THE PENNSYLVANIA RAILROAD

DIESEL ELECTRIC
ROAD LOCOMOTIVES

*Operating Instructions*

FOR

LOCOMOTIVE ENGinemEN, FIREMEN AND HELPERS

1949
THE PENNSYLVANIA RAILROAD

Eastern Region
Central Region
Western Region

DIESEL-ELECTRIC ROAD LOCOMOTIVES

OPERATING INSTRUCTIONS

FOR QUALIFYING LOCOMOTIVE CREWS

Issued June 2, 1949

General Notice

The instructions contained herein have been compiled with the view to establishing a uniform method of instruction, examination and rating for Diesel-Electric Locomotive Enginemen, Fireman and Helpers who will be required to pass the examinations on these instructions and obtain not less than a minimum rating.

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GENERAL DESCRIPTION

The instructions set forth herein include a general section designated as Section 1, containing descriptive information and operating instructions applicable to all classes of Diesel-Electric Road Locomotives, and a steam generator section designated as Section 2, containing descriptive information and operating instructions for Steam Generators on classes so equipped.

A supplemental section for each class of Diesel-electric Road Locomotive, as indicated in the Index, provides additional descriptive information and operating instructions required for that class of locomotive.

Enginemen, Firemen and Helpers will be furnished with a copy of the instructions on Diesel-Electric Road Locomotives. They must avail themselves of the facilities provided in order to receive instructions and must continue to study the subjects as outlined in the instructions to become well informed, and must pass the required examinations.
SECTION 1 – GENERAL

Arrangement and Classification

A Diesel-electric locomotive is a locomotive propelled by electric traction motors geared to the driving axles, the power for which is supplied by one or more electric generators driven by one or more Diesel engines located on the locomotive.

When the Diesel-electric locomotive throttle is opened the main generators are connected automatically to the traction motors and electric power flows to the motors to move the locomotive. As the throttle is opened wider the Diesel engines speed up, delivering more mechanical power to the main generators and thus more electric power is generated for the traction motors. When the throttle is wide open the Diesel engines run at their maximum speed, and the power output of the main generators regulates itself so that the traction motors are supplied with the required horsepower up to maximum rating for any combination of speed and train load.

A locomotive consists of one unit, or two or more units operating in multiple. When operating in multiple, the several units are under control from one operating cab. Locomotive units with operating cabs are designated as “A” units; those without operating cabs as “B” units. A control station is provided on “B” units from which the unit may be operated independently for hostling.

There may be two operating cabs on a complete locomotive, one at each end, so that the locomotive may be operated in either direction without turning.

The classification used for Diesel-electric road locomotives designates the class of locomotive by two initial letters followed by a number. The first letter designates the manufacturer of the Diesel engines, the second letter the service, passenger or freight, and the following number designates the number of coupled units making up the complete locomotive.
Thus, the road passenger locomotives are:

EP-3—three units, Electro-Motive Division of General Motors Corp.
BP-l—two semi-permanently connected units, Baldwin Locomotive Works.
AP-3—three units, American Locomotive Company.
BP-3—three units, Baldwin Locomotive Works.
FP-3—three units, Fairbanks, Morse & Co.

Similarly, the road freight locomotives are:

EF-4—four units, Electra-Motive Division of General Motors Corp.
FF-3—three units, Fairbanks, Morse & Co.
AF-4—four units, American Locomotive Company.
BF-4—four units, Baldwin Locomotive Works.

The nominal rating of all of the various classes of Diesel-electric road locomotives is 6000 Diesel-engine horsepower.

The EP-3 and BP-3 passenger locomotives are made up of two “A” units and one “B” unit, each unit containing two 1000-hp Diesel engines with two three-axle trucks under each unit.

The BP-l locomotive consists of two semi-permanently connected “A” units, each unit containing two 1500-hp Diesel engines, and having an articulated main frame with eight driving axles and two four-wheel guiding trucks.

The AP-3 and FP-3 locomotives consist of two “A” units and one “B” unit, each unit containing one 2000-hp Diesel engine with two three-axle trucks under each unit.

The EF-4, AF-4 and BF-4 locomotives are made up of two “A” units and two “B” units, each unit containing one 1500-hp Diesel engine with two two-axle trucks under each unit.

The FF-3 locomotive is made up of two “A” units and one “B” unit, each unit containing one 2000-hp Diesel engine with two three-axle trucks under each unit.

The “Front” end of a locomotive unit is designated by the letter “F” painted on each side. On “A” units the operating cab is at the “Front” end.
The “Right” and “Left” sides of a locomotive unit are designated by the right and left hands when in the locomotive unit facing the “Front” end.

The hostler’s operating position on “B” units is on the “Right” side of the unit.

The trucks, axles, traction motors and Diesel engines on a unit are numbered consecutively beginning with No. 1 at the “Front” end of the unit.

**Diesel Engine**

Bearing the name of its inventor, Dr. Rudolf Diesel, the Diesel is an internal-combustion, compression-ignition, fuel oil burning engine.

An internal-combustion engine is one that derives its power from the burning of a charge of fuel inside the cylinders. Fuel is sprayed into the cylinders of a Diesel engine through mechanically or pressure-operated fuel injectors.

Compression-ignition means that the charge of fuel is ignited by coming into contact with highly compressed, and hence highly heated air in the combustion chambers of the cylinders. This is the main distinguishing feature between the Diesel and other internal-combustion engines, where ignition is achieved by the use of an electric spark or a “hot-spot”.

Diesel engines, and internal-combustion engines in general, are divided into two main groups-the "two cycle” and the “four cycle” engines. The “two” and “four” designate the number of strokes of a piston necessary to complete a cycle of operation in a cylinder, the cycle being the intake, compression, power and exhaust events.

Both non-supercharged (normally aspirated) and supercharged engines are in use today. In non-supercharged engines, intake air is induced into the cylinders at prevailing atmospheric pressure. In supercharged engines, intake air is forced into the cylinders by an intake air pump (supercharger).

A supercharger, as used on internal-combustion engines, is a mechanical device for supplying the engine with a greater weight and volume of intake air than would normally be induced at prevailing atmospheric pressure. It may be either mechanically
driven, or powered by an exhaust gas driven turbine built integral with the supercharger, the latter arrangement being known as a turbo-supercharger.

The increased amount of intake air induced by supercharging increases the power that can be obtained from a given size of cylinder by causing a more complete combustion of the fuel charge, with a proportionate increase in power output.

**Diesel Engine Governor**

The governor is a speed sensitive device primarily used to control or limit the speed of an engine. As used on the Diesel engines in locomotive service, it measures the rotative speed of the engine through direct mechanical connections to the engine, or through an electrical connection to a tachometer-generator driven by the engine; and its function is to control the speed of the engine at a setting determined by the position of the throttle lever on the engineman’s control stand.

The engineman’s throttle lever is connected to the governor in one of several ways as follows:

1. By direct mechanical linkage to the governor control shaft.
2. By electrical connections to a pneumatic or hydraulic mechanism which may be either mechanically connected to the governor control shaft or built integral with the governor.
3. By straight pneumatic connection to an air actuator which is mechanically linked to the governor control shaft.

The governor, in all cases, is mechanically connected to the fuel injection system of the engine so that it can vary the amount of fuel injected into the cylinders.

Under certain conditions, such as sudden loss of electrical load caused by wheel slippage or ground relay tripping, the governor may fail to limit the engine to its maximum speed. All Diesel engines in locomotive service are provided with an overspeed stop mechanism, which automatically shuts the engine down should its speed go approximately 10% above the maximum governed speed. The overspeed stop device may function through an electrical connection to the governor, or through direct mechanical connection to the engine.
Diesel Engine Cooling System

The water and air circulating cooling system is designed to carry away and disperse the excess heat generated inside an engine.

The system consists of an expansion or storage water tank, a water circulating pump usually mounted on and driven by the engine, the circulating passages and jackets in the engine, a radiator through which air is drawn by mechanically or motor-driven fans, the flow of air being further controlled by shutters, and the necessary piping, gauges, valves and filling, venting and drain connections.

Diesel Engine Lubricating Oil System

The lubricating oil circulating system is designed to supply lubricating oil, under pressure, to the various working parts of the engine and associated equipment.

The elements of the pressure lubrication system are storage space for the oil, a positive displacement suction and pressure circulating pump mounted on and driven by the engine, the strainer and filter units, headers and passages in the engine, an oil cooler, and the necessary piping, valves, gauges, and filling and drain connections.

Diesel Engine Fuel Oil System

The system is designed to supply fuel oil under pressure to the individual engine cylinders.

The system consists of a fuel supply tank, a fuel transfer pump electrically-driven, fuel injection pumps and injectors, filter units, and the necessary piping, valves, gauges, and filling, venting and drain connections.

The fuel system on each unit of a locomotive is equipped with an emergency fuel cut-off valve located in the suction line between the fuel supply tank and the fuel transfer pump. This valve is tripped through cable connections to pull handles at various locations on the unit and, if tripped, must be reset manually to the “open” position. To reset emergency fuel cut-off valve, raise the valve stem and slip crutch under stem to hold the valve open.
Electric Power System

The Diesel engines of a Diesel-electric locomotive each drive a main direct-current generator which is direct connected to the crankshaft of the engine. The electric power from this generator is transmitted by electric cables to drive the traction motors which are geared to the driving axles. These cables provide the means to carry the current flow from the generator to the motors and for its return to the generator. The path of this flow is known as the "circuit", and on Diesel-electric locomotives is completed without return through the locomotive frame or ground, and is thus known as an ungrounded circuit. If a ground should occur due to the failure of insulation in the cables or other electrical apparatus connected to the circuit, serious damage may result. To protect against such damage, a ground relay is provided, which gives an alarm indication, removes electric power from the circuit, or both. Connection of the power circuit from the main generator to the traction motors is made through power switches operated by air or electrically; such power switches are known as "contactors".

In starting a train, high pulling power (tractive effort), is required. In an electric motor the mechanical force is proportional to the current (amperage), so that in starting a high current is required. At standstill, a low voltage is sufficient to produce a high current in the motors, so that low generator voltage and low generator speed are used. As the locomotive speed, and consequently the motor speed, increases, a higher voltage is necessary to produce the required current through the motors because of counter-voltage generated internally in the motors, and consequently the generator voltage must be increased by increasing its speed, if high current is to be maintained.

The speed of the Diesel engine and its main generator is controlled by the throttle lever and governor and, as the Diesel engine is speeded up, the voltage of the generator increases to a maximum of about 1000 volts.

The current (amperage) drops rapidly after the initial acceleration of the train for any throttle position, and at full throttle the current continues to drop as long as the train is accelerating (increasing in speed).
For a given engine speed, the main generator is regulated to produce a substantially constant maximum power output. Under conditions of constant power output, the product of tractive effort times speed is constant for all speeds; in other words, as speed increases, pulling power must decrease accordingly. In the same way the product of generator voltage times amperes is constant for all amperages, and, as the train speed increases, the current decreases and the voltage must increase accordingly.

After the main generator has reached its maximum rated voltage, however, and the speed of the train continues to increase, the current will continue to fall off and thus the power output (which is the product of current times voltage), will decrease. Under these conditions, the full output of the Diesel engines is no longer being utilized. Full output can, however, be again put into use by two different methods; one method is traction motor field shunting, and the other is changing the connections of the traction motors to the main generator from series to parallel. The act of making these changes is called Transition.

Transition. Transition is accomplished automatically on some locomotives. It can be controlled or limited manually on other locomotives by a transition lever which is located on the control stand along with the throttle lever and reverse lever.

At starting and at lower speeds the traction motors fed by one main generator may be connected in series, or in series-parallel; that is, the current flows first through one motor, or pair of motors, and then through the other motor, or pair of motors. In this way, the counter-voltages generated internally in the traction motors are also in series and add together, so that double the main generator voltage is required to cause the current flow as would be required with only one motor connected to the generator. If, however, transition to parallel connection is made at higher speeds, as is done on some classes of locomotive, that is, if the motors are reconnected to the generator so that the current divides equally and flows through all motors in parallel, the counter-voltages generated in the motors are not added together, and the current will flow in each motor as though it alone were connected to the generator. Under this condition, the same main generator voltage will produce twice the current.
flow per traction motor as for the series or series-parallel connection. Thus, the same maximum generator voltage will produce twice the motor current, which represents tractive effort, or pulling power, and full utilization of engine output can again be obtained for higher speeds, by transition to parallel connection of the motors.

The second form of transition, which obtains on all locomotives, is known as traction motor “field shunting”. The traction motors are of the “series” type; that is, the same current flows through the motor armature winding (rotating portion), and the motor field winding (stationary portion), in series. The speed of the traction motors, and thus the locomotive, can be increased by by-passing some of the current from the motor field winding through a resistance. This will permit a greater current to flow through the motor armature winding by reducing the back-voltage generated by the motor. Thus, similarly to the transition to parallel connection, it will permit the same maximum main generator voltage to produce more current through the traction motors and permit fuller use of engine output. Field shunting can be accomplished in a number of steps as is used on some locomotives, and it can also be done with series, series-parallel, or full parallel operation, and is always used at the higher speed for a given motor connection.

Reversing.

The direction in which a d-c series motor rotates is determined by the relative direction in which current flows through the armature winding and the field winding. If the current flow is reversed through one or the other, the motor will turn in the opposite direction. If, however, both are reversed there will be no change in the direction of rotation of the motor. Although either can be done, the traction motors are usually reversed by reversing the field winding connections. The reversing switches which accomplish this are operated through the reverse lever on the control stand. The motors must not, under any conditions, be reversed while in motion.

Load Control.

Control of the power output of the main generator, so that the Diesel engine will not slow down below the speed determined by the throttle lever position, is known as “load control”. As more power is required for a given throttle position, the speed governor on the
Diesel engine admits more fuel until the predetermined fuel limit for that engine speed is reached. If the power requirements increase beyond this point the Diesel engine will be unable to maintain its speed. However, at this point the load control will automatically reduce the power output of the generator and thus permit the Diesel engine to run at normal speed. This is accomplished by reducing the current (known as exciting current) through the main field winding of the generator. This, in turn, reduces the voltage generated by the main generator and hence its current and power output.

**Dynamic Braking.**

Dynamic braking is a means for retarding the train which can be used on a locomotive propelled by electric motors. The traction motors are connected to act as generators operated by the energy of the moving train. On Diesel-electric locomotives having dynamic braking, the electrical energy thus produced is dissipated as heat in a bank of resistances called grids. Dynamic braking is effective, of course, only on the wheels of the locomotive which have traction motors, and the same care should be used in applying the dynamic brake as in using the independent brake on the locomotive. The independent air brake and the dynamic brake must not both be used at the same time, as the driving wheels may slide.

Dynamic braking is accomplished by actuating switches which connect the traction motor armature windings to the grids and by applying current to the traction motor field windings from the main generator. The greater the current applied to the field windings, the greater is the braking current generated by the traction motors.

As the locomotive slows down, the slower speed of the traction motors reduces the amount of power generated and consequently the braking effect of the dynamic brake decreases, so that it is not practical to stop a train with the dynamic brake. In order to prevent overloading of the traction motors, dynamic braking must be limited to the amount of current which can be carried safely by the motors. If it is not possible to hold the train to the desired speed by means of the dynamic brake, the automatic air brake may be applied in conjunction with the dynamic brake, keeping off the locomotive brakes. On classes having dynamic braking, where a transition lever is used, the amount of dynamic braking power is controlled by the position in its braking range of the transition lever, and,
where no transition lever is provided, the reverse lever has a dynamic braking position and braking power is controlled by the throttle lever.

Control System

The power circuits of the Diesel engine main generators are electrically independent of each other on each unit of a locomotive and on the same unit if more than one Diesel engine main generator is located on a unit. Since, however, they must all be controlled from one location on the locomotive, they are all connected by a multiple-unit control system.

This system permits the control of engine speed of all engines by the throttle lever on the control stand, the forward or reverse operation of the locomotive by the reverse lever on the control stand, the stopping of all Diesel engines on the locomotive, if required, and the operation of power circuit transitions where manually controlled by the transition lever on the control stand, and the operation and control of dynamic braking on all units, where the locomotives are so equipped. On locomotives equipped with steam heat generators, a panel located at the fireman’s position contains controls for shutting the steam train line valves at all steam generators and also for operating the steam generator separator blow-down valves.

The control system is energized by the nominally 64-volt battery circuit consisting of a 32-cell battery on each unit charged by the auxiliary generators. A control switch at the engineman’s position is closed to establish power control on the control stand at that location and on some locomotives, fuel pump and generator field switches must also be closed at the engineman’s location before control is established at the operating end of the locomotive.

All locomotives have at the engineman’s position, load indicating ammeters giving the amount of electric current passing through the motors. In order to prevent overheating and damaging the electrical equipment, this must be used as a guide in the operation of the throttle lever and transition lever during running and during braking, if dynamic braking is used.

Auxiliary Power System

All Diesel-electric locomotive units are equipped with an auxiliary generator driven by the Diesel engine. This generator is used
to charge the storage battery and to supply low voltage power to auxiliary and control apparatus when the Diesel engine is running.

On some classes of locomotives the traction motor blowers for cooling the traction motors are motor driven by power from the main generators or separate blower generators, and on other classes the traction motor blowers are driven by mechanical connection to the Diesel engine crankshaft.

On some locomotives an alternating-current generator (alternator), driven by the Diesel engine, supplies power for the traction motor blowers and also for the engine radiator cooling fan motors.

On the other classes of locomotives the engine radiator cooling fans are motor operated by power from the main generator, a fan and blower generator or are mechanically driven by the Diesel engine.

The traction motors will be overheated and seriously damaged if the locomotive is continued under load with the blowers inoperative.

In addition to the fans for engine radiator cooling and blowers for traction motor cooling, fans are also required for cooling the grids used to dissipate the electrical energy when dynamic braking is used. These fans are operated by making connection across a portion of the braking grids, thus using some of the power generated in braking to operate the fans. With this arrangement, the fans operate only when dynamic braking is in operation and fan speed depends upon the braking current.

On all Diesel-electric locomotives the fuel transfer pump at each Diesel engine is motor-driven from the battery-auxiliary generator circuit. In this way fuel pressure is always available when a Diesel engine is to be started and prompt shut-off can be obtained when desired.

The current to supply (excite) the main generator field winding is taken from the auxiliary generator and battery circuit, or, on some locomotives, from a separate exciter generator driven-by the Diesel engine.

**Lighting and Battery System**

All locomotive units have a 32-cell, nominally 64-volt, storage battery.
One of the principal functions of the battery is to crank the Diesel-engine. Each engine on the locomotive is started individually by starting controls located on a panel nearby to the engine. After the engines are started, they are controlled or may be stopped from the engineman’s location. Starting up must, however, be done at each individual engine.

The battery is charged from the auxiliary generator or generators on the unit, and the charging voltage is controlled by a voltage regulator to maintain a constant voltage of approximately 74 volts. When the engine is not running, or if its speed is too low to give sufficient auxiliary generator voltage to charge the battery, a reverse-current relay open the connections to the battery to prevent the battery discharging into the auxiliary generator.

The battery is used for lights in the operating cab and engine room and provides power to the control and indication circuits of the locomotive.

The locomotives are equipped with a motor-generator set on the “A” units which provides a well-regulated supply of 32 volts for the operation of the trainphone equipment and cab signals. This set is operated from battery power. The 32-volt output of these generators is used also to operate the headlight of the locomotive.

The battery circuits generally have fuses to protect against overloads or short circuits. In some cases, thermal overload circuit breakers are used in place of fuses, and may be reset after tripping open.

A main battery switch is provided to disconnect the battery from its circuits when the unit is shut down.

**Compressed Air System**

Each Diesel engine drives a direct-connected, two-stage, air compressor which takes air from the atmosphere and delivers it under pressure to the main reservoir, where the air is stored and cooled and in which the moisture contained in the air is condensed into water from where it can be readily drained before it enters the various operating parts of the air system. Air from the main reservoirs is piped to the air brake system, the air control system, and to the other air-operated devices used throughout the locomotive. The main reservoir air is connected between units by flexible hose.
connections so that the combined capacity of the several air compressors, as well as the combined volumes of the several main reservoirs, are available throughout the entire locomotive.

**Air Compressors.**

Several types and sizes of air compressors are used, the size depending on the rotative speed of the Diesel engines and the number on each unit. Two and three-cylinder compressors are used. The two-cylinder compressors have one low pressure and one high pressure cylinder. The three-cylinder compressors have two low-pressure cylinders and one high-pressure cylinder. In either case a radiator type intercooler is located between the low and high-pressure cylinders for cooling the air. A self-contained lubricating oil system lubricates the compressor from a supply of oil carried in the air compressor crankcase.

**Air Compressor Governor.**

Main reservoir pressure is controlled by a governor system of loading and unloading control. This type of system is necessitated by the continuous running of the air compressors all the time the Diesel engines are running. The governors are electrically controlled and synchronized between the several locomotive units to maintain a main reservoir pressure of between 125 and 140 pounds. Safety valves are provided to prevent excessive main reservoir pressure if governor control is defective or cut out.

**Air Control System.**

Air pressure is used for operating electrical contactors, reversers, and for controlling the rotative speed of the Diesel engines on some classes; and is supplied from the main reservoirs through reducing valves to a control reservoir on each unit. Control air pressure is maintained at from 70 to 80 pounds pressure by the reducing valves. On some classes of locomotives, control air pressure is used for operation of the cooling system radiator shutters.

**Use of Main Reservoir Pressure.**

Main reservoir pressure is used for the operation of the cooling system radiator shutters on some classes.

The locomotive bell, horns, windshield wipers, and sanders are operated by air at main reservoir pressure.
On units equipped with a steam generator, air for atomization is supplied from the main reservoirs through a separate reducing valve set at 70 pounds.

Air for operation of the communicating signal whistle and cab signal warning whistle is supplied from the main reservoirs through other reducing valves set at 45 pounds.

The air system also includes various filters to clean the air and a number of cocks and valves for shutting off local air supply when necessary and for draining the system when required.

**Air Brake System**

The 24-RL locomotive brake equipment is used on all classes of Diesel-electric road locomotives, the only difference between classes being that the passenger class locomotives are equipped for electro-pneumatic operation as well as pneumatic operation, while the freight class locomotives are equipped for pneumatic operation alone.

The equipment includes (on each “A” unit):

- **An automatic brake valve**, DSE24H for passenger and DS24H for freight, by means of which the brake system on the locomotive and train is charged and controlled.

- **An independent brake valve**, S40D for passenger, and S40F for freight, by means of which the locomotive brakes may be controlled independently of the train brakes.

- **Combined equalizing and reduction limiting reservoir** for service and first-service reduction of brake pipe pressure.

- **A rotair valve**, type K2 or K2A, for cutting out the independent brake valve on all “A” units except the one from which the locomotive is being operated and for selecting the emergency brake cylinder pressure development required by the type and length of train handled.

The K2 rotair valve has three positions: “Passenger,” “Lap,” and “Freight.” It should be set in “Lap” position on all “A” units except in the cab from which the locomotive is being operated, where it should be set in “Passenger” position, for non-controlled emergency brake cylinder pressure development, or “Freight” posi-
tion for controlled emergency brake cylinder pressure development. When the K2 rotair valve is used, a controlled emergency pipe is connected between units.

The K2A rotair valve has four positions: “Passenger,” “Passenger Lap,” “Freight Lap,” and “Freight.” It should be set in “Passenger Lap” or “Freight Lap” on all “A” units except in the cab from which the locomotive is to be operated where it should be in “Passenger” or “Freight” position. When in “Passenger” or “Passenger Lap,” non-controlled development of emergency brake cylinder pressure obtains. When in “Freight” or “Freight Lap,” controlled development of emergency brake cylinder pressure obtains.

With the K2 valve in “Freight” position, controlled emergency on the entire locomotive can be nullified by placing the independent brake valve in full “Application” position during emergency application but, with the K2A valve in “Freight” position, only on the unit from which locomotive is being operated can the controlled emergency application be nullified.

The electro-pneumatic master controller operates under control of the automatic brake valve during electro-pneumatic applications of the brake to energize the proper magnet valve on the 21-B magnet valve bracket.

The 21-B magnet valve bracket contains an application magnet valve, a release magnet valve, and a cut-off valve. The magnet valves control straight air pipe pressure under control of the master controller.

The D-24 control valve operates to control the application and release of locomotive brakes. A dead engine cock on the control valve, normally in “Live” position, is provided to charge main reservoirs from the brake pipe, when placed in “Dead” position.

Relay valves control the flow of air to and from the brake cylinders to apply and release the brakes.

The combined displacement, auxiliary and emergency reservoir is used with the control valve to synchronize locomotive brake cylinder pressure development with that on the train during service application and to provide high brake cylinder pressure during emergency applications.
The H-5-A relay air valve controls automatic sanding during emergency applications.

Various valves and cocks in the piping by means of which the flow of air can be cut off when required.

The air brake equipment on the “B” units includes the control valve, combined displacement, auxiliary and emergency reservoir, and relay valves. A controlled emergency cock on the control valve selects the type of brake cylinder pressure development according to its position. The controlled emergency cock has three positions: “P” for passenger, or non-controlled, “L” for lap, and "F" for freight, or controlled emergency.

“B” units are equipped with a hostler’s brake valve by means of which the brakes on the unit can be controlled if necessary to move the unit alone. A reducing valve adjusted to brake pipe pressure furnishes air to the brake pipe to release automatic applications. Two cut-out cocks, one under hostler’s brake valve and the other in the reducing valve pipe connection to the brake pipe must be open to permit control from the hostler’s brake valve.

Safety Control System

Dead-man and overspeed safety control features are included to reduce the power output of the Diesel engines and apply the brakes in service should the engineman become incapacitated or the maximum permissible speed be exceeded.

The equipment comprising the safety control feature includes:

The double heading cock which cuts out the safety control feature on trailing cabs when it is closed or in the “number two” position.

A service application portion of the automatic brake valve which, when actuated, will initiate a service application of the brakes.

A safety control check valve, operated by depressing the automatic brake valve handle to suppress a dead-man application.

A diaphragm foot valve having a pedal which, when held down, suppresses a dead-man application.

A warning whistle which will sound for a limited time before a safety control application occurs, should both the automatic brake valve
handle and the diaphragm foot valve pedal be released from a depressed position with little or no brake cylinder pressure present.

**An H-24 relayair valve** which operates to suppress a safety control application when about 30 pounds brake cylinder pressure exists. The HZ4 relayair valve has provision for, and, on some classes, includes an application insuring feature, an overspeed application feature and an overspeed suppression feature.

**An overspeed magnet valve** which must be electrically energized to suppress a safety control application with the brakes released. A whistle is provided which will blow whenever the magnet valve is de-energized.

**A safety control cock**, normally sealed in the open position, located on the service application portion of the brake valve. Closing this cock cuts out the safety control features.

**A cut-out cock**, normally sealed in the open position, is located in the pipe between the diaphragm foot valve and the H-24 relayair valve. Closing this cock cuts out the dead-man feature.

**A cut-out cock**, normally sealed in the open position, is located in the pipe between the overspeed magnet valve and the brake valve. Closing this cock cuts out the overspeed safety control.

An emergency application of the brakes from any cause or a safety control application operates a pneumatically controlled switch to remove the power from the traction motors and requires that the throttle lever be placed in “Idle” position before power can be reapplied.

**Fire Fighting System**

This system is an arrangement of equipment for detecting and extinguishing any fires likely to occur in or about a locomotive.

The fire detecting system consists of electric thermostats, mounted at strategic points in each unit of the locomotive, and connected in parallel to a relay and warning device in each operating cab. An excess temperature condition will cause one or more of the thermostats to close its contacts, energizing the relay which operates the warning device.

The fire extinguishing system consists of two sets of two 50-lb. capacity carbon dioxide cylinders installed in each engine room,
two hose stations on each side of each locomotive unit—one near the front and one near the rear of each side, and two remote control pull boxes mounted near each hose station and connected by flexible steel cables to the control heads on the cylinders, one box mounted inside of the unit near the hose rack and one on the outside within reach of the ground.

The two sets of cylinders in each locomotive unit are cross-connected by piping so that one set acts as a reserve for the other. The cylinders are connected to the hose stations by piping in which is installed, just ahead of each hose, a normally closed, quick-acting direction valve which must be opened before that respective hose can be used on a fire.

Each hose station is equipped with 50 ft. of flexible hose complete with discharge horn and squeeze-grip discharge valve.

The pull boxes are so connected to the two sets of cylinders in each locomotive unit that both sets can be operated from either side of the unit.

The systems in each locomotive unit are connected by means of a flexible connection so that the total carbon dioxide supply of each unit can be used as a reserve supply for the other.

**Operating Instructions for Carbon Dioxide (CO-Two) System.**

1. Open pull box.
2. Pull handle hard. (This releases the carbon dioxide from both cylinders in one set).
3. Throw lever to left on quick-acting direction valve in piping adjacent to hose rack. (This fills hose with carbon dioxide).
4. Run discharge hose to fire.
5. Squeeze valve lever on discharge horn to release the carbon dioxide.
6. Direct discharge at base of flame.
7. If additional carbon dioxide is required, operate pull box for the other set of cylinders in the unit.
To obtain carbon dioxide from cylinders in adjoining unit.

1. Throw lever to left on direction valve above door in end of adjoining unit.
2. Discharge cylinders as required in adjoining unit by following instructions 1 and 2 above.

Note: After any fire has been extinguished, return all direction valves to closed position; bleed hose line of gas by squeezing valve lever on discharge horn.

Carbon dioxide is a non-conductor of electricity, which makes its use desirable in combating electrical fires, and it is not poisonous. However, it does not carry oxygen in any form for sustaining human life and when there is any question as to the amount of carbon dioxide in a confined space, where a fire has been extinguished, care should be exercised before entering to see that the space is completely ventilated.

Anyone overcome by carbon dioxide should be moved quickly into fresh air and artificial respiration applied.

The carbon dioxide system in each locomotive unit is supplemented by two 30-lb. “Dugas” hand extinguishers, primarily for fires on outside and not to be used inside unless fire is not extinguished by carbon dioxide system.

Procedure in Case of Fire.

1. **If a Fire Alarm is Received** (Light, Bell or both):
   a. Stop all Diesel engines by operating emergency engine stop at engineman’s position, and stop all fuel pumps by opening fuel pump push button switch or circuit breaker at engineman’s position, on classes so equipped.
   b. Investigate.

If Fire is Discovered:
   a. Stop engines and fuel pumps, if not already done, and make full service application of brakes, if not already done.
   b. Pull emergency fuel cut-off on unit or units involved.
c. Use Fire Extinguishing Equipment as follows:

1. Running gear beneath cab:
   Use “Dugas” hand extinguishers.

2. Traction Motors:
   Use carbon dioxide (CO-Two) hose system.

3. Locomotive Interiors:
   Use carbon dioxide (CO-Two) hose system.

4. In event extinguishers fail or become exhausted before fire is extinguished, use any other extinguisher at any location.

**NOTE—FIRE HAZARDS**

Where continued operation of any Diesel engine, steam generator, or other apparatus would constitute a fire hazard due to fuel oil leaks or for other reasons, that apparatus must be shut down until the hazardous condition is corrected.

**Locomotive Operation**

**Inspection.**

When taking charge of a locomotive, a thorough inspection should be made of the entire locomotive to determine if any one is working on or about the locomotive; if any equipment is missing or under repairs, or if any tools or equipment have been left on or near any of the operating parts.

If locomotive consists of several units, see that all electrical jumpers are properly connected between units. See that all air hoses are connected between units and the cocks opened.

On passenger locomotives, see that the steam heat connections between units are properly made and the valves open.

On each unit: Check fuel oil level, lubricating oil level, cooling water level, and steam generator water supply tank level.

See that drains are closed on air reservoirs, cooling water systems, and lubricating oil systems.

See that all outside connections (steam, fuel, water, or electrical) are disconnected and clear of locomotive.
Preparation for Service.

In preparing the locomotive for service, see that the battery switches are closed on each unit and check the several light circuits to see that they operate properly.

At engineman’s position in cab of controlling unit note that throttle lever is in “Idle” position, reverse lever in “Off” position, and transition lever, where used, in “Off” position. Close control switch and fuel pump switch, when provided, leaving generator field switch open on classes so equipped. See that automatic brake valve handle is in “Running” position and double heading cock open. See that independent brake valve handle is in full “Application” position and rotair valve in “Passenger” position. On all units, close all switches on distribution panel, noting that all fuses are in place or on classes so equipped close all circuit breakers on contactor compartment panel.

At engineman’s position in cab of trailing unit, note that throttle lever is in “Idle” position, that reverse lever is in “Off” position and handle removed and that transition lever, when used, is in “Off” position. See that automatic brake valve handle is removed in “Running” position and double heading cock closed. See that independent brake valve handle is removed in “Release and Running” position and rotair valve is in “Passenger Lap” or “Lap” position. See that control switch is open and, on classes so equipped, see that fuel pump and generator field switches are open. Start each Diesel engine from its engine control panel and note that proper lubricating oil pressures obtain after which isolation switch should be closed in “Run” or “On” position.

Check charge indicators to see that auxiliary generators are functioning properly and that the batteries are receiving a charge.

See that all engines are “on the line” by opening throttle, with reverse lever in “Off” position and generator field switch open (on locomotives so equipped), checking each Diesel engine to see that it is running at a speed corresponding to throttle position.

Where steam generators are provided and are to be operated, start the steam generator on the units required. Note: A steam generator should not be operated on a unit for more than several
minutes unless at least one of the auxiliary generators on the unit is in service.

Where required, departure test of cab signals must be made.

Where required, departure test of trainphone must be made.

When proper main reservoir pressure obtains, test air brake equipment to see that it functions properly from both ends in all positions of the brake valves and that the safety control equipment is cut in and operative.

Before attempting to move locomotive, see that chocks or chains are removed from under the wheels and that the hand brakes are fully released on all units.

Engine cooling water temperature should be at least 125° F. before operating under load.

**Cab Signals.**

The cab signal circuits are supplied with 32-volt power from a motor-generator set. This set is operated from the battery or auxiliary generator circuit through a 50-ampere thermal overload circuit breaker. The 32-volt output of the motor-generator set is the normal supply to the cab signal equipment, trainphone and the headlight.

**Changing Ends.**

To change operating ends, the following procedure should be followed:

See that throttle lever is in “Idle” position.

See that transition lever, where used, is in “Off” position.

Remove reverse lever in “Off” position.

Make a full service brake pipe reduction (at least 20 pounds).

Close double heading cock.

Remove automatic brake valve handle in “Running” position.

Place rotair valve in “Passenger Lap” or “Lap” position.

Remove independent brake valve handle in “Release and Running” position.
Open generator field switch, where provided.

Open control switch.

Open fuel pump switch, where provided, except that, on some classes, fuel pump switch must be left closed until fuel pump switch on other end is closed, after which it must be opened.

Proceed to end being cut in.

Close control switch.

Close fuel pump switch, where provided.

Put reverse lever in place and leave in “Off” position.

See that throttle lever is in “Idle” position.

See that transition lever, where used, is in "Off" position.

Put independent brake valve handle in place and move to full “Application” position.

Place rotair valve in “Passenger” position.

Put automatic brake valve handle in place and leave it in “Running” position.

Open double heading cock SLOWLY.

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To Move Locomotive:

Close generator field switch, where provided.

Place reverse lever in “Forward” or “Reverse” position.

Place transition lever, where provided, in “No. 1” position.

On classes where transition lever is provided and automatic transition is being used, transition lever should be placed in position specified for the particular class of locomotive after any shifting movements have been completed. On classes where manual transition is being used, movement of the transition lever should be made as indicated by the load indicating ammeter.

Hold either dead-man pedal or automatic brake valve handle in depressed position to prevent dead-man operation.

Release all brakes.
Open throttle to first notch and note that amperage is indicated on load ammeter.

Open throttle gradually, pausing in each position long enough to permit load ammeter pointer to settle to a steady reading, until locomotive starts to move. Further movement of throttle lever depends on proper handling of train due to slack action and permissible speed. During starting and acceleration the load ammeter pointer may move into the red portion of the scale without any restrictions. This is desirable in order to permit high tractive effort.

Road Operation.

During operation over the road the load ammeter pointer must be kept in the white portion of the scale, except under the conditions prescribed under each class of locomotive.

In braking the train for slowdowns or stops, the brake may be applied while using power, however, the throttle lever should be placed in a lower notch while braking and power must be shut off before the stop is completed.

When crossing railroads at grade the throttle lever must be placed in a low notch to prevent arcing between the traction motor brushes and commutators.

A locomotive must NOT be operated through water deep enough to touch the traction motors. When passing through water to the level of the rail head, reduce speed to not over 5 mph.

The reverse lever must NOT be moved to the position for operation in the opposite direction while the locomotive is in motion. When leaving the locomotive cab, the reverse lever must be removed in "Off" position.

Care must be exercised to prevent operating the emergency engine stop except in emergency. The emergency engine stop is operated by pushing the stop button on some classes, while on other classes the throttle lever incorporates a stop position which is made available by pushing an unlatch button on the end of the throttle lever. When the emergency engine stop is operated, all Diesel engines on the locomotive will stop.

On classes of locomotives incorporating dynamic braking, train speed may be controlled by its use in the following manner:
With throttle lever in “Idle” position, move transition lever on classes so equipped to “Off” position or move reverse lever to “Braking” position where provided and pause until train slack is adjusted. Move transition lever on classes so equipped to “B” position. The load ammeter will indicate the amount of braking current being generated by the traction motors. If current is below maximum permitted and further braking effort is required, move transition lever or throttle lever, on classes where throttle lever is used for this purpose, into braking zone. As speed decreases, traction motor braking current will decrease and lever may be moved further into the braking zone, being careful not to exceed the maximum permissible current. A dynamic brake warning light will light if maximum permissible current is exceeded on any unit. If train speed cannot be properly controlled by use of the dynamic brake alone, the automatic air brake may be applied to supplement it, keeping the locomotive brakes released to avoid wheel slide.

The Diesel-electric locomotives are equipped with wheel slip relays which operate to reduce the power output of the Diesel engines when wheel slipping occurs and light an indicating light, operate a buzzer, or both. When wheel slipping stops the relays reset automatically. If slipping condition is minor, no action need be taken. If, however, slipping continues, throttle lever position should be reduced; sand should be applied if necessary. The use of sand should be restricted to absolute necessity. Do **not** apply sand while wheels are slipping.

If necessary to pump air faster when locomotive is standing or drifting, place reverse lever in “Off” position and open generator field switch, on locomotives so equipped, and move throttle lever to position to obtain pumping rate required.

**Isolating a Diesel Engine.**

Multiple-unit control of the several Diesel engines on a locomotive being completed through an isolation switch located on the engine control panel of each Diesel engine, permits one or more of the engines to be removed from multiple-unit control. This is known as isolating an engine and is done by operating the isolation switch to its isolation position. The engine is then removed from multiple-unit control and operates at idling speed. The act of returning the engine to operation under multiple-unit control is
known as putting the engine “on the line”, and is accomplished by moving the isolation switch to its “Run” position.

If an engine is to be stopped it should first be isolated and then a the “stop” switch, or button where provided, should be operated, or the isolation switch turned to the “Off” position on locomotives so equipped. After the engine has stopped the fuel pump switch should be placed in the “Off” position.

Ground Relay Operation.

If a ground relay operates it must be reset manually. Before resetting a ground relay the Diesel engine must be isolated. If, after several repeated operations, the relay fails to remain reset, the Diesel engine should be left off the line.

If it is necessary, in order to handle the train to operate the Diesel engine involved, traction motor cut-out switches are provided on some classes to cut out traction motors. If cutting out traction motors eliminates the grounded condition, the Diesel engine may be restored to service to operate the remaining traction motors. If, however, the condition cannot be overcome in this manner, a manual ground relay cut-out switch is provided which prevents further operation of the ground relay. This cut-out switch is sealed and should be operated only in an unusual emergency and proper report made if seal is broken, otherwise the Diesel engine must be left off the line.

If traction motor is cut out enroute or an engine is left off the line due to ground relay operation, or if a ground relay is cut out by means of manual ground relay cut-out switch, a message must be sent to the Superintendent and inspection of traction motors must be made at first terminal where competent employes are available.

Safety Control Operation.

After a safety control application occurs, due to operation of the dead-man or locomotive overspeed devices, or when an emergency application of the brakes occurs from any other cause, in order to restore power to the locomotive the throttle lever must be returned to “Idle” position, the dead-man pedal depressed, the automatic brake valve handle placed in “Lap” position until brake pipe reduction is completed, after which brakes may be released in the normal manner.
If unable to recover a safety control application of the brakes or if safety control applications recur with the dead-man pedal held down and speed below maximum permitted, the safety features may be cut out provided that after the safety features are cut out, the engineman is not alone in the operating end while the train is in motion. A report to the Superintendent must be made without delay to the train.

**Leaving the Locomotive.**

If necessary to leave locomotive unattended at a terminal, weather conditions permitting, all Diesel engines should be shut down, battery switches opened, and lighting switches opened on units having lighting not connected through the battery switch. Air brakes should be released, hand brakes applied and, when necessary, the wheels should be chocked.

**Freezing Weather Precautions.**

During freezing weather, in order to prevent freezing of the locomotive water systems:

On locomotives equipped with steam generators, at least one steam generator should be kept in service, together with a Diesel engine on the same unit, and the necessary valves operated to furnish steam to the water supply tanks on the locomotive and to other steam generators and Diesel engines on the locomotive that are not operating.

On locomotives equipped with standby heaters, if a Diesel engine is shut down, the standby heater should be operated.

If steam from local plant is available, connection can be made to steam train line on locomotives so equipped, necessary valves operated on the locomotive, and the steam used to prevent freezing of the locomotive water systems. If plant steam is used, it will not be necessary to operate the Diesel engines, standby heaters or steam generators on the locomotive.

If the Diesel engines are to be shut down and steam is not available or standby heaters are not provided, all water must be drained from the locomotive.
## DIESEL-ELECTRIC LOCOMOTIVE OPERATION

### INDICATION AND RESULT OF ABNORMAL CONDITIONS OF VARIOUS CLASSES

<table>
<thead>
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<th>CONDITION</th>
<th>INDICATION AND RESULT</th>
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<td><strong>Class AF-4</strong></td>
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<tr>
<td><strong>1. High cooling water temp.</strong></td>
<td>a b c d</td>
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<tr>
<td><strong>2. Low lube oil pressure</strong></td>
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<tr>
<td><strong>3. High lube oil suction</strong></td>
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<td><strong>4. Wheels slipping</strong></td>
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<td><strong>5. Ground relay operation</strong></td>
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<td><strong>6. Deadman operation</strong></td>
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<td><strong>7. Diesel engine overspeed</strong></td>
<td>e m (See 15)</td>
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<tr>
<td><strong>8. Locomotive overspeed</strong></td>
<td>a f g h l w</td>
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<td><strong>9. No a-c voltage</strong></td>
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<tr>
<td><strong>10. Low governor oil Press.</strong></td>
<td>e (See 15)</td>
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<td><strong>11. Steam generator shut down</strong></td>
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<td><strong>12. Emergency brake Appl'n.</strong></td>
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<td><strong>13. Radiator fan stopped</strong></td>
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<td><strong>14. Trac. Mtr. Blower stopped</strong></td>
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<td><strong>15. Engine stopped</strong></td>
<td>a b c d</td>
</tr>
<tr>
<td><strong>16. Excessive dynamic brake</strong></td>
<td>---</td>
</tr>
</tbody>
</table>

### NOTES

- * Wheel slip relays reset automatically when slipping stops.
- † With isolation switch “On”
  - When throttle is open: Reduces Eng. Speed.
  - When dynamic braking: Reduces Eng. Speed.
  - Stops engine in 5th or 6th notch: Reduces load 25%.
  - With engine stop switch in “On” position: Reduces load 25%.

### Indication or Result

- a — Indicating light in operating cab
- b — Indicating light in engine room
- c — Bell
- e — Stops engine
- d — Buzzer
- f — Idles engine
- g — Unloads generator by removing excitation
- h — Removes power from motors by opening power contactors
- i — Operates “PC” switch
- j — Starts fuel pumps
- k — Reset button on governor protrudes
- l — Applies brake
- m — Reset button on tachometer generator protrudes
- n — Manual reset lever trips
- o — High lube oil temperature has same results as high cooling water temperature
- w — Warning whistle

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June, 1949.
Diesel-Electric Road Locomotives

Operating Instructions

SECTION 2 – OIL-FIRED STEAM GENERATORS

Description

The steam generator for train heating, located on each passenger unit, is of the forced-circulation, coiled water tube type. It is oil-fired and has electric ignition. The heat absorption portion consists of three compactly wound coils of steel tubing, connected in series to form a single tube several hundred feet in length set within a firebox.

Water is forced into the outer coil of this tube by a feed pump, which takes its supply of water from supply tanks located on each unit, through a water treatment tank. These supply tanks are gauged by dial-type gauges, on each unit. On classes having air-operated gauges, an air valve, adjacent to the gauge, must be opened to get a reading, and should be closed after the reading has been taken. Oil is supplied to the burner by a fuel pump which takes its supply from the Diesel engine fuel supply tanks on each unit through a knife edge filter, while air for combustion is delivered to the combustion chamber by a blower. The hot combustion gases pass through the coil layers before flowing to the stack. The water in its passage through the coils is heated and converted into steam. The steam flows from the coils to an external steam separator and from it to the train line. After filling the coils with cold water, steam is generated to full operating pressure in several minutes after the fire is lighted.

During operation, a slight excess of water is circulated through the coils to flush out scale forming material. The water and sludge are removed from the steam in the separator and fall to a sump in the bottom of that vessel. The sludge is blown out periodically through a blowdown valve. The excess water accumulates and rises in the separator and overflows through a return water outlet pipe, through steam traps, and a coil type heat-exchanger, and returns to the water supply tank. In flowing through the coil, the
hot return water preheats the feed water which flows through the casing of the heat-exchanger.

The rated capacity of each steam generator is 3000 pounds of water evaporation per hour from feed water of 60º F. to steam at 300 psi.

The steam output of the steam generator is automatically controlled, in accordance with the demand, by a water by-pass regulator which by-passes a varying amount of the water from the pump and thus regulates the amount being delivered to the coils.

The steam train line pressure is regulated by adjusting the handwheel on the water by-pass regulator and may be controlled between 50 and 290 pounds. The length of train and the weather conditions will determine what the setting should be.

The burner which burns Diesel fuel oil, consists of a fuel spray head which is equipped with a spray nozzle and is of the air atomizing type. Air for atomizing, or breaking the fuel into a fine spray, is supplied from the main reservoirs through a reducing valve and through a solenoid-operated valve. This spray is ignited by spark plugs as it issues from the nozzle. Should the air pressure be too low for proper atomization or the solenoid-operated air valve be closed, a valve within the spray head will close to prevent the discharge of fuel oil into the combustion chamber. The amount of fuel delivered to the burner is regulated by the servo-fuel control in proportion to the amount of water entering the steam generating coils. To control the amount of combustion air to the firebox, the servo-fuel control is linked to a damper in the air intake stack. Both functions are accomplished by adjustable cams.

The motor which drives the water pump, fuel pump and blower is a combination motor-converter which furnishes alternating-current to a transformer for the electric ignition.

A main switch is provided to complete the circuit from the battery or auxiliary generator to the steam generator and is located on or adjacent to the steam generator.

A control switch, located on the front of the steam generator, has three positions, “Off,” “Fill,” and “Run.” The motor will not start unless this switch is in “Fill” or “Run” position.
With the switch in “Fill” position, water will be pumped into the steam generator, the fuel cut-off valve is shut, the solenoid operated air valve is closed, and the burner will not light. Turning the switch to “Run” position opens the fuel cut-off valve, opens the solenoid-operated air valve, and the burner should start at once.

A control panel, also mounted on the steam generator, contains the relays and resistors required for starting and accelerating the motor, and contains an overload relay to protect the motor, which can be reset, if necessary, by pushing a button on the relay located behind small door on cover of control panel.

A stack switch, operated by a temperature sensitive helix, stops the motor when stack temperature exceeds 900° F. A reset button on the stack switch will protrude when the switch is tripped by excessive temperature and must be pushed in to reset. Operation of the stack switch, due to excessive temperature, will operate the alarm pilot relay and the alarm will sound.

The stack switch also incorporates low temperature contacts which work in conjunction with an outfire relay. These contacts are open when the stack temperature is below 240° F. Should the fire fail to start or the stack temperature fail to reach 240° F. within about 45 seconds, the outfire relay contacts will open, the time delay being incorporated in the relay. The motor will stop and the alarm will sound.

If the fire lights, stack temperature will rise rapidly above 240° F. and the low temperature contacts on the stack switch will prevent the outfire relay from opening.

When the fire is out, due to reaching the required steam pressure setting, the outfire relay will remain closed even though stack temperature may go below 240° F. However, if the fire should go out due to lack of fuel or other cause the stack temperature drops below 240° F., the outfire relay and stack switch will open, the motor will stop and alarm will sound.

The alarm circuit is operated by an alarm pilot relay which sounds the alarm and lights the “Boiler Off” indicating lights, if either the overload relay, coil blowdown switch or stack high temperature switch is open with the control switch in either “Fill” or “Run” position, or if the fire has failed to start and stack tempera-
ture has not reached 240º F. within 45 seconds with the control switch in “Run” position.

If an insufficient amount of water is flowing to the coils, the servo-fuel control will open the low water cut-off switch to de-energize the air solenoid valve. Lack of atomizing air will then cause the burner to shut down and, when the stack temperature drops, the outfire relay will stop the motor and sound the alarm.

A steam temperature limit control operates a fuel metering valve to reduce the flow of fuel to the burner, when steam temperature becomes excessive or, in the absence of steam, to protect the coils from damage. This control does not shut down the motor or sound the alarm.

Two safety valves, located on the steam separator, protect against excessive pressure and are set at 295 and 300 pounds, respectively.

Four 15 ampere fuses, two in the control circuit and two in the ignition circuit, are located in the control panel and protect their respective circuits from overload.

A water pressure relief valve, located in the discharge pipe of the water pump, close to the pump, set to open at between 500 and 600 pounds, protects against excessive water pressure when the coils become obstructed or the line closed.

Adjacent to the water pressure relief valve is a water pump test valve, opening into a funnel, by means of which it can be determined if the pump is delivering water.

A coil blowdown valve is provided to blow out sludge and water when shutting down the steam generator. A switch, incorporated in this valve, prevents operation of the motor unless the coil blowdown valve is closed.

A fuel pressure regulator is provided to maintain a constant fuel manifold pressure of approximately 155 pounds.

A panel above the control switch incorporates two fuel oil pressure gauges, one indicating manifold fuel pressure and one indicating nozzle fuel pressure, an atomizing air gauge, and a steam train line pressure gauge. A steam pressure gauge located on the steam separator shows steam generator pressure.
A system of remote controls is provided so that the separators may be blown down periodically and the steam shut off the train line without the necessity of leaving the operating cab. The remote control panel is located at the fireman’s position in each operating cab and includes a master switch for cutting in the panel controls, a push button by means of which the separator blowdowns can be opened and a push button which operates the solenoid-controlled steam train line shut-off valves on all units. After a train line shut-off valve is actuated from the remote control panel it is necessary to reset the valve at the steam generator before steam can again be admitted to the train line. A third push button, marked “soot blower,” is not used. A steam train line pressure gauge is also located on the remote control panel.

OPERATION

Before Starting

1. Before attempting to start steam generator the following valves should be checked (for purpose of identification, normally open valves have wheel-type handles, and normally closed valves have tee-type handles).

Normally Open:

Water suction stop valve—In suction pipe between supply tank and water treatment tank.

Coil shut-off valve—In coil feed water pipe between heat-exchanger and steam generator.

Water by-pass regulator shut-off valve—In line to water by-pass regulator.

Steam generator stop and check valve—In main steam outlet pipe at steam separator.

Return water outlet valve—Between separator and steam traps.

Water return valve—Between flow indicator and water supply tank.

Atomizing air admission valve—Between main reservoir and reducing valve.
Steam shut-off valve to steam generator steam pressure gauge—In small pipe at steam separator.

Steam shut-off valve to water by-pass regulator—In small pipe from steam train line.

Steam shut-off valve to steam train line gauge—In small pipe from steam train line.

**Normally Closed:**

Wash-out solution admission valves—In wash-out pipe at steam generator and at heat-exchanger.

Three-way heat-exchanger wash-out valve—In wash-out pipe connection to heat-exchanger outlet pipe.

Three-way steam separator wash-out valve—In wash-out outlet pipe connection to separator blowdown pipe.

Manual water by-pass valve—In by-pass pipe around water by-pass regulator.

Coil blowdown valve—In branch from coil feed water pipe.

Water pump test valve—In discharge pipe at water pump.

Steam shut-off valve for standby heating—In small pipe between steam train line and steam separator, or in steam pipe from steam train line to steam generator heating radiator on locomotives so equipped.

Water system drain valves—Located:

a. At water supply tank.

b. In water suction line at supply tank.

c. At water treatment tank.

d. In water suction line to pump.

2. Check stack switch reset button to see that it is in.

3. Check overload relay reset button to see that it is in.

4. Turn handle on fuel oil knife edge suction filter several turns in a clockwise rotation to insure that filter is free of dirt.
Starting Steam Generator.

1. Open steam separator blowdown valve (foot-operated)—leave open for approximately one minute—then close steam separator blowdown valve.

2. Open fill test valve-located in branch of return water pipe from steam separator to steam traps.

3. Close steam generator main switch.

4. Place control switch in “Fill” position.

Motor should start and water pump should fill coils with water. If motor fails to start check fuses in control circuit, and fuses or circuit breakers to main switch. Check spark through sight glass. If no spark is present check fuses in ignition circuit and check for loose or broken cable connections to spark plugs.

5. When coils are filled as indicated by a full flow of water from fill test valve, close valve and open steam separator blowdown valve, and latch in “Open” position.

6. Place control switch in “Off” position until motor has stopped.

7. Place control switch in “Run” position—fire should start.

8. Check water pressure gauge, located on servo-fuel control, which should show approximately 100 pounds above steam pressure. Excessive pressure indicates that the coils are becoming obstructed or the line closed, and proper report should be made.

9. Check fuel oil pressures:

   Fuel manifold pressure should be approximately 155 pounds.

   Fuel nozzle pressure should be between 20 and 80 pounds, depending on position of servo-fuel control.

10. Check atomizing air pressure—should be approximately 70 pounds.
11. When 25 pounds steam pressure obtains, close steam separator blowdown valve.

   Open steam separator blowdown valve several times for approximately five-second intervals during first several minutes of operation.

12. Set water by-pass regulator for steam train line pressure required.

13. See that steam train line stop valve is closed, and latch solenoid-operated steam train line shut-off valve in “Open” position.

14. When opening steam train line stop valve into steam train line, it should be opened gradually.

When preparing locomotive for service after steam generator has been lighted and full pressure obtains, with steam train line end valves on each end closed, open steam train line stop valves on steam generators in service and blow out condensation from steam train line by opening end valves. After doing this, the end valves should permit a slight escape of steam to prevent freezing in cold weather.

Notes: 1. It may take from 5 to 10 minutes to fill coils, if entirely empty. Do not start steam generator until coils have been filled with water.

2. Caution:

   Before operating coil blowdown, separator blowdown, or blowing out of steam train line, ascertain that no person is in a position where the steam will contact him.

While Steam Generator is in Operation.

   Steam separator must be blown down at least every 45 minutes for a period of from 3 to 5 seconds each time.

   Turn handle on fuel oil knife edge suction filter several turns in clockwise rotation at division points and intermediate terminal points.
Shutting Down Steam Generator.

1. Close steam train line stop valve.
2. Place control switch in “Off” position.
3. Open coil blowdown valve—reducing generator steam pressure to 50 pounds.
5. Open separator blowdown valve and latch in open position until all pressure is released.
6. Close separator blowdown valve.
7. Fill coils with water as described for starting steam generator.
8. Place control switch in “Off” position.
9. Open main switch.
10. Close atomizing air valve.

Trouble Shooting

In the event that steam generator shuts down alarm bell will ring, and indicating light marked “Boiler Off” will light.

1. Turn control switch to “Off” position to stop alarm.
2. Check stack switch reset button to see that it is in.
3. Check overload relay reset button to see that it is in.
4. Fill coils with water as described in starting, place control switch in “Off” position until motor has stopped, then start fire by placing control switch in “Run” position.

If fire fails to start:

a. Check ignition spark.

b. Check atomizing air pressure—adjust reducing valve if necessary.

c. Check water pressure—if low, close water by-pass regulator shut-off valve and if burner starts at once, indication is that water by-pass regulator is defective.
Control steam train line pressure by manual water by-pass valve.

Note: Failure of the water by-pass regulator to by-pass a sufficient amount of water will result in steam train line pressure higher than the setting of regulator—Use manual water by-pass valve to control steam train line pressure.

**Freezing Weather Precautions**

During freezing weather steam pressure must be available in the steam train line in order to protect water supply tanks and idle steam generators from freezing.

To protect water supply tank, open steam valve in pipe from steam train line to water supply tank on all units sufficiently to prevent freezing.

On idle steam generators, open steam shut-off valve for standby heating in small pipe between steam train line and steam separator and open coil blowdown valve at steam generator, or, on locomotives so equipped, open valve from steam train line to steam generator heating radiator.

If all steam generators on locomotives are idle, steam may be made available through connection to another locomotive or plant steam line.

If steam pressure is not available, the complete system and water supply tanks must be drained.
Diesel-Electric Road Locomotives

Operating Instructions

SECTION 3 – CLASS EP-3

General Data—Locomotives

Builder................................................. Electro Motive Division—General Motors
Horsepower Rating.................................... 6000 H.P.
Gear Ratio .................................................. 22/55
Maximum Speed ........................................ 98 M.P.H.
Units Per Locomotive ......................... Two “A”, One “B”
Trucks Per Unit ........................................ Two
Axles Per Truck.............................. Three
Traction Motors Per Truck ................. Two
Wheel Diameter ........................................... 36”
Journal Size ........................................... 6½"x12”
Brake Schedule..................................... Westinghouse 24-RL

Maximum Overall Dimensions :
“A” Unit    “B” Unit
Height.......................... 15′—5”       14′—8-7/16”
Width.......................... 10′—6-7/8”     10′—6-7/8”
Length ................................... 71′—1¼”    70′—0”

Total Weight ........................................ 319,600 lb. 306,100 lb.
Weight on Drivers .............................. 215,400 lb. 206,300 lb.

Steam Generator Water Supply
Tank Capacity.................................... 1200 gal. 1200 gal.
Fuel Oil Capacity .............................. 1200 gal. 1200 gal.
Sand Capacity...................................... 16 cu. ft. None

General Data—Diesel Engine

Make and Model ................................... E.M.D. —567-A
Horsepower at Governed R.P.M........... 1000 H.P. at 800 R.P.M.
Type.................................................... Vee—2 cycle
Number of Cylinders ......................... Twelve
Bore and Stroke ......................... 8½" x 10"
Idling Speed ................................. 275 R.P.M.
Firing Order .................................. 1-12-7-4-3-10-9-5-2-11-8-6
Number of Engines Per Unit.......... Two
Lubricating Oil Capacity, Each
   Engine..................................... 165 gal.
Cooling Water Capacity, Each
   Engine..................................... No. 1 Engine-192 gal.
   No. 2 Engine-187 gal.

Diesel Engine

Being a two-cycle engine, only two strokes of a piston are required to complete a cycle of cylinder events. Exhaust and intake events take place during part of the power and compression strokes, respectively. Since the pistons are not required to function as air pumps, a specially designed blower handling a large volume of air at low pressure, is used to supply air to the cylinders. Two of these blowers are mounted on each engine, and driven by blower drive gears in the camshaft gear train. On each blower air intake housing is mounted an air filter for removing dust from the intake air.

The cycle of events in a cylinder of this engine is explained in the following four paragraphs:

At the lower end of its downward stroke, the piston uncovers a row of air inlet ports in the cylinder liner admitting blower air to the cylinder from the air box surrounding the cylinders. This flow of air through the inlet ports at the bottom of the cylinder and out through the open exhaust valves (four per cylinder) at the top, produces complete scavenging (cleaning) leaving the cylinder full of clean air when the piston covers the inlet ports on its upward stroke.

As the piston continues on the upward stroke, the exhaust valves close and the charge of air is compressed to about one-sixteenth of its initial volume, or to about 600 lb. per square inch pressure. Air, when compressed to this extent, increases in temperature to approximately 1000 degrees F. This high compression is maintained at all loads and speeds, because the air intake is never throttled.

Shortly before the piston reaches the top dead center of its stroke, the fuel, atomized by high pressure, is injected into the combustion chamber. The fuel is ignited by the high temperature of
the air and continues to burn until the charge is consumed. The burning charge rapidly builds up a high pressure which acts on the piston, forcing it downward on the power stroke.

Just before the piston reaches the end of the power stroke, the exhaust valves open, releasing the combustion gases to the atmosphere, and the piston, still going down, again uncovers the air inlet ports. By this time the exhaust gases have expanded to the point where the pressure is lower in the cylinder than in the air box. The cycle of events is then repeated.

The main generator, auxiliary generator, engine blowers and oil separator are mounted on the “Rear” end of the engine. The governor, electro-pneumatic governor control, water pumps and lubricating oil pumps are mounted on the “Front” end.

The cylinders are arranged in two banks, with six cylinders in each bank, and with an angle of 45 degrees between banks. The “Right” and “Left” banks (sides) of the engine are designated by the right and left hands respectively when facing the “Rear” end of the engine.

The cylinders are numbered from front to rear, starting with No. 1 at front end of the right bank, and ending with No. 6 at rear end of the right bank, and beginning with No. 7 at the front end of the left bank and ending with No. 12 at the rear end of the left bank.

The direction of rotation of the engine is counter-clockwise, when facing the rear end of the Diesel engine.

**Diesel Engine Governor and Governor Control**

The hydraulic type governor on this engine contains four essential sections, the oil supply, the speed control column, the power piston and the compensating mechanism. Each section has a definite function in controlling the speed of the engine.

The self-contained oil system consists of a storage sump, rotary gear pump, ball check valves and accumulator. The capacity of the governor is three pints, and engine lubricating oil should be used. The oil acts as a lubricant for the moving parts in the governor as well as the hydraulic medium.

To vary the speed of the engine with throttle changes, or to maintain a constant speed with load changes, the amount of fuel injected
into the cylinders must be varied. The amount of fuel injected is determined by the position of the power piston, and its position is determined by spring-loaded, rotating flyweights. The movement of the flyweights causes a change in the position of the pilot valve plunger controlling the supply of oil which actuates the power piston. The engine speed at which the flyweights actuate the pilot valve plunger is determined by the position of the governor control arm. The governor control arm changes the pressure of a speeder spring which controls the pilot valve plunger through the movement of the flyweights. The position of the governor control arm is determined by throttle lever position through electro-pneumatic governor control. The flyweights and pilot valve plunger are located in the central portion of the governor known as the speed control column.

The power piston supplies the force to move the injector control racks through injector linkage.

The compensating mechanism prevents the engine from racing or hunting by stopping the movement of the power piston after it has traveled a sufficient amount to give the desired speed.

The governor is mounted on the front end of engine and driven through a 90-degree bevel gear drive, which is in turn driven by a spur gear in the accessory drive gear train by means of a serrated shaft. The drive assembly is lubricated by the engine lubricating oil through drilled passages in the housing.

The various throttle lever positions and the corresponding Diesel engine R.P.M. are as follows:

<table>
<thead>
<tr>
<th>Throttle Lever Position</th>
<th>Engine R.P.M.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Off</td>
<td>0</td>
</tr>
<tr>
<td>Idle</td>
<td>275</td>
</tr>
<tr>
<td>1</td>
<td>275</td>
</tr>
<tr>
<td>2</td>
<td>350</td>
</tr>
<tr>
<td>3</td>
<td>425</td>
</tr>
<tr>
<td>4</td>
<td>500</td>
</tr>
<tr>
<td>5</td>
<td>575</td>
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<tr>
<td>6</td>
<td>650</td>
</tr>
<tr>
<td>7</td>
<td>725</td>
</tr>
<tr>
<td>8</td>
<td>800</td>
</tr>
</tbody>
</table>

The overspeed stop device on the engine is a flyweight mounted on the right-hand camshaft counterweight which, when the engine
speed reaches approximately 880 R.P.M., operates small cams under each injector rocker arm to make the rocker arm inoperative, thus preventing injection of fuel into the cylinders and stopping the engine.

The overspeed stop must be reset manually by turning the resetting lever in a counter-clockwise direction until it latches. The resetting lever is located on the front end of the engine directly behind the governor.

**Diesel Engine Cooling System**

The cooling systems of the several engines of the locomotive are similar to and independent of each other. They are designed to operate at “G” valve level so that, when the engines are shut down, the water level is below the radiators, thus giving protection against the radiators freezing during shut-downs in cold weather.

Two centrifugal water pumps, located on the front end of each engine, draw water from a water tank which is part of the water tank and oil cooler assembly located overhead at the front end of each engine. The pumps circulate the water to the bottom of each cylinder liner, up through the cored passages of the liner and cylinder head and out through the outlet manifold. From the engine, the water flows to two groups of radiator sections located in the roof hatch directly over each engine. Here the water is cooled, and returns through the oil cooler to the water tank.

The water temperature of each system may be checked on a dial-type gauge located on each water tank. Ideal operating temperature is 165 degrees F. It is recommended that an operating temperature of 150 degrees F. to 180 degrees F. be maintained.

Radiator shutters control the flow of air to the radiators and thus regulate the temperature of the engine cooling water. The shutters are normally operated automatically by pneumatic cylinders which are actuated by air supplied from the main reservoir at full pressure through magnet valves. The magnet valves are operated by the shutter relays which in turn are operated by the engine temperature control switches. The control switch for each engine is connected by a capillary tube with a temperature bulb located in the cooling system between the engine and the radiators. Current for the magnet valves, relays and switches is taken from
the “PC” wire of the low voltage system through a 6-ampere fuse located in the No. 1 shutter relay box.

The engine temperature control switch for each engine is mounted adjacent to the shutter relays. The shutter relays and magnet valves are located on the right-hand side of the unit, just below the ceiling sheets. The three shutters per unit, with their respective operating mechanisms including the air cylinders, are located overhead; one at each end of the unit, and the third between the two radiator assemblies at approximately the middle of the unit.

When the engine temperature control switch on each engine closes, it operates the corresponding shutter relay. Closing of the No. 1 shutter relay operates magnet valves which admit air to the operating cylinders of the front and middle shutters causing them to open. Similarly, closing of the engine temperature control switch of the No. 2 engine will operate No. 2 shutter relay. This shutter relay will operate the magnet valves controlling the rear and middle set of shutters.

As the operation of either shutter relay in a unit will cause the middle set of shutters to open, the middle shutters will be open as long as either engine requires open, shutters. Only when both engines require closed shutters will the middle set of shutters be closed.

The shutter operating linkage is connected to a manual operating lever which is latched to a notched quadrant. The quadrant is moved by the action of the air cylinder, carrying the manual operating lever with it and thus operating the shutters. This construction permits manual operation of the shutters should any failure of the electro-pneumatic shutter control system occur. During automatic operation, the manual lever is left latched in the “Closed” notch of the quadrant.

When one engine is off the line and idling in cold weather, it may be necessary to take special action to prevent its cooling water temperature from falling too low when the action of the other engine opens the middle shutters. This may be done by opening the manual operating lever, of the engine under power, one or more notches as required. Such action will minimize the time during which the middle shutters will be open.
Each engine is equipped with two radiator cooling fans, one located overhead at each end of the engine. The fans are Vee belt driven from the engine through sheaves and jackshafts, and their speeds are proportional to the speed of the engines.

The engine high temperature alarm switch is a thermal switch, located on the side of each engine control panel, which connects with a thermal element in the cooling water outlet manifold of the engine. If the outlet water temperature exceeds 203 degrees F., this switch closes and lights the hot engine alarm signal lights and rings the alarm bells throughout the locomotive.

When it is necessary to add water to an engine cooling system, proceed as follows:

1. Shut down engine and open “G” valve. (The “G” valve, in the cooling system of the No. 1 engine, is located under the No. 1 cooling water tank and, in-the cooling system of the No. 2 engine, is located on the engine room wall to the right of the No. 2 cooling water tank).

2. Add water slowly until it runs out the “G” valve. (There are filler pipes located on the roof of the locomotive above the water tanks, and side filler pipes located underneath the locomotive frame).

3. Close the “G” valve.

The minimum water level for the No. 1 cooling system is indicated at the lower try cock under the No. 1 cooling water tank. Minimum level for the No. 2 cooling system is indicated by a line painted on the No. 2 cooling water tank near the water level gauge. The engines should never be operated with the water below these levels.

If a locomotive is to be left standing, or a Diesel engine is shut down, where there is a danger of freezing, steam should be supplied to the system or the cooling water system should be drained.

For supplying steam to the cooling system, each system has a connection with the steam train line through steam admission valve “D” and check valve “E” which are located at the right front corner of the engine at the floor level. The check valve “E” prevents water from draining into the steam train line.
Steam can be supplied by connecting an outside steam line to the steam train line connection at either end of a unit, or by operating the steam generator.

When steam is to be supplied to the cooling system, valves “D” and “G” should be opened. Valve “G” must be open so that condensation will not build up and freeze in the radiators. Steam being supplied to the cooling system should not be allowed to exceed 50 pounds pressure.

To drain an engine cooling system, first open the “G” valve, then open the “C” valve which is located below the right-hand water pump close to the locomotive floor. To completely drain a system in freezing weather, open valves as above and remove pipe plugs from the water pumps.

The pressure gauge on the outlet side of the water pumps should be observed periodically as a check on the operation of the cooling system. A high pressure indicates an obstruction in the cooling system; a low pressure indicates insufficient water supply to the pump, or a faulty pump.

**Diesel Engine Lubricating Oil System**

The lubricating oil systems of the several engines of the locomotive are similar to and independent of each other.

The oil is stored in the oil pan of the engine and is gauged by a bayonet-type gauge in the oil pan on the left side of the engine. With the engine running, the gauge should show oil between “Low” and “Full”. When the engine is shut down and first filled, the level on the bayonet should show “System Uncharged;” but after the engine has been run and shut down, the level on the bayonet should show “System Charged.” The difference when the engine is shut down is due to some of the oil being trapped in the lines, filters and tank.

Oil may be added by removing oil filler cover on the oil filter tank above the strainer chamber and pouring the required amount through the strainer basket. The oil filter tank is located on the floor at the front end of each engine and contains a group of four filter elements.
The engine lubricating oil system is a pressure system using two positive displacement gear-type pumps combined in a single unit. One pump delivers oil for the pressure lubricating system, the other for piston cooling. The oil supply for these pumps is drawn from the lubricating oil filter tank through a common suction pipe.

A scavenging oil pump is used to draw oil from the engine oil pan through a strainer, pump it through the lubricating oil cooler to the filters and oil filter tank strainer chamber.

The lubricating oil pump unit is located centrally on the front of each engine, and the scavenging oil pump on the lower left front corner of each engine.

The oil cooler, located on the top of the cooling water tank, provides for the transfer of heat from the lubricating oil to the cooling water. Therefore, there is a definite relation between lubricating oil temperature and cooling water temperature.

A dial-type gauge located on the side of the oil filter tank shows the pressure of the oil being delivered to the oil cooler by the scavenging oil pump. At idle, a pressure in excess of 30 pounds with hot oil, is an indication of a dirty oil cooler. A by-pass valve located in a pipe between the scavenging oil pump and the strainer chamber of the oil filter tank, set to open at about 60 pounds, permits oil to flow direct to the oil filter tank. This by-pass valve may operate at high engine speeds, with low lubricating oil temperature or with the piping or cooler restricted, so that the gauge may indicate pressure of about 60 pounds under any of these conditions.

Two dial-type oil pressure gauges are located on the engine control panel. The right-hand gauge shows “Main Bearing” oil pressure and the left-hand gauge shows “Piston Cooling” oil pressure. Main bearing oil pressure must be maintained at all times.

When starting a cold engine, the oil pressure should start to build up immediately and should rise to about 40 pounds. With the engine warm, this pressure should be approximately 28 pounds at 800 rpm and normally, should not drop below 20 pounds. At idle, the pressure should be at least 15 pounds. If the water temperature cannot be held below 180° F., main bearing oil pressure will decrease and it is permissible to operate with this pressure as low as 15 pounds at 800 rpm.
Piston cooling oil pressure should average 20 to 30 pounds at 800 rpm and 4 to 8 pounds at idle, with a warm engine. Piston cooling oil pressure should never be below 15 pounds at 800 rpm.

If lubricating oil pressures drop below the above limits, the engine should not be continued in operation.

A low oil pressure alarm switch, connected to the Diesel engine lubricating oil system, operates the low oil warning and causes the Diesel engine to return to idle whenever lubricating oil pressure fails. A lubricating oil suction alarm switch, connected to the suction side of the lubricating oil and piston cooling oil pumps, operates in the same manner if suction strainer becomes clogged or obstructed.

**Diesel Engine Fuel Oil System**

The fuel oil systems of the several Diesel engines of the locomotive are similar to and independent of each other except that one fuel supply tank, mounted under each unit of the locomotive, supplies fuel for both Diesel engines of the unit.

A sight glass gauge is located on each side of the fuel supply tank adjacent to the fuel oil filler. The sight glass indicates the level of the fuel oil, from a point 4½” below the top of the tank to the top of the tank.

A dial-type fuel gauge is located on the fireman’s instrument panel in the cab of the “A” units and on the bulkhead above the No. 1 traction motor blower on the “B” units. An air valve, adjacent to these gauges, must be opened to get a reading, and should be closed after the reading has been taken. The gauge is calibrated in inches from 0 to 28.

An electrically-driven fuel transfer pump for each Diesel engine, draws the fuel from the supply sump of the fuel supply tank, through a suction line and filter, then pumps the oil through filters to the injectors.

The suction filter is in the fuel oil suction line below the fuel transfer pump motor. The pump discharge filter is in the discharge line of the fuel transfer pump and is located adjacent to the pump. After passing through the discharge filter, the fuel flows through a Duplex sintered bronze filter located in the fuel oil line to the injectors on the right side of the Diesel engine near the front.
Each injector has two small sintered bronze filters at the fuel oil pipe connections to the injector.

A fuel oil sight glass and relief valve assembly is located above the fuel transfer pump. Its purpose is to indicate the condition of the various filters in the fuel system and the flow of fuel oil through the system, and to control the fuel oil pressure. The left-hand relief valve is set at 60 pounds, the center valve at 100 pounds, and the right-hand valve at 5 pounds. The 60-lb. relief valve operates to relieve the system of excess pressure when the filters or lines on the pressure side of the fuel transfer pump become obstructed, in which case fuel would flow through the sight glass below this valve and return to the supply tank. A globe valve, located in the piping connected to the relief valve, permits cutting out the 60-lb. Relief valve. With the 60-lb. relief valve cut out, the 100-lb. relief valve protects the system in the same manner and when the pressure builds up to 100 pounds fuel will show in the sight glass under the 100-lb. relief valve. The 5-lb. relief valve is in the return line from the injectors, and fuel should show in the sight glass below this valve whenever the fuel transfer pump is running.

An individual injector is provided for each cylinder. A cam on the camshaft operates the injector at the proper time. The stroke of the injectors is constant at all times. The amount of fuel oil injected at each stroke is controlled by the engine governor which varies the effective stroke of the injectors. A layshaft manual control lever, attached to the injector layshaft at the front end of the Diesel engine, may be used to shut the engine down by pulling it toward the wall of the locomotive. Moving the lever toward the engine increases the effective stroke of the injectors.

The emergency fuel cut-off valve, located under the fuel supply tank in the piping between the fuel tank sump and the supply sump, can be closed by pulling one of the several pull rings on the unit located as follows:

Two—one on each side of unit in small box with lift cover adjacent to fuel supply tank filler.

One—located on bulkhead in operating cab on “A” units or on side wall at hostler’s position in “B” units.
Electric Power System

Main Generator.

Each unit contains two Diesel engines of 1000 horsepower each. A main generator is connected to each engine through a flexible coupling. The generator is cooled by air drawn from the commutator end by a fan mounted on the flexible coupling, and feeds the two motors on the truck directly under its engine. Each main generator and its associated motors are electrically independent of the other generator on the unit except for certain low voltage control wiring.

Auxiliary Generator.

One auxiliary generator is mounted on each main generator and is belt-driven from a sheave on the main generator shaft. The two auxiliary generators on each unit operate in parallel when both engines are running and are used to charge the storage battery on the unit and to supply low voltage power.

Control Stand.

The control stand at the engineman’s position on “A” units contains the throttle lever and reverse lever. A transition lever is not provided as this class of locomotive is not equipped for manual transition or dynamic braking. The throttle lever operates electrically the electro-pneumatic governor controls of the engines. The reverse lever operates the reversers by electro-pneumatic control.

Reverser.

The reverser for the two motors on a truck is an air-operated reversing switch and is located in the high voltage cabinet.

When the locomotive is to be towed, the reverser drums should be locked in neutral. During normal operation a locking pin is screwed into the left-hand side of the reverser. To lock the reverser drum in neutral this pin should be removed and inserted in the hole on the opposite side. Turn the drum to its neutral position and the pin will engage with the threaded hole in the shaft.

Traction Motors.

One traction motor drives the leading axle and one the trailing axle of each truck through spur gears (22:55 ratio). The two trac-
Traction motors on each truck are air-cooled by a blower, chain driven by the Diesel engine. The traction motors are connected in series at starting and low speeds, and in parallel by automatic transition at approximately 28 mph, and in parallel with shunted fields at 68 mph. Transition back to parallel occurs automatically. Backward transition from parallel to series takes place when the throttle lever is placed in idle position.

High Voltage Cabinet.

The two high voltage cabinets on each unit, one for each engine, are mounted on the side wall at the rear of their respective engines and contain the following apparatus:

Three main power contactors, operates by air pressure through magnet valves; one series contactor, marked “S” and two parallel contactors, marked “Pl” and “P2”.

Traction motor field shunting contactor, two-pole, marked “M”, air-operated through a magnet valve, connects the field shunting resistors across the traction motor field windings for shunted field operation.

Reverser, a rotary drum switch, air-operated through magnet valves.

Transition relay, marked ‘VI”, controlled by main generator voltage which operates in conjunction with the time delay relay to close the parallel contactors during transition. This relay also operates with the shunt field and battery field contactors, causing the latter to open during transition.

Time delay relay, marked “VT”, allows time for generator voltage to decrease before closing the parallel contactors during transition from series to parallel.

Ground protective relay, marked “GR”, opens the battery field and shunt field contactors and brings the engine to idle if a ground occurs in the high voltage system. The relay can be reset by pushing an insulated button on the relay. The ground relay can be cut out in emergency by opening a sealed knife switch in the cabinet. If this is done ground protection is removed. A ground on the low voltage system will also trip the relay when the engine is started.
Wheel slip relay, marked “WSR”, compares the voltage, and hence the speed, of the two motors on a truck. If the speeds are different, indicating slipping of one pair of wheels, indication is given to the engineman and power is automatically reduced, but slipping will probably resume if the condition is not corrected.

Resistors: Certain resistors used in the control and power circuits are located in or on the cabinet.

Low Voltage Cabinet.

A low voltage cabinet built as a part of the high voltage cabinet, but with separate doors, is provided for each engine, containing the following:

Engine starting contactors, marked “ST+” and “ST-”, two magnetic type switches used to crank the engine from the battery, which close when the start switch button is pressed and the isolation switch is in the “Start” position.

Battery field contactor, marked “BF”, closes when throttle lever is in notches 1 to 8, inclusive, supplying battery power to the main generator battery field. Opens during transition to reduce generator output.

Generator shunt field contactor, marked “SH”, closes when throttle lever is in notches 1 to 8, inclusive, connecting main generator shunt field to main generator armature. Opens during transition to reduce generator output.

Battery charging contactor, marked “BC”, closes when auxiliary generator voltage is high enough to charge the battery.

Voltage regulator, regulates voltage of auxiliary generator at 74 volts throughout operating speed range of the engine.

Reverse current relay, marked “RCR”, controls operation of battery charging contactor to prevent battery discharging through auxiliary generator.

Battery charging switch: A hand-operated knife switch which connects the auxiliary generator and its associated battery charging apparatus to the battery.
Fuses:
- One—30-ampere auxiliary generator field fuse.
- One—60-ampere main generator battery field fuse.
- One—150-ampere battery charging fuse.
- Two—100-ampere steam generator fuses (No. 2 cabinet only).

Distribution Panel.

One distribution panel for each unit is mounted on the cab wall behind the fireman on “A” units, and at the “F” end on “B” units, and contains:

Main battery switch, a knife switch which, when open, isolates all circuits from the battery except external charging receptacles.

Control switch, a knife switch which connects the control system to the battery.

Train control and speed governor switch, a knife switch which supplies battery power to the cab signal, trainphone and headlight motor-generator set, and for overspeed and speed governor control.

Light switch, a knife switch which is the master switch for all lights.

Fuse test light and test blocks, for testing fuses.

Fuses:
- One—400-ampere starting fuse.
- One—100-ampere external charging receptacle fuse.
- One—80-ampere control fuse.
- One—60-ampere train control and speed governor fuse.
- Eleven fuses from 10 to 30 amperes for circuits controlled by switches on the control push button switch box, for engine room lights and for remote steam generator control.

Battery charge indicator, indicates net charge or discharge through battery, except starting current or external charging current.

Lighting transfer switch, mounted adjacent to distribution panel, connects lighting circuits to battery or to external power source.
Control Push Button Switch Box.

The control push button switch box is located above the enginem an’s window in the operating cab, and contains the following push button switches:

- **Cab signal**
- **Bright headlight**
- **Dim headlight**
- **Class (Marker) lights**
- **Number and gauge lights**
- **Defroster motor**
- **Engineman’s (order) light**
- **Attendant call push button**

*Control*, completes the multiple-unit control circuit to the throttle control, the start and stop switches of the engine control on each unit, the air shutter relays and magnet valves, and the alarm bells and lights.

*Fuel pump*, completes the multiple-unit circuit to the fuel pump contactors on each unit, and to all master “E” governor control magnet valves.

*Generator field*, completes the multiple-unit circuit through the throttle and reverser circuits to the battery field and shunt field contactors.

Engine Control Panel.

One engine control panel for each Diesel engine is located on the right side wall of the unit at the front end of the engine, containing the following:

- **Start switch button** for engine.
- **Stop switch button** for engine.
- **Fuel pump switch** and lo-ampere fuel pump fuse for engine.

*Isolation switch*, two-position switch; when thrown to “Start” position, engine will run at idling speed only and will not provide
power for the locomotive; when thrown to “Run” position, engine is under control of engineman’s throttle lever.

**Master “E” magnet valve**, controls air supply to “A”, “B” and “C” valves of electro-pneumatic governor control. Opening the circuit to this valve through operation of isolation switch, or of fuel pump push button switch, PC switch, ground relay or lubricating oil switches will bring the engine to idle (except in No. 5 or No. 6 throttle lever positions with isolation switch in “Run” position when engine will stop).

**Gauges:**  Piston cooling oil pressure.
Main bearing oil pressure.

**Warning lights:**  Low oil pressure.
Steam boiler failure.
Hot engine.

**Fuel pump contactor**, (on No. 1 engine panel of unit only) completes the circuit to fuel pump switches at both engine control panels of unit.

**Electro-Pneumatic Governor Control.**

All Diesel engines of the locomotive are controlled with one throttle lever through an electro-pneumatic governor control located at the front end of each engine. This governor control assembly consists of four magnet valves marked “A”, “B”, “C”, and “D”, and an air engine. Electrical circuits between the throttle lever and the governor controls operate different combinations of magnet valves. The magnet valves open to admit air to various cylinders of the air engine which in turn operates the governor control arm through suitable linkages. Various combinations of magnet valves result in the required engine speed for each throttle position.

Air is supplied to the “A”, “B”, and “C” magnet valves through the Master “E” magnet valve, while the “D” magnet valve has an independent supply. Air supply to the air engine through the “D” magnet valve alone shuts down the Diesel engine.

**Load Control.**

Load control, which loads the Diesel engine according to the throttle setting, is provided by a load regulator located on the side wall of the locomotive near each engine. This regulator prevents
overloading of the engine. If the engine demands more fuel to maintain its speed than the predetermined setting for the throttle position, the load regulator reduces the load on the engine by reducing the field excitation of the main generator. In the same way, if the engine requires less fuel than the predetermined setting, or balance point, for the throttle position, the load regulator increases load by increasing excitation on the main generator.

The load regulator has two principal parts: a pilot valve attached to the governor and a hydraulic rotary vane type motor attached to a commutator type rheostat which is in the generator battery field circuit.

**Pneumatic Control Switch and Relay.**

The pneumatic control (PC) switch is an air-operated switch which is mounted together with the PC relay in the nose of “A” units. This switch is tripped by safety control operation of the air brakes (dead-man, locomotive overspeed) and by emergency brake application. When the switch is tripped, the relay reduces the speed of engines to idle (except in No. 5 or No. 6 throttle lever position when engine will stop), shuts off all fuel pumps, and lights an indicating light. To reset the switch and relay, the throttle lever must be returned to “Idle” and brake pipe pressure restored.

**Compressed Air System**

Each Diesel engine on the locomotive drives a direct-connected two-stage, two-cylinder air compressor. The compressor has its own oil pump and pressure-lubricating system. Oil level in the crankcase can be checked on the bayonet-type gauge. The inter-cooler between the two stages has a 50-lb. safety valve.

Main reservoir pressure is controlled by an electrically-actuated governor set to cut in at 125 pounds pressure and to cut out at 140 pounds pressure. Main reservoirs are protected against excessive pressure by a 165-lb. safety valve in the discharge pipe at each compressor and a 150-lb. safety valve located in the piping adjacent to the main reservoirs.

Drains are located at the intercoolers, oil sump reservoirs, filters and main reservoirs, by means of which condensation may be drained from the system.
On each unit main reservoir air, through a reducing valve set at nominally 80 pounds, is supplied to a control air reservoir from where it is piped to the electro-pneumatic governor control on each engine and to pneumatically-operated switches in the high voltage cabinets. Control air pressure gauges are located on top of the high voltage cabinets. Cut-out cocks are located in piping to the reducing valves and to each of the high voltage cabinets. The control air reservoir is equipped with a drain cock through which condensation may be drained from the reservoir.

Main reservoir pressure is used for operation of the, air brakes, sanders, horns, windshield wipers, bell ringers and shutters. The steam generator water supply tank and the fuel supply tank gauges are air-operated through separate reducing valves.

Air Brake System

No. 24-RL brake equipment is used, with the K-2-A rotair valve on the “A” units.

Each of the two trucks under each unit is equipped with four brake cylinders. Four side-vented cut-out cocks, each of which cuts out and releases one brake cylinder on each side of a truck, are located on the right side of each unit.

Locomotive Operation

Inspection and Preparation for Service.

After locomotive has been properly inspected:

1. At the distribution panel on each unit:
   a. See that all fuses are in place and all switches closed.

2. At engineman’s position in controlling unit:
   a. See that throttle lever is in “Idle” position.
   b. See that reverse lever is in “Off” position.
   c. Close control and fuel pump push button switches.

3. At engineman’s position in trailing cab:
   a. See that throttle lever is in “Idle” position.
   b. See that reverse lever is removed.
c. See that control, fuel pump and generator field push button switches are open.

4. At each Diesel engine control panel:
   a. Place isolation switch in “Run” position. Alarm should sound and low oil warning light should light.
   b. Place isolation switch in “Start” position.
   c. Close fuel pump switch and note that full flow of fuel obtains in 5-pound sight glass.
   d. See that manual layshaft lever is in or near “Idle” position.
   e. Press engine start push button and hold until engine starts.
   f. After main bearing oil pressure gauge indicates at least 15 pounds, place isolation switch in “Run” position.
   g. See that proper pressures obtain on main bearing oil pressure, piston cooling oil pressure gauges and lubricating oil gauge on filter tank.

5. At the low voltage cabinet for each engine:
   a. See that all fuses are in place.
   a. See that battery charging switch is closed.

6. At the distribution panel on each unit:
   a. Check battery charge indicator to see that it indicates charge through the battery.

### Moving the Locomotive and Road Operation.

To move the locomotive:

1. Close generator field push button switch.
2. Place foot on dead-man pedal and release air brakes.
3. Place reverse lever in “Forward” or “Reverse” position as required.
4. Move throttle lever to position required to start locomotive or train, pausing in each notch position. In starting a
heavy train, care must be exercised to properly control slack action before accelerating.

Use of Load Ammeter.

When accelerating a train from a standing start or low speed, the pointer of the load ammeter may swing full scale but must return to the left of the red triangle as speed increases.

With throttle lever in eighth notch position the maximum continuous permissible current is 625 amperes as indicated by the red triangle. Operation at ampere loads above 625 amperes is permissible under any one of the following limitations with throttle lever in eighth notch positions:

<table>
<thead>
<tr>
<th>Amperes</th>
<th>Maximum Distance</th>
</tr>
</thead>
<tbody>
<tr>
<td>680</td>
<td>20 miles</td>
</tr>
<tr>
<td>705</td>
<td>15</td>
</tr>
<tr>
<td>740</td>
<td>10</td>
</tr>
<tr>
<td>815</td>
<td>5</td>
</tr>
<tr>
<td>945</td>
<td>2</td>
</tr>
</tbody>
</table>

Note: If unable to operate at or below maximum continuous rating after operating under any one of the above overload limitations, tonnage must be reduced or help obtained.

Operation Without Load Ammeter.

If necessary to operate without load ammeter, the following minimum speeds must be maintained after acceleration to avoid overload:

<table>
<thead>
<tr>
<th>Throttle Lever Position</th>
<th>Minimum Speed (M.P.H.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>8th notch</td>
<td>34</td>
</tr>
<tr>
<td>7</td>
<td>28</td>
</tr>
<tr>
<td>6</td>
<td>22</td>
</tr>
<tr>
<td>5</td>
<td>16½</td>
</tr>
<tr>
<td>4</td>
<td>12</td>
</tr>
<tr>
<td>3</td>
<td>7</td>
</tr>
</tbody>
</table>

With throttle lever in 8th notch position, the minimum continuous speed is 34 mph. Operation at speeds below 34 mph is permissible.
under any one of the following limitations with throttle lever in 8th notch position:

<table>
<thead>
<tr>
<th>Speed</th>
<th>Maximum Distance</th>
</tr>
</thead>
<tbody>
<tr>
<td>30.0 mph</td>
<td>20 miles</td>
</tr>
<tr>
<td>28.5</td>
<td>15</td>
</tr>
<tr>
<td>26.5</td>
<td>10</td>
</tr>
<tr>
<td>23.0</td>
<td>5</td>
</tr>
<tr>
<td>18.5</td>
<td>2</td>
</tr>
</tbody>
</table>

**Transition.**

When starting a train, the throttle lever should be advanced to the 8th notch position as promptly as proper train handling and speed restrictions will permit. Forward transition from series to parallel operation will take place automatically at approximately 28 mph with throttle lever in 8th notch position. This will be indicated by a flash of the wheel slip light. After forward transition from series to parallel has taken place, the throttle lever should not be placed in “Idle” position until speed drops to 23 mph when throttle lever must be returned to “Idle” position to permit backward transition from parallel to series to take place.

One step of traction motor field shunting takes place automatically at approximately 68 mph and is indicated by an increase in the load ammeter reading. Backward transition from field shunting is automatic.

**Isolating a Diesel Engine.**

If necessary to isolate a Diesel engine:

1. See that Diesel engine is idling, and, if necessary, reduce to idling speed through use of the layshaft manual control lever.

2. Place isolation switch in “Start” position.

**Putting a Diesel Engine on the Line.**

If necessary to put Diesel engine on the line with throttle lever in other than “Idle” position, the movement of the layshaft manual control lever must be retarded manually so that Diesel engine comes up to speed gradually when isolation switch is moved to “Run” position.
Emergency Engine Stop.

Stopping of all Diesel engines in emergency is accomplished by pressing in the button on the end of the throttle lever and moving the throttle lever to “Stop” position. The throttle lever must be returned to “Idle” position before Diesel engines can be restarted. The operation of the emergency engine stop depends upon the control push button switch being closed.

Ground Relay, Operation.

If a ground relay operates, the Diesel engine should be isolated, the ground relay reset and Diesel engine placed back on the line. An operation of the ground relay does not operate an alarm, but removes power from the traction motors and returns Diesel engine to idling speed, except that if throttle lever is in 5th or 6th notch position the Diesel engine will stop. Under this condition, when Diesel engine stops, low oil warning light will light and alarm will sound.

Low Oil Warning Indication.

Low oil warning will be given if a Diesel engine stops with the isolation switch in “Run” position. This may be due to operation of the ground relay with throttle lever in 5th or 6th notch position, overspeed stop or lack of fuel.

If the low oil warning is due to low lubricating oil pressure or high lubricating oil suction, the Diesel engine will return to idling speed, except if the throttle lever is in 5th or 6th notch position, in which case Diesel engine will stop. If operation is due to lubricating oil failure, check lubricating oil level in crankcase of Diesel engine and examine external piping of lubricating oil system for leaks before endeavoring to restart Diesel engine. If, however, low oil warning is due to a condition other than low oil pressure or high suction, the condition should be corrected if possible, and Diesel engine started and placed back on the line.

Hot Engine Warning Indication.

High cooling water temperature will cause an operation of the hot engine warning. Check temperature indicators on cooling water tanks to determine which engine is causing the warning to operate. See that system contains sufficient water, that fans are operating.
and shutters are open, and operate shutters manually if necessary. If unable to control water temperature, Diesel engine should be isolated.

When one engine is isolated and idling in cold weather, it may be necessary to open the manual shutter lever, at the end of the other engine on the unit, one or more notches as required to prevent low cooling water temperature on isolated engine.

Notes:

1. When attempting to start Diesel engines, if no fuel appears in 5-pound sight glass, see that fuel pump is running and, if not, check fuses and position of switches in control and fuel pump circuits. If fuel pump is running and fuel shows in 60-pound sight glass and not in 5-pound sight glass, move handle of sintered bronze duplex filter to opposite position. If this does not permit fuel to flow through 5-pound sight glass, Diesel engine may be operated to terminal point with 60-pound relief valve cut out.

If fuel pump is running and no fuel shows in sight glasses, check fuel supply, emergency fuel cut-off valve, and fuel oil suction line to pump for leaks.

2. If Diesel engine does not rotate when engine start push button is pressed, see that isolation switch is in “Start” position, test 400-ampere starting fuse on distribution panel and check starting contactors in low voltage cabinet.

3. If Diesel engine rotates but does not fire, see that layshaft manual control lever is in or near “Idle” position and check overspeed stop and reset if necessary.

4. If locomotive fails to move with Diesel engines running and throttle opened, see that reverse lever is in proper position, generator field push button switch closed and brakes released. If this does not overcome trouble test 30-ampere control fuse on distribution panel in cab, and see that all isolation switches are in “Run” position.

5. If locomotive moves but one or more of the several Diesel engines fails to deliver power, the following checks should be made:

   a. See that isolation switches are in “Run” position.
b. Check control reservoir pressure.

c. Check ground relay and reset if tripped.

d. See that all starting contactors are open.

e. Test 60-ampere battery field fuses in low voltage cabinets.

6. When changing operating ends, before proceeding to end being cut in, the control, generator field, and fuel pump push button switches should be opened. The control and fuel pump push button switches on the end being cut in should then be closed promptly, since the fuel transfer pumps are shut down while the switches are open and the engines will stop within a few minutes.

7. When a low battery condition exists on a leading “A” unit, with both auxiliary generators inoperative, the locomotive may be controlled from the operating cab of this unit as follows:

a. Open control and fuel pump push button switches on leading “A” unit.

b. Close control and fuel pump push button switches on any one of the trailing units.

c. Close generator field push button switch on leading “A” unit.

d. Close locomotive overspeed cut-out cock on leading “A” unit to prevent undesired operation.

If a light on the front end is required, the following additional steps must be taken:

e. Open all switches on distribution panel of leading “A” unit, except main battery switch and lighting switch, and open steam generator main switch.

f. Turn off all individual lighting switches on leading “A” unit, except class (marker) lights. Gauge light switches may be closed if necessary.
Diesel-Electric Road Locomotives

Operating Instructions

SECTION 4 – CLASS BP-1

General Data-Locomotive

Builder.............................................. Baldwin Locomotive Works
Horsepower Rating........................... 6000 H.P.
Gear Ratio ........................................ 22/57
Maximum Speed .............................. 100 M.P.H.
Units Per Locomotive ...................... Two “A”.
Wheel Arrangement .......................... 4-8-8-4 : 4-8-8-4
   Two Articulated Driving Wheel
   Frames and Two Idling 4-wheel
   Trucks Per Unit.
Axles Per Unit ................................. Driving—8
   Idle—4
Traction Motors Per Unit ............... 8
Wheel Diameter ............................... 42”
Journal Size ................................. 7” x 13”
Brake Schedule............................. Westinghouse 24-RL

Maximum Overall Dimensions:       Per Unit
   Height ...................................... 15’—4-5/8”
   Width ...................................... 10’-6”
   Length ..................................... 91’-6”
Total Weight ............................... 593,710 lb.
Weight on Drivers ....................... 409,000 lb.
Steam Generator Water Supply
   Tank Capacity ........................... 2,500 gal.
Fuel Oil Capacity .......................... 3,500 gal.
Sand Capacity ............................... 40 cu. ft.
General Data-Diesel Engine

Make and Model........................................ B.L.W.-608 S.C.
Horsepower at Governed R.P.M. ................. 1500 H.P. at 625 R.P.M.
Type .............................................................. In Line—4-cycle
Number of Cylinders ................................... Eight
Bore and Stroke ........................................... 12¾” x 15½”
Idling Speed............................................... 250 R.P.M.
Firing Order ............................................... 1-4-7-6-8-5-2-3
Number of Engines Per Unit ...................... Two
Lubricating Oil Capacity, Each
   Engine ..................................................... 190 gal.
Cooling Water Capacity, Each
   Engine ..................................................... 300 gal.

Diesel Engine

The engine is a four-cycle engine, requiring four strokes of the piston to complete the cycle of cylinder events. The engine has eight cylinders in line and uses a turbo-supercharger to furnish combustion air to the cylinders.

The cycle of events in a cylinder of this engine is explained in the following paragraph:

The piston moves downward on the intake stroke with the two intake valves open. Air is forced into the cylinder by the supercharger at approximately 5 or 6 pounds pressure. On the following upward, or compression, stroke of the piston, this air is compressed to about one-twelfth of its volume, all valves in the cylinder head being closed. Shortly before the piston reaches upper dead center the fuel, atomized by high pressure, is injected into the combustion chamber and is ignited by the high temperature of the compressed air. The burning fuel charge rapidly builds up a high pressure and the resulting expansion of gases forces the piston downward for the power stroke. On the following upward, or exhaust, stroke, the burnt gases are expelled through the two exhaust valves. The cycle is then repeated beginning with the intake stroke.

The main generator, auxiliary and exciter generators and turbo-supercharger are mounted on the “Rear” end of the engine. The
lubricating oil pump and cooling water pump are mounted on the “Front” end. The “Right” and “Left” sides of the engine are designated by the right and left hands, respectively, when facing the “Rear”, or generator end of the Diesel engine.

The cylinders are numbered from rear to front, starting with No. 1 at the rear end and ending with No. 8 at the front end. The direction of rotation of the engine is counter-clockwise when facing the rear, or generator, end.

**Diesel Engine Governor and Governor Control**

The hydraulic type governor on this engine is similar in design and functions to that described in “Section S-Class EP-3.”

The governor is mounted on the right side near the rear end of the engine and is driven from the camshaft by a set of bevel gears. The drive assembly is lubricated by the engine lubricating oil through a separate line.

The engine governor is controlled by an actuator which is pneumatically operated by throttle pipe air pressure. Multiple-unit operation of all the engines on the locomotive from one control stand is obtained through the train-lined throttle pipe. Throttle pipe air pressure is controlled from 0 pounds to 65 pounds pressure by the position of the throttle lever at the engineman’s control stand; 0 pounds at “Idle” position, 65 pounds with throttle lever in wide open position.

With throttle lever in “Idle” position the Diesel engines should run at 250 rpm; with throttle lever in wide open position the Diesel engines should run at 625 rpm. Intermediate positions of the throttle lever should result in rotative speed of the Diesel engines corresponding to the extent of movement.

The overspeed stop device, located on the right side of the Diesel engine just below the engine governor, is driven through bevel gears from the camshaft. It consists of a flywheel, containing a spring loaded counterweight, which, when Diesel engine speed reaches 690 rpm, trips a latch. This permits a spring loaded plunger to contact a bell crank on the injector fuel control shaft (layshaft) moving it and the fuel racks to the no-injection position, thereby stopping the Diesel engine.
The overspeed stop must be manually reset by inserting a small bar, through a hole in the housing, into the tripping lever and pushing downward until latch engages.

**Diesel Engine Cooling System**

The cooling systems of the several engines of the locomotive are similar to and independent of each other.

A centrifugal water pump located at the front end of the engine draws water from the radiator header at the top of the system on the left side of the engine and circulates the water around the engine cylinder liners and through the jackets to an engine water manifold from where it passes to the radiators on the right side of the engine. The two sets of radiators are cross-connected with each other and connected to an expansion tank lying above and between them.

The water temperature may be checked by a dial-type thermometer located on the engine control panel. The temperature of the cooling water will vary between 150 and 160° F. under normal operating conditions.

The shutters for controlling cooling water temperature are operated by air at control reservoir pressure through a magnet valve. The shutters are fully open at all times when the cooling fans are running. Air from the control reservoir through a 17-lb. Reducing valve and a thermostatically controlled air valve (Grad-U-Stat) operates pneumatic switches which control the shutter magnet valve and also the speed of the motor-driven radiator cooling fans. The radiator cooling fans operate at four different rates of speed depending upon water temperature and are supplied with power from the main generator.

A three-position fan and shutter control switch, located on the engine control panel, operates as follows:

- **“Off”** — Fans will not operate; shutters are closed.
- **“On”** — Fans operate at medium speed; shutters are fully open, but may be adjusted by hand.
- **“Automatic”** — Operation of fans and shutters regulated by temperature control switches.

Located on the end frame of the fan assembly near the roof at the end of the radiator compartment, are the Grad-U-Stat, the
pneumatic temperature control switches, the reducing valve and gauge, and the shutter operating mechanism with manual operating handle.

A hot water control switch set at 190°F will act on the engine shut-down solenoid valve to stop the engine, when the engine cooling water temperature becomes excessive.

The cooling system may be filled with water either through the filler cap located on the roof over the radiator section or through the filler lines located on each side of the unit.

The water level in the cooling system is indicated by a glass water gauge located on the end of the expansion tank above the fan and shutter control assembly. Water must show in this gauge glass at all times when the Diesel engine is being operated.

If a locomotive is to be left standing, or a Diesel engine is to be shut down, where there is danger of freezing, steam may be supplied to the system or the cooling water system should be drained.

For supplying steam to the cooling system, each system has a connection with the steam train line through a steam admission valve located adjacent to the cooling water pump. This valve can be recognized by the presence of a check valve adjacent to it in the same line.

Steam can be supplied by connecting an outside steam line to the steam train line connection at either end, or by operating a steam generator.

To drain an engine cooling system, open the radiator drain valve and the drain valve at the water pump.

**Diesel Engine Lubricating Oil System**

The lubricating oil systems of the several engines of the locomotive are similar to, and independent of each other.

The lubricating oil supply is carried in the crankcase of the engine. A bayonet-type oil level gauge, located on the right-hand side of the engine near the front end, shows the level of the lubricating oil in the crankcase. The oil level should be maintained between the “High” and “Low” level marks on the gauge with the
engine shut down, allowing at least 5 minutes after the engine is stopped before checking.

Oil may be added to the system, if necessary, through the oil filler opening equipped with a screw cap, located adjacent to the bayonet gauge.

The lubricating oil pump, located on the left side of the engine near the front, draws the oil from the crankcase through a suction line, check valve, and suction strainer; then pumps it through the oil cooling radiators and a metal edge type strainer to an internal header from where it flows to the bearings, pistons, and all internal parts requiring lubrication. A branch from the lubricating oil pump discharge line carries the oil to three by-pass type filters from which the oil returns to the crankcase. The by-pass filters are located along the right side of the engine.

The flow of air through the oil cooling radiators is controlled by the shutters and fans which are thermostatically regulated by the temperature of the engine cooling water.

The dial-type gauge, located on the engine control panel, shows lubricating oil pressure delivered to the lubricating oil header and should show about 65 pounds pressure at full engine speed. At lower speeds the pressure will be proportionately lower. At no time should the pressure drop below 20 pounds.

If lubricating oil pressure cannot be maintained above 20 pounds pressure, the engine must be shut down. Oil pressure at the engine header is regulated by a by-pass valve set at 65 pounds. Any pressure in excess of this will cause oil to be by-passed to the crankcase of the engine.

If the pressure on the system becomes excessive, a relief by-pass valve, set at 90 pounds, will spill the pump output into the crankcase.

If the pressure drop through the radiator system exceeds 25 pounds, due to obstruction, the radiators will be by-passed by a relief valve.

A hand-operated pump, adjacent to the mechanically-driven lubricating oil pump, is provided to prime the system when required.

A low lubricating oil pressure switch, connected to the engine header, operates to shut down the Diesel engine, sound the alarm.
and light the “engine stopped” light, when lubricating oil pressure drops to 15 pounds.

**Diesel Engine Fuel Oil System**

The fuel oil systems of the several Diesel engines of the locomotive are similar to and independent of each other, except that the two engines receive their fuel from a common fuel supply tank on each unit and the two fuel transfer pumps are connected by valved piping for emergency operation.

The fuel supply tank is incorporated in the frame of the locomotive unit and may be filled from either side. A sight glass gauge is provided on each side of the unit and indicates the level of fuel oil in the tank.

An electrically-driven fuel transfer pump, located on the left side of each Diesel engine, draws fuel from the supply tank through a suction line and metal edge type strainer and delivers it, through a triple unit cotton twine type filter, to the fuel oil manifold which is connected to each of the fuel injection pumps. A valved pipe connection, between the discharge lines of both transfer pumps on a unit, permits operation of both Diesel engines with one pump, if the other pump fails. The valve in the connecting pipe must be open to accomplish this but should be used only in an emergency.

A duplex dial-type gauge is located on the engine control panel: One hand shows the fuel pressure on the discharge side of the fuel transfer pump; the other hand shows the pressure on the return end of the fuel oil manifold. The gauge hands should show, normally, 35 pounds and 25 pounds, respectively.

Fuel oil pressures are controlled by two pressure relief valves, one located in the discharge line of the fuel transfer pump set at approximately 35 pounds, and the other located at the return end of the fuel oil manifold set at approximately 25 pounds. Fuel pressure relieved by either of these valves will return oil to the supply tank.

An individual fuel injection pump, connected by high pressure piping to an individual injector, is provided for each cylinder of the Diesel engine. A cam on the camshaft operates the fuel injection pump at the proper time to deliver fuel to the injector. The stroke of the fuel injection pumps is constant at all times. The amount of
fuel injected at each stroke is controlled by the engine governor which varies the effective stroke of the fuel injection pumps.

The emergency fuel cut-off valve is located in the suction line from the fuel supply tank on the floor on the left of the unit between the two Diesel engines. It may be closed by pulling either one of the rings on the unit located as follows:

One—on bulkhead behind fireman’s position in the cab.

One—below skirt on right side of unit near cab ladder.

A branch from the fuel transfer pump discharge line is connected to the engine shut-down solenoid valve on the left side of the Diesel engine. When the circuit to the solenoid valve is made up, fuel oil under pressure flows to an engine shut-down cylinder, located on the right side of the engine, and pushes its piston out, permitting movement of the fuel racks under control of the engine governor. Opening of the circuit to the solenoid valve permits the fuel oil to flow to the supply tank and a spring in the shut-down cylinder moves the piston to a position which holds the fuel racks in the no-injection position, stopping the Diesel engine.

Electric Power System

Main Generator.

Each unit contains two Diesel engines of 1500 horsepower each. A main generator is connected to each Diesel engine by a coupling. The generator is self-ventilated and feeds power to the four traction motors under the half of the main frame directly under the engine and also to the radiator fan motors. The two traction motor blower motors on the unit are fed by the main generator of the Diesel engine which is first put on the line. With two Diesel engines running, if the one which is operating the blower motors shuts down, the other will automatically feed the blower motors.

Auxiliary Generator and Exciter.

An auxiliary generator and exciter set is mounted on and belt-driven by each main generator. The two auxiliary generators on each locomotive unit operate in parallel if both engines are running, and are used to charge the storage battery on the unit and to supply low voltage power.
The exciter supplies power to the main generator field windings and is specially wound to maintain constant power output of the main generator.

**Control Stand.**

The control stand at the engineman’s position contains the throttle lever and reverse lever. No transition lever is provided as this class of locomotive is not equipped for manual transition or dynamic braking. The throttle lever controls engine speed pneumatically, by controlling the engine governors through a throttle pipe and pneumatic governor actuators, and connects the motors to the generators in the running positions, and also operates a pneumatic load control actuator. The reverse lever operates the reversers by electric-pneumatic control.

**Traction Motors.**

Each unit has eight traction motors, one for each driving axle, geared through spur gears (22:57 ratio). Four traction motors are connected to each main generator. The motors are permanently connected in series-parallel. Transition consists of two steps of traction motor field shunting, which take place automatically at 33 and 52 mph, respectively. Backward transition is also automatic. A single motor-driven blower (two per unit) is used to force-ventilate the four traction motors under each Diesel engine.

**Power Equipment Cabinet.**

One power equipment cabinet for both engines of the unit is located on the right-hand aisle and contains the following apparatus:

- **Four main power contactors,** operated by air-pressure through magnet valves, marked “P1” and “P2” for No. 1 engine, and “P3” and “P4” for No. 2 engine.
- **Sixteen traction motor field shunting contactors,** marked “M1” to “M8,” inclusive, for No. 1 engine, and “M9” to “M16,” inclusive, for No. 2 engine.
- **Two reversers,** operated by air pressure through magnet valves, one for each group of four motors.
- **Two blower motor field shunting contactors,** marked “B1” and “B2.”
Two blower alarm relays, marked “BR1” and “BR2,” for blown fuse or no voltage on blower motors.

Two ground relays, marked “GR1” and “GR2,” for grounds in high voltage circuits, with manual reset button; can be cut out in emergency by opening sealed knife switch mounted with relay.

One blower motor fuse, 110-ampere.

Resistors, for traction motor and blower motor field shunting and for wheel slip.

Control Equipment Cabinet.

One control equipment cabinet, for both engines of the unit, is located on the left-hand aisle of each unit, containing:

One standby lighting transfer switch, for external power (on outside of cabinet).

Three indicating lights; One for blower stopped indication. Two for ground indication (one for each engine).

Four blower motor contactors, so interlocked that blowers will operate from the engine which is first put on the line, marked “B3” and “B5” for No. 1 engine, and “B4” and “B6,” for No. 2 engine.

One battery knife switch, connects battery to all auxiliary circuits except lights.

One control contactor, marked “CR”.

One control relay, marked “CRI”.

Four engine starting armature contactors, marked “G1” and “G3” for No. 1 engine, and “G2” and “G4” for No. 2 engine.

One starting protective relay, marked “PT.”

Four wheel slip relays, marked “WS1” and “WS2” for No. 1 engine, and “WS3” and “WS4” for No. 2 engine.

One emergency engine stop contactor, marked “ES.”

Four fan and blower motor field shunting relays, marked “R1” and “R3” for No. 1 engine, and “R2” and “R4” for No. 2 engine.
Five generator field contactors:

Marked “GF”—starting, shunts field weakening resistor.
  “GF1”—running field, No. 1 engine.
  “GF2”—running field, No. 2 engine.
  “GF11”—starting field, No. 1 engine.
  “GF21”—starting field, No. 2 engine.

Two exciter field contactors, marked “EF1” for No. 1 engine, and “EF2” for No. 2 engine.

Two power control contactors, marked “FR1” for No. 1 engine, and “FR2” for No. 2 engine.

Two traction motor field shunting relays, marked “FS1” and “FS2”, controlled by main generator voltage of Diesel engine on unit which is first put on the line.

Ten radiator fan motor contactors, marked “F1” to “F5,” inclusive, for No. 1 engine and “F11” to “F15,” inclusive, for No. 2 engine.

Four traction motor cut-out switches, marked “TMCO1,” to “TMC04,” inclusive.

Two power cut-out circuit breakers, X-ampere, marked “PCO1” for No. 1 engine, and “PC02” for No. 2 engine.

Two engine shut-down alarm relays, marked “SG1” for No. 1 engine and “SG2” for No. 2 engine.

One engine room lighting master circuit breaker, 35-ampere.

One fan and shutter control fuse, 15-ampere.

One main control fuse, 30-ampere.

Two radiator fan motor fuses, 175-ampere.

Auxiliary Equipment Cabinet.

One auxiliary equipment cabinet for both engines of a unit is located at the rear end of each unit, containing:

One emergency engine stop circuit breaker, 15-ampere, operates shutdown contactor “ES.”

One battery charge indicator.
One battery charge indicator selector switch, for indicating the output of either auxiliary generator, or the battery charge or discharge.

Two reverse current relays, one for the auxiliary generator of each engine.

Two voltage regulators, one for the auxiliary generator of each engine.

Two battery charging contactors, marked “Al” for No. 1 engine, and “A2” for No. 2 engine.

Two auxiliary generator fuses, 150-ampere.
In the cabinet in the “Al” unit only are also located the following:

Two trainphone, cab signal and headlight fuses, 60-ampere.

One motor-generator set transfer switch, for operating trainphone, cab signals and headlight from one-half battery voltage in case of motor-generator set failure.

Control Push Button Switch Box.
Located on the left side of the control stand, containing the following push button switches:

Control, establishes multiple-unit power control through the throttle and reverse levers, to the reversers, field contactors, and main power contactors and completes the circuit to the master control magnet valve.

Cab signal control, completes the circuit to cab signals.

Emergency engine stop, operates emergency engine stop contactors, shutting down all engines on the locomotive.

Attendant call.

Defroster motor.

Marker lights.

Gauge lights.

Number lights.

Each of these switches is fused with a separate 15-ampere fuse located in the switch box. A locking device on the top of the box, with a removable key, locks the control and cab signal switches against unauthorized operation.
Engine Control Panel.

One mounted on the left-hand wall adjacent to each engine, containing the following:

**Engine stop circuit breaker, 15-ampere.**

**Engine start push button No. 1.**

**Engine start push button No. 2.**

**Engine fuel pump circuit breaker, 15-ampere.**

**Engine isolating switch,** when in “Off” position engine will run only at idling speed and will not provide power for the locomotive. When in “On” position, the engine is under control of the engineman’s throttle lever.

**Auxiliary generator field circuit breaker, 15-ampere.**

**Radiator fan and shutter control switch,** a three-position switch.

Each panel contains an engine water temperature gauge, and lubricating and fuel oil pressure gauges.

**Load Control.**

Control to prevent overloading of the Diesel engine is provided by means of a carbonstat load regulator.

The carbonstat is connected in series with the exciter four-pole field and is a hydraulically-operated resistance-changing device mounted on the engine, consisting of a carbon pile resistor held under pressure by a spring. The spring is sensitive to changes in the governor and also, by pneumatic connection, to changes in the throttle. Pressure changes vary the current through the exciter field and thus vary the main generator output, permitting the Diesel engine to run at uniform speed and output without overloading at each throttle lever position.

**Power Knockout Switch.**

A pneumatically-operated switch located in the nose of each unit, which removes control from the power circuits producing the same result as moving the throttle to “Idle” position. It operates when an emergency brake application is made, or when the dead-man or overspeed control is actuated. To reset the switch the throttle.
lever must be returned to “Idle” position and brake pipe pressure restored.

**Master Control Magnet Valve.**

This valve, designated “MCV,” located in the nose of each unit, which, when operated by closing the control push button switch, opens the supply of air from the control stand to the throttle pipe for multiple-unit control of Diesel engine speed.

**Throttle Unloading Magnet Valve.**

This valve, located on the front end of each Diesel engine, designated “TV1” for the No. 1 engine, and “TV2” for the No. 2 engine, is actuated by wheel slip relays or by isolation switch in “Off” position, permitting Diesel engine to run at idling speed only. When circuit to throttle unloading magnet valve is open, Diesel engine speed is under control of throttle lever.

**Engine Shut-down Solenoid Valve.**

One located on each Diesel engine near the fuel transfer pump, designated “SDV1” for the No. 1 engine and “SDV2” for the No. 2 engine, cuts off fuel pressure to engine shut-down cylinder, causing fuel racks to move to no-injection position, stopping the Diesel engine. This valve operates to stop the Diesel engine when the engine stop switch is in the “Off” position, or when the engine water high temperature or the lubricating oil pressure switch operates.

**Compressed Air System**

Each Diesel engine on the locomotive drives a direct-connected, two-stage, three-cylinder air compressor. The compressor has its own oil pump and pressure-lubricating system. Oil level in the crankcase can be checked on the bayonet-type gauge. The inter-cooler between the two stages has a 50-lb. safety valve.

Main reservoir pressure is controlled by an electrically-actuated governor set to cut in at 125 pounds pressure and to cut out at 140 pounds pressure. Main reservoirs are protected against excessive pressure by a 165-lb. safety valve in the discharge pipe at each compressor and a 150-lb. safety valve located in the piping adjacent to the main reservoirs.
Automatic drain valves, operating under control of the air compressor governors, are located in the main reservoir piping. These valves operate automatically to drain condensation from the main reservoirs. In addition to these drains, each unit is equipped with manually-operated drain cocks by means of which condensation may be drained.

Air is supplied to a control reservoir through a reducing valve set at 70 pounds. Control air is used to operate the reversers, main power contactors and to furnish the air supply through the throttle control to the pneumatic actuators. Control air is used also to operate the radiator shutters and, through a separate reducing valve set at 17 pounds, to operate the radiator fan and shutter controls. A control air pressure gauge is located in the nose of each unit.

Main reservoir pressure is used for operation of the air brake system, windshield wipers, horn, bell, and sanders.

**Air Brake System**

This class of locomotive uses Type 24-RL air brake equipment with K-Z rotair valves.

There are twenty brake cylinders on each unit for which are provided six side-vented cut-out cocks. The cut-out cocks are in groups of three; one group located on the right side of the unit under the operating cab, and the other group on the left side near the rear end of the unit. One cut-out cock in each group cuts out both brake cylinders on the idling truck on its respective end of the unit. The other two cut-out cocks in each group each cut out four driver brake cylinders, two on each side of the unit.

**Locomotive Operation**

**Inspection and Preparation for Service.**

After locomotive has been properly inspected:

1. At engineman’s position in controlling unit:
   a. See that throttle lever is in “Idle” position.
   b. See that reverse lever is in “Off” position.
   c. Close control push button switch.
2. At engineman’s position in trailing unit:
   a. See that throttle lever is in “Idle” position.
   b. See that reverse lever is removed.
   c. See that control push button is open, switch box locked and key removed.

3. At control equipment cabinet on each unit:
   a. See that all fuses are in place and all switches and circuit breakers are closed.

4. At each Diesel engine control panel:
   a. Place fuel pump circuit breaker in “On” position and note that fuel oil pressure is indicated on the gauge.
   b. Place engine stop circuit breaker in “On” position. Alarm should sound.
   c. Press engine start push button No. 1 and hold in until engine fires and at least 20 pounds lubricating oil pressure obtains.
      If the engine does not turn fast enough to start, the cranking speed can be increased by pressing engine start push button No. 2, while push button No. 1 is held in.
   d. Place the isolation switch in “On” position.
   e. See that radiator fan and shutter control switch is in “Automatic” position.
   f. After both engines on a unit have been started, place auxiliary generator field circuit breaker on each engine control panel on the unit in “On” position.

5. At auxiliary equipment cabinet on each unit:
   a. See that all fuses are in place.
   b. Check battery charge indicator, in all positions of selector switch for output of each auxiliary generator and battery charge.

Moving the Locomotive and Road Operation.

1. Place foot on dead-man pedal and release air brakes.
2. Place reverse lever in “Forward” or “Reverse” position as required.

3. Move throttle lever to first notch position and pause until load ammeters indicate current. Throttle lever should be advanced slowly to the position necessary to start train. In starting a heavy train, care must be exercised to properly control slack action before accelerating.

Use of Load Ammeter.

The division between the white and red scales on the load ammeter indicates the maximum permissible continuous current, which is 1800 amperes. Operation at loads above 1800 amperes is permissible under any one of the following limitations with throttle lever in wide open position:

<table>
<thead>
<tr>
<th>Amperes</th>
<th>Time Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>40 minutes</td>
</tr>
<tr>
<td>2200</td>
<td>20</td>
</tr>
<tr>
<td>2600</td>
<td>10</td>
</tr>
<tr>
<td>3000</td>
<td>6</td>
</tr>
<tr>
<td>3660</td>
<td>4</td>
</tr>
</tbody>
</table>

If the load ammeter readings differ, the higher reading will govern.

Note: If unable to operate at or below maximum continuous rating after operating under any one of the above overload limitations, tonnage must be reduced or help obtained.

Operation Without Load Ammeter.

If necessary to operate without load ammeter with throttle lever in wide open position, the minimum continuous speed is 17.8 mph in order to avoid overload.

Operation at speeds below 17.8 mph is permissible under any one of the following limitations with throttle lever in wide open position:

<table>
<thead>
<tr>
<th>Speed (mph)</th>
<th>Time Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>16.0</td>
<td>40 minutes</td>
</tr>
<tr>
<td>13.5</td>
<td>20</td>
</tr>
<tr>
<td>10.0</td>
<td>10</td>
</tr>
<tr>
<td>7.5</td>
<td>6</td>
</tr>
<tr>
<td>5.0</td>
<td>4</td>
</tr>
</tbody>
</table>
Isolating a Diesel Engine.
If necessary to isolate a Diesel engine:
1. Place isolation switch in “Off” position.

Putting a Diesel Engine on the Line.
If necessary to put a Diesel engine on the line, regardless of throttle lever position, place isolation switch in “On” position. Diesel engine will automatically come up gradually to speed corresponding to throttle position.

Emergency Engine Stop.
Stopping of all Diesel engines in an emergency is accomplished by closing any one of the emergency engine stop switches. All emergency engine stop switches must be in the open position before any Diesel engine can be restarted.

Ground Relay Operation.
If a ground relay operates, the Diesel engine should be isolated, the ground relay reset and the Diesel engine placed back on the line. When a ground relay operates, “Ground” indicating light in cab will light and indicating light for Diesel engine involved will light on control equipment cabinet; the speed of that Diesel engine will reduce to idle and power will be removed from the traction motors associated with it.

If the ground relay fails to remain reset, traction motor cut-out switches located in the control equipment cabinet, may be operated. If cutting out one pair of traction motors removes the ground, Diesel engine may be put back on the line to operate the other pair of traction motors.

Note: When a pair of traction motors is cut out, the load as indicated by the load ammeter for that engine must be restricted to one-half the current rating.

Engine or Blower Stopped Warning Indication.
An “Engine or Blower Stopped” indicating light is located at the fireman’s position in each operating cab. This light indicates Diesel engine stopped or failure of the traction motor blowers and
also indicates operation of the Attendant Call push button. Alarm will sound. A “Blower Stopped” indicating light also is located in the control equipment cabinet of each unit.

If alarm is due to blower failure, isolation switches of both engines on the unit should be placed in “Off” position. Check blower motor fuse and renew if necessary. The unit must not be operated under load with the blowers shut down.

If, however, the alarm is due to an engine shutting down, this may be caused by high cooling water temperature, low lubricating oil pressure, Diesel engine overspeed stop, or lack of fuel:

1. Check water temperature and, if excessive, check shutter and fan operation, renewing fuses if necessary, and check cooling water level.

2. Check fuel oil pressure.

3. Check overspeed stop.

4. Check lubricating oil level in crankcase of engine and examine external piping of lubricating oil system for leaks.

Notes:

1. When attempting to start a Diesel engine, if no fuel pressure is obtained, check that fuel pump is running and, if not, check fuel pump circuit breaker on the engine control panel and the emergency engine shut-down switches (four per locomotive). If fuel pump is running, check fuel supply, emergency fuel cut-off valve, and fuel oil suction line to pump for leaks.

2. If Diesel engine does not rotate when engine start push button is pressed, check that isolation switch is in “OR” position and that engine stop circuit breaker is in “On” position. Check starting contactors in control equipment cabinet.

3. If Diesel engine rotates but does not fire, check overspeed stop and reset if necessary. While Diesel engine is rotating, see that piston of engine shut-down cylinder moves out to permit free operation of injector layshaft.

4. If locomotive fails to move with Diesel engines running and throttle opened, the following checks should be made:

   a. See that reverse lever is in proper position and brakes released.
b. See that control push button is closed, and check E-ampere control fuse in push button switch box on controlling unit.

c. See that cut-out cock in control air supply pipe to control stand is open.

d. Check control reservoir pressure gauge in nose of controlling unit.

e. Check 30-ampere control fuse in control equipment cabinet on controlling unit.

f. Check position of all power cut-out circuit breakers and isolation switches.

5. If locomotive moves but one or more of the several Diesel engines fails to deliver power, the following checks should be made:

   a. See that isolation switches are in “On” position.

   b. Check ground relays and reset if tripped.

   c. Check control reservoir pressure.

   d. See that all starting contactors are open.

   e. Check throttle pipe for leaks including connection between units, and see that cut-out cocks in throttle pipe are fully opened.

6. When changing operating ends, before proceeding to end being cut in, see that control push button switch box is locked with control push button switch open.

7. When a low battery condition exists on lead operating unit, with both auxiliary generators inoperative, the locomotive may be controlled from the operating cab of this unit as follows:

   a. Open battery switch on leading unit.

   b. Close control push button switches on both units.

   c. Close cut-out cock in air supply pipe to control stand on trailing unit.

   d. Close control contactor, marked “CR,” in control equipment cabinet on leading unit using flag stick.
Diesel-Electric Road Locomotives

Operating Instructions

SECTION 5 – CLASS AP-3

General Data—Locomotive

Builder.............................................. American Locomotive Company
Horsepower Rating ...................... 6000 H.P.
Gear Ratio ........................................ 23/60
Maximum Speed ......................... 100 M.P.H.
Units Per Locomotive ...................... Two “A,” One “B”
Trucks Per Unit ................................. Two
Axles Per Truck ................................ Three
Traction Motors Per Truck ............... Two
Wheel Diameter ...................................... 40”
Journal Size ...................................... 6½”x12”
Brake Schedule ................................. Westinghouse 24-RL
Maximum Overall Dimensions: “A” Unit “B” Unit
Height .............................................. 15’-5” 14’-11”
Width .............................................. 10’-6½” 10’-6½”
Length .............................................. 65’-8” 63’-6”
Total Weight ................................. 312,200 lb. 306,900 lb.
Weight on Drivers ............................ 208,100 lb. 204,600 lb.

Steam Generator Water Supply
Tank Capacity ................................. 1300 gal. 1900 gal.
Fuel Oil Capacity ............................... 1200 gal. 1200 gal.
Sand Capacity .................................. 22 cu. ft. 22 cu. ft.

General Data—Diesel Engine

Make and Model ................................. Alco 244-V
Horsepower at Governed R.P.M........... 2000 H.P. at 1000 R.P.M.
Type .................................................. Vee—4-cycle
Number of Cylinders ....................... Sixteen
Bore and Stroke ............................. 9”x10½”
Idling Speed ..................................... 350 R.P.M.
Firing Order ................................. 1R-1L-5R-5L-7R-7L-3R-3L-
                                      8R-8L-4R-4L-2R-2L-6R-6L
Number of Engines Per Unit......... One
Lubricating Oil Capacity, Each
  Engine ......................................... 230 gal.
Cooling Water Capacity, Each
  Engine ......................................... 330 gal.

Diesel Engine

The engine used on this class of locomotive is a sixteen-cylinder, vee-type, four-cycle, turbo-supercharged Diesel engine.

The cycle of events in a cylinder of this engine is the same as that described in “Section 4-Class BP-1,” except that, the maximum pressure of the air delivered to the cylinder by the turbo-supercharger is approximately 18½ pounds instead of 5 or 6 pounds.

The main generator, auxiliary generator, blower generator, and exciter are mounted on the “Rear” end of the engine. The governor, turbo-supercharger, water pump, and lubricating oil pump are mounted on the “Front” end.

The cylinders are arranged in two banks, with eight cylinders in each bank, with an angle of 45 degrees between banks. The “Right” and “Left” banks (sides) of the engine are designated by the right and left hands, respectively, when facing the “Rear” end of the engine.

The cylinders are numbered from front to rear on each bank and designated as right or left beginning with “1R” at the front end of the right bank and ending with “8R” at the rear end of the right bank, and beginning with “1L” at the front end of the left bank and ending with “8L” at the rear end of the left bank.

The direction of rotation of the engine is counter-clockwise, when facing the rear end of the Diesel engine.
Diesel Engine Governor and Governor Control

The electric-hydraulic governor on this engine is located on the left side of the engine at the front end. It incorporates a speed responsive servo-mechanism which controls engine fuel and generator excitation, a positioning mechanism which serves as a fuel limit, a magnetically-latched spring-opened clutch, which overrides the speed-servo and will move the fuel control shaft (layshaft) to the no-injection position whenever the holding coil current is interrupted, and a hydraulic pressure regulator, which maintains the pressure on the hydraulic source for the speed-servo and fuel limit.

The governor hydraulic oil system operates with 125 pounds pressure. The oil used is SAE-10 turbine oil contained in a reservoir of 2½-gallon capacity located directly under the governor. Oil level should be maintained at “Full” mark on the bayonet gauge with the Diesel engine shut down. A pump, driven by the fuel transfer pump motor, receives oil from the reservoir through a strainer and delivers it, through a filter, to the governor. A low oil pressure switch, marked “GOP”, will shut down the engine, by interrupting the current to the magnetic clutch, when the oil pressure drops below 75 pounds.

A gear-driven tachometer-generator, mounted on the left side of the engine at the rear end, measures engine speed and transmits electrically the speed indication to the governor.

To vary the speed of the engine with throttle changes, or to maintain a constant speed with load changes, the amount of fuel injected into the cylinders must be varied. The amount of fuel injected is determined by the position of a power piston in the governor. The tachometer-generator operates a pilot valve (#1) of the speed-servo, through a solenoid, against a reference spring. Movement of the solenoid causes a change in the position of the pilot valve (#1), controlling the supply of oil to the power piston. The engine speed at which the solenoid actuates the pilot valve (#1) is determined by the resistance in the solenoid circuit. The resistance in the solenoid circuit is determined by the throttle lever positions through the operation of sequence relays. The power piston supplies the energy to move the fuel control shaft (layshaft), through the magnetic clutch.

A second pilot valve (#2), controlled in the same manner as the first one, controls the supply of oil to a second power piston. This
power piston positions a cam to limit the movement of the fuel control shaft and hence the maximum amount of fuel injected for each throttle lever notch position.

In order to prevent fluctuations in Diesel engine speed (hunting), following increase or decrease of engine speed due to throttle lever position changes or a change in load without movement of throttle lever, a stabilizing coil is provided on the solenoid which operates pilot valve (#1). The stabilizing coil is responsive to the rate of change of engine speed or torque and is used to prevent overtravel of the fuel control shaft.

The various throttle lever positions and the corresponding Diesel engine rpm and maximum horsepower are as follows:

<table>
<thead>
<tr>
<th>Throttle Lever Position</th>
<th>R. P. M.</th>
<th>Horsepower</th>
</tr>
</thead>
<tbody>
<tr>
<td>Idle</td>
<td>350</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>350</td>
<td>75</td>
</tr>
<tr>
<td>2</td>
<td>450</td>
<td>225</td>
</tr>
<tr>
<td>3</td>
<td>550</td>
<td>400</td>
</tr>
<tr>
<td>4</td>
<td>655</td>
<td>625</td>
</tr>
<tr>
<td>5</td>
<td>765</td>
<td>1000</td>
</tr>
<tr>
<td>6</td>
<td>860</td>
<td>1225</td>
</tr>
<tr>
<td>7</td>
<td>920</td>
<td>1600</td>
</tr>
<tr>
<td>8</td>
<td>1000</td>
<td>2000</td>
</tr>
</tbody>
</table>

The overspeed stop device on this engine is a centrifugally-operated switch mounted under the tachometer-generator which, when engine speed reaches approximately 1100 rpm, interrupts the current to the coil of the magnetic clutch of the governor. To reset the overspeed stop the switch must be manually reset by pushing the reset button.

**Diesel Engine Cooling System**

The cooling systems of the Diesel engines on the several units of the locomotive are similar to each other.

A centrifugal water pump, mounted on the front end of the engine, draws water from the lubricating oil cooler located at the front end of the engine. The pump circulates the water through two headers, one for each bank of cylinders, located within the cylinder block.
Individual jumpers connect the headers with the jackets of each cylinder. The cooling water rises between the jacket and the liner and enters the cylinder head through three openings. After passing through the cylinder heads, it flows through two outlet water headers to the radiators and from there to the oil cooler. An expansion tank, located under the roof just back of the turbo-supercharger exhaust, is connected to the water pump suction line. The radiators, located overhead in the rear end of the unit, are vented into the expansion tank.

The cooling water temperature may be checked on a gauge located on the engine control panel. An operating temperature of 140 degrees F. to 160 degrees F. should be maintained.

The shutters for controlling cooling water temperature are operated by air at main reservoir pressure through a temperature-controlled valve. The shutters must be fully open before the cooling fan can operate.

A mechanically-driven cooling fan draws air through the radiators for dissipating the heat in the cooling water to the atmosphere. The speed of the cooling fan is varied by an eddy current clutch regulated by a relay. Relay operation is determined by a water temperature bulb located in the discharge line between the radiators and the oil cooler.

A fan control switch located on the engine control panel selects either automatic or manual operation of the fan. A limit switch operated by the shutter linkage completes the fan control circuit when the shutters are fully open. With the shutters open and fan control switch in “Automatic” position, the fan operates under thermostatic control. With the shutters open and fan control switch in “Manual” position, the speed of the fans may be controlled by a manual fan control rheostat operated by a dial located on the engine control panel below the fan control switch.

Two shutter operating mechanisms with manual operating handles are provided, one on each side wall of the unit just ahead of the cooling water radiators. During automatic operation of the shutters, the wing nuts on the operating handles must be loose to permit free movement of the handles. During manual operation of the shutters, the operating handles may be secured in any desired position by tightening the wing nuts. To operate shutters manually,
the cut-out cock in the air line to the shutter operating cylinders must be closed and the air vented by opening the vent-valve in the tee connection at the air filter. These are located on the left side wall below the shutter operating mechanism. The shutters must be secured in fully open position if fan operation is required.

A high temperature alarm switch set at 185°F will operate to light the hot engine lights and sound the alarm should cooling water temperature become excessive.

The cooling system can be filled either through the filler cap located on the roof over the expansion tank or through the filler nozzle on the right side of the unit over the rear truck.

The water level in the cooling system is indicated by a glass water gauge located on the expansion tank over the right aisle. Water must show in this gauge glass at all times.

The cab heaters on “A” units are supplied with hot water from the engine cooling system and are provided with separate inlet and outlet valves for each heater, located in the nose of the unit.

If the locomotive is to be left standing, or a Diesel engine is shut down where there is danger of freezing, steam may be supplied to the system or the cooling water system may be drained.

For supplying steam to the cooling system, a connection from the steam train line is provided through a steam admission valve, a check valve and choke located in small pipe to water pump suction line.

Steam can be supplied by connecting an outside steam line to the steam train line connection at either end of the unit, or by operating a steam generator on another unit.

To drain an engine cooling system, open the drain valve located in the right aisle at the base of the oil cooler, open both the inlet and outlet valves at each cab heater and open vent valve on top of each cab heater.

**Diesel Engine Lubricating Oil System**

The lubricating oil systems of the Diesel engines on the several units of the locomotive are similar to each other.

The lubricating oil supply is carried in the crankcase of the engine. A bayonet-type oil level gauge, located on the right side of
the Diesel engine, shows the level of the lubricating oil in the crankcase. The oil level should be maintained between the “High” and “Low” level marks on the gauge with the engine idling. The crankcase exhauster should be shut down while gauging oil.

Oil may be added to the system if necessary through the oil filler opening located adjacent to the bayonet gauge.

The lubricating oil pump, located on the front end of the engine, draws the oil from the crankcase through a suction line, pumps it through the lubricating oil filter and the oil cooler, then to the engine lubricating oil headers which distribute it to the individual points requiring lubrication.

The oil cooler, located at the front end of the Diesel engine, provides for the transfer of heat from the lubricating oil to the cooling water. Therefore, there is a definite relation between lubricating oil temperature and cooling water temperature.

The oil pressure to the main bearing header is maintained at a maximum of 65 pounds by a regulating valve located at the pump discharge. The rocker arm headers are supplied through a 17-lb. reducing valve. The turbo-supercharger header is supplied through a filter and separate 17-lb. reducing valve.

Two dial-type gauges, located on the engine control panel, indicate lubricating oil pressures. One gauge shows lubricating oil pressure at the end of the main bearing header and show 50 to 65 pounds pressure at full engine speed, and should show at least 20 pounds at idling speed. The other gauge is a duplex gauge; one hand (black) showing rocker arm oil pressure, and the other hand (red) showing turbo-supercharger oil pressure. Both hands of this gauge should show 15 to 17 pounds pressure.

Two low lubricating oil pressure switches are connected to the end of the main bearing header. If for any reason the lubricating oil pressure drops to 20 pounds the first switch will operate and, if throttle lever is above the fourth notch, the Diesel engine speed will reduce to idle. If the lubricating oil pressure drops to 7 pounds, the second switch will shut down the engine. In either case alarm will sound and “low lubricating oil pressure” light will light.

**Diesel Engine Fuel Oil System**

The fuel oil systems of the Diesel engines on the several units of the locomotive are similar to each other.
A fuel supply tank is mounted under each unit of the locomotive and may be filled from either side. A sight glass gauge is provided on each side of the unit and indicates the upper level in the tank.

A dial-type fuel gauge is located on the right side wall adjacent to the engine control panel. An air valve below the gauge must be opened to get a reading and should be closed after the reading has been taken. The gauge is calibrated in inches and gallons.

An electrically-driven fuel transfer pump, located on the left side of the Diesel engine near the front end, draws the fuel from the fuel supply tank through a suction line and a duplex suction filter and delivers it through a single felt disc-type discharge filter to a fuel oil header passing around the engine. The header connects to each fuel injection pump. Fuel oil pressure is controlled by two pressure relief valves, one located in the discharge line of the fuel transfer pump set at approximately 75 pounds, and one located at the return end of the fuel oil header set at 35 to 40 pounds. Fuel pressure relieved by either of these valves will return oil to the supply tank.

A dial-type gauge, located on the engine control panel, indicates fuel oil pressure at the return end of the header and should show 35 to 40 pounds.

An individual fuel injection pump, connected by high pressure piping to an individual injector, is provided for each cylinder of the Diesel engine. A cam on the camshaft operates the fuel injector pump at the proper time to deliver fuel to the injector. The stroke of the fuel injection pumps is constant at all times. The amount of fuel injected at each stroke is controlled by the engine governor which varies the effective stroke of the fuel injection pumps.

The emergency fuel cut-off valve is located under the unit in the suction line from the fuel supply tank. It may be closed by pulling any one of the several pulls on the unit, located as follows:

- Two—pear-shaped, in skirt on each side of unit near fuel sight glass.
- Two—pear-shaped, inside engineroom on sidewall near shutter operating mechanism.
- One—pull-ring, on side door frame in cab in “A” units behind engineman’s position.
Electric Power System:

Main Generator:

Each unit contains a single Diesel engine of 2000 horsepower. The main generator is connected to the Diesel engine by a coupling. The generator is self-ventilated and feeds power to the four traction motors of the unit.

Auxiliary Generators:

An auxiliary generator, a blower generator and an exciter are gear-driven from a shaft extension of the main generator. The gearing is lubricated by a separate oil supply using Diesel engine lubricating oil. The oil capacity is 5 pints and may be gauged with a bayonet-type gauge. The auxiliary generator, operating at 74 volts, is used to charge the storage battery on the unit and to supply low voltage power. The blower generator operating at 150 to 230 volts furnishes power to operate the two motor-driven traction motor blowers. The exciter is of the amplidyne generator type and provides excitation to the main generator field winding.

Control Stand:

The control stand at the engineman’s position in “A” units contains the throttle lever, reverse lever, and transition lever. The throttle lever operates electrically the electro-hydraulic governor controls of the engine. The reverse lever operates the reversers by electro-pneumatic control. The transition lever operates electrically to limit the automatic transition of the motor connections. Automatic transition will not progress beyond the setting of the transition lever. Automatic transition of the motor circuits is used to secure maximum power as train speed increases. Full engine power will not be available, if the train speed exceeds the speed at which automatic transition would normally take place, if the transition lever has not been advanced beyond that setting. Transition takes place automatically for both increasing and decreasing speed at the following points:

<table>
<thead>
<tr>
<th>Position</th>
<th>Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1–2</td>
<td>17.0 mph</td>
</tr>
<tr>
<td>2–3</td>
<td>28.1</td>
</tr>
<tr>
<td>3–4</td>
<td>49.0</td>
</tr>
</tbody>
</table>
In road operation the transition lever is normally in the No. 4 position. For terminal switching the transition lever should be in the No. 1 position, as the reverse lever cannot be operated unless the transition lever is in the No. 1 or in the “Off” position.

Reverser:

The reverser is an air-operated rotary drum switch located in the contactor compartment. If the reverser fails to operate by operating the reverse lever at the control stand or by pressing the magnet valve buttons at the reverser, a manual operating handle is provided on the reverser frame. The handle may be inserted in the hole provided in casting on top of operating shaft in order to move it to the position corresponding with movement of train. When the locomotive is to be towed, the reverser drums should be locked in neutral. The drum should be turned to its neutral position, and a locking pin inserted in the hole provided at the top of the reverser.

Traction Motors.

One traction motor drives the leading axle and one the trailing axle of each truck through spur gears (23/60 ratio). The two traction motors on each truck are air-cooled by a separate motor-driven blower, one over each truck. The four traction motors on a unit are connected in series-parallel at starting and low speeds and in parallel at 28.1 mph by automatic transition (unless restricted by the position of the transition lever). Field shunting is provided and takes place in series-parallel at 17.0 mph and in parallel at 49.0 mph (unless restricted by the position of the transition lever).

Contactor Compartment.

A contactor compartment on each unit is mounted at the main generator end of the engineroom. On “A” units this compartment forms a part of the bulkhead between the engineroom and the operating cab. The compartment contains the apparatus for main and auxiliary power control, and, mounted on the cab side in “A” units and on the front of the compartment in “B” units, is the panel containing the thermal overload circuit breakers for the control and auxiliary circuits. There are no fuses in the locomotive electrical circuits, the thermal circuit breakers performing their function. The following are in the contactor compartment:
Main power contactors, air-operated through magnet valves, two series contactors, marked “S1” and ‘S21;” four parallel contactors, marked “P1,” “P2,” “P21” and “P22.”

Field shunting cam controller, A multiple contact motor-driven cam switch which connects the field shunting resistors across the traction motor field windings in 17 graduated steps for shunted field operation.

Reverser, a rotary drum switch air-operated through magnet valves.

Engine starting contactors, marked “GS1” and “GS2,” used to crank the engine from the battery, closed when the start switch is turned to “Start” position and the isolation switch is in “Idle” position.

Generator field contactor, marked “GF,” closed when control circuit breaker is closed at engineman’s position and the throttle lever is in notches No. 1 to No. 8, inclusive, to provide excitation to the main generator field; opens during transition to reduce generator output.

Fuel pump contactor, marked “FPC,” closed when fuel pump switch is closed on engine control panel and fuel pump circuit breaker is closed at engineman’s position. Furnishes battery power to operate fuel pump, crankcase exhauster and excitation motor-generator set.

Battery contactor, marked “B,” closes when auxiliary generator voltage is high enough to charge battery.

Reverse current relay, marked “RC,” controls operation of battery contactor to prevent battery from discharging through auxiliary generator.

Voltage regulator, regulates voltage of auxiliary generator at 74 volts throughout operating speed range of engine.

Relay panel, with glass cover, contains:

Sequence relays, marked “AVF” and “CVF,” and current limit adjusting resistors.

Exciter field relay, marked “EF,” closed when throttle lever is in notches No. 1 to No. 8, inclusive.
Ground relay, marked “GR,” reduces engine speed to idle on power circuit ground, with manual reset button, and with sealed hand-operated knife cut-out switch for use in emergency separately mounted in contactor compartment.

Transfer relay, marked “TR,” closed during transition to and when operating in parallel connection of motors.

Wheel slip relays, marked ‘WS1” and “WS2,” compare voltage for “2” and “3,” and “1” and “4” traction motor armatures, respectively; if speeds, and thus voltages, are different, operates alarm buzzer and light, and tends to reduce engine speed to idle.

Blower stopped relay, marked “BLR,” operates on low blower generator voltage, sounding alarm and lighting lights.

Time delay relay, marked “TDR.”

Braking relays, marked “BR1,” “BR2” and “BWR” (not used).

Various capacitors, rectifiers and resistors.

Field shunting control panel, contains:

Time delay relay, marked “AR.”

Cam switch motor auxiliary control relays, marked “CSU” and “CSD.”

Current limit shunting control relays, marked “SCU” and “SCD.”

Time delay capacitor, marked “SCC.”

Cam switch notching relay, marked “IP1.”

Excitation panel, contains static regulator for excitation control of main generator, consisting of transformer, rectifiers, reactors and resistors.

Motor cut-out switch, manually-operated, to cut out either “2” and “3,” or “1” and “4” motors in case of grounds or for other reasons. Unit may be operated without other precautions as to load with pair of motors cut out, as compensation is automatic.
Miscellaneous, in the contactor compartment:

Load ammeter shunt, in No. 1 motor circuit.
Resistors, field shunting.
Resistors, various.

Speed Relay Panel.

The speed relay panel for transition is located inside the control stand on “A” units and in a separate cabinet on the right side of “B” unit near the steam generator.

This panel contains the following relays with associated rectifiers, capacitors, reactors and resistors:

Marked “LS1” and “CR1,” for 1-2 transition.
“LS2” and “CR2,” for 2-3 transition.
“LS3” and “CR3,” for 3-4 transition.

On “A” units this panel also contains:

Overspeed warning relay, marked “LS4,” operates at 99 mph.
Overspeed relay, marked “LOS,” operates at 104 mph.
Dead-man relay, marked “DMR.”

Circuit Breaker Panel.

This panel is mounted on the front of contactor compartment and contains the following thermal overload circuit breakers:

Control negative 150-ampre
Control positive 150 ”
Auxiliary generator 200 ”
Auxiliary generator field 15 ”
Crankcase exhauster 15 ”
Motor-generator set 70 ”
Field pump 35 ”
Cab lights and auxiliaries 15 ” ("A" units only)
Engine room lights 15 ”
Headlight 15-ampre ("A" units only)
Blower generator 200"
Blower generator field 15"
Steam generator negative 100"
Steam generator positive 100"

This panel also contains:

Battery charge indicator
Compartment light switch

Engineman’s Control Stand.

The following switches, circuit breakers, rheostat controls, and indicating lights are mounted at the engineman’s position:

Control circuit breaker, 15-ampere, completes the multiple unit control circuit to the throttle control, emergency engine stop, and to the engine start circuits and the alarm bells and lights.

Fuel pump circuit breaker, 15-ampere, completes the multiple-unit control circuit to the fuel pump contactor on each unit.

Generator field circuit breaker, 15-ampere, completes the multiple-unit control through throttle and transition lever circuits to the field shunting control and the reverser circuits and through the throttle circuits to the exciter field relay.

Emergency engine stop push button
Headlight switch
Number light switch
Marker light switch
Hood light switch
defroster control rheostat
Gauge light rheostat and control switch
Cab heater control rheostat
Indicating lights:
- Hot engines
- Low lube oil pressure
- Boiler flame out
- Wheel slip
- Locomotive overspeed

**Engine Control Panel.**

This panel is located on the right side wall of the unit near the Diesel engine, and contains the following indicators and controls:

- **Engine speed indicator**
- **Lubricating oil pressure gauge**
- **Fuel oil pressure gauge**
- **Turbo-supercharger and rocker arm oil pressure gauge**
- **Turbo-supercharger air pressure gauge**
- **Engine water temperature gauge**

Indicating lights:
- Ground relay trip or blower stopped: White
- Boiler flame out: White
- Low lube oil pressure: Green
- Hot engine: Red
- Crankcase exhauster running: Amber

**Isolation switch,** a six-position dial switch for stopping, isolating, or limiting maximum speed, of engine.

Positions marked: “Off,” “Idle,” “2,” “4,” “6,” and “Run.”

**Engine start switch,** for cranking engine.

**Fuel pump switch,** for controlling fuel pump, crankcase exhauster and motor-generator set.

**Panel light switch.**

**Radiator fan control switch,** for selecting manual or automatic operation of radiator fans.
Manual radiator fan control, a dial rheostat for controlling radiator fan speed with manual operation.

Main battery switch, a manually-operated switch located below the engine control panel, for isolating the battery.

The following apparatus also is located in the engine control panel:

Sequence relays, marked “AVS,” “BVS,” “CVS” and “DVS.”

Engine stop relay, marked “ESR.”

Oil pressure control relay, marked “OPR.”

Safety relay, marked “SAR.”

Signal relay, marked “SR.”

Engine temperature switch, marked “ETS.”

Governor oil pressure switch, marked “GOP.”

Lubricating oil pressure switches, marked “OPS1.”

Radiator fan control relay.

Governor rectifiers and capacitors.

Miscellaneous resistors, for speed adjustment and governor operation.

Load Control.

An excitation system is provided on this class of locomotive, which furnishes excitation current to the shunt field of the main generator through an amplidyne exciter, so regulated that the following are limited:

1. Diesel engine power
2. Generator load current
3. Generator field current

Diesel engine power is determined by the Diesel engine governor for the various positions of the throttle lever. Through a connection from the governor to the exciter field, the load on main generator is limited to the available Diesel engine power for each throttle lever position.
Generator load current and field current are limited by means of a static regulator which automatically increases or decreases the control field current of the exciter to maintain controlled output of the main generator for each throttle lever position.

The power for the excitation control system is furnished by a 400-cycle motor-driven alternator located in the nose on “A” units and on the left side near the front on “B” units. The output of the alternator is used through a transformer and rectifiers to supply excitation to the exciter control field and through separate transformer windings to supply power to the static regulator.

**Pneumatic Control Switch and Dead-man Relay.**

The pneumatic control (PC) switch is an air-operated switch mounted in the nose on “A” units. This switch is tripped by safety control operation of the air brakes (dead-man, locomotive overspeed) and by emergency brake application. When the switch is tripped it operates the dead-man relay, “DMR,” to reduce the speed of the Diesel engines to idle and remove power from the traction motors. To reset the switch and relay, the throttle lever must be returned to “Idle” and brake pipe pressure restored.

**Compressed Air System**

The Diesel engine on each unit of the locomotive drives a direct-connected, two-stage, three-cylinder air compressor. The compressor has its own oil pump and pressure lubricating system. Oil level in the crankcase can be checked on a bayonet-type gauge. The intercooler between the two stages has two 50-lb. safety valves.

Main reservoir pressure is controlled by an electrically-actuated governor set to cut in at 125 pounds pressure and to cut out at 140 pounds pressure. Main reservoirs are protected against excessive pressure by a 165-lb. safety valve in the discharge pipe from the air compressor and a 150-lb. safety valve located in the piping adjacent to the main reservoirs.

Drains are located on the intercooler, filter, and on each of the main reservoirs by means of which condensation may be drained from the system.

Air is supplied to a control reservoir through a strainer and check, and a reducing valve set at 70 pounds. Control air is used to operate the reverser and main power contactors. A control air
pressure gauge is located in the nose on “A” units and on the left front side on “B” units.

Main reservoir pressure is used for operation of the air brake system, radiator shutters, windshield wipers, horn, bell, and sanders. The steam generator water supply tank and fuel supply tank gauges are air-operated through separate reducing valves.

Air Brake System

This class of locomotive uses Type 24-RL air brake equipment, with K-2-A rotair valve on the “A” units.

Each of the two trucks under each unit is equipped with four brake cylinders. Four side-vented cut-out cocks, each of which cuts out and releases one brake cylinder on each side of a truck, are located on the right side of each unit.

Locomotive Operation

Inspection and Preparation for Service.

After locomotive has been properly inspected:

1. At the circuit breaker panel on each unit:
   a. See that all circuit breakers are closed.

2. At engineman’s position in controlling unit:
   a. See that the throttle lever is in “Idle” position.
   b. See that transition lever is in “Off” position.
   c. See that reverse lever is in “Off” position.
   d. Close control and fuel pump circuit breakers.

3. At engineman’s position in trailing cab:
   a. See that throttle lever is in “Idle” position.
   b. See that transition lever is in “Off” position.
   c. See that reverse lever is removed.
   d. See that control, fuel pump, and generator field circuit breakers are open.

4. At each Diesel engine control panel:
   a. See that battery switch is closed.
b. Close fuel pump switch and note that at least 30 pounds pressure is indicated on the fuel oil pressure gauge.

c. Place isolation switch in “Idle” position. Alarm should sound and low lube oil pressure light should light. Wait approximately ten seconds for engine governor to reset.

d. Turn engine start switch to “Start” position and hold until engine fires, lubricating oil pressure gauge shows pressure, alarm stops and low lube oil pressure light goes out.

e. Place isolation switch in “Run” position, pausing several seconds in each intermediate position.

f. Check that proper lubricating oil pressures obtain.

5. At circuit breaker panel on each unit:

   a. Check battery charge indicator to see that it indicates charge through the battery. Open crankcase exhauster circuit breaker and check lubricating oil level in crankcase of Diesel engine with engine idling.

   b. Close crankcase exhauster circuit breaker.

Moving the Locomotive and Road Operation.

To move the locomotive:

1. Close generator field circuit breaker.

2. Place foot on dead-man pedal and release air brakes.

3. Place reverse lever in “Forward” or “Reverse” position as required.

4. Place transition lever in position desired. Due to mechanical interlocking, reverse lever can be moved only with transition lever in “Off” or No. 1 position, so that for shifting movements transition lever should not be advanced beyond the No. 1 position. For normal road operation the transition lever should be placed in No. 4 position thus permitting full automatic transition to occur.

5. Move throttle lever to position required to start locomotive or train, pausing in each notch position. In starting a heavy train, care must be exercised to properly control slack action before accelerating.
Use of Load Ammeter.

When accelerating a train from a standing start or low speed, the pointer of the load ammeter may swing into the red zone but must return to the left as speed increases.

With throttle lever in eighth notch position the maximum continuous permissible amperes is 900 amperes as indicated by the end of the white zone.

Operation in the red zone indicates a heavy overload, normally used for starting or accelerating a train, and should be limited to approximately four minutes. Operating in the yellow zone is permissible for a consecutive or accumulated time not to exceed ninety minutes.

Operation Without Load Ammeter.

With throttle lever in eighth notch position, the minimum continuous speed is 23 mph. Operation at speeds below 23 mph is permissible under any one of the following limitations with throttle lever in eighth notch position:

<table>
<thead>
<tr>
<th>Speed</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>18 mph</td>
<td>90 minutes</td>
</tr>
<tr>
<td>15</td>
<td>10</td>
</tr>
<tr>
<td>12</td>
<td>4</td>
</tr>
</tbody>
</table>

Isolating A Diesel Engine.

If necessary to isolate a Diesel engine:

1. Place isolation switch in “Idle” position. If Diesel engine is running above idling speed, due to throttle being open, move isolation switch from “Run” to “Idle” position, pausing in intermediate positions until Diesel engine speed levels off.

Putting A Diesel Engine on the Line.

If necessary to put a Diesel engine on the line, move isolation switch to “Run” position, pausing several seconds in each intermediate position. If throttle is open, pause in each position until Diesel engine speed levels off before moving to next position. Diesel
engine speed may be limited, regardless of throttle lever position, by having isolation switch in one of its intermediate positions; that is, if switch is in No. 2 position, Diesel engine will not run faster than the speed corresponding to No. 2 position of the throttle lever even though throttle lever is moved to higher notch positions.

**Cutting Out Fuel Injection Pumps.**

Each fuel injection pump may be cut out individually by pushing in on fuel pump rack and flipping latch, located to the right of each injection pump, into position holding fuel rack in. No more than two injection pumps on each side should be cut out at any one time. If cutting out injection pumps causes excessive vibration, the engine should be shut down.

**Emergency Engine Stop.**

Stopping of all Diesel engines in emergency is accomplished by pushing the emergency engine stop push button on the control stand. The operation of the emergency engine stop depends on the control circuit breaker, on the control stand, being in closed position.

**Ground Relay Trip or Blower Stopped Indication.**

If ground relay trips or if traction motor blower stops, alarm will sound and ground relay trip or blower stopped indicating light on unit involved, will light.

If alarm is due to blower failure, isolate engine involved, check blower generator and blower generator field circuit breakers and reset if necessary. Under no conditions should the unit be operated under load with the blowers inoperative.

If the alarm is due to ground relay tripping, Diesel engine speed will reduce to idle and the power will be removed from the traction motors on that unit.

If the ground relay fails to remain reset, the traction motor cut-out switch, located in the contactor compartment, may be operated. If cutting out one pair of traction motors removes the ground fault, Diesel engine may be continued in operation with that circuit cut out.
Low Lube Oil Warning.

If lubricating oil pressure drops to 20 pounds with throttle lever in the fifth notch position or above, alarm will sound, low lube oil indicating light will light on control stand and on engine control panel of Diesel engine involved, and Diesel engine speed will reduce to idle. If lubricating oil pressure drops to 7 pounds with throttle lever in any notch position, alarm will sound, indicating lights will light, and Diesel engine on unit involved will shut down. Check lubricating oil level in crankcase of Diesel engine and examine external piping of lubricating oil system for leaks before restoring Diesel engine to service.

Hot Engine Warning Indication.

High cooling water temperature will cause an operation of the hot engine warning. Check temperature indicators on each Diesel engine control panel to determine which engine is causing the warning to operate. See that system contains sufficient water, that fans are operating and shutters are open. Operate shutters manually, if necessary, and control temperature by setting dial on engine control panel with fan control switch in “Manual” position.

Notes :

1. When attempting to start a Diesel engine, if no fuel oil pressure is obtained, see that fuel transfer pump is running and, if not, check the following circuit breakers:
   
   On circuit breaker panel:
   - Control positive
   - Control negative
   - Fuel pump
   
   At engineman’s control stand:
   - Fuel pump

   If fuel transfer pump is running, check fuel supply, emergency fuel cut-off valve, fuel oil suction line to pump for leaks, and turn handle on duplex fuel oil filter to opposite position.

2. If Diesel engine does not rotate when engine start switch is closed, see that isolation switch is in “Idle” position, check control circuit breaker at engineman’s control stand, and check engine starting contactors (GS-1 and GS-2).
3. If Diesel engine rotates but does not fire, observe that the fuel racks on the injection pumps come out, and, if not, release engine start switch. Place isolation switch in “Off” position, check governor oil supply, and overspeed switch, place isolation switch in “Idle” position and wait about ten seconds for governor to reset, then place engine start switch in “Start” position.

4. If locomotive fails to move with Diesel engines running and throttle opened, the following checks should be made:
   a. See that reverse lever is in proper position.
   b. See that brakes are released.
   c. See that transition lever is in running position.
   d. See that generator field circuit breaker on control stand is closed.
   e. See that isolation switches are in a running position.
   f. Check control reservoir air pressure.

5. If locomotive moves but one or more of the several units fails to deliver power, the following checks should be made:
   a. See that isolation switches are in proper position.
   b. Check control reservoir pressure on each unit.
   c. See that starting contactors are open.
   d. Check circuit breakers on circuit breaker panel on each unit.

6. When changing operating ends, the fuel pump circuit breaker on control stand of end being cut out must be left closed until fuel pump circuit breaker on control stand of end being cut in is closed, or all Diesel engines will stop.

7. When a low battery condition exists on leading “A” unit, with auxiliary generator inoperative, the locomotive can be controlled from the operating cab of this unit as follows:
   a. Open control and fuel pump circuit breakers at control stand on leading “A” unit.
   b. Close control and fuel pump circuit breakers at control stand of trailing unit.
   c. Close generator field circuit breaker on control stand of leading “A” unit.
d. Close locomotive overspeed cut-out cock on leading “A” unit to prevent undesired operation.

If necessary to have headlight, the following additional steps must be taken:

e. Open all circuit breakers on circuit breaker panel on leading “A” unit, except headlight and engine room lights circuit breakers.

f. Open cab signal m-g set circuit breaker and close headlight emergency switch to battery position in nose of leading “A” unit.
Diesel-Electric Road Locomotives

Operating Instructions

SECTION 6 – CLASS BP-3

General Data—Locomotive

Builder.............................................. Baldwin Locomotive Works
Horsepower Rating......................... 6000 H.P.
Gear Ratio ........................................ 22/57
Maximum Speed ............................. 100 M.P.H.
Units Per Locomotive .................... Two “A”, One “B”.
Trucks Per Unit ............................... Two
Axles Per Truck .............................. Three
Traction Motors Per Truck ............... Two
Wheel Diameter ............................. 42"
Journal Size .................................... 7”x13”
Brake Schedule............................... Westinghouse 24-RL

Maximum Overall Dimensions:  
“A” Unit  “B” Unit
Height......................................... 14’-10½”  14’-10½”
Width.......................................... 10’-6”  10’-6”
Length......................................... 80’-0”  78’-2½”

Total Weight ................................ 387,100 lb. 374,500 lb.
Weight on Drivers .......................... 257,200 lb. 250,000 lb.

Steam Generator Water Supply
Tank Capacity.............................. 1370 gal.  1370 gal.
Fuel Oil Capacity ............................ 1200 gal.  1200 gal.
Sand Capacity ............................... 30 cu. ft.  30 cu. ft.

General Data—Diesel Engine

Make and Model .............................. B.L.W.-606 S.C.
Horsepower at Governed R.P.M. ..... 1000 H.P. at 625 R.P.M.
Type .................................................. In line--4-cycle
Number of Cylinders ..................... Six
Bore and Stroke .......................... 12½”x15½”
Idling Speed .............................. 315 R.P.M.
Firing Order ............................... 1-2-4-6-5-3
Number of Engines Per Unit ............ Two
Lubricating Oil Capacity, Each
  Engine ....................................... 165 gal.
Cooling Water Capacity, Each
  Engine ...................................... 287 gal.

**Diesel Engine**

The Diesel engine on this class of locomotive is the same as that described under “Diesel Engine” in “Section 4—Class BP-l,” except that it has six cylinders instead of eight.

The cylinders on this engine are numbered from **rear** to **front**, starting with “1” at the rear end and ending with “6” at the front end.

**Diesel Engine Governor and Governor Control**

Same as described in “Section 4—Class BP-l,” except that the idling speed of the Diesel engine is 315 rpm.

**Diesel Engine Cooling System**

The cooling systems of the several engines on the locomotive are similar to, and independent of, each other.

Water is circulated through the cooling system by a centrifugal water pump located on the front end of the engine. The pump circulates water around the engine cylinder liners and through the jackets to an engine water manifold, from which it is piped to the cooling radiators located overhead at the rear end of the engine. After passing through the radiators, the water flows through the oil cooling heat-exchanger and back to the pump. An expansion tank, located overhead at the front end of the engine, is connected to the suction side of the pump. The radiators and the engine water manifold are vented into the expansion tank.
Water temperature may be checked on a dial-type thermometer, located on the side wall opposite the engine control panel. The temperature of the cooling water will vary between 150 ° F. and 160 ° F. under normal operating conditions.

Shutters for controlling cooling water temperature are operated by air at control reservoir pressure through a magnet valve. The shutters are fully open at all times when the cooling fans are running. Air from the control reservoir through a 17-lb. reducing valve, and a thermostatically-controlled air valve (Grad-U-Stat), operates pneumatic switches which control the shutter magnet valve and also the speed of motor-driven radiator cooling fans. The radiator cooling fans operate at two different rates of speed, depending upon water temperature, and are supplied with power from the main generator.

A three-position fan and shutter control switch, located on the engine control panel, operates as follows:

- **"Off"** — Fans will not operate; shutters are closed.
- **"Man"** — Fans operate at low speed; shutters may be adjusted by hand to any desired position.
- **"Auto"** — Operation of fans and shutters controlled by temperature control switches.

The shutter operating mechanism with manual operating handle is located on the end of the radiator section over the rear end of the engine. The Grad-U-Stat and pneumatic temperature switches are in the equipment cabinet for each engine, and the reducing valve and filter are located in the No. 2 equipment cabinet.

A separate water temperature switch, set at 190° F., will act on the engine shut-down solenoid valve to stop the engine when the engine cooling water temperature becomes excessive. Operation of the water temperature switch will sound the alarm and light the “hot engine” light on the engine control panel of the engine involved.

The cooling system may be filled through a filling connection at each side of the unit or at the filling connection on the roof over the expansion tank.

The water level in the cooling system is indicated by a glass water gauge located on the expansion tank. Water must show in this gauge glass at all times when the Diesel engine is being operated.
If a locomotive is to be left standing, or a Diesel engine is shut down, where there is danger of freezing, steam may be supplied to the system or the cooling water system should be drained.

For supplying steam to the cooling systems, connection with the steam train line is made through a steam admission valve located adjacent to the steam generator connecting to the cooling water systems through a check and shut-off valve near the water pump of each Diesel engine.

Steam can be supplied by connecting an outside steam line to the steam train line at either end, or by operating a steam generator.

To drain an engine cooling system, open the radiator drain valves (one on each side) and the engine drain valve at the water pump.

### Diesel Engine Lubricating Oil System

The lubricating oil systems of the several engines of the locomotive are similar to, and independent of, each other.

The lubricating oil supply is carried in the crankcase of the engine. A bayonet-type oil level gauge, located on the right-hand side of the engine near the front end, shows the level of the lubricating oil in the crankcase. The oil level should be maintained between the “High” and “Low” level marks on the gauge with the engine shut down, allowing at least 5 minutes after the engine is stopped before checking.

Oil may be added to the system, if necessary, through the oil filler opening equipped with a screw cap, located adjacent to the bayonet gauge.

The lubricating oil pump, located on the left side of the engine near the front, draws oil from the engine crankcase through a suction line, check valve and strainer; then pumps it through an absorbent-type full flow filter and a metal edge type strainer and then through an oil cooling heat-exchanger to an internal header from where it flows to the bearings, pistons, and all internal parts requiring lubrication.

The oil cooling heat-exchanger, located at the front end of the Diesel engine, provides for the transfer of heat from the lubricating oil to the cooling water. Therefore, there is a definite relation between lubricating oil temperature and cooling water temperature.
A dial-type gauge, located on the side wall opposite the engine control panel, shows lubricating oil pressure delivered to the lubricating oil header and should show about 65 pounds pressure at full engine speed. At lower speeds the pressure will be proportionately lower. At no time should the pressure drop below 20 pounds. If lubricating oil pressure cannot be maintained above 20 pounds, the engine must be shut down.

The turbo-charger is supplied with lubricating oil through a filter and reducing valve set at 20 pounds. A separate dial-type gauge, located on the side wall opposite the engine control panel, shows turbo-charger oil pressure.

If the pressure on the lubricating oil system becomes excessive, a relief by-pass valve, set at 125 pounds, will spill the pump output into the crankcase.

If the pressure drop through the oil cooling heat-exchanger exceeds 25 pounds, due to obstruction, the heat-exchanger will be bypassed by a relief valve.

A low lubricating oil pressure switch, connected to the engine header, operates to shut down the Diesel engine and sound the alarm when lubricating oil pressure drops to 15 pounds.

**Diesel Engine Fuel Oil System**

The fuel oil systems of the several Diesel engines of the locomotive are similar to, and independent of, each other, except that one fuel supply tank, mounted under each unit of the locomotive, supplies fuel for both Diesel engines of the unit, and the two fuel transfer pumps are connected by valved piping for emergency operation.

A dial-type fuel gauge and a sight glass gauge are located on each side of the fuel supply tank. The dial-type gauge is graduated from “Full” to “Empty” and the sight glass indicates the level of fuel oil from a point 4½” below the top of the tank to the top of the tank.

An electrically-driven fuel transfer pump, located on the right side of each Diesel engine, draws fuel from the supply tank through a separate suction line and a metal edge type strainer and delivers it, through a triple unit cotton twine type filter, to the fuel oil manifold which is connected to each of the fuel injection pumps. A valved pipe connection, between the discharge lines of both transfer pumps
on a unit, permits operation of both Diesel engines with one pump if the other fails. A valve at each pump in the connecting pipe must be open to accomplish this, but should be used only in an emergency.

A dial-type gauge located on the side wall opposite the engine control panel, shows the fuel pressure at the fuel manifold and should show normally 25 pounds pressure.

Fuel oil pressures are controlled by two pressure relief valves, one located in the discharge line of the fuel transfer pump set at approximately 35 pounds, and the other located at the end of the fuel oil manifold, set at approximately 25 pounds. Fuel pressure relieved by either of these valves will return oil to the supply tank.

An individual fuel injection pump, connected by high pressure piping to an individual injector, is provided for each cylinder of the Diesel engine. A cam on the camshaft operates the fuel injection pump at the proper time to deliver fuel to the injector. The stroke of the fuel injection pumps is constant at all times. The amount of fuel injected at each stroke is controlled by the engine governor which varies the effective stroke of the fuel injection pumps.

Three emergency fuel cut-off valves are located under the unit in the suction lines from the fuel supply tank, one on the right-hand side of the unit for the No. 1 engine and two on the left-hand side of the unit for the No. 2 engine and the steam generator. All valves may be closed by pulling any one of three pull rings on the unit, located as follows:

One — in the cab back of engineman’s position in “A” units and at the hostler’s position in “B” units.

Two — on outside above fuel tank on each side of the unit.

A branch from the fuel transfer pump discharge line is connected to the engine shut-down solenoid valve on the front end of the engine. When the circuit to the solenoid valve is made up, fuel oil under pressure flows to an engine shut-down cylinder, located on the right side of the engine, and pushes its piston out, permitting movement of the fuel racks under control of the engine governor. Opening of the circuit to the solenoid valve permits the fuel oil to flow to the supply tank and a spring in the shut-down cylinder moves the piston to a position which holds the fuel racks in the “no-injection” position, stopping the Diesel engine.
Electric Power System

Main Generator.

Each unit contains two Diesel engines of 1000 horsepower each. A main generator is connected to each Diesel engine by a coupling and feeds the two traction motors on the truck under its engine, and also the radiator cooling fan motors. The traction motor blowers are belt-driven by the Diesel engines.

Auxiliary Generator and Exciter.

Same as that described under “Sect. 4, Class BP-l.”

Control Stand.

Same as that described under “Sect. 4, Class BP-l.”

Traction Motors:

One traction motor drives the leading axle and one the trailing axle of each truck through spur gears (22:57 ratio). The two traction motors on each truck are air cooled by a single blower. The traction motors are permanently connected in parallel. Transition consists of one step of traction motor field shunting, which takes place automatically at 55 m.p.h. Backward transition is also automatic.

Electrical Equipment Cabinets.

The two electrical equipment cabinets on each unit, marked No. 1 for the No. 1 engine and No. 2 for the No. 2 engine, are located to the rear of and on the right side of their respective engines, with doors opening on the right and left aisles of the unit, respectively, and contain the following apparatus:

Four main power contactors, operated by air pressure through magnet valves marked “P-l” and “P-2” in the No. 1 cabinet, and “P-3” and “P-4” in the No. 2 cabinet.

Four traction motor field shunting contactors, marked “Ml” and “M2” in the No. 1 cabinet, and “M3” and “M4” in the No. 2 cabinet.

Two reversers, operated by air pressure through magnet valves, marked, “For. 1” and “Rev. 1” in the No. 1 cabinet, and “For. 2” and “Rev. 2” in the No. 2 cabinet.
Two ground relays, marked “GR1” in the No. 1 cabinet, and “GR2” in the No. 2 cabinet, for grounds in high voltage circuits, with manual reset button located on engine control panel; can be cut out in emergency by opening sealed circuit breaker mounted on engine control panel.

One control contactor, marked “CR,” in No. 2 cabinet.

One control relay, marked “COR,” in No. 2 cabinet.

Four engine starting armature contactors, marked “G1” and “G3” in the No. 1 cabinet, and “G2” and “G4” in the No. 2 cabinet.

Two starting protective relays, marked “PT1” in the No. 1 cabinet, and “PT2” in the No. 2 cabinet.

Two wheel slip relays, marked “WS1” in the No. 1 cabinet, and “WS2” in the No. 2 cabinet.

Two emergency engine stop contactors, marked “ES” and “ESX,” both in No. 2 cabinet.

Two fan motor field shunting relays, marked “R1” in the No. 1 cabinet, and “R2” in the No. 2 cabinet.

Six generator field contactors:

Marked “GF10” in No. 1 cabinet, starting, shunts field weakening resistor.
“GF11” in No. 1 cabinet, running.
“GF12” in No. 1 cabinet, starting.
“GF20” in No. 2 cabinet, starting, shunts field weakening resistor.
“GF21” in No. 2 cabinet, running.
“GF22” in No. 2 cabinet, starting.

Two exciter field contactors, marked “EF1” in the No. 1 cabinet, and “EF2” in the No. 2 cabinet.

Two power control contactors, marked “FR1,” in the No. 1 cabinet, and “FR2” in the No. 2 cabinet.

One traction motor field shunting relay, marked “FS” in the No. 1 cabinet.
Six radiator fan motor contactors, marked “F1,” “F3” and “F5” in the No. 1 cabinet, and “F2,” “F4” and “F6” in the No. 2 cabinet.

Two engine shut-down alarm relays, marked “SG1” in the No. 1 cabinet, and “SG2” in the No. 2 cabinet.

Four water temperature control switches, marked “TS1” and “TS3” in the No. 1 cabinet, and “TS2” and “TS4” in the No. 2 cabinet.

One boiler alarm relay, marked “BOR” in the No. 1 cabinet. One fire alarm relay, marked “FAR” in the No. 2 cabinet.

Two battery charging contactors, marked “AI” in the No. 1 cabinet, and “A2” in the No. 2 cabinet.

Two reverse current relays, marked “RC1” in the No. 1 cabinet, and “RC2” in the No. 2 cabinet.

Two voltage regulators, marked “VR1” in the No. 1 cabinet, and “VR2” in the No. 2 cabinet.

Two shutter control magnet valves, marked “SV1” in the No. 1 cabinet and “SV2” in the No. 2 cabinet.

Resistors, for traction motor field shunting and radiator fan control.

Fuses
2 — Auxiliary generator (one in each cabinet), 175-ampere.
2 — Fan and shutter control (one in each cabinet), 15-ampere.
2 — Radiator cooling fan motor (one in each cabinet), 175-ampere.
2 — Cab signal (in No. 2 cabinet “A” units only), 70-ampere.
1 — Control (in No. 1 cabinet only), 10-ampere.

Thermal overload circuit breakers
1 — Cab signal motor-generator set (at motor-generator set in rear of “A” units), 50-ampere.
1 — Master lighting (in No. 1 cabinet), 35-ampere.
Hand-operated switches

2—Main battery switches, (one in each cabinet).

1—Battery emergency transfer switch for headlight and cab signals (in No. 2 cabinet “A” units).

1—Steam generator transfer switch (in No. 1 cabinet).

1—Standby lighting transfer switch (in No. 1 cabinet).

2—Fuel pump transfer switches, (one in each cabinet).

1—Control disconnecting switch (in No. 1 cabinet).

4—Traction motor cut-out switches, marked “TMCO1” and “TMCO2” in No. 1 cabinet and “TMC03” and “TMC04” in No. 2 cabinet.

1—Fuse tester (in No. 1 cabinet).

Control Push Button Switch Box.

The control push button switch box is located on the left side of the engineman’s control stand, in each operating cab, and contains the following push button switches:

**Control**, establishes the multiple-unit power control through the throttle and reverse levers, to the reversers, field contactors, and main power contactors, and completes the circuit to the master control magnet valve.

**Overspeed**, completes the circuit to the overspeed magnet valve, (fuse only; switch not used).

**Cab signal**, completes the circuit to cab signals.

**Defroster Fans**.

**Attendant call**.

**Marker lights**.

**Back-up light**.

**Gauge light**.

**Number lights**.
Emergency engine stop, operates emergency engine stop contactors, shutting down all engines on the locomotive.

Each of these switches is fused with a separate 15-ampere fuse, located in the switch box. A locking device on the top of the box, with a removable key, locks the control switch against unauthorized operation.

At Engineman’s Position.

The following are located at the engineman’s position:

Headlight switch, with “Full,” “Off” and “Dim” positions.

Gauge light dimming rheostat.

Cab heater fan circuit breaker, 15-ampere.

Electra-pneumatic brake circuit breaker, 15-ampere.

Speed governor circuit breaker, 15-ampere.

Hood light switch.

Engine Control Panel.

An engine control panel, similar to that described in “Section 4—Class BP-I,” is mounted above the electrical equipment cabinet for each engine. No fuel pump circuit breaker is provided, the fuel transfer pump being started by closing the engine stop circuit breaker.

The following are located on each panel:

Engine start push button No. 1.

Engine start push button No. 2.

Ground relay reset push button.

Hot engine indicating light.

Ground relay indicating light.

Power cut-out circuit breaker, 15-ampere.

Engine stop circuit breaker, 15-ampere.

Auxiliary generator field circuit breaker, 25-ampere.

Cabinet lights circuit breaker, 15-ampere.
Ground relay cut-out circuit breaker, (sealed), 15-ampere.
Engine idle (isolation) switch.
Fan and shutter control switch.
Battery charge indicator selector switch (No. 1 panel only).
Battery charge indicator (No. 1 panel only).

The following gauges are located on the side wall of the unit opposite each engine control panel:
Fuel oil pressure at engine.
Lubricating oil pressure.
Turbo-charger oil pressure.
Engine water temperature.

**Load Control.**
Same as described in “Section 4—Class BP-l.”

**Power Knockout Switch.**
Same as described in “Section 4—Class BP-l.”

**Master Control Magnet Valve.**
Same as described in “Section 4—Class BP-l.”

**Throttle Unloading Magnet Valve.**
Same as described in “Section 4—Class BP-l,” mounted on the rear end of the Diesel engine frame.

**Engine Shut-down Solenoid Valve.**
Same as described in “Section 4—Class BP-l,” mounted on the front end of the Diesel engine.

**Compressed Air System**
Same as described in “Section 4—Class BP-l,” except that a control air gauge is located in the nose on “A” units and at the hostler’s position on “B” units.
Air Brake System

This class of locomotive uses Type 24-RL air brake equipment with K-2 rotair valves on the “A” units.

Each of the two trucks under each unit is equipped with four brake cylinders. Two side-vented cut-out cocks, each of which cuts out and releases all brake cylinders on a truck, are located on the right side of each unit.

Locomotive Operation

Inspection and Preparation for Service.

After locomotive has been properly inspected:

1. In electrical equipment cabinet for each engine:
   a. See that all fuses are in place and all switches and circuit breakers are closed.

2. At engineman’s position in controlling unit:
   a. See that throttle lever is in “Idle” position.
   b. See that reverse lever is in “Off” position.
   c. Close control push button switch.

3. At engineman’s position in trailing unit:
   a. See that throttle lever is in “Idle” position.
   b. See that reverse lever is removed.
   c. See that control push button switch is open, switch box locked, and key removed.

4. At each Diesel engine control panel:
   a. Place engine stop circuit breaker in “On” position. Alarm should sound. Note that fuel oil pressure is indicated on the gauge.
   b. Press engine start push button No. 1 and hold in until engine fires and at least 20 pounds lubricating oil pressure obtains. If the engine does not turn fast enough to start, the cranking speed can be increased by pressing engine start push button No. 2 while push button No. 1 is held in.
c. Place engine idle (isolation) switch in “On” position.

d. See that power cut-out circuit breaker is in “On” position.

e. See that radiator fan and shutter control switch is in automatic (“Auto”) position.

f. After both engines on a unit have been started, place auxiliary generator field circuit breaker on each engine control panel on the unit in “On” position.

5. At engine control panel for No. 1 engine on each unit:

   a. Check battery charge indicator in both positions of selector switch for battery charge from each auxiliary generator.

Moving the Locomotive and Road Operation.

1. Place foot on dead-man pedal and release air brakes.

2. Place reverse lever in “Forward” or “Reverse” position as required.

3. Move throttle lever to first notch position and pause until load ammeter indicates current. Throttle lever should be advanced slowly to the position necessary to start train. In starting a heavy train, care must be exercised to properly control slack action before accelerating.

Use of Load Ammeter.

The division between the white and the red scales on the load ammeter indicates the maximum permissible continuous current which is 1800 amperes. Operation at loads above 1800 amperes is permissible under any one of the following limitations with throttle lever in wide open position:

<table>
<thead>
<tr>
<th>Amperes</th>
<th>Time Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>40 minutes</td>
</tr>
<tr>
<td>2200</td>
<td>20</td>
</tr>
<tr>
<td>2600</td>
<td>10</td>
</tr>
<tr>
<td>3000</td>
<td>6</td>
</tr>
<tr>
<td>3600</td>
<td>4</td>
</tr>
</tbody>
</table>
Note: If unable to operate at or below maximum continuous rating after operating under any one of the above overload limitations, tonnage must be reduced or help obtained.

Operation Without Load Ammeter.

If necessary to operate without load ammeter with throttle lever in wide open position, the minimum continuous speed is 23 mph in order to avoid overload.

Operation at speeds below 23 mph is permissible under any one of the following limitations with throttle lever in wide open position:

<table>
<thead>
<tr>
<th>Speed (mph)</th>
<th>Time Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>21.0</td>
<td>40 minutes</td>
</tr>
<tr>
<td>18.0</td>
<td>20</td>
</tr>
<tr>
<td>13.5</td>
<td>10</td>
</tr>
<tr>
<td>10.0</td>
<td>6</td>
</tr>
<tr>
<td>5.0</td>
<td>4</td>
</tr>
</tbody>
</table>

Isolating a Diesel Engine.

If necessary to isolate a Diesel engine:

1. Place engine idle (isolation) switch in “Idle” position.

Note: A steam generator transfer switch is provided in the No. 1 electrical equipment cabinet. If a Diesel engine is shut down, the transfer switch should be placed in position for operation of the steam generator from the other engine. The steam generator must be shut down before the transfer switch is operated.

Putting a Diesel Engine on the Line.

If necessary to put a Diesel engine on the line, regardless of throttle lever position, place the engine idle (isolation) switch in a “On” position. Diesel engine will automatically come up gradually to speed corresponding to throttle position.

Emergency Engine Stop.

Stopping of all Diesel engines in an emergency is accomplished by closing any one of the emergency engine stop push button switches,
located on the push button switch box in each unit. All emergency engine stop push button switches must be in the open position before any Diesel engine can be restarted.

**Ground Relay Operation.**

If a ground relay operates, the Diesel engine should be isolated, the ground relay reset, and the Diesel engine placed back on the line.

When ground relay operates, alarm will sound, “ground” indicating light will light on engine control panel of Diesel engine involved, the speed of that Diesel engine will reduce to idle, and power will be removed from the traction motors associated with it.

If the ground relay fails to remain reset, traction motor cut-out switches, located in the electrical equipment cabinet, may be operated. The Diesel engine must be isolated before operating the traction motor cut-out switches. If cutting out one traction motor removes the ground, Diesel engine may be put back on the line to operate the other traction motor.

**Note:** When a traction motor fed by the No. 1 engine of the leading “A” unit is cut out, the load as indicated by the load ammeter must be restricted to one-half the current rating.

**Engine Stopped Warning Indication.**

When a Diesel engine stops due to operation of water temperature switch, low lubricating oil pressure switch, overspeed stop, emergency engine stop, or lack of fuel, an alarm will sound.

If the engine stops due to high cooling water temperature, the “hot engine” indicating light will light on the engine control panel of the Diesel engine involved. Check cooling water level and check shutter and fan operation, renewing fan motor and fan and shutter control fuses in electrical equipment cabinet, if necessary. If automatic fan and shutter controls will not function properly, place the fan and shutter control switch in “Man” position and adjust shutters by hand.

If the engine stops due to a cause other than high cooling water temperature, check fuel oil pressure, overspeed stop, and lubricating oil level in crankcase of engine and examine external piping of lubricating oil system for leaks.
Notes.

1. When attempting to start a Diesel engine, if no fuel pressure is obtained check that fuel pump is running and, if not, check that engine stop circuit breaker on engine control panel is closed, that control disconnecting switch in No. 1 electrical equipment cabinet is closed, that fuel pump transfer switch in electrical equipment cabinet for engine being started is closed to position for operating its fuel pump, and that the emergency engine stop push button switch is open on each unit. If the fuel pump is running, check fuel supply, emergency fuel cut-off valve, and fuel suction line to pump for leaks.

2. If Diesel engine does not rotate when engine start push button is pressed, check that isolation switch is in “Idle” position. Check that battery switch is closed and check starting contactors in electrical equipment cabinet.

3. If Diesel engine rotates but does not fire, check overspeed stop and reset, if necessary, and check oil supply in engine governor. While Diesel engine is rotating, see that piston of Diesel engine shut-down cylinder moves out to permit free operation of injector layshaft.

4. If locomotive fails to move with Diesel engines running and throttle opened, the following checks should be made:
   
a. See that reverse lever is in proper position and brakes released.

b. See that control push button switch is closed, and check 15-ampere control fuse in push button switch box on controlling unit.

c. See that cut-out cock in control air supply pipe to control stand is open.

d. Check control reservoir pressure gauge in nose of controlling unit.

e. Check 70-ampere control fuse in the No. 1 electrical equipment cabinet on controlling unit.

f. Check position of all power cut-out circuit breakers and isolation switches.
5. If locomotive moves but one or more of the Diesel engines fails to deliver power, the following checks should be made:

   a. See that isolation switches are in “On” position.
   b. Check ground relays and reset if tripped.
   c. Check control reservoir pressure.
   d. See that all starting contactors are open.
   e. Check throttle pipe for leaks including connection between units, and see that cut-out cocks in throttle pipe are fully opened.
   f. Check 70-ampere control fuse on units affected.

6. When changing operating ends, before proceeding to the end being cut in, see that control push button switch box is locked with control push button switch open.

7. When a low battery condition exists on lead operating unit, with both auxiliary generators inoperative, the locomotive can be controlled from the operating cab of this unit as follows:

   a. Open control disconnect switch and battery switch in No. 1 electrical equipment cabinet, and open battery switch in No. 2 cabinet, on leading “A” unit.
   b. Close control push button switch on leading “A” unit.
   c. Close control push button switch, and close cut-out cock in air supply pipe to control stand, on a trailing unit.
   d. Close control contactor, marked “CR”, in No. 2 electrical equipment cabinet on leading “A” unit, using flag stick.
   e. 70-ampere control fuse in No. 1 cabinets and 15-ampere control fuse in control push button switch boxes must be good.
Diesel-Electric Road Locomotives

Operating Instructions

SECTION 7 – CLASS FP-3

General Data—Locomotives

Builder.............................................. Fairbanks, Morse & Co.
Horsepower Rating......................... 6000 H.P.
Gear Ratio ........................................ 23:64
Maximum Speed .............................. 100 M.P.H.
Units Per Locomotive ...................... Two “A”, One “B”
Trucks Per Unit ................................. Two
Axles Per Truck................................ Three
Traction Motors Per Truck............... Two
Wheel Diameter ............................... 42”
Journal Size ...................................... 6½”x12”
Brake Schedule................................. Westinghouse 24-RL

Maximum Overall Dimensions:

<table>
<thead>
<tr>
<th></th>
<th>“A” Unit</th>
<th>“B” Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height</td>
<td>15’-3”</td>
<td>15’-0”</td>
</tr>
<tr>
<td>Width</td>
<td>10’-6¼”</td>
<td>10’-6¼”</td>
</tr>
<tr>
<td>Length</td>
<td>64’-10”</td>
<td>64’-10”</td>
</tr>
<tr>
<td>Total Weight</td>
<td>331,400 lbs.</td>
<td>332,800 lbs.</td>
</tr>
<tr>
<td>Weight on Drivers</td>
<td>230,800 lbs.</td>
<td>232,100 lbs.</td>
</tr>
<tr>
<td>Steam Generator Water Supply</td>
<td>1200 gals.</td>
<td>2260 gals.</td>
</tr>
<tr>
<td>Fuel Oil Capacity</td>
<td>1650 gals.</td>
<td>1220 gals.</td>
</tr>
<tr>
<td>Sand Capacity</td>
<td>20 cu. ft.</td>
<td>40 cu. ft.</td>
</tr>
</tbody>
</table>

General Data—Diesel Engine

Make and Model .......................... F-M 38 D 8 1/8
Horsepower at Governed R.P.M. ........ 2000 H.P. at 850 R.P.M.
Type .................................................. In Line. Opposed Piston
                      2-cycle
Number of Cylinders ..................... Ten
Bore and Stroke ............................. 8-1/8”x10”x10”
Idling R.P.M. .................................... 300 R.P.M.
Firing Order ................................. 1-8-7-3-5-9-4-2-10-6
Number of Engines Per Unit .......... One
Lubricating Oil Capacity,
    Each Engine ............................... 360 gals.
Cooling Water Capacity,
    Each Engine ............................... 367 gals.

Diesel Engine

Same as described in “Section 9—Class FF-3.”

Diesel Engine Governor and Governor Control

Same as described in “Section 9—Class FF-3.”

Diesel Engine Cooling System

Same as described in “Section 9—Class FF-3,” except that a steam generator is provided and the standby heater is omitted.

If a locomotive is to be left standing or a Diesel engine is shut down where there is danger of freezing, steam may be supplied to the system or the cooling water system should be drained.

For supplying steam to the cooling system, a connection from the steam train line is provided through a steam admission valve, check valve and choke located in small pipe to water pump suction line.

Steam can be supplied by connecting an outside steam line to the steam train line connection at either end of the unit, or by operating a steam generator on another unit.

Diesel Engine Lubricating Oil System

Same as described in “Section 9—Class FF-3”.
Diesel Engine Fuel Oil System

Same as described in “Section 9—Class FF-3”.

Electric Power System

Same as described in “Section 9—Class FF-3”, with the following exceptions:

1. Transition takes place automatically for both increasing and decreasing speed at the following points:

<table>
<thead>
<tr>
<th>Position</th>
<th>Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-2</td>
<td>25 mph</td>
</tr>
<tr>
<td>2-3</td>
<td>33</td>
</tr>
<tr>
<td>3-4</td>
<td>64</td>
</tr>
</tbody>
</table>

2. One traction motor drives the leading axle and one the trailing axle of each truck through spur gears (23/64 ratio). The two traction motors on each truck are air cooled by a separate motor-driven blower, one over each truck. The four traction motors on a unit are connected in series—parallel at starting and low speeds and in parallel at 33 mph by automatic transition (unless restricted by the position of the transition lever). Field shunting is provided and takes place in series-parallel at 25 mph and in parallel at 64 mph (unless restricted by the position of the transition lever).

3. Compartment Control Panel includes two 80-ampere thermal overload circuit breakers for the steam generator.

4. Overspeed relay, marked “LOS”, located in the nose of “A” units, operates at 105 mph.

5. Standby heater controls are omitted on panel at left rear of engine room.

6. A boiler flame out indicating light is located on the engine control panel of each unit and in the operating cab of “A” units.

Compressed Air System

Same as described in “Section 9—Class FF-3”, except that this class of locomotive has the electro-pneumatic features included in the air brake system.
Operation

Same as described in “Section 9—Class FF-3”, with the following exceptions:

When operating without load ammeter with the throttle lever in 8th notch position, the minimum continuous speed is 22 mph. Operation at speeds below 22 mph is permissible under the following limitations with throttle lever in 8th notch position:

<table>
<thead>
<tr>
<th>Speed</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>18 mph</td>
<td>90 minutes</td>
</tr>
<tr>
<td>12</td>
<td>4</td>
</tr>
</tbody>
</table>

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Diesel-Electric Road Locomotives
Operating Instructions

SECTION 8 – CLASS EF-4

General Data—Locomotive

Builder.............................................. Electro-Motive Division—General Motors Corp.

Horsepower Rating......................... 6000 H.P.
Gear Ratio ........................................ 15/62
Maximum Speed ......................... 65 M.P.H.
Units Per Locomotive ..................... Two “A”, Two “B”
Trucks Per Unit ................................. Two
Axles Per Truck................................. Two
Traction Motors Per Truck ............... Two
Wheel Diameter ............................... 40”
Journal Size ................................. 6½”x12”
Brake Schedule.............................. Westinghouse 24-RL

Maximum Overall Dimensions:  
“A” Unit  “B” Unit
Height........................................... 15’-5”  14’-9¼”
Width........................................... 10’-6-7/8”  10’-6-7/8”
Length ........................................ 50’-8-3/8”  50’-0¾”

Total Weight .................................. 238,000 lb.  227,000 lb.
Weight on Drivers ....................... 238,000 lb.  227,000 lb.
Fuel Oil Capacity ................. 1200 gal.  1200 gal.
Sand Capacity ................................ 16 cu. ft.  16 cu. ft.

General Data—Diesel Engine

Make and Model .............................. E.M.D.—567-B
Horsepower at Governed R.P.M...... 1500 H.P. at 800 R.P.M.
Type .......................................................... Vee-2-cycle
Number of Cylinders ...................... Sixteen
Bore and Stroke ............................... 8½” x 10”
Idling Speed ........................................ 275 R.P.M.
Firing Order ................................. 1-8-9-16-3-6-11-14-4-5-12-13-2-7-10-15
Number of Engines Per Unit .......... One
Lubricating Oil Capacity,
   Each Engine ...................................... 200 gal.
Cooling Water Capacity ................. “A” Unit—230 gal.
   “B” Unit—215 gal.

Diesel Engine

The Diesel engine used on this class of locomotive is the same as that described under “Diesel Engine” in “Section 3—Class EP-3” except that it has sixteen cylinders instead of twelve.

The cylinders on this engine are numbered from front to rear, starting with “1” at the front end of the right bank and ending with “8” at the rear end of the right bank, and beginning with “9” at the front end of the left bank and ending with “16” at the rear end of the left bank.

Diesel Engine Governor and Governor Control

The hydraulic type governor on this engine is similar to that described under “Diesel Engine Governor and Governor Control” in “Section 3—Class EP-3”.

The fuel control portions of both governors are identical, but the pressure on the speeder spring in this governor is controlled by a hydraulically-positioned speed setting piston, instead of by a governor control arm mechanically positioned by an electro-pneumatic governor control. The position of the speed setting piston is determined by throttle lever position through electro-hydraulic governor control built into the upper portion of the governor.

The throttle positions and corresponding Diesel engine R.P.M. are the same as those given in “Section 3—Class EP-3”
The overspeed stop device is the same as that described in “Section 3—Class EP-3”.

**Diesel Engine Cooling System**

The cooling systems of the several engines of the locomotive are similar to each other, except that the cab heaters are incorporated in the cooling system of the engine on “A” units. The cooling systems are so designed that the water level is below the radiators when the engine is shut down, thus giving protection against the radiators freezing during shut-downs in cold weather.

Two centrifugal water pumps, mounted on the front end of the engine, draw water from the lubricating oil cooler and water tank assembly, which is located on a floor stand at the front end of the engine. The pumps circulate the water to the bottom of each cylinder liner, up through the cored passages of the liner and cylinder head and through the outlet manifold to two banks of radiator sections, located in the main hatch over the engine. Here the water is cooled and returns through the oil cooler assembly to the engine.

The water temperature of the system may be checked on a dial-type gauge located in the suction line to the left hand water pump on the engine, which indicates the temperature of the water going into the engine. This gauge has a color-coded dial on which the 120 and 190-degree F. points are indicated by black lines. The dial is colored blue below 120 degrees F., green from 120 to 190 degrees F., yellow merging into red from 190 to 200-degrees F., and full red above 200 degrees F. The normal operating range, of 150 to 180 degrees F., is indicated by a wide area of the green section.

Engine cooling water temperature is controlled by automatic operation of radiator shutters and motor-driven cooling fans.

Four electrically-driven cooling fans, located above and between the radiators, draw air through the radiators for dissipating the heat from the cooling water to the atmosphere. The a-c motor-driven fans receive their power from an alternator built into the main generator. The fan motors are automatically started consecutively at 169 degrees F. water temperature, according to cooling demands, until all fan motors are operating at 178 degrees F. All fans stop and the shutters close when cooling water temperature
drops to 163 degrees F. Operation of the cooling fans is controlled by a thermostatic switch assembly, located in the engine cooling water outlet pipe on the left side of the engine between the engine and the radiators.

Two sets of radiator shutters, one set located in each sidewall of the unit, are operated automatically by pneumatic cylinders, with main reservoir air pressure, through a magnet valve. A shutter switch is provided for summer and winter conditions. With the switch in “Summer” position, the shutters open at 166 degrees F. water temperature, before the cooling fans start. With the switch in “Winter” position, the shutters open at 175 degrees F. when the third cooling fan starts.

The engine high temperature alarm switch is a thermal switch located on the left side of each unit, between the dynamic brake grid hatch and the cooling hatch, next to the shutter magnet valve. It connects with a thermal element in the cooling water outlet manifold of the engine. If the outlet water temperature exceeds 203 degrees F., this switch closes, lights the hot engine alarm signal light only in the unit having high cooling water temperature, and operates the signal relay which rings the alarm bells throughout the locomotive.

When it is necessary to add water to an engine cooling system, proceed as follows:

1. Shut down engine and open “G” valve. (The “G” valve is located above and to the rear of the left rear side engine room door.)

2. Add water slowly until it runs out the “G” valve. (There is a filler pipe on the roof of each unit directly above the water tank, and side fillers under the rear of each unit on either side.)

3. Close the “G” valve.

There are two 16-inch water gauge glasses located on the water tank above the engine control and instrument panel. These are so arranged that the glasses overlap and provide full operating water level coverage. The proper operating level is indicated by a stencil on the water tank next to the water gauge glasses.

The cab heaters on “A” units are supplied with hot water from the Diesel engine cooling system through a separate inlet valve, located above the steps leading into the cab.
If a locomotive is to be left standing or a Diesel engine is shut down where there is danger of freezing, the standby heaters can be used, steam can be supplied to the systems or all water must be drained from the systems.

The standby heater, suitably piped into the cooling water system on each unit, heats and circulates the water in the cooling system. An electrically-driven centrifugal pump circulates the cooling water through a jacket in the heater. Fuel oil, gravity fed to the heater from a fifteen-gallon tank, is burned in the firebox of the heater. The cooling water, in its passage through the jacket absorbs the heat generated in the firebox. The Diesel engine fuel transfer pump supplies the fuel oil to the heater tank. Necessary valves, for controlling the fuel oil and water flow, are included in the system.

To start the standby heater:

1. Open the water circulation valves.
2. Place torch furnished with heater in fuel ring through lighting door and open fuel metering valve to the stop in order to saturate torch with fuel oil.
3. Light torch and place it over burner through lighting door.
4. After about one-half minute, start circulating pump and blower fan with damper closed. Remove torch after fire has ignited and torch has burned out. This should take three to five minutes.
5. Open damper slowly a sufficient amount to obtain a clear stack with a minimum amount of excess air to maintain white flame tips.

To stop the standby heater:

1. Close fuel metering valve.
2. Stop blower motor after fire has burned out.
3. Close the water circulation valves.

For supplying steam to the cooling system, a connection to the steam train line is provided through steam admission valve and check valve located in small pipe to water pump discharge line on left side of engine. The following valves should be opened:

1. “G” valve.
2. Steam admission valve at engine.
   On “A” units open also:
   1. Cab heater inlet valve.
   2. Cab heater steam valves.
   3. Steam admission valve to cab heaters at foot of steps, on right side, leading into cab.

To drain an engine cooling system, first open “G” valve, then open valve at floor under water tank and oil cooler assembly at front end of engine and remove pipe plug in bottom of right bank water pump.

To drain heaters on “A” units, open cab heater inlet valve located above the steps leading into the cab and open cab heater drain valve located behind the No. 2 sand box on left side of unit. After this valve drains completely, open steam valves at each cab heater, and open steam line drain valve on right side of engine room at foot of cab steps.

**Diesel Engine Lubricating Oil System**

The lubricating oil systems of the Diesel engines, on the several units of the locomotive are similar to each other. The oil is stored in the oil pan of the engine, and is gauged by a bayonet-type gauge in the oil pan on the left side of the engine.

With the engine running, the bayonet gauge should show oil between “Low” and “Full”. When the engine is shut down and first filled, the level on the bayonet should show “System Uncharged;” but after the engine has been run and shut down, the level on the bayonet gauge should show “System Charged”. The difference, when the engine is shut down, is due to some of the oil being trapped in the lines, filters and strainer tank.

When oil is added to the system, it must be poured through the opening having the square cap, on top of the strainer tank mounted on the front end of the engine at the right side.

The engine lubricating oil system is a pressure system using two positive displacement, gear-type pumps combined in a single unit. One pump delivers oil for the pressure lubricating system, the other for piston cooling. The oil supply for these pumps is drawn from the lubricating oil strainer tank through a common suction pipe.
A scavenging oil pump is used to draw oil from the engine oil pan through a strainer, pump it through the lubricating oil filter to the lubricating oil cooler, and then to the strainer tank.

The lubricating oil pump unit is centrally located on the front of the engine, and the scavenging oil pump on the lower left front corner of the engine.

The oil cooler, located adjacent to the cooling water tank on the floor stand at the front end of the engine, provides for the transfer of heat from the lubricating oil to the cooling water. Therefore, there is a definite relation between the lubricating oil temperature and the cooling water temperature.

A dial-type pressure gauge, located on the right hand side of the engine control panel, shows the lubricating oil pressure being delivered to the main bearings. Lubricating oil pressure must be maintained at all times. When starting a cold engine, the oil pressure should start to build up immediately and should rise to about 50 pounds. With the engine warm, this pressure should be approximately 35 to 40 pounds at 800 R.P.M. and normally should not drop below 20 pounds. At idle, pressure should be at least 6 pounds. If the water temperature cannot be held below 180 degrees F., main bearing oil pressure will decrease and it is permissible to operate with this pressure as low as 15 pounds at 800 rpm.

If lubricating oil pressure drops below 15 pounds at 800 rpm, the lubricating oil failure shut-down system will stop the Diesel engine.

A color-coded dial-type gauge, also located on the engine control panel, on the left hand side, shows lubricating oil pump suction. The color-coded dial is marked off in green, yellow and red blocks. Under normal conditions, the needle of the gauge should be within the green portion of the dial. If the needle is in the yellow or red portion, it indicates clogged lubricating oil strainers in the strainer tank and, if the strainers become sufficiently clogged, the lubricating oil failure shut-down system will stop the Diesel engine.

Automatic shut-down of the Diesel engine, in the event of lubricating oil pressure failure or excessive lubricating oil pump suction, is provided by the lubricating oil failure shut-down system incorporated in the engine governor.

When the lubricating oil failure shut-down system stops the engine, alarm bells will sound on all units of the locomotive and the
yellow “low oil” and blue “alternator failure” indicating lights will show in the unit concerned, and a push button on the front of the governor housing will move out exposing a red band around the shaft of the button. The push button must be pushed in and the isolation switch moved to “Start” position to cut out the lights and stop the alarm bells. The push button must be reset before the engine can be started. If the condition which caused the shut-down still exists, a time delay of approximately 40 seconds, with the engine running at idling speed, is provided to allow a check for the cause of the shut-down before the engine will again stop.

### Diesel Engine Fuel Oil System

The fuel oil systems of the Diesel engines on the several units of the locomotive are similar to each other.

A fuel supply tank is mounted under each unit of the locomotive and may be filled from either side.

A sight glass gauge, located on each side of the supply tank adjacent to the fuel oil filler, indicates the level of the fuel oil from a point 4½” below the top of the tank to the top of the tank.

A dial-type fuel gauge is located on the engine control panel on each unit. An air valve, also on the engine control panel, must be opened to get a reading and should be closed after the reading has been taken. The gauge is calibrated in inches from 0 to 28.

An electrically-driven fuel oil transfer pump, located under the lubricating oil filter on the floor stand at the front end of the engine, draws the fuel from the supply sump of the fuel supply tank through a suction line and filter, then pumps the fuel oil through filters to the injectors.

A fuel filter assembly consisting of two sintered bronze elements, an orifice and sight glass, and a 60-lb. relief valve and sight glass is mounted on the right front end of the engine. The fuel being pumped to the injectors passes through both filter elements. Each injector has two small filters at the fuel oil pipe connections to the injector.

The fuel returning from the injectors passes through a manifold, through the sight glass nearest the engine, and through an orifice to the return line to the fuel supply tank. Fuel should show in this sight glass whenever the fuel transfer pump is running.
If fuel oil pressure at the fuel transfer pump discharge builds up to 60 pounds, due to obstructions in the fuel oil lines or filters, fuel oil will show in the 60-lb. sight glass and no attempt should be made to run the Diesel engine until the condition has been corrected.

The injectors and injector control shaft are the same as described under “Diesel Engine Fuel Oil System” in “Section 3—Class EP3”.

The emergency fuel cut-off valve, located under the unit in the piping between the fuel supply tank sump and the supply sump, can be closed by pulling one of the several pull rings located on the unit as follows:

Two— one on each side of unit in small box with lift cover adjacent to fuel supply tank filler.

One— in operating cab on “A” units, on bulkhead, above door behind fireman’s position.

One— on left side wall near rear side door on “B” units.

Electric Power System

Main Generator.

Each unit contains a single Diesel engine of 1500 horsepower. The main generator is connected to the Diesel engine through a flexible coupling. The generator is cooled by a blower coupled to the end of the auxiliary generator shaft.

Alternator.

An alternator is built into the engine end of the main generator and supplies alternating current power for traction motor blower and radiator cooling fan motors.

Auxiliary Generator.

The auxiliary generator, mounted on the main generator and driven through flexible couplings from the rear gear train of the engine, is used to charge the storage battery on the unit and to supply low voltage power.

Control Stand.

The control stand at the engineman’s position in “A” units, contains the throttle lever, reverse lever and transition lever. The
throttle lever operates electrically the electro-hydraulic governor controls. The reverse lever operates the reversers by electro-pneumatic control.

The transition lever, when moved to the left of its “Off” position, sets up control circuits for changing the traction motor connections when operating in manual transition and, when using automatic transition, provides full automatic forward and backward transition, without the forestalling feature. When moved to the right of its “Off” position, the transition lever controls the dynamic brake.

A selector switch, located in the electrical control cabinet on each unit, is provided to select manual or automatic transition as required. The switch has two positions, “Manual” and “Automatic”, and should be secured in either position with a pin provided for the purpose. The selector switches on all units of a locomotive must be in the same position.

Automatic transition should occur for both increasing and decreasing speed at the following points with throttle in 8th position:

<table>
<thead>
<tr>
<th>Load Ammeter Pointer at Line Between</th>
<th>Approximate Speed, M. P. H.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Forward</td>
</tr>
<tr>
<td>1 and 2</td>
<td>20</td>
</tr>
<tr>
<td>2 and 3</td>
<td>26</td>
</tr>
<tr>
<td>3 and 4</td>
<td>54</td>
</tr>
</tbody>
</table>

**Reverser.**

The reverser is an air-operated reversing switch located in the electrical control cabinet of each unit. When the locomotive is to be towed in a train, the reverser drums should be locked in neutral. During normal operation, a locking pin is screwed into the left-hand side of the reverser. To lock the reverser drum in neutral, this pin should be removed and inserted in the hole in the opposite side.

Turn the drum to its neutral position and the pin will engage with the threaded hole in the shaft.

**Traction Motors.**

A traction motor drives each pair of wheels through spur gears (15:62 ratio). The four traction motors under each unit are air-
cooled by motor-driven blowers, one blower for each motor. The four traction motors on a unit are connected in series-parallel at starting and low speeds, and in series-parallel with shunted fields, parallel, and parallel with shunted fields by the progressive steps of transition at higher speeds.

**Electrical Control Cabinet.**

The electrical control cabinet is located near the generator end of the Diesel engine on each unit and contains high voltage apparatus, low voltage apparatus and the low voltage panel and distribution panel. The high voltage apparatus in this cabinet should not be worked on while the unit is in operation.

**High Voltage Apparatus.**

- Six main power contactors, operated by air pressure through magnet valves; two series contactors, marked “S14” and “S23”; four parallel contactors, marked “P1” to “P4”, inclusive.
- Traction motor field shunting contactor, four pole, air-operated through a magnet valve, marked “M”.
- Reverser, a rotary drum switch, air-operated through magnet valves.
- Parallel relay, marked “PR”, located on low voltage panel; a relay energized by transition relay which operates in conjunction with the time delay relay to close the parallel contactors during transition. This relay also operates with the shunt field and battery field contactors causing them to open during transition.
- Ground protective relay, marked “GR”, opens the battery and shunt field contactors and reduces engine speed to idle if a ground occurs in the high voltage system. The relay can be reset by means of a reset lever. The ground relay can be cut out in emergency by opening a sealed knife switch in the electrical control cabinet. When this is done, ground protection is removed.
- Wheel slip relays, marked “WSR1” and “WSR2”, each compare the voltage and hence the speed of two motors. If the speeds are different, indicating slipping of one pair of wheels, indication is given to the engineman and power is automatically reduced, but slipping will probably resume if the condition is not corrected.
Generator shunt field contactor, marked “SH”, closes when throttle lever is in notches 1 to 8, inclusive, connecting main generator shunt field to main generator armature; opens during transition to reduce generator output.

Forward transition voltage relay, marked “FTR”.

Backward transition current relay, marked “BTR”. (on some units).

Backward transition series relay, marked “BTS” (when “BTR” is not used).

Backward transition parallel relay, marked “BTP” (when “BTR” is not used).

Time delay backward relay, marked “TDB”.

Meter relay, marked “MR”, located in nose on “A” units.

Resistors, for wheel slip relay, shunt field discharge, and shunt field contactor.

Load ammeter shunt, in No. 4 traction motor circuit.

Brake contactor, three-pole, air-operated through a magnet valve, marked “B”, connects the four traction motor fields in series to the main generator during dynamic braking; closed when transition lever is in “Off” or in braking positions.

Field loop contactor, marked “FL”, connects dynamic brake control rheostat (actuated by transition lever in braking positions) and unit selector switch resistors in series with the field loop circuit. The field loop connects all main generator battery fields in series across the auxiliary generator-battery circuit of the controlling unit during dynamic braking. The contactor is energized when the transition lever is in “Off” or in braking positions.

Dynamic braking relay, marked “BR”, closed when the transition lever is in “Off” or in braking positions; when closed, establishes cam-switch in “Tow” position and partially completes circuit to braking contactors; when open establishes “Motor” position of cam-switch and partially completes circuit to the traction motor contactors.

Cam switch, marked “CS”, a cam-type switch operated by air pressure through magnet valves controlled by braking relay; when
in “Motor” position connects the traction motor armatures in series with their respective fields; when in “Tow” position, disconnects the traction motor armatures from the fields and connects a braking resistor (grid) across each armature.

**Dynamic brake warning relay**, marked “BWR”, operates the dynamic brake warning light on the instrument panel in the engineer’s cab, indicating excessive braking current.

**Low Voltage Apparatus.**

**Engine starting contactors**, marked “ST+” and “ST—”, close when start switch button is pressed and isolation switch is in “Start” position, connecting battery to main generator for engine starting.

**Voltage regulator**, regulates voltage of auxiliary generator at 74 volts throughout operating speed range of the engine.

** Resistors**, for battery field discharge and for braking control.

**Automatic transition differential relay**, marked “KP” (used only when “BTR” relay is used).

**Time delay relay**, marked “TD”.

**Selector switch**, marked “CO”, closed for automatic transition.

**On Low Voltage Panel:**

**Battery field contactor**, marked “BF”, closed when throttle lever is in notches 1 to 8, inclusive, connecting main generator battery field to the battery, opens during transition from “2” to “3” or from “3” to “2” position, closed also when transition lever is in braking positions.

**Battery charging contactor**, marked “BC”, connects auxiliary generator to battery; operated by reverse current relay, closed when auxiliary generator voltage is high enough to charge battery.

**Reverse current relay**, marked “RCR”, controls operation of battery charging contactor to prevent battery from discharging through auxiliary generator.

**Battery charging switch**, a hand operated knife switch which connects the auxiliary generator and its associated battery-charging equipment to the battery.
No AC voltage relay, marked “NVR”, operates when a-c voltage fails in alternator circuit, actuates alarm bell and reduces engine speed to idle, lights blue “alternator failure” light on unit affected.

Signal relay, marked “SR”, operates alarm bell.

Compressor control relay, marked “CR”.

Fuses— One—30-ampere, auxiliary generator field fuse.
One—35-ampere, alternator field fuse.
One—80-ampere, main generator battery field fuse.
One—150-ampere, battery charging fuse.

Distribution Panel.

Main battery switch, a knife switch which when open isolates all circuits from the battery except external charging receptacles.

Control switch, a knife switch which connects the control system to the battery.

Train control and speed governor switch, a knife switch which supplies battery power to the cab signal, trainphone and headlight motor-generator set, and for speed governor control.

Light switch, a knife switch which is the master switch for all lights.

Battery charge indicator, indicates net charge or discharge through battery, except starting current or external charging current.

Fuse test light and test blocks, for testing fuses.

Fuses:
One—400 ampere, starting fuse.
One—100-ampere, external charging receptacle fuse.
One—80-ampere, control fuse.
One—60-ampere, train control and speed governor fuse.

Other fuses from 10 to 30 amperes for circuits controlled by switches on the cab push button switch box and for fuel pump and engine room lights.

Indicating Lights.

A panel, located on the electrical control cabinet on the engine room side, contains the following indicating lights:
A repeater panel, located above the rear door on each unit, contains the following indicating lights:

- Hot engine: Red
- Low oil: Yellow
- Alternator failure: Blue

**Fan Control Cabinet:**

The fan control cabinet, located over the right aisle adjacent to the engine control panel, contains:

- **Cooling fan motor contactors**, marked “AC1” to “AC4”, inclusive, connect the cooling fan motors to the alternator, controlled individually by the thermostat switch, starting one after another as required by cooling water temperature; with manually-reset thermal overload circuit breakers.

- **Temperature control relay**, marked “TCR”.

- **Transfer relays**, marked “TR1” and “TR2”, reverse order of closing of two fan motor contactors each in order to equalize the work done by the individual fans.

- **Shutter switch**, controls shutters for “Winter” or “Summer” operation.

**Control Push Button Switch Box:**

The control push button switch box is located above the engineer’s window, on the right-hand side of the cab and contains the following push-button switches:

- Cab signal.
- Bright headlight.
- Dim headlight.
- Class (marker) lights.
- Number and gauge lights.
- Defroster motor.
- Engineer’s (order)light.
- Attendant call push button.
Control, completes the multiple-unit control circuit to the throttle control, start and stop switches of the engine control on each unit, compressor control, and to alarm bells and lights.

Fuel pump, completes the multiple-unit circuit to the fuel pump contactor on each unit which supplies power to the fuel pump, the thermostatic cooling fan and shutter control; also completes circuit to lubricating oil failure alarm and “ER” relay on each unit.

Generator field, completes the circuit through the throttle lever in notches 1 to 8, inclusive, to the transition control and to the battery field and shunt field contactors.

Engine Control Panel.

The engine control panel mounted on the floor stand at the front end of the engine, contains the following:

Start switch button, for engine.

Stop switch button, for engine.

Fuel pump switch, for engine.

Isolation switch, two-position switch, when thrown to “Start” position engine will run at idling speed only and will not provide power for the locomotive; when thrown to “Run” position engine is under control of engineman’s throttle lever.

Fuel pump contactor, completes the circuit to the fuel pump and to the fan and shutter control.

“ER” relay, completes the circuit to the “A”, “B” and “C” solenoids of electro-hydraulic governor control; opening of the circuit to this relay through operation of the isolation switch, fuel pump push button, “PC” switch or other protective device will reduce engine speed to idle (except in 5th or 6th throttle positions with isolation switch in “Run” position when engine will stop.)

Gauges: Lube oil suction.

Main bearing oil pressure.

Fuel.
Electro-Hydraulic Governor Control.

An electro-hydraulic governor control incorporated in the engine governor of each engine permits multiple-unit control of all engines of the locomotive with one throttle lever. This assembly consists of four solenoids, marked “A”, “B”, “C”, and “D”. An electrical connection between the throttle and the governor control on each engine operates different combinations of solenoids. Various combinations of the solenoids result in the required engine speed for each throttle position.

An “overriding” solenoid, marked “O”, is included in the governor assembly which affects engine load only and not engine speed. When this solenoid is operated it causes lifting of the load regulating pilot valve, forcing the load regulator to minimum generator field excitation position, reducing load on the generator.

Load Control.

Load control, which loads the Diesel engine according to the throttle setting, is provided by a load regulator mounted below the engine control panel. This regulator prevents overloading of the engine. If the engine demands more fuel to maintain its speed than the predetermined setting for the throttle position, the load regulator reduces the load on the engine by reducing the excitation of the main generator. In the same way, if the engine requires less fuel than the predetermined setting, or balance point, for the throttle position, the regulator increases load by increasing excitation on the main generator.

The load regulator has two components; a pilot valve included in the governor and a hydraulic rotary vane-type motor attached to a commutator rheostat which is in the generator-battery field circuit.

During transition to and from parallel motor connection the over-riding solenoid in the governor assembly also causes the load regulator to reduce generator excitation while transition is being made.

Pneumatic Control Switch and Relay.

The pneumatic control (PC) switch and relay used on this class of locomotive is the same as that described in “Section 3—Class EP-3”.
Dynamic Braking.

The dynamic brake system employed on this class of locomotive uses a field loop, made continuous between the several units of the locomotive through separate jumpers, which connects all main generator battery fields on the locomotive in series across the auxiliary generator-battery circuit of the controlling unit. A unit selector switch, in each operating cab, should be set to a position corresponding to the number of units making up the locomotive, whether or not all units are operative. If a “B” unit is used as the trailing unit, the field loop jumper must be removed from the trailing end receptacle to permit a short-circuiting bar, included in the receptacle, to complete the loop circuit.

The dynamic braking grids, located above each aisle near the front end of each unit, are cooled by direct-current motor-driven blowers. The motor-driven blowers receive their power through connections across a portion of the grids.

Compressed Air System

Each Diesel engine on the locomotive drives a direct-connected two-stage, three-cylinder air compressor. The compressor has its own oil pump and pressure-lubricating system. Oil level in the crankcase can be checked on a bayonet-type gauge. The inter-cooler between the two stages has a 50-lb. safety valve.

Main reservoir pressure is controlled by an electrically-actuated governor system set to cut in at 125 pounds pressure and to cut out at 140 pounds pressure. Main reservoirs are protected against excessive pressure by a 165-lb. safety valve located in the discharge pipe at the compressor and a 150-lb. safety valve located in the piping adjacent to the main reservoirs.

Drains are located at the intercooler, oil sump reservoirs, filters and main reservoirs, by means of which condensation may be drained from the system.

On each unit main reservoir air through a reducing valve set at nominally 80 pounds is supplied to a control reservoir from where it is piped to pneumatically-operated switches and contactors in the electrical control cabinet. A control air pressure gauge is located in the cabinet adjacent to the distribution panel. Cut-out cocks are located in the piping to the reducing valve and in the electrical con-
trol cabinet. The control air reservoir is equipped with a drain cock through which condensation may be drained from the reservoir.

Main reservoir pressure is used for operation of the air brakes, sanders, horn, windshield wipers, bell ringer and shutters. The fuel supply tank gauge is air-operated through a separate reducing valve.

**Air Brake System**

No. 24-RL brake equipment is used, with the K-2-A rotair valve on the “A” units.

Each of the two trucks under each unit is equipped with four brake cylinders. Two-side-vented cut-out cocks, each of which cuts out and releases all brake cylinders on a truck, are located on the right side of each unit.

**Locomotive Operation**

After locomotive has been properly inspected:

1. At electrical control cabinet:
   a. Check that all fuses are in place and all switches closed on distribution panel.
   b. Check that all fuses are in place and battery charging switch is closed on low voltage panel.
   c. Check that selector switch for transition is in “Automatic” or “Manual” position as required. Switches on all units must be in the same position.

2. At engineman’s position in controlling unit:
   a. Check that throttle lever is in “Idle” position.
   b. Check that transition lever is in “Off” position.
   c. Check that reverse lever is in “Off” position.
   d. Check that unit selector switch is in proper position.
   e. Close control and fuel pump push button switches.

3. At engineman’s position in trailing cab:
   a. Check that throttle lever is in “Idle” position.
b. Check that transition lever is in “Off” position.
c. Check that reverse lever is removed.
d. Check that unit selector switch is in proper position.
e. Check that control, fuel pump and generator field push button switches are open.

4. At each Diesel engine control panel:
   a. Place isolation switch in “Run” position. Alarm should sound.
   b. Place isolation switch in “Start” position.
   c. Close fuel oil pump switch and note that full flow of fuel obtains in sight glass nearest engine.
   d. Check that manual layshaft lever is in or near “Idle” position.
   e. Press engine start push button and hold until engine starts.
   f. After lubricating oil pressure builds up, place isolation switch in “Run” position.
   g. Check for proper indication on lubricating oil pressure and lubricating oil suction gauges.

5. At electrical control cabinet on each unit:
   a. Check battery charge indicator on distribution panel to see that it indicates charge through the batteries.

Moving the Locomotive and Road Operation.

To move the locomotive:

1. Close generator field push button switch.
2. Place foot on dead-man pedal and release air brakes.
3. Place reverse lever in “Forward” or “Reverse” position as required.
4. Place transition lever in position as follows:
   a. If operating with selector switches in “Manual” position,
transition lever must be placed in No. 1 position and must only be advanced as indicated by the load ammeter.

b. If operating with selector switches in “Automatic” position, transition lever should be placed in No. 1 position and should not be advanced as full automatic forward and backward transition takes place in this position of the transition lever.

5. Move throttle lever to position required to start locomotive or train, pausing in each notch position. In starting a heavy train, care must be exercised to properly control slack action before accelerating.

To apply the dynamic brake:

1. Move throttle lever to “Idle” position.
2. See that reverse lever is in “Forward” position.
3. Wait ten seconds and then place transition lever in “Off” position.
4. Move transition lever to “B” position, and advance lever to give braking power required, using care to properly control slack action.

Use of Load Ammeter.

The load ammeter scale is divided into colored sections. Four green sections, numbered to correspond to the transition lever positions, and an overload section merging from yellow to red serve as a guide to the operation of the locomotive.

When accelerating a train from a standing start or low speed, the pointer on the load ammeter may swing full scale. The distance in miles that the locomotive may be operated, with the pointer in the overload section, is indicated by the small numbers above the vertical lines dividing this section. If, after operating the locomotive with pointer in the overload portion for any one of the indicated distances, the pointer does not move into the green portion, tonnage must be reduced or help obtained.

When using manual transition, with throttle lever in 8th position, movement of the transition lever should be made as indicated by the load ammeter as follows:
a. As pointer moves into any green section, the transition lever should be moved to the position corresponding to the number of that section.

b. With transition lever in No. 3 or No. 4 position, the pointer may move into the white section between "3" and "4" green sections without moving transition lever but when pointer moves into green section, transition lever must be placed in position corresponding to the number of that green section.

When operating with automatic transition, it should be noted that transition occurs at approximately the points indicated by the load ammeter.

A red triangle, located on the load ammeter scale, indicates the maximum allowable current while using the dynamic brake.

When operating with throttle lever in other than 8th position, using manual transition, the locomotive speed at which the transition lever should be moved is as follows:

<table>
<thead>
<tr>
<th>Speed M.P.H.</th>
<th>Transition Lever Position</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>1 to 2</td>
</tr>
<tr>
<td>25</td>
<td>2 to 3</td>
</tr>
<tr>
<td>50</td>
<td>3 to 4</td>
</tr>
<tr>
<td>50</td>
<td>4 to 3</td>
</tr>
<tr>
<td>25</td>
<td>3 to 2</td>
</tr>
<tr>
<td>20</td>
<td>2 to 1</td>
</tr>
</tbody>
</table>

Operation Without Load Ammeter.

If necessary to operate without load ammeter, transition should be made according to the preceding table and the following minimum speeds must be maintained after acceleration to avoid overload:

<table>
<thead>
<tr>
<th>Throttle Lever Position</th>
<th>Minimum Speed M.P.H.</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>15.5</td>
</tr>
<tr>
<td>7</td>
<td>12.0</td>
</tr>
<tr>
<td>6</td>
<td>9.5</td>
</tr>
<tr>
<td>5</td>
<td>7.0</td>
</tr>
</tbody>
</table>
With throttle lever in 8th position, the minimum continuous speed is 15.5 MPH. Operating at speeds below 15.5 MPH is permissible under any one of the following limitations with throttle lever in 8th position:

<table>
<thead>
<tr>
<th>Speed M.P.H.</th>
<th>Maximum Distance</th>
</tr>
</thead>
<tbody>
<tr>
<td>13.9</td>
<td>8 miles</td>
</tr>
<tr>
<td>12.7</td>
<td>4</td>
</tr>
<tr>
<td>11.3</td>
<td>2</td>
</tr>
<tr>
<td>9.6</td>
<td>1</td>
</tr>
</tbody>
</table>

Isolating A Diesel Engine:

If necessary to isolate a Diesel engine:

1. See that Diesel engine is idling, and if necessary, reduce to idling speed through use of the layshaft manual control lever.

2. Place isolation switch in “Start” position.

Note: If necessary to isolate a Diesel engine while using dynamic brake, Diesel engine must be stopped by using the layshaft manual control lever before moving isolation switch to “Start” position and, except in an emergency, the isolation switch should not be moved to “Start” position while transition lever is to the right of “B” position.

Putting a Diesel Engine on the Line:

If necessary to put Diesel engine on the line with throttle lever in other than “Idle” position, the movement of the layshaft manual control lever must be retarded manually so that the Diesel engine comes up to speed gradually when isolation switch is moved to “Run” position.

Note: Isolation switch must not be moved to “Run” position while dynamic brake is in operation.

Emergency Engine Stop:

Same as described in “Section 3—Class EP-3”.

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Ground Relay Operation:

Same as described in “Section 3—Class EP-3”, except that, if the engine stops, the “alternator failure” instead of the ‘low oil” warning light will light and alarm will sound.

Low Oil Indication:

“Low oil” indicating lights will light on the unit involved, and alarm bells throughout the locomotive will sound if a Diesel engine shuts down due to a lubricating oil failure. The engine governor reset push button must be pressed in to put out the low oil light. Check lubricating oil level in crankcase of Diesel engine and examine external piping of lubricating oil system for leaks before attempting to restart the engine. If Diesel engine is started and run at idling speed, without correcting the low oil condition which caused the shut down, the lubricating oil failure shut down system will stop the engine in approximately 40 seconds.

Hot Engine Warning Indication:

High cooling water temperature will cause the “hot engine” indicating lights to light on the unit involved and sound the alarm bells throughout the locomotive. Check cooling water level, check the automatic shutter and cooling fan operation, and reset thermal overload fan motor circuit breakers if necessary.

Alternator Failure Indication:

Failure of the alternating current system, or stopping of the Diesel engine from any cause, with the isolation switch in “Run” position, will cause the “alternator failure” lights to light on the unit involved and the alarm bells to sound throughout the locomotive. Placing the isolation switch in “Start” position will put out the lights and stop the alarm bells.

If indication is due to failure of the alternating current system, check the 35-ampere alternator field fuse on low voltage panel and replace if necessary.

Unit must not be operated under load with alternating current system inoperative.
Notes:

1. When attempting to start Diesel engines, if no fuel oil appears in sight glass nearest engine, check that fuel pump is running and, if not, check fuses and position of switches in control and fuel pump circuits. If fuel pump is running, and fuel shows in the 60-lb. Sight glass, filters should be cleaned. If fuel pump is running and no fuel shows in either sight glass, check fuel supply, emergency fuel cut-off valve, and fuel oil suction line to pump for leaks.

2. If Diesel engine does not rotate when engine start push button is pressed, check that isolation switch is in “Start” position, test 400-ampere starting fuse on distribution panel and check starting contactors.

3. If Diesel engine rotates but does not fire, check that layshaft manual control lever is in or near “Idle” position, that governor push button is in, and check overspeed stop and reset if necessary.

4. If locomotive fails to move with Diesel engines running and throttle opened, see that reverse lever is in proper position, that transition lever is in proper position, that generator field push button switch is closed, and brakes released. Check also the 30-ampere control fuse on distribution panel and that all isolation switches are in “Run” position.

5. If locomotive moves but one or more of the Diesel engines fails to deliver power, the following checks should be made:
   a. See that isolation switches are in “Run” position.
      b. Check control reservoir air pressure.
      c. Check ground relays, reset if tripped.
      d. Check starting contactors in open position.
      e. Test 80-ampere battery field fuses on low voltage panels.

6. When changing operating ends, before proceeding to end being cut in, the control, generator field and fuel pump push button switches should be opened. The control and fuel pump push button switches on the end being cut in should then be closed promptly, as the fuel transfer pumps will be shut down and the engines will stop within a few minutes.
Diesel-Electric Road Locomotives
Operating Instructions

SECTION 9 – CLASS FF-3

General Data—Locomotive

Builder.............................................. Fairbanks, Morse & Co.
Horsepower Rating ......................6000 H.P.
Gear Ratio ........................................ 17:70
Maximum Speed .............................. 68 M.P.H.
Units Per Locomotive ...................... Two “A”, One “B”
Units Per Unit ................................. Two
Axles Per Truck ................................. Three
Traction Motors Per Truck ............... Two
Wheel Diameter ............................... 42”
Journal Size ...................................... 6½”x12”
Brake Schedule................................. Westinghouse 24-RL

Maximum Overall Dimensions: 

<table>
<thead>
<tr>
<th></th>
<th>“A” Unit</th>
<th>“B” Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height</td>
<td>15’-3”</td>
<td>15’-0”</td>
</tr>
<tr>
<td>Width</td>
<td>10’-6¼”</td>
<td>10’-6¼”</td>
</tr>
<tr>
<td>Length</td>
<td>64’-10”</td>
<td>64’-10”</td>
</tr>
</tbody>
</table>

Total Weight ...................... 335,160 lbs. 354,100 lbs
Weight on Drivers .............. 245,720 lbs. 245,140 lbs.
Fuel Oil Capacity .............. 1650 gal. 1650 gal.
Sand Capacity ................. 20 cu. ft. 40 cu. ft.

General Data—Diesel Engine

Make and Model ....................... F-M 38D8 1/8
Horsepower at Governed R.P.M....... 2,000 H.P. at 850 R.P.M.
Type .................................................. In Line-Opposed Piston—2-cycle

Number of Cylinders ...................... Ten
Bore and Stroke ............................. 8-1/8”x10”x10”
Idling R.P.M. ................................. 300 R.P.M.
Firing Order ................................. 1-8-7-3-5-9-4-2-10-6
Number of Engines Per Unit .......... One
Lubricating Oil Capacity, Each Engine ......................... 360 gals.
Cooling Water Capacity, Each Engine ......................... 367 gals.

**Diesel Engine**

The engine used in this class of locomotive is a ten-cylinder, in-line, two-cycle, opposed piston type.

This type of engine has no cylinder heads and air from a specially designed blower is introduced into the cylinder and compressed between two pistons which work vertically toward each other in each cylinder. The blower is mounted on the engine and driven by the upper crankshaft through a flexible gear drive.

The upper and lower pistons drive separate crankshafts which are interconnected by a vertical gear drive incorporating a flexible coupling of coil spring design.

The cycle of events in a cylinder of this engine is similar to that described in “Section 3—Class EP-3”, except that there are no valves, and fresh air is admitted to the cylinders and exhaust gases are expelled by the pistons uncovering and covering the inlet and exhaust ports near the upper and lower ends, respectively, of the cylinder.

The main generator, auxiliary generator, fan and blower generator, and exciter are mounted on the “Rear” end of the engine. The governor, water pumps, and lubricating oil pump are mounted on the “Front” end of the engine.
The cylinders are arranged vertically and in line. The “Right” and “Left” sides of the engine are designated by the right and left hands, respectively, when facing the “Rear” end of the engine. The cylinders are numbered from front to rear, beginning with “1” at the “Front” end and ending with “10” at the “Rear” end. The direction of rotation of the lower crankshaft is counter-clockwise when facing the rear end of the Diesel engine.

**Diesel Engine Governor and Governor Control**

The electric-hydraulic governor on this engine is located on the left side of the engine at the front end. It is identical to and operates the same as the governor described in “Section 5—Class AP-3”. The governor oil pump is part of the motor-alternator pump set which is located on the floor at the front end of the engine. The tachometer generator is mounted on the Diesel engine ahead of the governor.

The various throttle lever positions and the corresponding Diesel engine rpm and maximum horsepower are as follows:

<table>
<thead>
<tr>
<th>Throttle Lever Position</th>
<th>R.P.M.</th>
<th>Horsepower</th>
</tr>
</thead>
<tbody>
<tr>
<td>Idle</td>
<td>300</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>300</td>
<td>74</td>
</tr>
<tr>
<td>2</td>
<td>375</td>
<td>270</td>
</tr>
<tr>
<td>3</td>
<td>450</td>
<td>475</td>
</tr>
<tr>
<td>4</td>
<td>525</td>
<td>725</td>
</tr>
<tr>
<td>5</td>
<td>600</td>
<td>1050</td>
</tr>
<tr>
<td>6</td>
<td>675</td>
<td>1350</td>
</tr>
<tr>
<td>7</td>
<td>750</td>
<td>1660</td>
</tr>
<tr>
<td>8</td>
<td>850</td>
<td>2000</td>
</tr>
</tbody>
</table>

The overspeed stop device on this engine is a centrifugally-operated latch mounted on the right camshaft at the front end of the engine which, when engine speed reaches 935-950 rpm, trips and forces a plunger against the fuel cut-out lever, moving the fuel racks to the no-injection position, stopping the Diesel engine. The fuel cut-out lever is also acted upon by a hand-operated emergency stop.
push button. Pushing this button also stops the engine as described above. When the engine has been stopped by the emergency stop button or by the overspeed stop, it cannot be started again until the reset lever has been manually operated.

The emergency stop button and the reset lever are both located on the left front end of the engine.

**Diesel Engine Cooling System**

The cooling systems of the Diesel engines on the several units of the locomotive are similar to each other, except that the cab heaters are incorporated in the cooling system of the engine on “A” units.

The cooling water system is made up of two interconnected systems. One system is used for the purpose of cooling the Diesel engine lubricating oil, the other system is used for cooling the Diesel engine.

Two centrifugal water pumps are located on the front end of the engine. One pump draws water from the cooling water tank located on the floor at the right rear end of the unit and circulates it through the lubricating oil heat-exchanger located over the water tank. After leaving the heat exchanger, the water flows through the two rear radiators and back to the tank.

The other pump draws water from the cooling water tank, located on the floor at the left rear end of the unit, and pumps it through the casing of the two exhaust elbows and into the engine. After circulating through the engine, the water flows out of the water header into the four front radiators, and from there drains back to its own water tank.

The radiators are arranged in two banks of three sections each and are located in the side walls of the unit over the rear truck. Normally, the radiators are full of water. However, in severely cold weather the cooling system should be operated at “low level”. A “low level” drain valve is located near the engine cooling water tank in the drain line from the pipe between the engine cooling water tank and the expansion tank. To obtain “low level”, the “low level” valve should be opened, with the engine shut down, and closed after flow of water stops.

Both cooling water tanks are vented into the expansion tank which is located overhead at the rear end of the unit.
The cooling water temperature may be checked on a dial-type gauge, located in the outlet pipe from the engine water header at the right front end of the engine.

An operating temperature of 140 to 185 degrees F. should be maintained.

Shutters for controlling cooling water temperature are opened and closed by servo-motors operated by oil pressure from the Diesel engine lubricating oil system. Three servo-motors are provided; two operate the engine cooling water radiator shutter sections, one on each side of the unit, and the third operates through linkage the rear or heat-exchanger water radiator shutters on both sides of the unit.

Each servo-motor is controlled by a pilot valve operated by a thermostatic device. For the two side servo-motors, the thermo-stats are inserted in the Diesel engine cooling water system and, for the rear servo-motor, in the outlet water connection of the heat-exchanger.

Two electrically-driven radiator fans, located above and between the radiators, draw air through the radiators for dissipating the heat from the cooling water to the atmosphere. The motor-driven fans receive their power from the fan and blower generator. The fan motors are started automatically by fan control switches coupled to the rear shutter servo-motor and the servo-motor on the left side of the unit. When either shutter is approximately one-half open, a cam in the control switch closes the “slow speed” contacts which starts the fans in series. When either shutter approaches full-open position, a second cam in the control switch operates “high speed” contacts of the switch and the fan motors are then connected in parallel and operate at high speed. The speed of the radiator fans may be further controlled by operation of a switch on the compartment control panel. The switch has two positions marked “Fast” and “Slow”. Both of the speeds by automatic control will be lower when this switch is in “Slow” position. The switch should normally be kept in “Slow” position when outside temperature is below 75 to 80 degrees F.

To operate the shutters manually; the pin connection at the servo-motor must be removed and the shutters positioned by hand.
An engine water temperature switch, located in the engine control panel, is set at 200 degrees F. and operates to reduce the load on the engine by 25 per cent, and to light the “hot engine” lights and ring the alarm bells throughout the locomotive.

The cooling system can be filled through filler nozzles located on each side of the unit over the front wheels of the rear truck. The water should be run into the system until it runs out of the opposite filler pipe.

The water level in the cooling system is indicated by glass water gauges, one located on the expansion tank and one on the engine cooling water tank. Water should show in the expansion tank gauge glass at all times, unless the system is being operated at “low level” during cold weather. When operating at “low level”, with the engine running, water should show in the gauge glass on the engine cooling water tank, above the red mark painted on the tank in back of the glass.

Cab heaters on “A” units are supplied with hot water from the engine cooling system and are provided with common inlet and outlet valves for both heaters, the valves being located in the nose of the unit in front of the fireman’s position.

If a locomotive is to be left standing, or a Diesel engine is shut down when there is danger of freezing, the standby heaters may be used or all water drained from the systems.

The standby heater suitably piped into the cooling water system, heats and circulates the engine cooling water. An electrically-driven centrifugal pump circulates the cooling water through the heater. Fuel oil from the main fuel supply tank, fed by a separate electrically-driven fuel pump, is burned in the firebox of the heater. The piping includes a valve in the water line at the heater, which must be opened to circulate the water through the heater. A second valve, located near the engine on “A” units, is provided to supply hot water to the cab heaters when the engine is shut down. A small line with a ¼ inch valve is provided from the heater delivery pipe to the toilet water tank heating coil.

To start the standby heater:

1. Open the water circulation valves described in preceding paragraph.
2. Close both standby heater circuit breakers, marked “Positive” and “Negative”, on control panel near heater.

3. Check that manual fuel by-pass valve is fully closed.

4. Push “start” button on control box near heater. The circulating pump should start, the fuel pump should start and the fire should light.

To stop the standby heater:
1. Open the circuit breakers.
2. Close the water circulation valves.

To drain an engine cooling system:

a. Open all drain valves in water piping system.

b. Remove: Lower drain plugs of both exhaust manifold water jackets, adjacent to No. 10 cylinder (two).
   Drain plugs on the underside of both exhaust “L” water jackets (two).
   Drain plug on the water inlet header nameplate (one).
   Drain plugs on the bottom of each water pump (two).
   Drain plug in bottom of oil cooler head (one).

c. Empty water treatment device.

d. Drain toilet water tank.

e. Drain cab heaters.

**Diesel Engine Lubricating Oil System**

The lubricating oil systems of the Diesel engines on the several units of the locomotive are similar to each other.

The lubricating oil supply is carried in the crankcase of the engine. A bayonet-type oil level gauge, located on the left side of the Diesel engine, shows the level of the lubricating oil in the crankcase.

If the engine is running when the oil level is checked, read the side of the bayonet gauge marked “Engine Running”. The gauge should show between “fill System” and “Add oil”.
If the engine is stopped, read the side of the bayonet gauge marked “Engine Stopped”. When the engine is first filled, the gauge should show “Oil Change—New Fill”; but after the engine has been run and shut down, the gauge should show between “Full Engine” and “Add Oil”. The difference in oil level, when the engine has been run and shut down, is due to some of the oil being trapped in the lines, filter and heat-exchanger.

Oil may be added to the system by removing the cover from the oil filler box, located adjacent to the bayonet gauge, and pouring in the required amount.

The lubricating oil pump, located on the front end of the engine, draws oil from the crankcase through a suction line and pumps the major portion through the heat-exchanger. The remaining portion is by-passed through the oil filter, located to the rear of the heat-exchanger. After passing through the heat-exchanger and the filter, the oil is circulated through the engine and then returned to the crankcase.

The heat-exchanger provides for the transfer of heat from the lubricating oil to the cooling water. Therefore, there is a definite relation between lubricating oil temperature and oil cooling water temperature.

If the pressure drop through the filters and heat-exchanger exceeds 27 pounds, oil will be by-passed direct to the engine through a spring-loaded relief valve.

The oil pressure to the engine oil header is maintained at a maximum of 70 pounds by a regulating valve located in the pump discharge. If the pressure on the system becomes excessive, this valve will cause oil to be returned direct to the crankcase.

A dial-type gauge, located on the engine control panel, shows lubricating oil pressure to the engine oil header. Normal lubricating oil pressure with throttle lever in 8th position is 20 to 35 pounds. At idling speed the lubricating oil pressure should be above 8 pounds.

A low lubricating oil pressure switch, marked “OPS”, is connected to the upper lubricating oil header at the right front end of the engine, and will shut down the engine if oil pressure drops to 5 pounds, and the alarm bells will sound and “low oil pressure” lights will light throughout the locomotive.
An oil temperature switch, located in the engine control panel, is set at 215 degrees F. and operates to reduce the load on the engine by 25 percent, and to light the “hot engine” lights and ring the alarm bells throughout the locomotive.

The temperature of the lubricating oil may be checked on a dial-type gauge located in the return line from the heat-exchanger at the right front end of the engine.

**Diesel Engine Fuel Oil System**

The fuel oil systems of the Diesel engines on the several units of the locomotive are similar to each other.

A fuel supply tank is mounted under each unit of the locomotive and may be filled from either side. A sight glass gauge is provided on each side of the unit, adjacent to the filler openings, to indicate the upper level in the tank.

A dial-type fuel gauge is located on the left side of the engine room. A door in the floor gives access to the gauge. The gauge is calibrated with proportionate markings from “Empty” to “Full”.

A fuel transfer pump, mounted on the motor-driven alternator and pump set, draws the fuel from the fuel supply tank through a suction line and strainer, and delivers it through a discharge filter to a fuel oil header passing around the engine. The header connects to each fuel injection pump. Fuel oil pressure is controlled by two pressure relief valves, one located in the discharge line of the fuel transfer pump set at approximately 35 pounds, and one located at the return end of the fuel oil header set at approximately 15 pounds. Fuel pressure relieved by either of these valves will return oil to the supply tank.

A dial-type gauge, located on the engine control panel, indicates fuel oil pressure in the header and should normally show above 15 pounds with the engine idling.

Each cylinder of the Diesel engine is provided with two individual fuel injection pumps connected by high pressure piping to two individual injectors, one on each side of the cylinder. A cam on the camshaft operates the fuel injection pump at the proper time to deliver fuel to the injector. The stroke of the fuel injection pumps is constant at all times. The amount of fuel injected at each stroke
is controlled by the engine governor which varies the effective stroke of the fuel injection pumps.

The emergency fuel cut-off valve is located under the unit on the left side in the suction line from the fuel supply tank. It may be closed by pulling any one of the several pulls on the unit, located as follows:

Two—one on each side on the outside just ahead of the side skirting.

One—in operating cab on “A” units, near floor, behind engine-man’s position, or on right side wall of “B” units opposite main generator.

**Electric Power System**

**Main Generator.**

Similar to that described under “Section 5—Class AP-3”.

**Auxiliary Generators.**

Similar to those described under “Section 5—Class AP-3”, except a fan and blower generator furnishes power to operate the two motor-driven traction motor blowers and also the two motor-driven radiator cooling fans.

**Control Stand.**

Similar to that described under “Section 5—Class AP-3”, except that transition takes place automatically for both increasing and decreasing speed at the following points:

<table>
<thead>
<tr>
<th>Position</th>
<th>Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1–2</td>
<td>17 MPH</td>
</tr>
<tr>
<td>2–3</td>
<td>22</td>
</tr>
<tr>
<td>3–4</td>
<td>43</td>
</tr>
</tbody>
</table>

**Dynamic Braking.**

When moved to the left of its “Off” position, the transition lever controls the dynamic brake.

**Reverser.**

Similar to that described under “Section 5—Class AP-3”.
Traction Motors.

One traction motor drives the leading axle and one the trailing axle of each truck through spur gears (17/70 ratio). The two traction motors on each truck are air-cooled by a separate motor-driven blower, one over each truck. The four traction motors on a unit are connected in series-parallel at starting and low speeds and in parallel at 22 mph by automatic transition (unless restricted by the position of the transition lever). Field shunting is provided and takes place in series-parallel at 17.0 mph and in parallel at 43.0 mph (unless restricted by the position of the transition lever).

Contactor Compartment.

A contactor compartment on each unit is mounted at the generator end of the engine room. The compartment contains the apparatus for main and auxiliary power control. There are no fuses in the locomotive electrical circuits, thermal circuit breakers performing their function, except for one 300-ampere fan and blower generator fuse.

The following are in the contactor compartment:

- **Main power contactors**, same as “Section 5—Class AP-3”.
- **Field shunting contactors**, marked “M1”, “M2”, “M3” and “M4”, connect the field shunting resistors across the traction motor field windings for shunted field operation.
- **Reversers**, same as “Section 5—Class AP-3”.
- **Engine starting contactors**, same as “Section 5—Class AP-3”.
- **Generator field contactor**, same as “Section 5—Class AP-3”.
- **Fuel pump contactor**, marked “FP”, closed when fuel pump switch is closed at engine control panel and fuel pump circuit breaker is closed at engineman’s position. Furnishes battery power to operate the motor-alternator pump set.
- **Battery contactor**, same as “Section 5—Class AP-3”.
- **Reverse current relay**, same as “Section 5—Class AP-3”.
- **Voltage regulator**, same as “Section 5—Class AP3”.
- **Braking contactors**, marked “BC1” and “BC2”, connect braking resistors across traction motor armatures for dynamic braking.
Braking switch, marked “SW”, controlled by braking relay, connects traction motor circuits for dynamic braking when transition lever is in “Off” or “B” (braking) positions.

Radiator fan contactors, marked “WI”, “W2” and “W3”, connect radiator fans to fan and blower generator, in either series or parallel connection under control of fan control switches at shutter servo-motors.

Transition speed relays, marked:
“CR1” and “LS1”, for 1-2 transition.
“CR2” and “LS2”, for 2-3 transition.
“CR3” and “LS3”, for 3-4 transition.
Associated rectifiers, capacitors, reactors and resistors.

Relay panel, with glass cover, contains:
Sequence relays, marked “AVF” and CVF”, and current limit adjusting resistors.
Exciter field relay, marked “EF”, closed when throttle lever is in notches 1 to 8, inclusive, and also during dynamic braking.
Ground relay, marked “GR”, drops engine to idle on power circuit ground, with manual reset button, and with sealed hand-operated knife cut-out switch separately mounted in contactor compartment.
Transfer relay, marked “TR”, closed during transition to and when operating in parallel connection of motors, closed when operating with one motor cut out and during dynamic braking.
Wheel slip relays, marked “WS1” and “WS2”, compare voltage for “2” and “3”, and “1” and “4” traction motor armatures, respectively; if speeds, and thus voltages, are different, operates alarm buzzer and light and reduces load on main generator.
Time delay relay, marked “TDR”.
Braking relays, marked “BR1” and “BR2”, closed when transition lever is in “Off” or “B” positions and reverse lever is in “Forward” position to set up dynamic braking circuits.
Brake warning relay, marked “BWR”, operates warning light if dynamic brake application is exceeding motor capacity.

Various capacitors, rectifiers and resistors.

**Excitation panel** contains static regulator for excitation control of main generator, consisting of transformer, rectifiers, reactors and resistors.

**Motor cut-out switch**, manually operated, to cut out any one of the four traction motors in case of grounds or for other reasons.

**Miscellaneous**, in contactor compartment:
- Load ammeter shunt, in No. 1 motor circuit.
- Shunts: generator output, for test purposes; generator field current, for test purposes; in No. 4 motor circuit, for test purposes.
- Test connection box.
- Excitation stabilizing capacity panel.
- Various resistors.
- Fan and blower generator fuse—300-ampere.
- Control air pressure gauge.

**Compartment Control Panel.**

This panel is mounted on the front of the contactor compartment and contains the following:

- **Compartment light switch.**
- **Engine room lighting switches (two).**
- **Radiator fan speed control switch.**
- **Battery charge indicator.**

**Thermal overload circuit breakers:**
- One—15ampere, lighting.
- One—15-ampere, auxiliary generator voltage regulator.
- One—150-ampere (“A” units), control positive.
- 100-ampere (“B” units), control positive.
One—150-ampere ("A" units), control negative.
100-ampere ("B" units), control negative.

One—200-ampere, auxiliary generator.

Switch Panel.

This panel is located on the right aisle side of the contactor compartment and contains:

**Step light switch,** ("A" units only).

**Engine room aisle light switch,** ("A" units only).

**Thermal overload circuit breakers:**

One—25-ampere, governor (all units), completes through the fuel pump contactor the circuits to the governor, battery contactor, fan and blower generator field, fan motor control and engine starting contactors.

One—15-ampere, fuel pump ("B" units only), completes control to fuel pump contactor when operating from hostler’s position.

Engineman’s Control Stand.

The following switches, circuit breakers, rheostat controls and indicating lights are mounted at the engineman’s position:

**Headlight circuit breaker,** 15-ampere.

**Control circuit breaker,** 25-ampere, completes multiple unit control to the throttle control, engine start and stop circuits on each unit, alarm bells and lights and safety controls.

**Cab signal circuit breaker,** 15-ampere, completes circuit to cab signals.

**Fuel pump circuit breaker,** 15-ampere, completes multiple unit control through fuel pump contactor on each unit of motor-alternator pump sets.

**Engine stop button,** emergency stop for all engines.

**Order light switch.**

**Headlight bright and dim switch.**
Generator field switch, completes multiple unit control through the throttle and transition lever circuits to the reversers, exciter field relays and field shunting control.

Gauge light rheostat and switch.
Cab heater rheostat and switch.
Defroster rheostat and switch.
Attendant call button.

Indicating lights.
- Hot engine (Red)
- Low lube oil pressure (Yellow)
- Wheel slip (White)
- Dynamic brake overload (White)
- Fire warning (Blue)

Fireman’s Position.

The following switches and rheostat controls are mounted at the fireman’s position:

- Hood light switch.
- Classification (marker) light switch.
- Number light switch.
- Cab heater rheostat and switch.
- Defroster rheostat and switch.

Nose of “A” Units.

Overspeed relay cabinet.

- Overspeed relay, marked “LOS”, operates at 68 mph.
- Safety control relay, marked “DMR”.

Heater and defroster circuit breaker, 15-ampere.
Fire alarm circuit breaker, 15-ampere.
Panel at Left Rear of Engine Room.

Cab signal M-G set circuit breakers (two) 50-ampere. (“A” units only).

Standby heater circuit breakers (two), 15-ampere.

“Start” button for standby heater (on standby heater control box).

Engine Control Panel.

This panel is located on the right side wall of the unit near the Diesel engine, and contains the following indicators and controls:

**Engine speed indicator.**

**Lubricating oil pressure gauge.**

**Fuel oil pressure gauge.**

**Indicating lights:**

- Ground relay tripped (White)
- Low lube oil pressure (Yellow)
- Hot engine (Red)

**Engine control (isolation) switch,** a six-position dial switch for cranking, stopping, isolating, or limiting maximum speed, of Diesel engine.

Positions marked: “Off”, “Idle”, “2”, “4”, “6” and “Run”.

The “Start” position is obtained by turning switch knob from “Off” to “Idle” position and pulling out on switch knob.

**Fuel pump switch,** for starting and stopping the motor-alternator which drives the fuel transfer and governor oil pumps.

**Main battery switch,** a manually-operated switch, separately mounted in the right aisle at the air compressor, for isolating the battery.

The following apparatus also is located in the engine control panel:

**Engine speed sequence relays,** marked “AVS”, “BVS”, “CVS”, and “DVS”.

**Engine stop relay,** marked “ESR”.

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Safety relay, marked “SAR”.

Signal relay, marked “SR”.

Engine temperature relay, marked “ETS”, operated by closing of either engine water temperature switch or lube oil temperature switch.

Water temperature switch, marked “WTS”.

Governor oil pressure switch, marked “GOP”.

Oil temperature switch, marked “OTS”.

Miscellaneous resistors, rectifiers and capacitors.

Load Control.

Same as “Section 5—Class AP-3”, except that the 400-cycle alternator is part of the motor-alternator pump set located on the floor at the front end of the Diesel engine.

Pneumatic Control Switch And Safety Control Relay.

Same as “Section 5—Class AP-3”, except that the pneumatic control switch is marked “PCS” and the dead-man relay is designated as the “safety control relay” but marked “DMR”.

Dynamic Braking.

The dynamic braking grids, located above the right aisle of each unit, are cooled by direct current motor-driven blowers. The motor-driven blowers receive their power through connections across a portion of the grids.

Compressed Air System

The Diesel engine on each unit of the locomotive drives a direct-connected, two-stage, three-cylinder air compressor. The compressor has its own oil pump and pressure lubricating system. The intercooler between the two stages has two 50-lb. safety valves.

Main reservoir pressure is controlled by an electrically-actuated governor, set to cut in at 125 pounds pressure and to cut out at 140 pounds pressure. Main reservoirs are protected against excessive pressure by a 165-lb. safety valve in the discharge pipe from
the air compressor and a 150-lb. safety valve located in the piping adjacent to the main reservoirs.

Drains are located on the inter-cooler, filter, and on each of the main reservoirs by means of which condensation may be drained from the system.

Air is supplied to a control reservoir through a strainer and check and a reducing valve set at 70 pounds. A control air pressure gauge is located in the contactor compartment. Control air is used to operate the reverser, braking switch and main power contactors.

Main reservoir pressure is used for operation of the air brake system, horn, bell, sanders and windshield wipers.

**Air Brake System**

This class of locomotive uses Type 24-RL air brake equipment, with K-2 rotair valve on the “A” units.

Each of the two trucks under each unit is equipped with six brake cylinders. Two side-vented cut-out cocks, each of which cuts out and releases all brake cylinders on a truck, are located on the right side of each unit.

**Locomotive Operation**

**Inspection and Preparation for Service.**

After the locomotive has been properly inspected:

1. At the contactor compartment panels on all units:
   a. See that control negative, control positive, governor, auxiliary generator, voltage regulator, and auxiliary generator circuit breakers are closed.
   b. See that radiator fan speed control switch is in proper position.

2. At engineman’s position in controlling unit:
   a. See that throttle lever is in “Idle” position.
   b. See that transition lever is in “Off” position.
   c. See that reverse lever is in “Off” position.
d. Close control and fuel pump circuit breakers.

3. At engineman’s position in trailing cab:
   a. See that throttle lever is in “Idle” position.
   b. See that transition lever is in “Off” position.
   c. See that reverse lever is removed.
   d. See that control and fuel pump circuit breakers and generator field switch are open.

4. At each Diesel engine control panel:
   After seeing that main battery switch is closed:
   a. Close fuel pump switch. Fuel oil pressure gauge should show at least 15 pounds pressure before the engine is started.
   b. Place engine control (isolation) switch in “Idle” position. Alarm should sound and low lube oil pressure light should light. Wait ten seconds for engine governor to reset.
   c. Pull out on engine control (isolation) switch knob to “Start” position and hold until engine fires, lubricating oil pressure gauge shows pressure, alarm stops and low lube oil pressure light goes out.
   d. Rotate isolation switch to “Run” position, pausing several seconds in each intermediate position.
   e. Check that proper lubricating oil pressure obtains.

5. At compartment control panel on each unit:
   a. Check charge indicator to see that it indicates a charge through the battery.

Moving the Locomotive and Road Operation.

To move the locomotive:
1. Close generator field switch.
2. Place foot on dead-man pedal and release air brakes.
3. Place reverse lever in “Forward” or “Reverse” position as required.

4. Place transition lever in position desired. Due to mechanical interlocking, the reverse lever can be moved only with transition lever in “Off” or No. 1 position, so that for shifting movements the transition lever should not be advanced beyond the No. 1 position. For normal road operation, the transition lever should be placed in No. 4 position, thus permitting full automatic transition to occur.

5. Move throttle lever to position required to start the train, pausing in each notch position. In starting a heavy train, care must be exercised to properly control slack action before accelerating.

To apply the dynamic brake:

1. Move throttle lever to “Idle” position.

2. See that reverse lever is in “Forward” position.

3. Place transition lever in “Off” position.

4. Move transition lever to “B” position and advance lever to give braking power required, using care to properly control slack action.

Use of Load Ammeter.

The load ammeter is divided into three colored sections on the outer (load scale) band:

- Red —at high current end of scale.
- Yellow —at left of the red, extending up to 1180 amperes.
- White —at left of the yellow, extending up to 1050 amperes.

When accelerating a train from a standing start or low speed, the pointer of the load ammeter may swing into the red zone, but must return to the left as speed increases.

With throttle lever in 8th notch position, the maximum continuous permissible amperes is 1050, as indicated by the end of the white zone.
Operation in the red zone indicates a heavy overload used for starting or accelerating a train and should be limited to approximately four minutes. Operation in the yellow zone is permissible for a consecutive or accumulated time not to exceed ninety minutes.

The inner (braking) scale of the load ammeter is divided into a white and a red section for use during dynamic braking. Movement of the pointer into the red scale indicates that excessive dynamic braking is being used and the brake warning light will light.

**Operation without Load Ammeter.**

With the throttle lever in 8th notch position the minimum continuous speed is 15.5 mph. Operation at speeds below 15.5 mph is permissible under the following limitations with throttle lever in 8th notch position:

<table>
<thead>
<tr>
<th>Speed</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>12 mph</td>
<td>90 minutes</td>
</tr>
<tr>
<td>8</td>
<td>4</td>
</tr>
</tbody>
</table>

**Isolating a Diesel Engine.**

If necessary to isolate a Diesel engine:

1. Place isolation switch in “Idle” position. If Diesel engine is running above idling speed due to throttle being open, move isolation switch from “Run” to “Idle” position, pausing in intermediate positions until Diesel engine speed levels off.

**Putting a Diesel Engine on the Line.**

If necessary to put a Diesel engine on the line, move isolation switch to “Run” position, pausing several seconds in each intermediate position. If throttle is open, pause in each position until Diesel engine speed levels off before moving to next position. Diesel engine speed may be limited regardless of throttle lever position by having isolation switch in one of its intermediate positions; that is, if switch is in No. 2 position, Diesel engine will not run faster than the speed corresponding to the 2nd notch position of the throttle lever, even though throttle lever is moved to higher notch positions.

**Note:** Isolation switch must not be moved from “Idle” to a running position while dynamic brake is in use.
Cutting Out Fuel Injection Pumps.

Each fuel injection pump may be cut out individually by disengaging the fuel control rod plunger from the control rack adjusting collar at the fuel injection pump. To cut out a complete cylinder, the fuel injection pump on each side must be cut out. If cutting out injection pumps causes excessive vibration, the engine should be shut down.

Emergency Engine Stop.

Stopping of all Diesel engines in emergency is accomplished by pushing the emergency stop push button on the control stand. The operation of the emergency engine stop depends on the control circuit breaker on the control stand being in closed position.

After stopping the engines in this manner, the engine control (isolation) switches on all units must be moved to “Off” position before any engine can be started, or the control circuit breaker in the leading “A” unit may be opened momentarily before the engines are started.

Ground Relay Operation.

If ground relay trips, alarm will sound and indicating light on unit involved will light. The Diesel engine speed will reduce to idle and power will be removed from the traction motors on that unit.

If the ground relay fails to remain reset, the traction motor cut-out switch located in the contactor compartment may be operated. If cutting out any one of the traction motors removes the ground fault, the Diesel engine may be continued in operation with that motor cut out.

Low Lube Oil Pressure Warning.

If lubricating oil pressure drops to 5 pounds, alarm will sound, indicating lights will light, and Diesel engine on unit involved will shut down. Check lubricating oil level in crankcase of Diesel engine, and examine external piping of lubricating oil system for leaks before restoring Diesel engine to service.

Hot Engine Warning Indication.

High cooling water temperature or high lubricating oil temperature will cause an operation of the hot engine warning. Alarm will
sound, indicating lights will light, and the load on the Diesel engine involved will be reduced by 25 percent. See that the cooling system contains sufficient water, that fans are operating and shutters are open. Check that radiator fan speed control switch is in “Fast” position and, if necessary, position the shutters manually. If shutters are open and fans are not running, check 300-ampere fan and blower generator fuse in contactor compartment.

Notes:

1. When attempting to start a Diesel engine, if no fuel oil pressure is obtained, see that fuel transfer pump is running, and, if not, check the following circuit breakers:
   - On compartment control panel:
     - Control positive.
     - Control negative.
   - On engineman’s control stand:
     - Fuel pump.

   If fuel transfer pump is running, check fuel supply, emergency fuel cut-off valve and the fuel oil suction line to pump for leaks.

2. If Diesel engine does not rotate when isolation switch knob is pulled to “Start” position, check control circuit breaker at engineman’s control stand, governor circuit breaker on switch panel and check starting contactors (GS 1 and GS 2).

3. If Diesel engine rotates but does not fire, observe that fuel racks on the injection pumps move out and, if not, release isolation switch and move it to “Off” position. Check governor oil supply and overspeed stop, place isolation switch in “Idle” position and wait about 10 seconds for governor to reset, then pull isolation switch to “Start” position.

4. If locomotive fails to move with Diesel engines running and throttle opened, the following checks should be made:
   a. See that reverse lever is in proper position.
   b. See that brakes are released.
   c. See that transition lever is in a running position.
d. See that generator field switch on control stand is closed.

e. See that isolation switches are in a running position.

f. Check control reservoir air pressure.

5. If locomotive moves but one or more of the several units fails to deliver power, the following checks should be made:

a. See that isolation switches are in proper position.

b. Check control reservoir pressure on each unit.

c. See that starting contactors are open.

d. Check circuit breakers on compartment control panel.

6. When changing operating ends, the fuel pump circuit breaker on control stand of end being cut out must be left **closed** until fuel pump circuit breaker on control stand of end being cut in is closed, or all Diesel engines will stop.
Diesel-Electric Road Locomotives

Operating Instructions

SECTION 10 – CLASS AF-4

General Data—Locomotive

Builder............................................. American Locomotive Company
Horsepower Rating ...................... 6000 H.P.
Gear Ratio ........................................ 18:74
Maximum Speed .............................. 65 M.P.H.
Units Per Locomotive ...................... Two “A”, One “B”
Trucks Per Unit ................................. Two
Axles Per Truck ................................. Two
Traction Motors Per Truck ................ Two
Wheel Diameter ............................... 40”
Journal Size ...................................... 6½”x12”
Brake Schedule................................. Westinghouse 24-RL

Maximum Overall Dimensions:

<table>
<thead>
<tr>
<th></th>
<th>“A” Unit</th>
<th>“B” Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height</td>
<td>14’-10”</td>
<td>14’4½”</td>
</tr>
<tr>
<td>Width</td>
<td>10-6½”</td>
<td>10’-6½”</td>
</tr>
<tr>
<td>Length</td>
<td>51’-6”</td>
<td>50’-2”</td>
</tr>
</tbody>
</table>

Total Weight .................................. 244,600 lbs. 235,200 lbs.
Weight on Drivers ............................ 244,600 lbs. 235,200 lbs.
Fuel Oil Capacity ............................. 1200 gal. 1200 gal.
Sand Capacity ................................. 22 cu. ft. 22 cu. ft.

General Data—Diesel Engine

Make and Model ............................... Alco 244-V
Horsepower at Governed R.P.M....... 1500 H.P. at 1000 R.P.M.
Type ............................................... Vee-4-cycle
Number of Cylinders ......................... Twelve
Bore and Stroke ............................... 9”xl0½”
Idling Speed...................................... 350 R.P.M.
Firing Order ................................. IR-1L-4R-4L-2R-2L-6R-6L-3R-3L-5R-5L
Number of Engines Per Unit............. One
Lubricating Oil Capacity,
    Each Engine .............................. 200 gal.
Cooling Water Capacity,
    Each Engine .............................. 250 gal.

**Diesel Engine**

Same as described in “Section 5—Class AP-3”, with the following exceptions:

Six cylinders in each bank instead of eight, which are designated “1R” to “6R” and “1L” to “6L”.

**Diesel Engine Governor and Governor Control**

Same as described in “Section 5—Class AP-3”, except that the various throttle lever positions and corresponding Diesel engine R.P.M. and maximum horsepower are as follows:

<table>
<thead>
<tr>
<th>Throttle Lever Position</th>
<th>R.P.M.</th>
<th>Horsepower</th>
</tr>
</thead>
<tbody>
<tr>
<td>Idle</td>
<td>350</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>350</td>
<td>60</td>
</tr>
<tr>
<td>2</td>
<td>450</td>
<td>175</td>
</tr>
<tr>
<td>3</td>
<td>550</td>
<td>300</td>
</tr>
<tr>
<td>4</td>
<td>655</td>
<td>525</td>
</tr>
<tr>
<td>5</td>
<td>765</td>
<td>725</td>
</tr>
<tr>
<td>6</td>
<td>860</td>
<td>890</td>
</tr>
<tr>
<td>7</td>
<td>920</td>
<td>1150</td>
</tr>
<tr>
<td>8</td>
<td>1000</td>
<td>1500</td>
</tr>
</tbody>
</table>
Diesel Engine Cooling System

Same as described in “Section 5—Class AP-3”, except that no steam train line is provided and there are no steam generators on this locomotive. However, to prevent freezing in cold weather, steam can be supplied to the cooling system by connecting an outside steam line to a pipe line provided with the necessary operating valves, choke and check valve, which leads to the suction side of the water pump on each unit.

A standby heater is also provided on each unit for freezing weather protection, which is the same as that described in “Section 9—Class FF-3”.

Diesel Engine Lubricating Oil System

Same as described in “Section 5—Class AP-3”.

Diesel Engine Fuel Oil System

Same as described in “Section 5—Class AP-3”.

Electric Power System

Main Generator.

Same as described in “Section 5—Class AP-3”, except that each unit contains a single Diesel engine of 1500 horsepower instead of 2000 horsepower.

Auxiliary Generator.

Same as described in “Section 5—Class AP-3”.

Control Stand.

Same as described in “Section 5—Class AP-3”, except that transition takes place automatically for both increasing and decreasing speeds at the following points:

<table>
<thead>
<tr>
<th>Transition Lever Position</th>
<th>Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-2</td>
<td>18½ mph</td>
</tr>
<tr>
<td>2-3</td>
<td>23</td>
</tr>
<tr>
<td>3-4</td>
<td>49</td>
</tr>
</tbody>
</table>
Dynamic Braking.

When moved to the left of its “Off” position, the transition lever controls the dynamic brake.

Reverser.

Same as described in “Section 5—Class AP-3”.

Traction Motors.

Same as “Section 5—Class AP-3”, except that one traction motor drives each pair of wheels through spur gears (18:74 ratio), and the four traction motors on a unit are connected in series-parallel at starting and low speeds, and in series-parallel with shunted fields at 18½ mph, parallel at 23 mph, and parallel with shunted fields at 49 mph by the progressive steps of transition, unless restricted by the position of the transition lever.

Contactor Compartment.

The contactor compartment on each unit is the same as described in “Section 5—Class AP-3”, and contains similar apparatus with the following exceptions:

Field shunting contactors, marked “M1”, “M2”, “M3” and “M4”, connect the field shunting resistors across the traction motor field windings for shunted field operation. (Field shunting cam controller is omitted).

Relay panel, with glass cover, same as described under “Section 5—Class AP-3”, except that braking relays, marked “BR1”, “BR2” and “BWR” are used for dynamic braking.

Field shunting control panel, omitted.

Braking contactors, marked “B1” and “B2”, connect braking resistors across traction motor armatures for dynamic braking.

Braking switch, marked “SW”, controlled by braking relay, connects traction motor circuits for dynamic braking when transition lever is in “Off” or “B” (braking) positions.

Speed Relay Panel.

Same as “Section 5—Class AP-3”, except that overspeed warning relay operates at 63.0 mph and the overspeed relay operates at 68.0 mph.
Circuit Breaker Panel.

Same as “Section 5—Class AP-3”, except that steam generator circuit breakers are omitted.

Engineman’s Control Stand.

Same as “Section 5—Class AP-3”, except that “boiler flame out” indicating light is not used and dynamic brake warning light is added.

Engine Control Panel.

Same as “Section 5—Class AP-3”, except that “boiler flame out” indicating light is not used.

Load Control.

Same as “Section 5—Class AP-3”.

Pneumatic Control Switch and Dead-man Relay.

Same as “Section 5—Class AP-3”.

Compressed Air System

Same as “Section 5—Class AP-3”.

Air Brake System

Same as described in “Section 5—Class AP-3”, except that two side-vented cut-out cocks, each of which cuts out and releases all brake cylinders on a truck, are located on the right side of each unit.

Locomotive Operation

Inspection and Preparation for Service.

Same as described in “Section 5—Class AP-3”.

Moving the Locomotive and Road Operation.

Same as described in “Section 5—Class AP-3”, except that the dynamic brake is applied as follows:

1. Move throttle lever to “Idle” position.
2. See that reverse lever is in “Forward” position.

3. Place transition lever in “Off” position.

4. Move transition lever to “B” position and advance lever to give braking power required, using care to properly control slack action.

**Use of Load Ammeter.**

Same as described under “Section 5—Class AP-3”, except that the inner (braking) scale, divided into a white and red section, is for use during dynamic braking. Movement of the pointer into the red section of the scale indicates that excessive dynamic braking current is being used and the brake warning light will light.

**Operation Without Load Ammeter.**

With the throttle lever in 8th notch position the minimum continuous speed is 10.7 mph. Operation at speeds below 10.7 mph is permissible under any one of the following limitations with throttle lever in 8th notch position:

<table>
<thead>
<tr>
<th>Speed (mph)</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.0</td>
<td>90 minutes</td>
</tr>
<tr>
<td>7.0</td>
<td>10</td>
</tr>
<tr>
<td>6.0</td>
<td>4</td>
</tr>
</tbody>
</table>

**Isolating a Diesel Engine.**

Same as described in “Section 5—Class AP-3”.

**Putting a Diesel Engine on the Line.**

Same as described in “Section 5—Class AP-3”.

Note: Isolation switch must not be moved from “Idle” to a running position while dynamic brake is in use.

**Cutting out Fuel Injection Pumps.**

Same as described in “Section 5—Class AP-3”.

**Emergency Engine Stop.**

Same as described in “Section 5—Class AP-3”.

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Ground Relay Trip or Blower Stopped Indication.

Same as described in “Section 5—Class AP-3”.

Low Lube Oil Warning.

Same as described in “Section 5—Class AP-3”.

Hot Engine Warning Indication.

Same as described in “Section 5—Class AP-3”.

Notes :

Notes 1 to 7, inclusive; same as described in “Section 5—Class AP-3”, except omit Note 7.
Diesel-Electric Road Locomotives

Operating Instructions

SECTION 11 – CLASS BF-4

General Data-Locomotive

Builder.............................................. Baldwin Locomotive Works
Horsepower Rating...................... 6000 H.P.
Gear Ratio................................. 15/63
Maximum Speed ..................... 65 M.P.H.
Units Per Locomotive.............. Two “A”, Two “B”
Trucks Per Unit ....................... Two
Axles Per Truck........................ Two
Traction Motors Per Truck......... Two
Wheel Diameter ......................... 42”
Journal Size .............................. 6½”x12”
Brake Schedule.......................... Westinghouse 24-RL

Maximum Overall Dimensions:

<table>
<thead>
<tr>
<th></th>
<th>&quot;A&quot; Unit</th>
<th>&quot;B&quot; Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height</td>
<td>14’-10½”</td>
<td>14’10½”</td>
</tr>
<tr>
<td>Width</td>
<td>10-6”</td>
<td>10’-6”</td>
</tr>
<tr>
<td>Length</td>
<td>54’-4½”</td>
<td>52’-7”</td>
</tr>
<tr>
<td>Total Weight</td>
<td>266,300 lbs.</td>
<td>257,300 lbs.</td>
</tr>
<tr>
<td>Weight on Drivers</td>
<td>266,300 lbs</td>
<td>257,300 lbs</td>
</tr>
<tr>
<td>Fuel Oil Capacity</td>
<td>1200 gal.</td>
<td>1200 gal.</td>
</tr>
<tr>
<td>Sand Capacity</td>
<td>20 cu. ft.</td>
<td>20 cu. ft.</td>
</tr>
</tbody>
</table>

General Data-Diesel Engine

Make and Model .......................... B.L.W.-608 S.C.
Horsepower at Governed R.P.M..... 1500 H.P. at 625 R.P.M.
Type .................................................. In Line—4 cycle
Number of Cylinders ......................... Eight
Bore and Stroke ................................. 12½” x 15½”
Idling Speed ................................. 250 R.P.M.
Firing Order ................................. 1-4-7-6-8-5-2-3
Number of Engines Per Unit .......... One
Lubricating Oil Capacity .......... 190 Gal. per engine
Cooling Water Capacity .............. 325 Gal. per engine

Diesel Engine

Same as described in “Section 4—Class BP-1.”

Diesel Engine Governor and Governor Control

Same as described in “Section 4—Class BP-1.”

Diesel Engine Cooling System

The cooling systems of the several engines on the locomotive are similar to, and independent of, each other.

Water is circulated through the cooling system by a centrifugal water pump located on the front end of the engine. The pump circulates water around the engine cylinder liners and through the jackets to an engine water manifold, from which it is piped to the cooling radiators located overhead at the rear of each unit. After passing through the radiators, the water flows through the oil cooling heat-exchanger located at the front end of the engine, and back to the pump. An expansion tank located overhead at the rear of the engine, is connected to the suction side of the pump. The radiators and engine water manifold are vented into the expansion tank. A radiator by-pass pipe connects the engine water manifold to the suction line of the water pump. A butterfly valve, located, in the pipe connection at the engine water manifold, directs the flow of water to the radiator by-pass pipe to rapidly increase cooling water temperature during warm up periods. The butterfly valve is operated by main reservoir air pressure through a thermostatically controlled air valve and cylinder. A manually operated
valve, located on the left side of Diesel engine near the front end normally sealed in the “Automatic” position, permits manual control of the butterfly valve. With the valve in the “Automatic” position, the butterfly valve is under thermostatic control. With the valve in “Manual” position, the butterfly valve assumes a position for by-passing the minimum amount of water.

Water temperature may be checked on a dial-type thermometer, located on the side wall opposite the engine control panel. The temperature of the cooling water will vary between 150” and 160” F. under normal operating conditions.

Shutters for controlling cooling water temperature are operated by main reservoir air pressure through magnet valves. The shutters are fully open at all times when the cooling fans are running, except when using the dynamic brake. During dynamic braking the cooling fans draw cooling air through the resistor grids, and one section of shutters only is thermostatically controlled for the cooling water radiators as required.

Air from the main reservoirs through a 17-lb. reducing valve, and a thermostatically-controlled air valve (Grad-U-Stat), operates pneumatic switches which control the shutter magnet valves and also the speed of motor-driven cooling fans. The cooling fans operate at two different rates of speed, depending on cooling water temperature, and are supplied with power from the main generator, except when dynamic braking is being used, when they are supplied with power from the traction motors by connection across the dynamic braking grids and the speed is controlled by the amount of braking current being developed.

A three-position fan and shutter control switch, located on the engine control panel, operates as follows:

“Off” — Fans will not operate; shutters are closed.

“On” — Shutters are open; fans operate with thermostatic speed control.

“Auto” — Operation of fans and shutters controlled by temperature switches.

The shutter operating mechanisms are located on the bulkheads at each end of the radiator compartment in the rear of the unit. The Grad-U-Stat and pneumatic temperature switches, together
with the reducing valve and filter, are located on the rear bulkhead of the radiator compartment.

A separate water temperature switch, located on the front end of the Diesel engine and set at 190° F., will act on the engine shut-down solenoid valve to stop the engine when the engine cooling water temperature becomes excessive. Operation of the water temperature switch will sound the alarm throughout the locomotive and will light the “hot-engine” light on the engine control panel of the Diesel engine involved.

A “radiator fan stopped” light, located on the engine control panel will light if the radiator fan circuit is opened due to overload. When using the dynamic brake, the alarm will sound throughout the locomotive when any one of the “radiator fan stopped” lights light.

The cooling system may be filled through a filling connection on either side of each unit over the front of the No. ‘2 truck, or at the filling connection on the roof over the expansion tank.

The water level in the cooling system is indicated by a glass water gauge, located on the expansion tank. Water must show in this gauge glass at all times when the Diesel engine is running.

If a locomotive is to be left standing, or a Diesel engine is shut down, where there is danger of freezing, the standby heater may be used or all water should be drained from the system.

The standby heater on this class of locomotive is similar to that described in “Section 9—Class FF-3”, except that only one circuit breaker is used instead of two, and is located on a stand adjacent to the heater.

To drain an engine cooling system, open the drain valve located in drain line adjacent to water pump suction line and the drain valve in drain line from cab heater piping.

**Diesel Engine Lubricating Oil System**

Same as described in “Section 6—Class BP-3.”

**Diesel Engine Fuel Oil System**

Same as described in “Section 6—Class BP-3”, with the following exceptions:
As there is only one Diesel engine on each unit the fuel oil system is entirely independent.

Two sight glass gauges, one near the top and one near the bottom, are located on the right side of the fuel tank. The upper glass gauge only is provided on the left side of tank.

Two emergency fuel cut-off valves are located under the unit in the suction lines from the fuel supply tank, one on the left side of the unit for the Diesel engine and one on the right side of the unit for the standby heater. Both valves may be closed by pulling any one of the pull rings on the unit, located as follows:

One—in the cab back of engineman’s position in “A” units only.
One—at hostler’s position on “B” units only.
Two—on outside above fuel tank on each side of the unit.

Electric Power System

Main Generator.

Each unit contains one Diesel engine of 1500 horsepower. A main generator is connected to the Diesel engine by a coupling and feeds the four traction motors and the radiator cooling fan motors. The traction motor blowers are mechanically driven from the Diesel engine.

Auxiliary Generator and Exciter.

An auxiliary generator and exciter set is mounted on and belt driven by the main generator. The auxiliary generator is used to charge the storage battery on the unit and to supply low voltage power.

The exciter supplies power to the main generator field windings and is specially wound to maintain constant power output of the main generator.

Control Stand.

Same as that described under “Section 4—Class BP-I”, except that the reverse lever incorporates a “Dynamic Braking “position ahead of the “Forward” position. With the reverse lever in “Dynamic Braking” position and the dynamic braking switch in “On”
position, the movement of the throttle lever controls the amount of dynamic braking current.

**Traction Motors.**

Each unit has four traction motors, one for each axle, geared through spur gears (15:63 ratio). The two traction motors on each truck are air cooled by a single blower. The traction motors are permanently connected in series-parallel, the No. 1 and No. 3 traction motors comprise the No. 1 traction motor circuit, the No. 2 and No. 4 traction motors comprise the No. 2 circuit. Transition consists of two steps of field shunting, which takes place automatically at 20 and 30 mph, respectively. Backward transition is also automatic.

**Electrical Equipment Cabinet.**

The electrical equipment cabinet is located near the generator end of the engine room on each unit and contains the following apparatus:

- **Two main power contactors**, operated by air pressure through magnet valves marked “P-1” and “P-2”.

- **Eight traction motor field shunting contactors**, marked “M-1”, “M-3”, “M-5”, and “M-7” for the No. 1 traction motor circuit and “M-2”, “M-4”, “M-6” and “M-8” for the No. 2 traction motor circuit.

- **One reverser**, operated by air pressure through magnet valves.

- **One ground relay**, marked “GR”, for grounds in the high voltage circuit, with manual reset button located on engine control panel; can be cut out in emergency by opening sealed circuit breaker mounted on engine control panel.

- **One control contactor**, marked “CR”.

- **One control relay**, marked “CR-1”.

- **Two engine starting armature contactors**, marked “G-1” and “G-2”.

- **One starting protective relay**, marked “PT”.

- **Two wheel slip relays**, marked “WS-1” for the No. 1 traction motor circuit and “WS-2” for the No. 2 traction motor circuit.
One emergency engine stop contactor, marked “ES”.

One fan motor field shunting relay, marked “RFR”.

Four generator field contactors, marked “GF-1”, “GF-2”, “GF-11” and “GF-12.”

Five exciter field contactors, marked “EF-1”, “EF-2”, “EF-3”, “EF-4” and “EF-5”.

One power control contactor, marked “FR”.

Two traction motor field shunting relays, marked “FS-1” and “FS-2.”

Six fan motor contactors, marked “F1”, “F2”, “F3”, “F4”, “F5”, and “F6”. “F1” incorporates an overload relay with manual reset button located on engine control panel.

One signal relay, marked “SG”.

One time delay magnet valve, marked “TDV” supplies air to time delay relays.

Two time delay relays, marked “TD-1” and “TD-2” air operated to control starting of cooling fans.

One fire alarm relay, marked “FAR”.

One battery charging contactor, marked “A”.

One reverse current relay, marked “RC”.

One voltage regulator, marked “VR”.

One lighting circuit breaker. (“B” units only), 25 ampere.

Two traction motor cut-out switches, marked “TMCO #1” for the No. 1 and “TMCO #2” for the No. 2 traction motor circuit.

One control cut-out circuit breaker, 50-ampere.

One battery switch.

One auxiliary generator circuit breaker, 100-ampere.

One cam switch, controlled by magnet valves marked “CSM” for motoring position and “CSB” for braking position.

Two dynamic braking contactors, marked “BR1” and “BR2”
One brake warning relay, marked “BWR”.

One protective braking relay, marked “PBR”.

One brake regulating relay, marked “DBR”.

Various resistors and shunts.

Engine Control Panel.

An engine control panel, mounted on the electrical equipment cabinet in the left aisle on “B” units and on the rear of the cabinet adjacent to the left aisle in “A” units, contains the following:

One battery charge indicator.

One ground relay cut-out circuit breaker, 15-ampere, sealed in “On” position.

Ground indicating light.

Hot-engine indicating light.

Dynamic brake overload indicating light.

Radiator fan stopped indicating light.

Engine start push button No. 1.

Engine start push button No. 2.

Fan reset push button for resetting “F-I” contactor.

Ground relay reset push button.

Isolation switch, when in “Idle” position engine will run only at idling speed and will not provide power for the locomotive. When in “Run” position, the engine is under control of the throttle lever.

Fan and shutter control switch, a three position switch.

Dynamic brake cut-out switch, when in the “On” position completes the braking control circuits; when in the “Off” position, cuts out the dynamic brake on the unit.

Engine stop circuit breaker, 15-ampere.

Power cut-out circuit breaker, 15-ampere.
Auxiliary generator field circuit breaker, 35-ampere.

Exciter field circuit breaker, 35-ampere.

Control Circuit Breaker Box.

The control circuit breaker box is located to the left of the control stand in operating cab in “A” units, and contains the following thermal-overload 15-ampere circuit breakers:

Control, establishes the multiple-unit power control through the throttle and reverse levers, to the reversers, field contactors, and completes the circuit to the master control magnet valve.

Cab signal, completes the circuit to cab signals.

Defroster fans.

Marker lights.

Rear backup light.

Number and instrument panel lights.

Headlight.

Emergency engine stop.

An attendant call push button switch is also located on control circuit breaker box on “A” units.

The control circuit breaker box is located at the hostler’s position in “B” units and contains the following thermal-overload 15-ampere circuit breakers:

Control.

Marker lights, No. 1 end.

Headlight, No. 1 end.

Headlight, No. 2 end.

Marker lights, No. 2 end.

Emergency engine stop.

At Enginerman’s Position

The following are located at the engineman’s position:

Headlight switch, with “Full”, “Off” and “Dim” positions.
Gauge light dimming rheostat.
Cab heater fan circuit breaker, E-ampere.
Cab heater fan rheostat.
Dynamic brake warning light.

At Fireman’s Position.
The following are located at fireman’s position:
Cab heater fan circuit breaker, 15-ampere.
Cab heater fan rheostat.
Four indicating lights for fire alarm system (one for each unit).

Load Control.
Same as described in “Section 4—Class BP-l”.

Power Knockout Switch.
Same as described in “Section 4—Class BP-l”.

Master Control Magnet Valve.
Same as described in “Section 4—Class BP-l”.

Throttle Unloading Magnet Valves.
The throttle unloading magnet valves are located on the left side wall of engine room adjacent to the Diesel engine, and are designated as “TV-1” and “TV-2”. “TV-1” is actuated by wheel slip relay operating, ground relay operating, or placing isolation switch in “Idle” position. “TV-2” is actuated by placing throttle lever in “Idle” position. Actuating either valve causes Diesel engine to return to or remain at idling speed.

Engine Shut-Down Solenoid Valve.
Same as described in “Section 4—Class BP-l”, mounted on the front end of the Diesel engine.
Auxiliary Equipment Stand.

Cab signal and trainphone equipment is located on a stand at rear end of "A" units only. The 50-ampere circuit breaker for the motor-generator set is located on the left side of stand. A panel on the rear of the stand includes a 5-ampere trainphone circuit breaker, a 25-ampere lighting circuit breaker and a transfer switch for supplying 32-volt power to cab signal, trainphone and headlight circuits from the motor-generator set or one-half the battery depending on its position. A panel on the right side houses the standby heater controls and includes a circuit breaker and starting push button. The standby lighting transfer switch and transformer are mounted on front of the stand.

On "B" units the standby heater controls are mounted on an individual stand at the rear of the unit. The lighting circuit breaker is located in the electrical equipment cabinet and the standby lighting transfer switch and transformer are located on top of the electrical equipment cabinet.

Dynamic Braking.

The dynamic brake system used on this class of locomotive is controlled by the throttle lever when the reverse lever is in its "Dynamic Braking" position. In order to complete the dynamic braking circuits, the dynamic brake cut-out switch, located on the engine control panel on each unit, must be in the "On" position. When the throttle lever is advanced for dynamic braking, the large radiator shutters will close, or will remain in closed position directing the flow of air through the dynamic braking grids and operating shutter limit switches located on rear bulkhead of radiator compartment, thereby completing the dynamic braking circuit.

Control of the traction motor field strength is a function of the main generator output which is varied by changing the speed of the Diesel engine and augmented by the action of the carbonstat load regulator. The dynamic braking resistance grids are cooled by the cooling fans which are powered by braking current through a connection across one of the dynamic braking grids, while using the dynamic brakes.
Compressed Air System

Same as described in “Section 4—Class BP-I” with the following exceptions:

Main reservoir air pressure is used to furnish air supply through the throttle control to the pneumatic actuators. Main reservoir air pressure is used to operate the radiator shutters and, through a separate reducing valve set at 1’7 pounds, to operate the radiator fan and shutter controls. A control air pressure gauge is located in the nose of “A” units and one the hostler’s gauge panel on “B” units. A main reservoir after cooler, in the piping between the No. 1 and No. 2 main reservoirs, is located in front of the fuel oil tank behind the front truck and is used to cool the air before it passes to the air system piping.

Air Brake System

Same as described in “Section 6-Class BP-3.”

Locomotive Operation

Inspection and Preparation for Service.

After locomotive has been properly inspected:

1. In electrical equipment cabinet on each unit:
   a. See that all switches and circuit breakers are closed (in the “On” position).

2. At engineman’s position in controlling unit:
   a. See that throttle lever is in “Idle” position.
   b. See that reverse lever is in “Off” position.
   c. Close control circuit breaker.
   d. See that emergency engine stop circuit breaker is in “Off” position.

3. At engineman’s position in trailing unit:
   a. See that throttle lever is in “Idle” position.
   b. See that reverse lever is removed.
c. See that control and emergency engine stop circuit breakers are in “Off” position.

4. At hostler’s position in “B” units:
   a. See that control and emergency engine stop circuit breakers are in the “Off” position.
   b. See that reverse lever is removed.
   c. See that throttle lever is in “Idle” position.
   d. See that the cut-out cocks are closed. (One at the reducing valve and one in the piping under brake valve).

5. At each Diesel engine control panel:
   a. Place engine stop circuit breaker in “On” position. Alarm should sound. Note that fuel oil pressure is indicated on the gauge.
   b. Press engine start push button No. 1 and hold in until engine fires and at least 20 pounds lubricating oil pressure obtains. If engine does not turn fast enough to start, the cranking speed can be increased by pressing engine start push button No. 2 while push button No. 1 is held in.
   c. Place isolation switch in “Run” position.
   d. See that power cut-out circuit breaker is in “On” position.
   e. See that fan and shutter control switch is in automatic (“Auto”) position.
   f. Close auxiliary generator and exciter field circuit breakers. (Note that battery charge indicator indicates charge).
   g. See that dynamic brake cut-out switch is in “On” position.

Moving the Locomotive and Road Operation.

To move the locomotive:

1. Place foot on deadman pedal and release air brakes.
2. Place reverse lever in “Forward” or “Reverse” position as required.

3. Move throttle lever to first notch position and pause until load ammeter indicates current. Throttle lever should be advanced slowly to the position necessary to start train. In starting a heavy train, care must be exercised to properly control slack action before accelerating.

To apply the dynamic brake:
1. Move throttle lever to “Idle” position.
2. Place reverse lever in “Dynamic Braking” position.
3. Move throttle lever to first notch position and wait until current shows on load ammeter, then advance throttle lever to obtain braking power required, using care to properly control slack action.

Note: When using dynamic brake, the current as indicated by the load ammeter must be limited to 750 amperes. The indicating light will light if this current is exceeded on any unit. Dynamic braking should not be used at speeds above 50 mph.

Use of Load Ammeter.

The division between the white and red scales on the load ammeter indicates the maximum permissible continuous current which is 925 amperes. Operation at loads above 925 amperes is permissible under any one of the following limitations with throttle lever in wide open position

<table>
<thead>
<tr>
<th>Amperes</th>
<th>Time Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>1000</td>
<td>30 minutes</td>
</tr>
<tr>
<td>1050</td>
<td>20</td>
</tr>
<tr>
<td>1175</td>
<td>10</td>
</tr>
<tr>
<td>1325</td>
<td>5</td>
</tr>
</tbody>
</table>

Note: If unable to operate at or below the maximum continuous rating after operating under any one of the above overload limitations, tonnage must be reduced or help obtained.
Operation without Load Ammeter.

If necessary to operate without load ammeter with throttle lever in wide open position, the minimum continuous speed is 10.5 mph in order to avoid overload.

Operation at speeds below 10.5 mph is permissible under any one of the following limitations with throttle lever in wide open position:

<table>
<thead>
<tr>
<th>Speed (mph)</th>
<th>Time Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.5</td>
<td>30 minutes</td>
</tr>
<tr>
<td>9.0</td>
<td>20</td>
</tr>
<tr>
<td>8.0</td>
<td>10</td>
</tr>
<tr>
<td>6.5</td>
<td>5</td>
</tr>
</tbody>
</table>

Isolating a Diesel Engine.

Same as described in “Section 4—Class BP-l.”

Putting a Diesel Engine on the Line.

Same as described in “Section 4—Class BP-l.”

Emergency Engine Stop.

Same as described in “Section 4—Class BP-l.”

Ground Relay Operation.

Same as described in “Section 6—Class BP-3”, except that the load ammeter is connected in the No. 1 traction motor circuit and when the No. 1 traction motor circuit is cut out on the leading “A” unit, no indication will be given on load ammeter. With the No. 2 traction motor circuit cut out and No. 1 traction motor circuit not cut out the load ammeter may be used with normal limitations.

Engine Stopped Warning Indication.

Same as described in “Section 6-Class BP-3”, with the following exceptions:

If the “Radiator Fan Stopped” indicating light is lit, push the fan reset push button on engine control panel to reset the “F-1” contactor. There are no manual control levers for shutter operation.
Notes:

1. When attempting to start a Diesel engine, if no fuel pressure is obtained check that fuel pump is running and, if not, check that engine stop circuit breaker on control panel is “On”, that control cut-out circuit breaker in electrical equipment cabinet is “On” and that battery switch is closed. If the fuel pump is running, check fuel supply, emergency fuel cut-off valve, and fuel oil suction line to pump for leaks.

2. If Diesel engine does not rotate when engine start push button is pressed, check that battery switch is closed, that isolation switch is in “Idle” position and check starting contactors in electrical equipment cabinet.

3. If Diesel engine rotates but does not fire, check overspeed stop and reset if necessary and check oil supply in engine governor. While Diesel engine is rotating, see that piston of Diesel engine shut-down cylinder moves out to permit free operation of injector layshaft.

4. If locomotive fails to move with Diesel engines running and throttle opened, the following checks should be made:
   a. See that reverse lever is in proper position and brakes released.
   b. See that control circuit breaker in cab of controlling unit is in the “On” position.
   c. See that cut-out cock in air supply pipe to control stand is open.
   d. Check control reservoir gauge in nose of controlling unit.
   e. Check position of power cut-out circuit breakers, exciter field circuit breakers, and isolation switches on all units.

5. If locomotive moves but one or more of the Diesel engines fails to deliver power, the following checks should be made:
   a. See that isolation switches are in “Run” position.
   b. Check ground relays and reset if tripped.
   c. Check control reservoir pressures.
d. See that all starting contactors are open.

e. Check throttle pipe for leaks including connection between units and see that cut-out cocks in throttle pipe are fully opened.

f. Check exciter field circuit breaker and power cut-out circuit breaker on engine control panel on units affected.

6. When changing operating ends, before proceeding to end being cut in, see that control circuit breaker in cab is “Open”.

7. When a low battery condition exists on lead operating unit, with auxiliary generator inoperative, the locomotive can be controlled from the operating cab of this unit as follows:

a. Open control cut-out circuit breaker in electrical equipment cabinet on leading “A” unit.

b. Close control circuit breaker in cab of leading “A” unit.

c. Close control circuit breaker, and close cut-out cock in air supply pipe to control stand, on a trailing unit.

d. Close control contactor, marked “CR”, in electrical equipment cabinet on leading “A” unit, using flag stick.