LOCOMOTIVE TRAINEE TO LOCOMOTIVE ASSISTANTS COURSE

LESSON NO. 8

The diesel-electric locomotive has now become the main locomotive in use and the Locomotive Assistant although he does not have to fully understand electricity should have some knowledge of the terms used and the purpose of the main electrical equipment.

Electricity cannot be seen but the result of a current flow can:- in the form of light as from an electric light bulb, heat as from an electric heater and in the form of work when an electric motor turns a mechanical load.

To help with the understanding of electricity the flow can be likened to the flow of water.

VOLT:

This is the unit of electrical pressure developed by a battery or a generator and can be likened to the pressure of water from a tap.

The electrical pressure between two points is called the voltage and is measured by a voltmeter.

AMPERE (Amp):

This is the unit of electrical current, the current being the rate of flow of electricity in a conductor. Electrical current can be likened to the rate of flow of water in a hose.

Electrical current is measured in amperes (amps) by an ammeter.

CONDUCTOR:

This is a material which allows the passage of an electrical current such as copper wire and other metals. A conductor can be likened to the bore of a hose through which water is flowing.

INSULATOR:

This is a material such as rubber, glass, porcelain or mica which prevents the passage or leakage of an electrical current. It can be likened to a good quality hose material which prevents water leaks.

RESISTANCE : OHM:

A resistance is placed in an electric circuit to "resist" and reduce the rate of flow of electricity or current just as a restriction placed in a hose would cut down the flow of water.

The resistance material is a conductor of electricity, but it does not conduct as well as say copper.

The term "ohm" refers to the unit of electrical resistance.

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FLOW OF CURRENT : CIRCUIT:

To obtain a flow of water from a hose there must be water pressure difference between the supply to the hose and the hose outlet.

Similarly, to obtain a flow of electrical current there must be an electrical pressure (voltage) difference between the supply point and the return conductor. This pressure difference is produced between the two terminals of a generator or a battery as the case may be.

Also for electricity to flow, we must have a continuous circuit; that is, from the output terminal of the battery (or generator) through a wire to the load (light, heater, or motor, etc.) and back to the input terminal. If a wire in the circuit is broken or a switch in the circuit is open current will cease to flow. This condition is called an "open circuit".

DIRECT CURRENT (D.C.):

D.C. or direct current, so named because it flows in one direction through a conductor is produced from batteries and D.C. generators. Generally all equipment on locomotives is operated by D.C.

BATTERY:

This is often referred to as a storage place for electricity just as you would refer to a water tank as a storage place for water.

A battery has two terminals, one being referred to as the "positive" terminal and marked with a + sign, while the other is called the "negative" terminal and is marked with a - sign.

By connecting a wire to each terminal and connecting the loose ends to a suitable resistance electricity will flow from the positive terminal through the wire and resistance back to the negative terminal of the battery. Thus a circuit is formed for the current to flow.

The resistance placed in the circuit can be referred to as the "load" on the circuit and this load will generate heat. If you keep the load on the battery continuously the battery will discharge completely. When in this state the battery is said to be "flat".

If a wire or a metal object were placed between + and - terminals of a battery very high current would flow because there would be little resistance in the circuit. This situation is called a "short circuit". This is a very dangerous condition as the flash may damage your eyes or burn your hands. Also the battery may explode and as it is filled with sulphuric acid this acid may get in your eyes.

MAGNETS:

You can make a permanent magnet out of a piece of hard steel by placing it in the centre of a coil of wire fed by D.C. current. After the current has been switched off the hard steel will retain magnetism.

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The permanent magnet is seldom used for locomotive equipment. However an electro-magnet is used to operate all kinds of equipment. An electro-magnet is basically a coil of wire with a soft iron core, when current is switched on the core is powerfully magnetised, but when the current is switched off the magnetism is quickly lost.

The power of the attracting force of the electro-magnet is used to make motors run and allow generators to produce electricity.

RELAYS:

These are generally small electro-magnet operated switches operating contacts in the low voltage system.

CONTACTORS:

On diesel-electric locomotives high currents are carried by the traction "power" circuits and small switches such as used at home could not be used as they would overheat immediately and burn up. Large switches called "contactors" are therefore used to close and open high current, high voltage circuits.

These contactors are generally of two types:-

(a) Electro-pneumatic (E.P.) on which a small electro-magnet is switched on and its energy operates a valve which allows compressed air to push up a piston which closes the contactor contacts.

The small electro-magnet combination is called a "magnet valve".

(b) Electro-magnet (E.M.) on which a large electro-magnet is switched on and the power of this electro-magnet is used to close the contacts directly.

The large electro-magnet is called the "operating coil".

REVERSERS:

A reverser is a high current switch which reverses the flow of current in the traction motor field coils to enable the motors to reverse their direction of rotation so that the locomotive can be made to travel in the opposite direction.

DIRECT CURRENT GENERATORS:

The principle of a generator is that if a loop of wire is moved rapidly across the end of a magnet a small voltage will be induced into the wire loop.

A.D.C. generator has many loops or turns of wire on the armature (armature coils) which revolves close to a number of large electro-magnets (field coils with soft iron cores in this case). Hence considerable voltages are induced in the armature coils. The current which flows to and from the voltage producing armature is collected at the commutator by means of carbon brushes.

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The faster the armature rotates the greater the voltage produced. The voltage may also be varied by increasing or decreasing the magnetic strength of the field coils by varying the current through the coils.

MAIN GENERATOR:

This large generator is coupled to the diesel engine crankshaft. The electric power from the generator is supplied to the traction motors which in turn drive the locomotive. Thus mechanical power is converted into electrical power and back to mechanical power.

The voltage produced by main generators can rise to 1000 volts. It is the source of the locomotive's high voltage supply.

AUXILIARY GENERATOR:

This is a comparatively small generator which produces 74 or 110 volts depending on the class of locomotive. The current from the generator is used for charging the battery, providing lighting and control power supply, running auxiliary machines and providing current for some of the main generator field coils.

The auxiliary generator and the battery is the source of the low voltage supply.

TRACTION MOTORS:

The traction motors change electrical energy from the main generator into mechanical energy to turn the road wheels of the locomotive. The transmission is by means of a pinion mounted on the armature shaft which drives a gear-wheel fitted to the axle of the driving wheels.

The motors are partly supported by the driving wheel axles and partly by the bogie. A case around the gears keeps out the dirt and holds the gear-wheel lubrication.

The construction of a motor is similar to a generator but in the traction motor current is fed into the brushes from the generator and this current flowing in the armature coils and field coils causes a turning effort on the armature coils to produce rotation.

TRACTION MOTOR BLOWER:

When an electrical current flows in a conductor heat is produced in the conductor (the greater the current the more the heat) so when current flows in a traction motor one form of energy created is heat. If the heat becomes excessive the insulation in the traction motor could be damaged. Traction motors are designed as small as possible and their design takes into account that cooling air will be available at all times.

To maintain the termperature of the traction motor armature and field coils within reasonable limits it is necessary to blow cooling air through them and this is the duty of the traction motor blowers.

On some locomotives, the blower fans are operated by mechanical means while on others they are driven by electric motors. The cooling air is drawn from outside the locomotive through filters.

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DYNAMIC BRAKE:

This is a form of brake that operates only on the locomotive and is obtained by changing the traction motors into generators and by using up the generated power in resistances.

When the traction motors are acting like generators instead of driving the train they retard the train by tending to prevent the driving wheels from rotating.

The control of the dynamic brake is given to the driver so that he can increase and decrease the braking effort by increasing or decreasing the amount of current generated by the traction motors.

The traction motors, acting as generators are given an electrical load to use up the power generated and this is done by connecting a resistance in the motor circuit. This resistance is called the "braking resistance" and it uses up the electricity generated by converting it into heat.

In doing so the resistances get very hot. To prevent the resistances from burning out resistance blowers are used to force cool air through the resistance grids to keep them at a safe temperature.

ENGINE ROOM FANS:

These are provided to force a draught of air into the engine room for cooling purposes and also to build up the air pressure slightly above atmospheric pressure to prevent dust from entering the engine room.

FUSES:

These are important and essential parts of electrical circuits. When a fault occurs in a circuit the wiring can be overloaded and made to carry more current than it was designed for.

When this happens, the wiring can become overheated also the machine or appliance, and ultimately cause a fire.

To prevent this happening a fuse is placed in the circuit forming a "weak link" which will break the circuit stopping the flow of current.

If the current becomes too high, the fuse wire will melt or "blow" and must be renewed before that circuit can be used again. Some fuses must be replaced with a new one while others may be rewired and replaced.

The "rating" of the fuse, or of the fuse wire to be used is marked on the fuse holder; do not on any account, use "heavier" or higher rated fuse wire or fuses. If this is done and a fault has not been attended to, or one occurs, the higher rated fuse may not "blow" or melt in time to prevent damage or a fire and may cause the operator to be electrocuted. If a too "light" or lower rated fuse were used, it could blow when the machine was being used near its full power as it may not be able to carry the current required. This could cause trouble and delays as the operator would think that the machine was faulty and could waste a lot of time looking for the fault.

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When a fuse blows always test the new fuse before using it. Needless delays have been caused by using "dud" fuses so don't put the blown fuse back with (or near) the spare fuses. Put it in the lunch tray in the cab and write in the repair book which circuit had given trouble and where the dud fuse has been placed.

CIRCUIT BREAKERS:

A circuit breaker has the appearance of a switch, but has an automatic tripping device to break the circuit if the current exceeds a predetermined setting.

When tripped the switch goes to a midway position between "off" and "on" and must be turned fully off before it can be reset. As the circuit breaker operates on a thermal action it may be necessary to wait for a moment or two to allow it to cool down before being able to reset it.

Do not jump to the conclusion that there is something else wrong with the machine or appliance if the circuit breaker cannot be reset immediately after a fault has occurred and make sure it is first moved to the "off" position and then reset.

If a fuse blows or a circuit breaker trips after being replaced or reset, a fault has occurred in the circuit and this should be attended to before attempting to use it again. The Enginedriver is usually the member concerned with renewing fuses or resetting circuit breakers, but the Locomotive Assistant should know how to handle them.

SWITCHES:

The common type of switches are used for various purposes, generally for opening and closing low voltage circuits.

BATTERY ISOLATING SWITCH:

As the name infers, this switch isolates the battery from other low voltage equipment and is mainly used as a safeguard when stabling a locomotive or when work is to be carried out on electrical equipment normally fed from the battery.

AMMETERS:

These are placed on the control panel and are provided so the amount of current flowing in the circuit can be seen by the driver.

It will be seen from this lesson that to make a simple circuit the following are required.

(a) A source of voltage such as a battery or generator.

(b) A load of some kind through which the current will flow (lamp, heater or motor).

(c) A switch or contactor to enable the circuit to be closed or opened as required.

(d) A fuse or circuit breaker to open the circuit should the current reach a value which may cause damage.

(e) Connecting wires between various components of the circuit.

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The diesel-electric locomotive consists of a diesel engine which develops the mechanical power and this turning force is used to drive the main generator. The main generator changes mechanical power into electrical power which is used to turn the traction motor armatures. The armature of each traction motor is geared to a driving axle and when the armatures of the traction motors turn they turn the axles and wheels and the locomotive will move.

LOCOMOTIVE EQUIPMENT:

The following equipment is also required on a locomotive:-

A compressor to supply air for all air operated equipment. The compressor may be driven by the engine or electrically driven.

A Cooling Fan driven from the engine, to force air through the radiators to cool the engine cooling water.

A Fuel Transfer Pump to draw fuel from the tank.

The Fuel Injection Pumps to force fuel through the injection nozzles into the combustion chamber.

An Engine Governor to control the output of the engine.

A Load Regulator to control the output of the main generator and ensure that the engine is never overloaded.

The Main Reservoirs to store the air compressed into them by the compressor.

An Electrical Cabinet which contains the various switches, fuses, contactors and relays necessary to control the operation of the locomotive.

The Water Pumps driven from the engine to circulate the cooling water through the engine cooling system.

The Oil Pumps driven from the engine to circulate the lubricating oil through the engine oil system.

The Fuel, Oil and Water Systems necessary for the operation of the engine.

The Dynamic Brake System with the braking resistance and resistance cooling fan.

The Battery provides power to rotate the engine to get it started. It is also required to provide low voltage power such as lighting when the diesel engine is stopped.

The Overspeed Device protects the engine from overspeeding by cutting off the fuel to the engine when it operates.

The Wiring and Cables carry the necessary current to the electrical equipment on the locomotive and in many cases for the protection of the wiring are placed in piping.

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COLOURS OF PIPES:

To enable staff to trace pipe lines on locomotives, pipes are marked with different colours such as -

Lubricating Oil	Salmon Pink
Cooling Water	Field Green
Compressed air up to 1400 kPa	White
Electrical Services	Light Orange
Diesel Fuel	Lino Brown

POWER BOGIES:

These are 4 or 6 wheel bogies that carry the traction motors which provide the motive power of the locomotive.

They carry the weight of the locomotive through bogie centres which allow the bogies to pivot and take up their correct position on curves.

The axleboxes which move up and down in the horn guides, depending on the unevenness of the track, are fitted with bearings which locate the wheels and axles.

Laminated and coil springs are fitted to dampen out the shocks caused by track irregularities.

CAB EQUIPMENT

The equipment in cabs differ, depending on the type of locomotive and a Locomotive Assistant should make himself familiar with the different types of controls so that in an emergency he will know how to stop the train or engine.

Throttle. This is used to enable the Enginedriver to supply power to the traction motors and to cut off power when necessary.

Also, by operating the throttle the engine speed can be increased or decreased. By this means the Enginedriver has control of the power output of the engine, and thus the speed of the locomotive.

All the necessary air gauges, warning lights and ammeters are fitted but these differ with the type of locomotive.

Reverse Lever. This is provided to enable the locomotive to be worked in either direction.

Automatic Brake Valve. This is used to apply or to release the brakes on the locomotive and the train.

Independent Brake Valve. This is used to apply or to release the brakes on the locomotive, independent of the train brakes.

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STARTING THE ENGINE:

To start the engine, power from the battery is fed into the main generator which then acts like a starter motor on a motor car and rotates the engine to get it started.

STOPPING THE ENGINE:

Various means are used to stop the engine and the controls to enable this to be done are in the cab. On some locomotive a stop button is used while on others a master switch key is used.

OPERATION OF LOCOMOTIVE:

To enable you to understand more clearly how the locomotive operates we will now consider a mechanical analogy of a diesel-electric locomotive (see Fig. 1). Here the engine drives a pump which forces water through pipes to water wheels which drive the axles.

In this analogy,

(a) The pump corresponds to the main generator.

(b) The water wheels correspond to the traction motors.

(c) The pipes correspond to the connecting electrical cables.

(d) The valve corresponds to the main contactors.

At first, let us assume that the diesel engine is idling with the valve closed. The pump (main generator) is producing pressure (voltage) but there is no flow of water (current) so the water wheels (motors) do not revolve.

Now suppose the throttle is moved to notch "1": this opens the valve, (closes contactors) and water (current) begins to flow. This flow causes pressure against the blades of the water wheels. If the locomotive has a heavy train the pressure (voltage) will not be enough to move the wheels. The Enginedriver now notches up the throttle and the diesel engine speeds up. The pump now increases the water pressure (voltage). This causes more water (current) to flow to the water wheels (motor). He continues to notch up the throttle until there are enough gallons of water per minute (amperes) flowing to start the wheels turning. As they revolve the locomotive and train begin to move. As the Enginedriver continues to advance his throttle the diesel engine speeds up, pressure and flow increase and the locomotive accelerates.

Now if we look at what happens when the Enginedriver notches up his throttle on a diesel-electric locomotive, we will see that it can be compared with the action of the water. When the throttle is placed on Notch "1", it causes various contactors to close, connecting the main generator to the traction motors and the locomotive moves.

By notching up the throttle the speed of the diesel engine (and the main generator) is increased and at the same time the main generator field strength is increased. Thus the main generator voltage is increased and this supplies an increased current to the motors which tend to drive the locomotive faster.

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JUMPERS:

Most types of diesel electric locomotives are designed to operate coupled together in multiple if required by inserting electrical jumpers to connect the necessary circuits on each locomotive. The locomotives can then be controlled by one crew on the leading locomotive. The Locomotive Assistant will often be called upon to insert these jumpers and the care and handling of them will be dealt with fully in the servicing section.

In order to obtain efficient locomotive operation it is necessary to understand some knowledge of:-

Combustion:

Combustion is a process in which fuel combines with oxygen and in doing so gives off heat.

The essential requirements for combustion are as follows:-

(a) A supply of fuel.

(b) A supply of oxygen from the air.

(c) The fuel and the air must be heated to ignition temperature, or above the flash point of the fuel oil, which would be approximately 65°C.

The flash point is the lowest temperature at which an inflammable vapour is given off by the fuel. However, when fuel is ignited in a cylinder, it is necessary to raise the temperature above the flash point to approximately 105°C before the fuel will burn steadily.

When the piston is at the top of the compression stroke the air in the cylinder is compressed to such a degree that it develops a sufficient temperature to ignite the fuel that has been sprayed into it.

In a diesel engine the firing or burning of the fuel and oxygen in the combustion chamber produces heat which is converted into power. Therefore the more air that can be supplied to the cylinders of an engine the more fuel the engine will be able to burn and thus more heat will be generated to be converted into power.

Supply of Air:

The air which enters the inlet manifold of a diesel engine can be supplied in two different ways, by Induction and by Super-charging.

1. Natural Induction:

This system allows only atmospheric pressure at the inlet valve and as air, like water, will only flow when there is a pressure difference it will flow into the cylinder on the induction stroke as the pressure in the cylinder then is below atmospheric pressure. The air that is taken into the cylinder in this case would be below atmospheric pressure. As the fuel requires oxygen for it to burn and there would be only a certain amount of oxygen trapped in the cylinder, the amount of fuel injected should not be more than the amount that could be completely burnt on the power stroke. The power of this type of engine is thus limited.

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2. Supercharging:

To allow an engine to develop a higher power without increasing the size of the engine it is necessary to increase the weight, or amount of air, in the cylinder during the power stroke; thus the engine will develop more power. To get more air into the cylinder a blower is used. The purpose of this blower is to blow or force air into the inlet manifold to raise the pressure above atmospheric pressure and thus provide the cylinders with a greater weight of air during induction. Engines supplied with air in this manner are referred to as supercharged or pressure-charged engines. The blowers are designed to boost the cylinder air pressure to about 50 kPa above atmospheric pressure which is about 103 kPa.

SUPERCHARGERS:

There are two types of super-chargers used, the Roots Blower and the Turbo-Blower.

1. Roots Blower:

The Roots Blower is mechanically driven from the engine crankshaft. It consists of a pair of helical three-lobed rotors. The lobes are like big hollow ear teeth and they roll round one another like the teeth of gears, but do not quite touch each other. They also rotate in different directions. As they rotate, air is trapped by the lobes and forced through to the engine thus increasing the pressure to the cylinders.

2. Turbo Blower:

These are driven by the exhaust gases from the engine. When the engine starts the flow of exhaust gases from the exhaust manifold is directed through a nozzle to a turbine wheel which is mounted on a common shaft with an air impeller.

The exhaust gases passing over the turbine wheel force it and the impeller to rotate.

Incoming air from a filter enters around the centre of the rotating impeller, becomes compressed, and is forced through to an inlet manifold thus increasing the pressure of air. A boost pressure gauge is fitted to some types of locomotives which shows the amount of supercharging taking place.

Both these types of blowers reply on the speed of the diesel engine to increase their output. So that the higher the revolutions of the engine the greater the supercharging.

EXHAUST GASES:

By keeping a check on the colour of the exhaust gases the enginedriver can tell if complete combustion is taking place.

These gases also indicate other faults, depending on their colour, as follows:-

1. Black:

Indicates that too much fuel is being injected into the cylinder for the amount of air, thus all fuel is not being burnt.

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2. White:

Indicates that there is too much air for the amount of fuel being injected into the cylinder. It could also indicate water is entering the cylinder.

3. Blue:

Indicates that the piston rings are allowing lubricating oil to leak past and burn as fuel.

4. Light grey or no colour:

Indicates complete combustion is taking place.

It is important that a careful check should be kept on the colour of the exhaust gases both by the Enginedriver and the Locomotive Assistant.

CRANK CASE COVERS:

These covers are placed on the lower part of the engine crankcase for the purpose of inspecting the big ends and crankshaft. They are quite simple to remove but every care should be taken before they are removed.

When the engine is running heated lubricating oil forms gases and providing these gases are not mixed with air they are too rich to cause an explosion.

If mixed with the proper proportion of air, however, these gases could cause an explosion.

As long as crankcase covers are left on there is no danger of an explosion because air cannot enter.

If the crankcase covers have to be removed, the engine must be stopped and allowed to cool for at least 15 to 20 minutes, or longer if possible before the covers are removed.

This will allow time for the gases and any overheated bearings to cool off.

After the covers have been removed blow the gases out from the crankcase with an air hose or a non-electric blower. No naked lights or smoking must be allowed near the locomotive after or during the removal of covers.

Under no circumstances should an engine that has stopped through a seizure or suspected seizure be restarted or even barred round until it has had time to cool down.

Here is a list of pictures and diagrams supplied with this lesson:

Sectional elevation, Da Locomotive.
Controller.
Traction motor showing nose suspension bracket.
Traction motor showing driving pinion.
Mixed traffic locomotive.
Typical motored bogie.
Axle and axle bearing.
Reverser switch.

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Electro - pneumatic contactor.
Load Regulator.
Principle of a direct current generator.
Basic generator and motor principle.
Control plug and socket.
Mechanical analogy of a diesel-electric locomotive drive.
Arrangement of pressure-charge and exhaust-induction circuits.
Schematic external air flow.
Rootes Blower and blower operation.