INTRODUCTION

"The perfect symphony of design and efficiency."

Kirloskar engines: Prime movers to the Indian nation.

1946 saw Kirloskar Oil Engines Limited (KOEL) taking shape. A powerhouse today, it easily stands out as India's leading manufacturer of engines. Giving its customers a wide choice ranging from 3 hp to 300 hp, and 2400 hp to 8000 hp. Manufactured in both air-cooled and liquid-cooled versions, every detail in these engines is carefully perfected.

A variety so large also makes these engines the backbone in many an industry. Including the role of prime movers for industrial, agricultural, construction, power generation and marine applications. On the other hand, engines ranging from 2400 hp to 8000 hp are also used for marine propulsion and auxiliary power on naval and coast guard ships. Such a wide acceptance has resulted in the manufacture of 187,000 engines in the year ending March 2001.

Being a leader is also about being driven by technology. And that means constant technology up-gradation, using in-house research, investment in state-of-the-art manufacturing facilities with thoroughly perfected processes. All aimed at one goal: Deliver well thought-out quality products and services to the customers at competitive prices. Of special mention are critical components like crankcases, crankshafts, camshafts, gear casing, cylinder heads and connecting rods that are manufactured in-house. And for KOEL's exclusive use, even special purpose machines to achieve critical degrees of precision that international specifications demand. This practice towards achieving efficiency and performance is a mantra at all KOEL plants, starting from the main engine manufacturing plant at Pune to all the other units at Nashik, Ahmednagar, Rajkot, Indore and Kolhapur.

This rigorous internal quality pace easily makes sure that KOEL's processes meet all the standards that global specifications demand. In 1992, ABS QE (USA) awarded KOEL the prestigious ISO 9001 certification for its Quality Management Systems. Similarly, the belief that industry and environment can co-exist, led to in-house development of the environmental-friendly engines produced using environmental-friendly manufacturing facilities. Recognition for this came as an ISO 14001 certification for Environment Management Systems.

Product support:

Assurance through adequate product support is derived out of clear thought processes. Coupled with the most extensive service network in the country. Around 90% of Kirloskar engines are with in 100 km of a Kirloskar Service Dealer. 176 Service Dealerships are operating efficiently to provide relentless service to the customers. The dealership locations and infrastructure is continuously assessed based on the Kirloskar engine population build up in each territory and the customer's emerging service needs. Out of these, 41 Service Dealership locations provide 24-hour service as of August 2001, with the number growing steadily. Add on, Kirloskar Service Managers, Service Engineers and Technicians have been stationed at 21 Kirloskar Area Offices. A well spread out service network manned by about 1,500 Kirloskar trained engineers and technicians ensure prompt service and easy availability of genuine spare parts, making sure that there's always the highest up-time for Kirloskar engines.

All-pervasive IT in operations:

Having forethought and foreseen the power of the Information Technology (IT) to transform the businesses, Kirloskar installed Oracle's Enterprise solutions in 1998.

This exercise by itself is noted to be one of the most extensive installation of Oracle© in the manufacturing industry.

The installation of ERP was followed by net enabled business processes in 2000. This networked Kirloskar Service Dealers, OEMs, Area Sales Offices, Suppliers and the Logistic Providers into a closely-knit digital community. Such a high internet-led IT-focus has helped Kirloskar service its customers with a newfound efficiency, 365 days a year, 24 hours a day. So whether it's the latest service information or parts availability, expect complete information access at the touch of a button.

Engine series, the Specific anecdote:

Design detail and performance delivery make every Kirloskar engine a well thought-out engine. These engines go through painstaking scrutiny leaving minimal chances for any kind of flaws or inadequacies before reaching the customer as a finished product. Making every Kirloskar product enjoy a strong presence in various fields of applications such as pumpsets, gensets, agricultural machinery, farm tractors, earthmoving and material handling. The Indian Army, the Navy and the Air Force also accept them for arduous applications in extremely demanding environs like deserts, snow-clad mountains, and the blue sea, which is adequate proof for justifying the excellence of the well thought-out engines.

Recognition for the well-thought engines is also not new. In 1999, excellence and experience crafted the R1040 engine series, which was acclaimed for its innovation by the Institute of Directors, Government of India, which conferred the Golden Peacock Award. Likewise, the eco-friendly R1040 engine series are the first Indian design to be tested in the United States to comply with the US Tier I emission standards for off-road use. They also meet the European COM Stage I emission norms. The turbocharged and the turbocharged after-cooled engines from the same series meet the European COM Stage II emission norms and US Tier II emission norms for off-road use at economical fuel consumptions. To add to its advantages, is the fact that it operates real silently, thus reducing noise pollution. Reason enough for Kirloskar engines to enjoy the status of well thought-out engines.

Engine series, the Tech anecdote:

Specially designed Combustion:

The piston is designed to have centralised cavity. High air to fuel ratio, injectors with smaller spray holes and large number of holes ensure proper combustion of fuel.

Robust Design:

This engine is specially designed for heavy duty industrial use and is not derived from light automotive engines. The crankcase is integral with rigid structure at bottom and top ends with stiffening provided by specially designed beam structure. As a result, It can be used as load bearing member in typical application like Agricultural Tractor, Forklift Truck etc. This rigid structure also ensures minimum cylinder bore distortion, low lube oil consumption, extended life of lube oil and reduced particulates emission.

The rigid and integral cylinder head is equipped with replaceable valve seats and valve guides. The heads are provided with six bolts per cylinder to ensure uniform clamping. Steel backbone cylinder head gasket ensures proper sealing.

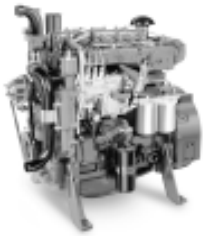
The combustion system is designed to ensure low exhaust emission and low combustion noise. The entire lube oil circuit is in-built in crankcase hence no external piping on the engine, which avoids leakages. Lube oil cooler is of modern plate type design, which is compact and efficient. Crankshaft is of forged alloy steel with hardened journals and pins.

Serviceability:

All service points such as dipstick, lube oil filling, lube oil filter, fuel pump, injectors are on one side. This side is the cooler side, and thus, adds to operator comfort.

Injectors are housed outside rocker cover to enable easy maintenance.

Wet liners ensure low cost of maintenance as compared to engines with dry liners. Also Wet liners are easy to replace at site, without any special tooling.



Silent Operation:

Rigid Engine Structure and Crowned Gears in gear train substantially reduce the engine noise.

Low Operating Cost:

Low specific fuel consumption, low lube oil consumption and extended lube oil change period of 400 hrs (with recommended lube oil grade) reduces the operating cost. Lube oil consumption is less than 0.3 % of fuel consumption, which is very low in its class, and hence, does not call for frequent top-ups.

Applications in Power Generation:

Continuous and Standby Power for Cold Storages, Operation Theatres, Diagnostic Centres, Hospitals, Hotels, Rice Mills, Gas Stations, Information Technology Parks, Cell Phone Operators, etc.

Index

Forward.

This Workshop Manual has been prepared for the use of KOEL distributors, Authorized dealers and service workshops. It contains guidelines to the dismantling and assembly of the engine, along with operating tolerances and clearances required for assembling and carry out important settings during overhauling of the engine.
It is presumed that this vital task will be carried out by trained technicians, hence detailed description and instruction about basic repairs have been omitted. Technicians not using tools and procedures as recommended in this manual, will be fully responsible for the engine's operating life and their personal safety.

When repairing/ reconditioning the engine, it is recommended to use only genuine KIRLOSKAR spares to maintain the excellent quality and reliability of the engine.

Regarding routine care and maintenance of the R-1040, R-1080 engine, please refer to the Maintenance Manual No. 4H.082.02.0.02

As continuos improvements will be carried out on the engine from time to time, the Workshop manual is subject to change without notice. However these improvements will be communicated through appropriate bulletins and the changes will be incorporated in the manual during reprinting.

When ordering spare parts, always mention engine model, the full engine number as punched on the engine name plate and the publication number of the part list manual, as this will help us to supply correct parts within the shortest possible time.

Kirloskar Oil Engines Limited
Laxmanrao Kirloskar Road,
Khadki, PUNE: 411 003 (India)

General Instruction:

The engine will come for a‘ Top Overhaul after every 3000 Hrs., and for a Major Overhaul after about 9000 Hrs. provided the engine is maintained properly as per the instruction given in the R-1040 Maintenance Manual No. 4H.082.02.0.02, with the recommended Fuel, oil, filters and genuine spare parts.

Before proceeding with the work of dismantling the engine, clean the engine externally with Diesel or Kerosene and finally with pressurized water. Before cleaning take the necessary safety precaution and cover all engine openings.

For satisfactory results, the engine should be dismantled and assembled in a clean, dust free and well lighted room.

Dismantling and assembly will be convenient and fast on a service trolley

After cleaning the parts properly, keep these in clean trays or container. Parts which are likely to get rusted due to whether should be coated with recommended anti rust oils or fresh engine lubricating oil. Machined and polished surfaces of parts which are likely to get scratched / damaged should be kept separately on wooden pallets/ containers.

Use of proper tools and special tools is recommended . Use of adequate capacity lifting device is recommended to prevent accidental injuries to personnel and damage to the engine.

ENGINE DESCRIPTION :

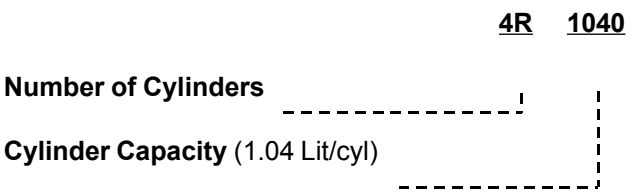
The KIRLOSKAR 1040 series of engine is a vertical, water cooled, Direct Injection, in-line Compression Ignition engine, available in 3 and 4 cylinder in the naturally aspirated version. The 4 cylinder version for Power Generation Application is also available in turbo-charged version.

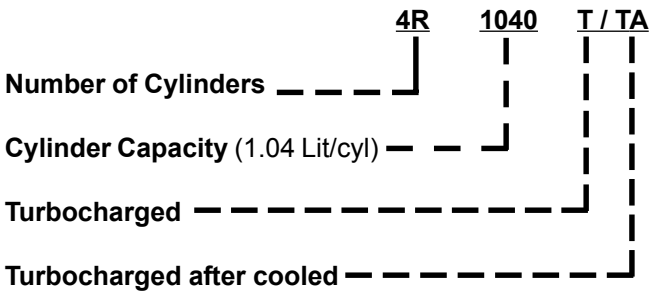
The standard direction of rotation is anti-clockwise when looking at the flywheel from the Flywheel end. Cylinders are numbered ascending from the flywheel end side, with No.1 cylinder being nearest to the flywheel.

The engine has an integral block and crank case for rigidity and a single piece cylinder head unit covering all cylinders, with replaceable valve seat inserts. Each cylinder has two valves namely, one inlet and one exhaust. The valve nearest to the flywheel is the inlet valve followed by the exhaust valve. This sequence of valves continues uniformly for all cylinders.

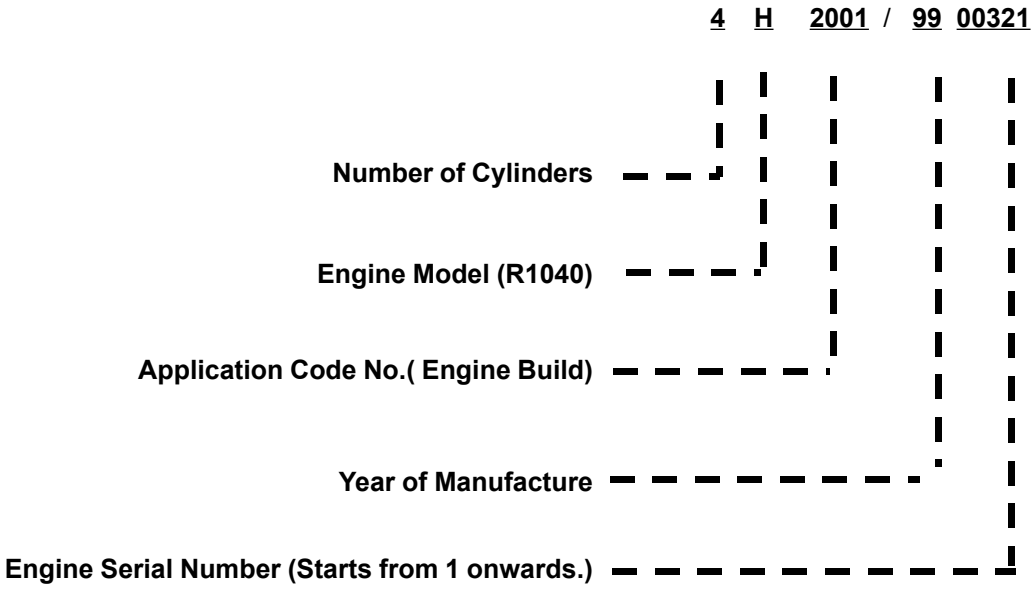
The Engine Name Plate:
The engine number is punched on the crankcase and the name plate which is fitted to the side of the crankcase on the air inlet manifold side for easy accessibility and visibility.

Model Designation





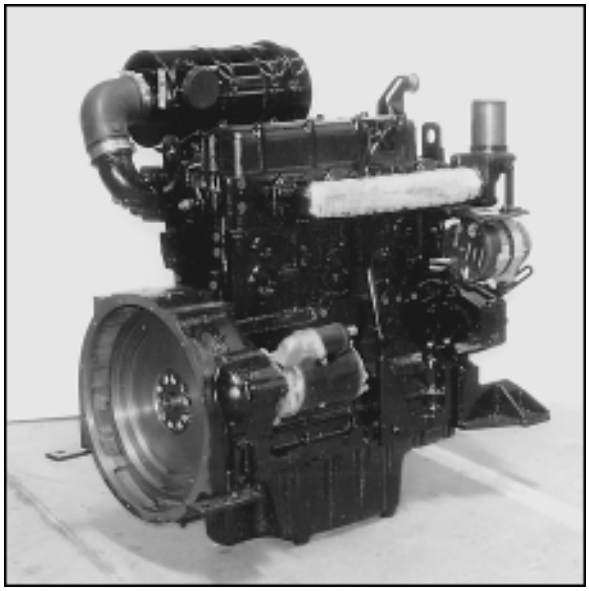
The Numbering System.



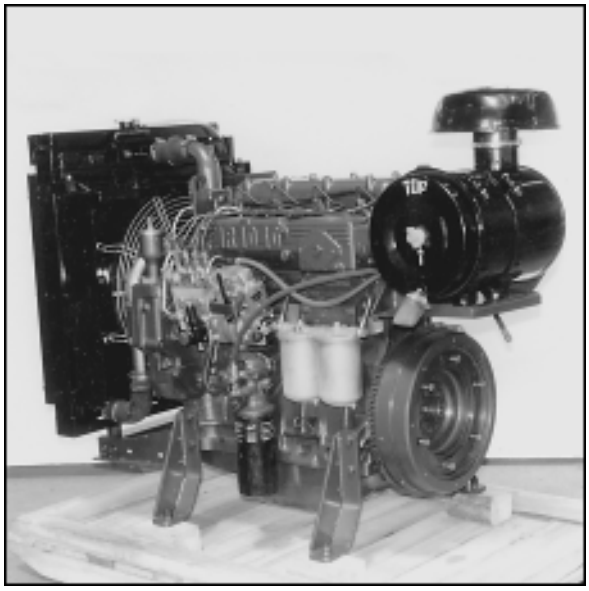
As engines are built for more than one applications their builds will differ from one application to another. It is therefore recommended that when ordering spares the full engine number as punched on the name plate be furnished, so that correct parts are made available with the least possible delay.

ENGINE ILLUSTRATION :

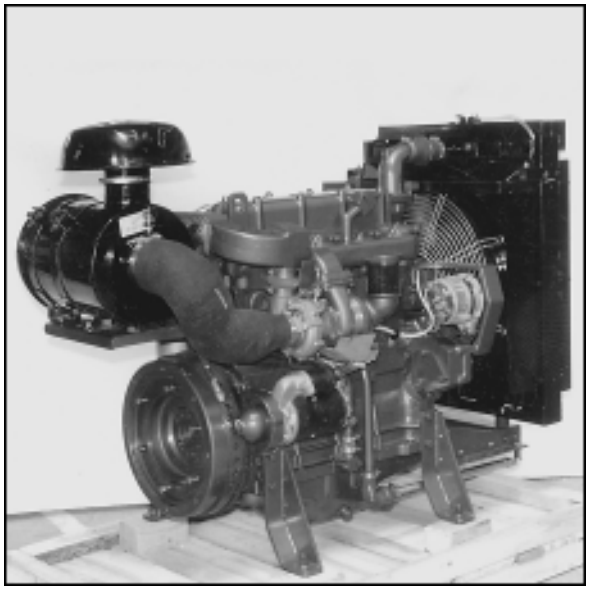
4R1040 INDUSTRIAL ENGINE
(View - Fuel Pump Side.)



4R1040 INDUSTRIAL ENGINE
(View -Exhaust Manifold Side.)



4R1040 POWER GENERATION T/C ENGINE
(View - Fuel Pump Side.)



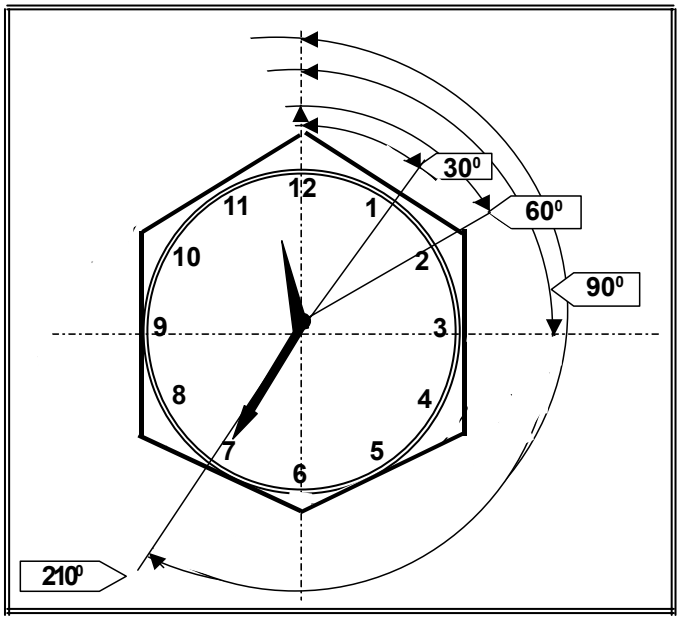
4R1040 POWER GENERATION T/C ENGINE
(View -Exhaust Manifold Side.)

GENERAL SPECIFICATIONS -R 1040 ENGINE :

Sr. No.	Parameter	Unit	SPECIFICATION					
			3R1040	3R1040	4R1040	4R1040	4R1040	4R1040-T
1.1	Cylinders	Number	3	3	4	4	4	4
1.2	Swept volume	CC	3120	3120	4160	4160	4160	4160
1.3	Aspiration		Naturally Aspirated					Turbo
1.4	Application		Ind/Tract Appli	Power Genset	Industrial Appli.	Power Genset	Tractor Appli.	Power Genset
1.5	Working Cycle		Four Stroke Cycle					
1.6	Combustion System		Direct Injection					
1.7	Bore	mm	105	105	105	105	105	105
1.8	Stroke	mm	120	120	120	120	120	120
1.9	Direction of rotation		Counter clockwise (looking from flywheel end.)					
1.10	Compression ratio-		18: 1	18: 1	18: 1	18: 1	18: 1	17:1
1.11	Class of governing	IS10000)	8 -10%	4 1/2	8 -10%	4 1/2%	8 -10%	4 1/2%
1.12	Net continuous Power	HP	—	40 /46	—	54.3 /62	—	83/90
		Kw	—	29,5/33,8	—	39,9/ 45,6	—	61/66,2
1.13	Rated speed	rpm	—	1500/1800	—	1500/1800	—	1500/1800
1.14	Rating standard	BS 5514/ IS10002	BS 5514 (IS 10002) or (SAE J 1995)					
1.15	Brake Horse Power	HP	50	—	76	—	76	—
		Kw	36,8	—	55,9	—	55,9	—
1.16	Rated speed	rpm	2000	—	2200	—	2200	—
1.17	Power consumed by Radiator fan	HP	2	2	2	2	2	2
1.18	Low idling speed	rpm	650 ± 50	—	650 ± 50	—	650 ± 50	—
1.19	High idling speed	rpm	2120-2160	—	2380-2400	—	2380-2400	—
1.20	S FC at rated speed at maximum torque point (Gross output)	g /hp-hr	168	165	167	160	160	154
1.21	Firing Order		1-3-2	1-3-2	1-3-4-2	1-3-4-2	1-3-4-2	1-3-4-2
1.22	Cyl No.1		From Flywheel end side					
1.23	Valve clearance							
	a Inlet (Cold)	mm	0.25	0.25	0.25	0.25	0.25	0.25
	b Exhaust (Cold)	mm	0.3	0.3	0.3	0.3	0.3	0.3
1.24	Fuel Timing	^{0}BTDC	15±1 (Variable Speed with Auto Timer)	18±1 (1500 rpm)	15±1 (Variable Speed with Auto Timer	18±1 (1500 rpm)	18±1 (Variable Speed w/o Auto Timer)	18±1 (1500 rpm)
			18±1 (Variable Speed w/o Auto Timer)	20±1 (1800 rpm)	18±1 (Variable Speed w/o Auto Timer)	20±1 (1800 rpm)		20±1 (1800 rpm)
1.25	Fuel Injection Pressure	bar	280+5					
1.26	Lube.Oil Consumption	%	0.3% of actual fuel consumption					
1.27	Dry weight of engine:							
a	(w/o flywheel & bell housing)	kg	389	—	430	—	430	—
b	(with flywheel & SAE 3 flywheel hsg.)	kg	425	—	513,5	—	513, 5	—
c	(with radiator and w/o bell housing)	kg	—	—	—	494	—	521
d	(With flywheel and SAE -3 flywheel housing and radiator.)	kg	—	—	—	522	—	550

TIGHTENING HIGH TENSILE FASTNERS BY ANGULAR METHOD:

To avoid faulty assembly the following information on tightening of High Tensile fasteners is important. The angular tightening procedure differs from the one normally applied. The tightening angle is particularly important, hence the figure shown below indicates how the various angles can be readily obtained by comparison of the clock face.



Clamp a tommy bar extension in the slot of the angular tool. A specified angle can be turned with reference to the graduation stamped on the outer dial of the angular tool or in relation to the Hex Head of the bolt which can also be taken as a reference.

During angular tightening following instructions should be adhered to.

1. Before fitting the bolt lightly lubricate the threads and the seating face of the bolt head with fresh engine oil.

2. Hand tighten the bolt till it rests on the seating face of the bolt head

3. Apply the initial torque as shown in the tightening table.

4. Tighten the bolt by angular torque, as required in stages as shown in the tightening table.

TIGHTENING TORQUE TABLE - R1040 :

Sr	Description	Initial Torque kgm.	Tightening Method Angle/kgm			Total Angle/kgm Torque
			Stage-1	Stage-2	Stage-3	
1.	Balance Weight Bolts: M12x1.75x60mm long 10,9 (Quality)	3	30^0	30^0	—	60^0
2.	Main Bearing Bolt. M14x2x128mm long 10,9 (Quality)	3	60^0	45^0	—	105^0
3.	Connecting Rod Bolt M12x1.5x55mm long 10,9 (Quality)	3	30^0	60^0	—	90^0
4.	Cyl. Head bolt M12x1.75x12.9mm long	3	6	10	12	12 kgm
5.	Crank Pulley Bolt M 24x2x110mm long 10,9 (Quality)					
	- With Power take off	5	25	50	73	73 kgm
	- W/o Power take off	5	25	48	—	48 kgm
6.	Flywheel bolt M 10x1x45mm long 10,9 (Quality)	3	30^0	60^0	—	90^0
7.	Flywheel Hsg. bolt M 10 x 1.5 x 40 mm long 10,9 (Quality)	5	—	—	—	5 kgm
8.	Nut for Injector stud. M 10	3	—	—	—	3 kgm
9.	Nut for Fuel Pump shaft M 14	8	—	—	—	8 kgm
10.	All M10x1.5 Screws/bolts 8,8.(Quality)	3,5	—	—	—	3,5 kgm
11.	All M8x1.25 Screws/bolts 8,8 (Quality)	2,5	—	—	—	2,5 kgm

R1040 ENGINE RUNNING DIMENSIONS, CLEARANCES OF IMPORTANT COMPONENTS AND CONDEMNATION LIMITS (LIMIT VALUE)

(All Dimensions in mm.)

1.	**CYLINDER HEAD**		
1.1	Valve guide outside dia	15 + 0.056 / + 0.045	
1.2	Valve guide bore in cylinder head	15 + 0.018 /+ 0.000	
1.3	Valve guide inside dia (Pressed in)	8 + 0.015	
1.4	Valve stem diameter		
1.4.1	Inlet	7.96 - 0.02	
1.4.2	Exhaust	7.94 - 0.02	
1.5	Valve stem clearance in guide, normal		
1.5.1	Inlet	0.04 to 0.075	
1.5.2	Limit value		0.2
1.6.	Valve stem clearance, normal		
1.6.1	Exhaust	0.06 to 0.95	
1.6.2	Limit value		0.3
1.7.	Valve seat insert.(In head)		
1.7.1	Inlet valve seat O/D	48.5 + 0.070 /+ 0.054	
1.7.2	Counter bore I/D in cyl. Head	48.5 + 0.025 /+ 0.000	
1.7.3	Exhaust valve seat O/D	44.2 + 0.070 /+ 0.054	
1.7.4	Counter bore in cyl. head	44.2 + 0.025 /+ 0.000	
1.7.5	Valve Insert Seat angle	$45^0 \pm 10'$	
1.8	Valve seat sealing width		
1.8.1	Inlet	2.45 + 0.5	
1.8.2	Exhaust	2.06 + 0.5	
1.9	Valve bore diameter in cylinder head		
1.9.1	Inlet	44.5 ± 0.1	
1.9.2	Exhaust	42.2 ± 0.1	
1.9.3	Seat angle	$45^0 20' \pm 10'$	
1.10	Rim thickness		
1.10.1	Inlet	1.2 - 0.2	
1.10.2	Exhaust	1.5 - 0.2	
1.10.3	Wear limit		0.3
1.11	Valve recess (Distance between cyl. head face and valve face)	0.6 + 0.1	
1.11.1	Limit value		0.8
1.12	Valve spring total coils	7	
1.12.1	Free length	59 ± 1.9	
1.12.2	Free length limit value (Fatigue limit)		56
1.13	Nominal length of cylinder head bolt	145 + 0.8	
1.13.1	Limit value	146.5 + 0.5	
1.14	Valve rocker bush ID (Pressed in lever)	18.014 + 0.049	
1.14.1	Steel back outside dia.	18.0 - 0.006 /- 0.017	
1.14.2	Clearance, normal	0.02 - 0.08	

1.14.3	Limit value		0.2
1.15	Cylinder head surface Flatness	0.05	
1.16	Limit Value		0.06
2)	**CYLINDER LINER**		
2.1	Bore (Normal)	105 + 0.035 /+ 0.000	
2.2	Wear limit		0.2
2.3	Permissible Ovality		0.2
2.4	Liner projection above block	0.03 - .0.08	
3)	**PISTON**		
3.1	Normal Dia. (As punched on the crown)	105	
3.2	Piston Dia	104.76 ± 0.009	
3.3	At top of skirts	104.44 + 0.039	
3.4	Along piston pin axis	104.67 ± 0.009	
3.5	Across piston pin axis	104.22 ± 0.039	
3.6	Piston pin bore	35 + 0.009/ + 0.003	
3.7	Piston pin O/D	35 - 0.011	
3.8	Piston ring groove width		
3.8.1	1st groove.	2.67 - 0.25	
3.8.2	2nd groove	2 + 0.040 /+0.060	
3.8.3	Oil control ring groove	2+ 0.030 /+0.060	
4)	**PISTON RINGS**		
4.1	Land Side clearance		
4.2	1st compression ring	0.075 to 0.100	
4.2.1	Limit value		0.30
4.3	2nd compression ring	0.050 to 0.090	
4.3.1	Limit value		0.30
4.4	Oil control ring	0.040 to 0.110	
4.4.1	Limit value		0.15
4.5	Butt gaps (As measured in liner bore)		
4.5.1	1st. Compression ring	0.30 to 0.50	
4.5.2	Gap limit value		1.5
4.6.1	2nd Compression ring	0.25 to 0.50	
4.6.2	Gap limit value		1.5
4.7.1	Oil control ring	0.25 to 0.55	
4.7.2	Gap limit value		1.5
5)	**CONNECTING ROD**		
5.1	LE bearing bore	64 + 0. 019	
5.2	Bearing ID	60 + 0.039	
5.3	Number of under sizes	4 u/s in steps of 0.25	
5.4	Minimum ID	59.5 + 0.039	

5.4.1	Limit value		0.3 (Replacement of brg. is governed by lub oil pressure.)
5.5	Width of bearing	25.0 - 0.2	
5.6	Connecting rod width.	33.6 - 0.082 /0.140	
5.7	Side clearance - normal	0.3 to 0.4	
5.7.1	Limit value		0.48 to 0.581
5.8	Con-rod s/e bush I/D (Pressed in).	35.04 + 0.046	
5.9	Clearance- bush & Piston pin - Normal	0.04 to 0.091	
5.9.1	Limit value		0.25
6)	**INTERMEDIATE GEAR & SUPPORT**		
6.1	Bearing inside dia.	75 + 0.060 + 0.030	
6.2	Journal dia.	75 - 0.029 - 0.010	
6.3	Bearing clearance - normal	0.04 - 0.089	
6.3.1	Limit value		0.1
6.4	End play	0.10 to 0.30	
6.4.1	Limit value		0.40
7)	**CAM SHAFT**		
7.1	Camshaft End play	0.2 to 0.3	
7.2	Radial clearance	0.03 to 0.100 mm	
7.3.1	Limit value		0.2
7.4	Bush bearing inside dia.	47.980 + 0.054	
7.5	Journal OD.	47.950 - 0.03 - 0.05	
8)	**CRANKSHAFT**		
8.1	Crank pin dia.	59.97 - 0.010 - 0.029	
8.1.1	Limit Value		58.97
8.1.2	Ovality wear Limit		0.02
8.1.3	No. of under sizes	4 u/s in steps of 0.25 mm each	
8.1.4	Nominal Hardness	58. 3 RC	
8.1.5	Limit value		50 Rc
8.2	Journal dia	70.0 - 010 - 0.029	
8.2.1	Limit Value		69
8.2.2	Ovality wear Limit	0.02	
8.2.3	No. of undersize	4 u/s in steps of 0.25 mm each	
8.2.4	Nominal Hardness	58 ± 3 Rc	
8.2.5	Limit value		50 Rc

8.2.6	Length of journal	37 + 0.039	
8.3	Main bearing bore ID	74,5 + 0.019	
8.4	Main bearing ID	70.042 + 0.039	
8.4.1	No. of under sizes	4 u/s in steps of 0.25 mm each	
8.4.2	Radial clearance in main bearing		
8.4.3	- normal.	0,052 to 0,110	
8.4.3	Limit value		0.3 (Replacement of bearing is governed by lub oil pressure.)
8.5	Parallelism between all pin with respect to end journals	0,02	
8.6	Concentricity between all intermediate journals with respect to end journals.	0,06	
8.7	Filet Radius	4.5 R	
8.8	Thrust ring thickness	2.985 - 0.05	
8.8.1	Limit Value		2.621
8.8.2	No. of over sizes available.	0.25 & 0.50 mm O/S	
8.9	Crankshaft end play - normal	0.15 to 0.314	
8.9.1	Limit value		0.8
9)	**LUB OIL PUMP**		
9.1	Pump speed RPM	Corresponding to engine speed.	
9.2	Delivery at 4.0 kg/cm2 (LPM)	39	
9.3	End float of rotor pair in pump - normal	0.026 - 0.063	
9.3.1	Limit		0.1
9.4	Limit value for Radial clearance	0.25	
9.5	Backlash between LOP driving gear. & intermediate Gear.	0.100 - 0.275	
9.6	Backlash between Intermediate Gear & crankshaft gear	0.05 - 0.27	
9.7	Relief valve on pump opens at	5 to 6 kg/cm2	
9.8	Grade of lub oil to be used	As recommended in the engine Maintenance Manual.	

LIST OF SPECIAL TOOLS :

Sr No.	Tool Part No.	Tool Description
1	2H.950.02.0.00	Piston Inserting Guide.
2	03.950.18.0.00	Small end bush Removing & Pressing Mandrel
3	03.950.17.0.00	Crank Pulley Holding Spanner (For Power Generation Engines)
4	4H.950.04.0.00	Crank Pulley Holding Spanner (For Industrial Application.)
5.	4H.950.06.0.00	Special Heavy Duty Socket Spanner for Crank Pulley Bolt
6.	03.950.15.0.00	Nozzle Washer removing tool -from Cyl. Head
7	03.950.12.0.00	Valve Rocker Bush Removing & Pressing Mandrel
8.	4H.950.12.0.00	Exhaust valve seat Pressing Mandrel
9.	4H.950.13.0.00	Inlet valve seat Pressing Mandrel
10.	03.950.09.0.00	Flywheel Puller
11.	03.950.05.0.00	Valve Guide Removing Punch
12	4h.950.11.0.00	Valve Guide Pressing Mandrel
13.	2H.950.10.0.00	Intermediate Gear With Bush Mounting Mandrel
14	4H.950.01.0.00	Cam bush (GE) Pressing Mandrel
15		Mandrel for Inpositioning Fitment of G.E. oil seal
15	2H.036.91.0.00 2H.036.92.0.00	Oil seal pressing mandrel and locating bolt for G.E. oil seal (fitment of oil seal without front cover)
15a	2H.036.93.0.00	Dust lip expanding mandrel for G.E. oil seal
16	2H.950.13.0.00	F.W.E. Oil Seal Pressing Mandrel & Seal Sleeve Ring Tool
17	03.950.03.0.00	Angular Tool Device
18	4H.950.16.0.00	Injector Removal Tool
19	03.950.27.0.00	Fuel Pump Gear Hub Removing Puller
20	4H.950.05.0.00	Auto Timer removing Puller.
21	4H.950.07.0.00	Cylinder Liner Removing Tool
22	4H.950.03.0.00	Cylinder Liner Pressing Tool
23	4H.950.02.0.00	Valve Spring Compressor
24	4H.950.09.0.00	Auto Timer Center Nut Tightening Tool
25	2H.950.09.0.00	Wire Snap Ring Fitting Mandrel
26	4H.950.17.0.00	Stem Seal Fitting Mandrel

STANDARD WORKSHOP TOOLS :

Sr. No.	TOOL DESCRIPTION	TOOL SPECIFICATION
1.	Double ended spanner	10 x 12 mm
2	“	13 x 17 mm
3.	“	14 x 17 mm
4.	“	16 x 18 mm
5.	“	19 x 22 mm
6.	Ring spanner	12 x 13 mm
7.	“	14 x 17 mm
8.	“	16 x 18 mm
9.	“	19 x 22 mm
10.	Box Spanner	14 mm
11.	“	16 mm
12.	“	18 mm
13.	“	19 mm
14.	“	22 mm
15.	“	36 mm
16.	Speeder wrench	600 mm long
17.	Extension	225 mm long
18.	Extension	100 mm long
19.	Extension	200 mm long
20.	Ratchet	300 mm long
21.	Cutting Pliers	150 mm long
22.	Screw Driver	150 mm long
23.	Screw Driver	200 mm long
24.	Ball Hammer	1 kg
25.	Teflon Mallet	400 mm dia
26.	Internal circlip pliers	155 mm
27.	Centre Punch	100 mm long
28.	Flat File	300 mm long
29.	Half round file	200 mm long
30.	Micrometer	0 -100 mm
31.	Feeler gauge set	150 mm long
32.	Torque Wrench	EVT 600 RR 0-7 kgm
33.	Torque wrench	EVT 1200 RR
34.	Allen Socket	17mm

7. ENGINE PRESERVATION :

Engines are given preservative treatment before being despatched from the factory. As all engines will not be commissioned immediately, but may be after a few months or even a year, this treatment is necessary if the engines have to remain unused for a long time. If the engines have to be used after a year these have to be re-preserved.

7.1 PROPERTIES OF PRESERVATIVE OILS :

Preservative oils recommended are products manufactured by reputed Indian Oil Companies and can be used in preserving the engines systems. Where these oils are not available suitable equivalent preservative oils from the local market should be selected and used. For the correct selection of oils following parameters are given as guideline.

7.2 RECOMMENDED PRESERVATIVES :

The under mentioned preservatives are recommended to be used on engines which are required to be closed for a prolonged period of time (more than 12 months).

Lubricating & Manufacturer	Fuel System	Cooling System	For use on external metal unpainted parts
Bharat Petrolium Ltd	Bharat Preserve 30	BP Sherol B Emulsion (Mix with water 1:20)	Bharat Rustrol 152
Hindustan Petrolium	Autoprun T 120	Koolkut 40 (Mix with water -5%)	Rustop 274
Indian Oil Corporation.	Servo Preserve 30	Servo Cut S (Mix with water -15%)	Servo RP 125
Tide water Oil Co.	Veedol 30/40	Veedol Amulkut 4 (Mix with water 1:15)	

7.2.1 Lubrication & Fuel System Preservatives :

These are specially formulated running-in oils to be used in bench test operation in diesel engine manufacturing plants. These oils control wear and tear rubbing of components particularly the bearings, piston rings and cylinder liners. A right balance of anti-rust and other additives incorporated in the oil prevents the internal components from rusting for a reasonable time. The life of these oils is approximately 12 months and hence if the engine is required to be kept out of service for more than 12 months it has to be re-preserved.

7.2.2 The Cooling System :

These are water based fluids containing sodium nitrite which has rust preventive properties. When mixed with water in the correct proportion it forms a extremely stable milky emulsion of ‘oil in water‘ type. This when circulated in the cooling system leaves a layer of oil the walls of the liner and the water jacket and water passages of the system.

Caution: It is imperative to maintain the ratio of oil and water as prescribed. Excessive preservative oils in water will cause the emulsion to thicken and become a whitish grease like paste, which is harmful to the engine.

7.2.3 For External Polished/Unpainted Surfaces :

These are rust proof solvents for external use only. On applying, the solvent evaporates leaving a protective coating on the surface.

7.3 PRESERVATION PROCEDURE :

- Drain out the water from the radiator. Fill the radiator with fresh water. Add preservative oil to the water as per the prescribed ratio.
- Start the engine and run it at idle rpm for about 15 minutes or till the engine is properly warmed up.
- Stop the engine, drain out lubricating oil from the sump. Refill sump with suitable preservative oil.
- Run the engine at low idle speed for about 2 minute and stop.
- Disconnect the battery.
- Drain out the fuel from tank, pump and the High Pressure lines.
- Fill the fuel pump with suitable preservative oil with the help of the hand priming pump.
- Rotate the engine till oil has reached the High Pressure lines and injectors. A distinct squeak heard from all the injectors shows that oil is also sprayed in the combustion chambers.
- Drain out oil from the Fuel Pump.
- Drain out the oil from the sump.
- Drain out the water and oil mix from the engine block and the radiator. Keep the radiator filler mouth open so that any water left inside the engine will evaporate and dry up.
- Spray the Exhaust outlet and silencer from inside with preservative oil removed from the engine.
- AFTER THE ABOVE IS OPERATION IS COMPLETED DO NOT ROTATE THE ENGINE CRANKSHAFT.
- Treat all external unpainted surfaces with two coats of anti-rust, giving the first coat time to dry, and then apply the second coat.
- Cover all openings such as air cleaner inlet, exhaust opening with waterproof paper and seal them with adhesive tape.
- Attach labels to each item describing the treatment and date of treatment.
- Replace the fuel filters elements in dry condition
- Replace the oil filter in dry condition
- After keeping the radiator filler cap open for three days, close the cap and seal.
- Cover the engine and keep it in a protective place away from the atmosphere.
  Re-Preservation:
- If the engine is to be stored for a further period of time the engine will have to be re-treated every 12-15 months as per the procedure shown above.

7.4 DE-PRESERVATION - BEFORE RE-COMMISSIONING THE ENGINE

- Remove the covers from all openings.
- Remove the labels.
- Remove the external rust preventive coating with Kerosene or NC Thinner.
- Fill prescribed quantity of recommended grade of engine lubricating oil in the sump up-to the high level mark.
- Fill cooling system with coolant.
- Fill H S Diesel and bleed the system.
- Reconnect the fully charged battery.
- The engine is ready to be commissioned.
- Note: Lubricating Oil, Fuel and Coolant can be topped up during engine commissioning without flushing the preservative from the engine system. Only the anti-rust coatings applied externally, has to be removed.

CONSUMABLES REQUIRED :

Sr. No.	Consumables	Use
1.	**H S DIESEL OIL.** Confirming to:IS: 1460, 1995 BS: 2869-A1, DIN 51 601 (Sulphur content of less than 0.25%.)	Engine Fuel
2.	**LUBRICATING OILS:** K-Oil 20W-40 OR Any other recognized brand of oil meeting the below specification	Engine Lubricating Oil

Indian Std	American and European Standards		
IS13656:1993	U S Military	API	CCMC
EDL-2	MIL-L-2104C	CD/CD+	
EDL-3	MIL-L-2103E	CE/CF-4	D4
EDL-4		CF-4	D5

Indl. Appli	Power cation	Generation
4R1040		
First Fill	11.5	11.5
Oil Change	10	10
Max Capacity	9. 5	9. 5
Min. Capacity	7. 5	6. 5
3R1040.		
First Fill	9.0	9.0
Oil Change	8.0	8.0
Max Capacity	7.5	7.5
Min Capacity	6.5	6.0

3.	**Coolant:** - K-Kool - Servo Kool	Additive to be mixed with water in the radiator. Improves cooling efficiency and protects water jacket from rust.
4.	**Thread Lock Cement:** - Loctite 242 - Anabond	Prevents low torque bolts from getting loose. Should be used on: a. Oil sump bolts b. Oil Seal Housing c. Gear Cover d. Rocker Cover
5.	**Sealing Compound :** - Zeelac - Loctite	Sealing compound to prevent water or oil seepage between two metallic joints - Liner fitting in crankcase
6.	**Gasket sealing Compound :** - RTV Blue - Silastic - Permatex Ultra Blue:	To be used where chances of leakage is there due to splashing etc. - Sump Joint - Water pump & Volute casing

9. TOP OVERHAULING :

9.1: Dismantling :

- Disconnect the battery. Remove it and store it in a dry place, on a wooden plank. (Refer to Inspection & Service procedure No. 11.34)

- Remove the radiator fan.

- Disconnect wiring from the alternator.

- Remove fan belt and if worn or damaged, discard it

Remove the alternator from the engine give it to a competent Auto Electrician for checking and recondition. - (Refer to Inspection & Service procedure No.11.34)

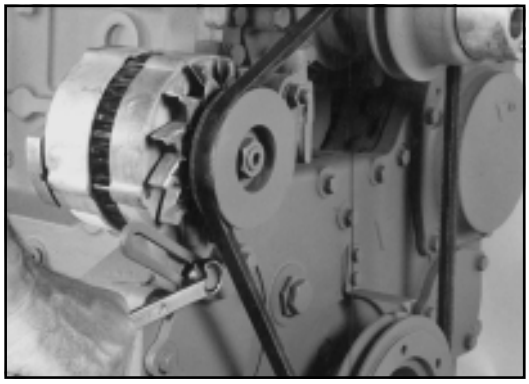


Fig 7-1

- Drain out water from the radiator. (Where coolant is used, collect it in a container for reuse again)

- Drain the Lubricating oil from the sump, Discard the 'O' ring of the drain plug.

- Disconnect the radiator from the engine, discard the old hoses .

- Disconnect the air cleaner and hose assembly from the bracket and inlet manifold. Remove the hose and check. If found cracked or damaged discard it.

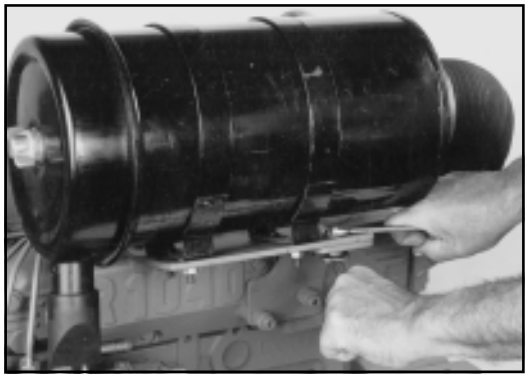


Fig. 7-2

- Disconnect the exhaust pipe from the exhaust flange

On Turbocharged engines :

- Disconnect the rubber hose, connecting the air cleaner to the Turbocharger

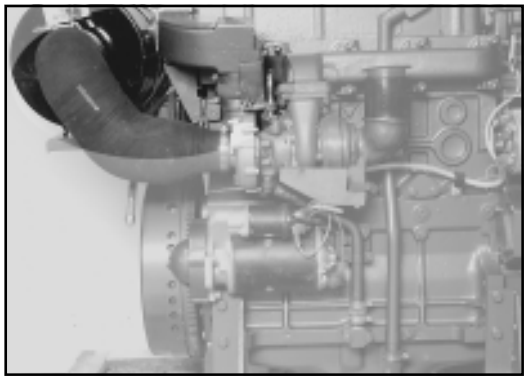


Fig 7-3

- Disconnect the air delivery pipe with the heat shield from the Turbocharger air outlet and air inlet manifold.
- Disconnect the exhaust pipe from the turbocharger expansion bellow flange. Discard the joint
- Disconnect and remove the exhaust diffuser from the bracket.

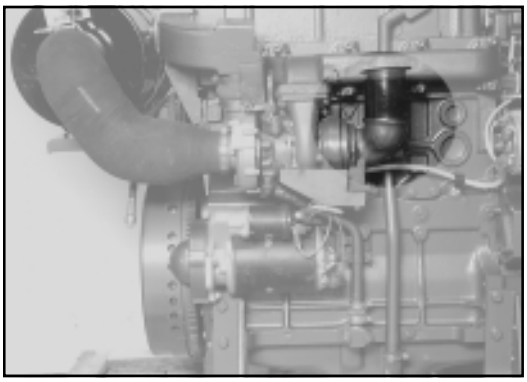


Fig 7-4

- Disconnect the lub. oil inlet and drain pipe to and from the Turbocharger.

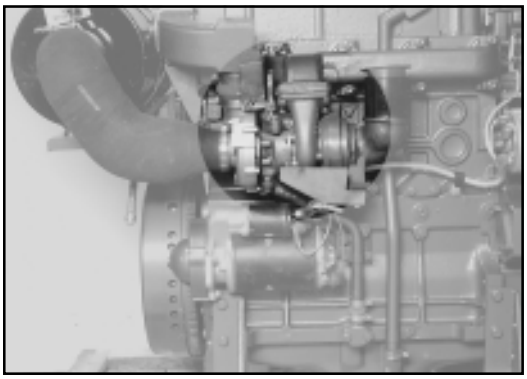


Fig 7-5

- Disconnect the turbocharger from the exhaust manifold. Discard the joint.

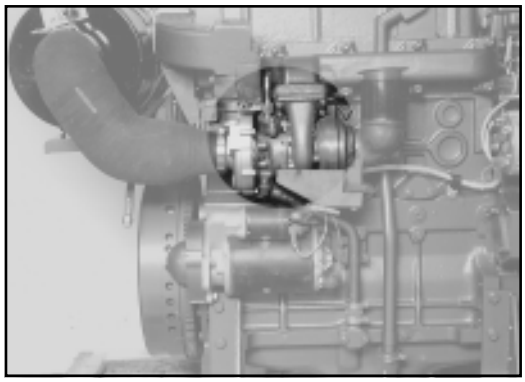


Fig 7-6

- Check Turbocharger Axial and Radial Play If play exceeds the recommended limits, recondition the Turbocharger. (Refer to inspection & servicing procedure No. 11.11)

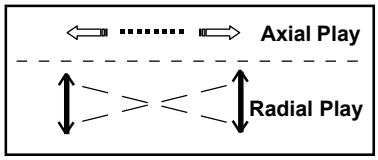


Fig 7-7

- Disconnect and remove the High Pressure pipe between fuel pump and injectors.

Fig. 7-8

- Cover the fuel pump openings and the HP pipe openings with caps or tie the ends with a piece of clean plastic sheet.

Fig. 7-9

- Disconnect and remove the leak off pipe and the fuel return extension.

Fig. 7-10

- Remove the injector yoke

Fig. 7-11

- Remove the injector from the head. Discard the sealing ring. Send the injector to an authorized MICO dealer for reconditioning
- If injector is stuck in the head, remove it out with special tool 4H.950.16. 0
- Remove and discard the nozzle sealing washers. If washer is stuck do not try it with a sharp instrument. Remove with Tool No.03.950.15.0.00

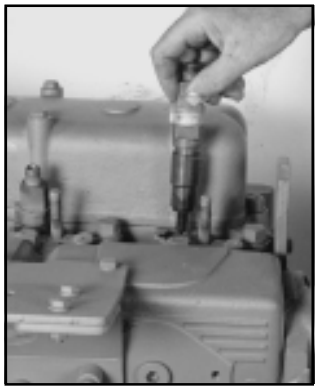


Fig. 7-12

- Disconnect and remove the air inlet manifold. Discard the old joints.

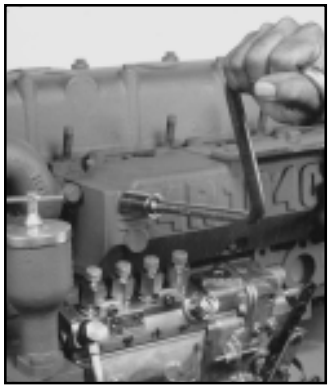


Fig. 7-13

- Unscrew and remove the oil filter with a strap tool, damage and discard the filter cartridge.

Fig. 7-14

- Disconnect and remove the breather assembly.

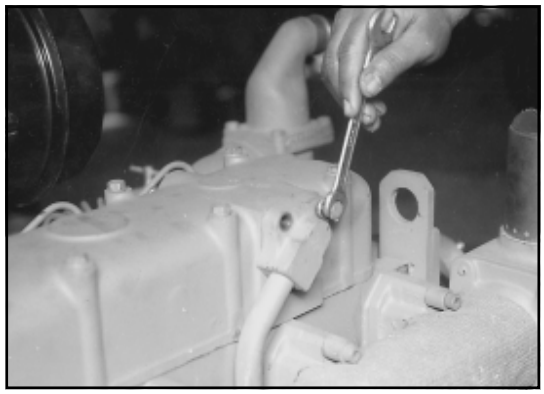


Fig. 7-15

- Disconnect the thermostat housing assembly from the water pump and the cylinder head. Discard the thermostat and joints

Fig. 7-16

- Remove the rocker cover. Discard the joint.

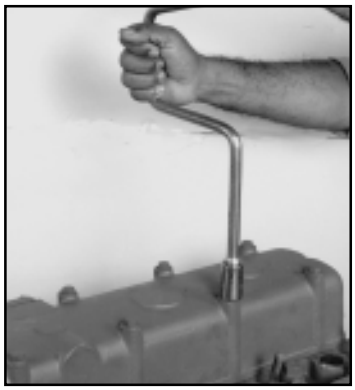


Fig. 7-17

- Loosen all valves adjusting lock nuts and screws to reduce pressure on the rocker assembly.

Fig. 7-18

- Dismantle and remove the rocker assembly from the head.

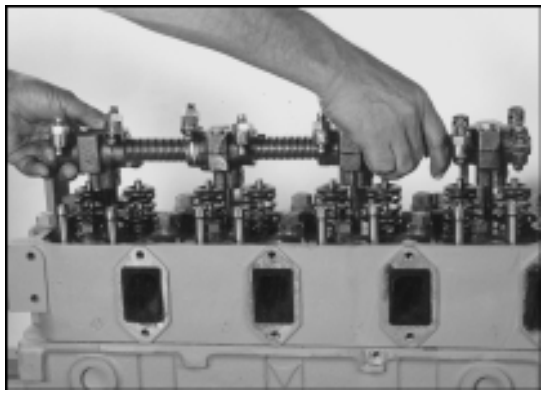


Fig. 7-19

- Remove the push rods and keep them safely aside to avoid damage.

Fig. 7-20

- Loosen cylinder head bolts. Remove the cylinder head from the engine block. Discard the cylinder head gasket.

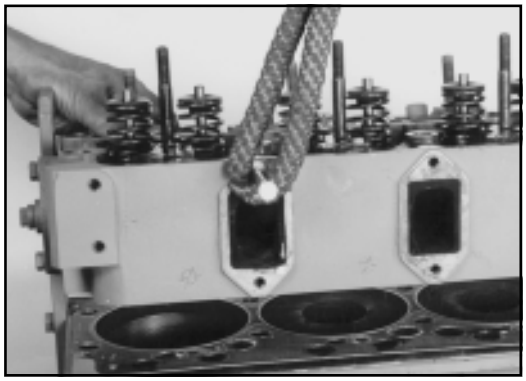


Fig. 7-21

- Loosen and remove the lub oil sump. Discard the joint

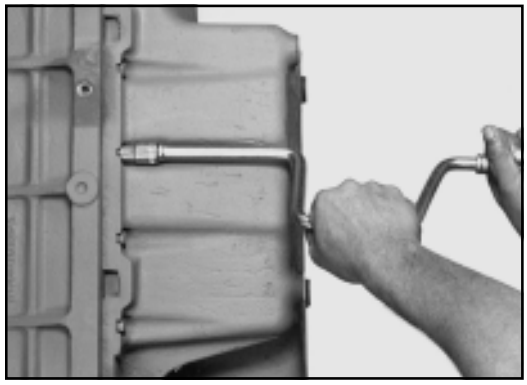


Fig. 7-22

- Remove the bolts of the Lub, oil suction tube clamp. Unscrew the union nut at the lubricating oil pump end and remove the suction tube assembly

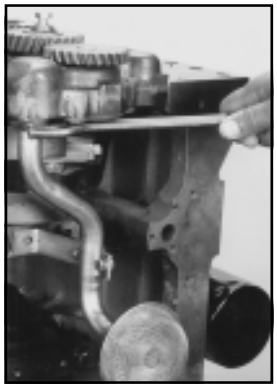


Fig. 7-23

- Loosen con rod cap bolts a few threads. Gently tap with a hammer on the bolts head to dislodge the cap from the con-rod. Remove the con-rod cap along with the bearing shell. Do not disturb the combination of the con-rod cap and bearing shell.

- Tap the piston assembly gently out from the oil sump side using a wooden handle and pull it out by hand from the top.
  Caution: Do not disturb the con-rod and bearing shell combination.)

Fig. 7-24

- Check numbers on the con-rod and cap and reassemble as a set again.

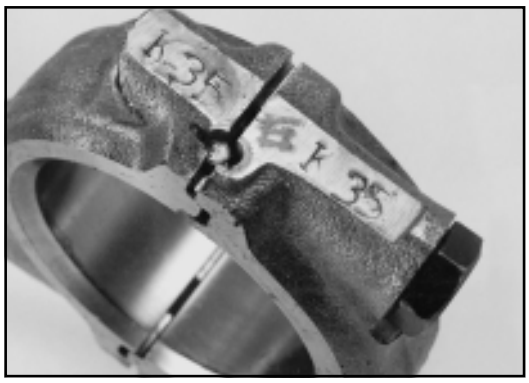


Fig. 7-25

- Punch number on the 'I ' section the con-rod assembly according to the cylinder number, so during re-assembly the correct con-rod and cyl. liner is re-assembled again. (No1 cylinder is from the fly wheel side)

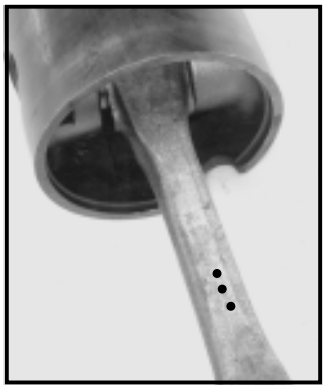


Fig. 7-26

- Follow the procedure with the other pistons and con rod assemblies also.

- Remove piston rings from the piston with a ring expander. Discard the rings.

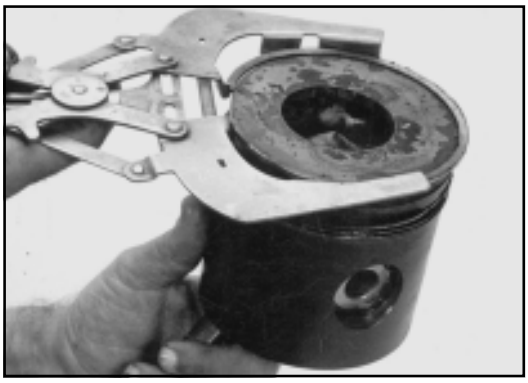


Fig. 7-27

9.2 Cleaning and Inspection :

Note:

- For satisfactory performance of the Diesel engine, cleanliness is of the utmost importance during overhauling /reconditioning. Remove all traces of carbon from the components without scratching / damaging them. Components can also be cleaned with solvents, which do not affect or damage the components. Before assembly, the components should be cleaned with clean fuel oil and dried.

Caution: Avoid using sharp instruments, emery paper and steel wool or steel brush for cleaning, as these can damage the polish surfaces of finished components.

- Dismantle the piston from the con-rod.
  Note : Maintain the combination of piston, piston pin and con-rod.

Fig. 7-28

- Remove the carbon from the piston's crown using a blunt screw driver or the old piston ring.

Fig. 7-29

- Remove carbon from piston ring groove using the old piston ring. (Refer to Inspection & Service procedure No. 11-5)

Fig. 7-30

- After cleaning the piston check the piston. (Refer to Inspection & Service procedure No. 11-5) Replace piston if required.

- Inspect the con-rod assembly (Refer to Inspection & Service procedure No. 11-4)

- Inspect con-rod bolts for thread damage & other damages, replace bolt if required.

- **At major overhaul replace all the bolts.**

- Visually inspect the liner condition for wear, step, scratch marks etc. Inspect liner. (Refer to Inspection & Service procedure No. 11.3) Remove the liner using tool No. 4H.950.07.00.0.

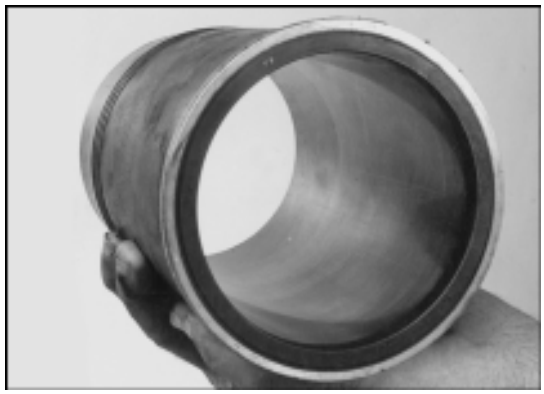


Fig. 7-32

- Clean and inspect the new piston ring sets before fitting.

- Check Butt clearance (Refer to Inspection & Service procedure No. 11-17) (Refer to Specification Data)

- Remove the carbon and clean the cylinder head's machined face check surface flatness (Refer to Inspection & Service procedure No. 11-12)

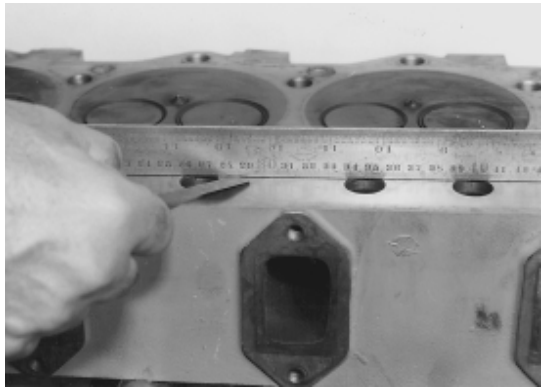


Fig. 7-33

- Check distance between valve face and cylinder head face. (Refer to Inspection & Service procedure No. 11-13) (Refer to Specification Data)

- Number the valves before removing them from the head, according to the respective cylinder.

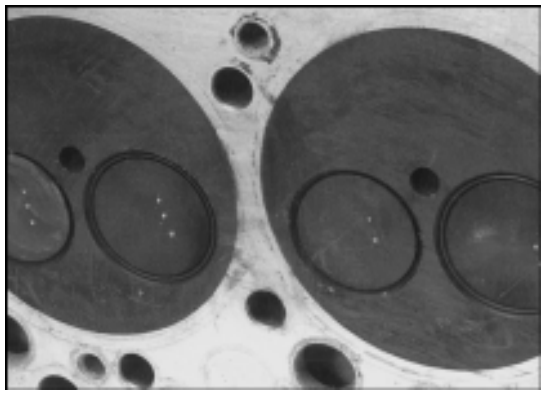


Fig. 7-34

- Using a valve spring compressor tool No.4H.950.02.0 remove the collets, springs, collar etc.

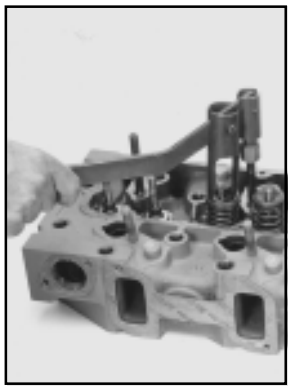


Fig. 7-35

- Remove the valves and the valve stem seals. Discard the valve stem seals.

- Clean the Cylinder Head and inspect it . (Refer to Inspection & Service procedure No. 11-6)

- Carry out valve lapping. (Refer to Inspection & Service procedure No. 11-23)

- Check valve for proper sealing by the pencil erase test. (Refer to Inspection & Service procedure No. 11-24)

- Assemble and lock the valve assembly.

- Check the valve for good sealing by the fuel leakage test. (Refer to Inspection & Service procedure No. 11-25)

- Check cylinder head Bolts, for thread damaged cracks etc. Replace defective bolts.

- Dismantle the valve rocker assembly after removing the ‘E’ circlip.

- Inspect rocker shaft for wear, (Refer specification Data) Replace if required.

- Clean the internal oil passages and blow with compressed air.

- Check rocker lever toes for wear. Replace if found worn

- Inspect rocker lever bush for wear and tear. Replace bush if found worn (Refer specification Data)

- Check condition of the rocker adjusting screws and nuts. Replace if required.

- Clean and check rocker supports .

- Reassemble the rocker assembly as shown in Fig. 7-37

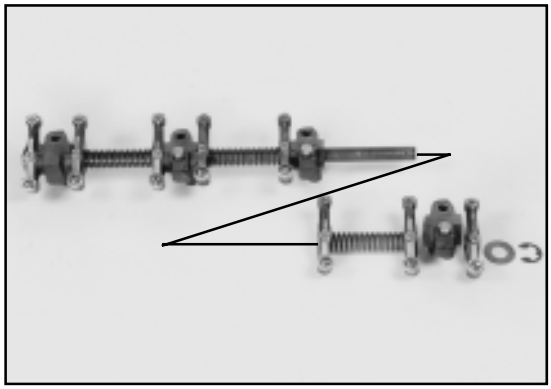


Fig. 7-37

- Check straightness of push rods by rolling them with the palms of the hand on a flat surface.

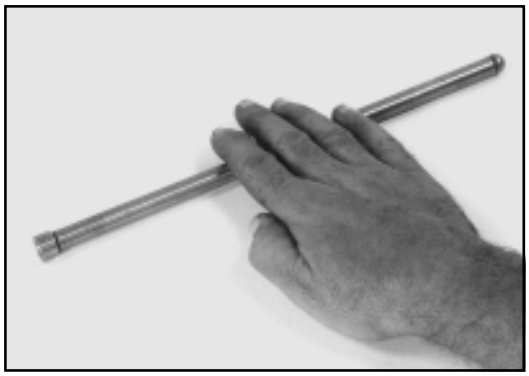


Fig. 7-38

- Check the push rod cup and cone and clean oil cavity in push rods by compressed air. Replace damaged push rods.

Fig. 7-39

- Overhaul turbocharger with a new overhauling kit if play exceeds the specified limits. (Refer to Turbocharger Specification Data)
  (Refer to Inspection & Servicing procedure No. 11-11)

- Before cleaning the air inlet manifold check it for presence of oil or dust. (Oil indicates faulty turbocharger seals where as dust indicates faulty air cleaner, hose and connections.)

9.3: ASSEMBLY :

Important : All joints, gaskets, 'O' rings and copper washers should be replaced when re-assembling the engine.

- If the liners are removed refit or replace liner with new set of liner joint rings.

Fig. 7-40

- Apply 'Zeelac' or any recommended gasket cement to the liner's collar or the crank case flange to prevent water leakage. Install liner in the crank case with liner pressing tool 4H.950.03.0.00 Press the liner till it rests firmly in the crank case cavity.

Fig. 7-41

- Measure the liner projection above the crankcase face with a dial gauge. (Refer specification Data)

Fig. 7-42

- Assemble the piston and connecting rod. (Refer to Inspection & Service procedure No. 11-16)

- Fit new piston rings into the Piston grooves with a ring expander. (Refer to Inspection & Service procedure No. 11-19)

- Set the ring gaps at 120^0 interval to each other.(Avoid setting the ring gaps along piston pin's axis.)

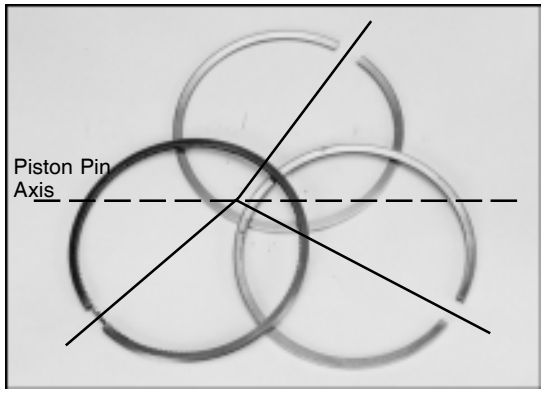


Fig. 7-43

- Insert the piston and con-rod assembly in the cylinder liner. Fit the connecting rod cap and tighten the bolts as specified. (Refer to Inspection & Service procedure No. 11-22)

Fig. 7-44

- Apply liquid sealant to the union nut thread and fit the suction tube assembly.

- Fit oil sump joint to the sump assembly and assemble the sump with a new joint. Apply Loctite 242 or equivalent thread lock adhesive to the bolt threads and tighten the bolts evenly as specified. (Refer tightening torque chart.)

- Fit and tighten the drain plug with a new sealing ring.

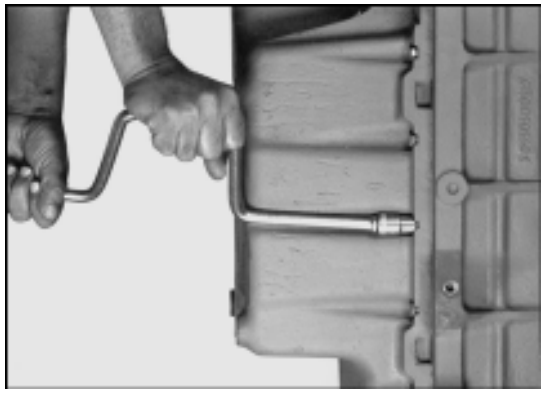


Fig. 7-45

- Wipe clean the cylinder head and crankcase surfaces with a clean cloth. Fit a new cylinder head gasket on the crankcase with the 'TOP' mark facing up.
Caution: Do not apply any gasket Cement.

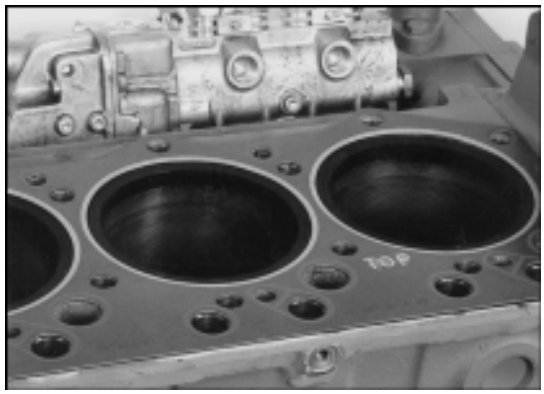


Fig. 7-46

- Install the head on the crankcase and tighten head bolts as per the given sequence shown in Fig.7.47 and to the prescribed torque.
  (Refer to tightening Torque chart)

Exhaust Side

	11	3	5	13		
15	7	1	9	17		
18	10	2	8	16		
	14	6	4	12		

GE FWE

Inlet Side

Fig. 7-47

- Carefully insert push rods in their cavities
  Caution: Push rods dropped casually in the push-rod cavity can by mistake go into the oil drain cavity provided in the crankcase and is difficult to pull out.

Fig. 7-48

- Match and Fit the rocker lever assembly. Torque the support nuts as specified.
  (Refer tightening torque chart.)

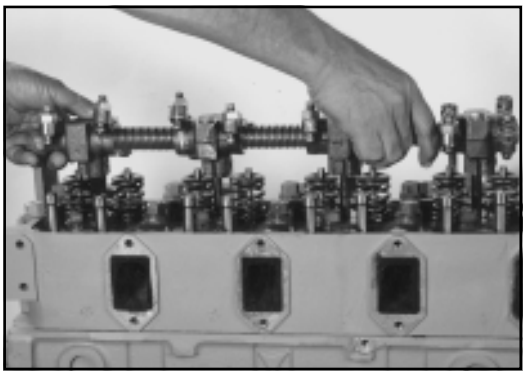


Fig. 7-49

- Adjust tappet clearance. (Refer to Inspection & Service procedure No. 11-29)
- Fit rocker cover with new rocker cover joint and tighten.
- Connect and tighten the breather assembly.

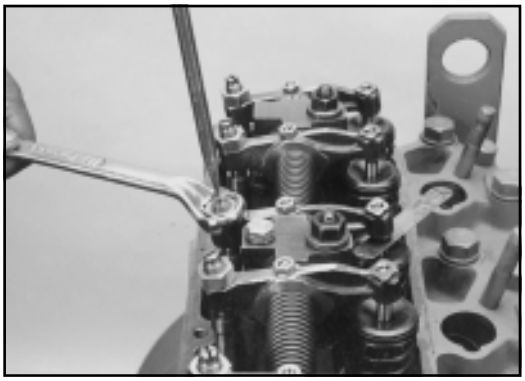


Fig. 7- 50

- Install a new thermostat element of the prescribed range in the housing. (if required) Assemble the engine with new joints and hoses and tighten. **(Use soap and water solution to insert the hoses)**

- Fit and tighten the inlet and exhaust manifolds with new joints.

- Fit the turbocharger to the exhaust manifold flange with a new gasket.

- Connect the Oil inlet and oil drain pipes to the turbocharger

- Connect new air inlet hose with new clips between Turbocharger and the air inlet manifold.

- Fit the heat shield.

- Install reconditioned / repaired injector with new nozzle washer.

- Fit the injector yoke and nut. Tighten to the specified torque. (Refer tightening torque table)

- Wipe the HP pipe externally. Remove the protective covers from the pipe ends and clean the pipes internally with compressed air only and fit.

- Connect fuel overflow pipes with new copper washers. Connect to the return line.

- Replace the Pre and Micro fuel filter elements.

- Service the fuel feed pump strainer under the feed pump. (where provided)

- **Replace the air cleaner elements, with new rubber seals and assemble. Install new air cleaner hose and hose clips.**

- Where Oil bath type air cleaner is provided service the same and fit. (Refer to Inspection & Service procedure No. 11-37)

- Connect the radiator with new hoses and hose clips.

- Check radiator cap is as per specification and in good condition. Replace if required.

Fig. 7- 51

- Connect the exhaust pipe with new joint.
- Fit the reconditioned/repaired alternator
- Fit a new fan belt and tighten the belt as specified. (Check the belt tension with the belt tensioning gauge.)
- Reconnect electrical connections
- Fit a new Lubricating oil filter cartridge .
- (Refer to Inspection & Service Procedure No. 11-30)
- Fill the sump with fresh engine oil as specified in the manual.
- Fill radiator with plain soft water and check for leaks.
- Reconnect the battery.
- Remove air lock from the fuel system.
- (Refer to Inspection & Service Procedure No. 11-31)
- Start the engine and run on low idle speed.
- Check oil pressure. It should be within the limits specified in the Maintenance Manual
- Check battery charging.
- Check for external oil and water leakage and rectify these.
- Warm the engine up with radiator cap not fitted Add radiator cleaning compound and clean the radiator as directed.
- (Refer to Inspection & Service Procedure No. 11-33)
- Flush the radiator twice to remove any trace of the compound. Refill with fresh water and add the recommended coolant as specified by manufacturer.

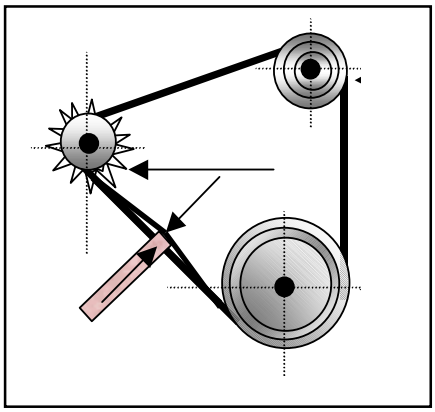


Fig. 7- 51 a

10. MAJOR OVERHAUL :

10.1 Engine Dismantling

For dismantling the upper half of the engine from, please refer to **chapter 9 on ENGINE TOP OVERHAULING (Dismantling)** and proceed further.

- After dismantling the cylinder head proceed as follows:

- Disconnect and remove the electric starter. (Refer Inspection & Servicing Procedure No. 11-34c)

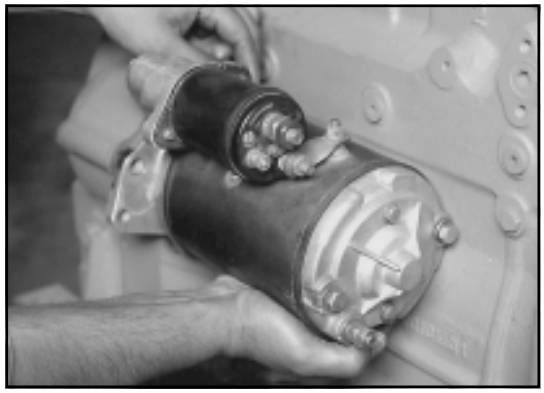


Fig. 8 -1

- Unscrew and remove the Lubricating oil filter cartridge with a strap tool from the filter header, destroy and discard the element.

- Disconnect the oil supply line from filter header to the fuel pump. Dismantle the filter header from the crankcase.

Fig. 8 -2

- Dismantle the oil cooling element from the header after unscrewing the central bolt. In later model engines lub oil cooler element is mounted with four bolts.

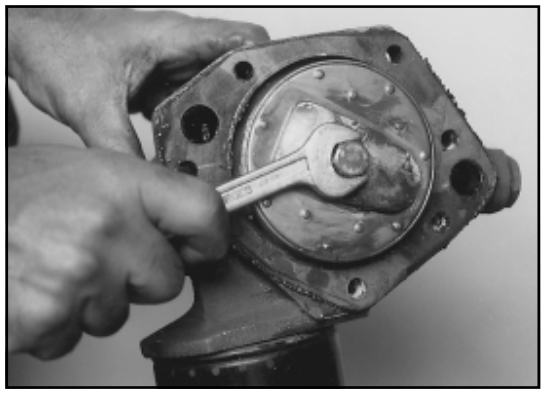


Fig. 8-3

- Lock the crank pulley with the crank pulley holding tool, and loosen the flywheel bolts.

- Loosen and remove the crank pulley.
  (On engines for Generating set application the crank pulley bolt is loosened after locking the pulley with special tool No. 03.950.17.0.00)
  (The bolt is of left hand thread and should be turned clockwise to loosen.)

- (On other application engines the crank pulley bolt is loosened after locking the pulley with special tool No.4H.950.04.0.00
  (Pulley bolt is of left hand thread and should be turned clockwise to loosen.)

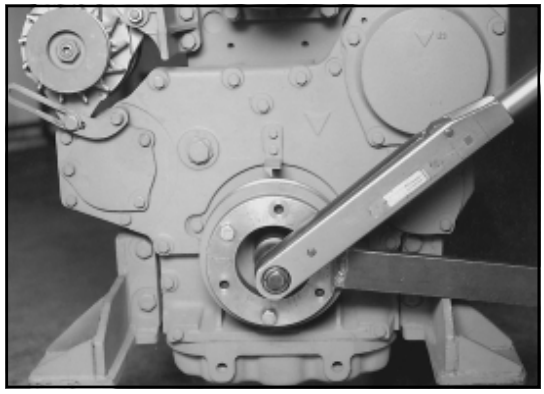


Fig. 8-4

- Remove the fuel pump cover. The removed gear cover bolts may be used as puller bolts.

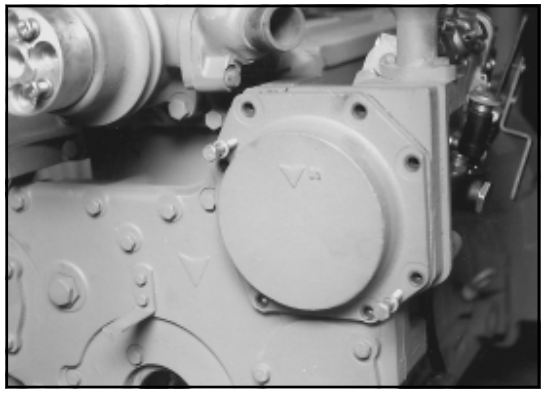


Fig. 8 -5

- **Remove the auto timer centre nut with tool 4H.950.09.0.00**

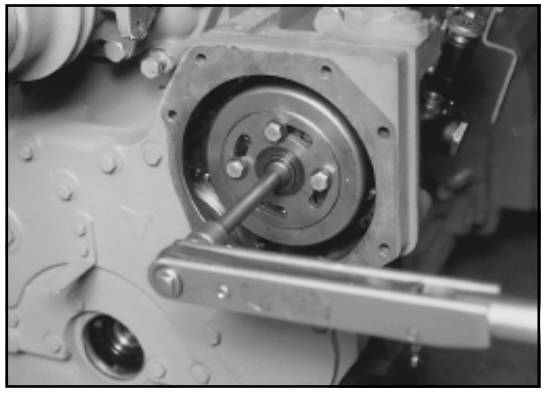


Fig. 8 - 6

- **Using the special puller No.4H.950.05.0.00 remove the auto timer along with the fuel pump gear.**

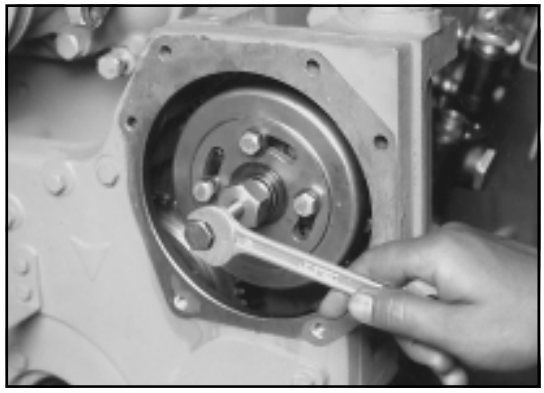


Fig. 8 -7

- Dismantle and take out the fuel pump from the engine.

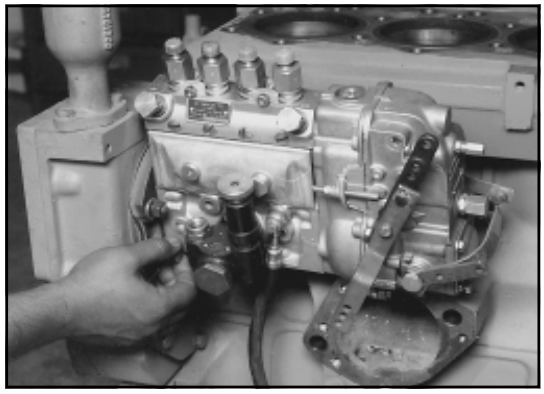


Fig. 8 -8

- Disconnect and remove the water pump assembly along with the delivery volute from the engine.

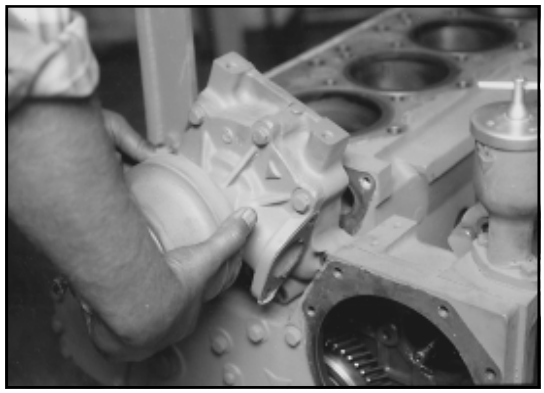


Fig. 8 -9

- Remove the front cover.

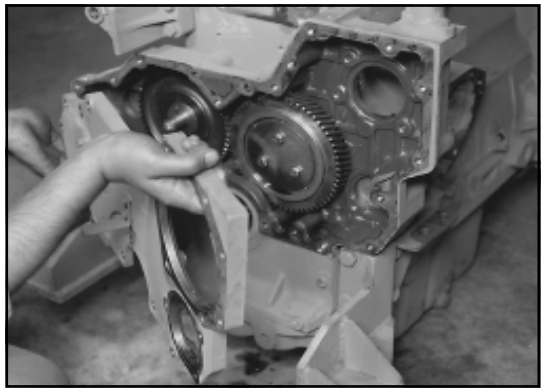


Fig. 8 -10

- Remove the camshaft end play controlling spring and cup from the camshaft boss.

- **Pull out the intermediate gear support with tool No.2H.950.10.0.00.** The intermediate gear and support are pulled out together.

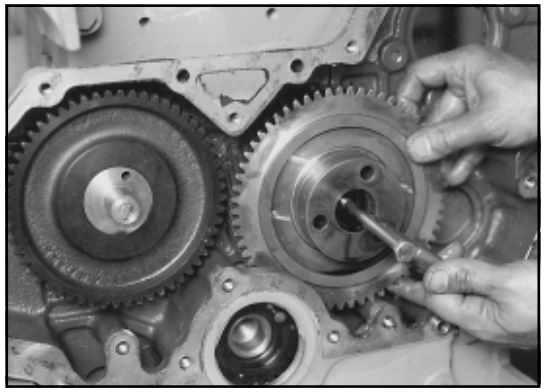


Fig. 8 -11

- Remove the hydraulic pump where provided.

- Remove the flywheel. Inspect the starter ring.

- Remove the oil sump.

Fig. 8 -12

- Dismantle and remove the suction tube assembly after opening the union nut.

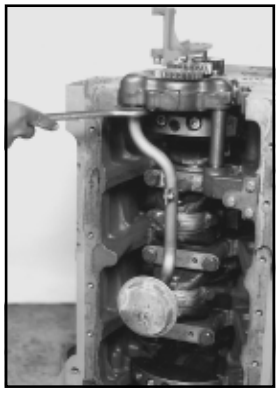


Fig. 8 -13

- Dismantle the lubricating oil pump. Remove the delivery tube and discard the sealing rings. Unscrew and remove the delivery body.

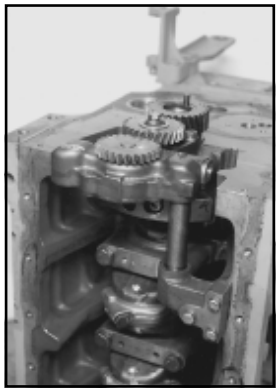


Fig. 8 -14

- Fully press the tappets in their bores and pull out the camshaft.

Fig. 8-15

- Remove the tappets from their bores.

- Dismantle and remove gear cover from the crank case. Discard the oil seal.

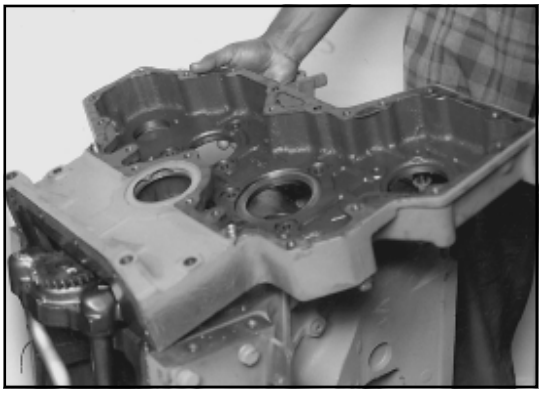


Fig. 8 -16

- Loosen and remove the connecting rod and piston assembly - Number the con- rod according to cylinder.

- Over turn the crank case on its top face.

- Remove the flywheel housing from the crankcase.

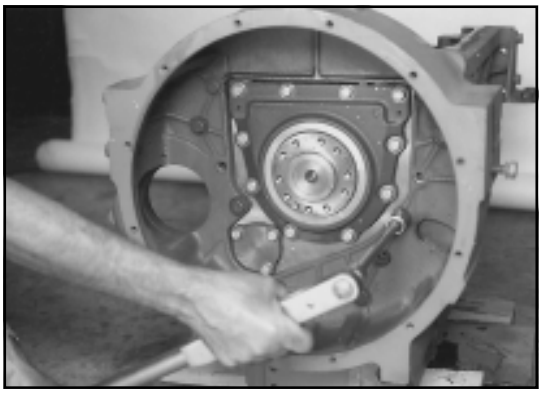


Fig. 8 -17

- Dismantle and remove FWE oil seal housing. Discard the oil seal.

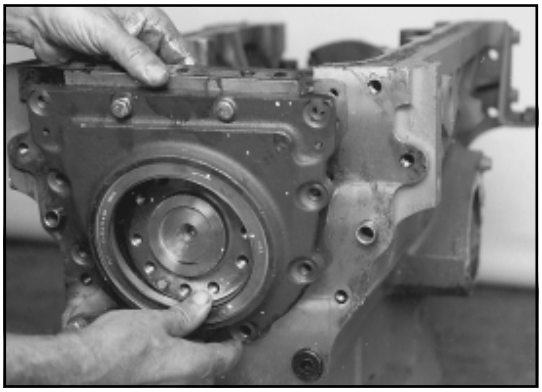


Fig. 8 -18

- Remove the oil seal housing support plate. Discard plate for oil seal housing (FWE).

- Loosen and remove the main bearing caps.
  (Don't separate the bearings shells Keep them as a pair.)

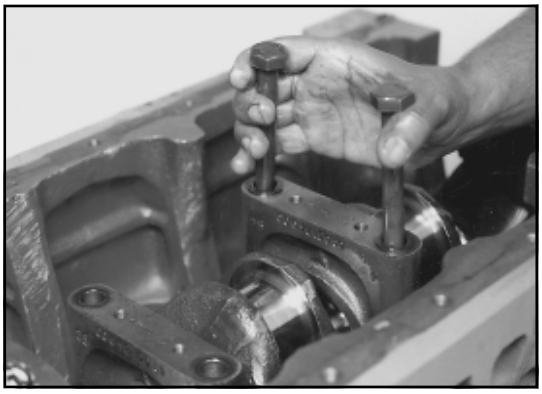


Fig. 8 -19

- Using a proper lifting tackle lift the crankshaft from the crank case.

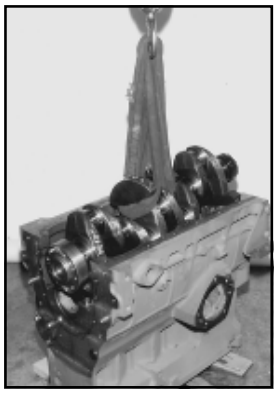


Fig. 8 -20

- Take out the thrust washers and keep them aside.

- Remove all core plugs, screw plugs from the crankcase. Discard the old sealing washers

- With a screw driver unscrew and remove the slotted pins.

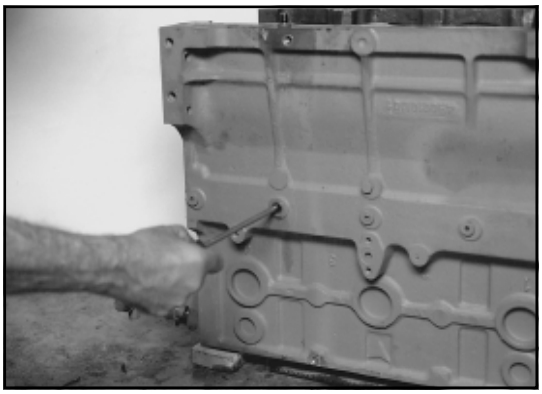


Fig. 8 -21

- Disconnect and remove oil spray nozzles from the crank case (On Turbocharged Engines.)

- Fit and align the oil spray nozzles and tighten them with special tool. (on Turbocharged engines)

- Fit the slotted pin in the oil galleries and tighten with Screw driver.

- Apply liquid sealant to core plug threads plugs and secure with new sealing washers.

- Follow the same procedure with the main oil gallery plugs.

- **Align the lubricating oil hole correctly and press new cam bush in the gear end bore only with mandrel No. 4H.950.01.0.00 (The balance cam bores are without bushes).**

- Fit the cam bore blanking plate on the fly wheel end side of the crankcase with a new joint.

- Apply 'Zealac' to the liner collar cavity in the crankcase. Fit the liner with new liner joint rings with soap solution. **Use liner pressing mandrel, Tool No.4H.950.03.0**

- Measure the liner projection above the crankcase (Refer specification Data)

- Turn the engine over, with the crank case opening upwards.

- Wipe and lubricate tappet and tappet bores and fit the tappets in the bore Check tappets are free in their movement.

- Install and fit the crankshaft in the crank case. (Refer to Inspection & Servicing Procedure No. 11-20)

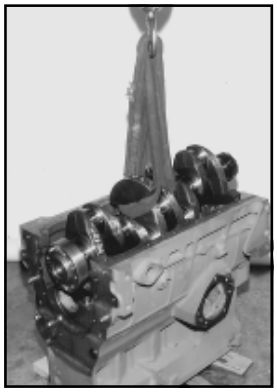


Fig. 8 -22a

10.2 Cleaning Inspection & Servicing of sub-assemblies :

After de-carbonizing and cleaning check/ inspect the components. Worn and unserviceable components / assemblies should be reconditioned / replaced with new ones. The Inspection & Servicing procedure given in Chapter 9 of this manual is mostly to guide the Service Engineer or Technician in the proper repair / overhaul of the engine and its sub-assemblies, and also to carry out the adjustments and settings as required.

10.3 ENGINE ASSEMBLY :

Important :
All joints, gaskets, 'O' rings and copper washers should be replaced when re-assembling the engine.

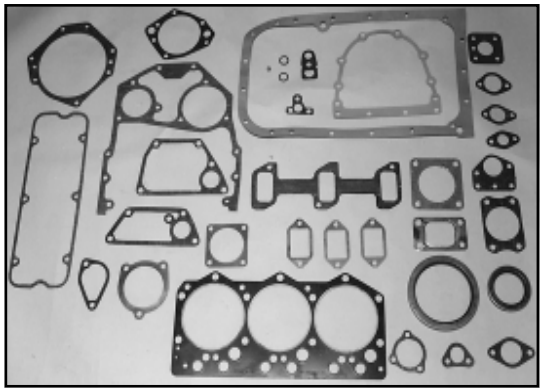


Fig. 8-22

It is recommended that all important fasteners should be replaced during major overhauling.

It is important that during assembly correct type of Gasket Cements and Engineering Adhesives should be used. KOEL recommends the use of Gasket Cements and adhesives or their equivalent to ensure a correct assembly and leak free joints.

Please note that recently KOEL has introduce control swell joints for all R 1040 & R 1080 series engine.

CAUTION : It is recommended not to use any type of adhesives or sealants on this control swell joints.

Before using of gasket cement and Adhesives the joining surfaces should be clean and dry to ensure good bonding.

After cleaning and Inspection, the engine should be assembled within the shortest period of time to avoid dust contamination and misplaced parts. The assembly must take place in a well ventilated, lighted and dust free room. Store the cleaned usable engine components properly after coating them with protective oils and duly labelled.

CAUTION : DO NOT USE Cotton Waste while cleaning and assembly of the engine. Use only fluff free cotton cloth.

- Fit a new plate for oil seal housing.

- Fit a new oil seal to the F.W.E housing (Refer to Inspection & Servicing Procedure No. 11-35) and assemble the housing to the crankcase a new joint.

- Check condition crank gear Dowel. If dowel is loose or damaged, replace the dowel.

- Fit the crank gear to the crankshaft. Ensure the timing mark punched on the gear is on the outside and visible.

- Fit and secure the lubricating oil pump.

- Fit new 'O' rings at both ends of the delivery tube. Press the one end of the tube into the Lubricating Oil Pump outlet port.

- At the other end of the delivery tube fit the delivery body with a new joint and secure it to the crankcase.

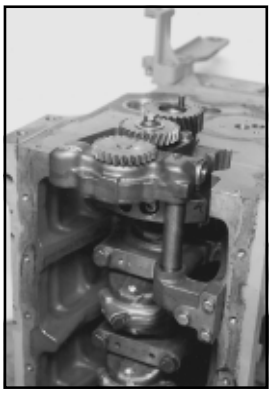


Fig. 8-22b

- Install the gear casing with a new joint and tighten.

- Fit the hydraulic pump with new joint, where provided.

- Where hydraulic pump is not provided, fit the blanking plate with a new joint.

- Assemble and secure the intermediate gear assembly with thrust washer and retaining plate.
  Match the timing marks of the intermediate gear and the crank gear .

- Check the end play of the intermediate gear with a feeler gauge between the intermediate gear and retaining plate. If clearance exceeds the specified limit use new thrust washer. (Refer to Specification Data)

- Lubricate and insert the camshaft thrust washer on the camshaft. Wipe and lubricate the camshaft journal and also the cam bores in the crankcase.

- Insert the camshaft in the crank case. **Match the timing marks of the cam gear with the timing marks on the intermediate gear.** (Refer to the timing diagram on section 11-32)

- Install the serviced fuel pump with a new joint.

- Align the auto timer's key way with the fuel pump shaft's key. Fit and secure the timer with the special nut. **(Note: Auto timer is not provided on PG engines.)**

- Fit the flywheel housing to the crank case after matching with the hollow dowels and torque as specified. (Refer to tightening torque table)

- Assemble the connecting rod and piston (Refer to Inspection & Servicing Procedure No. 11-16)

- Check piston ring butt clearance in the liner with new piston rings. (Refer to Inspection & Servicing Procedure No. 11-17)

- Fit the new set of piston rings in piston grooves (Refer to Inspection & Servicing Procedure No. 11-19)

- Install piston with rings in the liner and tighten the con-rod bolts. (Refer to Inspection & Servicing Procedure No. 11-22)

- Fit the suction tube to the lubricating oil pump and tighten the union nut fully. Fit and secure the oil suction tube clamp.

- Insert a new oil seal in the gear cover. (Refer to Inspection & Servicing Procedure No. 11-36)

- Install the cup and spring camshaft end play controlling spring and cup on the camshaft boss.

- Fit and secure the front cover with new joint.

- Fit the crank pulley and tighten the bolt to the specified torque after locking the pulley.

- Mount the flywheel fasten and torque the bolts (Refer to tightening Torque table)

- Set the Fuel timing and fit the fuel pump gear and lock it in position. (Refer to Inspection & Servicing Procedure No. 11-28)

For assembly of the upper half of the engine, please refer to the assembly portion in the ENGINE TOP OVERHAULING section.

- Mount the flywheel fasten and torque the bolts (Refer to tightening Torque table)

- Set the Fuel timing and fit the fuel pump gear and lock it in position. (Refer to Inspection & Servicing Procedure No. 11-28)

For assembly of the upper half of the engine, please refer to the assembly portion in the ENGINE TOP OVERHAULING section 9.

11. INSPECTION SERVICING & INSTALLATION OF SUB ASSEMBLIES :

INDEX

Sr. No.	Inspection & Servicing Procedure.	Reference No.
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20.	Fitting Crank shaft in Crank Case	11.20
21.	Checking the Crank Shaft end play	11.21
22.	Fitting of Piston and Con-rod Assembly in liner.	11.22
23.	Valve Lapping	11.23
24.	Valve checking by Pencil Erase Test	11.24
25.	Valve checking by Fuel leakage test	11.25
26.	Inspection of Oil Spray nozzle.	11.26
27.	Checking the Gear Back lash.	11.27
28.	Setting the Fuel timing	11.28
29.	Valve Tappet Setting	11.29
30.	Replacing the Spin-On type lub. oil filter	11.30
31.	Bleeding the Fuel System	11.31
32.	Inspection & Servicing the Lub. Oil Cooler	11.32
33.	Inspection & Servicing of the Radiator	11.33
34.	Inspection & Servicing the Auto Electricals	11.34
35.	Fitting the F.W.E. Oil Seal	11.35
36.	Fitting the G.E Oil seal	11.36
37.	Servicing the Oil Bath type Air Cleaner	11.37

11.1. Inspection & Servicing the Crank case :

- Remove the cylinder liners with tool No. 4H.950.07.0.00. Discard the liner sealing rings.
- Clean the crankcase and oil passages with clean fuel oil and blow dry with compressed air.
- Visually inspect crankcase for cracks and other damages. Replace the crankcase if found damaged.
- Clean the threaded holes by running proper taps. Where holes are blind, apply grease while running a tap.
- Visually inspect the main bearing bores and caps. Further check the main bores with a dial gauge.
- Before fitting the main bearing caps for checking diameter, ensure the following :
- Condition of hollow dowels. Replace damaged dowels if required.
- Check the crankcase and main bearing cap assembly numbers are the same. Fig.9 -1

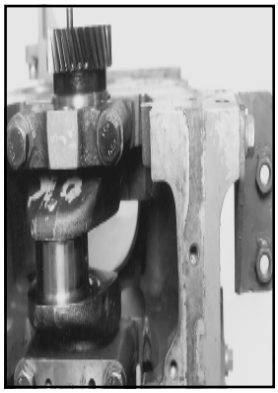


Fig.9-1

- Fit the caps sequentially in the acceding order 1, 2, 3, 4, 5. No 1 starting from the flywheel side. Check the both bearing locating notches on the crank case cavity and bearing caps are on the same side.
- Tighten cap with new bolts & washers to the prescribed torque. (Refer to tightening torque table)
- While tightening the bolts take care of the following:
- Apply oil to bolt threads
- Apply initial torque with a torque wrench. (Refer to tightening torque table)
- Torque by angular method in steps. (Refer to tightening torque table)
- Set dial gauge to the bore's correct size with a Micrometer.
- Measure the bores at 2 planes and at 60^0 angles. Fig.9-2
- Record and check values with the specification. (Refer to Specification Data.)

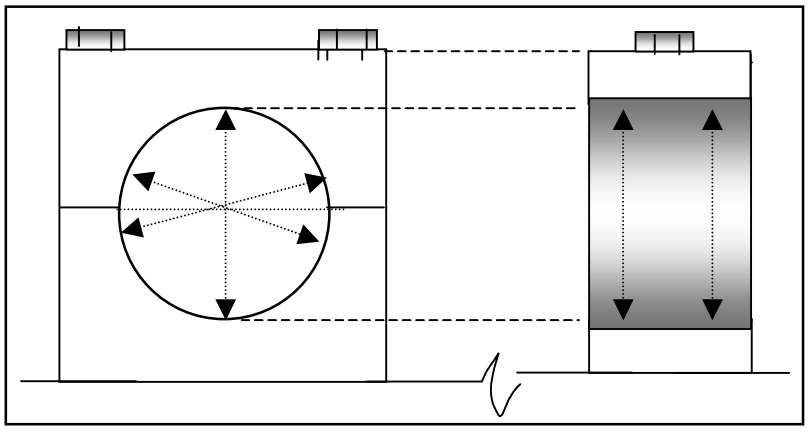


Fig.9-2

- Inspect cam bores and cam bush I.D. for visible damage and wear.
- With a dial gauge check the Internal diameter of the G.E. cam bush at 2 planes and at right angle. Fig.9-3. Similarly measure the cam bores. Compare the recorded values with the specification. (Refer to Specification Data.) Replace the bush if required.
- If cam bores are damaged replace the crankcase.

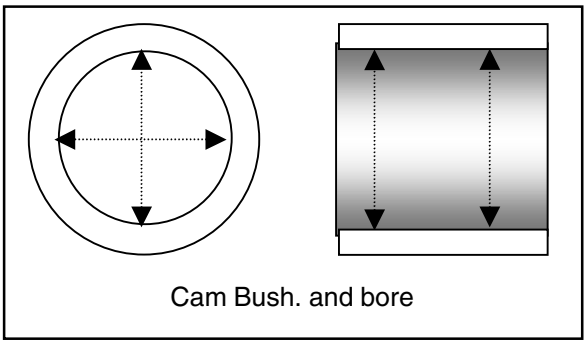


Fig.9-3

- Fit the old thrust rings to the crankcase and cap and measure total thickness with micrometer. Fig.9-4
- Also measure the distance (W) between the thrust faces of the thrust journal of the crank shaft. Calculate the clearance and check with the specification. If the calculated clearance exceeds the specified limit, then carry out the above exercise with new set of STD thrust rings.

Fig.9-4

- Inspect the cavity of the liner collar resting face bore in the crankcase .
- Check the condition of lower liner cavity where the liner joint rings sits. If deep grooves are noticed, recondition or replace the crankcase.

11.2. Inspection & Servicing the Crank shaft :

- Clean the crankshaft before inspecting it.
- Check crank gear for abnormal wear and broken teeth. Replace crank gear if required.
- Check condition of the gear's dowel pin. Replace if required.

- Support the crank shaft at the outer journals on ‘V’ blocks and check the diameter of the journals and pins. Fig.9-6
- Note these down in the format given below. Compare the readings with the values as specified. (Refer to Specification Data)

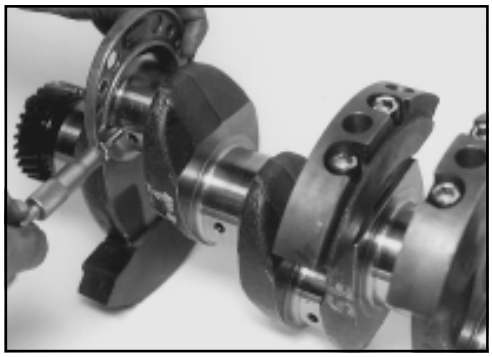


Fig.9 -6

- Check the hardness of the journals and Pins with a non-indenting type hardness tester. (Rockwell ‘C’ scale.) and note these down in the format given below and compare the values with the specifi cation.
- Check oil seal journal flange where the Flywheel end oil seal fits for any noticeable grooving / wear, on the oil seal contact zone. Fig.9-7. If groove is deep it may cause oil leakage between the oil seal, recondition the journal.

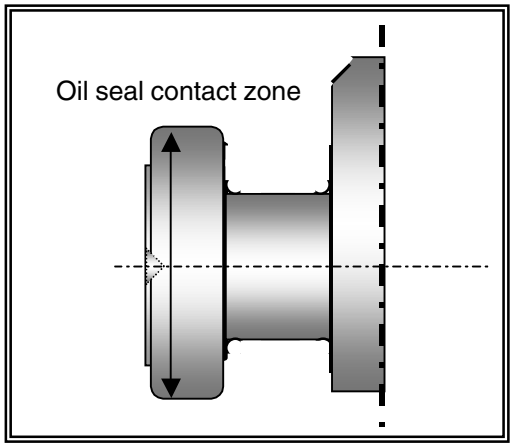


Fig.9-7

- Check the width (W) of No.1 locating journal where the thrust washer contact. If the width exceeds the prescribed limit, machine the faces of the thrust journal’s to the next over size. Fig.9-8

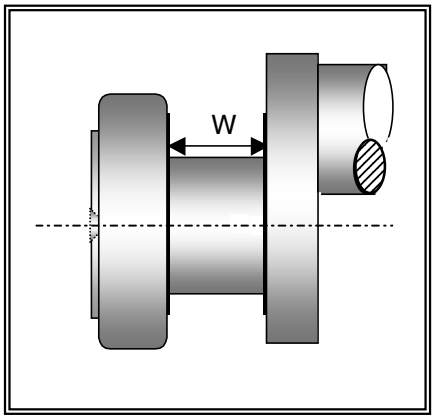


Fig.9-8

11.2.1 Inspection of crankshaft before reconditioning.

- The crankshaft's journals and pins should be checked for cracks by the Magnaflux method, before grinding.
- Remove the balance weights before sending the crankshaft for machining.
- **Before removing the balance weights, punch numbers in the ascending order 1-2-3-4 on the balance weights and corresponding crankshaft webs, with No. 1 being nearest to the flywheel.** Numbers should be punched on one side of the balance weight and webs for correct repositioning of weights during re-assembly. **Discard old balance weight bolts.**

11.2.2 Precautions during machining:

- **All journals and pins must be ground uniformly to the same under size diameter and within the tolerance as given in the specification.**
- Fillet radius of journals and pins must be maintained as per specification. Fig.9-9
  There should be no sharp corners / edges on the journals and pins. These must removed by rounding them off or dimple them.

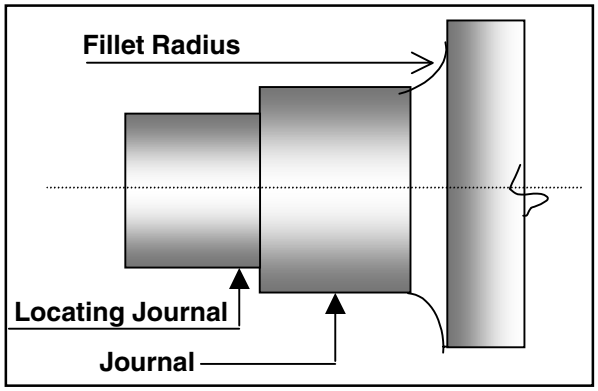


Fig.9-9

- No visible tool marks / scratches should be on the fillet radius or the polished surface areas.
- Oil holes on the journals and pins must be rounded off and polished after completing under sizing. Fig.9-10

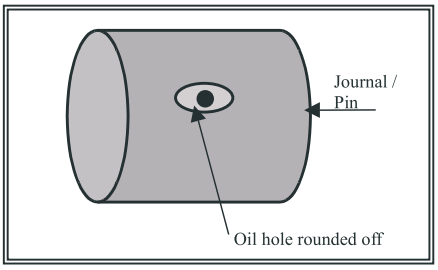


Fig.9-10

- Ensure the thrust faces of journals and pins are not machined.
- Locating diameter of flywheel and vibration damper should not be machined.
- As and when required the thrust faces of the thrust journal should be machined (No. 1 Journal) to the prescribed oversize limit.(W) Fig.9-11

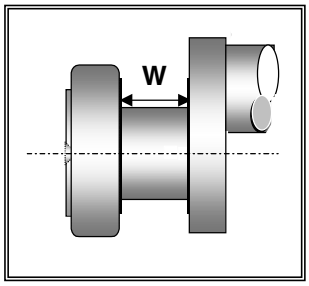


Fig.9-11

11.2.3 After grinding:

- Inspect the journals and pins diameter with a micrometer. (Refer to Specification Data)
- Inspect hardness of the newly ground journals and pins. (Refer to Specification Data)
- Inspect and ensure that the fillet radius is maintained as per specification. (Refer to Specification Data)
- Check for parallelism between journals and pins. (Refer to Specification Data)
- Inspect and ensure that there are no visible tooling marks / scratches on the fillet radius and the polished surfaces of the crankshaft.
- If oil seal journal flange is reconditioned, check the finish of resting zone.
- Use correct size tap (Refer to tool list 4.4.) to clean the threaded holes in the crankshaft where bal ance weight bolts fit.
- Clean the crankshaft and oil passages with clean fuel oil. Remove all traces of abrasive material from the oil passages. Blow-dry with compressed air.
- Balance weight bolts should be replaced at every major Overhaul.
- Refit the numbered balance weights to their respective webs and tighten bolts as per specification. (Refer to tightening torque table.)

	D I A M E T E R.				**H A R D N E E S (RC).**				**REMARKS**
Plane Journal No.	**A1**	**A2**	**B1**	**B2**	**A1**	**A2**	**B1**	**B2**	**All dimensions in mm**
Journal 1									**Journal Std. Ø :0,0 -0,010 / -0,029**
Journal 2									**Hardness Std: 58.3Rc**
Journal 3									
Journal 4									
Journal 5									
Pin 1									**Pin std. Ø : 59,97-0,010/ -0,029**
Pin 2									**Hardness Std: 58.3 Rc**
Pin 3									
Pin 4									
Locating Journal width Hardness :			**Std width: Std:**		**37 +0.039/0.00 58.3 RC**				**Note: No.1 journal is the thrust journal.**

11.3. Inspection & Servicing the Cylinder Liner:

- Visually check the liner condition from inside for excessive wear, step, scratch marks etc.
- Inspect liner externally for pitting etc.
- Check liner's ovality and taper wear with a dial bore gauge at three planes and at right angles as shown in the Fig.9-12

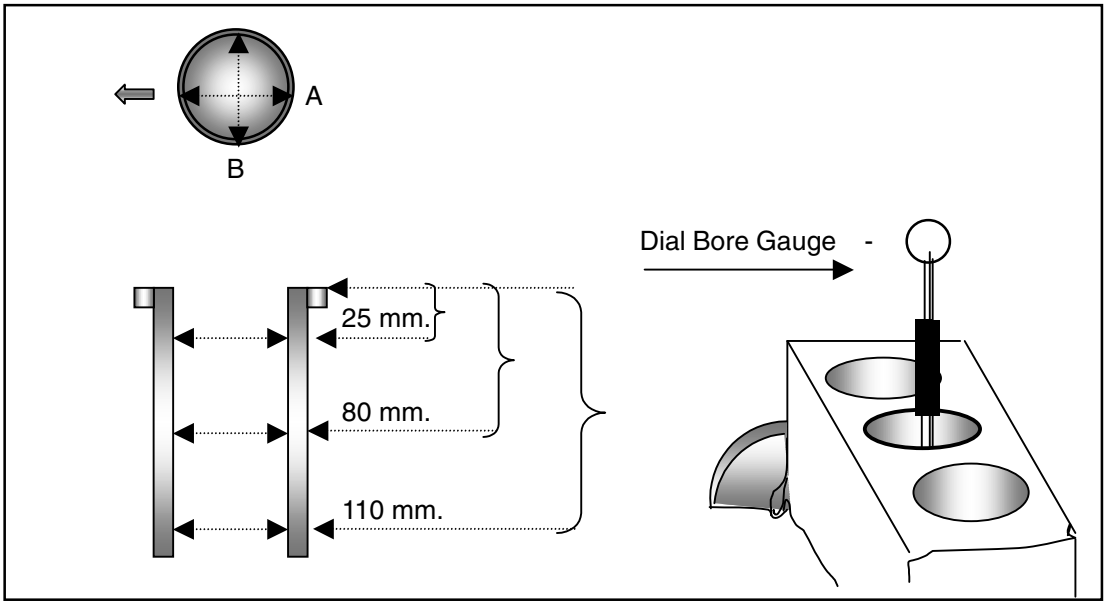


Fig. 9 -12

- Discard the liner if any of the conditions are found not satisfactory and if the wear exceeds the specified limits. (Refer to Specification Data).

Note : When refitting the old liner or replacing the liner, always fit new liner joint rings.

11.4. Inspection & Servicing the Connecting rod.

- Inspect the connecting rod assembly after it is thoroughly cleaned.
- Check the "I section of the connecting rod for notches or hit marks. If the notch is insignificant dimple it out, but if the notch is deep, replace the connecting rod.
- Inspect the connecting rods for parallelism of the small end and the large end bore on a fixture. Replace con-rod if a bend or twist is noticed.
- Check small end bush internal diameter with dial gauge Fig. 9-14 (Refer specification Data). Re place bush if diameter exceeds specified value.

Fig. 9 -14

Caution: When pressing new S E. bush, take care to match the oil holes.

- Check big end bore for any visible damage. If bore is found damaged replace the connecting rod, do not recondition it.
- Check big end bore diameter with a dial gauge. Fig. 9-15

Fig. 9-15

- If any of the above defects are noticed replace the connecting rod.
- Note: When replacing connecting rod, replace con. rod bolt as per specification.

11.5. Inspection & Servicing the Piston:

- After cleaning visually check the overall condition of the piston.
- Inspect piston's crown for surface cracks, burning marks and erosion.
- Inspect the side walls for seizure or scoring marks.
- Inspect piston ring grooves for damage.
- Check the land clearance between ring grooves and piston ring. (Refer specification Data.) as shown in the Fig. 9-16

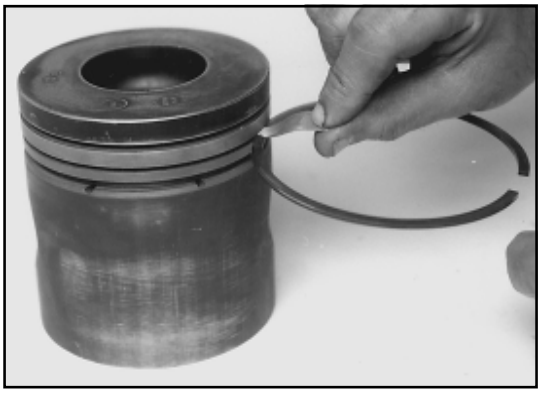


Fig. 9-16

- It is recommended to checking land clearance with new piston rings.
- Inspect piston pin bore diameter (Refer specification Data.)
- Check the bore for wear and rubbing marks or other damage.
- If any of the above defect is noticed or if the clearance values do not comply with the specification, replace the piston assembly.
- Inspect piston pin diameter at the center where small end bush fits. Fig. 9-17
- Replace pin if diameter is less than the specified limits. (Refer specification Data)

Fig. 9-17

11.6. Inspection & Servicing the Cylinder Head.

- De-carbonize the head. Do not use a sharp tool / instrument to scrape off the carbon. Do not scuff or nick the polished surface of the head.
- Clean the Cylinder Head with clean fuel oil. Check the head's polished surface for flatness. Fig. 9-18 (Refer to Inspection & Servicing Procedure No.11-12)

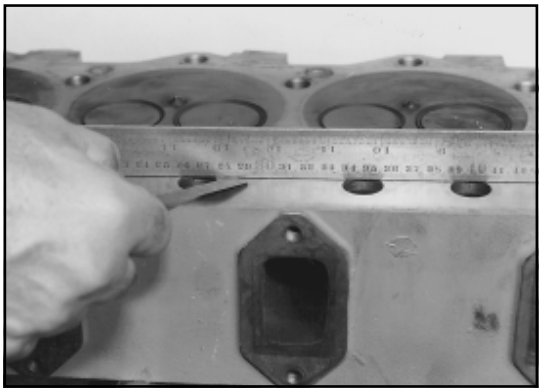


Fig. 9-18

On turbo-charged engines, check the flatness of inlet and exhaust port seating faces and also the manifolds faces. Fig. 9-19

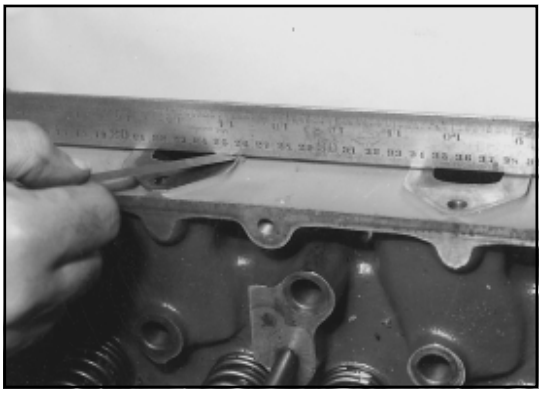


Fig. 9-19

- Check the distance between valve face and cylinder head face. (valve recess) Fig.9-20 (Refer to Inspection & Servicing Procedure No. 11-13)

Fig.9-20

- **Punch numbers on the valve cone according to cylinder numbers, Fig.9-21 No.1 being on the F.W.E. side. Do not disturb the set combination of the valves in their seats. Remove the valves. Discard stem seal.**
- De-carbonize and remove the carbon found on the Combustion chamber and in the exhaust ports..
- Replace valve guides irrespective of their condition. (Refer to Inspection and Servicing Procedure No.11-14)
- Check valve seat condition in the head. Look for burn marks heavy pitting and other damages.
- If required polish valve seat inserts with proper grooming tool.
- **Replace valve seat inserts if beyond repairs. (Individual valve seat inserts can be replaced as re quired)**
- Check valve for cracks, burns, erosion etc. Replace damaged valve.
- Check the valve stem diameter. Replace valve, if stem diameter has worn beyond specified limits. (Refer to specification Data)

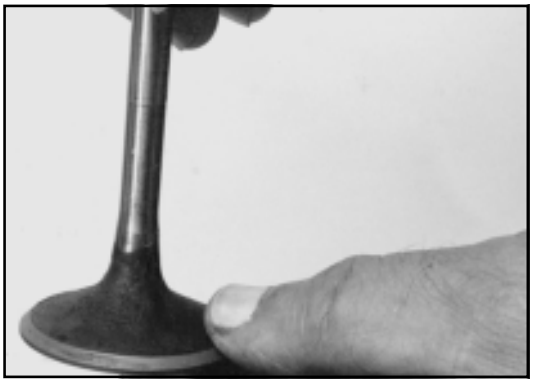


Fig.9-21

- Measure free length of valve spring, check for cracks or other damages. Fig.9-22. Replace if re quired. (Refer to Specification Data.)

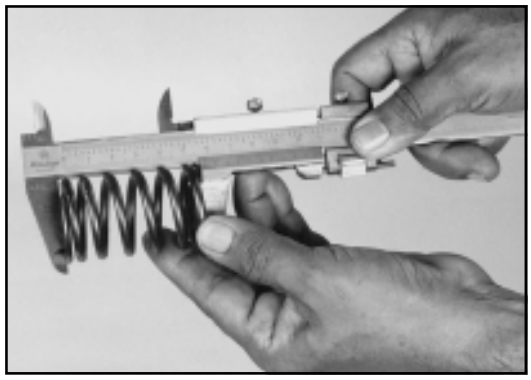


Fig.9-22

11.7. Inspection & Servicing the Camshaft:

- Do not separate the cam-gear from the camshaft, as the gear is shrunk fit.
- Check journal diameters with a micrometer Fig.9-23. If journals are worn replace the camshaft with gear.

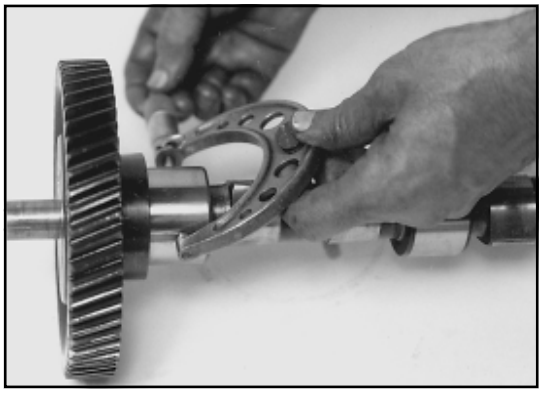


Fig.9-23

- Checking cam toes for excessive wear. Replace camshaft and gear assembly if the toe is excessive worn out. Fig.9-24

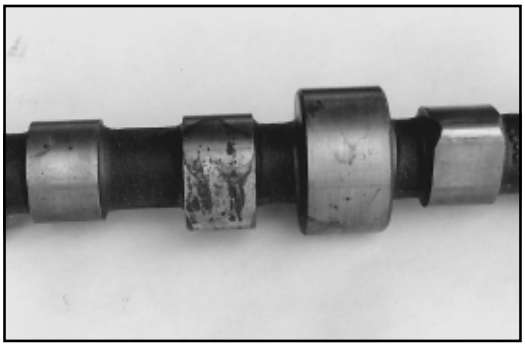


Fig.9-24

- Check the thrust washer If found worn or scratched replace it.

11.8. Inspection & Servicing the Intermediate gear Assembly :

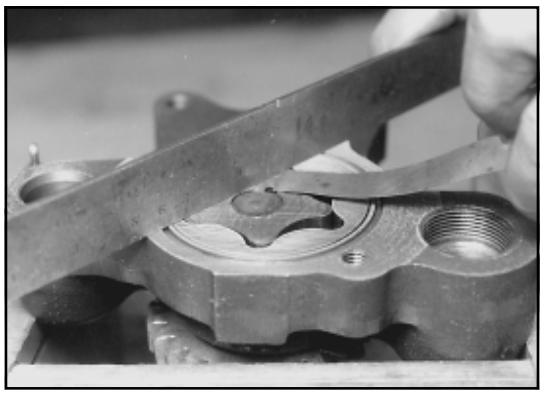
- Check the intermediate gear for wear and damage to its teeth. If wear or damage is severe replace the gear along with the bush bearing.
- Inspect intermediate gear bush Internal Diameter at two places and at right angles in pressed condi tion. If diameter exceeds the specified limits replace the bush.
- Inspect the gear support journal diameter for wear with micrometer at two planes and at right angles Fig.9-25. If wear exceeds the specified limit replace the gear support. (Having a slot for oil supply to auto timer) (Refer to Specification Data).

Fig.9-25

- Replace the thrust washers.
- Replace the fasteners if found damaged or elongated.

11.9. Inspection & Servicing the Lub oil pump :

- Remove the back plate from the lubricating oil pump.
- Remove the ‘O’ ring from the groove in the pump body.
- Check end clearance between pump rotor and pump body with a straight edge and a feeler gauge Fig.9-26.If clearance exceeds the specified limit (Refer to Specification Data), replace the pump assembly.



- Inspect radial clearance between the inner and outer rotor all round with a feeler gauge Fig.9-27. If the gap exceeds the prescribed limit (Refer to Specification Data), replace the pump assembly.

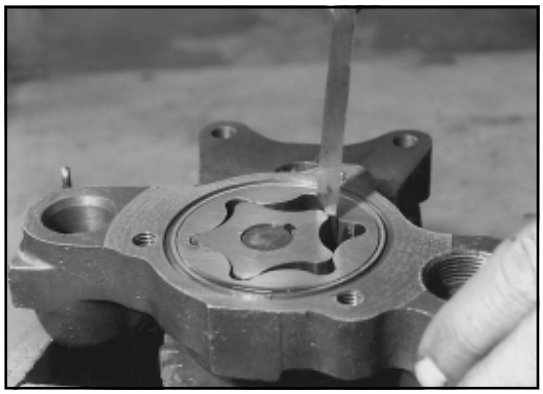


Fig.9-26

- Clean and inspect oil relief valve assembly. If the relief valve plunger is scored and sluggish replace the plunger. Assemble the relief valve with a new split pin..

11.10. Inspection & Servicing the Water Pump :

- Remove the fan and check the water pump for shaft play and leakage. Even if a slight play or leakage is observed, recondition the water pump.

Note: For reconditioning the pump a mechanical /hydraulic press is essential.

11.10.1 Dismantling :

- Remove the spacer from the water pump.
- Remove the ‘ V’ belt pulley from the hub.
- Dis-assemble the water pump assembly from the delivery volute casing.
- Support the hub on a suitable support and press the shaft out from the hub. (If difficulty is encoun tered to press the shaft out, heat the hub evenly with a blow torch to about 750 - 800 C. and press the shaft out)
- Press out the shaft and impeller from the bearing housing.

Caution : Do not try to remove the impeller from the shaft unless it is broken, as the impeller will break in the process.)

- Remove the water seal assembly and oil seal from the impeller side of the housing, and discard them.
- Remove the bearing circlip and remove the front and rear bearings along with the spacer. Discard the bearings.
- Remove the ceramic ring along with the rubber boot from the impeller cavity and discard.

11.10.2 Cleaning and Inspection :

- Clean the bearing housing with clean fuel oil.
- Inspect the bearing housing for cracks/ damage. If found damaged replace pump.
- Remove rust, grease and scale formations from the shaft and impeller assembly.
- Inspect the shaft and impeller assembly for cracks, wear or damage. Replace if required
- De-scale and clean the volute casing.

Assembly :

Note : When reconditioning the water pump replace all parts contained in the repair kit.

- Manually pack grease in to the inner and outer bearings. (Use Lithium based high melting point grease. (~ 180^{0}c)
- Press the inner bearing (small) till it rests in its cavity.
- Insert the spacer. Fill the place around it with about 15-20 gms. of grease.
- Press outer bearing and fit the circlip in the groove.
- Fit the oil seal, the lip facing outwards and visible.
- Fit the new water seal assembly, the carbon face visible.
- Install the rubber boot in the impeller cavity and fit the water seal ceramic ring in it.

Caution : Do not use undue force when fitting the ceramic ring, as it can crack, thus making the seal unserviceable.

- Lightly apply fresh lubricating oil to the water seal's carbon face.
- Apply soap solution to the shafts boss where the oil seal comes in contact.
- Insert the shaft assembly into the pump housing.
- Check gap between the impeller and the bearing housing. It should be between 0.6 - 0.8 mm Fig.9-29

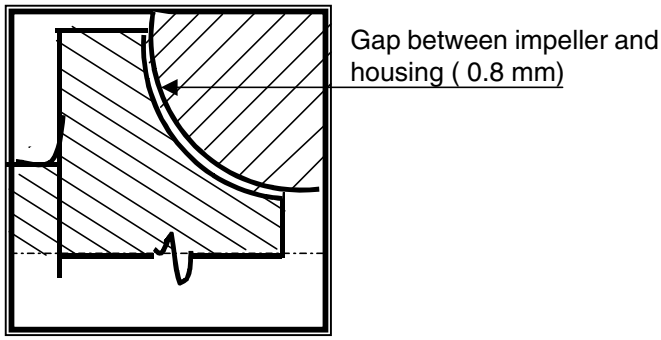


Fig.9-29

- Press the hub onto the shaft, keeping the hub's larger boss towards the outside. Press till the hub's inner face rests on the bearing.
- Check the assembly for leakage and free rotation.
- Grease the bearings with a grease gun before commissioning the pump.

11.11. Checking & Servicing the Turbocharger:

11.11.1 Principle of Operation:

- Exhaust gases from an engine which would normally be wasted, is used to drive a turbine and shaft assembly in the turbocharger. On the other side of the same shaft a compressor wheel is fitted. This enables the turbine to drive the compressor, which in turn draws air from the atmosphere and feeds this pre-compressed air to the engine. This enables more fuel to be mixed and burned with a greater mass of charged air and increases the power output from a same capacity cylinder. Better availabil ity of air enhances better combustion, leading to better fuel consumption and less emission.

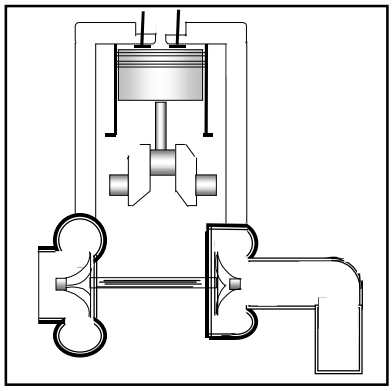


Fig.9-30

The advantage of modern turbocharged engine over a naturally aspirated engine with identical power output is as follows :

- Lower emission
- Lower engine noise
- Better torque characteristics.
- Smaller engine and less weight.
  As a result, turbochargers contribute significantly to the protection of the environment and better utilisation of energy resources

Exploded View of Turbocharger Sk-12

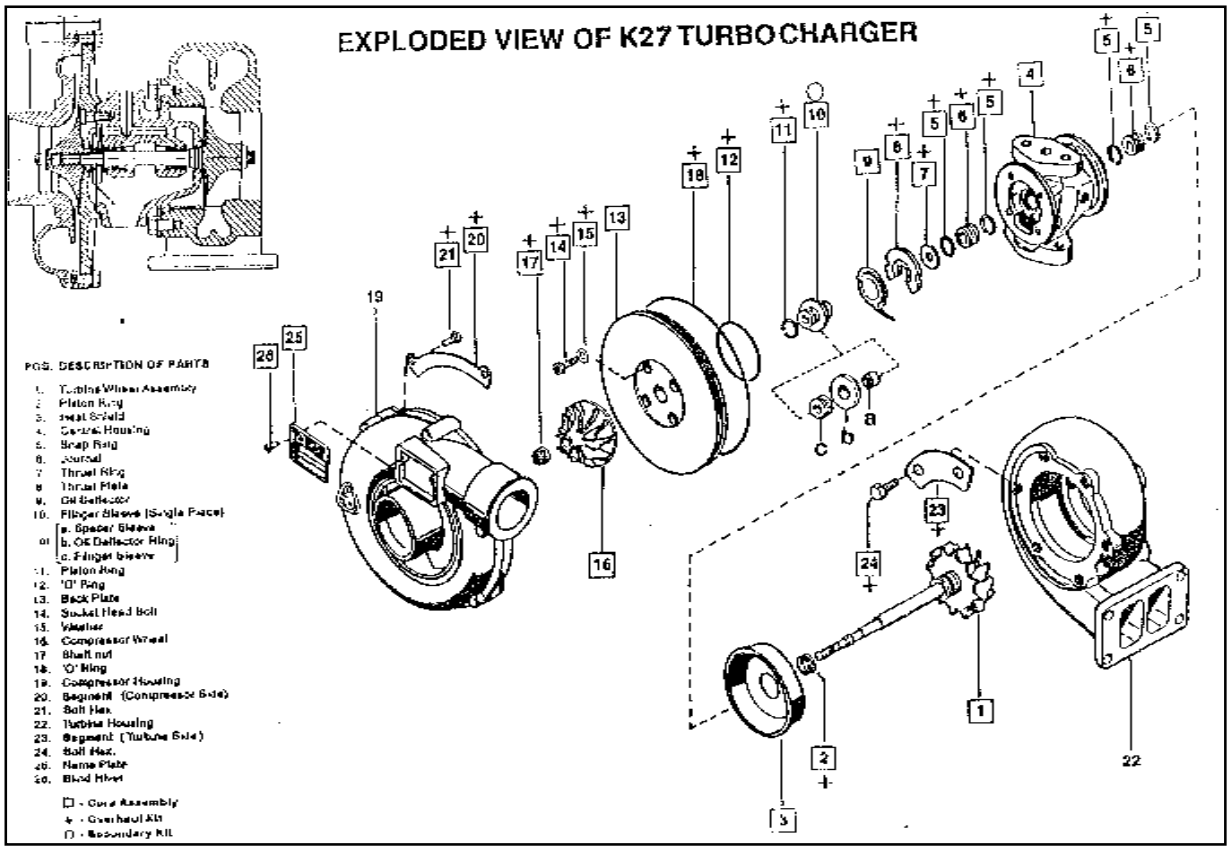


Fig.9-31

Re conditioning :

- **The turbocharger must be repaired / reconditioned by authorised KOEL service dealers only, as special tools and expert knowledge is required.**
- Before dismantling the turbocharger for reconditioning ensure that the following kit is available.
  1. Overhauling kit.
- Tables and charts given at the end of this chapter are only as a guide and reference to the technician repairing the turbocharger.

11.11.2 Dismantling :

- Mark the turbine and the compressor housing position in relation to the central housing and the back plate. This will help to re-position of housings during re-assembling.
- Clamp the turbine housing inlet flange in a vice. (Vice jaw clamps must be used so as not to damage the flange.)

- Remove the bolts and lock plates of the turbine and compressor housing and discard them.
- Using a plastic or rubber mallet Tap out the housings. (If housing is stuck, treat stuck part with rust remover cum penetrating oil to release housing and remove it.)

Caution : As the turbine and compressor wheels are now exposed, they may get damaged due to improper handling.

- Clamp the turbine locking tool in a vice jaw. Using a 'T' spanner loosen and remove the compres sor nut. Discard the nut

Caution: Before loosening the compressor wheel nut check if the nut's is left hand or right hand threads.

- Using a hand press or even a vertical drill, press out the turbine & shaft assembly from the compres sor wheel.
- Carefully remove the turbine & shaft assembly from the central housing.
- Remove the heat shield
- Remove the sealing (Piston) rings from the turbine & shaft assembly using pliers. Discard them.
- Clamp central housing, across the oil inlet and outlet flange, in a vice and remove the screws hold ing the back plate. Remove back plate. Caution: The Screws are secured with a thread lock seal compound and may be difficult to remove
- Remove and discard 'O' ring (big) from the back plate.
- Push out the flinger sleeve from the back plate. Remove the sealing (piston) ring from the flinger sleeve and discard it.
- Remove the sealing ring (small) from the central housing groove and discard it.
- Remove the oil deflector.
- Take out the thrust plate and discard it.
- Pull out the thrust ring and spacer sleeve from the central housing.
- Remove the outer snap rings with snap ring pliers and discard them.
- Remove both the bush bearings and discard them.
- Do not remove the inside snap rings, if they are in good condition and do not have any
- wear marks.

11.11.3 Cleaning & Inspection of components :

- All components should be cleaned with clean fuel oil and dried.
- All traces of carbon and oil residue should be removed from the central housing.
- During cleaning take care and remove the stuck LOCKLITE residues.
- Clean oil passages in the central housing to ensure oil flow to the hot spots and high speed components inside the housing.
- Clean both the turbine and compressor housings by sand blasting (where available) or with clean fuel oil.

a. Central Housing :

- Check the central housing for cracks or damages.
- Inspect sealing ring area at the turbine side of housing for wear and tear or damage.
- Check the bearing bores in bearing housing for wear / damage.
- Examine condition of snap ring groove in the bearing housing.
- Check the oil passages in the central housing for any foreign material.
- Inspect the condition of the flinger sleeve's center bore and sealing ring groove.
- Check the sealing area in the back plate where sealing ring fits for wear / damage.
- Replace all worn and damaged components.

b. Turbine Housing :

- Examine turbine housing for cracks.(Cracks up to 10 mm in length, in only the vicinity of the tongue and partitioning wall are permissible)

- Examine housing for scaling in divide wall of gas inlet. If heavy scaling is noticed replace housing.
- Inspect the housing for deformity.
- Replace the turbine housing if any of the above defects are noticed.

c. Compressor Housing :

- Check housing for rubbing marks - Rubbing traces of 0.02 mm depth are acceptable.
- Check for deformity and any other damage to housing.
- Replace compressor housing if any of the above defects are noticed.

d. Turbine wheel & shaft Assembly :

- Examine the shaft for scoring / wear at bearing seating areas.
- Check shaft diameter at bearing areas.
- Check if shaft is true.
- Check sealing ring grooves in the shaft for damage.
- Inspect turbine wheel, for bent or broken blades. If blades are slightly bent at the tips do not try to straighten them as they will break and unbalance the wheel.
- Check turbine wheel tips for burning marks and erosion.
- Check turbine wheels blade edges for rubbing marks.
- Replace turbine & wheel assembly if any of the above defects are noticed.

e. Compressor wheel :

- Check compressor wheel blades for traces of rubbing.
- Inspect if the compressor's wheel blades are bent or broken. If blades are slightly bent at the tips do not try to straighten them as they will break and unbalance the wheel.
- Replace compressor wheel if any of the above defects are noticed.

f. Heat Shield :

- Inspect heat shield for deformity, cracks or erosion.
- Replace heat shield if any of the above defects are noticed.

11.11.4 Assembly :

- When reconditioning the turbocharger extreme cleanliness should be observed.
- All components supplied in the Overhauling kit should be replaced.
- Lubricate and install new bush bearings.
- Fit new snap rings (dish side faces the bearings) in the central housing .
- After bearings are locked in position check the bearings are free in their cavities.
- Install new sealing rings in the grooves of the turbine & shaft assembly.
- Clamp the central housing on a vice jaw with the turbine side facing up.
- Put the heat shield concentrically matching the central bore.
- Lubricate the shaft and rings lightly. Set the piston ring gaps opposite to each other.
- Insert the turbine wheel & shaft assembly into the central housing till the rings rest on the sealing cavity lip. Do not force the shaft in. Rotate shaft once or twice with hand so that the rings centralise in their groove. Rotate again, and while rotating lightly tap the wheel in with the palm of the hand. The rings will slip into the cavity without damage.
- Carefully turn the central housing so the compressor side is facing up.
- Pre-lubricated spacer sleeve and thrust ring and install it onto the shaft and in the housing cavity.
- Lubricate and install a new thrust washer in the housing.
- Fit the oil deflector plate over the thrust washer.
- Fit new 'O' ring, (small) with the larger collar on top, in the housing groove.
  Install new sealing ring in the flinger sleeve groove.
- Install flinger sleeve along with the sealing ring into the back plate central bore. Insert it from the central housing end.

- Lightly coat the new ‘O’ ring (large) with acid proof grease and fit it onto the groove of the back plate.
- Fit the back plate to the central housing. Fit new screws with washers after treating them with LOCTITE 640.
- Measure the turbine contour gap between turbine housing and turbine wheel.

Method :
- Fit the turbine housing to the central housing and fix it with hex screws.
- Place dial gauge pointer on the turbine wheel hub.
- Press hub in, and set pointer to ‘0’.
- Press shaft and wheel against the pointer and note result.
- Remove the turbine housing.
- Heat the compressor wheel to a max. of 1300 C in an oven. Lubricate shaft lightly with oil where the wheel fits. Mount compressor wheel on the shaft and to initial torque.
- Measure contour gap between compressor housing and wheel.

Method :
- Mount the compressor housing to the back plate and bolt it down.
- Fit a dial gauge with the plunger resting on the compressor wheel hub.
- Set the dial to ‘0’.
- Lift the compressor wheel to the max and note the measurement. (Refer table 11.11.6) (Basic torque to the shaft nut should be applied within 5 minutes of preheating of the compressor wheel)
- After cooling for about 10 minutes, unscrew the shaft nut a few threads again, apply thread lock adhesive such as Loctite 242 and torque to the specified torque & angle.

  Caution: When applying torque to the shaft nut take care that there is no bending effects to the shaft.

- Rotate the shaft to check if it rotates freely and the assembly is correct

Checking axial play Method :

- Place dial gauge pointer on the turbine wheel’s hub face.
- Press hub in, and set pointer to ‘0’.
- Press shaft and wheel from opposite side against the pointer and not the result.
- Lubricate the housing bolts with heat resisting compound such as ‘NEVERSEEZ’ or other anti-seize compound and tighten to the prescribed torque
- To store the unit, Cover all oil and air openings

11.11.5 TURBOCHARGER TIGHTENING TORQUE

Sr. No.	Fitting nut or screw	Tightening Procedure	Tightening Torque (in Nm or angle torque)
1.	Compressor wheel shaft nut M6 AF	Basic Torque angular torque	$5 + 60^0 - 5^0$
2.	Back plate.	Tightening Torque	10
3.	Compressor Housing	Tightening Torque	7
4.	Turbine Housing	Tightening Torque (With anti seize paste)	20

11.11.6 FITS & CLEARANCES

1.	Axial Clearance	0.11	
2.	Radial Clearance	0.19	
3.	Contour Gap - Turbine side	1.0	Between turbine wheel & housing
4.	Contour Gap - compressor side	0.96	Between compressor wheel & hsg.

11.11.7 PERIODICAL INSPECTION OF TURBOCHARGER:

APPLICATION	INSPECTION INTERVAL		
Construction Equipment & Gen-set application	Every 6 months	12 months	24months
Agriculture Machinery.	Every 6 months	12 months	24 months
Automotive Application.	Every 6 months	12 months	24 months
Items to be Inspected			
Inspect rotor freeness	●		
Inspect rotor play		●	
Overhauling Turbocharger			● If required
Replace air filter element	See Engine Manual		
Replace oil filter element	See Engine Manual		
Change engine oil.	See Engine Manual		

11.12. Inspecting the cylinder head surface flatness.

- Remove and clean carbon from the polished flat surface of the head.
- Check the flatness of the surface.
- Flatness to be checked at 6 places as shown in the Fig.9-33
- Use a 24" straight edge and a feeler gauge to ascertain the flatness of the head as shown in Fig.9-32

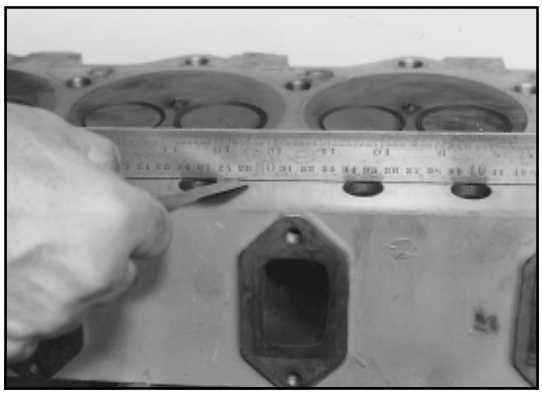


Fig.9-33

(Method.)

- Place the straight edge on the polished surface of the head
- Pass a feeler gauge between the straight edge and the head. (Not under the valve cavities)
- If a feeler gauge thicker than specified passes through the gap, (Refer to Specification Data) the face of the head requires re-facing.
- Correct the flatness by reface the head.
- Using a large thick plate glass smear emery paste over the glass surface. Sprinkle diesel on the paste so that it spread it evenly when refacing. Place the head, face towards the plate and lap. Lap it with a even pressure and length wise, till the high spots are removed. If this should fail to reduce the gap replace the cylinder head.
- This operation can also be carried out in a well equipped machine shop.
- On turbocharged engines the exhaust and inlet manifold seating faces should also be checked for flatness.

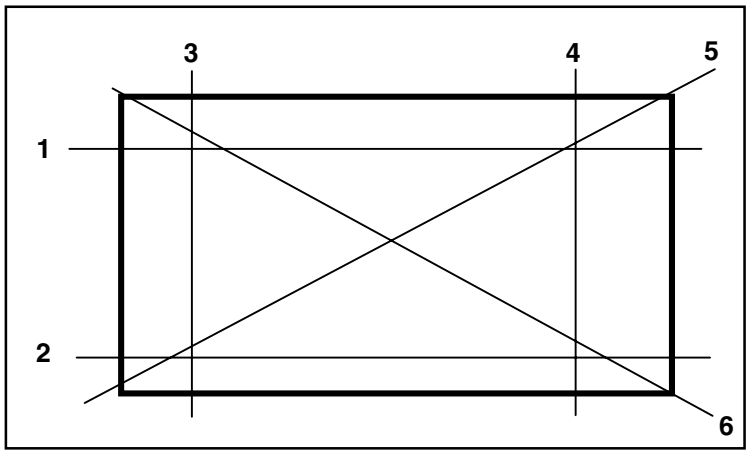


Fig.9-33

11.13. Inspecting the Valve recess in Cyl Head.

- Before dismantling the valves check the valve recess. Fig.9-34 The valve recess is the distance between the valve face and the cylinder head face. This can be checked with the help of a straight edge and a feeler gauge. Insert the feeler gauge between the valve face and the straight edge. If the gauge passes through the gap effortlessly, the gap is more than specified. (Refer to Specification Data) In such case. the valve, possibly the valve seat insert or even both the valve and valve seat insert must be replaced.

Fig.9-34

11.14 Replacing valve guides :

- Punch out the old valve guide from the valve cavity side of the head with Tool No.03.950.12.0
- Clean the guide bores with a cloth.
- Check the bores for scoring or any other damage.
- Insert the wire snap ring onto the machined guide with Tool No. 4H.950.09.0
- Press the valve guide from cylinder head top with Pressing Tool No. 4H.950.11.0 till the wire snap ring rests on the cylinder head. Fig. 9-35
- With Tool No.4H.950.17.0 Press new stem seals on the guide.
- If the guide bore in the head is damaged and requires to be over sized, semi-finished valve guides are also available for the purpose.
- ***Note: It is recommended that all bores should be oversized together to the same diameter, even if one or two guide bores are damaged.***

Fig.9-35

11.15. Replacing Valve Seat Inserts :

- Remove the valve seat inserts with the help of a chisel. Take care not to damage the insert bore in the cylinder head.
- Alternatively insert can be removed by cutting it on an appropriate lathe in a machine shop.
- Remove old valve guides
- Clean and remove all burr particles from the bore.
- Note: Inlet valve seat insert and exhaust valve seat insert diameters are different.
- Fit new valve guides. (Refer to Inspection & Servicing procedure No. 9-14 on page)
- Cool the valve seat inserts in Dry Ice for about 20/30 minutes or cool in liquid Nitrogen for about 5-6 minutes and fit in the head bore and press it immediately.
- Caution: When using liquid Nitrogen, avoid direct contact with liquid Nitrogen to avoid injury to the body due to its sub zero cooling effect. It is recommended to wear gloves when working.
- Fit inlet valve seat insert with Tool No. 4H.950.13. 0
- Fit exhaust valve seat insert with Tool No. 4H.950.12. 0
  Ensure the seats are fitted squarely and completely in the bore.

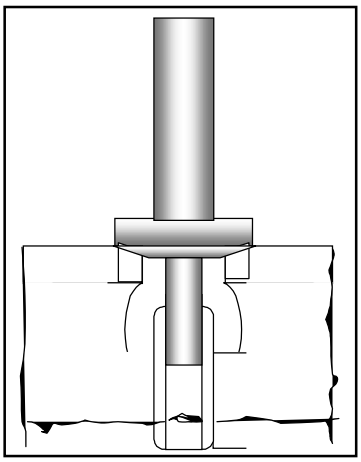


Fig.9-36

11.16. Assembly of the Piston & Con-rod :

- Apply oil to the piston pin and con-rod S.E. bush
- Install a circlip in one end of the piston pin cavity.
- Assemble the connecting rod to the Piston. Ensure the 'AC' mark punched on the piston crown is on the opposite side of the on-rod cap Fig.9-37
- Press the pin into the assembly. (Piston pin is clearance fit and should be fitted by pushing with the thumb and should not be driven by a hammer.
- Fit the second circlip in place

Fig.9-37

11.17 Checking Piston Ring Butt clearance :

- Butt clearance, also known as end clearance, is the gap between piston ring ends. This gap is very crucial and should be maintained as specified in the manual. Check Butt clearance with new rings.

Method :

- Insert one piston ring at a time in the liner. To set the ring squarely inside the liner push it down of liner with a piston (As shown in Fig.9.38)
- Measure the gap between ring openings with a feeler gauge..
- Keep the checked rings in the respective liner.
- Follow this procedure with the next set of rings in another liner
- Repeat the procedure with the rest of the rings of the set.
- This way, rings checked in a liner should be installed in that respective liner only.

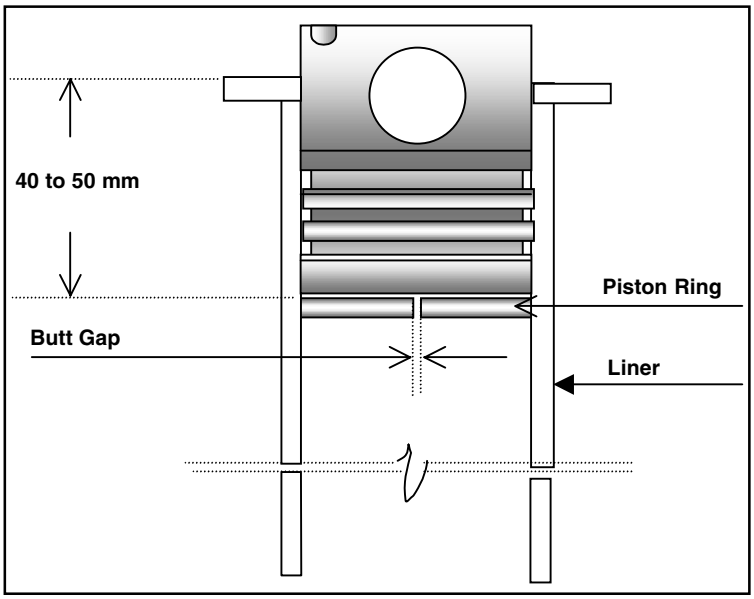


Fig.9.38

11.18. Checking internal diameter of main and Con-rod bearing shells :

- Main bearings are available in two halves, in finished condition and available in 4 under size. As these are thin walled bearings, they should be pre-loaded in the main bores.
- During fitting, the bearing shells should not be scraped, touched or polished. The bearing shells should only be cleaned in clean fuel oil and fitted. Under no circumstance bearings should be wiped after cleaning.
- Set dial gauge to the correct size (Std or o/s) and measure the bearing ID at 2 planes and at as near the bearing parting line and at vertical Fig.9-39
- Record the values and check these with the specification data.)

Fig. 9-39

11.19. Fitting of Piston Rings on Piston :

- Before fitting the piston rings in the piston ring groove, ensure the following:
- When installing piston rings, the manufacturer's name or 'TOP' stamped should be facing the piston crown.
- Install correct rings in their proper sequence. (Refer to Fig.9-40)
- Piston rings should be installed with a ring expander, to avoid premature failure.

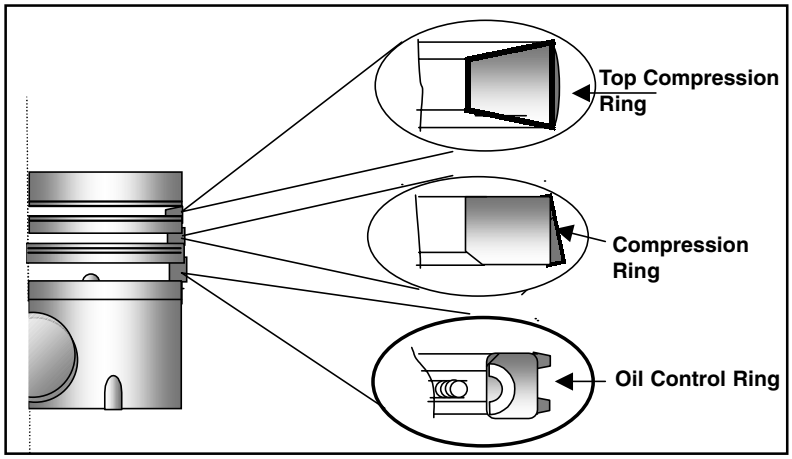


Fig.9-40

- Ring gaps to be spaced at 120^0. Gaps should not be set along the axis of the piston pin, as shown in

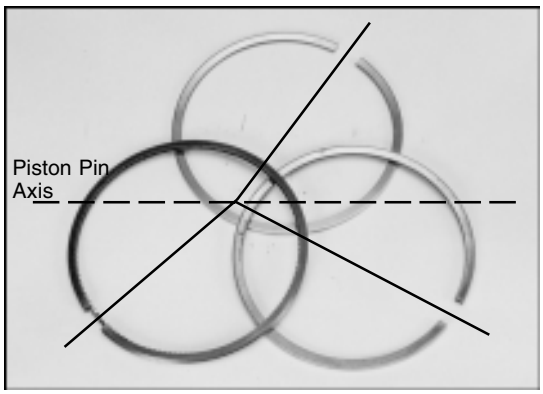


Fig.9-41

11.20 Fitting the Crankshaft in Crankcase :

- Wipe clean the crankcase main bearing bores and caps where the bearings sit.
- Fit the bearing shell halves in the crankcase bearing cavity and the bearing caps without applying any oil to the bearing back.
- Check bearing shells are fitted correctly and are engaged properly in the locating notches.
- Fit the correct thickness thrust washer in their respective slots provided in the locating bearing bore and cap. (nearest to the flywheel.)
- Wipe the crankshaft journals.
- Lightly wipe the bearings in the crank case. Apply fresh lubricating oil with a brush to the journals, bearings and the and thrust washers.
- Lower the crankshaft in the crankcase.
- Rotate the crankshaft and see that it is free.
- Check the cap numbers, apply oil and fit the caps with dowels.
- While fitting the caps ensure the following:
  a. The serial number on crankcase and main bearing caps are the same.
  b. The caps are fitted sequentially in the acceding order 1, 2, 3, 4, 5, No 1 starting from the flywheel side.
  c. The bearing locating notches on the crank case and bearing caps are on the same side.
- Tighten the main bearing caps as follows :
  a. Lubricate the bolt threads with engine oil.
  b. Apply initial torque (See Torque table) with torque wrench.
  c. Torque the caps starting from centre going outwards.
  d. Finally tighten by angular method in steps, tightening from the centre cap and going outwards. (See torque table)
  e. Rotate the crankshaft hand and check it is free and smooth.
  f. Check the crankshaft end play Fig.9-42. (Refer to Inspection & Servicing Procedure No. 11-21)

11.21. Checking the Crank shaft end play :

- Crankshaft end play can be checked either with a feeler gauge or a dial gauge. For accurate reading the dial gauge is preferred.
- With Feeler Gauge :
  To check end play, shift the crankshaft with a lever towards the fly wheel end side. Insert the feeler gauge in the gap at the flywheel end side between the thrust washer and the crankshaft locating journal face and check the clearance with dial gauge.
- Fit a dial gauge with a magnetic base on the crankcase either on the gear side or the flywheel end side Fig.9-42. Push the crankshaft away from the dial gauge with a lever. Set the dial at ‘O’. Again move the crankshaft to wards the dial gauge and take the reading.

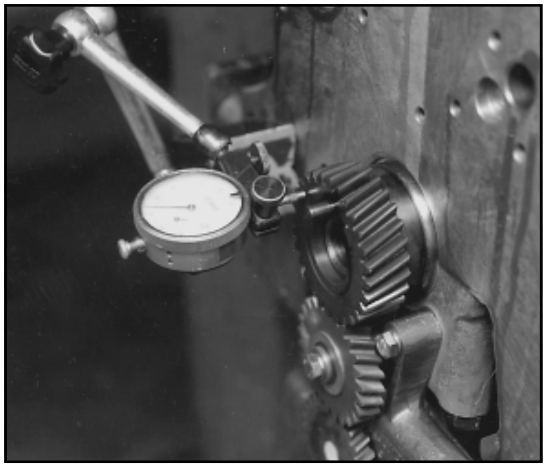


Fig.9-42

11.22. Fitting the Piston and Con-rod Assembly in liner :

- Select the assembled piston and con-rod assembly. Check the cylinder number punched/ etched on it.
- Set the piston rings gaps at 120^0 interval (shown in Fig.9-41). Ensure ring gaps are not be in line with the axis of the piston pin.
- Lightly lubricate piston rings with fresh engine oil.
- Set the ring inserting guide tool (2H.950.02.0.00). onto the piston with rings.
- Remove the con-rod cap from the con-rod keeping the bearing halves in place.
- Wipe the crank pin and cylinder liner. Apply fresh engine oil with a brush to the crank pin and cylinder liner.
- Turn the crankshaft and bring the respective cylinder crank pin to TDC.
- Insert the con- rod from the top of the liner ensuring the 'AC' mark on the piston crown is towards the camshaft / tappet side.
- Tap the piston into the liner with a wooden handle, and at the same time guiding the con-rod large end bore towards the crank pin till it snugly fits on it.
- Recheck fitting of the con-rod on to the crank pin.
- Lubricate bearing shell in the cap, Fit the cap taking care that the both bearing notches are on the same side.
- Tighten the con-rod bolts evenly and firmly.
- Follow the same procedure with the other piston / con-rod assemblies.
- After all the con-rods are fitted and tightened, torque the bolts as per specification. (Refer to Torque table)
- Check con-rod is free in its end play.

11.23. Valve Lapping.

- Before proceeding with valve lapping :
- Check the valve recess is within the prescribed limit. (Refer to Inspection & Servicing Procedure 9-13 on page) (Refer to Specification Data) If not replace the valve or the valve seat or both valve and valve seat.
- Check condition of both the valve face and the valve seats in the head.
- If the valve face is in relatively good condition only light lapping with a fine lapping paste will be required to ensure a good seating.
- If valve face is damaged, the face will have to be refaced to the correct angle without reducing the rim thickness.
- If the valve rim thickness is already reduced replace the valve
- Also check the valve stem diameter for wear and tear. Replace valve if required.
- Similarly if the seat in the head has to be refaced, the re-facing will be done with a seat grooming tool to the required angle. It is recommended to fit new valve guides (Refer to Inspection & Servic ing Procedure No. 11-14) before re-cutting or fitting new valve seats.
- If valve seat is damaged beyond repairs replace valve seat. (Refer to Inspection & Servicing Proce dure No. 11-15)

  Valve lapping
- Thoroughly de-carbonize and clean the valve and cylinder head before proceeding with valve lapping.
- Apply a small quantity of coarse lapping compound all around the valve seat.
- Dip the valve stem in fresh clean oil and insert the numbered valve it in the respective valve guide.
- Lap the valve and seat by rotating the valve back and forth in a half turn with a gentle but firm pressure by means of a cupped valve-grinding tool.
- After every few turns, lift the valve off slightly from the seat and give it a half turn and tap. This is essential to uniformly spread the grinding paste.

- Keep grinding until the rough gritty feeling of the coarse compound turns relatively smooth.
- Remove the valve, wipe the compound from the valve and seat and check for a contact pattern. When a relatively good flawless pattern is achieved, proceed with the next step and lap the valve again with the fine lapping compound.
- After lapping, visually inspect both valve face and seat. The finished contact pattern on both should be even, without flaw or break, scratch or depression marks Fig.9-44

Fig.9-44

Note : If a shining line or scratches are visible on the seats after lapping, it is possible that the lapping was carried out with a heavy hand. Such valves will have to again lightly re-lapped with the fine compound.

- Wash the valves and cylinder head with clean fuel to remove all trace of the harmful abrasive material and dry with compressed air.
- Before assembling the lapped valve assembly, confirmed seating is good. This can be ascertained by a 'pencil erase test'. (Refer to Inspection & Servicing Procedure No. 11-24)
- Wipe and lightly lubricate the valve stem. Assemble valve in its original seat with valve spring and new stem seal and lock it in position as shown in Fig.9-45

Fitting sequence of valve assembly

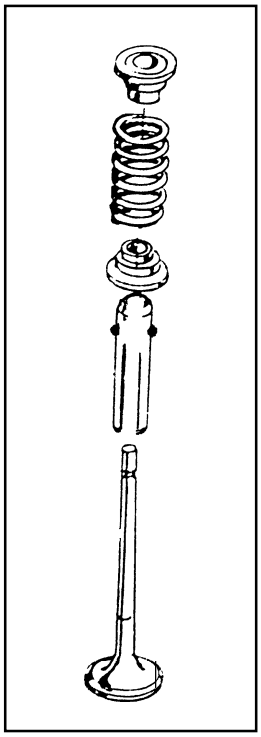


Fig.9-45

- After locking the valve, check sealing of the seats. This should be checked by carrying out the fuel leakage test. (Refer to Inspection & Servicing Procedure No. 11-25)

11.24. Valve checking by the Pencil Erase Test :

- The pencil erase test is a simple test and should be carried out before the valve is assembled and locked. This test ensures that the valve seat is properly lapped and the sealing is good.

Method :

- Draw a zigzag line on the lapped surface of the valve seat with a soft lead pencil as shown in Fig.9-46
- Fit the valve in its seat in the head. With a slight but firm pressure turn the valve once to 90 degrees or 1/4 turn.

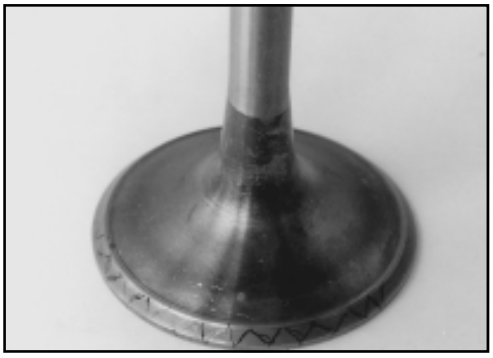


Fig.9-46

- Remove the valve from the cylinder head and inspect pencil line. The line should be completely erased over the seat Fig.9-47. This proves a proper seating and a good sealing.

Fig.9-47

11.25. Valve checking by Fuel Leakage Test :

- After assembling the lapped valves, lock the collar, spring and cone in position with the valve collets. Pour clean fuel oil into the air inlet and subsequently exhaust gas ports.
- Check if the liquid leaks out between the valve face and seat. Fig.9-48
- No fuel oil will leak out between the seats if sealing is effective,
- If sealing is ineffective, fuel will leak out between a valve and seat. This oil leak may be due to dirt on the valve seat. Tap the valve lightly on the stem with a hammer to remove the leak.

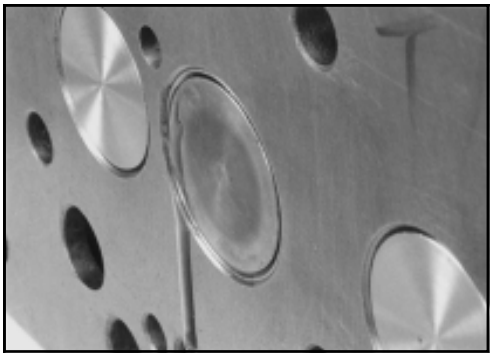


Fig.9-48

11.26. Inspection & Servicing of Oil Spray Nozzles :

- It is recommended to check the oil spray nozzle before refitting these back to the engine. Old unserviceable oil spray nozzles should be replaced with new oil spray nozzle.
- The criteria to retain the old nozzles are as follows :
  a. Min actuating Pressure 0.4 kg/cm^2(minimum)
  b. Min. spray length. 40 mm (minimum)
  c. Spray angle 5^0 at 40 mm length (Radius of 25 mm)
  Above can be checked with the help of a card-board disc.

- Old spray nozzles must be checked before refitting them or this can lead to piston damage.

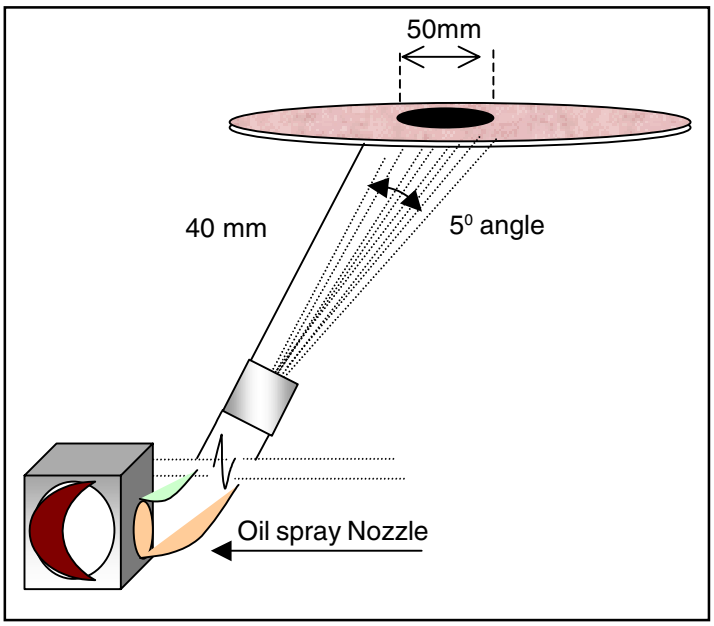


Fig.9-49

11.27. Checking the Gear back lash :

- Back lash is the gap between gear teeth.
- To check gear back lash fit a magnetic base dial gauge on the crankcase face.
- Set dial gauge pointer on a tooth of the gear required to be checked. Fig.9-50
- Engage the gear to one side and set the dial to ‘0’.
- Oscillate the gear back and forth within its free movement.
- Check the reading on dial gauge.
- Repeat this procedure at four places at right angles.

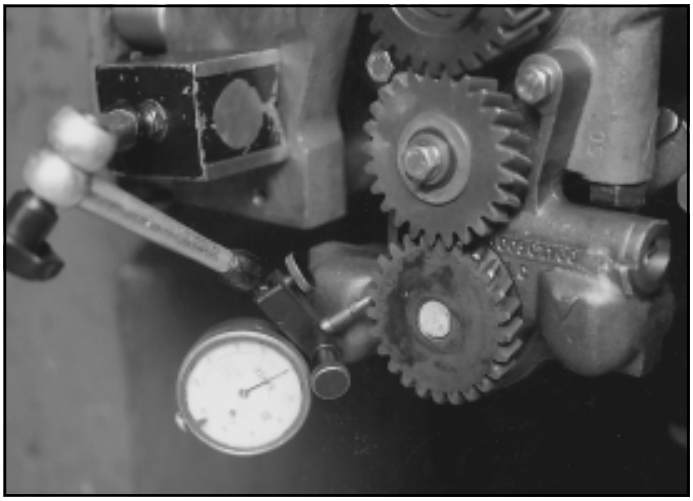


Fig.9-50

Recommended Gear Back lash

a.	Intermediate Gear - Crank Gear	0.02	-	0.26	mm
b.	Oil pump Idler gear - Crank gear	0.05	-	0.27	mm
c.	Oil Pump driving gear - Idler Gear	0.098	-	0.35	mm
d.	Cam Gear - Intermediate Gear	0.02	-	0.26	mm
e.	Intermediate gear - Fuel Pump Gear	0.02	-	0.26	mm
f.	Hyd. Pump Gear (Optional) Cam Gear	0.0	-	0.440	mm

R1040 GEAR TRAIN DIAGRAM

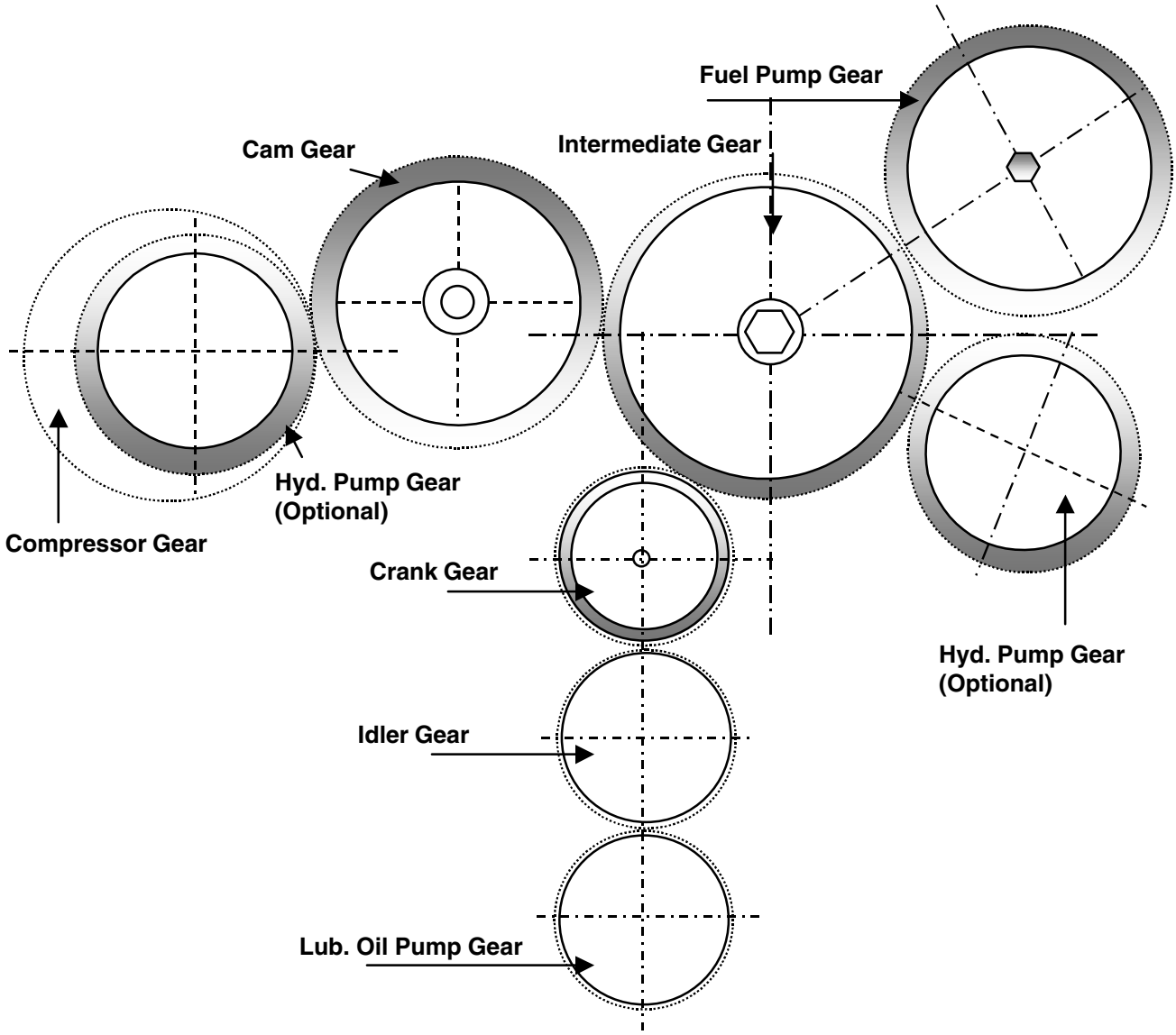


Fig.9-51

11.28. Setting the Fuel Timing :

Once the fuel pump is mounted with the Auto timer tightened to the pump shaft, proceed as follows:

- Remove the side cover of the fuel pump.
- Check the position of the plungers inside.
- Using the special spanner turn the fuel pump shaft clockwise till No.1 plunger (first plunger on the fly wheel end side) has started its upward stroke. Fig.9-52

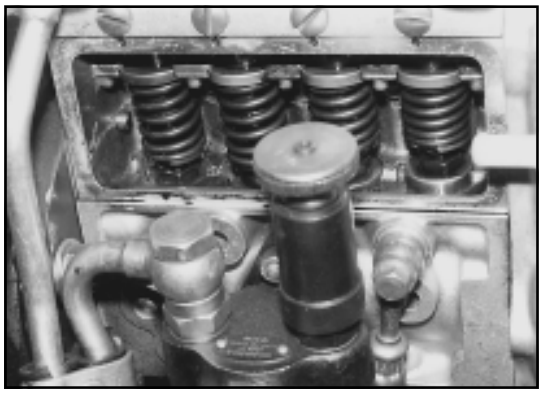


Fig.9-52

- Rotate the crank shaft till No.1 piston (Flywheel end side) comes on TDC compression stroke. (Check this by rotating both inlet and exhaust push with fingers to find out they are free). If not turn the crankshaft again by another 360^0. Also confirm this by checking if the 'T' mark on the crank pulley is in front of the pointer. Fig.9-53
- Rotate the crankshaft now in the counter-clockwise direction, till the fuel injection timing mark 'I' on the crank pulley is in front of the pointer.

Fig.9-53

- Remove the delivery valve holder of No.1 plunger. Only take out the delivery valve without the spring.
- Place it in a container of clean diesel to prevent damaging it.
- Tighten the delivery valve holder back firmly.
- Fit a 'Swan neck' pipe or a High pressure pipe to the holder. (The free opening of the pipe should be lower than the fuel pump.
- Connect fuel line to the fuel pump inlet.
- Operate the hand priming pump till fuel start flowing freely the swan neck pipe.
- While still operating the hand pump, rotate the fuel pump shaft slowly in clockwise direction.
- The free flowing fuel should turn to drops and stop completely. Stop rotating the fuel pump shaft.
- This is the exact SPILL CUT OFF point.
- Without disturbing the fuel pump shaft position fit the fuel pump gear to the auto timer and tighten.
- Recheck the timing again.
- To recheck turn the crank shaft counter clockwise till fuel starts flowing out freely again.
- Now turn the crank shaft again slowly in the clockwise direction.
- At a certain point the spill cut happens. Stop turning the crankshaft at this point.

- Recheck the position of the ' I ' timing mark on the crank pulley, it should be in front of the pointer.
- With the timing set, tighten the fasteners of the fuel pump gear fully.
- Fully tighten auto timer shaft nut with the special spanner No.4H.950.09.0 Fig.9-54

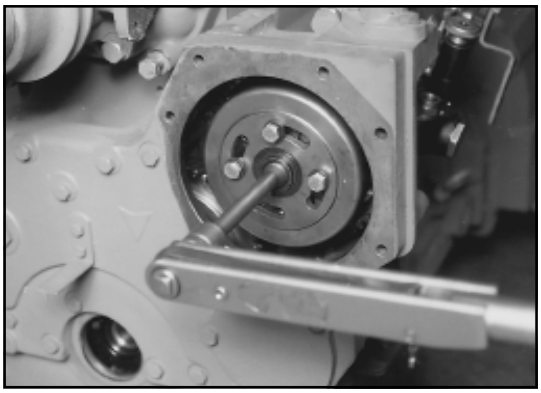


Fig.9-54

- Remove the 'Swan neck' or High Pressure pipe.
- Replace the delivery valve and tighten holder to the specified torque.
- Fit and secure the fuel pumps side cover again with its rubber gasket.

11.29. Valve Tappet Setting :

Firing Order:

1.	3 Cylinder engine	1-2-3	Each Cylinder will come to TDC at 240^0
2.	4 Cylinder engine	1-3-4-2	Each cylinder will come to TDC at 180^0

Two methods are universally used to adjust tappet clearance in the field.

Method -1

- Bring the first cylinder (Fly wheel end side) to TDC compression stroke. The 'T' mark on the crank pulley will coincide with the pointer. Check both inlet and exhaust valves are free and do not move when the crankshaft is rocked back and forth. If not, rotate the crankshaft a full 360^0
- Tools required: 6" screw driver, a correct size ring spanner and a correct thickness feeler gauge.
- Set the gaps on both the inlet and the exhaust tappets of the cylinder as specified (See specification data.) The feeler gauge should slide firmly but freely in the gap.
- Turn the pulley in the clockwise direction till the next cylinder in firing order comes to TDC com pression stroke. Continue with the process till all the cylinders are covered and all tappets are set. Fig.9-55

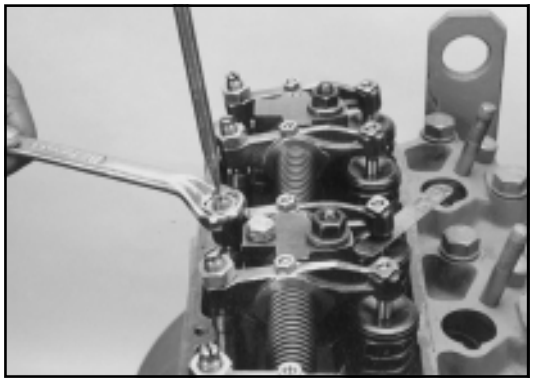


Fig.9-55

Method -2
This is a relatively simple and less time consuming method. In this method, multiple tappets can be set in one position of the crankshaft

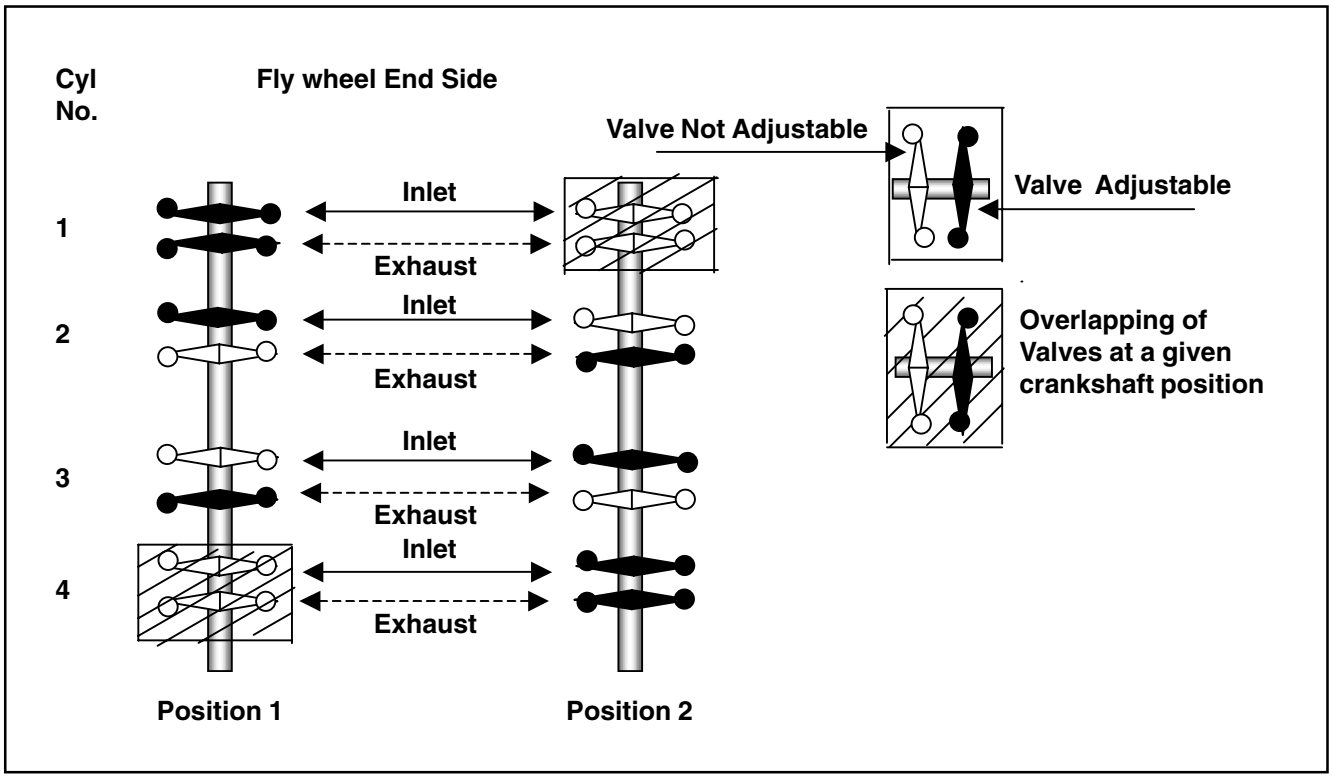
Position 1
With cylinder No.1 in TDC compression position, set the following valves:

3 Cylinder engine.			4 Cylinder Engine.		
Cylinder No.1	Inlet	Exhaust	Cylinder No.1	Inlet	Exhaust
Cylinder No.2	-	Exhaust	Cylinder No.2	Inlet	-
Cylinder No.3	Inlet	-	Cylinder No.3	-	Exhaust
			Cylinder No.4	-	-

Position 2
Rotate the crankshaft one full rotation (360^0) and again bring No 1 cylinder to TDC position. The engine is now at TDC with both valves in overlapping position and are not free to rotate. In this position set the following valves. Refer to Fig.9-56

Cylinder No.1	-	-	Cylinder No.1	-	-
Cylinder No.2	Inlet	-	Cylinder No.2	-	Exhaust
Cylinder No.3	-	Exhaust	Cylinder No.3	Inlet	-
			Cylinder No.4	Inlet	Exhaust

Note: Valves can be set at whatever position the crankshaft comes first as shown in the below sketch.



11.30. Servicing Spin -On type lubricating oil filter :

- The spin-on filter should be replaced at every oil change, or whenever the oil is changed for any reason.
- Unscrew the filter cartridge with a strap tool in the counter-clockwise direction. (Strap Tool is commercially available)
- Remove the cartridge and destroy it.
- Clean the sealing surface of the filter carrier with a dry cloth.
- Apply a light film of oil with a brush to rubber seal of new cartridge.
- Screw cartridge into place by hand till the seal is evenly seated.
- Tighten the cartridge firmly by giving half a turn.

11.31. Bleeding the Fuel System :

- Before starting the engine the fuel system should be bleed thoroughly. All air should be removed or it will affect the engine's performance.
- Loosen the vent screw given on the pre-filter's head. Operate the hand priming pump till fuel flows freely out without any air bubbles. Retighten the vent screw.
- Similarly loosen the vent screw on the micro filter head and carry out similar operation.
- Where vent screw is provided on the Fuel pump carry out similar operation.

11.32. Inspection & Servicing the oil cooler :

The oil cooler is a stainless steel disc type plate cooler. It is located in a cavity provided in the lubricating filter header. In normal condition servicing for the plate type oil cooler is not required, but if the cooler is removed for any reason then it has to be serviced. To approach the cooler, it is necessary to dismantle and remove the filter header.

Servicing :

- Remove the cooler from the header by removing the set bolt and special washer. Fig.9-57
- Plug the coolers oil inlet and outlet openings.

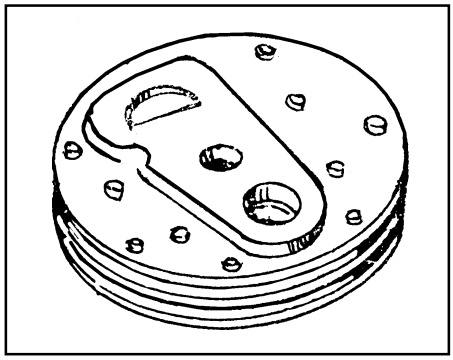


Fig.9-57

- Clean the cooler externally with soap water/Petrol to remove rust etc from it.
  Caution: Do not use acid based or alkaline based cleaners. Refrain from using sharp instrument as this may damage the cooler.
- In a bowl of clean fuel oil dip the cooler element after removing the plugs. Clean the oil side of the cooler by vigorously shaking the element in the fuel. With the cooler still dipped in fuel oil direct compressed air very slowly from the oil outlet to clean the inside of the cooler by agitation method. Rinse it twice in clean fuel oil and flush it with fresh Lubricating oil.
- Install the cooler back in the header with new joint, and torque as specified.

11.33. Inspection & Servicing of the Radiator :

- Disconnect radiator from the engine.
- Discard all old hoses.
- Check the radiator cap and replace if required.
- Check radiator core for tube leaks, and damaged fins. Have these repaired.
- Also check for leaks which usually take place between the soldered joints of the core and header tanks, and water inlet & outlet connections where the hoses fit.

Caution : It is not recommended to manually clean the radiator. As this causes damage to the radiator core (cooling tubes) and renders the tubes unserviceable.

- Radiators should be cleaned with specially formulated radiator cleaning compounds.
- It is advisable to carry out cleaning of the radiator while mounted to the engine, as this way both the radiator and the engine's water jacket are cleaned.
- Cleaning should be carried out strictly as per instructions of the cleaning compound manufacturer.

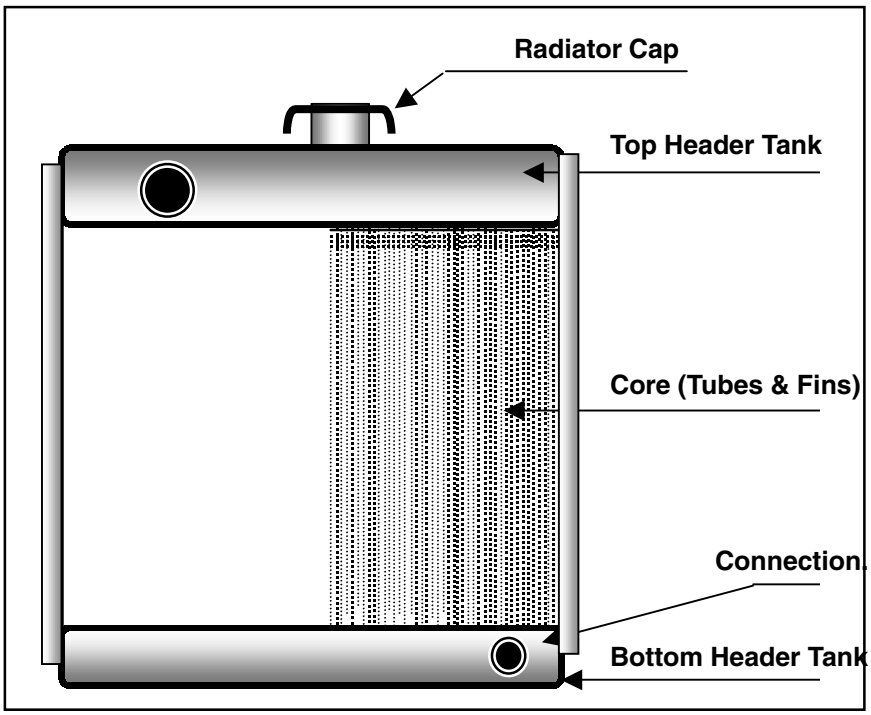


Fig.9-58

11.34. Inspection & Servicing of Auto Electricals :

a.) Battery :

- Disconnect the battery from the engine.
- Fully charge the battery and keep it in a dry place on a wooden plank
- After every 30 days recharge the battery on a low charge.
- On a reconditioned engine fit a fully charged battery, as the engine will initially draw more current during cranking and will also take a longer time to start.

b.) Alternator :

- Disconnect and remove the alternator from the engine and have it reconditioned by an Authorized Auto Electrical Dealer.
- Under no circumstance short the leads of the alternator to see that it is developing current, as this will damage the alternator.

c.) Starter :

- Disconnect and get the starter repaired / reconditioned by an Authorized Auto Electrical Dealer.

Oil Seal Fitment.

PTFE oil seals are used on R1040 engines instead of conventional rubber oil seals. These are the 'Double Lip Oil Seal', one lip for preventing dust damaging the seal and shaft and the second lip to prevent oil coming out. The oil seal is very effective and will reduce wear and tear to engine components if installed properly. The fitting instructions given in Servicing Procedures 11.35 and 11.36 must be strictly followed to avoid future problem with the oil seal.

11.35 Fitment procedure for the F.W.E. Oil Seal :

Note: IT IS RECOMMENDED TO USE OF A MECHANICAL OR HYDRAULIC PRESS TO FIT THE F.W.E. SEAL DO NOT APPLY OIL TO THE SEAL OR SHAFT. OIL SEAL SHOULD BE INSTALLED DRY.

- Clean the oil seal bore in the housing with a clean dry cloth.
- Place the oil seal housing on a clean surface under the press.
- Remove the oil seal from its packing and install immediately.
- Locate the oil seal by hand on the entry chamfer of the housing.
- Place the inserting mandrel flat on the seals metallic face.
- Press the oil seal under a press, till the mandrel rests against the housing's face.
- Remove the mandrel.

Sleeve Tool :

- Fit the seal sleeve tool over the installed oil seal from the oil seal's steel casing side. Ensure both the dust seal and oil sealing lips are positioned correctly on the sleeve.
- Wipe the crankshaft's oil seal journal flange with a dry clean cloth.
- Locate the housing assembly, with the oil seal and sleeve to the crankshaft journal flange.
- Press the assembly to the crankcase till the dowels are engaged.
- Pull out the sleeve Seal tool.
- Fasten housing to the crankcase

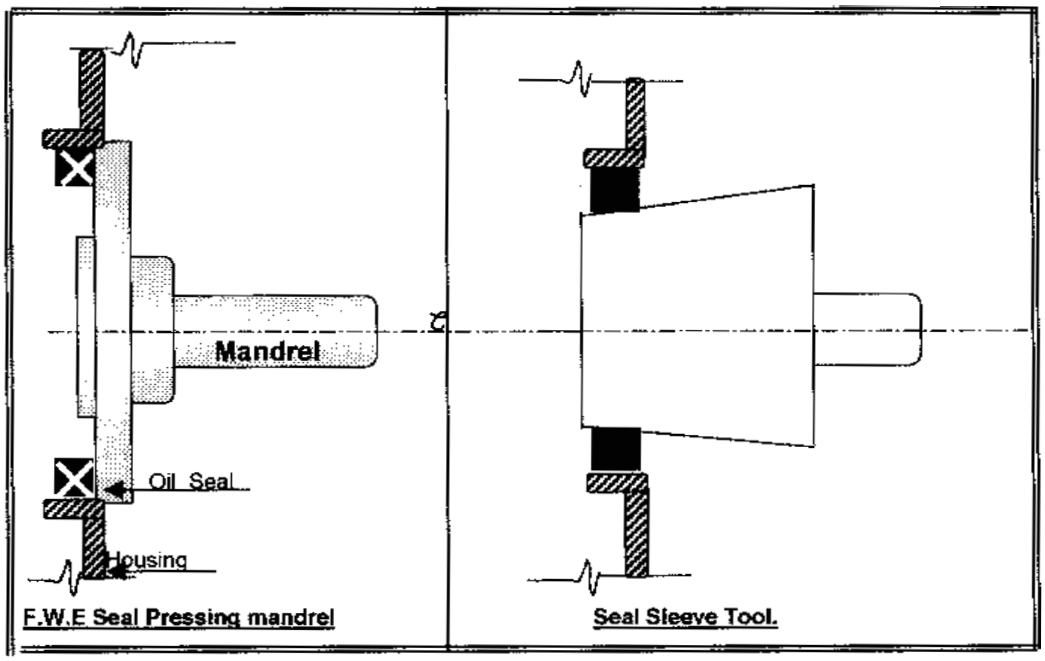


Fig.9-59

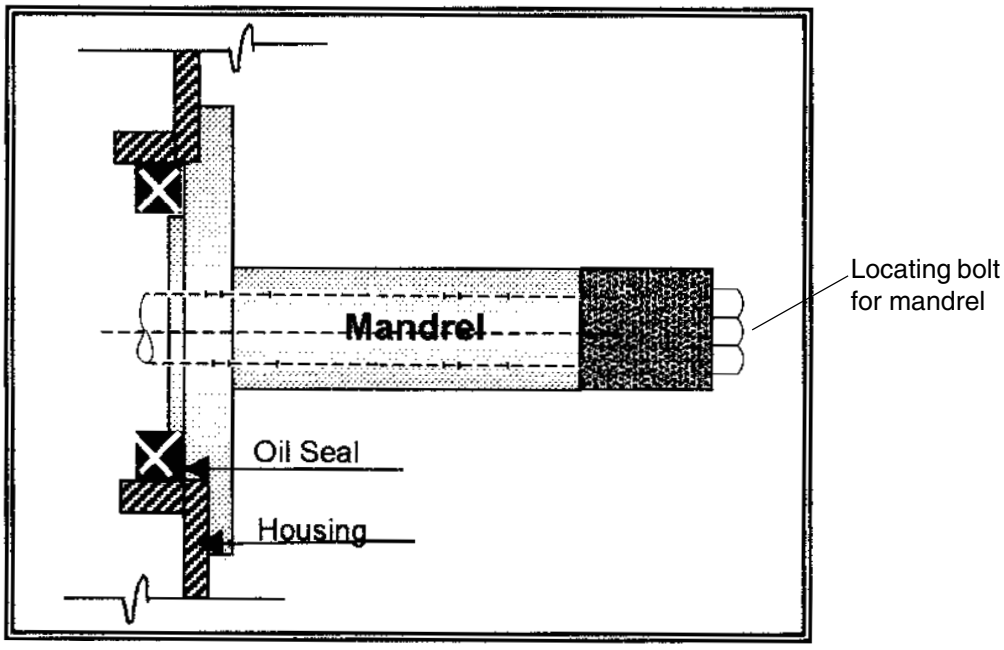
11.36 Fitment Procedure for G.E. Oil Seal :

Note : DO NOT APPLY OIL TO THE SEAL OR THE PULLEY. OIL SEAL SHOULD BE INSTALLED DRY.

- Clean the oil seal locating bore in the Gear Cover.
- Remove oil seal from its packing and install immediately.
- Locate the oil seal by hand on the oil seal mandrel (4H.950.21.0.00)

CAUTION : DO NOT APPLY ANY OIL TO THE SEAL OR HOUSING

- Place the inserting mandrel flat on the gear cover face.
- Fit the locating bolt on crankshaft G.E. side.
- Hammer the oil seal untill the mandrel stops against the gear cover face.
- Wipe the pulley and insert immediately in dry condition.
- Fasten the crank pulley bolt



G.E. Oil Seal Pressing Mandrel

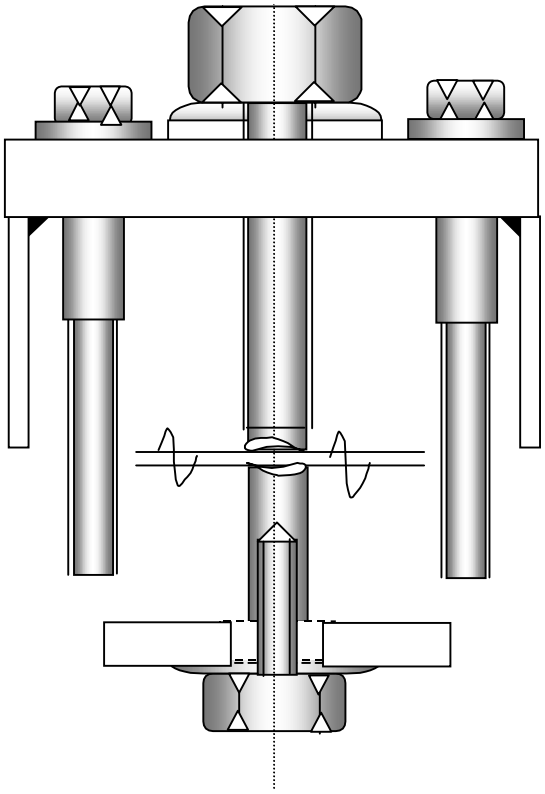
Fig.9-60

11.37 Servicing Oil Bath Type Air Cleaner :

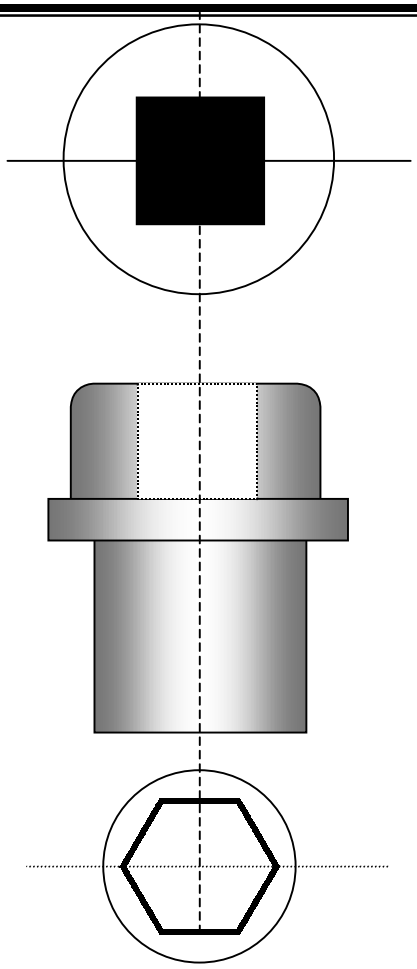
Oil bath air cleaner should be serviced before refitting to the engine.

- Dismantle and separate the oil bath from the oil cleaner body.
- Drain out old oil from the oil bath and clean the bath with fuel oil and wipe it dry.
- Check and discard the old sealing rings and washers.
- remove the primary wire mesh element from the body and clean it in a soap & water solution. Final cleaning should be done by water pressure from the opposite side till all sediment is removed from the element. Dry it properly.
- Also clean the air cleaner body along with the secondary wire mesh element into a trough of soap water solution.
- To clean pass compressed air at high pressure with water from the air outlet side. Air passed with water causes water to agitate. It is by this method of back flushing the element will be cleaned. Continue till air bubbles flow out freely from the inlet of the air cleaner.
- Clean the air cleaner body with plain pressurized water about twice to remove all trace of soap.
- Dry thoroughly with compressed air.
- Fit new sealing rings and seal washers.
- Fit the air cleaner body to the engine.
- Fill fresh Lubricating in the oil bath, up to the oil filling mark.
- Fit the bath to the body and clamp it.

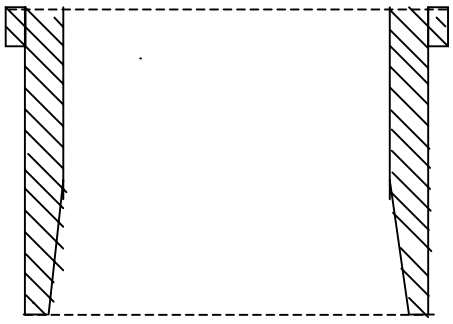
SPECIAL TOOL ILLUSTRATION:



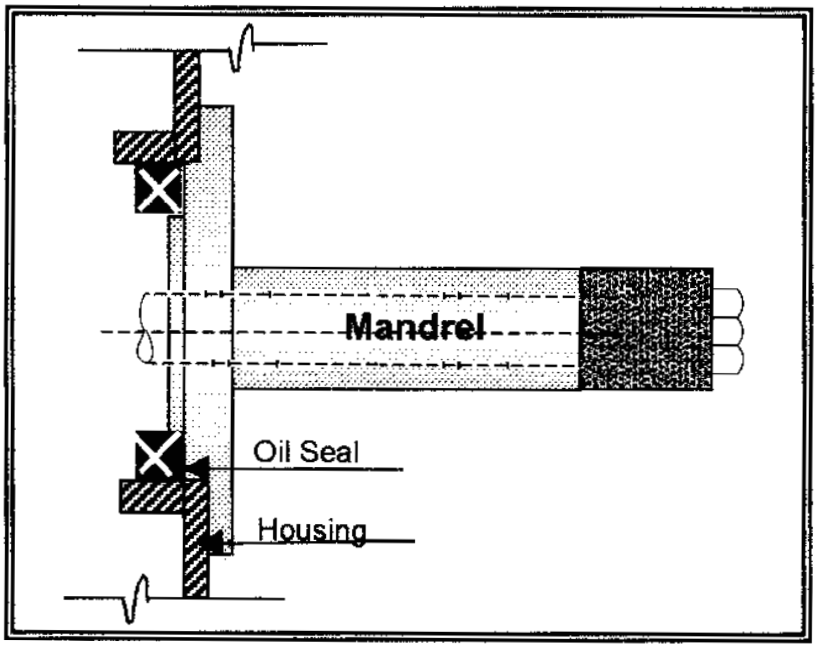
Cylinder Liner Removing Mandrel
(Tool No. 4H.950.07.0)



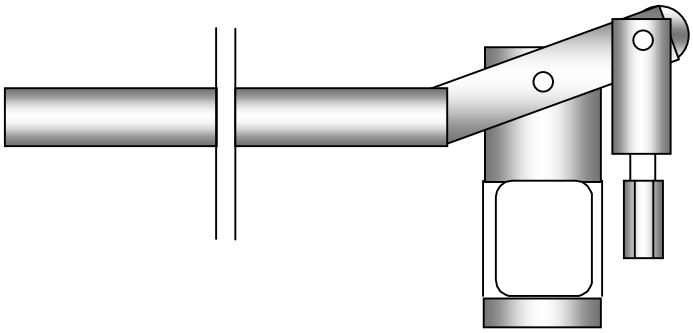
Special; Socket for Crank Pulley Nut
(Tool No.4H.950.06.0)



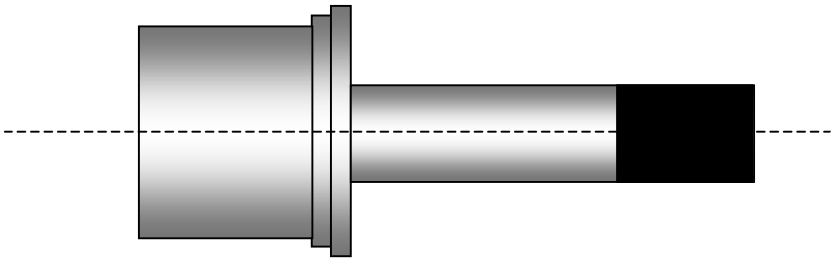
Piston Inserting Guide.
(Tool No.2H.950.02.0)



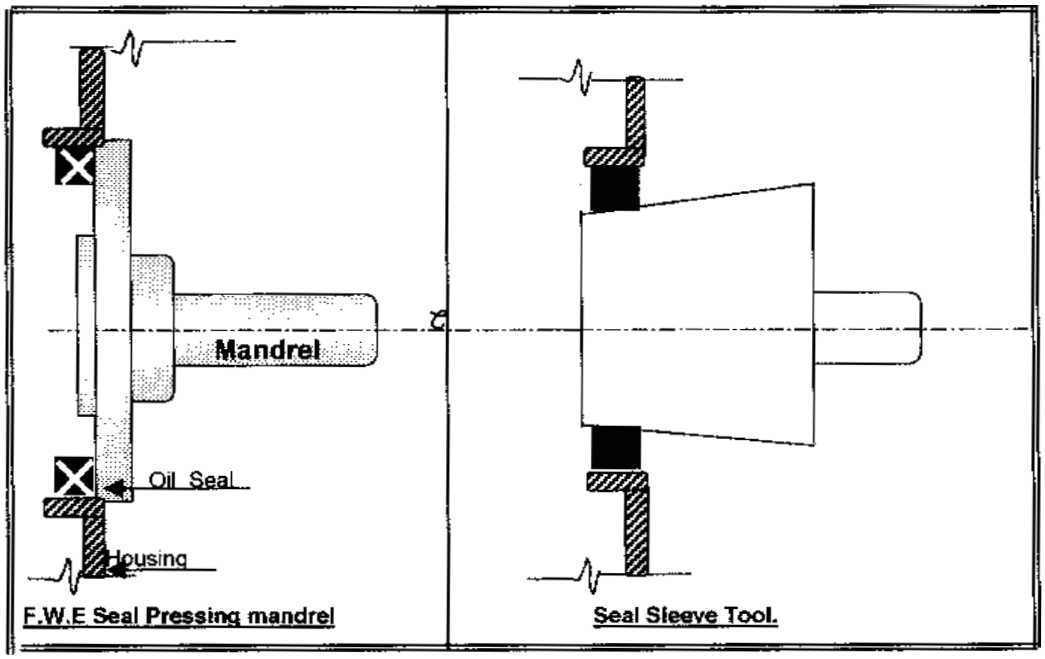
G.E. Oil seal pressing mandrel.



Valve Spring Compressor
(Tool No 4H.950.02.0)



Gear End Cambush Pressing Mandrel
(Tool No.4H.950.01.0)


Mandrel
Oil Seal
Housing
F.W.E Seal Pressing mandrel
Seal Sleeve Tool.

2H.950.13.0.00

12. TROUBLE SHOOTING

12-1. Engine fails to rotate :

- Battery run down.
- Defective Starter
- Loose /dislodged battery cable.
- Engine used after a long period
- Engine seized.

12.2. Engine rotates slowly during starting:

- Battery weak
- Battery cable loose
- Faulty starter
- Small capacity battery

12.3. Engine rotates, but does not start :

- No Fuel in tank
- Fuel Quality poor
- Air in Fuel line
- Leaking Fuel line.
- Fuel line clogged.
- Fuel filter clogged
- Incorrect control lever setting
- Fuel pump defective
- Incorrect fuel timing
- Incorrect tappet setting.
- Cylinder head gasket blown
- Engine not used for a long time
- Worn /damaged piston rings

12.4. Engine has Starting Difficulty:

- Clogged /Dirty air cleaner
- Poor quality Fuel
- Air in fuel line
- Incorrect valve and fuel timing
- Faulty fuel injector
- Engine used after a long period
- Leaking engine valves
- Broken / worn piston rings
- Engine needs decarbonising

12.5 Engine starts but stops after some time:

- Fuel tank cap vent hole blocked
- Air cleaner choked
- Engine has run out of fuel
- Air in fuel line
- Fuel filters choked

- Fault in fuel pump
- No water in radiator.
- Gasket blown
- Engine Piston / liner seized
- Engine bearing seized
- Engine needs overhauling

12.6. Engine Lacks power:

- Choked /Dirty air cleaner
- Faulty air cleaner hose.
- Excessive exhaust back pressure
- De-rating not calculated
- Fuel quality poor.
- Choked fuel line
- Choked fuel filters
- All cylinders not firing
- Loose H P Connection
- Fuel injector faulty
- Water and fuel mixed.
- Incorrect valve and fuel timing.
- Leaking engine valves
- Faulty turbocharger
- Broken / worn piston rings
- Worn out Liners
- Damaged main and CR bearings
- Faulty Governor setting
- Improper alignment with driven unit
- Engine has come for Overhauling

12.7. Engine misfires during operation:

- Engine used after a long time
- Air in fuel line
- Faulty Injector
- Water mixed with fuel
- Faulty fuel pump
- All cylinders not firing
- Incorrect valve setting

12.8. Engine does not reach its governing speed:

- Choked Fuel filters
- Choked fuel line
- Control lever setting incorrect
- Engine over loaded

12.9. Engine speed does not remain constant:

- Choked Fuel filters
- Choked fuel line

- Faulty injectors
- Faulty Fuel pump
- Faulty governor adjustment
- Excessive governor linkage play.
- One or more cylinders not firing.

12.10 Excessive smoke at No Load:

- Choked air cleaner
- Fuel timing incorrect.
- Incorrect injector pressure
- Faulty / dribbling nozzle
- Defective fuel pump
- Incorrect tappet setting
- Low compression
- Incorrect valve timing
- Valves leaking
- Stuck /broken piston rings
- Worn piston rings and liners
- Worn out main / con-rod bearing
- Incorrect fuel pump setting
- All cylinders not firing properly
- Faulty turbocharger.
- Engine needs overhauling

12.11. Excessive smoke at full load:

- Air cleaner choked
- Derating not considered
- Poor quality of fuel
- Control lever not properly set.
- Faulty injector
- Incorrect fuel setting
- Fault in Fuel pump
- Engine over heated.
- Engine overloaded
- Valve spring broken
- Incorrect Tappet setting
- Broken piston rings.
- Crankshaft end play excessive
- Damaged bearings
- Damaged valve guide and valve
- All cylinders not firing properly
- Turbocharger sluggish.
- Engine requires overhauling

12.12. Engine Overheats:

- Choked air cleaner
- Excessive exhaust back pressure
- Faulty injector
- Retarded fuel timing
- Incorrect grade of lub oil used.
- Dirty choked oil suction strainer
- Prolonged oil change period
- Lub. oil dilution
- Choked lub oil filter
- No coolant in radiator
- Clogged Radiator
- Faulty thermostat element
- Fan inadequate
- Engine overloaded
- Tappet setting incorrect
- Improper alignment with driven unit
- Broken piston rings.
- Excessive crankshaft end play
- Damaged bearings
- Damaged valve guide and valve
- All cylinders not firing properly
- Turbocharger not functioning .

12.13. Excessive Fuel consumption:

- Dirty air cleaner
- Excessive exhaust back pressure
- Fuel quality poor.
- External fuel leakage
- Wrong Fuel timing
- Faulty Injectors
- Faulty Fuel Pump
- Overloading of engine
- Incorrect tappet setting
- Damaged Piston rings & liners
- Excessive Carbon build up in the combustion chamber
- Bearings wear beyond specification
- Engine needs overhauling

12.14. Engine gives out blue smoke:

- Wrong grade of lub oil
- Excess oil in the sump.
- Over filling the Oil in air cleaner
- TC seals leaking
- Worn Piston and Liner.
- Worn out Valve stem and guide

12.15. Engine gives out white smoke:

- Water mixed with Diesel
-Water entering the combustion chamber

12.16. Mixing of Diesel with Lub. oil:

- Faulty fuel feed pump
- Dribbling Injector nozzle
- Broken piston rings
- Worn piston & liner
- All cylinder not firing properly

12.17. Excessive lub. oil consumption:

- Wrong brand of lub oil
- Wrong grade of Lub oil
- Excess oil in the sump.
- Idling for prolonged period
- External oil leakage.
- Engine overheats
- Worn T/C oil seals
- Worn Piston rings & Liner
- Worn valve and Guides.

12.18. Low Lub Oil Pressure:

- Oil change overdue
- Wrong brand and grade of oil
- Wrong grade of Lub oil
- Choked suction tube
- Choked oil cooler
- Lub oil dilution
- Choked oil filter
- Choked oil passages
- Faulty oil pump
- Faulty pressure regulating valve

- Defective by pass valve.
- Over loading of engine
- Over heating of engine
- Incorrect tappet setting
- Incorrect Fuel timing
- Worn main bearings
- Engine need overhauling

12.19. Fast bearing wear:

- Prolonged oil change period
- Fuel Dilution with oil
- Poor quality of oil
- Oil starvation due to

a) Choked suction strainer

b) Choked filter
c) By-pass valve remains open
- Water dilution with oil
- Oil level in sump low
- Overloading the engine
- Bearing Seizure

12.20. Excessive Piston ring and liner wear:

- Dust entry from air intake system
- Poor quality of fuel
- Wrong grade of lub oil
- Prolonged oil change periods
- Dirty oil filter
- Over heating
- Engine Overloading
- Broken piston rings
- Piston & liner seizure

12.21. Excessive Valve & Valve guide wear:

- Dust entry from air system
- Poor quality of fuel
- Wrong grade of lub oil
- Prolonged oil change periods
- Dirty oil filter
- Over heating
- Improper lubrication at rockers

12.22. Valve spring breaking:

- Water contamination with oil
- Pitted valve spring.
- Engine re-commissioned after a long time.
- Engines Preservation not done
- Worn out valves and valve guides

12.23. Fuel Injection equipment wear excessive:

- Poor quality of fuel
- Filter element used of poor quality.
- Water contamination with Fuel

12.24. Diesel Knock:

- Diesel quality not as recommended
- Fuel timing far advanced
- Injector pressure setting high.
- Incorrect valve timing
- Wrong specification high pressure pipe fitted.

12.25. Mechanical knock :

- Incorrect tappet setting
- Broken piston ring
- Excessive clearance between the piston pin and piston pin bore.
- Excess clearance between piston and liner
- Excessive clearance in Con rod bearing.

12.26. Excessive Vibration:

- All engine cylinders are not firing
- Faulty engine mounting
- Mounting bolts loose
- Improper exhaust clamping
- Alignment with driven machinery incorrect

12.27. Battery runs down frequently:

- Check battery condition.
- Fan belt loose
- Dynamo / Cut out defective
- Alternator defective.
- Defective wiring.

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