CHARGE AIR SYSTEM (Turbo Supercharging)
(AIR INTAKE SYSTEM - ALCO)

INTRODUCTION:

The Diesel Engine produces mechanical energy by converting heat energy derived from burning of fuel inside the cylinder. For efficient burning of fuel, availability of sufficient fresh air in proper ratio is essential.

In a naturally aspirated engine, during the suction stroke, air is being sucked into the cylinder from the atmosphere. The volume of air thus drawn into the cylinder through restricted inlet valve passage, within a limited time would also be limited and at a pressure slightly less than the atmosphere. The availability of less quantity of air of low density inside the cylinder would limit the scope of burning of fuel. Hence mechanical power generated inside the cylinder is also limited.

In supercharged or pressure charged engine, during the suction stroke, pressurized air of high density is being charged into the cylinder through the open suction or inlet valve. Air of higher density containing more oxygen will make it possible to inject more fuel into the same size of cylinder and produce more power, by effectively burning it. As artificial measures are used to increase the volume of fresh charge air into the system; thus this system also termed as Artificial Aspirated System

ADVANTAGES OF SUPER CHARGED ENGINE:-

- A supercharged engine of given bore and stroke dimensions can produce 50% or more power than a naturally aspirated engine. The power to weight ratio in such cases is much more favorable.
- Results in better scavenging, and it ensures carbon free cylinders and valves and better health for the engine also.
- Better ignition due to higher temperatures developed by higher compression in the cylinder.
- Better fuel efficiency due to complete combustion of fuel by ensuring availability of matching quantity of air or oxygen.
- Reduction in thermal loading of the engine components by reducing the exhaust gas temperatures.
- Due to the availability of matching quantity of air or oxygen with respect to fuel, complete combustion occurs. As a result, polluting substances like NO_x, CO, CO_2, SO_x, and Particulate Matter (soot particle/suspended particle) emission reduces significantly.

TURBO- SUPERCHARGER SYSTEM

The Turbo-supercharger is generally provided at the free end of the locomotive, above the After-cooler. Generally TSC is having four casings- 1) Gas Inlet Casing, 2)Turbine Casing, 3) Intermediate Casing, 4) Blower Casing.

Gas inlet casing is connected with extended exhaust manifold. In exhaust manifold, gas comes from 14 exhaust elbows and remaining R1 & L1 exhaust elbows are connected directly to gas inlet casing (in case of 16 cylinder locomotives). One dome and nozzle ring is provided in this casing.

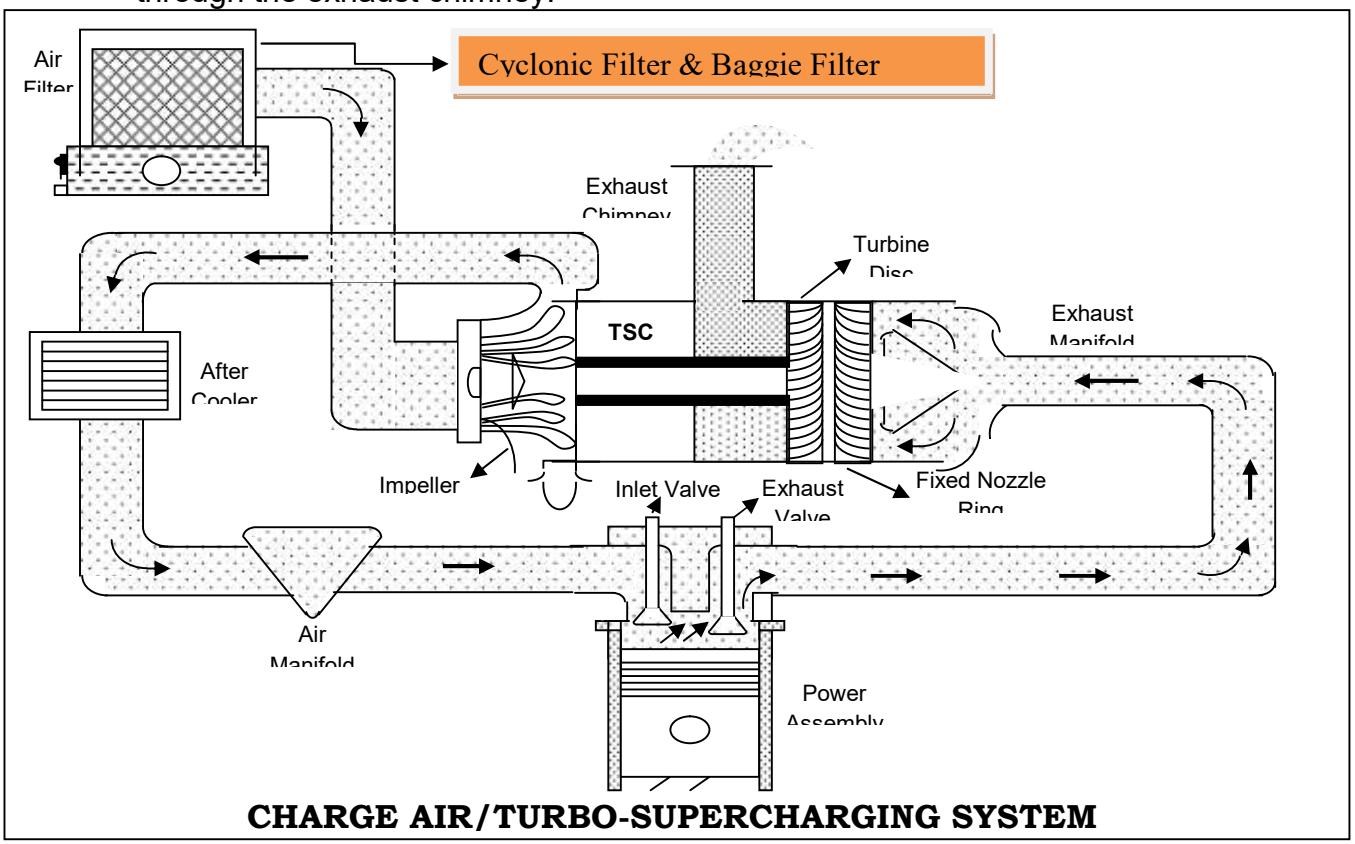
Rotor assembly comprises of common shaft, turbine disc with blade and impeller. It is mounted over the intermediate casing.

One side of the blower casing is connected with air filter and other side is connected with expansion joints to after-cooler. After-cooler is connected with "V" gallery or air channel. The inlet passage of every cylinder is connected to this air channel to suck fresh air as per the pre-set cycle.

WORKING PRINCIPLES OF CHARGE AIR SYSTEM

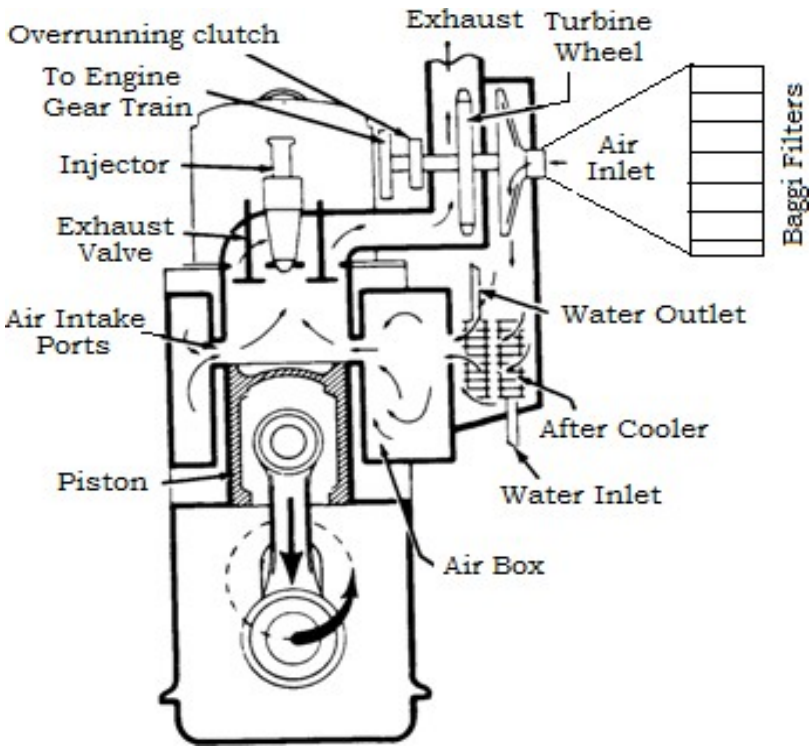
The exhaust gas discharge from all the cylinders accumulate in the common exhaust manifold at the end of which, Turbo-supercharger is fitted.

The gas under pressure there after enters the turbo-supercharger through the torpedo shaped bell mouth connector and then passes through the fixed nozzle ring. Then it is directed on the turbine blades at increased pressure and at the most suitable angle to achieve rotary motion of the turbine at maximum efficiency. After rotating the turbine, the exhaust gas goes out to the atmosphere through the exhaust chimney.



CHARGE AIR/TURBO-SUPERCHARGING SYSTEM

AIR INTAKE SYSTEM (HHP)



This system is used to increase air supply to engine to produce more HP. To achieve this, a turbo super charger working either by gear or exhaust gas is used. During engine starting and light load operation the sun-gear shaft of rotor shaft assembly receive drive from the main crank shaft through the planet gear system and a overriding clutch. When the engine works on full load (approximately in 6th notch) the overriding clutch in the drive gear is disengaged and the rotor shaft is driven by the velocity of exhaust gas. Clean air from the clean air compartment is drawn by the blower of the turbo super charger through Baggi filters. (Baggi filters are made by fiberglass material and coated with oil) and delivered to after cooler on both sides of the engine. Cooled air from the after cooler is collected in the respective air boxes and from there enters combustion chamber through inlet ports.

FUEL OIL SYSTEM (ALCO)

INTRODUCTION:-

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 in correctly atomised form. The system injects correctly metered amount of fuel into the cylinder in highly atomised form. High pressure of fuel in the system is required to lift the nozzle valve and for better penetration of fuel into the combustion chamber. High pressure also helps in proper atomization; as a result smaller droplets of fuel come in better contact with the fresh air in the combustion chamber, resulting in better combustion. As the locomotive engine is a variable speed and variable load engine with variable requirement of fuel, thus proper metering of fuel quantity is very important. Time of fuel injection is also important for better combustion.

The fuel oil system consists of two integrated system:-

- Fuel Feed System
- Fuel Injection System

Fuel feed system comprising of following major components:-

(i) Fuel oil tank

(ii) Dirt Collector / Trap Filter

(iii) Fuel Primary Filter

(iv) Fuel Booster Pump

(v) Fuel Relief valve

(vi) Fuel Secondary Filter

(vii) Fuel regulating Valve

(viii) Associated pipe lines, T-Jumpers, FOP Gauge etc.

Fuel Injection system comprising of following major components:-

(i) Fuel Injection Pump

(ii) High Pressure Tubes

(iii) Fuel Injection Nozzle

FUEL FEED SYSTEM:-

After switching "ON", the fuel booster pump (1.5 HP with motor of 72 Volts) starts sucking oil from the fuel tank, filtered through a primary filter. The capacity of the fuel tank depends upon the type of locomotives – it is 4500 Ltrs for WDS6, 5000 Ltrs for WDM2 locomotives and 6000 Ltrs for WDG2, WDM3A, WDP3A,WDG3A, WDM3D. The primary filter can restrict pollutants or contaminants of above 45 micron sizes. Baffle walls are there inside the tank to arrest surge of oil during movement of loco. A strainer filter, an indirect vent, drain plug and glow rod type oil level indication are also provided in the fuel tank. The filter is provided with paper type filter element.

Because of variable consumption by the engine, the delivery pressure of the pump may rise. It will increase load on the pump and its drive motor. A spring loaded relief valve is provided for by-passing the excess oil back to the fuel tank, thus releasing the excess load on pump and motor. It is adjusted to a pressure of 5.5 Kg/cm2. The oil passes through the paper type secondary filter and proceeds to right side fuel header. The secondary filter generally restricts the contaminants of above 18 micron sizes. The fuel header is connected to eight numbers of Fuel Injection Pumps (FIPs) on the right bank of the engine and a steady oil supply is maintained to the pump at 4.5 Kg/cm2.

The fuel then passes on the left side header through a fuel cross over pipe and reaches eight FIPs on the left bank. The regulating valve after the left side header takes care of the excess pressure of 4.5 Kg/cm2 by by-passing the extra oil back to the tank. A gauge connection is taken from here to the driver's cabin for indicating fuel oil pressure (FOP).

FUEL INJECTION PUMP:-

1. Fuel Injection Pump: - Pumps used in the diesel locos are of single acting, constant stroke and plunger type with the effective working stroke; however being adjustable. The pump consists of housing, delivery valve and spring delivery valve holder, element (plunger & barrel assembly), plunger spring, a geared control sleeve and control rack (rod) assembly. The pump element comprises a barrel and a plunger, which are match assembled to a very close tolerance.

   The fuel injection pump has three functions-

   (i) To raise the fuel oil pressure to a value, that will effectively atomize the fuel.

   (ii) To supply the correct quantity of fuel to the injection nozzle commensurate with the power & speed requirement of the engine.

   (iii) To accurately time the delivery of the fuel for the efficient and economical operation of engine.

2. High Pressure Tubes: - The high pressure tube is then passed on to respective fuel injector nozzles.

   Snubber Valve: - A snubber Valve is fitted on the fuel injection pump at the top of the delivery valve holder using a tubing union sleeve and nut.
   It is basically a check valve that restricts fuel flow in the reverse direction through a small orifice. It's function is to dampen shock waves travelling through the high pressure line resulting from sudden closure of the delivery valve and the nozzle valve.
3. Fuel Injection Nozzle:- The fuel injection nozzles are the closed, hydraulically operated, differential type consisting of two parts- nozzle body and nozzle valve (pin).

   At the tip of the nozzle body, there are 9 spray holes (330 microns in size) through which fuel passes into the combustion chamber. The spring loaded nozzle valve controls the flow. The fuel which enters into the combustion chamber is in highly atomized form and attains high velocity to penetrate most of the pressurized hot air to have complete combustion. The discharge pressure range is from 3800 PSI to 4050 PSI.

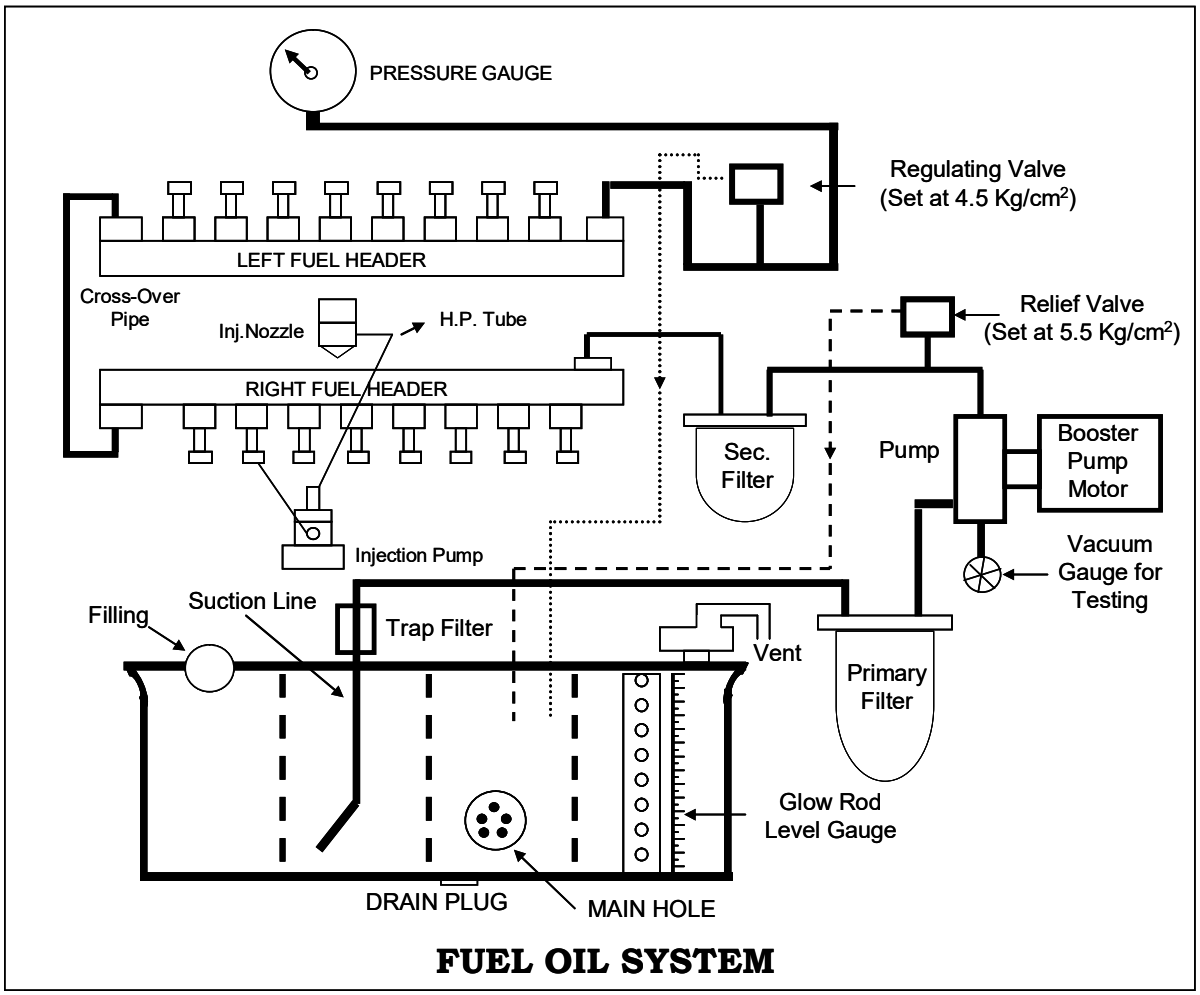
Efficiency checking of Fuel Feed System – Orifice Test.

Orifice test is conducted to ascertain the efficiency of the fuel feed system by simulating the full load condition. The procedure of testing is as under

An orifice plate of 1/8 inch is fitted in the system before the regulating valve.

(i) A container to be placed under the orifice to collect the oil that would leak through it during the test.
(ii) The fuel booster pump to be switched ON for 60 second.

The rate of leakage should be about 9 ltrs. of fuel per minute through the orifice (with the engine in stopped condition). The system should be able to maintain 3.7 – 3.8 Kg/cm2 pressure with this rate of leakage, which simulates approximately the full load consumption by the engine



FUEL OIL SYSTEM

In the event of drop in pressure, the rate of leakage would also be less indicating some defect in the system reducing its efficiency to meet the full requirement of fuel during peak load.

This test is very easy, reliable and saves time as well as fuel.

FUEL OIL SYSTEM (HHP)

Fuel oil system consist of

1) Fuel feed system - Draw the fuel from the tank and feed to the headers.
2) Fuel injection system - Supply correct quantity of fuel to the engine at right time according to the requirements

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Fuel feed system

Required amount of Fuel oil is stored in the Fuel tank, which is located in underneath of the chassis between two trucks. Maximum capacity of the tank is 6000 (In WDP4D – 5000) and minimum tank balance required is 1000 Lts. Glow rod gauge with scale is provided on both sides of the fuel tank to read the fuel balance. A wheel cock is provided in the bottom of the glow rod gauge, enable to dummy the glow rod gauge, if glow rod is damaged. When Fuel Pump motor starts working, fuel oil is sucked from the tank through strainer and delivered to primary filter. Oil filtered in the primary filter and flowing to secondary filters (spin on type filter), where filtered finely and fed to both side fuel headers.

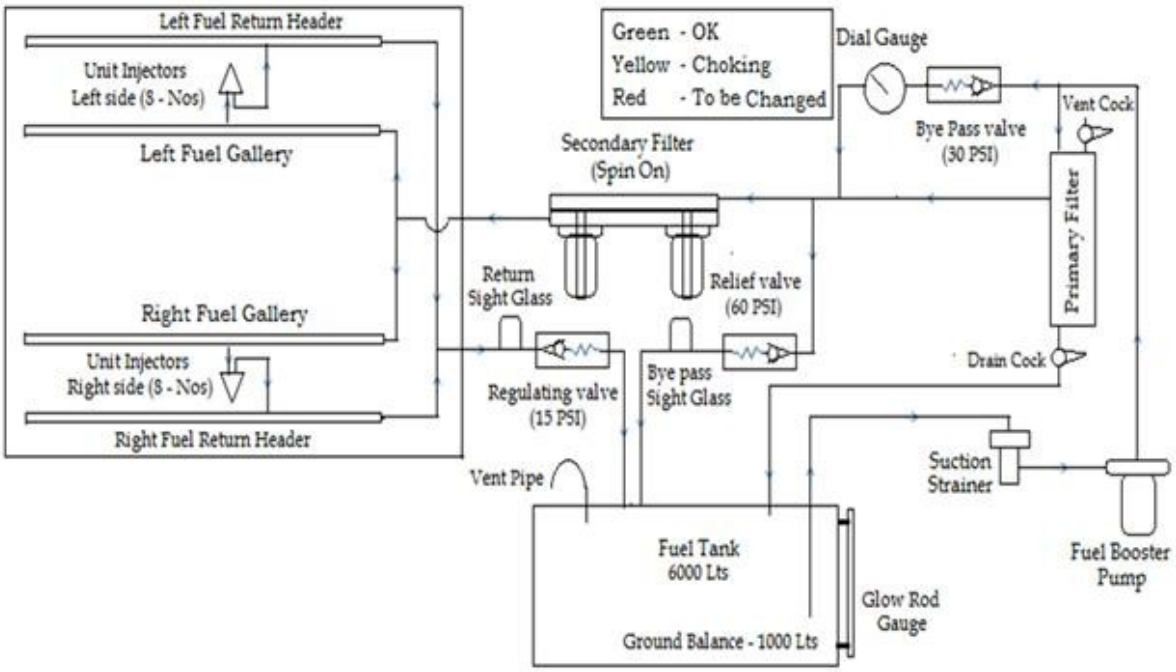
From header, oil is supplied to injectors through individual jumper pipes. Excess oil from the injectors is collected in the return headers and taken back to the fuel tank through a regulating valve, which is set at 15 PSI. In the return pipe a sight glass (Return sight glass) is provided to indicate the availability of oil in the header, which is located above the spin on filters near the engine block. Normally this sight glass is fully filled with oil without bubbles. Presence of bubbles in this glass indicates air drawing in the suction side and no oil indicates trouble in the Fuel system. A bye-pass valve set at 30 PSI is provided across the primary filter to bye-pass the primary filter, when choked. A condition gauge is provided to indicate the status of the primary filter and it is located at the right side of the loco in engine accessories room. The condition gauge shows Green colour if the filters are good, yellow if it choked and red when blocked. A Relief valve, which is set at 60 PSI is provided between Primary and secondary spin on filter, enable to protect the Fuel pump from overloading when Spin on filters are clogged. It releases the excess oil to the tank through a sight glass (Bye-Pass sight glass).

Normally this sight glass is to be empty. If found oil in this glass, shed has to be informed, since it indicates spin on filters are choked. To change the filter element in primary filter, a vent and drain cock is provided; enable to drain the accumulated oil from the filter to tank. Vent pipes are provided on both sides of the fuel tank, to maintain air pressure during system is working and expel the air from the tank to atmosphere during fueling.

Fuel injection system:

The fuel oil available at each unit injector is pressurised by the centre cam lobe of the camshaft to very high pressure and will be injected in to the cylinder in atomized form in time. The quantity of fuel to be injected is regulated and controlled by engine governor according to the notch and load conditions. The governor operates fuel control shaft and controls the fuel racks.

FUEL OIL SYSTEM



Fuel oil System – Points to be Remember:

1. Minimum fuel oil balance 1000 Lts.
2. No pressure gauge available in the system, however to maintain pressure relief and regulating valve is provided.
3. Two sight glasses are provided for system analysis.
   (i) Return Sight Glass
   a) Oil must full and clear in this sight glass during priming and engine running.
   b) If oil with bubbles during priming, indicates air drawing in the suction line.
   c) If bubbles found in engine running condition, indicates leaky injector.
   d) If bubbles found in higher notches and affect hauling power indicates the system is air locked. To release air lock, vent cock provided in the fuel oil primary filter may be used.

(ii) Bye-Pass Sight Glass

a) Oil in the bye-pass sight glass indicates the excess oil pressure in the system. It may be due to spin on filters clogging condition.
b) Hence it is mandatory to check the fuel oil primary filter condition gauge while take over charge to avoid spin on filters failure.

4. During Fuel pump failure, while using stand by motor, the concerned COC to be opened and the normal COC to be closed.
5. In case of Governor Booster pump failure, lay shaft (provided at engine free end left side) can be used for cranking.
6. Tightness of Governor amphenol plug to be ensured in case of engine not firing. (Governor request to be confirmed in the display).

LUBE OIL SYSTEM (ALCO)

ESSENTIAL FEATURES OF LUBE OIL SYSTEM ON DIESEL LOCOMOTIVE:

The lubricating oil, besides providing a film of soft slippery oil in between frictional surfaces to reduce friction and wear, also serves the following purposes –

- Cooling of bearings, pistons etc.
- Protection of metal surfaces from corrosion, surface damage and wear.
- Keep the components clean and free from carbons, lacquer deposits and prevent damage due to deposits.

The importance of lube oil system is comparable to the blood circulation system in the human body. Safety of engine, its components and their life span will largely depend upon the correct quality oil in correct quantity and pressure to various location of diesel engine.

The Lubricating Oil System of Diesel Locos essentially consists of –

- Gear type circulating pump (driven by the engine crankshaft).
  Discharge capacity:314gallons per minite.
- Spring loaded relief valve(Set at 9.0 Kg/Cm2).
- Lube oil filter tank accommodating eight nos. of filter elements(filter perforation limit:13 to 15 micron) / Moatti Filter.
- Lube oil cooler(Conventional/Plate type lube oil cooler).
  Spring loaded regulating valve (Set at 7.0 Kg/Cm2).

Oil Pressure Switch (OPS) which is meant to automatically shut down the engine, in case of a drop of lube oil pressure below 1.3 kg/cm2 (where locomotive provided with 17MG8 Governor).In case of Woodward Governor/MCBG, the engine will shut down automatically by tripping Governor plunger.

Centrifugal Lube Oil Cleaner:. The benefits derived by Centrifugal lube oil cleaner is listed below –

Most effective filtration – removal of contamination down to 0.5 micron.
Reduced loading of full fins filters.
Paper element life extended from 1 month to 3 months.

- Oil pressure gauge, which indicates the main header oil pressure.
- Oil sump having capacity: 1270 Litres / 1450 Litres.
- RR 606 multi grade oil is used .

The kinematic viscosity of the lube oil(RR-606) is 166 cst at 37.40 C. The serviceable limit of the same is 150-237 cst at 37.40 C. At high temperature of 1000 C, the kinematic viscosity of the lube oil becomes 12.8- 20.5 cst (serviceable limit). Due to this low viscous property at this high temperature, the lube oil is not able to function properly and not able to cool or lubricate the engine parts properly. As a result engine parts may get damaged. Thus high temperature is not desirable for proper functioning of the lube oil system, as well as the locomotives.

LONG LIFE LUBRICATING OIL FILTER ELEMENT:

Lube oil Filter is a critical item affecting the life of power pack of locomotive. Long life lube oil filter elements use on the ALCO/DLW built diesel locomotives has been introduced with useful life as follows.

(A) 122 days life without on board Centrifugal lube oil cleaner.
(B) 244 days life with on board Centrifugal lube oil cleaner.

CONSTRUCTIONAL FEATURES:

- Structural strength of the element is such that the element having following properties.
  A) Not damaged by handling during transportation and installation.
  B) Not collapse in service.
  C) Not permit the lube oil to by-pass the filter paper.
- The filter paper is corrugated, impregnated with suitable resin on both sides. The filter paper is having a good dirt or contaminants retention efficiency. The mean pore size is 14 ± 2 microns and maximum pore size 45 microns. The filter element is not having a tendency to migrate into the lube oil system during service.
- The filter paper pleats is uniformly distributed around the centre tube and suitably joined together so as not to permit any films of oil through the joint.
- The paper pleats are encircled by flexible cottons nothing bonded to the peaks of the pleats by suitable adhesive and holding the pleated cylinder tightly.
- The perforated outer wrapper is made from a high density paper with round/ square holes perforation.
- Centre tube, made out of perforated steel tube of adequate thickness.
- The end caps are bonded by a suitable adhesive pleated paper and synthetic rubber gasket is provided at the bottom end cap extension piece.
- The filter paper ,cotton netting and perforated outer wrapper should not be become brittle or rapture or get otherwise affected by hot engine oil at usual operating temperature in service up to a period of 130 days. The normal temperature of oil in service about 95°C but it can rise to about 150 °C at times.

The lubricating oil, besides providing a film of soft slippery oil in between frictional surfaces to reduce friction and wear, also serves the following purposes –

- Cooling of bearings, pistons etc.
- Protection of metal surfaces from corrosion, surface damage and wear.
- Keep the components clean and free from carbons, lacquer deposits and prevent damage due to deposits.

The Lubricating Oil System of Diesel Locos essentially consists of :

- Gear type circulating pump (driven by the engine crankshaft).
- Spring loaded relief valve.
- Lube oil filter tank accommodating eight nos. of filter elements.
- Differential bypass valve across filter.
- Lube oil cooler.
- Spring loaded regulating valve.
- Lube oil strainer.
- Oil Pressure Switch (OPS) which is meant to automatically shut down the engine, in case of a drop of lube oil pressure below 1.3 kg/cm2.
- Oil pressure gauge, which indicates the main header oil pressure.
- Oil sump having capacity 1270 Ltrs (WDM2, WDM2C, WDG2,WDG3 etc). And in case of newly introduced Alco WDM3D the capacity is 1450 ltrs.
- RR 606 multi grade oil is used in Alco locomotives.

Lubricating Oil System:

When the Engine is started, the lube oil pump (discharge rate 314 gallons/min) draws oil from the engine sump and delivers it to the filters. The delivery pressure of the pump is to be controlled as the pump is driven by an engine of variable speed and would often have higher delivery pressure on load than actually required. Higher pressure may endanger the safety of filters, pipe lines and joints.

The lube oil relief valve set at 7.5 Kg/cm2 (in case of aluminium piston fitted in engine) release the delivery pressure above its setting and bypass it back to the oil sump. In case of steel cap pistons provided in engine, relief valve set at 9.0 Kg/cm2.

The oil then flows through the filter tank containing eight Nos. paper type filter elements. The filter has a bypass valve across it, set at a differential pressure of 1.4 Kg/cm2. In case the differential pressure across the filter housing is more than 1.4 Kg/cm2 due to choking of filters, the valve opens up to bypass a part of lube oil without filtration to reduce pressure on filters, which increases the life of battery.

After the filtration, the oil passes through the lube oil cooler, gets cooled by transferring heat to the water.

A regulating valve (adjusted at 6.0 Kg/cm2 in case of Aluminium pistons & 6.5 Kg/cm2 in case of steel cap pistons provided in the engine block) is provided at the discharge side of cooler to regulate the pressure. Excess pressure is regulated by sending the oil back to the engine oil sump.

The oil then enters the main oil header after passing through another stage of filtration in the strainer type filter where it is distributed to various locations for lubrication.

Direct individual connections are taken from the main oil header to all the main bearings. Oil thus pass through the main bearings supporting the crankshaft on the engine block, pass through the crankpin to lubricate the connecting rod big end bearing and the crank pin journals, reach the small end through rifle drill hole and after lubricating the gudgeon pin and bearings, enters into pistons. The pistons are provided with spiral oil passages inside them for internal circulation of lube oil. This is done with the purpose of cooling the pistons which are thermally loaded components. After circulating through the piston the oil returns to the sump, but in this process a part of the oil hits the running connecting rod and splashes on to the cylinder liners for their lubrication. A line from the main oil header is connected to a gauge in the driver's cabin to indicate pressure level. Lube oil pressure drop to less than 1.3 Kg/cm2 would automatically shut down the engine through a safety device called "Oil Pressure Switch (OPS)" to protect it from damage due to insufficient lubrication.

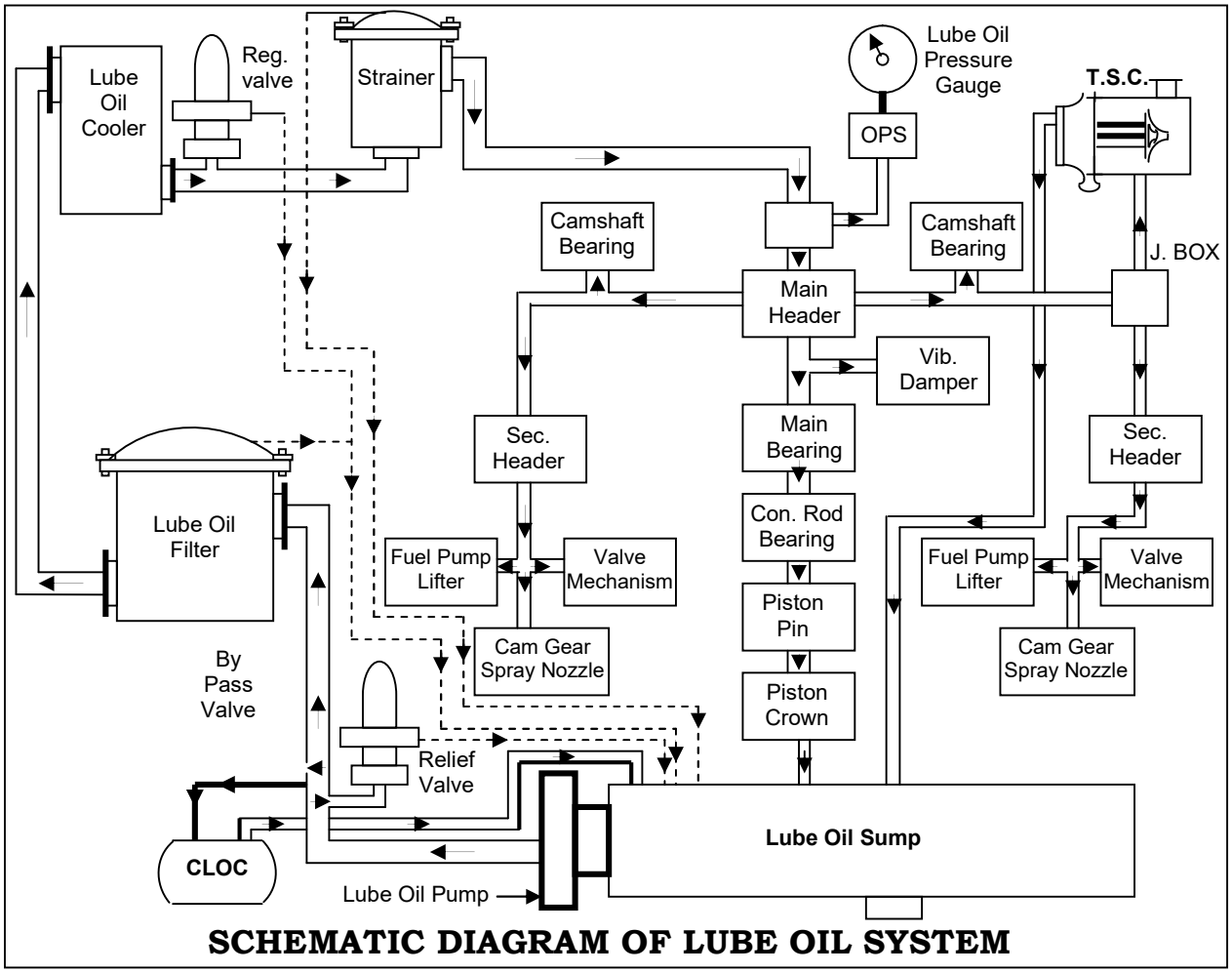
From the main oil header, two branch lines are taken to the right and left side secondary headers to lubricate the components on both banks of the V-shaped engine block. Each branch line of the secondary header lubricate the cam shaft bearings, fuel pump lifters, valve lever mechanism and spray oil to lubricate the gears for cam shaft drive. A separate connection is taken to the TSC from the right side header for lubricating its bearings. After circulation to all the points of lubrication, the oil returns back to the sump for recirculation through the same circuit.

The kinematic viscosity of the lube oil is 166 cst at 37.40 C. The serviceable limit of the same is 150-237 cst at 37.40 C. At high temperature of 1000 C, the kinematic viscosity of the lube oil becomes 12.8- 20.5 cst. Due to this low viscous property at this high temperature, the lube oil is not able to function properly and not able to cool or lubricate the engine parts properly. As a result engine parts may get damaged. Thus high temperature is not desirable for proper functioning of the lube oil system, as well as the locomotives. In addition to the above, Indian Railway has started installation of Centrifugal Lube Oil Cleaner on all locomotives. The inlet port drawn oil from the main lube oil pipe from a point after the relief valve and outlet is terminated into the engine oil sump.

The benefits derived by Centrifugal lube oil cleaner is listed below:

Most effective filtration – removal of contamination down to 0.5 micron.

- Reduced loading of full fins filters.
- Paper element life extended from 1 month to 3 months.
- 400 Litres of oil saved per loco per annum due to oil lost in filter changes.
- No operational cost.
- No consumable cost.



SCHEMATIC DIAGRAM OF LUBE OIL SYSTEM

Various causes leading to the failures of locomotives on account of Lube Oil System are as follows –

- External leakage resulting in failure of loco due to less oil in sump. (The point of external leakages – Valves lever cover, Crank case cover, Crank case explosion cover, Push rod grommets, Extension shaft / oil seal, face joint of lube oil relief / regulating and bye pass valves, from armoured / dresser or metallic joint, lube oil filter housing cover perished “O” ring / cracked / broken fly nuts / cracked filter housing, lube oil filter drain cock / strainer drain cock, bursting of flexible pipes, lube oil pump face joint or flange joint etc.)
- Leakage from lube oil cooler tubes, resulting in mixing of lube oil in water.
- Defective lube oil pump – pressure not building up or breakage of any of the components.
- Excessive oil through from CCE motor exhaust pipe – due to oil choking of return oil passage to the sump.
- Quality of lube oil – due to contamination in any form i.e. by fuel oil, cooling water, soot etc, change in properties like viscosity PH value etc.
- Improper setting of relief, regulating valve.
- Choking of filter elements.
- Improper setting of oil pressure switch.

SPECTROGRAPHIC ANALYSIS OF LUBE OIL

To ensure quality of lube oil, spectrographic analysis is carried out. The usual physics -Chemical analysis of used diesel engine crankcase oil provides following information regarding –

- Dilution with fuels.
- Contamination with cooling water.
- Extent of insoluble matter.
- Acidity.

It does not however give indication in respect of wear pattern of the engine components which may be resulting due to the above or from other cause.

With the help of spectrograph, it is possible to determine the various metal contaminations quickly and accurately. This analysis helps in—

- Predicting the required maintenance.

- Scheduling the overhauls thus avoiding unexpected down time and thereby increasing the locomotive availability & reliability.
- Eliminating the premature engine removal.
- Preventing costly engine failures resulting from the incipient wear of engine components.
- Controlling the quality of lube oil supplies.

The probable reasons against each wear metal concentrations are listed below.

Element	Abnormal ppm	Critical ppm	Comment
Copper	10	20	Bushing wear
Lead	5	10	Main/Connecting rod bearing wear.
Tin	5	10	Main/Connecting rod bearing wear.
Iron	20	50	Wear of Piston ring, Piston, Liners, Crankshaft journal, Gear trains, Cam etc. If only Iron is high, wear of gear train is suspected. If iron is high along with Copper and lead , Crankshaft is suspected. If iron is high along with Chromium and Aluminum , Piston rings/piston or liner are suspected.
Chromium	5	10	If Sodium is normal, Liner wear is indicated otherwise water leakage.
Sodium	30	50	Water leakage.
Aluminum	5	10	Piston wear.
Silicon	15	20	Inefficient air filtration.

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PERFORMANCE REQUIREMENT:

1. **END LOAD TEST:** A tensile load of 20 Kgs applied at the end caps of the filter elements for 5 minutes shall not cause any damage.
2. **HIGH TEMPERATURE TEST:** The filter element shall be soaked in engine oil maintained at a constant temperature of 130°C ± 5 °C for a period of 24 hours. The filter shall be subjected to end load test before cools down below 70°C.
3. **PRESSURE DROP VS FLOW RATE:** The filter element shall be tested for determining its pressure drop vs flow rate characteristics with clean engine oil temperature of 80 ± 2 °C, the flow capacity of the filter element should be minimum 150 litre / min with pressure drop not exceeding 0.4 Kg/cm² across the element.

4. **RESISTANCE TO WATER CONTAMINATION:** Pleat collapse and premature plugging of filter element does not occur when the lubricating oil is contaminated with water.

LUBE OIL SYSTEM (HHP)

The capacity of this system is 1457 litres and type of oil used is RR 520 MG. To read the oil level Dipstick is provided on both the sides of the Engine block. Dipstick has Full and Low marks. In between them 25 dots are provided and each dots indicates 25 litres. When lube oil level reaches to 5 dots from low mark shed has to be informed.

The lubricating oil system is a combination of four oil systems.

1. Scavenging oil system,
2. Piston cooling oil system
3. Main lubricating oil system
4. Soak back or turbo lube system

Each system has individual pump for its working. The main lube oil pump, piston cooling oil pump and scavenging oil pumps are gear driven by the engine crank shaft. The main lube oil pump and piston cooling oil pump is in single housing and driven by a common drive shaft but the delivery is separate. The soak back or turbo lube pump is driven by an electric motor.

Scavenging Oil System:

The scavenging oil pump is a positive displacement, helical gear type pump. This pump takes lube oil from the course filtration side of the strainer and delivered to the lube oil filter. After filtration oil goes to lube oil cooler where it is cooled by the cooling water. Then oil is taken to lube oil strainer fine mesh side, where it is filtered once again. A bye-pass valve set at 40 PSI is provided across the filter, gets open if the filter is clogged or pressure difference reaches above 40 PSI to protect the engine moving parts from dry start.

Piston Cooling Oil System:

The piston cooling oil pump receives oil from a common suction pipe from strainer fine mesh side and delivers to right and left side piston cooling oil manifold. From the piston cooling oil manifold through individual jet pipe oil directed as stream to each piston grooves for cool the piston crown and lubricate the piston pin bearing, then drain back in to the sump.

Main Lubricating Oil System:

The main lube oil pump receives oil from a common suction pipe from strainer fine mesh side and delivers to the main lube oil manifold, which is located above the crankshaft inside the engine block. A pressure relief valve set at125 PSI is provided between the main lube oil pump and main lube oil manifold to release excess oil back to the sump. From the main lube oil manifold through individual oil tubes, main bearings receive oil on its upper portion. After lubricate main bearings, through the drilled passage in the crankshaft oil is supplied to the connecting rod big end bearings. From the front end of the crankshaft oil is taken to vibration damper and accessory drive gear. From the rear end of the manifold oil enters Gear train through the idle gear stub shaft. Oil passes in the stub shaft base is distributed to various parts through various passages. One passage conducts oil to the left bank camshaft drive gear stub shaft bracket through a jumper. Second passage conducts oil to the Right Bank camshaft drive stub shaft bracket and also for turbo charger oil filter.

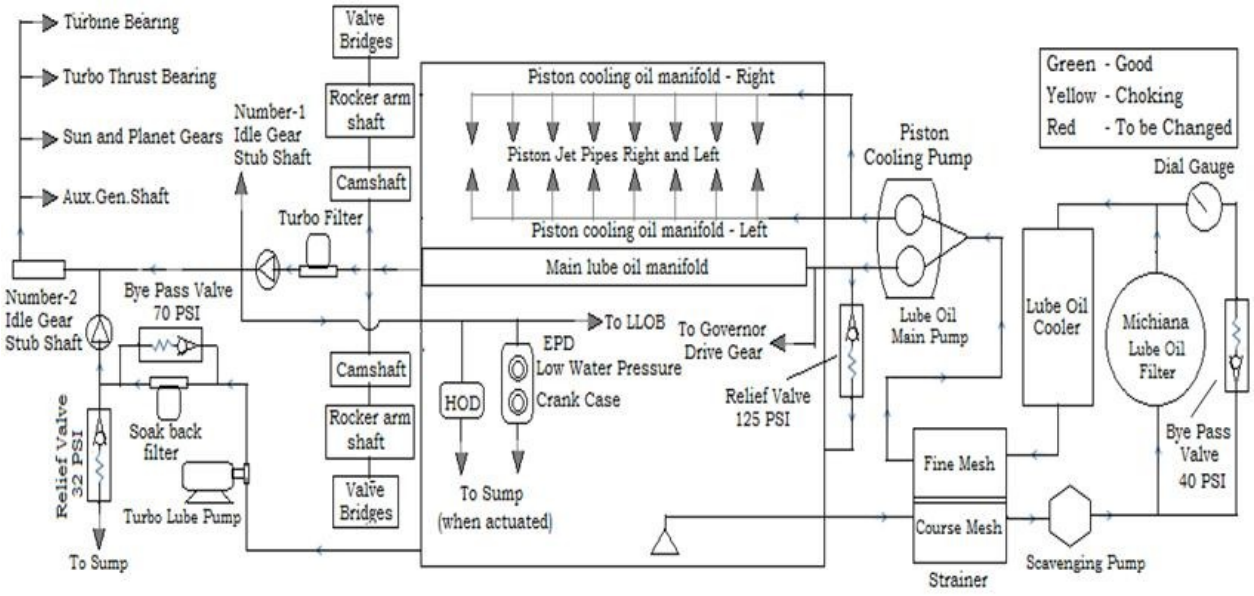
From the camshaft through radial holes oil is conducted to each camshaft bearing. From each camshaft bearing through oil line oil is supplied to the rocker arm shaft, rocker arm cam follower assemblies, hydraulic lash adjusters, rocker arm and then return to the sump. After filtration in the turbo charger oil filter, oil is send to No.1 Idle Gear Stub shaft gear. Low lube oil pressure shut down device in the Governor, which protects the engine from lack of lubrication by brings the engine to shutdown when lube oil pressure is dropped below 8-12 PSI at idle and 25-29 PSI at full speed. In the pipe line leading to the Low lube oil pressure shut down device, Safety devices Hot oil detector (HOD) and Engine protection devices (EPD) are provided.

The HOD brings the engine to shut down, when lube oil temperature reaches above 1240 C and EPD brings the engine to shut down when water pump is failed or positive pressure developed inside the crank case duly trips the Low water pressure or crank case button respectively. Turbo oil manifold for turbo charger cooling and lubricates turbo bearings, idler gear, planet gear assembly and auxiliary drive bore. The turbo charger oil filter heads contains 2 check valves. One to prevent the entry of lube oil to main system from the soak back system during soak back pump operation and the another to prevent lube oil from main system to the soak back system when the engine is running.

Soak Back Oil System:

To remove the residual heat from the turbo super charger after engine shutdown and pre lubricate the turbo bearings before cranking, this system is provided and controlled automatically by the locomotive computer. A turbo soak back pump motor located at engine room right side is used to operate this system. The operation of the motor is controlled by LCC and run for 35 minutes (maximum) during starting and after shut down the diesel engine. When this motor starts to work, the turbo soak back pump draws oil from the sump, feed oil through a soak back filter and finally to the turbo. A 70-PSI bypass valve is provided inside the soak back filter housing to bypass filter whenever it clogs to protect Turbo- charger. A relief valve set at 32 PSI is provided in the filter head, will return the delivered oil from soak back pump, back to engine sump if turbo receives oil from main system.

LUBE OIL SYSTEM



LUBE OIL SYSTEM – POINTS TO BE REMEMBER:

1. While TOC a loco, lube oil filter conditional gauge is to be checked for find the healthiness of filter.
2. Lube oil level to be maintained, 5 Dots from low mark and to be checked in engine running in Idle.
3. Lube oil pressure will be maintained 30 – 120 PSI in the system and LLOB will trip when lube oil pressure drops below 8 - 10 PSI in Idle and 28 – 30 PSI in eighth notch.
4. Changing the Isolation Switch from Stop / Start / Isolate to Run Position

immediately after cranking to avoid shut down of loco due to LLOB / LWP Operation.

5. Never make attempt to re-crank the engine when crank case button in the EPD is tripped.
6. After shutting down a loco do not switch off yellow labeled breaker (Computer Control and ibed lubrication completes.

WATER COOLING SYSTEM (ALCO)

After combustion of fuel in the cylinder, about 25% to 30% of heat produced inside the cylinder is absorbed by the components surrounding the combustion chamber i.e. Piston, Cylinder Liner, Cylinder Head, etc. Unless the heat is taken away from them, the components are likely to fail under thermal stresses. All internal combustion engines are provided with cooling system, designed to cool the excessively hot components, distribute the heat to other surrounding components to maintain uniform temperature throughout the engine and finally dissipating the excess heat to atmosphere to keep the engine temperature within suitable limits.

The Locos (WDM2/WDM2C/WDG2/WDG3A etc) is having closed circuit pressurized water cooling system for the engine. The system is filled in by 1210 Ltrs.of demineralised water treated with corrosion inhibitor in two interconnected expansion tanks (Capacity 155 ltrs. each) on the top of the locomotive. The corrosion resistant chemical compound is HPCL Power cool. This is provided to prevent the effect of the following problems like (i)scale formation inside the radiator tube, which may reduce the water pathway and thus reduce the heat dissipation, also it acts as non-conductive surface that restricts heat dissipation; (ii) lesser heat dissipation due to bubble formation in the water jacket around the exterior surface of the cylinder liner due to high exhaust temperature, which in turn create a non-conductive layer around cylinder liner and heat dissipation becomes lesser. 36 litrs of HPCl power cool added in the system.

A centrifugal pump, located at the free end bottom side of the engine, driven by the engine crankshaft through a gear, suck water from the system and deliver through the outlet under pressure (out let pressure 2.2 Kg/cm2 to 2.6 Kg/cm2 & discharge rate 2457 Ltrs per minute). The outlet of the pump is connected with three way flange type connector/elbow.

- One end connected to the left bank of the cylinder block. A diversion is also taken from this line for circulation through the after-cooler to cool the charge air for engine. Water from the after-cooler then returns to the same line to enter the engine block and circulate around cylinder liners, cylinder heads on the left bank and then pass on to water outlet header. Individual inlet connection with water jumper pipes and outlet by water riser pipes are provided to each cylinder head for entry and outlet of water from the cylinder head to the water outlet header. Water then proceeds to the right radiator through a bubble collector that is provided to collect the air bubbles formed due to evaporation and passes them on to the expansion tank to avoid air lock in the system and release its heat to the atmosphere before circulation to the engine.

- The other end connection leads to the right bank of the cylinder bank. After cooling the cylinder liners, heads, etc on the right bank, it reaches the left side radiator. Before it enters the radiator, a connection is taken to the water temperature manifold, where a temperature gauge is fitted to indicate the water temperature. Three other switches **ETS-1, ETS-2 & ETS-3** are also provided. **ETS-1** is for start rotation of radiator fan at low speeds through eddy current clutch at 680C, **ETS-2** pick up at 740C and accelerates the radiator

fan to full speed. **ETS-3** is supposed to bring the engine idle with audiovisual alarm at 920C.

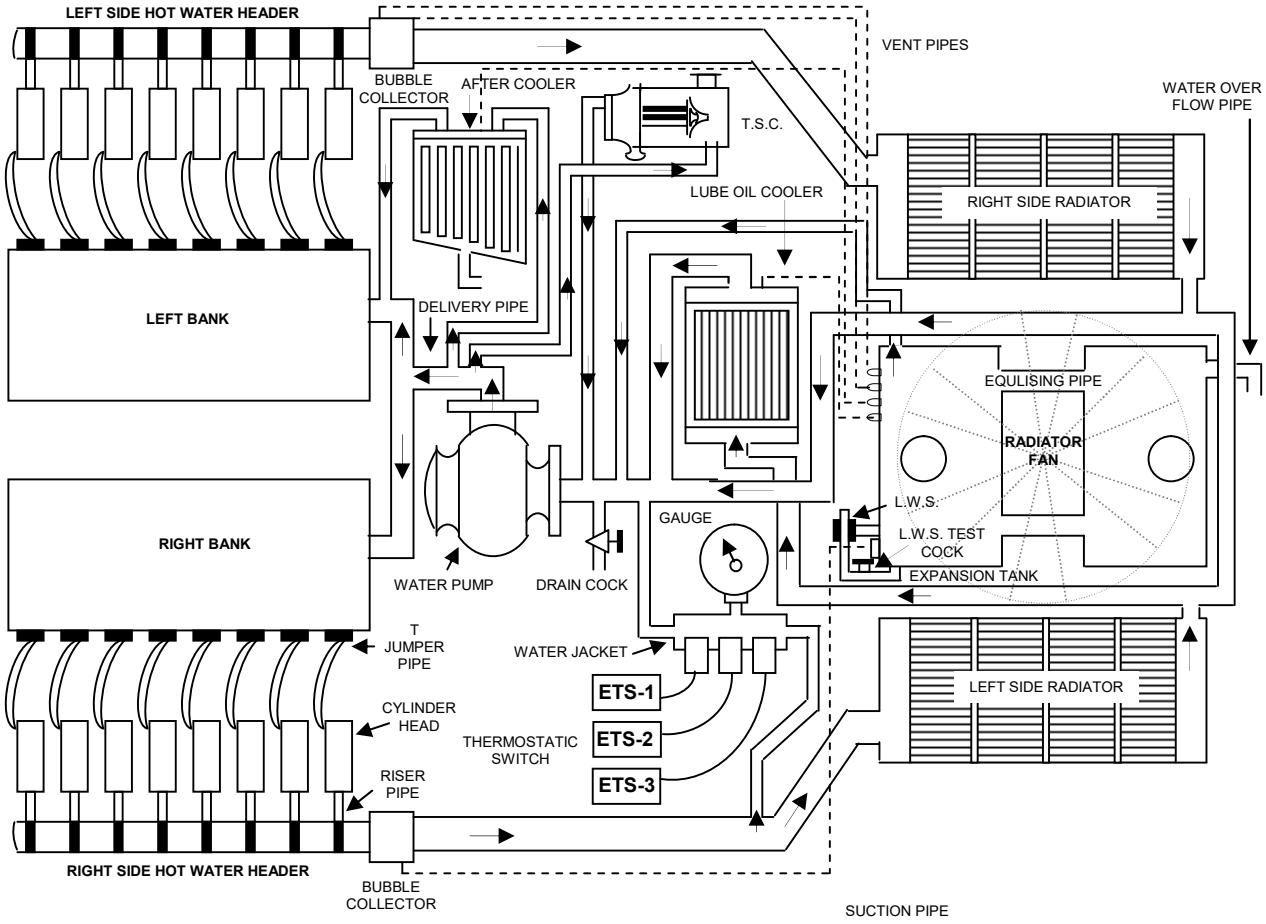
One water connection taken from this three way elbow through adopter to the TSC through a flexible pipe to cool intermediate casing, turbine casing and bearings. After cooling water returns to the inlet side of the pump.

Water temperature is controlled by controlling the movement of radiator fan. Cool water from the left side radiator passes through the lube oil cooler and cools lube oil. After lube oil cooler, it units with right side radiator outlet, to be bank again to the suction side of the pump for recirculation.

Apart from Hot engine alarm, another safety device in the form of LWS (Low Water Switch) is also provided. It shut down the engine if the water level falls below 1 inch from the bottom of the expansion tank.

Vent lines are provided from after-cooler, lube oil cooler, radiators, TSC bubble collector, water return header (both side) bubble collector etc. to maintain uninterrupted circulation of cooling water by eliminating the hazard of air locks in the system.

Cooling water is subjected to laboratory test at regular intervals for quality control. Contamination, chloride contents and hardness etc are checked to reduce corrosion and scaling.



WATER COOLING SYSTEM

COOLING WATER SYSTEM (HHP)

The capacity of expansion tank is 625 and total system is 1045 Lts. To read the water level gauge is provided in the right side of the Expansion tank. It has two readings full and low with respect to the status of the engine when running or dead. Normally the water level is to be below full level and at least low level according to the status of the engine. If less shed has to be informed. There are two numbers of gear driven centrifugal type water pumps available in this system and mounted on the engine block.

The lube oil cooler outlet forms the suction for both the pumps. When crank shaft starts to rotate, both water pumps start their working, draws water from the suction and delivered to water inlet manifold. The outlet of the right side water pump is sent to right water inlet manifold and left side water pump is sent to left water inlet manifold. From the water inlet manifold water enter to all the cylinder liner jackets through individual water jumper pipes and cools the cylinder liners.

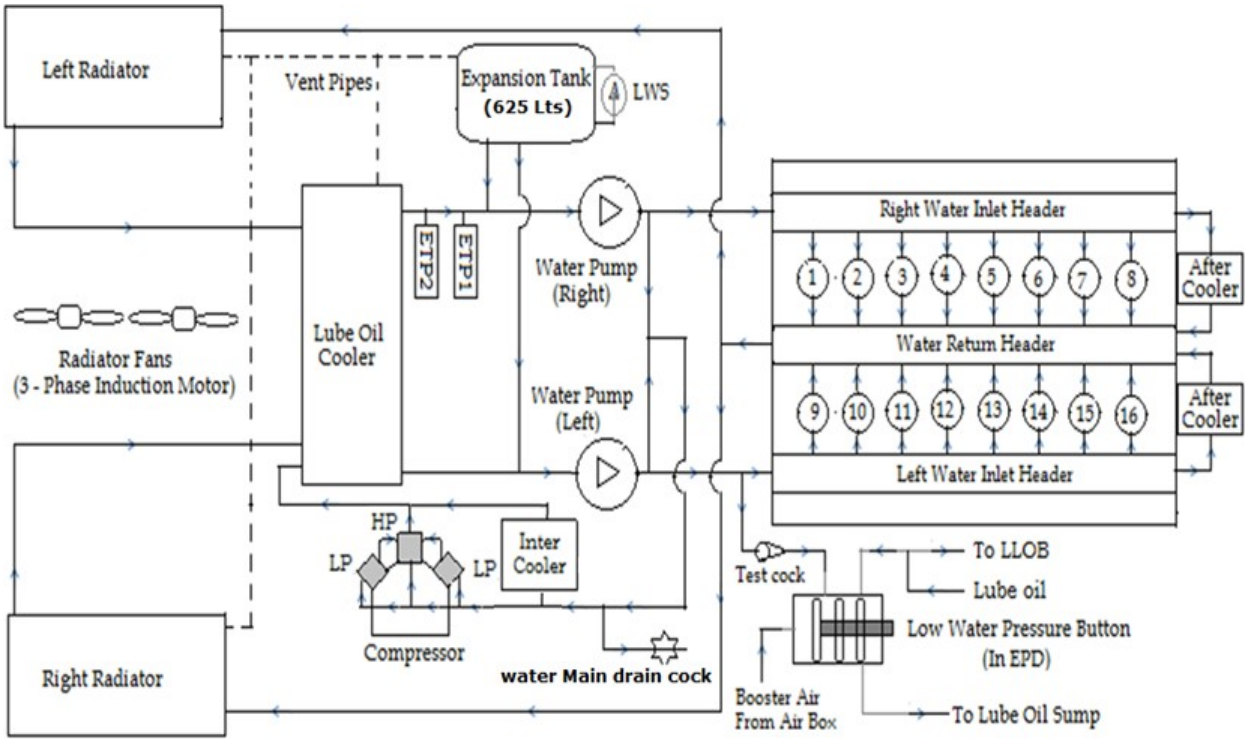
After cooling the cylinder liners water enter the cylinder head through 12 circular passages and cool the combustion chamber of the cylinder head and then collected in the water outlet manifold. At the rear end of both water inlet manifolds, water is taken to after coolers to cool the booster air and then collected in the water outlet manifold. The outlet of both the pumps are connected together and taken to compressor to cool the compressor cylinders and the compressed air inside the inter cooler. The collected water in the water outlet manifold is taken to radiators, which are located in a hatch at the top of the long hood of the loco.

A bye-pass line is provided between the inlet and outlet lines of the radiators in order to reduce velocity in the radiator tubes. To cool the water in the radiator, two electrical motor operated radiator fans are used and controlled by the Locomotive control computer (LCC). The LCC maintain the water temperature between 79 and 850 C. Two Engine Temperature probes (ETP1 and ETP2) are provided to measure the water temperature.

Among the sensors, the higher value is taken as reference by the LCC. To simulate water temperature (up to 520 C), LCC increases the engine speed automatically. If water temperature increases above 960 C, maximum loco power will restrict to sixth notch limit but RPM is according to the throttle position. If water temperature increases above1010 C, engine speed comes to idle.

To make up water level in the system, from the expansion tank, Equalising pipes are provided to the inlet of compressor and both water pumps. To protect the engine from lack of cooling Low water Switch (LWS) and Low water pressure button (LWP in EPD) is provided in this system. LWS is available in WDP4 Locos in the left side of the expansion tank. It brings the engine to shutdown when water level is low. LWP is available in all locos in the EPD and connected with the system at the outlet of the left water pump through a three way cock. It brings the engine to shutdown when water pressure is low in the system.

COOLING WATER SYSTEM



COOLING WATER SYSTEM – POINTS TO BE REMEMBER:

1. Check the working of radiator fan physically even its status is “ON” in the display.

2. Operate the water filling cock lever handle in clockwise and also up to 90 degrees only. Otherwise it may damage the filling cock lever.

3. Before and after cranking water level to be ensured as the limit prescribed in the glow dot gauge. However in en-route while TOC if water level is below minimum in shutdown condition and after cranking if the level is above minimum mark in

running position, work the train duly give information to shed.

4. If water level reducing, check for external leakages and leakage in the tell tale pipe. If any leakage noticed, slack the spring loaded cap in the expansion tank to reduce the rate of leakage.

5. Check the engine lube oil and Compressor sump in case of water level running down.

6. If unable to reset low water button, ensure water level and LWP test cock is in open position and then press and hold LWP button for 15 seconds.

7. If engine shutdown with low water level in display, ensure water level. If level is low inform shed. If sufficient water level is available, short the wires provided in LWS and crank.

ENGINE TEMPERATURE PROTECTION:

The normal operating water temperature is 79 to 85o C and it is monitored by ETP1 and ETP2. Maximum of ETP1 or ETP2 is considered as engine water temperature.

Temperature	System Action
Water > 85° C	One Fan will be made ON in slow speed. Within 20 seconds if water temperature not dropped second fan is switched ON in slow speed. Within next 20 seconds if water temperature not dropped First Fan will run at Fast and second one at slow speeds. Within next 20 seconds if water temperature not dropped, both Fans will run at Fast speed. Both Fans will stop when water temperature drops below 79° C.
Water > 96° C	Engine RPM remains high but Traction power limited to 6th Notch. Display shows message “High water temperature – TH 6 Limit”
Water - 101° C	Along with message “High water temperature - TH 6 Limit” Bell Rings after 5 minutes Engine comes to Idle.

Lube oil above 122° C Engine come to shut down by Hot Oil Detector operation
It cannot be reset. Loco is to be failed for this trouble.

AIR BRAKE SYSTEM (ALCO)

Air brake system:

As the name implies the media of brake application is compressed air. The compressed air is supplied by compressor (expressor) housed in the locomotive, which charges the complete air brake system, the brake pipes and feed pipes (in case of Twin pipe system),. The feed pipe of locomotive is connected to the auxiliary reservoir of trailing stock and the auxiliary reservoir is connected to distributor valve which is further connected to the brake cylinder. During brake application, the driver in the loco drops the brake pipe pressure. This action connects the auxiliary reservoir to the brake cylinder through the distributor valve.

The compressed air from the auxiliary reservoir pushes the brake cylinder piston outside. This action pushes the brake block against the wheel and brakes are applied. For releasing the brakes the brake pipes are again charged by compressed air through the compressor in the loco. This action disconnects the brake cylinder from the Auxiliary reservoir and connects the brake cylinder to the atmosphere through distributor valve. As a result the compressed air is drained out from the brake cylinder causing the brakes to come in released position.

On the basis of type of release, air brake system is classified as:

- Direct release air brake system
- Graduated release air brake system
- Both direct and graduated release is further available in two forms viz.
- Single pipe and
- Twin pipe

Graduated Release Air Brake System:

On Indian Railway Graduated application can be done gradually i.e. in steps by moving A-9 Auto valve in steps. Brakes are applied in steps depending upon the movement of A-9 increased in steps the brakes are released in steps and exhaust of brake locking up air pressure in brake cylinder during successive brake application and release. As a result driver has an effective control on trains during run and maintains speed.

Single pipe Graduated Release:

The system works only on brake pipe i.e. single pipe air brake system. Goods trains of Indian Railway are working on single pipe system. If feed pipe of twin pipe graduated release brake system is required to be isolated due to any damage to feed pipe, then passenger trains also work on single pipe system.

Charging: Brake pipe is charged to 5 Kg/cm2 pressure which in turn charges control reservoir and auxiliary reservoir to 5 Kg/cm2 pressure via distributor valve. Brake cylinders are connected to atmosphere through exhaust port of distributor valve.
Application: In brake application, the brakes can be applied in steps. In order to apply brakes on train, certain amount of pressure in brake pipe is to be reduced as indicated below in table. When brakes are applied through A-9 drivers brake valve in such a way that it disconnects the control reservoir of distributor valves from brake pipe and connects auxiliary reservoir to brake cylinder, which apply brakes.
Release: For releasing brakes the brake pipe is again charged to 5 Kg/cm2 pressure by A-9 driver's brake valve. The auxiliary reservoir gets isolated from brake cylinder and brake cylinder is vented to atmosphere through distributor valve and thus brakes are released.

Twin Pipe Graduated Release:

In this system in addition to brake pipe another pipe is provided on locomotive and train which is called feed pipe. Train feed pipe is charged at 6 Kg/cm2 by loco compressor through feed valve provided on loco. This feed pipe is connected to auxiliary reservoir of each coach. A check valve is provided between feed pipe and auxiliary reservoir to prevent bleeding of air to atmosphere during train parting.

The main advantage of twin pipe brake system is to release the brakes faster than single pipe brake system. Secondly there is no exhaustibility and the system is always ready for cyclic application.

Charging: When A-9 automatic brake valve handle is moved to released position, the control air pressure i.e. 5 Kg/cm2 actuates additional C2 relay valve, which connects the main reservoir air to brake pipe and charge the system up to 5 Kg/cm2 including control reservoir of distributor valve. Similarly feed pipe of locomotive and auxiliary reservoir of trailing stock are charged up to 6 Kg/cm2 and brake cylinder is connected to atmosphere, so long brake pipe pressure is 5 Kg/cm2.

Application: Brake application in this system also is similar to single pipe brake system. Since auxiliary reservoir is also connected to feed pipe hence it is continuously charged with 6 Kg/cm2 pressure even though the brakes are in applied condition.

During brake application the magnitude of braking force is proportional to the reduction in brake pipe pressure. Different stages of brake application are being indicated below-

Description	BP Pressure
Release position	5.0 Kg/cm2
Minimum Application	4.5 to 4.7 Kg/cm2
Full Service Application	3.5 to 3.7 Kg/cm2
Over reduction	2.5 to 2.8 Kg/cm2
Emergency Application	To zero

The maximum braking force is attained when full service brake is applied and brake pipe pressure is in range between 3.4 to 3.6 Kg/cm2. Any further reduction helps in hastening application of brake in train. The maximum proportional brake cylinder pressure 1.8 Kg/cm2 on locomotive and 3.8 + 0.1 Kg/cm2 on trailing stock.

Release: Brakes can be released by recharging brake pipe to pressure by moving A-9 driver's brake valve handle to release position. This actuates distributor valve to isolate auxiliary reservoir from brake cylinder and brake cylinder is connected to atmosphere through distributor valve and control reservoir is again connected with brake pipe there by releasing the brakes.

IRAB (INDIAN RAILWAY AIR BRAKE)

SALIENT FEATURES OF IRAB SYSTEM:

1. The locomotive brakes can be applied with any desired pressure independently.
2. All air brake valves have self lapping arrangements.
3. Loco brake can be applied by automatic brake valve (A9)
4. Shortest braking distance is possible during emergency braking application.
5. Suitable for MU operation.
6. Emergency brake application is possible from any loco coupled together.

SUB SYSTEM:

1. Independent Brake System
2. Brake Pipe System
3. Proportionate Brake system
4. Feed pipe system

The different valves that are used in the IRAB system are being listed out with their functions in the below stated table-

Charging:

For charging BP, A-9 handle is put in release position. Now MAR-2 pressure goes to six different places such as (1) Port No:30 of A-9 valve (2) Port NO:2 of Additional C-2 relay valve through airflow measuring valve (3) Port No:1 of C-2 relay valve (4) Port No:63 of MU-2B valve (5) C3-W distributor valve (6) D-1 pilot valve (Rotex Magnet Valve).

MAR pressure at port No:30 of A-9 valve is adjusted to 5 Kg/cm2 in release condition this pilot air goes from port No:30 to port No:5 and reaches port No:3 of MU-2B valve if the 3/8" COC of working control stand is open. This pilot pressure comes out from port No:13 of MU-2B valve when it is in lead position. This pilot air finally goes to port No:2 of Additional C-2 relay valve is connected . So MAR pressure waiting at port No:1 regulated to 5 Kg/cm2 and comes to port No:3. This air charges the brake pipe if the ¾" COC in open condition.

The C3-W distributor valve has three pipe connections viz. BP, BC, and MAR. When BP is charged with 5 Kg/cm2 pressure it balances the MAR pressure and thus no pressure goes to BC pipe.

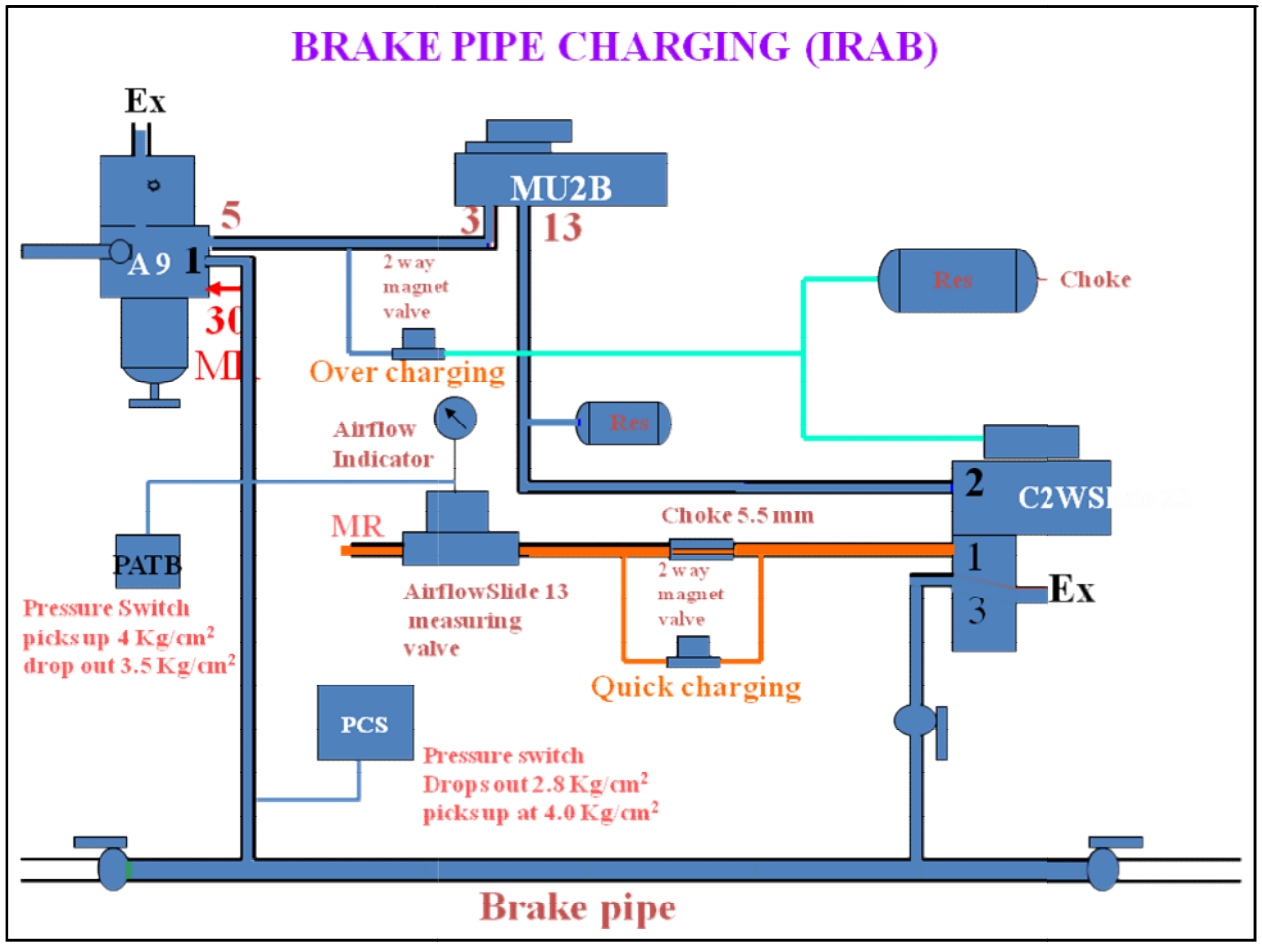
Application:

Pilot air pressure, at port No:2 of Additional C-2 relay valve is reduced through exhaust port of A-9 valve. Therefore, BP pressure is also reduced proportionately and train brake is applied.

As BP pressure, drops at the BP port of distributor valve the balance gets disturbed, MAR pressure get a path, and enters the BC pipe. This air is limited to 3.5 Kg/cm2 with the help of limiting valve and goes to D-1 pilot valve (Rotex Magnet valve) from here it enters the F1 selector valve at port No:4 and comes out from port No:16 and finally reaches the port No:2 of C-2 relay valve through 24 AD check valve. Therefore MAR pressure waiting at port No:1 of C-2 relay valve get a path through port No:3 and goes to brake cylinder and loco brakes get applied.

Release:

For release of brake, A-9 handle is kept in release position so that the exhaust port of A-9 valve is closed. At that time, MAR pressure goes to the Additional C-2 relay valve as a result exhaust port closes. Air from MAR passes through Additional C-2 relay valve port No:3 and charges the brake pipe and Additional C-2 relay vale charges its position to lead position. Simultaneously 5 Kg/cm2 pressure charges the train pipe and as a result, brake are released.



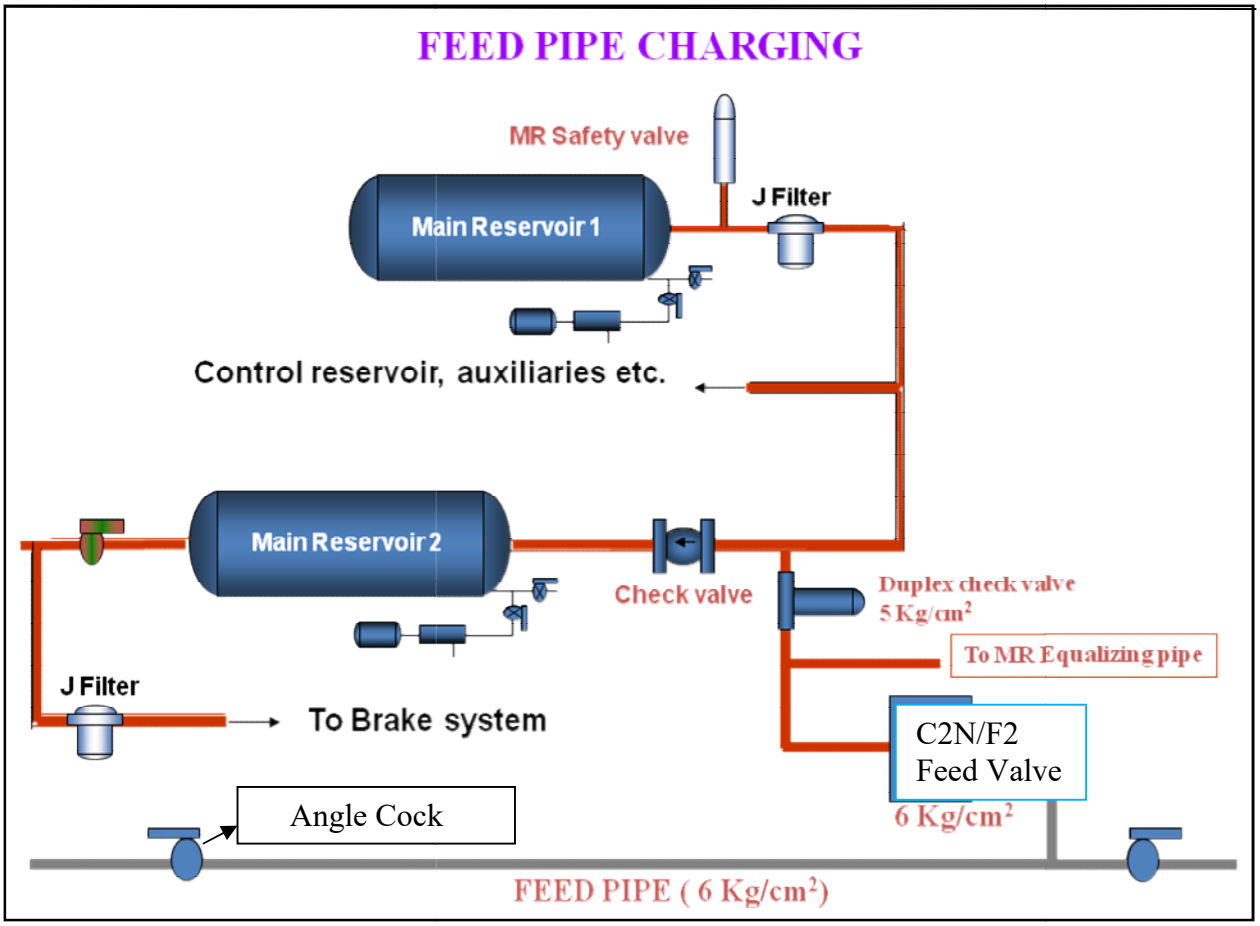
During Dynamic Braking:

When dynamic brake is applied Rotex Magnet Valve (D-1 pilot air valve) is energized, and the MAR pressure waiting there comes out and closes the passage of air coming from limiting valve to F1 selector valve. In this way even if A-9 is applied, loco brake will not be applied.

FEED PIPE CHARGING:

With the view of quicker release and thereby minimizing the releasing time of air brakes train, a further arrangement has been made with necessary equipment like duplex valve, 1¼" cock, D-24B feed valve with a feed pipe leaving 2 angle cut out cocks on front and rear side of locomotive along with respective feed pipe air hoses and palm ends in addition to single pipe working. This is known as twin pipe air brake working system.

The compressed air from MAR, flows to Duplex valve which operates at 5 Kg/cm2 pressure and then gives passage to enter D24B feed valve through 1¼" cock at open position. Where this air is adjusted to 6 Kg/cm2 by adjusting valve and then this air flows to charge the feed pipe at 6 Kg/cm2 which can be shown in the 2nd gauge on the control stand.



Now the train is attached to the locomotive with CBC coupling and then FP air hose of vehicle next to locomotive and their respective angle cocks should be opened. In this way all-remaining FP air hoses of all vehicles and their respective angle cocks should be opened but the rear most angle cock is kept in closed position. Then the angle cock of the FP air hose of loco is opened. Then the entire FP of train is charged by 6 Kg/cm2 air pressure flow and feeds the auxiliary reservoir of each and every vehicle through dirt collector. Isolation cock is kept in open position and check valve works as a non return valve. Quicker filling of auxiliary reservoir causes quicker release of brakes due to quicker balancing of distributor valve.

AIR BRAKE:

Principle of working:

Compressed air is used for getting brake applied which is supplied to the train pipe from locomotive with the help of A-9 valve. The brake pipe pressure is originally charged to 5 Kg/cm2 of the compressed air.

Charging:

The compressed air from the locomotive is regulated to 5 Kg/cm2 at driver's brake valve, and charged to the brake system throughout the length of the train. The auxiliary reservoir and control reservoir of all wagons are charged to level pressure through distributor valve and brake cylinder is connected to the exhaust port with D.V.

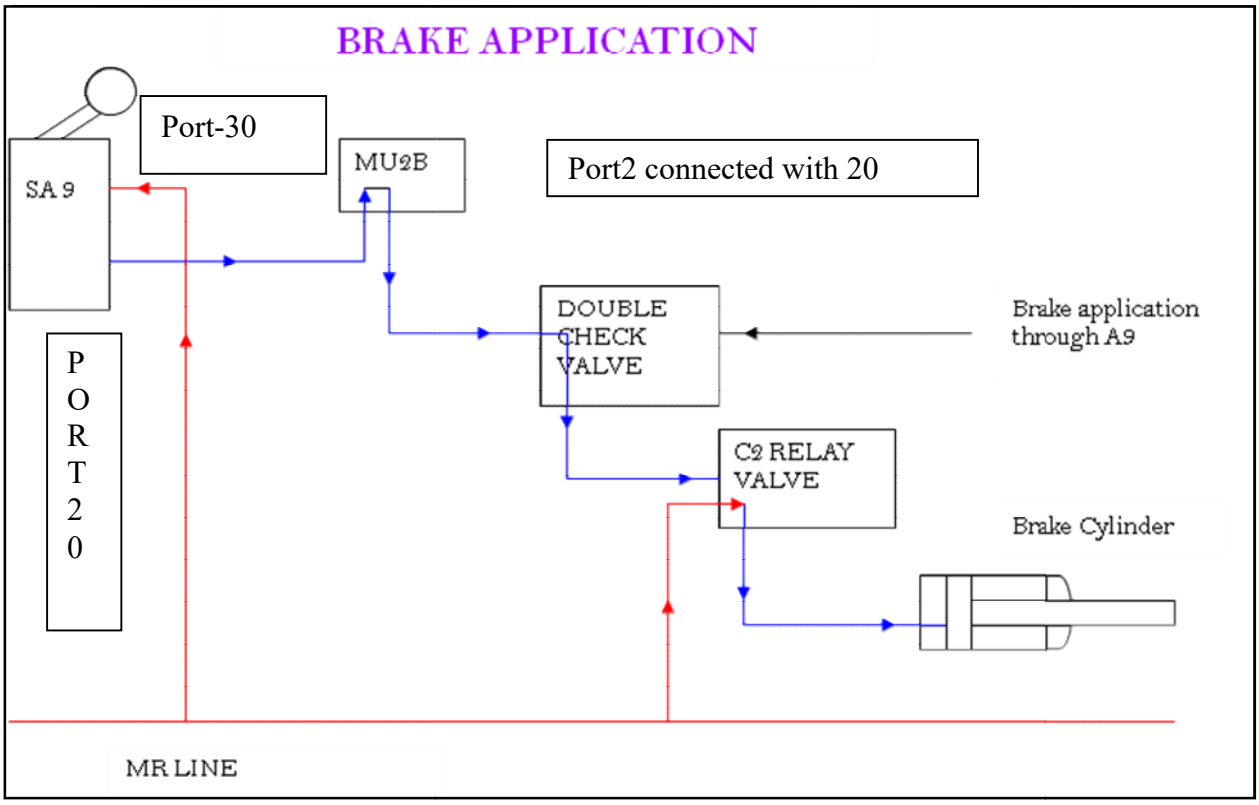
Application:

A reduction of brake pipe pressure will cause brake application by admitting compressed air into the brake cylinder from auxiliary reservoir through distributor valve. The brake application is proportional to the reduction of pressure in train pipe.

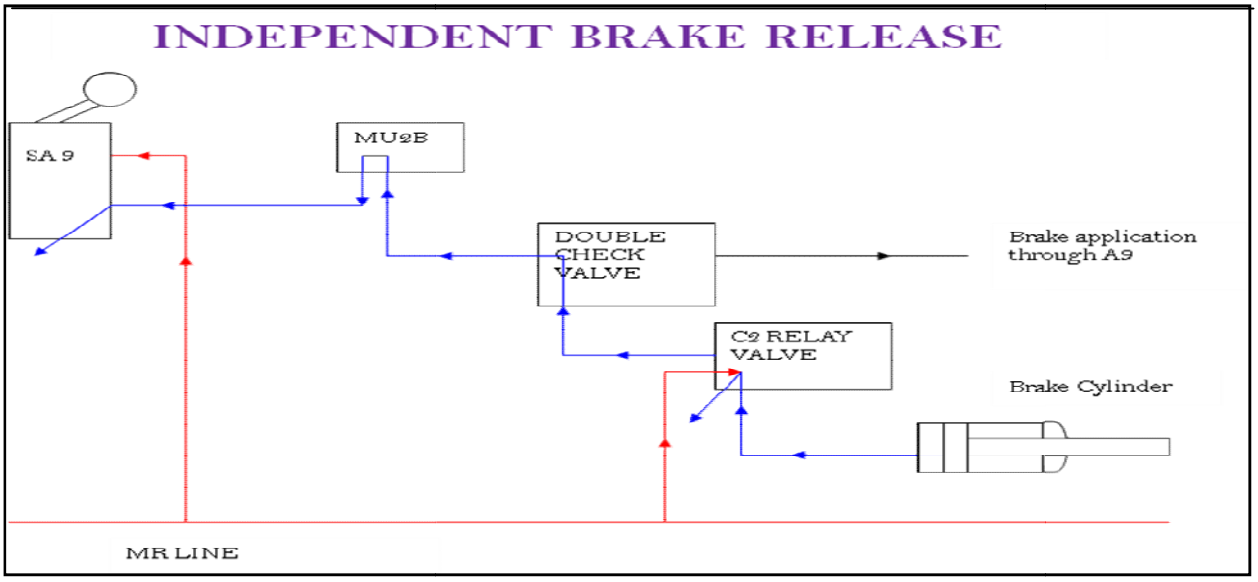
Release:

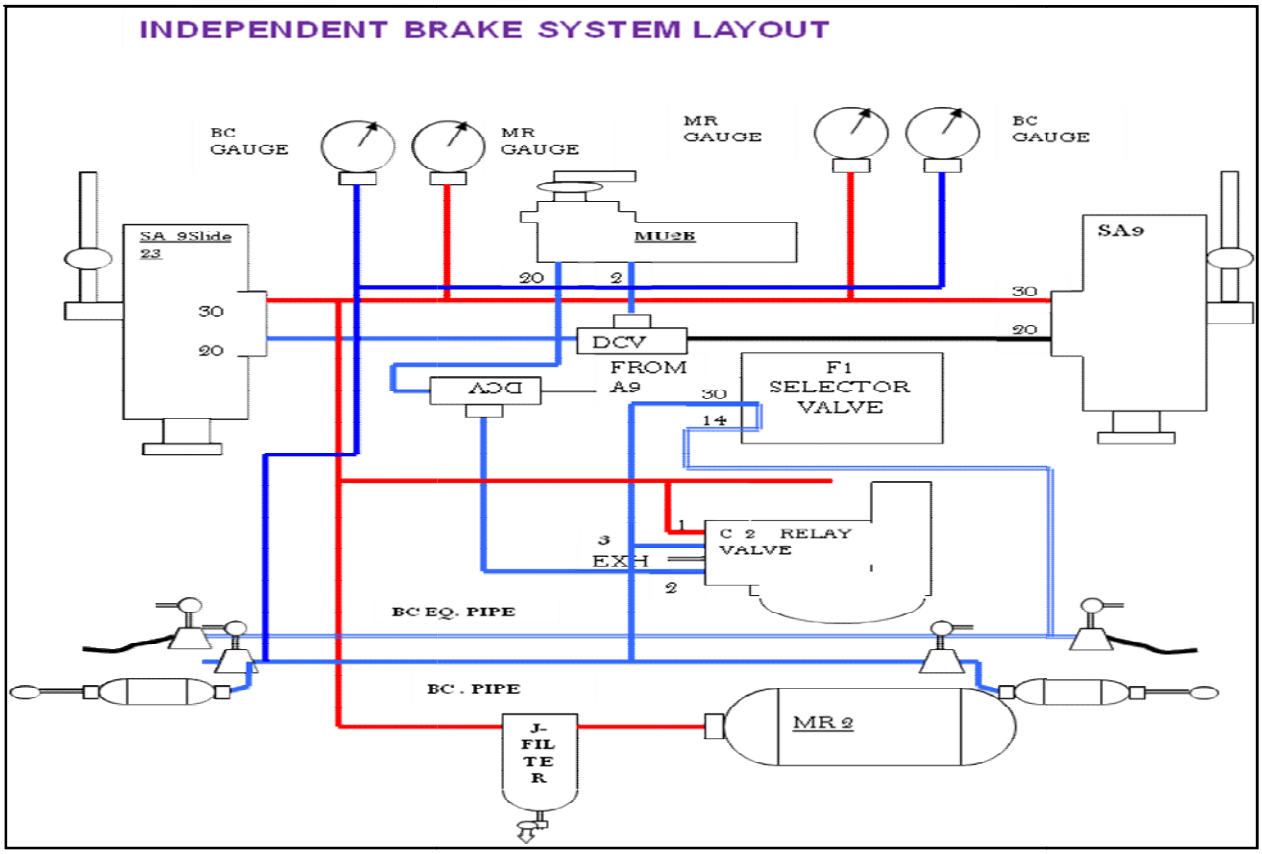
When the brake pipe pressure is increased, the distributor valve responds to the pressure increase and brake cylinder pressure exhausts to the atmosphere and also recharges auxiliary reservoir to the level of the pressure in brake pipe.

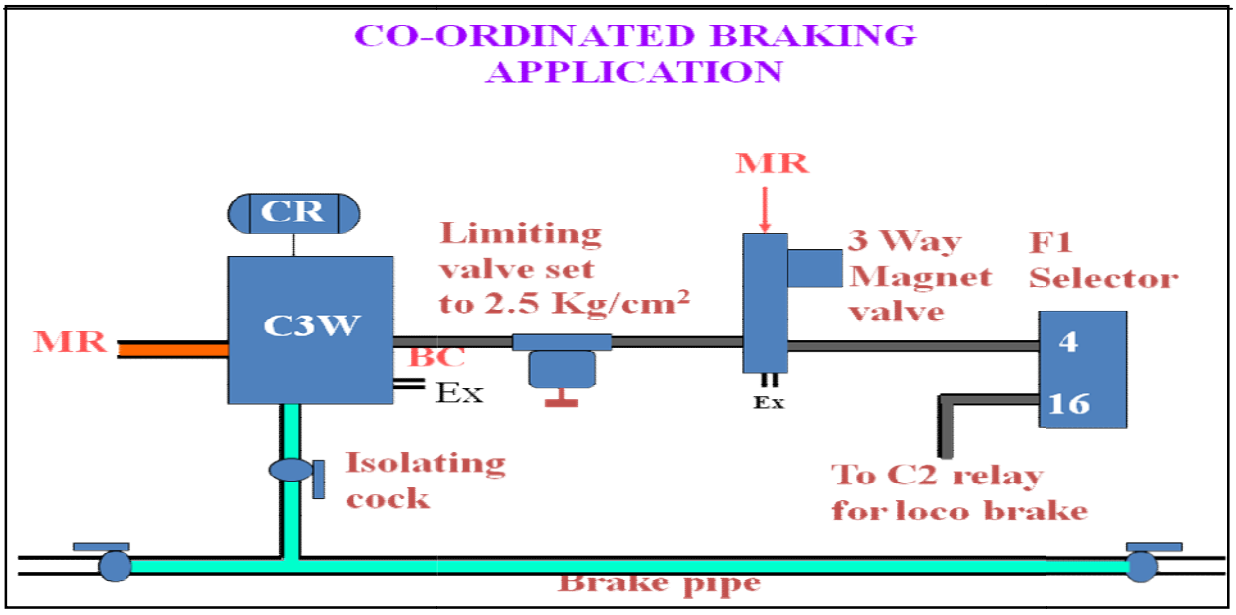
The brake pipe pressure discharge rate should not be less than 0.5 Kg/cm2 otherwise distributor valve will not operate. So it is advisable in case of engine shut down on run brake pipe pressure should be dropped by A-9 handle. The discharge pressure should be more than 0.5 per minute through A-9 valve to control the train.



INDEPENDENT BRAKE SYSTEM
BRAKE APPLICATION




INDEPENDENT BRAKE SYSTEM LAYOUT
BC GAUGE
MR GAUGE
MR GAUGE
BC GAUGE
SA 9Slide 23
MU2B
SA9
30
20
20
2
30
20
DCV
FROM A9
F1 SELECTOR VALVE
30
14
3
EXH
2
C 2 RELAY VALVE
BC EQ. PIPE
BC . PIPE
J-FIL TE R
MR 2


CO-ORDINATED BRAKING APPLICATION
MR
CR
Limiting valve set to 2.5 Kg/cm²
3 Way Magnet valve
F1 Selector
MR
C3W
BC
Ex
Ex
4
16
Isolating cock
To C2 relay for loco brake
Brake pipe

COMPUTER CONTROLLED BRAKE SYSTEM (FOR HHP LOCO)

MAIN CONCEPTS

This is an Electro Pneumatic Brake system. Since the brake equipments are controlled by electro pneumatic operation, for the working of the system

1) Always Electrical power is required.
2) A minimum main reservoir pressure of 4 kg/cm2 is required.

The CCB system is equipped with a pneumatic back up (KE Valve) that operates in parallel to the microprocessor control and is always in operation. This brake system automatically effect the blended brake (Auto brake and Dynamic brake), when Auto brake handle is in service zone. When MR Equaliser pressure is dropped below 6.8 kg/ cm2, according to the CCB feedback EM 2000 raises the engine speed up to fourth notch, enable to builds up or to maintain it with message in display. CCB makes emergency application of loco brake, without charging BC Equaliser, if MR Equaliser pressure is dropped below 3.2 kg/cm2. Even the BP leakage rate is below insensitivity, the system applies emergency brake, if Brake Pipe pressure (Train line) is dropped below 2.8 kg/cm2. While power up this system, until the microprocessor system gains control of the brake system, the locomotive brakes are under control of the pneumatic backup system.

If the CCB system set up is for Lead mode, during power up, the computer will not take control of the brake system until

a) The automatic brake handle is moved to the Full Service position for a minimum of 10 seconds and returned to the Running position
b) The brake cylinder pressure is dropped zero kg/cm2.
c) If the Automatic brake valve handle had previously been placed in Emergency position, then the handle must remain in the emergency position for 60 seconds.

If the CCB system is set up for Trail or Helper (Banker) mode on power up, the computer will not take control of the brake system until brake cylinder pressure is dropped to zero kg/cm2.

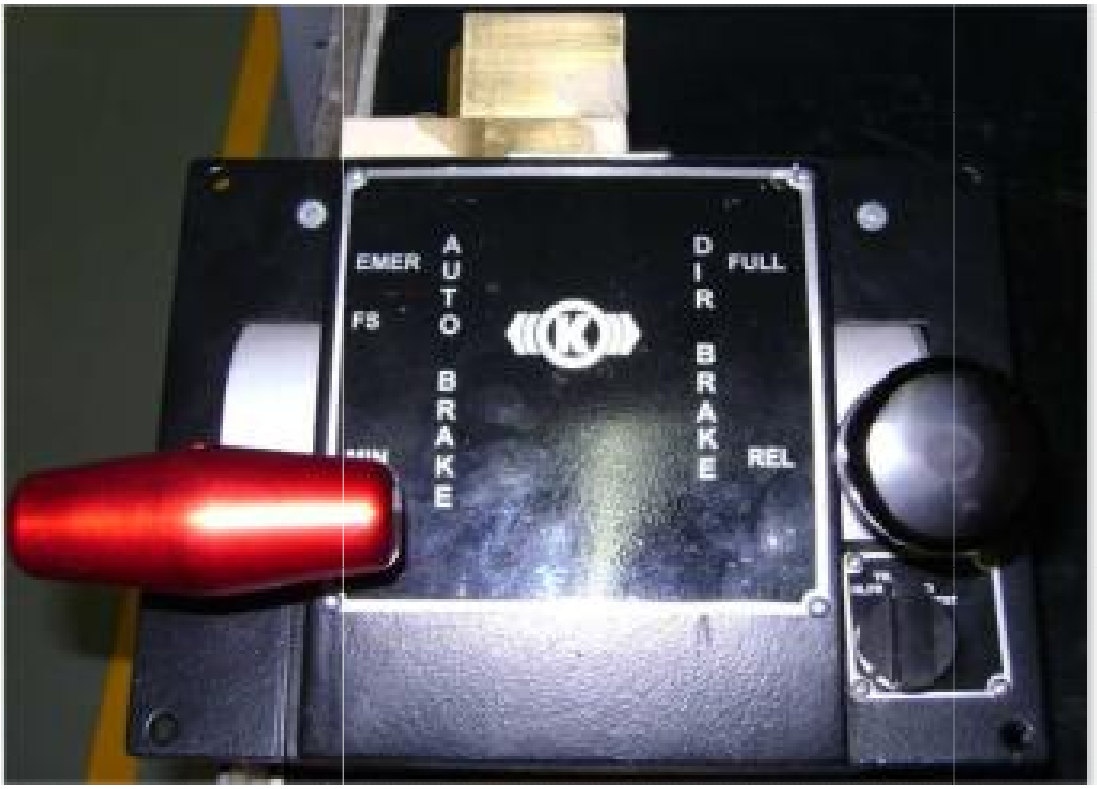
The system includes the following main components:

a) Brake Valve Controller (BVC)
b) Computer Relay Unit (CRU
c) Pneumatic Control Unit (PCU)
d) Voltage Conditioning Unit (VCU
e) Pneumatic back up (KE valve)
f) Diagnostic

BRAKE VALVE CONTROLLER

a) It is an interface device of the operator with CCB.
b) It is located in the Control consoles and consists of an Auto Brake Valve, Direct Brake Valve with a bail off ring and a Lead Trail Switch (Selection Switch).

BRAKE VALVE CONTROLLER



AUTO BRAKE VALVE

This valve controls the BP Pressure and has five positions and they are

Release - It is a spring loaded position and start to function if the handle is hold for 3 seconds in release position to facilitates quick and over charging of BP Pressure up to5.7 Kg/cm2 at a constant rate of 0.05 kg/cm per second and will remain at that level for a period of 60 seconds. After 60 seconds, BP Pr. will slowly bleed off (for 240 secs) at the rate of0.002 kg/ cm2 per second and stopped when BP Pr. reaches 5.2Kg/cm2.

Run - It is the normal working position, and creates BP pressure of 5.2Kg/cm2

Minimum Reduction - To drop BP Pressure from 5.2 to 4.7 Kg/cm2

Full Service - To vary BP Pressure from 4.7 to 3.7 Kg/cm2

Emergency - To drop BP Pressure Rapidly to Zero

DIRECT BRAKE VALVE

This valve controls the BC Pressure and has two positions and they are

Application - It is a free variable position from Release to Full, which varies BC pressure from 0 to 5.2 Kg/cm2

Release - To exhaust the charged BC Pressure to zero by the application position of this handle.

A Bail of ring is provided at the top portion of this handle to nullify conjunction brake. When bail off ring is operated BC and BC Eq. Pr. will be exhausted results conjunction brake gets release.

Bail off ring is operated by a pull and release. If it holds for more than 180 seconds bail off feature will be failed with message **"Bail off cut off"** in the LCC Display.

LEAD TRAIL SWITCH (SELECTION SWITCH)

It is a manual operated Rotary switch and is located on the lower right corner of the BVC Unit.

To operate this switch

a) Bring the loco to dead stop.
b) Press down and Change the knob to the required position. It has four positions for air brake set up.

Position	Function and Purpose
LEAD	1) Set up air brake system for locomotive to lead 2) To select the console from which operation to be carried. 3) Auto and Direct brake handles will function normally
TRAIL	1) Set up air brake system for locomotives in trail. 2) Disable the Auto brake handle except Emergency. 3) Disable the Direct Brake handle operation.
TEST	1) Cut off BP Charging, Holds BP and ER Pressure for BP leakage test 2) Full application of direct brake will be done irrespective of Direct brakes handle position to secure the loco.
HELPER	1) Brings ER Pressure to zero to avoid system Penalty. 2) Cut off BP Pipe to avoid dual braking /Release 3) Disable the Auto brake handle except Emergency and allows the Direct Brake handle operation

CCB will accept the position of the LT Switch in the working console if in non working console it is placed in “Trail”. Otherwise EM 2000 will display “Air Brake failure, Check for proper Lead Trail set up” message and applies penalty brake.

VOLTAGE CONDITIONING UNIT

It is located in the nose compartment near air brake equipment rake. It receives 72 Volt DC supply from locomotive battery and gives 24 volt filtered DC output. Supplies power for the operation of the brake valves and air brake computer.

PNEUMATIC CONTROL UNIT

It is located in the nose compartment near air brake equipment rake. It is a laminated aluminium panel and most of the pneumatic and electro-pneumatic valves are mounted on it. It responds to the CCB Computer to develop ER, BP, BC and BC Eq. Pressure.

During power failure or critical diagnostic detection, it arranges

a) Exhaust the BP at service rate
b) Automatic lap of BP, BC and BC Equaliser pressure for Trail operation.
c) Pneumatic control of Brake Cylinder pressure instead of electronic control.

COMPUTER RELAY UNIT

It is located in the nose compartment near air brake equipment rake. It comprises of a computer and an input / output unit and provided electronic control for brake system. It receives brake commands from operator and dictates logically the PCU Unit to control and develop pressures. It monitors the train line pressure and commands the development of BC Pressure. According to the signals from locomotive control system it initiates penalty brake application at service rate.

This unit has a Pass / Goods selection switch and 12 printed circuit boards for processing and a mother board to feed memory for the CCB working.

1. DB1 - Supplies power for magnet valves and relay
2. SV2 - Supplies power for Air Brake Computer
3. SVJ - Supplies power to (MVER, MVEM, MVBP, MV 53)
4. SS9A - Supplies power to Short Hood Console
5. SS9B - Supplies power to Long Hood Console
6. DIZ - Displays the fault code
7. COM - Mother Board (For working memory)
8. CPZ - Central processing unit
9. EPA1 - Equalising Reservoir Control

10. EPA2 - Brake Cylinder Control
11. AD / ADZ - Analog /Digital converter
12. EPA3 - Direct Brake Control (BC-Equaliser)
13. FOR - Fiber Optic Receiver

BACK UP (KE VALVE)

It is located in the nose compartment near air brake equipment rake. A manual operating handle 9Goods / Pass) is provided in this valve to control the rate of application / release. When the handle is in goods, the application rate is slow and faster if it is in passenger.

This valves provide loco brake application

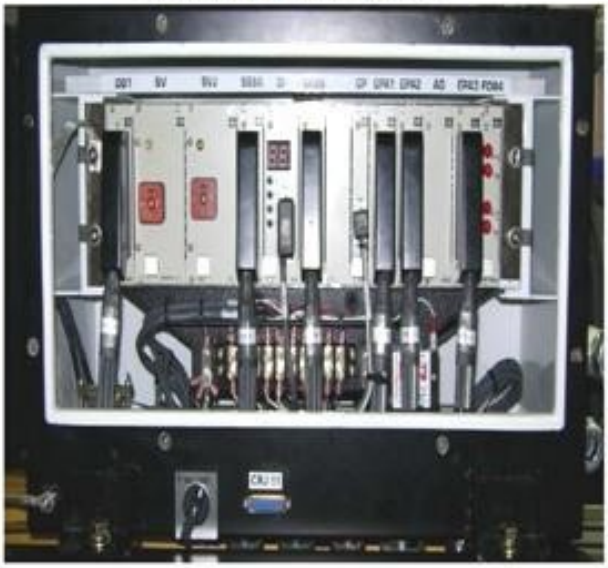
a) If the power supply to the system is cutoff
b) In dead loco, when BP Pipe only connected and if dead engine cock is opened.

DIAGNOSTIC

a) It identifies the probable device, which cause the fault and displays the information to the operator and send to main loco computer.
b) Monitor the braking system and applies penalty brake if critical fault is detected.
c) Allows the operator to scrutinise the brake system by conducting self test to restore itself or to confirm the working status of the loco.

VOLTAGE CONDITIONING UNIT

COMPUTRE RELAY UNIT



PNEUMATIC CONTROL UNIT

KE VALVE