Supervisors Training Centre,
South Central Railway

ISM - 03

DIESEL THEORY (MDT – 02)

September 2020

INDEX

MDT-2

1.Power pack

Power pack components

- **Engine Base**
- **Engine Block**
- **Crank Shaft**
- **Camshaft**
- **Liner**
- **Piston & Piston Ring**
- **Connecting Rod**
-
- **Cylinder Head & Valves**

Engine base:

When diesel engines were of low speed and low horsepower the engine base and blocks were made of heavy cast iron casting. In older types engines one of the main functions of the base was to take the crank shaft. In the modern engines the crank shaft is underhung from the engine block.

The engine base of ALCO Locos WDM2, WDM4 are made from weldable quality steel to specification IS-2062 with 0.2% of carbon.

The engine bases of ALCO Locos have following functions.

It has to -

a) Support the engine block

b) Serve as oil sump

c) Accommodate lube oil main header

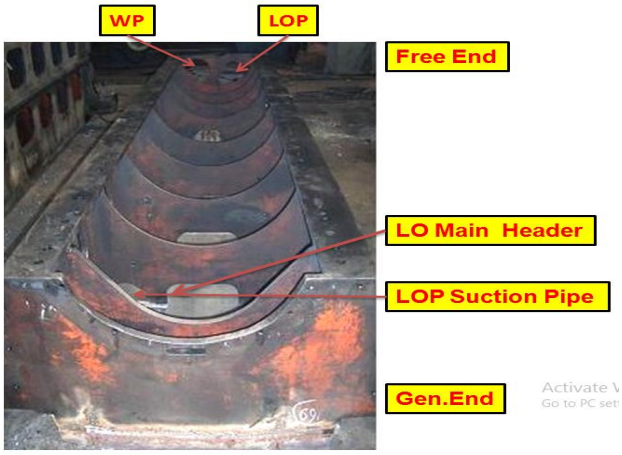
d) Take lube oil pump and water pump at the free end

e) Allow openings for crank case inspection

f) Take fitment of crank case explosion cover

g) Foundation pads are provided for transmitting load to the chassis and als to take lower blots of the main generator magnet frame.

A perforated screen is fitted to the base to prevent foreign matter like pieces of metal etc. getting access to the sump. The top face of the base which takes the engine block is machined smooth and a sealing compound is applied before fitting the block to make the crank case air tight so that crank case vacuum can be maintained.

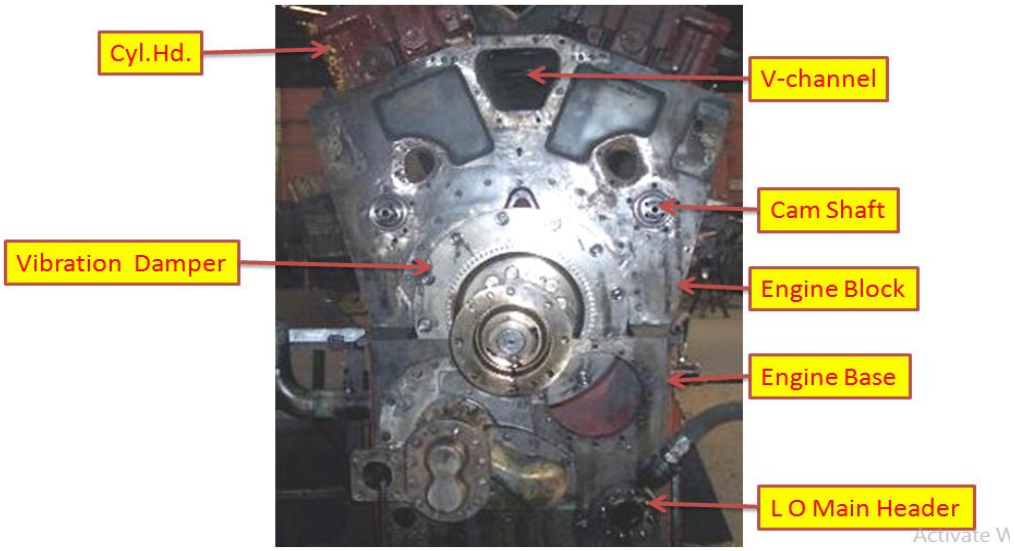


Engine base

Engine block

The engine block is the most important and very highly stressed structure on which are fitted a number of important fittings like crank shaft, cam shaft, cylinder heads**,** cylinder liners, pistons**, c**onnecting rods, fuel injection pumps and cross-head, turbo support, governor etc to form a complete Power pack.

This structure is fabricated from low carbon steel to specification IS-2062. The saddle, however, is a forging out of steel to specification IS-1875.



Engine Base & Block

Crank shaft

It is the medium of transforming reciprocating motion to rotary motion.

The ALCO crankshafts are manufactured from chrome-molybdenum steel equivalent to SAE 4140. The process of forging is such that continuous grain is maintained.

The standard Locomotives of Indian Railways are with single-piece crankshaft with welded counter weights.

Output of the engine is collected from crankshaft (T/Gen mounted on it converts Mechanical energy into electrical energy).

It gives mechanical drive to Camshaft, Expressor, Radiator Fan and other allied components like water pump, lube oil pump, Tr. Motor Blowers etc.

Counter weights are provided for dynamic balancing of the crankshaft; they are welded.

The portions of crank shaft which form the axis of rotation are called main journals where it is housed in the engine block through main bearings

The eccentric portions where piston is connected through connecting rod are called crankpins

Crankshaft of WDM2 type engine has 9 main journals and 8 crankpins to accommodate 16 pistons in a V shaped engine.

It is only removed for maintenance in POH Schedule.

Crank shaft gear

- Mounted at Power- take-off end and meshes with Camshaft Gear.
- Made in 2 halves, accurately fitted and keyed to the crankshaft.
- Gear is held in place by 4 bolts and has locating dowel to position the halve as they are assembled.
- Gear is 4 pitch straight Spur type.

Note:i) Spilt Gear is statically balanced and halves are not interchangeable

ii) Replacement must be in matched pairs.

ii) Metal to Metal joint formed by both halve of gear to be checked using Feeler Gauge.

iv) It should not be possible to insert Feeler gauge more than 1/4".

Crank shaft split gear

Crank web deflection*:* Checking of crank web deflection is one of the major works while assembling engine.

Main generator is coupled at one end of the crankshaft, whose other end is supported on a bearing housed at the magnet frame. As such, due to mislocation of magnet frame, if axis of armature does not completely align with the axis of the crankshaft, the unbalanced mass of armature will cause uneven loading on crank web at different angular positions during rotation. This causes deflection on crank web, which will be changing at various positions of crankshaft during rotation. Such kind of continuous cyclic variation of load leads to main bearing seizure and breakage of crankshaft.

Correction is made by adding or subtracting shims at the mountings of magnet frame with engine block. The magnet frame is mounted at two locations with the engine block and at two locations at the base. Adjustable shims are provided at the mountings of the magnet frame with the block.

Cam shaft

In diesel engine the cam shaft performs the vital role of opening and closing inlet and exhaust valves and allowing timely injection of fuel inside the cylinder. Usual practice is to provide 3 cams for each cylinder the two outer cams being for exhaust and inlet valves and the central cam being for fuel injection. Like most of the Diesel engine manufacturers, ALCO engines have cams integral with camshaft. Each camshaft section takes care of two cylinders.

The rifle hole is made in the center of the shaft for lubrication of cam bearings. Lubrication to

cam lobes is provided by oil coming from valve lever mechanism via the push rod.

- Opening and closing of Inlet & Exhaust valves and to operate FIP timely.
- Providing speed information to Governor
- Driving OST for tripping & engine shutdown in case of high speed
- 3 Cams are provided for each Cylinder.
- Lubrication delivered to bearings through an internal drilled hole .
- Rollers for Fuel pump cross head lifters and Valve push rod lifters ride on cams,
- Cam lobes and rollers are lubricated through gravity fed oil dropping from cylinder head through push rod holes.
- Lateral movement of Camshaft restricted by Thrust bearing, located at free.

  Camshaft Thrust : 0.006” - 0.012”(New), 0.022” (Limit)

Backlash : 0.006” - 0.010”

- Camshaft Bearings (Bi Metal):
  - Examine for pitting, shelling and wear.
  - ID : 4.511”(limit)
  - Running Dimensional checks:

2. SUPER CHARGING

REQUIREMENT OF AIR SUPER CHARGING SYSTEM

Diesel engine Uses chemical energy to generate Heat energy. This heat energy will be later converted into Mechanical energy. To produce the heat energy, fuel is burned inside the combustion chamber. For efficient burning more oxygen is required. For supplying more fuel, SUPER CHARGING is required. In this process air is introduced into the engine cylinder at a density more than ambient. This will produce more power than a naturally aspirated engine for the same bore and stroke dimension. Super charging causes better scavenging also.

ADVANTAGES OF SUPER CHARGING

- Better cooling of components.
- Saves them from failure due to thermal stresses.
- Enhances the service life.
- Better fuel efficiency.
- Power to weight ratio is much more.

METHODS OF SUPERCHARGING

- **Separately driven air compressor:**

  This type of supercharging used on four wheel drive military vehicles. This method provides high SFC.

- **Blowers driven by exhaust gas.**

  Here turbocharger uses the energy of waste Exhaust gas. This is a very efficient & economical method. Blowers run by the exhaust gas driven turbine.

AIR BRAKE SYSTEM

INTRODUCTION

IRAB – 1 brake system is a complete air brake version, in which only compressor unit is used instead of Expresser for creating air pressure in the brake system and all the brake valves are panel mounted.

SALIENT FEATURES OF IRAB – 1 SYSTEM

1. Locomotives Brakes can be applied and released through independent brake valve SA9, independently.

2. Formation brakes can be applied & released through Automatic brake valve A9.

3. Locomotive brakes are applied automatically when formation brakes are applied.

4. It is suitable for MU operation also, with which the brakes of trailing units are controlled from leading unit.

5. Brakes in the rear loco are synchronized with lead loco brakes.

6. Emergency brake application is available to have minimum possible braking distance, from any control stand and any loco.

7. Safety devices are incorporated to bring the engine to idle in case of emergency brake application and train parting.

8. In case of train parting between the locos, both the locos will have automatic brake application.

9. Automatic brake and Dynamic brakes are inter locked. So that, Auto Brake will be released automatically when the DB is applied.

10. The system can work either with single pipe / dual pipe.

AIR BRAKE SYSTEM VALVES

SL. NO	DESCRIPTION	PURPOSE
1.	A9. Automatic Valve	Brake application for Loco as well as formations.
2.	SA 9 Independent Brake Valve	Brake Application for Loco alone
3.	MU – 2B	M.U. Operation, used as gate valve
4.	F 1 – Selector	M.U. Operation, used as gate valve
5.	$C_{2.}$ W. or Additional $C_{2.}$ Valve	Feeding B. P. Pressure to the formation
6.	24 A. Double Check Valve	This will allow only one operation at a time.
7.	$C_{3.}$ W. Distributor Valve	Proportionate Brake valve application during A9. application.
8.	$C_{2.}$ Relay Valve	For Locomotive Brake.
9.	Pressure Switch	Loco will be brought to idle during A9 emergency application.
10.	D1. Emergency Valve	For Emergency brake application.
11.	D1. Pilot air valve	During Dynamic brake Loco brake will be released.

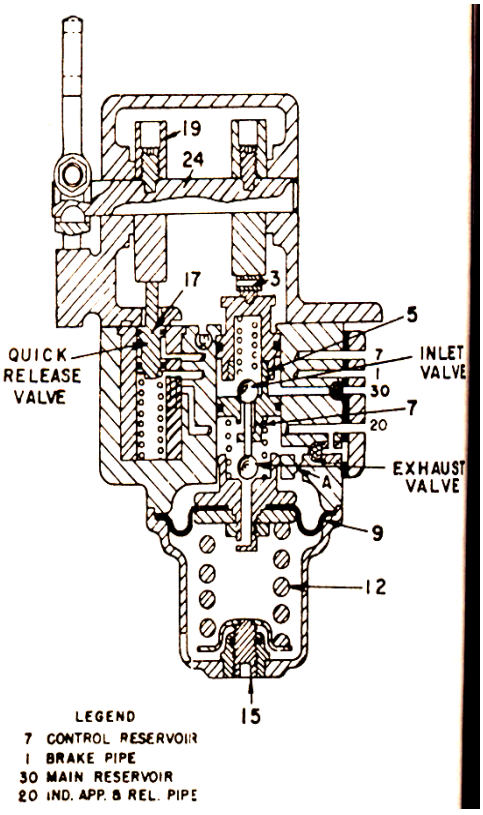
12.	Pressure Limiting Valve	Pilot air to C_2 Relay valve for synchronized brake application is Limited to 2.5 kg / Cm^2
13.	M. R. Safety Valve	When M. R. Pressure goes beyond 10.5 kg / Cm^2 This valve will operate and release excess pressure from MR.
14.	Duplex Check Valve Set at 6 kg / Cm^2	This valve will connect MR1 with feed valve when MR pressure exceeds 6 kg / Cm^2
15.	D 24 – Feed Valve	For Feed pipe Pr: 6 kg / Cm^2.

IMPORTANT VALVES PROVIDED IN IRAB – 1 SYSTEM.

SA 9 INDEPENDENT BRAKE VALVE:

It is a variable pressure-reducing valve, sends pilot air to C2 relay valve to charge brake cylinder for application and release of loco brake independently. The outlet pressure can be varied from 0 to max (3.0 Kg / Cm2) by moving its handle. Its handle has three distinct positions.

1. Application
2. Release
3. Quick release – In IRAB, this position is not active.

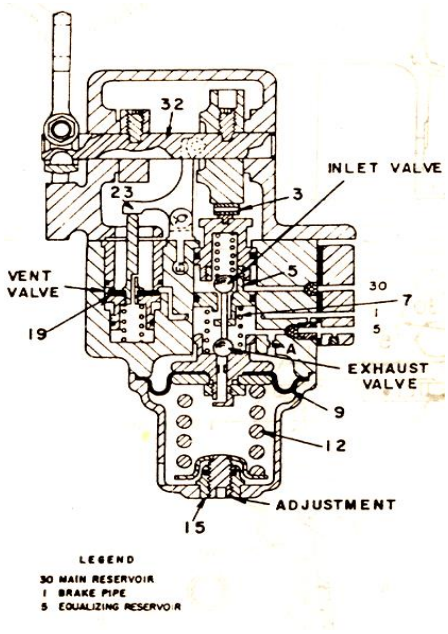


SA9 INDEPENDENT BRAKE

The output pressure is zero at release position and the pressure is max (3.0 Kg / Cm2) at application position. The handle can be placed at any position between release and application to have desired out let pressure(i.e., brake cylinder pressure)

A9 – AUTOMATIC BRAKE VALVE

The valve is also a variable pressure-reducing valve. Its duty is to send pilot air for charging/ exhausting B.P. pressure through C2W relay valve for releasing and application of loco and formation brake. In release condition it charges BP up to 5.0 Kg/cm^2(max). The BP pressure can be varied by moving its handle.

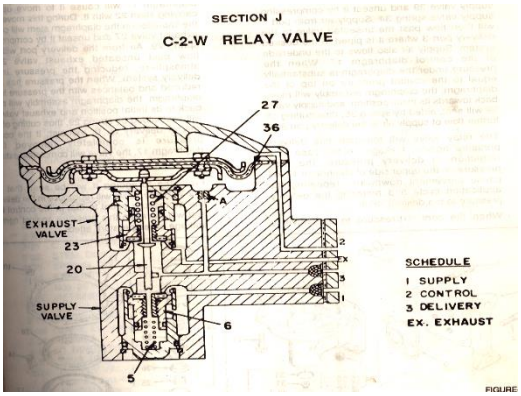


The handle has 5 distinct positions.

1. Release (BP= 5 Kg/cm^2)
2. Minimum release (BP = 4.5 to 4.3 Kg/cm^2, BC = 0.5 to 0.7 Kg/cm^2)
3. Full service (BP = 3.2 to 3 Kg/cm^2, BC = 2.5 Kg/cm^2)
4. Over reduction (BP = 2.5 Kg/cm^2, BC = 2.5 Kg/cm^2)
5. Emergency (BP = 0 Kg/cm^2, BC = 2.5 Kg/cm^2)

The outlet pressure (Brake pipe) is maximum i.e. 5Kg/ cm^2 when the handle is at release position. The pressure will reduce when the handle is moved to application zone. The BP pressure will correspond to the position of the handle between Min and Full service and will be zero at emergency.

C_2 RELAY VALVE



It is a high capacity relay air valve.

It gets pilot air from SA9/ A9 and supply MR air to the brake cylinders at a pressure equal to the pilot air pressure at a higher rate. Thereby it applies and releases the brake.

C_2 W – Relay VALVE: It is similar to C_2 relay valve with some additional features. It is connected to the BP charging/ exhausting system. It gets pilot air from A9 brake valve and it charges/ exhausts BP accordingly. As compared to C2 relay valve it is having an additional diaphragm and pusher pin above the main diaphragm. If air is charged above this diaphragm, it pushes the main diaphragm and increases the pressure setting for the main diaphragm with the same pilot air from A9. This increment is limited by another arrangement so that the outlet pressure cannot build up more than 5.4 Kg/Cm^2. This function is called as overcharging function. It helps to release the brake binding in any of the variable from the locomotive cab.

C_3W- Distributor VALVE

It is an automatic brake application valve. It is used for conjunction brake application in the locomotive in proportion to the formation brake. It is having two air chambers. Control

reservoir (CR) and Brake Pipe (BP). If BP ≥ CR, Brake is released, i.e. BC = 0 and when BP < CR brakes are applied. The difference between CR and BP pressure will decide the amount of BC pressure. As BP is common in the train and locomotive hence according to the BP drop page the brake application and release will be synchronized in the formation and locomotive.

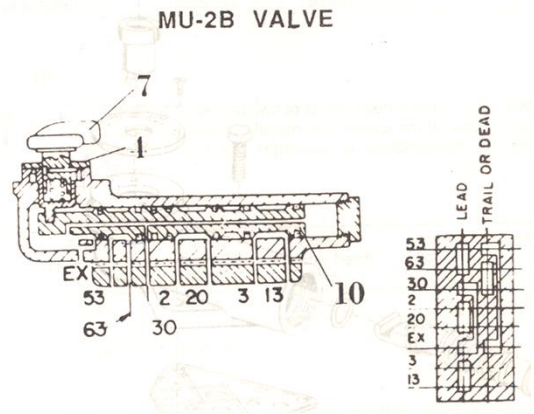
MU – 2B: -

It is manually operated change over valve. It makes the system to be controlled from the same unit or the leading unit. It also isolates the drivers control for application and release of brakes in trailing loco.

The knob of this valve has 2 positions.

1. Lead
2. Trail or Dead.

There are many ports in this valve and their connections are changed as under:



Lead	2,20	3,13	63,53	60 – Exhaust
Trail or Dead	--	--	63 - 30	53 – Exhaust

F1 – SELECTOR: -

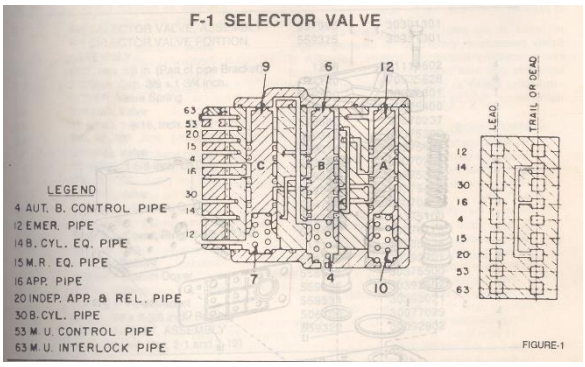
This valve is also a change over valve.

It has 2 positions:

1. Lead
2. Trail or dead.

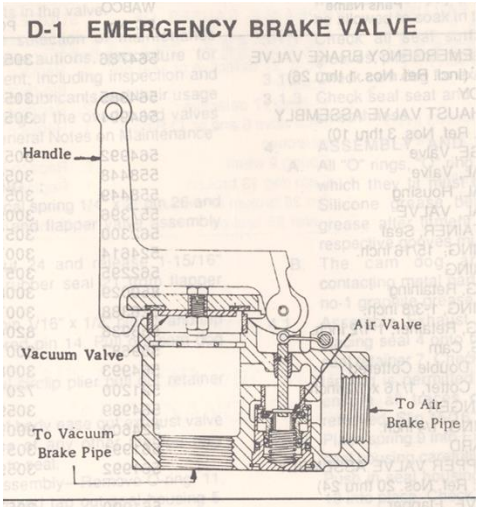
The position is changed automatically according to the position of MU2B valve. Port 30 from MU2B is piped to this valve. When there is no pressure in this port F1 selector will assume, lead position. If air pressure is supplied from the port, F1 selector will assume Trail or dead position.

This valve also has many ports and the connections are given below.



Lead	4-16	30 – 14
Trail or dead	14-16-20	

In co-ordination with MU2B, this valve makes the system to operate as a lead unit or trail unit.



D1 – EMERGENCY VALVE:-

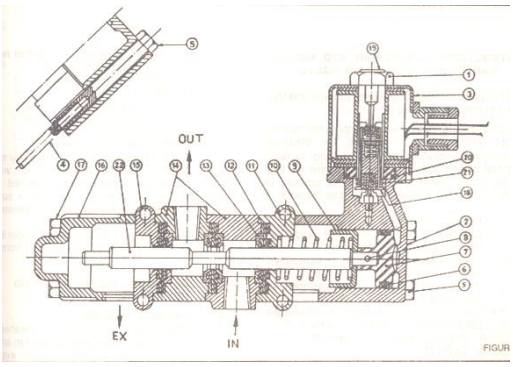
This valve is a flap valve with suitable lever. It is connected directly with the Brake pipe. If this valve is opened, BP drops to Zero at the faster rate and thus brake application is made very fast with maximum braking effort and minimum braking distance.

1. In case of emergency, when the assistant driver notices any obstruction / defect in track which the driver could not notice, the assistant driver can operate independently.

2. When the normal application of brakes is not possible or not affected, the driver or assistant driver can use this valve to stop the train.

D1. PILOT AIR VALVE CUM BRAKE ISOLATING VALVE

It is an electrically operated solenoid valve. Whenever Dynamic Brake is applied it disconnects the supply from C3W Distributor valve and connects it to Exhaust. Thus it nullifies the loco brake application through A9 when dynamic brake is applied.



D1. PILOT AIR VALVE CUM BRAKE ISOLATING VALVE

PRESSURE LIMITING VALVE :-

This will control the Output pressure of C_3 W valve to

the desired level. This valve is fitted at the outlet of C3W valve to limit the Brake Cylinder pressure to 2.5Kg/Cm^2.

PRESSURE LIMITING VALVE

24-A DOUBLE CHECK VALVE :

This connects two inlet passages in a common outlet. At a time it connects only one of the two inlet passages with the outlet by isolating the other.

24A-DOUBLE CHECK VALVE

AIR FLOW MEASURING VALVE

This valve indicates charging rate of BP / the leakage of BP pipe through an indicator, which is calibrated in term of No of wagons. Indicator is located at driver's control stand. MR air is connected to C2 W relay valve through Air Flow Measuring valve.

Construction:

MR air is connected to C2 W relay valve through inlet and outlet passages of AFM valve. Disc valve controls inlet and outlet passage of AFM valve. Disc valve has two small ports, one connects MR air to the top chamber of Disc Valve and other connects MR from top chamber of disc valve to Additional C2 Relay valve. Top chamber of Disc valve is the bottom of main diaphragm. Disc valve is pressed down through a follower & spring on its seat. Choke B is provided to connect MR air to top chamber of main diaphragm. Choke C is provided to supply `main diaphragm top chamber air' to indicator, when diaphragm moves down word. Choke D is provided regulate air supplied through choke C towards indicator.

Working:

When the brake pipe is fully charged with air and the air brake is in the release condition, the air flowing from the main air supply through the Airflow measuring valve and to the brake pipe is that necessary to overcome leakage. In this condition the disc valve is closed as shown in diagram and air from the main supply passes through choke A in to the top chamber of disc valve and out to the Additional C2-Relay valve. It also passes in to the chamber under the diaphragm via the space around the follower. At the same time, air from the main supply passes through a filter and choke B in to the chamber above the diaphragm.

So long as the pressures above and below the diaphragm are equal, the diaphragm floats against the choke C. As brake pipe leakage occurs, the pressure at the outlet port and under the diaphragm falls and the diaphragm is moved down away from the choke C and permits air entering the chamber above the diaphragm via choke B, to flow through choke C to an indicator and through choke D to atmosphere.

Choke D is smaller than choke C and an intermediate pressure builds up in the passage between them and registers on the indicator. This intermediate pressure is related to the flow of air through choke C that is controlled by the diaphragm reacting to the pressure under it. As the pressure under the diaphragm depend upon the fall of pressure at the outlet port relative to the main supply pressure, being guided by the flow rate towards BP to make good the leakages during run. It also determines the flow of air through choke A. The indicator therefore provides a visual indication of the amount of air flowing to the brake pipe.

During initial charging or release of brakes, when a large quantity of air passed to the brake pipe, the pressure at the out let port and in spring chamber reduces sufficiently. It allows the supply pressure to lift the disc valve off its seat and permit unrestricted flow of air to the brake pipe through C2 W-Relay valve. Under these conditions a high intermediate pressure builds up in the passages between chokes C and D, and the indicator indicates a high rate of airflow.

Choke D is variable to facilitate calibration and may be altered by means of an adjusting screw, turning the screw clockwise reduces the aperture and turning it anticlockwise enlarges it.

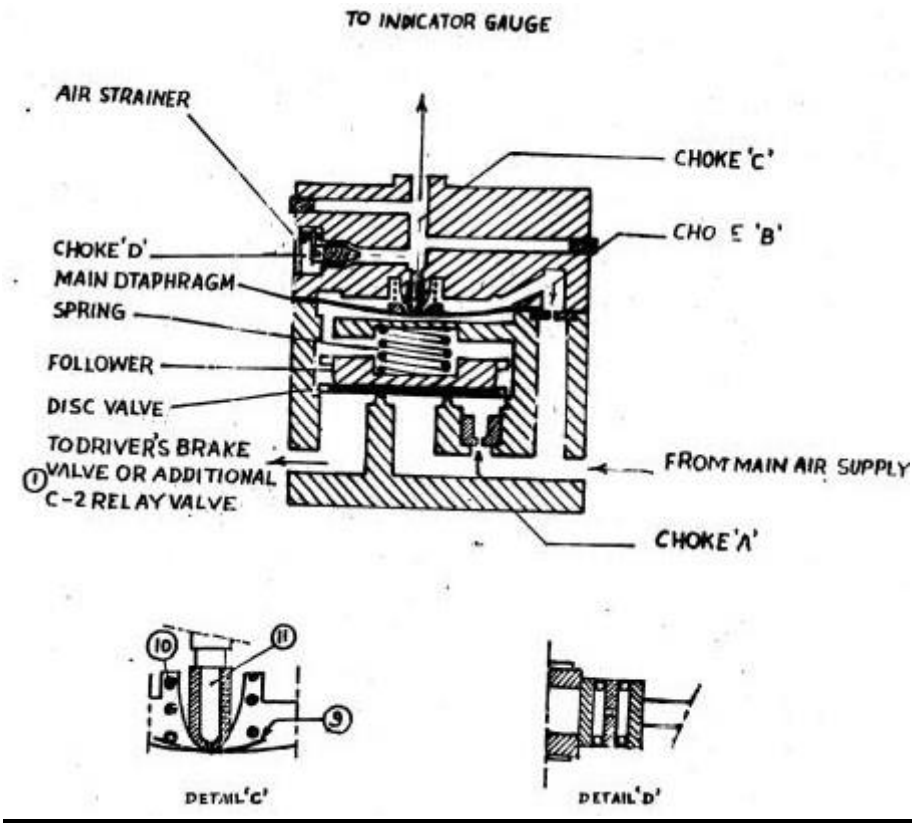
Calibration

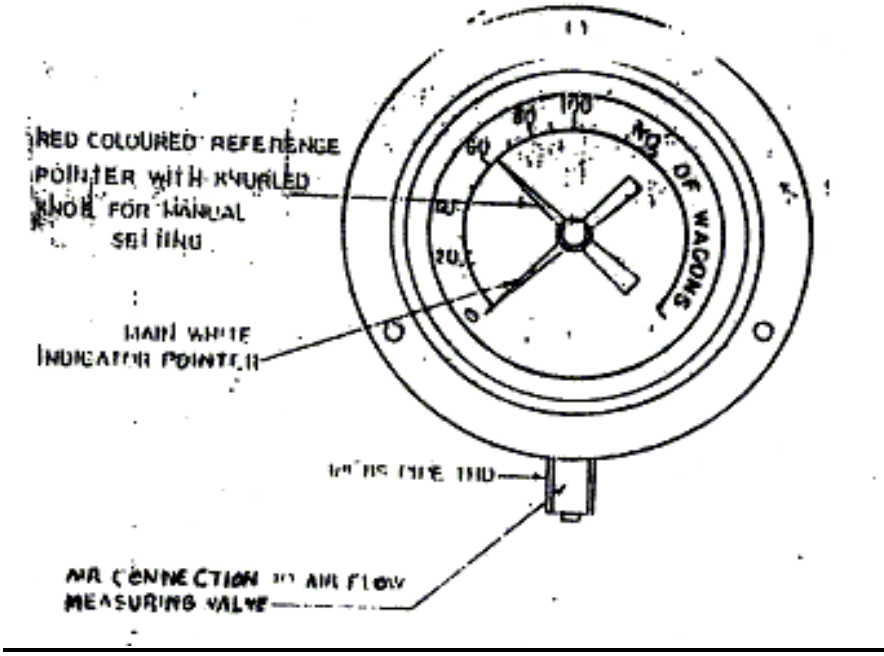
The Airflow measuring valve includes a calibration choke enclosed by a vent plug. This feature is provided to facilitate the calibration of the equipment on the vehicle.

There is a test stand, where the needle valve setting is calibrated on 130 psi charging line. Where AFM valve indicator gauge reads 70 psi/ 100 wagons reading.

AIR FLOW INDICATOR

It is an air pressure gauge with two pointers. Red pointer is called reference pointer, which is attached to a knurled knob and protrudes through the dial glass, so that it can be set manually in any desired position, where as the other pointer (White) moves on the scale depending up on the air flow. The indicator is connected to the measuring valve through R-6 relay valve. The scale on the gauge is calibrated in terms of number of wagons. The 60 marks correspond to the maximum rate of airflow that can be accepted to overcome leakage on a 60 wagon train and so on





AIR FLOW INDICATOR

INDEPENDENT BRAKE-APPLICATION AND RELEASE.

Independent brake application and release is controlled through SA9 Brake handle. When SA9 handle is kept in released position, Brakes are in released condition. When SA9 handle is moved to application zone, it supplies pilot air to C2 relay valve through Port No: 20 to Port No: 2 of MU2B. In lead loco or single unit loco MU2B is kept in lead position. In this, Port No 2 & 20 are interconnected and air from MU2B will come out through port 20. This air acts as Pilot air for C_2 relay valve, entering at Port No 2 (Pilot port) through a double check valve. This pressure acts at the top of main diaphragm of C_2 relay valve. (In trailing loco the MU2B is kept in trail position, port No 2 & 20 are isolated hence brake cannot be applied from the trailing loco).

C2 relay valve in turn will supply air to the Brake Cylinder through port 3 at a pressure equal to pressure at port 2.

There are two Brake cylinders in locos. The outlet air from C2 relay valve goes to the brake cylinders and applies the brakes.

One branch from C_2 relay outlet is connected to F1 selector port 30. Since MU2B is in lead, F1 selector also will be in lead and hence the air at port 30 comes out through port 14 and charges the brake cylinder-equalizing pipe. Normally the COCs at both the ends of BC equalizing pipe are in closed condition. This pipe will be coupled to the trailing loco in MU operation to apply the brakes in trail loco.

If the SA9 handle is moved to release position, the pilot air supplied to C2 relay port 2 will be withdrawn and exhausted through SA9 exhaust port. In turn, C_2 relay valve will withdraw the brake cylinder pressure and exhaust it through exhaust port, till the Brake cylinder pressure is equal to pilot air pressure at port 2. (In this case 0). The pilot air for Brake cylinder pressure will be proportionate to the position of SA9 handle during application and release. A gauge pipe is connected after the front truck Brake cylinder COC to indicate the BC pressure to the driver's control stand.

AUTOMATIC BRAKE APPLICATION AND RELEASE.

BP CHARGING:

The charging and exhausting of BP is done through A9 Brake handle for application and release of formation brake in conjunction with Loco Brake. When the A9 handle is kept in release position, it supplies pilot air at 5 Kg/Cm^2 to the port 2 of C_2W relay air valve through MU2B port 3 and 13. A volume reservoir is also connected at this line to dampen fluctuation of pressure. C_2W valve thus charges the BP equal to the pilot pressure. At the outlet of C_2W valve, a ¾" COC is fitted which should be open in single unit / lead unit and closed in trailing unit.

At the inlet to C_2W relay valve, an airflow-measuring valve is fitted which is connected to an Air Flow Indicator Gauge situated at Driver's Cab. The indicator indicates the rate of MR airflow through C_2W relay valve i.e. rate of charging of BP. This arrangement is used to find the condition of brake pipe. If the leakage in B Pipe is high, the indication will show a higher valve. If there is no leakage the indicator show zero.

MONITORING OF BP CHARGING:

While starting a train after coupling and charging the Brake pipe, the driver should check the indicator reading. It should be less than the number of vehicles in that train. (The graduations are in 'No of wagons') and turn Red needle and align with the white needle. While working, if BP starts leaking, the white needle will overshoot the red needle. This is the indication of a problem / leakage in Brake pipe. On getting this indication, the driver should stop, investigate the reason for BP leakage and rectify.

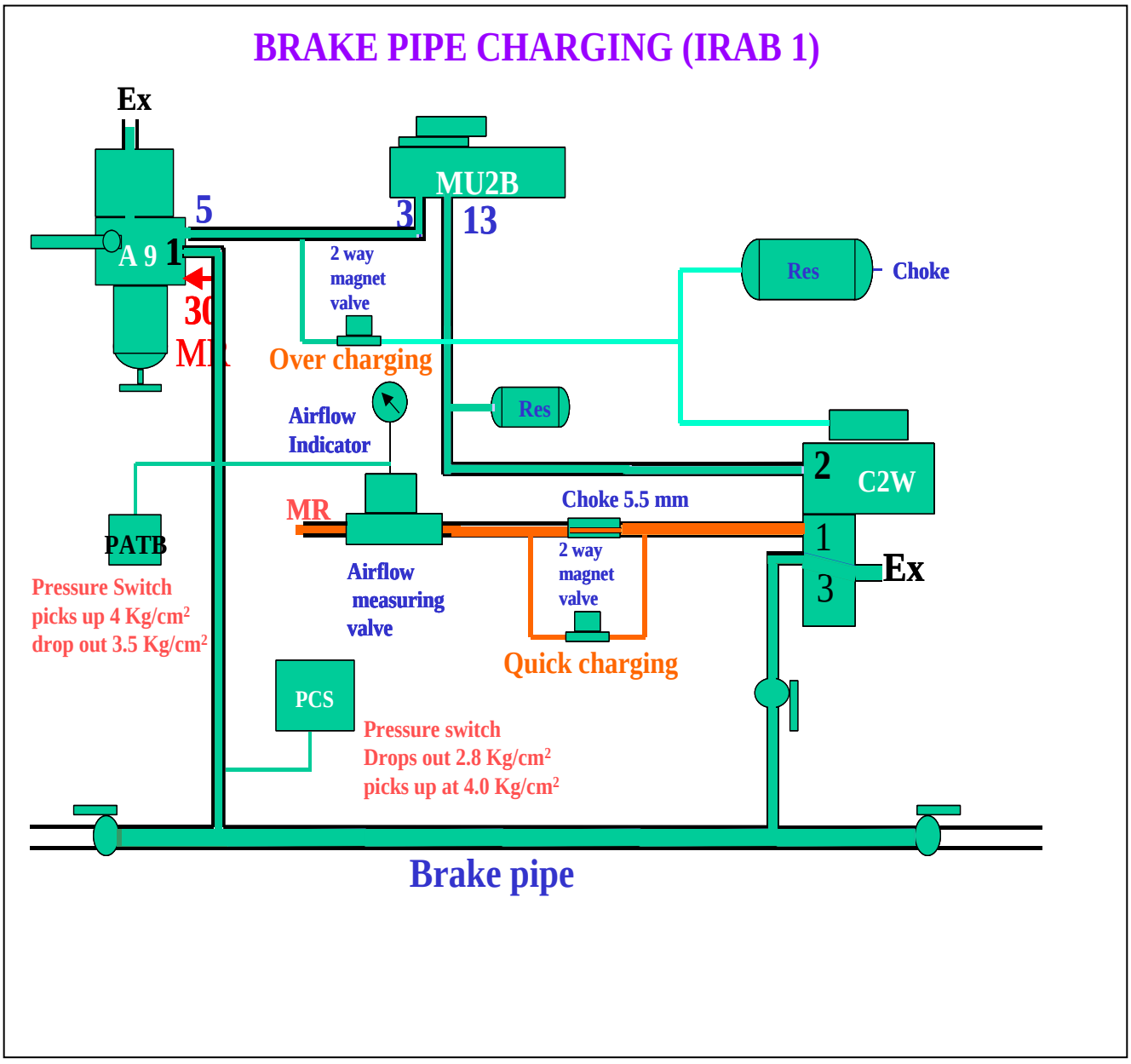
When the A9 valve handle is moved to application zone i.e. to min. reduction, or more, A9 valve reduces the pilot air to C2W and hence C2W also reduces the brake pipe pressure (BP charging rate drops to zero).

When A9 handle is kept in Emergency, the Brake pipe drop to zero immediately causing emergency brake application in formation (BP charging rate drops to zero).

During release the rate of charging of BP is very high and the white needle deflection of Airflow indicator shoots up and then stabilizes, which should not be misunderstood as defect in Brake pipe.

AUTOMATIC / CONJUCTION BRAKE IN LOCOMOTIVES:

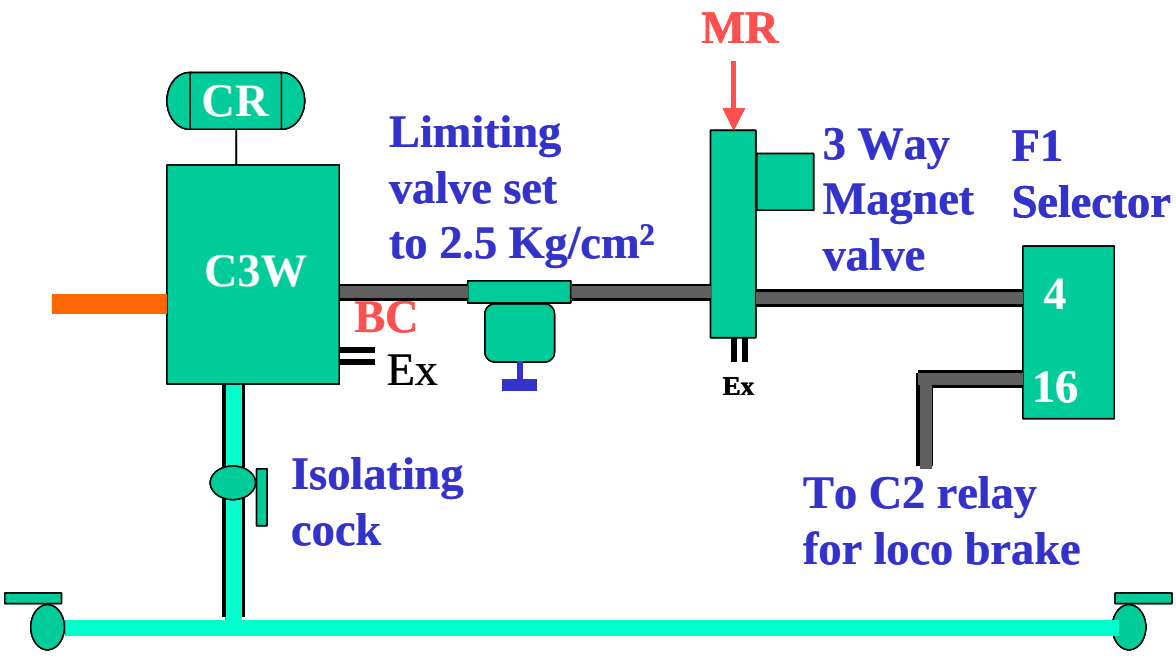
The arrangements of valves are shown in sketch.



avoid delay due to brake binding, the brake pipe is charged more than 5 Kg/cm^2 (i.e.,5 Kg/Cm^2 max). By doing so, the C3W valves of all the vehicles will be forced to release the brakes, because as per general logic brake releases when BP is equal to or more than CR. This is done by the overcharging function in this system.

For overcharging, the crew should press overcharging button, in certain cases switch. This switch energizes the 2-way magnet valve, supplying BP pilot air to C_2W relay valve. This pressure increases the setting of C_2W valve to 5.4 Kg/Cm2 (this is done by charging the top diaphragm to an additional value). The overcharging continues till the button/ switch hold pressed. It is advisable not to allow the BP to rise more unnecessarily long time to resume the normal operation. The switch should be released as soon as the BP rises to 5.2 Kg/Cm^2.

CO-ORDINATED BRAKING APPLICATION



QUCIK CHARGING FUNCTION:

Normally to meet the leakages in the BP line during running condition a 5.5 mm choke is provided at the inlet to the C2 relay valve, the purpose of providing choke is just to meet the loss of BP during run. Otherwise excess rate of charging will not reduce the BP for application of brake and indication in case of Chain pulling / guard's brake application. But during initial charging and releasing of brake BP need to be charged faster. To charge the pipes faster, a bypass for this choke is provided with a 2 way magnet valve. On energizing the magnet valve, the choke is bypassed to normal opening ¾", resuming the normal capacity of C_2W relay valve. This should be used to avoid auto flasher to switch ON during releasing the brakes (which takes place if the charging time is more than 60 sec).

SAFETY DEVICES

These safety devices are shown in the sketches.

A9 EMERGENCY:

The A9 emergency is applied BP will be reduced to zero. When the pressure is less than 2.5Kg/Cm^2 the PCS operate and brings the engine to idle.

TRAIN PARTING:

When train parting occurs, air leaks out heavily through the brake pipe causing Airflow indicator to shoot up. When the reading goes beyond 80 wagons (4.0 Kg/cm^2) at the indicator pipe, the PCS operates and brings the engine to idle. If the trouble is rectified and the reading reduces to 70 wagons, (3.5 Kg/ Cm^2 at the indication pipe) this PCS resets and allow the engine to rise.

DIESEL LOCOMOTIVE TWIN PIPE DUAL BRAKE SYSTEM

INTRODUCTION

Diesel locomotives of Indian Railways are equipped with brake system designed by either M/S WABCO/ USA or M/S KNORR Germany or IRAB-1 Indian Railways or M/S KNORR Brake (NYAB). Initially locomotives were equipped with M/S WABCO, USA designed 28LV-1 Brake system for use in vacuum brake train only. In 80's locomotives were switched over to 28LAV-1 Brake system for use both in vacuum and air braked Trains.

In 90's some of the locomotives were equipped with IRAB-1 brake system, which are suitable for only air-braked trains. Recently acquired WDG4 and WDP4 locomotives are equipped with CCB (computer control brake) system designed by KNORR BRIMSE (NYAB), which are suitable for air braked train only.

Important feature of the 28LAV-1 brake system

1. Locomotive brakes may be applied with any desired pressure between the minimum and maximum. This pressure will be maintained automatically in the locomotive brake cylinders against normal leakage from them.
2. The locomotive brakes can be graduated on & off with either the automatic or the independent brake valve.
3. It is always possible to release the locomotive brakes with the independent brake valve, even when automatically applied.
4. The maximum braking position emergency, ensuring the shortest possible stops distance.
5. It is always possible to haul both vacuum / air brake trains.
6. Automatic brake application and power cut off with idle rpm of engine is always possible during train parting.
7. Multiple unit operation is also possible.

INDEPENDENT BRAKE SYSTEM (LOCO BRAKE)

Introduction:

Loco brake system is provided to stop the Locomotive, whenever it runs as light engine. It is purely compressed air brake system known as independent brake system. For this separate air circuit is provided in 28LAV-1 & IRAB-1 Brake system which is independent to other air circuit. SA9 Independent brake valve is provided in driving control stand for application & release of loco brake. Valve has three positions i.e. quick release, release and application.

Purpose of this system:

Independent Brake System is designed to apply and release brake on locomotive only, especially when the locomotive is moving independently.

System brake valves:

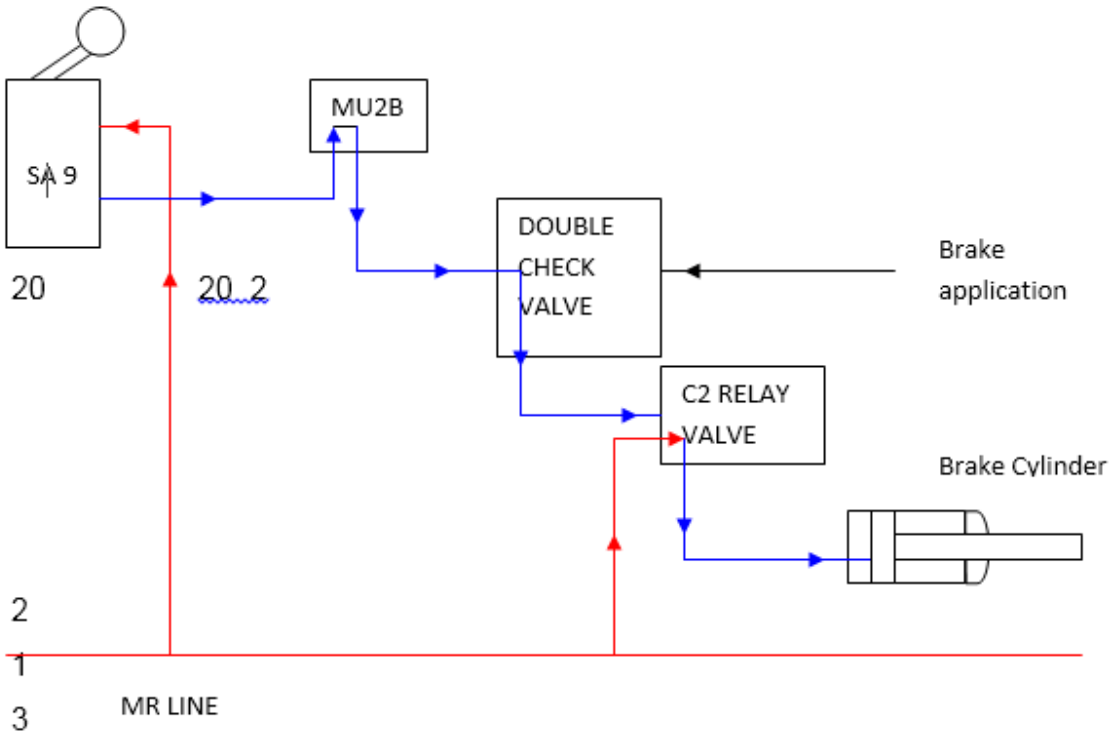
System consists of SA9 Independent Brake valve, Double check valve and C2-Relay valve.

Description of loco brake (Independent brake) system

The SA9 Valve handle is kept normally in release position (right side). MR air is always available at port no.30 of SA9 valve. When handle is brought in application potion (left side) than SA9 port 30 connects port 20 and starts supplying pilot air to C2-Relay air valve. The pilot air passes through MU2B Valve port no. 2&20 and inters to C2-Relay at port no.2. See the line diagram of loco brake system. The pilot air pressure depends upon the handle position; in full application it is 3.5kg/cm2. The C2-relay air valve actuates after getting pilot air and connects MR pressure to brake cylinders of locomotive through port no.1&3. The brake cylinder pressure depends upon pilot air pressure, supplied into C2-Relay

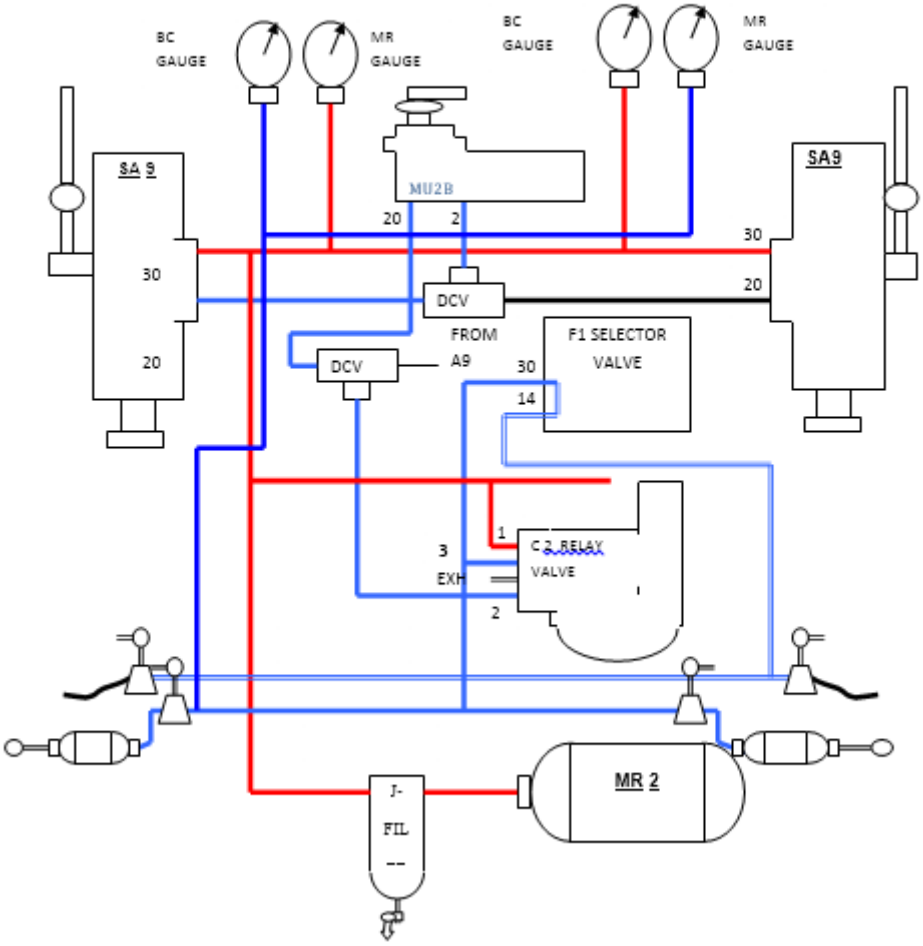
chamber through port no.2. For full brake application SA9 handle is moved to maximum travel position. In this way independent brake/loco brake is applied. Gauge line connection is taken from BC pipe near front truck of locomotive to the driver's control stand for indicating brake cylinder pressure. When SA9 handle is placed in release position, loco brakes are released. For detailed understanding see the internal function of the SA9 valve & C2-Relay valve.

SA9 Brake valve handle is normally kept in release position. It can be applied to any desired pressure between the minimum and maximum through SA9 valve handle. This pressure will be automatically maintained in the locomotive brake cylinders against normal leakage from them. The locomotive brake can be graduated on and off with either the automatic (A9) or the independent brake valves (SA9). It is always possible to release the locomotive brake with SA9 valve.



INDEPENDENT BRAKE APPLICATION

INDEPENDENT BRAKE SYSTEM LAYOUT



VACCUM BRAKE SYSTEM

INTRODUCTION

Indian Railway runs both the trains vacuum and air brake. In vacuum brake train brakes are controlled through vacuum of train pipe. After coupling the locomotive with the vacuum brake train the vacuum hoses are connected to obtain vacuum in train pipe. The exhauster unit of the locomotive is connected with vacuum train pipe through a vacuum control valve (VA1A/ VA1B), to create the vacuum in the train pipe as well as the Vacuum cylinders of each coach/wagon. A9 automatic brake valve is provided in driving control stand through which vacuum is controlled for application and release of brake. Normally valve handle is kept in release position.

PURPOSE OF THIS SYSTEM

This system is designed to apply and release brakes on vacuum brake train. Which is achieved through A9 Automatic Brake valve.

VACUUM BRAKE SYSTEM VALVES

System consists of A9 Automatic Brake valve, VA1B Control valve and HS4 Control valve.

DESCRIPTION OF VACCUM BRAKE SYSTEM

Locomotive and train has a long vacuum brake pipe, in which 56cm vac. is maintained through an exhauster unit and a vacuum control valve (VA1A/ VA1B). A9 automatic brake valve is provided in driving control stand to apply vacuum brake in the train. When A9 handle is placed in application zone, train pipe vacuum drops and brakes are applied through vacuum cylinders of coaches.

The function of A9 valve is to supply Brake Pipe pressure in 28 LV1 system or to provide control air pressure to Add.C2-Relay valve for charging Brake Pipe in 28 LAV1 system. The function of VA1B control valve is to control vacuum according to control air pressure of Brake Pipe. The function of HS4 valve is to supply 1.7kg/cm2-air pressure to bottom chamber of VA1B control valve at port no.1. Other valves are provided in this circuit for MU operation. See line diagram of vacuum brake circuit.

CHARGING OF SYSTEM

Air at 8 to 10kg/cm2 pressure is charged at different valves through MR-2 (See the line diagram of vacuum system) i.e. at port no.30 of A9 valve, port no.1 of Add.C2-Relay valve and port no.1 of HS4 control pressure valve. A9 valve handle is kept at release position normally. In release position, A9valve will supply control pressure to additional C2-Relay valve through MU2B valve. After getting supply of control pressure, Add.c2-relay valve will charge BP according to control Air Pressure. BP pipe is connected to VA1B control valve top chamber at port no.3. At port no.1 control pressure at 1.7kg/cm2 is supplied through HS4 control valve. VA1-B control valve maintains 56cm vacuum in train pipe by connecting it to Expressor.

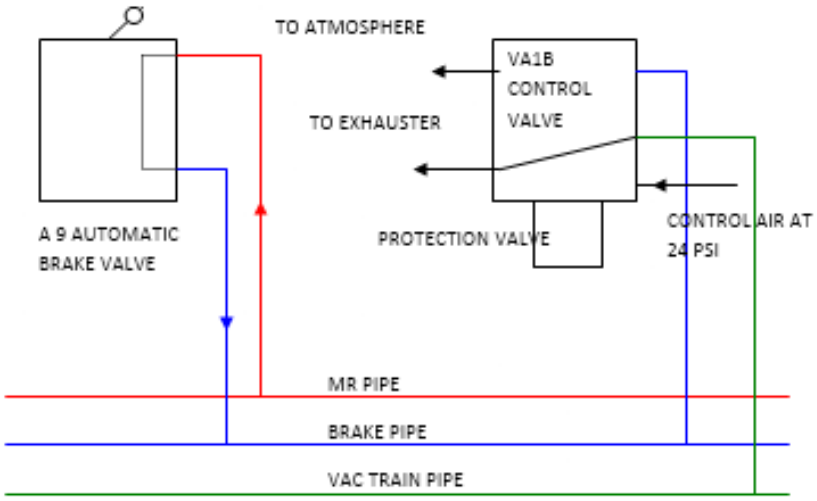
APPLICATION OF BRAKE

A9 handle is moved in application zone for brake application. A9 reduces Control pressure to Add.C2 Relay valve. Add. C2 Relay reduces BP pressure in proportion to control pressure droppage. BP pressure drops to zero if A9handle is moved at over reduction position. If handle is placed at emergency position BP will drop to zero immediately within 3 sec. Due to dropping BP pressure, brakes are applied in train through distributor valve in case of air brake train. In case of vacuum brake train, control pressure at the top chamber of VA1B control valve is dropped, which causes movement of spool valve connecting train pipe to atmosphere and applies brake.

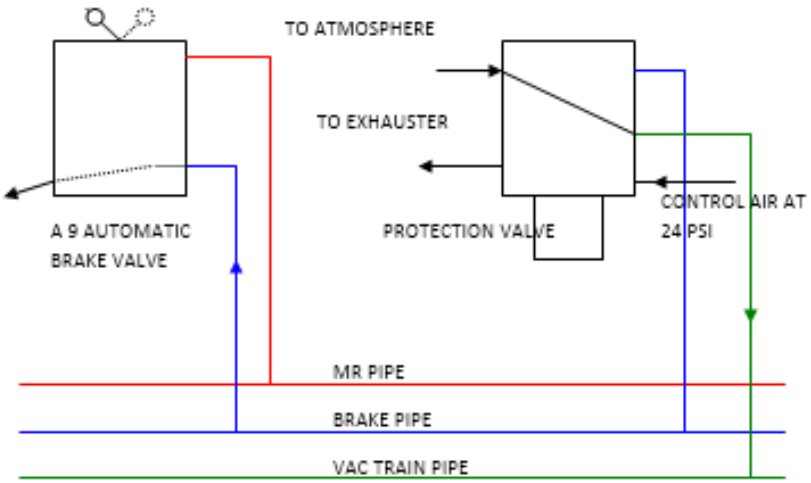
RELEASING OF BRAKE

When handle is moved to release position, A9 valve starts supplying full control pressure to additional C2 Relay valve, which in turn charges Brake Pipe. When pressure increases to 5kg/cm2 and brakes are fully released.

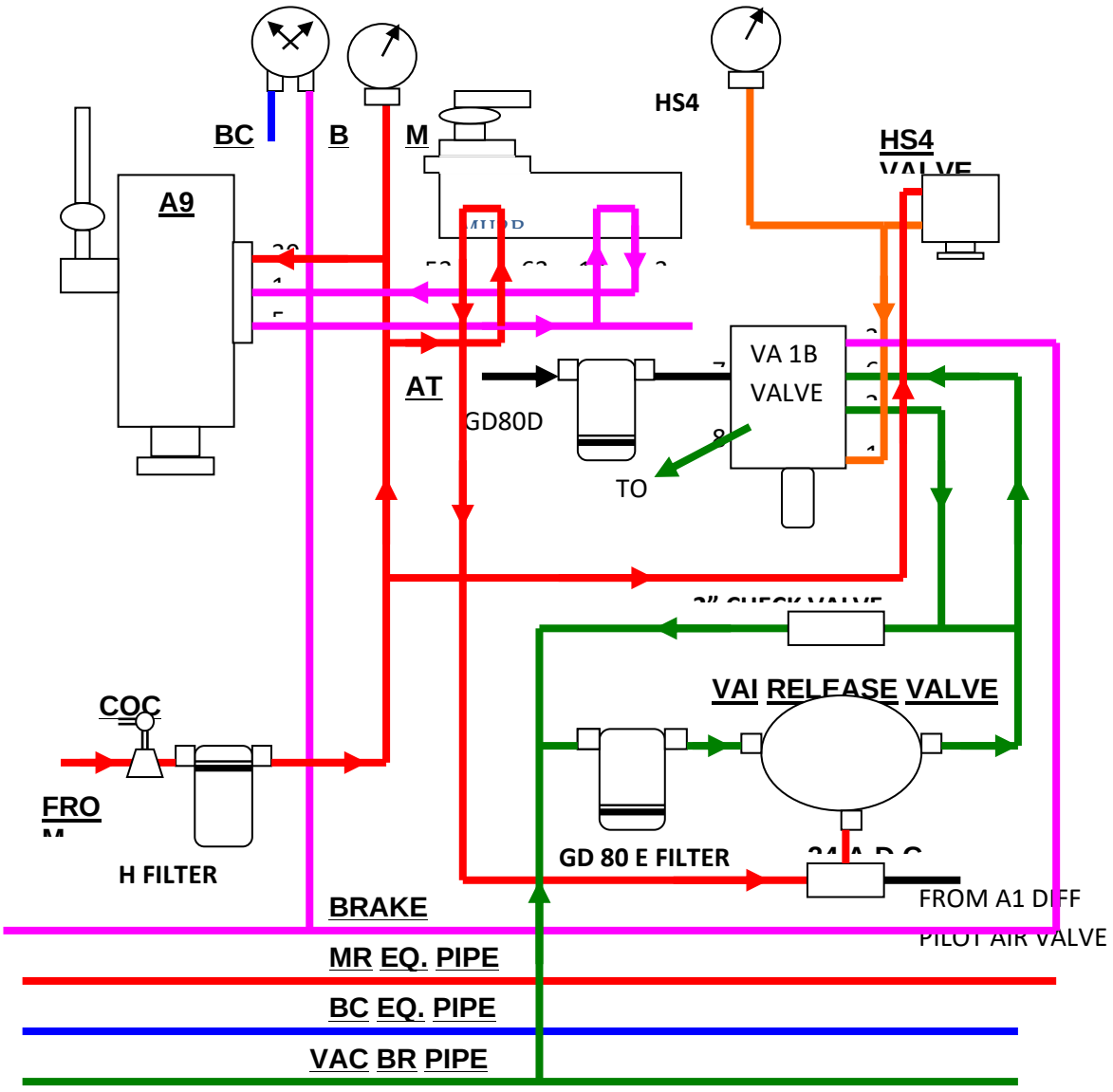
VACUUM BRAKE RELEASE POSITION



VACUUM BRAKE APPLICATION POSITION



VACUUM BRAKE SYSTEM



VACUUM TROUBLE IN TRAIN

Following test are recommended:-

1. BLOCKAGE TEST: Remove one end of the vacuum hose pipe and raise it upwards. If more than 8cm vacuum is created, there is a blockage in the system.

2. EFFICIENCY TEST: Against an 8 mm leak disc, the loco should create 53 cm vacuum.

3. LEAKAGE TEST: Vacuum on dummy and on leak disc should not vary more than 3 cm.

The Board has therefore standardized the vacuum level in engine and brake van for all Railways in both the traction.

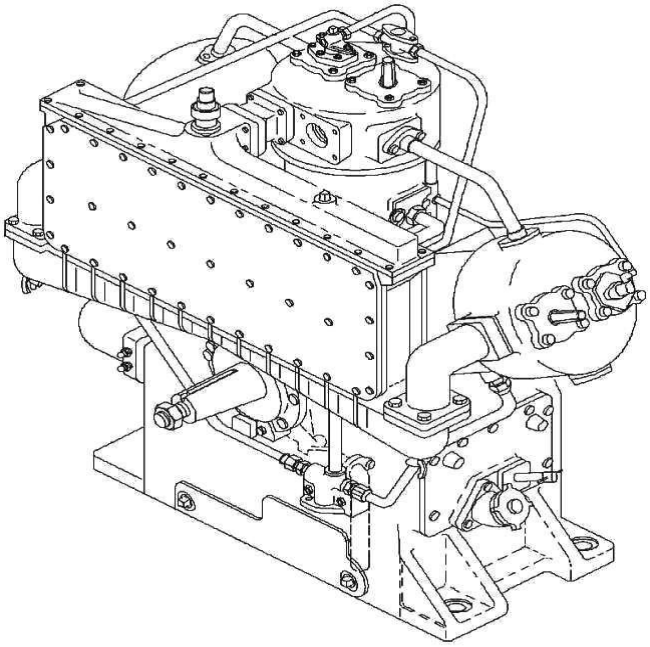
Type of service	Engine	Brake van	Average
M/E	53	47	50
Passenger	50	44	47
Goods	46	38	42

3. COMPRESSORS:

WORKING OF COMPRESSOR

Compressed air in HHP locomotive is used for the locomotive brake system as well as for auxiliary systems such as sanders, bell, horn, windshield wipers, rail lube systems, and radar head air cleaner.

The HHP locomotive uses WLNA9BB model three cylinder air compressor which is a two stage (low-pressure and high-pressure) compressor. The compressor is water-cooled. The compressor is mechanically driven by a driveshaft from the front or accessory end of the locomotive engine. This driveshaft is equipped with flexible couplings to couple the compressor.



WLNA9BB - AIR COMPRESSOR ASSEMBLY

The compressor is equipped with three cylinders, two low pressures and one (in the center) high pressure. Air is sucked through two dry pamic type air filters and compressed by the two low pressure cylinders. After that the low-pressure compressed air passed through an

intercooler. The intercooler reduced the compressed air temperatures. A pressure relief valve is provided on the intercooler for intercooler safety. After this the compressed air moves on to the high-pressure cylinder where it is again compressed to main reservoir pressure. Between the compressor and main reservoir an after cooler cooling coil is provided to reduce the air temperature.

The compressor has its' own internal oil pump and pressure lubricating system with an oil filter. The oil level is checked during running by means of the dipstick mounted on the side of the compressor crankcase. When adding oil in the compressor it must be in stop position.

At idle speed and normal operating temperature, the oil pressure should be between 18-25 psi. A plugged opening is provided for installation of an oil pressure gauge

AIR COMPRESSOR MAINTENANCE

The compressor oil level should be checked regularly using the dipstick, and the oil level should be kept at the full mark. The compressor oil and compressor oil filter should be changed at the scheduled maintenance intervals.

The compressor air filters should be changed out at the scheduled maintenance intervals. Remove the filters by first removing the nuts attached to the clamps on the filter housing. Swing the clamps to the side and remove the retainer screen. The filter housing and screen should be cleaned whenever the filter elements are change out. When the application of test gauges are required for maintenance ensure that the gauges are removed and the proper sized plug inserted and tightened before returning the locomotive to service.

Air compressor change out and overhaul should be done at the scheduled maintenance intervals.

AIR COMPRESSOR CONTROL

The standard air compressor on a GT46MAC locomotive is coupled directly to the diesel engine through a driveshaft and when the engine is running, the air compressor is being

driven. Therefore an unloader assembly, mounted on the compressor, is required to control when the compressor is actually pumping air.

The intake or suction valves of the compressor contain unloaders that block the valve open when pneumatically activated. With the intake valves blocked open the compressor is incapable of compressing, whether it is rotated or not. These unloaders are controlled pneumatically, through the unloader magnet valve.

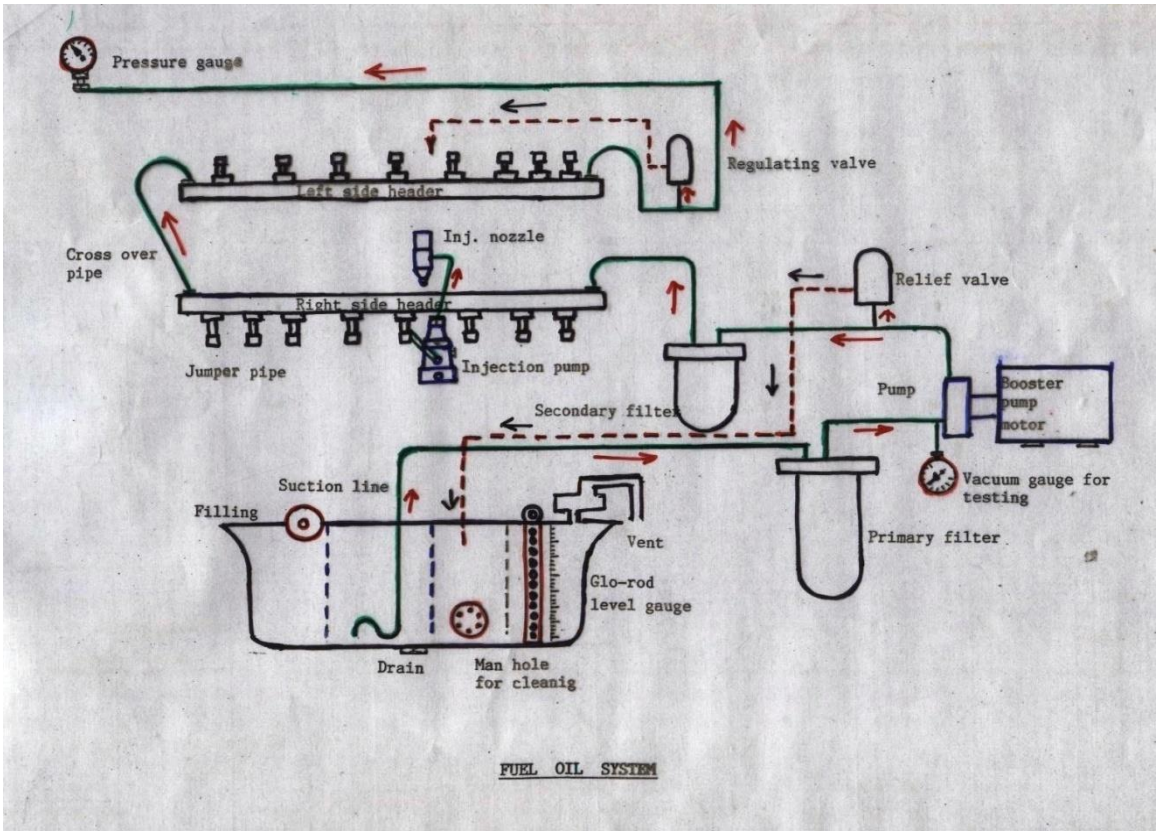
This valve is called the MV-CC, or Magnet Valve Compressor Control.

The locomotive computer, the EM2000, controls the MV-CC in turn. When the locomotive is started, the computer picks up the MV-CC, allowing main reservoir air through to activate the unloaders. When the computer, monitoring main reservoir pressure, notes that the pressure is below the required pre-programmed maximum pressure it drops out the MV-CC. This releases the unloaders causing the compressor to load.

4. FUEL OIL SYSTEM

INTRODUCTION

All locomotive units have individual fuel oil system. The fuel oil system is designed to introduce fuel oil into the engine cylinders at the correct time, at correct pressure, at correct quantity and correctly atomized. The system injects into the cylinder correctly metered amount of fuel in highly atomized form. High pressure of fuel is required to lift the nozzle valve and for better penetration of fuel into the combustion chamber. High pressure also helps in proper atomization so that the small droplets come in better contact with the fresh air in the combustion chamber, resulting in better combustion. Metering of fuel quantity is important because the locomotive engine is a variable speed and variable load engine with variable requirement of fuel. Time of fuel injection is also important for better combustion.



FUEL OIL SYSTEM

The fuel oil system consists of two integrated systems.

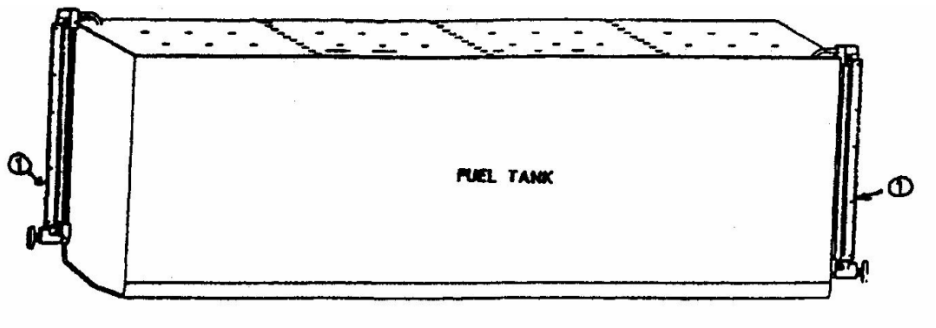
- Fuel feed system.
- Fuel injection system.

FUEL FEED SYSTEM AND ITS ASSOCIATE COMPONENTS

Fuel feed system provides the back-up support to the fuel injection pumps by maintaining steady supply of fuel to them at the required pressure so that the fuel pump can meter and deliver the oil to the cylinder at correct pressure and time. The fuel feed system includes the following:-

Fuel oil tank:

A fuel oil tank of required capacity (normally 5000ltrs), is fabricated under the superstructure of the locomotive and located in between the two bogies. Baffle walls are used inside it to arrest surge of oil when the locomotive is moving. A strainer filter at the filling plug, an indirect vent, drain plug, and glow rod type level indicators are also provided.

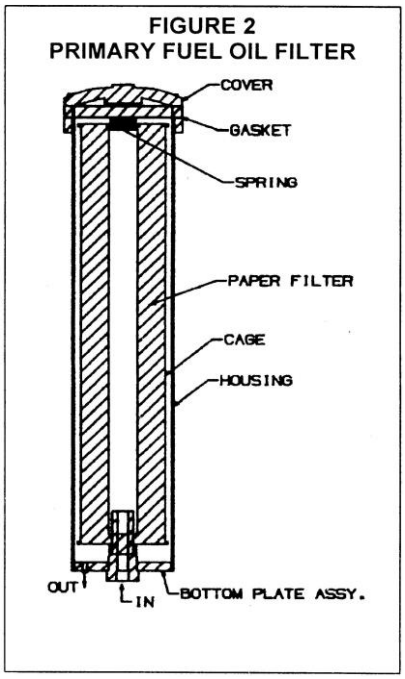


FUEL OIL TANK

Fuel primary filter:

A filter is provided on the suction side of the fuel transfer pump to allow only filtered oil into the pump. This enhances the working life of the fuel transfer pump. This filter is most often a

renewable bleached cotton waste packed filter, commonly known as socks type filter element. These socks type filters are coarse filters and have a greater ability to absorb moisture, and are economical. However, in certain places, it has been replaced by paper type filter, which have longer service life.



PRIMARY FUEL OIL FILTER

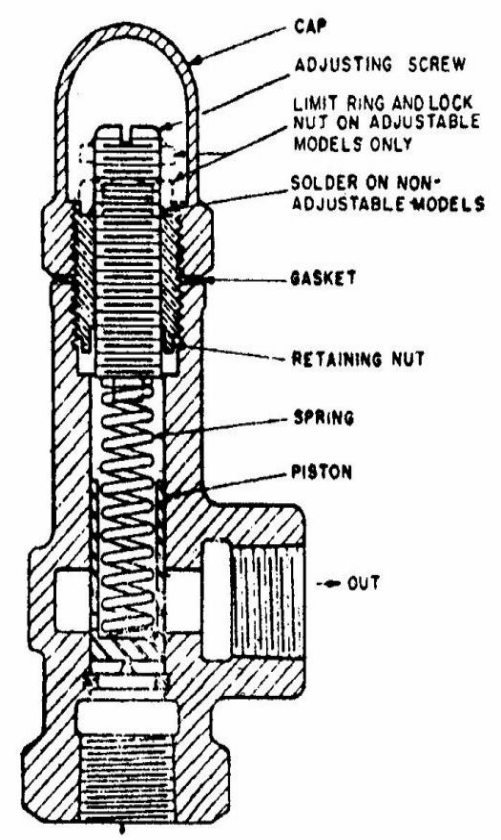
Fuel transfer pump or booster pump:

The fuel feed system has a transfer pump to lift the fuel from the tank. The gear type pump is driven by a dc motor, which is run by storage batteries through a suitable circuit. The pump capacity is 14 litres per minute at 1725 rpm at pressure 4 to 4.8 kg/sq.cm.

Fuel relief valve:

The spring- loaded relief valve is meant for by passing excess oil back to the fuel tank, thus releasing excess load on the pump and on the motor, to ensure their safety. It is adjusted to

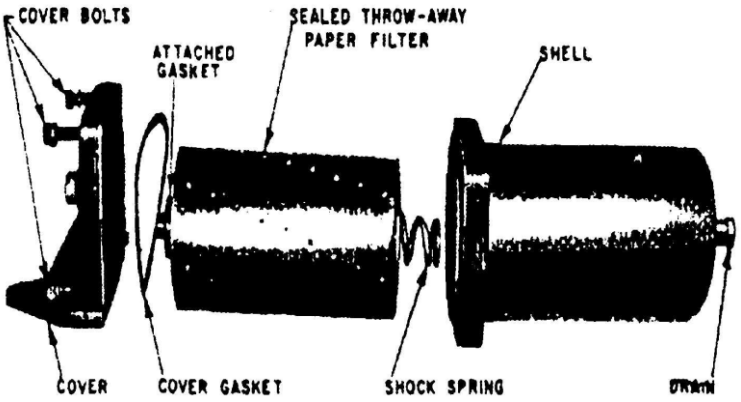
a required pressure (normally 5 kg/cm^2), and it by- passes the excess fuel back to the oil tank. It also ensures the safety of the secondary filter and the pipe lines.



FUEL RELIEF AND REGULATING VALVE

Fuel secondary filter:

The fuel secondary filter is located after the booster pump in the fuel feed system. The filter used is a paper type filter, cartridge of finer quality, renewable at regular intervals. This filter arrests the finer dirt particles left over by the primary filter and ensures longer life of the fuel injection equipment.



SECONDARY FUEL OIL FILTER

Fuel regulating valve:

The fuel-regulating valve is spring-loaded valve of similar design as the fuel relief valve. It is located after the secondary filter in the fuel feed system. This valve is adjusted to the required pressure (3 kg/cm^2), and always maintains the same pressure in the fuel feed system by releasing the excess oil to the fuel oil tank. There is no by-passing of oil if the pressure is less than the adjusted level.

FUNCTIONING OF FUEL FEED SYSTEM

The fuel booster pump or transfer pump is switched on and the pump starts sucking oil from the fuel oil tank, filtered through the primary filter. Because of variable consumption by the engine, the delivery pressure of the pump may rise increasing load on the pump and its drive motor. When the rate of consumption of the fuel by the engine is low, the relief valve ensures the safety of the components by releasing load, by- passing the excess pressure back to the tank. Then oil passes through the paper type secondary filter and proceeds to the right side fuel header. The fuel header is connected to eight numbers of fuel injection pumps on the right-bank of the engine, and a steady oil supply is maintained to the pumps

at a pressure of 3 Kg./ sq. cm. Then the fuel oil passes on to the left side header and reaches eight fuel injection pumps on the left bank through jumper pipes. The regulating valve remaining after the left side fuel header, takes care of excess pressure over 3 Kg/cm Square by passing the extra oil back to the tank. A gauge connection is taken from here leading to the driver's cabin for indicating the fuel oil feed pressure. Thus the fuel feed system keeps fuel continuously available to the fuel injection pumps, which the pumps may use or refuse depending on the demand of the engine.

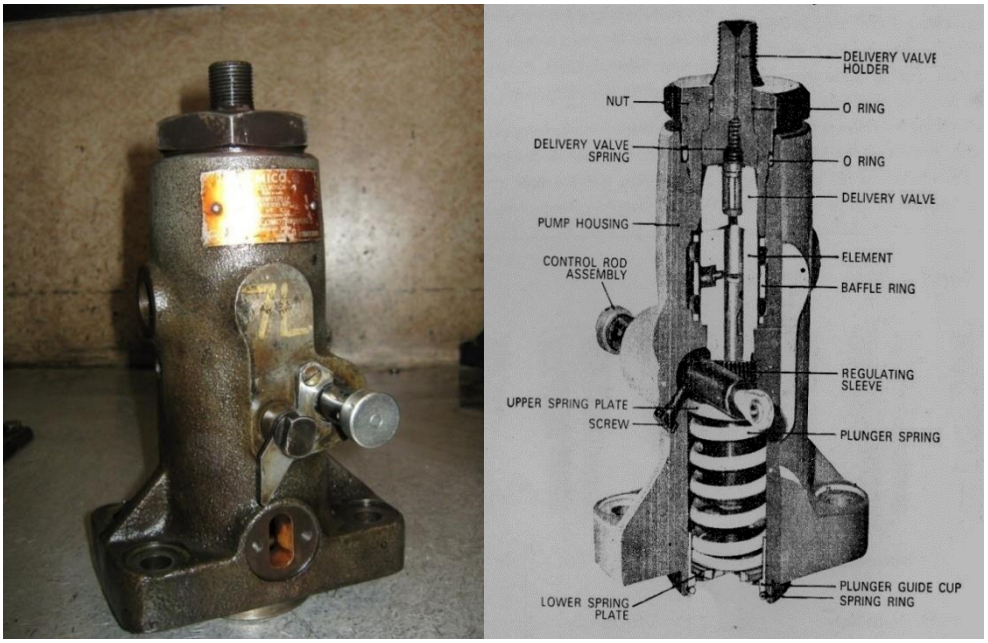
FUEL INJECTION SYSTEM

When diesel engine is started, all fuel injection pumps start functioning. According to firing order all F.I. pumps start discharging fuel oil at high pressure to their respective nozzles through high pressure line tube. Fuel injection nozzle injects fuel oil to combustion chamber at 4000 psi. The internal function of F.I. pump and nozzle are described below.

Fuel Injection Pump:

It is a constant stroke plunger type pump with variable quantity of fuel delivery to suit the demands of the engine. The fuel cam controls the pumping stroke of the plunger. The length of the stroke of the plunger and the time of the stroke is dependent on the cam angle and cam profile, and the plunger spring controls the return stroke of the plunger. The plunger moves inside the barrel, which has very close tolerances with the plunger. When the plunger reaches to the BDC, spill ports in the barrel, which are connected to the fuel feed system, open up. Oil then fills up the empty space inside the barrel. At the correct time in the diesel cycle, the fuel cam pushes the plunger forward, and the moving plunger covers the spill ports. Thus, the oil trapped in the barrel is forced out through the delivery valve to be injected into the combustion chamber through the injection nozzle. The plunger has two identical helical grooves or helix cut at the top edge with the relief slot. At the bottom of the plunger, there is a lug to fit into the slot of the control sleeve. When the rotation of the engine moves the camshaft, the fuel cam moves the plunger to make the upward stroke. It may also

rotate slightly, if necessary through the engine governor, control shaft, control rack, and control sleeve. This rotary movement of the plunger along with reciprocating stroke changes the position of the helical relief in respect to the spill port and oil, instead of being delivered through the pump outlet, escapes back to the low pressure feed system. The governor for engine speed control, on sensing the requirement of fuel, controls the rotary motion of the plunger, while it also has reciprocating pumping strokes. Thus, the alignment of helix relief with the spill ports will determine the effectiveness of the stroke. If the helix is constantly in alignment with the spill ports, it bypasses the entire amount of oil, and nothing is delivered by the pump. The engine stops because of no fuel injected, and this is known as 'NO-FUEL' position. When alignment of helix relief with spill port is delayed, it results in a partly effective stroke and engine runs at low speed and power output is not the maximum. When the helix is not in alignment with the spill port throughout the stroke, this is known as 'FULL FUEL POSITION', because the entire stroke is effective. Oil is then passed through the delivery valve, which is spring loaded. It opens at the oil pressure developed by the pump plunger. This helps in increasing the delivery pressure of oil. it functions as a non-return valve, retaining oil in the high pressure line. This also helps in snap termination of fuel injection, to arrest the tendency of dribbling during the fuel injection. The specially designed delivery valve opens up due to the pressure built up by the pumping stroke of plunger. When the oil pressure drops inside the barrel, the landing on the valve moves backward to increase the space available in the high-pressure line. Thus, the pressure inside the high-pressure line collapses, helping in snap termination of fuel injection. This reduces the chances of dribbling at the beginning or end of fuel injection through the fuel injection nozzles.



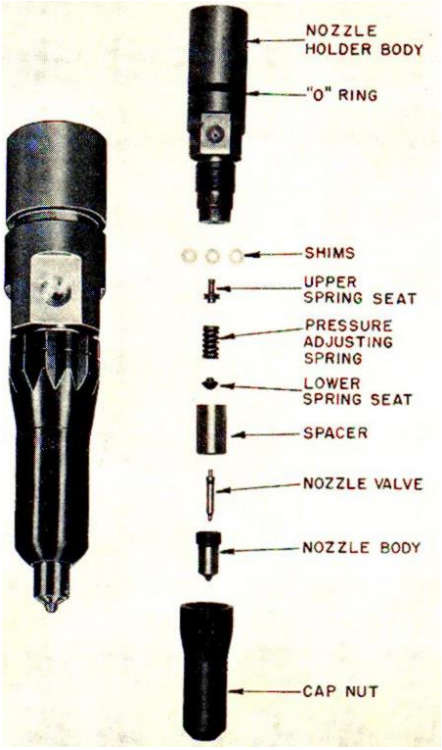
FUEL INJECTION PUMP

Fuel Injection Nozzle:

The fuel injection nozzle or the fuel injector is fitted in the cylinder head with its tip projected inside the combustion chamber. It remains connected to the respective fuel injection pump with a steel tube known as fuel high pressure line. The fuel injection nozzle is of multi-hole needle valve type operating against spring tension. The needle valve closes the oil holes by blocking the oil holes due to spring pressure. Proper angle on the valve and the valve seat, and perfect bearing ensures proper closing of the valve.

Due to the delivery stroke of the fuel injection pump, pressure of fuel oil in the fuel duct and the pressure chamber inside the nozzle increases. When the pressure of oil is higher than the valve spring pressure, valve moves away from its seat, which uncovers the small holes in the nozzle tip. High-pressure oil is then injected into the combustion chamber through these holes in a highly atomised form. Due to injection, hydraulic pressure drops, and the valve returns back to its seat terminating the fuel injection, termination of fuel

injection may also be due to the bypassing of fuel injection through the helix in the fuel injection pump causing a sudden drop in pressure.



INJECTOR

SUMMARY:

Fuel Feed System is responsible for supply of clean oil with adequate quantity at required pressure to Fuel Injection System, to meet the requirement of fuel oil of the engine at rated output. In Fuel Feed System, Fuel tank acts as reservoir of HSD oil of the engine; Primary and Secondary filters maintain cleanliness of oil in the system. Fuel Booster Pump works for generating pressure and maintaining adequate supply of fuel in the system; Relief and Regulating Valves maintain constant pressure in the feed system.

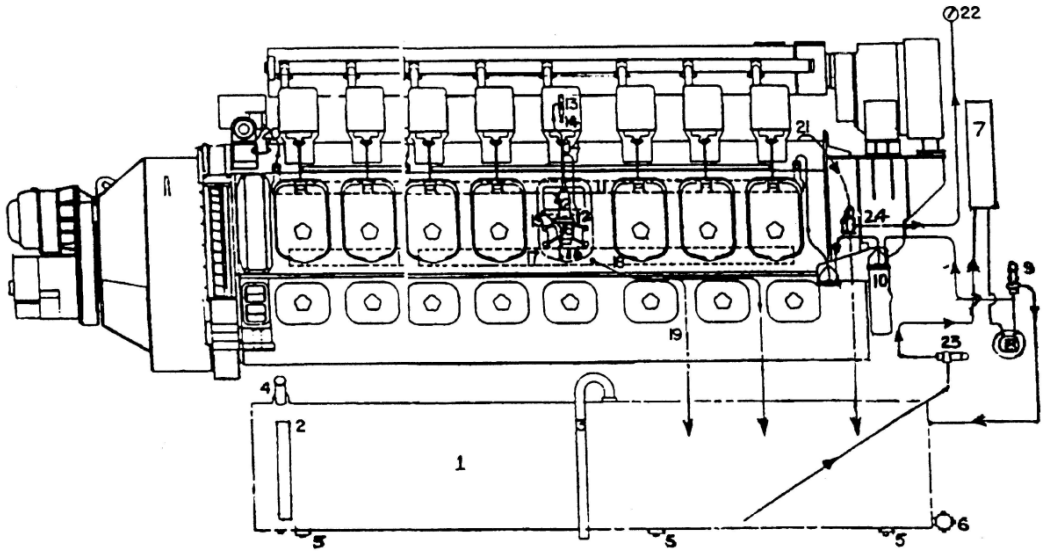
Fuel Injection System comprises of mainly two components.

(a) Fuel Injection Pump.

(b) Fuel Injection Nozzle.

Fuel Injection Pump is a plunger type Pump having constant stroke with variable delivery. The quantity of fuel delivered is decided by the position of the helix groove that varies with the twisting of the plunger according to the fuel rack position. Hence it is responsible for supplying correct quantity of pressurized fuel up to the nozzle. Nozzle is responsible for delivering pressurized fuel in atomized form into the combustion chamber. The breaking pressure i.e. the final pressure at which fuel is released into the combustion chamber is decided by the setting of Nozzle Valve Spring pressure.

FIGURE 1
NUMBERING SEQUENCE INDICATES OIL FLOW THROUGH THE SYSTEM



Numbering sequence indicated oil flow through the system

1–Fuel Tank
2–Fuel Level Gauge
3–Vent
4–Filter Pipe
5–Washout Plug
6–Condensation Drain
7–Primary Filter
8–Fuel Booster Pump
9–Pressure Relief–Valve (75 psi)
10–Secondary Filter
11–Fuel Oil Header
12–Injection Pump
13–Injection Nozzle
14–Nozzle Leaknut
15–Drain From Control Shaft Compartment
16–Drain From Fuel–Pump
17–Drain Channel
18–Drain to Tank (RS)
19–Drain to Tank (LS)
20–Header Crossover Line
21–Fuel Oil Rectum
22–Pressure Gauge
23–Fuel Trap
24–Pressure Regulating–Valve (35 psi)

5. LUBE OIL SYSTEM

(ALCO'S LUBE OIL SYSTEM)

PURPOSE OF LUBRICATION

1. To reduce the friction and enable smooth operation between two moving surfaces.
2. To reduce wear and tear.
3. To reduce the temperature developed due to friction.
4. To clean and wash away the metal particles caused by wear and tear from the bearing surfaces.

MAJOR COMPONENTS OF LUBE OIL SYSTEM

1. Lube oil pump(Gear type)
2. Spring loaded Relief valve (Adjusted to 7.5 kg/cm2)
3. Lube oil filter tank (8 nos filter, pore size-12-16 micron)/Moatti filter
4. Conv. Lube oil cooler/Plate type lube oil cooler
5. Regulating valve
6. Centrifuge Cleaner(start at 2.5 kgf/cm2)
7. Oil sump
8. Lube oil strainer

1. LUBE OIL PUMP:

This is located at free end of engine slightly towards the right. Supply of oil in, adequate quantities and at the desired pressure is vitally depending upon the pump. A gear driven type pump has been provided. The gear pump is mounted on the free end of the engine

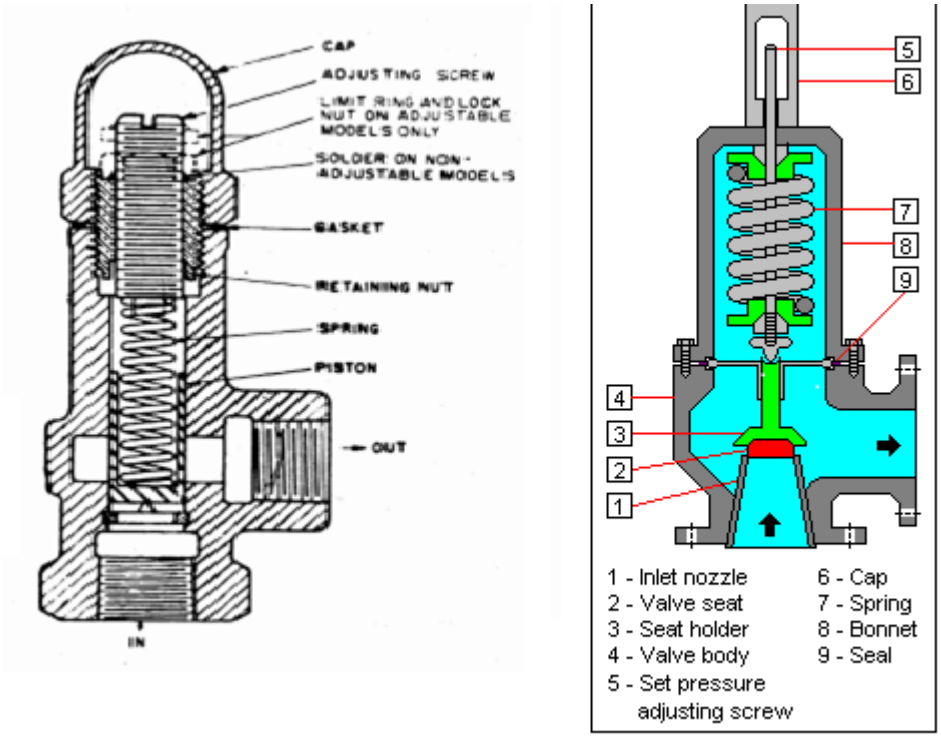
base and is driven by the crankshaft gear. The suction line is in built into the engine base and the discharge is into the external piping.

The pump develops a partial vacuum, causing the fluid to flow into the pump inlet under atmospheric pressure. The fluid trapped between the helical gear teeth and the pump housing is then injected out at the outlet side at a pressure. The delivery of the pump is directly proportional to the speed of rotation. The pump is designed to supply **1190 litres per minute** at **6.3 Kg/cm^2** when the engine is operating at **1000 rpm** and the pump speed then is **1180 rpm.**

LUBE OIL PUMP (cut section)

2. RELIEF VALVE:

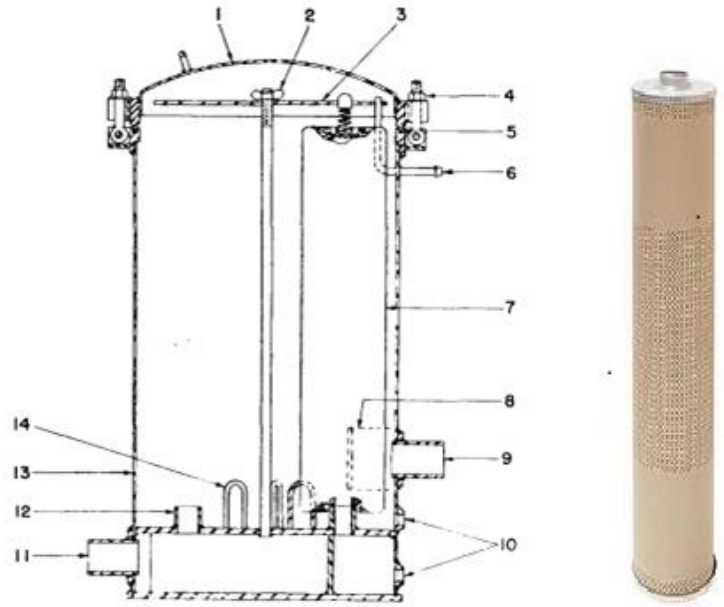
This Valve is fitted at the delivery side of the lube oil pump to ensure that oil pressure does not exceed a determined level. It is set at around **7.5 Kg/cm^2** (105- 110psi). This protects the system from damage due to excessive pressure on cold starting through by passing a portion of the oil to engine sump.



RELIEF/REGULATING VALVE (CUT SECTION)

3. LUBE OIL FILTERS:

Paper type, disposable cartridge filters are used for the engine lube oil system. These filters are extremely fine and are required to trap contaminants to around 10 microns in size. The filters are located in radiator room. Two drain valves are provided in the filter tank as well as a vent line to eliminate any formation of air pockets.



1. Cover
2. Guide Plate Wing Nut
3. Guide Plate
4. Cover Nut
5. "O" Ring
6. Vent
7. Paper Filter
8. Baffle
9. Oil Inlet
10. Drains
11. Oil Outlet
12. Standpipe
13. Shell
14. Hairpin Guides

Paper type lube oil filter

MOATTI FILTER:

In the modified locos, Moatti type filters are used in place of paper type filters.

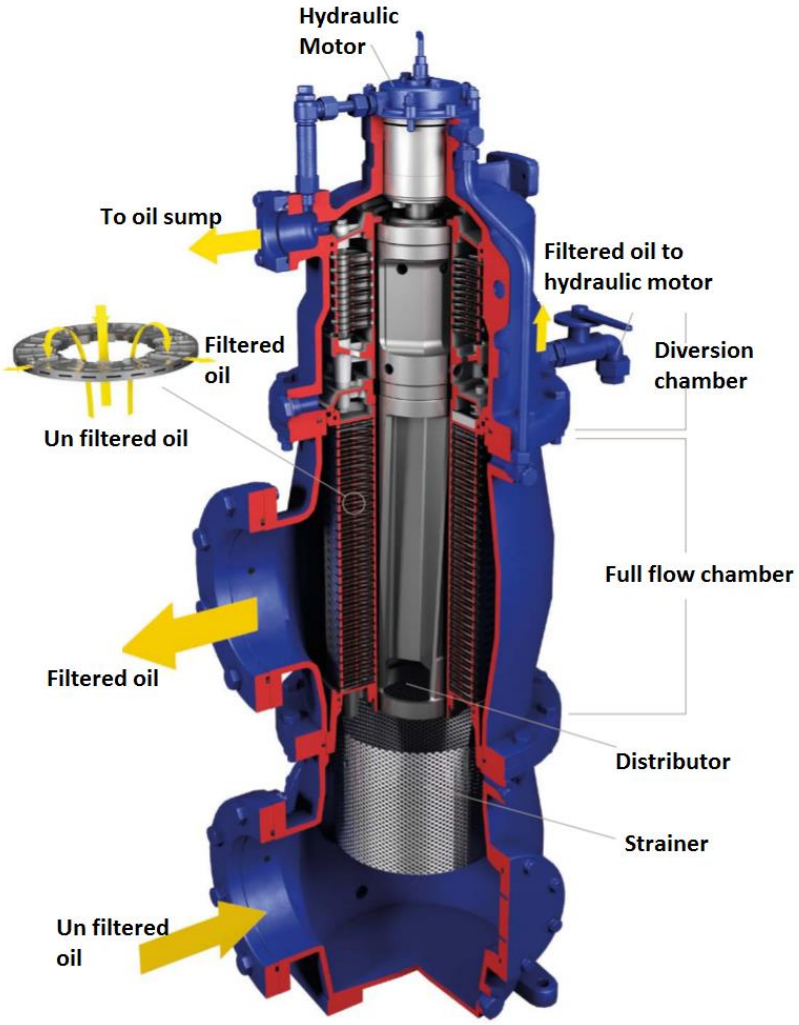
The Moatti filters are “Automatic back flushing” filters which cleans its filter elements by back flushing, thus decreasing the pressure drop across it.

The filter consists of

- The filter housing
- The filtering unit and distributor.
- The hydraulic motor

The filter housing can be divided into two chambers –

- First chamber, where the cleaning of the oil occurs is called “Full flow chamber”.
- The second chamber where the impurities stopped by the full flow chamber are collected is called “Diversion chamber”. The filter unit contains disc type filter elements placed on top of one another forming a very robust filter disc stack. The distributor, driven by the hydraulic motor, feeds unfiltered oil to all the columns except one that is open for back flushing. In this way, each column is back flushed once per rotation of distributor.



MOATTI FILTER

4. CENTRIFUGE FILTER:

In the modified locos, centrifuge filters are placed in parallel to the paper type filters for the effective filtering of the oil.

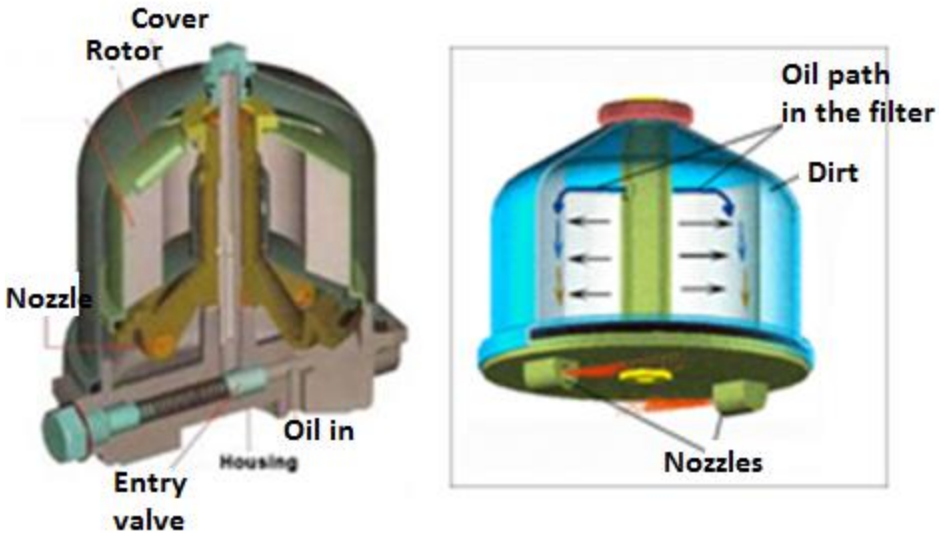
They provide the following advantages.

- Reduced engine wear.
- Longer oil change intervals.
- Longer filter life.
- Saves 400 litres of lube oil/loco/yr viz. oil lost in 8 filter changes
- No operating cost

The working of the centrifuge filter is as follows:

- The Separation in a centrifuge is effected purely by the centrifugal forces acting on the dirt particles.
- The oil is admitted into the centrifuge rotor under pressure from engine oil gallery.
- After circulation of the rotor, oil is ejected through a pair of nozzles at bottom of the rotor.
- This gives reaction force to the rotor and rotates it with dirty oil inside it about a shaft at about 600 rpm.
- Due to this rotation, the dirt particles inside rotor experience centrifugal force of about 2000 times gravity and are thrown out on the rotor wall.

-
- The particles stick on the rotor wall and form a sludge cake which is removed during servicing.



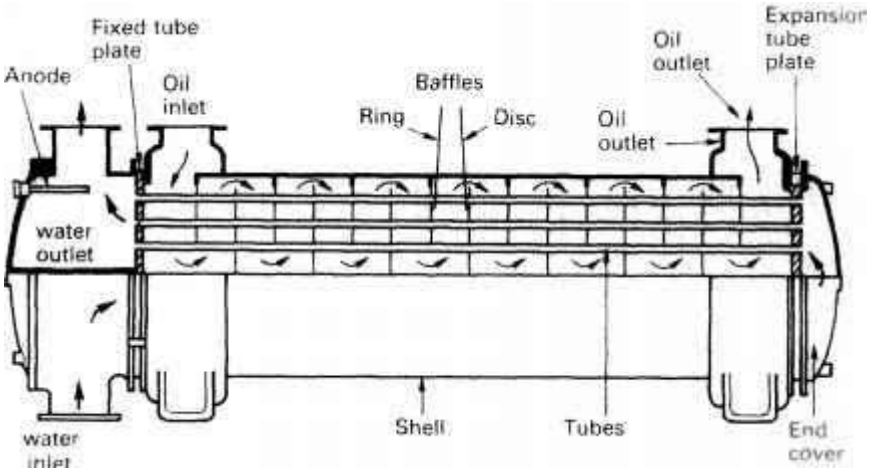
CENTRIFUGE FILTER

5. LUBE OIL COOLER

This is located in radiator room. Lube oil cooler is a heat exchanger, which removes unwanted heat from the engine oil and ensures supply of oil to the engine at a reasonable temperature.

The engine receives heat from two main sources that is the combustion heat and from bearing friction. In ALCO engines, lube oil is circulated through oil passages provided in the engine piston there by oil extracts substantial quantity of heat of combustion.

Conventional lube oil cooler is of shell and tube type heat exchanger, consisting of bundle of tubes enclosed shell. Cooling water from the radiator enters the cooler and flows through the tubes. Baffles are provided inside the shell to channel the oil flow around the tubes for removal of heat from the oil.



SHELL AND TUBE TYPE LUBE OIL COOLER

Plate type cooler: In Plate type cooler, alternate stainless steel plates with water & Lube Oil flows through the passages.Heat transfer rate has been improved *from* 190 KW to 295 KW.

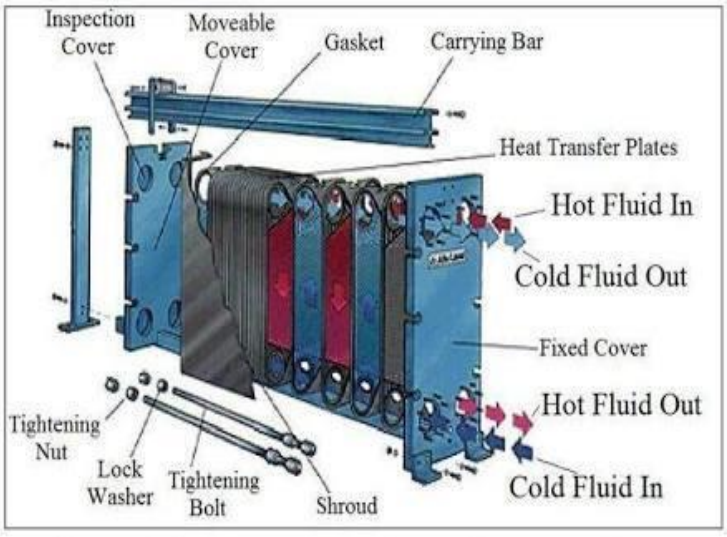


PLATE TYPE LUBE OIL COOLER

6. PRESSURE REGULATING VALVE:

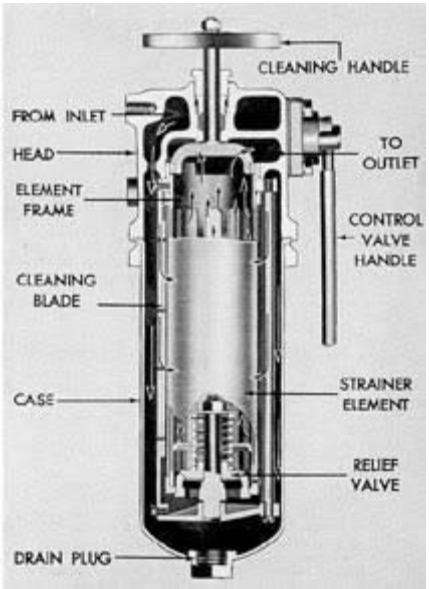
This located at the discharge side of the cooler and before the strainer. It regulates the flow of oil through the cooler and the lube oil pressure in the system. The setting of the valve is **4.2 Kg/cm$^{2.}$** If the pressure is high, some of the oil is bypassed to the sump as a result of lifting of the valve.

NOTE: Regulating valve is not available in loco provided with Moatti type lube oil filters.

7. LUBE OIL STRAINER:

The lube oil strainer is located at left side free end of the engine just before the lube oil header. The strainer removes coarse insoluble particles in the oil, which would be present normally in unfiltered oil only. Under normal operating conditions, the strainer will not trap any particles, as the paper type filters would have filtered all the particles. The strainer is essentially a last or final defence against contaminants. This is of gasket type with oil entering at the bottom, flows through a hollow tube to the top and into the space between the tube and a strainer screen. The oil then passes through the fine screen and goes out of the strainer shell.

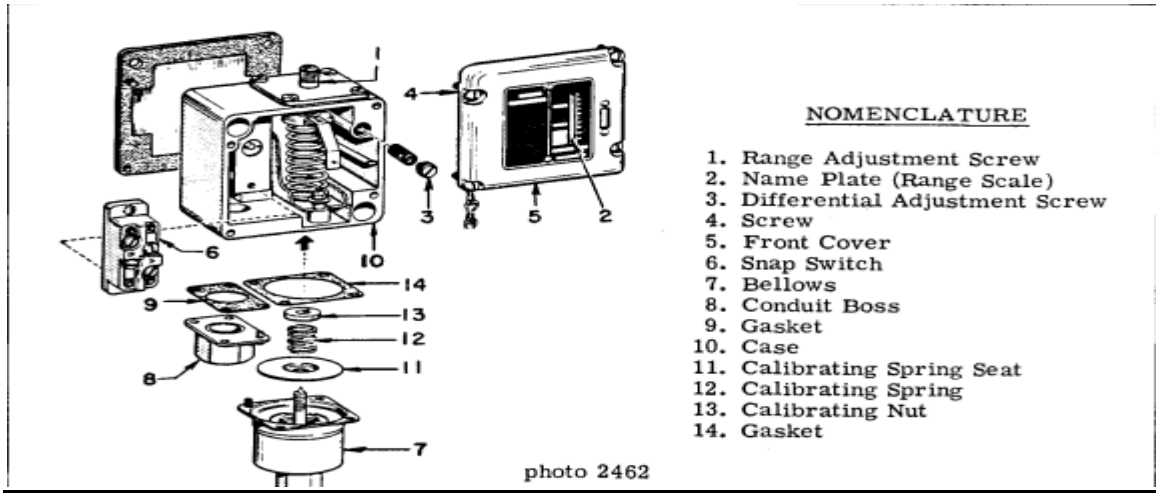
NOTE: Lube oil strainer is not available in loco provided with Moatti type lube oil filters.



LUBE OIL STRAINER

8. LOW LUBE OIL PRESSURE SWITCH:

This is provided to protect the engine from low lubricating oil pressure by operating at a predetermined pressure and shutting down the engine with bell ringing and amber light simultaneously. The setting of OPS is closing at 1.6Kg/cm^2 and opens at 1.3 Kg/cm^2 Normally a steady oil pressure under idling conditions, at water temperature of 80 ^{0} C is obtained in the region of 2.5Kg/cm^2. When suddenly notching down, the transient low pressure may be 5-7psi below the steady pressure. So to obviate the possibility of engine shut down the LOPS setting could be 1.6 Kg/cm^2. For engines using steel cap pistons an additional OPS is provided which causes shut down of the engine if oil pressure goes below 3.2 Kg/cm^2 on 7th or 8th notch. (It picks up at 3.5 Kg/cm^2 and drops at 3.2 Kg/cm^2). With a low pressure in the system, caused by any reason, the lube oil loses its load carrying capacity between the bearings. As this is an important duty and purpose of the lube oil system in our locos the diesel engine has to be protected from any possible damage to the components due to lack of lubrication or lack of cooling oil in the piston crown. This switch is provided in the locos fitted with GE governor.



LOW LUBE OIL PRESSURE SWITCH

DESCRIPTION:

In Diesel loco lubricating oil is stored in the sump located at the bottom of the crankcase. The capacity of the sump is 910 litresin WDM2 and 1260 litres in WDG3A.

The lube oil pump is mounted at the free end of the engine and is driven by the main crankshaft through gears. When the engine starts working the lube oil pump also works. It draws the oil from the sump and delivers it to the lube oil filter, which is located at radiator room. A pressure relief valve is provided in between pump and filter to release the excess pressure and control the discharge pressure at **7.5 Kg/cm^2** in order to protect the pump.

From the filter, the oil next flows through lube oil cooler where cooling water cools it. A bye–pass valve is fitted between inlet and outlet of the filter. This valve bye passes the lube oil when the difference in pressure between inlet and outlet of filter exceeds **1.4 Kg/cm^2**. It also bye-pass the lube oil during cold start.

Note: In some locos the bypass valve is not provided. In its place a pre lubrication pump driven by motor is provided which will work with battery supply before cranking.

The outlet of the lube oil cooler is connected to lube oil strainer. Before the strainer two connections are taken. One connection is for regulating valve, which is set at **4.2 Kg/cm^2**. Second connection is to Turbo super charger for lubrication of rotor bearings. The oil then returns to sump.

The oil filtered in the strainer is then enters into the lube oil main header inside the engine block. Three branch pipes are taking off at a point after the strainer.

i. One pipe for lube oil pressure gauge and OPS available in the cabin.

ii second pipe to left side auxiliary header.

iii third pipe to right side auxiliary header.

From Left auxiliary header two more pipe connections are taken to supply lube oil to **Vibration Damper** and **left side camshaft bearing**. From Right auxiliary header one

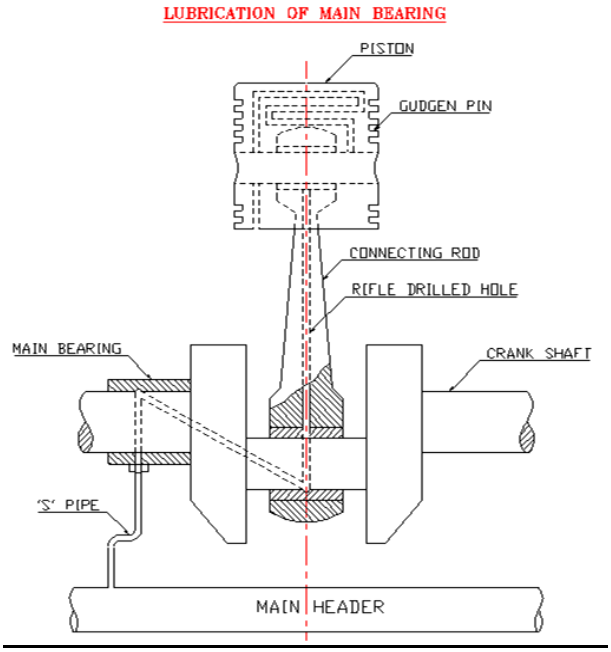
From Right auxiliary header one branch pipe is taken off and is given to **right side camshaft bearing /OSTA** for lubrication.

From Left/Right auxiliary headers for each cylinder two-branch pipes are taken to lubricate valve lever mechanism and FIP support. At the end of both auxiliary headers connection is given to cam gears for lubrication (Spray nozzle).

LUBRICATION TO MAIN BEARINGS:

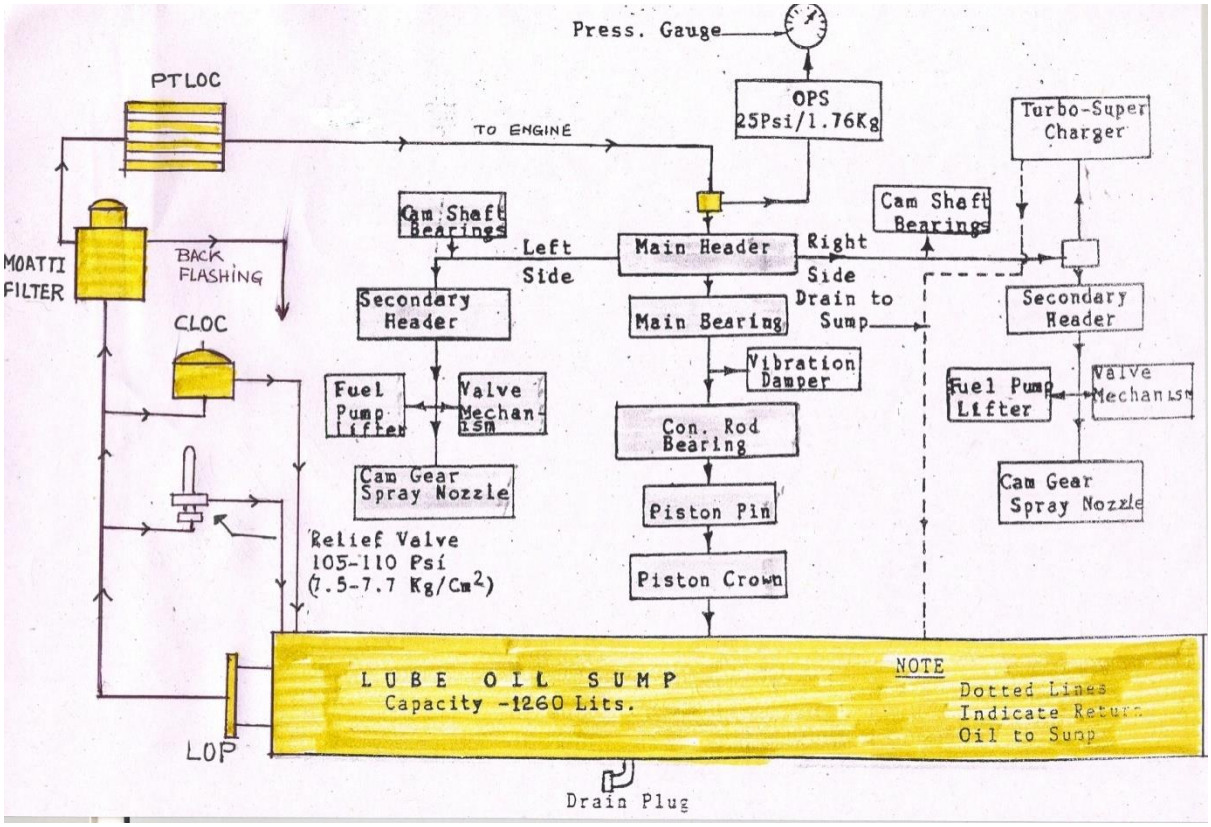
The lube oil from the 'Main Header' is taken to the Crankshaft main bearing (9 Nos) through individual pipes called **'S'** pipes. After lubricating the main bearings, through drilled passage inside the crankshaft the oil reaches the crank pins and big end bearings. From there through '**RIFLE DRILLED** ' holes in the connecting rod, the oil goes to the piston pin and then goes to the piston crown through the internal holes available in piston called ' Cooling Grooves'. On circulating inside the piston crown the lube oil cools the piston crown since they are exposed to very high heat during combustion.

After cooling the piston crown, the oil drops down. The rotating crankshaft and connecting rod big end splash the oil all over the cylinder liners. Thus the inner surface of the cylinder liners is lubricated and the carbon deposits are washed. The oil control rings evenly spread the splashed oil and then oil scrapper rings during down ward movement of piston scrap oil down. Certain quantity of lube oil is always retained in "**HONEY COMB HOLES**" of cylinder liner for better lubrication. The lube oil falls on base screen is then goes to the sump. The lube oil filter, and strainer are connected to sump by vent pipes so as to carry the Vapour into the sump.



LUBRICATION OF MAIN BEARINGS

The schematic of the lube oil system is as below:



LUBE OIL SYSTEM (MODIFIED)

LUBRICTION POINTS:

- FROM MAIN HEADER PIPE
  - All Main bearing
  - Crank pin, Connecting rod big bearing & crank pin journals. further through riffle hole lube oil reach to Gudgeon pin (Piston pin) &bearings
  - From piston pin to piston to piston crown (For cooling the piston)
  - Splash lubrication of Cylinder liner (when oil is returning to the sump after cooling the piston)

- FROM SECONDARY HEADER (LEFT SIDE)
  - Cam shaft bearing.
  - V/V lever mechanism & Cam lobe.
  - Cam gear for cam shaft drive.
- FROM SECONDARY HEADER (RIGHT SIDE)
  - Cam shaft bearing.
  - V/V lever mechanism & Cam lobe.
  - Cam gear for cam shaft drive.
- OTHER CONNECTIONS (R/S)
  - To Governor (From right side secondary header)
  - To TSC(for bearing)
- FROM NEAR STRAINER

  Pressure gauge & OP

CRANK CASE EXHAUSTER:

For the efficient working of the engine and also to maintain certain amount of vacuum in the crank case by expelling the hot oiled vapour (hot fumes) emitting from the oil from the sump, this crank case exhauster is provided. It is driven by an electrical motor, which gets supply from the batteries before cranking and from auxiliary generator after cranking the diesel engine.

CRANK CASE EXPLOSION DOORS

These are provided on the diesel engine crankcase to avoid extensive damage due to positive pressure developed inside engine crankcase. This may happen due to failure of CCEM which when unnoticed by engine crew for a considerably long period and whenever there is a main bearing failure. Whenever the pressure inside the crankcase exceeds a certain limit these doors may open and prevent damage to the engine block.

This is provided in place of one of the inspection doors, one on each side. This opens whenever the pressure inside exceeds a preset value and releases the excess pressure and again closes when the pressure drops down below the spring tension. When the explosion doors open it indicate that a positive pressure is prevailing in the crankcase. The reason may be due to

a) Failure of any one of the main bearing, big end bearings.

b) Failure of the crank case exhauster on run not noticed in engine room. In the event of experiencing this engine should be shut down immediately.

6. COOLING WATER SYSTEM

COOLING OF HEAT ENGINES

The components, which are having contact with the exhaust gas, will get hot. The components like pistons and bearing metals would become so hot and thus seizure could occur.

Therefore this heat must be maintained with fairly close limits to achieve maximum power.

Too high the temperature would cause detonation and too cool would make the engine fuel consumption uneconomical.

Our diesel engine is a heavy-duty engine with enormous horse power output, the cooling water system which is employed to maintain the temperature and cool the components like cylinder liners, cylinder heads and turbo super charger is actually a “Circulating water system” assisted by a gear driven water pumps.

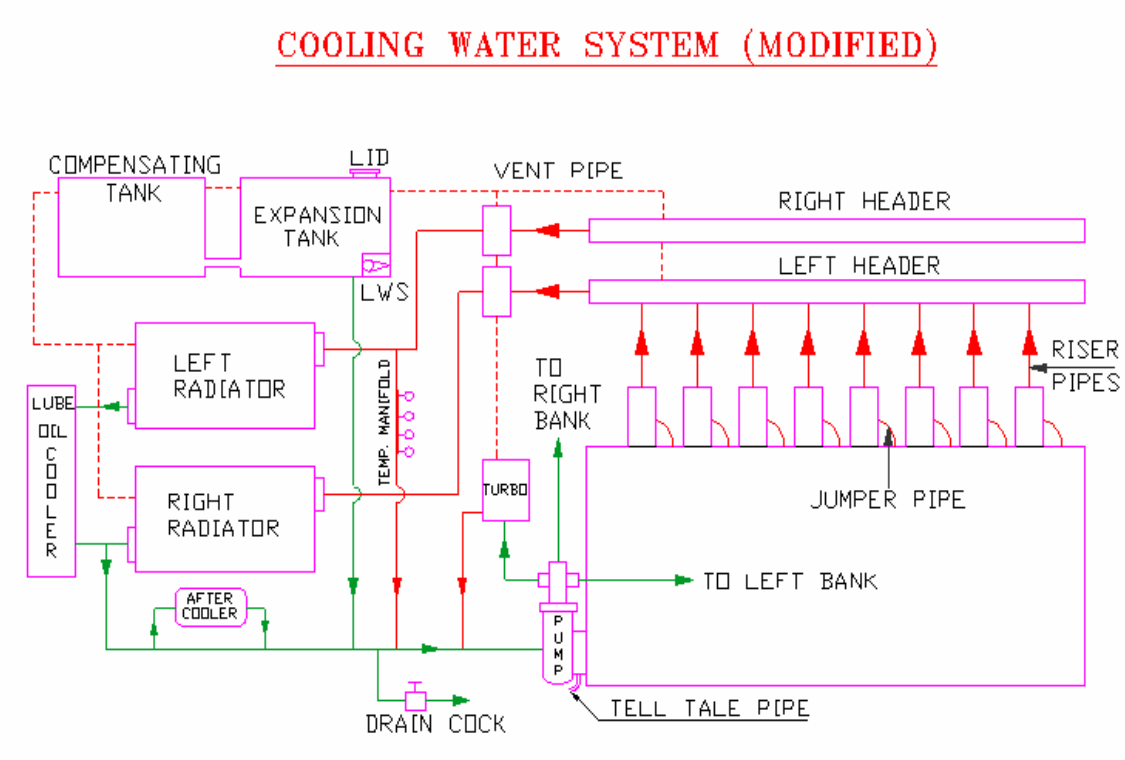
In addition to cooling of the above components the cooling water helps to cool the hot lube oil retuning to the sump before being sent back to the system.

FUNCTIONS OF COOLING WATER SYSTEM

Cooling water is used in locos for three functions:

1. To absorb the heat from the lube oil and the power pack.
2. To cool the turbo super charger, which get heated on account of exhaust gases.
3. To cool the super charged air in the after cooler.

The heat absorbed by the cooling water will be dissipated through radiators to the atmosphere and the water is again circulated.



COOLING WATER SYSTEM

DESCRIPTION:

In the cooling water system a centrifugal pump gear driven from crankshaft circulates the water. In this system the water is kept full flow in the system and also the expansion tank, which serves as an additional reservoir.

When the engine is working cooled water is drawn by the pump and discharged towards the delivery side into the three-way elbow. Three different connections are taken from three-way elbow.

1. One connection is taken through a flexible water pipe to the turbo super charger. The water enters in the turbo inlet casing at the bottom and circulates in its hollow passage to cool the intermediate casing walls between the blower and turbine end bearings, which are in constant connection with exhaust gases. From the intermediate casing water enters in the turbine casing through four circular interconnecting passages situated 90 degree apart on the periphery of the casing.
2. The second connection from the three-way elbow is taken through a steel pipe to the left bank of the cylinder block.
3. The 3rd connection from the three-way elbow is taken to right bank of the cylinder. In both the banks the cooling water enters the engine block and circulates outside the cylinder liners and cools it. Then water is conducted to the individual cylinder heads through water jumper pipes. By flowing into the cavities of cylinder heads, water cools the cylinder heads. From every cylinder heads, water flows to the common water return headers on the left and right sides through individual raiser pipes.

From the water return headers, water is made pass through the “Bubble Collector” before reaching the radiators.

This has done to break the bubbles formed by the water vapour. Various vent pipes are also provided to prevent steam formation in the system.

Right side water return header is connected to the left side radiator.

Left side water return header is connected to the right side radiator.

Water entering the radiators is naturally cooled by atmospheric air, and air drawn by the rotation of radiator fan.

After passing through the tubes of the left radiator water is taken to lube oil cooler. Here water passes through tubes to cool the lube oil, flowing around the water tubes.

From the lube oil cooler water joins with the right side radiator outlet pipe and flows towards the suction side of the water pump.

From the out let of right radiator a connection is taken to after cooler where water flows through the tubes around which super charge air flows around and gets cooled.

From the after cooler, the water joins to the suction pipe.

The water circulation is repeated again and again as described above.

Two pipes interconnect the expansion tanks that are provided on either side of the radiator compartment. The water in the expansion tank is utilized to supplement the water loss during circulation due to the evaporation or leak. An important safety device is provided in the expansion tank. This is called **Low Water Switch** (LWS). This is connected to the expansion tank to shut down the engine whenever the water level falls low. The capacity of the cooling water system is **1210 liters**.

COMPONENTS IN COOLING WATER SYSTEM

EXPANSION TANK:

This is located at the top most level of the system and this serves as a reserve tank. An auxiliary tank is also provided above the radiator room. Both the tanks are interconnected .To indicate the water level a gauge is provided inside the radiator room on the right side of head light. While taking over charge water level should be above the half mark of the gauge. The capacity of the cooling water system is 1210litres. Expansion tank and auxiliary tank are supplementing the loss in the system. A pipe is connected from the expansion tank to the system on the suction line.

An overflow pipe is provided in the expansion tank. In some locos the tank will be having a lid with holes for venting water vapour and thus avoids development of pressure inside tank. If not due to the pressure, water may siphon off from the tank through over flow pipe. Due to any reason if the temperature goes high the water level will go at low as described above. In some locos a pressure cap is provided in place of lid which will operate and release excess pressure in expansion tank. This is provided to avoid complete siphoning of water. Expansion tank is connected with various vent pipes of the cooling water system i.e. after cooler, turbo super charger, bubble collectors, lube oil cooler and both side radiators for venting the steam.

Note: - Distilled water or Demineralised water is used in cooling water system with any one of the following chemical compounds.

Indion-1344 –8.2 kg/loco

Nalco-2100- 36 litres/loco

XGT –120 litres/loco

LOW WATER SWITCH:

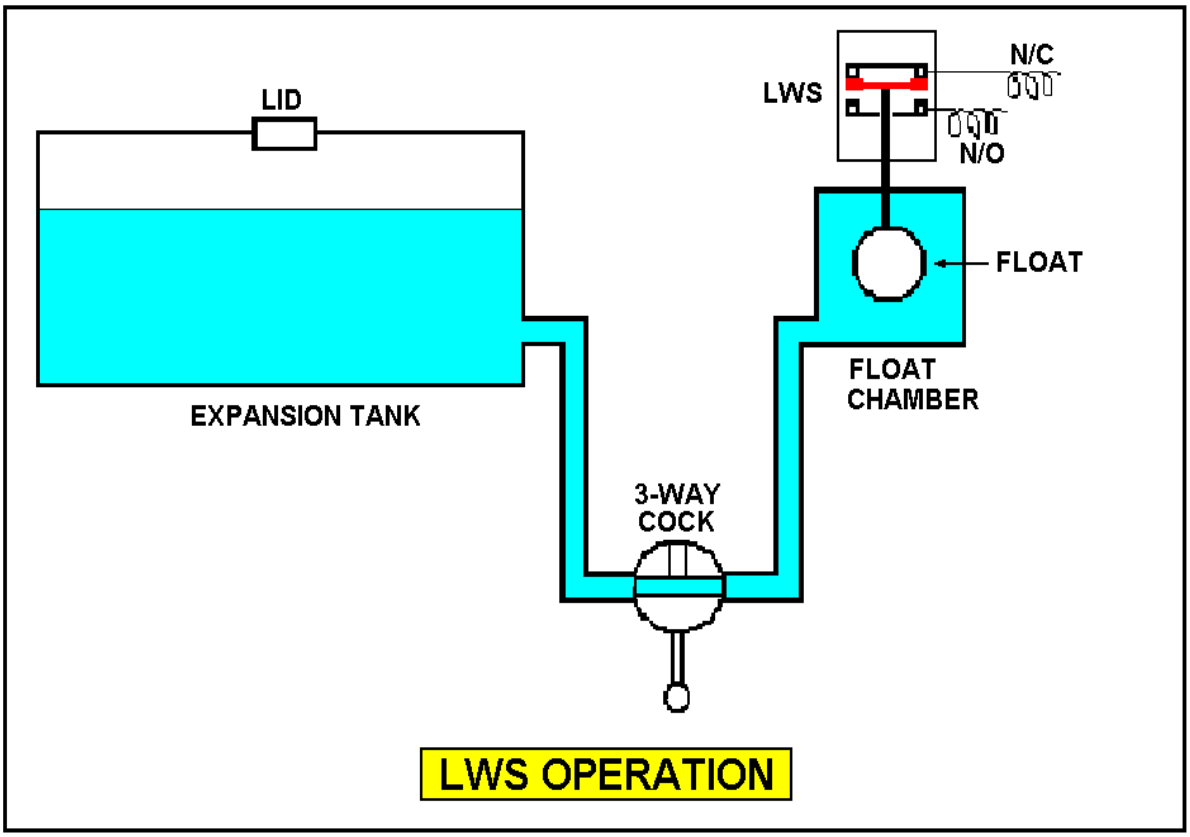
This is an important safety device provided to protect the engine from the damages caused due to lack of cooling water. This will shut down the engine when the water level falls down **1”** level from the bottom of expansion tank.

A connection pipe is taken from the expansion tank to LWS float chamber, with a 3 way cut out cock. This cock is provided to facilitate testing of LWS without draining the water

from the system. When the water level goes down the float in the chamber drops and movable contact from the other end of the fulcrum is lifted which will make contact with the electrical sources. This will send signals to the governor to shut down the engine.

Normally LWS COC must be in open position i.e. to connect the tank and the float chamber. While testing the LWS this COC is to be closed. In this position water flow from the expansion tank stops and water in the float chamber drains out which will operate the switch.

Now a day's electronic water level indicator is provided in the cab. This is hawing 3 LEDs. 1) Green which indicates water is full. 2) Yellow which indicates water is half. 3) Red which indicates water is to be added. It is also provided with emergency switch for by passing LWS. Whenever LWS malfunctions this switch has to be operated after ensuring sufficient water level.



TEMPERATURE CONTROL DEVICE:

Cooling water absorbs heat from components and so become hot, and it must be cooled before being sent back to the system. Water from the engine block is taken to the radiators and cooled by air, when air passes through the radiators.

Whenever temperature of the water increases, the cooling process in the radiators has to be intensified. For this a radiator fan is provided which is driven by EDDY CURRENT CLUTCH. When temperature rises to 68^0 C thermostat switch no 1 (TS1) gets energised through a sensing element and it operates R1 contactor located in the control compartment. Now a certain amount **6-6.5 amps**) is supplied to operate **ECC**.

EDDY CURRENT CLUTCH (ECC) ASSEMBLY:

This is provided in the radiator room to start and stop radiator fan according to water temperature. ECC Unit is consisting of 2 portions

1. Outer Drum
2. Inner Drum

The outer drum is directly connected to the engine extension shaft and will be rotating continuously as long as engine is working. The inner drum is connected to the radiator fan through a right angle gear unit. The inner drum has an ECC coil provided in between a set of spiders.

When there is no supply in the coil of the inner drum, the fan does not work. When water temperature reaches 68^0 Celsius TS1 operates, R1 contactor picks up and auxiliary

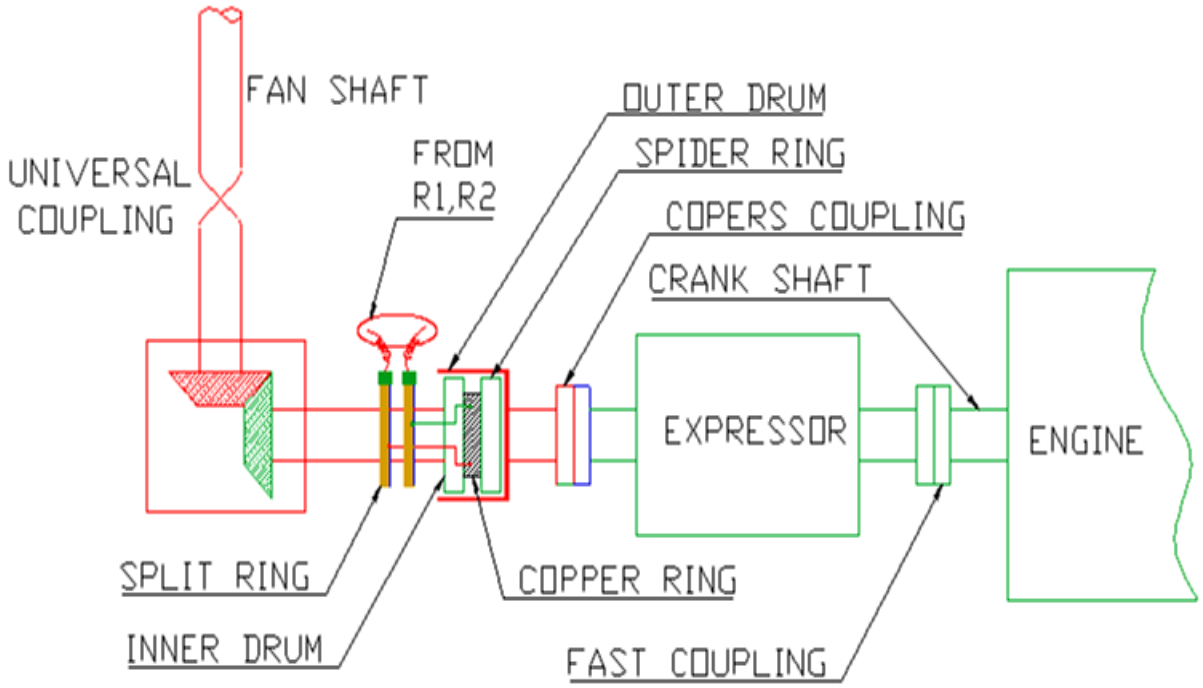
generator current is supplied to ECC coil. So the outer drum and the inner drum will be magnetically clutched and radiator fan starts working at minimum speed. That is the speed will be around 70% of the engine crankshaft speed. TS1 gets reenergized and R1 contactor will drop when water temperature falls down to 66^0 C due to which radiator fan stops working.

If the water temperature further rises to 74^0 C in spite of the radiator working at minimum speed, another switch TS2 will operates, R2 contactor picks up. This will supply more current to ECC coil (**12.5 amps)** and so the radiator fan will work at high speed, the speed of the radiator fan will be around 120 % of the engine speed. TS2 will get de-energised to drop R2 contactor when water temperature falls down to 72^0 C due to which radiator fan will work at minimum speed.

In both the above cases the principle is evacuating the air inside the radiator room and thereby creating partial vacuum, so outside air is drawn through radiators to bring down the temperature. When the cooled air contacts with radiator tubes, hot water passing through the radiators gets cooled. The hot air is blown out to the atmosphere by the radiator fan.

NOTE: After starting the diesel engine, the engine speed should not be raised till the water temperature level attains 49^0 C.

EDDY CURRENT CLUTCH



HOT ENGINE ALARM:

When the loco is continuously working for longer period, at full load condition i.e. climbing a steep gradient hauling full load of the section with highest notch position and the atmospheric temperature is also high, the engine cooling water temperature will still go up in spite of the fan working at full speed.

When the temperature reaches 85^0 C ETS will get energised and an alarm will sound in the cab and red lamp will glow in both control stands. These audible and visible indications given by the signal relay (SR). This is called “HOT ENGINE ALARM**”**. When this is heard the Loco pilot is warned that the engine condition is very hot. On hearing this alarm the Loco pilot shall bring the throttle to idle and check for causes. The observations made by the Loco pilot during his examinations for experiencing hot engine alarm, must be recorded by the Loco pilot in the loco repair book. If radiator fan found working he must do fast air pumping. If section is not favourable ease the throttle and try to clear the section in lower notches and then do fast air pumping. When the temperature goes below 83^0 C the hot engine alarm will be stopped and the Loco pilot can resume normal working.

Faster Air Pumping:

When the Loco pilot wants to bring down the engine temperature quickly faster air pumping has to be done. The procedure is as follows.

1. Keep the REVERSER in neutral (only in stationary locos)
2. Keep GF in off position.
3. Keep ECS in run position.
4. Then raise the throttle to 5^{th} notch

The engine speed will rise without loading of main generator i.e. without burning more fuel. When the fuel supply is reduced and the engine is working at high rpm, in turn the water pump and radiator fan will work at high speed. So the temperature will come down very quickly. When the water temperature falls to normal limit engine can be loaded again.

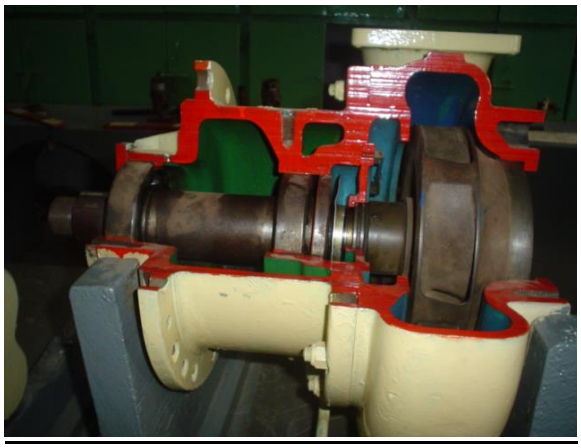
Reasons For Repeated Hot Engine Alarm:

REASONS	REMEDIES
a) Radiator room door opened.	Close the door and secure it
b) Radiator fan not working	
i) TSI/R1 Defective	Switch ON ERF switch.
ii) TS2/R2 Defective	Switch ON ERF switch.
iii) Wire connection cut	Secure it
iv) Carbon brushes worn out.	Check carbon brushes and renew it.
v) ECC coil defect	Inform shed
vi) Right angle gear unit/ Universal coupling defect	Inform shed
c) Expansion tank	
i) In sufficient water level	Add water duly consulting shed
ii) Lube Oil contamination in water	Inform shed
iii) No circulation of water due to Pump defect	Inform shed
d) Radiators dirty and hence air passage blocked	Clean with compressed air.
e) Water passage blocked due to	Inform shed

scale formation. f) ETS malfunctions	Check water temperature gauge if found less inform shed.

CENTRIFUGAL WATER PUMP:

The water pump is situated on the left side free end of the engine. The pump circulates water in the cooling system. The pump is getting its drive from the diesel engine crankshaft through a step gear. The gear ratio is 79:46 (79 drive shaft and 46 driven shaft). The capacity of water pump delivery is 2457 Litres per minute, at a speed of **1720 RPM**. The lifting capacity is 3 feet. The pressure developed by the pump will be 30 PSI at a temperature of 180 ^{0}



CENTRIFUGAL WATER PUMP

TELL TALE PIPE:

Water seals and oil seals are provided in the water pump and sometimes they may develop defects. So the visual indication is given to the Loco pilot through a pipe fitted on the water

pump. This is called ‘Tell Tale Pipe’. If water is seen coming through this pipe, it indicates the defective water seal and similarly the oil seal.

1. Whenever water is leaking through TTP. Loco should not be taken overcharge from shed.
2. If this is noticed enroute contact shed, the loco can be worked onwards carefully watching the water level.
3. While taking over charge in enroute normally 8 drops per minute is allowed.
4. If the leakage is very heavy, loco should not be worked further.
5. When oil leak is noticed from shed, the shift supervisor should be informed for rectification or certification.
6. Oil leak noticed enroute inform shed and work onwards duly checking the oil level in the sump and make the entry in the repair book.

NOTE: Under any circumstances TTP should not be plugged.

IMPORTANT CHECKS TO BE MADE IN COOLING WATER SYSTEM:

1. Water level in the expansion tank.
2. Water main drain cock is tightly closed. This is located in the Expresser room. If it is not closed properly water may run down on run causing hot engine alarm. If level of water goes too low the engine may shutdown by the action of LWS.
3. LWS COC must be open. If it is not in proper open position or if closed, the engine will be cranked but will not get fired at the time of starting.
4. Whirling action of the water in the expansion tank must be ensured after cranking the loco. By this the proper working of water pump is ensured.
5. Ensure the Expansion tank lid or pressure cap is secured properly.

6.

7. No oil or water leak through TTP.
8. There should be no leak in the system, especially the jumper pipe joints, water raiser pipes, header pipes and the radiators while TOC.
9. If any one of the vent pipes is leaking and it is notices on run, it must be bandaged. On no account vent pipes are to be dummied.
10. Before leaving shed, among the 10 tests, the radiator fan test must be conducted positively.
11. It is always better to rotate the radiator fan manually before cranking. This is done to check the free operation of the fan ensuring the condition of right angle gear unit and universal coupling.

OPERATING WATER LEVEL:

The operating water level indicator indicate minimum and maximum water level with the engine running or stopped. The water level mark should not be permitted to go below the applicable “low” water level mark. Progressive lowering of the water in the gauge glass indicates a water leak in the cooling system, and should be reported.

The coolant is circulated through the engine to transfer heat from the engine components to the radiators. **Engine coolant** is composed of **water, corrosion inhibitor**, and when considered necessary, **antifreeze**.

COOLANT:

To be suitable for use in EMD engines, a coolant must meet four Basic requirements:

- Adequately transfer heat energy through the cooling system
- Not form scale or sludge deposits

-
- Prevent corrosion inside the cooling system
- Can’t deteriorate seals or gaskets in the cooling system

WATER:

The water in some areas contains elements such as excessive solids, hardness salts, or corrosive elements such as chlorides that make it unsuitable for use in the cooling systems of EMD engines. Water from these sources should be processed by **softening, de-ionizing,** or **distillation** to make it suitable for cooling system use.

7. SHED LAYOUT

MAKING OF LAY OUT OF 100 LOCO DIESEL SHED AND FACILITIES

- A uni-directional movement of locomotive in the shed is preferable.
- Separate entrance and exit points should be provided to avoid bottlenecks.
- The layout should permit a locomotive to skip stage of servicing without hampering the Flow of Other locomotives.
- The shed should have covered accommodation in its repair area for about 25-30% of the fleet Homed. The yard of the maintenance shed should be able to hold at a time about 50% of the total holding of the shed.
- Each line in the covered repair area of the shed should be able to hold 3 locomotives. The layout should provide for possibility of expansion width-wise i.e. by providing more lines side by side.

FOLLOWING POINT SHOULD BE CONSIDERED WHILE CONSTRUCTING A SHED

- ✓ The shed should have three level working floor arrangements.
- ✓ This facilitates simultaneous and expeditious maintenance service as well as repairs.
- ✓ The flooring should be such that spilt oil can be easily removed.
- ✓ Pits should have convex flooring and efficient drainage.
- ✓ Flooring in heavily lifting bays should be strengthened.
- ✓ Platforms and ramps should be provided
- ✓ Minimize dust nuisance in working area.
- ✓ Uniform roof height
- ✓ Protect personnel working all elevated platform falling down.
- ✓ Roof extractors should be provided to expel harmful diesel fumes.

- ✓ covered space as under should be provided to take in a part of the

The shed layout should permit future expansion of the covered area in a manner to accommodate more lines under the covered area. The expansion along the length of running lines is not advisable.

THE SHED BUILDINGS SHOULD NORMALLY INCLUDE

1. Injection room, Battery room, (with exhauster)

2. Break test room,

3. Welding booth,

4. Machine room,

5. Blacksmith shop and coppersmith shop.

6. Break test equipment room, (air-conditioned)

7. Filters' benches,

8. Lubricants store with pump house, (dust proof)

9. Stores,

10. Tool stores,

11. Distillation plant and boiler room, or other water treatment plant.

12. Laboratory,

13. Lockers and washing room,

14. Supervisors' room,

15. Shed officers' room,

16. Library-cum-lecturer room,

17. Lube oil filter plant,

18. Water load box computerized & dust proof,

19. ROC room

FACILITES LIFTING AND MATERIAL HANDING

- Over head crane of suitable capacity should be provided to **serve the heavy repair** – way the free space, part of the machine shops and the store For lifting of smaller locomotive, heavy hydraulic jacks could be used Battery moving trolley car should be used for transportation of scrap For lifting heavier locomotives, electrically operated heavy lifting jacks

- **Shed Lighting**: Lighting inside the shed with fluorescent tube is desirable .illumination at platform and floor level of the minimum of 20 foot candles should be provided. Bulk head fitting for direct lighting of the under gear. Plug point at 24 volt should be made available at all levels in the pits. Yard lighting should result in an even illumination of 3-4 foot candles. Fuel Supplies Installation-For storage of fuel oil tank should be provided above ground level. The tank should be approachable by road as well. For day to day fueling and decanting. An electric pump must be provided .total storage capacity provided should hold a minimum of 10 day consumption. The delivery hose should be installed such that the nozzle does not touch the ground when not in use, and is suitably protected from rain and dust.

-

- **Sanding:** Proper storage facilities for sand should be provided to keep the sand dry. In places where rainfall is heavy, sand drying facilities should also be provided. Arrangement should be made for sand to be fed to locomotives by gravity.

- **Washing**: A proper washing apron should be provided for washing of locomotives.

- **Shed storage**: The storage room should be preferably at platform level and provided with a rail siding to help direct loading and unloading of storage wagons. The storage should have an approach by road as well. Suitable to avoid damage to components. Since the maintenance of diesel locos requires a ready stock of a large number of spares. Generous accommodation should be provided for the storage.

- **Battery room**: A separate battery room should be provided preferably at platform level. Care should be taken to provide exhausters to exhaust harmful fumes etc. from the battery room. Battery charging plant should be installed with points available beside the bits to allow direct Charging of batteries while in position on the locomotives.

- **Compressed air**: Supply of compressed air should be arranged care being taken to install the air compressor in a place where minimum disturbance and vibration to the surrounding are caused. Compressed air points should be provided near each servicing berth.

- **Lubricating oils**: Lubricating oil storage tanks should be located at convenient sites to make lubricating oil readily available at the pits. Facilities for drainage of engine lubricating oil from locomotives should be to enable easy collection and removal of engine lubricating oil without spilling and dirtying the service pits. The yard should be of sufficiently generous dimensions to permit free mobility for normal working and to

- meet with emergencies, and it should provide adequate holding capacity for at least 50% of the fleet homed in that shed.

- **Fire Fighting**: Adequate safety measures must he adopted against fire hazards in the shed. Since large volumes of petroleum products are handled, special precautions are necessary. Fire fighting equipment such as hydrants, hoses, extinguishers and for alarm boxes etc. should be conspicuously visible both at day and at night.

- **Training School**:-For proper maintenance of the sophisticated equipment on diesel locomotives, the work force has to be adequately trained.

- **Laboratories**: -

  For following testing

  - ✓ Spectrograph for lube oil testing.
  - ✓ Magna flux testing machine.
  - ✓ Rubber tensile testing machine.
  - ✓ Zyglo testing machine.
  - ✓ Oscilloscope.
  - ✓ Ultra sonic testing machine

- **M &P: - Following M&P is required**

  - ✓ E.O.T cranes 40 tons & 10 Tons.
  - ✓ Whiting Jacks.
  - ✓ Tram beam 3 Ton cranes.

- ✓ Pillar cranes with 1.5/1ton hoists -16
- ✓ Forklift truck (2T)-2.
- ✓ Platform Truck (2T)-5.
- ✓ Pick up van-2.
- ✓ Truck 3 tons-1.
- ✓ Monorail with hoist for battery room, heavy switches gear and piston assembly.
- ✓ Hoist for Governor, heavy switch gear.
- ✓ Floor wheel lathe.
- ✓ Dynamic balancing machine.
- ✓ Water and Grid load Box.

8. GM LOCOS

The main characteristics of GT46 MAC, GM Loco

AC-AC locomotives hitherto manufactured by M/s.General Motors company/American GT 46MAC the axle load is around 20.5 tons.

GT46MAC is provided with the following special features-

1. **Performance Specifications**

- 4000 TCV locomotive.
- Higher tractive and braking effort capability – 540 KN starting TE and 270 KN braking Effort.
- 11% improvement in fuel efficiency over existing WDM2 locos.

2. **Performance Impact**

- The GT46MAC provides unit reduction, fuel savings and additional revenue tonnage capability.
- Operation of fewer units results in significant maintenance and operating savings

3. **Reliability and Serviceability**

- 90-day maintenance intervals
- AC motors double traction motor life
- No running maintenance required on traction motors, No brushes, commentator, nor rotor Insulation, No flashovers/ground relays

-
- Bogie Inverter Control High level of reliability with fewer parts
- 1.6 million kilometre (I million mile) overhaul with HTSC bogie.
- 6 year engine overhaul period.

4. **Computer Control, a 32 BIT computer control for locomotive controls having following features -**

- Trouble Shooting and Self-Diagnostics.
- Alpha Numeric display.
- Archive memory and Data logging.
- Radar based super series Wheel Slip/Slide Control System.

5. **Engine**

- 4,000 TCV, 16-710G3B
- High efficiency turbocharger
- Unit fuel injectors which eliminate the problematic HP tube.
- Low emissions
- Laser hardened cylinder liners.
- Inconel valves and Hydraulic valve adjuster.
- Durable crankcase and piston structure.

6. **AC Traction Technology**

- Simple, robust motor design

- Higher efficiency-lower temperatures
- Doubles motor overhaul interval
- Utilizes bogie –controlled AC traction inverters for higher inherent reliability
- All weather adhesion of 32%
- High adhesion and Tractive effort
- Maintenance-free traction motors
- No limitation of minimum continuous speed
- High reliability and availability.
- Lower rolling resistance and higher energy efficiency

7. **HTSC Bogie-Basic**

- No wearing surfaces extent bogies overhaul intervals to 1.6 million kilometres (one million miles).
- Dual high adhesion and high speed.
- Available gear ratios for heavy haul and passenger operation.
- Reduced wear of components extends bogie overhaul intervals to 1.6 million kilometres (one million miles)

8. **Improved mechanical systems, the notable being-**

- Microprocessor based engine cooling system
- High lube oil sump capacity

- Self-cleaning inertial type primary filter
- Efficient secondary air filtration

9. **Improved Miscellaneous Electrical Systems:**

- Wide range dynamic brakes effective down to near standstill
- Maintenance-free roller suspension bearings having lower rolling resistance
- Efficient filtration for electronic cabinet.

10. **Cab Features**

- Desk style control console
- Air operated windshield wipers
- Multi-resettable vigilance controls (optional)

11. **Air System**

- Knorr CCB Electronic Air Brake System
- Direct drive WLN air compressor

12. **Safety Aspects**

- Increased crashworthiness requirements
- Cab design and overall car body configuration provides improved visibility
- Anti-climberavailable

CHARGE AIR SYSTEM OF HHP LOCOS

Diesel Engine in WDG4/WDP4 locomotive is a super charged fuel-efficient and two stroke engines. Since the locomotive is provided with two-stroke engine, the inlet air requirement for proper combustion of the fuel is high. To fulfil the requirement of the engine a special turbo super charger is provided in this locomotive to supply required quantum of air in each notch according to load and speed condition.

REQUIREMENT OF AIR SUPER CHARGING SYSTEM

Diesel engine Uses chemical energy to generate Heat energy. This heat energy will be later converted into Mechanical energy. To produce the heat energy, fuel is burned inside the combustion chamber. For efficient burning more oxygen is required. For supplying more fuel, SUPER CHARGING is required. In this process air is introduced into the engine cylinder at a density more than ambient. This will produce more power than a naturally aspirated engine for the same bore and stroke dimension. Super charging causes better scavenging also.

ADVANTAGES OF SUPER CHARGING

- Better cooling of components.
- Saves them from failure due to thermal stresses.
- Enhances the service life.
- Better fuel efficiency.
- Power to weight ratio is much more.

COMPONENTS OF CHARGE AIR SYSTEM

Air intake system is dividing in the following steps.

1. Inertial air intake/cyclonic type air intake filters
2. Clean air chamber
3. Baggy type engine air intake secondary filters.
4. Turbo super charger.
5. After coolers.
6. Air boxes.

1. **Cyclonic Filters**:

Air from the atmosphere is taken into cyclonic filters provided on both sides of the locomotive outside the clean air chamber. AC motor driven dustbin blower creates partial vacuum in clean air chamber and draws air from the atmosphere. The dust, dirt and suspended particles in the drawn air will be expelled out by centrifugal action created by inertial/cyclonic filters. Pure filtered air will be taken inside clean air chamber and dustbin blower will pump the dust and dirt out down the locomotive.

2. **Clean air chamber;**

Air from the clean air chamber is further utilized for the following.

a) The diesel engine through secondary air intake baggy filters.

b) For cooling of all six traction motors and main alternator by TM blower and for the air compressor air intake.

c) Air is taken to cool both the TCC's through TCC electronic blower.

d) Compressed air is taken to pressurize electrical control cabinet to protect components from entry of dust.

3. **Baggy Type Engine Air intake Filter:**

Air from the clean air chamber is drawn by turbo through engine mounted baggie type secondary air intake filters, which further filters the intake air for the engine, and clean air is pumped to engine air boxes by turbo charger.

4. **Turbo Charger**:

The turbo charger is basically provided to increase the engine horsepower output to it maximum extent and provide better fuel economy. The turbo charger provided in this locomotive is of a special type single stage turbine, which maintains constant air to fuel ratio throughout the engine operation.

At the beginning stage turbo is directly driven by the engine through a gear train approximately with gear ratio of 1:18 and after reaching 6^{th} notch in load, turbo mechanical drive will be disengaged by overriding clutch since the energy in exhaust gases from the engine is sufficient to drive the turbo. Air then is compressed by the turbo impeller and is directed to after coolers through diffuser casing.

5. **After Coolers:**

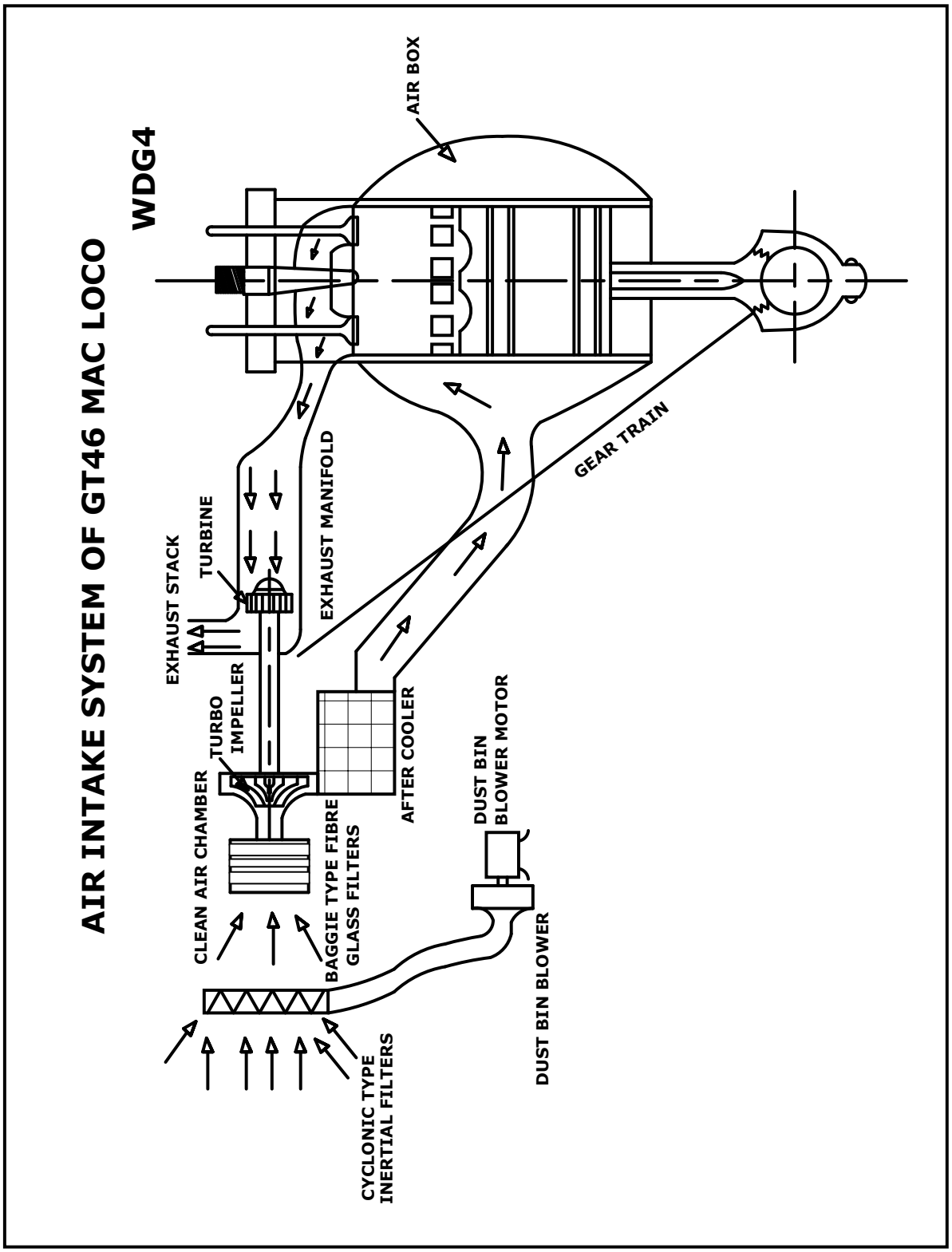
Two after cooler are provided in this locomotive one on either bank of engine. After cooler is water-cooled type to take out heat from the compressed engine intake air to supply high dense air for complete combustion of the fuel in combustion chamber. The water for after cooler is taken from the engine cooling water system.

6. **Air Boxes**:

Air boxes are provided one on each bank of the engine to supply the high dense clean air for the engine requirement. Air from the air box is taken into individual

cylinder through cylinder liner port openings during suction stroke when piston uncovers the inlet force.

The huge air box on either side of the engine helps to cool the cylinder continuously since the compressed and after cooled air is surrounded the cylinders. A common drain from both bank air boxes is provided down in between two trucks, which drains the water or oil, which is collected in the air boxes. Drivers or crew are required to see this air box drain pipe and report to shed if they found water traces which is the symptom of water leakage in the air intake system.


AIR INTAKE SYSTEM OF GT46 MAC LOCO
WDG4
AIR BOX
GEAR TRAIN
EXHAUST MANIFOLD
TURBINE
EXHAUST STACK
TURBO IMPELLER
AFTER COOLER
DUST BIN BLOWER MOTOR
CLEAN AIR CHAMBER
BAGGIE TYPE FIBRE GLASS FILTERS
DUST BIN BLOWER
CYCLONIC TYPE INERTIAL FILTERS

TESTING OF CHARGE AIR SYSTEM

Roller clutch test:

1. Idle engine until normal operating temperature is reached. (If engine cannot be started, remove rubber boot from turbo inlet and verify that the impeller locks up when attempting to turn in a clockwise direction by hand. If this does not occur, either the clutch has completely failed or a planetary gear train failure has occurred. Refer to paragraph Additional External Inspections.)
2. With engine warmed-up, push injector control linkage lever inward, increasing engine speed to approximately 700 RPM.
3. Pull injector control linkage lever out completely to “No Fuel” position, overriding the engine governor. (At this time, the clutch will disengage, allowing the turbine to spin free of the gear drive.)
4. As the engine begins to stall, push the injector linkage lever in once again, providing more fuel, which should increase engine speed. The decelerating turbine wheel will “meet” the accelerating engine gear train and the roller clutch should engage, providing sufficient air for continued engine speed increase.

   If the clutch fails to engage, the injector rack linkage will move toward “full fuel” position, black smoke will emit from the exhaust duct due to a lack of air, and the engine may stall. These symptoms indicate an imminent clutch failure, consequently the turbocharger should be replaced. Turbocharger roller-type clutches tend to fail gradually rather than suddenly. This characteristic refers to the fact that in early stages of clutch wear-out, the slippage may be intermittent. In such instances, the engine may smoke heavily or stall during speed changes, yet behave normally later. To ensure that the clutch is not in this early stage of failure, the aforementioned test procedure may

5.

be repeated a few times. However, articles stating that as many as **30** consecutive tests may be required are in error.To avoid damaging a good clutch, injector linkage manipulation should not be performed more than **2** or ***3*** times to qualify a clutch. If the clutch is in fact defective, the turbo should exhibit the reference symptoms within this number of trails.

FUEL OIL SYSTEM (HHP)

The fuel oil system is designed to supply fuel to the engine in **correct quantity and at the right time** according to the engine requirements. The fuel oil system draws fuel from fuel tank, filter the fuel, pressurise the fuel, and inject the fuel into the engine in correct quantity in atomised condition.

Fuel Oil System Consist Of

1. Fuel feed system

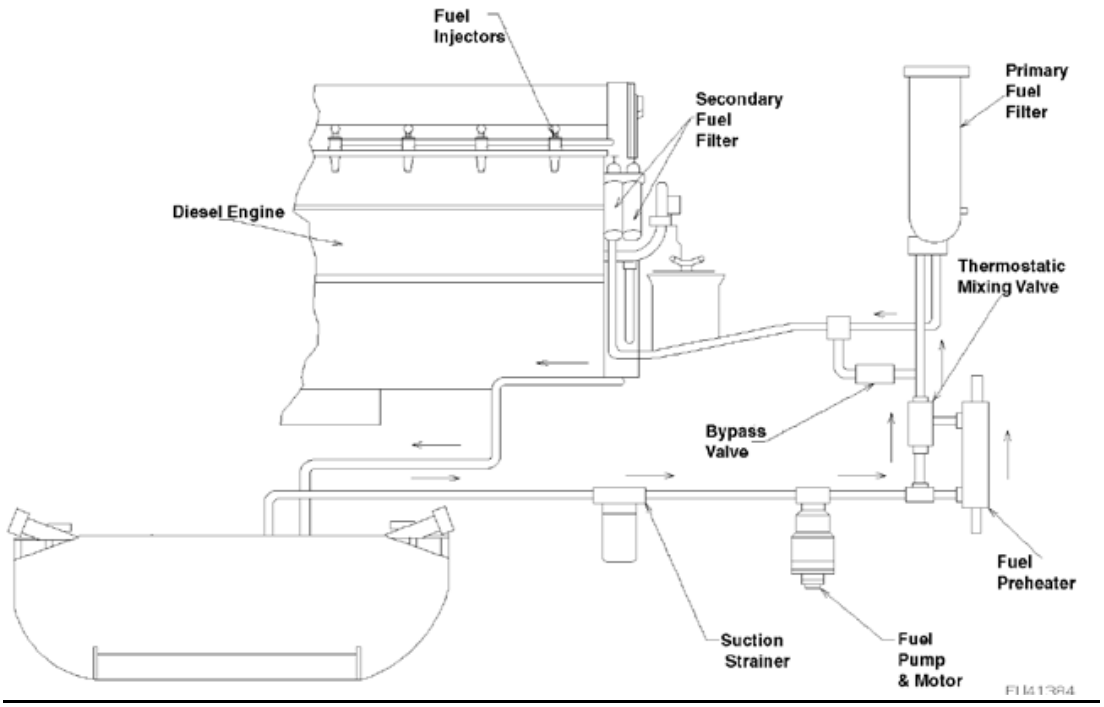
2.Fuel injection system

FUEL FEED SYSTEM

Fuel is drawn from the fuel oil tank through a suction strainer by the fuel pump. The strainer separates foreign particles from the fuel oil, and protects the fuel pump. The pump is designed to supply adequate quantity of fuel to the engine at various speeds and load conditions.

Fuel then goes into primary filter. This primary filter is provided with a 30 PSI bypas valve with sight glasses, which should be normally empty. Whenever primary filter is choked/clogged and the pressure difference reaches 30 PSI this bypass valve opens allowing the fuel directly to the system, which can be noticed by the flow of bypass fuel in the sight glass. Under such cases, the primary filter element is changed.

The fuel then passes to 02 engine mounted secondary filters, which are of spin-on type. Secondary fuel filters are also provided with a bye-pas value, which is set at 60 PSI. Whenever the filters are choked/ clogged and the pressure difference across the secondary filters reaches 60 PSI, this bye-pass valve opens and diverts the fuel oil back to fuel tank, avoiding damage to fuel injectors due to unfiltered fuel oil. A bye-pass sight glass is also provided to indicate the condition of the fuel secondary filters and the sight should be normally empty.



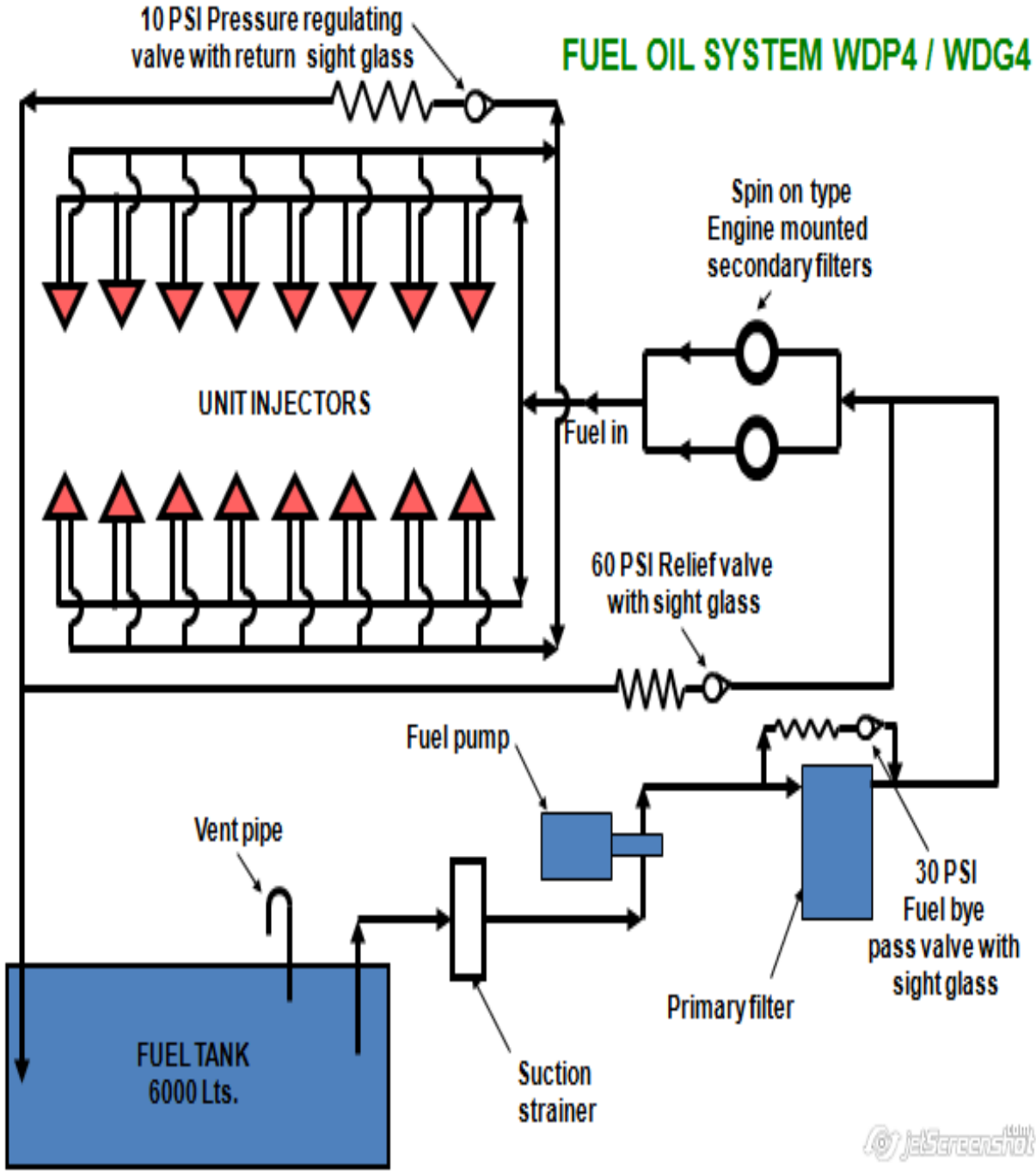
FUEL OIL SYSTEM

The secondary filters the fuel oil is supplied to all unit injectors through fuel supply manifolds located inside the top deck on the both banks. The governor controls the quantity of fuel to be injected through the injectors to the engine.At the end of the fuel supply manifolds, a regulating valve with a sight glass is provided which is set to 10 PSI. The regulating valve ensures constant fuel supply to all unit injector in all working conditions. If the system is working properly the sight glass should indicate clear and clean fuel oil flow all the time. Air bubbles, interrupted fuel flow or no fuel flow in the return sight glass indicates problem in the fuel feed system.

FUEL INJECTION SYSTEM

Fuel supplied by the fuel feed system is always available at all the unit fuel injectors. The fuel oil available at each injector are to be pressurized to very high pressure, timed and to be injected in the cylinder in atomized form. The timing of each unit injector is decided by the camshaft and the fuel is pressurized by the in-built fuel injection pump which is operated by individual cam lobe of the cam shaft.

The quantity of fuel to be injected will be regulated and controlled by engine mounted wood word governor according to the notch and load conditions. The governor operates fuel control shaft, linkage mechanism and fuel racks. The individual fuel injector nozzle does the atomization of the fuel to be injected in the cylinder.


FUEL OIL SYSTEM WDP4 / WDG4
10 PSI Pressure regulating valve with return sight glass
Spin on type Engine mounted secondary filters
UNIT INJECTORS
Fuel in
60 PSI Relief valve with sight glass
Fuel pump
Vent pipe
30 PSI Fuel bye pass valve with sight glass
Primary filter
FUEL TANK 6000 Lts.
Suction strainer

LUBE OIL SYSTEM

The complete engine lubricating oil system is a combination of 04 oil systems. These are:

(1) Scavenging oil system

(2) Main lubricating oil system

(3) Piston cooling oil system

(4) Soak Back or turbo lube system

LUBE OIL PUMPS

- Each system has its own lube oil pump.
- The main lube oil pump, piston cooling oil pump and scavenging oil pumps are driven from the accessory gear train at the front end of the engine.
- The soak back or turbo lube system is driven by a electric motor.
- The main lube oil pump and piston cooling oil pump is a individual pump but both contained in one housing and driven from a common drive shaft.

Scavenging Oil System

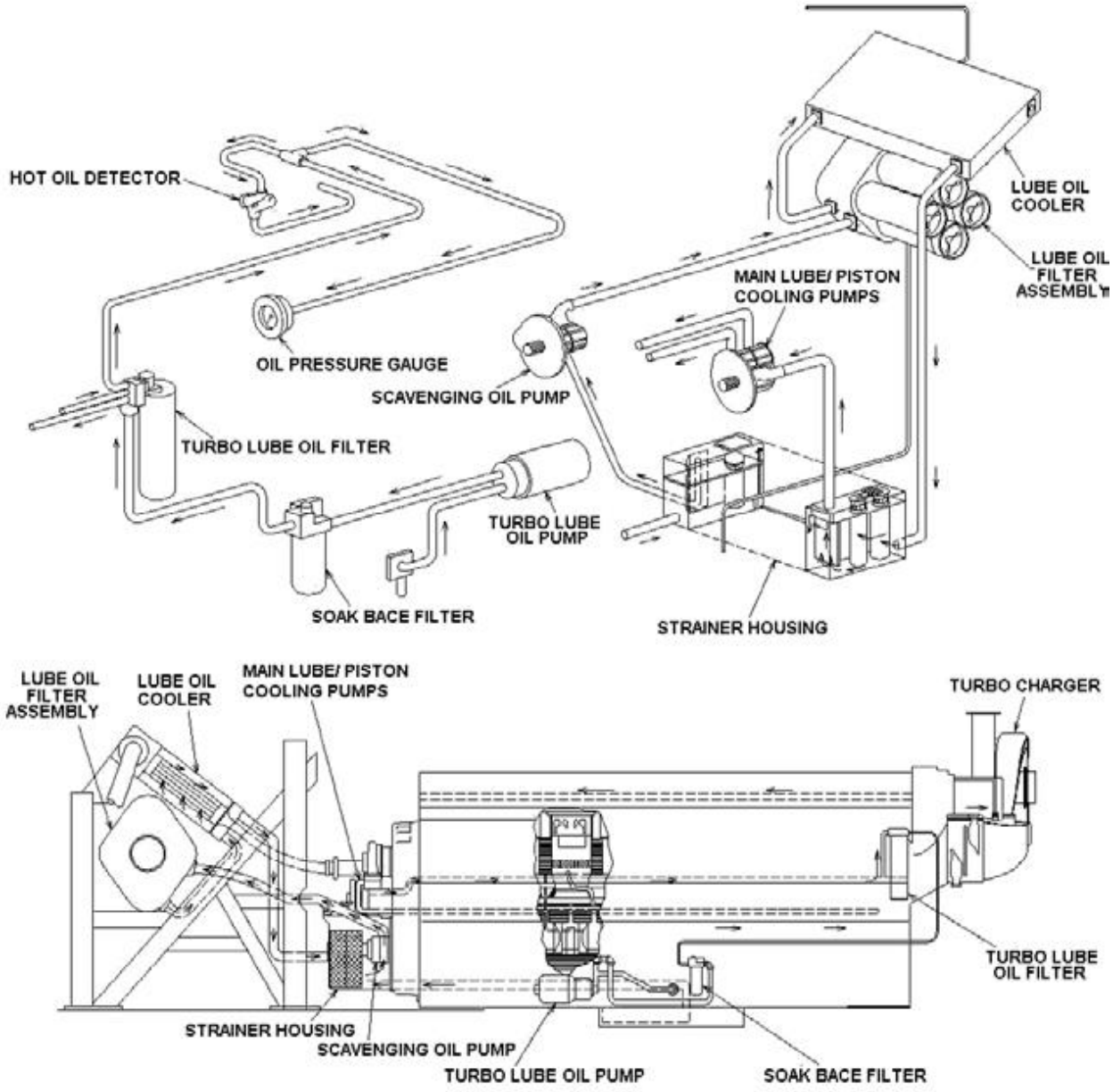
The scavenging oil pump is a positive displacement, helical gear type pump. This pump takes lube oil from 02 sources- from the engine oil sump and from the oil strainer.
The pump feed lube oil to lube oil filter tank (also called Michiana oil filter). Oil from the filter tank gose to lube oil cooler where it is cooled by the engine cooling system. Oil then passes to lube oil strainer where it is filtered once again. The oil filter (Michiana oil filter) contain 5 paper type filter elements. A bypass valve provided across the filter tank and set at 40 PSI. If the filter is clogged and pressure difference reaches to 40 PSI oil is bye passed to lube oil cooler. This ensures adequate lube oil supply to the engine avoiding damages to the moving parts. The oil filter and the lube oil cooler are located in the equipment rake.The lube oil strainer is having 02 fine mesh strainer elements.

Piston Cooling Oil System:

There is a suction pipe (coming from the lube oil strainer) for the piston cooling oil system and the main lube oil system. The piston cooling oil system pump receives oil from a common suction pipe and delivers oil to the 2 piston cooling oil manifolds extending the full length of the engine, one on each bank. A piston cooling oil pipe at each cylinder directs a stream of oil to cool the underside of the piston crown. This stream of oil also lubricate the ring belt. Some of this oil enters oil grooves in the piston pin bearing for lubrication. Oil after cooling and lubrication drains back in to the oil sump.

Main Lubricating Oil System:

The main lubricating oil system supplies oil under pressure to most of the moving parts of the engine. The main lube oil pump takes oil from the strainer housing through a common suction. Oil from the pump goes to the main oil manifold, which is located above the crankshaft, extends to the length of the engine. Maximum oil pressure in the system is control by a relief valve in the passage between the pump and the main oil manifold. The pressure relief valve is set to 125PSI, which relives excess oil back to the sump.



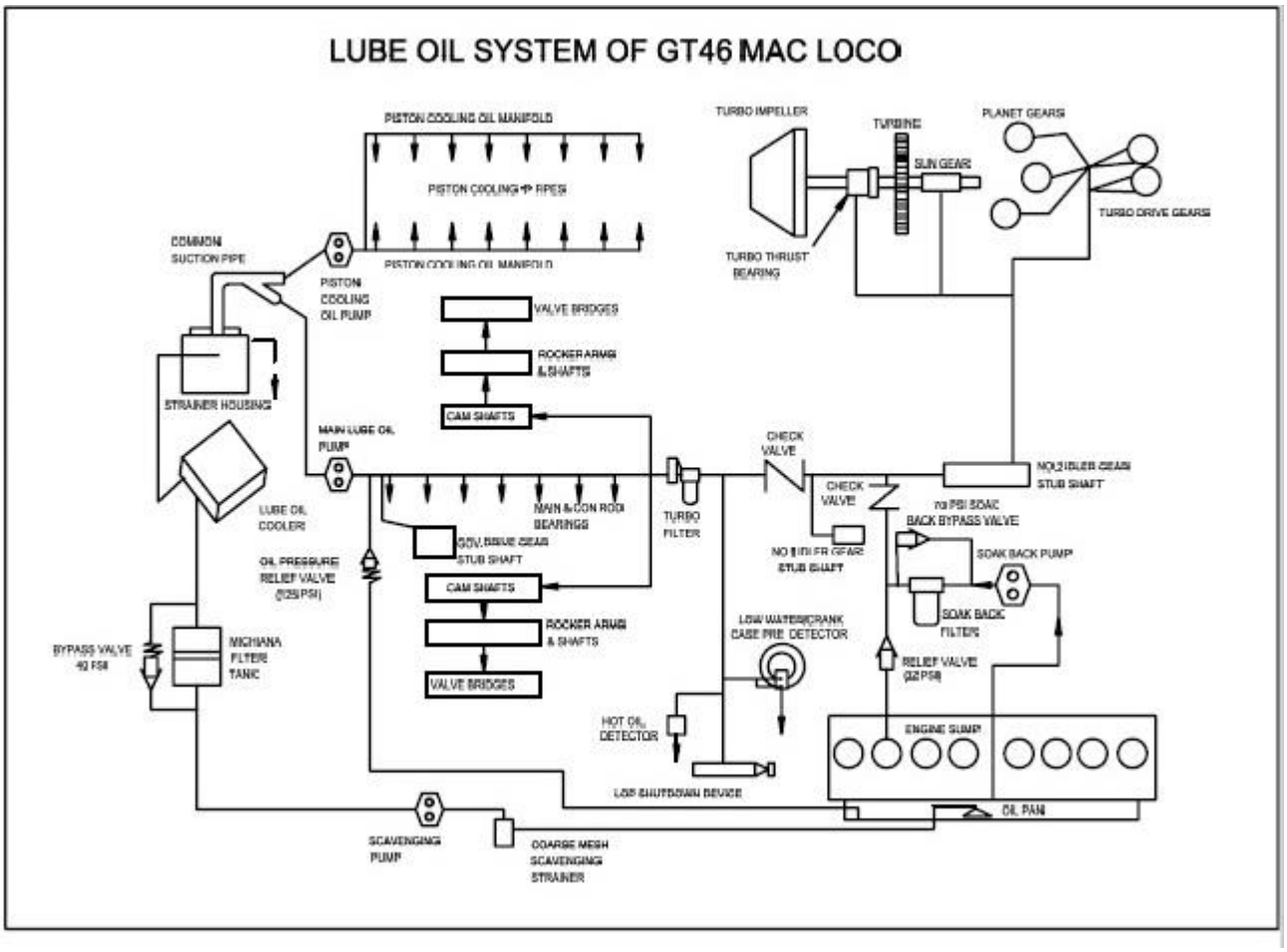
LUBE OIL SYSTEM (HHP)

Oil tubes in the centre of the each main bearing receives oil from the main manifold to the upper half of the crankshaft main bearings. Drilled passage in the crankshaft supplies oil to the connecting rod bearings, vibration damper and accessory drive gear at the front end of the crankshaft. Oil from the manifold enters gear train at the rear end of the engine at the idler gear stub shaft. Oil passes in the base of the stub shaft from where oil is distributed

to various parts through passage. One passage conducts oil to the left bank camshaft drive gear stub shaft bracket through a jumper. Another passage conducts oil to the Right Bank camshaft drive stub shaft bracket and the turbo charger oil filter supply line.

Oil enters the hollow bore camshaft from the camshaft stub shafts. Radial holes in the camshafts conducts oil to each camshaft bearing. An oil line from each camshaft bearing at each cylinder supplies oil to the rocker arm shaft, rocker arm cam follower assemblies, hydraulic lash adjusters and to rocker arm. Leaks of oil return to the sump.

The turbo charger oil filter supply line sands oil to the turbo lube oil filter which sands oil to the turbo oil manifold and then to turbo for cooling and lubrication. A branch line taken to the wood word governor low lube oil pressure shut downdevice and also to the hot oil detector. The minimum oil pressure is approximately 8-12 PSI at idle and 25-29 PSI at full speed. In the event of insufficient oil pressure, a shutdown feature in the governor will automatically protect the engine by shutting down.



LUBE OIL SYSTEM

The turbo charger oil filter provides additional protection for the high-speed bearing and other lubricated areas of the turbo. The filter heads contains 2 check valves, one to prevent the lube oil from the soak back system from going into the turbo charger filter during soak back pump operation and the other to prevent lube oil from the turbo charger filter from entering the soak back system when the engine is running. Passages in the turbo charger conducts oil to the turbo bearings, idler gear, planet gear assembly and auxiliary drive bore.

Soak Back Oil System:

To ensure lubrication of the turbo charger prior to the engine start and the removal of residual heat from the turbo after engine shutdown, a separate lube oil pressure source is provided. This pressure system is controlled automatically by the locomotive control system.

An electrically operated turbo soak back pump draws oil from the oil sump, feed the oil through a soak back filter and finally to the turbo. A 70-PSI soak back filter bypass valve is provided inside the soak back filter housing to bypass filter whenever it clogs to protect Turbo-charger.

This soak back pump automatically starts working before cranking the engine. When the engine start, the motor driven soak back pump is still running, main lube oil pressure from the engine driven pump becomes greater than the motor driven soak back pump pressure. As there is no outlet for the lower pressure oil, the relief valve is provided in the filter head set to 32 PSI will return the oil back to engine sump.Considerable heat will remain in the metal parts of the turbine when the engine is shutdown and due to sudden cut off oil supply to the bearings, damage or more wear will take place in the bearings since the turbo rotor will be rotating even after the engine stops due to its momentum. To avoid the thermal stressing and unwanted wear in the bearings due to no oil supply, this soak back pump automatically starts working after shutting down of the engine. Soak back pump will be

working for 30 to 35 minute approximately even after engine shutdown. This ultimately increases the life of the turbo.

LUBE OIL SEPARATOR:

The oil separator is an elbow shaped cylindrical housing containing a wire mesh screen element. It is mounted on turbo charger housing. An elbow assembly connects the separator to the ejector tube assembly in the exhaust stack. The eductor tube in the exhaust stack creates suction in the engine crankcase and draws up oil vapor from the engine crankcase, while doing so. The oil drawn will be collected on the wire mesh element and drain back to the engine sump.

HOT OIL DETECTOR:

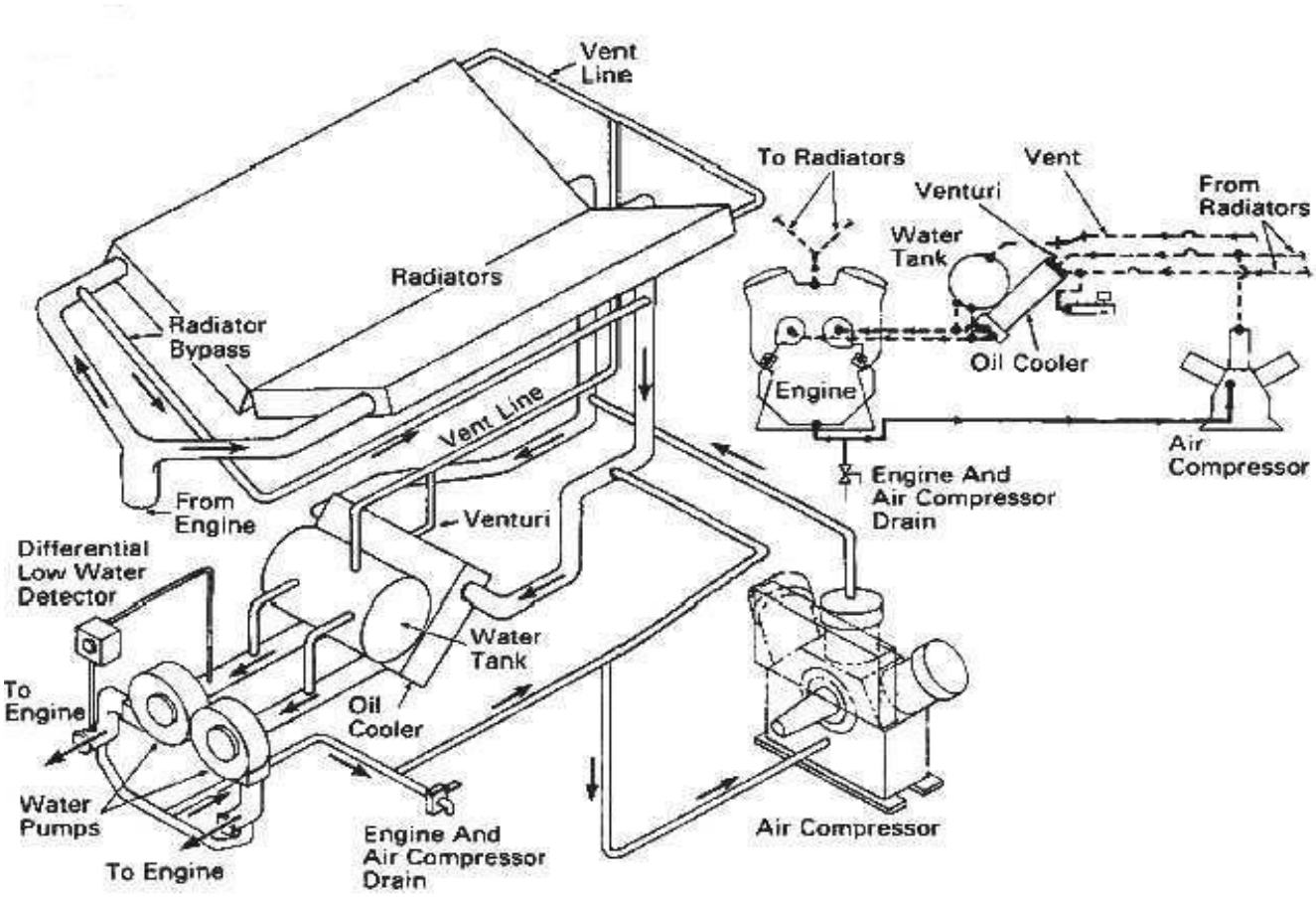
Normally there is a close relationship between engine coolant temperature and engine lube oil temperature. Hot oil detector senses the oil temperature and send informations to EM2000. If the temperature of the oil exceeds approximately 255 degree F (124 degree C) EM 2000 will shut down the engine through governor and the fault will be display

COOLING WATER SYSTEM OF WDG4/WDP4

Engine cooling water system is a closed loop pressurized water cooling system. The engine cooling system consists of engine driven centrifugal water pumps (2), replaceable inlet water manifolds (2) with an individual jumper line to each liner, cylinder head discharge elbows, and an outlet manifold through which cooling water is circulated. The centrifugal water pumps (one on an 8 cylinder engine) are mounted on the accessory drive housing and are driven by the governor drive gear. The water cooling system cools all the engine cylinder liners, cylinder heads, after cooler, lube oil cooler and compressor.

- In the water cooling system, there are 02 no. of engine mounted **water pumps (centrifugal type)**.
- The water pump receives water from the radiator through lube oil cooler.
- Water from the water pump is sent to the two (left and right bank) **water main headers (also called water inlet manifold).**
- From the water main header water enter to all the cylinder liner jackets through water jumper.
- After cooling the cylinder liners water enter in the cylinder head through 12 holes which are matched to cylinder liner with “O” rings and cool the combustion chamber of the cylinder head.
- Outlet water from each cylinder head goes to the **return header (also called water outlet manifold)** which carries water to the radiator.
- Each **water main header** is connected at the rear end from where water pipe line carries water to cool the after cooler.
- Water from the after cooler goes to water return header and through water return header to radiator.

-
- A water pipe line from the water pump carry water to compressor to cool the compressor liners, cylinder head, valves and the compressed air inside the inter cooler. Air compressor cooling is done whenever engine is running.

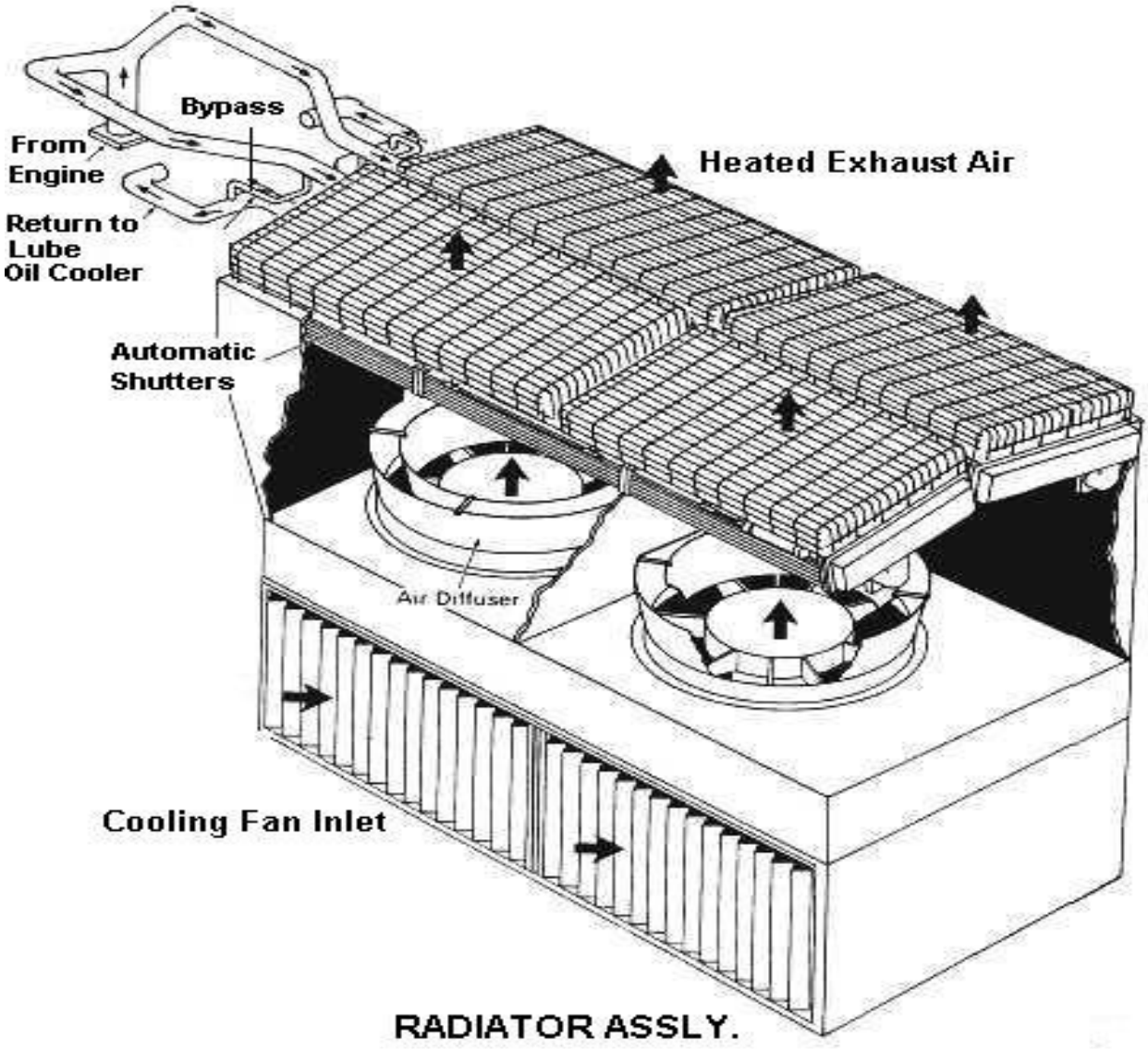


WATER COOLING SYSTEM IN WDG4/WDP4

DETAILS ABOUT RADIATOR

- The radiators are located in a hatch at the top of the long hood end of the locomotive.
- The hatch contains the radiator assemblies, which are grouped in two banks. Each radiator bank consists of two quad length radiator core assemblies, bolted end-to-end.

-
- Headers are mounted on the radiator core to form the inlet and outlet ends of the radiator assembly, a bypass line is provided between the inlet and outlet lines in order to reduce velocity in the radiator tubes.
- Two 8-blade 52” cooling fans, which operate independently, are located under the radiators in the long hood carboy structure. They are numbered 1, and 2, with the No. 1 fan being closest to the driver cab.
- The water pump inlet side is connected to an expansion tank for makeup water in the water system. The expansion tank is located in the equipment rack.



TEMPERATURE CONTROL BY THE COOLING SYSTEM

- Mainly the two electronic **temperature sensing probes (ETP1& ETP 2)**, **EM2000 computer** and the **radiator fans** take part in controlling the water temperature.
- Two electronic temperature-sensing probes (ETP1& ETP 2) are located in the water pipe line between the lube oil cooler to the inlet of the water pump on the engine left side.
- Temperature probe readings are converted by **ADA Module** from analog to digital signals which are used by the EM2000 to control all cooling functions.
- Each cooling fan is driven by a **two-speed AC motor**, which in turn is powered by the companion alternator.
- As the engine coolant temperature rises, the fans are energized in sequence by the control computer (slow speed). As additional cooling is required, the fans switch to full speed in progression as coolant temperature rises. As coolant temperature drops, the fans switch off one at a time.
- The cooling fans are controlled by the computer which acts on the contactors. The computer also controls the fan sequencing duty cycle (on period/total period) and speed (low or high) to ensure even fan and contactor wear.
- The engine water temperature can be observed by a gauge located on the inlet line to water pump. The gauge is color coded to indicate **cold (Blue), normal (green) and hot (red).**
- When the engine temperature becomes excessively high, the EM 2000 will display "**HOT ENGINE**"- and **throttle 6 limit**" message. The computer will initiate the

- reduction in engine speed and load up to 6th notch. This condition will remain in effect until the temperature return to safe limit.
- If the engine water temperature is below 115 ^{0}F (46 ^{0}C), the engine speed will be raised to throttle 2 automatically by the computer.
- Once the engine water temperature reaches above 125 0F (52 0C), the engine speed will be reduced to IDLE.
- The reason for engine speed up will be displayed to the driver on EM 2000 computer monitor as "**Engine speed increase- low water temperature**".

COOLING SYSTEM PRESSURIZATION

The cooling system is pressurized to increase the boiling point of the coolant, prevent cavitations at the water pumps during high transient temperature conditions, and to provide uniform cooling throughout the operating range of the diesel engine. The expansion tank has a pressure cap that regulates system pressure at 7, 12, or 20 psi (48, 82 or 138 KPu) depending on engine requirements.

OPERATING WATER LEVEL

The operating water level indicator indicate minimum and maximum water level with the engine running or stopped. The water level mark should not be permitted to go below the applicable "low" water level mark. Progressive lowering of the water in the gauge glass indicates a water leak in the cooling system, and should be reported.

The coolant is circulated through the engine to transfer heat from the engine components to the radiators. **Engine coolant** is composed of **water, corrosion inhibitor**, and when considered necessary, **antifreeze**.

COOLANT:

To be suitable for use in EMD engines, a coolant must meet four Basic requirements:

- Adequately transfer heat energy through the cooling system

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- Not form scale or sludge deposits
- Prevent corrosion inside the cooling system
- Can’t deteriorate seals or gaskets in the cooling system

WATER

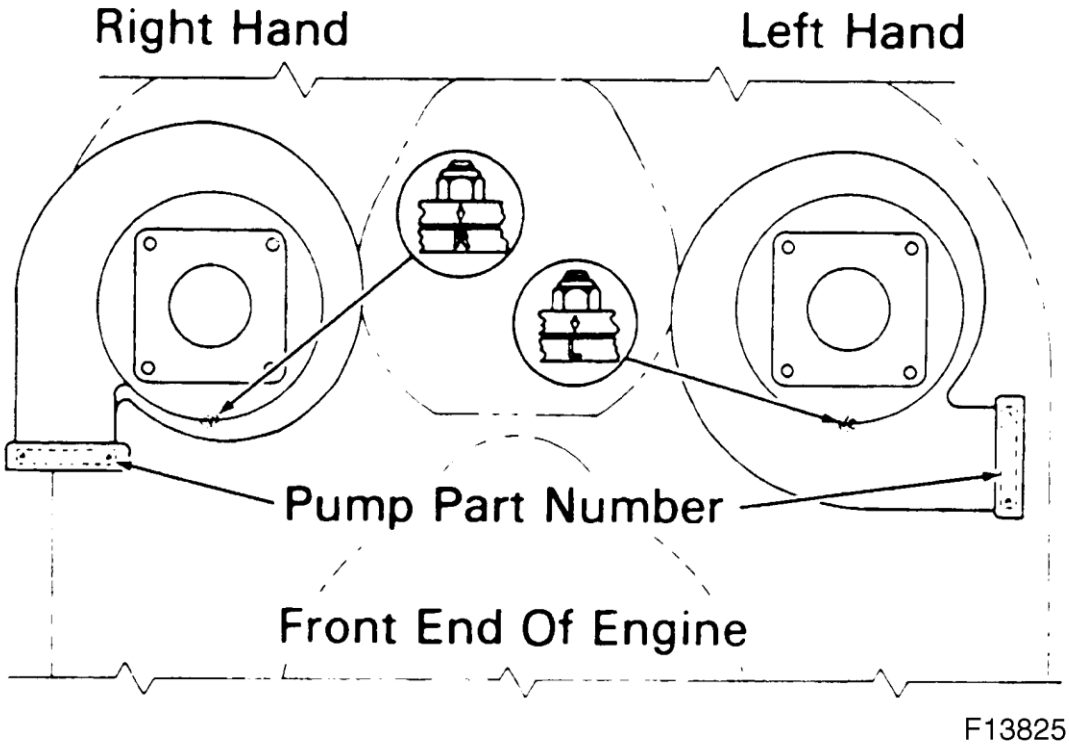
The water in some areas contains elements such as excessive solids, hardness salts, or corrosive elements such as chlorides that make it unsuitable for use in the cooling systems of EMD engines. Water from these sources should be processed by **softening, de-ionizing,** or **distillation** to make it suitable for cooling system use.

CORROSION INHIBITOR:

The main type of corrosion inhibitor for EMD engines is the **borate-nitrate type**. Borate-nitrate is available in powder, pellet, and liquid form. Powder and pellet form inhibitors should be dissolved in water in a separate container before being added to the cooling system. The level of borate-nitrate should be maintained in a concentration above **5625** parts per million.

WATER PUMPS:

The two engine cooling water pumps ***(one on*** 8 ***cylinder engines)*** are self-draining centrifugal pumps, which rotate in the opposite direction of the engine crankshaft.


Right Hand
Left Hand
Pump Part Number
Front End Of Engine
F13825

WATER PUMPS

COMPUTER CONTROLLED BRAKE SYSTEM (CCB)

The loco is equipped with a KNORR brake system. The KNORR systemis computer controlled air brake system (CCB).The CCB equipment is a complete microprocessor based airbrake control system. All logics are computer controlled.The driver uses one of the two control stands (cab control unit (CCU) tocontrol the CCB system. Emergency applications are also initiatedpneumatically in parallel with computer initiated emergency applications.The main parts of the CCB system are as follow:

BRAKE VALVE CONTROLLER (BVC)

AutomaticBrake Valve :(This isfor the full train withloco.)

Automatic Brake valve having 5 positions:

- **Release/Overcharging)**

(Spring-loaded)-5kg/cm^2.

- **Running:**

ER and BP Pr. =5.2kg; /cm^2.

- **Minimum service:**

ER/BP reduceto4.7kg/cm^2,BCP=1.1kg/cm^2

- **Full Service**

ER reducesto3.4kg/cm^2, BCP= 4.35kgs/cm^2

- **Emergency**

ER reducesto0, BP, reducesto<1.0kg/cm2

BCP=4.35kg/cm^2,BCEP=3.57kg/cm^2

ER =Equalizing reservoir pressure

BP=Brake Pipe pressure

BCP=Brake cylinderpressure

Independent BrakeValve:

(This is for the loco brake only) It is direct Brakes having following positions

- **Release positions**

  BCP=0

- **Applicationzone**

  Max Brakeposition:BCP5.2kg/cm^2

  BCEP=3.7Kg/cm^2

  BCEP =Brake cylinder equalizing pressure

- **Bail off**

  When an automatic brake is applied,lifting the bail off ring which is provided in the brake valve handle in any position will release BC as a result of BP reduction. Independent brake handle bail off ring is spring-loaded and by lifting it the bail off function will actuate.

CONTROLSTAND

Selector Switch or Air Brake Trial /Lead Set UpSwitch:

The trail/Lead setup switch is located on the brake control next to independent brake handle. The switch has the following 3 positions:

- **Trail**

  Used with loco in trailing position and on non-working control of the working loco.

- **Lead-In:**

  Used with loco in leading unit or controlling unit in MU consists.Airbrakesystem responds to air brake handle movements when trail/Lead switch is in this position.

- **Lead-Out:**

  Used during brake pipe leakage testing and on banking loco control stand.

Air Brake Equipment Rack:

Provided in the nose compartment consisting following:

- Voltage conditioning Unit (VCU)
- ComputerRelay Unit (CRU) or Air Brake computer
- AnalogConverters.
- MagnetValves
- PneumaticValves
- Filters
- Transducers
- KEDistributor Valve (Back-upvalve)
- Reservoirs

BrakePipe ControlSystem

According tothe autobrake valve controller handle position, signals fromthe brake handlewill go to the fibre optic receiver(FOR)then to the air brake computer. Computer will send signals to analog converter.

The analog converter operates magnet valves provided in it and from the magnet valves piloting air pressure will go to the other main magnet valve which is controlled by CCB computer. The output air pressure of the main magnet valve is called as equalizing Reservoir and is acting as pilot pressure for the BP relay valve. BP relay valve is a self-lapping pressure maintaining pneumatic valve which maintains the BP pressure to the level of ER against train brake pipe leakage conditions.

There are transducers provided in the ER pipe and BP pipe to send feed backsignals to the computer regarding the pressures available or maintained in the respective pipelines.

Emergency Application:

An emergency application means to apply brakes at the maximum rate. When the brake valve handle is placed in the emergency position, ER reduces at the faster rate to zero pressure and also the brake valve mechanically opens a vent valve. In addition the brake controller is provided with a switch which opens sending an emergency signal to the computer. Then the computer energizes an emergency magnet valve (MVEM). The opening of MVEM vents the pilot port of the high capacity BP relay pneumatic valve (PVEM) exhausting BP pressure.

Automatic Brake Application on Loco:

The brake pipes transducer (BPT) provided in the BP pipe detects the reduction in BP and sends signal to computer. The computer calculates the required brake cylinder pressure and commands the BC analog converter to maintain the desired rate of pressure level in the brake cylinder. The brake cylinder analog converter operates a BC magnet valve. The output pressure of the BC magnet valve work as a pilot pressure for the BC relay valve. BC relay valve is a self-lapping pressure maintaining pneumatic

valve which will come to thelap position when matches with the BC pilot air pressure. The application is complete if the BC pressure is maintained at the level commanded by the computer until the brake valve handle is again moved.

Bail-Off Automatic Application:

When the automatic brake is applied lifting the bail-off ring provided in the independent brake valve handle in any position will release the brake cylinders of loco.

On the Lead Unit, the CCB Computer commands the BC analog convertor to release the pilot air pressure, which, in turn drives the BC relay valve to release the BC pressure if an emergency brake has been made, the brake will re applyto maximum as soon as the bail off ring is released

NOTE;- If the bail-off continuous for longer than 50 seconds the BC pressure will be restored and a fault will be displayed on the EM2000 display screen. The crew messages the centre point of display and it will indicate fault condition that required immediate attention.

Independent BrakeOperation:

According to the independent brake valve controller handle position, signals from the brake valve handle will go to the fibre optic receiver (FOR) and then to the computer. Computer will send signals to the BC analog converter. The analog converter operates the BC relay valve. BC relay valve is a self lapping pressure maintaining pneumatic valve which will come to the lap position when matches with the BC pilots air pressure.

Any leakage in the BC pipe will be noticed by the BC transducer (BCT) and the feedback signals will go to CCB computer. Then computer will in turn take corrective action to maintain BC pressure. The BC equalizing pipe (BCEP) is used to supply air to end from all the trailing units of the locomotive consists to control application and release of both automatic and

independent brakes. The only exception to this operation is locomotive consist separation.

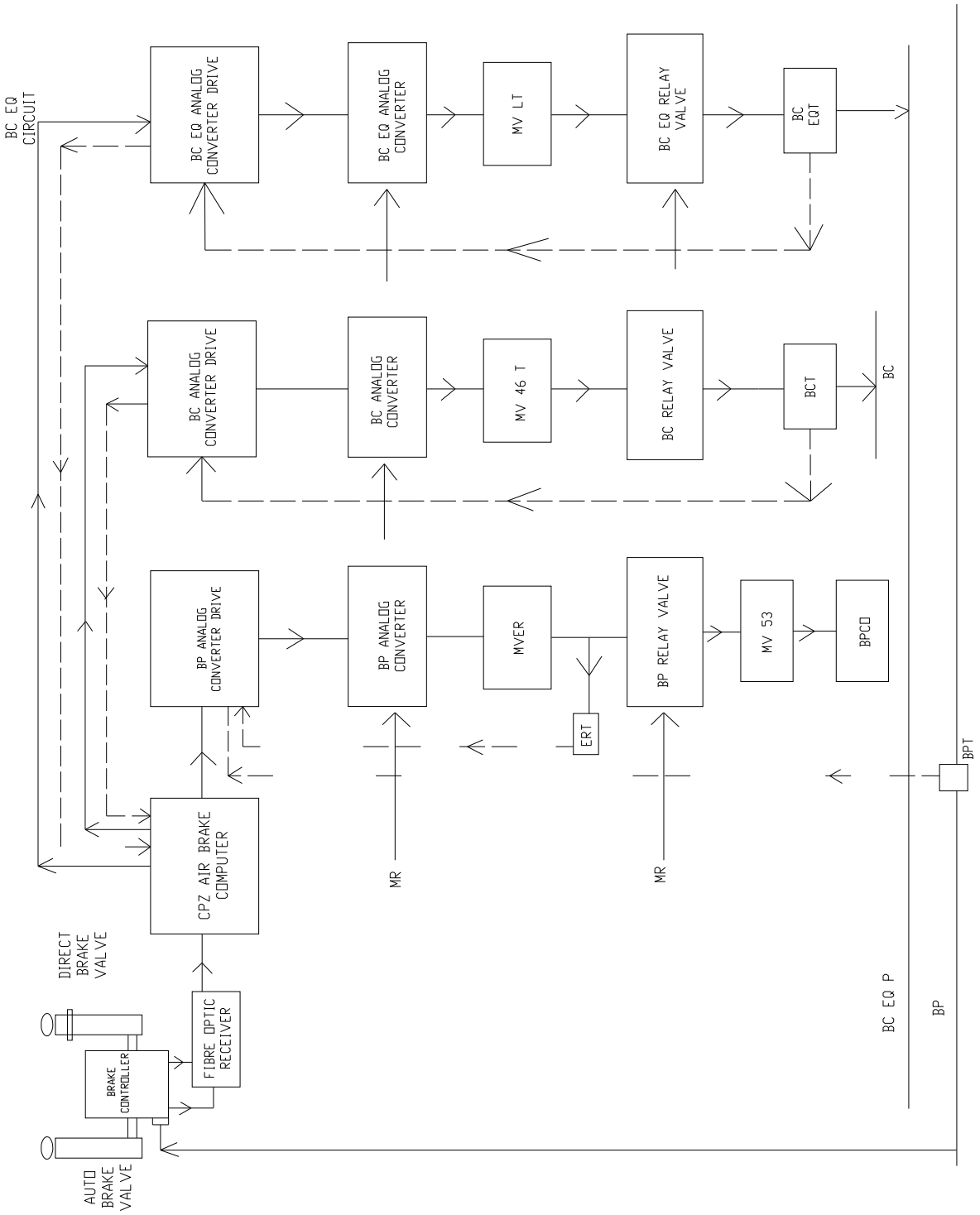
According to the service positions of the brake controller valve handles, CCB computer gets signals from the FOR. Then the computer sends the signals to BCEP analog converter to supply piloting air pressure to BCEP relay valve when the BC pressure equalizes BCEP, the BCEP relay valve moves to LAP position.

Maximum BCEP=3.7Kg/Cm^2

Introduction toBlended Brake System

The passenger service locomotive is equipped with a blended brake system. It simultaneously applies dynamic braking and air braking when the driver operates the automatic air brake handle in the service zone.

The Knorr CCB air brake system controls the air brakes on the locomotive and carriages coupled in trains and requests the required amount of dynamic braking from EM2000 computer for blended brake operation.



COMPUTER CONTROLLED BRAKE SYSTEM