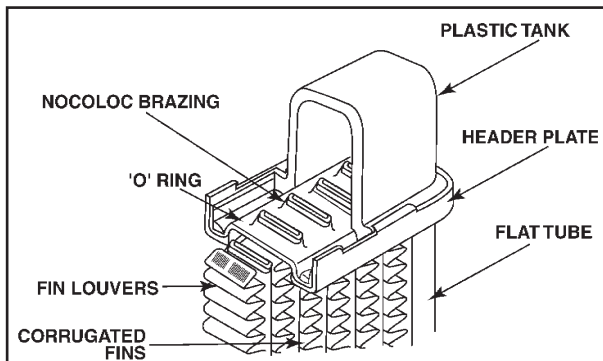
Lift the latch and rotate the end cover for opening of air cleaner

Ensure that the latch is sitting in the slot. This condition only ensures air cleaner end cover is properly fitted with the air cleaner housing otherwise end cover may fall off and damage.

Dust evacuator on the end cover should always point vertically down.



1.10 ALUMINIUM RADIATORS AND CHARGE AIR COOLER



1.10.0 Service Instruction

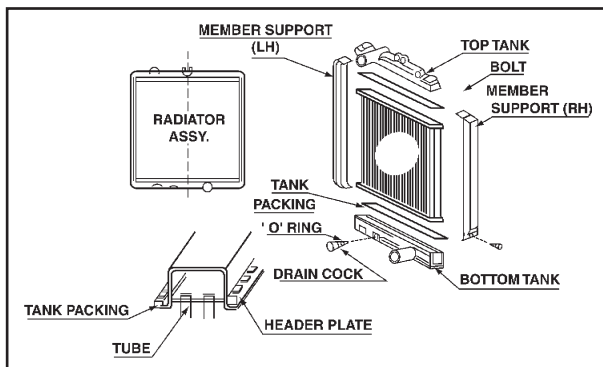
1.10.0.0 Introduction

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

1.10.0.1 Details of Radiator



A typical radiator is shown for reference.



CAUTION

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

1.10.0.2 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 Epoxy based system)
- * Alumaseal container
- * Araldite applicator
- * Brush



NOTE

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

1.10.0.3 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.



CAUTION

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

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.



CAUTION

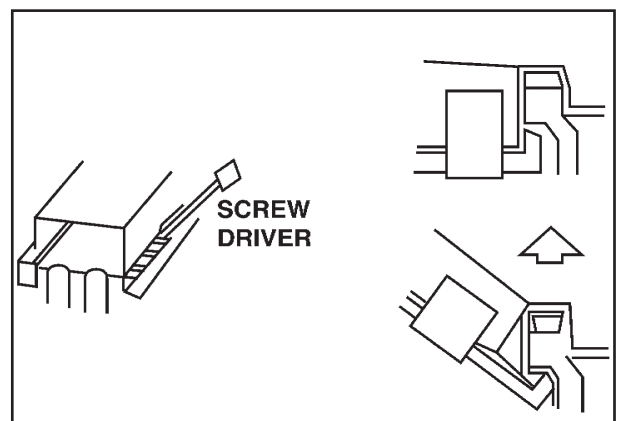
Do not use the water tank that is used for copper radiators.

Sealing the leakage spot -

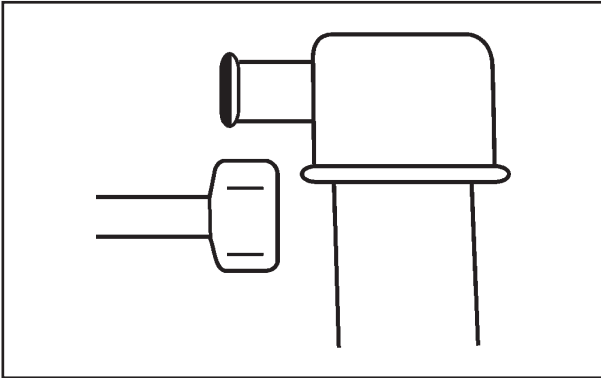
Following procedures shall be adopted for arresting leakages at different locations of the radiator.

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.

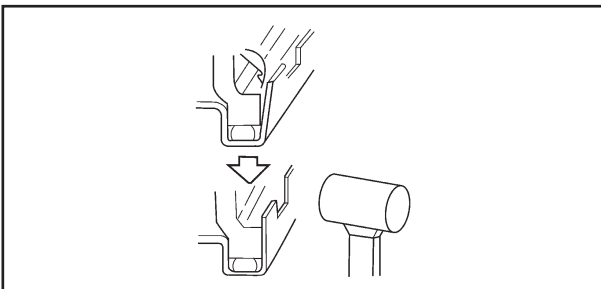
NOTE

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.

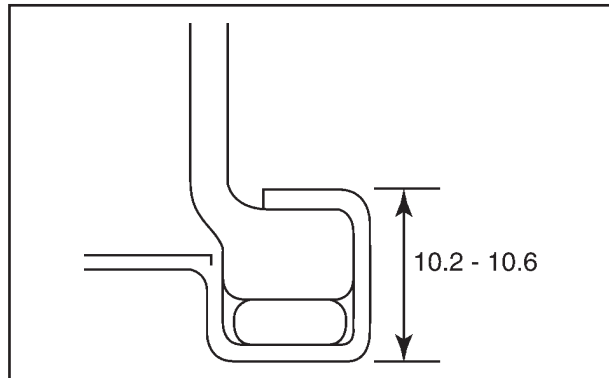
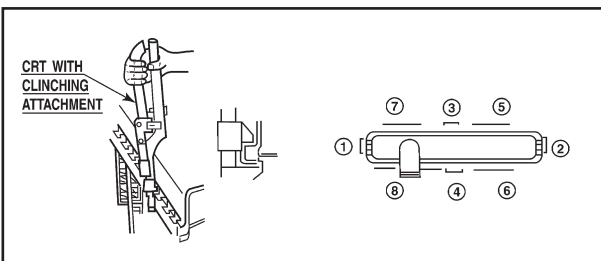
CAUTION

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.

CAUTION

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 1.10.0.4.
- * 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.


NOTE

- * **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 as shown in point 4.2.


NOTE

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

1.10.0.4 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.

1.10.0.5 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.



1.11 TURBOCHARGER

1.11.0 General

In exhaust gas turbocharging, the thermal energy in the exhaust gas, which would normally be wasted, is used to drive a turbine.

The turbine drives a compressor, which draws in filtered air and feeds this, at a higher pressure, to the engine.

This enables more fuel to be burnt with a greater mass of charge air, increasing engine power output.

Better air availability enhances better combustion, thus leading to lower fuel consumption and less emission.

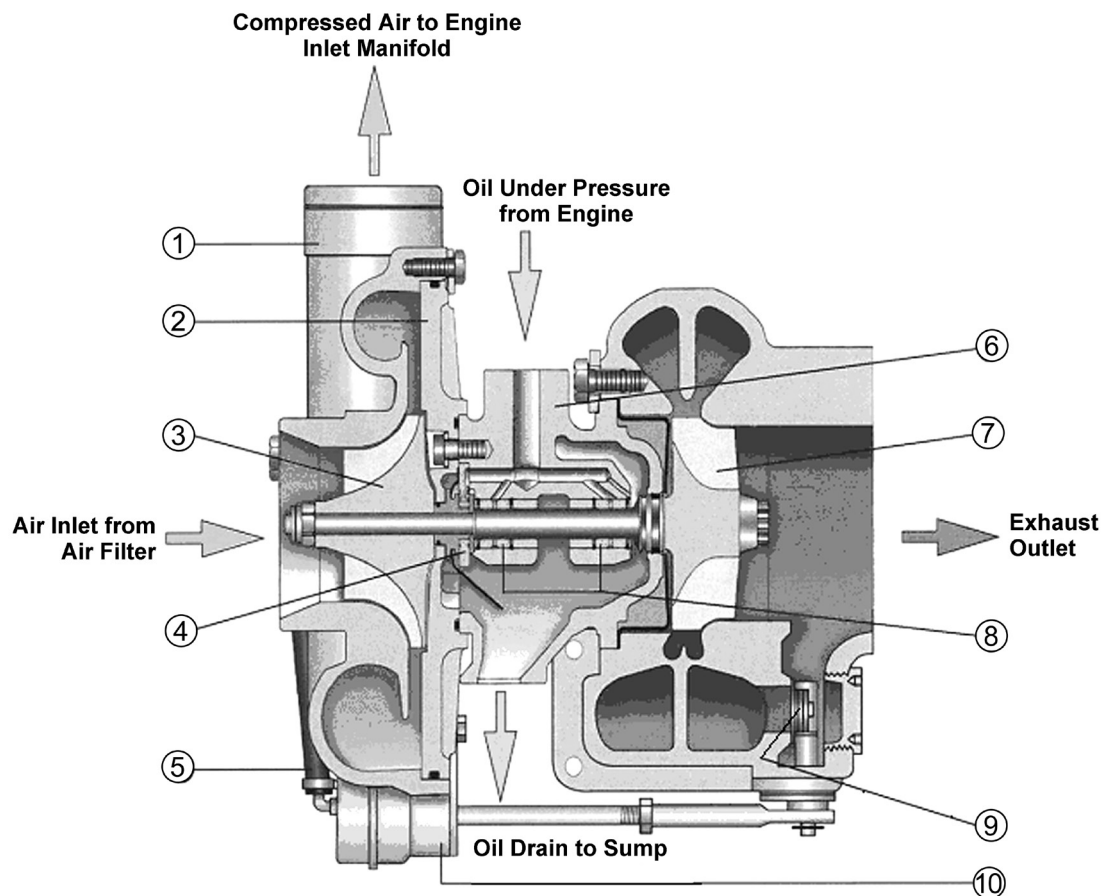
1.11.0.0 Design and Operation

Turbocharger is operated on the exhaust gas, which is normally wasted.

Turbocharger consists of:

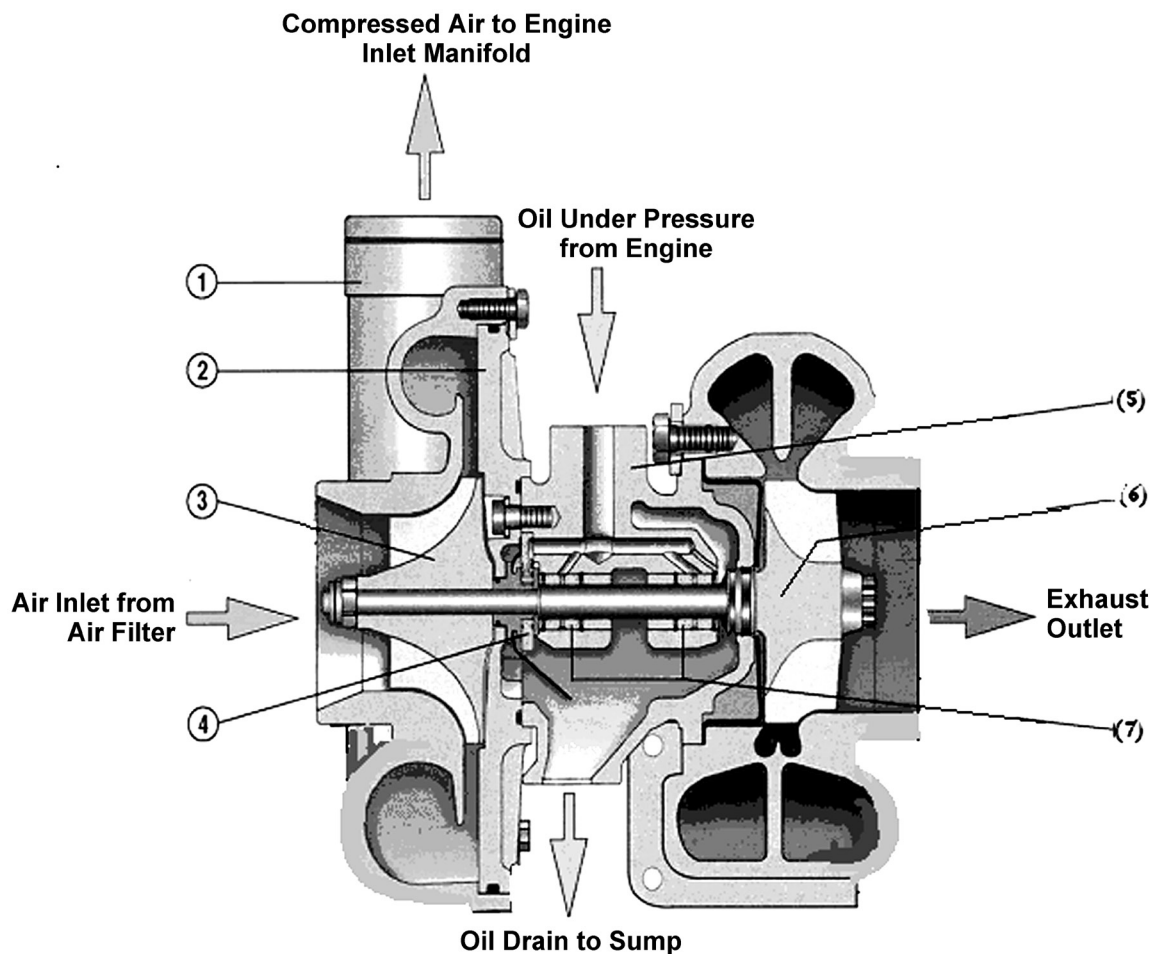
1. Turbine wheel
2. Turbine housing
3. Compressor wheel
4. Compressor housing
5. Journals
6. Bearing housing
7. Waste gate (When provided)
8. Actuator (moved by the boost pressure opens or closes the waste gate valve)

Exhaust gas is used to drive the turbine wheel. Turbine wheel rotates the compressor wheel, which is mounted on the same shaft. Compressor wheel sucks the clean air through the air filter. The clean air is compressed and sent into the engine.



- | | |
|------------------------------------|---------------------------|
| 1. Air Outlet from Compressor | 6. Center Bearing Housing |
| 2. Back Plate | 7. Turbine Wheel |
| 3. Compressor Wheel | 8. Journals |
| 4. Thrust Bearing | 9. Waste Gate Valve |
| 5. Boost Pressure Hose to Actuator | 10. Actuator |

Turbocharger with Waste gate



1. Air Outlet from Compressor
2. Back Plate
3. Compressor Wheel
4. Thrust Bearing

5. Center Bearing Housing
6. Turbine Wheel
7. Journals

Turbocharger without Waste gate

Due to more air in the engine more fuel can be burnt. Due to more fuel and more air, we get more power from the same engine. When waste gate valve is fitted, at higher engine speeds the waste gate limits the exhaust gas flow through the turbine by diverting a portion of the exhaust gas direct to the exhaust pipe.

1.11.0.1 Benefits of Turbocharging

Lower fuel consumption
Lower emission
Better torque characteristics
Lower weight and a smaller engine package
Lower engine noise
Altitude compensating

1.11.0.2 For Enhancing Turbocharger Life

Turbocharger needs CLEAN ENGINE OIL & CLEAN AIR (from the air filter) for it's proper functioning and durability for the following reasons.

1. Oil contaminated with dirt or foreign material will wear the journals and journal seating area.

2. Dirt in the oil also blocks the oil holes in the journals (bearings) and bearing housing leading to oil starvation to the turbocharger.
3. Filtered oil at required pressure is essential to lubricate and cool the journals.
4. The clearances between the rotating parts are very close (in microns)
5. Turbocharger rotor assembly rotates at high speeds above 1,00,000 rpm at the rated engine power. Therefore turbocharger rotating parts are balanced to very high accuracy for optimum performance.
6. Since turbocharger compressor wheel is made of aluminum alloy rotating at very high speeds, dust, sand or any foreign particle entering in to the turbocharger compressor housing will damage the compressor wheel blades, which will lead to turbocharger failure.
7. Damaged blades will lead to imbalance in the rotor assembly resulting in shaft or bearing failure.



1.11.0.3 Preliminary Checks

If your Turbo engine does not run the way it Should,

Do not start your Search For Defects at the Turbocharger.

Check for the following:

- a. Is the clutch slipping?
- b. Does the vehicle brake drag?
- c. Is the throttle opening fully?
- d. Is the air filter system blocked?
- e. Is the compression of the engine low?
- f. Is the fuel injection system correct?
- g. Does the crankcase breather system function?
- h. Is the exhaust pipe blocked/ damaged?

After the above inspection now you can look at the turbocharger for cause of trouble.

Please do not try to service or repair the Turbocharger yourself.

Consult TEL Service centre along with AL Service engineer.

If all parameters outside turbocharger are satisfactory as per the checklist given earlier, inspect the turbocharger.

Disconnect compressor inlet and turbine outlet pipes and visually examine both the wheels. If no fault is found remove turbocharger from the engine and send it for detailed inspection by TEL Service Centre. (Please refer to serviceable parts while overhauling.)

1.11.1 Precautions to be taken for Turbocharger Installation

Check air cleaner (filter element) and it's connecting pipes for blockage, distortion etc, and should be cleaned / replaced.

Check and clean engine intake and exhaust manifold pipes. The oil feed and drainpipe to the turbocharger should be examined for dirt, cracks, distortion, etc. pipes should be thoroughly cleaned before fitment. If found damaged it should be replaced.

Remove any tape or cover used as temporary cover to the pipe inlet.

Examine the engine oil and the oil filter condition.

Replace the oil and the filter element if necessary. (Adhere to Ashok Leyland's recommendation for correct grade & change period).

Use recommended new gaskets for fitment of the turbocharger to the engine. Do not apply gasket sealant (Shellac, Anabond, grease etc.,) at the oil inlet and the oil outlet flanges for pasting the gaskets.

Do not use a strainer type gasket . (This is a temporary gasket used only for the initial testing in the Factory)

Ensure correct fitment of the turbocharger to the engine (rotate the turbine shaft and check for its free rotation).

Fitment of inlet and outlet pipes (to turbocharger) under strain may result in turbocharger failure.



NOTE

After long storage before starting the engine, fill-up the oil feed hole of the turbocharger with clean engine oil to ensure lubrication during start-up.

Crank the engine till you notice oil pressure in the gauge before you start the engine.

Start the engine and idle for two minutes before accelerating the engine.

Check the engine oil pressure.

Do not run the engine if oil pressure is found less than that recommended.

When the engine in running, check all air, oil and exhaust connections for leaks.



CAUTION

Do not accelerate the engine immediately after start.

Idle the engine for at least two minutes after start and before the engine is stopped.

1.11.2 Do's and Don'ts

Do's

- * Regular change of engine oil / oil filter.
- * Regular change / cleaning of air filter element.
- * Check for oil pressure at engine idling condition. (Minimum oil pressure to be as per recommendation during idling.)
- * Idle the engine for two minutes after starting the engine.
- * Idle the engine for two minutes before switching off the engine.
- * Periodic cleaning of crankcase breather is necessary to allow free flow of oil from turbocharger outlet.
- * Regularly check all air, oil and exhaust connections for leaks and abnormal dust / oil / carbon build up.


Don'ts

- * Don't run the engine with low oil pressure.
- * Don't put the engine under full load immediately after starting. (Always run the engine/vehicle at moderate speed and load for a few minutes before going to full load and speed.)
- * Don't switch off the engine under full load.
- * Don't run the engine with DAMAGED
 - Oil feed and drain pipes
 - Pipes between air filter and turbocharger
 - Exhaust pipes
- * Don't run with Leaky connections from the air cleaner to the turbocharger and turbocharger to the inlet manifold.

CAUTION

Don't open the Turbocharger yourself.

Please contact the Ashok Leyland Authorised Dealers for any turbocharger problems.

As the turbocharger is precision built, assembled and tested by highly skilled personnel, we do not recommend opening of the Turbocharger for servicing by unauthorised persons.

However, if need be, please contact Turbo Energy Ltd Service centres for assistance for servicing Turbochargers.

1.11.3 Turbo Charger Trouble Shooting

Possible Cause	Engine Lacks power	Black smoke	Blue Smoke	Turbocharger noisy	High oil consumption	Oil leak from compressor side	Oil leak from turbine seal
Dirty air cleaner	✓	✓	✓				✓
Restricted compressor intake duct / piping	✓	✓	✓	✓			✓
Restricted air duct from compressor to intake manifold	✓	✓		✓			
Air leak in pipe from air cleaner to turbocharger				✓			
Air leak in pipe from compressor to inlet manifold	✓	✓	✓	✓			
Air leak from inlet manifold	✓	✓	✓	✓			
Foreign object in exhaust manifold (from engine)	✓	✓	✓	✓			✓
Restricted exhaust system	✓	✓					✓
Exhaust manifold cracked, gaskets blown or missing	✓	✓		✓			
Gas leak at turbine inlet/exhaust manifold joint	✓	✓		✓			
Gas leak in exhaust piping				✓			
Restricted turbocharger oil drain line			✓			✓	✓
Restricted/blocked/distorted crankcase breather			✓			✓	✓
Turbocharger bearing housing sludged or coked			✓			✓	✓
Fuel Injection System defective / incorrectly adjusted	✓	✓					
Engine valve timing incorrect	✓	✓					
Worn engine piston / piston rings / liners	✓	✓	✓			✓	
Eroded valves and / or pistons	✓	✓	✓			✓	✓
Excessive dirt build up on compressor wheel and housing	✓	✓	✓	✓		✓	✓
Boost pressure control swing valve / poppet valve doesn't close/damaged	✓	✓					
Boost pressure pipe to actuator leaking / damaged	✓						
Piston ring sealing defective			✓			✓	✓
Turbocharger journal (bearing) defective	✓	✓	✓	✓	✓	✓	✓
Foreign body damage on compressor / turbine wheels	✓	✓		✓	✓		
Insufficient oil supply to turbocharger	✓	✓		✓	✓		



1.12 MAINTENANCE PROGRAMME

SL. NO.	CHECK LIST	Daily	First 50 hours only	Every 250 hours	REMARKS
1	Check level and top up				
	a) Oil in engine	✓	✓		
	b) Coolant level in heat exchanger (for marine application)	✓	✓		
	c) Coolant in radiator	✓	✓		
	d) Oil in aircleaner		✓		
	e) Electrolite in battery		✓		
2	Check tightness of				
	a) Battery terminals & apply petroleum jelly		✓	✓	
	b) Fan belt and tighten if necessary		✓	✓	
	c) Hose connections in cooling systems		✓	✓	
	d) Hose clamp of charge air cooler / turbocharger		✓	✓	
	e) Connections at seawater pump (for marine application)		✓	✓	
	f) Fuel piping connections		✓	✓	
	g) Exhaust piping connections		✓	✓	
	h) Engine mountings		✓	✓	
	i) Engine to drive unit coupling		✓	✓	
	j) Electrical connections at instrument panel		✓	✓	
	k) Radiator mtg, stay & gap between fan and cowl (for industrial application)		✓	✓	
	l) Injection pump mounting		✓	✓	
	m) Cylinder head nuts				First 250 Hours and thereafter every 2500 Hours
3	Run the engine, check and record				
	a) Oil pressure	✓	✓		
	b) Battery charging	✓	✓		
	c) Idling RPM	✓	✓	✓	
	d) Maximum RPM	✓	✓	✓	
	e) Maximum operating temperature	✓	✓	✓	
4.	Check leakage from				
	a) Fuel piping & injector high pressure lines		✓	✓	
	b) Exhaust manifold, flange & connections		✓	✓	
	c) Engine oil filter and other areas		✓	✓	
	d) Coolant hoses		✓	✓	



SL. NO.	CHECK LIST	Daily	First 50 hours only	Every 250 hours	REMARKS
5	Clean				
	a) Fuel feed pump strainer		✓	✓	
	b) Fuel ter bowl, drain till clear fuel appears and then bleed the system		✓		
	c) Strainer in fuel tank			✓	
	d) Engine breather				Every 500 Hours
6	Replace/Fill				
	a) Replace engine oil and oil filter at scheduled hours				Refer OM Manual
	b) Main Fuel Filter & Mud Filter				Refer OM Manual
	c) Coolant				Every 5000 Hours or 24 months
	d) Cooling sys tem hoses and rubber pads for radiator mounting and stay rods				Every 2000 Hours
	e) Fuel hoses				Every 3500 Hours
	f) Air filter element - dry type air cleaner				Whenever vacuum indicator shows red band (or) 1000 hrs whichever is earlier
7	Check & reset				
	a) Injection pump timing		✓		
	b) Adjust valve clearance				During every oil change
	c) Injector opening pressure (if required)				Every 3500 hours.
	d) Recalibrate Fuel Injection Pump (if required)				Every 3500 Hours.
8	Check charge air cooler				
	a) For any blockage of fins and clean the cooler if necessary			✓	
	b) Hoses for any damage			✓	

24X7 Toll Free No



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