Enriching Lives

OPERATION
AND
MAINTENANCE MANUAL
FOR

KIRLOSKAR DIESELS

4SL 9059 /4SL 9059T
6SL 9088 / 6SL 9088T

(F6.175.02.0.00)

KIRLOSKAR OIL ENGINES LIMITED
Regd. Office: Laxmanrao Kirloskar Road, Khadki, Pune - 411 003, INDIA.
Tel.: +91 (20) 2581 0341, 2581 5341. Fax: +91 (20) 2581 3208, 25810209.
email: global@koel.co.in Website: www.koel.co.in

KIRLOSKAR OIL ENGINES LIMITED

LAXMANRAQ KIRLOSKAR ROAD, PUNE 411 003 (INDIA)

GUARANTEE

WITHIN a period of 12 calendar months (or within six calendar months, where the machinery has run continuously day and night) after the Engine has been taken delivery of by you, we expressly guarantee, in lieu of any warranty implied by law, to make good any defective parts in machinery of our own manufacture, which defect develops under proper use and arises solely from faulty material or workmanship, provided always that such defective parts are promptly returned carriage paid to our works, and provided that Fuel and Lubricants approved by us, have been continuously used. The repaired or new parts will be delivered free of cost. Ex-works. At the termination of such period of 12 calander months (or 6 calendar months at the case may be) all liability on our part ceases. In the case of goods not of our manufacture, you are entitiled to the benefits of our Guarantee given to us in respect there of and our liability in respect of such goods is limited to the Guarantee given by the Manufacturer. In no case shall we be liable for the fitting charges of replacement parts. The defective parts replaced by us shall became our property. All goods are supplied on the condition that we shall not be liable for any loss incurred through stoppages or any consequential changes.

This guarantee shall not apply to fair wear and tear or to damage due to negligence or improper handling by the purchaser, or his employees or agents, or in the case of repairs or alterations carried out by the purchaser without our knowledge, or approval, or due to damage by any cause beyond our control. This guarantee does not apply to reconditioned or second-hand combination sets or Engines.

The Engines shall be deemed to have been taken over by the customer upon despatch from our Works in the case of direct deliveries Ex-Factory, and from the godowns of our authorised dealers viz. Distributors and Dealers, in the case of supplies from their stock and this guarantee shall come into effect from that time. We will not be responsible for loss or damage to goods beyond the delivery stated in our tender and we will repair or replace free of charge goods damaged in transit upto the point of delivery by us, as specified above.

KIRLOSKAR OIL ENGINES LIMITED

FOREWORD

Dear Customer,

We are glad to welcome you to the family of **KIRLOSKAR SL90** series engines Owners. This new series is the outcome of long research and experience in manufacturing of Diesel Engines for various industrial, agricultural, automotive, marine and power generation. Kirloskar products have been accepted by customers the world over for their reliability, low running cost and simplicity in maintenance. Prompt after sales service through country-wide network of Dealers and Distributors is one of the plus points in buying Kirloskar products.

We assure you that all necessary safety precautions and regulations have been observed in the design, selection of materials and manufacture of SL90 series engines. All the units undergo rigorous tests and trials before being delivered to customers.

This manual deals with engine operation and maintenance. The maximum performance of the engine largely depends on its proper maintenance and upkeep. So be sure to maintain your engine properly as per the instructions and schedule given in this manual. We recommend that only trained staff should be permitted to perform the operating and maintenance task. Always use the genuine **KIRLOSKAR SPARE PARTS** if at all required.

In addition to the publication of this manual we maintain facilities for training operators and owners in the maintenance of KIRLOSKAR DIESELS. You can avail yourself of these facilities by contacting our authorised Distributor/Dealer nearest to you.

Thanking you and congratulating you for choosing this model, we wish you to be proud owners of **KIRLOSKAR SL90** series engines for many years to come.

FOREWORD

In case of difficulty please contact-

KIRLOSKAR OIL ENGINES LTD.
Laxmanrao Kirloskar Road, Khadki,
Pune-411003 (INDIA)

Phone : 310341
Gram : KOEL PUNE (India)
Telex : 0145-7245-KOEL PN
Telefax : (0212) 313208 / 310209

BRIEF TECHNICAL DESCRIPTION

* COMBUSTION -

Combustion process with direct multiple jet injection for naturally aspirated and turbocharged engines. This combustion process offers
- Low fuel consumption
- Reduced emission of pollutants
- Less noise

* CYLINDER HEADS -

Individual cylinder heads made of gray cast iron and provided with cooling passages, the helical inlet ports, tuned to the respective combustion method are designed for best fuel-air mixing. The high rigidity cylinder head is fastened by seven collar-bolts. The specially designed cylinder head gasket ensures reliable sealing against gas, coolant, oil and reduces the cylinder head volume.
The inlet and exhaust valves are made of high temperature resistant valve steel. The valve stems are chromium plated or plasma nitrided and valves seats are made of molybdenum fine casting alloy.

* CRANKCASE & CYLINDER LINERS -

Inspite of its lightweight thin walled gray casting, the ribbed crank-case is highly resistant to bending and twisting, thus considerably increasing its life. Its cast-in oil and coolant channels make an excellent seal. The wet cylinder liners are made of high grade centrifugal casting and are plateau honed. The rigid liner collar support in the crank-case as well as the optimum bottom liner support ensure high liner roundness resulting in low oil consumption, favourable cooling conditions and a reduced noise level.

ENGINE DESCRIPTION

* DRIVING GEAR -

Piston is of aluminium alloy which is lower in weight, having good thermal conductivity and more favourable high temperature stability. Conrod and crankshaft are designed to suit different conditions of loading for naturally aspirated and turbocharged engines. High quality materials of bearings sustain the higher mechanical stresses caused by ignition pressure of turbocharged engines. The special design of spray oil cooling protects the piston under any operating conditions from overheating , jamming or seizing owing to burnt piston rings.
The forged crankshaft is provided with two counterweights for each crank pin, giving it best dynamic balance and reduced bearing loads. Bearings are made of ternary copper-lead alloy.

* CLOSED COOLING SYSTEM -

In cast coolant ducts, plug-in coolant pump and integrated twin thermostat provide for maximum tightness of the cooling system. For better security,connection of tubing and channels are not sealed by asbestos packings, but with elastomer rubber packing rings.

* FUEL INJECTION SYSTEM -

Fuel injection system consists multicylinder in-line fuel injection pump, mechanical fly-weight type governor, feed pump with primary filter sieve, two stage filter of 1.1 lit capacity, the high pressure fuel injection pipes and fuel injector having multihole injection nozzle. Optionally, the injection pump may be equipped with a fixed speed or variable speed governor.
The automatic injection timing device is integrated in the pump drive gear for special application.

* LUBRICATING SYSTEM -

All SL90 series engines are equipped with built in gear pumps driven by the crankshaft through an intermediate gear. The lub oil drawn from the crankcase bottom passes through a special oil/water heat exchanger, which results into fast engine warm-up at starting and optimum oil cooling at rated capacity, thus providing best lubricating quality. Oil is strained by a combination of disposable standard filter cartridges in the main current and a large centrifuge in the bypass.

* EXHAUST GAS TURBOCHARGER -
(For turbocharged engines)

Turbochargers, which are specially modified to match this engine type,are arranged at the right side in direct connection to the exhaust manifold. Charged air designed for minimum flow losses, and all connections are dust protected.

* ELECTRICAL EQUIPMENT -

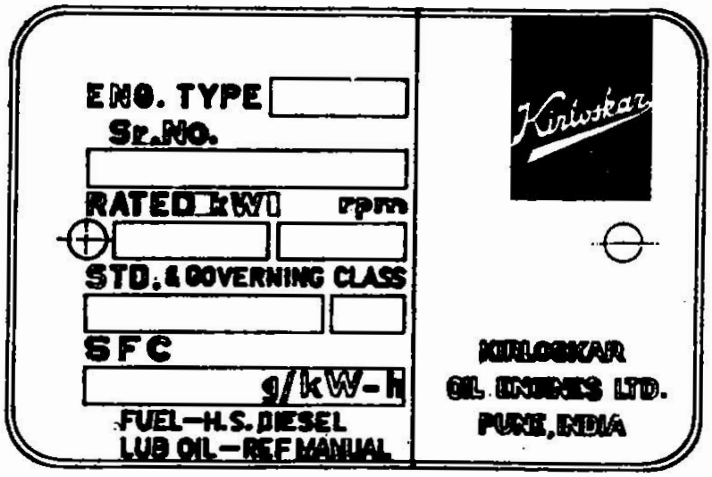
The engines are provided with 24V, -ve earth, sliding armature starters for reliable starting down to -10°C. For battery charging an alternator/dynamo with charging ammeter is also provided.
An electrical cold starting equipment with solenoid valve and starting device could be provided on special request.

ENGINE NUMBERING SYSTEM

The model designation, engine rating and engine serial number are punched on name plate which is fixed on flywheel housing. When ordering spare parts or any correspondence related to engine problem it is essential to quote the model designation and complete engine number.

ENGINE DESCRIPTION

ENGINE NAME PLATE -



ENGINE NUMBERING SYSTEM -

F6 . 4001 / 94 101

- 101 — Engine serial number.
- 94 — Year of manufacture
- 4001 — Application code no.(i.e. built of the engine)
- F6 — Engine model no.

MODEL IDENTIFICATION -

The engine model is punched on name plate in column 'TYPE'.
The first digit indicates no.of cylinders, next 4 digits indicate engine series (i.e. SL90), the two digits after engine series indicate the piston displacement, while last digit/digits indicates breathing (naturally aspirated except when letter T/TA for turbocharged is present).

Examples :

6 SL90 88 T	**4 SL90 59 T**
6 -6 Cylinders	4 - 4 cylinders
SL90 -Engine series	SL90 -Engine series
88 -Piston displacement 8.8lit.	59 - Piston displacement 5.9lit.
T -Turbocharged	T -Turbocharged

- (TA for Turbocharged after cooled)

CONTENTS

SUBJECT	SECTION
FUEL, LUBRICANTS, COOLANT	**1**
Fuel	1.1
Lubricants	1.2
Coolant	1.3
PUTTING INTO OPERATION	**2**
Fuel supply	2.1
Oil level	2.2
Coolant level	2.3
To start-up the engine	2.4
Heating up the engine	2.5
Shutdown of engine	2.6
Supervision during operation	2.7
MAINTENANCE	**3**
Maintenance schedule for running-in period	3.1
Regular maintenance schedule-Table	3.2
Maintenance - Fuel system	3.3
Maintenance - Lub oil system	3.4
Maintenance - Air cleaner	3.5
Maintenance - Cooling system	3.6
Other Maintenance	3.7
TROUBLE SHOOTING	**4**
SPECIFICATION, TIGHTENING TORQUES, ENGINE PRESERVATION	**5**
LUB. OIL RECOMMENDATION TABLES	**--**
INSTRUCTION MANUAL FOR GARRETT T-O4E TURBOCHARGER	**6**

1. FUEL , LUBRICANTS , COOLANT

1.1 FUEL

The performance of the engine depends upon supply of clean and correct grade of fuel. The fuel injection equipment is manufactured to very close tolerances and slightest amount of dirt in fuel can cause wear on the injection equipment.

Always use a reputable branded grade of diesel fuel having a sulphur content of below 0.5%. In case of higher sulphur content, the periods between oil changes should be shortened.

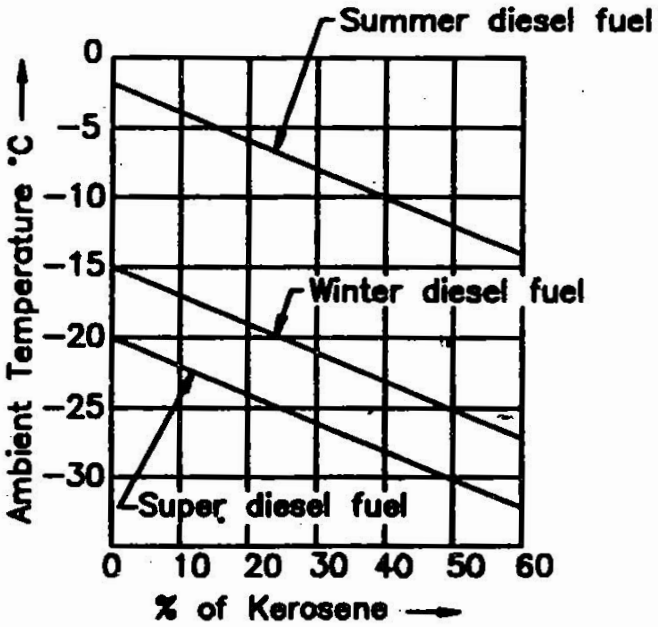
The following fuel specifications are approved-

H.S.Diesel Oil corresponding to

- IS:1460
- BS2869:A1 and A2
  (In case of A2, note sulphur content)
- ASTM D975-81:1-D and 2-D
- VV-F-800C:DF-A,DF-1 and DF-2
- DIN 51 601

WINTER-GRADE FUEL

At low temperatures, waxing may occur and clog the fuel system, thus causing operational troubles. In the case of ambient temperatures below 0°C, use winter-grade diesel fuel (down to -15°C). Normally, this is offered at filling stations in good time before the cold season starts. Diesel fuel with additives (super diesel) is fre-



quently also on sale for use at temperatures down to -20°C .

* At temperatures as low as -15°C to -20°C, kerosene should mixed with the diesel fuel.The necessary percentages for admixing are to be seen in the diagram at right.

IMPORTANT NOTE :

Prepare the blend in the tank itself. Fill in the necessary amount of kerosene first, then add diesel fuel.

1.2 LUBE OIL

Lube oils of correct viscosity and detergency grades should be used, to ensure optimum engine performance.

For detergency, the oil should comply with the following specifications.

INDIAN STD.	EQUIVALENT PERFORMANCE LEVEL		
(IS:13656)	US Military	API	CCMC
E - DL1	---	CC	---
E - DL2	MIL-L-45199B	CD	---
E - DL3	---	CDplus	---
E - DL4	---	---	D5

For viscosity, the recommended SAE No. should be used. SAE J300C specifies the viscosity of the lubricating oil for each SAE number. Tables below show the lube oil brands from established manufacturers, which are recommended.

NOTE :
Referring to the column "Atmospheric Temp. °C" in the Tables, anticipated lowest temperatures at the time of starting should be used as a reference in Winter. While in Summer, the highest temperature of the day should be used as a reference.

LUBE OIL RECOMMENDATIONS (MONOGRADE OILS) FOR N.A.. ENGINES

- Refer Table I (Page 73)

LUBE OIL RECOMMENDATIONS (MONOGRADE OILS) FOR TURBOCHARGED ENGINES

- Refer Table II (Page 74)

MULTIGRADE OILS

Multigrade oils can be used, where -

a) atmospheric temperature variations between minimum and maximum is very wide, during engine operation, or
b) non-availability of monograde oils.

LUBE OIL RECOMMENDATIONS (MULTIGRADE OILS) FOR N.A. ENGINES

- Refer Table III (Page 75)

LUBE OIL RECOMMENDATIONS (MULTIGRADE OILS) FOR TURBOCHARGED ENGINES

- Refer Table IV (Page 76)

QUANTITY OF OIL FILLING

For 6 cyl. engines :

* For first filling -23.5 litres * For change of oil - 21.0 litres

For 4 cyl. engines :

* For first filling -18.0 litres * For change of oil - 16.0 litres

!CAUTION

NO GUARANTEE CLAIMS WILL BE ACKNOWLEDGED ON THE GROUNDS OF ENGINE DAMAGES DUE TO USE OF UNSUITABLE ENGINE LUBE OILS.

1.3 COOLANT

Use soft water for engine cooling and anticorrossion oils to avoid rust formation. Water should be clear and free of any corrosive chemicals such as chloride, sulphates and acids. We recommend to use a coolant blend of soft water and rust preventing compound as mentioned below-

Add 2.5cc per litre of one of the following oils to cooling water

i) Shell Donac C
ii) Shell BOC Bocut cutting compound
iii) S/V Solvoc 1535 oil
iv) Caltex soluble oil C
v) AQUAT-720

In summer, with no antifreeze, fill system with water as mentioned above.
In winter, select an antifreeze, and use with water as required by temperature.
Ethylene glycol anti-freeze diluted with coolant blend as mentioned above in the following proportion is recommended for use in (radiator) cooling system.

Ambient temperature -^{0}C	Ratio by volume of antifreeze to cooling water
+5 to -5	20:80
-6 to -15	33:67
-16 to -25	40:60
below -25	50:50 (max. permissible ratio)

!CAUTION

IF ANTIFREEZE SOLUTION IS NOT IN USE AND THE ENGINE HAS TO BE LEFT OPEN WITH TEMPERATURES

CLOSE TO FREEZING POINT, THE COOLING SYSTEM MUST BE COMPLETELY DRAINED AND A NOTICE IS TO BE PLACED ON THE ENGINE THAT THE COOLING SYSTEM IS EMPTY AND THE DRAIN TAPS ARE OPEN.

***

2. PUTTING INTO OPERATION

Daily Check -

* **the fuel supply**
* **the oil level**
* **the coolant level**

2.1 FUEL SUPPLY

- Check content of fuel tank either by means of electric fuel indicator or, in case of stationary engines, by means of a dip rod.
- When filling in fuel, be careful to add clean fuel only that has to be filtered workmanlike.
- After prolonged standstill, after interference with the fuel system (change of filter), or after the fuel tank was emptied completely, ventilate the system (see 3.1)

2.2 OIL LEVEL

- Check the oil level every day before starting the engine.
- Check the oil level when the engine is cold and in horizontal position.
- When a dipstick is used, the oil level must be between the top mark and bottom mark of the dipstick.

Fig.2.1

PUTTING INTO OPERATION

IT IS ABSOLUTELY IMPERMISSIBLE THAT THE OIL LEVEL REMAINS FOR A LONGER TIME BELOW THE BOTTOM MARK ON DIPSTICK.

When filling up oil, use exclusively the brand which is recommended in 1.2. Take care during oil filling that no foreign particles get entered into the engine alongwith oil.

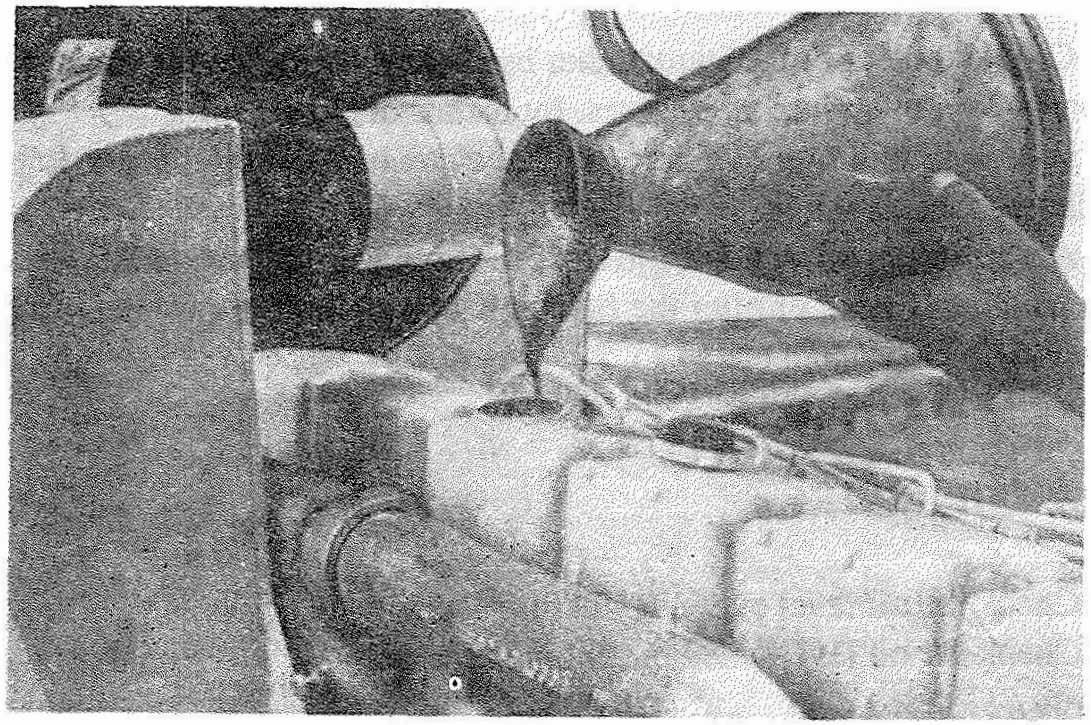


Fig.2.2

Note : During the running in period, the engine will consume more lube oil than normally. After about 75 hours operating time the oil consumption will attain the permissible value of appr. 0.5% of the fuel consumption.

2.3 COOLANT LEVEL

Inspect the coolant level **every day** before starting the engine.

If coolant has to be added, fill in only the prescribed coolant (see 1.3)

Fill in coolant through the neck of the radiator till it flows through the radiator overflow pipe.

CAUTION

DO NOT OPEN RADIATOR WHILE THE ENGINE IS HOT. THE COOLANT SYSTEM IS UNDER PRESSURE.

ADD COOLANT ONLY WHEN THE COOLANT SYSTEM IS COLD. THE TEMPERATURE DIFFERENCE BETWEEN THE COOLANT SYSTEM OF THE ENGINE AND THE COOLANT BEING ADDED MUST NOT EXCEED 50°C.

2.4 TO START UP THE ENGINE

- The battery master switch shall be closed.
- The ignition key shall be inserted into the ignition switch.

Positions of ignition switch

O - off
I - electrical equipent live
II - starting of engine

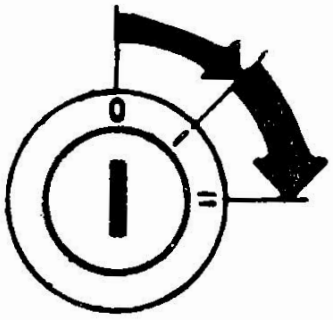


Fig.2.3

- Set ignition key to its position

The battery charging signal lamp(1) and the oil pressure signal lamp(2) light up.

PUTTING INTO OPERATION

Note : The ignition switch provides non-restart interlocking. Therefore, before repeating the trial to start up the engin the key must be set first to "O" and again to its positions "I" and "II".

AT TEMPERATURES ABOVE 0°C

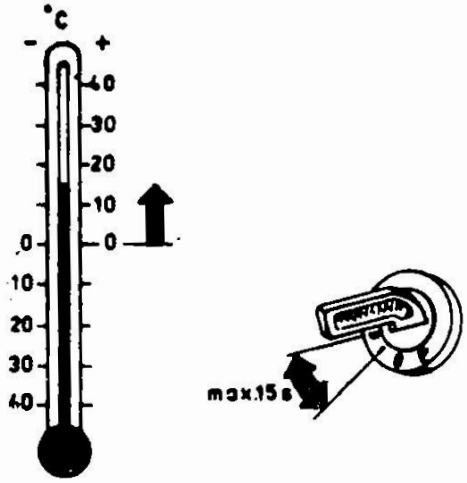


Fig.2.4

STARTING CYCLE

1st trial	starting	max.15 sec
	rest	30 sec.
2nd trial	starting	max.15 sec.
	rest	30 sec.
3rd trial	starting	max.15 sec
	rest	5 min.

Duly observe the **5 minutes** rest after a futile starting cycle. Look for possible causes of the trouble (see Table,Chapter 4.) and redress them.

- As soon as the engine is running independently,both the battery charging signal lamp and the oil pressure signal lamp must extinguish.

AT TEMPERATURES BELOW 0°C

When cold starting device is provided on your engine, separate instructions for engine starting are provided depending upon the starting aid provided based on the needs of environmental conditions. Please refer these instructions.

2.5 HEATING UP THE ENGINE

- The cold engine must not run at excessively high speed. The lube oil still is very viscous and cannot be conveyed to oll parts of the engine. Therefore, the risk of jamming of frictional parts is very great.
- Have the engine heat up at low load (low speed setting).
- Do not overload the engine by excessively low or high running speed.
- Likewise, do not load the engine to the limit of its capacity before it has attained its normal operating temperature.
- Avoid prolonged no-load running of the engine.

2.6 SHUTDOWN OF ENGINE

- If the engine was subject to heavy load, have it run for a brief period of time under no-load condition to cool it down and thus prevent continued heating up after standstill.
- Move speed control lever 1 to slow speed position.
- Actuate shut down lever 2 until engine stops completely. (Fig. 2.5)
- Remove the ingnition key, set battery main switch to "OFF".
- In case of gravity fuel supply, close the stop valve in the fuel pipe.

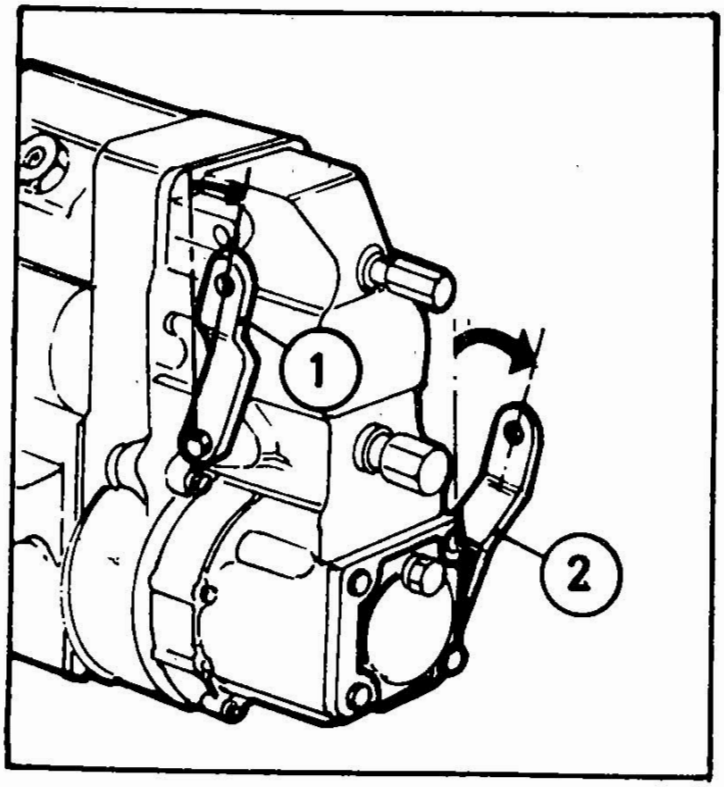


Fig.2.5

2.7 SUPERVISION DURING OPERATION

- Rated oil pressure values during operation of the engine:

No-load run	- 80 to 170 kPa (0.8 to 1.7 kgf/cm^2)
Rated speed	- 350 to 450 kPa (3.5 to 4.5 kgf/cm^2)

- If the oil pressure decreases below 80 kPa (0.8 kgf/cm^2) at no-load speed and below 150 kPa (1.5 kgf/cm^2) at rated speed, respectively, **stop immediately** the engine and refer section 4: TROUBLES to find out the possible causes.

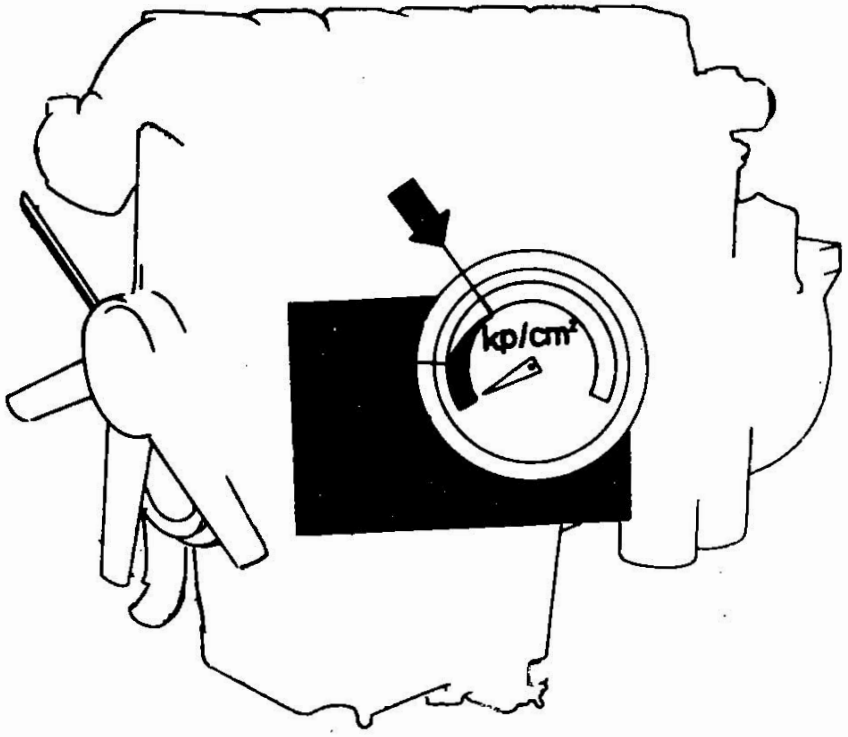


Fig.2.6

PUTTING INTO OPERATION

- After the engine has started running, both the red battery charging signal lamp and the oil pressure signal lamp must extinguish.
- The optimum operating range of the coolant is from 80°C to 95°C.
- At temperatures below 80°C, heavy wear and increased fuel consumption will result.
- Temperatures above 95°C and up to 110°C as maximum indicate overloading of the engine and are permissible only up to a maximum lapse of 10 minutes.

***

3. MAINTENANCE - SCHEDULE

Maintenance is the most important factor for both the life and keeping the engine in the best operating condition. Preventive maintenance is more economical than corrective repairs. Be sure to maintain your engine according to schedule given in the Maintenance-Table for running-in period and later in regular intervals, respectively.

OBSERVE STRICTLY THE SPECIFIED MAINTENANCE SCHEDULE.

3.1 MAINTENANCE SCHEDULE FOR RUNNING-IN PERIOD.

PERFORM AT FOLLOWING INTERVALS	REFER SECTION	INSPECTION AND MAINTENANCE TASK
DAILY	3.4	LUBRICATION
	3.4.1	*Check engine oil level,top-up if repaired.
	3.3	FUEL SUPPLY
	3.3.1	*Drain sediments from fuel tank.
		*Fill up the fuel tank at the end of each working day. Never wait until the tank is empty.
	3.5	AIR SYSTEM
	3.5.1	*Remove dust accumulated in the dry type air filter bowl, through vacuator valve.
	3.6	COOLING SYSTEM
	3.6.1	*Check coolant level in radiator, top-up if required.
AFTER FIRST 50 HOURS	3.4	LUBRICATION
	3.4.2	*Change Engine Oil.
	3.4.3	*Clean centrifugal filter.
	3.4.4	*Change spin-on type filters.
	3.3	FUEL SUPPLY
	3.3.2	*Tighten fuel piping.
	3.5	AIR SYSTEM
	3.5.1	*(None)

	3.6	COOLING SYSTEM
		*(None)
	3.7	OTHER MAINTENANCE
	3.7.1	*Check valve tappet clearance.
	3.7.2	*Check 'V' belts tension.
	3.7.3	*Check electrolyte level and specific gravity in the battery.
		*Check all external fasteners,especially those of manifolds,bends, turbocharger, engine mounting and rubber hoses.
		*Check leaks, if any and correct.

3.2 REGULAR MAINTENANCE SCHEDULE TABLE

PERFORM AT FOLLOWING INTERVALS	REFER SECTION	INSPECTION AND MAINTENANCE
(A) DAILY	3.4	LUBRICATION
	3.4.1	*Check engine oil level,top-up if required.
	3.3	FUEL SUPPLY
	3.3.1	*Drain water and sediment accumulated at the bottom of fuel tank before starting the engine.
		*Fill-up the fuel tank at the end of each working day.
	3.5	AIR SYSTEM
	3.5.1	*Remove dust accumulated in the dry type air filter bowl, through vacuator valve.
	3.6	COOLING SYSTEM
	3.6.1	*Check coolant level in radiator, top up if required.

(B)		*REPEAT 'A'
AFTER	3.5	AIR SYSTEM
EVERY	3.5.1	*In very dusty condition, clean the bowl of dry type air cleaner and if necessary change the element. (In normal working condition, this is to be done only when a need for air cleaner service is indicated by the restriction indicator)
50		
HOURS		
	3.7	OTHER MAINTENANCE
	3.7.2	*Check 'V' belt tension and adjust if required.
	3.7.3	*Check electrolyte level in the battery. *Check the cable connections at starter, battery, dynamo/ alternator and control panel.
(C)		*REPEAT 'A'& 'B'
AFTER	3.4	LUBRICATION
EVERY	3.4.2	*Change engine oil.
300	3.4.3	*Clean centrifugal filter.
HOURS	3.3	FUEL SUPPLY
	3.3.5	*Drain sediments and water accumulated at the bottom of fuel filter bowls.
	3.3.3	*Clean the filter sieve with clean diesel, fitted on feed pump inlet.
(D)		*REPEAT 'A', 'B' & 'C'
AFTER	3.4	LUBRICATION
EVERY	3.4.4	*Change the main oil filter (spin-on type)
600	3.3	FUEL SUPPLY
HOURS	3.3.5	*Replace the prefilter insert of fuel filter. **(DO NOT CHANGE PRE-FILTER & MICRO FILTER INSERT AT THE SAME TIME, FIRST CHANGE THE PREFILTER INSERT AND AFTER ABOUT 200 TO 250 HOURS CHANGE MICRO-FILTER INSERT.)**

MAINTENANCE - SCHEDULE

	3.7	OTHER MAINTENANCE
	3.7.1	*Check valve tappet clearance, adjust if required.
(E)		*REPEAT 'A', 'B' ,'C' & 'D'
AFTER	3.3	FUEL SUPPLY
EVERY	3.3.7	*Check fuel injector and adjust if required
1200	3.3.1	*Clean the fuel tank thoroughly.
HOURS	3.6	COOLING SYSTEM
	3.6.1	*Clean radiator externally.
	3.6.2	*Check thermostat element.
	3.7	OTHER MAINTENANCE
	3.7.4	*Inspect electrical unit i.e. starter, dynamo/ alternator, regulator etc. Replace as re quired.

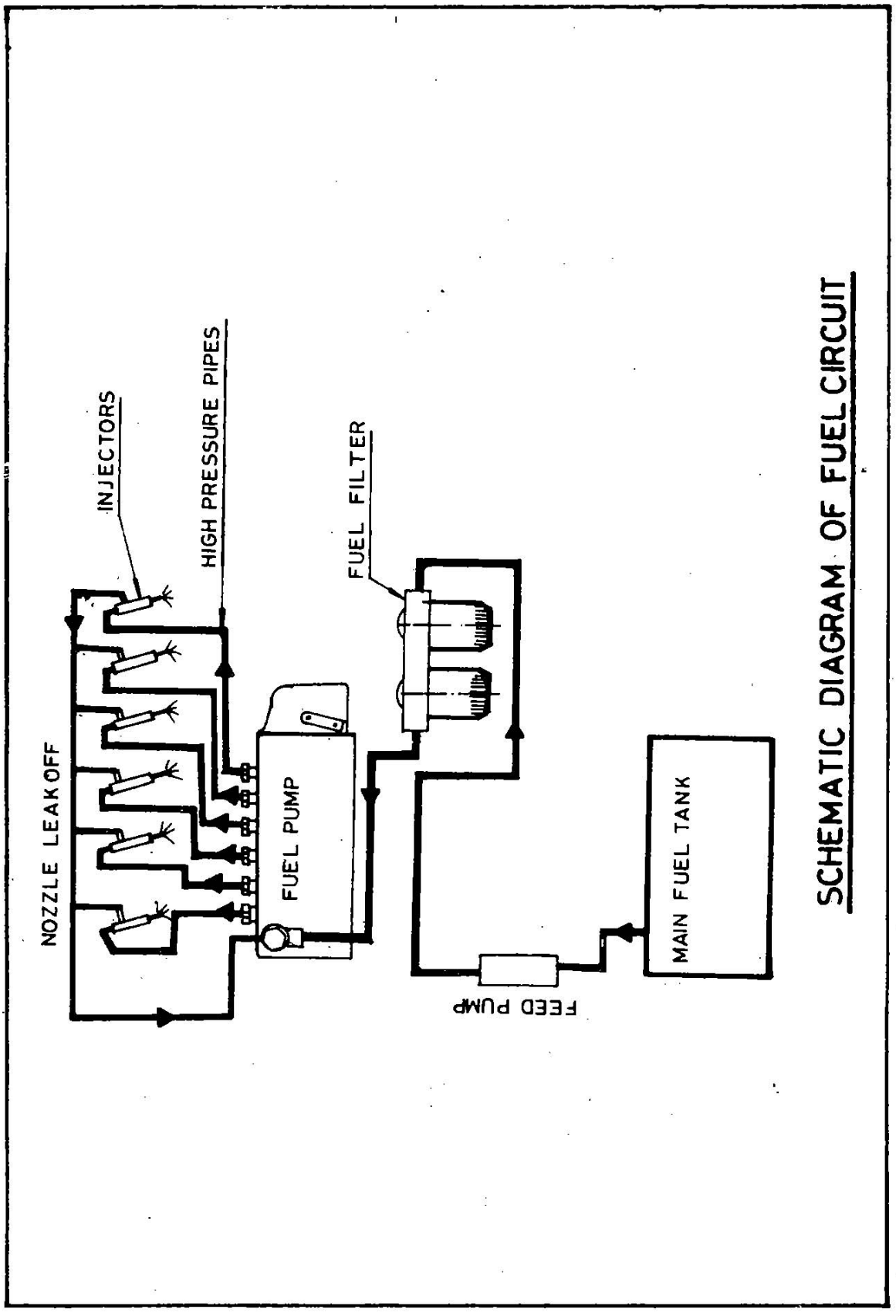

SCHEMATIC DIAGRAM OF FUEL CIRCUIT
INJECTORS
HIGH PRESSURE PIPES
FUEL FILTER
NOZZLE LEAK OFF
FUEL PUMP
FEED PUMP
MAIN FUEL TANK

Fig.3.1

3.3 MAINTENANCE - FUEL SYSTEM

3.3.1 FUEL TANK

To avoid ingress of dirt during operation, always use a proper fuel tank cap with a good rubber sealing. In case of detachable type of cap, while fitting ensure that the cap does not pick-up dust or grit, otherwise it will go to the fuel.
To minimise water contamination due to condensation of moisture, it is advisable to fill the fuel tank in the evening, after the day's work is over. Drain the fuel tank to remove the sediment accumulated at the bottom of the tank. Ensure that the breather hole is not blocked.
Clean the tank thoroughly every after 1200 hours or 6-months whichever is earlier. Clean tank with diesel, do not use water for cleaning, it will lead to rusting and scale formation.

3.3.2 LOW PRESSURE FUEL PIPES

The pipes which connect the fuel tank, feed pump, filter and fuel injection pump can also be a source of trouble if not looked after. Make sure that all the joints , banjo bolts are tight so that there is no leaks. Do not try to do makeshift repair with soap or some other crude sealing. Remove the defective pipes immediately and fit and replace them with new ones because cracks and loose joints will let the air in and cause 'air locks' or, fuel will be unnecessarily wasted due to leakages.

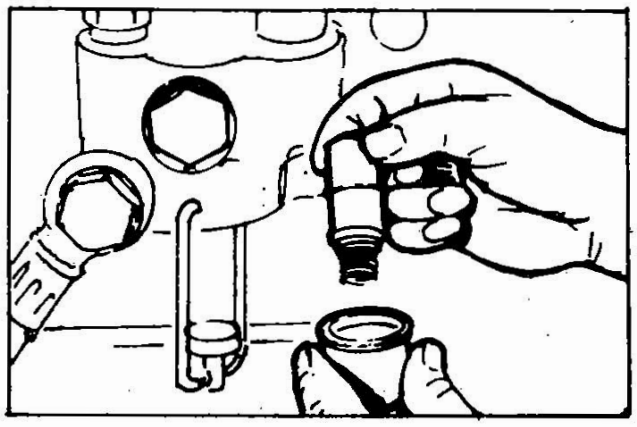


Fig.3.2

3.3.3 FEED PUMP

Clean the preliminary filter sieve (Fig.3-2) of the feed

pump every after 125 hours. You can do this conveniently at the time of engine oil change. Examine the rubber sealing washer for the filter bowl. If it is cut, distorted or has become too hard, use a new washer. Otherwise, this will create 'airlocks'. Examine the feed pump valves and springs (Fig.3-3). If the surface is pitted or worn-out; replace the valves.

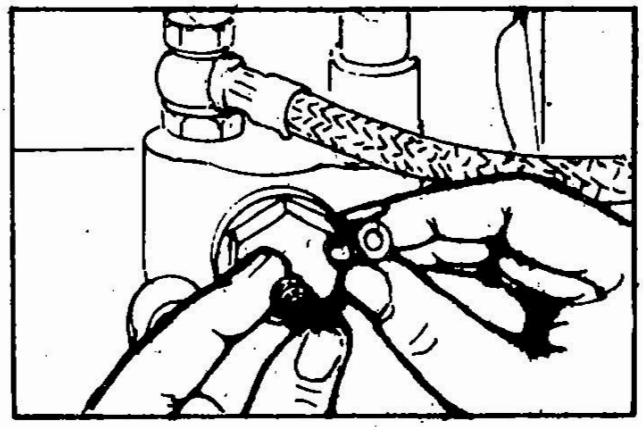


Fig.3.3

3.3.4 VENTING OF FUEL SYSTEM

Venting of the fuel system is necessary
- before the first start-up,
- after prolonged standstill period,
- if the system has taken air due to leakages in the piping or all diesel fuel has been drained from the tank,
- after replacement of fuel filter element.

To remove the air-lock proceed as follows-
a) Fill-up the fuel tank, if empty.
b) Check leakage in the fuel line, if any remove it
c) Loosen the vent screw on the primary fuel filter.

d) Rotate the knurled screw of hand primer in anticlockwise direction untill manual operation of pump is possible. Operate the hand primer upward-downward till fuel oil flows out of vent screw without air bubbles(Fig.3-4).

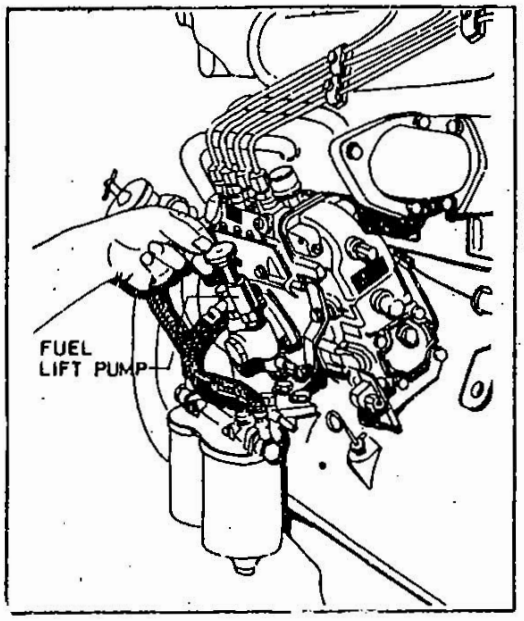


Fig.3.4

e) Tighten the vent screw and then similarly bleed the micro-filter by opening the vent screw on micro-filter. Tighten it after removing the air lock.
f) Loosen the vent screw of the fuel pump gallery and operate the fuel lift pump till the fuel flows free of bubbles. Tighten the vent screw.

g) Always remember to screw in the hand primer completely after operating it for bleeding the system. If it is not done, there is ingress of dirt and it reciprocates unnecessarily during engine running and wears out prematurely.

3.3.5 FUEL FILTERS

a) Drain the fuel filter bowls to remove the sediments and water which accumulate at the bottom of bowls (Fig.3-5). This would enhance the life of filter inserts considerably.
b) Replace the filter inserts at recommended intervals given in 3.2 " Regular Maintenance Schedule". Before replacing a

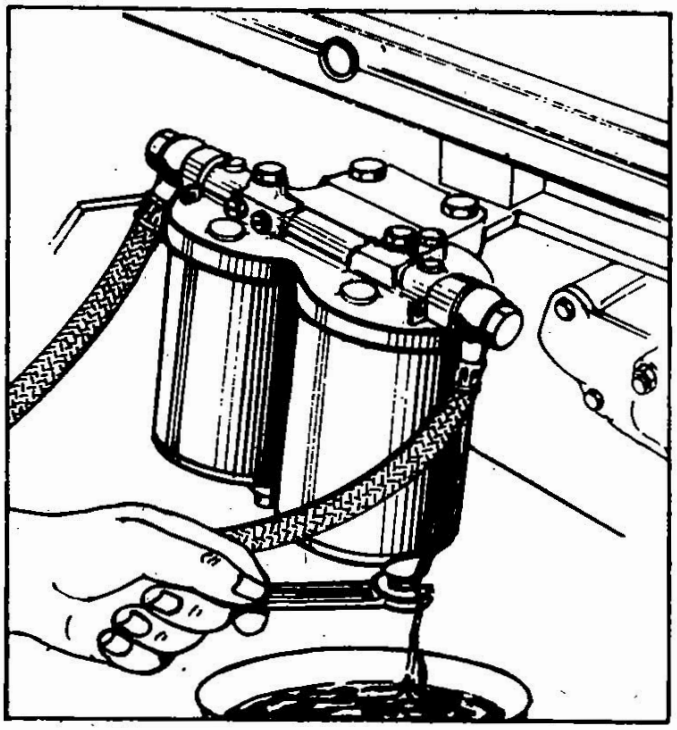


Fig.3.5

filter insert, clean the outside of filter assembly thoroughly Loosen the centre-bolt and remove the bowl (Fig.3-6). Take out the old insert.

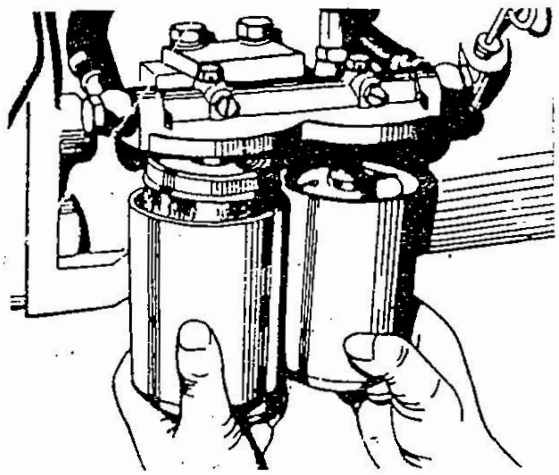


Fig.3.6

NEVER TRY TO CLEAN AND RE-USE THE OLD FILTER INSERTS

Clean the interior of the filter bowl thoroughly with diesel and blow with compressed air. Check the sealing ring in the filter cover, if damaged replace the ring. Fit the new insert. Assemble the bowl and tighten the centre bolt to the torque of 20Nm(2kgm).

IMPORTANT NOTE :

i) Since a filter attains maximum efficiency only after a layer of dirt has been deposited on the surface of filter insert, the primary and micro filter inserts should not be replaced at the same time. First change the primary filter insert and after about 200 to 250 hours change the micro-filter insert.
ii) Too frequent replacement of filter inserts, for example at the time of every engine oil change is harmful to your fuel injection equipment and is a waste of money.

3.3.6 FUEL INJECTION PUMP

As far as maintenance of the fuel injection pump is concerned, there is not much that one has to do. Do not tamper with pump,always contact our authorised dealer or MICO Service Dealer nearest to you in case of any trouble.

3.3.7 FUEL INJECTOR

The injector do not need any periodical maintenance. However, after every 1200 hours check the nozzle spray. Nozzle spray is to be checked on nozzle tester. If the nozzle tester is not available the alternative method is to test nozzle spray on engine as below -

Disconnect the high pressure pipe, remove the injector from the engine (Fig.3-9).
Refit the high pressure pipe on fuel pump and injector such that the nozzle will point out away from the engine.Crank the engine slowly till nozzle starts spraying. The nozzle should squirt out fine misty spray. If the nozzle does not spray, or if it gives solid squirt, or it dribbles after the spray has stopped, the nozzle should be cleaned.

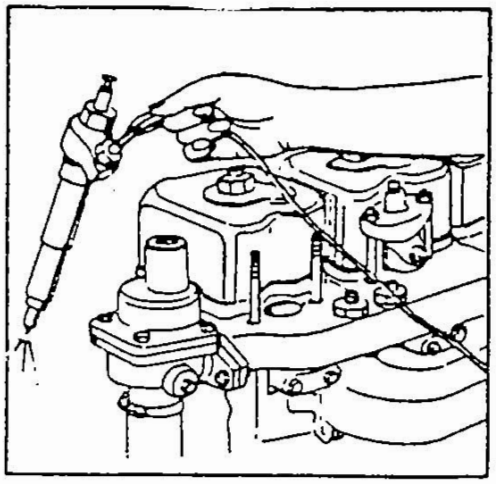


Fig 3.9

Replace the nozzle sealing washer and refit the nozzle, connect the high pressure pipe.

! CAUTION

WHILE CHECKING NOZZLE SPRAY, BE CAREFUL TO SEE THAT THE NOZZLE SPRAY IS NOT DIRECTED TO YOUR BODY. THE FORCE BEHIND THE SPRAY WILL CAUSE IT TO PENETRATE THE BODY SKIN.

MAINTENANCE - FUEL SYSTEM

IMPORTANT NOTE :

Since the fuel injection equipment is most sophisticated precision made, do not tamper with it. It should be attended to only in a well equipped service station.

MAINTENANCE - LUB. OIL SYSTEM

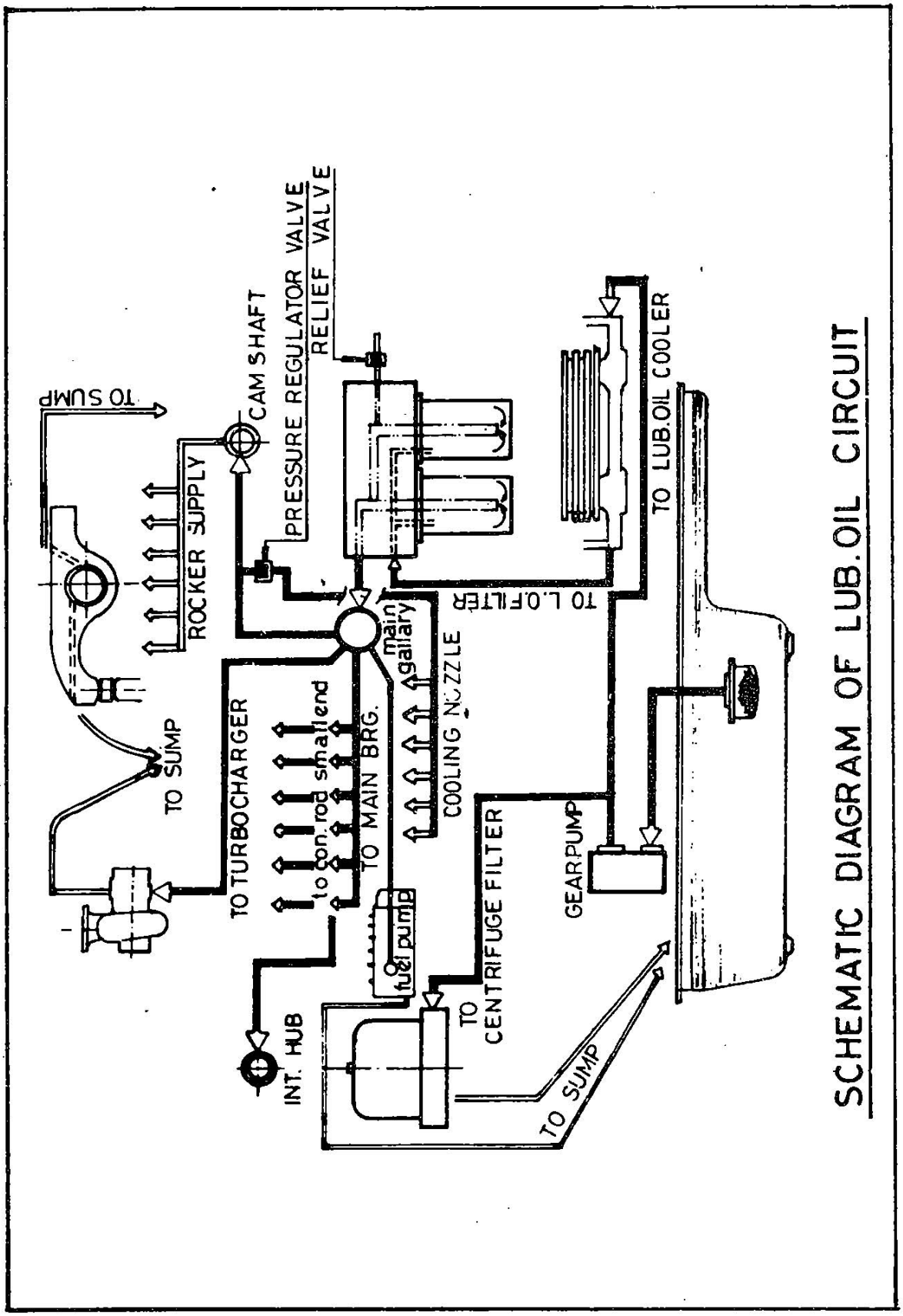


Fig.3.10

3.4.1 CHECKING OF LUB. OIL LEVEL

Check engine oil level with the help of dipstick. This is to be done every day before stating the engine. For details refer section-2.

3.4.2 CHANGE ENGINE LUB. OIL

On new engine after first 50 hours change the engine oil. Thereafter every 300 hours the oil is to be changed. Carry out oil change when the engine is hot.(oil temp. 50 ^{0}C min.). Proceed by unscrewing drain plug at the bottom of the sump (Fig.3-11).
When all old oil has run off, refit drain plug and fill in fresh oil in the sump upto top mark on dipstick, but not higher. Following a short trial run check level again. The quantity of oil to be filled in is given in section -1.

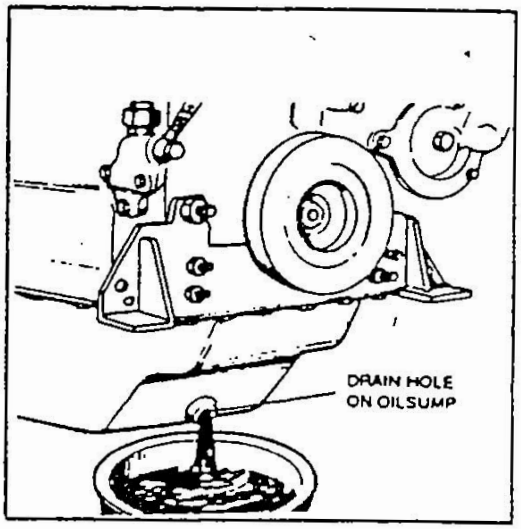


Fig.3.11

The oil also can be filled in through the centrifugal filter. For this remove the filter cover and rotor, fill the oil slowly.

IMPORTANT NOTE :

1. Use exclusively engine lub oil to the specification given in tables section -1
2. Change oil at regular intervals given in maintenance schedule. However, change oil in any case not later than at the end of 12 months, irrespective of the actual service record.

3.4.3 CENTRIFUGAL FILTER

Clean centrifugal filter at the time of engine oil change (every 300 hours) Carry out servicing when oil is still warm. Clean surroundings of the centrifuge cleaner and cleaner itself, before opening it for servicing. This will avoid dirt entering into oil passage when cleaner is opened.

1. Unscrew the top nut of the cleaner and remove the cover (Fig.3-12)

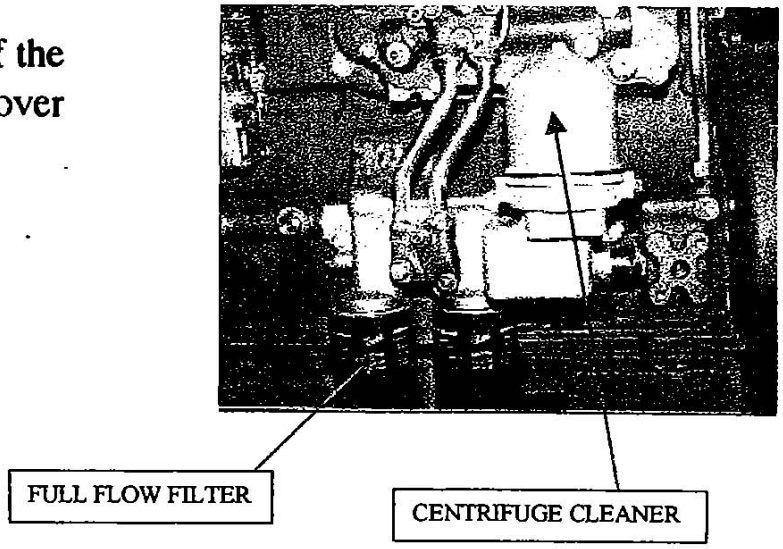


Fig.3.12

2. Lift rotor by about 60 mm; and allow oil in the rotor to drain in the lower housing. Put back rotor in its position with the special clamp tool still on (Fig.3-13).

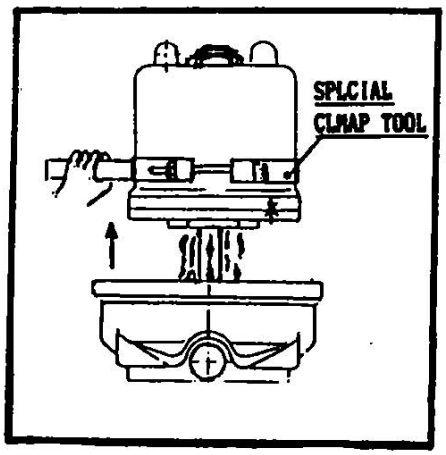


Fig.3.13

3. Unclamp rotor nut by using a box/ring/tube spanner of 32 mm.
Lift rotor by holding rotor cover and tap lightly, with wooden or plastic mallet, on top of rotor. The inner rotor will separate itself from the cover by doing so. (Fig.3-14).

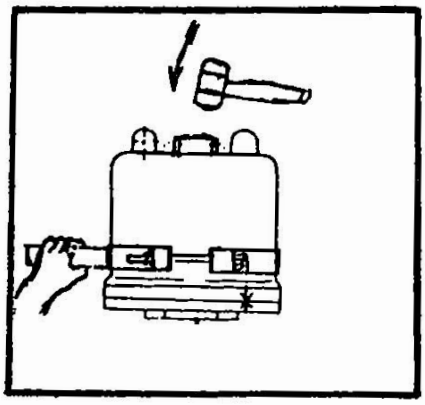


Fig.3.14

4. Remove sludge collected in rotor cover by using steel strip or blade. Clean all rotor inner parts in kerosene/diesel or similar such detergent. Blow with compressed air, nozzles fitted on top of rotor cover. Check the condition of rubber rings in housing and rotor for cuts/damages. Replace the rubber rings if required (Fig.3-15).

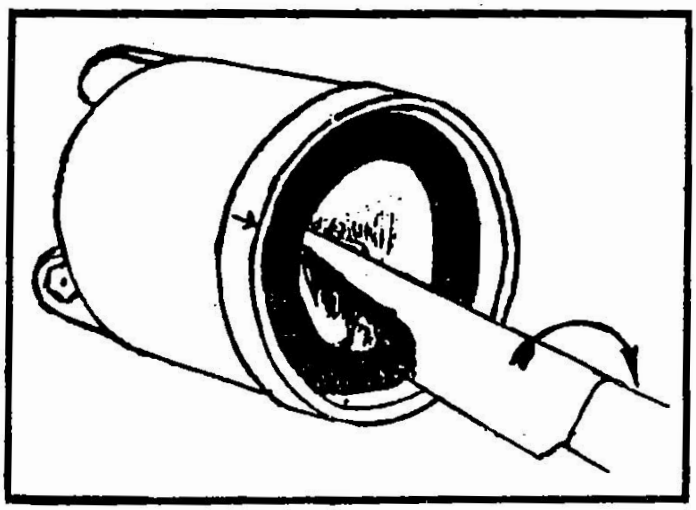


Fig.3.15

5. Place new paper wrapper in the rotor cover (Fig.3-16). Assemble all rotor parts in proper order, and close rotor cover.

MATCH ARROW MARKS ON ROTOR AND COVER.

Tighten cover nut with 2 kgm torque.

(It is convenient to put rotor back on its central shaft for this operation)

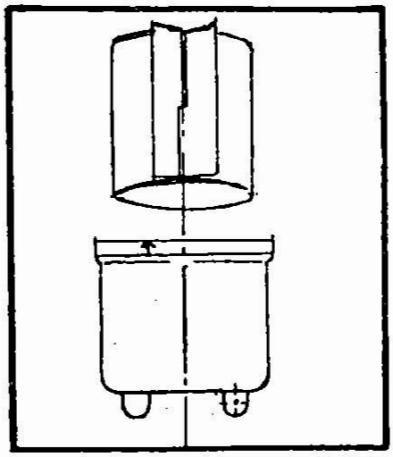


Fig.3.16

Remove special clamp tool fitted on rotor cover. Confirm that the rotor rotates freely on the shaft.

6. Close cleaner's cover and tighten top nut (Fig.3-17).

7. Ensure that the oil inlet pipe to cleaner is in position and start the engine to which the cleaner connected. Run the engine for a few minutes to check leakages . Stop the engine when the oil has become fairly warm. You should hear for a few seconds, humming sound from the cleaner, if the cleaner is functioning properly.

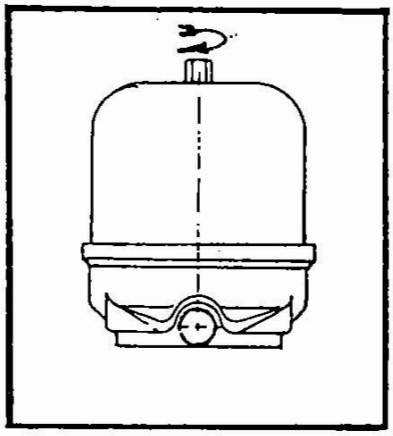


Fig.3.17

3.4.4 LUB OIL FILTER- MAIN

A spin-on type lub. oil filter, make is used on engine as main lub oil filter. These filters are of throw-away type and not to be cleaned and reused.
A signal lamp in the instrument panel indicates the necessity to change the filters.
If, no signal lamp is provided in the panel, replace filters at recommended intervals given in 3.2 "Regular Maintenance Schedule Table."

To replace the filter, proceed as below-

* Clean surroundings of the filter and filter itself externally, before removing it for replacement. This will avoid dirt entering into the filter assembly before fitting new filter.
* Hold the filter at bottom portion and turn it clockwise till it separates from the filter bracket (Fig.3-18)
* Check the condition of rubber ring between filter and header. Replace it if required.
* Assemble new spin-on filter in reversed order of disassembly. Always replace both filters at the same time.
* Check perfect sealing of spin-on filters in a test run of the engine, check orderly seat of the cable connectors of the oil pressure controller and bypass valve.

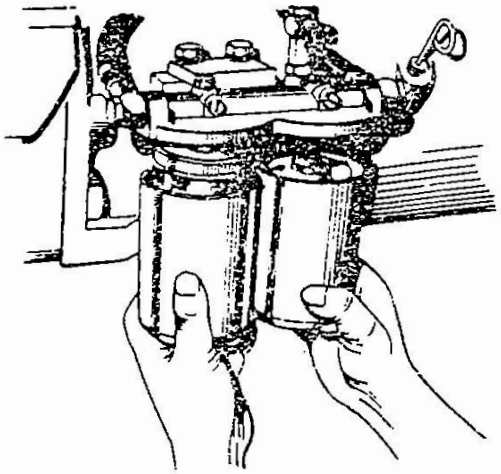


Fig.3.18

!CAUTION

SPIN-ON TYPE FILTERS ARE INTENDED FOR ONE-WAY USE ONLY AND THEREFORE MUST NOT BE CLEANED AND RE-USED. THROW IT AWAY.

MAINTENANCE - AIR CLEANER

3.5.1 DRY TYPE AIR FILTER

Dry type air cleaner is fitted with a paper filter element. The restriction indicator is mounted on the air cleaner, which indicates the condition of the filter element. A vacuator valve is fitted at the bottom of the air cleaner to remove the dust accumulated in the air cleaner housing.
The air cleaner outlet is connected to turbocharger air inlet with the help of rubber hoses, clips and sheet metal connector. The turbocharger is connected to air inlet manifold and exhaust manifold by cast iron bends/sheet metal bends.

a) Daily check the condition of rubber hoses and hose clips before starting the engine. Damaged hose/clip must be replaced immediately.

b) Make sure that the vacuator valve is not damaged or plugged.
Daily remove dust accumulated in the air cleaner housing through this vacuator valve before starting the engine.
Discharge the dust ejector valve by pressing apart the lips of the ejection slot, applying pressure as indicated in Fig.3-19.
Clean the ejection slot from time to time.

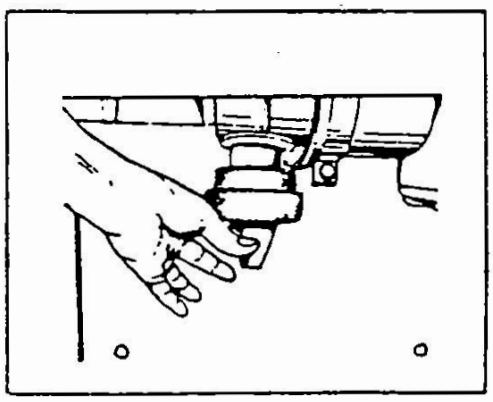


Fig.3.19

c) A restriction indicator indicates the necessity to change the filter element. When the air cleaner element is choked, a red signal will be seen through the transparent window of the indicator when the engine is running and will stay even after engine is stopped. This is an

indication that the element must be changed (Fig.3-20). After replacing the element, reset the indicator by pushing the reset button provided on the top of the indicator.

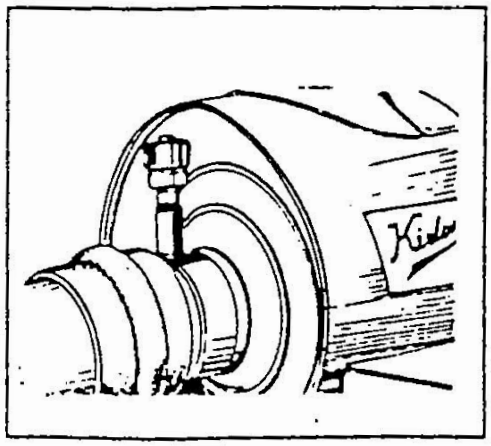


Fig.3.20

d) To remove the filter insert, first unclamp the end cover and take out the filter element (Fig.3-21).

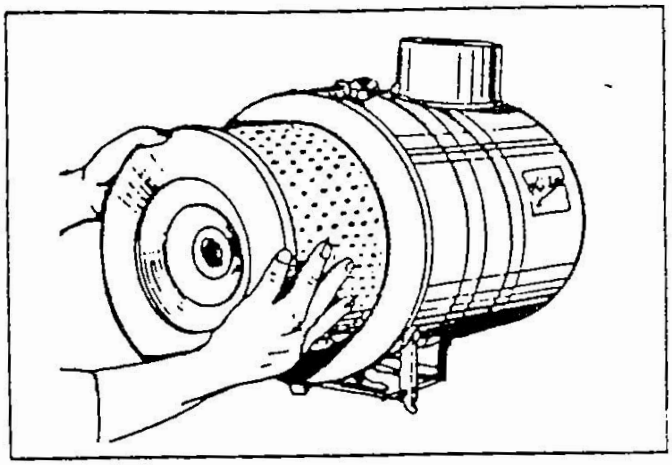


Fig.3.21

!CAUTION

i) SINCE THIS IS DRY TYPE AIR CLEANER, DO NOT USE/ FILL A SINGLE DROP OF OIL IN IT.
ii) THE CLEANING OF DRY TYPE AIR FILTER ELEMENT BY TAPPING, POUNDING OR COMPRESSED AIR IS NOT RECOMMENDED, IF CHOKED CHANGE IT.

e) Use a damp cloth to wipe out all excess dust in the air cleaner housing. Carefully check the element for damage or crack. Replace the element if there is any crack in the element. Reinstall the element in the housing and refit the end cover.

NOTE :

The replacement period of filter element totally depends upon the atmospheric conditions and proper maintenance of the engine. Under very dusty condition, the frequency of replacement of air filter element is more than the normal atmospheric conditions.
Irrespective of the above instructions, inspect the filter element and rubber hoses at an intervals of 600 hours for excessive accumulation of dirt. Change the filter element if necessary.

3.5.2 TURBOCHARGER

The turbocharger make "GARRETT T-04E" is used on turbocharged engines. For detail instructions of its operation and servicing refer section-6.

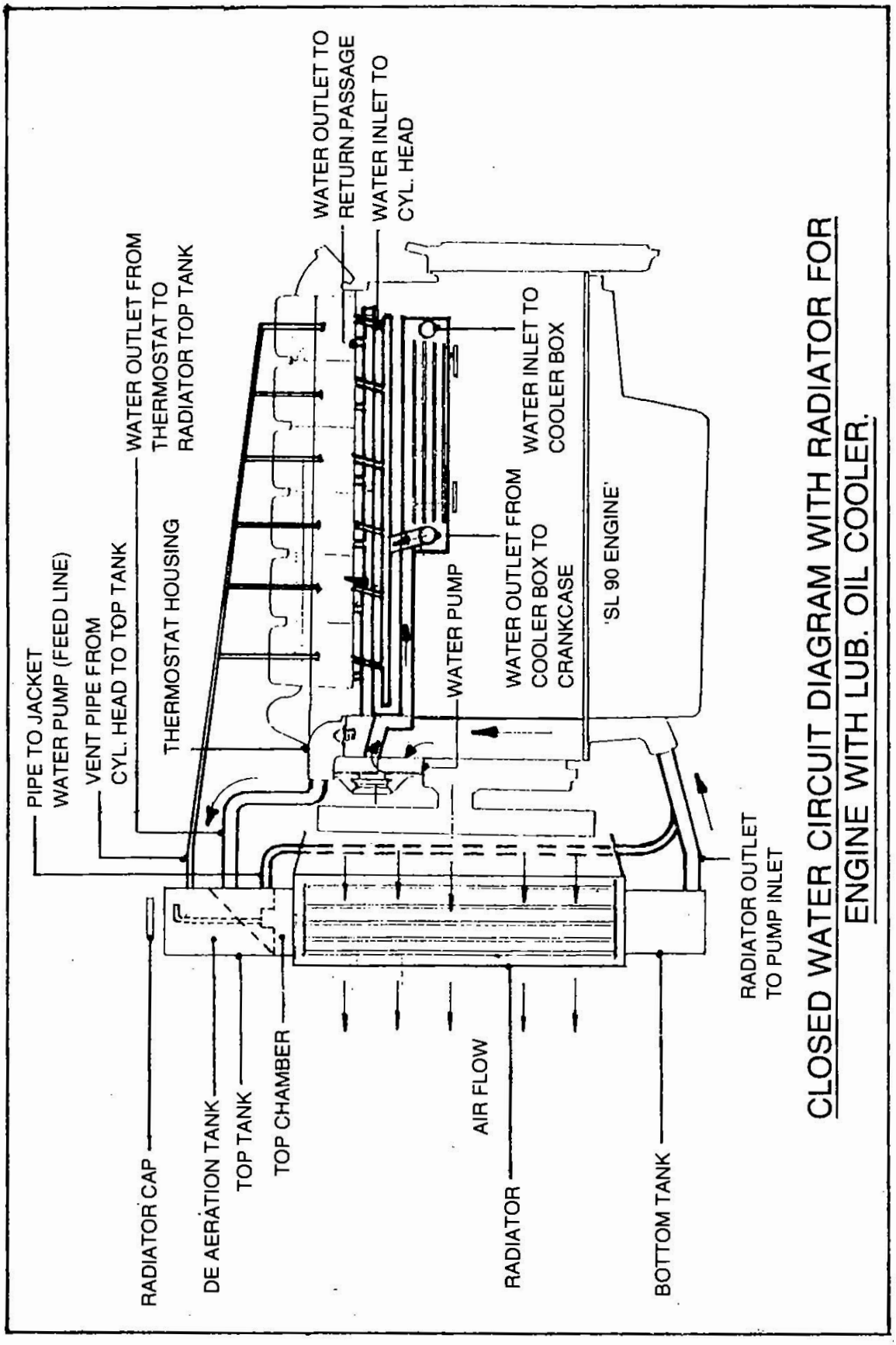

CLOSED WATER CIRCUIT DIAGRAM WITH RADIATOR FOR ENGINE WITH LUB. OIL COOLER.
PIPE TO JACKET WATER PUMP (FEED LINE)
VENT PIPE FROM CYL. HEAD TO TOP TANK
THERMOSTAT HOUSING
WATER OUTLET FROM THERMOSTAT TO RADIATOR TOP TANK
WATER OUTLET TO RETURN PASSAGE
WATER INLET TO CYL. HEAD
WATER INLET TO COOLER BOX
WATER OUTLET FROM COOLER BOX TO CRANKCASE
WATER PUMP
'SL 90 ENGINE'
RADIATOR OUTLET TO PUMP INLET
RADIATOR CAP
DE AERATION TANK
TOP TANK
TOP CHAMBER
AIR FLOW
RADIATOR
BOTTOM TANK

Fig.3.22

MAINTENANCE - COOLING SYSTEM

Engine cooling system contains radiator (with deaeration system), radiator fan, water pump and temperature controller i.e. thermostat. The schematic diagram (Fig.3-22) shows the water circuit. The engine control panel consists water temperature gauge as well as high water temperature trip for engine safety.
For chemical treatment of cooling water in engine jacket and radiator, refer section-1.

3.6.1 RADIATOR (with deaeration system)

Deaeration arrangement has been incorporated on radiators supplied with SL90 series engines. Deaeration system includes-

- Radiator with deaeration tank in the top tank.

- Water feed line from the deaeration tank (bottom most level) to suction bend of the engine coolent pump.

- Vent connection from cylinder heads to the deaeration tank in expansion space.

Above connections are required besides the normal connections viz. radiator inlet and outlet as shown in water circuit fig. 3.22.

a) COMMISSIONING CHECKS

The following checks are to be observed at the time of first filling of coolent in the system and whenever radiator is drained off for some reason.

i) Remove the radiator cap and fill in coolent through the neck of the radiator. Ensure that the complete water system inclusive of top tank (deaeration tank), radiator core, engine jacket, cylinder heads and all connecting piping is completely filled up. This can be easily checked by disconnect ing vent line from cylinder head to top tank after all air bubbles are vented out and steady water stream is attained.

ii) First system fill take longer time, which can be reduced by removing top cover of thermostat housing. Secure this cover tight if removed and check that all air bubbles are vented out and steady flow of coolent from vent line is attained.

iii) Ensure all connections are secured tight after system fill-up. Secure radiator cap.

iv) Start the engine and feel the temperature of cylinder head and top tank. Higher temperature of cylinder head indicates that the system is not thoroughly primed. Open the vent connection at the top tank and check the flow of water. Bubble formation indicates that the system is not completely vented. Stop the engine immediately and repeat the step (i).

v) Restart the engine and take it to high idling speed. Watch the water temperature, it should stabilise between 74 deg to 86 deg.c on full load.

vi) In case of any abnormality, consult OE/SD/KOEL office nearest to you.

WARNING

FAILURE IN CARRING OUT ABOVE SETS CAN LEAD TO SERIOUS ENGINE THROUBLES. THE WARRANTY IS VOID IF CASES OF THIS NATURE ARE REPORTED

b) ROUTINE MAINTENANCE -

Top-up radiator every day before starting the engine. For more details refer Section-2.

MAINTENANCE - COOLING SYSTEM

Draining of water is absolutely necessary if temperature below freezing point is to be expected. For draining, remove the radiator cap and unscrew the drain plug on the bottom tank of the radiator.

Ensure refilling of cooling system before next start. Follow the procedure and checks as given in 3.6.1(a).

After short run trial of the engine, check again the coolent level in the radiator.

It is recommended to clean radiator externally every after 1200 hours of operation, by blowing pressurised air in the reverse direction of the flow of radiator fan. Do not spill water on radiator fins.

!CAUTION

DO NOT USE CONCENTRATED SODA LYE TO CLEAN THE COOLING SYSTEM BECAUSE IT COULD CORRODE ALUMINIUM PARTS.

3.6.2 THERMOSTAT

a) A thermostat having twin elements is used in the water circuit (Fig.3-23). Thermostat is provided to attain working temperature quickly during warm-up period and maintains desired temperature of coolant during running of the engine.

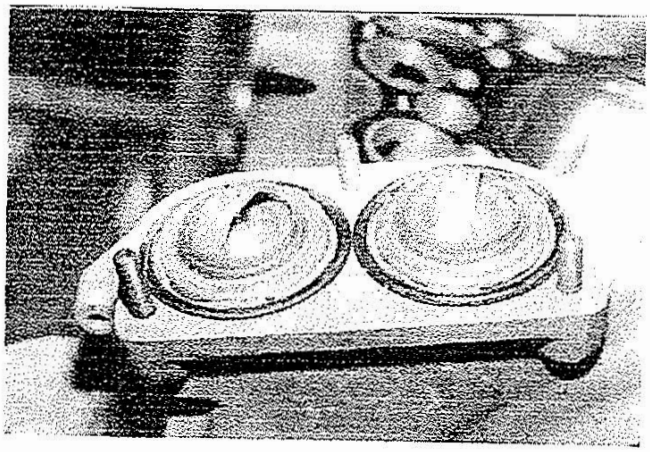


Fig.3.23

Opening begins at	74°C
Full open at	84°C
Opening stroke	10 mm

b) Normally thermostat does not require regular maintenance. Its safe operation shall be checked if sudden deviations from the prescribed coolant temperature should occur. Visual inspection will reveal whether or not the element rests in its seat i.e. whether or not it closes tightly (Fig.3-24).

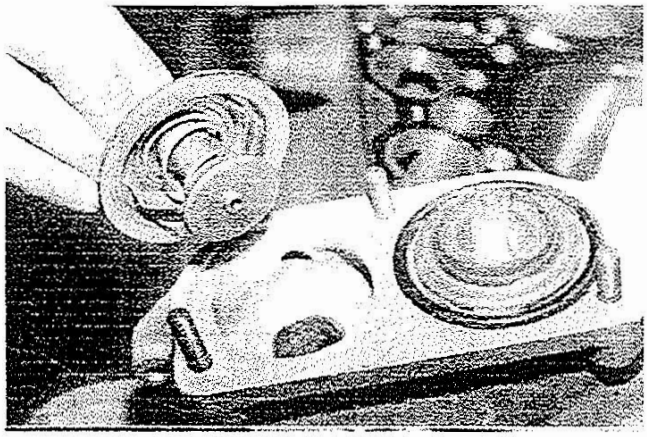


Fig.3.24

IT IS ABSOLUTELY NECESSARY TO REPLACE DEFECTIVE ELEMENTS.

OTHER MAINTENANCE

3.7.1 VALVE CLEARANCE

Under normal working conditions, every after 600 running hours check the valve clearance.
Where working conditions are severe, e.g. heavy load variation, stop and go duty or high dust content of air, the valve clearance should generally be checked at shorter intervals.
Valve clearance is the requisite gap between the rocker arms and valves. Good engine performance and power output depend on its correct setting which can be done by a skilled mechanic according to the instructions below :

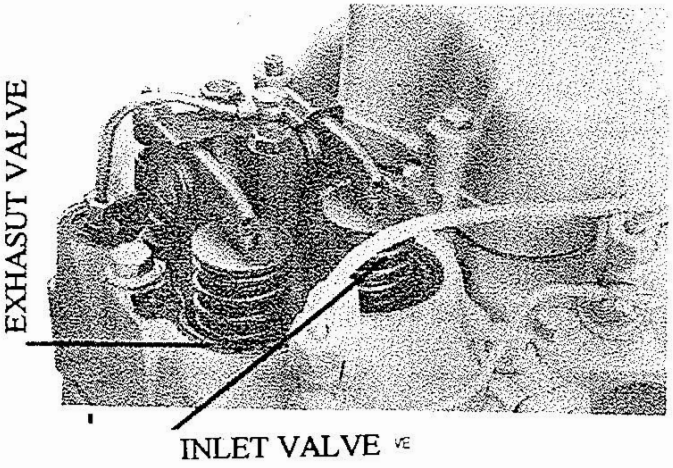


Fig.3.25

a)Check clearance when engine is cold. The designation of valves begins at the fly-wheel end giving alternatively the inlet and exhaust valves (Fig.3.25).

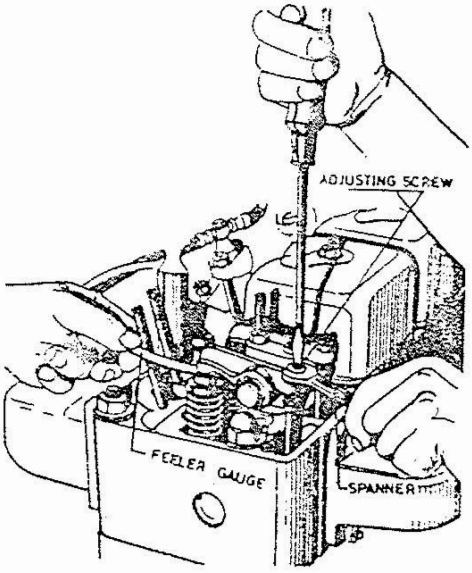


Fig.3.26

b)Crank the engine until both the valves of the cylinder (on which the clearance is being checked) are closed. At this position both the push rods are free in movement.
Insert a feeler gauge of 0.35mm in the gap between rocker arm toe and inlet valve stem tip.The valve clearance is correct when the feeler gauge can be inserted with a slight drag.Failing this, loosen lock nut of adjusting screw through one or two turns and by means of screw driver (Fig.3.26). Retighten the lock

nut. Similarly adjust the valve clearance on exhaust valve by inserting the feeler gauge of 0.55mm. Adjust valve clearance for all other cylinders.

3.7.2 V-BELTS

a)Inspect V-belt over whole length for damage or cracks. Renew damaged or cracked V-belts.

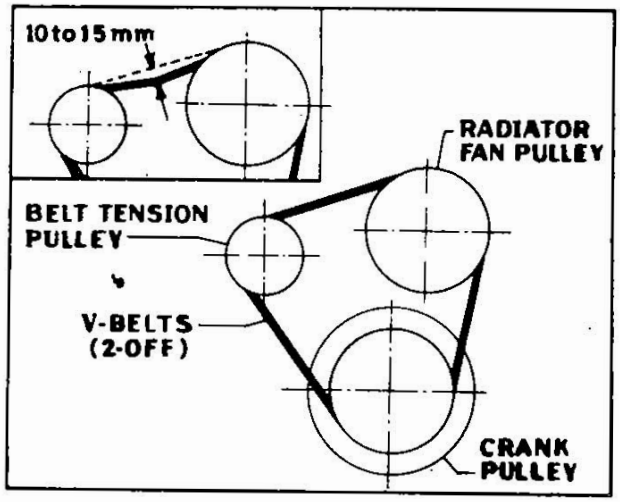


Fig.3.27

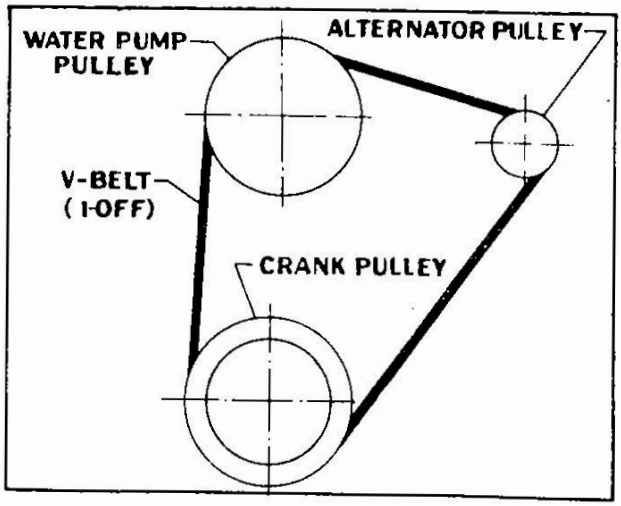


Fig.3.28

b)Check by pressing with the thumb midway between the pulleys to see whether the V-belt deflects inwards by not more than 10-15mm. (Fig.3-27).

! CAUTION

NEVER CHECK /RETENTION/RENEW/V-BELTS WHILE ENGINE IS RUNNING.

c)Check V-belt tension after every 50 hrs. or whenever it is replaced by new one. Adjust the tension as given below:

(i)V-belts for radiator fan drive:

*2-'V' belts are used to drive the radiator fan (Fig.3-27) from crank-pulley together with belt tensioning unit.

*Loosen nut of tow rod and tension tube (Fig.3-29). Turn the tow rod in clockwise direction to set the idler segment for suitable tightening of 'V'belts or vice-versa. Check the tension as explained in 'b' above. After adjusting the desired tension, retighten the nut.

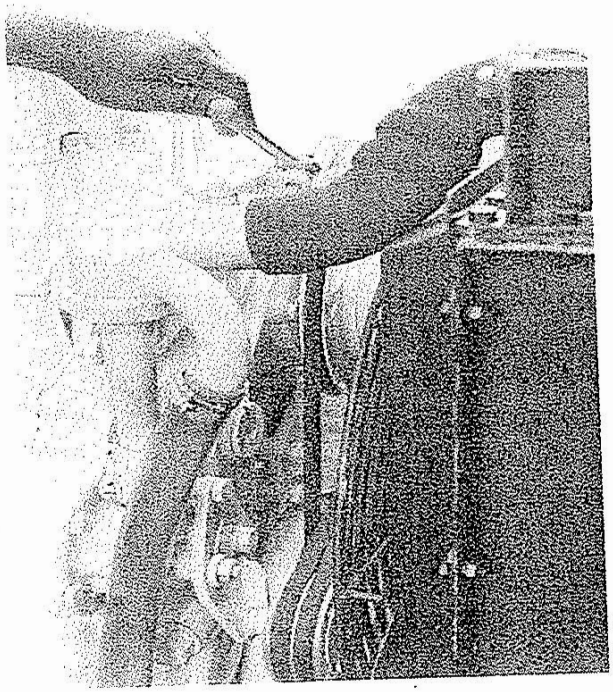


Fig.3.29

Note : After replacing the 'V'belt, check and adjust the tension again after approx. 15min. of operation.

(ii) 'V'Belt for water pump and alternator :

*A single belt is used to drive water pump and alternator/dynamo from crank pulley (Fig.3-28).

*A belt tensioning lever is provided on alternator/dynamo to adjust the belt tension.

*Loosen the nuts of alternator mounting on gear casing and belt tensioning unit. Move the alternator/dynamo upward or downward in

the slot of tensing lever till a desired belt tension is achieved. Retighten the nuts firmly which are already loosen (Fig.3-30). Check the tension again.

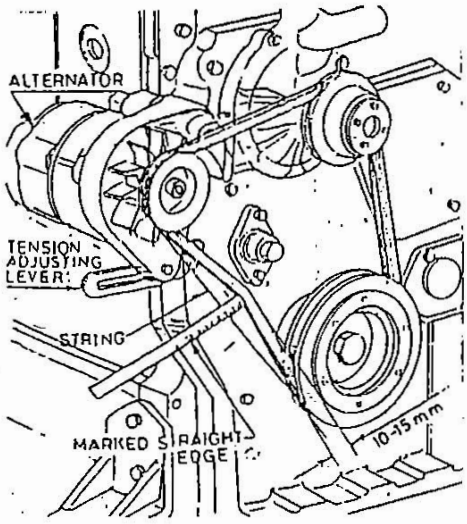


Fig.3.30

3.7.3 BATTERIES

*Inspect acid density of batteries every month (Fig.3-31)

*Unscrew screw plugs.

*Check acid level (15mm above plate surfaces)

*If the level is deficient, use distilled water only for refilling. The outside of batteries must be clean and dry.

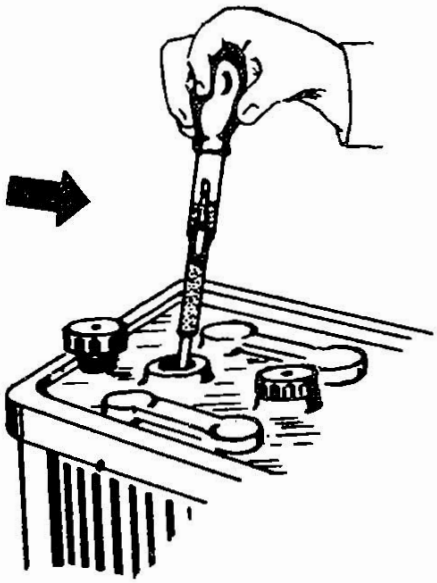


Fig.3.31

*Check tight fit of terminals, apply acidproofing grease for protection against corrosion.

*Be careful and keep in mind that the electolyte of batteries contains

corroding sulphuric acid. If your skin accidentally contacts the electrolyte, rinse immediately with sufficient quantities of water.

*Do not use any naked flame when handling batteries! The formation of oxyhydrogen gas involves the risk of explosion.

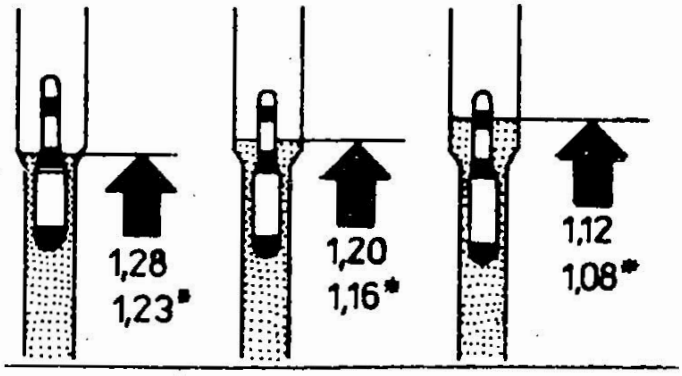


Fig.3.32

*When the battery is discharged or when the engine shall be shut down over a prolonged period of time (for more than 6 weeks) and when the cold season begins, the battery shall be maintained by a battery servicing shop.

3.7.4 STARTER AND ALTERNATOR OR / DYNAMO

Check the brushes and commutator of starting motor and dynamo. The worm-out components should be replaced. If the dynamo is provided on the engine , inject few drops of SAE 30 oil into the hole at the centre of commutator bracket of the dynamo. Clean the contact points of regulator.

THE DETAILED SERVICING OR REPAIRS SHOULD BE DONE IN NEAREST LUCAS SERVICE STATION.

4. TROUBLE SHOOTING

Trouble	Cause	Redress
Engine does not start.	No fuel in tank.	Fill in fuel, vent fuel system.
	Air in fuel system.	Vent fuel system.
	In sufficient speed of starter.	Charge batteries.
Engine does not start at temperatures below 0°C	See above, or the ready to start signal lamp does not light.	Cf.above, or change lamp.
	Defect of series resistor solenoid valve, or flame heater plug.	Consult authorized workshop.
	Paraffin precipitation of fuel.	Heat up fuel pipings, change filter.
Engine starts up but stalls after brief time.	Fuel tank cock closed.	Open cock.
	Dirt in primary fuel cleaner or in fuel filter.	Clean or change filter cartridge respectively.
	No fuel in tank, no conveyance of fuel.	Fill in fuel, vent fuel system, inspect safe operation of fuel pump, replace if necessary, check safe venting of tank.
	Water or dirt in fuel system.	Clean fuel tank, fill in clean fuel, replace filter, vent fuel system.

TROUBLE SHOOTING

Trouble	Cause	Redress
No power and misfiring of engine.	Interruption of air supply or heavy jamming of air filter.	Inspect, replace if necessary, or clean.
	Air in fuel system.	Vent fuel system.
	Fuel filter jammed.	Change filter.
	Start of fuel supply misset.	Reset start of fuel supply.
	Defect of exhaust brake.	Inspect and repair.
Engine emits white or bluish fumes.	Retarted start of fuel supply.	Set correct start of fuel supply.
	Engine is still cold.	Permit engine to heat up in operation.
	Missetting of fuel injection system.	Check start of fuel supply. Inspect injectors.
Engine emits black fumes.	Engine is overloaded.	Reset fuel injection system, consult workshop.
	Air filter jammed.	Change air filter element.
	Fuel injection piping loose or broken.	Tighten fuel injection piping or replace it, respec tively.

Trouble	Cause	Redress
Heavy knocking of engine.	Start of fuel supply too early.	Set correct start of fuel supply.
	Missetting of valve air gaps.	Adjust correct valve air gaps.
	Mechanical defects of engine.	Consult authorised workshop.
Engine grows excessively hot.	Slipping of V-belts.	Tighten or replace V-belts.
	V-belts broken.	Replace V-belts.
	Defect of temperature governor.	Emergency operation;forced opening of valve plate.
	Defect of temperature controller.	Perform electrical check of temperature controller.
	Defect of fan clutch.	Replace fan clutch or lock it by means of two hexagon head screws M8x25.
	Defect of coolant temparature indicator.	Inspect thermometer and temperature sensor.
	Lack of coolant.	Fill in coolant.
	Radiator is dirty.	Clean radiator.
	Missetting of fuel supply.	Set correct begin of fuel supply.
	Intake or exhaust system jammed.	Redress cause of trouble.

TROUBLE SHOOTING

Trouble	Cause	Redress
	Heavy dirt accumulation on cylinder elements.	Consult workshop.
Irregular speed of engine.	Defect of speed governor.	Inspect fuel injection pump and governer.
Excessively high fuel consumption.	Missetting of fuel injection system.	Check fuel injection system.
	Leakage in fuel system.	Check.
	Injection of excessively great fuel quantity, engine emits black fumes.	Have fuel injection pump adjusted by specialized workshop.
	Leakage of solenoid valve of cold starting device.	Replace solenoid valve.
	Jammed air filter.	Replace air filter.
	Engine is worn.	Consult authorised workshop.
	Defective exhaust brake.	Consult workshop.
Excessively low oil pressure.	Jammed paper filter cartridge.	Replace paper filter cartridge.
	Deficient oil level.	Check and add oil.
	Pressure gauge or pressure gauge tube loose or defective.	Inspect and replace or tighten.

TROUBLE SHOOTING

Trouble	Cause	Redress
	Leakage in oil system.	Check.
	Improper lube oil (viscosity).	Check brand of oil.
	Defect of control valve for cooling of pistons.	Replace valve.
	Heavy wear of bearings.	Consult authorised workshop.
Increasing oil consumption.	Leakage in oil system.	Inspect pipings,filters,and ducts for tightness.
	Excessively high oil level.	Defect of air filter system, and cooling of pistons, consult authorized workshop.
No dirt deposits in centrifugal filter.	Rotor jams.	Inspect rotor bearings,inspect oil supply to rotor.
Heavy blowing from venting hose of engine.	Excessively high oil level, damages of cylinder elements.	Adjust oil level, consult authorized workshop.
No air supply from piston compressor	Defect of cylinder element or of valve plate.	Consult authorized workshop.
Battery charging signal lamp alight while ignition is switched off.	Defective insulation in fanned cable.	Consult authorized workshop.

TROUBLE SHOOTING

Trouble	Cause	Redress
Battery charging signal lamp does not light up when ignition is switched on.	Defect of signal lamp.	Replace signal lamp.
	Interruption of D^+ governor and generator.	Plug in connector.
	Brush holder and sliprings are very dirty or worn off.	Clean or replace.
	Battery discharged.	Change battery.
Battery charging signal lamp alight during normal operation.	Broken V-belt.	Replace V-belt.
	Defective generator.	Inspect or consult workshop.
Dim or unsteady light of battery charging signal lamp during normal operation (and might black out at high engine speed).	Heavy wear or breakage of brushes.	Replace brushes.
	Grease between brushes and slipring.	Clean
	High contact resistance of D^+ across governer and generator,charging wire interrupted.	Clean terminals, make up safe connection.
Heavy boiling of battery.	Defective governer, excessive contact resistance of negative polarity across brush holder and endshild bearing of generator.	Consult authorized workshop.
Startor does not run.	Battery discharged.	Charge battery.

TROUBLE SHOOTING

Trouble	Cause	Redress
Deficient speed of starter.	Starter terminal voltage too low.	Check battery cells,recharge battery.
	Oxidized or loose terminal connections.	Clean and fasten terminals.
	Carbon brushes jam or are worn.	Clean or replace brushes.

5. SPECIFICATIONS

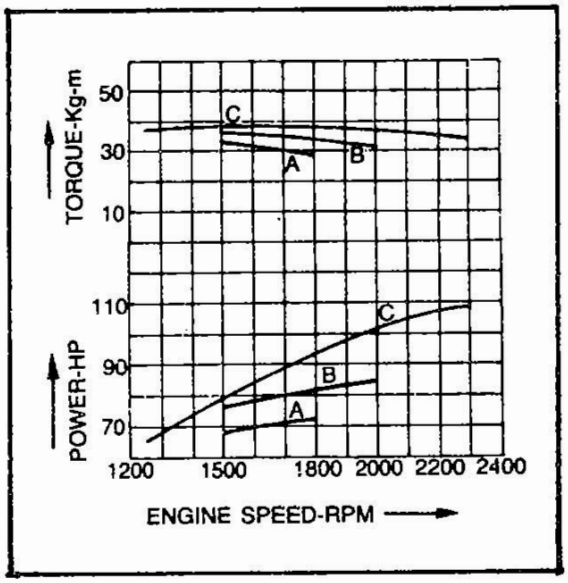
GENERAL DATA

Model	4SL9059	4SL9059T	6SL9088	6SL9088T
Manufacturer	Kirloskar Oil Engines Ltd; Pune (India)			
Mode of operation	Direct injection 4 stroke diesel engine			
Charge	Naturally aspirated	Turbo	Naturally aspirated	Turbo
No. of and arrangement of cylinders	Vertical in-line 4-cylinders		Vertical in-line 6-cylinders	
Cooling	Water-cooled			
Direction of rotation (looking at power take-off end)	Counter-clockwise			
Bore x stroke (mm)	118 x 135			
Swept volume (lit)	5.91	5.91	8.86	8.86
Compression ratio	10.35	9.90	10.35	9.90
Mean piston speed at rated engine speed (m/sec)	(2300rpm)	(2200rpm)	(2300rpm)	(2200rpm)
Max. mean effective pressure (kg/cm2)	8.0	11.2	8.0	11.5
Max. torque(kg-m)	37.21	52.55	56.32	81.2
at an engine speed (rpm)	1500±50	1500±50	1250±50	1500±50
Max. lub oil consumption at P_B (g/kwh)	1.00	0.95	1.00	0.95
Overall dimensions (mm)				
Length	1000	1000	1298	1298
Width	725	720	725	720
Height	970	977	1014	1021
Weight (basic version) (kg)	545	560	685	725
Flywheel housing	According to SAE 1			

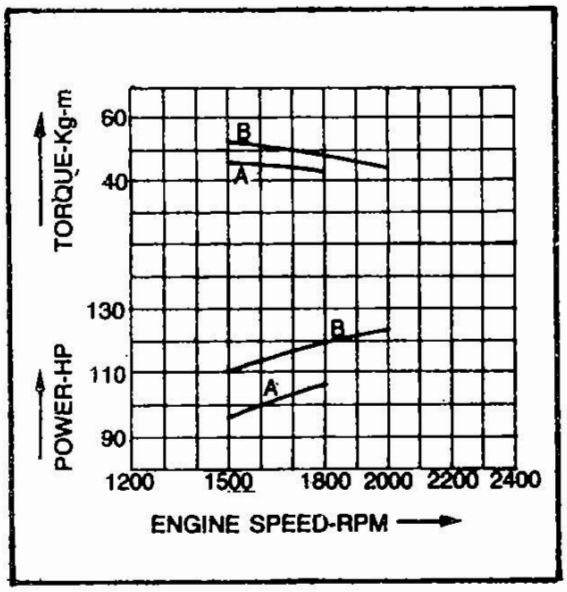
SPECIFICATIONS

PERFORMANCE CURVES

4SL9059



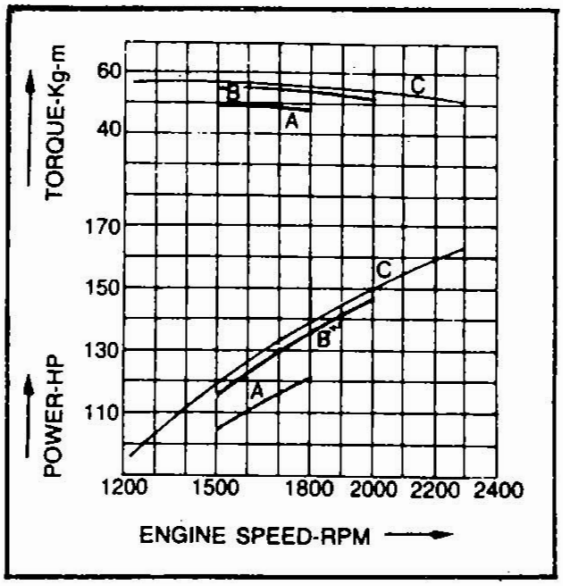
4SL9059T

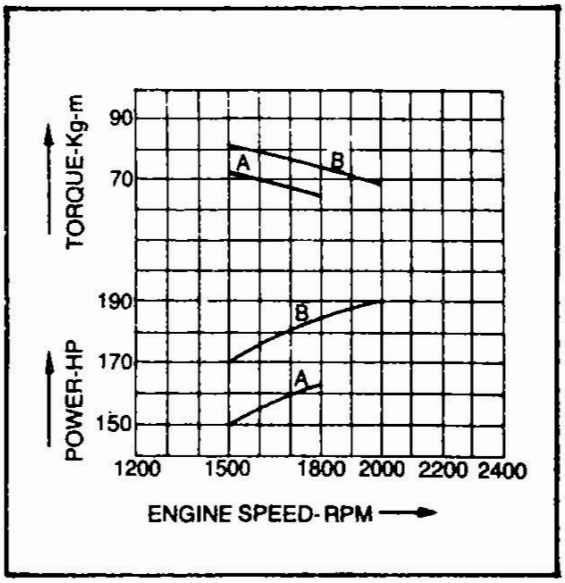


	Power Ratings									
	P_A Continuous. According to DIN 6271				P_B Intermittent. According to DIN 6271				P_C Maximum. According to DIN 70020	
	4SL9059		4SL9059T		4SL9059		4SL9059T		4SL9059	
rpm	kW	bhp	kW	bhp	kW	bhp	kW	bhp	kW	bhp
1250	—	—	—	—	—	—	—	—	48.00	65.20
1400	—	—	—	—	—	—	—	—	53.40	72.55
1500	50.00	67.90	70.50	96.00	56.00	76.10	81.00	110.0	57.00	77.40
1600	51.55	70.04	73.60	100.0	58.00	78.80	83.00	113.0	61.00	82.88
1800	53.00	72.00	78.00	106.0	60.00	81.50	88.00	119.5	69.00	93.80
2000	—	—	—	—	64.00	87.00	91.00	123.5	75.00	101.9
2200	—	—	—	—	—	—	—	—	78.00	105.9
2300	—	—	—	—	—	—	—	—	80.00	108.7

PERFORMANCE CURVES

6SL9088 **6SL9088 T**





	Power Ratings									
	P_A Continuous. According to DIN 6271				P_B Intermittent. According to DIN 6271				P_C Maximum. According to DIN 70020	
	6SL9088		6SL9088T		6SL9088		6SL9088T		6SL9088	
rpm	kW	bhp	kW	bhp	kW	bhp	kW	bhp	kW	bhp
1250	—	—	—	—	—	—	—	—	72.00	97.80
1400	—	—	—	—	—	—	—	—	—	—
1500	77.00	104.5	110.0	150.0	85.00	115.5	125.0	170.0	86.50	117.5
1600	81.00	110.0	114.0	155.0	89.80	122.0	130.0	176.6	93.00	126.4
1800	89.00	121.0	120.0	163.0	100.0	136.0	136.0	185.0	102.0	138.5
2000	—	—	—	—	106.0	144.0	140.0	190.0	110.0	149.5
2200	—	—	—	—	—	—	—	—	113.0	153.5
2300	—	—	—	—	—	—	—	—	120.0	163.0

SPECIFICATIONS

COOLING SYSTEM

Type of cooling	- Liquid circulation cooling with centrifugal pump
Thermostat	- Heat expansive material governor Opening begins at 74°C Full open at 84°C
Fan	- Sheet metal fan with 6 blades.
Cooling liquid type	- For details refer section-1.3

LUBRICATING SYSTEM

Type of lubrication	- Forced feed lubrication with gear pump.	
Lube of filters	- 2-Spin on, paper filters in main stream and 1-centrifuge filter in by pass stream.	
Oil pressure-		
idling speed	- 80 to 170 kPa (0.8 to 1.7 kg/cm^2)	
rated speed	- 410 to 430 kPa (4.1 to 4.3 kg/cm^2)	
Lube oil	- Refer "lube oil recommendation tables" given in Section-1.2	
Lube oil filling		
	- 6 cyl. engines	4 cyl. engines
first filling	23.5 lit.	18 lit.
during or oil change	21.0 lit.	16 lit.

FUEL SYSTEM

Fuel injection pump	- MICO make, in-line fuel injection pump
Fuel injection timing	- $26^0 \pm 1^0$
Fuel filter	- MICO make; two stage filter, first primary filter element of felt type and second micro filter element of paper type.
Governor	- Mechanical, fly weight, fix speed governor (for Genset application)
Injector	- MICO make

Injector opening pressure	- 214 - 222 kg/cm^2
Diesel fuel	- For details refer section -1.1

TIMING GEAR

Inlet valve opens	- 8^0 before TDC
Inlet valve closes	- 28^0 after BDC
Exhaust valve opens	- 44^0 before BDC
Exhaust valve closes	- 8^0 after TDC
Firing order	
For 6 cyl engines	- 1-5-3-6-2-4
For 4 cyl. engines	- 1-3-4-2
	(cylinder numbers start from flywheel end)
Valve clearance (in cold)	
Inlet valve	- 0.35mm
Exhaust valve	- 0.55mm

AIR SYSTEM

Turbocharger (for turbocharged engines)	- Make 'GARRETT' model T-04E'
Air filter	- Dry air filter with one way paper filter cartridge and restriction indicator

ELECTRICAL INSTALLATION

System voltage	- 24 V (Floating / -ve earth)
Starter	- LUCAS No. SM130PE
Alternator	- LUCAS No. GAC 5 R-24 522
Charging Ammeter	- -50-0- +50 range

SPECIFICATIONS

GAUGES

Lub.oil pressure gauge	- 0 to 7 kg/cm^2 range	
Lub.oil temperature gauge	- Electrical,24V, 50^0 to 150^{0}C range	Alternative equivalent mechanical gauges
Water temperature gauge	- Electrical,24V, 40^0 to 120^{0}C range	

TIGHTENING TORQUES

To prevent faulty assembly, following information on tightening of high tensile bolts is important. The bolts are to be tighten in stages as specified in the table below. For connecting rod bolt and main bearing cap bolt use angle torque method with the help of goniometer. The tightening angles for these two bolts are particularly important, hence Fig.5-1 indicates the various angles can be readily obtained by comparison with a clock face.

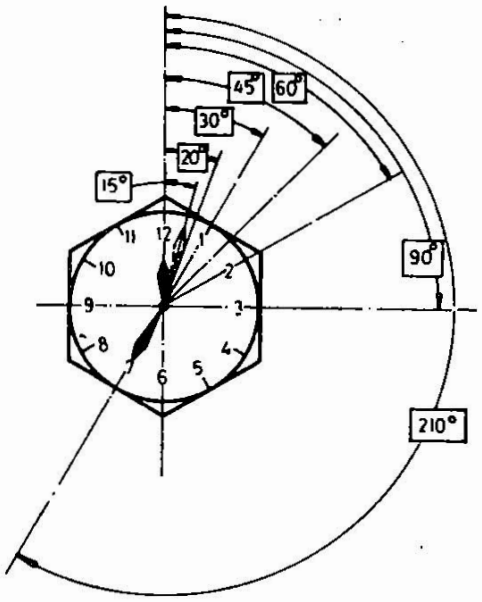


Fig.5.1

Tommy bar is to be clamped in the tool slot and specified angle is to be turned with reference to the initial graduation on outer dial of the tool or a relation of hex. head of bolt can be referred.

NOTE :

1. Lubricate threads and seating face of bolt with engine oil before it is assembled.
2. Screw the bolt by hand till it is engaged upto the seating face.

TIGHTENING TORQUES

3. Apply initial torque and tighten the bolts according to the angles/torques in stages as specified in the 'Tightening table.'
4. In case of replacing main and big end bearings/overhaul/piston seizures, fit new bolts for main bearing cap and connecting rod cap.

1 Nm = 0.10197162 kgm
= 0.73756215 lb.ft.

TIGHTENING TABLE

Fastener	Size	Initial torque (Nm)	Tightening method				
			Torque wrench Final torque		Angle of rotation (Goniometer)		
		Stage I	Stage II	Stage III	Stage II	Stage III	Stage IV
Cylinder head bolt - Short	M14x139	50	100	$140^{\pm 10}$	—	—	—
- Long	M14x159	50	100	$140^{\pm 10}$	—	—	—
Connecting rod bolt	M16x1.5 x 73	50	$210^{\pm 10.5}$	—	65^0 $\pm 5^0$	—	—
Main bearing cap bolt	M16x150	60	$270^{\pm 13.5}$	—	45^0	30^0	30^0 $+10^0$
Intermediate gear bolt	M14x1.5 x 65	—	170^{+10}	—	—	—	—
Balance weight bolt	M16x50	—	$258^{\pm 8}$	—	—	—	—
Flywheel bolt	M16x45	—	$240^{\pm 10}$	—	—	—	—
Crank pulley bolt	M20x1.5 x 65	—	$300^{\pm 10}$	—	—	—	—
Flywheel housing bolt	M12x55	—	$105^{\pm 5}$	—	—	—	—
Rocker support bolt	M10x80	—	60^{+10}	—	—	—	—
Nut for exhaust manifold	M10	—	50^{-10}	—	—	—	—
Nut for fuel injector fork	M10	—	30^{+5}	—	—	—	—

ENGINE PRESERVATIONS

A) Following preservation procedure is recommended for engine/ equipments to be supplied overseas and also when it is to be kept idle (out of use) for prolonged period (more than 12 months).

1) Using H.S.D.fuel, run the engine at approx.70 % of max.rated speed with no load for approx. 5 min. to warm up the engine. (In case of 'Fixed speed' engines like engine for Genset, it can be run at Rated speed).

2) After stopping the engine, drain lub.oil from sump and refill with suitable preservative oil (Ref. Annexure-I).

3) Run the engine on no load for 3 min. During this time the preservative will be circulated throughout the lub.oil system of engine. Stop the engine and disconnect diesel fuel supply to fuel pump inlet.

4) Prepare a solution of Diesel+Preservation oil (5:1 ratio) in a separate tank,and connect fuel line from tank, directly to fuel pump inlet ensuring gravity feed & by-passing the fuel filter.

5) Drain coolant from cooling system and thoroughly flush with clean water. The system then should be filled with mixture of water and any of the cooling system preservatives mentioned in Annexure I.

6) Electrically crank the engine till it filters and let run for 30 seconds (during this time the diesel in fuel pump gallery and high pressure pipes will be displaced by Diesel+Preservative oil mixture). Stop the engine.

Engine speed during above running :

- In case of variable speed engines, the engine should be run approximately at 800 to 1000 rpm.
- In case of fixed speed engines, i.e.for Genset, pumpset etc. the engine should run at no load and rated speed.

ENGINE PRESERVATIONS

7) Close the air inlet Manifold (or the aircleaner inlet) and crank the engine by starter for 5 to 10 seconds. This will ensure coating of Diesel + Preservative oil on the combustion chamber surfaces.

8) Drain preservative oil from oil sump, reinstall drain plugs and reconnect fuel filter into the fuel pipe line.

9) Drain emulsion of water and preservative from cooling system.

10) Treat all unpainted external ferrous metal parts with two coats of suitable rust preventor (Ref.Annexure I) allowing sufficient time for the first coat to thoroughly dry before applying second coat:

11) All vents i.e. engine inlet pipe, exhaust pipe, air cleaner inlet, coolant inlet/outlet, crankcase breather etc. to be carefully sealed with water proof paper and water proof adhesive tape.

12) Dipstick on engine to be sealed in place, with water proof adhesive tape.

13) **IMPORTANT NOTE :**
"DO NOT ROTATE CRANKSHAFT AFTER ABOVE MENTIONED OPERATIONS".

14) Loosen 'V' Belt tension.

15) Battery for engine starting, if provided, should be disconnected and stored in a cool, dry place after ensuring the electrolyte level (Refill with distilled water if necessary).
It is recommended to recharge the battery every 30 days.

16) Tag engine to indicate that it has been treated with preservatives, and should not be turned over until ready to run, due to possible reduction of protective film. The tag should show the date of treatment and validity date

17) With above preservation procedure, the engine can safely be stored for period of 12 months maximum. It is preferable to wrap the engine in polythelene bag and store in Dry shade.

If the engine is to be stored unused for more than 12 months, the preservation procedure mentioned above should be repeated every 12 months.

18) Periodically inspect the engine for rust or corrosion and take corrective action if any.

B) Commissioning of 'Preserved' Engine

1) Remove all the sealing tapes/papers from various openings.

2) Remove the rust Preventive coating from those unpainted machined surfaces which are interfacing surfaces for the driven equipment.

This can be done by using NC Thinner.

3) Fill recommended grade of lub. oil in the oil sump. For quantity of oil to be filled-in refer Section-1.2.

4) Fill cooling system with suitable coolant as recommended in Section-1.3.

5) Readjust the v-belt tension after checking the condition of v-belts Replace the v belt if necessary.

6) Reconnect a fully charged Battery of recommended voltage and Amp-hr capacity ensuring correct polarity connection (where applicable).

The engine is now ready for reuse.

RECOMMENDED PRESERVATIVES

MANUFACTURER / TYPE OF PRESERVATIVE	BHARAT PETROLEUM	INDIAN OIL	HINDUSTAN PETROLEUM	CASTROL INDIA	TIDE WATER OIL CO.
Engine lub. oil and fuel system	Bharat preserve oil 30	Servo preserve 30	Autoprun T 120	---	Veedol 30/40
Engine cooling system	Bharat Sherol B Emulsion with water ratio 1:20	Survo cut $ 20% Emulsion with water	Koolkit 40 5% Emulsion with water	---	Veedol Amullkut 4 Emulsion with water in ratio1:15
Unpainted ferrous metal parts	Bharat Rustrol 152	Servo RP 125	Rustop 274	Rustilo DW 904	Veedol Ruspro IT

TABLE - I : LUB OIL RECOMMENDATIONS (MONOGRADE OILS) FOR N.A. ENGINES

ATMOS-PHERIC TEMP. °C	VISCO-SITY NO.	DETER-GENCY GRADE	EQUIVALENT TRADE NAMES							
			BHARAT PETROLEUM	HINDUSTAN PETROLEUM	CASTROL	TIDE WATER OIL CO.	GULF OIL	CHEMOLEUMS (CALTEX)	INDIAN OIL CO.	PENNZOIL INDIA LTD.
-15 to -5	SAE 10W	E-DL3	BHARAT ACTUMA ULTRA OIL 10W (E-DL2)	HYLUBE X3-10W (E-DL2)	CASTROL CRD 10 (E-DL2)	–	GULF SUPER DUTY MOTOR OIL 10W	DLO 300 MIL-C SAE 10W	–	PENNZOIL LLMO 10W
-5 to 10	SAE 20	E-DL3	BHARAT ACTUMA ULTRA OIL 20/20W (E-DL2)	HYLUBE MILCY 30	CASTROL CRD 20W/20 (E-DL2)	–	GULF SUPER DUTY MOTOR OIL 20	DLO 300 MIL-C SAE 20/20W	–	PENNZOIL LLMO 20
10 to 45	SAE 30	E-DL3	BHARAT ACTUMA ULTRA SUPER OIL 30 (TCA)	HYLUBE MILCY 30	CASTROL CRD 30 (Xtra)	–	GULF SUPER DUTY MOTOR OIL 30	DLO 300 MIL-C SAE 30	–	PENNZOIL LLMO 30
Above 45	SAE 40	E-DL3	BHARAT ACTUMA ULTRA SUPER OIL 40 (TCA)	HYLUBE MILCY 40	CASTROL CRD 40 (Xtra)	–	GULF SUPER DUTY MOTOR OIL 40	DLO 300 MIL-C SAE 40	–	PENNZOIL LLMO 40
-15 to 0	SAE 10 W	E-DL3	–	–	–	–	–	–	SERVO ULTRA 10W (E-DL2)	–
0 to 35	SAE 30	E-DL3	–	–	–	VEEDOL HDC 30	–	–	SERVO PRIDE 30	–
Above 35	SAE 40	E-DL3	–	–	–	VEEDOL HDC 40	–	–	SERVO PRIDE 40	–

TABLE - II : LUB OIL RECOMMENDATIONS (MONOGRADE OILS) FOR TURBOCHARGED ENGINES

ATMOS-PHERIC TEMP. °C	VISCO-SITY NO.	DETER-GENCY GRADE	EQUIVALENT TRADE NAMES							
			BHARAT PETROLEUM	HINDUSTAN PETROLEUM	CASTROL	TIDE WATER OIL CO.	GULF OIL	CHEMOLEUMS (CALTEX)	INDIAN OIL CO.	PENNZOIL INDIA LTD.
-15 to -5	SAE 20W	E-DL3	--	--	CASTROL DUESOL SUPER 20W/40	--	GULF SUPER DUTY MOTOR OIL 20	CHEMOLEUMS DLO 300 OIL SAE 20/20W	--	PENNZOIL LLMO 20
-5 to 10	SAE 30	E-DL3	BHARAT ACTUMA ULTRA SUPER 30 (TCA)	HYLUBE MILCY 30	CASTROL CRD 30 (Xtra)	--	GULF SUPER DUTY MOTOR OIL 30	CHEMOLEUMS DLO 300 OIL SAE 30	SERVO PRIDE 30	PENNZOIL LLMO 30
Above 10	SAE 40	E-DL3	BHARAT ACTUMA ULTRA SUPER 40 (TCA)	HYLUBE MILCY 40	CASTROL CRD 40 (Xtra)	--	GULF SUPER DUTY MOTOR OIL 40	CHEMOLEUMS DLO 300 OIL SAE 40	SERVO PRIDE 40	PENNZOIL LLMO 40
0 to 30	SAE 30	E-DL3	--	--	--	VEEDOL HDC 30	--	--	--	--
Above 30	SAE 40	E-DL3	--	--	--	VEEDOL HDC 40	--	--	--	--

TABLE - III : LUB OIL RECOMMENDATIONS (MULTIGRADE OILS) FOR N.A. ENGINES

ATMOS-PHERIC TEMP. °C	DETER-GENCY GRADE	EQUIVALENT TRADE NAMES							
		BHARAT PETROLEUM	HINDUSTAN PETROLEUM	CASTROL	TIDE WATER OIL CO.	GULF OIL	CHEMOLEUMS (CALTEX)	INDIAN OIL CO.	PENNZOIL INDIA LTD.
-15 to 45	E-DL1	BHARAT ACTUMA ULTRA OIL 10W30 (E-DL2)	HP SUPER ENGINE OIL 20W40	–	–	GULF LUBE XHD 20W40	–	SERVO SUPER MULTIGRADE 10W30 (HD 3)	PENNZOIL ZDX 10W30
	E-DL3	–	HYLUBE EXTRA 20W40	–	–	GULF SUPER DUTY MOTOR OIL 20W40 OR GULF SUPER DUTY PLUS 15W40	–	–	–
-5 to 45	E-DL1	BHARAT ACTUMA MULTIGRADE OIL 20W40	–	–	VEEDOL HDB 20W40 OR HDB 15W40	–	MULTI DLO 100 MIL-B SAE 20W40	SERVO SUPER MULTIGRADE 20W40	PENNZOIL ZDX 20W30
	E-DL3	BHARAT ACTUMA ULTRA SUPER OIL 20W40 (E-DL2)	–	–	VEEDOL HDC 20W40 OR HDC 15W40	–	DLO 300 MIL-C SAE 20W40	SERVO PRIDE 20W40 OR SERVO PREMIUM 20W40	PENNZOIL LLMO 20W40
- 5 to 45 and above	E-DL1	BHARAT ACTUMA MULTIGRADE OIL 20W50	HP SUPER ENGINE OIL 20W50	–	–	–	SUPREME SF SAE 20 W50	SERVO SUPER MULTI GRADE 20W50	PENNZOIL ZDX 20W50
	E-DL3	–	–	–	–	–	DLO 300 MIL-C SAE 20W40	–	–
-15 to -5	E-DL1	–	–	CASTROL CRB 10W30	–	–	–	–	–
	E-DL3	–	–	–	–	–	–	–	–
-5 to 45	E-DL1	–	–	CASTROL CRB 20W40	–	–	–	–	–
	E-DL3	–	–	CASTROL DUESOL SUPER OIL 20W40 OR CASTROL CRD 20W40	–	–	–	–	–

TABLE - IV : LUB OIL RECOMMENDATIONS (MULTIGRADE OILS) FOR TURBOCHARGED ENGINES

ATMOS-PHERIC TEMP. °C	VISCO-SITY NO.	DETER-GENCY GRADE	EQUIVALENT TRADE NAMES							
			BHARAT PETROLEUM	HINDUSTAN PETROLEUM	CASTROL	TIDE WATER OIL CO.	GULF OIL	CHEMOLEUMS (CALTEX)	INDIAN OIL CO.	PENNZOIL INDIA LTD.
-15 to 45	SAE 10W30	E-DL3	–	–	–	–	–	–	–	–
-5 to 45	SAE 20W40	E-DL3	BHARAT ACTUMA ULTRA SUPER OIL 20W40 (E-DL2)	HYLUBE EXTRA 20W40	CASTROL DEUSOL SUPER 20W40 OR CASTROL CRD 20W40 (E-DL2)	VEEDOL HDC 20W40	GULF SUPER DUTY MOTOR OIL 20W40	CHEMOLEUMS DLO 300 OIL 20W40	SERVO PRIDE 20W40 OR SERVO PREMIUM 20W40 (E-DL2)	PENNZOIL LLMO 20W40

INSTRUCTION, OPERATION, SERVICE AND MAINTENANCE

FOR

GARRETT T-04E TURBOCHARGER

AIRESEARCH TURBOCHARGER DIVISION,
EAST PIMBO, SKELMERSDALE, LANCASHIRE, U.K.
TELEPHONE : SKELMERSDALE (0696)22391, TELEX : 627634

TURBOCHARGER

TURBOCHARGER - CONTENTS

SECT.	SUBJECT
6.1	EXPLODED VIEW & PARTS LIST OF TO4E TURBOCHARGER
6.2	INTRODUCTION & DESCRIPTION
6.2.1	- General
6.2.2	- Purpose
6.2.3	- Description
6.3	INSTALLATION
6.3.1	- General
6.3.2	- Orientation
6.3.3	- Lubrication requirements
6.3.4	- Oil drain requirements
6.3.5	- Air duct requirements
6.3.6	- Mounting the turbocharger
6.4	OPERATION, SERVICE & MAINTENANCE
6.4.1	- Operation
6.4.2	- Periodic inspection
6.4.3	- Trouble shooting

TURBOCHARGER

EXPLODED VIEW OF T04E TURBOCHARGER

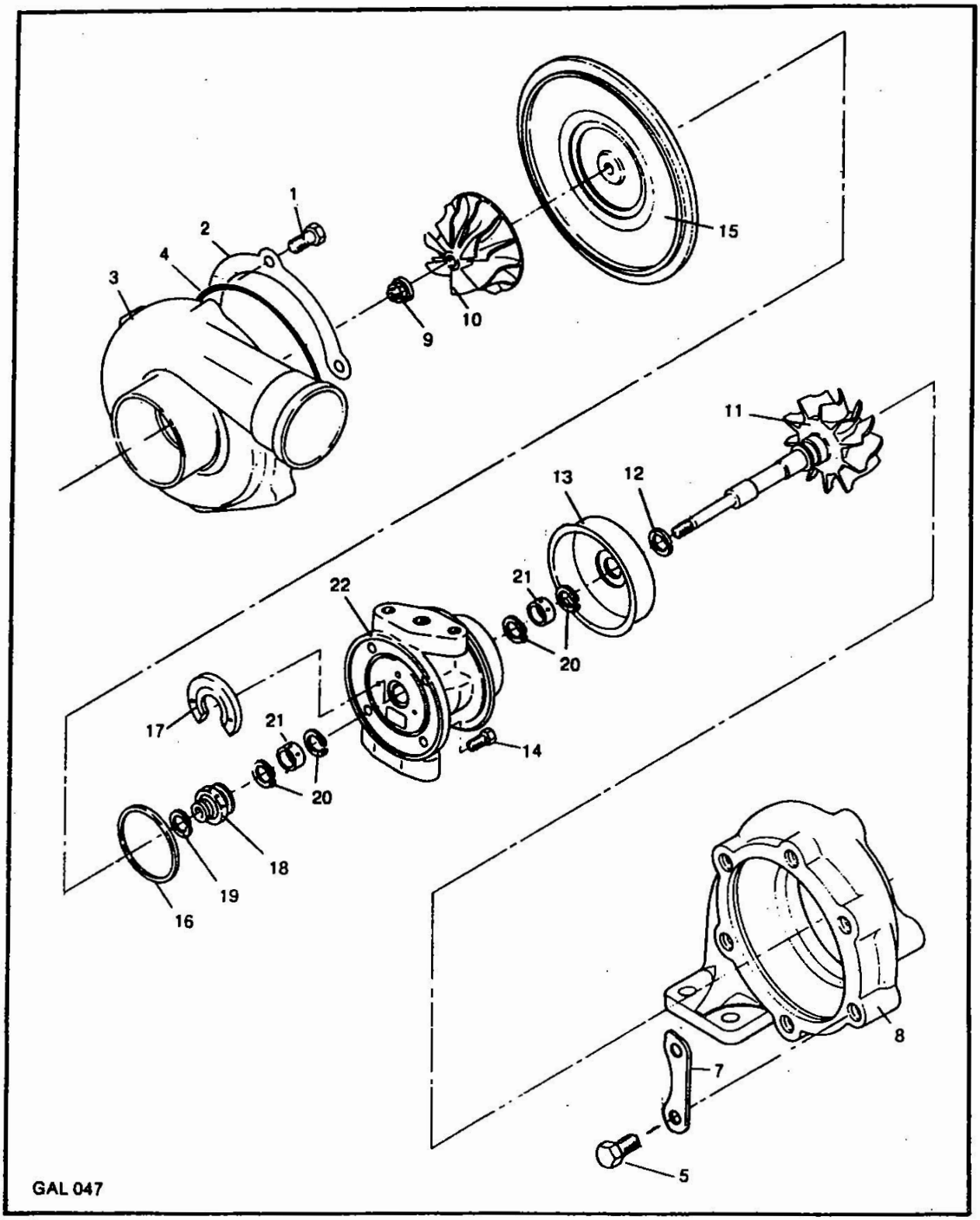


Illustration for reference only. May not resemble actual part.

Fig. 6.1

6.1 PARTS LIST

ITEM	GARRETT PART NO.	DESCRIPTION	QTY.
-	4520720005	Turbocharger	1
9-22	4474500096	C.H.R.A.	1
1	4009750203	Bolts	6
2	4431360001	Clamps	2
3	4432190010	Compressor housing	1
5	4004500001	Bolts	6
7	4069080002	Clamps	3
8	4085990063	Turbine housing	1
9	4007680011	Lock nut	1
10	4422930009	Compressor wheel	1
11	4101880006	Turbine wheel	1
12	4080490009	Piston ring	1
13	4092990000	Shroud wheel	1
14	4441010202	Bolts	4
15	4080450031	Backplate	1
16	4004240000	Seal ring	1
17	4069070001	Thrust bearing	1
18	4445060002	Thrust collar	1
19	4038180009	Piston ring	1
20	4005680000	Retaining rings	4
21	4107750001	Journal bearings	2
22	4300270022	Centre housing assly.	1
-	4321970001	Oil inlet gasket	-
-	4136710001	Oil drain gasket	-
-	4682450000	Service kit	-

NOTE :

DO NOT STRIP A TURBOCHARGER BEYOND C.H.R.A. STAGE.

SCHEMATIC FLOW DIAGRAM

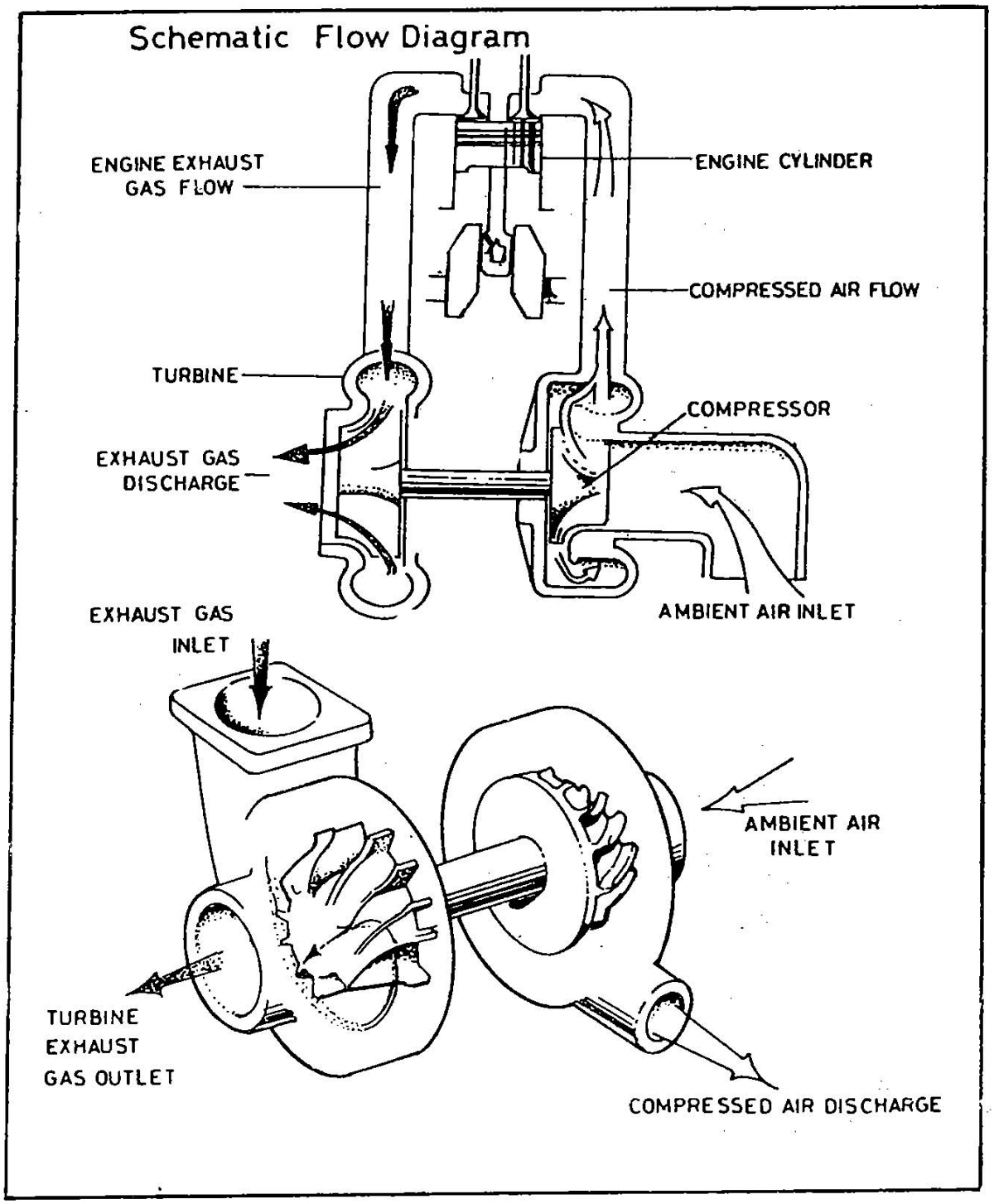


Fig. 6.2

6.2 INTRODUCTION & DESCRIPTION

6.2.1 GENERAL

This publication outlines the instructions for the installation, operation & service maintenance of the relevant turbocharger manufactured by the divisions, subsidiaries and licensees of the Garrett corporation. All the necessary instructions are given for installation, operation and maintenance of turbocharger. However, if warranty consideration is desired, all parts must be returned in the condition as stripped. No parts should be cleaned.

IMPORTANT
The part number, serial number, model number and other pertinent information appear on the name-plate attached to the turbocharger. This information should be included in all correspondence with Garrett Airesearch Ltd.

6.2.2 PURPOSE

These turbochargers are designed to increase the power output and efficiency of an engine by supplying compressed air to the engine intake manifold. The power to drive the turbocharger is expected from energy in the exhaust gas.

6.2.3 DESCRIPTION

The turbocharger consists of radial inward flow turbine, a centrifugal compressor wheel, a center housing which serves to support the rotating assembly, bearings and seals, a turbine housing and compressor housing. Engine oil is pumped under pressure through passages in the center housing. The oil is directed to journal bearings and thrust bearings through passages in the center housing. Oil is sealed from the compressor and turbine by seal arrangements at both ends of the center housing. Oil drains by gravity back to the engine sump.

TURBOCHARGER - INSTALLATION

6.3 INSTALLATION

6.3.1 GENERAL

The turbocharger is shipped assembled. Do not remove covers and plugs until just prior to installation, and always be extremely careful that no foreign material enters the unit.

6.3.2 ORIENTATION

Both turbine housing and compressor housing may be rotated with respect to the centre housing. The centre line of the oil drain in the centre housing should be within 35^0 of vertical after the turbocharger has been installed.

6.3.3 LUBRICATION REQUIREMENTS

The oil supply should be engine oil which has been filtered by a full flow filter of 20 micron filtration. An auxiliary full flow 20 micron filter should be used, if the engine oil filter is not 20 micron. These filters must have by-pass valves to prevent stoppage of oil, if the auxiliary filter becomes loaded with dirt. Oil pressure at the turbocharger oil inlet must be a minimum of 0.7 kg/cm^2. Minimum full speed oil pressure at the turbocharger oil inlet should be 1.4 kg/cm^2. Minimum bore of oil supply line should be 6.3mm in normal temperature conditions. For low temperature conditions, the oil inlet pipe bore should be 9.5mm.

6.3.4 OIL DRAIN REQUIREMENTS

The oil must drain from the turbocharger by gravity under all operating conditions. Minimum ID of oil drain line should be 19mm.

6.3.5 AIR DUCT REQUIREMENTS

All air duct connections must be air tight. Inlet air to compressor must be free from dirt and protected from contamination.

6.3.6 MOUNTING THE TURBOCHARGER

Just prior to mounting the unit, prime the lubrication system. Fill the centre housing with new, clean oil through the oil inlet hole. Turn rotating assembly by hand to coat the bearings and thrust sur-faces with oil. Coat the threads of the attaching bolts or studs with a high temperature thread lubricant. Then secure the turbocharger to its mount. Connect the air ducts and make sure that all connections are airtight. Flush oil through the oil inlet line and make certain the line is clean and unobstructed. Fill the engine and the oil inlet line with new, clean lubricating oil, then connect the line. Connect the oil return line.

NOTE:

WHEN INSTALLING TURBOCHARGER FIT AIR AND EXHAUST DUCTING IN SUCH A MANNER AS TO IMPOSE NO MECHANICAL LOADS ON THE TURBOCHARGER.

6.4 OPERATION, SERVICE AND MAINTENANCE

6.4.1 OPERATION

Turbocharger operation is entirely automatic. No special procedures beyond those by the engine manufacturer are required. As engine power output increases and decreases, the turbocharger responds to deliver the required amount of air. However, to ensure maximum turb-ocharger service life, observe the following precautions-

a) During initial run-in, before starting the engine, make sure the turbocharger and oil supply lines have been filled with oil as directed in paragraph 6.3.6.

b) Do not operate the engine above idle (on full load incase of genset) before normal engine oil pressure has been established. Applying full throttle immediately upon initial start-up can operate the turbocharger at excessive speed before the bearing receive adequate lubrication (this is referred to as "oil lag"). Operation of the turbocharger without a sufficient oil supply for a period as short as 5 seconds can cause bearing failure.

c) Check all air ducts and gaskets for leaks. Repair any leaks before proceeding. Inlet air to compressor must be free of dirt and contamination.

d) Before engine shut-down, operate the engine at low idle speed (at no load for genset) for a few minutes to allow the turbo-charger to decelerate. Shutting the engine down from a high operating speed or full load can cause the turbocharger to continue to rotate after engine pressure has dropped to zero, damaging the turbocharger bearings.

e) During exposure to temperatures low enough to congeal engine oil, or following long period of non operation, or after engine oil change, or any service that involves oil drainage, pre-oil the turbocharger by cranking the engine until normal oil pressure has been established.

Then start the engine and run at idle speed (no load in case of genset) for a few minutes before operating at higher rpm or full load.

6.4.2 PERIODIC INSPECTION

The frequency of inspection will depend upon the proper maintenance of engine and turbocharger and use of recommended grades of lub. oil, fuel and coolant.
The following checks should be made-

a) Check the engine crankcase breather to make sure that there is no restriction to air flow.

b) Inspect and service the engine air cleaner as recommend in section - 3.5.1.

c) Check and if necessary replace hardened or deteriorated flexible oil hoses when replacing engine oil filter. Deterioration of lining can cause liner flake-off and plug turbocharger oil passages causing turbocharger failure.

CAUTION!
BEFORE THE OIL LINES HAVE BEEN INSTALLED, PRIME THE TURBOCHARGER WITH CLEAN ENGINE OIL THROUGH THE OIL INLET.

d) Inspect all air ducting connections for leaks. Make this check with the engine shut down, and with the engine running. Check at the manifold connections to the turbine inlet and at the engine exhaust manifold gasket.

e) Remove the air inlet duct and compressor housing and check for dirt or dust build-up. Remove all such foreign matter, determine and correct cause of build-up. Use soft brush on compressor when as uneven deposits can affect rotor balance and cause bearing failure.

f) With the compressor housing removed, push the compressor wheel towards the turbine wheel end and turn rotating assembly by hand; check for binding and rubbing. Listen carefully for unusual noises. If binding or rubbing is evident, remove the turbocharger for disassembly and inspection.

CAUTION!

DO NOT OPERATE THE TURBOCHARGER IF A LEAK EXISTS IN THE AIR OR IF THE AIR CLEANER IS NOT FILTERING EFFICIENTLY. DUST LEAKING IN TO THE AIR DUCTING CAN DAMAGE THE ENGINE.

TURBOCHARGER - TROUBLE SHOOTING

6.4.3 TROUBLE SHOOTING

TROUBLE	PROBABLE CAUSE	REMEDY
Noisy operation or vibration	*Bearings are not being lubricated	Supply required oil pressure. Clean or replace oil line. If trouble persists, overhaul the turbocharger.
	*Leak in engine intake or exhaust manifold	Tighten loose connections or replace manifold gaskets if necessary.
Engine does not deliver rated power.	*Engine faults	Refer Section-4 of this manual.
	*Clogged manifold system	Clear all ducting.
	*Foreign material lodged in compressor wheel or turbine.	Disassemble and clean.
	*Excessive dirt build-up in compressor	Thoroughly clean compressor assembly. Clean air cleaner and check for leakage.
	*Leak in engine intake or exhaust manifold	Tighten loose connections or replace manifold gaskets as necessary.
	*Rotating assembly bearing seizure	Overhaul turbocharger.

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KIRLOSKAR OIL ENGINES LTD.

AREA OFFICE ADDRESSES

KIRLOSKAR OIL ENGINES LTD.
NEW NATRAJ COMPLEX
GURUKUL ROAD, MEMNAGAR,
AHMEDABAD - 380 052.
PHONE : (079) 7450237, 747374

KIRLOSKAR OIL ENGINES LTD.
100, RASHTRIYA VIDYALAYA RD.,
OPP. LALBAUG WEST GATE,
BANGALORE - 560 004.
PHONE : (080) 6611562, 624988

KIRLOSKAR OIL ENGINES LTD.
NO. 26, FOREST PARK,
BHUBANESWAR - 751 009.
PHONE : (0674) 404082

KIRLOSKAR OIL ENGINES LTD.
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BOMBAY - 400 039.
PHONE : (022) 2020931, 2020828

KIRLOSKAR OIL ENGINES LTD.
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230/A, A.J.C. BOSE ROAD,
CALCUTTA - 700 020.
PHONE : (033) 2747731, 2473363, 407653

KIRLOSKAR OIL ENGINES LTD.
39/3299, 1ST FLOOR,
M.S. CHAMBERS,
ALAPPAT ROAD, RAVIPURAM
COCHIN - 682 016.
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KIRLOSKAR OIL ENGINES LTD.
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PHONE : (0361) 562894

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PHONE : (0141) 361789, 363389

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(0522) 73130, 77936

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FEROZE GANDHI MARKET,
LUDHIANA - 141 002.
PHONE : (0161) 38979

KIRLOSKAR OIL ENGINES LTD.
JAYALAKSHMI ESTATE,
4TH FLOOR,
8, HADDOWS ROAD,
MADRAS - 600 006.
PHONE : (044) 8270981, 8271998,
8279226

KIRLOSKAR OIL ENGINES LTD.
VIJAYSHRI COMMERCIAL COMPLEX
80, P.L. SHARMA ROAD,
MEERUT CANTT - 250 002.
PHONE : (0121) 543967, 543968

KIRLOSKAR OIL ENGINES LTD.
221, SOMADUTT CHAMBERS-II,
9, BHAIKAJI CAMA PLACE,
NEW DELHI - 110 066.
PHONE : (011) 6873499, 6873475,
6873415

KIRLOSKAR OIL ENGINES LTD.
EXHIBITION ROAD,
PATNA - 800 001.
PHONE : (0612) 222274, 223818

KIRLOSKAR OIL ENGINES LTD.
'CHANDRALOK', 1ST FLOOR,
111, SAROJINI DEVI ROAD,
SECUNDERABAD - 500 003.
PHONE : (040) 843892