DIESEL ENGINE AND ITS SYSTEMS

The DPC (Driving Power Car) has a single power pack consisting of a diesel engine, model KTA-50-L (Kirloskar Cummins Ltd).

SPECIFICATION

01	Exact description and Model of the engine	: Cummins KTA-50-L
02	Rated output	: 1400 BHP
03	Maximum intermittent traction rating at site condition given below	: 1600 BHP @ 2100 RPM
04	Site conditions	
	Ambiant température	: 55Deg. C
	Altitude above mean Sea level	: 1000M
	Relative Humidity	: Above 40%
05	Rated speed at continuous rating	: 1800 RPM
06	Type of cycle	: Four stroke
07	Method of pressure charging	: Turbo charging
	♦ Pressure ratio of the compressor at the rated output	: 2.4
	♦ Single stage/ Two stage	: Single stage
	♦ No. of Turbochargers used	: Two
	♦ Make and model of Turbocharger	: Cummins
08	Type of exhaust system	: Pulse type
09	Cooling method of the charge air	: By engine coolant.
10	Type of combustion chamber	: Direct injection chamber
11	Fuel Injection equipment	: Unit type FIP and injector
12	Fuel pump	: PT-fuel pump
13	Number of cylinders	: 16 Cylinder (8 cyl. per bank)
14	Arrangement	: "V"-Type 60 degree
15	Cylinder bore	: 159mm
16	Piston Stroke	: 159 mm
17	Total displacement	: 50 Lts
18	Cubic capacity/ Cylinder	: 3.13 Lts./ Cyl.
19	Compression Ratio:	: 13.8: 1
20	Firing Order	: 1R-1L-3R-3L-7R-7L-5R-5L-8R-8L-6R-6L-2R-2L-4R-4L
21	Mean piston speed at the rated speed	: 9.5 m/s.
22	Brake mean effective pressure	: 12.58 Kg/Cm^2
23	Maximum combustion pressure at the rated output	: 141 Kg/Cm^2 (2000 PSI)
24	Compression pressure at No load at Minimum idling speed	: 350 PSI
25	Minimum No-load idling speed (A low idle features is provided on the Engine)	: 700 RPM
26	Max. no load RPM under steady conditions	: 2070 RPM
27	Minimum firing speed	: 150 RPM.
28	**Piston**	
	♦ Type of piston used	: Single piece (Al alloy)
	♦ No. of Piston Rings used	: Four Nos.
	♦ Configuration of the Rings (All the rings are located above the Gudgeon Pin)	: 3 compression, 1oil control
	♦ Piston cooling method	: By engine Lube oil.

29 Cooling System

- ♦ Cooling Circuit : Closed loop cooling circuit.
- ♦ Cooling system type : Pressurized
- ♦ Water pump type(Make) : Mannesman Rexroth AZFO 28/QR
- ♦ Coolant temperature at the outlet from the Engine(Normal operating range) : 72 Deg. C to 95 Deg. C.
- ♦ Heat absorbed by the cooling water at the rated output : 17500 BTU/Min.
- ♦ Rate of flow of water : 40 lpm @ 1500 rpm
- ♦ Water tank capacity : 153 Litre
- ♦ Treatment recommended for water : Borate base compound

30 Lube Oil System

- ♦ Temp. of lube(Normal operating range) : 82 Deg. C to 107 Deg. C.
- ♦ Max. permissible temperature of lube oil : 121 Deg. C for short time
- ♦ Heat absorbed by the cooling oil at the rated output : This heat is the part of heat rejected to cooling water.
- ♦ Sump Capacity : 151 Liters
- ♦ Brand of oil recommended : Multi grade CF4 15-W-40

31 Lube oil Consumption at the rated output : 0.14 Lit / Hr

32 LOC % of fuel consumption : 0.14% of fuel consumption (Max. is 0.25% of fuel consumption)

33 Lubricating oil pressure at the rated speed at the normal operating temperature : 3.4 to 6.16 Kg/cm^2

34 Maximum pressure of charge air in the intake manifold at the rated output : 1.278 Kg/Cm^2 (37" of Hg.)

35 Maximum pressure of gases in the exhaust manifold at the rated out put(At output of TSC) : 3" of Hg.

36 Maximum RPM of turbocharger at the rated output : 63600 RPM.

37 Maximum permissible RPM of the turbocharger : 100000 RPM.

38 Temperature of exhaust gases at Turbo inlet at the rated output : 600 to 630 Deg. C.

39 Maximum permissible temperature for which the turbo charger components have been designed : 735 Deg. C.

40 Heat balance of the Engine:

Useful output	: 38.6%
Exhaust	: 35.3%
Coolant	: 24.4%
Ambient	: 1.7%

41 Weight of the engine complete with all items excluding water and lubricating oil : 4858 Kg.

42 Weight of the water contained in the engine : 155 Kg. approx.

43 Weight of the oil contained in the engine : 150 Kg. approx.

44 Specific fuel consumption.

- ♦ Indicate the lower heating value of the fuel used in arriving at the specific fuel consumption figures : 10000Kcal/Kg. (154.17gm/BHP/Hr)

45 Fuel oil consumption at idle in L/H : 4.16 Lit/ Hr.

46 Type of governor : LCC CGA Make

47 Safety devices provided on the engine.

- Over speed trip safety device
- Low lubricating oil pressure safety device
- High water temperature safety device
- Low water level safety device

48 Transmission System

♦ **Alternator type**	: BHEL TA 7003 BX C. Greaves C1012 TA
♦ Maximum speed	: 1800 rpm
♦ Maximum voltage	: 900 V
♦ Maximum current	: 2145 A
♦ Continuous rating low voltage	: 550 V, 1660 A, 1800 rpm
♦ Continuous rating high voltage	: 900 V, 990 A, 1800 rpm
♦ Weight with accessories (Approx.)	: 4400 Kg
♦ **Traction motor type**	: BHEL TM 4303 AZ C. Greaves C1005 TM
♦ Maximum speed	: 2772 rpm
♦ Number of TM per DPC	: Four
♦ Continuous voltage	: 550 V
♦ Continuous current	: 415 A
♦ One hour rating	: 455 V, 550 A,
♦ Weight per unit (Approx.)	: 2200 Kg
♦ Gear ratio	: 20: 91
♦ Suspension	: Axle hung, nose suspended
♦ Auxiliary generator	: KEL A 18122 FM
♦ Rating	: 110A DC, 135V DC, 18.5KW
♦ Unit weight	: 445 Kg.

SYSTEM DESCRIPTION

The various systems of the KTA 50 L, power pack used in DEMU are described in this section. The various systems of diesel engines are as follows:

1. Air Intake and Exhaust system
2. Fuel system
3. Lube oil system
4. Cooling water system
5. Hydraulic oil system

AIR INTAKE AND EXHAUST SYSTEM

Air is drawn through the supercharger portion of the turbo supercharger which compresses and feeds the compressed air to the cylinders via an after cooler which cools the air.

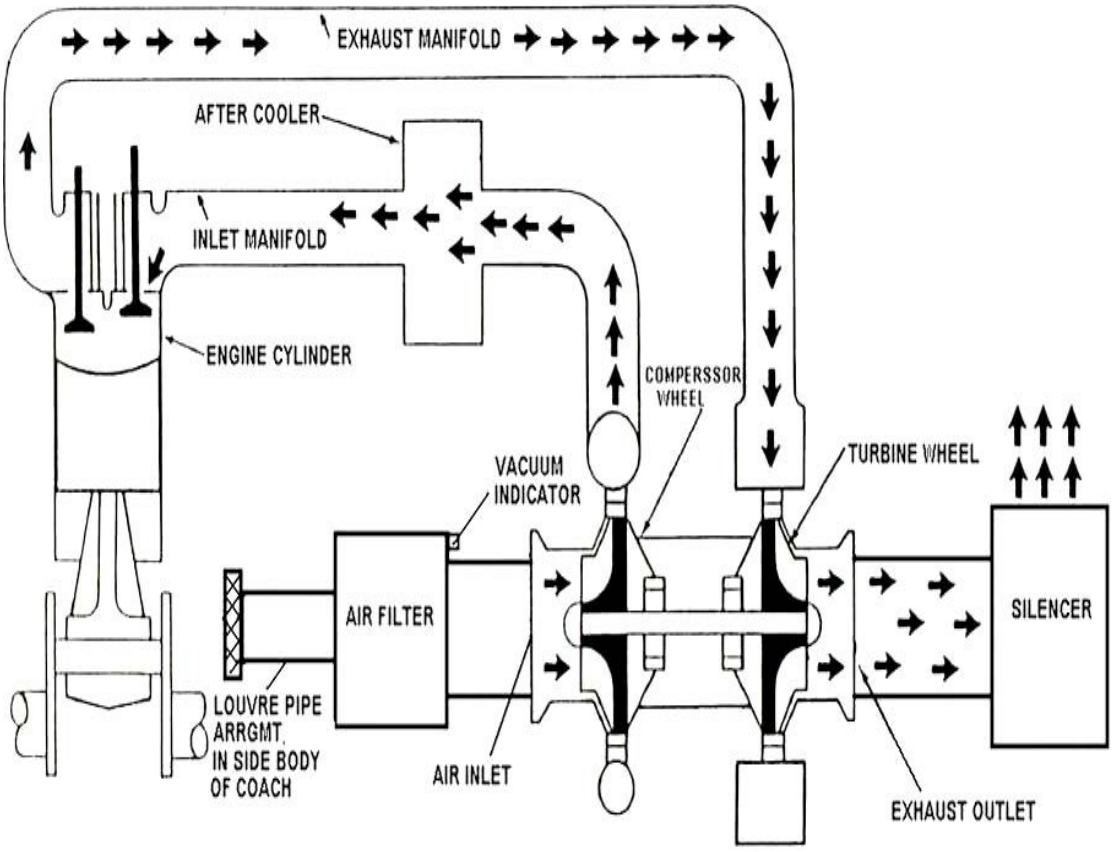
The air filter is provided to remove harmful dust, abrasive particles from the air. If these particles are permitted to enter the engine, the particles mix with the lubricating oil to form an abrasive paste which will quickly wear out piston rings, cylinder liners, pistons, valve guides etc. causing high lubricating oil consumption and blow by.

The cooling of air helps in increasing the density. A vacuum indicator is available in the air filter that indicates a red band when the accumulated dust is beyond the permitted level and it is necessary to service the air cleaner element.

Air cleaner element can be cleaned with the use of pressurized air at not more then 30 PSI.
The exhaust air from the cylinder drives the turbine portion of the turbo super charger, which helps in utilisation of residual heat of exhaust gases.

The exhaust gases are exhausted through a silencer kept on the dished rooftop of the DEMU. Flexible stainless steel connection between the turbo supercharger and silencer allows for expansion due to heat of the exhaust gases.

A schematic of air intake and exhaust system of DEMU is shown in figure.



CHARGE AIR AND EXHAUST SYSTEM

Checking of Inlet Air Restriction

This unit is mounted on the air filter outlet. The red flag in indicator gradually rises as cartridge loads with dirt. After changing or replacing cartridge, reset indicator by pushing reset button.

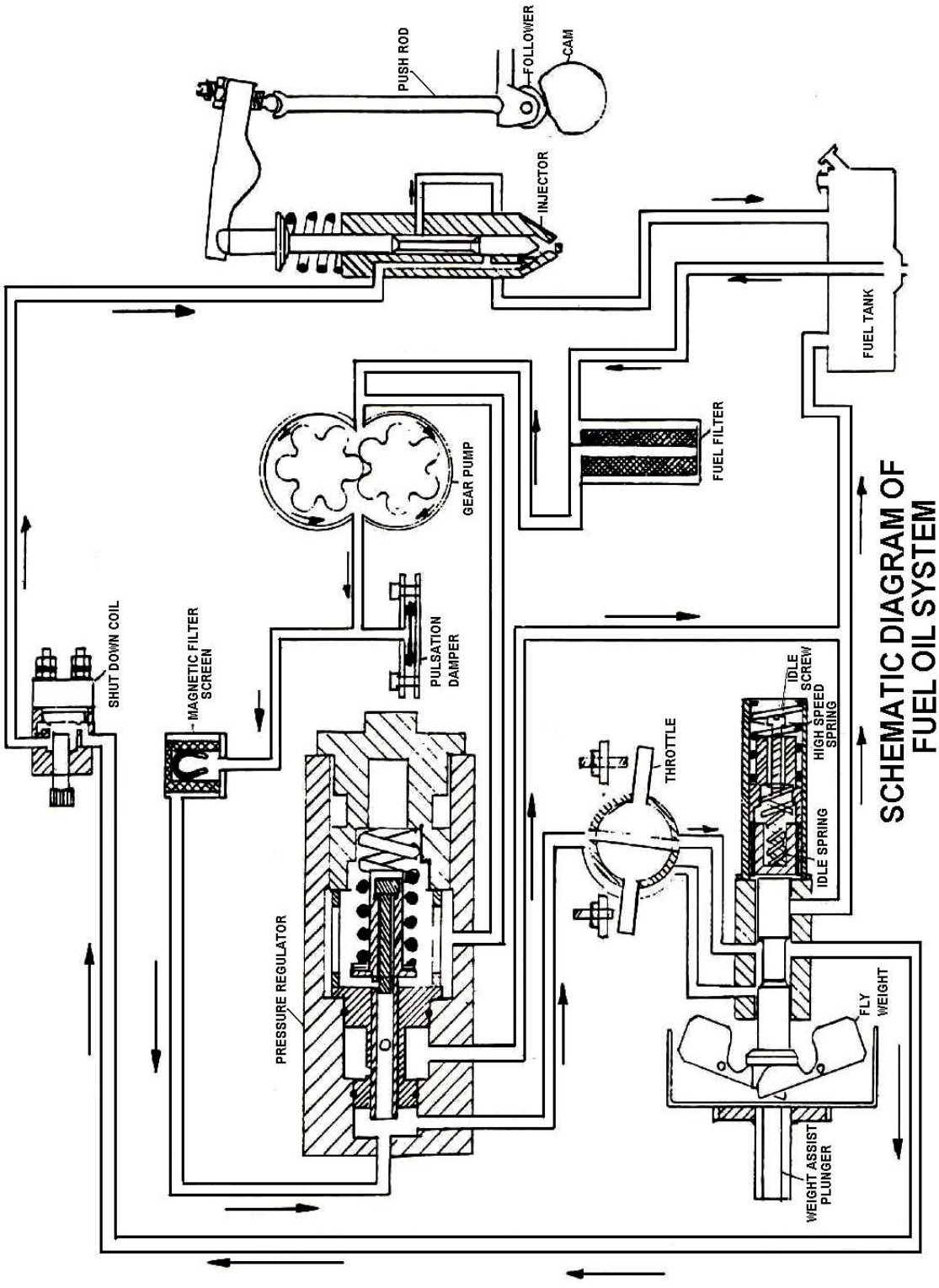
Fig. Vacuum indicator for air restriction

Air restriction on turbocharged / after cooled engines must not exceed 25 inches (635 mm) of water column. Air restriction for naturally aspirated engines must not exceed 20 inches (508 mm) of water column.

Filter Element Replacement:

- Remove the old filter element gently. Do not bump it while still inside, otherwise it will lead to dropped dirt and dust that will contaminate the clean side of filter housing, before the new filter element has a chance to do its job.
- Clean the inside of the housing carefully. Dirt left in the air cleaner housing is harmful for engine. Use a clean, damp cloth to wipe all surface clean. Check it visually to make sure it's clean before putting in a new filter.
- Clean the gasket sealing surface of the housing. An improper gasket seal is one of the most common causes of engine contamination. Make sure that all hardened dirt ridges are completely removed, both on the bottom and top of the air cleaner.
- Check for uneven dirt patterns. The old filter has valuable clues to dust leakage or gasket sealing problems. A pattern on the element clean side is a sign that the old filter element was not firmly sealed or that a dust leak exists. Identify the cause of that leak and rectify it before installing a new filter.
- Press new gasket to see that it springs action. Make sure that new filter is made with a highly compressible gasket that springs back (promptly) when finger pressure is released.
- Ensure air-tight fit on all connections and ducts. Check that all clamps and flange joint are tight, as well as the air cleaner mounting bolts, Seal any leaks immediately, any leakages mean dirt is directly entering in the engine.

FUEL OIL SYSTEM



The main components of the fuel system of KTA50L engine are described below:

1. Gear Pump

Fuel enters the rear side of gear pump housing. Gear pump has two spur gears. One of the gear shafts is a drive shaft, which is driven by the accessory drive gear shaft and rotates at engine speed. It creates a vacuum to draw fuel, but adds no pressure to the flowing fuel.

2. Cooling kit

In PT fuel pumps a drilling runs up along the back of all shafts bores to a fitting on top of the gear pump housing. Fuels from the shafts bores passes out through the valve in the fitting and through the drain line to the fuel tank.

3. Pulsation Damper

As the gear pump teeth mesh and unmesh, considerable turbulance is created in the fuel. To eliminate this roughness a pulsation damper is connected through a drilling, to the gear pump cavity.

4. Filter Screen

Pressurized fuel flow into the center of the filter screen, which is located at the top of the fuel pump. Dirt and other materials are removed at by this filter.

6. Governor

The pressure in the fuel as it reaches the governor plunger is hydraulic pressure. The restriction to fuel flow which creates most of this pressure is built into the PT pump by placing the surface of the idler plunger against the end of the governor plunger.

In this manner fuel is being held in the governor plunger by the surface of the idler plunger. However, the idler gear is only under spring pressure, so as volume of flow increases, fuel will soon push the idler plunger back, if no other outlet is found.

But there are two other outlets for governor plunger fuel.

The idler port which allows fuel to escape during low speeds.

The amount of fuel by- passed depends upon the resistance offered to fuel flow. This resistance is developed by the position of the governor plunger and idler plunger and it is controlled by the forces which try to hold them together during fuel, flow as they are, when the pump is not operating and the size of the idler plunger counter bore.

The governor plunger is acted upon by the two forces. One of the forces is by the governor weight forces which depends on the engine speed. As the accessory drive shafts rotates, it revolves the PT pump shaft which in turn rotates the governor weight carrier. And thus the weight force governor plunger towards the governor barrel.

7. Weight Assist Plunger

At low speeds, governor weight force is not strong enough to move the plunger back very far. So a force is built into the pump with a short plunger known as weight assist plunger, which is held against the governor plunger by its spring and shim pressure while engine speed is slow and remains in contact so long as low speed prevents the weight feet from pushing back on the governor plunger.

Another force is acting upon governor plunger, which is opposing the force of the governor weight and weight assist plunger. This force comes from the following:

1. Idle spring behind idler plunger (button).
2. The torque spring over the governor plunger. As the fly weights fly apart and exert force on the plunger, this spring is pressed against the barrel. Depending upon the length and strength of the torque spring.
3. The large governor (high speed) spring. The fuel pressure is controlled on the principle of liquid flow through the least resistance path. When a log of fuel is required to go to the engine for high speed for high torque operation, the idler plunger must be force close to the end of the governor plunger so that very little fuel can escape there.

This will create high pressure on the fuel in the governor plunger and barrel and lot of it flows through the throttle opening and on to the injectors.

If the operator closes the throttle more fuel escapes immediately from the end of the plunger. Slower engine speed immediately decreases weight pressure on the governor plunger permitting fuel to escape even more easily at the end of the plunger. Fuel thus escaping is returned to the suction side of the gear pump and recirculated. Pressure in the barrel depends upon the strength of the opposing forces built into the pump. Another control over fuel flow restriction is the size of the counter bore in the idler plunger surface.

If the counter bore in the idler plunger is small, fuel has much difficulty in escaping thus pressure increases. If the pressure is larger, fuel can escape more easily and consequently pressure will be lower in the governor plunger and barrel.

8. Throttle Shaft

From the governor plunger fuel passes to the throttle shaft which has a restriction plunger. Under this plunger there are a few shims. This restriction plunger controls the fuel passage in the throttle shaft. When shims are removed from the plunger, it reduces the fuel passage in the shaft and reduces fuel flow to the injector by reducing the fuel pressure. If shims are added, it increases the fuel passage and increases the fuel flow by increasing the fuel pressure.

9. Shut down Valve

The shut down valve has final control of the flow from the pump to the injector. Fuel flow can be controlled by mechanically or electrically operated solenoid. The valve is activated by closed electrical contacts when ignition switch is moved to 'ON' position.
The electrical coil draws the metal plate off the sealing edges and allows fuel to flow from the pump to the injectors.
When the ignition switch is moved to 'OFF' position, the metal plate sits on sealing edge thus stopping the fuel flow to the injector.

10. How Auto Governor controls engine speed

During cranking of an engine the engine speed should reach 190 to 250 RPM. At 150 RPM, a good gear pump will be able to pick up fuel, at these speeds, the idle spring and weight assist spring will hold the governor plunger and idler plunger together, but fuel pressure is not height.

As engine fires and speed increases, gear pump delivery also increases. But governor weight force also increases. Fuel pressure continues to rise and increase fuel flow to the engine.
As engine speed reaches 800 to 1000 RPM approximately, resistance to governor weight force increases, as idle spring and torque spring start getting compressed.

The high resistance presented by these two springs keeps the plunger surfaces very close together and continually increases fuel to engine- raising engine speed or torque.
Fuel flow continues to increase, as the throttle comes to full open, until the high speed governor spring is compressed enough that its resistance will balance the force exerted on the governor plunger.

At this point the engine's governor cut off speed has been reached, and unless position is changed to reduce it, fuel flow will continue at this 'governed' rate.

A wide open throttle will soon allow engine speed to increase beyond a safe speed in order to save the engine from such a damaging high speed and consequent failure (particularly valve and injector train damage, governor plunger is provided with small four holes through which fuel is dumped and speed decreases.

As the throttle is closed, the engine speed reduces to idle speed. Reduced governor weight speed moves the plunger back until it aligns idle port.

11. PTD Injector

The PTD injectors consist of a short rigid plunger barrel and adapter. The injector cup is a separate piece. The adaptor, barrel and cup are attached by a long threads sleeve.
The injector plunger is a steel plunger fitted into the barrel with very close tolerance. The fact that the barrel and cup are separate makes excellent alignment possible.

Startup stroke (Fuel Circulates)

Fuel at low pressure enters the injector and flows through the inlet orifice through internal drillings around the annular groove in the injector cup and up the drain passage to the fuel tank. The amount of fuel flowing through the injector is determined by the fuel pressure at the inlet orifice and the inlet orifice diameter. Fuel pressure is also determined by engine speed, governor and throttle. Ref. fig "A"

Upstroke complete (Fuel enter injector cup)

When the injector plunger moves upward, the metering orifice is uncovered and fuel enters the injector cup. The amount is determined by the fuel pressure. The drain passage is blocked momentarily, stopping circulation of fuel and isolating the metering orifice from pressure pulsation's. Ref. fig. "B"

Down Stroke (Fuel Injection)

Ref. fig. 2d. As the plunger moves down and closes the metering orifice, fuel entry into the cup is cut off. As the plunger continues down, it forces fuel out of the cup through tiny holes at high pressure as a fine spray. This assures complete combustion of fuel in the cylinder. When the drain passage is uncovered by the plunger under cut, fuel again begin to flow through the return passage to the fuel tank. Ref. fig "C"

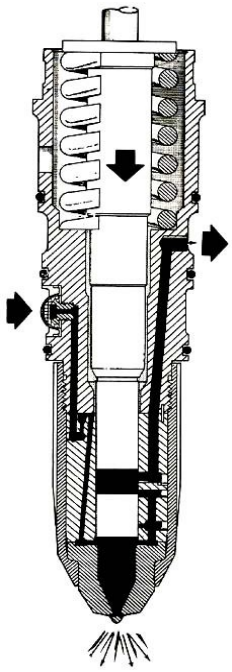


Fig. "A"

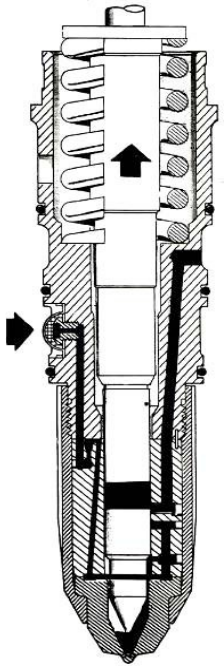


Fig. "B"

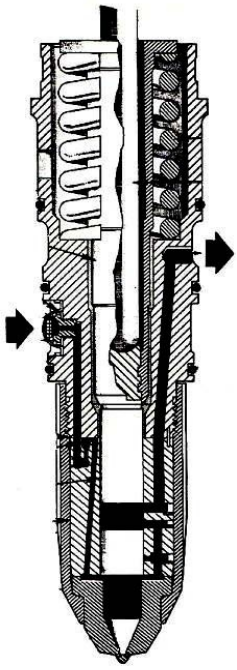


Fig. "C"

After injection is complete the plunger remains seated until the next metering and injection cycle. No fuel is reaching the injector cup. However it does flow freely through the injector and returns to the fuel tank.

A check ball is fitted to PTD injectors to prevent back pressure flowing up the inlet line feeding other injectors. The back pressure is created by the down traveling injector plunger closing the inlet orifice before the drain drillings is open. The back pressure acts on the checks ball which is snapped down against its seat, thereby preventing this pressure feeding the next injector.
A defective check ball or seat would cause slow deceleration and more noticeably slow engine shut down. From low idle to stop should take about 1-2 seconds. If a check ball is not seating this time can be up to 3-5 minutes. The defective injector can be detected by holding down each injector in turn until the engine stops in the recommended time.

Injector Operation

There are basically three operation functions which affect the injectors in an engine.

Adjustment

Any moving parts no matter how well they are lubricated wear takes place. When we talk of injector adjustment we mean the amount of movement between the maximum lift and maximum down position also the load on the injector plunger, against the cup on the fuel down position, If the total travels or loading are incorrect, then the important metering and atomization qualities are affected.
It is therefore necessary that each half yearly maintenance check to ensure that the injectors and valves are adjusted correctly. This can be done by torque wrench.

Calibration

The flow factor controlled by the flow orifice is an important point in the performance in an engine. Although this should not alter service, it is recommended that each POH maintenance, all injectors are removed and recalibrated.

Non Operation

Should one injector cease to inject fuel, then of course, a misfire results. To detect which cylinder is causing the trouble, the most accurate method is to check exhaust manifold temperature with a pyrometer or thermal chalk. The injector plungers can also be held down, in turn until the faulty injector is isolated.

There are reasons why an injector will not operate:

- Seized plunger
- Blocked inlet orifice or filter
- Blocked spray holes

To detect if the spray holes are open, remove the injector from the head and withdraw the plunger spring. Put a few drops of fuel into the cup and replace the plunger. Force the plunger down to inject fuel from the spray holes.

The spray pattern can be formed on a piece of white paper; If one or more holes blocked, then a new cup should be fitted.

Cleaning of an orifice filter screen may be done with compressed air.
When installing a new or the original injector the following points should be observed.

- Clean injector sleeve with a clean rag.
- Check body cup detail against engine performance.
- Renew injector body 'O' rings.
- Lubricate body 'O' rings with clean engine oil.
- Always adjust valves and injectors as described in this manual after refitting injectors.

Water Separator

Water Separator uses centrifuging principle for separating out the water or sludge from diesel.

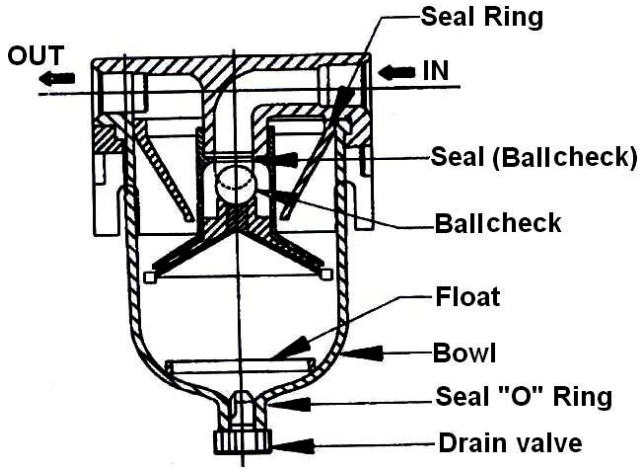


Fig. Water Separator

The water or sludge is collected in the bottom of the housing and is drained out manually by operating the drain valve provided at the bottom. For this operation, the engine should be shut down and upper handle is required to be unscrewed so as to induct atmospheric pressure on the housing. Close the drain valve and tighten the top "T" handle.
This water separator should be connected in between fuel tank and fuel filter. When vacuum drop is 8.00 inches (203.2 mm) of mercury column replace the filter assembly.

Changing of fuel filter element

- Loosen cap screw which holds shell to head
- Discard 'O' rings and discard fuel filter element.
- Install new 'O' rings and. Install new element.
- Fill can with fuel and assemble shell to head with cap screw.

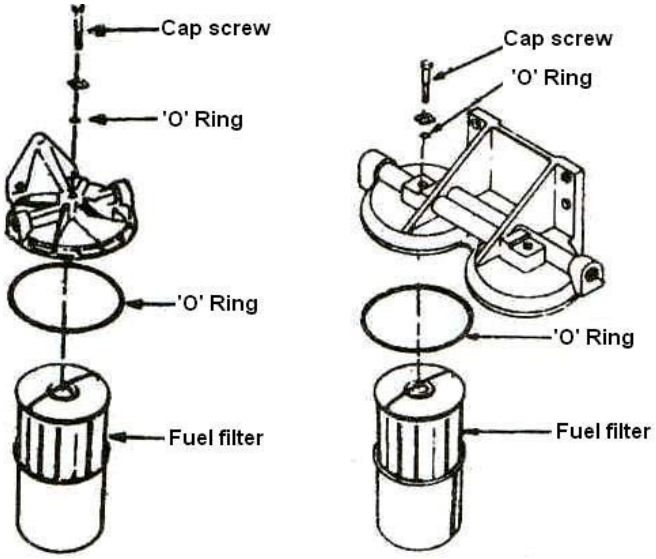
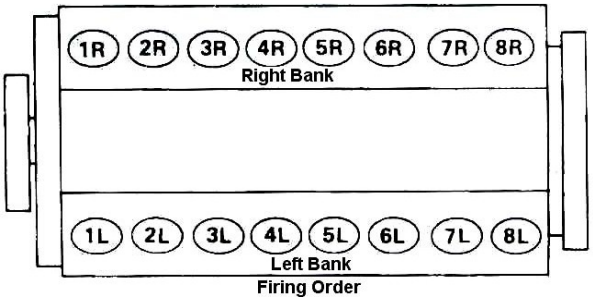


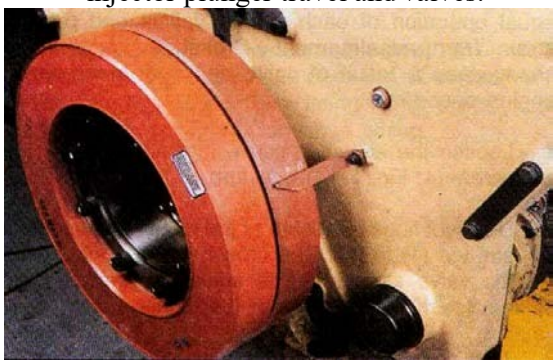
Fig. Exploded view of Fuel Filter

INJECTOR AND VALVE ADJUSTMENT

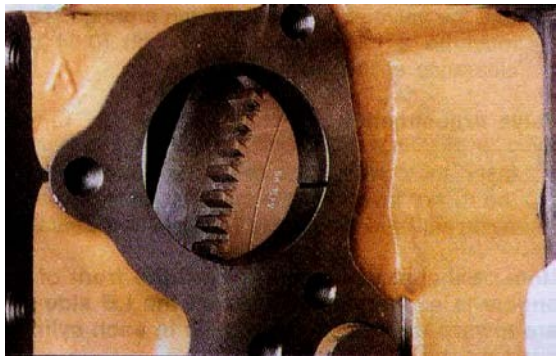


Valve Set Mark Alignment

- There are three locations in the engine where valve and injector alignment marks may be viewed.
- Injector plunger travel and valves both may be set on one cylinder at the same valve set location.
- The crankshaft must be turned through two (2) complete revolutions to properly set all injector plunger travel and valves.



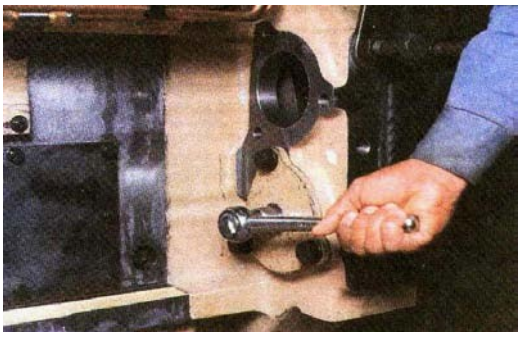
VS Mark on Vibration damper

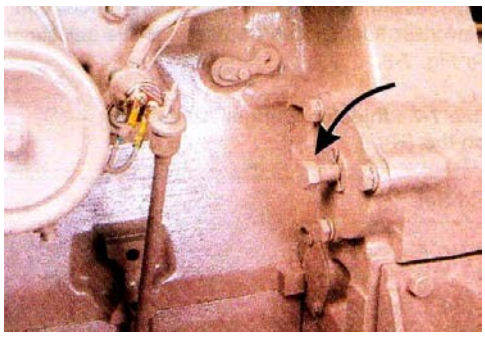


VS Mark on right bank flywheel

Note: The barring mechanism may be located on either the left bank or right bank at the flywheel housing. The cover plate on opening "A" or "C" directly above the barring mechanism must be removed when viewing the timing marks at the flywheel housing.

- When viewing the engine at the vibration damper, align the timing marks on the damper with the pointer on the gear case cover.
- When barring the engine from the right bank at the flywheel housing "A" VS timing marks on the flywheel must align with the scribe mark when viewed through the opening marked "A" on the flywheel housing.
- When barring the engine from the left bank at the flywheel housing "C" VS timing marks on the flywheel must align with the scribe mark when viewed through the opening marked "C" on the flywheel housing.





Engine barring device

Injector Plunger Adjustment

- Bar the engine in the direction of rotation until the appropriate valve set mark is aligned with the scribe mark on the flywheel housing or until a valve set mark on the vibration damper is aligned with the pointer on the gear case cover
  Note: Any valve set position may be used as a starting point when adjusting the injectors, crossheads and valves. Determine which of the two (2) cylinder indicated have both valves closed (rocker levers free). This cylinder is in position for injector plunger travel, crosshead and valve adjustment.

- Set up support block on the rocker lever housing, of the cylinder selected, with the dial indicator extension on the injector plunger top.
  Note: Make sure that Dial Indicator extension is secured in the indicator stem and is not touching the rocker lever.

- Using the rocker lever actuator, depress the lever toward the injector until the plunger is bottomed in the cup to squeeze the oil film from the cup. Allow the injector plunger to rise, bottom again, hold in the bottom position and set the indicator zero. Check the extension contact with the plunger top.
- Allow the plunger to rise then bottom the plunger again, release the lever, the indicator must show travel as indicated in Table.

Table for Adjustment Limits Using Dial Indicator Method and adjust in Inch or mm.

Injector Plunger Travel	Valve Clearance	
	Intake	Exhaust
0.308" ± 0.001"	0.014"	0.027"
(7.82 ± 0.03) mm	(0.36) mm	(0.69) mm

- If the adjusting screw locknuts were loosened for adjustment tighten to 40 to 45 ft-Ibs torque and actuate the plunger several times as a check of the adjustment. Tighten the locknuts to 30 to 35 ft-Ibs torque.

- Remove Dial Indicator Kit.

Crosshead Adjustment

- Crossheads are used to operate two valves with one rocker lever. An adjusting screw is provided to assure equal operation of each pair of valves and prevent strain from misalignment. Crosshead adjustment changes as a result of valve and seat wear during engine operation.
- Loosen the adjusting screw locknut, back off the screw one turn.
- Use light finger pressure at the rocker lever contact surface to hold the crosshead in contact with the valve stem. The adjusting screw should not touch the valve stem at this point.

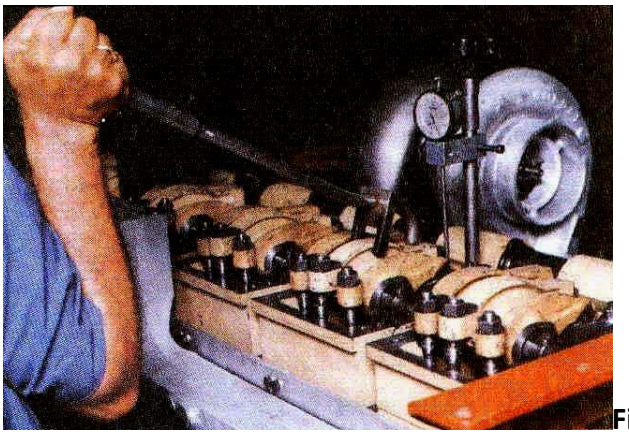


Fig. Actuating rocker lever

- Turn down the adjusting screw until it touches the valve stem.
- Using Torque Wrench Extension to hold the adjusting screw in position, tighten the locknut to 22 to 26 ft-Ibs torque. If the torque wrench adapter is not used, hold the adjusting screw with a screwdriver; tighten the locknut to 25 to 30 ft-Ibs torque.
- Check the clearance between the cross head and the valve spring retainer with a gauge. There must be a minimum of 0.025 inch (0.64 mm) clearance at this point.

Valve Adjustment

- Insert the correct thickness feeler gauge between the rocker lever and the cross head for the valves being adjusted. See above Table for valve clearance.
  Note: Exhaust valves are toward the front of the engine in each cylinder head on the LB side and are toward the rear of the engine in each cylinder head on the RB *side.*

- If adjustment is required, loosen the locknut and turn the adjusting screw down until the rocker lever just touches the feeler gauge; lock the adjusting screw in this position with the locknut.

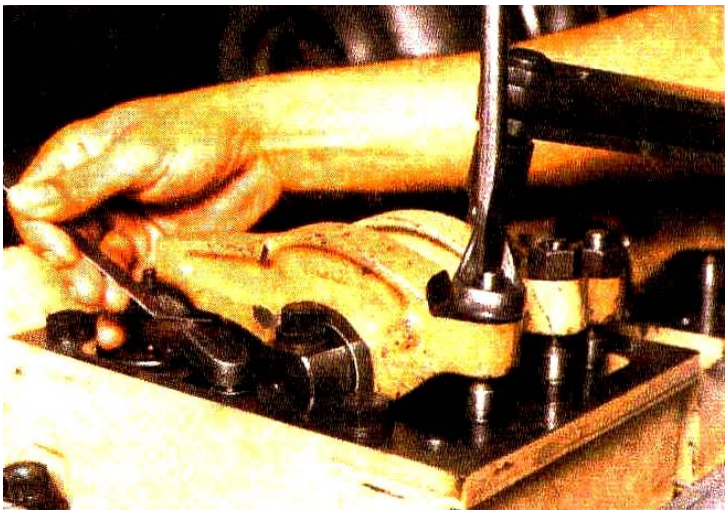


Fig. Adjustment of cross head clearance

- Tighten the locknut to 40 to 45 ft-Ibs torque. When using torque wrench adapter tighten the locknuts to 30 to 35 ft-Ibs torque.
- After completing the injector plunger travel, cross head and valve adjustment on this cylinder, bar the engine in the direction of rotation until the next valve set mark is aligned with the scribe mark at the flywheel housing or the pointer on the gear case cover; repeat the procedure. (See Fig's for cylinder arrangement and engine firing order).
- Discard old rocker cover gaskets and use new gaskets. Mount rocker covers and tighten cap screws 30 ft-Ibs.

LUBRICATING OIL SYSTEM

KT A 50 L diesel engines have force-feed lubricating oil system with low lube oil protection device. The lube oil system is four fold.

- To lubricate all the moving parts in an engine.
- To help in seal combustion chamber from the crankcase.
- To clean the engine by picking up foreign particles.
- To cool the parts that it contacts.

The main components of the lube oil system are described below:

1. Lubricating Pump

The lubricating pump used in engine is gear type positive displacement pump. This has two gears meshing with each other which when rotated draws oil from engine sump and delivers it at a pressure for lubrication.

2. Lube oil Full Flow Filters

Lube oil filters playa very important role in protecting engines. When the lube oil passes through the filter element, most of the larger foreign particles suspended in the oil are trapped in the element. The purpose of lube oil filters is to remove this foreign matter before it can harm the engine.

3. Bypass Filter

The function of bypass filter is to assist the full flow filter by trapping the finer dirt particles that get through the full flow filter. Lubricating oil bypass filter plumbed, parallel to full flow

filter, into the engine, has much finer filtering media with less porous passages than the full flow filter element.

4. Lube Oil Cooler

In lube oil cooler, the coolant passages through tubes. The. lubricating oil circulates around outside all these tubes. Water passage through tubes and absorbs heat from oil when its temperature is higher than it but heats oil when its temperature is lower than that of water.

5. Piston Cooling Nozzle/Jets

The piston cooling nozzle/jets make up another important part of the engine lubricating system. Combustion heat generated by supercharging the engine, the piston cooling jets are used on the engine to cool the pistons.

WORKING

The lubricating oil circulating pump, mounted on the free end side of the engine sump, draws the lubricating oil from the engine sump and feed it into the system. A relief valve at the discharge side of the pump protects the pump from high pressure and controls the discharge pressure by passing a portion of the oil back to the sump. The remainder of the oil flows on through the regulating valve set at 70 psi and then passes through full flow filter, which is equipped with a differential pressure by-pass valve to hold a relatively constant pressure across the filter. From the filter the oil flows on through the lube oil cooler and then into the main lubricating oil header of the engine to provide pressure lubrication to the bearing surfaces.

A pipe connection from lube oil cooler goes to the both turbo super charger for cooling and lubricating the of the TSC and drain in the sump. A branch line of the lube oil goes for by pass filter for filtration of lubricating oil.

Branch lines leading from the main header supply lubricating oil to the main bearings, connecting rods, cylinder heads, piston cooling jets and return to the sump. Another branch feeds the oil to camshaft bearings & cam follower. Sub header supplies oil to accessory drive like PT fuel pump & water pump etc.

A small line leads to the pressure gauge and the low lube oil pressure switch for engine safety. The normal lube oil pressure of the engine is 3.4 Kg/ cm2 to 6.2-kg/ cm2 at the rated speed and normal temp.

Checking of Lube Oil level by dipstick.

- Oil gauge dipstick is located on the engine. For accurate readings, oil level should not be checked for approximately 15 minutes after engine shutdown.
- Keep dipstick with the pan with which it was originally fitted. Keep oil level as near "H" (high) mark as possible.

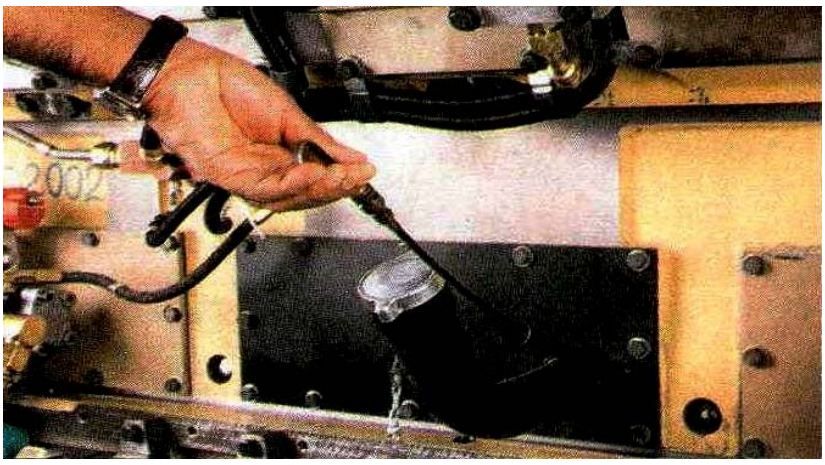


Fig. Checking of engine lube oil level

Changing procedure of lube oil filter elements

- Loosen centre bolt securing lube oil filter housing to lubricating oil pump.
- Remove filter element, cut it open and check for metal particles, if found check for source. Discard "O" ring and element. Insert new filter element into the housing.

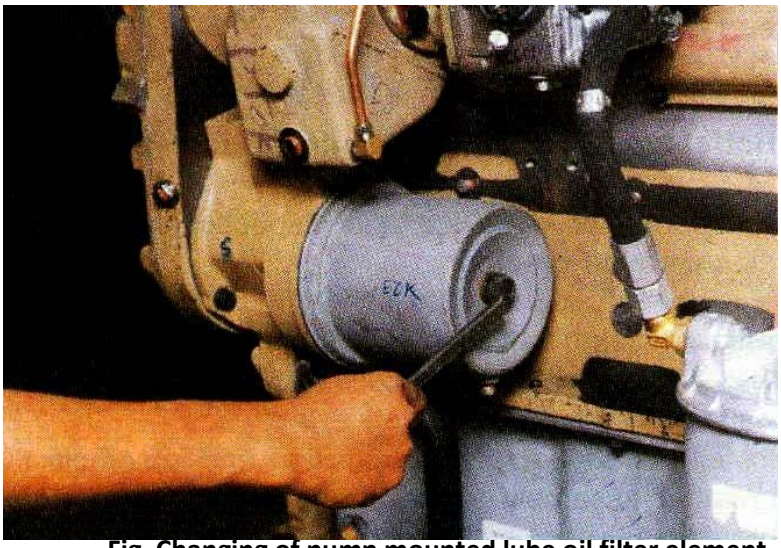


Fig. Changing of pump mounted lube oil filter element

- Install new rectangular seal on the pilot located on the lube pump.
- Install housing and element assembly with its mounting bolt and washers.
- Remove plug on housing, fill clean oil and replace the plug.
- Torque the housing retaining bolt to 30 to 35 ft. Ibs.
- Check for leaks when engine start, recheck engine oil level; add oil as necessary to bring the oil level to "H" mark on the dipstick.**Cleaning/ changing of engine breather**
- Remove the wing nut, lock washer and plain washer.
- Remove washer and gasket.
- Lift off the cover and lift out the breather baffles.
- Discard baffles, clean cover and body. Inspect the body and cover for cracks, dents or breaks.
- Clean the baffles in suitable solvent and replace if necessary.
- Inspect gasket. Replace if necessary. Install the rubber gasket in the Cover position the cover assembly to the body.
- Inspect gasket. Replace if necessary. Install the gasket, washer and wing nut Tighten securely.

Changing of lube oil by-pass filter element

- Loosen four cap screws from head and remove head of L.O. by-pass filter.
- Takeout element and remove ring sealing between head and shell.
- Replace ring sealing and element. Fill filter with some oil and reassemble.
- When the engine runs check for leaks, shut down the engine. Add oil as necessary to bring the oil level to the "H" mark on the dipstick.

Fig. Lube oil by-pass filter element

Oil Sample Collection

Three methods are commonly used to collect oil samples for analysis. They are:

1. Sample Valve Method:
2. Vacuum Pump Method:
3. Oil Drain Method:

Engine Oil changing procedure

- Start the engine and bring engine to operating temperature, now shut down the engine.
- Remove drain plug from bottom oil pan, and drain oil
- Install drain plug in oil pan. (Torque to 65 to 70 ft-Ibs for cast iron or sheet metal oil pans. Apply 40 to 45 torque ft-Ibs for aluminium oil pans).
- Fill the crankcase to "H" (high level) mark on the dipstick.
- Start engine and visually check for oil leaks.
- Shut down the engine; allow 15 minutes for oil to drain back into the pan, recheck the oil level with the dipstick. Add oil, as required.

HYDRAULIC OIL SYSTEM

The purpose of hydraulic system is to transfer the required power from engine to radiator and ventilation fans. For power transmission hydraulic system comprises of

1. Hydraulic tank
2. Hydraulic pump
3. Hydraulic Motor
4. Hydraulic oil cooler
5. Manifold block
6. Pressure relief valve
7. Thermatic valve
8. Return line filter
9. Return block
10. Hydraulic oil level indicator
11. Remote PRV
12. Shut-off valve
13. Hydraulic pressure gauge
14. Hydraulic temp gauge

Variable / Fixed displacement pump

This pump is mounted on the engine and it is directly driven by engine gear drive with 1: 1: 1 drive ratio. It has a pilot control valve. Hydraulic pump has nine cylinders whose movements are obtained from rotation of drive shaft. Cylinders suck & deliver oil by their reciprocating motion proportional to stroke length of the cylinders. These strokes are directly controlled by inclination of the swash plate whose position is governed by pilot control valve.

Fixed displacement pump construction is similar to hydraulic motor except that the port plate that receives and delivers oil is of different design. It has swash plate fixed at definite angle and pump flow is proportional to the rotational speed of the driving shaft. Pump has a case drain return line, freely flowing back to the tank. In case of fixed displacement pump, thermatic valve is not required.

Thermatic valve:

Thermatic control valve is mounted on engine's hot water outlet, which controls movement of plunger with rise in engine coolant temperature. When engine water temperature is below 82
°C, liquid from pump pilot valve freely passes through the valve assembly. When temperature rises above 82 °C, thermal probe. expands and start moving the plunger to create restriction to incoming flow and generates back pressure.

Hydraulic Motor:

Hydraulic motor is of bent axis design with fixed displacement of cylinders, where inlet of pressurized liquid causes development of torque and speed to output shaft. In case of hydraulic motor output, rotational speed of the motor is directly proportional to flow going to the pump and pressure of the liquid is directly proportional to the torque developed by the shaft.

Fixed displacement Hydraulic pump

Fixed displacement hydraulic pump is used to drive ventilation fan. The pump is mounted on engine and driven by belts from left (LB) accessory drive of the engine. Pump delivers flow proportional to rotational speed of the driving shaft.

Details of Pump and Motor as given below :-

S.no.	Description	Model	Flow rate	Pressure setting
1.	**Radiator system**			
	Pump			
	a) Fixed displacement	A2FO63	112 lpm @ 1980rpm	170 bar
	b) Variable displacement	A10VO71	126 lpm @ 1980rpm	170 bar
	Motor			
	a) Fixed displacement	A2FM 28	51 lpm @ 1600rpm	-
2.	**Ventilation system**			
	a) Pump			
	Fixed displacement	A2FO 28	38 lpm @ 1503rpm	90 bar
	b) Motor			
	Fixed displacement	A2FM 12	16 lpm @ 1200rpm	-

Manifold block:

Manifold block is a steel solid block which houses several non return valve (check valves) & pressure relief valve to encase complicated circuit inside and also to facilitate hose connections to various points in the system. There are two types of manifold blocks used in hydraulic systems as described in the hydraulic circuits.

Return Line Filter:

The filter is mounted on hydraulic tank, which cleans the hydraulic oil that may get contaminated due to poor handling or undesirable entry of dust in the system. It has a restriction indicator at the top of the head, which starts showing red signal whenever return backpressure is above 2.5 bars.

Strainer:

Strainer is fitted inside the hydraulic tank in the suction line to the main and vent Pumps. There are chances of ingress of dirt particles in the hydraulic tank during initial filling and scheduled maintenance of the hydraulic system.

Pressure relief valve:

Pressure relief is always connected in main delivery pressure line to limit the system pressure to set value. System pressure acts on the main spool. At the same time pressure acts via a pilot line fitted with jets, on pilot poppet. If system pressure exceeds the value set with the spring, the pilot poppet opens and pilot oil is allowed to flow back to the tank.

Remote pressure control valve (for remote control)

Remote pressure control valve is used as additional pressure adjustment facility to the system at the time of installation, testing and reduction of system pressure from outside radiator assembly. This valve is hard knob operated, connection to pilot valve of main pressure regulating valve.

Hydraulic System Maintenance:

Hydraulic Oil for hydraulic system is expected to give a very long life, if maintained properly. One should be careful to monitor these factors, which are detrimental to oil life.

- Hydraulic oil temperature should be within the best operating. range i.e. 20°C to 60°C.
- A variation of 10° below or above this range reduces the oil life to half of the recommended period.
- Dirt entry into the system because of poor handling, transportation gasket leakage etc. is not desired.
- Viscosity of the oil should not be outside the range (74.5 to 167 mm2/second) measured within 20° C to 80 °C temperature range.
- Avoid mixing of water with the oil, which may occur during rainy season.
- Check presence of water during every 300 hours of engine maintenance by draining the bottom plug.
- Check if cloudiness is observed in the oil. Presence of water will destroy the lubricating properties of oil and cause fast wear.
- Avoid foaming of the oil, which normally occurs due to heavy churning of oil or suction of air by hydraulic pump.

Hydraulic System Do's & Don'ts:

Do's	Don'ts
Change oil after every 2000 hours of operation.	Do not exceed oil change interval more than one year or 2000 hours, whichever is earlier.
Filter Element should be changed immediately after restriction indicator shows" RED" mark.	Do not clean and re-use filter element
Replace Hoses & 'O' rings after every 6000 hours of operation or 2 years, whichever is earlier.	Do not re-use any "O" ring or Dowty washers during re-assembly.
Oil contamination level should be checked every month.	Do not use oil with contamination level exceed the limits.
Do check the thermatic valve in hot water temp bath. It should close hydraulic flow at 90 Deg. C.	Do not repair the thermatic valve. Do not reuse the thermatic valve in case flow does not seize at 90 Deg. C.
During re-fitting carefully align and route the houses.	Do not apply force or twist the hoses for alignment and tightening.

Hose Routing and Installation Instructions:

- Always provide some slack in the hose to allow for shrinkage/ expansion due the hydraulic pressure.
- Do not install the hose with the twist in it. High operating pressure tends to force it straight. This can loosen the fitting nuts.
- Protect the hoses from the hot surface with suitable installation,
- Separate the hoses from the abrasive surfaces with help of suitable protective sleeves.
- At bends, provide enough hose for wide radius curve. Too tight a bend pinches the hose and restricts the flow. Use the right fittings or adapters as specified in the parts book to avoid the tight bends.
- During re-assembly of adapters or hoses use the specified Dowty washers and "O' rings as parts book.

Instructions for replacement of hydraulic pumps:

(During replacement of the failed pump with new pump)

- Flush the system and replace the oil, clean the oil through filter trolley, as required.
- The new pump is to be tested for free movement of the rotor, by hand.
- Remove the old pump after disconnecting the end connections.
- Mount the new pump in place.
- Connect the end connections with new 'O' rings or seals as required.
- Ensure that the leak-off line is routed with loop and fill up the pump housing with oil.
- Then start and rotate the engine slowly and check the pressure at the pump outlet Also check for any leakage from the pump housing sealing.
- After the water temperature is increased the thermatic valve starts closing and the pump outlet pressure should increase gradually.
- Then slowly increase the engine speed and check whether the pump outlet pressure rises to the required pressure.
- Adjust the maximum required pressure at rated engine speed with the pressure regulator valve provided in the system.

Procedure for checking Leak-off from the pumps/ motors:

The checking of leak-off from the pumps and motors gives the information about the condition of the rotating and reciprocating components. It should be checked during every oil change period. The leak-off hose from the pump motor should be removed and the oil should be collected in the measuring jar for one minute. This quantity should not exceed 5% of the rated flow.

Use of Filtration Trolley:

The hydraulic oil filter trolley is useful for cleaning the oil conveniently during operation to ensure the oil cleanliness consistently up to oil change. Two types of filtration are suitable below:

1. Filter trolley should consist of the suitable pump and glass fiber filter with absolute filtration capacity up to 10 microns. This filter is with replaceable filter element and should be provided with coarse pre-filter.
2. Another type of filter trolley consists of centrifugal filter in place of filter element with cleaning capacity of up to 10 microns.

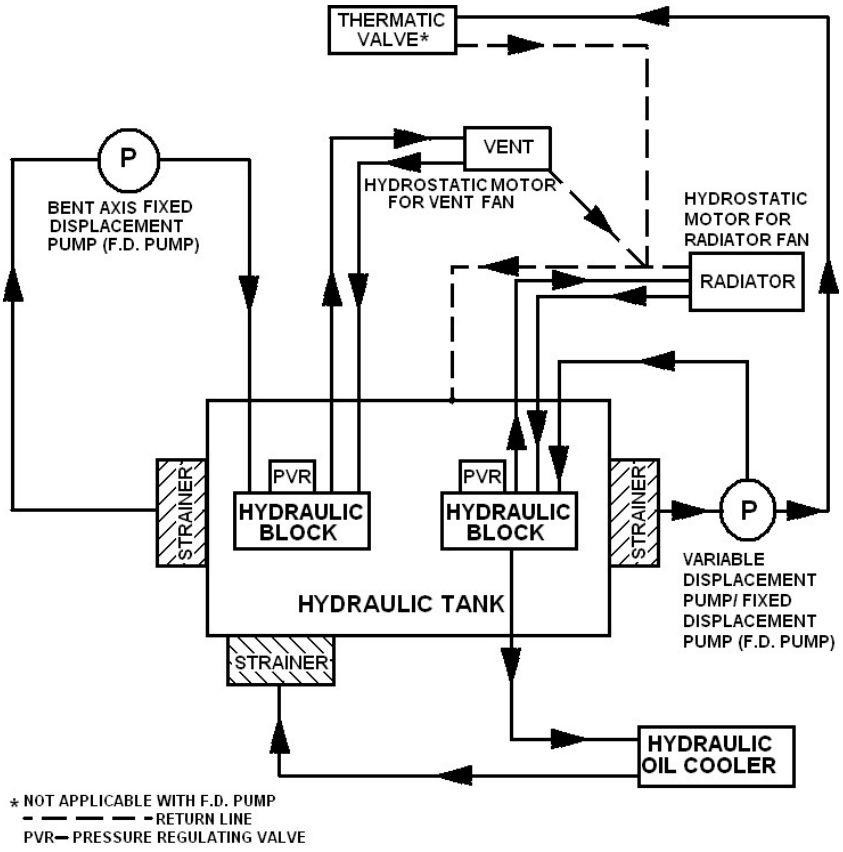
Filter trolley is kept outside the bogie and connected with the oil tank with suitable hose connections. The filtration is carried out for about half an hour to get the required oil cleanliness level.

Specifications of Filtration Trolley

1. Pump Flow Rate - 20 lpm
2. Operating Pressure - 10 Bar
3. Filter options
   a) Two stage filtration using glass fiber filtration media.
   b) Single stage filtration using Centrifugal Filter capable of removing particles 10 microns and above.
4. Inlet and outlet connections - 1" BSP

Flushing of DEMU Main and Vent system:

Bypass hydraulic pump, hydraulic motors and hydraulic block using adapters. 1" BSP hose should be connected from inlet of Filtration Cart to outlet of hydraulic tank. Another hose of l' BSP should be used to connect outlet of Filtration Trolley to inlet of hydraulic pump inlet hose. After this initial preparation is done, start the electrical motor on filtration cart and circulate oil in the system for about two hours.
A schematic of the hydraulic oil system of DEMU with KCL engine is shown in schematic diagram of hydraulic oil system.



HYDRAULIC OIL SYSTEM (KCL)

COOLING WATER SYSTEM

The cooling system is with side-mounted radiators. Cooling system is pressurized by 7PSI pressure cap and vacuum valve. A schematic of the cooling water system of DEMU is shown in schematic diagram of the cooling water system.

Specifications

No. of radiators	4 Nos
No. of radiator fans	2 Nos
Weight of radiators (3 nos.)	252 Kg each
(1 no.)	341 Kg (With oil cooler)
Radiator coolant volume	288 Liters
System pressure	7 PSI
Maximum water outlet temp	95 Deg. C
Limiting ambient temp	55 Deg. C
Radiator core area (total)	60 Sq. Ft.
Maximum fan speed	2100 rpm
Air velocity across the core	1123 Ft/min

Major components in the cooling system:

Expansion tank:

The capacity of expansion tank is 85 liters. It collects vent out air from engine and radiators. Venting from engine & radiators are directly connected to the expansion tank. A filler neck is provided on the expansion tank for filling the coolant. Pressure relief valve is mounted separately to maintain system pressure 7 PSI during operation

Radiators:

Four radiators (two on each side) are supplied in case of side-mounted radiators. Radiators can be cleaned easily by air / water jet from inside to out of radiator compartment. Radiators are supported with anti-vibration mountings to guard against rail vibrations.

Hydraulic oil coolers:

Hydraulic oil cooler is located in the radiator compartment. It is situated at the right bank (RB) side of the engine, before the RB radiator, so that it receives cold air first for cooling. Hydraulic oil cooler is double pass type of radiator. This cooler maintains the hydraulic oil temperature below 70 Deg. C.

Radiator Fans:

Radiator fans are located on top at the center of the radiator compartment. The fans are driven by hydraulic motors. Radiator fan sucks air through the radiators and throws out the hot air to the atmosphere.

Ventilation fan:

Ventilation fan is located on top of the engine compartment. Like radiator fan it is also

driven by hydraulic motor. Since the engine is mounted in the closed compartment (coach), ventilation is required to keep the compartment cool, within 60 °C max.

SCHEMATIC DIAGRAM OF COOLING WATER SYSTEM