



## NORTH WESTERN RAILWAY SUPERVISOR'S TRAINING CENTRE, AJMER



## COURSE TEXT BOOK MSE/MJR (DIESEL)- SESSION - III

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## FOREWORD

I am extremely happy to know that STC/Ajmer is publishing a continual series of course text books which will be useful for newly recruited JE's & SSE's. This book will surely help in grasping required knowledge to improve their awareness of safety and work areas.

This course text book **(MSE/MJR (Diesel) IIIrd Session)** has been compiled as per Railway Board's prescribed module containing full technical topics regarding Diesel Traction which shall be handy for Supervisors maintaining Diesel Locomotives in various Diesel Sheds and Workshops as well.

I congratulate Director STC/Ajmer and his faculty for bringing about all the relevant topics in the form of text book.

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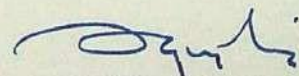


## FOREWORD

I am glad to know that STC/All is publishing Technical books which shall be handy and useful for Direct recruited JE's & SSE's. This course book MSE/MJR (Diesel) IIIrd Session contains latest relevant topics as per the Railway Board's prescribed module which will upgrade and enhance the knowledge of Supervisor Trainees.

It is my hope and expectation that this book will provide effective learning experience during training and thereafter in respective work areas.

I congratulate Director and his team of STC in this endeavor.

  
(S.K. Gupta)

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### **FOREWORD**

Mechanical Department is most responsible towards Safety of Railways. In this regard, Railway Board framed Training Module for Direct Recruited trainee Supervisors, who are required systematic and gravitational knowledge of their field as they are the backbone of Mechanical Department.

STC/Ajmer plays a vital role in imparting qualitative & effective theoretical & practical training to develop their professional aptitude. The main thrust of this book is application oriented with the appropriate theoretical inputs and trainee can develop self-reliance in training and taking problems in their work related field.

I am pleased that STC Ajmer is constantly publishing course books as per module prescribed by Railway Board. We take an opportunity with the inspiration of our CWE, Shri Sudhir Gupta to present a course book for trainee MSE/MJR (Diesel) of IIIrd Session separately. The object of this book is to present the subject matter prescribed by Railway Board module in a most concise, compact and in lucid manner. I would like to thank our Hon'ble PCME, Shri Virendra Kumar for their benevolent guidance in this regard.

I acknowledge and appreciate sincere efforts done by our experienced faculty Shri Prakash Kewalramani in bringing out this book. I would like to express thanks to Shri Amar C. Gaharwal Sr. Instructor, Shri Surendra Tak, Chief Typist and Smt. Manisha Khandey, PS as chief coordinator of this edition.

Any errors, omissions and suggestions for the improvement of this book brought to our notice will be gratefully acknowledged and incorporated in the next edition.

**(N.S PATIYAL)**  
Director, STC AII NWR

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# **DIESEL LOCOMOTIVE**

## **INTRODUCTION**

A diesel engine can be either two-stroke or four-stroke and, except for its ignition, is much like any other internal combustion engine. It is one of three types--V, vertical in-line, or horizontal--depending on the arrangement of its cylinders. The fuel system includes the fuel tank, fuel and ignition pumps, filters, injection nozzle, and emergency fuel cut-off valve. The fuel tank has baffle plates to prevent surging and a pit to catch sediment so that it can be drained out. In some locomotives, the fuel tank is above the pump and fuel enters the pump by gravity. In others, fuel is pumped from the tank into the main pump by an auxiliary pump. The fuel pump creates the injection pressure and determines the amount of fuel injected into the cylinders by the injectors.

In an engine with a water-cooling system, water is run through water jackets between the cylinders and cylinder liners. The water is directed through a radiator to cool it. Louvers on the front of the radiator can be opened and closed to regulate the heat escaping from it. Occasionally, an engine is designed so that the pistons are cooled also by their lubricating oil. When this is done, a special oil radiator, with its own cooling fan, is provided in addition to the water cooling radiator.

Lubricating oil should have some detergent properties so that contaminating materials can be kept in suspension and filtered out by strainers made of gauze, steel wool, or closely spaced plates. Brakes for a locomotive can be the kind that controls the locomotive, the train, or both. Air pressure for the brakes is supplied by a compressor.

The weight of the locomotive is carried by the trucks, which also absorb lateral thrusts and oppose the tilting tendency. A truck is made of frames, wheels, axles, journals and journal boxes, bolsters, springs, bearings, and brake rigging. Most locomotives are equipped with chains to limit the swing of the trucks in case of derailment. Locomotives larger than 40 tons use four-wheel rigid trucks, four wheel swing bolster trucks, or six-wheel swing bolster trucks.

Accessories supported by the locomotive engine include a bell, horn, speed recorder, wipers, sanding system, temperature controls, and engine and cab heaters. Measures of electrical pressure, resistance, and quantity are called volts, ohms, and amperes. A volt is the unit of pressure leaving the generator or battery; an ohm is a unit of resistance; and an ampere is the unit used to measure power available to the receiving mechanism, such as one of the traction motors. Ohm's law states the relationship between these: current equals to voltage divided by resistance. Voltage is measured by a voltmeter and amperage by an ammeter.

Wiring diagrams, using lines and standardized symbols and abbreviations, are used in tracing circuits and locating troubles on diesel-electric locomotives. Wiring in the electric system is built to carry a specific load of current; current heavier than that specified is called an overload. Since an overload in the wiring can harm equipment, fuses and circuit breakers are provided to break the circuit before damage occurs.

Mechanical energy can be changed into electrical energy, or electrical into mechanical, by a dynamo. If the mechanical energy is changed into electrical, the dynamo is called a generator; if the electrical energy is changed into mechanical, the dynamo is a motor. A generator can be either the alternating current or the direct - current type. Current is set up in the generator's armature coil whenever the coil cuts across the lines of magnetic force between the generator's poles. With an alternating-current generator, the current flows through the coil first in one direction then the other unless the generator has a commutator to

turn the alternating current into a direct current. If a generator has many coils, connected to form a closed circuit, a direct current is supplied. Direct current generator coils can be connected in series, in shunt, or in a combination of series and shunt. Like a generator, a motor can also be connected in shunt or in series.

Mechanical transmission is not preferable/suitable in locomotive because of the locomotive's size and weight, gears large enough to control it would be too large and bulky to be practical. Mechanical gear transmission of power to the wheels is therefore replaced by electrical transmission. To change the mechanical force from the engine into electrical power, an alternator is operated by the engine's crankshaft. The output of the alternator is rectified with the help of static rectifiers and cables transmit the power to traction motors and the traction motors turn the wheels. Traction motors are series-wound, direct current motors and are provided with a shunt. Their function is to convert electrical energy from the generator into mechanical force to turn the locomotive wheels.

Electrical circuits in the locomotive are connected in series, in parallel, or in series-parallel, a combination of the two. Circuits are opened and closed by contactors, operated either by compressed air in heavy circuits, or by current from the battery in circuits where the current is low. Auxiliary switches to control the connecting or breakings of circuits are called interlocks. A relay is a device that changes connections in one part of a circuit in response to changes taking place in another part. Changing traction motors from series connection to series-parallel or parallel connection is known as transition. It can be done by connecting the motors in parallel or by shunting off part of the current drawn into the circuit, forcing more current to be drawn from the generator. A traction motor cut out switch is used to take the motors out of circuit if there is an electrical failure.

In dynamic braking, the locomotive's wheels are used to drive the traction motors, which acting like generators, slow the locomotive's speed without causing wear of the wheels. When brakes are applied, a pneumatic switch stops the engine, stops the fuel pump, and turns on indicating lights.

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# **TRANSMISSION SYSTEM OF DIESEL LOCOMOTIVES**

A diesel locomotive must fulfil the following essential requirements-

1. It should be able to move a heavy load and hence should exert a very high starting torque at the axles.
2. It should be able to cover a very wide speed range.
3. It should be able to run in either direction with ease.

Further, the diesel engine has the following drawbacks:

- It cannot start on its own.
- To start the engine, it has to be cranked at a particular speed, known as a starting speed.
- Once the engine is started, it cannot be kept running below a certain speed known as the lower critical speed (normally 35-40% of the rated speed). Low critical speed means that speed at which the engine can keep itself running along with its auxiliaries and accessories without smoke and vibrations.
- The engine cannot be allowed to run above a certain speed known as high critical speed. It is 112 to 115% of rated speed. The high critical speed is the speed at which the engine can keep itself running without damaging itself due to thermal loading, and centrifugal forces.
- It is a constant torque engine for a particular fuel setting irrespective of its speed. It can develop rated power at rated speed and fuel setting only.
- It is unidirectional.
- To de-clutch power, the engine has to be shut down, or a separate mechanism has to be introduced.

To satisfy the above operating requirements of the locomotive, it becomes necessary to introduce an inter-mediate device between the diesel engine and the locomotive wheels. This device, called transmission, should accept whatever the diesel engine gives, with all its limitations mentioned above and be able to feed the axles in such a way that the locomotive fulfils the essential requirements.

## **FUNCTIONS OF AN IDEAL TRANSMISSION**

- It should be able to multiply the torque and reduce the speed to such a level that the train can be started without a jerk.
- Once the train has started, it should decrease the torque and increase the speed as required, automatically.
- The torque & speed characteristics should be verified uniformly throughout the traction depending upon the road requirements, so that the power transmission is jerk free.
- It should be capable of reversing the power transmission easily, with identical torque & speed characteristics in both the directions.
- It should be light, robust, and should occupy very little space.
- It should be reliable and ask for minimum maintenance.
- It should be approachable easily for maintenance and ask for minimum nos. of consumable.
- It should not transmit road shocks and vibrations to the engine.
- It should have good efficiency, good utilisation factor, and good degree of transmission.
- It should be capable of starting the engine, if required.
- It should be able to apply brakes, if required.

Keeping in mind the above requirements, following transmission systems are used in diesel locomotives:

- a) Hydraulic transmission
- b) Electrical transmission

**Hydraulic Transmission** - In this, hydraulic torque converter act as a clutch and gear box combined into one with infinite gear ratio. The output torque can be varied infinitely from zero to more than engine torque. One side of the torque converter (impeller end) is connected to the engine and continuously rotates while other side (turbine end) is connected to wheel by suitable gear train. The hydraulic transmission attains peak efficiency at specific speed and fall steeply on either side of it. By multi-staging, high efficiency can be maintained in the entire working range. This transmission system has advantages of having very high starting torque at zero speed, uniform torque curve and high power to weight ratio. Hydraulic transmission system is suitable for relatively low horse power and high speed engines. The transmission efficiency of this system is less than mechanical transmission system and only 70% of the engine speed can be achieved.

**Electrical Transmission** - Most of the diesel loco-motives have electrical transmission system. In this, engine is permanently connected to generator/alternator. The output of the generator/alternator is fed to traction motors through a control circuit which varies the torque- speed relationship. The traction motors are directly mounted on the axles and rotates the axle through gear. The advantages of this system are that speed control is easy as current through motors is to be controlled for speed control of the locomotive, the system has low maintenance cost and separate reservoir is not required. Transmission efficiency of this system is higher than hydraulic transmission system but less than mechanical transmission system. However, this transmission system is heavier than hydraulic transmission system and not suitable for very high speed engines as compared to hydraulic transmission system.

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# CONSTRUCTIONAL DETAILS OF A DIESEL LOCOMOTIVE

A diesel locomotive consists of truck / bogie, loco chassis and superstructure. The bogies are of 4 or 6 wheel type depending on the horse power and overall length of the individual locomotive unit. The truck assemblies are made up of cast-steel or welded steel frame, axle-mounted traction motors, wheel brakes, axle suspension and springs. The construction may also provide for air duct to the motors for forced ventilation from a blower.

The chassis of loco is robust steel structure fabricated of steel plates which supports and carry all the assemblies of super structure. Super structure of the locomotive can be divided into six main compartments:

1. Nose compartment
2. Driver's cab
3. Main Generator compartment
4. Engine room
5. Compressor compartment
6. Radiator fan compartment

**Nose Compartment** - This compartment houses dynamic grid resistance, grid blower motor, sand box, panel mounted brake system, head light etc.

**Driver's Cab** - Driver drives the locomotive from control stands on which air brake control valves, pressure gauges indicating lube oil, fuel oil & booster air pressure, mechanical & electrical speedometer and load meter etc. are provided.

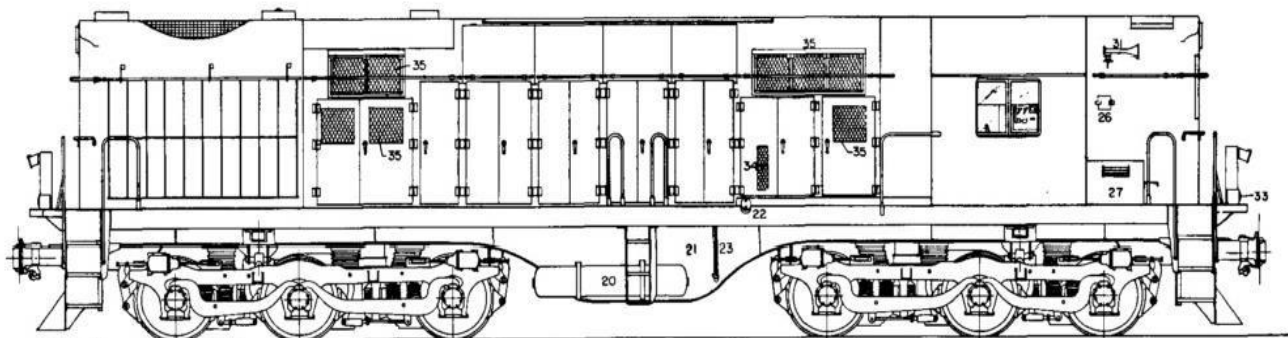
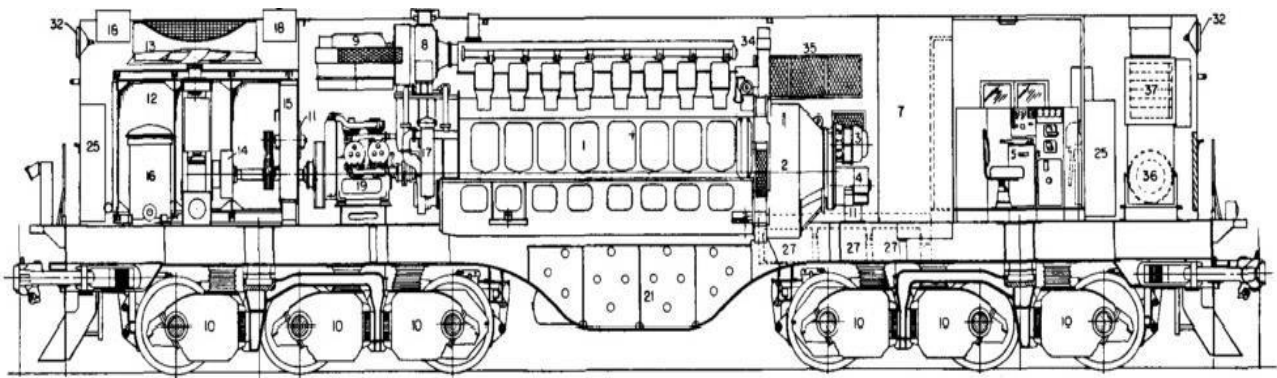
**Main Generator Compartment** - Traction generator, excitation gen., auxiliary generator and front traction motor blower are housed in this compartment.

**Engine Room** - Diesel engine is kept in this compartment. Other important items of this compartment are after cooler, turbocharger, governor, fuel injection pump, fuel oil filter, lube oil filter, compressor spline coupling, extension shaft, lube oil pump and water pump.

**Compressor Compartment** - Compressor is kept here. It produces compressed air which is used for braking purpose. Fuel booster pump and motor are also kept here.

**Radiator Compartment** - Radiator compartment has two (left and right) radiator panels, lube oil cooler, radiator fan, right angle gear box for driving radiator fan, eddy current clutch which connects right angle gear box to diesel engine's extension shaft.

Driver cabin end of the locomotive is known as Short Hood and the radiator room end is known as Long Hood. When the driver stands in the cabin facing the Nose compartment, his right hand side is the right hand side of the locomotive and the left hand side is the left hand side of the locomotive. Generator room end of the engine block is called Power take off end and the Compressor Room end of the engine block is called Free End.



### Parts List:

- |  |                                  |
|--|----------------------------------|
| 1. Engine                                  | 20. Main Air Reservoir           |
| 2. Main Generator                          | 21. Fuel Tank                    |
| 3. Exciter                                 | 22. Fuel Tank Filling Connection |
| 4. Auxiliary Generator                     | 23. Fuel Tank Gauge              |
| 5. Control Stand                           | 24. Fuel Oil Filters             |
| 6. Brake Valves                            | 25. Sand Box                     |
| 7. Control Compartment                     | 26. Sand Box Cover               |
| 8. Turbosupercharger                       | 27. Batteries                    |
| 9. Turbosupercharger Filters -<br>Oil Bath | 28. Hand Brake                   |
| 10. Traction Motor                         | 29. Cab Seat                     |
| 11. Traction Motor Blower                  | 30. Gauge Panel                  |
| 12. Radiator                               | 31. Horn                         |
| 13. Radiator Fan                           | 32. Headlight                    |
| 14. Radiator Fan Clutch                    | 33. Aspect Lights                |
| 15. Lubricating Oil Cooler                 | 34. Generator Exhaust Air Duct   |
| 16. Lubricating Oil Filters                | 35. Air Filters                  |
| 17. Lubricating Oil Strainer               | 36. Dynamic Brake Blower         |
| 18. Engine Water Tank                      | 37. Dynamic Brake Grids          |
| 19. Compressor - Exhauster                 | 38. Tool Box                     |
|  | 39. Clothes Locker               |



## **DIESEL LOCOMOTIVE: POWER PACK AND ITS COMPONENTS**

Diesel engine of the diesel locomotive is also known as power pack. ALCO locomotive Engine has following major components:

1. Engine base
2. Engine block
3. Crank shaft
4. Cam shaft
5. Cylinder head
6. Valves
7. Piston
8. Piston rings
9. Cylinder liner
10. Connecting rod
11. Exhaust manifold
12. Governor (WW/MCBG)
13. Turbo supercharger
14. After-cooler assembly
15. Fuel injection Pumps & injectors
16. Lube oil pump
17. Water pump Assembly

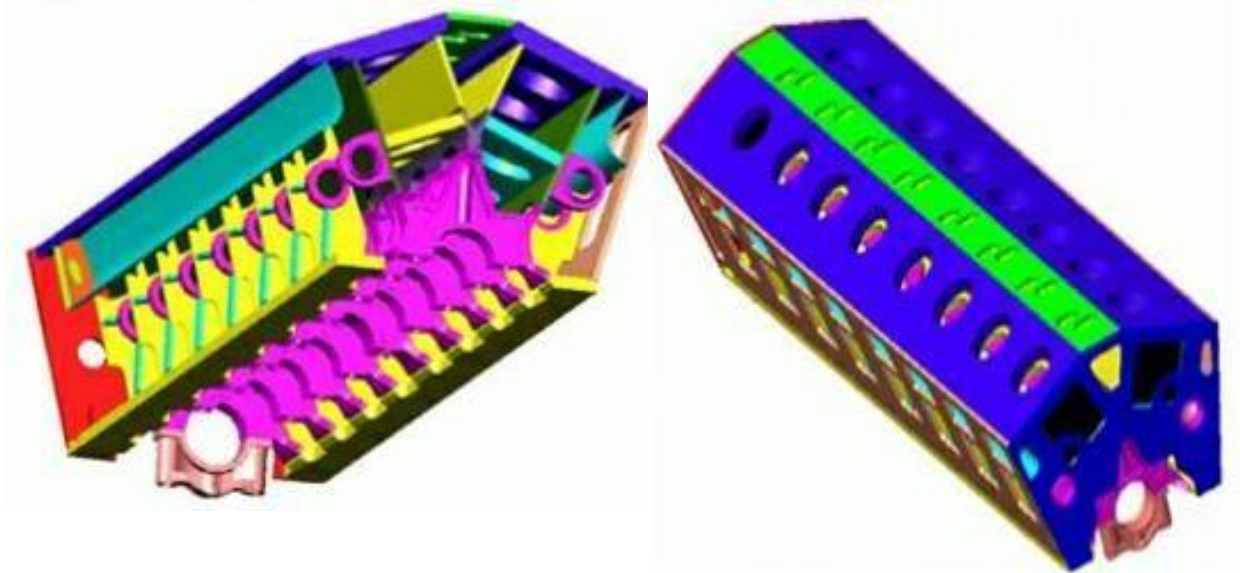
**Engine Base** - The engine base is a welded steel structure which provides the following: a mounting surface for the cylinder block, lubricating oil pump, water pump and four ending mounting pads: in addition it acts as a lubricating oil reservoir. Screens are fitted across the base at each cylinder location. Openings on each side of the base give access to the connecting rod bearings, crankshaft and main bearings; provides means for inspecting oil lines, piston skirts and cylinder liners. Removable doors enclose these openings. Also explosion doors are mounted on the right and left side of the base at the power take-off end. Lubricating oil is carried in the base below the base screens. A lubricating oil drain plug, bayonet gauge with high and low level markings and a filler pipe are located in the base. A crankcase exhauster is used to vent the base.

The engine base of the locomotive is made from weldable quality steel having 0.2% carbon. The engine base has following functions:-

- To support the locomotive
- To serve as oil sump
- To take lube oil and water pump
- To transmit load to chassis
- To allow openings for crank case inspection.

Foundation pads are provided for transmitting load to the chassis and also to take lower bolts of the main generator magnet frame.

**Engine Block** - The engine block is the most important and highly stressed structure on which a number of important fittings like crank shaft, cam shaft, cylinder heads, cylinder liners, fuel injection pump, cross head, turbo support, governor etc. are fitted. Like engine base, this structure is also fabricated from low carbon steel. The cylinder block, constructed from steel weldments, houses and supports the major components of the engine: crankshaft



and main bearings, camshaft, pushrods and lifters, connecting rods and pistons, cylinder liners, cylinder heads, crankcase exhauster, fuel pump crossheads and levers, and governor. It also provides mounting surfaces for the turbo supercharger support, exhaust manifold, air intake elbows, water elbows, and generator.

A replaceable liner sleeve is fitted into the lower liner bore of the cylinder block. It provides a wear surface for the lower fit of the liner. On salvaged blocks, a replaceable upper liner sleeve, with an "Oil ring (the same type used in the upper portion of the cylinder liner itself), is also fitted into the re-bored upper liner bore. Dimensions of the liner bore, without the upper sleeves. The crankshaft main bearing saddles, camshaft bearing supports, and the air intake manifold are integral parts of the block.

Cooling water, circulated by the water pump, flows through the oil cooler, into a passage in the cylinder block. There, it circulates around the cylinder liners. Water from the block is conducted to the cylinder heads by water jumpers.

**Crank Shaft** - The engine crank shaft is probably the singular costliest item of the locomotive. It is the medium of transforming reciprocating motion to rotary motion. The crank shaft may be assembled type or two piece bolted type or maybe a single piece forging. ALCO locomotive crank shafts are made of forged steel alloy, with its main bearing journals and crankpins machined to a high degree of smoothness. The shaft is slung under cylinder block and rotates on the main bearings (shells). It is supported by the bearing caps that are mounted to the saddles in the block with the stud bolts and nuts.

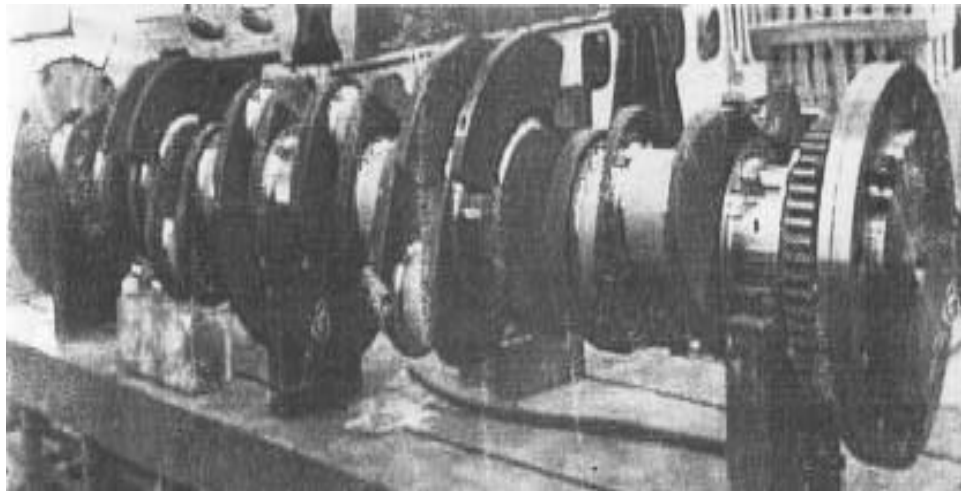
The crank shaft for the 12 and 16 cylinder "V" type engines is made of one piece of forged steel alloy, with its main bearing journals and crankpins machined to a high degree of smoothness. The shaft is slung under the cylinder block and rotates on the main bearings (shells), it is supported by bearings caps that are mounted to saddles in the block with stud bolts and nuts. The shaft's main bearings and crankpins are joined by a series of crankshaft webs, to which counterbalances are welded at intermittent locations for balancing purposes.

Two rods (right and left bank of the same cylinder number) are mounted side by side on each of the shaft's crankpins. The shaft is designed so that every two symmetrically opposite pins have the same radial throw position. A crankshaft gear, which drives the left and right

camshaft gears, is applied to the power take-off end of the shaft. The free end of the shaft provides the drive for the engine's cooling water and lubricating oil pumps.

The crankshaft forms an integral part of the engine's lubricating system. A continuous flow of oil passes under pressure from the main lubricating header in the engine's base to the bearing caps and bearings; through drilled passages in the shaft to the crankpins; and on the connecting rod bearings oil slingers and catchers are provided at both ends of the shaft to prevent oil leakage.

The crankshaft end thrust is restricted by the use of either: (a) individual installed in both sides of the center main bearings saddle an upper main thrust bearing shell or upper and lower main bearing thrust shells located at the journal nearest to the power take-off end of the shaft. All shells, thrust or otherwise, are of the lead-tin overlay type and are suitably strengthened by a steel backing.



**Engine Crank shaft mounted on V-blocks**

**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 in-side the cylinder. There are three cam lobes for each cylinder for operating inlet valve, fuel injection pump & exhaust valve respectively. ALCO cam shafts are made of steel having carbon content between 0.48 to 0.58%. The camshaft on -V type engine is located on either side of the cylinder block and extends the entire length of the engine. The camshaft is divided into sections one for every two cylinders and is joined at the section flanges by studs or stud bolts and nuts. A locating dowel is used to position each section. These shaft assemblies are completely inter changeable when complete, but sections of the two design cannot be inter-mixed because of different end fastening methods.

The camshaft rotates on bearings which are pressed into supports in the cylinder block. Lubrication is delivered to the bearing through an oil hole which runs the length of the camshaft. This hole feeds oil into smaller holes, located at each bearing journal. Each section of the camshaft has three integral cams for each cylinder. As the rollers for the fuel pump crosshead and valve pushrod lifters ride on the cams, the rotation of the camshaft actuates the engine's inlet and exhaust valves and fuel pumps.

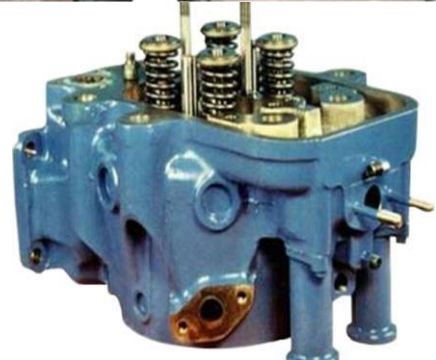


**CAMSHAFT SEGMENT**

**Cylinder Head** – The cylinder head is held on the cylinder liner by seven hold down studs provided on the cylinder block. It is subjected to very high shock stress and combustion temperature at the lower face which forms a part of the combustion chamber face. It is a complicated steel casting where cooling passages are cored for the purpose of cooling the cylinder head in addition to this provision is made for space for passage of inlet air and outlet gas. Further, space has to be left for fuel injection nozzles, valve guides and valve seat inserts. The cylinder shown head is secured to the cylinder block by seven studs. Individual water jumpers from the cylinder block to each cylinder head, conduct water from the cylinder block to water cooling passages in the cylinder heads.



The cooling water discharge from each head is carried to the water outlet header by individual elbow connections. Cored passages permit the admission of scavenging air and expulsion of exhaust gases. Metal-to-metal joints of the flat lap type form the gas seal between the cylinder heads and cylinder liners and prevent the escape of gases from the cylinders. No gasket is required between cylinder head and liner. Each head has suitable chambers for two air inlet valves, two exhaust valves and a fuel injection nozzle.



The valve lever bracket assembly, consisting of a bracket and two valve levers mounted on a valve lever shaft, is applied to the top of the cylinder head along with the equalizing yokes. The valve mechanism assembly and fuel injection nozzle on top of the head are enclosed by Aluminium cover.

**Valves** - Valves are the most important of the small components of the diesel engine. Valves operate at a very high temperature varying from 1250 to 1700 degree F. So the valve head is made from heat resistant austenitic material while stem is made from steel of specification SAE 4140.



**Piston** - The piston is the most important component in the diesel engine as it takes direct part in transmission of power. The combustion of fuel results in large amount of heat being developed, 18% of which is absorbed by piston only. To dissipate such a large amount of heat, pistons are generally made of aluminium alloy. The functions of the pistons are: -

- It compresses the air to required pressure & temperature.
- It receives the thrust of expanding gases and transmits the force through connecting rod (for rotating crankshaft).
- It forms the crosshead through which side thrust, due to angularity of connecting rod, is transmitted to the cylinder wall.
- With the help of piston rings, it prevents leakage of gas from combustion chamber to crank case.

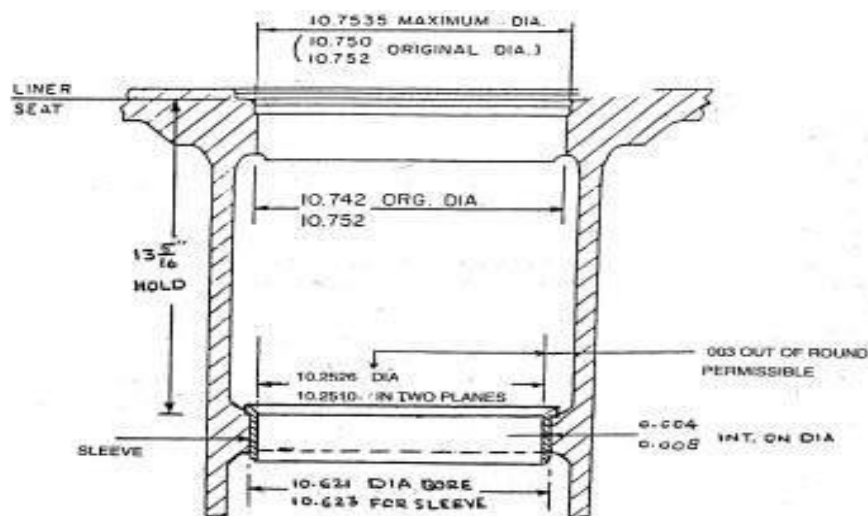
**Piston Pin** - The piston pin has a floating fit in the piston and a running fit in the steel-backed, bronze lined connecting rod bushing. A rolled sleeve is installed in the pin bore to seal in the cooling oil. Special snap rings are provided at each end of the pin to hold it in place.

**Piston Rings** - Main functions of piston rings are

- Preventing blow by air and combustion gases from getting into crank case.
- Scraps down excess lube oil from walls of cylinder liner and thus preventing excessive amount of lube oil from reaching combustion chamber. The piston rings are made from cast iron having open graphite structure.

**Cylinder Liner** - Cylinder liners are mainly of two type i.e. Dry liner and wet liner. Dry liners are those which never come in contact with coolant but fit in sleeve inside and already completes cylinder. Wet liners are those which not only form the cylinder wall but also form a part of the water jacket. ALCO liners are made of high strength close grain alloy cast iron.

Cylinder liner fit in the cylinder block with a metal to metal fit in ALCO Locos. Each liner has a collar on its upper end which seats in a counter bore in the cylinder block. One seal ring in grooves near the bottom of the liner, seal the fits between the liner and cylinder block.



LINER BORE WITH SLEEVE

**Connecting Rod** - Connecting rod is a member connecting piston and crank shaft and is a medium for converting the reciprocating motion to rotary motion. Connecting rod is mostly made of carbon steel or alloy steel forging.

**Exhaust Manifold** - It collects exhaust gases from all the cylinders and supply to turbo supercharger.

**After-cooler** - The engine is equipped with an after-cooler to cool inlet air to the engine after it is discharged from the turbo supercharger. The cooler consists of a tube bundle mounted in the air intake passage of the turbo supercharger support. The header contains the inlet and outlet cooler connections. The tube bundle consists of a series of finned tubes. A water connection at the base of the after-cooler cavity assures complete draining of the tubes. A tell-tale pipe is provided to indicate after cooler tubes leakage.

**Turbo Supercharger** - The turbo supercharger is a self-contained unit, composed of a gas turbine and centrifugal blower mounted on a common shaft with the necessary surrounding casing. The exhaust gases gas from the cylinders of the engine is conveyed through the exhaust manifold to the turbine, which utilises some of the velocity energy in the exhaust gas otherwise wasted. This energy in the gas is used to drive the blower, which furnishes all the air required by the engine, through the air intake manifold at a pressure above atmospheric.

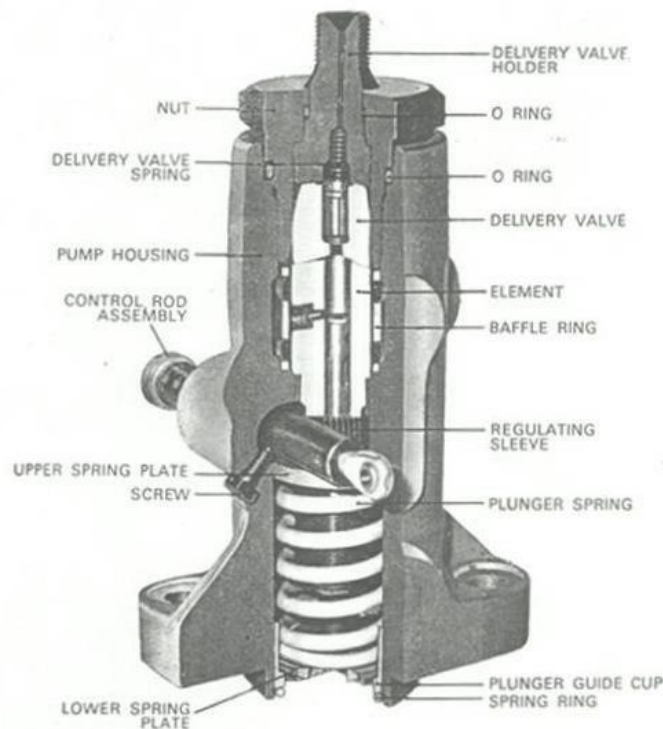
The turbo supercharger unit is used in conjunction with a multiple pipe exhaust manifold. In this system the compressed air delivered by the turbocharger accomplishes two ends: first, it scavenges the hot residual gases otherwise left in the cylinder at the end of exhaust stroke, and replaces these with cool fresh air, second, it fills the cylinder with an air charge of higher density during the suction stroke. The provision of greater amount of fresh air permits the combustion of a correspondingly higher amount of fuel and consequently a higher output from a turbocharged engine than one not so equipped.

**Fuel Injection Pumps & Injectors** - Fuel injection pump are of single acting, constant stroke and plunger type with the effective working stroke, however being adjustable. The pump consists primarily of a housing, delivery valve and spring, delivery valve holder, element (plunger and barrel assembly), plunger spring, a general 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:

- To raise fuel oil pressure to a value, this will efficiently atomise the fuel.
- To supply the correct quantity of fuel to injection nozzle commensurate with the power and speed requirement of the engine.
- To accurately time the delivery of the fuel for efficient and economical operation of the engine.
- Fuel oil enters pump from fuel oil header and fills

The sump surrounding the plunger barrel. When the plunger is at the bottom of its stroke, fuel flows through barrel ports, filling the space above the plunger and the cut away area of the helix. As the plunger moves upward, fuel is pumped back into the sump until barrel ports are closed. Further upward motion of the plunger raises the pressure of the trapped fuel. When the pressure is sufficient to overcome the force exerted on delivery valve by valve spring, delivery valve opens and fuel is discharged into high pressure pipe, leading to injector.



**Fuel Oil Inlet Header:** The fuel oil inlet header supplies fuel to the injection pumps, and is located in the control shaft compartment of the cylinder block. Fuel is drawn from the supply tank by a fuel booster pump, filtered, and discharged under pressure through a secondary filter into the header at the free end. From the header the fuel is distributed to the individual fuel injection pumps. Excess fuel drains to the supply tank.

**Fuel Pump rack Control Shaft:** Two fuel pump control shaft are provided and located in passage extending the full length of the cylinder block. It is made up of sections of shafting on which are mounted spring levers, bearing brackets and section couplings. Fuel rack control shaft is connected to governor through linkage at power take off end of the engine. Rotation of the shaft controls the fuel pump rack settings through spring loaded control levers mounted on the shaft. Individual levers permit any fuel pump to be manually cut out without affecting the control of the governor over the remaining fuel pumps. They also permit the engine to be shut down with one pump rack stuck in the open position. Crossover linkage between the right and left side pump control shafts required on V- type engines.

**Lubricating Oil Circulating Pump:** The lubricating oil circulating pump is of the positive displacement gear type. It is mounted on the free end of the base and is driven by the diesel engine crankshaft extension gear. The oil suction line from the sump is built into the engine base and lines up with the inlet passage cast into the pump casing. The pump discharges into external piping through a flange on the pump casing. A pressure relief valve is provided to protect the pump from excessive pressure and is located in the discharge piping.

**Water Pump:** The cooling water circulating Pump is located on the free end of the engine and is driven by the engine crank shaft extension shaft gear. The Pump frame is connected to the engine through a flanged connection and suction and discharge piping are connected directly to suction and discharge flanges of the pump.

In order to eliminate packing and its inherent maintenance problem, a mechanical seal has been installed i the pump. The pump is lubricated by oil thrown off the lube oil pump gear into the water pump bearing frame.

**After-cooler:** It is a simple radiator, which cools the air to increase its density. Scales formation on the tubes, both internally and externally, or choking of the tubes can reduce heat transfer capacity. This can also reduce the flow of air through it. This reduces the efficiency of the diesel engine. This is evident from black exhaust smoke emissions and a fall in booster pressure.



### **FIRING ORDER IN A MULTI-CYLINDER ENGINE**

In case of four stroke cycle engines, there is only one power stroke in four strokes of piston or every two revolutions of the crank shaft. It is therefore necessary to have a flywheel, to give a 'carry over' for the three 'waste' strokes and to ensure smoother power output. To increase the power output and to make it smoother, multi-cylinder engines are used in which, the firing strokes on different cylinders are suitably spaced in relations to the crank angles so that during the revolutions of the crank shaft, firing of the cylinders takes place one by one at regular intervals.

For even firing in a four stroke engine, each cylinder must be allowed to fire once in four strokes and for sixteen cylinder engine, it is  $720/16=45^\circ$ . For our railway standard engines, the following fire order has been prescribed-

#### **WDM<sub>2</sub> Locomotives**

1R1L-4R4L-7R7L-6R6L-8R8L-5R5L-2R2L-3R3L

#### **YDM<sub>4</sub> Locomotives**

1-4-2-6-3-5

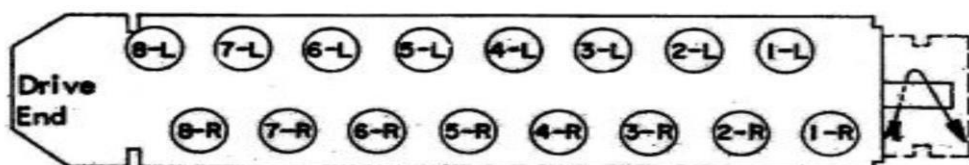
#### **WDS<sub>6</sub> Locomotives**

1-5-3-6-2-4

#### **WDP<sub>4</sub>/ WDG<sub>4</sub> EMD Locomotives**

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

**FIRING ORDER AND ENGINE ROTATION  
DLW- 16 CYLINDER 251 C**





## DATA SHEET FOR WDG3A LOCO

• Wheel Arrangement	: Co-Co
• Track Gauge	: 1676 mm
• Weight	: 123 t $\pm$ 2%
• Length over Buffers	: 19110mm
• Wheel Diameter	: 1092 mm
• Gear Ratio	: 18: 74
• Min radius of Curvature	: 117 m
• Maximum Speed	: 100 Kmph
• Diesel Engine	: Type: 251 C, 16 Cyl.- V
• HP	: 3100
• Brake	: IRAB-1
• Loco	: Air, Dynamic
• Train	: Air
• Fuel Tank Capacity	: 6000 litres
• Traction Alternator type	: T A 10102 EV
• Aux. Generator Type	: A G 3101 AY-1
• Exciter type	: A G 3101 AY-1
• Traction motor type	: TM 4907BZ
(With roller suspension bearings) Type	
• Eddy Current Clutch - Gear Box type	: EC 9005/2M/GB 11 A/M 1.312
(Gear Ratio 1:1.312)	
• Tacho Generator type	: T G 1404 AZ/M
• Axle Generator type	: A G 903 CX/M
• Traction Motors combination used	: 2S-3P 100% FF & 6-P 100%

## ENGINE DATA

The locomotive is powered by DLW built 16 Cylinder. ALCO 251C (WDG3A) design uprated, fuel - efficient engine capable of producing 3100 HP at 1050 rpm under standard conditions. The engine shall deliver 2900 HP at site condition and power input to traction motors at site shall be 2750 HP.

## ENGINE CHARACTERSTICS AND RATING

• Rated Power under standard condition *	: 3100 HP
• Engine Speed	
• Rated	: 1050 rpm
• Idle	: 350 rpm
• Cylinder formation	: 45 Deg.Vee
• Nos. of Cylinders	: 16 Nos.
• Bore and Strokes	: 9"X10- 1/2" (228.6 mm x 266.7 mm)
• Compression Ratio	: 11.75: 1
• Cycle	: 4 stroke
• Aspiration	: Turbo supercharged and charge
air	cooling
• Mean Piston Speed	: 1837.45 fpm (9.33 m /sec)
• BMEP	: 218.69 psi (15.08 Bar)
• Swept Volume per cylinder	: 668 Cu-in (10.95 Lit.)
• Total Swept Volume	: 10688 Cu-in (175.2 lit)

Nos. of Valve / Cylinder -

- Air Valve : 2 Nos.
- Exhaust Valve : 2 Nos.
- Crank Pin Diameter : 6"
- Crank Journal Diameter : 8 1/2"
- Wt. of Engine
  - Dry : 40798 lbs. (18506Kg.)
  - Wet : 44231 lbs. (20063 Kg.)
- Overall dimension of engine : 210-7/8" x 66" x 92"  
(5355 x 1676 x 2336 mm)
- Over speed trip set points. : 1180+20 rpm (Mech) OST
- Fuel Injection timing : 22.0 Deg.CA before TDC 23.0
- Firing order : 1R-1L-4R-4L-7R-7L-6R-6L-  
8R-8L-5R- 5L-2R- 2L-3R-3L
- Peak firing pressure (Max.) : 1775 PSI
- Specific fuel consumption at rated Load : 156 + 4 gm/BHP/hr
- Booster pressure : 1.8 – 2.2 bar
- Engine

#### **SAILENT FEATURES OF WDM2, WDM2C, WDG4**

S No	Description	WDM2	WDM2C	WDG4
1	Service	Goods / Coaching	Goods / Coaching	Goods
2	Length in meters	17.12	17.12	21.24
3	Weight in Tonnes	112.8	112.8	128.5
4	Max. speed in KMPH	110	120	100
5	Engine RPM in Idle	400	400	269
6	Engine RPM(8notch)	1000	1050	904
7	OSTA Tripping RPM	1110-1150	1160-1200	960-1045
8	Air Filtration	Panel type / Cyclonic with paper type secondary filter	Cyclonic with Bigger size filter and paper type secondary filter	Cyclonic type primary and baggy type secondary filter
9	Brake system	IRAB- 1	IRAB-1	CCB-KNORR
10	Lube oil sump capacity	910	1150	950
11	Fuel oil tank capacity	5000	5000	6000
12	Horse Power under idle condition	2600	3100	4
13	Input to Traction	2400 HP	2750 HP	3726 HP
14	Adhesion (Max. Tractive effort adhesive weight	24.5% / 30.4 T	24.5%/30.4T	43% / 55.1 T
15	Weight transfer to wheels through	Centre pivot 60% Side bearer 40%	Centre pivot 60% Side bearer 40%	Side rubber Resilient pads 100%
16	Axle load (Tonnes)	18.6	18.6	21.42
17	Bogie	Cast/ Fabricated	Cast/ Fabricated	High speed steel cast

S No	Description	WDM2	WDM2C	WDG4
18	Gear Ratio (Pinion: Bull gear)	18:65	18:65	17:90
19	Traction motor arrangements	LLR/LRR	LLR/LRR	LLL/RRR
20	Electrical transmission type	DC/DC	AC/DC	AC/AC
21	Cranking done by	Generator working as motor	Exciter and aux. Gen. working as motor	Two starter Motor AC
22	Master Controller	Alco model	UIC model with throttle wheel and reverser handle	Reverser handle throttle / DB Handle
23	Transition	3 with field shunting	1 (No field shunting)	No transition
24	In case of TN Isolation D.B.	Will not function	Will not function	Will function for working truck
25	TM Isolation	Defective TM can be isolated	Defective TM can be isolated	Particular truck to be isolated.
26	Type of Engine	4-Stroke V-16 Turbo super charge super engine	4-Stroke V-16 Turbo super charge super engine	2-Stroke V-16 Turbo super - charge super engine
27	Type of Turbo used	Exhaust Gas Driven Turbo	Exhaust Gas Driven Turbo	Gear/ Exhaust Gas Driven Turbo
28	Type of truck	Tri mount CO-CO type	Tri mount CO-CO type	Side load pads centre pivot CO-CO type
29	Type of Air compressor	Air compressor directly driven by engine	Air compressor directly driven by engine	Air compressor directly driven by engine through clutch type coupling
30	Compressor cooling	Air cooled	Air cooled	Water cooled
31	Fuel Injection system	Through separate fuel injection pump and injector	Through separate fuel injection pump and injector	Direct fuel injection by Unit injectors.
32	Engine lube oil system	One lube oil pump, gear driven for entire lube oil system	One lube oil pump, gear driven for entire lube oil system	Four lube oil pumps <ul style="list-style-type: none"> <li>• Scavenging oil pump gear driven.</li> <li>• Piston cooling oil pump gear driven.</li> <li>• Main lube oil pump gear driven.</li> <li>• Soak back pump for turbo, electric motor Driven.</li> </ul>

S No	Description	WDM2	WDM2C	WDG4
33	Cooling water system	One water pump gear driven, one radiator fan and drive from engine through ECC	One water pump gear driven, one radiator fan and drive from engine through ECC	Two water pump gear driven, two radiator fans driven by computer controlled electric motors.
34	LOC per every 100 ltrs. Of Fuel oil consumption	1.5 ltr.	1.5 ltr.	0.5 ltr.
35	Minimum radius of curvature (Meters)	73.2	73.2	64.92
36	Minimum continuous speed (kmph)	18	28.2	14.72 / 14.88
37	Displacement / cylinder	668.25 Cu.in. (10950.66 cc)	668.25 Cu.in. (10950.66 cc)	710 Cu.in (11634.82 cc)



**Engine Assembly (ALCO)**

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## LUBE OIL SYSTEM (ALCO LOCOS)

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

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

The system essentially consists of;

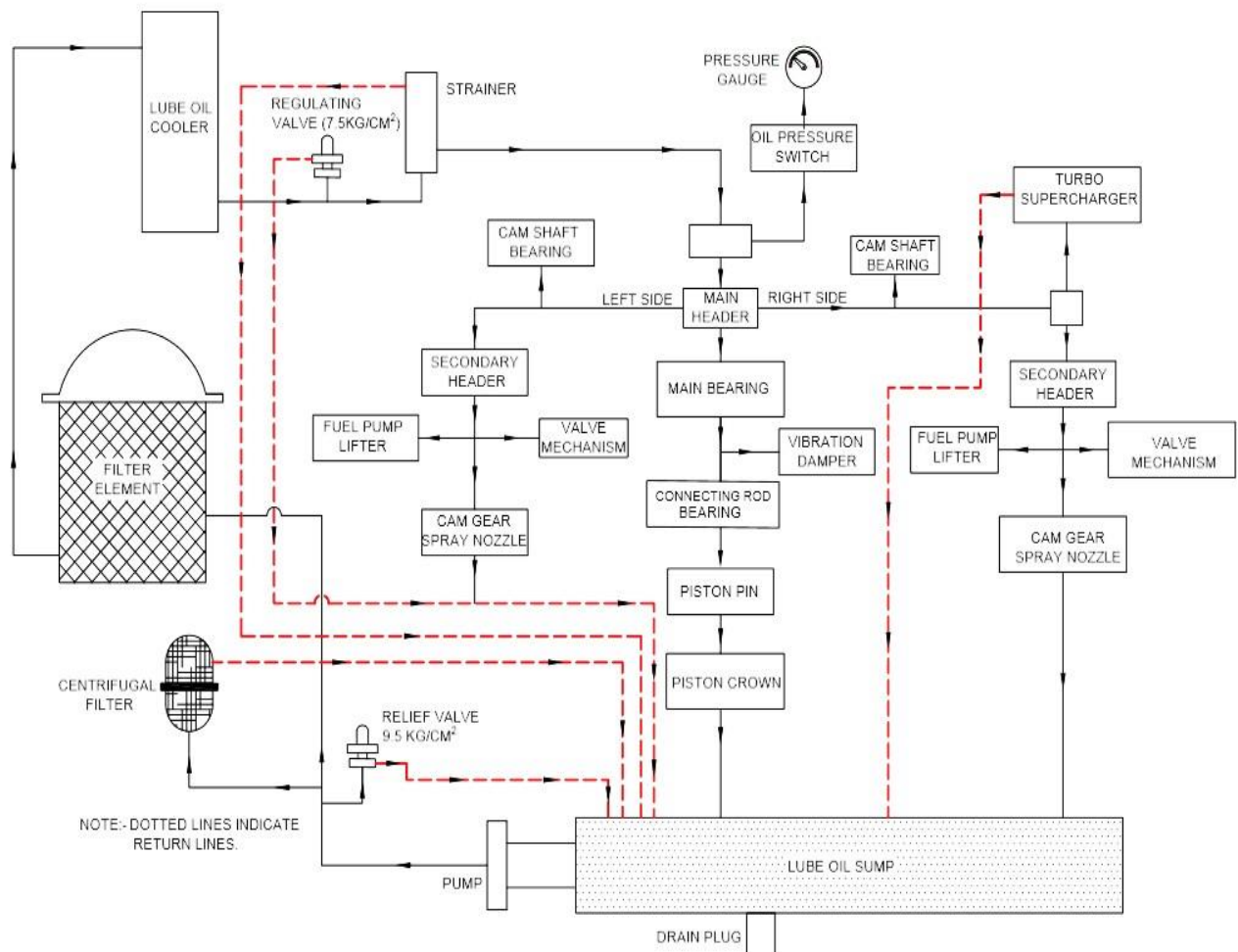
- Gear type oil circulating pump
- Relief valve
- Lube oil cooler
- Filters
- Regulating valve
- Strainer filters and associated pipelines.

When the engine is started the pump 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 pressures on load than actually required. Higher pressure may endanger the safety of filters, pipelines and joints. The relief valve set at  $9.5 \text{ kg/cm}^2$  releases the delivery pressure above its setting and bypasses it back to the oil sump. On line centrifuge filter is provided in between to cater filtration of lube oil of the line which (filtered oil) passes back to the sump. Oil then flows through the filter tank containing 8 paper type filter elements. After the filtration, the oil passes through the cooler, gets cooled by transferring heat to the water. A regulating valve adjusted at  $7.5 \text{ kg/cm}^2$  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 from 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 crank pin 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 pistons 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  $1.75 \text{ kg/cm}^2$  would automatically shut down the engine through a safety device called Oil Pressure Switch 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. 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, lubrication oil returns back to the sump for recirculation in the same circuit.



## LUBE OIL SYSTEM OF ALCO LOCO



### **MAJOR COMPONENTS OF LUBE OIL SYSTEM**

**Lube Oil Pump:** This is located at free end of the engine slightly towards the right. Supply of oil in adequate quantities and at desired pressure is vitally depending upon the pump. A gear driven type pump has been provided. This gear type pump has been provided. The suction line is 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 pumped out at the outlet side with pressure. The delivery of the pump is directly proportional to the speed of rotation.

**Relief Valve:** This valve is fitted at the delivery side of the lube oil pump to ensure that oil pressure does not exceed the pre-determined setting of about  $9.5 \text{ Kg/cm}^2$ . This protects the system from damage due to excessive pressure on cold through by passing a portion of the oil to engine sump.

**Lube Oil Filters:** Paper type, disposable cartridge filters are used for the engine lube oil system. The filters are located in radiator room. In some locos Moatti type filters are provided. On the top of this filter a condition indicating gauge is provided. It is having red and green zones. Whenever needle shows red LP has to inform shed.

**Lube Oil Cooler:** This is located in radiator room. Lube oil cooler is a heat exchanger, which removes heat from the lube oil and ensures supply of oil to the engine at a reasonable temperature. The viscosity of the oil is dependent on the temperature. The viscosity of the oil is dependent on the temperature. The viscosity of the oil is dependent on the temperature and mixing of combustion by products. The lube oil system can operate satisfactorily as long as the viscosity of the oil remains within the desired limit.

**Pressure Regulating Valve:** This is located at the discharge 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  $7.5 \text{ Kg/cm}^2$ . If the pressure is high, some of the oil is by passed to the sump (Regulating valve is not available in locos provided with Moatti type lube oil filter.)

**Lube Oil Strainer:** The lube oil strainer is located at left side free end of the engine. The strainer removes minute particles.

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

**Low Lube Oil Pressure Trip Assembly:** In the case of wood ward governor fitted locos an oil pipe is connected between the lube oil system and this assembly. This is constantly monitoring the lube oil pressure. If the lube oil pressure drops, this assembly senses it and trips a plunger with red band as an indication; simultaneously engine will shut down with an alarm indication (bell ringing and LED glowing). During cranking, if this is in tripped condition, engine will crank but not fire. The lube oil trip button has to be rested to normal position before cranking.

**Crank Case Exhauster :** This is provided to maintain certain amount of vacuum in the crank case by expelling the hot oil vapour (hot fumes). It is driven by an electric motor, which gets supply from the batteries before cranking and from auxiliary generator after cranking.

In the event of failure exhaust motor due to tripping of CCEB an amber coloured lamp will glow on the control panel/stand. If CCEM is failed the diesel engine must be shut down after clearing the section. While taking over charge if it is found that the exhauster is not working, do not attempt to crank the engine. On run it must be ensured very frequently that only oil vapour pressure comes out and no water particle is coming out through crank case exhauster passage. If the water contamination is found with lube oil in the sump, immediately engine must be shut down and shed should be contacted.

The possible sources for water entry into crank case may be due to ;

- Slight crack in the cylinder liners or the  $\text{—O}$  'rings provided at the bottom of the cylinder liner are perished.
- Damage to water seal in water circulating pump.
- Lube oil cooler tubes cracked when engine is in shut down position.

**Crank Case Inspection Doors:** The inspection covers are provided for the examination of crank shaft and other rotating parts by the maintenance staff in the shed. They are provided on both sides, 8 on each side. These doors must be secured tight.

**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 developed inside crankcase. This may happen due to failure of CCEM when unnoticed by engine crew for considerably longer period and whenever there is a main bearing failure. Whenever the pressure inside the crankcase exceeds a certain limit these doors will open and prevent damage to the engine block.

This is provided in place of one of the inspection doors, one of each side (L2& R7). This opens whenever the pressure inside exceeds a pre-set value and releases the excess pressure and again closes when the pressure drops down below the spring tension. When the explosion drops down below the spring tension. When the explosion doors open it indicates that a positive pressure is prevailing in the crankcase. Whenever this opens shut down the engine and inform PRC/shed.

**Moatti Lube Oil Filter:** In place of paper lube oil an automatic self-cleaning filtration unit has been installed on few locos. The main advantage of Moatti is the increase in oil renewal periodicity and elimination of paper filters and its handling.

**Centrifuge Oil Separator:** Centrifuge oil separator (COS) is provided in lube oil system to filter the carbon particles from the lube oil. Centrifuge oil separator is connected in the outlet of the lube oil pressure increases more than  $2\text{Kg/cm}^2$ .

The carbon particles in the lube oil get deposited on the drum due to centrifugal action thereby reduces the load on the filter and increases its renewal periodicity.

### **FAILURES/DEFECTS IN LUBE OIL SYSTEM**

Various causes leading to the failures of locomotive on account of lube oil system are as under:-

**External Leakage:** External leakage resulting in failure of loco due to short of lube oil. The points of external leakage are as under:

- Tappet cover-perishing of tappet cover gasket due to aging or improper material, improper fitment of gasket, improper tightening of tappet cover.
- Crank case cover: - wrong material, improper fitment or use of hammer for tightening.
- Crank case explosion cover.
- Push rod grommets: - Defective material, aging effect.
- Extension shaft oil seal:-worn out seal or building up of positive pressure inside the crank case.
- Face joint of lube oil relief, regulating-defective gasket or improper joint.
- From armored, dresser or metallic joint- due to misalignment, excessive gap between pipes or improper clamping.
- Lube oil filter housing cover - perished \_o' ring cracked broken fly nuts, cracked filter housing.
- Lube oil filter housing drain cock and strainer drain cock.
- Turbo lube oil filter housing due to working out center of bolt.
- Bursting of flexible pipes.
- Lube oil gauge pipes and pipe to Woodward governor Inadequate clamping, improper annealing.
- Lube oil pump face joint or flange joint.
- 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 throw from CCE motor exhaust pipe- due to choking of return oil passage to the sump.
- Quality of oil: - Due to contamination in any form by fuel oil, cooling water, soot, etc. Change in properties like viscosity, PH value, TBNE etc.
- Improper setting of relief, regulating or by pass valve
- Choking of filter elements.

## CORRECTIVE ACTIONS DURING MAINTENANCE

Following corrective action is required during maintenance to avoid failures on lube oil system account.

**External leakage:** Notch up the locomotive from idle to 8<sup>th</sup> notch and put CC motor in off condition for a small period of time and check the leakage at possible point. If leakage is noticed from tappet cover, crank case cover, dummy plate, explosion cover gasket, face joint of valves, change the gaskets. The push rod grommets may also be changed if leakage is found. Apply silicon compound while fitting the grommet. The leakage in extension shaft seal can be due to either worn out seal on positive pressure inside the crankcase. Normally the seal damaged due to misalignment of compressor with engine crank shaft or excessive crankshaft deflection. In such cases replace the seal and check Compressor alignment and crankshaft deflection. In case extension shaft seal is found perfect then attention is paid adequately to the power pack.

Following attention should be paid to avoid leakage from armoured and dressor couplings:- There should be no misalignment of pipes.

- Minimum gap between the two pipes should be maintained. In case of excessive gap, suitable length of the pipe is welded to one of the pipes.
- Ensure proper clamping at adequate distance.

Lube oil filter housing:-

- It must be ensured in every schedule that all fly nuts are intact and welding of the fly nuts is not cracked or broken.
- Tighten fly nuts crosswise at the time of replacement of lube oil filter housing \_o' ring.
- In case of premature failure of lube oil filter housing \_o' ring. Check warpage in housing cover on surface plate.
- Check crack in e housing visually in every trip.
- Test filter housing at 10Kg/Cm<sup>2</sup> during yearly schedule.
- Replace defective drain cock.
- Every loco should have provided with X-head dowel.
- Check lube oil cooler for leakages from welded j rivets in every trip. If lube oil is mixed in water, change cooler. Ensure hydraulic testing of lube oil cooler during yearly schedule.
- Check crack in turbo lube oil filter housing in every schedule.
- Replace all flexible pipes as per schedule.
- Pay adequate attention to lube oil gauge pipes and pipe to Woodward governor. Ensure adequate clamping. Check for loose seat and anneal the pipes.
- Ensure proper setting of OPS in specified schedule.
- Test relief regulating and bypass valves as per schedules.
- Ensure quality of lube oil through spectrographic analysis. Check its viscosity, TBNE, PH value and contamination regularly.

Following addition point will help in reducing the lube oil consumption of the locomotive:

- Heavy leakage of lube oil is also noticed from OST. It is essential that drain pipe of the OST housing to sump is cleaned, so that oil can go back into the sump freely without any obstruction. Moreover, adequate clearances in OST and vibration damper should be maintained.
- In case of excess oil throw from the engine exhaust due to weak power pack, attend locos on programmed basis.

- Ensure fitment of piston rings at 180° to each other avoiding the gudgeon pin side
- Check valve guide internal bore diameter during overhauling of cylinder heads Bore be checked either through pilots or with the help of air gauge.
- Check engine sump vacuum on load box at 8<sup>th</sup> notch. It should be minimum 0.9" of water. Positive pressure or less vacuum will increase LOC.
- Avoid water leakage in lube oil by providing proper quality \_O‘ rings on the liners. Check pitting/corrosion of the mating surfaces of the liner or the block. If water contamination is more than 0.25%, it will require lube oil change.
- Every filter change would amount to loss of some lube oil. If the filter life is less either due to poor filters material or due to poor engine condition, it will have adverse effect on lube oil consumption.

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## FUEL OIL SYSTEM (ALCO)

The fuel oil system is designed to inject correctly metered amount of fuel oil at correct high pressure into the engine cylinders at a stipulated time in a highly atomized form. High pressure of fuel is required for lifting the nozzle valve, penetration of fuel into pressurized combustion chamber and proper atomization. As the engine is a variable speed and load engine with variable fuel requirement within a particular range correct metered quantity is essential. Timing of injection is important to burn the fuel completely.

After switching 'ON', the fuel booster pump starts sucking oil from the fuel tank, filtered through a primary filter. The capacity of the fuel tank depends upon the type of locomotive i.e. 5000 litres for WDM<sub>2</sub>, 6000 litres for WDP<sub>3A</sub> and WDM<sub>3A</sub>. 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 level indicator are also provided in the fuel tank. The filter is having a socks type filter element.

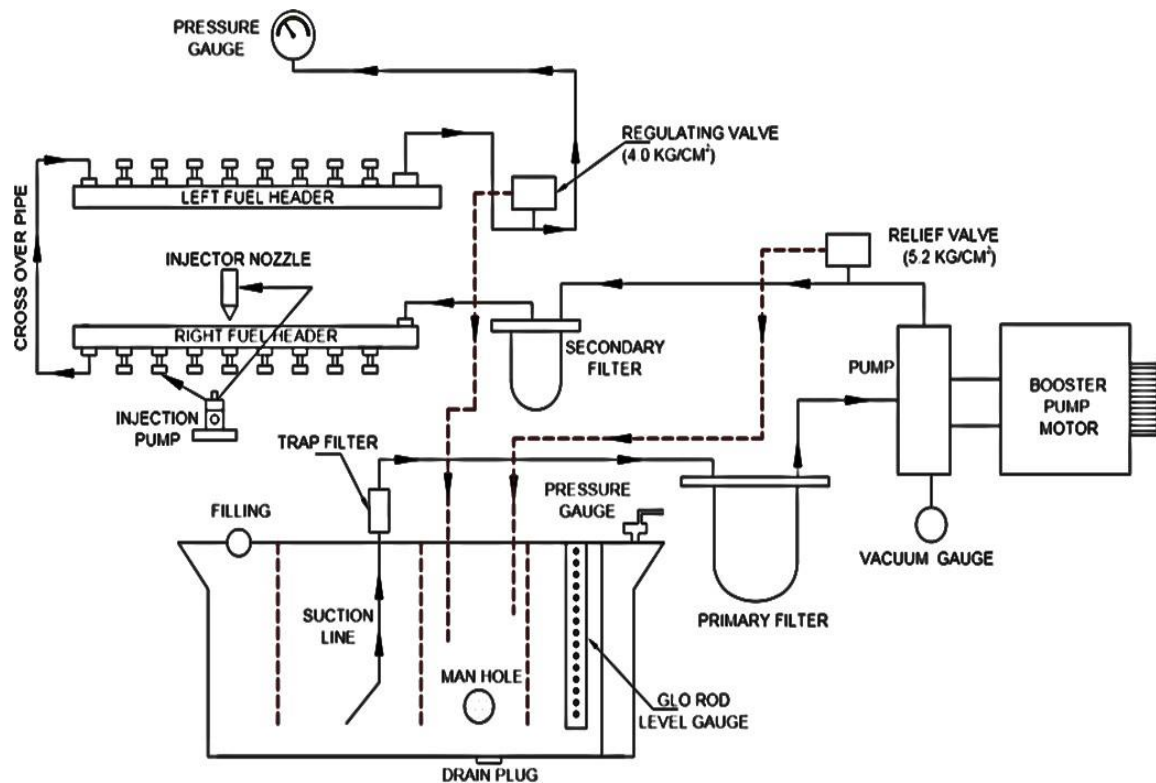
Because of the variable consumption by the engine the delivery pressure of the pump may increase, increasing load on the pump and its drive motor. A spring loaded relief valve is provided for by-passing the excess oil back to the fuel tank, thus releasing the excess load on pump and motor. It is adjusted to a pressure of 5.2 Kg/cm<sup>2</sup>. Then oil passes through the paper type secondary filter and proceeds to left side fuel header. The fuel header is connected to eight numbers of FIPs on the left bank of the engine and a steady oil supply is maintained to the pump at 3 Kg/cm<sup>2</sup>. The fuel then passes on to the right side header through a fuel cross over pipe and reaches eight FIPs on the right bank. The regulating valve after the right side header takes care of the excess pressure of 4 Kg/cm<sup>2</sup> by by-passing the extra oil back to the tank. A gauge connection is taken from here to the driver's cabin for indicating FOP.

The fuel injection pump used in diesel loco is a constant stroke plunger type pump with variable quantity of fuel delivery to suit the engine demand. The fuel cam controls the pumping stroke of the plunger. The High-pressure fuel is then passed on to respective fuel injector nozzles through a high-pressure tube. The fuel injection nozzle is fitted in the cylinder head with its tip projected inside the combustion chamber. Due to very high pressure range 3900 psi to 4050 psi, the nozzle valve is lifted passing the oil into the combustion chamber in highly atomized form.

### FAILURE OF LOCOMOTIVE DUE TO FUEL OIL SYSTEM

The locomotive generally fails due to fuel oil pressure not building up, which may be due to following reasons:-

- 1. Fuel - Less than 700 Litres fuel in tank.**
- 2. Clogging of fuel filters**
  - (a) Quality of primary and secondary filters-If the elements are not as per the RDSO specifications.
  - (b) Quality of HSD oil-When the fuel is contaminated with water, rust, dirt, dust, fungi or any micro-organism.
  - (c) Condition of HSD tank-The fuel in the tank is required to be free from water, dirt, dust, rust and other contaminations. It is known that some sort of micro-biological growth takes place inside the HSD storage tanks, but the condition worsens due to prolonged storage and the oil water inter phase becomes susceptible to infectious attack by micro-organisms. Such an attack would lead to constant build-up of bacterial and fungal cells, which can ultimately cause choking of filter pores.



**FUEL OIL SYSTEM OF ALCO LOCO**

### **3. Defective Fuel Booster Pump and Motor**

- (a) Rotor or idler gear damaged.
- (b) Leakages from the cover gasket.
- (c) Leakages from the pump seals.
- (d) Breakage of spring
- (e) Broken booster pump coupling.
- (f) Breakage of carbon brush
- (g) Commutator flashover.
- (h) Improper wire connections securing of fuel pump motor.

### **4. Leakages**

- (a) Suction pipe leaking.
- (b) Bursting of high pressure tubes.
- (c) Leakages from flexible and metallic pipes.
- (d) Leakages from banjo pipes.

### **5. Defective Fuel Injection Pump and Injector Nozzle**

- (a) Excessive hot pump.
- (b) Broken delivery valve spring.
- (c) Broken guide cup spring.
- (d) Working out or breakage of FIP foundation bolts
- (e) Injection nozzle stuck open or closed.
- (f) Injector nozzle cap cracked.

## **6. Relief and Regulating valve**

- (a) Sticking of relief and regulating valve

## **7. Battery switch not closed**

## **8. Fuel pump circuit breaker defective**

Following steps should be taken to enhance the reliability of fuel oil system:-

- (a) Checking of fuel oil vacuum in monthly schedule. In case the vacuum is less, pump should be removed for overhauling. The delivery of the pump should be checked after overhauling
- (b) Check the leakage of fuel oil from the fuel pump seal after starting the motor
- (c) Proper securing of wire connections of fuel pump motor.
- (d) Checking of carbon brush sizes in every trip schedule.
- (e) Check commutator in every schedule for flash over.
- (f) Ensure timely replacement of both primary and secondary filter.
- (g) Tighten cover bolts of the filter housings as per procedure.
- (h) Drain out water and sludge from the fuel tank of goods locos during T1 schedule and after 20 days for mail locos.
- (i) Drain out primary and secondary filter housing during every trip schedule after opening the dummy samples of oil drained out from the housing may also be given to lab for testing.
- (j) Correct setting of relief and regulating valve during quarterly schedule. Careful examination of seat of relief and regulating valve to be done.
- (k) Fuel cross over pipe to be modified by providing straight elbow in HY schedule. Fuel cross over pipe to be provided with proper sleeve to avoid rubbing of pipe with CC motor and cylinder head.
- (l) Clamp all fuel system pipes to avoid rubbing of pipes.
- (m) Torqueing of cross head bolts and FIP foundation bolts in monthly schedule sequentially.
- (n) Pump alignment with fuel inlet to be ensured. Looseness of fuel inlet bolts to be checked in trip schedule.
- (o) Check depth of fuel inlet elbow gasket seat and thickness of the gasket. Reject the elbow if the depth of the gasket head is more than the gasket seat.
- (p) Check distortion of banjo pipe on each removal and anneal or replace copper washer.

**Orifice test** is done to check the fuel feed system by simulating the fuel load conditions.

Testing procedure is given below:-

- (a) An orifice plate of 1/8" is fitted in the system before the regulating valve.
- (b) A container to be placed under the orifice to collect the leak off oil.
- (c) The fuel booster pump to be switched on for 60 seconds
- (d) The rate of leakage should be about 9 Litres per minute through the orifice, with the engine in stopped condition. The system should be able to maintain 3 Kg/cm<sup>2</sup> pressure with this leakage rate which approx. simulates the fuel load consumption by the engine. In case of drop in pressure the rate of leakage would also be less indicating some defect in the system.

This test is very easy and reliable and saves time as well as fuel. Also the fuel feed system can be checked under simulated conditions, which is otherwise not possible with the normal testing of engine.

## **Inspection And Maintenance of Fuel Injection Equipment's**

- (a) A dust proof room for overhauling and testing of fuel injection equipment's.
- (b) It must be remembered that certain components like plunger and barrel, the delivery valve and valve seat of FIP and the nozzle and valve body of the injector nozzle are matching components and never to be interchanged.

### **Fuel Injection Pump**

It is essential to check the following items during overhaul:

- (a) Seizure and slackness in plunger and barrel.
- (b) Scratches and scuffmarks on the plunger due to abrasives in fuel oil.
- (c) Erosion of helix edges on the plunger beyond stipulated limits.
- (d) Corrosion and pitting marks on plunger or barrel.
- (e) Discolouration due to heating in plunger and barrel.
- (f) Delivery valve spring, the valve and the valve seat need careful checking. Grinding the valve and valve seat to proper angle and lapping may have to be done if necessary to ensure perfect contact between the valve and seat.
- (g) Slackness between control rack and bushing, control rack and control sleeve and plunger lug, which produces lost motion and makes it difficult to adjust the rack movement accurately.
- (h) Wear on top or bottom of the guide cup.
- (i) Lapping of surface between the barrel and delivery valve body and also between delivery valve body and holder is required to have leak proof joints.
- (j) Plunger spring for cracks and loss of tension.

### **Calibration of FIP**

Each FIP is subjected to calibration test after overhaul to ensure that it delivers the same and stipulated amount of fuel at a particular rack position. The calibration and testing of FIPs are done on a specially designed machine. The blended test oil of recommended viscosity under controlled temperature is circulated through a pump at a specified pressure for feeding the pump under test. The oil discharged for 300 strokes of the pump is measured at idle and full load and should be as specified by the manufacturer.

### **Maintenance and Inspection of Fuel Injection Nozzle**

Criteria for good nozzle are proper atomization, correct spray pattern, and no leakage or dribbling.

- (a) Before a nozzle is put to test the must be rinsed in fuel oil, nozzle holes cleaned with wire brush and spray holes cleaned with steel wire of correct thickness.
- (b) Replace the O ring around the nozzle holder.
- (c) The nozzle and the valve need grinding if wear has taken place .this should be done with utmost care to avoid loss of hardened surface more than actually required. The grinding of valve face is done on a specially designed machine at the recommended angle. The valve and seat must have proper line contact to ensure perfect sealing. Lapping is necessary to achieve better line contact after grinding.
- (d) Valve lift must be checked with the help dial indicator. It shows the amount of wear on the valve face and seat. Following tests are conducted on a specially designed machine:-

### **Spray Pattern**

The spray of fuel should be properly atomized and uniform through all the holes. This can be judged with an impression taken on a blotting paper.

### **Spray Pressure**

The stipulated correct pressure at which the spray should take place is 3900-4050 psi for new and 3700-3800 psi for reconditioned nozzles. If the pressure is down to 3600 psi, the nozzle needs replacement. Shims are being used to increase or decrease the tension of nozzle spring, which increase or decrease the spray pressure.

### **Dribbling**

There should be no loose drops of fuel coming out of the nozzle before or after the injections.

The dribbling can be checked by having injections manually done couple of times quickly and check whether the nozzle tip is dry or leaky. Raising the pressure within 100 psi of set injection pressure and holding it for 10 seconds may also give a clear idea of the nozzle dribbling. The dribbling may occur due to improper pressure setting or dirt stuck up between the valve and valve seat or valve sticking inside the valve body.

### **Nozzle Chatter**

The chattering sound is a sort of cracking noise created due to free movement of the nozzle valve inside the valve body, it should be proper.

### **Nozzle Leak off Rate**

A very minute portion of the oil inside the nozzle passes through the clearance between the valve and the valve body for lubrication purpose. Excess clearance may cause excess leak off, thus reducing the amount of fuel actually injected. To check the leak off rate, create a pressure in the nozzle up to 3500 psi and hold the pressure till it drops to 1000 psi. The drop will be quicker in case of excessive leak off and the pressure drop will be quicker in case of excessive leak off rate. The leak off time recorded should be within stipulated limits.

### **High Pressure Tubes**

- (a) Zyglo testing of HP pipe before fitment.
- (b) These tubes are to be tested up to 5000 psi
- (c) The rubber ferrule to dampen the vibrations must be provided in these HP tubes.
- (d) Radius of HP pipes should be checked up on a fixture

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## **WATER COOLING SYSTEM (ALCO)**

After combustion of fuel in the engine, about 25 to 30% of heat produced inside the cylinder is absorbed by the components surrounding the combustion chamber i.e., Piston, cylinder, 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 a 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 WDM<sub>2</sub> loco is having closed circuit pressurized water-cooling system for the engine (earlier it used to be non-pressurized system). The system is filled in by 1210 litres of demineralised water treated with corrosion inhibitor in two inter-connected expansion tanks on the top of the locomotive.

A centrifugal pump driven by the engine crankshaft through a gear, suck water from the system and deliver through the outlet under pressure. The outlet of the pump has three branch lines from a three-way elbow to the following locations: -

- To the turbocharger through a flexible pipe to cool intermediate casing, turbine casing and bearings. After cooling, water returns to the inlet side of the pump through a bubble collector that is provided to collect the air bubbles formed due to evaporation and pass them on to the expansion tank to avoid air lock in the system.
- The second line leads 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 left radiator and release its heat to the atmosphere before recirculation to the engine.
- The third connection leads to the right bank of the cylinder block. After cooling the cylinder liners, heads, etc. on the right bank, it reaches the right 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 and the temperature of water is also shown on display unit. Two temperature sensors ETS- 1, ETS-2 are also provided. ETS 1 is for starting the movement of radiator fan at low speeds through eddy current clutch at 64°C. ETS-2 picks up at 68°C and accelerates the radiator fan to full speed. Audio-visual alarm at 92°C will start beeping to alert loco pilot to take corrective action to reduce engine water temperature. If water temperature rises further to 950 C, then control unit /Microprocessor will bring the engine to idle.

Water temperature is controlled by controlling the movement of radiator fan. Cooled water from the left side radiator passes through the lube oil cooler and cools lube oil. After lube oil cooler, it unites with right side radiator outlet, to be back again to the suction of the pump for re-circulation.

Apart from Hot Engine Alarm, another safety in the form of LWS is also provided. It shut down the engine if the water level falls below 1" from the bottom of the expansion tank.

## **Expansion Tank**

This is located at the topmost 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, gauge is provided inside the radiator room on the right side of head light. While taking overcharge water level should be above the half mark of the gauge. The capacity of cooling water system is 1210 litres. 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 is provided in the auxiliary tank. A pressure cap is provided on the auxiliary tank which will operate and release excess pressure. This is provided to avoid complete siphoning of water. Expansion tank is connected with various vent pipes of the cooling i.e. after cooler, turbo supercharger, bubble collector, lube oil cooler and both side radiator for venting the steam.

## **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 below 11 level from the bottom of expansion tank.

A pipe connection 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 of 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 electrical contact and send signal to the governor to shut down the engine.

Normally LWS COC must be in open position i.e. to connect the tank in the float chamber. While testing the LWS this COC is to be closed. In this position water flows from the expansion tank stops in 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 having 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.

Whenever LWS malfunctions this switch has to be operated after insuring sufficient water level.

## **EDDY CURRENT CLUTCH (ECC ASSEMBLY)**

This is provided in the radiator room to start and stop radiator fan according to water temperature.

## **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 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.

## **Tell Tale Pipe**

To identify the defects in water and oil seal system, a tell-tale pipe is provided in the water pump. In case of leakage LPs may deal as below.

- From shed Loco should not be taken with tell-tale pipe leakages.
- If this is noticed en-route contact shed and the loco can be onwards carefully watching the water level. If the leakage is very heavy, loco should not be worked further.

- If oil leak is noticed en-route, 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 tell-tale pipe should not be plugged.

### **Water Pressure Sensor**

It is provided in the delivery side of water pump to ensure working of the pump. Its feedback is given to microprocessor.

### **Oil Traces Found In Expansion Tank**

When oil traces are found in expansion tank that indicates the lube oil has entered into the water tubes in the lube oil cooler, that are cracked or burst, because the pressure of the lube oil is more than water in the cooler.

If the contamination is not very heavy the loco pilot can work duly informing shed. If oil traces are very heavy it may greatly affect the cooling process. Working in these conditions may lead to continuous hot engine alarm and the performance of the loco will be badly affected. So it is not advisable for a loco pilot to work a train with a loco heavy lube oil contamination in the water system.

Vent lines are provided from after cooler, lube oil cooler, radiators, TSC and bubble collector, etc. to maintain uninterrupted circulation of cooling water by eliminating the hazard of air lock 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.

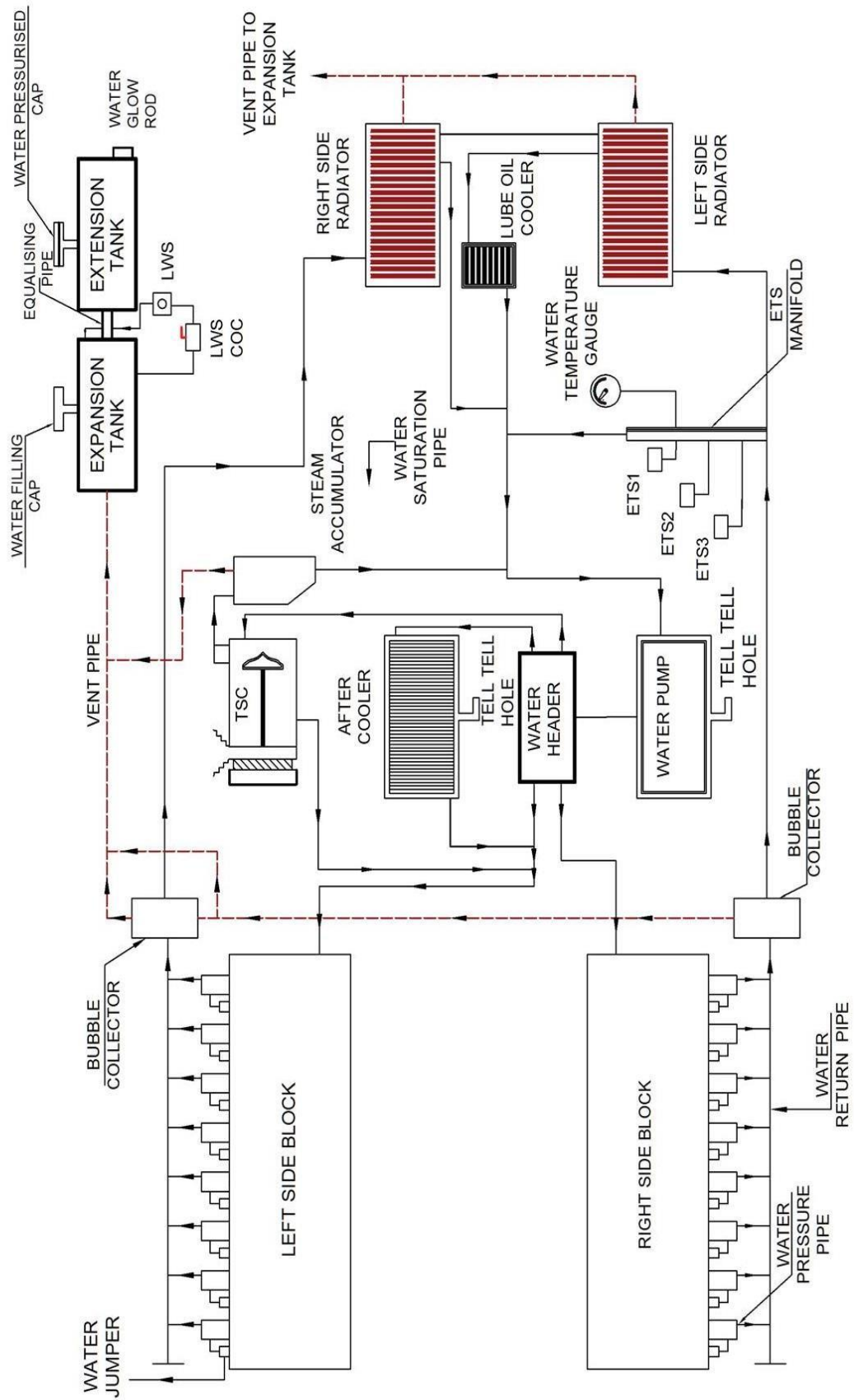
## **CAUSES OF FAILURES IN WATER COOLING SYSTEM**

### **Defective Water Pump**

Check water pump pressure at 8th notch. It should be  $1.8 \text{ Kg/cm}^2$  to  $2.2 \text{ kg/cm}^2$ . The main problem in the maintenance of the water pump is the water seal. Other reasons for failure can be breakage of pump shaft, working out of castle nut and split sleeve, breakage of impeller, radial and thrust bearing defective and break age of gear teeth. Following steps must be taken during maintenance to avoid failures:-

- Replace the water seals during yearly schedule.
- Zyglo testing of water pump shafts must be done. The shaft should also be checked for dimensional accuracy and run out.
- Adopt correct procedure of checking and fitting the split sleeve and torquing the castle nut. The castle nuts to be torqued at 220 ft. lbs.
- Check the condition of gear teeth during overhauling and keep the backlash within limits.
- Test the pump on test stand after overhauling to check the condition of seal.

## WATER COOLING SYSTEM OF ALCO LOCO



### Water Leakage through Various Joints and Pipes

Leakage of water through flexible pipes, metallic pipes, gaskets, dresser and Victaulic coupling, bubble collector, radiator equalizing pipes, etc. may lead to engine failure. Following steps should be taken to reduce incidences:-

1. Replace all the flexible pipes of the water system on time basis i.e. during yearly schedule and should be properly clamped at proper locations to prevent them from rubbing and getting punctured.
2. The metallic pipes should be aligned and clamped properly.
3. Replace all the gaskets during specified schedules. Water leakage through coupling joints should be checked in every schedule and in case of leakage gasket must be replaced.
4. Bubble collector support plate should be suitably strengthened to avoid leakage from armoured / Victaulic coupling of bubble collector due to vibration.
5. Pay proper attention while preparing armoured and dresser joints. There should be a minimum gap and alignment of the pipes should be proper. A gap of 1/8" to 1/4" is maintained in Victaulic coupling and 11 in dresser couplings.
6. Replace all three bolts dresser couplings with 4 bolt couplings.

### DATA SHEET FOR COOLING SYSTEM

Chemical additives required For Jacket Water	INDION1344 OR NALCO 2100, Indion-1344 be used 0.68 Kg. per 500 ltr. of DM / distilled water
Water required for initial Filling	1500 liters
Make – up Water Quantity	310 liters
Maximum J.W. Temperature at 100% load	90 <sup>0</sup> C
Minimum permissible J.W. temperature for starting engine	4 <sup>0</sup> – 6 <sup>0</sup> C
Quality of Water	De – mineralized

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## SUPER CHARGING

In an internal combustion, compression ignition type engine, for burning every pound of fuel, a certain amount of air is required. For increasing the horsepower output of each cylinder, the size of the cylinder can be increased, but it will result in increased weight which is not possible because it will also occupy more space.

The diesel engine, in which air under atmospheric pressure is supplied for burning the fuel inside the cylinder during the suction stroke, is called normally aspirated engine. If it is possible to increase the quantity of air available for combustion within the limited space of the combustion chamber (with the existing size of the cylinder) more fuel can be burnt and thereby increasing the horse power output. If the air is admitted into the cylinder at a pressure higher than atmospheric pressure, more quantity of air can be made available for combustion. So the process of admitting more air at a higher pressure in order to burn more quantity of fuel to increase the heat energy, in turn, more output of the engine, is called **Super Charging**.

Some methods of super charging are:

- a. Electrically driven motor to rotate a blower.
- b. Gear driven blower (mechanically) where the blower is getting drive from the engine through gears.
- c. By means of exhaust gas driven turbine to rotate a blower.

The last method is the most economical method, because we are utilizing the exhaust gas to drive the blower, which would have, otherwise, gone waste.

### ADVANTAGES OF SUPER CHARGING

1. The output of the existing engine can be increased, when there is a greater power demand.
2. The weight of the engine can be reduced so that the ratio, between the weight of the engine and the HP developed, can be increased.
3. The effect of altitude can overcome, as the air density is lower at higher places.
4. Better scavenging action can be ensured in the engine cylinders.
5. Due to cold fresh air forced into the cylinder, it will cool the combustion chamber well.

### TURBO SUPER CHARGER

The function of a turbocharger is to use the exhaust gas energy of an internal combustion engine (which would otherwise be wasted) to drive a turbine wheel and hence a blower. The blower increases the pressure and density of the charge in the engine cylinder, thereby increasing the power above that of a naturally aspirated engine.

Following are the advantages of a supercharged 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 favourable.
- Results in better scavenging and 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.

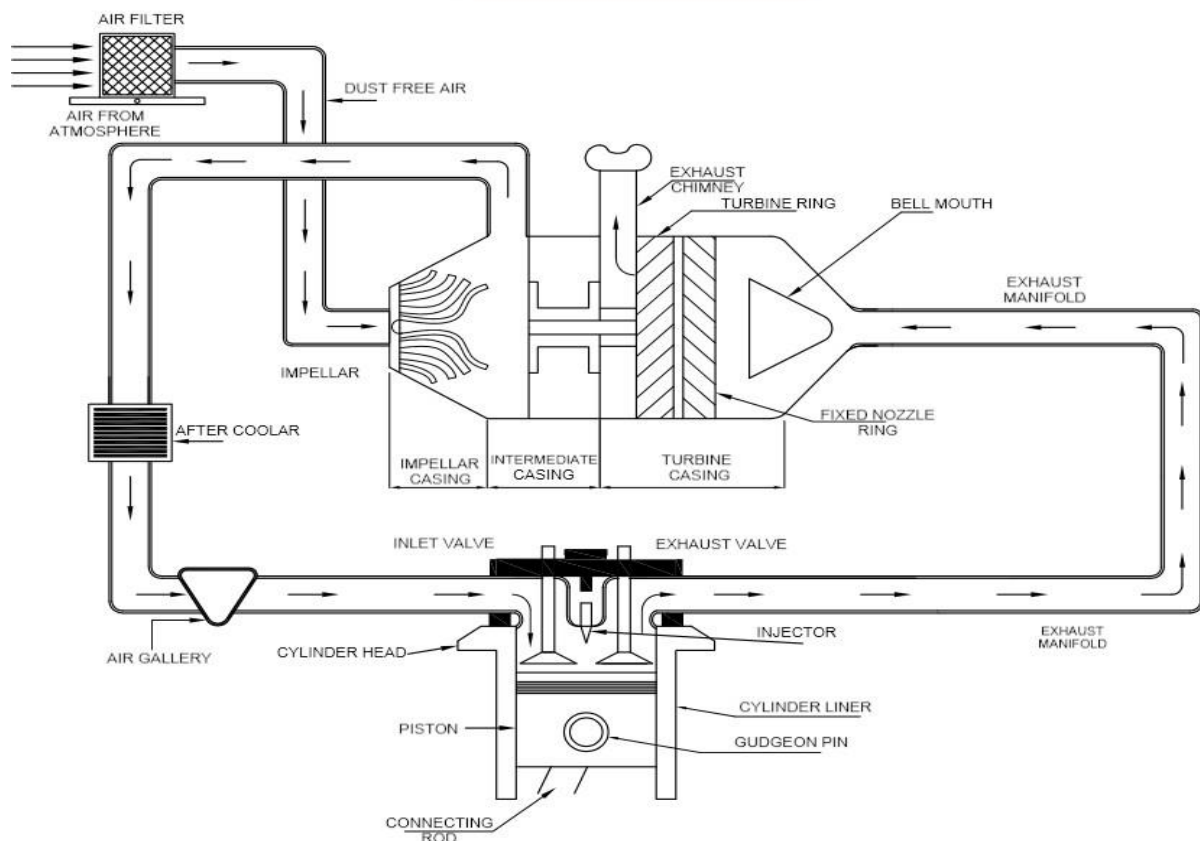
## Working Principles of Turbo Supercharging System

The exhaust gas discharged from all the cylinders accumulate in the common exhaust manifold at the end of which the TSC is fitted. The gas under pressure thereafter enters the TSC through the connector and the torpedo shaped bell mouth and then passes-through the fixed nozzle ring. The exhaust gases passing through the fixed nozzle ring is directed to the turbine blades at increased pressure and at a suitable angle to achieve rotary motion of the turbine at maximum efficiency. After rotating the turbine the exhaust gases go out to the atmosphere through the exhaust chimney. The turbine has a centrifugal blower mounted at the other end of the same turbine shaft and rotation of turbine drives the blower at equal speed. The blower connected to the atmosphere through a set of oil bath filters/cyclonic filters suck air from the atmosphere and deliver it at higher velocity. The air then passes through the diffuser inside the turbo, where the velocity is defused to increase the pressure of air before being delivered from turbo.

TSC consists of following main components;-

1. Gas inlet casing
2. Turbine casing
3. Intermediate casing
4. Blower casing with diffuser
5. Rotor assembly with turbine and blower on same shaft.

### TURBO SUPERCHARGER



**Gas Inlet Casing** - It is made of heat resistant CH-20 stainless steel. Its function is to take the hot gases from exhaust manifold to the nozzle ring.

**Turbine Casing** - It houses the turbine inside it and is cored to have water circulation through it for cooling purpose. This has oval shaped gas outlet passage at the top. It is fitted in between the inlet casing and intermediate casing.

**Intermediate Casing** - This is also water cooled and is made of alloy cast iron like turbine casing. It is in between the turbine casing and blower casing and separates the exhaust and the air sides. It also supports the turbine rotor on two tri-metallic bearings which are interference fit in the intermediate casing.

**Blower Housing Assembly** - It houses the blower. Air enters through the blower inlet axially and discharged radially from the blower through the diffuser.

**Rotor Assembly** - The rotor assembly consists of the rotor shaft, rotor blades, thrust collar, impeller, inducer, centre studs, nose piece, lock nut etc. assembled together. The rotor blades are fitted into slots and locked by tab lock washers. This is a dynamically balanced component as this has a very high rotational speed.

The cooling system is integral with that of engine. Circulation of water takes place through the turbine casing and intermediate casing which are in contact with exhaust gases. The cooling water after being circulated in turbo system returns back to the engine cooling system.

One branch line of lubricating system is connected to ISC filter and then the lube oil enters the TSC for lubricating its bearings. Oil seals are provided on both the turbine and blower ends of the bearings to prevent oil leakage from bearing to the blower or the turbine housing.

### **Lubricating System**

One branch line from the lubricating system of the engine is connected to the turbo supercharger. Oil from the lube oils system circulated through the turbo supercharger for lubrication of its bearings. After the lubrication is over, the oil returns back to the lube oil system through a return pipe. Oil seals are provided on both the turbine and blower ends of the bearings to prevent oil leakage to the blower or the turbine housing.

### **Cooling System**

The cooling system is integral to the water cooling system of the engine. Circulation of water takes place through the intermediate casing and the turbine casing, which are in contact with hot exhaust gases. The cooling water after being circulated through the turbo- supercharger returns back again to the cooling system of the locomotive.

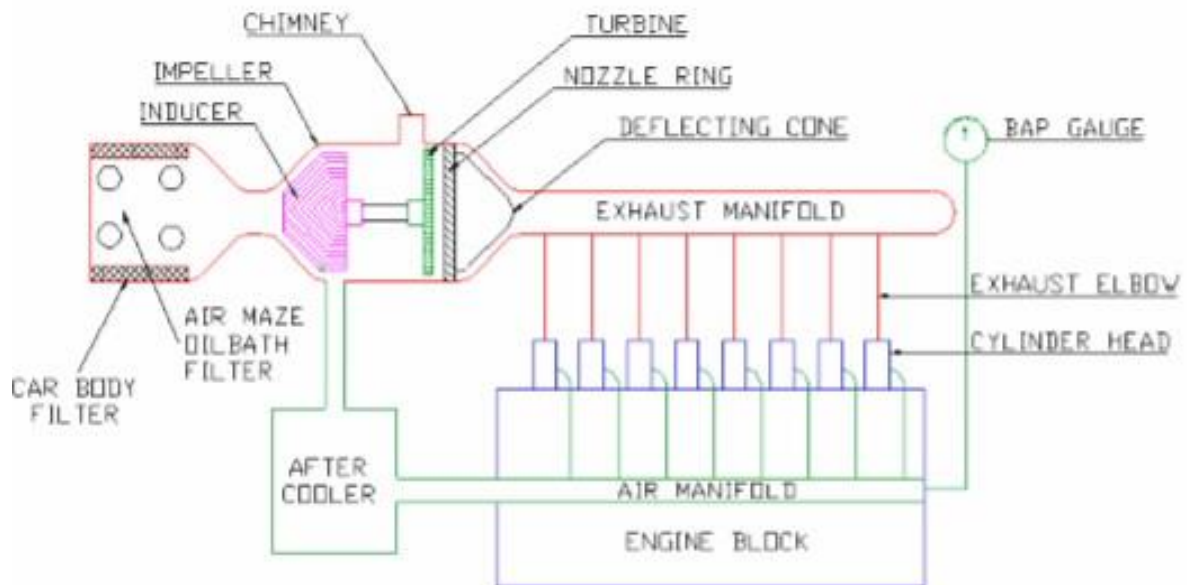
### **Air Cushioning**

Pressurized air from the blower casing is taken through a pipe inserted in the turbo to the space between the rotor disc and the intermediate casing. This arrangement is called air cushioning and is used for following purposes:-

1. To prevent hot gases coming in contact with the tube oil
2. To prevent leakage of lube oil through the oil seal.
3. To cool the hot turbine disc.
4. To reduce thrust load on the thrust face of the bearing.



**TURBOCHARGER**



**AIR INTAKE SYSTEM WDM2**

### **Turbocharger Surging**

Surging is defined as the operating point at which the compressor ceases to maintain a steady flow for a given booster pressure and reversal of the flow takes place. This is usually accompanied by noise in the form of pulsations, sometimes mildly and sometimes noisily with large amplitude. It is essential that surging during engine operation is avoided. Damage may be caused to the rotating parts with consequent damage to the complete turbocharger.

Following may give rise to surge:-

- A violent change of engine load or excessive overload.
- An excessive rise of cooling water temperature in the charge air cooler.
- Extreme fouling of the inlet or exhaust manifolds.
- Mismatching of compressor and turbine components in respect of a particular engine.
- The turbine nozzles and blades will accumulate carbon deposits from the burnt residue of fuel impurities and lubricating oil additives, resulting in high turbine speeds, high booster pressure and exhaust gas temperature rise. Continued deposits will raise the exhaust gas temperature sufficiently to cause surging.

## **TROUBLESHOOTING FOR LOW BOOSTER PRESSURE**

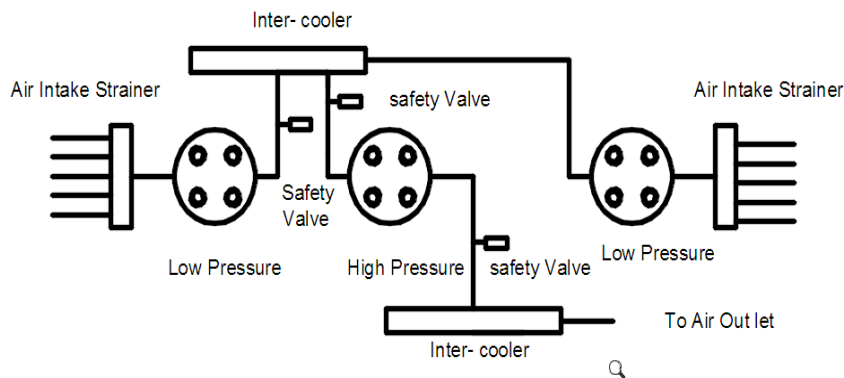
1. Any trouble or defect developed in fuel oil system. Watch the FOP gauge indication and rectify if necessary.
2. Any defect in the fuel injection system like blocked FIP or fuel rack sticky. Watch for the unusual beat in the exhaust and act accordingly.
3. Transition not picking up. Work with manual transition.
4. Defects in the excitation system-check the cards for slackness and wire connection in excitation panel slack/disconnected.
5. Oil seal failure.
6. Defects in the air intake system.
  - a. Leakage through exhaust elbow gaskets or cracked exhaust elbow.
  - b. Exhaust manifold cracked.
  - c. Gas inlet casing cracked or the connectors worked loose.
  - d. Cyclonic filters/Car body filters/air maze oil bath filters dirty preventing air passage.
  - e. Air inlet funnels slack-securing band or ring loose.
  - f. After cooler gasket joints leaking.
  - g. Air manifold leaking through inlet elbow gaskets or because of non-tightness of the lifting eyebolt at the power take-off end.
  - h. BAP gauge pipe leaky or gauge defective.

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## AIR COMPRESSOR

A two-stage Reciprocating Air Compressor (model ELGI - RR80101) is provided on Diesel locomotives. The air is compressed to required pressure in two stages i.e. in first stage by the LP cylinders and the second stage by the HP cylinder. The compressed air from the LP cylinder is taken to the inter cooler where it is cooled by a fan mounted on crankshaft itself. The cooled air is then sent to the HP cylinder where the pressure increases further. Then the compressed air is taken through the cooling coils for cooling again and then it is sent to the two main reservoirs (MR 1) and (MR 2) for storage purpose.

### SCHEMATIC DIAGRAM OF COMPRESSOR



### WORKING OF INLET AND DISCHARGE VALVES

The working of Air compressor is clearly depicted in above figure. When the piston of the low pressure cylinder moves towards the bottom dead center the combined action of the delivery valve return spring and the pressure differential developed between discharge manifold and the low pressure cylinder closes the delivery valve. At the same time, inlet valve open due to the pressure differential developed between the inside and outside of L P cylinder. Air at atmospheric pressure is drawn in through the filters and intake valves into the L.P. cylinders during the downwards strokes of the pistons. During the upward motion of the piston, the combined action of the inlet valve springs and the pressure differential developed between the inside and outside of the L P cylinder closes the inlet valves.

The air, which is trapped in the cylinder, gets compressed. The compressed air forcibly opens the delivery valves due to the formation of pressure differential, which has been developed between the discharge manifold and the cylinder. The compressed air is delivered into the discharge manifold. The intercooler outlet manifold is provided with a safety valve, which relieves the pressure if it reaches beyond 50 psi (3.5 Kg/cm<sup>2</sup>).

Air leaves the intercooler, entering the high pressure cylinder through its intake valve. As the high pressure piston moves upward, it compresses the air to higher pressure, forcing it out through the discharge valve and connecting pipe to the main air reservoir through an after cooler. Air leaving the high pressure cylinder is passed through the after cooler to reduce the temperature for the application. A safety valve is mounted at the outlet of high pressure cylinder, which relieves the pressure beyond 200 psi (14 kg/cm<sup>2</sup>). Both second and first stage receives power from the crankshaft individually. Crankshaft receives power from the locomotive engine, which is coupled, to the crankshaft using a coupling. The crankcase houses the crankshaft and connecting rod assembly, which receives and converts circular motion into reciprocating motion. Suction unloader valves on the low pressure cylinder head and High pressure cylinder head are operated pneumatically when pressure in the air receiver is above 140 psi (9.8 kg/cm<sup>2</sup>).

When the pilot air is passed into the Suction unloader valve it keeps the Suction valve open and air gets unloaded through the air filters of the compressor. The air receiver is sealed against leakage through the unloader assembly to the atmospheric vent by the complete movement of the unloader valve. When the air receiver pressure drops, the governor assumes the cut-in position.

A reciprocating lube oil pump is positioned inside the crankcase for lubricating all the moving parts. It is provided with lube oil pressure indicator valve and oil pressure relief valve. A float type oil level indicator is mounted on the side door to check the oil level in the crankcase. A breather valve is provided on the crankcase to maintain the crankcase vacuum. A dynamically balanced fan is fitted on the other end of the crankshaft with a fan guard with angular profile provided to divert the fan air to the cylinder and cylinder head for cooling the compressor.

### CHECKING OF OIL LEVEL

The oil level in the compressor sump has to be checked before taking over a loco and frequently on the run or whenever any trouble arises. For this, various types of arrangements are provided like:

1. Dial gauge
2. Sight glass
3. Dipstick.

**Dial Gauge:** The use of this gauge is latest. There will be three zones on the dial. Red, yellow and green, which will be denoting empty, add and full respectively. A float on the crank case sump oil is operated by the level of oil. The pointer is actuated by the float through which we will be assessing the oil level.

**Sight Glass:** These are provided on the side door of the crankcase and the oil is always visible through the glass. Two arrow marks are provided on the sight glass. The oil level should be at top arrow mark and should not be allowed to go below the bottom arrow mark. Sometimes the glass becomes black and oil level may not be visible. So in some locos in addition to the sight glass, a dipstick is also provided.

**Dip Stick:** Normally, it has got two markings, one high mark and one low mark. In some locos the dipstick has one high mark and 6 dots below it. The oil level should not be allowed to go below low mark in one type of dipstick and should not be allowed to go below the last dot in other type of dipstick.

### OIL PRESSURE INDICATOR

This is provided on the compressor unit. No pressure gauge is provided for indicating the lube oil pressure developed by the pump. Instead a visual indicating arrangement is provided on the body of the compressor unit on left side. Whenever the engine is started, the compressor lube oil pump starts working. The pump is connected to the lubrication efficiency indicator that has got a brass spindle. When the pump works the lube oil pressure will act under the piston that is spring loaded from the top. Because of the lube oil pressure action the piston is pushed up and so the brass spindle is projected out. If there is no oil pressure, the spindle will not project out. Thus indication is given to the LP about the working of the chain driven pump. Sometimes the pump may be working in good condition but the spindle may not project out. Sometimes the spindle may project out even in shut down condition. The first case may be due to bent spindle or high tension of the spring. The second case may be due to the spindle getting struck up.

If the LP notices these, he can remove the -TEST SCREW (dummy nut) and observe the oil coming with force. If so, he can proceed onwards. If oil is not coming with force that means the pump is not working. The LP should shut down the engine immediately to avoid extensive damage to the compressor components and shed should be informed.



## COMPRESSED AIR CIRCUIT

The compressed air reaching in MR1 is stored for supplying various purposes. From MR1 the air is taken to MR2 through a one way check valve. From the MR2 the compressed air is exclusively used for brake system equipment's only. Another connection is taken from MR1 to MR equaliser through a check cum choke valve (duplex check valve). From MR1 air is supplied to horns, sanders and wiper motor operations. Another branch pipe takes off to N1 reducing valve, which is provided to reduce the MR pressure to  $5 \text{ Kg/cm}^2$  and is stored in the control air reservoir. Air pressure from this reservoir is used for operation of EPPC, BKT and REV switches. The control air reservoir is provided in the nose compartment with a COC and gauge.

Normally main reservoir air pressure is maintained between  $8.2$  to  $9.8 \text{ Kg/cm}^2$  by an -NS-16 Air compressor governor or EPG type governor. This governor is located in the compressor room on the left side provided with a COC on MR air pipe from MR1. This COC is located on the right side of the compressor room.

## DESCRIPTION OF PARTS

### Crankshaft & Connecting Rods

Crankshaft s made of special alloy forged steel. So that deflection is minimised and the wear is reduced. A fan is mounted on the one end.

The driver to the crankshaft is taken from the engine thru a coupling. Rotational motion of the crankshaft is converted to reciprocating motion by slider crank mechanism.

Low pressure and high pressure stage connecting rods are interchangeable and are made of forged steel fitted with bimetal bearing on crankpin end and needle roller bearing on wrist pi end. However the lower portion and upper portion of the connecting rod must be kept as a matched set with orientation marks on the same side. The connecting rods are mounted over the crankpin adjacent to one another.



### Compressor Pistons

The low pressure piston are made of aluminium and elliptically ground on the outside diameter. The high pressure piston is cast iron.

Both low pressure and high pressure piston have two cross bevelled oil control rings, one nose scraper ring and one taper faced compression ring on the top. Piston reciprocates taking the power from the connecting rod.



Low Pressure  
Piston



High Pressure  
Piston

## Main Bearing

Two double row ball bearings are assembled on either side of the crankshaft, which takes the misalignment in geometrical tolerance and operation. The main bearings of the compressor are lubricating by the oil taken up during compressor operation and passes through the pocket in the end cover.

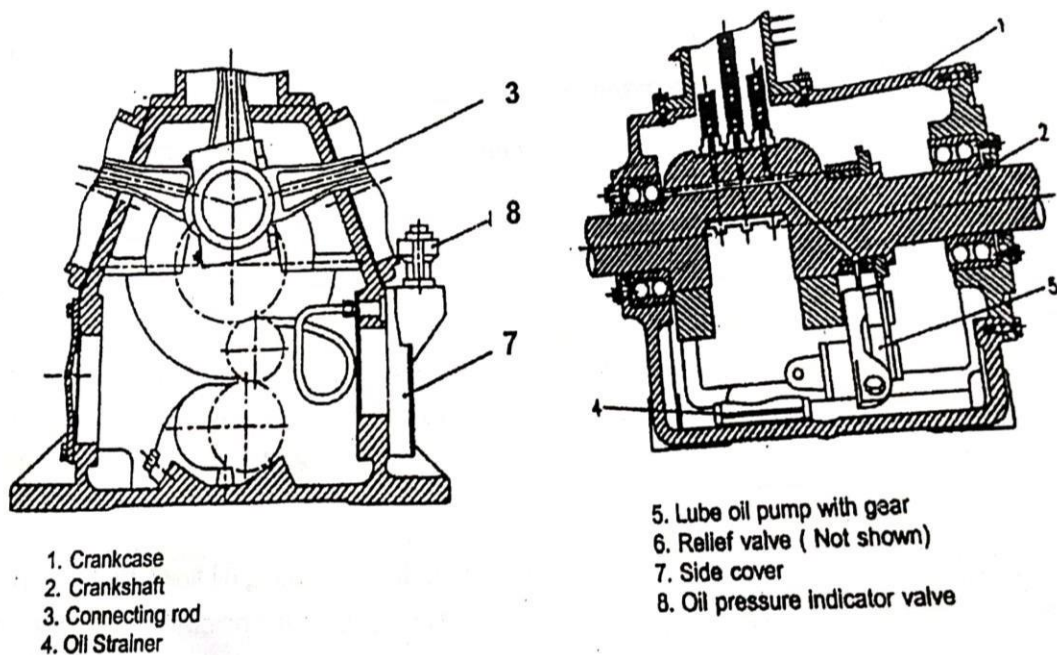
## Lubrication of Compressor

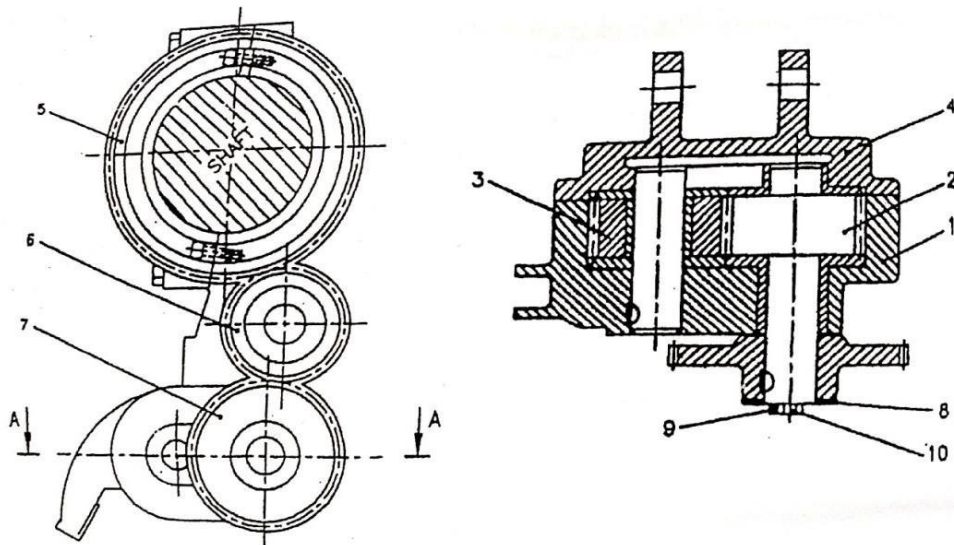
The compressor lubricating system is piloted by the gear drive oil pump. The oil pump circulates the oil under pressure. Drive is taken from the crankshaft by means of a set of gears with an idler, to pump the oil through the system. A primary oil filter which faces the inner side of the crankcase bottom filters the oil to prevent the ingress of external agents like dust and other solid particles from entering into the pump and the lubrication system. The filtered oil passed through the groove to the distributing ring.

Through the distribution ring, the lubricating oil flows to each crank pin in the crankshaft through the oil holes drilled in it. The oil lubricates the inner bearings of the connection rods through the groove provided and the needle roller bearing and gudgeon pin at small end through the hole drilled in the connecting rods. A relief valve fitted on the body of the oil pump maintains the oil pressure between 2.2 to 3.5 kg/cm<sup>2</sup>. It can be adjusted to the desired oil pressure.

In case the oil line pressure exceeds, the oil relief valve opens and allows the oil pass out of the pump, thus maintaining the set pressure. An oil pressure indicator valve, mounted on the side cover of crankcase helps to ensure the line pressure of the oil system. Recommended oil pressure is minimum 2.2 kg/cm<sup>2</sup> at idle and 3.5 kg/cm<sup>2</sup> at full speed. Oil seals fixed at the outer position of the two bearings prevent the oil leakage over the shaft and the atmospheric air entering into the crankcase.

Oil level can be checked visibly, and by the dipstick through the transparent oil level indicator, fitted on the side cover of the crankcase. The breather fitted on the crankcase maintains partial vacuum inside the crankcase which ensures better lubrication. Oil will overflow while filling when the maximum level is reached.

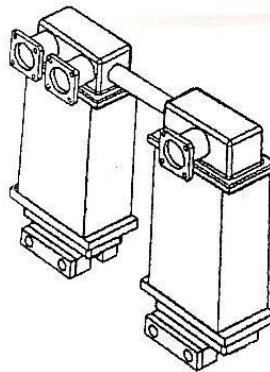




### Intercooler

The intercooler reduces the temperature of the compressed air leaving the first stage prior to entering the second stage in order to improve the overall thermodynamic efficiency of the system. The air from atmosphere is forced to flow through the exterior fins of the intercooler in the cross flow configuration to reduce the temperature of the compressed air.

A safety valve is provided at the manifold of the intercooler assembly, which opens at 50 psi.



### Oil Level Gauge:

Needle Position	Oil Capacity
Red start	6 liters
Yellow start	12 liters
Green start	14 liters
Grey start	21 liters



Oil Level in Crankcase

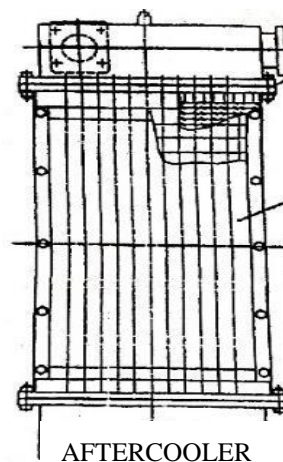
### Crankcase

The crankcase was employed as a sump for the lube oil, which houses 21 liters of lube oil. The side cover mounted on the crankcase is provided with an oil filling pipe which prevents over filling of oil. This pipe is closed with a threaded type cap and float type oil level indicator for indicating the level of oil in the crank case. The crankcase has four mounting holes for mounting the compressor in the locomotive.

The lube oil pump can be dismantled from the crankcase by removing the mounting pump. A breather valve is provided at the top of the crankcase, which keeps the crankcase in a partial vacuum condition. Oil seals were provided on both sides of the crankcase along the crankshaft axis, which prevents oil leaks and dust entering the crankcase.

### After cooler

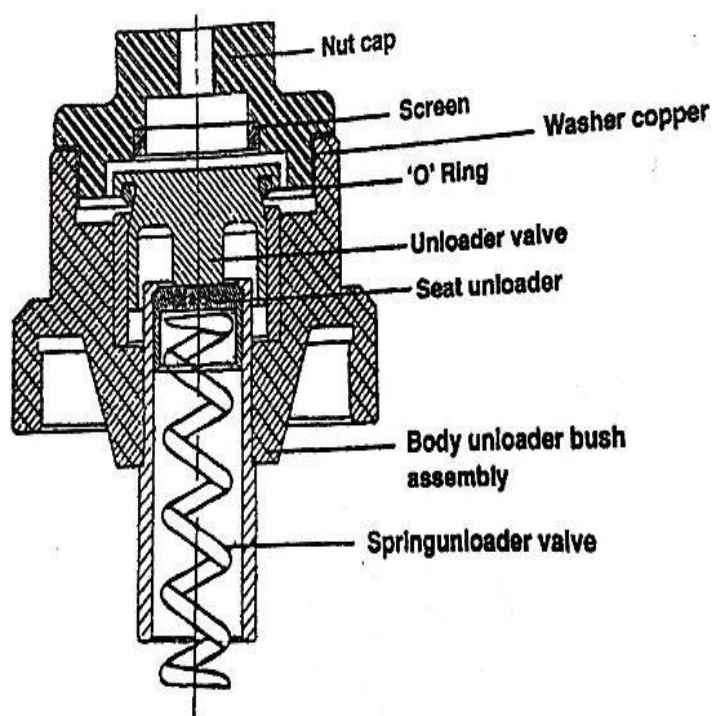
The after cooler assembly reduces the outlet temperature. The after cooler made with external finned copper pipes. A safety valve is provided at the manifold of the after cooler assembly, which has an opening pressure of 200 psig. Both intercooler and after cooler has a drain valve at the bottom to drain the condensate.



### Suction Unloader Valve

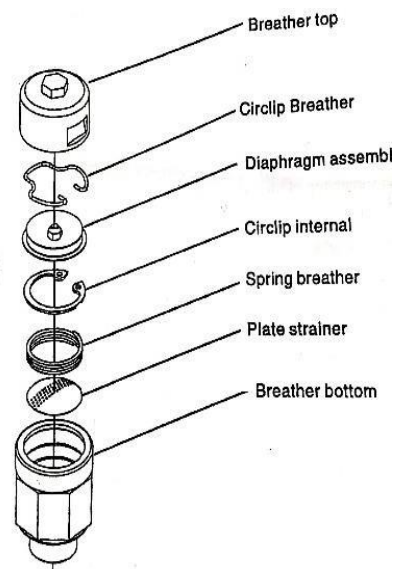
The unloader assemblies are a part of compression system located over the suction valve. It is pneumatically operated when the system pressure reaches 140 psig. The unloader valve in the unloader valve, spring, and unloader. This keeps the suction valve open during the suction and compressor without compression.

This acts like a control system for the main reservoir pressure between the cut-in and cut-out pressure as set by the end user by means of a solenoid pressure switch or other equipment not supplied by the original equipment manufacturer.



### Crankcase Breather Valve

The breather assembly is mounted on the crankcase. It operates check valve to provide a partial crank case vacuum during normal operation of the compressor and to discharge air displaced in the crankcase during the compressor process. The diaphragm assembly in the breather assembly acts as a one-way valve, which allows the air to flow through it from the crankcase to atmosphere. This process maintains adequate vacuum inside the crankcase.





## MAINTENANCE SCHEDULE

### Every 24 Months:

- Clean the Oil Level Indicator.
- Clean and inspects Unloader mechanism.
- Examine Aluminium pistons, Cast Iron Piston, and all Cylinders, replace if required.
- Replace the Suction and Discharge Valves.
- Replace the Connecting rod bearings.
- Replace the Breather Valve diaphragm assembly.
- Replace all the piston rings.
- Overhaul the pump assembly parts.
- Overhaul the connecting rod assembly.
- Replace the Air intake filter elements.

### Every 48 months:

- Replace the Oil Level Indicator.
- Replace the Aluminium pistons with gudgeon pin if required.
- Replace Cast Iron Piston with gudgeon pin if required.
- Replace all the Piston Rings in LP & HP.
- Replace connecting Rod Bearings.
- Replace the Low pressure & High pressure Cylinders.

### Air Dryer:

This is located in under truck between MR1 & MR2. It is provided to absorb moisture from compressed air before going to pneumatic system. The absorbed moisture is automatically drained. One COC is provided on inlet side and one COC on outlet side which is normally kept open. A bypass line is provided to bypass air dryer with a COC. This is kept normally in closed position.

Whenever MR pressure drops due to continuous blowing of air dryer or heavy leak in joints the following should be done by the loco pilot. Disconnect Electrical coupler in Air dryer unit. If not rectified, close inlet and outlet cut out cocks and open the by-pass the COC. If bypass COC is not provided dummy the drain port of air dryer. Now the air dryer is bye-passed and MR pressure will build up.

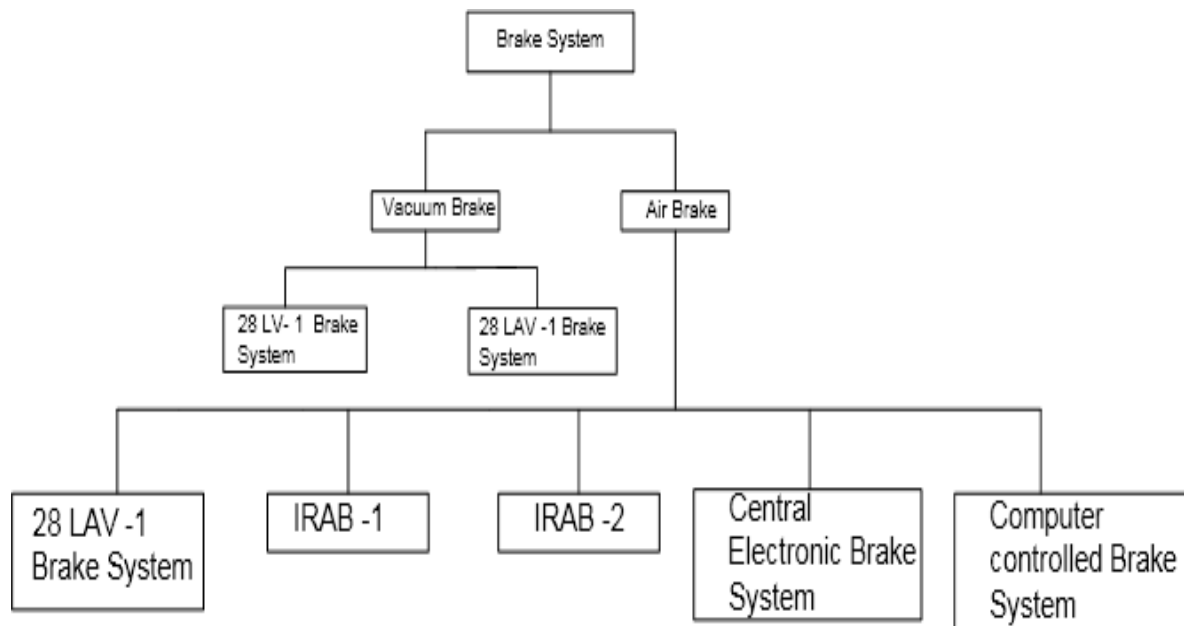


## CLEANING, INSPECTION AND REPAIRING

SL. NO.	Description	Clearance during assembly, mm		Max. Permissible clearance during overhauling mm
		Min.	Max.	
1.	LP Side			
	a) Piston to cylinder	0.210	0.275	0.330
	b) Groove side clearance			
	a. Compression ring	0.050	0.100	0.152
	b. Oil ring	0.040	0.090	0.152
	c) Piston ring closed gap			
	a. Compression ring	0.200	0.450	1.200
	b. Compression stepped ring	0.200	0.450	1.200
	c. Oil ring	0.200	0.450	1.200
2.	HP side			
	a) Piston to cylinder	0.175	0.225	0.300
	b) Groove side clearance			
	a. Compression ring	0.050	0.100	0.152
	b. Oil ring	0.050	0.100	0.152
	c) Piston ring closed gap			
	a. Compression stepped ring	0.200	0.450	1.200
	b. Compression plain ring	0.200	0.450	1.200
	c. Oil ring	0.200	0.450	1.200
	d) Gudgeon pin to bore	0.008	0.026	0.040
3.	Crankshaft			
	a) Con. Rod big end side clearance (3 con. Rods)	0.70	1.01	1.570
	b) Gear pump bore to crankshaft	0.110	0.165	0.254
	c) Gear pump end clearance	0.200	0.520	1.320
4.	Connecting rods			
	a) Con. Rod big end bore to crankshaft	0.031	0.060	0.152
	b) Con. Rod small end bore to gudgeon pin			
	a. LP	0.021	0.038	0.051
	b. HP	0.026	0.041	0.060
5.	Crankshaft main bearing			
	a) Fit to crankshaft	0.005	0.038	-
	b) Fit in crankshaft & end cover	0.005	0.036	0.254

\*\*\*\*\*

# BRAKE SYSTEM OF DIESEL LOCOMOTIVE



Diesel locomotives have complex brake system, either vacuum operated or compressed air operated. Conventionally the locomotive brake, commonly known as independent brake, was compressed air operated and train brake was vacuum operated. However, due to several advantage of pneumatic brake over vacuum brake, the train brake is also preferred to be air brake. As the brake is to be applied both on locomotive alone and on the complete train, from the locomotive itself, there must be provision of:

- Independent locomotive brake application and release.
- Train brake application and release.

**1. Independent Brake** - In Wabco design brake system, the independent brake is applied and released through SA9 brake valve, situated in driver control stand. This is also there in IRAB brake system, which is designed by Indian Railway. The SA9 brake valve has three positions, namely, application, release and quick release. The brake is applied on locomotive wheels through brake rigging connected to a brake cylinder piston rod. The brake cylinder is supplied with a maximum pressure of  $3.5\text{kg/cm}^2$  for brake application.

**2. Train Brake** - The train brake system is applied and released through A9-automatic brake valve, both in vacuum or air operated system. During train brake application, the brake is proportionately applied both on the locomotive and on the trailing stock. The brake valve has five positions, e.g. release, minimum reduction, full service, over reduction and emergency.

**Minimum Reduction:** by keeping the brake handle in this position partial brake application is possible.

**Full Service:** This is the normal position of brake application, which stops the train at normal braking distance.

**Over Reduction:** Train stops at shorter braking distance.



**Emergency:** In this position, the train stops at minimum possible braking distance. Driver goes for this position only in case of emergency. It leads to more wear and tear of the brake blocks and wheel treads.

## **TYPES OF BRAKE SYSTEM IN DIESEL LOCOMOTIVES**

<b>Brake system</b>	<b>Locomotives</b>
IRAB-1	WDM <sub>2B</sub> , WDM <sub>2C</sub> , WDG <sub>3</sub>
CCB	WDG <sub>4</sub> , WDP <sub>4</sub>

### **Independent Brake System (Loco Brake)**

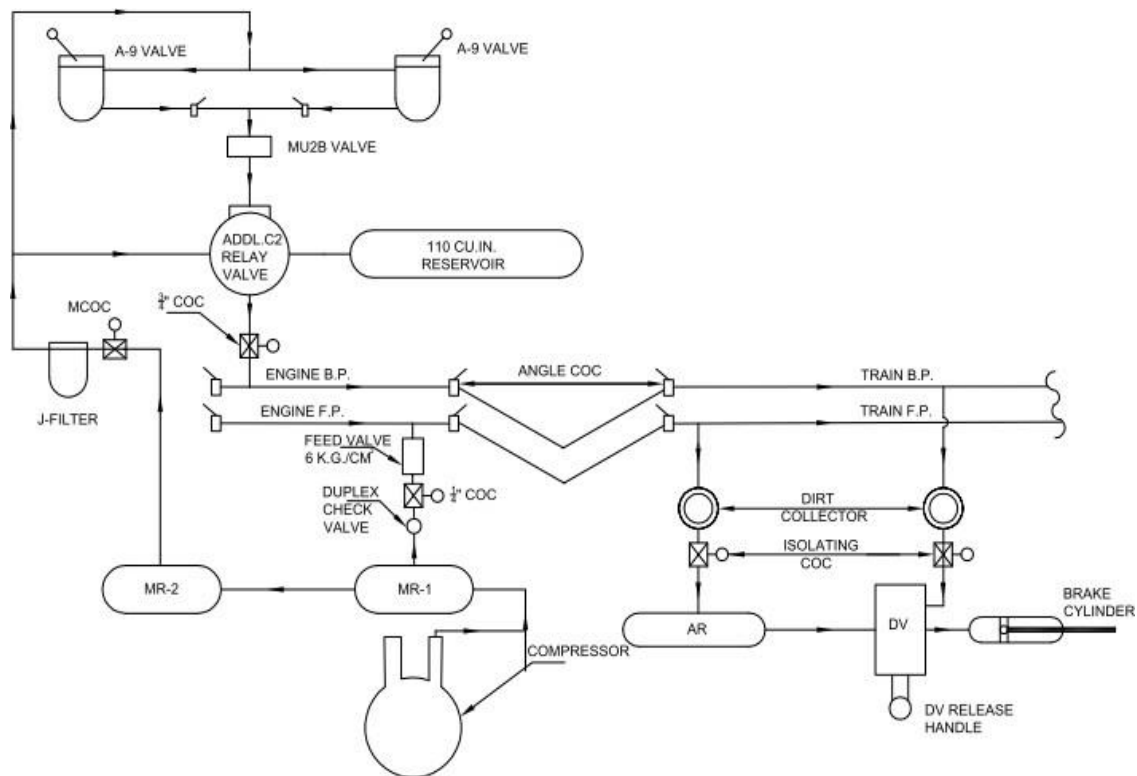
Loco brake system is provided to stop the Locomotive, whenever it runs as light engine. It is purely compressed air brake system, for which a separate air circuit is provided in 28LAV-1 and IRAB-1 brake system independent to other air circuits. SA9 independent valve is provided in driving control stand for application and release of loco brake. This valve has three positions i.e. quick release, release and application. Complete independent brake system consist of SA9 Independent Brake valve, double check valve and C2-relay valve.

This SA9 valve handle is kept normally in release position (right side). MR air is always available on port no. 30 of SA9 valve. When handle is brought on application position (left side), then 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. The pilot air pressure depends upon the handle position, at maximum it is 3.5kg/cm<sup>2</sup>. 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. When SA9 handle is placed in release position, loco brakes are released. A gauge line is taken from front truck of locomotive to driver's cabin control stand for indicating brake cylinder pressure.

### **AIR BRAKE SYSTEM: IRAB1:**

#### **SALIENT FEATURES OF IRAB 1 BRAKE SYSTEM**

1. Graduated brake applications and release
2. Independent loco brake
3. Automatic brake application
4. Conjunction brake application
5. Quick brake application during guard brake application or ICC pulling
6. Emergency brake
7. Automatic brake application during guard brake application or ICC pulling
8. Engine comes to IDLE during emergency application and train parting
9. Multiple unit operation
10. Feed pipe charging
11. only air brake trains can be worked



**AIR BRAKE SYSTEM**

## INDEPENDENT LOCO BRAKE APPLICATION

When SA9 handle is moved to application position Loco brake system takes place in two stages;

1. Brake cylinder pilot air charging
2. Brake cylinder pressure charging

### Brake Cylinder Pilot Air Charging

By the operation of SA 9 brake valve handle to application position and depending upon the position of handle movement, MR Pressure at port No 30 is reduced to set value max.  $3.5 \text{ kg/cm}^2$  and passes through port no 20 to MU2B port no. 2

Keeping MU2B IN LEAD position, the air from port no 2 to port no. 20 from MU2B, IT Passes on to the 24A double check valve and enters C2 relay air valve as BC pilot air in port no. 2

### Brake Cylinder Pressure Charging

Depending upon the pilot air pressure, MR pressure available at port No1 of C2 relay valve is reduced(equal to pressure available at port No: 2) and admitted to brake cylinders via port No: 3 so Loco brakes gets applied .

The same air pressure is supplied to the F1 selector valve ort No: 30 and passes through port No: 14 and charges the rake cylinder-equalizing pipeline. A connection to brake cylinder pressure gauge is taken from the front truck brake cylinder pipe to indicate the actual rake cylinder pressure. If front truck brake cylinder COC is locked, pressure gauge will not indicate.

## INDEPENDENT LOCO BRAKE RELEASE

When SA9 handle is moved to release position, Loco brake release takes place in two stages

1. Brake cylinder pilot air exhaust
2. Brake cylinder pressure exhaust

### Brake Cylinder Pilot Air Release

With the operative SA9 brake valve handle moved to RELEASE position and depending upon position of handle movement, port no. 20 is getting connected to exhaust port of SA9. So pilot air charged to port 2 of C2 relay valve is exhausted through exhaust port of SA9 valve.

### Brake Cylinder Pressure Exhaust

Due to pilot air supplied to C2 relay valves port no 2 getting exhausted through SA9 valve, C2 lay valve comes to release position, port No: 3 of C2 relay valve is connected to its exhaust port. This will lead to exhausting of brake cylinder pressure through exhaust port of C2 relay valve and brakes will be released.

## DESCRIPTION OF VALVES

### SA 9 Independent Loco Brake Valve

It is an automatic self-lapping pressure-maintaining valve located in both the control stands. It is used to and release loco brake. It is having three positions namely

1. application
2. release
3. quick release

It is having the following port connections

Port no: 30 MR2 input

Port no: 20 3.5 Kg/cm Brake cylinder pilot air out

Port no: 30 & 20 are used for loco brake application and release

**NOTE:** *Port No187 are plugged hence Quick release will not function*

This valve mainly consists of a regulating cam, which is controlled by the handle position. An inlet and exhaust valve assembly, a double ball check valve, which the opening and closing of inlet and exhaust ports, a regulating portion, and a quick release valve.

Regulating portion consists of a diaphragm and a pressure adjusting spring. MR pressure at 8-10 Kg/cm<sup>2</sup> is stored in ports no: 30, which surround the inlet valve assembly. By adjusting the regulating portion (Hand wheel) to the required setting of 3.5 Kg/cm<sup>2</sup>, double ball check valve closes the exhaust port and opens the inlet port. MR pressure available at no: through inlet port to port no: 20 as brake cylinder pilot air pressure. A portion of this pressure acts on top of the regulating portion diaphragm. In due course of time ie. When brake cylinder pilot air pressure fully charged to the required setting (3.5 Kg/cm<sup>2</sup>) in the port 20, regulating diaphragm assumes tapped condition duly closing the inlet and exhaust ports. (Lapped condition for on top and bottom of the dia. is equal and diaphragm assumes a flat position).

### 24 A Double Check Valve

This having two inlet and one outlet connections. Pressure supplied at one end pushes the piston inside the valve to close the other end to pass through the outlet.

### MU2B Valve

Multiple unit valves fitted in air brake panel makes the loco brake system as either LEAD or TRAIL (DEAD). It is having the positions namely- LEAD and TRIAL or DEAD.

In single loco and in leading loco of MU consist MU2B should always in LEAD position, when loco works as a trailing loco in multiple unit operation it will be in TRAIL or DEAD position. In dead loco also it should be in TRAIL or DEAD position

It is having the following ports:

- Port No: 63 MR input connection
- Port No: 53-Dummied
- Port No: 02 From SA9 port no. 20
- Port No: 20 To C2 relay valve port No.2
- Port No: 03 From A9 port no: 5
- Port No: 13- To port no. 2 of additional C2 relay valve
- Port 30 MU pipe to F1 selector exhaust port

Following port connections are made when position is changed.

Lead	Trail or Dead
Port no : 63 with 53	Port no : 63 with 30
Port no : 3 with 13	
Port no : 30 with exhaust	
Port no : 2 with 20	

### F1 Selector Valve

It has three pistons, mainly used in MU operation. When MU2B is in LEAD, it will be in LEAD Position. When is placed in TRAIL position, it be in TRAIL position During loco parting it automatically comes to AUTO LEAD position to apply loco brake in trailing loco.

It is having the following ports:

- Port No: 15 MR equalizing pipe
- Port No: 30 Brake cylinder pressure from C2 relay port no 3.
- Port NO: 14- Brake cylinder equalizing pipe
- Port No: 04 Brake Cylinder pilot air from port No.3 of C3WDV
- Port No: 16- Brake cylinder pilot air to C2 port No2 through 24A double check valve.
- Port No: 53& 63- From MU2B port No.53
- Port No: 20- Brake cylinder pilot air from port No.3 of C3WDV

Following port connections are made when position is changed.

Lead	Trail/dead	Auto dead
Port no : 30 with 14	Port no : 14 with 16 and 20	Port no :4 with 16
Port no : 4 with 16		

### F1 Selector in Lead Position

MR pressure from MR equalizer goes directly through port no 15 to the top of protection valve B pushes it down against the spring tension. As MR air keeps the 'B' valve in the bottom position it make a connection to port No 30 from top of C valve. As long as B valve in bottom position this connection is obtained as the port 30 is connected to the exhaust to MU2B valve there will not be any pressure. And hence the C valve is taking the top position enabling the port connection between 4 & 16.as there is no air pressure from top of a valve also it stands in top position due to spring tension so connecting port 30 and 14 Hence in lead position the protection valve 'A' and in top position while protection valve at the bottom position to obtain connection between 16& 4 and 14&30.

### **F1 Selector Valve in Trail Position**

MU2B valve sends MR pressure to port 53 of F1 selector. Ports 63 & 30 are interconnected between the bodies. So MR air reaches the top of 'C' valve through connections maintained by 'B' valve which is in the bottom position and pushes the 'C' valve down. This disconnects ports 16& 4. In the meantime the MR air through port 63, reaches the top of 'A' valve and pushes it down and hence disconnects ports 30& 14. This position of the valve connects ports 20&16 and also 14 through 'B' valve. So whenever brake cylinder pressure comes into port 14 through ports 16& 20 it reaches to C2 relay valve to apply the brakes of loco.

### **Application in MU Trailing Loco during Parting**

In trail position all the three valves ABC are in bottom position. In case of parting between, the MR from equalizer is drained. So the 'B' valve slides to the top position due to the spring tension. By doing so the air pressure on top of C valve is vented out through bottom port of 'B' valve and also ports 14, 16 and 20 are disconnected. As there is no air in the top so 'C' valve moves to top position. This connects ports No 4& 16. Thus F1 selector of the trailing loco repositions itself to auto lead position even though MU2B is kept in trail position. Once it attains the auto lead position, C3WDV of the trailing loco becomes active and send air pressure to C2 relay valve through ports 4 and 16 and so the Loco brakes are automatically applied.

### **C2 Relay Air Valve**

It is a relay valve fitted on air brake panel in nose compartment. It is having the following connection:

Port No. 1 MR Input connection

Port No.2 Brake cylinder pilot air from SA9 or C3WDV

Port No.3- Brake cylinder pressure outlet Exhaust Port

This relay air to the air to b air cylinders equal pressure of pill It consists valve pressure and a regulating Dia. MR2 pressure is stored in supply valve at port no 1 when pilot air is supplied to port 2 below the diaphragm, it lifts the diaphragm assembly, which opens the supply valve to connect port No.1 with port no 3, MR pressure passes through supply valve to port no 3 to port brake cylinders for brake application. A part of this air acts on the top of diaphragm to bring the valve to a condition dully disconnecting port no 3 from port no 1 when brake cylinder pressure is fully charged equal to pilot air brake cylinder pressure.

Whenever any leakage occurs in the brake cylinder pipeline this valve operates to supply air to maintain brake cylinder pressure equal to pilot air pressure as long as pilot air is supplied in port no 2.

### **Pressure switch RT 116**

It is provided to give audio signal when ICC chain pulled.

Setting:

Close at 3.5 Kg/sq.cm

Open at 4.0 Kg/sq.cm

### **Air Flow Measuring Valve**

It measures the quantity of air fed to the brake pipe through additional C2W relay valve, just like a water meter air is flows into brake pipe it gives indication to Airflow indicator.

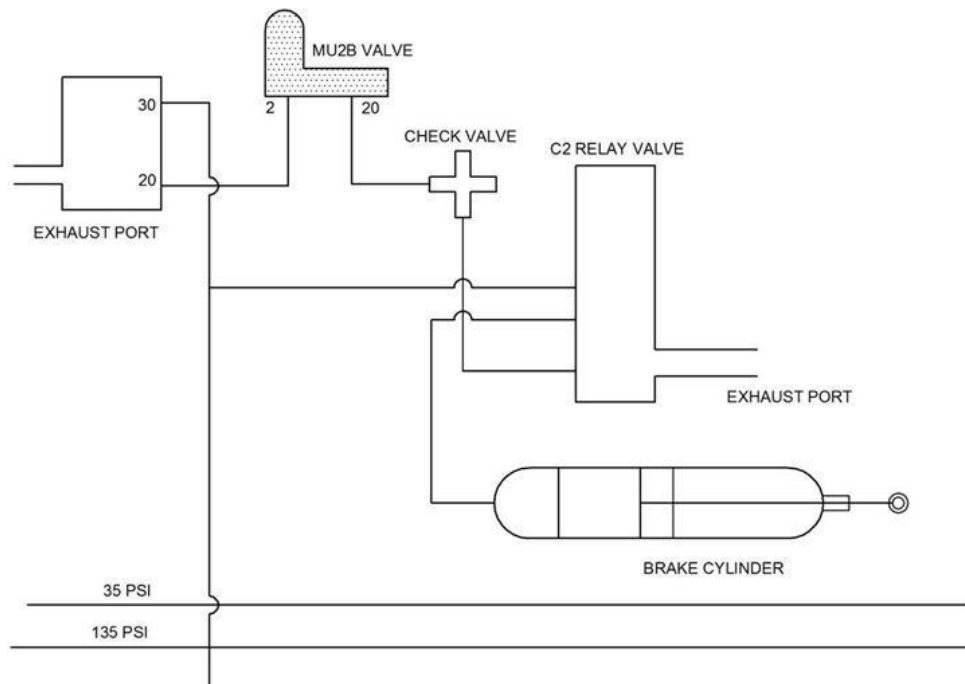
### **Air Flow Indicator**

It is a safety device which indicates rate of BP charging whenever there is an air flow into Brake pipe, white needle in the indicator shoots up above red needle to indicate the Loco pilot about rate of brake pipe charging. During train working, while keeping A9 in release position after application this white a needle shoots up. After brake pipe charging white needle comes

back to original position and remains below red needle. During the course of run if any leakage occurs and brake pipe again gets charged to compensate the leak, white needle shoots up above red needle.

On run if the white needle shooting up above the red needle, Loco pilot should take necessary action to protect adjacent line, stop the train and then attend the leakage in pipe. (While attaching to the formation, when A9 is in release position, brake pipe is getting charged in the brake pipe after brake pipe is charged in the entire formation RED needle should be positioned above WHITE needle).

#### SA9 OPERATION



Loco brake can be applied at any desired pressure between minimum and maximum. This pressure will automatically be maintained in the locomotive brake cylinders against their normal leakage. The locomotive brake can be graduated ON and OFF either the automatic (A9) or the independent brake valves (SA9). It is always possible to release the locomotive brakes with the SA9 valve.

#### **A-9 Automatic Brake Valve**

The A-9 Automatic brake Valve is a compact, self-lapping, pressure maintaining brake valve, which is capable of graduating the application or release of locomotive and train brakes. The A-9 Automatic Brake valve has five positions: Release, minimum reduction, full service, over reduction and emergency. The full service position is preceded by a zone in which brake pipe air is supplied or exhausted in proportion to brake valve handle movement through this zone, thus providing the graduation of an automatic application or release of the locomotive and train brakes.

The A-9 automatic brake valve maintains 5kg/cm<sup>2</sup> air pressure in brake pipe system against normal leakage at its release position. It also maintains air pressure drop in the system according to its handle position.

<b>A-9 valve Position</b>	<b>Amount of BP drop kg/cm<sup>2</sup></b>	<b>Amount of BP maintain kg/cm<sup>2</sup></b>
Release	0	5.0
Minimum Reduction	0.5	4.5
Full Service	1.5	3.5
Over Reduction	2.5	2.5
Emergency	5.0	0

The A-9 automatic brake valve consist of a self-lapping regulating portion, which supplies or exhaust the brake pipe pressure, and a vent which is actuated only when the brake valve handle is placed in emergency position for the purpose of venting brake pipe pressure at an emergency rate.

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## BOGIE OF ALCO LOCO

Forming the connection between the car body and the tracks, the bogie plays an important role in safety and comfort of passengers.

A bogie is a wheeled wagon or trolley. In mechanics terms, a bogie is a chassis or framework carrying wheels, attached to a vehicle. It can be fixed in place, as on a cargo truck, mounted on a swivel, as on a railway carriage or locomotive, or sprung as in the suspension of a caterpillar tracked vehicle. A bogie in the India, UK or a wheel truck, or simply truck in USA and Canada as well as in Mexico, is a structure underneath a train to which axles and hence wheels are attached through bearings.

Bogies serve a number of purposes-

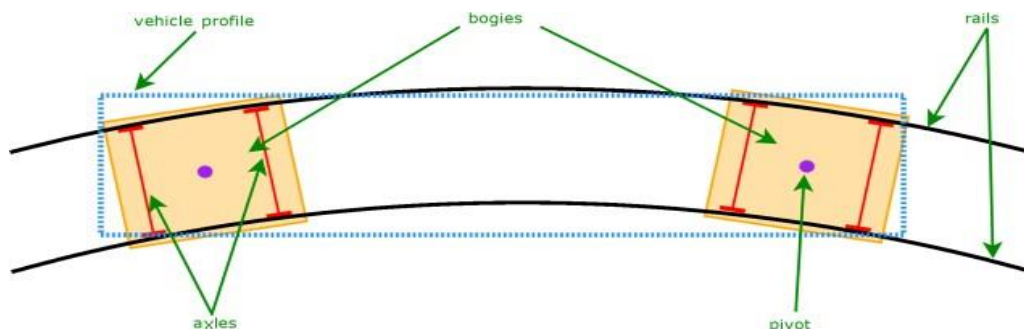
- To support the rail vehicle body.
- To run stably on both straight and curved tracks.
- To ensure ride comfort by absorbing vibrations and minimising centrifugal forces when the train runs on curved tracks at high speeds.
- To minimise generation of track irregularities and rail abrasion.

Usually two bogies are fitted to each carriage, wagon or locomotive, one at each end.

Key components of a bogie include;

- The bogie frame itself.
- Suspension to absorb shocks between the bogie frame and the rail vehicle body. Common types are coil springs or rubber airbags.
- At least one wheel set, composed of an axle with bearings and wheel at each end.
- Axle box suspension to absorb shocks between the axle bearings and the bogie frame. The axle box suspension usually consists of a spring between the bogie frame and axle bearings to permit up and down movement, and sliders to prevent lateral movement. A more modern design uses solid rubber springs & hydraulic dampers.
- Brake equipment.
- Traction motors.

The connection of the bogie with the rail vehicle allows a certain degree of rotational movement around a vertical axis (pivot or bolster), with side bearers preventing excessive movement. More modern bolsterless bogie designs omit these features, instead taking advantage of the sideways movement of the suspension to prevent rotational movement.



### TRI-MOUNT BOGIE

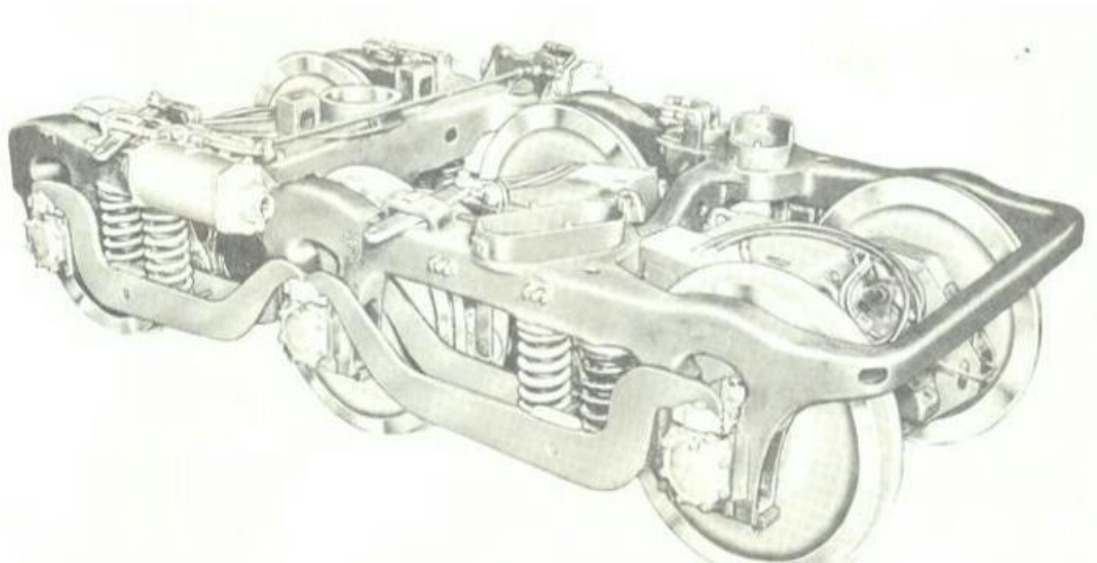
WDM2, WDM3A class broad gauge locomotives supplied by Alco products Inc., USA and the same classes of locomotives being built by the Diesel Locomotive Works (DLW) Varanasi are fitted with Alco's TRIMOUNT Rigid bolster, Swivel type, and three individually

motored axle bogies. Each of the three driving axles is driven by axle hung nose suspended traction motors. The tri-mount bogie consists of a single piece cast steel frame, which has a conventional bogie pivot (swivel bearing) carried in the cross member located between the leading and middle axles and two load bearers which are carried in cross member of the frame between the middle and trailing axles. The weight of the locomotive body is transferred to the bogie at the pivot and at the two load bearers to form a three-point support. The pivot carries approximately 60% of the vertical load and also receives and transmits traction and braking forces while the two load bearers share the remaining 40% of the vertical load. The load bearers are not designed to transmit any traction or braking forces.

The effect of the off centre pivot and the concentric loading pads is virtually that of a large diameter pivot (if a circle is drawn through the pivot centre and load bearers). This tends to minimise weight transfer due to tractive effort or braking force and maintain a higher factor of adhesion in service.

The construction of the pivot and loading pads is shown in the figure. The cylindrical pivot liner which transmits traction and braking forces and the circular liner which receives the vertical load are of medium carbon steel. The pivot bowl and loading pad oil pans are fitted with oil for lubrication of these liners. The oil pans are provided with dust shields. Resilient liners are provided between the foot of the loading pad and the bearing shoe. The lateral spacing of the pads afford stability against the tipping forces of the locomotive and the frictional resistance of the pads prevent nosing. Single stage suspension is used, consisting of long deflection helical springs and friction snubbers fitted inside one nest of each group of springs.

The frame is supported by these springs on four sets of double equaliser beams as shown:



### TRI- MOUNT BOGIE

Length of locomotive	17119.6 mm
Width of Locomotive	3009.9
Height of locomotive	4184.65mm
Weight of Dry Engine	112.8T
Bogie weight	23T
Pivot pin load 60%(each)	20.04 T
Side load bearer 40%(each)	06.68 T
Axle Load	18.8 T
Pinion & bull gear ratio	18:65
Wheel diameter(New)	1092 mm
Wheel diameter (condemned)	1016 mm
Piston Travel	95mm to 105 mm
Buffer Height	1105mm to 1030mm
Rail guard Height	88.9 mm to 114.3 mm
Design Speed	120 KMPH

#### Safety Fittings in Tri-Mount Bogie

- Dust guard for pivot pin & side load bearer
- Buffer
- Cattle Guard
- Rail Guard
- Safety bracket for Main Reservoir
- -Ull bracket for CBC
- Buffer lamp box
- Hand Brake Chain
- Tie Rod Safety Chain
- Equalizer beam safety bracket
- Brake Pull Rod "J" clamps
- Gear case "L" clamp for Gear case M/ Bolt
- Gear case "C" clamp
- Safety clamp for Air pipe.
- Bolster Pin(Safety Pin)
- Safety U bracket (connected with chassis & bogie cross beam)
- Seal of wick pad carrier plate bolt/screw
- Sealing of Traction motor caps dummy.

#### Various Parts of Bogie of WDG<sub>3A</sub> Loco Are:

- Vertical Damper (Primary Suspension)
- Wheel Set Assly.
- Outer & Inner Spring (Primary Suspension)
- Side Bearer (Secondary Suspension)
- Lateral Damper (Secondary Suspension)
- Bogie Frame
- Brake Cylinder
- T.M. Air Duct
- Traction Motor

## **BOGIES OF WDG<sub>3A</sub> LOCO**

WDG<sub>3A</sub> loco is provided with fabricated bogie. This is a three-axle bolster-less bogie with two-stage suspension with helical coil springs in primary stage and rubber compression springs in secondary stage of suspension & floating type centre pivot arrangement. The bogie frame is a fabricated box type construction, manufactured from steel plate to IS.2062 grade

\_\_C||. The locomotive car body weight is transferred directly to the bogie frame through four rubber –Compression|| spring assemblies. The lateral stiffness of rubber springs is utilized to provide lateral guidance at the secondary stage and provide the yaw stiffness for stability. Lateral spacing of rubber springs affords stability of locomotive on curves and damping provided by rubber springs and lateral dampers prevents nosing at high speed. The bogie frame is supported through –soft primary|| suspension consisting of eight pairs of helical coil springs (inner & outer). Two springs mounted on each equalizer, to provide ride quality and equalization of wheel-set loads. Equalizers in turn mounted on end Axle boxes directly with the help of Link & compensating beam on middle axle box. Axle box (with high speed bearings) are mounted on axle.

Centre pivot does not take any vertical load and is used only for transfer of traction and braking forces. All traction motor nose positions are oriented to the same side of each axle within the bogie frame. The relatively stiff secondary suspension, uni-directional arrangement of traction motors and low centre pivot limits the weight transfer between axles during adhesion. Traction and braking forces are transmitted from wheel-set to bogie frame through pivot pin arrangement.

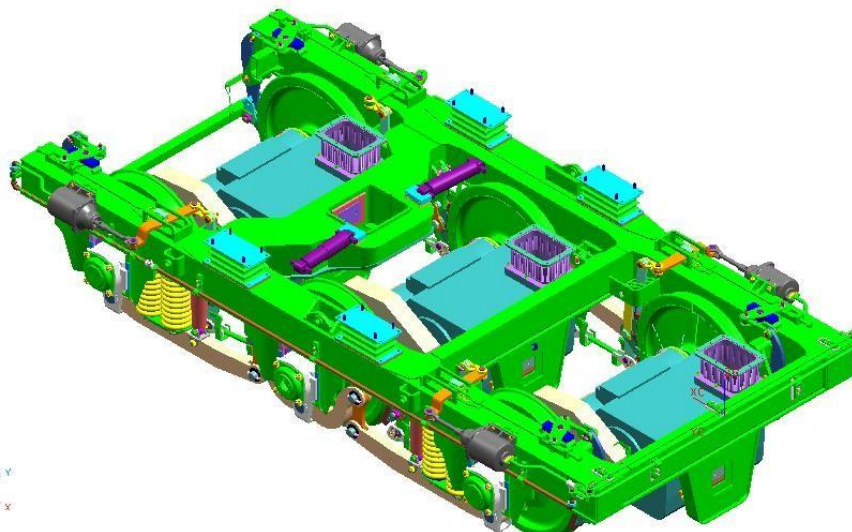
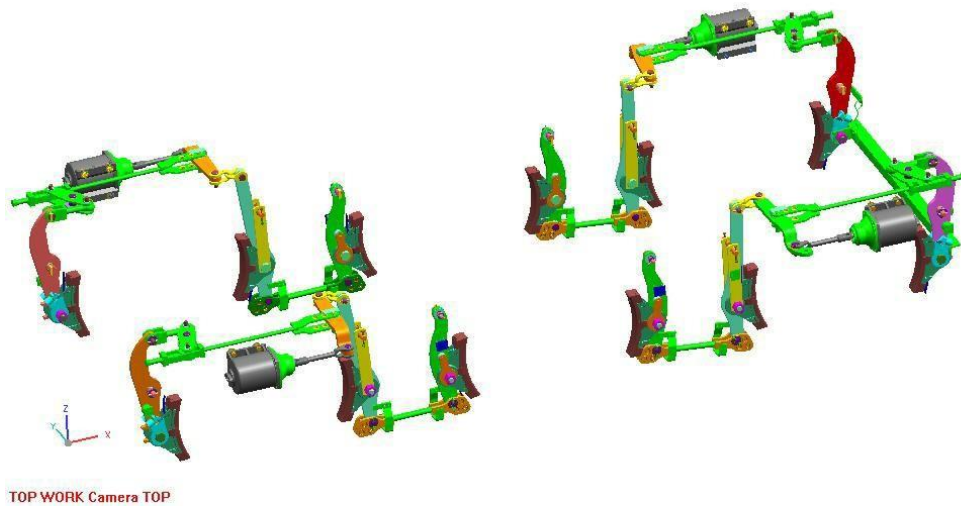
Four vertical hydraulic dampers are provided in primary stage between axle and bogie frame. Two hydraulic lateral dampers are provided in secondary stage between bogie frame and the loco under frame to supplement the damping provided by rubber springs. Lateral dampers are oriented in such a way that they provide damping both in lateral and yaw modes. Safety links are provided at the lateral stop locations between bogie frame and the under frame. These links serve to prevent separation of the bogie from the locomotive car body in case of derailment and also provide means of lifting the bogie along-with the locomotive car body.

The Bogie is provided with conventional type, double shoe per wheel powered by air brake cylinders. Manually operated slack adjusters top & bottom are provided to maintain the gap between brake shoe & wheel. In WDG3A bogies, four numbers Bogie mounted sand boxes provided for sanding during wheel slip.

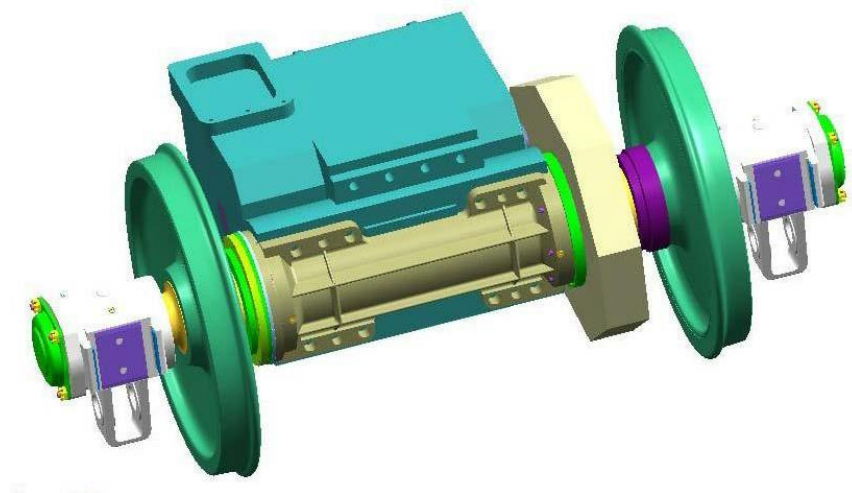
Wheel arrangement is of CO-CO type (3 axles with individual traction motors). Axle boxes are fitted with CRU journal bearings with conical thrust rubber pads.

Happy pads are used with suspension springs. Traction and braking forces are transmitted from wheel-set to bogie frame through horn guide.

## Brake Gear Arrangement Layout on Bogie



**Model of Bogie Gen. Arrgt. of WDG3A loco**



**Axle Wheel & Box Assembly**

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## SAFETY DEVICES IN ALCO LOCO

Following are the important safety devices of the diesel loco.

- Low lube oil switch.
- Hot engine alarm.
- Low water level safety devices.
- Safety auxiliary relay and over speed trip mechanism.
- Wheels slip protection devices.
- Pneumatic control switch.
- Ground relay.
- Auto switching on off flasher light.

1. **Low lube oil switch** - This safety device is provided to protect the engine against low lubricating oil pressure. It brings the engine to halt with audio visual indication, if the lube oil pressure falls below a pre-set value.
2. **Hot engine alarm** - This devices giver alarm if cool and water temperature exceeds the predetermined temperature limits. At predetermined temperature it starts the radiator fan to run at medium speed, then at faster speeds and finally brings engine to idle if the temperature is not able to be control by radiator fan. The feature or bringing engine to idle is bypassed in many locos , to enable the driver to cool the engine faster by fast pumping raising engine speed and consequently water pump and radiator fan RPM.
3. **Low water level safety devices** - This safety devices is provided against low cooling water level. If the cooling water level drops below a predetermined level. The alarm sounds and engine shut down. The LWS contact opens in clutch coil circuit and the governor clutch coil is de-energized. The engine is shut down through the governor circuit. Hot engine light comes due to energizing of wire SB and the alarm gong rings due to energizing of signal relay.
4. **Over speed trip mechanism** - This safety devices is provided to prevent the diesel engine from over speeding in case any open circuit takes place in the speed coil circuit of the governor, in addition to this a mechanical device is also provided to prevent engine from over speeding. This device is known over speed trip mechanism. Over speed trip assembly is fitted on right side accessory end of engine and id mounted on cam shaft assembly.
5. **Wheel slip protection devices** - This safety devices is provided to prevent the diesel engine to protect against the wheel slip. In case of wheel slip taking place, wheel slip buzzer sounds and the generator power gets reduced through a control circuit thus controlling wheel slip. Whenever wheel slip relay WSR 1 or WSR 2 or WSR 3 is energised wheel slip buzzer sounds by wire 10 through wire 13 and wheel slip light comes by closing WSR 1 or WSR 2 or WSR 3 interlocks, the PWM main turns off winding in the excitation system is connected across battery source and the generator power is reduced.
6. **Pneumatic control switch** - This switch (PCS) trips during emergency brake application, train parting, and when the vigilance control device being not minded by the driver at the specified time.
7. **Ground relay** - It senses the ground fault and brings the engine to idle with audio visual indication. In cases of starting ground it provides audio visual indication to the driver. The relay has a reset knob to ensure positive attention, in the event of its operation.

- 8 Auto switching on off flasher light** - During train parting and chain pulling this feature brings the engine to idle with application of train brake, providing audio visual indication , the flasher light is also switched on automatically.

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# **ROTATING EQUIPMENTS**

## **TRACTION GENERATOR (TG)**

The main generator or traction generator is a separately excited DC generator. The main field magnet coil consists of 10 or 12 field magnets and are excited by the exciter generator. The armature is coupled to DSL engine crank shaft. A cooling fan is attached to the armature for cooling the commutator and field coil. The generator has 10 or 12 brush arms and each brush arm is fitted with 6 nos. of carbon brushes.

When the DSL engine is running, the TG Armature starts rotating between the field magnets. When there is no current feeding from Exciter to the TG field, there will be no output from TG and the condition is called idle running of engine with 400RPM.

When the TG field is excited by the current supplied from Exciter magnetic field sets between field poles and the rotation of armature cuts the magnetic lines resulting in an output voltage from TG.

The output of the generator depends on 1) Armature speed through DSL engine and 2) the amount of current from Exciter generator. The output of the generator is supplied to the traction motors through carbon brushes, power contactors, BKT power switches, reverser power switches, bus bars and cables.

Power switches, Reverser power switches, bus bars and cables.

As the DSL engine cannot be started for the purpose of starting. During starting the TG works as a series motor by taking current from batteries. During dynamic braking the TG works as an Exciter and supplies current to all the traction motor fields, to enable them to work as generators for supplying braking effort to control the speed of train on down or level roads. The TG rotates in a counter clockwise direction (CCW) facing from commutator end.

## **MAIN GENERATOR GEAR CASE**

In ALCO loco at the commutator end, a gear is fitted on the Main generator shaft. The auxiliary generator, exciter and front truck traction motor blower are engaged to this gear with small gears. All the gears are enclosed in a gear case known as main generator gear case. The gear case must have sufficient oil always to ensure proper lubrication of the gears. SAE40 is used as lubricant in the gear case. To check up oil level a bayonet gauge is provided with the markings of Full –ADD- EMPTY. Some gauges are marked with MAX – MIN. It is the duty of the Loco pilot to check the oil levels while taking over charge of the loco. The oil level while taking over must be at full or MAX. While taking charge at enroute, the oil level can be between.

## **ALTERNATOR**

Alternator is a three phase star connected separately excited machine provided in AC/DC Locos. The armature windings are mounted on a stationary element called stator and the field winding on rotating element called rotor. Stator winding is a 10 pole 3 phase two layer star connected wave winding with two parallel circuits per phase housed in open slots. Excitation to the rotor field is supplied by exciter through slip rings.

The alternator (rotor) like DC generator is directly coupled to the diesel engine and driven by it. When the rotor is rotated by the diesel engine the stator winding cuts the magnetic flux of the rotor poles. Hence an AC output is available in the stator winding which is collected through bus bars. This AC output is fed to 3 phase rectifier to convert to DC and fed through BKT, REV, EPPC, bus bars, cables to DC traction motors mounted on the axles.

During dynamic braking the Alternator Works as an exciter and supplies current to all the traction motor fields, to enable them to work as generators for supplying braking effort to control the speed of train on down or level gradients.

### **AUXILIARY GENERATOR**

The AG Mounted on the TG is a Gear Driven self-excited shunt wound, 18HP, DC machine. The maximum RPM is 2386 at 1000 RPM of DSL engine. (Gear ratio 1: 2.386).

When the main generator starts to rotate the auxiliary generator also starts rotating. Then the auxiliary generator armature cuts the residual magnetism present in the field poles, thereby a small current gets generated and supplied to the auxiliary generator field coil through AGFB, VRR FUSE, VRR. The VRR controls the auxiliary generator field current to maintain constant output of 72+/- 1 volt irrespective of engine speed. As the field current is supplied from the AG itself, this is a self-excited machine.

The auxiliary generator supplies current to the following circuits.

- 1) Battery charging circuits.
- 2) FPM, CCEM, RFC circuits.
- 3) Lighting circuits.
- 4) Control circuits (relay, contactors, panels, magnetic valves, switches, brakkers, etc.)
- 5) EXCITER field coil circuits. (To enable to produce output in the Exciter.)

In AC/DC locos AG works as series motor during cranking and is also provided with a starting field.

### **EXCITER GENERATOR**

The EG mounted on TG is gear driven separately excited, shunt wound DC machine. It rotates at 2386 RPM at 1000 RPM of DSL engine. (Gear ratio is 1: 2.386). The purpose of exciter is to supply current to the separately excited shunt field of TA, The output of exciter controls the output of TA. The exciter shunt field is excited from auxiliary generator output supply through a network of resistors and exciter field transistor (EFT1) located in card no. 254 of excitation panel. If the exciter fails to produce its output, load meter will not respond and the loco will not move.

In AC/DC locos EG will work as series motor during cranking. It is also provided with starting field.

### **TACHO GENERATOR**

This is a three phase, 6 pole, and permanent magnet AC machine and is fitted in E Type Excitation locos. Only. This mounted on the engine block and is gear driven by the DSL engine cam shaft gear. The output is proportional to the engine speed. This is situated on the right side of the engine, just below the governor.

It Supplies current to excitation circuit through card no.186 (slot2) maintain the main generator voltage, current and HP limits for each notch through card no. 292/293 (in slot 7) . The frequency of this generator at maximum RPM of 2384 is 119.2 cycles per second and the gear ratio is 1: 2.384.

This is mounted on left side of second axle and is rotated by wheel movement. This supplies speed signals to the Transition circuits (TRP) and electrical speedometer. This is a permanent magnet, single phase AC machine. When loco moves the rotor turns thereby the voltage is induced in the stator coils, which varies with speed. This variable voltage is fed to a transformer (TET) rectifier and filter. The DC output supply is used for transition and electrical speedometers circuits. If fails to produce its output due to any reason the speedometer will not indicate and automatic transition system fails to operate. In such conditions it is advised to operate the manual transition duly watching the mechanical speedometer to maintain the desired speed of the train.

## TRACTION MOTORS

The traction motors are of four pole DC series type which is highly suitable for traction purpose. These are cooled by two blowers. One to supply air for three truck traction motors and the other supplies air to three traction motors in rear truck.

A pinion is shrunk fit on motor armature shaft. It meshes with a bull gear mounted on wheel axles. The gear ratio in terms of pinion and bull gear teeth is 18:65 in WDM<sub>2</sub>/WDM<sub>3A</sub> and 18:74 in WDG<sub>3A</sub> locos.

There are 6 traction motors mounted on 6 driving axles in loco under truck. The motors are to be counted from short hood side as 1 to 6. Each traction motor is having 4 cable (2 armature ends and 2 field coil ends) for external connections to enable to change the direction of rotation and to work as generator during dynamic brake application.

In WDM<sub>2</sub> locos the traction motors are connected across TG in series at starting and changes to series to parallel then to parallel with field shunting, depending on speed of the loco.

In WDM<sub>3A</sub> / WDG<sub>3A</sub> loco two traction motors are connected in series then across output of power rectifier at starting after transition all traction motors are connected parallel to power rectifier output, depending on speed of the loco. The speed of traction motor can be increased by the following methods.

- By increasing the voltage to the armature and
- By weakening the field current.

By changing the traction motor connections in different combination as stated above either the traction motor armature voltage is increased or field current is decreased to achieve more speed.

The driving power of a traction motor depends on the current flow through it. High Tractive effort and therefore high current is necessary to start a train from halt and the train gains speed less tractive effort is needed. A feature of electric motor is that while it is running it produces a voltage (back EMF) of its own, which tries to push back (oppose) the voltage that is being fed. The back EMF is in proportional to the speed of the motor. Thus as the train speed increases ( as the motor speed increases) a high back EMF is produced, which opposes the main supply voltage from the TG/TA, reducing the current flow into the motors resulting in slowing down of train on gradients. As the motor slows down, the back EMF reduces, thus more current is allowed to flow into motor and the torque will increase. The forward and reverse movements of the loco are obtained by changing the current direction through the traction motor field by the positioning of Reverser Power Switches.

### Traction Motor Data

RATING (continuous) at 45 Deg. C ambient	
Volts	325
Amps	1000
Rpm	430
KW	280
Insulation Class	H
WEIGHT (Approximate) Machine complete with gears & gearcase	3680 Kg

## FUEL PUMP MOTOR (FPM)

The FPM is a 1.5 HP, 1725 RPM, 22.5 Amps, 3 phase AC motors with an inverter is used in locos located in Compressor room. Before cranking the engine it gets current from the batteries and after cranking it gets current from auxiliary generator. The pump connected to

the motor by love joy coupling sucks fuel oil from tank and delivers it at a pressure to the fuel headers. The output of this pump is 5 gallons per minute at pressure of 5.3 Kg/cm<sup>2</sup>.

### **CRANKCASE EXHAUSTER MOTOR (CCEM)**

The CCEM with blow fitted at power off end is a 3000 RPM, 3 phase AC motors with an inverter is used in locos to exhaust hot fumes and vapors from the engine and delivers into the atmosphere through an exhaust outlet and maintains a desired amount of vacuum in the crankcase. Before cranking, the motor gets current from the batteries and after cranking, it gets current from auxiliary generator. In the case of motor failure due to, CCEB tripped or defective it will be indicated by an orange colour lamp. If the motor fails to work due to its internal problems (such as loose terminal connections, defective inverter etc.) , the CSLP will not indicate and hot fumes and vapor gets accumulated in the crank case and gets released by opening of crank case explosion doors.

### **DYNAMIC BRAKE BLOWER MOTOR (BKBL)**

This is a 65 HP, 3500 RPM, 325 volts, series motor. The motor is fitted in nose compartment with a fan to supply cooling air to the braking grid resistors to, dissipate heat during DB operation. Air is taken from the side of cabin through screened openings, and after passing through the grids the heated air is vented through the roof opening of the loco. The motor is connected across a section of braking grid resistors and its speed depends on the amount of braking current flowing through the grid resistors.

During DB, braking current flow through the braking grids, creating a difference of potential across the BKBL speed increases with the increase of braking current and more cooling is available automatically . The BKBL works as long as DB is applied. If this motor fails to work the Loco pilot are advised not apply DB further.

During APU modification, roof mounted Dynamic brake resistance (DBR) are provided and modified blower motor used for cooling of grid resistances.

### **EDDY CURRENT CLUTCH**

**Working Principle:** The function of radiator fan is to cool engine cooling water by drawing fresh air from the outside atmosphere through the cooling fins of radiator. This fan is driven through the right angled gear unit through radiator clutch. It is an electromagnetic clutch by which power is transmitted to the gear reduction unit for driving the fan. A separate excitation of the field coil in the inner rotor permits control of field strength. The ECC has an outer drum with copper coating inside, which is connected to the compressor extension shaft. As long as the engine is working, the outer drum will be rotating. It has got an inner rotor which is connected to RF through right angle gear unit.

Two temperature sensor switches (ETS1 & ETS2) provided in cooling water system controls the ECC automatically at 64 degree Celsius and 68 degree Celsius respectively. When no current flows in clutch coil, the outer drum only will be rotating at engine speed and the SPIDER or INNER ROTOR is at rest. When current is supplied to the coil (on closing R1), it produces magnetic field in the spider teeth. The magnetic field (which is proportional to the amount of current supplied to the clutch coil) is cut by the rotating outer drum, as a result eddy current gets produced in the outer drum. This in turn induces a magnetic flux causing a drag torque on the spider and the fan starts rotating through right angled gear box. The speed of the spider depends upon the current flowing through the coil. For e.g. when R2 is closed, resistor TCR is bypassed, permitting more current (12.5 A) to the clutch coil so as to make it run at the speed of the engine. It causes increased magnetic flux and thereby more torque in the inner spider shaft, increasing the fan speed to 110% of the engine RPM. The higher fan speed in respect of the engine RPM is obtained through the ratio provided in the right angle gear.

## **Construction of Clutch**

It consists of three main parts. Brush holder housing or assembly is installed on the horizontal shaft of the gear unit. Inner rotor or spider (also includes field coil), is keyed to the horizontal shaft of the gear unit. Outer rotor or outer drum is bolted to a flange at the end of the extension shaft and supported by a double row self-aligning ball bearing.

## **WHEEL SLIP**

Wheel slip occurs due to lack of adhesion between wheels and rails whenever the tractive force (pulling power) exceeds the adhesive force (grip between wheel and rail). Wheel slip happens due to excessive loads, brake binding, greasy/oily rails, wet rails etc. wheel slip is either momentary or continuous.

Wheel slips may cause the following.

1. Damages the electrical power equipment's i.e. TMs.
2. Damages the wheels (skidding) and rails (scabbing).

Under normal working conditions, the current taken by each motor is same. In case of any of above reason, current difference increase between two TMs, the micro-processor sense and indicate wheel slip message on display unit visually as well as beeps an audio alarm.

### **Sequence of Operation for Wheel Slip on Loco:**

- Reduces TA output voltage by reducing excitation.
- Wheel slip indication light glows (visual indication)
- Wheel slip buzzer sounds (audio indication)
- Automatic sanding to improve adhesion between wheels and rails.

## **TYPES OF WHEEL SLIP**

### **Momentary wheel slip**

This is caused by lack of adhesive power between rails and wheels. This may be due to wet rails, oil or greasy rails, excessive load. This can be avoided by reducing TH notch and then smooth re-application of power, by applying sand on rails to create adhesive power.

### **Continuous wheel slip**

This may due to -

- slipped pinion
- locked axle
- loose cables and bus bar connection in power circuit
- loose crimped terminal shoes in power circuit cables
- Foreign body/insulation in between contacts of BKT, REV.
- defective field shunt resistor
- defective field shunt contractors
- Burnt cable or bus bar connections in power circuit.
- Defective TMs
- Sluggish operation of EPPC.

## **REMEDIAL ACTION**

### **Slipped pinion**

This is because of the pinion worked out from the armature shaft. This can be detected by applying SA9 and giving power to TMs, by placing GF switch at ON. If, it is due to defective TMs/ cable /bus bar connection, then driver should cut off TM through display key pad.

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## EXCITATION SYSTEM

Excitation system is used to ensure that the traction generator demand i.e., the power required to rotate the generator armature, matches the capability of the diesel engine throughout its entire speed range. If adequate control of generator demand is not provided, one of the following will occur:-

1. If the generator demand exceeds engine ability, the engine will slow down (bog), with still further loss of power. The locomotive will be unable to perform its job and damage to the engine may result.
2. If generator demand is less than engine ability, the governor will reduce fuel to prevent the engine from over speeding, but it will not be possible to utilize the full rated power of the engine, and the locomotive will not be able to pull its rated load.

The excitation system must also impose electrical limits on the main generator i.e., maximum voltage and current to avoid the possibility of damage to the insulation by high voltage or excessive current. In a locomotive, the load on main generator at any fixed engine speed varies as locomotive track speed increases due to the counter EMF created by rotating armatures of the traction motors. The excitation controls must act to keep generator HP demand constant over a wide variation of terminal voltage.

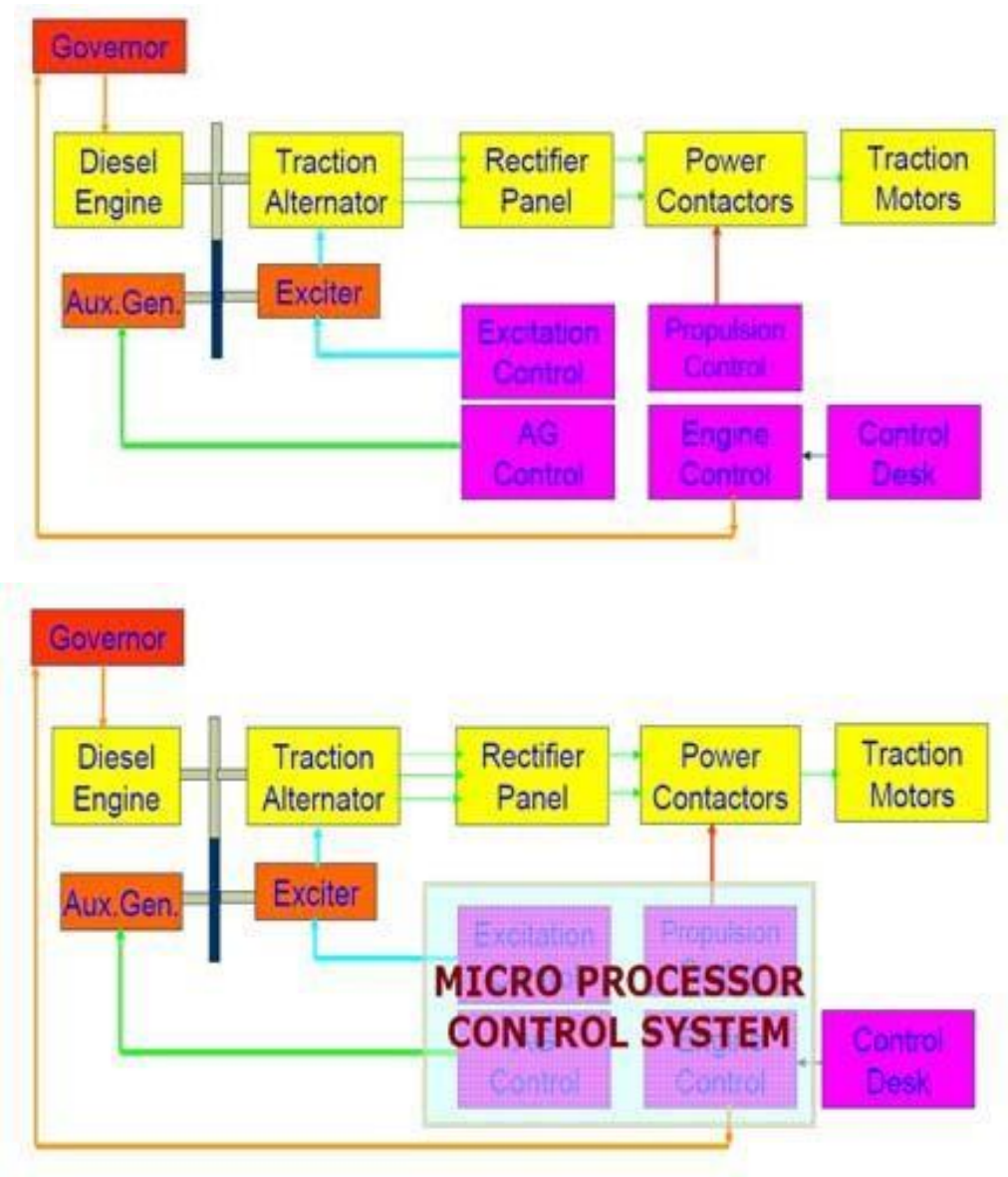
### TYPES OF EXCITATION SYSTEM

1. **A - TYPE:** Excitation is controlled with the help of amplifying generator used as exciter. A governor operated variable resistance called Load Control Rheostat controls the current.
2. **B - TYPE:** The system is known as 3 field excitation system. In this system, the exciter is having three fields namely the self-excited field, differential field and battery field. The self-excited field is connected as a shunt field with some limiting resistor in series to it. The differential field is connected in parallel to the main generator commutating field. This field acts as an opposition to the other two exciter fields. The battery field is supplied through battery and the current through this field is controlled by a governor operated rheostat called load control rheostat.
3. **C - TYPE:** It is also called split pole excitation system. The exciter is a special type of dc generator. Its pole pieces are split in two sections- a differential section and a shunt section. The differential field is wound on the differential section of each pole piece and is connected in series with traction generator. It opposes the action of the shunt field wound around shunt section and differential section of each pole piece.
4. **D - TYPE:** This is known as static excitation system. In this system, the exciter alternator supplies main generator of field current. The field of the alternator is fed from battery and is fixed. The output of exciter alternator is connected to three identical power reactors, one in each phase. These reactors control the current flow according to differential input signals received by them about speed of diesel engine, terminal voltage of main generator, MG current etc.
5. **E - TYPE:** Electronic excitation system is known as type E excitation system. In this system a dc generator called exciter excites main generator field. Average current flowing through exciter field is controlled by a power transistor called exciter field transistor working in switching mode. A magnetic amplifier called pulse width modulator controls the ON period and OFF period of EFT on getting different input signals of engine speed, main generator voltage and main generator current.

The type E excitation system as applied to ALCO locomotive is a system using semiconductor components. The system controls exciter generator field current, the

exciter output in turn controls traction generator output. The system provides the function of current limit, horsepower limit and voltage limit on the generator at each of the eight engine speeds available.

In Microprocessor controlled locos excitation is controlled through control unit cards.



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## TRANSITION SYSTEM

The purpose of transition is to obtain higher speed of the locomotive and still utilize the constant horsepower of the engine at a speed setting. The output characteristics of the traction generator, as determined by the excitation system, is such that it holds the diesel engine at approximately constant horsepower at a particular speed setting.

When the locomotive is starting, and is at low locomotive speeds, the main generator supplies a high current to the traction motor. As the traction Motor armatures begin turning, they generate a voltage commonly called back EMF. This back EMF increases the effective resistance to the current flow. Therefore, as the locomotive speed increases, the generator voltage must increase to maintain the traction motor current. The traction motor current will decrease however because of the constant power characteristics of the generator. With further increase in locomotive speed, if the back EMF reaches the voltage limits of generator, the generator current starts falling and the horsepower reduces.

However, by changing the generator motor connections, the back voltage is reduced and the generator can force more current to the motor to enable accelerations. To achieve higher starting torque, sometimes, two traction motors are connected in series during starting of the locomotive. In these locomotives, changing their connections from series to parallel can reduce the back EMF. Weakening the motor fields can also reduce back EMF. The change in the motor connections, or weakening of fields is known as an event of transition. The number of event is decided from the generator characteristics and the numbers of motors.

### FORWARD TRANSITION

In order to keep the engine working on the constant horsepower part of generator curve as much of the time as possible, transition is used. That is as locomotive speed changes, we change the traction motor circuit so that they will draw a value of current that falls on the horsepower curve.

At the start, the traction motor are connected to the generator as 2S-3P i.e. two traction motors in series and three parallel path with full field. This means the generators supplies current through three path to run six traction motors. So it has to supply only three times the signal motor current in starting. Even though the current drawn by each motor is very high, the generator is kept to reasonable size by using such a circuit.

The current drops off as the train moves out. This is shown by the arrows on the horsepower curve. At about 10 miles an hour we get on the full horse power portion of the curve. From this point it is necessary to stay on this part of the curve to get constant power from the engine. If we have a locomotive with 75 MPH gearing and 40 inch wheels, when we reach about 19.2 MPH (30.8 KMPH) point C is reached, the motor current will have dropped so much that continued acceleration would be at reduced horsepower along the field limit line.

To prevent this, the motor fields are shunted as 2S-3P WF, i.e. two motors in series three parallel paths with weak field. Part of the motor current then flows around the field) through the shunting contractors (FS21, FS22 etc.), and the shunting resistors. This causes motors to draw more current from the generator, because of fall in counter EMF. With this, operating point moves back down toward the bottom of horsepower curve .On some locomotives field shunting is done in two or more steps. This is done to keep the motor current to safe value.

As the train continues to accelerate, the generator current will again decrease (the generator current decreases as with the locomotive speed the back EMF of traction motors goes on increasing). At 30 M.P.H. (48 km/h), it will be back at the top of horsepower curve



again. To prevent unloading, the motor current must be again increased by 2nd.transition. This time we do this differently. We change the motor connections from series parallel to parallel. Instead of three paths for the generator current there are now six. This causes generator current to increase. The operating point is now backing at the bottom of the horsepower curve again. We call this 6P-FF i.e. six traction motors in parallel with full field.).

In making second transition the shunting contractors (FS21, 22 etc) are first opened. This un-shunts the motor fields. Then the series contactors S1, S2, S3 are opened and finally the parallel contactors, P1, P22, P31, P2, P22 and P32 pick up. This may happen in different sequence on various locomotives, but the end result is the same. Since the generator is at high voltage. Its voltage must be reduced before switching of motor can be safely accomplished. This is done by opening the generator field contactor- G.F.

This transition should take place at the right time. If it occurs too late, or at a too high a speed locomotive will lose power before transition. If it occurs too soon, there will be a loss of power after transition. In either case the operating point will not fall on the full horsepower curve.

As the train continues to accelerate, the generator current again drops off. By the time speed reaches 50.8 M.P.H. (81.7 kmph), the generator will again be operating at the top of the horsepower curve, point C. Now we go for parallel field shunting (transition 3). As in series field shunting, part of the motor current bypasses the motor field through the shunting resistor. The increased generator current moves the operating point down the horsepower curve, permitting further acceleration at full horsepower.

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### **BACKWARD TRANSITION**

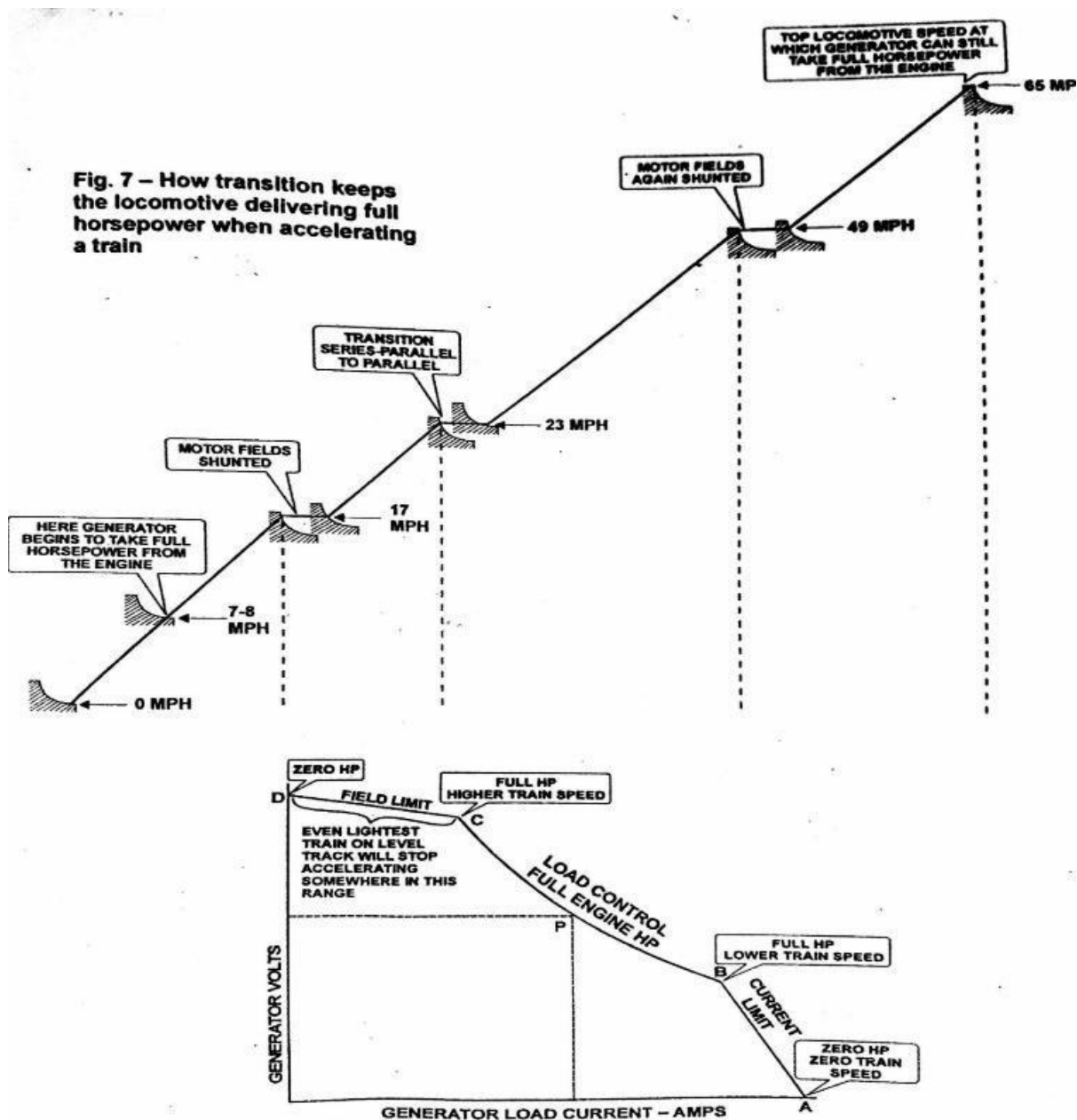
If the train hits sufficiently steep grade, it will begin to slow down. As the train slow down, generator current increase. At a speed of ground 30 M.P.H. the locomotive will be operating at the bottom of the full horsepower curve. Something must be done or the operating point will go below B on locomotives without current limits this could mean overheating the generator. With current limit the locomotive will operate at reduced power, which reduces engine efficiency. The current that the generator must supply can be reduced by making a backward transition. This will transfer the operating point back to the top of the horsepower curve point as shown. If the speed continues to drop unshunting is done.

There is one little difference in backward transition 3 to 2 from forward transition 2 to 3 on some locomotives, which at times is confusing. The generator field is left on in backward transition, but not in forward transition. There is a reason for it. If we look at the horsepower curve, we will see that backward transition takes place at point B where the generator current is high and the voltage is low. At this low voltage there is little chances of generator flashing ever when switching is done. Also during switching, this provides for the quickest rise to full voltage after the switching is completed so, we are still operating at full horsepower, but not at top of the horsepower curve.

### **AUTOMATIC TRANSITION**

We have seen that transition is made at a definite train speed and also at a definite point on the generator horsepower curve. This makes possible two methods of bringing about transition automatically, e.g.

- (i) Train speed based transition
- (ii) Generator volts and amps based transition



### Wheel Speed Based Transition (Electronically Controlled)

The type E transition control is a fully automatic transistorised system for controlling traction motor field shunting and connections. It consists of an axle driven generator and a control panel. In order to properly control transition, an accurate indication of that speed is required since transition is based upon locomotive track speed. The axle generator in combination generates this speed sensitive signal with a saturating transformer.

### GENERATOR VOLTAGE AND AMPERES BASED TRANSITION

The second method of controlling automatic transition is based on generator volts and amperes. Relays that pick up on generator voltage at the top of the generator horsepower curve bring about forward transition. Usually one relay is used for field shunting in series parallel and parallel. Another relay is used for series-parallel to parallel transition. One or more additional relays that operate in generator current at the bottom of the horsepower curve are also required for backward transition. For satisfactory operation, these relays should be accurately calibrated on the bench.

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## DYNAMIC BRAKING

By taking advantage of the traction motor's ability to act as a generator, the diesel electric locomotive offers a form of braking power which, without the use of air can be used as a speed controlling brake on grades or a slowing brake on level track. This is known as dynamic braking and is quite common on diesel electric locomotives.

The momentum of the train pushes the locomotive and turns the wheels, which drives the motors as generator. The output of the motors is fed into the braking resistors and the resistors heat up. The traction motor, working as a generator, resists the turning of the wheels and treads to stop it, so the motor is used to do the same thing as the brake shoes. In this case the braking resistor and motor instead of the brake shoes and wheel get hot. Hence, the blowers must cool them. The wheels and brake shoes do not wear because there is no rubbing,

The driver controls the braking by moving the selector handle. A load-meter shows him how much braking current he is getting. Use of dynamic brake lessens brake shoe and wheel wear on both locomotive and train. On long downgrades dynamic brake operation enables a train to be handled with fewer air applications this results in safer train operation, due to the locomotive and car wheels running cooler.

### MOTORS AS GENERATORS

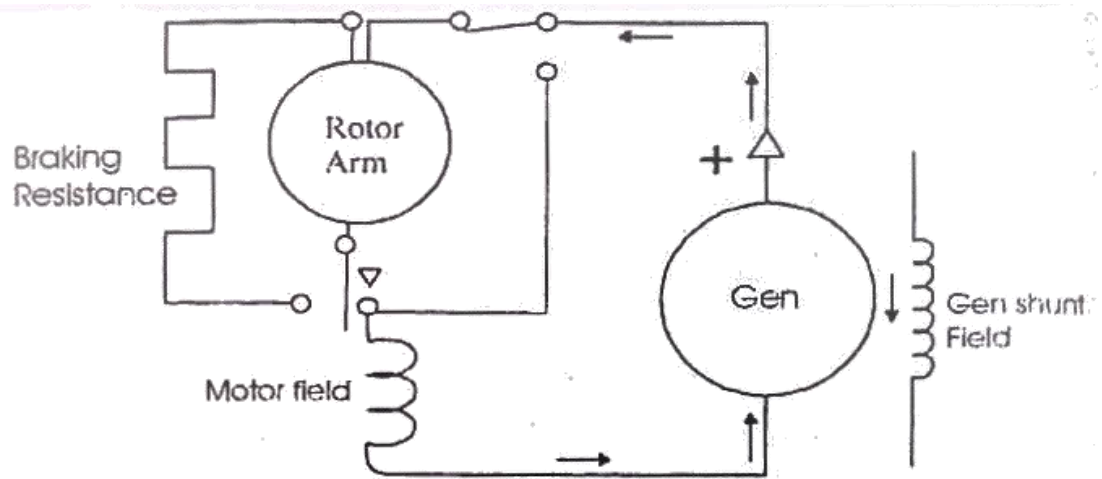
DC machine can be used as either a motor or a generator. Fig. (a) shows the motoring connections. Current is being pumped through the motor armature and field by the generator. This causes the motors to turn and move the locomotive. In Fig. (b) Switches have been shown to change the motor connections. Now the generator pumps current through the motor fields only. Two things have happened to the Armature-

1. It was cut off from the generator,
2. It was connected across the braking resistor

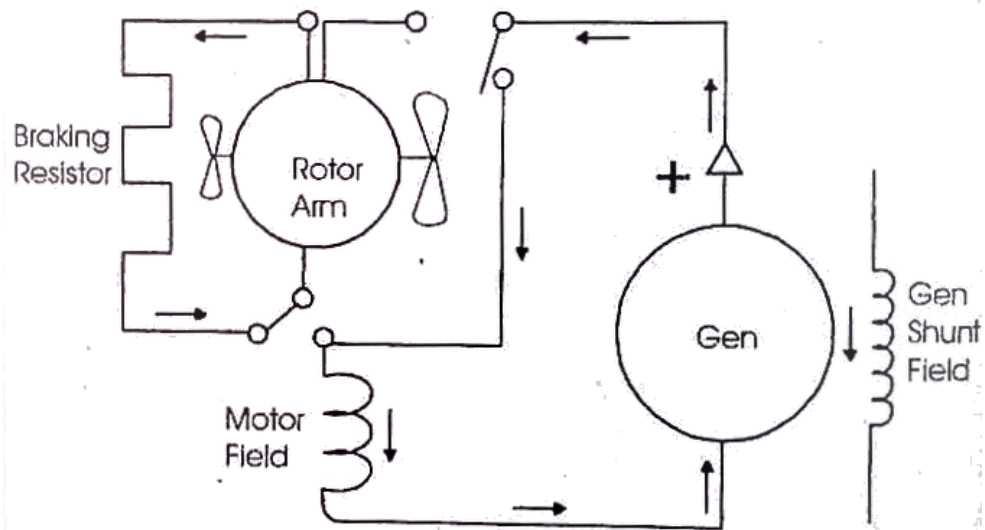
Now the motor field is separated from its armature and is pumping current through the field only. If the locomotive is moving, the wheels are turning and driving the armature. It is connected across a resistor so that it has load. In electrical language it is a separately excited generator with a load resistance.

In Fig (b) it can be seen that the field current is flowing in the same direction as in (a). But the armature current is reversed in (b). If the field current 39 (c) is reversed, the armature current will flow in the same direction as in motoring (a) i.e., if we change from motoring to braking, and the field current stays the same, the braking current will reverse. If the field current is reversed, the braking current will stay the same. There are some points about the Fig. circuit to be known for understanding dynamic braking.

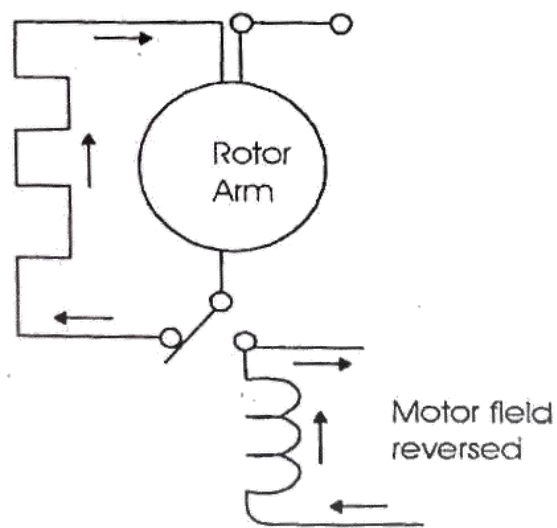
The more current we put through the motor field, (within certain limits) the more braking current we will get. The lower the braking resistance, the higher the braking current (this resistance is fixed when the locomotive is built). The faster the armature turns, the higher is the braking current. The higher the braking current, the more braking we get.



(A) Motoring Circuit



(b) Dynamic Braking Circuit



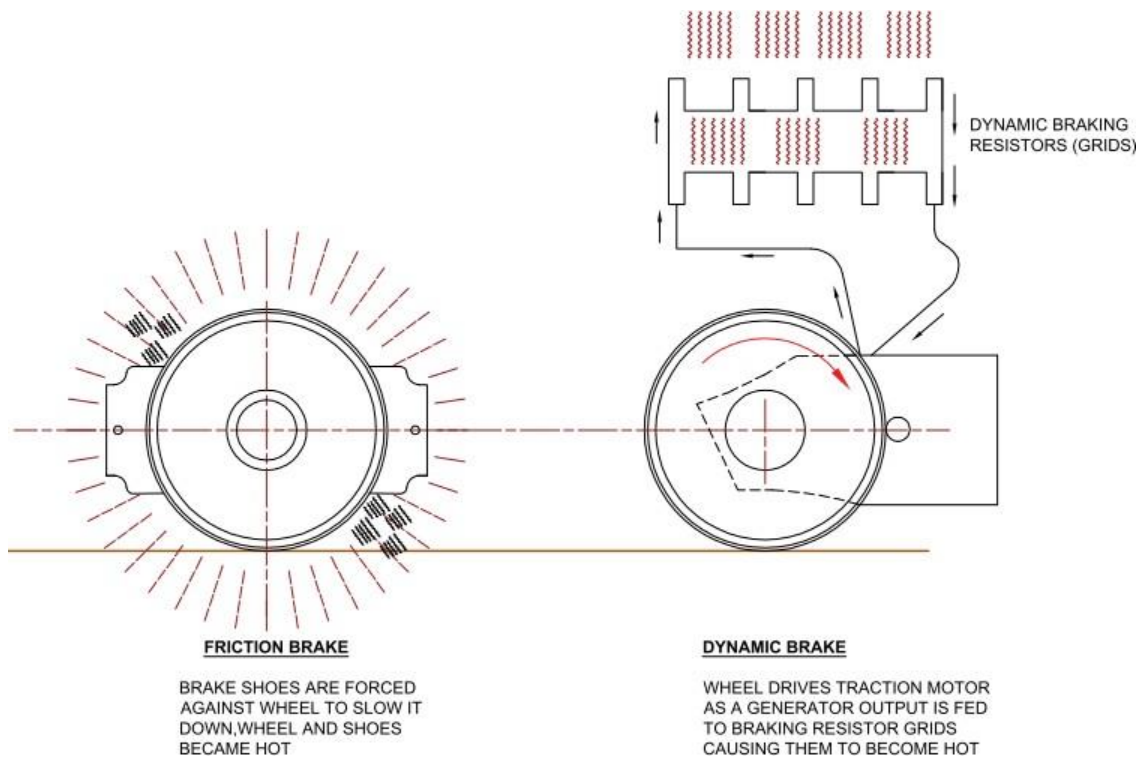
(C)

## BRAKING CONTROL

The key to controlling the output of almost any generator is its field. In this case, it is the traction motor field. Ref. Fig., the main generator supplies the current to the traction motor field. During braking, the generator is connected to the motor field only. By controlling this we control the dynamic braking current. The driver does this by moving the selector handle.

For example at high train speed we need a weak motor field to hold the braking current to a reasonable value. This calls for a small main generator output. The driver achieves this by moving the selector handle at low speed we need a strong motor field to get full braking current. He gets this by moving the selector handle further into the braking sector. The driver can get the amount of braking he wants for any speed by moving the selector handle.

The capacity of braking resistors is limited by the amount of heat it can withstand. To prevent them from getting damaged blower fans are used. The power for driving these fans is used from the power generated during the application of dynamic brake. When there is no braking current, the fans do not run, but as the braking increases, with that the braking current and heat increases and also the fan speed increases giving more cooling. Braking resistors usually require little attention. Dirt and water are the biggest source of trouble.



## RECALIBRATION OF SYSTEM

Assume that a train is drifting downgrade, and that the engine-man is preparing to apply the dynamic brake moves the throttle to -IDLE position. With the throttle in -idle all power contactors drop out and the motor generator circuits become completely de-energized.

Now the engine-man moves the selector handle from whatever motoring position it was in, to the -off and then to the -Big D' position. Moving the Selector Handle to 'Big D' accomplishes the following:

i) Causes braking switch (BKT) to throw reconnecting the power circuits.

- Connects all motor fields in series,
- Connects series motor fields across main generator,
- Connects motor armatures across braking grids,

ii) Energizes braking relay (BKR) which

- Raises engine speed to 4<sup>th</sup> notch,
- Replaces engine speed signal with braking control signal at reference-mixer circuit.
- Re-calibrates control circuits as required

iii) Sets up braking potentiometer (BKCP)

Figure shows a typical motor-generator circuit for a 4 motor locomotive. All power contactors are in their braking positions and the directions of current flow are shown.

**NOTE:** the starting field is in the circuit with the generator armature and motor fields during braking this is done to make the generator more stable at the very low range of voltages used in braking. Current in the starting field creates an opposite effect to that in the shunt field; consequently much more exciting terminal voltages then would otherwise be needed. This makes it possible to operate the exciter at output levels more nearly comparable to those in motoring.

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## CONTROL SYSTEM

3100 HP Broad Gauge Diesel Electric Locomotive is single cab, left hand drive (two control desk, left & right) CO - CO type having 6 axles and fitted with Wood Ward / MCBG governor. The locomotive employs AC/DC power transmission system. An Alternator type TA 10102EV is directly coupled with 3100 HP 16 cylinder Diesel Engine type 251 B. Three phase output of the Alternator with varying frequency and voltage depending on rpm of diesel engine and excitation level, is fed to Rectifier model AR 5400A. The rectified output from rectifier is fed to 6 DC series Traction Motors (4907BZ) which in turn move the locomotive. These motors are axle-hung, nose suspended type and are fitted on each axle of the locomotive.

The supply to the traction motors is through nine Electro-pneumatic motor contractors type M24PC2. At the time of starting all the six motors are connected in 2S-3P combination. After specified loco track speed all the six motors get connected in 6P. However, in event of fault or as per requirement any one of six motors can be disconnected from power circuit by motor cut-out switch and locomotive can thus be operated in 5P connections.

Direction of locomotive movement is selected by moving Reverse Handle to FORWARD or REVERSE position on Master Controller provided on Control Desk in the locomotive. Speed of the locomotive is varied by moving Throttle Handle on master controller from Idle to 8th notch position in eight predetermined steps.

Two DC machines type AG 3101AY-1 having two field windings namely shunt winding and series winding, are mounted on alternator and are driven by engine through gear. One of these machines is used as Auxiliary Generator (AG) delivering 72 volts DC regulated power supply for controls, auxiliary load and battery charging. Other machine is used as Exciter which feeds alternator field. Output of diesel engine is fully utilized by matching alternator requirement with that of engine. This is achieved by regulating shunt field winding of exciter through E-type excitation system or microprocessor control system.

### GENERAL DESCRIPTION OF LOCOMOTIVE CONTROLS

Most of the electrical equipment on the locomotive is mounted in a centrally located cabinet. The operator's control desk is located in the cab. Locomotive movement is directed by a series of controls: throttle, reverse and transition levers, automatic and independent brake valve handle, transition forestalling switch, and control switch.

**Throttle lever:** The throttle controls the speed of the diesel engine and, consequently, the power delivered to the traction motors. If a throttle functions through an electro pneumatic or electro-hydraulic governor, it is called an electric throttle and must be connected electrically to the governor; one that functions through the air system is called a pneumatic throttle and must set the governor through a pneumatic actuator. Some locomotives have a mechanical linkage between the throttle and governor.

1. A typical electric throttle has seven or eight running positions in addition to "stop" and "idle." As the throttle lever is moved through its operating range, various electrical connections are made between the low-voltage control lines and the solenoids in the governor. Fingers, making sliding contact with segments on a rotating drum or cylinder in the throttle, determine the fuel setting of the governor. The throttle is also interlocked mechanically with the reverser and with the transition lever if transition is controlled manually. These features ensure the opening of the main power switches when necessary during various stopping and reversing operations.



2. A pneumatic throttle is equivalent to a pressure regulating valve. Responding to the pressure established by the throttle, a pneumatic actuator determines the fuel setting of the governor. A pneumatic throttle has auxiliary contacts similar to those of the electric throttle for sequence and interlocking features. In multiple-unit operations, an airline furnishing air pressure equal to the control reservoir pressure is required between the units.

**Reverse lever:** The reverse lever controls magnet valves in the reverser, which turn the drum to change the connections of the traction motor fields. This lever must not be moved when the locomotive is moving because circuits may be shorted. If the locomotive is unattended, the lever should be taken off of the control desk in order to interlock the controls in an inoperative position. A seven position reverse lever, sometimes called a controller, is used on many manually controlled transition- type locomotives, instead of a transition lever.

### **LOAD REGULATOR**

Control of the power output of the main generator is known as load control. As load is imposed on the engine, the governor admits more fuel until the fuel limit for that speed is reached. Any attempt to increase the load beyond this point will cause the engine to slow down. At such a time, a load regulator in the generator excitation circuit automatically reduces the power output of the generator by reducing its field excitation and the diesel engine continues to run at normal speed.

### **REVERSER**

The reverser is an electro pneumatic switching device that reverses the direction of current in the traction motor field windings. When the fields are reversed, the traction motors change their direction of rotation thereby changing the direction of travel of the locomotive. The main switching element of the reverser is a rotating drum; on its surface are copper segments that contact different combinations of sliding fingers as the drum rotates. Magnet valves on the reverser are fed through interlocks on the main power switches to keep the reverser from turning except when the power circuits are open. When a magnet valve is energized, air is applied to the pneumatic mechanism to turn the drum and to establish the proper electrical connections. If the coil of a magnet valve is burned out, or if the air supply fails, the reverser may be thrown manually by depressing a button on the magnet valve. If the engine is dead, the drum can be turned by hand.

### **CUTOUT SWITCH**

A traction motor cutout switch is used to take the motors out of the circuit if there is an electrical failure in the circuit, such as a short circuit or ground. Three types of cutout switches are used: a toggle switch in each motor circuit; a multiple rotary switch which controls all motor circuits; and contacts mounted on the reverser. With rotary or toggle cutout switches, the control circuit to the main power switches passes through the traction motor cutout switch. When the cutout switch is open, the main power switches are therefore open, and the corresponding motors are disconnected from the generator. The switch setting should not be changed under heavy load because heavy currents are likely to arc and burn the contactors. Before opening a power circuit, idle the engine by the throttle or by an isolating switch.

### **MAIN CIRCUITS**

Power from the main generator is carried by electric cables to the traction motors, which are geared to the driving axles. The main power circuit is this path of current flowing from the generator through the cables and motors, and back to the generator. Locomotives have three types of circuits: series, parallel, and series-parallel. In a series circuit, the same current passes through each device and connection in completing its path to the source of supply, and the

total resistance of the circuit is equal to the sum of the resistance of all its portions. In a parallel circuit, the current from the source divides through two or more parallel paths and the total current from the source equals the sum of the current in the parallel paths. The resistance of a parallel circuit is always lower than the resistance of any of its individual parallel paths. A series of Christmas tree lights in which all go out when any one burns out (opens the circuit) is a familiar example of a series circuit; each bulb can stand only a portion of the voltage from a house circuit. The lights in which the other bulbs continue to burn when one burns out is a parallel circuit; each bulb operates on house voltage. If motors are connected in the same manner as the lamps, the same circuit characteristics apply. The difference in operating characteristics of motors at different voltages is a chief reason for the relatively greater number of methods used for connecting traction motors. Many different designs of main power circuits are used. Each circuit is independent of the others, except for the small wires in the wheel slip relay circuit. Connections in many locomotives are permanently joined in series-parallel. A tie between the motor circuits exists when portions of the circuits are in series parallel and no contactors are used. In order that full generator voltage can be applied when the motors are in series connection, a contactor will close if the tying circuit is in use and other contactors will open the circuit to and from the generator.

In electric drive, power can be easily varied. The throttle adjusts voltage, current, and tractive effort. While the throttle remains in the first notch, the current, or amperage, decreases rapidly because the motors, which are increasing speed, develop a greater counter-voltage. If the throttle is moved to a higher position, the fuel supply is increased and the engine and generator can deliver more power. When the throttle is advanced as far as possible, engine speed and generator voltage are at their maximum. Various devices are used to change the connections in the circuit. The most common are the contactors, interlocks, magnet valves, and relays.

**a) Contactors** are switches used for opening and closing circuits. In circuits where the current is low, the contactors are magnetically operated and are energized by current from the battery/AG. The magnet brings a movable contact into touch with a fixed contact in the main circuit; when they are not being used, a spring pulls the movable contact away. When a contactor is used in a traction motor circuit and has to handle heavier current, the contact tips must be pressed together tightly. Operated by compressed air, they are called pneumatic contactors although they use magnetic valves. When the operating circuit is closed and current flows through the coil, it moves the core by magnetic attraction and this movement opens the air valve.

**b) Interlocks** are auxiliary switches designed to control the connecting or breaking of circuits. Operated by another switch or perhaps by a contactor or valve, interlocks are called either "In" interlocks, closed when the main switch is closed, or "Out" interlocks, closed when the main switch is open.

**c) A magnet valve** consists of a magnet coil and a core acting upon an air valve. The coil is in the low-voltage control circuit and connected through interlocks, automatic controls, or manual controls in the same manner as the coil on a contactor. It usually returns to its de-energized position by spring action. The valve and coil are used in such applications as shutter control, compressor synchronization, and sanding, as well as in reversers and power switches as a built-in portion of the equipment.

**d) A relay**, a small magnetic electric switch consisting of a coil and several small contacts, changes connections in one part of a circuit in response to changes taking place elsewhere in the circuit. The relay coil may be in either the high-voltage or low-voltage circuits of the locomotive. Operating in much the same way as contactors, relays are not required to carry heavy current and are generally much smaller. They may be adjusted to open and close at

various voltages to respond to operating conditions. When the contacts of a relay close, they close the circuit to the coil of the contactor or magnet valve controlled by the relay. More than one contactor in a magnet valve can be controlled by a relay by building the relay with several sets of contacts.

**e) Transition lever**, ordinarily, a transition lever is provided on locomotives having manually controlled transition. It may also be installed on locomotives having automatic transition in order to control circuits during multiple-unit operation with locomotives having manual transition. A braking position, for dynamic braking, is sometimes provided. Because of the definite relationship between current and speed, the proper step of transition is usually indicated on the dial of the load ammeter or speedometer.

**f) Automatic brake valve handle**. The automatic brake valve controls the operation of brakes on the locomotive and on the cars when they are properly connected. The independent brake valve controls the operation of brakes on the locomotive only.

**g) Transition forestalling switch**. A transition forestalling switch on the control panel is used to prevent undesired forward transition on automatic equipment. Backward transition is determined by the operation of a backward transition relay, or by reducing the throttle to the idle position.

**h) Control switch**. A switch, usually called the control switch, connects the control circuits to their source of power. All controls except those for the locomotive lights and, in some models, the engine starting circuit are normally fed through this switch, or through interlocks whose setting is dependent on this switch. It is, therefore, equivalent to a master switch for locomotive controls on both the leading locomotive and on any trailing locomotive to which the controls are connected in multiple.

### **MULTIPLE- UNIT EQUIPMENT**

When locomotives are connected but their power systems remain independent, the process is known as double heading. However, if electrical connections are made and all locomotives are controlled from single loco, it is called multiple-unit operation. Equipment for connecting units in multiple consists of a jumper with the following control wires: control switch, forward-reverse control, throttle, sanding, and alarm and indicating circuits, and emergency shutdown switches. The wires are connected to a plug which is keyed in such a way that it can be inserted in the end receptacle of the locomotive in the correct position only. The locomotive from which operation is controlled is called the leading unit and the others trailing units. On all trailing units, engines are started and battery switches closed before operation begins.

### **AUXILIARY POWER SYSTEM**

The auxiliary generator is used to charge the storage battery and to power the low-voltage circuits for lighting, control equipment, fuel pump motor, and field excitation. It may be driven by belt or gear from the shaft of either the engine or the main generator and is usually mounted on the generator's frame. The auxiliary generator assumes the load after the battery has supplied power for starting the engines.

A breaker-type switch or a fuse disconnects the auxiliary generator; if this switch or fuse is open, the battery must supply all low-voltage requirements. Many locomotives also have an auxiliary generator field switch; it is opened when the locomotive is shut down and kept open until after the engines are started again. On locomotives having both these switches, the field switch is in the equipment cabinet.

- A. **Voltage Regulation**: The auxiliary generator output is regulated by changing the strength of the auxiliary generator field; if the speed of the auxiliary generator increases,

the shunt field strength must be decreased to maintain a constant voltage. A regulator may consist of a small torque motor or of relays which are sensitive to changes in voltage. The movement of these elements changes the resistance in the field circuit. The operating principle of the voltage regulator is that the voltage generated is proportional to the shunt field strength. The voltage regulator increases the resistance of the field, thereby reducing the flux. If such external conditions as generator speed, load, or internal shunt field resistance cause a change of torque on the torque motor armature, the armature will move the sectors in such a direction as to cut short field resistance in or out and re-establish the set voltage at the same voltage for every position.

- B. **Battery System:** The storage battery supplies power for cranking the engine and also to supply power to the control and lighting circuits before the engine is started. After the engine starts, these circuits draw on the auxiliary generator. The battery is beneath the under frame, beneath the cab floor, or in the compartment next to the cab. A switch in the equipment cabinet or on a nearby panel connects the battery to the auxiliary generator and control circuits. The battery ammeter indicates the rate of charge or discharge of the battery; it should indicate zero or various charge readings when the engine is running. As soon as the engine is cranked, the auxiliary generator starts to restore the current and the ammeter should register a charging current until the battery is charged. The battery may also be charged from shop circuits or terminal yard circuits through external charging receptacles. When the engine is shut down or if the auxiliary generator voltage drops too low to charge the battery, a reverse current relay opens a battery contactor between the auxiliary generator and the battery, preventing the battery from discharging back into the auxiliary generator windings.

## **DESCRIPTION OF ITEMS OF WDG3A**

### **Master Controller Type MC3802B**

Master Controller is a manually operated aluminium Cam operated contact switch for closing or opening of contacts in a sequence determined by design. The master controller is mounted with the help of three holes in the control stand. The overall size of the master controller is 540 x 260 x 654 mm and the weight is 50 Kg. The main body of the master controller comprises of aluminium casting, support bars and shafts. The support bars are fastened to the top and bottom plates by inserting both ends into the top and bottom plates and locked with the help of hollow pins inserted through drilled holes. The braking control potentiometer is fixed under the bottom plate with the help of three hexagonal pillars. The braking potentiometer is operated by the shaft of main drum. The interlocking mechanisms are mounted on top and bottom plates.

The Master controller has the following three mechanically interlocked handles for different features of the locomotive operation. The wheel and reverser handle opens or closes the cam operated auxiliary switches provided with pure silver tips on moving and fixed contacts.

- Removable reverse handle for FORWARD AND REVERSE OPERATION of the locomotive.
- Selector handle for MOTORING and DYNAMIC BRAKING
- Hand wheel for speed and power control. This wheel, besides the idle position, has 8 notch positions and provided 8 speeds of the diesel engine, thus giving 8 different H. P. outputs.
- Mechanical interlocking is provided in following way-
- Reverse handle can be removed at its own 'O' position, when 'M-B' selector handle is in 'M' position and main drum wheel is in 'Idle' position only.
- Reverse handle inserted in its 'O' position, main drum wheel can be moved at any position towards motoring or braking with the help of selector handle in position 'M' of 'B'. Reverse

handle cannot be removed until the selector handle is brought at position 'M' and main drum wheel is brought at Idle position.

- Reverse handle can be moved from position 'O' to position 'R' or from 'O' to position 'F' when main drum wheel is in position idle or position "O".
- Reverse handle removed, main drum wheel can be moved from 'O' to "Idle" or "Idle" to 'O' when 'M-B' selector handle is in position 'B' only.

### **Reverser/ Power Brake Switch**

The 6 motor reverser is remotely controlled offload operated power switch used for reversing the direction of rotation of traction motors. Similarly the power brake switch connects the motors and fields suitably by motoring and dynamic braking. The reverser BKT assemblies consist of the following main parts, power contact blocks interlocks, and cylinder assembly. These main parts along with other components are mounted on an end frame, cylinder and end frame have special mounting feet to bolt the reverser in position. When the reverser handle on a master controller is moved either to the forward or reverse position, the corresponding interlock on the reverser closes to activate either the forward or reverse magnet valve which in turn operate the main reverser contacts to switch traction motor fields to corresponding interlock on the reverser closes to activate either the forward or reverse magnet valve which in turn operate the main reverser contacts to switch traction motor fields to correspond to the position of the reverse handle. When the selector handle on master controller is moved to either motoring or braking position corresponding magnet valve energizes and puts the circuits in motoring/ braking modes accordingly.

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## LOAD BOX TESTING OF DIESEL LOCOS

This is a test to check the capability and performance of the engine by simulating the actual working condition of the locomotive at rated output, in static condition.

During load box test, the output of the engine is measured in terms of electrical parameter (volt and ampere). In this, the output of the generator is connected across a set of resistance (Load Resistance) instead of connecting it with the Traction Motors. The output of the engine is dissipated in terms of heat across the resistance during Load Box test.

### Types of Load Box Test

They are of two types, based on the type of load resistance connected:

- 1) Grid Resistance Load Box Test
- 2) Water Resistance Load Box Test

WATER RESISTANCE	GRID RESISTANCE
Load resistance can be varied at infinite stages, hence a continuous HP curve can be plotted through this.	Load Resistance can be changed only at limited stages (3 to 6). Hence a complete graph cannot be plotted to understand the complete behaviour of the output.
Load resistance can be changed during loaded condition.	To change the load resistance in grid type, the locomotive requires to be stepped down to lower notch as such load test gets interrupted as many times the resistance required to be changed.
Water load box can be conducted for a longer duration because of better heat dissipation facility	Grid resistance load box cannot be conducted for longer duration, as it gets heated up quickly causing hazardous environment and gives erratic reading.
Requires permanent establishment to setup water load box, hence cannot be shifted easily.	Comparatively handy and can be shifted with lesser effort.

### WHY, WHEN AND WHERE TO CONDUCT LOAD BOX TEST

#### Object

1. To see whether the engine gives designed output or not.
2. Whether all systems are functioning properly or not.
3. Whether any problem is connected to any system or component.

#### When

1. After new manufacturing
2. Before and after major repairs
3. Before and after major schedule.
4. To diagnose any specific problem existing in the engine

#### Where

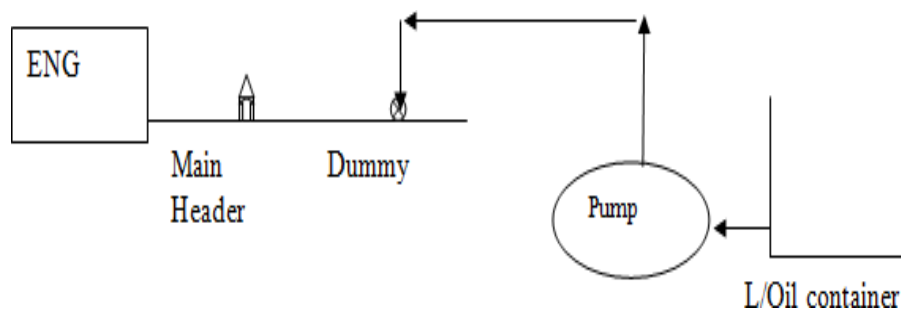
1. It is conducted on the specified Load Box area in the shed or in the workshop.  
(In case of GM locomotive, the facility of Load Box Test exists within the loco itself)

## PROCEDUR

### (A) PREPARATION FOR STARTING LOCO

1. Water filling
2. Fuel filling and bleeding test.
3. Supplement the engine with supplements e.g. TG/TA, Gear Box oil, Gov. oil, Compressor Oil, Intake filter oil, Right Angle gear box oil and also greasing Rod fan bearings, Horizontal shaft coupling, universal shaft coupling, cardium compound ( Servo Cot 170 T) filling in Compressor Coupling etc.
4. Pre lubrication.

Lube oil is not directly filled in the Engine sump. Instead , it is filled through an external pump by opening a dummy in the Lube oil main header (as shown in the figure below) so that the Lube oil can circulate through all the engine components and finally drops down to the sump. This is also termed as pre-lubrication. During pre-lubrication the following checks are necessary to carryout.



\*\*During pre-lubrication, test filters are necessary to be fitted to arrest the worn out metal particles and the metal chips left out in the process of overhauling or manufacture.

#### Check during Pre-Lubrication

The flow of lubricant during pre-lubrication will be as per the following pattern:

Oozing : Con Rod bearings, M/Bearings, cam bush, valve lever bushes

Spray like jets : Piston

Pouring : F.P. Support, valve lever, Yoke

Dripping : Liners

Trickling : Cam Gear.

### (B) STARTING

1. Engine is started immediately after pre-lubrication and allowed to run for a minute or two. During running unusual sound or leakage is observed, if any.
2. If O.K, run the engine for 5 minutes and stop. Check the following:
  - Check Main Bearing temperature, it should not vary more than 5°C from one bearing to another.
  - Check and rectify if any leakage is there in L/oil system (especially S pipes) or water system etc.
  - Check the lube oil sump strainer for any foreign particle, metal dust etc.
3. Run for 30 minutes; observe unusual sound, leakage, smoke etc. if any.
4. Stop engine and check Main Bearing temperature, internal leakage of water, Lube oil etc. (if any) Examine crank case for any foreign material or worn out metals.
5. Continue run until temperature reaches 120°F and check between two stretches of runs.
6. Run the engine for 6 to 8 hours to complete idle run.

### (C) Notch Up

1. Engine is then notched up to 8<sup>th</sup> notch with the continuation of 15 minutes run in each notch.
2. After notch up remove all the test filters and connect the original pipes before conducting load box. Check all the test filters for any foreign materials or worn out metal particles, if any. Take remedial measures accordingly.

Engine speed according to notches should be within in  $\pm 5$  RPM as follows:

At Notch	Engine RPM	At Notch	Engine RPM
1	400	5	750
2	450	6	850
3	550	7	950
4	650	8	1050

### (D) PRE LOAD TESTING

#### ➤ Shut Down Condition

##### 1. Electrical testing

- Conduct insulation test (Meggar test) between Power circuit to earth. Control circuit to earth. Power to Control and also in all cards.

**Range: 1 to 5 Mega Ohms**

- Check all carbon brushes of rotating equipment.

##### 2. Mechanical testing

Examine crank case for the following:-

- Foreign material, split pin, loose nut etc.
- Internal leakage, if any.

#### ➤ Running Condition

##### 1. Electrical testing

- Notch wise voltage at No Load to be checked connecting voltmeter Across CK1 & CK2 (fixed contact). Voltage is displayed directly on display unit in MEP locos.
- Check engine speed notch wise.
- Check reference volt across wire No 29 A & 4 as 24.4 volt (E type )
- Check AC Volt across 31L-31M, 31M-31N, 31N-31L as 100 to 105 V on 8<sup>th</sup> notch.
- Check Battery Volt (across CK1&CK2 moving contact):  $72 \pm 2$  volt.
- Check correct operation of LOPS, LWS, T1, T2 & ETS, GROUND RELAY, WSR etc.

##### 2. Mechanical testing

- Check correct setting of OST.
- Check Turbo Rundown Test: 90 to 180 sec.

### (E) PREPARATION FOR LOAD TESTING.

#### 1. Mechanical

- Fit adpoter for KIENE gauge removing all decompression plugs.
- Fit temperature gauge removing exhaust plugs.
- Fit temp gauge before and after TSC.
- Connect temp gauge before and after, After Cooler.
- Connect temp gauge before and after Lube Oil Cooler.
- Fit Pressure Gauge before and after Lube Oil Filter tank.
- Fit Pressure Gauge at Water Pump outlet and Water Headers.

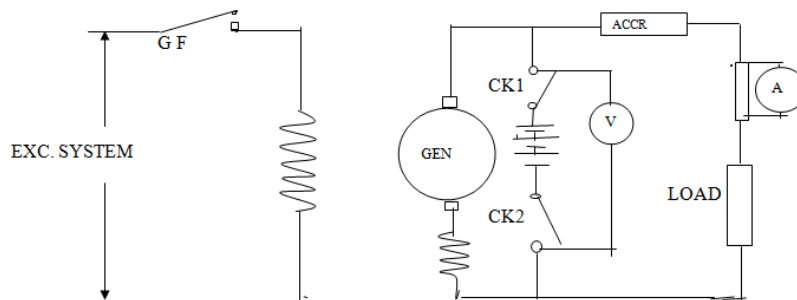


- Fit Vacuum Gauge at compressor Crank case.
- Fit Water Manometer at crank case cover for measuring Crank case Vacuum.  
(Specially fabricated for taking crankcase vacuum.)

Following mechanical parameters/readings are noted during load test.

- Lube oil pressure of engine, compressor at each notch.
- Fuel oil pressure on each notch.
- Booster Air Pressure
- Compression, firing pressure of each cylinder and exhaust gas temperature.
- Vacuum of engine sump and compressor.
- Lube oil pressure before and after lube oil filter housing.
- Air temperature before and after of after cooler.
- Water temperature at inlet of after cooler.
- Lube oil temperature before and after lube oil cooler.
- Exhaust gas temperature before and after turbo super charger
- OST trip RPM
- Fuel rack position at each notch
- Exhaust gas colour and remedy

## 2. Electrical



- Disconnect 3 GA-2 cable from MG/ rectifier negative terminal. In their place connect 3, 2300/24 cables at the negative side of water load box.
- Disconnect 3 motor armature cable A1, A2, A3 and 3 GA1 cables running each to P1, P21 and P31 from negative side of ACCR. Connect three 2300/24 cables instead of six to the positive side of the water box.
- Connect voltmeter, ammeter according to the figure, as above.

Electrical Parameters to be checked during Load Test of Loco

- Position of LCP at each Notch
- A C voltage at each Notch
- Reference voltage at each Notch
- No load Voltage at each Notch
- Load Current at each Notch
- Auxiliary Generator output voltage at each Notch
- Engine RPM
- Dynamic Brake voltage
- Dry Run Test in MEP Loco

## LOAD TEST OF DIESEL LOCO

- Check Engine Mechanical Over speed Trip – check over speed switch by running engine in 8<sup>th</sup> notch and shutting down the engine through increasing RPM by increasing fuel supply / putting MCBG knob on mechanical/electrical position. This speed should be at around 1130 rpm , if not so ; adjust the over speed rpm through over speed trip assembly by loosening the lock nut and screw the spring retainer in or out to increase or decrease the shutdown RPM.
- Set no load voltage

- With engine running at 8<sup>th</sup> notch, load engine to full load for 30 minutes and then check the engine Horsepower by noting generator / alternator voltage and current.
- Full load horse power for a diesel loco is the Horsepower input to the main generator / alternator for traction purposes (THP) and is obtained as :

$$\text{THP} = (\text{Volts} \times \text{Amperes}) / (746 \times \text{Generator efficiency})$$

For convenience in testing the denominator can be approximated as 700. These electrical readings are to be taken while the air compressor is running unloaded, the fan is running at full speed, the traction motor blowers are running against normal motor resistance or equivalent, and auxiliary generator is loaded as required by auxiliaries necessary for running the engine.

Standard conditions for rating of the engine:

- Air temp 60°F to be taken immediately ahead of air filter inlet to turbocharger. Fuel temp. 60°F
- Sea level to 1000 ft. altitude
- Specific gravity of fuel 0.845 ( API 36 at 60°F )
- The corrected THP can be approximately estimated as follows:

$$\begin{aligned} \text{Corrected THP} &= \text{observed THP} / (a) \times (b) \times (c) \\ &= (\text{Volts} \times \text{Amperes}) / (746 \times \text{Generator efficiency}) \times (a)(b)(c) \\ &= (\text{Volts} \times \text{Amperes}) / (746 \times 0.96) \times 0.98 \\ &= (\text{Volts} \times \text{Amperes}) / 700 \text{ (approx.)} \end{aligned}$$

Where a = correction factor for temp at engine air intake filter

b = correction factor altitude

c = correction factor for fuel density

Value of above correction factors to be taken from standard chart corresponding to standard conditions.

### **Turbo Smoke Analysis**

- A healthy engine will give colourless, odourless smoke.
- Black smoke means incomplete combustion.
- Greyish blue smoke means lube oil burning in combustion chamber. It indicates more valve guide clearance/ defective oil rings/ ovality in liners.
- Greyish Blue smoke accompanied with oil throw means defective turbine end oil seal of TSC or excessive clearance in valve guides.
- White smoke means water ingress in combustion chamber. Cracked cylinder head or bursting of after cooler tubes may be the cause.
- A flame from turbo means air starvation either due to choked air filters, defective TSC or completely choked after cooler.
- Intermittent Puffy black smoke means dribbling nozzles.
- If the smoke is clear in lower or higher notches and not in intermittent notches, it means that the notch wise Horse Power distribution is not proper.

### **Crank Case Smoke Analysis**

- Black smoke means poor blow by i.e., gases are going in the combustion chamber.
- White smoke means water leakage in crank case.
- Grey smoke means piston or main bearing likely to seize.
- Flame means a piston or bearing is already seized.

### **Sound Analysis**

- If there is smoke and hammering sound, then the piston or main bearing is going to seize and in case there is a flame also, it has already seized.
- If there is a chipping sound, valve sticking and tappet clearance are not proper.
- If there is a jingling sound, the governor is defective or control bar jam or loose racks.

- If there is rattling sound, either clamps or foundation bolts are loose.
- In case of hissing sound (not continuous), piston rings are in one line.
- If there is a rubbing/honing sound, some moving component is rubbing against each other.
- If it is howling sound (Continuous), clearances are narrow- turbine & nozzle ring, fan and fan guard, etc.

### **Current Limit**

Current limit depends upon the generator make. It should not be for longer time periods, otherwise the generator may get damaged. That is why at 8<sup>th</sup> notch only the time for taking readings is allowed.

### **Crank Case Vacuum**

Engine – 1.25ℓ of water on full load. If it is less than 0.9ℓ of water at any notch, lube oil consumption will go up. If more than 1.25ℓ of water, piston nearer to the CCE motor will starve for oil and cease.

Compressor Pressure at 8ℓ notch should be between 900-1100 psi, subjected to the difference between the highest pressure and lowest pressure of any cylinders limited to 45psi. Firing pressure at 8ℓ notch should be 1500-1800 psi subjected to 45 psi difference between maximum and minimum. If the difference is more than 100 psi, then there will be more load on vibration damper and fatigue signs will appear in crank shaft and piston pin holes.

Exhaust gases temperature before cylinder heads should be between 850-1000<sup>0</sup> F subjected to the difference between highest and lowest not exceeding 100<sup>0</sup> F.

Exhaust gases temperature before turbo should be in the range of 900-1100<sup>0</sup> F. If it is more than 50<sup>0</sup>F to cylinder head, it means fuel is burning in the exhaust manifold i.e., the combustion is not complete in combustion chamber. The faulty cylinder head can be detected through firing pressures. Exhaust gases temperature after turbo should be 850-1000<sup>0</sup>F. If there is approx. 100<sup>0</sup>F drop across turbo, it is very good. But if the drop is less than 50<sup>0</sup>F, it means turbo is not utilizing the heat it is supposed to absorb resulting in the poor efficiency of the turbo.

- If compression pressure is alright and the firing pressure is less- Fuel injection equipment is faulty.
- If both compression and firing pressures are bad with higher exhaust gases temperatures- Air starvation of Air/Fuel ratio not proper meaning pump output may be more.
- If compression pressure of one cylinder is less- Poor blow by.

### **Rack position**

The ideal notch wise rack position should be:

Notch	Rack opening
Idle	9 ± 0.5 mm
1 <sup>st</sup>	9 - 11 mm
2 <sup>nd</sup>	13.5 ± 0.5 mm
3 <sup>rd</sup>	16 ± 0.5 mm
4 <sup>th</sup>	19 ± 0.5 mm
5 <sup>th</sup>	21 ± 0.5 mm
6 <sup>th</sup>	24 ± 0.5 mm
7 <sup>th</sup>	27 ± 0.5 mm
8 <sup>th</sup>	29 ± 0.5 mm

\*\*\*\*\*

# TRACTION MOTOR

Traction motor is one of the important equipment fitted in diesel locomotive, which plays a vital role for smooth running of locomotive. The function of traction motor in the locomotive is to convert electrical energy to mechanical energy for rotating the wheel of the locomotive.

## PROBLEMS ASSOCIATED WITH TRACTION MOTOR

Failure of Traction Motor on line creates a setback in train service and also detention of the locomotive for longer period at the out station. At times, it so happen that the locomotive is to be brought to shed by lifting the corresponding wheel in a restricted speed. Hence, better maintenance practice from shed as well as shop are important to increase the high degree of reliability of Traction Motor and also to decrease the under repair position in shed on account of traction motor failure.

### Main causes of traction motor failures are as under:

1. Power ground failures due to
  - Problem of puncturing of interpole coils
  - Damaged insulation of leads
  - Low LR of armatures.
  - Carbon brush holder flashed or dislodged from its position.
  - Breakage of carbon brushes
  - Some object falling inside the traction motor
2. Wheel slip failures due to
  - Opening of interpole joints.
  - Breakage of interpole coil ends
  - Loosening of interpole bolts.
  - Breakage of traction motor pinion teeth.
  - PE bearing outer seal worked out.
3. Axle Locking due to
  - TM bearing seized
  - Breakage of pinion teeth or bull gear hindering free movement.
  - Leakage of cardium compound resulting in dry running.
  - Suspension bearing seized due to imperfections in wick pad assembly or traction motor magnet frame.
  - Gear case falling down due to bolt loosening, resulting in leakage of Cardium compound (Servo coat 170 T)

### Pay following attention in various schedules

#### M<sub>24</sub> Schedule

- Take out TM from bogie.
- Check initial IR, end play, bearing sound, and commutator run out i.e. (ovality).
- Check armature bar to bar drop test and main field & interpoles resistance values.
- Check visually condition of outgoing cables and their thimbles.
- Dismantle TM as per MI grinding of commutator should be done before dismantling if commutator ovality is more than 0.002".

**(a) Magnet Frame**

- Clean Magnet frame as per M I with orion-77 and bake in oven for 8 hours at 120°C.
- Apply F-93 finishing varnish on field as we as compole coils.
- Torque all MP & compole bolts at 55 kg m.
- Check all brush gear leads and RDP a thimbles of brush gear leads.
- HI- pot test of MF to be done at 1500 v for 15 sec.
- Check IR before and after HI- pot test.
- Check and attend nose wear plate, suspension bearings keys.
- Replace gear case holding lugs per requirement.
- Provide color coding on PVC sleeve of outgoing cables and crimping of thimbles.

**(b) Armature**

- Air blowing to be done.
- Clean pinion and check visually.
- Clean armature& outside bearing.
- Carry out mica under cutting & chamfering schedule.
- Seal PTFE"V" ring with araldite.
- Check final IR of armature and record.

**(c) Brush Holder Assembly**

- Remove c/brushes and clean brush holder.
- Check insulating pins for loosening.
- Conduct Hi-pot test at 3 KV and check IR of insulating pins.
- Check brush holder spring and check/ adjust spring pressure 4.5/5.5 kg.
- Assembled TM as per MI.
- Check light run test of TM at 90v for Two-Two hours in both directions.
- Check/Watch bearing temperature and bearing sound.
- Air blow TM after final checking of brush holder connections and gap. Check finally tightness of c/brush pigtail and fit inspection covers.
- Check final IR and End Play (170 to 300 micron) and record.

**(b) Gear Case, Gear Wheel and Pinion**

- Clean the gear case and check for any cracks. The holes for gear case bolts should be checked for correct size.
- Clean the gear wheel and pinion with xylol /Orient or suitable solvent. The teeth should be free from cracks and the flanks should have uniform, unscored polished appearance. The tooth profile should be substantially the same as that of new. If a gearwheel / pinion has chipped or broken or badly worn teeth, replace it.
- The Gear Wheel and pinion should be removed from service when the width at tooth tip or maximum wear per flank measures less or more than the following limit.

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# **MICROPROCESSOR CONTROL SYSTEM**

## **MEDHA MICOPROCESSOR LOCO**

The diesel locos working with DC traction motor employ AC/DC power transmission system. The basic block diagram of the locomotive control system is shown in fig given below. Traction alternator is directly coupled with diesel engine. The three phase output of the alternator with variable frequency and voltage is fed to a rectifier through the panel, depending on the RPM of diesel engine and excitation level of the alternator. The rectified DC output is fed to the traction motors mounted on individual axles through electro-pneumatic power contactors. At starting, the traction motors are connected in series-parallel. When a specified locomotive speed is achieved, motor transition takes place by changing the connection configuration of traction motors to series parallel to series parallel with shunt fields or series parallel with shunt field to parallel (6P) and vice versa, when the speed is reduced as per the setting done in the configuration parameters. For example, in WDM series locomotives, three transitions are provided such as series parallel, series parallel with field shunt and parallel.

The locomotive has a master controller on the control stand for control operations such as traction or braking mode, engine RPM and power level through eight notches. Control equipment on the locomotive works on a regulated power supply generated by an auxiliary generator. Fields current of the auxiliary generator is controlled by an AG control circuit to regulate its output voltage. A DC machine called EXCITER GENERATOR supplies power to the field winding of the alternator. Field winding of exciter is controlled by an exciter control circuit to maintain the required power level to the traction motors. To reduce the speed of a moving locomotive, in addition to mechanical braking, an electrical (dynamic) braking and a computer control braking systems are used in these locomotives. In dynamic braking system, the DC traction motors work as generators and dissipate the power generated in grid resistors. Thus, for operating a locomotive, following control systems are required:

- Auxiliary generator control for charging the on board batteries and supplying power to other equipment.
- Propulsion control to run the locomotive in traction/braking mode, forward/reverse direction, etc.
- Excitation control to run the locomotive at different power levels as per the requirement.
- Wheel slip control to detect the slipping of wheels and taking corrective action.
- Dynamic braking control.

## **LIMITATIONS OF NON-MICROPROCESSOR LOCO**

The older locomotive control system consists of different panels having analogue control circuits to achieve the desired operation. The control system being analogue type has following inherent limitations:

- Setting of power levels for different notches, transition speeds, etc. has to be done with potentiometers, which make the adjustments cumbersome and inaccurate.
- Regulating within the short term current ratings of traction motors is dependent on the loco pilot.
- In case of a failure in any equipment, there is no assistance to the loco pilot or maintenance staff regarding the exact fault and its remedies.
- There is no system self-tests.
- The wheel slip is detected based on the difference in currents of traction motors, and the control is not proportional to the amount of wheel slip.

- In case of faults, a larger portion of the system needs isolation, thus reducing the available power.
- The propulsion control logic uses a number of interlocking relays and contacts of contactors with associated wiring. This makes the system prompt to failure.
- It is not possible to have automatic recovery of faults, which are transient in nature.

## **FEATURES OF MEDHA CONTROL SYSTEM**

- MEP 660 overcomes all the above mentioned limitations. It also provides a superior control mechanism, protection to traction equipment, fault diagnostics, adaptability to different engine types, and flexibility in system configuration, etc.
- Microprocessor continuously monitors the train line signals and control excitation of the alternator, based on the operating requests of the loco pilot. It measures various analogue parameters and digital feedback signals from the traction equipment and controls the excitation in such a way to maintain a constant horse power of the diesel engine.
- The microprocessor control system eliminates various general purpose interlocking relays for propulsion control of the conventional system, thus reducing the number of interlocks and associated wiring, and enhancing the reliability of the locomotive working.
- The microprocessor system controls the excitation of the auxiliary generator so as to maintain a constant output voltage for battery charge as well as control circuits in spite of variation in the engine speed from idle to 8<sup>th</sup> notch.
- The wheel slip control in the microprocessor system is based on measuring the actual RPMs of all six wheels of the locomotive or traction motors depending on the type of sensors installed with the system. With this system, the slip can be identified at the very initial stage itself. Once the wheel slip is identified, it controls the excitation in such a way that it delivers maximum possible tractive effort depending upon the adhesion between the wheel and the rail in the given environmental and track conditions.
- The microprocessor control system also monitors currents, voltages, temperatures, etc., of various traction equipment's and controls them in such a way that they always operate within the set specified limits. This enhances the life of the traction equipment and improves the reliability and availability of the locomotive.
- Microprocessor has fault diagnostic capabilities. The system continuously monitors various operational parameters and checks for abnormalities in the functioning of various traction equipment's. In case if a fault is identified, an appropriate action by way of isolating a sub system or limiting the power ,etc., is taken to prevent further damage to the equipment and other connected equipment.
- MEP 660 control system has number of test modes, which help maintenance staff in identification and rectification of faults quickly.

## **ADVANTAGES OF MEDHA CONTROL SYSTEM**

### **Protection of Traction Equipment's**

- The exciter field current and armature current are measured and they are always limited to user-programmed levels, to prevent damage to the exciter. Accordingly, the traction alternator field winding is also protected.
- Traction alternator voltage, current and HP are limited continuously at each RPM so that they are never exceeded.
- All the traction motor currents are continuously monitored and the short term current limits are automatically observed a thermal modelling in the software continuously

calculates the power dissipated in the traction motor and its cooling at the given engine speed and protects against the over temperature of the traction motors. This philosophy allows maximum possible power to be delivered within the protection limits. In such case if temperature exceeds the safe limit, the excitation is reduced automatically to limit the traction motor with an appropriate warning message on the display. With this the dependence on the loco pilot's skills and attentiveness to observe short term current limit is avoided.

- It protects auxiliary generator and batteries.
- It protects the rectifier panel.
- It protects the wheels and traction motors as well as preventing the derailing.
- In case of engine over speed beyond the user programmed speed level, the engine automatically gets shut down.
- Traction motor flash-over is identified and the corresponding traction motor is automatically cut out to prevent the damage to the traction motors.
- Reversing of the locomotive movement at high speed is prohibited to prevent damage to the traction motors.
- During dynamic brake at high speed, the armature current is limited to the user-programmed level to prevent the damage to traction motors due to commutation limits. In the conventional system, loco pilot is expected to do this. With EMP 660 system, dependence on the loco pilot for such aspects is eliminated.
- Various protection measures which is existing in the conventional system are retained in the MEP 660 system such as low water shut down, hot engine, low oil pressure in governor, power circuit ground, control circuit ground, etc.
- Provision to protect the DB grids is provided by measuring the flow of current through the grids. The GBLWI current can be configured by the user. if the current exceeds beyond the limit, then the DB/self-load box is prohibited.

### **Power Deration during Power Ground**

Using power de-ration feature, notch power is de-rated, if the system senses traction alternator negative to ground leakage current (TANGI) as more than 0.4A and still permits the loco to work with de-rated power. For every 0.1A increment above 0.4 A of TANGI current, 20% of that notch power is de-rated. The de-ration continues till TANGI value reaches 0.9 amps and thereafter system declares power circuit ground fault along with engine idling and power cut off.

### **Provision for Extended DB**

In normal DB, at high speeds armature current is limited to 600A and at low speeds armature current is limited to 800A. On ALCO locomotives, the maximum dynamic braking effort is possible between 30 and 60 KMPH speeds only. The braking effort reduces below 30 KMPH, because the current flowing through the grid resistance reduces, because the armature develops maximum voltage with maximum field current at around 30 KMPH only. Below that speed, the traction motor armature voltage reduces as the locomotive speed drops down.

In order to extend the maximum braking effort at lower speed also, the extended dynamic brake feature is provided. This feature can be enabled or disabled through configurable flag. To achieve higher braking effort at lower speeds, increase the traction motor armature voltage by pumping more field current by lowering the grid resistance at lower speed. The first option is not possible because the maximum field current has already been attained and further cannot be increased.

Dynamic brake grid resistance value can be reduced by short circuiting some of the grid resistance, when the locomotive reaches a preset speed during the dynamic brake operation. When locomotive speed reaches 21 KMPH, the dynamic brake grid resistance is reduced to



0.185 ohm to 0.5 ohm by energizing EDBR relay and accordingly energizes six EDBC contactors which are connected in dynamic brake resistor network. As the resistance is reduced, the current through grid circuit increases and the braking effort is increased even at lower speeds. However, this is possible up to certain speed range and there after that braking effort is increased even at lower speeds. However this is possible up to certain speed range and there after that braking effort reduces. Again if the locomotive speed increases to 27 KMPH, EDBC contactors drop out and the resistance is restored. Normal dynamic brake operation continues.

### **Short Term Memory**

In the short term memory, events are recorded continuously with an interval of one second while the loco is running. Both internal and external memories can store up to 50 hours of data. Thereafter, the data swaps out as first in first out manner. In other words, latest 50 hours of data is available in internal or external short-term memory, respectively. The system automatically changes the recording interval from time basis to, change of parameter basis while the loco is in standstill condition to avoid clogging of memory with unwanted data.

**NOTE:** whenever the loco is involved in an accident LP has to operate memory freeze switch to freeze the data in short term memory.

### **Long Term Memory**

The events such as loco speed, shed name, loco no, fuel oil level related flags and real time in run hours are recorded with a resolution of 20 seconds. Both internal and external memories can store up to 90 days of data. There after the data is swapped off as first in first out basis.

### **Operator Configuration Memory**

In the operator configuration memory, data such as the locomotive loco number, shed name, loco type, TM type, TA type, Driver ID, train load, section name, G type, exciter type are recorded, when the system is powered ON or when any parameter is changed by the operator.

### **Self-Load Box Provision**

The microprocessor based control system MEP 660 provides a self-load box feature to ascertain healthiness of the engine. A simple load test is one utilizing the dynamic brake grids as resistive load to the alternator is automatically done, when the self-load box test mode is selected from the menu options provided on the display unit.

The movement of the loco to shed and preparation of the loco to load test are avoided with self-load box feature. This feature can save lot of locomotive hours that are spent to conduct simple load box tests on the diesel locomotive. Various parameters and the HP generated can be viewed on the display unit. No additional metering is required like conventional locos fitted with self-load box feature.

### **Provision of Power Setter Switch**

The power setter is a feature to bring the rear locos to idle without going to real locos and removing the MU cables to get the fuel efficiency. Power setter enable switch is similar to TE limit switch. Normally, this switch is in –disable position. When only single loco power is required, loco pilot keeps this switch in enable position. With, this TL1 status is high and wire 16D is OFF, the locomotive works in idle mode only, even if the throttle signals (TL15, TL12, TL7, and TL3) are available, whereas lead loco works as per notch position. While this switch is in enable position, power setter enabled message is displayed once in every five minutes. However, dynamic brake works normally in all locos and gets full control. When both the loco's power is required, loco pilot may simply keep this switch in disable position. Then all the locos work normally.

## **Fault Tolerance**

In the microprocessor control system MEP 660, fault tolerance is built in to the extent possible, so that the locomotive can keep running in spite of failure of some parts of the traction equipment or MEP 660 system. In these cases, the fault is registered in the error log with date and time stamps. Ten data packs are recorded from five seconds prior to three seconds after the occurrence of fault, fault second and fault instant, and the fault message is displayed on the display unit.

In the current measuring system, six current sensors are provided for all six traction motors and one current sensor is provided for the traction alternator current, which has to be the sum of all the traction motor currents. This system continuously checks the correctness of measurement by computing the sum of all the traction motor currents and comparing it with the traction alternator current.

Two independent voltage sensors are provided for auxiliary generator voltage and battery voltage measurement. In case of auxiliary generator voltage sensor failure, battery voltage sensor takes the control automatically and battery charging continues.

In case of any traction motor speed sensor cable cut or sensor faulty, wheel slip control is automatically taken over by current mode control for that wheel.

If engine speed sensor is failed, then the system works on Tacho generator, if MCBG (medha make) is provided on the loco. In case if second ESS is provided on the locomotive, the system automatically changes over to second ESS, if first ESS has failed. While designing the system, emphasis was given to keep the locomotive running, tolerating as many faults as possible by accommodating the fault by way of isolating a sub system or limiting power of the locomotive, etc., so that, at least that track section is cleared.

## **Rectifier Fuse Blown Out Protection**

In power rectifiers, fuses are provided in series with each diode. In case if any diode is short circuited, this fuse gets blown out and the diode is isolated from the circuit. This fuse is a special type having a micro switch. Whenever the fuse is blown out, system receives a digital input as high through the wire 111. When this input is HIGH, the system declares rectifier fuse blown fault and limits RPM and power to 4<sup>th</sup> notch to avoid further damage to the rectifier circuitry.

## **Fire Alarmer System**

Two individual digital inputs are taken from the fire alarmer system. One input is connected directly to MEP 660 and the second input is connected to train line wire no 11. With this combination of digital inputs, the microprocessor understands whether the fire accident is in lead locomotive or in one of the trail locomotives. Whenever the microprocessor senses these digital inputs status as high, it assumes that there is a fire accident and the following actions are carried out:

1. Initiates automatic shutdown of all the locomotives by energizing wire no 3 alone.
2. Initiates penalty brake application by energizing the VCD magnet valve, which causes the brake application in all locos.
3. SR relay is energized through digital output SR to sound the alarm gong and provides audio indication to the loco pilot.
4. If both digital inputs are high, MEP 660 displays a fault message ‘\_fire occurred in self loco. Check for fire and extinguish fire’ restrictions: engine shut down and provides visual indication to the loco pilot.

## **Pre/Post Lubrication**

Pre lubrication occurs at the time of cranking and post lubrication occurs after the engine is shut down, for a period of 5 to 10 minutes as set in the locomotive. During this period,

PRE/POST LED is turned ON. If the engine is cranked within 30 minutes after post lubrication is completed, then pre-lubrication is not required.

Pre lubrication feature is built in the system to provide lubrication before cranking on new locos. For the first few revolutions in every cranking, engine runs without lubrication, this may cause bearing seizure. During maintenance, the loco might have been kept dead without running for more than 24 hours due to various reasons. All the moving parts such as bearing get dry without any lubrication film. This may lead to bearing seizure. To avoid such damages, a pre lube facility has been built in the system. This feature can be enabled in the locos fitted with separate pre-lubrication pump and associated connections.

With pre-lube feature enabled, if loco pilot requests for cranking, initially the pre-lube pump is switched ON for duration of 60 seconds and then the normal cranking process is initiated.

After engine is shut down, the turbo will be running even if the engine RPM is zero. That means, the turbo is running without lubrication. To avoid such dry running of turbo bearing, post lubrication feature is incorporated in the system. Whenever the loco pilot stop engine, the lubrication pump is switched ON automatically for duration of five minutes to provide lubrication to turbo bearing. This pump is automatically switched off after five minutes. Circuit breaker should be kept ON during this time.

### **Intelligent Low Idle Speed**

Low idling feature has been provided to reduce the engine idling RPM from 400 to 350, provided the governor has such feature. This intelligent low idle feature is user settable and the flag '\_low idle enabled' has to be enabled in the configuration parameters to activate this feature.

Once the flag '-low idle enabled' is enabled, MEP 660 system reduces the engine IDLE RPM from 400 to 350, by energizing the governor solenoids AV and DV when the loco remains in non-powered state for more than five minutes and LOP is greater than 1.7 kg/cm<sup>2</sup>. While the system is in low idle mode, the system continuously monitors the lube oil pressure. If the lube oil pressure drops below 1.2 kg/cm<sup>2</sup>, the system automatically reverts back to idle mode by de-energizing the governor signals AV and DV. Thus, lube oil pressure increases and engine does not get shut down unnecessarily.

Once the conditions for low idle mode are resorted, the system automatically goes into low idle mode. The engine RPM rises to 400 as soon as the loco pilot advances the master handle to notch 1.

Pre lubrication feature takes place only if the locomotive is started after half an hour from the last shut down.

### **Auto Emergency Brake System**

Automatic emergency braking has been introduced on MEDHA made micro-processor based control system to avoid runaway train. In the ghat sections, the train brakes are applied automatically, whenever the loco speed is increased beyond the set limit. Once the brakes are applied, they can be released only when the train speed is reduced below 10 KMPH after pressing the AEB RESET switch provided on the AEB unit.

### **Auxiliary Power Unit**

Many of the goods trains are idling much of time in the station yards waiting for signals. The statistics of the train run hours says that 50% of the run time is idle hours only. While a diesel engine is idling at 400/350 RPM, the diesel engine consumes 25 to 30 litres of diesel oil per hour. During this idling period, only two jobs are done by the diesel engine. First is to compensate the leakages in the train formation to maintain proper brake pressures. Second function is to charge the locomotive batteries and to supply power to the control system.

Instead of running high horse power locomotive's diesel engine even in IDLE, if user runs a smaller engine with lower HP to fulfil above two requirements, fuel consumption can be reduced considerably. With this feature, MEP 660 provides an automatic changeover of main engine without loco pilot's intervention. MEP 660 automatically starts APU and shut down the main engine to reduce the power consumption, if system satisfies the following conditions:

- Locomotive is in IDLE condition for more than 10 minutes.
- Loco brakes are applied.
- Reverser handle is in neutral position.
- All other entry conditions are satisfied.
- APU safety devices such as low water level, etc. are in good condition.

System automatically comes out from fuel save mode, when loco pilot has to move the train by keeping reverser handle to forward/reverse direction.

### **Tractive Effort Limiting Provision**

The tractive effort of the locomotive can be limited through a toggle switch (TE LIMIT) provided on the CP's circuit breaker panel near ECS. This switch is normally kept in OFF position. To limit the tractive effort, loco pilot has to switch on the TE LIMIT switch. The system automatically recognizes the switch position and the traction alternator current is limited to 3000A.

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## NEW DEVELOPMENTS IN DIESEL LOCOS (ALCO)

**The new developments carried out in diesel LOCO ALCO are given below:**

- Introduction of higher horsepower diesel locomotives and to increase the HP rating of some of the existing locomotives to have more balancing speed potential.
- Introduction Of locomotive on requirement basis (Goods/ Passenger/ Shunting).
- Increase of adhesion % with lighter locomotive.
- Introduction of track friendly bogies and wheel arrangement to suit requirements of service and track condition.
- Introduction of panel mounted brake system.
- Introduction of fuel-efficient engine with necessary auxiliaries.
- Introduction of air-dryer to have moisture free compressed air system.
- Introduction of AC-AC transmission to improve reliability and minimize maintenance.
- Self-load test facility (Already introduced in GM locomotives).
- Introduction of computers for diagnostic and memory record with down-loading facility (introduced in GM locos and on trial basis in ALCO locos at DLW).
- Increase in maintenance intervals (minimum 90 days in place of existing 10 days) Introduction of better and reliable passenger safety features (release-run feature is introduced).
- Micro-processor based speed recorders.
- Crew friendly ergonomically designed diesel loco cab.
- Long life (92 days) lube oil filter and fuel oil filters,
- LED based flasher light units.
- Low maintenance battery - it requires topping after 92 days instead of 15 days-for earlier versions.

New technologies have been introduced in diesel locos with the prime objectives of reduction of SFC, increased HP, improved reliability and reduced cost of maintenance. These are described below:-

- 1. Higher efficiency T.S.C (Turbo Supercharged Engine)** - with lesser overhauling schedules, improved SFC (specific Fuel Consumption) and higher RPM.
- 2. Unit Cam Shaft** - Larger dia. cam has been introduced - Fuel cam dia. Increased from 82.75mm to 112.116mm and air/exhaust cam dia. increased from 80.12 to 118.32mm. Numbers of sections have been reduced to 2 from 8. Expected life is now 6 years
- 3. Piston and Barrel Shaped piston Rings**
  - Steel cap piston
  - GE Piston
  - Now Single bolt design has been introduced to solve problem of leakage past 6 bolts.
  - Trial with modified ring grooves below gudgeon pin-kaydon USA fuel efficient piston ring
- 4. 251 Plus Cylinder Head** - Modifications were done to improve heat transfer & to avoid cracks in exhaust part area, fire deck area and stud bosses especially for higher HP/Cylinder loco.
  - Thin wall section of fire deck for better heat transfer
  - Increased no. of cores (14) to increase water holding capacity
  - Use of frost plugs in place of threaded plugs
  - Al spacer to make good gap between rubber grommet & cylinder head.
  - Lighter by 8kg
  - Better swirling mechanism.
  - Retaining ring eliminated.

## **5. Exhaust valves of Inconel material**

- Inconel material with thicker neck with 30 seat angle.
- Inlet valve—same 21-4N material.
- Purpose Improved reliability and longer life on account of improved mechanical strength at higher temp (600°C)

## **6. Plate Type Lube Oil Cooler**

- Previously copper tubes with copper fins were being used. Now Alternate stainless steel plates are used with water & Lube Oil flowing through the passages.
- Heat transfer improved from 190-KW to 295 KW
- Higher reliability

## **7. Improved after Cooler - For more Effectiveness & fuel economy**

- Initially copper tubes with cu fins were used, now AL plates are used in the after cooler with zigzag plates soldered to it.
- Light Weight Aluminium construction (50%)
- Effectiveness 90%
- It is retrofit able

## **8. Mechanically Bonded Radiator - For more reliability & longer Life**

- Earlier rolled & soldered tubes were soldered with header, now seamless tubes are mechanically bonded with header.
- FRP Fan blades— weigh, less by about 25 kg, reduction of power Consumed by 4% & improved airdelivery.

## **9. Long life (92 days) Lube oil and fuel oil Filters**

- Reduced engine wear due to highly efficient separation of high density particles.
- Longer oil change intervals.
- Longer paper filters life.
- Saves 400 litres of lube oil/loco/yr. viz. oil lost in 8 filter changes
- No operating cost and negligible maintenance.

## **10. GD-80 filter - Disposable paper filter (life enhanced from 15 days to 90days)**

## **11. Inertial air filtration**

- Introducing glass fibre baggy type secondary filters.
- To avoid surging-complete design of air box, connector, holding arrangement of bags etc. modified.
- AC dust blower motor introduced in place of DC motor earlier.

## **12. Modified Lube Oil piping to improve Reliability & Maintainability**

- Use of better piping material ASTM-106A.
- Streamlined formed pipes.
- Improved designed bellow pipe joints

## **13. Rivet less Cage T.M. Bearing**

Life of present T.M .Bearings is 3 to 5 years and about 50% rejections are due to loosening and breaking of rivets. With this modification, the life will now increase to 9 years. This has already been introduced on all newer 4907 T.Ms.

## **14. Roller Suspension Bearing of Traction Motor**

- Objective of this is extended Maintenance schedule & higher reliability.
- MSU (Motor Suspension Unit) will enable T.M to be removed for repair etc.
- Light weight T.M. on WDP2 to reduce un-sprung mass and axle load for increased speed potential.

**15. Self-Cooled Rectifier**

Earlier cooling of rectifiers was from air, bled from FTM blower which led to oil & dust problems in rectifier. Now- in-built blower driven by A.C. Motor installed on top of rectifier unit.

**16. Cables**

E. Beam Irradiation Cables-50% thickness, very strong, resistant to oil, better insulation & mechanical strength. Its life is equal to loco life. Started with T.M lead cables & internal cables - Plan to switchover 100%.

**17. Low Maintenance Lead Acid battery**

Presently 10 days topping up and cleaning up of sulphation is carried out. With this Battery, 90 days schedule is possible, low internal resistance, thus low discharge.

**18. Non-chromate cooling water corrosion inhibitor - Indion-1344 or Nalco-2100.**

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# SHED LAYOUT

## **Following factors may be considered while finalizing the shed layout:**

- A unidirectional 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 home. 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. Expansion along the length of the running lines should not be adopted. The work area in the shed should be divided into two distinct portions, one dealing with servicing and light maintenance and the other with heavy repairs.
- Facilities should be provided in the same sequence in which an incoming locomotive is to be attended to.

## **Following points should be considered while constructing a Shed:**

A 3-level working floor arrangement should be provided. The rail level in the repair area is the same as the general shed floor level. The depressed floor area outside the rails is kept lower than the shed floor level so as to be able to attend effectively to the bogies and under-gear. The pit level between the rails is kept still lower to enable proper examination of under-gearing. Above the depressed floor level a platform level is provided which is at the same height.

Flooring should be easily washable so that split oil can be effectively removed. All flooring should be finished with a hard top to withstand abrasion resulting from handling of heavy parts and movement of material trollies etc. Wooden flooring is not recommended. Concrete flooring is acceptable. Flooring in the heavy lifting bays of the shed should be adequately strengthened. Special reinforcement is required in the location where heavy duty high lift jacks are installed.

To minimise cracking and to facilitate repairs flooring should be divided into rectangular panels, with sides not exceeding 2 meters, using dividing strips. The platforms and ramps as also steps should be protected with steel or cast iron edging of non-skid ding type.

Pits should have convex flooring and efficient drainage. Stilt arrangement consisting of steel beam on stub columns should be followed, so far as possible for supporting track in the pits, since it permits better lighting and ventilation of pits. The edge of the elevated platform should be suitably raised to provide a rim to prevent tools and materials from rolling off.

This also reduces the possibility of men slipping at the edge. To minimise the dust nuisance in working areas, a length of approximately 30 meters beyond the cover area should be paved. A uniform roof height should be preferably adopted for all bays to enable convenient construction and dispersion of natural light.

The minimum height is governed by the requirement of heavy lifting bay. The roof should be of a construction that caters for maximum natural light in working area. Translucent tended at a later date, so that minimum alterations are required to the structure and the foundations. To protect personnel working on the elevated platform from falling down, when the line is not occupied by a locomotive, chain guards should be provided.



These should be fixed in such a manner near the edge of the platform that they can be removed easily when a locomotive is placed alongside

## **SERVICING FACILITIES**

Following service facilities should be provided in a diesel shed for smooth and efficient functioning

### **1. Washing and Cleaning:**

A washing apron and pit laid with concrete and provided with good drainage, suitable hydrant points and adequate supply of water should be located well away from the shed building to clean the under-gearing and body of the locomotives. Manual washing with brushes (fitted with long handles) is recommended for small sheds.

Automatic washers, with mechanised sprays, brushes etc. can be justified only for very big running sheds with a large number of locomotives. Hose and nozzle arrangement for spraying the under-gearing with water under pressure will ensure proper removal of grease and oil from the chassis. Provision of a boiler to give a steam jet will be an additional help.

### **2. Fuel supply installation:** For fuelling the locomotives

### **3. Lubricating oil storage and dispensing system.**

### **4. Cooling water treatment and dispensing:** Diesel engine water should be treated in accordance with maintenance instructions laid down for different classes of locomotives. The most widely used treatment is that with chromate.

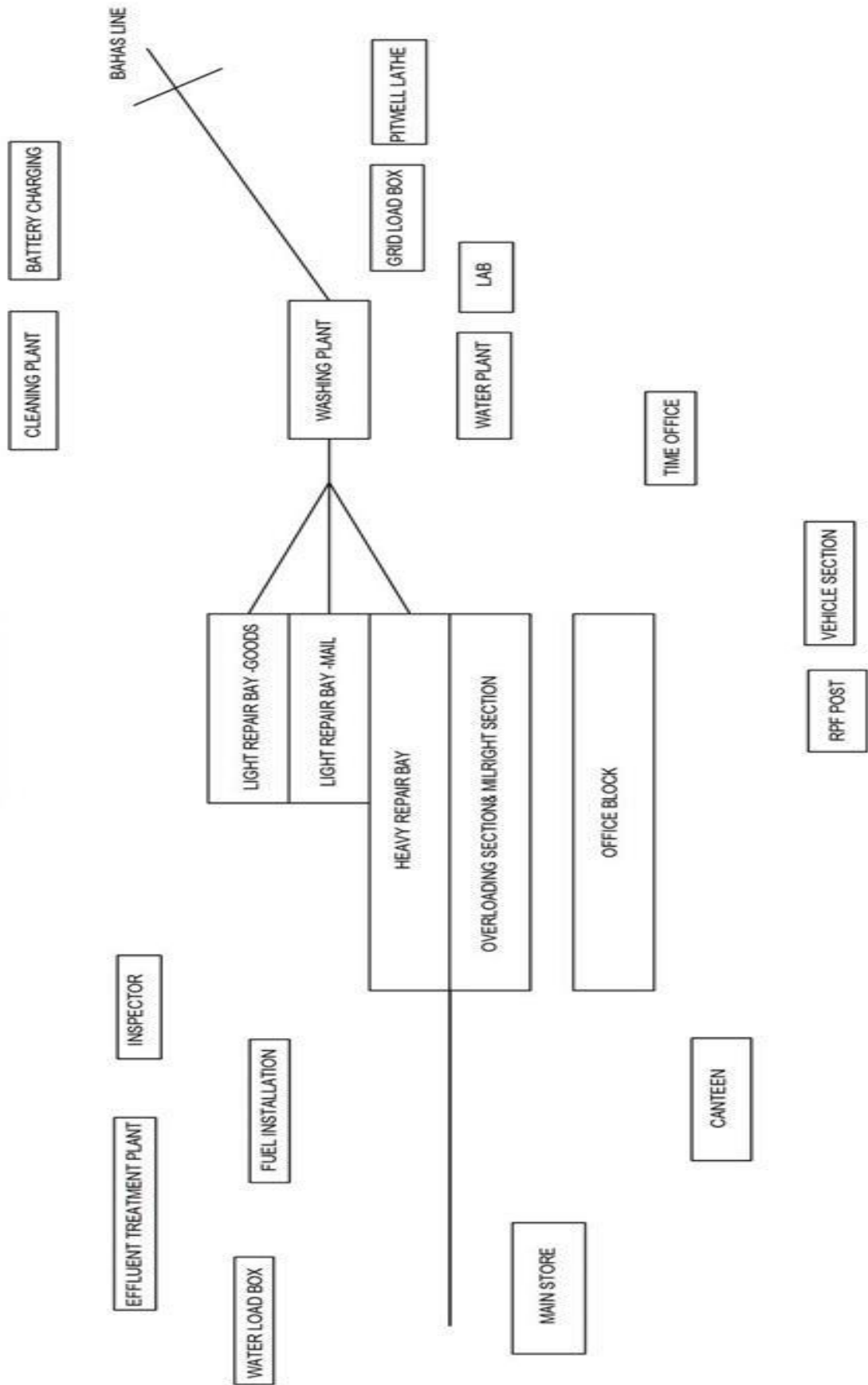
### **5. Repair Area:** The repair area of the shed is generally divided into two parts:-

- Light repair bay and
- Heavy repair bay including overhauling sections for various sub-assemblies.

All the minor schedules up to half yearly are carried out in Light repair bay. This area is further divided into two parts Mail Loco Repair bay and Goods section including Quarterly and HY schedule. In the sub-assembly overhauling area, separate areas should be demarcated for specialised repair groups such as-

- Diesel engines Electric rotating machines.
- Cylinder head, piston, connecting rod, etc.
- Turbo, Compressor, Governor, Fuel Injection room.
- Cooling equipment and radiators.
- Brake equipment and valves.
- Pumps, shafts, gears, etc. Speedometer, gauges, etc. Under-gearing components.
- Electrical test room including Excitation cards, BKT Reverser, etc.
- Filter cleaning Small Motors.
- Dynamic balancing.
- Air brake.
- Gasket room.
- Millright section
- Fitters' benches should be suitably provided in each of the demarcated areas.

## SHED LAYOUT



For ease of handling during repairs, suitable hoists and chain pulley blocks etc. should be provided. Special stands and carriers etc. for different components should be provided in the different repair areas.

For example connecting rod and piston assemblies after removal from the engine should be stacked on a rack with the connecting rods suspended from the gudgeon pins, Special holding trays etc. should similarly be provided for bearing shells, fuel injection nozzles etc.

**6. Shed Building:** The shed building, besides providing for the repair a machine shop etc., should accommodate the following, Battery charging and storage room preferably one end of the shed building, where fumes and gas can be easily exhausted to the atmosphere.

- a. Instrument repair and testing room.
- b. Fuel injection repair and testing room
- c. Engine governor repair and testing room.
- d. Brake testing room
- e. Flaw detector room (magnetic and zygo etc.)
- f. Filter storage.
- g. Tool room
- h. Lockers and washing room
- i. Laboratory Driver's lobby and lockers.
- j. Booking office.
- k. Supervisors' office rooms.
- l. Shed Officers' rooms.
- m. Office room and record room.
- n. Library.
- o. Lecture or meeting room.
- p. Fire Fighting equipment's.
- q. RPF post.
- r. Load Box Room & Pit Wheel Lathe area.

**7. Shed Stores:** The shed stores should have approach by both rail as well as road. The approaches should not interfere with other movements in the maintenance shed. Proper bins and racks should be provided for storage and handling of components, to avoid damage during handling and in storage. Adequate lifting facilities should be provided for handling heavy components. Use of fork lift trucks for this purpose is preferable. Special provision should be made for storage of rubber components since these are subject to deformation if not properly stacked and to ageing in the presence of air and due to effect of temperature.

While designing store building, due regard should be paid to the fire fighting precautions. To reduce material handling to a minimum and same time, small components frequently required should be stocked at platform level near work areas. Heavier components such as brake-shoes etc. can be conveniently stored at the depressed floor level.

**8. Lifting and Material Handling Facilities:** Overhead cranes of suitable capacity should be provided to serve heavy repairs area, free floor space, part of the machine shop and stores. Crane capacity should be sufficient to lift the heaviest single component or assembly. Heavy duty high lift electrically operated jacks be provided at suitable locations in the heavy area for lifting the locomotive. Hoists should be provided at all suitable work stations. Wherever it is possible to provide these facilities and dispense with overhead cranes, the structure can be made lighter. Hand carts and trolleys should be used for movement of components. Fork lift trucks should also be provided in large maintenance sheds.

**9. Illumination:** Good illumination is necessary for efficient work. In the repair area fluorescent light or mercury vapour lamps giving an even illumination of at least 200 lux at

platform and floor levels should be provided Pits should be provided with bulk head fitting direct lighting of the under-gear of the locomotive. Here also minimum illumination level of 200 necessary Low voltage plug points should be provided at work areas, including the pits, for use of portable hand lamps with flexible leads. Moveable trolleys provision of swivelling lights can be an alternative fixed pit lights.

- 10. Auxiliary Buildings:** A small shed should be provided in the vicinity of main shed building for stabilizing spare wheels of bogies. A 3-tonne gantry should serve the stable bogies. A 3-tonne gantry should loading endure line and the line next to it for proper loading of the wheels Under floor type of wheel lathe should be provide! In a large maintenance shed for in-situ re-profiling worn locomotive wheels. A separate shed for the under-floor wheel lathe is preferable. A load-box for testing a locomotive under power should be provided in every home shed. This applied to sheds handling only diesel-electric locomotives
- 11. Compressed Air:** Air compressor should be installed in a place where minimum disturbance due to vibrations and issued to the surroundings. A separate compressor is recommended outside the main shed building, pressed air pipe lines should be laid so as to reach working areas and adequate number of points should supply.
- 12. Laboratories:** In every diesel locomotives maintenance shed, it is worth to have a well-equipped laboratory to exercise troll on lubricating oil, fuel oil and cooling water .laboratory is also helpful in carrying out metal laurel and chemical inspection of parts and supplies received in the shed / shop. Following major equipment's are necessary in the laboratory-
  - Spectrograph for lube oil testing.
  - Magna flux testing machine Rubber tensile testing machine.
  - Zyglo testing machine
  - Oscilloscope Ultra sonic testing machine
  - Portable hardness testing machine
- 13. Cleaning and Washing:** Suitable cleaning and washing facilities are necessary in every shed for cleaning of components immediately after their dismantling and before any inspection or repair be undertaken. Degreasing and cleaning facilities either of the vapour type or hot bath or spray-jet cleaning machines are required in every shed/ diesel shops. Wherever justified, mechanized cleaning equipment should be provided. Special cleaning plants are required for turbocharger, after coolers, lube oil heat exchangers, radiators, piston assembly, etc.
- 14. Shed offices:** offices for Supervisors should be located near their place of work. This ensures effective and constant supervision of the repair work. 'The driver's booking office and lobby should be located near the point where the locomotives are inspected and prepared for dispatch. The General Administration and other office should provide for a meeting room
- 15. Plant and Equipment:** A list of machinery and plant required in maintenance sheds of different sizes is given below:-
  - E.O T. Cranes 120 tons & 10 Tons
  - Whiting Jacks set comprising of 5 jacks
  - Tram beam 3 Ton cranes,
  - Pillar cranes with 1.5/1 ton hoists
  - Forklift truck (3T)
  - Platform Truck (2T)
  - Pickup van
  - Monorail with hoist for battery room

- Hoist (100Kg) for Governor
- Heavy switch gear under floor wheel lathe Lathes
- Shaping machine and drilling machine
- Valve seat grinder and tool grinders
- Lap Master
- Testing and calibrating equipment's for various sub-assemblies
- Welding plants
- Cordless drills
- Bench Grinders & pneumatic grinders
- Pneumatic & hydraulic torque wrenches
- Hydraulic jacks of different capacities
- Dynamic balancing machine,
- Spray painting equipment
- Water and Grid load Box
- Every shed should be provided with equipment required for testing and calibrating various tools Machines and fixtures used in repair work

**16. Fire Fighting:** Adequate safety measures must be 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 fire alarm boxes etc. should be conspicuously visible both at day and at night.

**17. Training School:** For proper maintenance of the sophisticated equipment on diesel locomotives, the work force has to be equitably trained. Each large shed should, therefore, include a training school for imparting theoretical and practical training to various categories of staff. Provision of a hostel attached to the training school is necessary. The training school should be provided with a library with sufficient books and technical literature and audio visual aid for training. Model room in the training school should display cut-way models and working models of as many components as possible.

**18. Staff Amenities:** Toilet and washing facilities and water coolers should be available both inside the shed building and for the use of office staff. Adequate precautions are necessary against dermatitis amongst workers for handling fuel oil, lubricants etc. Suitable cleaning agents and ample washing facilities in the vicinity of areas where these products are handled are necessary. Use of hand protection cream before starting work and non-irritant cleaning soaps after completion of work should be enforced. Staff lockers rooms, cycle and scooter stand, canteen amenities should be provided in the shed/workshop along with suitable wash and change rooms.

**19. Environment friendly equipment's:** Incinerators to dispose of waste material. Effluent treatment plants are inevitably required as it has become a necessity to reduce pollutants and are a pre-requisite for obtaining ISO-14000 certification.

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# **GM/ EMD LOCOMOTIVE**

## **GM LOCOMOTIVES - SALIENT FEATURES**

AC-AC locomotives hitherto manufactured by GM have been only for the North American market which does not impose any major constraint on the layout primarily because axle loads are in region of 30T are permitted on North American Railroads. Development of the layout for GT46MAC the axle load for which is restricted to around 20.5T, was therefore, a major exercise in locomotive design.

The locomotive has been designed on the 'platform' concept i.e. the layout and the mounting of equipment is arranged in such a manner that retro fitment of equipment developed in future on existing locomotives as well as equipment changes/up gradation of the existing design of the locomotive can be implemented without any major change in the under frame, superstructure and even layout.

GT46MAC is provided with the following special features-

### **1. Performance Specifications**

- 4000 TCV locomotive
- Higher tractive and braking effort capability - 540kN starting TB and 270kN 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, commutator, nor rotor insulation o No flashovers/ground relays
- Bogie Inverter Control
- High level of reliability with fewer parts- million kilometre (1 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 -**

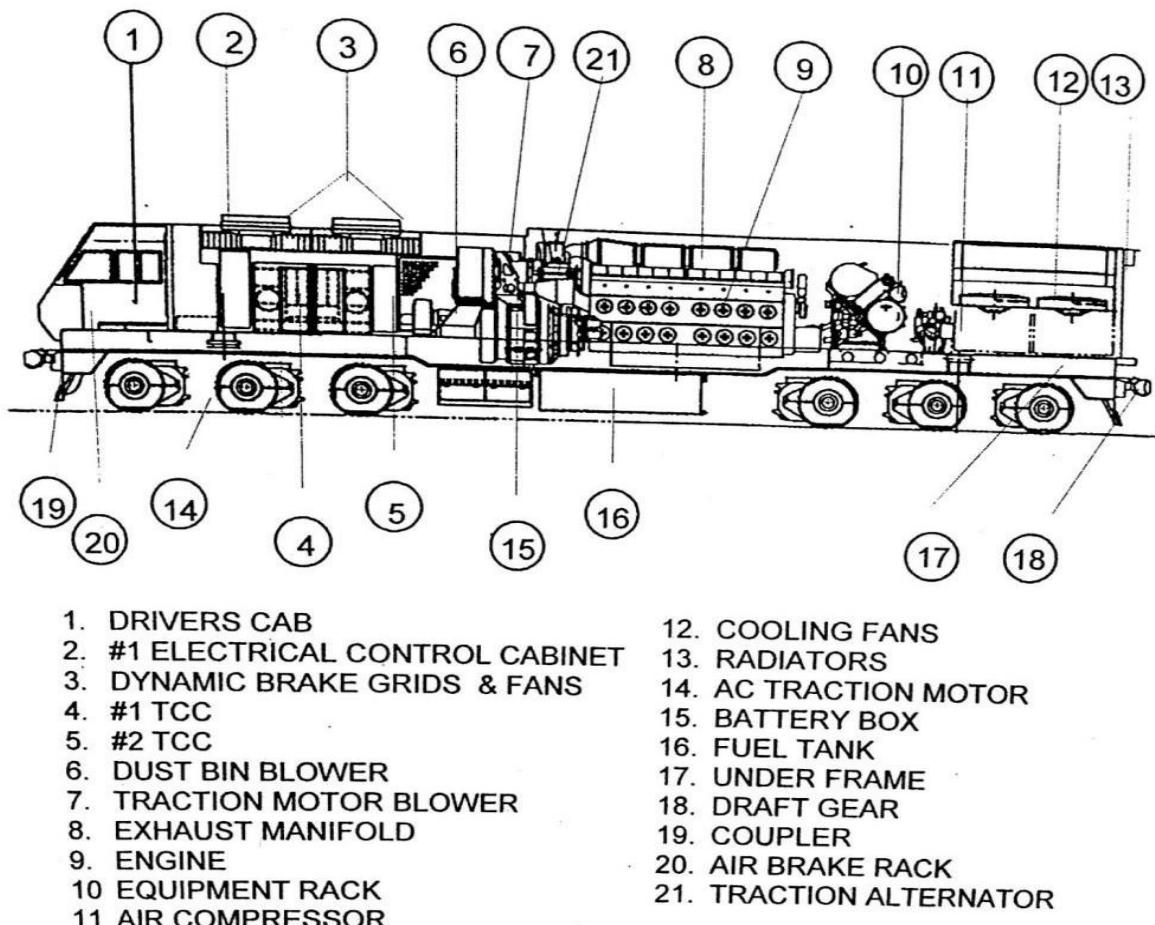
- Trouble Shooting and Self-Diagnostics
- Alpha Numeric display
- Archive memory and Data logging
- Radar based super series Wheel Slip/Slide Control system

### **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 Surface extend bogie overhaul intervals to 1.6 million kilometres (one million miles)
- Dual high adhesion and high speed
- Available gear ratios for heavy haul and passenger
- Reduced wear of components extends bogie overhaul operation 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 the notables being:** 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 I Electronic Air Brake System
- Direct drive WLN air compressor

#### **12. Safety Aspects**

- Increased crashworthiness requirements
- Cab design and overall carbody configuration provides improved visibility
- Anti-climber available

### **LOCOMOTIVE GENERAL DESCRIPTION**

The Electro-Motive GT46PAC diesel-electric locomotive is equipped with a turbocharged 16 cylinder diesel engine, which drives the traction alternator. (The traction alternator is an important component of the main generator assembly.) The traction alternator converts diesel engine mechanical power into alternating current electrical power. Internal rectifier banks in the main generator assembly convert traction alternator output alternating current to direct current.

Rectified DC power produced by the traction alternator is distributed through the DC link to DC/AC inverters in the Traction Control (TC) cabinet. Based on inputs from the locomotive computer (EM2000), traction inverters supply 3-phase AC power to four traction motors. The EM2000 responds to input signals from operating controls and feedback signals from the power equipment.

The traction control converter (TCC) is an electrical device that can convert AC to DC and invert DC into AC (traction power). The terms converter and inverter are used interchangeably in this manual.

Each traction motor is geared directly, with a single pinion, to a pair of driving wheels. The maximum speed of the locomotive is set by locomotive gear ratio (ratio of traction motor revolutions to wheel revolutions) and wheel size.

Although each GT46PAC locomotive is an independent power source, a number of locomotives may be combined in a multiple-unit (MU) tandem to increase total load capacity. The locomotives in tandem may be equipped with either AC or DC traction motors. Operating control functions are train lined through a 27-conductor MU cable. This enables the lead unit to simultaneously control other locomotives in tandem.

The GT46 PAC & MAC short hood or cab end is considered the front of the locomotive, although the GT46PAC can be operated in either direction. The cab has two drivers' consoles: one forward facing and one rearward facing.

**NOTE:** When a GT46PAC is the lead unit, with its cab end leading, the left side (No. 1) control console provides the best view ahead for the driver. When the locomotive is operated as the lead unit, with the cab end trailing, the right side (No. 2) control console provides the best view ahead. Trailing GT46PAC may be set up with the cab end leading or trailing.



The front of the No. 1 electrical control cabinet is the back wall of the locomotive cab. The EM2000 locomotive computer display, mounted on the front of the cabinet, indicates locomotive operating conditions, faults, and troubleshooting information from the locomotive computer.

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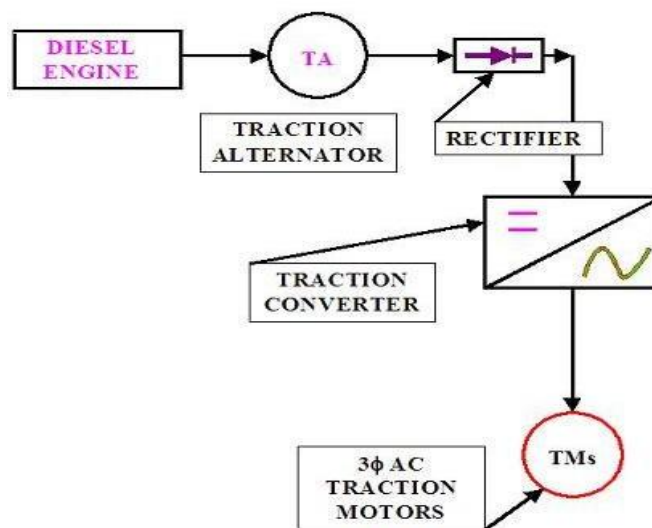
## GENERAL ENGINE ARRANGEMENT

The two stroke Electro-Motives diesel engine is a –Narrow V<sub>I</sub> type design consisting of two banks (or rows) of engine cylinder arrange with an angle of 45° between them. The engine is available in 16 and 20 cylinder models, depending on the desired horsepower output. The rear of the engine is usually called the flywheel end since this where the main generator is driven. The camshaft gear train and auxiliary generator drive are located on the rear of the engine. Engine rotation is left hand or anti clockwise as viewed from the rear facing towards the front.

The front end of the engine is commonly referred to as the governor end as this is the mounting location of this device. The water pumps, lube oil pumps and the pumps drive gears are also located on the front of the engine. All oil, fuel and cooling water connections for the engine are made on the front end. A drive connection is available on the front end of the crankshaft for accessory items such as air compressors, additional pumps or mechanically driven blowers

Engine orientation is established from the rear of the engine looking forward .The engine banks are termed left and right as viewed from the rear of the engine looking forward. The engine banks are termed left and right as viewed from the rear of the engine looking forward .Cylinder number one is always located on the right hand size. On a sixteen cylinder engine the cylinders on the right bank are numbered one through eight beginning with the front end. Cylinder number on all engines is at T.D.C. when the flywheel pointer reads 0°. The sixteen cylinder engine generates a power pulse every 22 ½° of crankshaft rotation.

### BASIC STRUCTURE OF GM ((EMD) LOCO



### ENGINE COMPONENTS AND CONSTRUCTION

#### COMPONENTS

In this section we will look at the major components of the diesel engine, their function and location .This section is intended to aid in identification of engine components and system . Repair and inspection is covered in the engine maintenance manual, maintenance instructions documents and in subsequent training manuals.

## **Crankcase**

A crankcase is the housing for the crankshaft reciprocating internal combustion engine. The enclosure forms the largest cavity in the engine and is located below the cylinder, which in a multi cylinder engine is usually integrated into one or several cylinder blocks. Crankcases have often been discrete parts, but more often they are integral with the cylinder bank(s), forming an engine block. Nevertheless, the area around the crankshaft is still usually called the crankcase. Crankcases and other basic engine structural components (e.g., cylinders, cylinder blocks, and integrated combinations thereof) are typically made of cast iron or cast aluminum via sand casting.

## **Crankshaft**

The crankshaft is a drop forged carbon steel assembly with induction hardened journals (main and throws). In the 16 cylinder engines the shaft is in two parts, bolted together between the #5 and 6 main bearings on the 16 cylinder. Crankshafts are dynamically balanced by using counter weights, which compensate for the rotating mass of the crankpin and lower part of the connecting rod.

Oil passages are drilled in the shaft to allow oil from the main bearings to lubricate the lower connecting rod bearings.

The ring gear and coupling disc bolted to the crankshaft provides the coupling for the generator, ring for engagement of the starting motors and holes for an engine turning bar to manually rotate the crankshaft. Degree and top dead center markings are stamped on the outer rim of the coupling disc for reference during maintenance procedures

## **Torsional Dampers**

A torsional damper (sometimes called harmonic balance) is applied to the front of the crankshaft, directly behind the accessory drive to absorb crankshaft torsional vibrations. Four types of torsional dampers have been applied to EMD engines over the years, the spring pack type, gear type viscous damper and the pendulum type.

## **Oil Pan**

The engine oil pan encloses the lower part of the crankcase assembly and serves as both a base for the engine and a storage sump for lubricating oil, handholes are provided at each cylinder location for inspection and servicing of engine components. Tubes in the oil pan correspond with holes in the crankcase base rail and serve as drains for the air boxes

## **Power Packs (Assemblies)**

Each cylinder of the diesel engine consists of power pack or power assembly which is made up of the following parts:

- Cylinder liners
- Cylinder head
- Piston And Rings
- Piston carrier assembly
- Connecting Rod Assembly

## **Cylinder Liner**

The cylinder liner is a cast iron assembly with brazed on outer sleeves. The unit comprises the cylinder itself, cylinder water jacket and intake ports. The intake ports are arranged in a row around the circumference of liner. This arrangement ensures complete cylinder scavenging. There are basically two types of cylinder liners cast iron and chrome.

Coolant enters the liner from a water manifold in the air box through a water jumper, into a flanged connection on the front lower side of the liner. Inside the water inlet is a deflector that prevents erosion and cold spots on the liner.

The unit comprises the cylinder itself, cylinder water jacket and intake ports. The intake ports are arranged in a row around the circumference of the liner. This arrangement ensures complete cylinder scavenging.

The coolant circulates through the lower liner, up passages between the ports and then through the upper liner. From there, the coolant passes through 12 outlet ports on the top of the liner to the cylinder head. The discharge holes are counter bored to retain red silicone seals with white reflow heat dams. A copper head seal is used between the liner the cylinder head. A special pilot stud at the 5 o'clock position to ensure proper gasket and head alignment.

The liner serial number is stamped below the water inlet on the side liner. There are basically two main types of cylinder liner: cast iron and chrome. These terms refer the treatment of the cylinder walls. The cylinder may have either chrome plated cylinder walls to be used with cast iron piston rings or laser hardened cast iron walls used with chrome rings. The type of liner applied is dependent on the type of service the engine is used for. Chrome liners are generally applied when the locomotive must burn high sulphur fuels because they are particularly to corrosion.

### **Piston and Rings**

The pistons in EMD engines are a cast iron alloy, one piece symmetrical design which may be either phosphate coated or tin coated depending on application. The piston has four compression rings on the upper portion to seal the cylinder from the crankcase. These rings are either ductile steel for use with chrome plated liners.

### **Piston Carrier**

The piston rides on a trunnion type carrier assembly .The carrier is fitted inside the piston and a thrust washer on top of the carrier allows the piston to rotate freely in the cylinder .There are two types of piston pin carrier combinations have been used, the plain bore and the rocking pin type .The plain bore piston pin is conventional shape and uses a bearing inserted retained in the carrier by tangs.

### **Connecting Rod**

The EMD engine uses an interlocking connecting rod design to connect the power assemblies to the power assemblies to the crankshaft .The connecting rod consists of fork rods ,blade rods basket halves and a set of connecting rod lower bearings with piston pins bolted directly to the connecting rods.

### **Cylinder Head**

The next component to be looked at is cylinder head. The cylinder head is a cast iron component, with passages for coolant and exhaust gases. Four exhaust valves control the flow of gases from the cylinder through the passages into the exhaust runner in the crankcase. Three basic types of exhaust valves have been used satellite, Inconel and heavy-headed Inconel. Twelve passages around the outer diameter of the fire face allow coolant to flow from the liner to the cylinder head.

### **Rocker Arm Assembly**

The rocker arm assembly acts as an operating mechanism for the exhaust valves and fuel injector and is held in place by two studs on the top of the head.

There are three rocker arms per cylinder; two exhaust and one injection .Rollers on one end of the rocker arms follow lobes on the camshafts. Force from the camshaft is transmitted to the fuel injector and to two valve bridges (one on each side of the injector).Each Valve Bridge has two hydraulic lash adjusters that open the exhaust valves and maintain proper valve adjustment.

### **Hold Down Crab System**

The power assemblies are held in the engine block by means of a crab bolt remaining system. There have been changes to the system over the evolution of the EMD diesel engine which has resulted in there being two distinct systems in use. The standard crab system is found on horsepower engines. This system uses an individual crab for each bolt.

### **Camshafts**

The typical 16 cylinder engine is equipped with two sectional camshafts, one per engine bank. The camshafts operate the fuel injectors(one per cylinder),and the exhaust valves(four per cylinder operated by two rocker arms and two valve bridges).At each cylinder location are three cam lobes ,one injector and two exhaust. The camshafts are a sectional design, with each section spanning four cylinders.

### **Rear Gear Train**

The rear gear train provides power to drive the camshafts and depending on engine model, the blowers/or turbocharger. The gear train is located on the rear, or flywheel end of the engine and consists of

- Crankshaft gear
- Lower idler gear
- Upper idler gear
- Left and right camshaft gears
- Turbo drive gear
- Blower drive gears

The camshafts are driven at 1:1, they make one revolution every revolution of the crankshaft.

### **Auxiliary Drive**

Also located on the rear of the engine block is an optional auxiliary drive gear,(used to drive an auxiliary generator in rail application).On blower engines, the auxiliary drive gear meshes with the top centre of the number 2 idler gear, with the drive flange located between the blowers.

On turbo engines the auxiliary drive assembly is mounted on the turbocharger housing and is driven by the outboard side of the right bank camshaft gear.

### **Clutch/Spring Drive Gear**

On turbocharged engines there are two types of number 2 idler gear/turbo drive gear assemblies, the spring drive gear and the clutch drive gear. The spring drive gear is used on engines with internal clutch turbochargers to absorb torsional vibration and cushion the gear train from the shock loads of the turbo clutch engaging and disengaging.

### **Accessory Drive**

The accessory drive gear train is located at the front or governor end of the engine and is used to power the oil pumps, water pumps and governor. The components are:

- Accessory drive gear
- Scavenging oil pump gear
- Main lube and piston
- Cooling pump gear
- Governor drive gear
- Water pump gear

The scavenging pump drive gear is powered directly off this gear as is the main lube and piston cooling pump drive gear. The governor drive gear is mounted on a stub shaft assembly above the main lube drive gear.

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## LUBRICATING OIL SYSTEM (GM LOCO)

Lubricating oil system consists of Engine sump, scavenging pump, and Main lube oil pump, Lube oil strainer housing, Filter assembly, Lube oil cooler assembly, and Turbo oil filter.

Oil from the engine sump is drawn by gear driven scavenging pump through a coarse mesh lube oil strainer element and lube oil filter tank in which 5 filter elements are housed. Oil from the filter tank flows to main lube oil pump through a lube oil cooler and fine mesh lube oil strainer elements.

A lube oil bye pass valve is provided across lube oil filter tank which is set at 40 psi. This valve is responsible for continuous oil supply to engine moving parts when filters are choked. A filter condition gauge is provided across the filter tank and is in parallel with bye pass valve to continuously indicate the condition of lube oil filters inside the filter tank.

Pressurized lube oil supplied by scavenging pump is further pressurized by a main lube oil pump. Main lube oil pump is basically having two pumps in one housing. One for piston cooling and the other for the complete engine moving parts including turbo charger. Piston cooling pump supplies pressurized oil to all the pistons through headers and piston cooling pipes on both banks. Oil supplied from piston cooling pipe cools the piston crown from the bottom and cylinder liners and piston rings while dropping down to the sump.

Pressurized oil from Main lube oil pump passes through pressure relief valve set at 125 psi, lubricate all 10 main bearings, 8 connecting rod bearings, both end engine gear trains, stub shafts, all cam bushes through drilled oil passages in cam shafts, valve lever mechanism, bridge assembly, Lash adjusters & exhaust valves etc.

Oil pipeline from the cam gear end lube oil main header is taken to engine Governor to shut down the engine in case of low lube oil pressure.

One 55V AC Electrical Motor (3/4 HP) driven pump (Turbo soak back pump) circulates engine lube oil to turbo before cranking and after shutting down the engine to protect the turbo running without oil and to cool turbo after the engine is shut down.

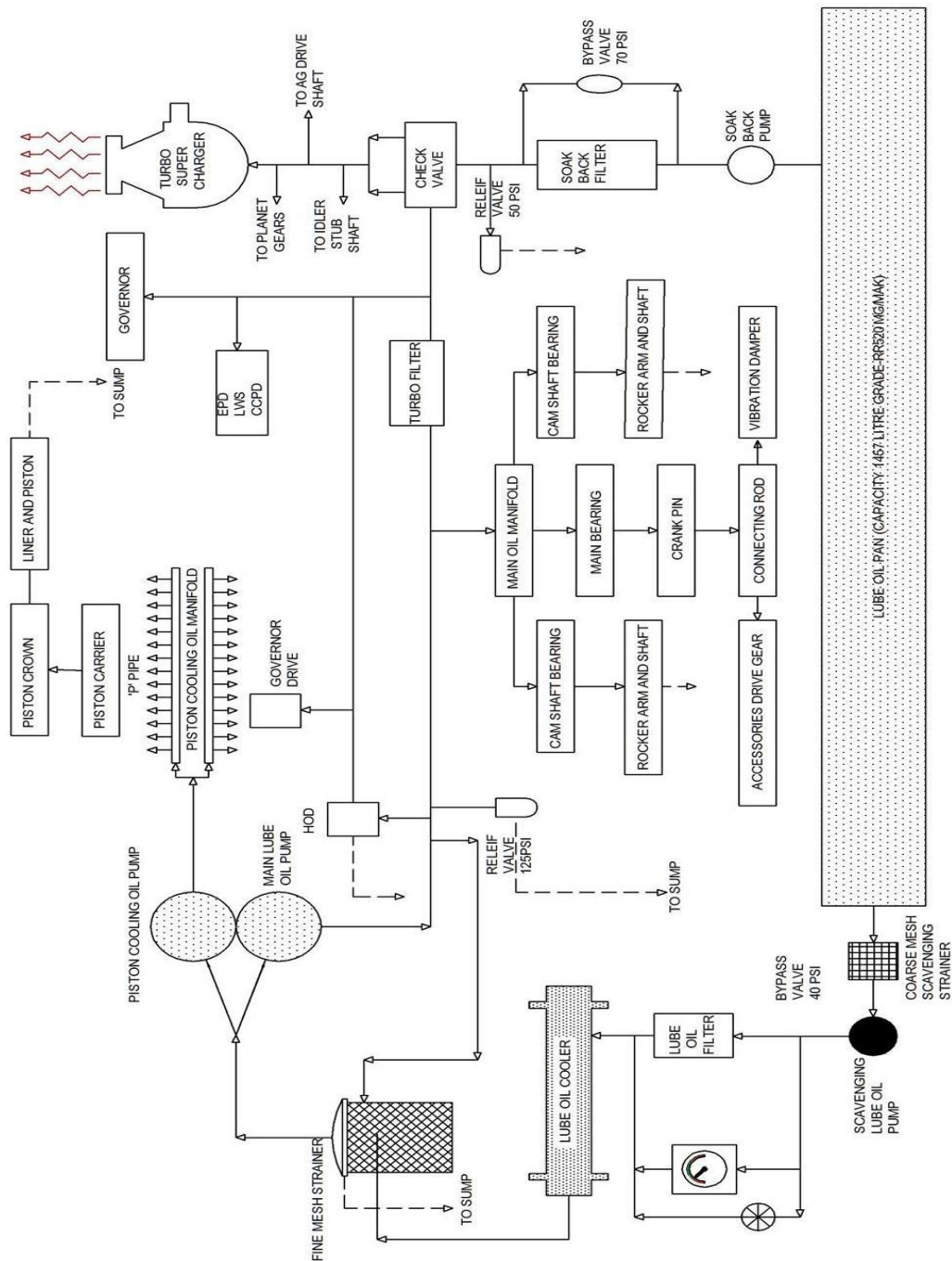
Working time of this Turbo soak back pump is decided by EM 2000. Turbo lube pump works for 15 minutes after engine shut down, if loco was working below 4th notch before shutting down of the engine and runs for 35 minutes after engine shut down, if loco was working above notch before shutting down of the engine.

Oil for the Turbo is taken from cam gear end lube oil main header through a paper type spin on filter.

### NOTE:

1. If the filter tank bye pass gauge needle shows Yellow (warning) and Red Zone, lube oil filters need change. A test plug is provided on the filter tank cover to measure the oil pressure inside filter tank by providing a gauge to assess filters condition. Oil pressure should not be more than 7 psi in Idle & 25 psi in 8th notch.
2. If the engine is shut down for more than 48 hours, pre-lubrication of the complete lube oil system is required to be done with an external pump (Engine crank shaft has to be barred or rotated manually pre lubrication).
3. Do not put off Turbo and computer control circuit breakers immediately after shutting down the engine. A minimum time of 15 Minutes has to be given for cooling down the Turbo.

## LUBE OIL SYSTEM OF EMD LOCO



### **CAPACITY OF OIL PAN**

950 Litres, in case of WDP4 (imported) & 1457 litres in case of WDG4 locos, also for DLW manufactured WDP4 locos.

### **RENEWAL OF FILTERS**

Operate the engine till it is warm, then shut down and open filter tank oil drain gate valve provided in lube oil strainer housing (Oil drains faster from the warm engine than cold engine). Once oil is drained, open filter housing cover to renew filters and clean interior of filter housing, drain pan and surrounding area. Replace filters with new elements (5 Nos). Ensure that the elements are fully seated over the oil outlet tubes inside the filter housing. Check 'O' rings in the circular grooves of filters. Renew filter tank cover 'O' ring. Close the cover and torque the cover nuts to 81 Nm (60 ft lbs) diagonally and close filter drain gate valve.

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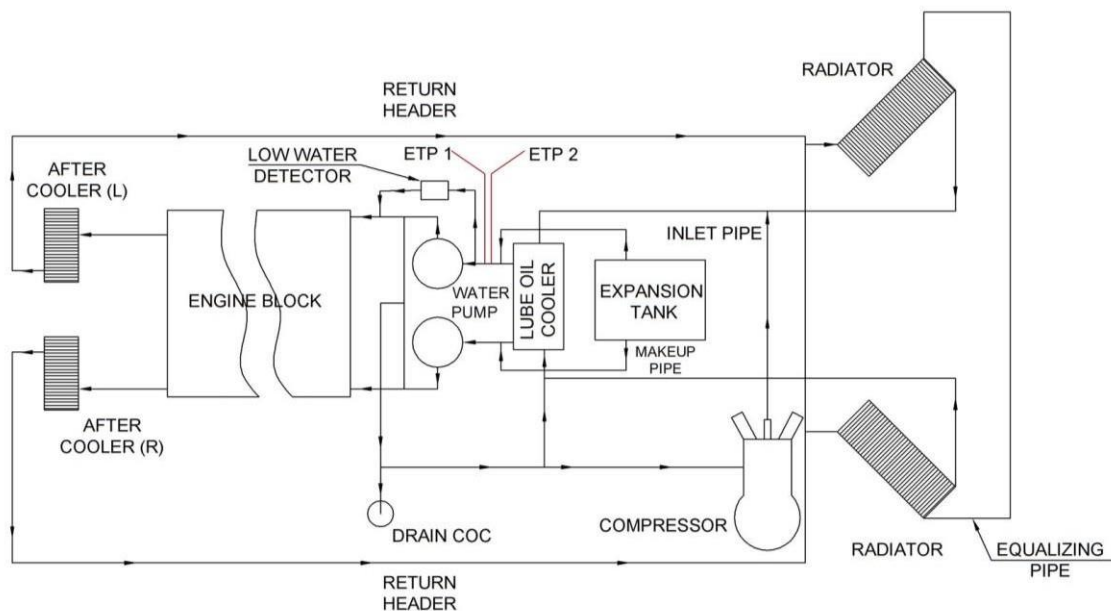
## COOLING SYSTEM OF DIESEL LOCOMOTIVE (GM LOCO)

Cooling System is a closed loop pressurized system. Water from the expansion tank as well as lube oil cooler is drawn by both bank gear driven water pumps, and is pumped to all the power assemblies through both bank water inlet manifold assemblies, water inlet tubes, cylinder head outlet elbows and both outlet header and water header of both banks are connected to both bank after coolers to cool the inlet air to the engine and collected back water return header.

Hot water from the engine outlet is cooled in both radiators and circulated back to engine through lube oil cooler. Hot water in the radiator is cooled by two AC motor driven Radiator Fans (8 blades 52" dia.) powered from the Companion Alternator, which is controlled by EM 2000 based on the feedbacks from Temperature Sensors (ETP1 & ETP2).

Radiator Fans get three phase AC supply from Companion Alternator through 2 sets of 300 amps fuses and 3 sets of Contactors for each fan. FCS (Fan Contactor Slow Speed) for half speed and FCFA and FCFB (Fan Contactor Fast Speed) for full speed. Temperature of the cooling system is maintained between 79°C and 87°C with help of the above computer controlled circuitry.

If, EM 2000 detects the failure of any one of the Temperature probes, it displays a crew message "Engine Temperature Feedback Failure" and stores the message in the Archive memory. If it detects both probes have failed, it ignores both the probes signal, remains in last operation status and engine goes back to idle with a message- "No Load-Engine Temperature Feedback Failure"



If for any reason one set of Fan fuse blows off or one Radiator Fan motor is not working, the coolant temperature will rise beyond max setting of 87°C. When the temperature exceeds 97°C, the following message will display on EM 2000 Screen- "Hot Engine-Throttle 6 limit" even though the throttle handle is on 7 or 8th notch. This will continue till the engine temperature reaches the safe limit.

A common outlet from both water pumps is taken to Air Compressor. Water taken to air compressor circulate through all 3 cylinders heads and Intercooler of the compressor. Outlet water from the air compressor is piped back to cooling system through lube oil cooler.

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## **FUEL OIL SYSTEM OF DIESEL LOCOMOTIVE (GM LOCO)**

Fuel oil system is designed to give constant volume/ pressured fuel to the injectors irrespective of load. As per throttle position and load requirement, Engine Governor controls the injector rack position. The system consists of fuel tank, suction strainer, and fuel pump, fuel filters, pressure control relief and by pass valves. Fuel Headers (one on each left and right bank) are fitted inside the top deck head frame assembly and connected to fuel injectors through individual fuel lines.

Fuel supplied to fuel injectors from the fuel pump is injected into cylinders as per the requirement and the excess fuel is used to cool and lubricate fuel injector parts taking away the heat to fuel tank through return fuel line.

### **GENERAL ARRANGEMENT**

Fuel from the fuel tank (of capacity 6000 litres.) is drawn the fuel booster pump through suction strainer, where suspended particles are filtered. Fuel from suction strainer flows to fuel booster pump which is a crescent type positive displacement gear pump. Pressurised fuel from the booster pump is piped to fuel primary filter which is a paper type filter in which fuel is filtered.

A by-pass valve and gauge is provided across fuel primary filter to prevent overloading fuel booster pump in case of choked fuel filter.

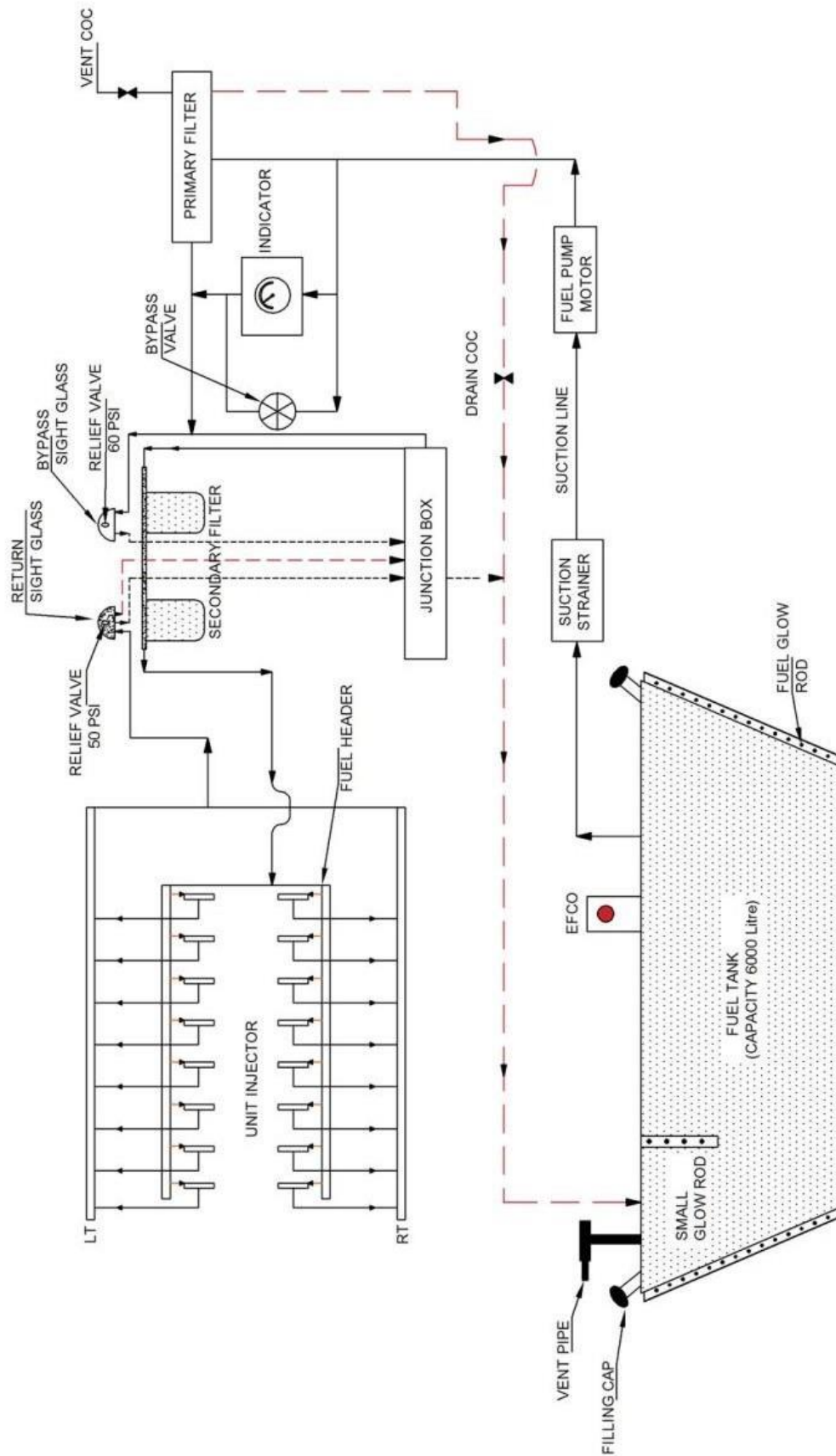
The by-pass valve is set at 30 psi and the gauge is having Green, Yellow & Red zones. Gauge needle in the Green zone indicates the healthy condition of the fuel primary filter. Yellow and Red zones indicate choked filter needs renewal. Fuel from primary filter flows to engine mounted spin-on secondary paper type filters.

A secondary filter by pass valve is provided for the fuel spin-on filters is set at 70 psi, which is placed inside a sight glass bowl provided over the spin-on housing. Oil inside this bowl indicate that the fuel spin-on filters are choked need to be replaced. This sight glass should be always empty.

Fuel flown to secondary filters enter both bank fuel headers after secondary/fine filtration. Fuels from both bank fuel headers enter individual fuel injectors through the fuel lines. According to the notch and load demand, engine governor meters the fuel supply to the engine cylinders by operating fuel racks of the injectors through linkages connected to fuel control shaft.

The excess fuel flows back to fuel return headers and to fuel tank through a return sight glass provided on the fuel spin-on filters with a 15 psi pressure regulating valve. This sight glass is near to the engine block which should be always full of fuel without air bubbles. Bubbles in the fuel return sight glass when the engine is in dead condition & fuel pump is running indicates air draw in suction side of the fuel booster pump. Bubbles after cranking the engine indicates the leaky fuel injector. Bubbles in higher notch with full load indicate insufficient fuel supply.

## FUEL OIL SYSTEM OF EMD LOCO



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## COMPRESSED AIR SYSTEM

Air Compressor used on WDG4/WDP4 locomotive is a three cylinder, two stage (low pressure and high pressure) water cooled air compressor. The compressor is mechanically driven by the engine with the help of flexible couplings and extension shaft from the front or accessory end of the diesel engine.

Atmospheric air is taken to the locomotive Clean Air Compartment through cyclonic filters. Filtered air from the cyclonic filter is compressed in the TM blower and taken to cool all the 6 TM's through the duct passage in the superstructure. Inlet air for the air compressor is also taken from the TM duct through two flexible hose pipes and individual air inlet filters of low pressure cylinders.

Air received at the compressor air inlet filters is filtered through these filters (fibre glass filters - one for each LP cylinder). Primary stage of air compression is done in LP cylinders and enters HP cylinders through a water cooled inter cooler. Air after secondary stage compression in the HP cylinder enters cooling coils laid inside radiator compartment. The atmospheric air drawn by radiator cooling fans passes through these cooling coils and the compressed air inside cooling coil gets cooled before entering Main reservoirs.

Compressed and cooled air enters MR1 (Main Reservoir of capacity 492 litres. MR 1 air is taken to feed MREQ pipe and also a pipeline is taken to MRET (Main Reservoir Pressure Transducer) in the CCB system. CCB system CRU (Computer Relay Unit) get continuous feedback from MRET regarding MR1 pressure so as to take corrective action by CCB in case of less main reservoir pressure/parting between locomotives.

MR1 outlet air further passes through a MR safety valve set at 10.5 kg/sq.cm pressure and enters air dryer. The air dryer separates moisture content in the compressed air (Purges out moisture through twin towers). Dry air from the air dryer is taken to Air Manifold (Located inside Air compressor compartment). From the air manifold the MR1 air is taken to operate – Sander magnet Valves, Horn Magnet Valves, MR1 & MR2 tank ABD Valve operating Magnet Valve (MV-EBT) and MVCC (Magnet Valve Compressor Control) which releases air pressure to operate compressor unloader valves on LP & HP cylinders. An air pipeline tapping is taken from MR1 tank outlet to MRPT (Main Reservoir Pressure Transducer). EM2000 get the feedback from MRPT regarding the compressed air pressure in the MR1 circuit. EM2000 decides and operates MVCC to load/unload air compressor accordingly.

When the MR1 pressure reaches 9.84kg./sq.cm. (140 psi), the MVCC is energized by EM2000 and the MVCC releases pilot air pressure to unloader valves to unload the air compressor. When MR pressure drops to 8.44 kg./sq.cm.(120 psi), MVCC is de-energized from EM2000 and the pilot air pressure supplied to unloader valves is withdrawn and released to atmosphere through MVCC valve. Thus, the loading & unloading of air compressor is controlled.

A pipeline is taken from MR1 outlet pipeline to MREQ pipe (main reservoir equalizing pipeline) and also, a tapping is taken from MREQ pipe to MRET (main reservoir equalizing transducer) in the CCB system. This will help to safeguard the trailing locomotive in a MU consist during parting between locomotives. Sudden pressure drop in the MREQ pipeline is sensed by MRET and CCB applies loco brakes from the trailing loco itself.

Another pipeline is taken after air dryer to D24-B (feed valve for feed pipe) valve in which MR1 pressure is regulated to 6 Kg./sq.cm and the feed pipe is charged from this valve.

Main pipeline from MR1 tank after passing through air dryer is taken to MR2 tank. Air from MR2 tank is taken to CCB system through MR2 final filter. There are two automatic blow down valves (ABD valves), one on each MR tanks. These valves are meant for draining the moisture from MR1 & MR2 tanks periodically. EM2000 computer is controlling the loading and unloading of air compressor based on the pressure feedback of main reservoir from MRPT. At the same time, EM2000 activates EBT (Electronic Blow-down Timer) valve by giving 74 V DC supply. EBT releases pilot air pressure to both the MR1 & MR2 ABD valves and ABD valves purges out the moisture collected inside MR1 & MR2 tanks. Both ABD mounted bottom of the MR tanks.

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## DIFFERENCE BETWEEN WDG<sub>4</sub> AND WDP<sub>4</sub> GM LOCOMOTIVES

S. NO.	DESCRIPTION	WDG <sub>4</sub>	WDP <sub>4</sub>
1.	Model	GT46MAC	GT46PAC
2.	Service	Goods	Passenger
3.	Speed	100kmph	160kmph
4.	Speedometer	0-120kmph	0-180kmph
5.	Weight	129Tonne	115.8tonnes
6.	No. of Axis	6	6
7.	No. of Traction Motor	6 (Each Bogie 3 Drivers)	4 (Each Bogie 2 Drivers)
8.	Under TCC1	1,2,& 3 Axle Tm	1, & 2 Axle Tm
9.	Under TCC2	4,5 & 6 Axle Tm	5 & 6 Axle Tm
10.	TM Pinion and Bull Gear Ratio	17:90	17:77
11.	Batteries	LEAD ACID	NICKEL CADMIUM
12.	No. of Batteries	2	10
13.	No. of Cells	32	50
14.	Cell Voltage	2.1	1.5
15.	Total Voltage	68	75
16.	Engine Starting Switch	Located Below Water Expansion Tank	Located in The Cab Itself
17.	For Quick Engine Firing	Governor Lay Shaft Manually Operation	Governor Booster Pump Starts Automatically
18.	Radar System	Located Between Front Bogie & Fuel Tank	Located Between Fuel Tank & Rear Bogie
19.	Cab Light Switch	Near Cab Light	In Control Stand Side Switch Panel
20.	Lube Oil Filter Drum	Only Bye-Pass Valve	Bye-Pass Valve With Gauge (Like Fuel Oil Primary Filter)
21.	Blended Brake	Not Provided	Provided
22.	Location of Blended Brake	Not Provided	On Engine Control Panel
23.	Low Water Level Switch	Not Provided	Provided in The Engine Cooling Water System
24.	Temperature Gauge	Not Provided	Located on The Inlet Line To The Water Pump
25.	Colour Code (Temperature Gauge)	Not Provided	Blue (Cold), Green (Normal) & Red (Hot)

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## HTSC BOGIE (High Tensile Steel Cast)

**Model:** HTSC

**Gear Ratio:** 77:17

### DRIVING WHEELS:

**Quantity:** 2 Powered Wheel Sets per bogie {truck}

1 Non-powered Wheel Set per bogie {truck}

**Diameter:** 1092 mm (43 inches)

### BRAKE RIGGING:

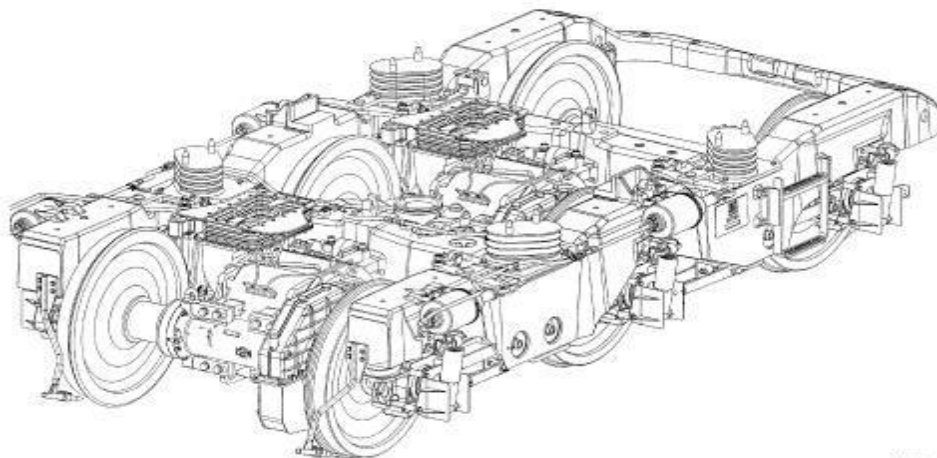
**Type:** Single Shoe 406.4mm (16 inches)

**Shoe Material:** Composite

**Brake Cylinders:** 4 per bogie {truck}

The GT46PAC locomotive is equipped with a modified HTSC (High Tensile Steel Cast) truck or bogie. This truck/bogie assembly supports the weight of the locomotive and provides the means for transmission of power to the rails. Unlike conventional rigid trucks/bogies, in which axles are held in parallel with each other, the HTSC truck/bogie is designed as a powered "bolsterless" unit. The trucks/bogies are equipped with two AC power traction motors and one unpowered idler axle/wheel set. The traditional rubber suspension spring "nose packs" on the motors are replaced with nose link assemblies (dogbones) that increase ease of disassembly and lowering of traction motor/wheel sets for maintenance.

The unsprung weight of the locomotive carbody is transferred directly to the truck/bogie frame through four rubber "compression" spring assemblies. These four spring assemblies are located at corner positions formed on the truck/bogie where the side beams and cross beams intersect, thus providing the yaw stiffness for tracking stability. This relatively stiff secondary spring suspension limits weight transfer between axles during adhesion as all traction motor nose positions are on the same side of each axle within the truck/bogie frame. (All the traction motors are arranged within a truck/bogie in one direction, providing good motor accessibility and adhesion characteristics.) The soft primary suspension, made up of twelve single coil journal springs (two at each journal), is designed to provide ride quality and equalization of wheel set loads for operation over track irregularities. Shock absorbers are used between the truck/bogie frame and locomotive underframe to damp the lateral movements of the bogie for stability at higher road speeds.

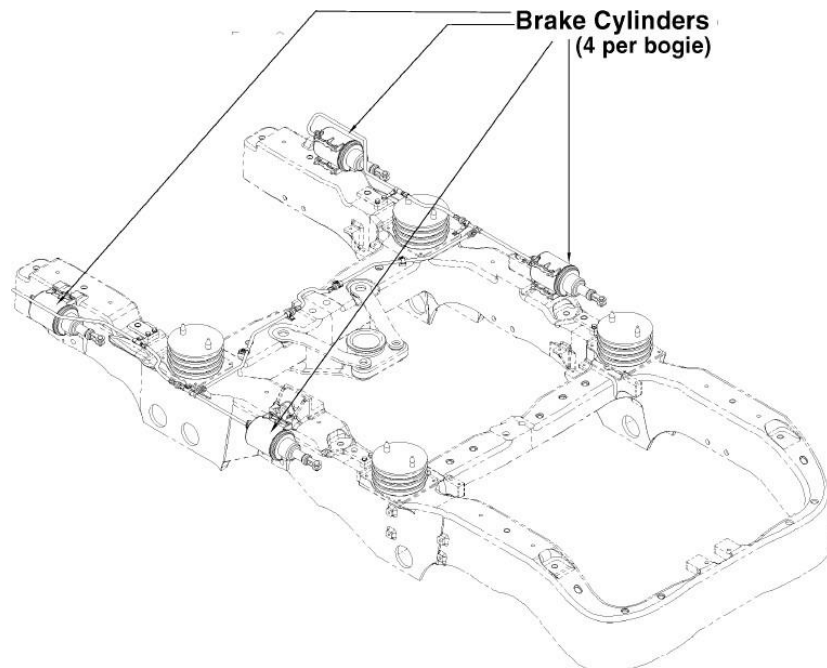


## **LATERAL SHOCK ABSORBERS AND SAFETY LINKS**

These safety links serve to prevent separation of the truck/bogie assembly from the locomotive in case of derailment and to provide a means of lifting the truck/bogie assembly along with the carbody. The journal bearing adapters transmit the vertical load from the springs to the axles. Rubber deflection pads on the adapters and nylon wear plates on the frame control the lateral thrust loads of the axles within the truck/bogie frame. These pads and wear plates are renewable and provide the means by which the lateral clearances can be maintained within limits. These limits are 15.9 mm (0.62") for the centre axles and 10.4 mm (0.37") for the end axles.

## **BRAKE CYLINDERS MOUNTING**

Air brake cylinders and brake rigging mounted on the truck/bogie are used to apply retarding forces to the wheels to slow and stop the locomotive. A single shoe system is used which provides a single composition type brake shoe at each wheel.



## **TRUCK/BOGIE FRAME**

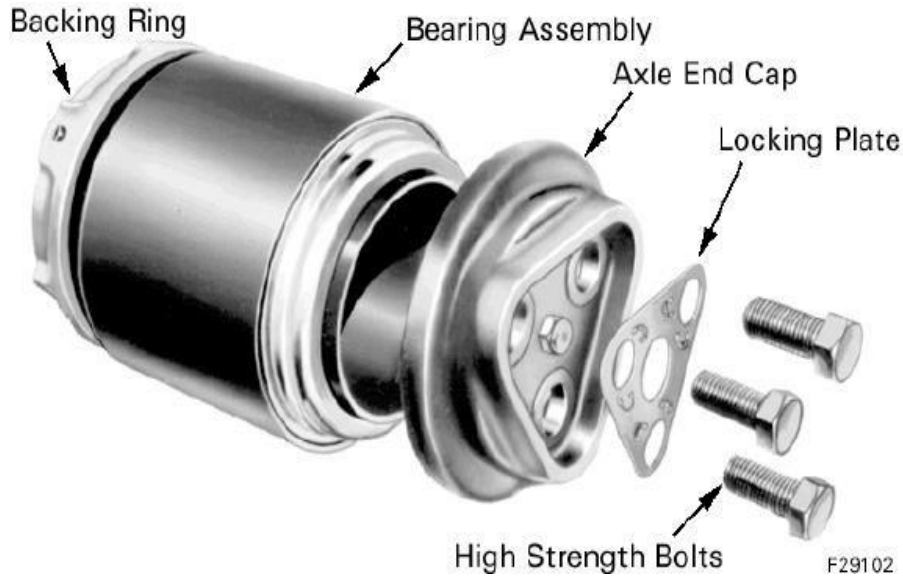
The truck/bogie frame is a one-piece high tensile steel casting (Hence the acronym, HTSC). It has been designed to hold all the major components of the truck/bogie assembly. During inspection; check for loose or broken equipment and integrity of components. Inspect all truck/bogie frame members for cracks or breaks. Check all worn areas. Worn spots can be repaired by building up the affected area with weld and then grinding the area back to its original form.

## **VERTICAL STOP CLEARANCE**

The vertical stop surfaces on the side of the truck/bogie frame are designed to mate with similar surfaces (vertical stops or shims) tack welded beneath the carbody under frame. Clearance is provided between the bogie vertical stops and the carbody underframe vertical stop shims during normal operation. These stops are designed to prevent the excessive tilting or leaning of the locomotive. These stops are not designed to carry a continuous load. The vertical stop clearances are (on a new assembly); 16 mm +/- 3.2 mm (0.62" +/- 0.12"). Vertical stop wear that is close to the limit can indicate relaxation of the rubber compression spring assemblies.

## JOURNAL BEARINGS

The GT46PAC locomotive is equipped with cartridge type grease lubricated journal bearings. These cartridge type bearings are self-contained, preassembled, pre-adjusted, pre-lubricated, and completely sealed. The bearings are applied and/or removed without exposing the bearing elements, seats, or lubricant to contamination or damage.



### Journal Bearing Adapter Assembly

The adapter serves to position the journal springs between the truck/bogie frame and the axle to transmit the vertical loads. It also provides the means to position and control the axle laterally within the frame, as well as longitudinal control through the attached traction rod. Roller bearings should be given a visual inspection for the following;

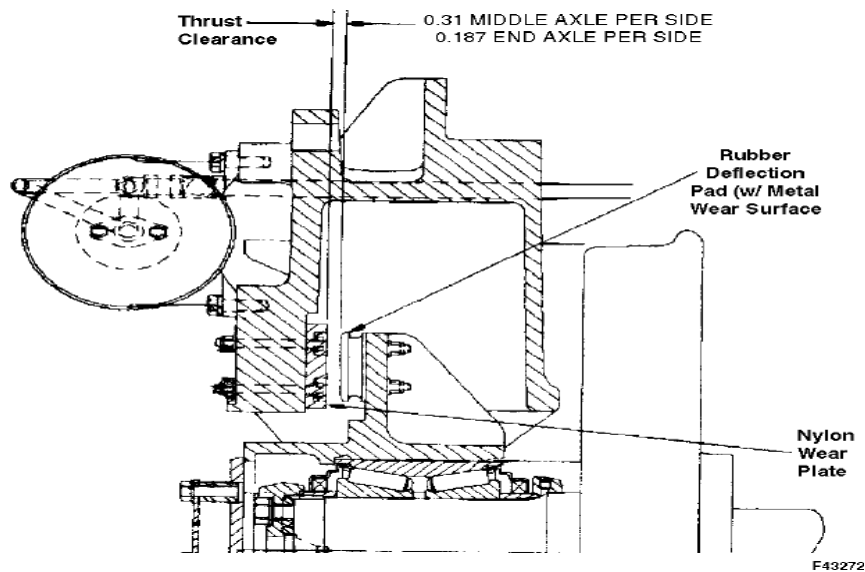
- Signs of overheating
- Excessive lubricant leakage
- Broken, loose, or missing parts (such as loose cap screws, etc.)
- Loose or defective seals
- Cracked or broken cups, end caps, or adapters, etc.

### AXLE LATERAL THRUST CLEARANCE

Each journal bearing adapter assembly, when installed on the end of an axle in the truck/bogie assembly, has a bracket section (or lug) that is positioned in (engages) a spring pocket of the truck/bogie frame. A rubber deflection pad is bolted to the bracket and a corresponding Nylon wear plate is mounted in the spring pocket.

The renewable rubber deflection pads and Nylon wear plates provide for control of the axle lateral thrust clearance. Clearance limits between these lateral wear surfaces are such that in normal operation, the clearance will not exceed the maximum limits in the scheduled period between truck/bogie reconditioning. The maximum limits are 7.87 mm (0.31") per side on the middle axles and 4.75 mm (0.187") per side on the end axles.





### Axle Lateral Thrust Clearance, Wear Plate and Deflection Pad

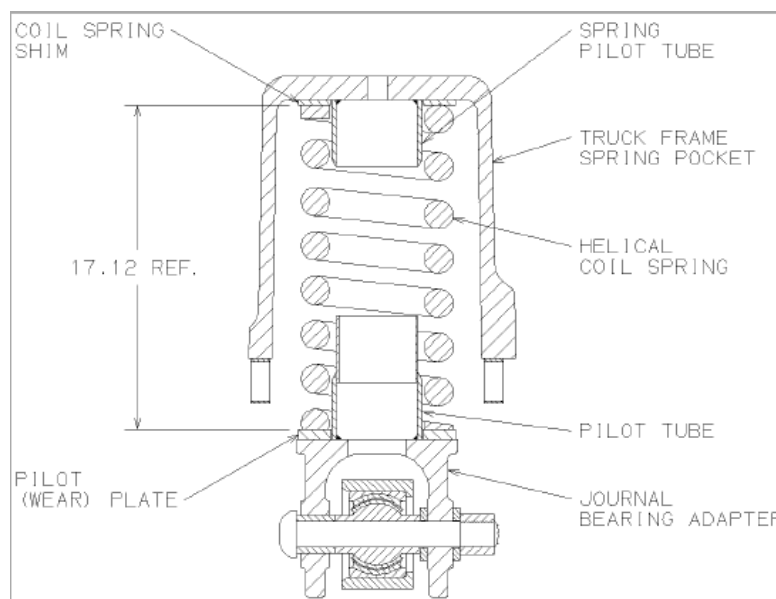
The renewable rubber deflection pads and Nylon wear plates provide for control of the axle lateral thrust clearance. Clearance limits between these lateral wear surfaces are such that in normal operation, the clearance will not exceed the maximum limits in the scheduled period between truck/bogie reconditioning. The maximum limits are 7.87 mm (0.31") per side on the middle axles and 4.75 mm (0.187") per side on the end axles.

### HELICAL COIL SPRINGS

Locomotive truck/bogie frame to axle journal primary suspension is provided by steel helical coil springs. Single coils are used that provide for large amounts of deflection. This assists in wheel load equalization, and improves ride quality over rough sections of track. It also aids in allowing yaw movement of the traction motor/axle wheel assemblies within the truck/bogie. Helical coil springs are specifically designed for various weight ranges, and provide the optimum suspension system for each range of locomotive weights.

### COIL SPRING SEATS

In order to secure the coil springs on the journal spring adapters, spring pilot tubes are used along with pilot wear plates between the springs and the adapter. Spring pilot pins and shims are also located in the truck/bogie frame spring pockets to perform the same function.



## **SHOCK ABSORBERS**

The GT46PAC truck/bogie is equipped with vertical primary shock absorbers and lateral secondary shock absorbers for high-speed operation. Partial failure of locomotive shock absorbers is a comparative rarity. Normally, when one fails there is no resistance to movement in compression or rebound. A simple manual test will usually detect these failures. If a shock absorber is new or has not been used (in storage, for example) for some time, it must be cycled to obtain consistent motion before being checked for control. Resistance developed during testing is proportional to the velocity of the test stroke. In other words, the harder and faster the shock is cycled, the more it will resist movement. Shock absorbers contain a reserve of hydraulic oil, and allow seepage to lubricate the shock's piston rod. A light film of oil is normal and is not a cause for rejection. However, as the remaining oil in the shock cannot be ascertained, any heavy leakage is cause for replacement of the shock.

Periodical check:

1. Check for leaking fluid. Make sure that oil has not been deposited from some other source.
2. Check the shock absorber per the Manual Qualification procedures before condemning.
3. Inspect bushing integrity. Bushings should not permit gross vertical or lateral movements of the shock absorber.

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## **ELECTRICAL SYSTEM**

GT46 MAC/PAC locomotives are equipped with 710 G3B type of Diesel Engine. The crankshaft of the Diesel Engine is directly coupled to the main alternator of TA17-CA6B type. The control for production and utilization of power is established through an elaborate electronic circuitry comprising of one main locomotive computer called EM 2000 and two traction computers called ASG computers. The brake system has a separate computer for itself.

The starting of the engine is established through two starting motors. These motors get their power supply from the batteries through starting contactors ST & STA. Once engine is cranked the ST and STA contactors drop out and the power supply to starting motors is cut off. After the engine is cranked the power supply for the control circuit is through Auxiliary Generator output. The AG is responsible for power supply to the whole of control circuit and the charging of batteries through battery charging assembly (BCA).

The computers (EM 2000, ASG1&2, CCB) get their power supply from the batteries when the loco is in shut down condition and from BCA output if loco is in cranked condition. EM 2000 gets its power supply from batteries/ AG output through PSM cards. The PSM cards get their input from battery/ AG through PRG which ensures that the supply for PSM cards is within acceptable voltage range by suitably regulating the battery/AG output voltage. PSM 300 and PSM 310 give +5V & +/- 12V respectively for EM 2000.

The PSM 320 gives +/- 15V which forms input for PDPs, ASC, Display, FCF and Radar. The companion alternator is housed with TA in one common enclosure and it gets its field excitation from AG output and produces three phase AC. This three phase AC is used for radiator fans ,inertial blower, TCC1 & 2 blowers, TCC electronic blower and the field excitation of main alternator. The excitation of main alternator field is effected and controlled through SCR assembly. The firing pulses to SCR assembly are supplied by FCD after amplification of weak gate signals generated by CPU of EM 2000.

The control of field excitation of Main Alternator is effected with the coordination of CPU, FCD & FCF. FCF supplies CA voltage and frequency data on which CPU counts the time necessary before generating a gate pulse. The generated pulse is a weak gate pulse which is amplified by FCD and applied across the gate of SCR unit. In this way, a wide range of power output from Main Alternator is obtained.

The 3 phase output thus generated is rectified through two rectifier banks inside the main alternator housing. The rectified output is available as DC link voltage which is applied across the two TCC units when loco is required to be propelled or across the 8 grid resistors through contactors B1, B2, B3 and B4 in case of Load Test.

The output of the Main Generator is available as DC link voltage which is applied across the two traction control converters. The DC available is processed by the TCCs to invert it in to AC supply which is applied across the traction motors. The TCC1 is responsible for power supply to TMs of Truck 1 and TCC2 for Truck 2.

The operation of TCCs is controlled by individual ASG computers for the two TCCs. The response of ASG depends on the demand received from EM 2000. The requirement of different speeds and torque is met by controlling the firing signal to the gate unit of GTOs in TCC units by the ASG. Thus various ranges of Torque and speed can be obtained.

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## EM 2000 COMPUTER

The EM 2000 is responsible for the total functioning of the Locomotive including Traction System and Air Brake System. Some of the important function of EM 2000 are outlined below:-

**EXCITATION:** It controls the excitation of the Main Alternator field supply by varying the timing of the gate pulses of the SCR assembly.

**I/O LOGIC:** It monitors the position of control devices in the cab and monitors and control ON/OFF devices on the locomotive, e.g. Governor Speed Solenoids Contactors, Relays, Magnet valves. It controls the alerter vigilance system also.

**DISPLAY:** It accepts inputs from CPU. Display information on the display screen and initiate diagnostic functions through display panel.

**COM 301:** Communication interface between EM 2000, TCC1, TCC2, KNORR Air brake computers & Event Recorder.

**MEM 300:** Stores fault data and operational data, and all the relevant data for locomotive operation.

**ADA 305:** Handles scaled analog inputs directly as well as through ASC and converts them to digital signals for the computer. It is also responsible for converting digital signals from CPU to analog signal that is required by receiving devices like TE Meter, Speedometer.

**CPU 302:** It is the Brain of EM 2000 which controls the total working of the locomotive, through all other computer/panel mounted modules.

**DIO:** These are three in number (namely 1, 2, and 3 from left to right) and inter changeable also. These are known as Digital Input and Output Modules. It acts as an interface between Locomotive 74V DC control system and computer 5V DC system. Input signals come from Breakers, Switches, Relay/Contactor inter locks giving the status of each. The output is either 74V DC or 0V DC across a relay or contactor coil, so the relay/ contactor is either picked up or dropped out. Each DIO has 24 inputs and 26 output channels.

**DISPLAY:** The display is used for information regarding any crew message, and also has key pad with 16 keys for use in recovering data, fault analysis, and to give commands to the computer to activate set of programs like self-tests, Traction Cut out, Isolation of speed signals, etc., it is mounted on the ECC1 door above the EM 2000.

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## ROTATING EQUIPMENTS

**TRACTION ALTERNATOR:** Diesel Electric Locomotive uses a Main Alternator to convert Mechanical power developed by the Diesel Engine into electrical power. The main alternator is a 3 phase alternator with two independent and inter woven sets of stator windings and a rotating field common to both the windings, in order to provide a higher output voltage.

The Traction Alternator houses two rectifier banks for converting AC into DC these are permanently connected in series.



Model – TA 17

Max Voltage – Rectifier output – 3000V DC.

Min Voltage – Rectifier output – 600V DC.

Brush Condemn – 38mm. Slip Rings – Min dia – 260mm.

No. Of Fuses/Bank – 15 (8407729)

No. of +ve Diode/Bank – 15 (White) (40029132)

No. of –ve Diode/Bank – 15

**COMPANION ALTERNATOR:** The companion Alternator is physically connected but electrically independent of the Traction Alternator. The Companion Alternator field (rotating field) is excited by a low voltage current output from Aux. Generator through a pair of slip rings adjacent to the slip rings of the main alternator.

The 3 phase AC output of the Companion Alternator coming from the stationary armature (stator) is connected to a terminal board on the left bottom of the Companion Alternator.

There are no controls in the Companion Alternator excitation circuit, thus it will be excited and developing power whenever the diesel engine is running and Auxiliary Generator is producing output.



Output voltage frequency will vary with speed of engine, Alternator winding temperature and load. The Companion Alternator provides power to the initial filter blower motor, radiator blower motors, TCC blower Motors, TCC Electronic Blower motor and excitation of the Main Generator field through SCRs. (3 Silicon Controlled Rectifiers).

Type – CA 6B

Power – 250KVA at 0.8 PF.

Voltage – 45-220V 3 Ph AC.

Max. Frequency – 120 Cycles/Sec at 900 rpm.

Max. Current – 600 amps.

Brush grade – AY.

No. of Brushes – 4 (+ 2 Nos. –ve 2 Nos.)

Condemning Length – 38mm.

### **AC AUXILIARY GENERATOR (BRUSH LESS)**



The AC auxiliary Generator consists of a pilot exciter assembly and a three phase AC Auxiliary Generator Field and armature assembly.

The pilot exciter assembly consists of a Stationary field, a rotating armature and rotating rectifier assembly. The AC Auxiliary Generator has a rotating field and stationary armature. The pilot exciter rotating armature and rotating rectifier assembly and the AC Auxiliary Generator rotating field are installed on a common shaft. During start up, residual magnetism of the pilot exciter stationary field induces voltage on the pilot exciter rotating armature. This AC voltage is rectified by the pilot exciter rectifier assembly and applied to the AC Auxiliary Generator rotating field. This rotating field induces voltage in the AC auxiliary generator stationary armature (stator). The small AC output voltage of the auxiliary generator is applied to the DVR (Digital Voltage Regulator module).

The Low AC Signal is used by DVR to determine if the Aux. Generator is turning, if it does, DVR will allow current from the batteries to flow in the exciter field of the Aux. Generator in order to produce the 3 phase 55V AC output.

Model – 5A – 8147

Output – 18 KW at 55V AC

The Aux. Generator supplies voltage to the 2 GTO power supplies, panel mounted module FCD (Firing control driver) and also to the full wave 3 phase rectifier (Battery Charger) assembly to obtain 74V DC for battery charging, companion alternator excitation and low voltage DC control power.

## **DYNAMIC BRAKE GRID BLOWER ASSEMBLY**



Model – DC Series Motor.

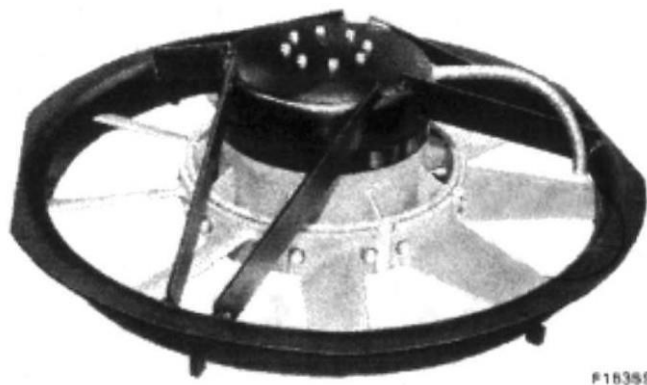
No. of Poles – 4

Capacity – 36 HP

Brush Condemn Length – 25.4 mm (1")

Each Dynamic Brake Grid cooling blower assembly consists of a 48" 10 blade fan powered by a series wound DC motor. During Dynamic Braking the locomotive Traction Motors operate as Generators supplying AC power to inverters. The inverters convert AC power into DC voltage and supply back to the DC link. The DC link is connected across the grids through contactors B1, B2, B3 & B4 and the Braking energy is dissipated as heat. A portion of the electrical grid is used to power grid blower motor (36 HP). To dissipate grid heat to atmosphere.

## **RADIATOR COOLING FAN MOTORS**



These motors are of inverted squirrel cage induction type and are an integral part of the cooling fan assembly. The term inverted indicates that they differ from the conventional squirrel cage motor in that the rotor is located outside the stator.

Two 52" Cooling Fans (8 blades) which operate independently are located at the hood under the radiators and blow the cooling air upwards through the radiator cores. They are numbered 1 and 2 with No. 1 close to the cab.

For fuel efficiency each cooling fan is driven by 2 speed AC Motor which in turn is powered by the Companion Alternator. As the engine coolant temperature rises the fans are energized by the computer control system through radiator fan contactors in slow speed and then in fast speed. Water Temperature Sensors ETP1 and ETP2 give the temperature of the coolant to the computer.

### **TCC ELECTRONIC BLOWER**

The cooling of TCC1 & TCC2 Electronic Components is effected by air supplied from TCC Electronic blower. Air is drawn from the central air compartment through 3 phase, TCC Electronic blower motor powered by the Companion Alternator and sent through 2 separate hose pipe and to each TCC filter (Dynacell). This air is used for cooling and pressurizing in some (but not all) parts of the inverter cabinet. The filter keeps dirt from contaminating areas containing DC Link Capacitors, Gate units and Traction Computers.

### **FILTER BLOWER MOTOR**

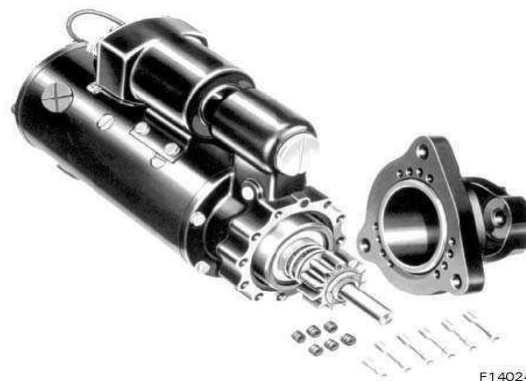
The filter blower motor is located just below the TCC electronic blower motor. The dust in the air which is removed by the cyclonic filter and collected at its bottom is drawn by the dust bin blower through hoses fitted on each cyclonic filter and thrown to the underframe of the locomotive through the passage below, this way the dust in the atmosphere air is removed in the central air compartment.

### **FUEL PUMP MOTOR**

The Fuel Pump Motor is a  $\frac{3}{4}$  HP 1200 rpm AC Motor which has inbuilt inverter to convert the 74V DC supply into 3 phase 55V AC. The pump supplies oil to the system through primary and secondary spin on filters. To protect the motor pump and to regulate fuel pressure the bye pass gauge and bye pass relief valves are provided. For easy maintenance the fuel inlet and outlet of the injector is passed through sight glasses.

The Fuel pump is mounted on the equipment rack. The motor is directly coupled to the fuel pump. During engine operation the pump supplies fuel oil for combustion and injector cooling. A bye pass valve is connected across the primary filter that protects the motor against overloading due to filter plugging.

### **STARTING MOTORS AND SOLENOIDS**



The loco is equipped with two starting motors each having two solenoids called pick up and holding solenoids. The starting motor solenoids are mounted on the starting motor housings. It contains concentrically wound PU (Pickup) and Hold coils. When energized by the pickup of STA contactor, the low resistance PU coil drives forward the starter motor pinion. To engage with the engine fly wheel ring wear. The switch inside solenoid closes when pinion is fully travelled resulting contactor pick up which in turn shorts out the PU coil. The high resistance HOLD coil, has sufficient energy to hold the pinion engaged. When the cranking signal is removed, the starting contactors drop out and starting motors pinions disengage from the engine ring gear. These motors are 64V DC series motors which are connected in parallel for cranking. Power circuits to the motors are inter locked so that the pinions of both starting motors must be engaged with the engine ring gear before cranking power can be applied for the motor.



## **TURBO LUBE PUMP MOTOR**

Model – 4 Pole  $\frac{3}{4}$  HP.

RPM – 1200

Voltage – 64-74V DC

The Turbo Lube Pump Motor is a  $\frac{3}{4}$  HP, 1200 rpm 64-74V DC Motor assembly, coupled directly to a lubrication oil pump and mounted at engine crank case on the left side of the locomotive. During engine startup, the pump provides lubrication for the Turbo Charger bearings and at shut down the computer (EM 2000) continues pump operation to carry away remaining heat from the Turbo Charger bearings.

## **AC TRACTION MOTORS**

AC-AC transmission has the advantage of high adhesion and high tractive effort, maintenance free Siemens ITB- 2622 - 0TA02



Three phase AC traction motors, high reliability and availability and higher energy efficiency. A specialty of this motor is that there is no separate stator frame resulting in reduction of weight. In braking mode, the three-phase motors act as generators and power is fed back to the DC link via the two inverters.

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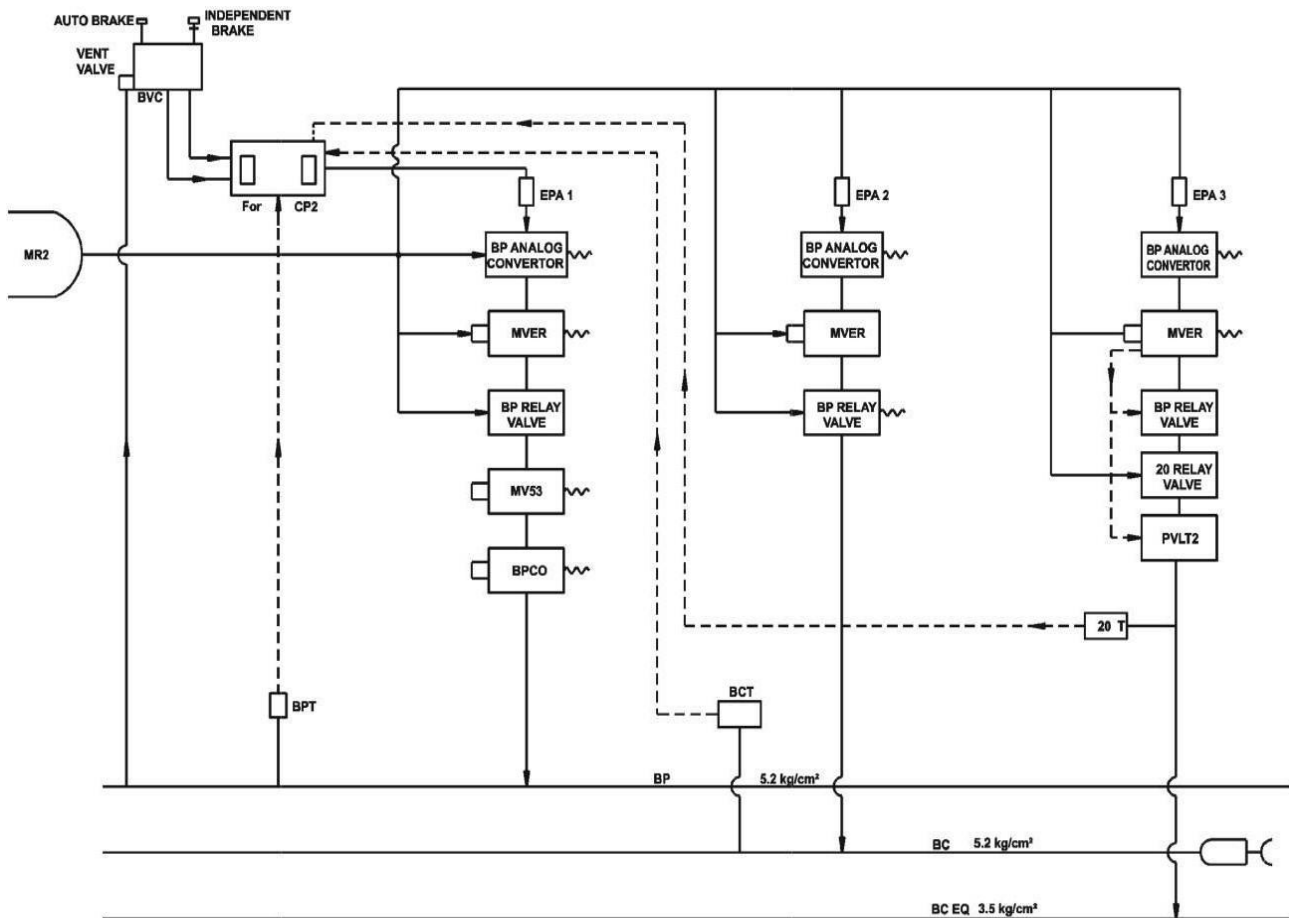
# COMPUTER CONTROLLED BRAKE SYSTEM

The loco is equipped with KNORR/NYAB CCB system. This system is an electro-pneumatic microprocessor based system. The CCB is mounted on a brake rack on the short hood (front) of the locomotive.

The brake rack consists of a 1. VCU (Voltage Conditioning Unit) 2. CRU (Computer Relay Unit) 3. PCU (Pneumatic Control Unit) 4. KE Valve for back up brake system. 5. Air Brake set up switch 6. Brake Valve Controllers (BVC) for drivers operation.

The brake valve controller consists of automatic (A9) and independent brake system (SA9) controllers. Each handle is attached to variable potentiometer that provide signal to the CP (Central processor) within the CCB. The handles are operated from front to rear side of the operator, so that the brakes are released when the handle is close to the operator. During the period of working, all the handles, i.e. Throttle, Auto Brake and Direct brake are moving upward motion. For braking action downward motion is for running the locomotive without braking.

Automatic brake (A9) controls the application and release of both the locomotive and train brakes having 5 positions Release, Run, Minimum Reduction, Full service and Emergency. Independent (SA9) controls the application and release of loco brakes having 2 positions Release application or full.



## **BRAKE EQUIPMENT RACK**

### **Computer Relay Unit:**

The computer relay unit contains computer & related modules used for control of the brake system. (One mother board and 12 other system boards). Digital display monitor for fault diagnostics.

### **Pneumatic Control Unit:**

The pneumatic control unit includes the equipment required to operate the pneumatic system. Mounted with electro pneumatic and pneumatic valves of both side of the manifold.

### **Voltage Conditioning Unit:**

1. The voltage conditioning unit is the main power supply for the CCB system.
2. The VCU reduces the incoming battery supply of 72 Volts DC to a filtered 24 volts DC to CRU of brake system.

### **Back up valve:**

The KE valve provides pneumatic back up function to allow basic air brake function in the event of failure of micro - processor control or KE valve will not maintain pressure against leakages valve mounted with 13 litres reservoir

**NOTE:** In MU loco separation, if both the loco CCB system in working, brake only used to work.

## **BRAKE VALVE CONTROLLER**

1. There are two brake valve controllers in the cab, one on each control stand.
2. The brake valve controller includes one Automatic & one independent brake control handle and one Lead/Train switch.
3. Two type brakes are used in controller:
  - a) Auto Brake (A9)
  - b) Independent Brake (SA9)

### **AUTO BRAKE (A9)**

1. The Automatic Brake fibre optic output signal commands the computer to the desired control of the brake pipe (BP) train line.
2. The Main function of Automatic brake valve is to control the formation as well as loco brakes, i.e., conjunction operation.
3. The Auto brake handle has five positions:-

<b>POSITIONS OF A9 HANDLE</b>	<b>BP PRESSURE</b>	<b>CORRESPONDING BP PRESSURE</b>
Release	5.7 kg/cm <sup>2</sup>	0
Run		5.2 kg/cm <sup>2</sup>
Minimum	4.7 kg/cm <sup>2</sup>	1.1 kg/cm <sup>2</sup>
Full service	3.4 kg/cm <sup>2</sup>	4.35 kg/cm <sup>2</sup>
Emergency	0	4.35 kg/cm <sup>2</sup> & BCEQ = 3.5 kg/cm <sup>2</sup>

**RELEASE:**

1. In this position, a frequency is transmitted to the computer to charge the BP at a faster rate to release the train brakes.
2. When Automatic brake handle is kept in release position BP increases from 5.2 to 5.7 kg/cm<sup>2</sup>. This is a spring loaded position. Leaving the handle from Release position will come back to RUN position. BP from 5.7 kg/cm<sup>2</sup> will come back slowly in normal pressure of 5.2 kg/cm<sup>2</sup> after 182 sec. should not use during train working.

**RUNNING:**

1. In this position, a frequency is transmitted to the computer to charge the BP fully, i.e., 5.2 kg/cm<sup>2</sup>.
2. In this position loco and formation brake release completely.

**MINIMUM:**

1. In this position brake pipe pressure reduces slightly to control the train.
2. In this position BP drops to 4.7 kg/cm<sup>2</sup> & BC pressure attains 1.1kg/cm<sup>2</sup>.

**FULL SERVICE:**

1. In this position brake pipe drops to 3.4 kg/cm<sup>2</sup> to control train & loco brakes in conjunction.
2. This position is also used to recover penalty brake application i.e., 10 seconds.

**EMERGENCY:**

1. In this position, BP dropping to —zeroll rapidly to control train loco brake.
2. The pneumatic position of the brake valve is connected directly to brake pipe (i.e., through emergency vent valve).
3. This position is also used to recover a penalty brake application (i.e., 60 seconds).
4. In emergency position electronic emergency brake also activated through CCB system.

**INDEPENDENT BRAKE**

1. The independent brake (SA9) release and apply is related to the brake application to loco only.
2. The independent brake handle has 2 position & a range of application zone between these two positions.
  - a. BC Pressure in Release – 0 kg/cm<sup>2</sup>
  - b. BC pressure in Full – 5.2 kg/cm<sup>2</sup>
3. In emergency position is bail off, loco brake will not release, as soon on release the trail off hart brakes will get applied again.
4. BAILOFF: when an Automatic brake is applied lifting the bail off ring provided on direct brake handle releases brake cylinder pressure of the loco to zero applied in conjunction with BP. During emergency braking BAIL OFF will not work for releasing the loco brake.

**PNEUMATIC CONTROL UNIT**

1. The pneumatic control unit is an Electro Pneumatic device that develops and destroys air from the Main reservoir to the locomotive:-
  - a. Brake cylinders.
  - b. Brake pipe.
  - c. Brake cylinder equalizing pipe.

2. The PCU has:-
  - a. Electro – Pneumatic control circuit.
  - b. High capacity Relay valves.
  - c. Analog converter valves
3. These are devices mounted on a laminated manifold that provide all inter valve connections minimizing the interface piping required.
4. There are 3 pressure control circuit in the PCU.
  - a. Brake pipe control circuit for use on formation.
  - b. Brake cylinder equalizing pipe control circuit for locos in MU operation.
  - c. Brake cylinder control circuit for loco brake.

#### **BRAKE PIPE SYSTEM**

- 1) Analog converter (AW4-ER).
- 2) Equalizing Reservoir, transducer.
- 3) MVER (ER MAGNET Valve).
- 4) BP relay (KR-5E0).v. MV 53 (53 Magnet Valve).
- 5) BPCO (Brake Pipe cut off valve).
- 6) Brake pipe Transducer (BPT).
- 7) Brake pipe fittings.
- 8) PVEM & MVEM (Emergency Pilot Air Valve & Emergency Magnet Valve to make the train line BP to zero either by driver option or by train parting without the knowledge of driver.

**NOTE:** ER is a pilot air to maintain train line BP through BP relay.

(Sl. No. 5, 6 & 7 for changing the system according to Lead trail mode selection).

#### **BRAKE CYLINDER CONTROL UNIT**

- 1) Analog Converter (Aw4-16)
- 2) 16 Pipe Transducer (16T)
- 3) 16 Magnet Valve (MV – 16T)
- 4) BC Relay (J-1)
- 5) BC Transducer (BCT)

**NOTE:** To operate the loco brake system from lead loco to trailing loco.

#### **BRAKE CYLINDER EQUALIZING PIPE CONTROL UNIT**

(To operate the loco brake system from lead loco to trailing loco)

- 1) BCE valve (Brake cylinder equalizing valve/20 portion valve).
- 2) MVLT (Magnet Valve Lead/Trail).
- 3) PVLTL (Pneumatic Valve for Lead/Trail).
- 4) PVLTL 2.
- 5) 20 Relay valves.
- 6) 20 Transducer.

#### **BRAKE CYLINDER EQUALIZING VALVE**

The purpose of the brake cylinder equalizing valve is to provide an air pressure to the brake cylinder equalizing pipe from the lead locomotive to control brake cylinder pressure on the trailing locomotive during both Automatic & Independent brake applications & release.

## **INDEPENDENT BRAKE VALVE**

Independent Brake provides independent control of the locomotive brakes irrespective of train braking effort.

- a. RELEASE: Brake Cylinder pressure 0 kg/cm<sup>2</sup>
- b. APPLICATION ZONE: the status is in between release and Full Application, i.e., 0 kg/cm<sup>2</sup> to 5.2 kg/cm<sup>2</sup>
- c. FULL APPLICATION: Brake Cylinder pressure is 5.2 kg/cm<sup>2</sup>
- d. BAILOFF: when an Automatic brake is applied, lifting the bail off ring provided on brake handle releases brake cylinder pressure of the loco to zero (i.e., Release for 60 seconds. But, loco brake re-applies immediately if the A9 handle is in emergency position.

## **SELECTOR SWITCH (LEAD TRAIL SET UP SWITCH)**

This is the switch connecting CCB system with EM 2000.

- a. TRAIL position is used when the loco is in trailing position as well as in the non-working control stand of the loco.
- b. LEAD position is used in the working control stand in the leading loco.
- c. HELPER position is used when the loco used as Banker (Helper) attached anywhere in the train formation other than LEAD. In this mode, the auto brake handle should be in FS only as like -of trial mode. In this mode, loco brake application and release can be obtained either by -Banker mode driver's direct brake or according to train line BP conjunction. The bail off ring also will be in working condition.
- d. TEST mode is used when leakage of BP pressure to ensure either in loco or train line BP. In this mode, direct brake will not function including bail off. Also the BC is applied to maximum, (i.e., 5.2 irrespective of the direct brake handle as a safety to avoid the driver to start the train without train line BP continuity.

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